IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent of:	Bici et al.	
U.S. Patent No.:	10,536,714	Attorney Docket No.: 54587-0016IP1
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Appl. Serial No.:	16/356,733	
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Title:	METHOD FOR CODING AN APPARATUS	

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DECLARATION OF JOSEPH HAVLICEK IN SUPPORT OF PETITION FOR INTER PARTES REVIEW OF U.S. PATENT NO. 10,536,714

I declare that all statements made in this declaration on my own knowledge are true and that all statements made on information and belief are believed to be true, and further, that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Date: June 6, 2025

By: ________________________

Joseph Havlicek

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I, Joseph Havlicek, do hereby declare that:

I. Introduction

1. My name is Joseph Havlicek, and I have been retained by counsel for ASUSTeK Computer Inc. and ASUS Computer International (collectively "ASUS") as an expert witness to assist in analyzing issues related to the patentability of certain claims of U.S. Patent No. 10,536,714 ("the '714 Patent"). I understand that ASUS intends to submit this declaration in support of a petition for *inter partes* review ("IPR") of the '714 Patent before the Patent Trial and Appeal Board ("PTAB") of the United States Patent and Trademark Office ("USPTO").

2. I am being compensated for my work in this matter at my standard hourly rate. My compensation in no way depends on the outcome of this proceeding or the content of my testimony.

3. My analysis here is based on my years of education, research and experience, as well as my investigation and study of relevant materials, including those cited herein. I may rely upon these materials, my knowledge and experience, and/or additional materials to further explain and corroborate my analysis, and to respond to any critiques of my analysis that may be raised during the course of the IPR proceeding in which this declaration is submitted.

4. I understand that earlier IPR proceedings, IPR2024-00604 and IPR2024-00605, were instituted before the Patent Trial and Appeal Board

concerning the ’714 Patent, in which AMAZON.COM, INC. and AMAZON.COM SERVICES LLC, (collectively, “Amazon”) were the petitioners (the “Amazon IPRs”). I understand that Dr. Charles Creusere submitted two declarations in the Amazon IPRs, which I have attached as **Appendices A and B** to the present declaration. I have reviewed Dr. Creusere’s declarations in their entirety, including the analysis, claim constructions, and supporting technical opinions presented therein. Based on my independent analysis of the ’714 Patent and the materials cited herein, I agree with the technical opinions and substance of Dr. Creusere’s declarations from the Amazon IPRs as for issues related to the grounds advanced in this Petition, and I adopt them as my own unless otherwise noted. Dr. Creusere’s declarations are fully incorporated herein as they relate to the grounds that are advanced in this Petition.

II. Materials Considered

5. In preparing this declaration, I considered the following materials in addition to Dr. Creusere’s declarations:

Exhibit No.	Description
ASUS-1001	U.S. Patent No. 10,536,714 to Bici, et al. (“the ’714 patent”)
ASUS-1002	Prosecution File History for the ’714 patent (“Prosecution History”)
ASUS-1004	U.S. Patent Application Publication No. 2011/0194609 to Rusert et al (“Rusert”)
ASUS-1005	U.S. Patent Application Publication No. 2011/0249721 to Karczewicz et al (“Karczewicz”)

ASUS-1006	U.S. Patent Application Publication No. 2014/0092981 to Lin et al ("Lin")
ASUS-1007	Nakamura et al., "Unification of derivation process for merge mode and MVP," Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, 6th Meeting, Torino, Italy, Jul. 14-22, 2011, Document JCTVC-F419 ("Nakamura Document")
ASUS-1012	U.S. Provisional Application 61/301,649 ("Rusert Provisional")
ASUS-1013	U.S. Provisional Application 61/500,903 ("Lin Provisional")
ASUS-1015	Prosecution File History for U.S. Patent No. 9,571,833 ("'833 Prosecution History")
ASUS-1017	European Prosecution File History for 12845839 ("European Prosecution History")
ASUS-1018	U.S. Patent Application Publication No. 2012/0128067 to Liu ("Liu")
ASUS-1019	Gary J. Sullivan, Recent Developments in Standardization of High Efficiency Video Coding (HEVC) ("Sullivan")
ASUS-1020	Frank Bossen, HEVC Complexity and Implementation Analysis ("Bossen")
ASUS-1021	Jian-Wei Chen et al, Introduction to H.264 advanced video coding. In: Proceedings of the 2006 Asia and South Pacific Design Automation Conference vol. 2006, pp. 736–741 (2006)
ASUS-1022	Won, Kwanghyun et al, Motion vector coding using decoder-side estimation of motion vector. In 2009 IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB). IEEE, 2009
ASUS-1023	Gary J. Sullivan et al, The H.264/AVC Advanced Video Coding Standard: Overview and Introduction to the Fidelity Range Extensions, SPIE Conference on Applications of Digital Image Processing XXVII, 2004
ASUS-1052	Institution Decision IPR2024-00604, Paper 11, November 7, 2024
ASUS-1053	Institution Decision IPR2024-00605, Paper 11, November 7, 2024

III. Qualifications

A. Summary

6. I received a Bachelor of Science degree in electrical engineering with

minors in mathematics and computer science from Virginia Tech in 1986. I also received a Master of Science Degree in electrical engineering, also from Virginia Tech, in 1988. I received the Ph.D. degree in Electrical and Computer Engineering from the University of Texas at Austin in 1996. My Ph.D. research was in the field of image processing.

7. From December 1984 to May 1987, I was a software engineer at Management Systems Laboratories in Blacksburg, VA. My job responsibilities included developing software for nuclear materials management under contract with the United States Department of Energy.

8. From June 1987 to January 1997, I was an electrical engineer at the United States Naval Research Laboratory. For the period of June 1987 through August 1989, I was an on-site contractor affiliated with SFA, Inc., Landover, Maryland. From August 1989 through January 1997, I was a federal government employee. I was on leave without pay from August 1987 through July 1988 while completing my Master of Science degree. I was also on leave without pay for much of the period from August 1990 through January 1997 while I completed my Ph.D. degree. My main job responsibilities at the United States Naval Research Laboratory included designing digital and analog circuits to process real-time video signals and designing and implementing target detection, tracking, and identification algorithms for real-time video signals. I was a recipient of the 1990

Department of the Navy Award of Merit for Group Achievement for this work.

9. From January 1993 through December 1993, I was an on-site contractor at International Business Machines (IBM) Corporation, Austin, TX. My main job responsibilities included designing and implementing image compression and decompression algorithms (CODECs) for IBM products.

10. Since January 1997, I have been a regular faculty member in the School of Electrical and Computer Engineering at the University of Oklahoma, Norman, OK. I was an Assistant Professor from January 1997 through June 2002. I was promoted to the rank of Associate Professor and granted tenure in July 2002. I was promoted to the rank of Professor in July 2007. I was appointed to the Williams Companies Foundation Presidential Professorship in April 2009. In April 2017 I was appointed to the Gerald Tuma Presidential Professorship.

11. My main job responsibilities at the University of Oklahoma include conducting academic research in electrical and computer engineering, teaching graduate and undergraduate courses in electrical and computer engineering, and performing professional and institutional service.

12. I am a member of several professional societies and organizations, including the Institute of Electrical and Electronics Engineers (IEEE), the IEEE Signal Processing Society, the IEEE Computer Society, and the IEEE Intelligent Transportation Society. I am a Senior Member of the IEEE. From November 2015

through February 2018, I served as a Senior Area Editor for the IEEE Transactions on Image Processing. I was formerly an Associate Editor for the IEEE Transactions on Image Processing from December 2010 through October 2015. I have served as a Technical Area Chair for the IEEE International Conference on Image Processing in the area of Image & Video Analysis, Synthesis, and Retrieval (2012, 2013) and have served on the organizing committee of that conference (2007). I have also served as a Technical Area Chair for the IEEE International Conference on Acoustics, Speech, and Signal Processing in the area of Image, Video, and Multidimensional Signal Processing (2012-2014).

13. For over 30 years, I have conducted research and taught classes in the field of image and video processing and analysis. My main scholarly contributions have been in the areas of modulation domain image models and image processing (AM-FM image models), video target tracking, and distributed control of video networks for intelligent transportation systems.

14. I have served as a supervisor or committee member for numerous Ph.D. dissertations and Master's theses. I have supervised 12 Ph.D. students to completion and am currently supervising three Ph.D. students. I have been a member of 68 additional doctoral dissertation committees. I have supervised 28 Master's students to completion. I am currently supervising one additional Master's students. I have been a member of 71 additional Master's thesis

committees. A listing of my Ph.D. and Master's supervisions and committee memberships is found in my curriculum vitae in Appendix CV.

15. I am co-founder and director of the University of Oklahoma Center for Intelligent Transportation Systems (CITS). Under my supervision, the Center has collaborated with the Oklahoma Department of Transportation since 1998 to design and implement the Oklahoma Statewide Intelligent Transportation System, including a geographically distributed video network that is currently deployed on major highways and interstates across the entire State of Oklahoma.

16. I teach a variety of courses at the University of Oklahoma, including the required junior-level Signals and Systems course ECE 3793 (taught 21 times), the graduate level Digital Image Processing course ECE 5273 (taught 26 times), and the graduate level Digital Signal Processing course ECE 5213 (taught 18 times).

17. Since joining the University of Oklahoma in January 1997, I have been Principal Investigator or Co-Principal Investigator on over 110 externally funded grants and contracts with a total value of over $27M. My main research contributions have been in the areas of signal, image, and video processing, video target tracking, and intelligent transportation systems. I have been author or coauthor on over 130 scholarly publications in these areas. I was a recipient of the 1990 Department of the Navy Award of Merit for Group Achievement for my

work in video target tracking. My research group at the University of Oklahoma originated the Virtual Traffic Management Center concept featured in a December 2014 FHWA technical report (Guidelines for Virtual Transportation Management Center Development) and a November 2014 FHWA national webinar with the same title. I have received a number of teaching awards, including the University of Oklahoma College of Engineering Outstanding Faculty Advisor Award (2005-2006) and the University of Texas Engineering Foundation Award for Exemplary Engineering Teaching while Pursuing a Graduate Degree (1992).

18. Since joining the faculty of the University of Oklahoma in 1997, I have taught numerous classes at both the graduate and undergraduate levels. At the graduate level, I have taught the following courses: Digital Signal Processing (ECE 5213), Digital Image Processing (ECE 5273 and CS 5273), Multimedia Communications (ECE 5973), Kalman Filtering (ECE 6973), and Advanced Image Processing (ECE 6283). At the undergraduate level, I have taught the following courses: Digital Signals and Filtering (ECE 2713), Microcomputer System Design (ECE 3223), Signals and Systems (ECE 3793), Digital Signal Processing (ECE 4213), Digital Image Processing (ECE 4973), and Multimedia Communications (ECE 4793).

IV. Legal Standards

19. I have been asked to provide my opinions as to whether claims 1-30

of the ’714 Patent would have been obvious to a person of ordinary skill in the art as of the earliest claimed priority date of the ’714 patent (November 4, 2011) (“Critical Date”).

20. I am an engineer by training and profession. The opinions I express in this declaration involve the application of my technical knowledge and experience to the evaluation of certain prior art with respect to the ’714 Patent. In addition, I understand that the following legal principles apply.

21. It is my understanding that, in determining whether claims of the ’714 patent are obvious in this proceeding, the claim terms are generally given their ordinary and customary meaning as understood by a person of ordinary skill in the relevant art. A person of ordinary skill in the art would read the claim terms in the context of the entire patent specification in which they appear, as well as the prosecution history of the patent.

22. It is my understanding that a claim is unpatentable under 35 U.S.C. § 103 if the claimed subject matter as a whole would have been obvious to a person of ordinary skill in the art at the time of the alleged invention. I also understand that an obviousness analysis takes into account the scope and content of the prior art, the differences between the claimed subject matter and the prior art, and the level of ordinary skill in the art at the time of the invention.

23. In determining the scope and content of the prior art, it is my

understanding that a reference is considered relevant prior art if it falls within the field of the inventor's endeavor. In addition, a reference is prior art if it is reasonably pertinent to the particular problem with which the inventor was involved. A reference is reasonably pertinent if it logically would have commended itself to an inventor's attention in considering his problem. If a reference relates to the same problem as the claimed invention, that supports use of the reference as prior art in an obviousness analysis.

24. To assess the differences between prior art and the claimed subject matter, it is my understanding that 35 U.S.C. § 103 requires the claimed invention to be considered as a whole. This "as a whole" assessment involves showing that one of ordinary skill in the art at the time of invention, confronted by the same problems as the inventor and with no knowledge of the claimed invention, would have selected the elements from the prior art and combined them in the claimed manner.

25. It is my further understanding that several rationales may be applied for combining references or modifying a reference to show obviousness of claimed subject matter. These rationales include: combining prior art elements according to known methods to yield predictable results; simple substitution of one known element for another to obtain predictable results; a predictable use of prior art elements according to their established functions; applying a known technique to a

known device (method or product) ready for improvement to yield predictable results; choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success; and some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify a prior art reference or to combine prior art teachings to arrive at the claimed invention.

V. Overview of the '714 Patent

26. The '714 Patent is directed to video encoding and decoding in the context of H.263, H.264, and Working Draft 4 of H.265/HEVC, which the purported patent admits were pre-existing video codecs that pre-dated the '714 patent. '714 Patent, 1:40-42, 2:21-25. Dr. Creusere's declarations (Appendices A & B) provides an overview of the subject matter of the '714 Patent, including background on digital video technologies, the field of art, the prosecution history, and the claims. See Creusere-Dec, §§I, II, III, V. Rather than repeat these aspects of Dr. Creusere's testimony, and to provide more focused testimony herein, I refer to Dr. Creusere's declaration for further discussion of the '714 Patent.

27. For reference, I provide the following listing of challenged claim elements from the '714 Patent:

[1pre] 1. A method comprising:

[1a] selecting a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for a block of pixels as a potential

spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates and is utilized to identify motion vector prediction candidates of which one spatial motion vector prediction candidate from the motion vector prediction list is signaled as the motion information for the prediction unit;

[1b] determining a subset of spatial motion vector prediction candidates based on a location of the block associated with the first spatial motion vector prediction candidate;

[1c] comparing motion information of the first spatial motion vector prediction candidate with motion information of spatial motion vector prediction candidates in the determined subset of spatial motion vector prediction candidates without making a comparison of each pair from the set of spatial motion vector prediction candidates;

[1d] determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and

[1e] causing information identifying the one spatial motion vector prediction candidate from the motion vector prediction list to be transmitted to a decoder or to be stored.

2. The method according to claim 1 further comprising selecting spatial motion vector prediction candidates from the set of spatial motion vector prediction candidates as the potential spatial motion vector prediction candidate in a predetermined order.

3. The method according to claim 1, further comprising comparing motion information of the potential spatial motion vector prediction candidate with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates.

4. The method according to claim 1 further comprising examining whether the block of pixels is divided into a first prediction unit and a second prediction unit; and if so, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the prediction unit is the second prediction unit.

[5pre]. The method according to claim 1, further comprising

[5a] determining a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list; and

[5b] limiting the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number.

[6pre] The method according to claim 5 comprising:

[6a] examining, if the number of spatial motion vector prediction candidates in the motion vector prediction list smaller than the maximum number;

[6b] if so, examining whether the prediction unit to which the potential spatial motion vector prediction candidate belongs is available for motion prediction;

[6c] if so, performing at least one of the following:

[6d] for a potential spatial motion vector prediction candidate on a left side of the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[6e] the received block of pixels is vertically divided into a first prediction unit and a second prediction unit;

[6f] the received block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and if the prediction unit is the second prediction unit, and the potential spatial motion vector prediction candidate has essentially

similar motion information than a spatial motion vector prediction candidate above the prediction unit;

[6g] for a potential spatial motion vector prediction candidate above the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[6h] the received block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and the prediction unit is the second prediction unit;

[6i] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit;

[6j] for a potential spatial motion vector prediction candidate, which is on a right side of the potential spatial motion vector prediction candidate above the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate above the prediction unit;

[6k] for a potential spatial motion vector prediction candidate, which is below the potential spatial motion vector prediction candidate on the left side

of the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit;

[6l] for a potential spatial motion vector prediction candidate cornerwise neighbouring the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[6m] all the other potential spatial motion vector prediction candidates have been included in the motion vector prediction list;

[6n] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate above the prediction unit;

[6o] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit.

7. The method according to claim 1 further comprising including a temporal motion prediction candidate into the motion vector prediction list.

8. The method according to claim 1 further comprising selecting one

motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the block of pixels.

[9pre] A method comprising:

[9a] selecting a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for an encoded block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the encoded block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates;

[9b] determining a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;

[9c] comparing motion information of the first spatial motion vector prediction candidate with motion information of another spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;

[9d] determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and

[9e] selecting a spatial motion vector prediction candidate from the motion vector prediction list for use in decoding the encoded block of pixels, wherein the spatial motion vector prediction candidate is selected from the motion vector prediction list using information that was received identifying a respective spatial motion vector prediction candidate from the motion vector prediction list constructed by an encoder.

10. The method according to claim 9 further comprising comparing motion information of the potential spatial motion vector prediction candidate with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates.

11. The method according to claim 9 further comprising examining whether the received encoded block of pixels is divided into a first prediction unit and a second prediction unit; and if so, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the prediction unit is the second prediction unit.

[12pre] The method according to claim 9 further comprising

[12a] determining a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list; and

[12b] limiting the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number.

[13pre]. The method according to claim 12 further comprising:

[13a] examining, if the number of spatial motion vector prediction candidates in the motion vector prediction list smaller than the maximum number; [13b] if so, examining whether the prediction unit to which the potential spatial motion vector prediction candidate belongs is available for motion prediction;

[13c] if so, performing at least one of the following:

[13d] for a potential spatial motion vector prediction candidate on a left side of the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[13e] the received encoded block of pixels is vertically divided into a first prediction unit and a second prediction unit;

[13f] the received encoded block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and if the prediction unit is the second prediction unit, and the potential spatial motion vector prediction candidate has essentially similar motion information than a spatial motion vector prediction candidate above the prediction unit;

[13g] for a potential spatial motion vector prediction candidate above the prediction unit, excluding the potential spatial motion vector prediction

candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[13h] the received encoded block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and the prediction unit is the second prediction unit;

[13i] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit;

[13j] for a potential spatial motion vector prediction candidate, which is on a right side of the potential spatial motion vector prediction candidate above the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate above the prediction unit;

[13k] for a potential spatial motion vector prediction candidate, which is below the potential spatial motion vector prediction candidate on the left side of the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion

information than the spatial motion vector prediction candidate on the left side of the prediction unit; and

[13l] for a potential spatial motion vector prediction candidate cornerwise neighbouring the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[13m] all the other potential spatial motion vector prediction candidates have been included in the motion vector prediction list;

[13n] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate above the prediction unit;

[13o] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit.

14. The method according to claim 9 further comprising selecting one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the encoded block of pixels.

[15pre] An apparatus comprising a processor and a memory including computer program code, the memory and the computer program code configured to, with the processor, cause the apparatus to:

[15a] select a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for a block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates and is utilized to identify motion vector prediction candidates of which one spatial motion vector prediction candidate from the motion vector prediction list is signaled as the motion information for the prediction unit;

[15b] determine a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;

[15c] compare motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;

[15d] determine to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on comparison of the motion information of the first spatial motion vector candidate with

motion information of the spatial motion vector prediction candidate; and

[15e] cause information identifying the one spatial motion vector prediction candidate from the motion vector prediction list to be transmitted to a decoder or to be stored.

16. The apparatus according to claim 15 wherein the apparatus is further caused to select spatial motion vector prediction candidates from the set of spatial motion vector prediction candidates as the potential spatial motion vector prediction candidate in a predetermined order.

17. The apparatus according to claim 15, wherein the apparatus is further caused to compare motion information of the potential spatial motion vector prediction candidate with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates.

18. The apparatus according to claim 15 wherein the apparatus is further caused to examine whether the block of pixels is divided into a first prediction unit and a second prediction unit; and if so, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if the prediction unit is the second prediction unit.

19. The apparatus according to claim 15, wherein the apparatus is further caused to:

determine a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list; and

limit the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number.

[20pre] The apparatus according to claim 19 wherein the apparatus is further caused to:

[20a] examine, if the number of spatial motion vector prediction candidates in the motion vector prediction list smaller than the maximum number;

[20b] if so, examine whether the prediction unit to which the potential spatial motion vector prediction candidate belongs is available for motion prediction;

[20c] if so, perform at least one of the following:

[20d] for a potential spatial motion vector prediction candidate on a left side of the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[20e] the received block of pixels is vertically divided into a first prediction unit and a second prediction unit;

[20f] the received block of pixels is horizontally divided into a first

prediction unit and a second prediction unit, and if the prediction unit is the second prediction unit, and the potential spatial motion vector prediction candidate has essentially similar motion information than a spatial motion vector prediction candidate above the prediction unit;

[20g] for a potential spatial motion vector prediction candidate above the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[20h] the received block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and the prediction unit is the second prediction unit;

[20i] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit;

[20j] for a potential spatial motion vector prediction candidate, which is on a right side of the potential spatial motion vector prediction candidate above the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate above the prediction unit;

[20k] for a potential spatial motion vector prediction candidate, which is below the potential spatial motion vector prediction candidate on the left side of the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit;

[20l] for a potential spatial motion vector prediction candidate cornerwise neighbouring the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[20m] all the other potential spatial motion vector prediction candidates have been included in the motion vector prediction list;

[20n] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate above the prediction unit;

[20o] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit.

21. The apparatus according to claim 15 wherein the apparatus is further caused to include a temporal motion prediction candidate into the motion

vector prediction list.

22. The apparatus according to claim 15 wherein the apparatus is further caused to select one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the block of pixels.

[23pre]. An apparatus comprising a processor and a memory including computer program code, the memory and the computer program code configured to, with the processor, cause the apparatus to:

[23b] determine a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;

[23c] compare motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;

[23d] determine to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on comparison of the motion information of the first spatial motion vector candidate with motion information of the spatial motion vector prediction candidate; and

[23e] select a spatial motion vector prediction candidate from the motion vector prediction list for use in decoding the encoded block of pixels, wherein the spatial motion vector prediction candidate is selected from the motion vector prediction list using information that was received identifying a respective spatial motion vector prediction candidate from the motion vector prediction list constructed by an encoder.

24. The apparatus according to claim 23 wherein the apparatus is further caused to compare motion information of the potential spatial motion vector prediction candidate with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates.

25. The apparatus according to claim 23 wherein the apparatus is further caused to examine whether the received encoded block of pixels is divided into a first prediction unit and a second prediction unit; and if so, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if the prediction unit is the second prediction unit.

[26pre] The apparatus according to claim 23 wherein the apparatus is further caused to:

[26a] determine a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list; and

[26b] limit the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number.

[27pre] The apparatus according to claim 26 wherein the apparatus is further caused to:

[27a] examine if the number of spatial motion vector prediction candidates in the motion vector prediction list smaller than the maximum number;

[27b] if so, examine whether the prediction unit to which the potential spatial motion vector prediction candidate belongs is available for motion prediction;

[27c] if so, perform at least one of the following:

[27d] for a potential spatial motion vector prediction candidate on a left side of the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[27e] the received encoded block of pixels is vertically divided into a first prediction unit and a second prediction unit;

[27f] the received encoded block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and if the prediction unit is the second prediction unit, and the potential spatial motion vector prediction

candidate has essentially similar motion information than a spatial motion vector prediction candidate above the prediction unit;

[27g] for a potential spatial motion vector prediction candidate above the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[27h] the received encoded block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and the prediction unit is the second prediction unit;

[27i] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit;

[27k] for a potential spatial motion vector prediction candidate, which is below the potential spatial motion vector prediction candidate on the left side of the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit; and

[27l] for a potential spatial motion vector prediction candidate cornerwise neighbouring the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[27m] all the other potential spatial motion vector prediction candidates have been included in the motion vector prediction list;

[27n] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate above the prediction unit;

[27o] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit.

28. The apparatus according to claim 23 wherein the apparatus is further caused to select one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the received encoded block of pixels.

[29pre] A non-transitory computer readable medium having stored thereon a computer executable program code for use by an encoder, said program codes comprising instructions for:

[29a] selecting a first spatial motion vector prediction candidate from a

set of spatial motion vector prediction candidates for a block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates and is utilized to identify motion vector prediction candidates of which one spatial motion vector prediction candidate from the motion vector prediction list is signaled as the motion information for the prediction unit;

[29b] determining a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;

[29c] comparing motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;

[29d] determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and

[29e] causing information identifying the one spatial motion vector

prediction candidate from the motion vector prediction list to be transmitted to a decoder or to be stored.

[30pre] A non-transitory computer readable medium having stored thereon a computer executable program code for use by an encoder, said program codes comprising instructions for:

[30a] selecting a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for an encoded block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the encoded block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates;

[30b] determining a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;

[30c] comparing motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;

[30d] determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and

[30e] selecting a spatial motion vector prediction candidate from the motion vector prediction list for use in decoding the encoded block of pixels, wherein the spatial motion vector prediction candidate is selected from the motion vector prediction list using information that was received identifying a respective spatial motion vector prediction candidate from the motion vector prediction list constructed by an encoder.

VI. Person of Ordinary Skill in the Art

28. It is my understanding the patentability of the claims of the ’714 Patent must be assessed from the perspective of a person of ordinary skill in the art at the time of the alleged invention (“POSITA”). For purposes of my analysis in this declaration, I have taken the earliest claimed priority date of the ’714 Patent (November 4, 2011) as the date of the alleged invention (“Critical Date”). I understand that the factors considered in determining the ordinary level of skill in a field of art include the level of education and experience of persons working in the field; the types of problems encountered in the field; the teachings of the prior art, and the sophistication of the technology at the time of the alleged invention. I understand that a POSITA is not a specific real individual, but rather is a

hypothetical individual having the qualities reflected by the factors above. I understand that a POSITA would also have knowledge from the teachings of the prior art, including the art cited below.

29. Taking these factors into consideration, it is my opinion that one of ordinary skill in the art in the field of digital video coding as of the Critical Date, would have had a 1) a bachelor's degree in electrical engineering, computer engineering, computer science, or a comparable field of study such as physics, and (2) approximately two to three years of practical experience with video encoding/decoding. Additional experience can substitute for the level of education, and vice-versa.

30. I have possessed the qualifications of a POSITA since the Critical Date of the '714 Patent, and long before.

VII. Claim Construction

31. For purposes of this *inter partes* review, I have considered the claim language, specification, and portions of the prosecution history to determine the meaning of the claim language as it would have been understood by a person of ordinary skill in the art at the time of the invention. The "plain and ordinary meaning" or *Phillips* standard has traditionally been applied in district court litigation, where a claim term is given its plain and ordinary meaning in view of the specification from the view-point of a person of ordinary skill in the art.

32. I have applied the *Phillips* standard in my analysis. Unless otherwise stated, I have applied the plain and ordinary meaning to claim terms.

A. "spatial motion vector prediction candidate"

33. Based on my review of the claims and specification of the '714 patent, it is my opinion that a POSITA would have understood a "spatial motion vector prediction candidate" to mean a candidate motion vector obtained from one or more previously-encoded blocks in the current frame.

34. The specification of the '714 patent states that "a spatial motion vector prediction is a prediction obtained only on the basis of information of one or more blocks of the same frame than the current frame." '714 patent, 3:9-14.

35. Furthermore, the specification "defines candidate motion vectors for the current frame by using… one or more neighbour blocks and/or other blocks of the current block in the same frame…" '714 patent, 12:51-56. Therefore, a spatial motion vector prediction candidate would be a candidate motion vector obtained only on the basis of information of one or more blocks of the current frame. See Ex-1001, 3:9-14, 12:51-56. The specification further states that spatial motion vector prediction candidates are obtained from "one or more already encoded block." Ex-1001, 12:58-59. That is, because spatial motion vector prediction candidates are "define[d]… by using one or more of the motion vectors of one or more neighbour blocks and/or other blocks of the current block in the same

frame[,]" each spatial motion vector prediction candidate "represents the motion vector of one or more already encoded block." '714 patent, 12:51-59.

B. "temporal motion vector prediction candidate"

36. Based on my review of the claims and specification of the '714 patent, it is my opinion that a POSITA would have understood a "temporal motion vector prediction candidate" to mean a candidate motion vector obtained from a previously-encoded frame.

37. The specification of the '714 patent states that a "temporal motion vector prediction is a prediction obtained on the basis of information of one or more blocks of a frame different from the current frame." '714 patent, 3:12-14. Furthermore, the specification that "for temporal prediction… motion vectors of a co-located block or other blocks in a previously encoded frame can be selected as candidate predictors for the current block." '714 patent, 12:63-13:3.

C. "the block"

38. Limitation [1b] recites "the block," which could be interpreted to refer to either (a) the "block of pixels" introduced in [1a], or (b) the block from which the first spatial motion vector candidate is obtained. For purposes of this IPR, disclosure is provided under both constructions. I understand that in IPR2024-00604 and IPR-2024-00605, the PTAB construed "the block" in limitation [1b] to mean "the block associated with the first special motion vector prediction

candidate."

D. "a subset of . . . candidates"

39. Limitation [1b] recites "a subset of … candidates," which means a subset of one or more candidates. The claims confirm that the subset may comprise one candidate. Limitation [1c] compares motion information of a potential candidate with motion information of "candidates in the determined subset" of limitation [1b]; dependent claim 3 further specifies that the potential candidate is compared with "at most one other" candidate. The specification includes embodiments where the subset is a single candidate. '714 Patent, 15:50- 16:39 (e.g., block A1 is compared with block B1, block B0 is compared with block B1, block A0 is compared with block A1), Fig. 8b.

VIII. Grounds 1 and 2

40. In Section III of his declarations, Dr. Creusere provides an overview of the Rusert, Karaczewicz, and Lin prior art references. Creusere-Decs, §III. Dr. Creusere then analyzed these prior art references and explained in detail why a POSITA would have found it obvious to combine the teachings of Rusert, Karaczewicz, and Lin to arrive at the alleged inventions described in claims 1-30 of the 714 Patent. *Id.*, §VI.A. I have carefully reviewed Dr. Creusere's analysis in this regard, and I agree with and adopt his analysis as my own. It is clear that a predictable combination of Rusert, Karaczewicz, and Lin would have rendered

claims 1-30 of the 714 Patent obvious before the Critical Date for the reasons articulated in Dr. Creusere's declarations.

41. In addition, it is my opinion that Rusert's table 1 discloses a maximum code length of 2, and when the code length is 2, the motion information of the potential spatial motion vector prediction candidate is always compared to the motion information of at most one other spatial motion vector prediction candidate. ASUS-1004, ¶88, Table 1.

IX. Conclusion

42. In conclusion, I find the claims of the '714 patent addressed herein to be rendered obvious in their entirety, based upon the prior art combinations of Rusert, Karczewicz, and Lin, and the supporting prior art of these combinations.

43. The findings and opinions set forth in this declaration are based on my work and examinations to date.

44. I may continue my examinations. I may also receive additional documentation and other factual evidence over the course of this IPR that will allow me to supplement and/or refine my opinions. I reserve the right to add to, alter, or delete my opinions and my declaration upon discovery of any additional information. I reserve the right to make such changes as may be deemed necessary.

45. In signing this declaration, I recognize that the declaration will be

filed as evidence in an IPR before the PTAB. I also recognize that I may be subject to cross-examination in the case and that cross-examination will take place within the United States. If cross-examination is required of me, I will appear for cross-examination within the United States during the time allotted for cross-examination.

Appendix CV

Joseph P. Havlicek

The University of Oklahoma, School of Electrical & Computer Engineering
110 W. Boyd, DEH 150, Norman, OK 73019
E-mail: joebob@ou.edu Gmail: joseph.p.havlicek@gmail.com
http://www.ou.edu/content/coe/ece/faculty_directory/dr_havlicek.html

Title: Gerald Tuma Presidential Professor & Williams Companies Foundation Presidential Professor
Unit: School of Electrical and Computer Engineering
Director: OU Center for Intelligent Transportation Systems
Member: OU Institute for Biomedical Engineering, Science, and Technology

- **Citizenship:** USA

- **Education:**

PhD EE The University of Texas at Austin, 1996.
Dissertation: "AM-FM Image Models."
Advisor: Prof. Alan C. Bovik.
MSEE Virginia Tech, 1988.
Thesis: "Median Filtering for Target Detection in an Airborne Threat Warning System."
Advisor: Prof. John C. McKeeman.
BSEE Virginia Tech, 1986. Minors in Mathematics, Computer Science.

- **Professional Experience:**

1/97 - present: School of Electrical & Computer Engineering, Univ. OK, Norman, OK

Gerald Tuma Presidential Professor:	4/17 - present
Williams Companies Foundation Presidential Professor:	4/09 - present
Professor:	7/07 - present
Associate Professor:	7/02 - 6/07
Assistant Professor:	1/97 - 6/02

Held tenure track position requiring research, teaching, and service, as well as establishment of strong, externally funded research programs in signal, image, and video processing and intelligent transportation systems. Director and co-founder, OU Center for Intelligent Transportation Systems. Member, OU Institute for Biomedical Engineering, Science, and Technology. Total external grants and contracts exceeding $27M.

6/87 - 1/97: U.S. Naval Research Laboratory, Washington, DC
Electrical Engineer
(Was affiliated with SFA, Inc., Landover MD, from 6/87-8/89)
(Was on *leave without pay* during semesters spent at UT Austin)
Engineering member of the team that developed the Navy's first two-color infrared missile warning receiver (Fly's Eye). The production version of this system protected Navy and Marine helicopters from surface to air missile attacks in Afghanistan and Iraq. Received the Department of the Navy Award of Merit for Group Achievement for this work. Designed and analyzed new algorithms for infrared target detection, tracking, and identification. Designed digital architectures for real-time implementation. Conducted experimental work on airborne and ground-based platforms. Extensive field experience at China Lake Naval Weapons Center, Miramar Naval Air Station, Patuxent River Naval Air Station, and Sandia National Laboratories.

6/93 - 12/96: Dept. Electrical & Computer Engineering, University of Texas, Austin, TX
Assistant Director, Laboratory for Vision Systems
Senior student administrator of laboratory whose members include approximately 12 research-supported graduate students. Authored and integrated grant proposals. Briefed sponsors. Authored contract reports. Reviewed papers for journals and conferences. Advised graduate students. Supervised honors undergraduate projects. Substitute lecturer for both graduate and undergraduate courses in the systems area.

1/93 - 12/93: Dept. E51, Still Video Products, IBM Corporation, Austin, TX
Software Developer
(on-sight contractor affiliated with Ralph Kirkley Associates, Austin, TX)
Developed C code for IBM PS/2 computers under OS/2 and MS Windows to port an implementation of the JPEG image compression/decompression standard from the IBM M/ACPA card to the IBM AudioVation card.

8/87 - 8/88: Bradley Department of Electrical Engineering, VPI & SU, Blacksburg, VA
Graduate Research Assistant
Under contract with NRL, led 9-man team in chip-level simulation of a real-time nonlinear image filter. Under contract with IBM, investigated the feasibility and performance of networks of LEO store-and-forward communication satellites.

12/84 - 5/87: Management Systems Laboratories, Blacksburg, VA
Software Engineer
Under contract with DOE, designed and implemented management decision support software for nuclear materials management on IBM mainframe computers.

► **Expert Testimony History:**

- In the matter of *Unified Patents, LLC Request for Ex Parte Reexamination Against U.S. Patent No. 10,574,982 assigned to Dolby Video Compression, LLC*. Provided opinions and testimony at Examiner interview. Retained by Fish & Richardson P.C. on behalf of Dolby Video Compression, LLC, San Francisco, CA, 12/24 - present.
- In the matter of *University of British Columbia v. Caption Health, Inc., et al.*, Case No. 5:24-cv-03200-EKL, U.S. District Court for the Northern District of California. Reviewed source code and provided infringement analysis. Retained by Perkins Coie LLP on behalf of University of British Columbia, Vancouver, BC, Canada, 12/24 - present.
- In the matter of *Omnitracs v. Motive Technologies*, Case No. 3:23-cv-05261, U.S. District Court for the Northern District of California. Provided infringement analysis, patent benefit analysis, and noninfringement allegation test specifications. Retained by Kirkland & Ellis LLP on behalf of Omnitracs, LLC, Westlake, TX, XRS Corporation, Burnsville, MN, and SmartDrive Systems, Inc., San Diego, CA, 7/24 - 9/24.
- In the matter of *Amazon.com, Inc. and Amazon.com Services LLC v. Nokia Technologies Oy*, petition for IPR of U.S. Patent No. 8,050,321, USPTO Case No. IPR2024-00691. Provided IPR expert declaration, testified at deposition. Retained by Perkins Coie LLP on behalf of Amazon.com, Inc. and Amazon.com Services LLC, Seattle, WA, 11/23 - present.
- In the matter of *Amazon.com, Inc. and Amazon.com Services LLC v. Nokia Technologies Oy*, petition for IPR of U.S. Patent No. 8,204,134, USPTO Case No. IPR2024-00725. Provided IPR expert declaration. Retained by Perkins Coie LLP on behalf of Amazon.com, Inc. and Amazon.com Services LLC, Seattle, WA, 11/23 - 4/24.
- In the matter of *Amazon.com, Inc. and Amazon.com Services LLC v. Nokia Technologies Oy*, petition for IPR of U.S. Patent No. 7,532,808, USPTO Case No. IPR2024-00847, IPR2024-00848. Provided IPR expert declaration. Retained by Perkins Coie LLP on behalf of Amazon.com, Inc. and Amazon.com Services LLC, Seattle, WA, 11/23 - present.
- In the matter of *Certain Video Capable Electronic Devices, Including Computers, Streaming Devices, Televisions, Cameras, and Components and modules Thereof*, USITC Investigation No. 337-TA-1379. Provided two declarations. Retained by Perkins Coie LLP on behalf of Amazon.com, Inc. and Amazon.com Services LLC, Seattle, WA, 11/23 - 5/24.
- In the matter of *Certain Electronic Devices, Including Smartphones, Computers, Tablet Computers, and Components Thereof*, USITC Investigation No. 337-TA-1373. Provided nonin-

fringement analysis and one declaration. Retained by Fish & Richardson P.C. on behalf of Intel Corporation, Santa Clara, CA, and Lenovo Group Limited, Hong Kong S.A.R., China, Lenovo (United States) Inc., Morrisville, NC, and Motorola Mobility LLC, Chicago, IL, 11/23 - 3/24.

- In the matter of *Unified Patents, LLC Request for Reexamination Against U.S. Patent No. 7,739,714 assigned to Distributed Media Solutions LLC (an affiliate of IP Investments).* Provided one *Ex Parte* Reexam declaration. Retained by Greenberg Traurig LLP on behalf of Unified Patents LLC, San Jose, CA, 10/23 - 12/23.
- In the matter of *Advanced Coding Technologies LLC v. Samsung Electronics Co. LTD and Samsung Electronics America, Inc., Case No. 2:22-cv-00499, U.S. District Court for the Eastern District of TX.* Provided two expert reports, testified at deposition. Retained by Fish & Richardson P.C. on behalf of Samsung Electronics Co. LTD, Suwon, South Korea, and Samsung Electronics America, Inc., Ridgefield Park, NJ, 5/23 - 8/24.
- In the matter of *State of Texas v. Meta Platforms, Inc.*, Cause No. 22-0121. Provided technical consulting to support Meta's defense related to facial recognition software. Retained by Gibson, Dunn & Crutcher LLP on behalf of Meta Platforms, Inc., Menlo Park, CA, 6/23 - 3/24.
- In the matter of *Certain Video Processing Devices and Products Containing Same*, USITC Investigation No. 337-TA-1323. Provided one expert report, testified at deposition. Retained by Fish & Richardson P.C. on behalf of ASUSTek Computer Inc., Taipei, Taiwan, and ASUS Computer International, Fremont, CA, 2/23 - 5/23.
- In the matter of *Unified Patents, LLC Request for Reexamination Against U.S. Patent No. 9,497,469 assigned to Velos Media LLC.* Provided one *Ex Parte* Reexam declaration. Retained by Greenberg Traurig LLP on behalf of Unified Patents LLC, San Jose, CA, 12/22 - 2/23.
- In the matter of *Certain Video Processing Devices and Products Containing Same*, USITC Investigation No. 337-TA-1323. Provided noninfringement analysis. Retained by Perkins Coie LLP on behalf of Intel Corporation, Santa Clara, CA, 10/22 - 12/22.
- In the matter of *TCL Electronics Holdings Ltd. v. LG Electronics Inc.*, petition for IPR of U.S. Patent No. 7,839,452, USPTO Case No. IPR2023-00461. Provided one IPR declaration. Retained by PV Law LLP on behalf of TCL Electronics Holdings Ltd. and associated companies, Huizhou, Guangdong, China, 8/22 - 5/23.
- In the matter of *PerDiemCo LLC v. CalAmp Corp.*, Case No. 1:20-cv-01397-VAC-SRF, U.S. District Court for the District of DE. Provided noninfringement analysis; case settled. Retained by Barnes & Thornburg LLP on behalf of CalAmp Corp., Irvine, CA, 6/22 - 4/23.
- In the matter of *DigiMedia Tech, LLC v. Lenovo (United States) Inc. and Motorola Mobility LLC*, Case No. 1:21-cv-00227-MN, U.S. District Court for the District of DE. Provided one declaration. Retained by Kilpatrick, Townsend & Stockton LLP on behalf of Lenovo (United States) Inc., Morrisville, NC, and Motorola Mobility LLC, Chicago, IL, 1/22 - 3/22.
- In the matter of *EyesMatch Ltd. and Memomi Labs Inc. v. Facebook, Inc., Instragram, LLC, and WhatsApp LLC*, Case No. 1-21-cv-00111, U.S. District Court for the District of DE. Provided two declarations. Retained by Cooley LLP on behalf of Facebook Inc., Instagram, LLC, and WhatsApp LLC, Menlo Park, CA, 1/22 - 7/22.
- In the matters of certain petitions for IPR associated with *Certain Fitness Devices, Streaming Components Thereof, and Systems Containing the Same*, USITC Investigation No. 337-TA-1265. Worked on five IPR petitions that were ultimately not filed. Retained by Cooley LLP on behalf of Peloton Interactive, Inc. (New York), lululemon athletica Inc. (Vancouver, BC) and Curiouser Products Inc. (New York) d/b/a MIRROR, and iFIT Inc. (Logan, UT), FreeMotion Fitness, Inc. (Logan, UT) and NordicTrack, Inc. (Logan, UT), 9/21 - 4/22.
- In the matter of *Unified Patents, LLC Request for Reexamination Against U.S. Patent No. 10,244,252 assigned to Electronics and Telecommunications Research Institute.* Provided one *Ex Parte* Reexam declaration. Retained by Greenberg Traurig LLP on behalf of Unified Patents LLC, San Jose, CA, 8/21 - 10/21.
- In the matter of *Indect USA Corp. v. Park Assist, LLC*, Case No. 3:18-cv-2409-BEN-MDD, U.S. District Court for the Southern District of CA. Provided one expert report, testified at deposition, testified at trial. Retained by Foley & Lardner LLP on behalf of Indect USA Corp., Denver, CO, 4/21 - 9/22.

- In the matter of *Unified Patents LLC v. GE Video Compression LLC*, Petition for *Ex Parte* Reexamination of U.S. Patent No. 6,795,583. Provided one *Ex Parte* Reexam declaration. Retained by Desmarais LLP on behalf of Unified Patents LLC, San Jose, CA, 9/20 - 04/21.
- In the matter of *Unified Patents LLC v. Electronics and Telecommunications Research Institute, Kwangwoon University Research Institute for Industry Cooperation, Industry-Academia Cooperation Group of Sejong University*, petition for IPR of U.S. Patent No. 9,736,484, Case No. IPR2021-00368. Provided one IPR declaration. Retained by Greenberg Traurig LLP on behalf of Unified Patents LLC, San Jose, CA, 9/20 - 12/20.
- In the matter of *Certain Electronic Devices, Including Computers, Tablet Computers, and Components and Modules Thereof*, USITC Investigation No. 337-TA-1208. Provided two expert reports, testified at deposition. Retained by WilmerHale LLP on behalf of Lenovo (United States) Inc., Morrisville, NC, 8/20 - 3/21.
- In the matter of *Park Assist, LLC v. San Diego County Regional Airport Authority and Ace Parking Management, Inc.*, Case No. 3:18-cv-02068-BEN-MDD, U.S. District Court for the Southern District of CA. Testified at deposition, provided one claim construction declaration. Retained by Morrison & Foerster LLP on behalf of SDCRAA, San Diego, CA, 7/20 - 03/21.
- In the matter of *LG Electronics Inc. v. Hisense Electronics Manufacturing Company of America Corp.*, Civil Case No. 2:19-cv-09474-JAK, U.S. District Court for the Central District of CA, Western Division. Provided one claim construction declaration, testified at deposition. Retained by Covington & Burling LLP on behalf of Hisense Electronics Manufacturing Company of America, Inc., Suwanee, GA, 7/20 - 1/21.
- In the matter of *Renesas Electronics Corporation v. Broadcom Corporation*, petition for IPR of U.S. Patent No. 8,284,844, USPTO Case No. IPR2019-01040. Provided one IPR declaration. Retained by Steptoe & Johnson LLP on behalf of Broadcom Limited, San Jose, CA, 6/20 - 7/20.
- In the matter of *Hisense Electronics Manufacturing Company of America v. LG Electronics Inc.*, petition for IPR of U.S. Patent No. 7,839,452, USPTO Case No. IPR2020-01208. Provided one IPR declaration. Retained by Covington & Burling LLP on behalf of Hisense Electronics Manufacturing Company of America, Inc., Suwanee, GA, 3/20 - 1/21.
- In the matter of *Nokia Technologies v. Lenovo (Shanghai) Electronics Tech. Co. Ltd, et al., 19-CV-0427 (E.D.N.C.) and related Nokia v. Lenovo cases including in Germany and India*. I was briefly retained to perform analysis of reference picture management in H.264 and H.265. Retained by Cooley LLP on behalf of Nvidia Corp., Santa Clara, CA, 1/20 - 3/20.
- In the matter of *Intel Corporation v. Dynamic Data Technologies, LLC*. Provided one IPR declaration; case settled before filing. Retained by Perkins Coie LLP on behalf of Intel Corporation, Santa Clara, CA, 3/19 - 6/19.
- In the matter of *Unified Patents LLC v. Velos Media, LLC*, petition for IPR of U.S. Patent No. 8,885,956, USPTO Case No. IPR2019-01130. Provided one IPR declaration. Retained by Greenberg Traurig LLP on behalf of Unified Patents LLC, San Jose, CA, 2/19 - 12/19.
- In the matter of *Unified Patents LLC v. Velos Media, LLC*, petition for IPR of U.S. Patent No. 10,110,898, USPTO Case No. IPR2019-00763. Provided two declarations, testified at deposition. Retained by Winston & Strawn LLP and Greenberg Traurig LLP on behalf of Unified Patents LLC, San Jose, CA, 10/18 - 04/20.
- In the matter of *Avago Technologies General IP (Singapore) Pte. Ltd. v. Nintendo of Europe GmbH*. Provided written opinions to the German Federal Patent Court. Retained by Freshfields Bruckhaus Deringer LLP on behalf of Avago Technologies General IP (Singapore) Pte. Ltd., 9/18 - 10/18.
- In the matter of *Certain Infotainment Systems, Components Thereof, and Automobiles Containing the Same*, USITC Investigation No. 337-TA-1119. Provided infringement analysis, one declaration. Retained by Steptoe & Johnson LLP on behalf of Broadcom Limited, San Jose, CA, 3/18 - 2/19.
- In the matter of *Cisco Systems, Inc. v. Realtime Adaptive Streaming, LLC*, petition for IPR of U.S. Patent No. 8,934,535, USPTO Case No. IPR2018-01384. Provided one IPR declaration. Retained by Winston & Strawn LLP on behalf of Cisco Systems, Inc., San Jose, CA, 3/18 - 8/18.
- In the matter of *Avago Technologies General IP (Singapore) Pte. Ltd. v. Audi AG*. Provided written opinion to the German Federal Patent Court. Retained by Grünecker Patent- und

Rechtsanwälte PartG mbB on behalf of Avago Technologies General IP (Singapore) Pte. Ltd., 3/18 - 11/18.

- In the matter of *Certain Semiconductor Devices and Consumer Audiovisual Products Containing the Same*, USITC Investigation No. 337-TA-1047. Testified at deposition and trial. Provided three expert reports, two declarations, and three witness statements. Retained by Steptoe & Johnson LLP and Kilpatrick, Townsend & Stockton LLP on behalf of Broadcom Limited, San Jose, CA, 3/17 - 12/17.
- In the matter of *Certain Semiconductor Integrated Circuits and Products Containing Same*, USITC Investigation No. 337-TA-840. Infringement analysis and one written declaration. Retained by Covington & Burling LLP on behalf of Microchip Technology, Chandler, AZ, 2/17/12 - 3/21/12.

► Honors & Awards:

- Top Reviewer Recognition, 2024 IEEE International Conference on Image Processing.
- Outstanding Reviewer Recognition Award, 2022 IEEE International Conference on Acoustics, Speech, and Signal Processing.
- Best Reviewer Award, 2020 IEEE International Conference on Image Processing.
- Top Reviewer Certificate, 2020 IEEE International Conference on Image Processing, awarded to top 3% out of over 700 reviewers.
- Named to the University of Oklahoma Gerald Tuma Presidential Professorship, 2017.
- *2014 IEEE International Conference on Image Processing Top 10% Paper Award*, for C.T. Nguyen and J.P. Havlicek, "On the amplitude and phase computation of the AM-FM image model."
- Named to the University of Oklahoma Williams Companies Foundation Presidential Professorship, 2009.
- Oklahoma Highway Safety Office Project Director's Award, FY 2009, co-recipient with Dr. R.D. Barnes, for implementing police electronic crash reporting in the State of Oklahoma.
- IEEE Maximum Impedance Award, OU School of ECE, 2007.
- University of Oklahoma College of Engineering Outstanding Faculty Advisor Award, 2005-2006.
- Oklahoma Highway Safety Office Award of Excellence, FY 2005, presented to the OU ITS Lab for enhancing traffic records management through project SAFE-T.
- Oklahoma Highway Safety Office Project Director's Award, FY 2003, co-recipient with Dr. J.J. Sluss, Jr., for enhancing highway safety through ITS projects.
- University of Oklahoma College of Engineering Brandon H. Griffith Faculty Award, 2003.
- Listed at number 22 in OU *FY 99 Awards – Top 25 Faculty/Staff – Norman Campus*.
- IEEE Favorite Instructor Award, OU School of ECE, 1998, 2000.
- University of Texas Engineering Foundation Award for Exemplary Engineering Teaching while Pursuing a Graduate Degree, 1992.
- Department of the Navy Award of Merit for Group Achievement, 1990.
- Management Systems Laboratories Outstanding Student Employee Scholarship, 1987.
- Eta Kappa Nu Honor Society
- Tau Beta Pi Honor Society
- Phi Kappa Phi Honor Society
- Listed in *Who's Who in America*, 2002 Ed.

► Professional Memberships:

- Institute of Electrical and Electronics Engineers (IEEE), Senior Member
- IEEE Signal Processing Society
- IEEE Intelligent Transportation Systems Society
- IEEE Computer Society

► Professional Service:

- National Science Foundation, Proposal Review Panelist: 2022, 2020, 2012.
- Senior Area Editor, *IEEE Transactions on Image Processing*, Nov. 2015 - Feb. 2018.
- Associate Editor, *IEEE Transactions on Image Processing*, Dec. 2010 - Oct. 2015.
- Associate Editor, *IEEE Transactions on Industrial Informatics*, Jan. 2010 - Jul. 2013.

- *IEEE International Conference on Image Processing (ICIP)*
  - Reviewer (1998 - present).
  - 2016: Paper Awards Committee.
  - 2013: Technical Area Chair for EDICS 6.1: Image & Video Analysis, Synthesis, and Retrieval.
  - 2012: Technical Area Chair for EDICS 6.2: Image & Video Analysis, Synthesis, and Retrieval; Session Chair.
  - 2007: Publications Chair, Organizing Committee, and Session Chair.
- *IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP)*
  - Reviewer (2005-present).
  - 2012, 2013, 2014: IVMSP Technical Area Chair
- *IEEE Southwest Symposium on Image Analysis and Interpretation (SSIAI)*
  - 2024: Technical Program Committee, Session Chair.
  - 2020: Technical Program Committee, Session Chair.
  - 2016: Technical Program Committee.
  - 2012, 2014: Technical Program Committee, Session Chair.
  - 2010: General Co-Chair (with Prof. Scott Acton, University of Virginia).
  - 2008: Technical Program Co-Chair (with Prof. Scott Acton, University of Virginia).
  - 2006: Technical Program Co-Chair (with Prof. Til Aach, RWTH Aachen University, Germany).
  - 2004: Technical Program Co-Chair (with Prof. Til Aach, Medical University of Luebeck, Germany).
  - 2002: Publicity Chairman, Technical Program Committee, Session Chair.
  - 2000: Publicity Chairman, Technical Program Committee, Session Chair.
  - 1998: Technical Program Committee, Session Chair.
- *IEEE International Conference on Intelligent Transportation Systems (ITSC)*
  - 2013: Reviewer
  - 2011: Session Chair, reviewer.
  - 2009: Technical Program Committee, Special Session Organizer, Session Chair.
- *IEEE Workshop on Perception Beyond the Visible Spectrum*
  - 2014, 2015: Technical Program Committee.
- *IEEE Int'l. Workshop on Object Tracking and Classification Beyond the Visible Spectrum*
  - 2009, 2013: Technical Program Committee.
- *European Signal Processing Conference (EUSIPCO)*
  - 2015, 2016, 2017, 2018: Reviewer
- *45th IEEE Midwest Symposium on Circuits and Systems (2002)*: Session Organizer and Session Chair.
- *IEEE Asilomar Conference on Signals, Systems, and Computers*
  - 2000, 2001: special session organizer
- Presently serving or have served as a reviewer for *IEEE Transactions on Signal Processing*; *IEEE Transactions on Image Processing*; *IEEE Signal Processing Letters*; *IEEE Transactions on Pattern Analysis and Machine Intelligence*; *IEEE Transactions on Circuits and Systems II*; *IEEE Transactions on Communications*; *IEEE Transactions on Industrial Informatics*; *IEEE Transactions on Parallel and Distributed Systems*; *IEEE Transactions on Education*; *IEEE Transactions on Information Technology in Biomedicine*; *Journal of the Optical Society of America – A*; *IEE Proceedings – Vision, Image & Signal Processing*; *IEE Electronics Letters*; *EURASIP Journal on Applied Signal Processing*; *Journal of Electronic Imaging*; *Pattern Recognition Letters*; *Multidimensional Systems and Signal Processing*; *Signal Processing*.

▶ **Committee Assignments and University Service:**

- Committee A, School of Electrical & Computer Engineering (tenure and promotion/executive committee) (Aug 14 - Aug 16, Nov 04 - Aug 08, Aug 23 - present)

- Chairman, Graduate Studies Committee, School of Electrical & Computer Engineering (Aug 08 - Jul 13)
- School of Electrical & Computer Engineering Graduate Liaison (Aug 08 - Jul 13)
- Graduate Studies Committee, School of Electrical & Computer Engineering (Aug 08 - Jul 13, Aug 97 - Aug 06)
- Chairman, Undergraduate Studies Committee, School of Electrical & Computer Engineering (Dec 21 - Aug 23)
- School of Electrical & Computer Engineering Undergraduate Program Committee (May 19 - May 20)
- Chairman, College of Engineering PP03 Faculty Task Force (Mar 12 - Apr 13) (task force to revise and rewrite policies and procedures for faculty tenure, promotion, annual evaluations, and workload)
- University of Oklahoma Conflict of Interest Advisory Committee (Aug 15 - present, Co-Chair Jan 21 - present).
- University of Oklahoma Conflict of Interest Officer Search Committee (Oct 21 - Jan 22)
- University of Oklahoma Graduate Council (Aug 10 - Jun 13)
- College of Engineering E-Club Faculty Co-Advisor (May 00 - May 04), Advisor (May 04 - Jan 06) (*this is the largest student organization on the OU campus*)
- Faculty Senate (Aug 02 - May 05)
- College of Engineering Academic Misconduct Board and Grade Appeals Board (Jun 03 - Jun 05)
- Coordinator, Systems Area Faculty Interest Group (FIG) (Dec 08 - present, Oct 00 - Aug 02)
- School of Music piano faculty search committee (Sep 19 - Mar 21, Sep 16 - Dec 16, Sep 12 - Dec 12)
- School of Electrical & Computer Engineering Director Search Committee (Oct 04 - Jun 05)
- School of ECE Faculty Search Committee (97, 02, 03, 05, 06, 07, 14, 15, 17, 18)

► **Teaching:**

1/97 - present: School of Electrical & Computer Eng., University of OK, Norman, OK

- ECE2713, Digital Signals and Filtering (SP 18, SP 19, SP 20, SP 21, SP 22, SP 23, SP 24, SP25)
- ECE3223, Microcomputer System Design (FA 97)
- ECE3793, Signals and Systems (SP 97, FA 98, SP 99, FA 99, SP 00, FA 00, SP 01, SP 02, FA 02, SP 03, FA 03, SP 04, FA 04, SP 05, FA 05, SP 06, SP 07, SP 08, SP 15, SP 16, SP 17)
- ECE3960, Honors Reading (SP 00)
- ECE3980, Honors Research (FA 01, SP 02, SP 03, FA 11, SP 12, SP 19, SP 25)
- ECE4213, Digital Signal Processing (FA 02, FA 06, FA 07, FA 08, FA 09, FA 10, FA 11, FA 12, FA 14, FA 15, FA 16, FA 17, FA 18, FA 19, FA 20, FA 21, FA 22, FA 23)
- ECE4973, Digital Image Processing (SP 98)
- ECE4990, Special Studies (various semesters SP 98 – present)
- ECE5213, Digital Signal Processing (FA 02, FA 06, FA 07, FA 08, FA 09, FA 10, FA 11, FA 12, FA 14, FA 15, FA 16, FA 17, FA 18, FA 19, FA 20, FA 21, FA 22, FA 23)
- CS5273, Digital Image Processing (SP 98, FA 00, SP 02, SP 03, SP 04, SP 05)
- ECE5273, Digital Image Processing (SP 98, FA 00, SP 02, SP 03, SP 04, SP 05, SP 06, SP 07, SP 08, SP 09, SP 10, SP 11, SP 12, SP 13, SP 14, SP 15, SP 16, SP 17, SP 18, SP 19, SP 20, SP 21, SP 22, SP 23, SP 24, SP 25)
- ECE5973/ECE4973, Multimedia Communications (FA 98)
- ECE5973, Kalman Filtering (FA 99, FA 03, FA 05)
- ECE5980, Thesis Research (SP 99 – present)
- ECE5990, Special Problems (various semesters FA 97 – present)
- ECE6283, Advanced Image Processing (FA 04)
- ECE6973, Advanced Image Processing (FA 01)
- ECE6980, Dissertation Research (SP 00 – present)

9/90 - 6/93: Dept. Electrical & Computer Eng., University of Texas, Austin, TX

- EE464K, Senior Design Projects (FA 90 – Summer 93)

1/91 - 12/96: Dept. Electrical & Computer Eng., University of Texas, Austin, TX

- EE381K, Topic 10: Image Processing (substitute lecturer)
- EE381K, Topic 8: Digital Signal Processing (substitute lecturer)
- EE380L, Topic 7: Computer Vision (substitute lecturer)
- EE351K, Probability and Random Processes (substitute lecturer)

► **Graduate Degree Production:**

Ph.D. Supervisions Completed:

1. Peter Tay, "An Optimally Well Localized Multi-Channel Parallel Perfect Reconstruction Filter Bank," October, 2003.
2. Guangwei Mu "WAAS Error, Integrity and Availability Modeling for GPS-based Aircraft Landing System," April, 2004 (co-supervised with Dr. Jim Sluss).
3. Hengqing Wen, "Anti-Spoof Design for TDMA Based GPS/LAAS Landing Aid," December, 2004.
4. Yunhua Wang, "Multiplierless CSD Techniques for High Performance FPGA Implementations of Digital Filters," April, 2007 (co-supervised with Dr. Linda DeBrunner).
5. Osama Alkhouli, "Hirschman Optimal Transform Least Mean Square Adaptive Filters," October, 2007 (co-supervised with Dr. Victor DeBrunner).
6. Ngao D. Mamuya, "Biometric Classification with Factor Analysis," May, 2010.
7. Nicholas A. Mould, "Neighborhood-Level Learning Techniques for Nonparametric Scene Models," May, 2012.
8. Chuong T. Nguyen, "Modulation Domain Image Processing," May, 2012.
9. Ekasit Vorakitolan, "Video CODEC with Adaptive Frame Rate Control for Intelligent Transportation System Applications," May, 2014.
10. Patrick Adrian Campbell, "High-Fidelity and Perfect Reconstruction Techniques for Synthesizing Modulation Domain Filtered Images," December, 2016.
11. Johnathan D. Williams, "Extended Observation Particle Filter with SVD Template Generation Implemented for GPU," December, 2018.
12. John R. Junger III, "Object Detection in Dual-Band Infrared," November 2023.

Ph.D. Supervisions in Progress:

- Elnaz Aghdaei
- Obada Muhammad (Biomedical Engineering)

Additional Ph.D. Committees Served on:

1. Madhavi Kadiyala, "Design of Optimal Subband Filter Banks for Image Discrimination," October, 1999.
2. Mohamed Allali, "Digital Signal Processing on the Unit Sphere via a Ramanujan Set of Rotations and Planar Wavelets" (interdisciplinary: Electrical Engineering and Mathematics), July, 2000.
3. Yunxiang Wu, "Iterative Decoding for Magnetic Recording Channels," September, 2000.
4. Helen Jun Xing, "Performance Evaluation of CDMA Systems," April, 2001.
5. Pamela Pike, "Leisure Piano Lessons: A Case Study of Lifelong Learning" (Music – DMA), May, 2001.
6. Longji Wang, "Active Vibration Control Systems in the Frequency and Sub-Band Domain," July, 2001.
7. Sebastian Torres, "Estimation of Doppler and Polarimetric Variables for Weather Radars," October, 2001.
8. Valliappa Lakshmanan, "A Hierarchical, Multiscale Texture Segmentation Algorithm for Real-World Scenes," October, 2001.
9. Richard Todd, "Design of Low-Density Parity Check Codes for Magnetic Recording Channels," December, 2002.
10. Guoping Wang, "A High-Performance Inner-Product Processor for Real and Complex Numbers," April, 2003.
11. Leslie Fife, "TriM: Tri-Modal Data Communication in Mobile Ad-Hoc Network Database Systems" (Computer Science), December, 2003.

12. Kuo-Liang Li, "Usage and Development of Piano Method Books in Tiawan: Interviews and Observations with Piano Teachers" (Music – DMA), April, 2004.
13. Weijun Tan, "Low-Density Parity-Check Coding for High-Density Magnetic Recording Systems," July, 2004.
14. Haitao Xia, "Error-Correction Coding for High-Density Magnetic Recording Channels," September, 2004.
15. Yongshen Ni, "Fuzzy Correlation and Regression Analysis," April, 2005.
16. Dayong Zhou, "Adaptive Nonlinear System Compensation Techniques and their Applications to Digital Communication and Control Systems," April, 2005.
17. Xiaojuan Hu, "FIR Filter Design for Area Efficient Implementation," May, 2005.
18. Lesley Sisterhen, "The Use of Imagery, Mental Practice, and Relaxation Techniques for Musical Performance Enhancement" (Music – DMA), June, 2005.
19. Su Yang, "Design of PHY & MAC Layer Protocols for Inter-Vehicle Communications," October, 2005.
20. Rob Sulman, "Affine Group Actions on Euclidean Space" (Mathematics), April, 2006.
21. Peng Yan, "A Study on Mobile Ad Hoc Networks Equipped with Free-Space Optical Capabilities," December, 2006.
22. Yan Zhai, "Improved Nonlinear Filtering for Target Tracking," April, 2007.
23. Cheng Zhong, "Efficient Soft-Decision Decoding of Reed-Solomon Codes," May, 2008.
24. Yih-Ru Huang, "Optoelectronics Three-Dimensional Tracking System for Collision Risk Model," April, 2009.
25. Mari Iida, "The Acceptance of Western Piano Music in Japan and the Career of Takahiro Sonoda" (Music – DMA), April, 2009.
26. Yong Ma, "Multi-Modal Behavior and Clustering in Dynamical Systems with Applications to Wind Farms," April, 2009.
27. Yuzhen Xue, "Identification and Estimation of Multi-Modal Complex Dynamic System," May, 2009.
28. B.H.M. Priyantha Wijesinghe, "Development of a Prototype In-Situ Fatigue Sensor for Structural Health Monitoring of Highway Bridges" (Civil Engineering), April, 2010.
29. Han Wang, "Parallel Subspace Subcodes of Reed-Solomon Codes for Magnetic Recording Channels," May, 2010.
30. Yahia Tachwali, "Cognitive Radio Solution for IEEE 802.22," July, 2010.
31. Wei Guan, "Some Local and Global Aspects of Mathematical Digital Signal Processing" (Mathematics), August, 2010.
32. Molly Donovan Wong, "Development and Characterization of a High Energy Phase Contrast X-Ray Imaging System Prototype," June, 2011.
33. Chenxi Lin, "Problems in the Design and Operation of Uncertain Complex Engineering Systems," July, 2011.
34. Jie Lu, "Distributed Computation and Optimization over Networks," July, 2011.
35. Rodney Keele, "Advances in Modeling and signal processing for Bit-Patterned Magnetic Recording Channels with Written-In Errors," April, 2012.
36. Di Wang, "Learning Visual Features for Grasp Selection and Control" (Computer Science), April, 2012.
37. Phuong Pham, "Target Tracking Using Wireless Sensor Networks," November, 2012.
38. Lina Sawalha, "Exploiting Heterogeneous Multicore Processors through Fine-Grained Scheduling and Low-Overhead Thread Migration," December, 2012.
39. Nickolas LaSorte, "The Coexistence of Wireless Medical Devices in the Presence of Heterogeneous Wireless Networks," April, 2013.
40. Shang Wang, "Waveform and Transceiver Optimization for Multi-Functional Airborne Radar Through Adaptive Processing," May, 2013.
41. Enfeng Jiang, "Channel Detection on Two-Dimensional Magnetic Recording," July, 2013.
42. David Sandmann, "Design and Implementation of a Precision Three-Dimensional Binocular Image Tracker for Departing Aircraft," November, 2013.
43. Min Zhu, "EEG/MEG Sparse Source Imaging and its Application in Epilepsy," December, 2013.
44. Seyed Hossein Hosseini, "Revealing Additional Information About Electricity Market Underlying Power System Using Power System Principles and Published Market Results," Septem-

ber, 2014.

45. James M. Kurdzo, “Pulse Compression Waveforms and Applications for Weather Radar” (Meteorology), October, 2015.
46. Peng F. Tang, “Analysis of Backbone Technique: A Hilbert Transform and Discrete Hilbert Transform-Based Technique,” December, 2015.
47. Benjamin P. Carlson, “Phenotype Operators for Improved Performance of Heuristic Encoding within Genetic Algorithms” (Computer Science), April, 2016.
48. Erik Petrich, “Real-Time 3-D Scene Reconstruction,” May, 2016.
49. Kristina Henckel, “A Pianistic Analysis of Bedřich Smetana’s Piano Cycle *Dreams, Six Characteristic Pieces for Piano*” (Music – DMA), November, 2016.
50. Milad Javadi, “New Implication of Short Circuit Analysis in Assessing Impact of Renewable Energy Resources on System Strength of a Power Grid,” June, 2017.
51. Xining Yu, “Digital Signal Processing Based Real-Time Phased Array Radar Backend System and Optimization Algorithms,” October, 2017.
52. Muhammad Usman Ghani, “Optimization of a High-Energy X-Ray Inline Phase Sensitive Imaging System for Diagnosis of Breast Cancer,” April, 2018.
53. Chuang Li, “Reconstructing Resting State Networks from EEG,” August, 2018.
54. Craig Edwards, “The Enumeration Problem on Numerical Monoids” (Mathematics), May, 2019.
55. Faranak Aghaei, “Developing Novel Computer-Aided Detection and Diagnosis Systems of Medical Images,” November, 2019.
56. Elizabeth Pacheco, “New Simple Representations of Leavitt Path Algebras” (Mathematics), December, 2019.
57. John Price, “From Bagatelles to Capriolen: Eugen d’Albert and his Later Keyboard Works” (Music – DMA), July, 2020.
58. Shajid Islam, “Probe-Based, Quasi-Near-Field Phased Array Calibration,” December, 2020.
59. Morteza Heidari, “Applying Novel Machine Learning Technology to Optimize Computer-Aided Detection and Diagnosis of Medical Images,” April, 2021.
60. Seyedehnafiseh Mirniaharikandehei, “Developing Novel Quantitative Imaging Analysis Schemes Based on Machine Learning for Cancer Research,” April, 2021.
61. Fauzia Ahmed, “Evaluation of Transfemoral Prosthesis Performance Control Using Artificial Neural Network Controllers,” April, 2021.
62. David Marvel, “Selected Songs of Nadia Boulanger: Formal Analysis and Adaptation for Brass Chamber Music” (Music – DMA), December, 2021.
63. Ali Khan, “Diffuse Optical Tomography of Spontaneous Brain Fluctuations in Humans” (Biomedical Engineering), April, 2022.
64. Farid Omoumi, “Subjective Evaluation of the In-Line Phase-Sensitive Imaging Systems in Breast Cancer Screening and Diagnosis,” July, 2022.
65. Wenwen Li, “Multi-Persistence Homology and Topological Robotics” (Mathematics), April, 2023.
66. Hyeri Kim, “Robust Velocity Unfolding for Weather Radar Based on Convolutional Neural Networks,” April, 2023.
67. Precious K. Jatau, “Machine Learning for Classifying Biological Radar Echos with S-Band Polarimetric Radar,” November, 2023.

M.S. Supervisions Completed:

1. Santha Parameswaran, “Modulation Domain Forecasting of Nonstationary and Chaotic Time Series,” March, 2000 (co-supervised with Dr. Monte Tull).
2. Tanachit Tangsukson, “AM-FM Texture Segmentation,” May, 2000.
3. Altaf Ahmed, “Designing a Global IP Routing Strategy,” July, 2001 (co-supervised with Dr. Jim Sluss).
4. Igor Ivić, “Demonstration of an Efficient Method for Estimating Spectral Moments,” November, 2001.
5. Chee-Hong Gan, “Design of a GIS-Based Traffic Management Center Software Control Platform for Oklahoma Department of Transportation,” April, 2002 (co-supervised with Dr. Jim Sluss).
6. Kok-Hoong Chow, “MPLS Modeling and Simulation in Optical Networks,” July, 2002 (co-

supervised with Dr. Jim Sluss).

7. Fabrice Ouandji, "Modulation Domain Texture Features for Content-Based Image Retrieval (CBIR)," July, 2004.
8. Ekasit Vorakitolan, "Work Zone Features for Oklahoma's Statewide Intelligent Transportation System," July, 2004.
9. Nantapol Kitiyanan, "AM-FM Fingerprint Reference Point Detection and Matching," November, 2004.
10. Krishnapraveen Suri, "Phase Reconstruction from Multicomponent AM-FM Image Representations," April, 2005.
11. Roy Sivley, "Perfect Reconstruction AM-FM Image Models," March, 2006.
12. Prakash K. Parthasarathy, "Minimum Entropy Based FIR Filter Estimation," December, 2006 (co-supervised with Dr. Victor DeBrunner).
13. Chuong Nguyen, "Dual-Domain Target Tracking," June, 2007.
14. Linda Ouandji, "Advanced Voice and Multimedia Communications System for the ODOT ITS Network," October, 2008.
15. Adrian Campbell, "AM-FM Image Processing Toolbox," December, 2008.
16. Colin Johnston, "Advanced Multi-Channel Dual Domain Constrained Adaptation Particle Filter for Infrared Target Tracking," April, 2009.
17. Anagha Wankhede, "Orientation Selective Perfect Reconstruction Filterbank Toolbox," May, 2010.
18. Basel Kilani, "Statewide Console for Distributed Control of Intelligent Transportation Systems," December, 2010.
19. Sahithi Peddireddy, "Reduction of Beat Type Digital Video Noise Using AM-FM Image Filters," December, 2011.
20. Shawna Ong, "Auxiliary Particle Filter for Modulation Domain Infrared Target Tracking," May, 2012.
21. John R. Jünger III, "The Comparison of Taylor Series and Unscented Transform Kalman Filters," May, 2012 (co-supervised with Dr. S. Lakshmivarahan).
22. Md. Ridwanul Alam, "Tissue Classification-Based Automated Threshold Selection (TCATS) for Segmentation of Bone in Marrow Proliferation Assessments," May, 2015.
23. Jesyca Fuenmayor Bello, "A State Vector Augmentation Method for Including Velocity Information in the Likelihood Function of the SIR Video Target Tracking Filter," July, 2016.
24. Hesham Makhlouf, "Police Electronic Citation Mobile System for Statewide Deployment in Oklahoma," April, 2018.
25. Rodrigo Collao Benitez, "Developing Affordable Smart Solutions for Police Reporting," July, 2018.
26. Brandon Carson, "Automatic Bone Structure Segmentation of Under-Sampled CT/FLT-PET Volumes for HSCT Patients," July, 2021.
27. Favio Hurtado, "Multiclass Bone Segmentation of PET/CT Scans for Automatic SUV Extraction," December, 2021.

M.S. Supervisions in Progress:

- Tristan N. Arian
- Lucas J. Powers

Additional M.S. Committees Served on:

1. Kirankumar Govindarajan, "Implementation of a Wavelet Vocoder," July, 1997.
2. Tod Bussert, "Using Artificial Neural Networks to Improve the Mechanical Signature Analysis Test," December, 1997.
3. Georgios Lezos, "Neural Network and Fuzzy Logic Techniques for Time Series Forecasting," December, 1998.
4. Chetan Anantharaman, "Implementation of Generic Subband/Wavelet Architectures for Image Coding," April, 1999.
5. Mir Sayed Ali, "A CORSIM Traffic Model to Support ITS and DTA in Oklahoma City," February, 2000.
6. Aaron Bansemer, "Retrieval and Analysis of the Electric Field in Thunderstorms" (Meteorology), April, 2000.

7. James Shields, "Design and Implementation of a High-Speed Multiplexer-Based Parallel Multiplier," May, 2000.
8. Rick Pendergraft, "A Performance Evaluation of an Augmented GPS Landing System," September, 2001.
9. Sudhir Rai, "Signal Analysis of Heart Rate Variability Data," December, 2001.
10. Rupa Balan, "Neural Network Modeling of Heart Rate Variability," April, 2002.
11. Anand Mohan, "Low Power and Low Space FIR Filter Design," June, 2002.
12. Alan Harris, "A Fiber Bragg Grating Load Cell," July, 2002.
13. Mahmuda Afroz, "A Design to Measure the Strain of a Large Structure Using Fiber Bragg Gratings," July, 2002.
14. Santiago Rendón, "A Statistical Evaluation of a Protected Service Volume Using an Augmented GPS Landing System," August, 2002.
15. Yuan Chen, "Effects of Digital Watermarking on Digital X-Ray Images," January, 2003.
16. Scott Graham, "A Video System for LAAS/WAAS Data Analysis," May, 2003.
17. Ewa Matusiak, "Uncertainty Principles for Finite Abelian Group and Applications" (interdisciplinary program in Signal Processing, Computational & Applied Mathematics — *SigCAM*), May, 2003.
18. Totrakool Khongsap, "Quantization on a Sphere" (interdisciplinary program in Signal Processing, Computational & Applied Mathematics — *SigCAM*), May, 2003.
19. Minh Quang Ta, "Minimum Entropy Estimation of FIR Filters," May, 2003.
20. Eric Wainright, "Wavelength Diversity in Free-Space Optics to Alleviate Fog Effects," December, 2003.
21. Benjamin Mohr, "Design, Implementation and Testing of a New Curved Path Navigator for LAAS and WAAS," April, 2004.
22. Erik Petrich, "Image Processing Methods for Product Label Identification on Cylindrical Surfaces," July, 2004.
23. John Paul Nguyenkim, "Implementation of a Redundant Binary Co-Processor onto an FPGA for Complex Arithmetic Signal Processing," September, 2004.
24. Anil Babu Chalamalasetti, "Analysis of Radar Signals with Oversampling in Range," September, 2004.
25. Yih-Ru Huang, "Evaluation of a Real Time DGPS (LAAS) Landing System for Missed Approaches and Guided Missed Approaches," September, 2004.
26. Wei Zhang, "Efficient Multiplierless Filter Implementations for Embedded Systems," October, 2004.
27. Ashish Parajuli, "Speech Enhancement Based on Perceptual Wavelet Thresholding and Auditory Masking," December, 2004.
28. Ayodeji Fajebe, "A Software Methodology for Embedded Intelligent Systems," February, 2005.
29. Abderrahmane Bennis, "Division and Square-Root Based on Redundant Binary Numbers," April, 2005.
30. Roland Ferenczhalmy, "Analysis of Adsorption and Desorption Kinetics of Volatile Analytes Using Mid-Infrared Laser Absorption Spectroscopy," August, 2005.
31. Deepak V. Bhogaraju, "Entropy Uncertainty in FIR Filter Implementations," September, 2005.
32. Benjamin Blevins, "Stereoscopic Tracking of Approaching Aircraft," December, 2005.
33. Brian Birk, "The Design and Implementation of a Fault Tolerant LAAS Base Station," May, 2006.
34. Nicholas Mould, "Reconfigurable Computing Architectures: Dynamic and Steering Vector Methods," May 2006.
35. Rodolfo Salas, "Control Electronics for Laser Absorption Spectroscopy," May, 2006.
36. Matthew S. Falk, "Developing a New Airway Criteria Using Aircraft's Required Navigational Performance," December, 2006.
37. Hieu Thai, "System Identification of Bridges Under a Moving Load and Implementation of the Bridge Monitoring System," March, 2007.
38. Kevin Ford, "Computer Hardware for Vibration Mitigation and Monitoring," March, 2007.
39. Molly Donovan, "Performance Evaluation of a Phase Contrast X-Ray Imaging Prototype System," June, 2007.

40. Kyle Sparger, "Roadside Data Collection and Monitoring using GPRS Cellular Network," July, 2007.
41. Patrick Macklin, "Development and Integration of a Power Management Board for the Collision Risk Model," September, 2007.
42. Adriana Sofia Otero, "Adaptive Localized Route Maintenance Mechanism to Improve Performance of VoIP Over Ad Hoc Networks," April, 2010.
43. Jasper Staab, "Binary Mimicry in the Executable File," May, 2010.
44. Yasmin Jahir, "AODVH: Multipath Routing Protocol for Hybrid Nodes in Disaster Area Wireless Network (DAWN)," July, 2010.
45. Jordan Kuehn, "FPGA Real-Time Motion Control and Automation of Biped Robot," December, 2010.
46. Jacob Henderson, "Application of Magnetic Field Distortion Characteristics for use in Autonomous Location Detection," May, 2011.
47. Sonya Wolff, "Pre-Execution: An Elegant Approach to the Memory Wall," July, 2011.
48. Feng Nai, "Wind Turbine Clutter Mitigation for Weather Radars," November, 2011.
49. Vasiliy Mayer, "Redefining Airway Constraints Based on En Route Flight Tests," December, 2011.
50. Sina Asadallahi, "Distributed Adaptive Backoff Reservation Protocol for 802.11 Wireless Networks," July, 2012.
51. Nathan McVay, "Sensitivity Analysis of Long Term Bias Error in the Global Positioning System," October, 2012.
52. Timothy Wilson, "Remote Desktop Capability for Labview Programs on an Android Platform," November, 2012.
53. Muhammad Usman Ghani, "Quantitative Analysis of Contrast to Noise Ratio Using a Phase Contrast X-Ray Imaging Prototype," October, 2013.
54. Marcin Rutkowski, "Glitching-Aware Model Characterization Methodology for Power Estimation Techniques in CMOS Arithmetic Structures," May, 2014.
55. Kevin Windham, "Subsampling Effects on Range Migration Correction in SAR Imaging," July, 2014.
56. Milad Javadi, "Identification of Simultaneously Congested Transmission Lines in Power Market," December, 2014.
57. Nastaran Emaminejad, "Exploring the new CT Image Features to Improve Lung Cancer Diagnosis and Treatment Efficacy Assessment," April, 2015.
58. Faranak Aghaei, "Computer-Aided Breast MR Image Feature Analysis for Prediction of Tumor Response to Chemotherapy," April, 2015.
59. David Schvartzman Cohenca, "Weather Radar Spatio-Temporal Saliency (WR-STS)," June, 2015.
60. Lesya Borowska, "Experiments on Electromagnetic Leakage from Laptops," May, 2017.
61. Jiaxi Zhu, "Low-Cost, Software Defined FMCW Radar for Observations of Drones," May, 2017.
62. Johnny O'Keeffe, "Neuroimaging Features of Adults with and without Amnestic Mild Cognitive Impairment," July, 2017.
63. Lucia R. Fitzmorris, "Learning Assisted Decoupled Software Pipelining (LA-DSWP)," April, 2018.
64. Precious Jatau, "A Fuzzy Logic Algorithm for Separating Radar Echos from Birds and Insect at S-band," July, 2018.
65. Bradley Gregory, "Objective Characterization of In-Line Phase Contrast X-Ray Imaging Prototype Using a Mid-Energy Beam," July, 2019.
66. Brian Carlton, "Nonlinear Amplifier Amplitude Modulation Distortion Mitigation Techniques," April, 2022.
67. Trey T. Crump, "An Analysis of the Information Content of Radar Detection," July, 2022.
68. Roman A. Munoz, "A Study on Diffusion Probabilistic Models for Image Generation," November, 2023.
69. Aminat B. Oyeleke, "Distributed Matrix Analysis and Computation Over Networks," April, 2024.
70. Erfan Seifi, "Developing an Algorithm Integrating Voice and Imaging Analysis to Recognize Facial Features and Deficiencies After Oral Surgery," April, 2024.

71. Summer Edwards, "Multimodal Imaging Approaches Using Functional Near-Infrared Spectroscopy, Electroencephalography and Transcranial Magnetic Stimulation" (Biomedical Engineering), July, 2024.

► **Externally Funded Grants and Contracts:**

1. R.D. Barnes (PI) and J.P. Havlicek, "Police Automated Records Information System FY24," State of Oklahoma, Highway Safety Office, **$121,614**, 10/1/23-9/30/24. OU Pink Sheet Credit: 50% ($60,807).
2. J.P. Havlicek (PI), M. Atiquzzaman, and R.D. Barnes, "SAFE-T: Statewide Analysis for Engineering & Technology," State of Oklahoma, Department of Transportation, **$117,867**, 1/1/23-6/30/24. OU Pink Sheet Credit: 34% ($40,075).
3. J.P. Havlicek (PI) and R.D. Barnes, "Oklahoma Intelligent Transportation System CY 2024," State of Oklahoma, Department of Transportation, **$381,862**, 12/1/23-6/30/24. OU Pink Sheet Credit: 50% ($190,931).
4. S.M. Schaefer, S. Hampton, F. Cianfarani, J. Havlicek, and R. Barnes, "Oklahoma State Housing Assessment," Oklahoma Housing Finance Authority, **$925,487**, 1/1/23-12/31/27. OU Pink Sheet Credit: 20% ($185,097).
5. R.D. Barnes (PI) and J.P. Havlicek, "Police Automated Records Information Systems FY23," State of Oklahoma, Highway Safety Office, **$97,427**, 10/1/22-9/30/23. OU Pink Sheet Credit: 50% ($48,714).
6. J.P. Havlicek (PI) and R.D. Barnes, "Oklahoma Intelligent Transportation System FFY 2023," State of Oklahoma, Department of Transportation, **$500,299**, 7/1/22-10/31/24. OU Pink Sheet Credit: 50% ($250,150).
7. R.D. Barnes (PI) and J.P. Havlicek, "PARIS FY22," State of Oklahoma, Highway Safety Office, **$194,855**, 10/1/21-9/30/22. OU Pink Sheet Credit: 50% ($97,427).
8. J.P. Havlicek (PI), M. Atiquzzaman, and R.D. Barnes, "SAFE-T: Statewide Analysis for Engineering & Technology," State of Oklahoma, Department of Transportation, **$117,867**, 10/1/21-9/30/22. OU Pink Sheet Credit: 34% ($40,075).
9. J.P. Havlicek (PI) and R.D. Barnes, "Oklahoma Intelligent Transportation System FFY 2022," State of Oklahoma, Department of Transportation, **$770,000**, 7/1/21-12/31/22. OU Pink Sheet Credit: 50% ($385,000).
10. K.M. Williams (PI), J.L. Holter Chakrabarty, Y. Yanik, S.K. Vesely, and J.P. Havlicek, et al., including Emory University/Children's Hospital of Atlanta, OU Health Sciences Center, OU Norman Campus, and University of Michigan, "Multi-institutional Prospective Pilot **R**esearch of Imaging and blood biomarker **EV**aluation of **E**ngraftment after **AL**ogeneic Hematopoietic Stem Cell Transplantation in Children and Adults (REVEAL)," NIH Title: "Imaging and Blood Biomarkers to Predict Graft Failure after HSCT," US Dept. Health and Human Services, National Institutes of Health, National Heart, Lung, and Blood Institute. **$2,913,713**. 6/1/20-7/31/25. Prime contractor: Emory University/CHOA; subcontract awarded to OU Norman Campus: $34,476 for Period 4 (8/01/23-7/31/24); $34,478 for Period 3 (8/01/22-7/31/23); $40,562 for Period 2 (8/01/21-7/31/22); $40,562 for Period 1 (8/15/20-8/31/21). Subcontract PI: J.P. Havlicek. OU Pink Sheet Credit: 100% ($150,078).
11. J.P. Havlicek (PI) and R.D. Barnes, "PARIS D360 Database Update," State of Oklahoma, Department of Public Safety, **$28,246**, 5/7/21-6/30/21. OU Pink Sheet Credit: 50% ($14,123).
12. J.P. Havlicek (PI), M. Atiquzzaman, and R.D. Barnes, "SAFE-T: Statewide Analysis for Engineering & Technology," State of Oklahoma, Department of Transportation, **$117,867**, 10/1/20-9/30/21. OU Pink Sheet Credit: 34% ($40,075).
13. R.D. Barnes (PI) and J.P. Havlicek, "Drive Oklahoma: Oklahoma's Intelligent Transportation System FY21," State of Oklahoma, Department of Transportation, **$700,000**, 7/1/20-12/31/21. OU Pink Sheet Credit: 50% ($350,000).
14. R.D. Barnes (PI), J.P. Havlicek, and M. Atiquzzaman, "Electronic Police Records 2020 (Supplement)," State of Oklahoma, Highway Safety Office, **$112,140**, 10/1/19-9/30/20. OU Pink Sheet Credit: 40% ($44,856).
15. R.D. Barnes (PI), J.P. Havlicek, and M. Atiquzzaman, "Electronic Police Records 2020," State of Oklahoma, Highway Safety Office, **$112,140**, 10/1/19-9/30/20. OU Pink Sheet Credit: 40% ($44,856).

16. M. Atiquzzaman (PI), J.P. Havlicek, and R.D. Barnes, "SAFE-T: Statewide Analysis for Engineering & Technology," State of Oklahoma, Highway Safety Office, **$98,830**, 10/1/19-9/30/20. OU Pink Sheet Credit: 20% ($19,766).
17. R.D. Barnes (PI) and J.P. Havlicek, "Intelligent Transportation Systems 2020," State of Oklahoma, Department of Transportation, **$700,000**, 7/1/19-6/30/20. OU Pink Sheet Credit: 50% ($350,000).
18. J.P. Havlicek (PI), R.D. Barnes, and M. Atiquzzaman, "Oklahoma Impaired Driver Database," State of Oklahoma, Highway Safety Office, **$36,297**, 10/1/18-9/30/19. OU Pink Sheet Credit: 34% ($12,341).
19. R.D. Barnes (PI), J.P. Havlicek, and M. Atiquzzaman, "Police Automated Records Information System (PARIS)," State of Oklahoma, Highway Safety Office, **$199,088**, 10/1/18-9/30/19. OU Pink Sheet Credit: 40% ($79,635).
20. M. Atiquzzaman (PI), J.P. Havlicek, and R.D. Barnes, "SAFE-T: Statewide Analysis for Engineering & Technology," State of Oklahoma, Highway Safety Office, **$98,196**, 10/1/18-9/30/19. OU Pink Sheet Credit: 20% ($19,639).
21. R.D. Barnes (PI) and J.P. Havlicek, "Traffic Incident Management (TIM) Report Analysis," State of Oklahoma, Department of Transportation, **$60,000**, 9/27/18-7/31/19. OU Pink Sheet Credit: 50% ($30,000).
22. J.L. Holter Chakrabarty (PI), J.P. Havlicek, and S.K. Vesely, "FLT Imaging to Detect Relapse in Leukemia Patients Following Transplantation," US Dept. Health and Human Services, National Institutes of Health. **$49,799**. 9/1/18-6/30/19. Prime contractor: University of Oklahoma Health Sciences Center; subcontract awarded to OU Norman Campus: $13,218. Subcontract PI: J.P. Havlicek. OU Pink Sheet Credit: 100% ($13,218).
23. R.D. Barnes (PI) and J.P. Havlicek, "Hardware and Software for Next Generation ITS," State of Oklahoma, Department of Transportation, **$700,000**, 7/1/18-6/30/19. OU Pink Sheet Credit: 50% ($350,000).
24. R.D. Barnes (PI) and J.P. Havlicek, "Expanding PARIS+ to Regional Police Agencies," Southern Plains Transportation Center, **$39,738**, 10/15/17-5/30/18. OU Pink Sheet Credit: 50% ($19,869).
25. J.P. Havlicek (PI), R.D. Barnes, and M. Atiquzzaman, "OU Impaired Driver Database Hosting and Support," State of Oklahoma, Highway Safety Office, **$36,000**, 10/1/17-9/30/18. OU Pink Sheet Credit: 34% ($12,240).
26. R.D. Barnes (PI), J.P. Havlicek, and M. Atiquzzaman, "PARIS Software Development and Integration," State of Oklahoma, Highway Safety Office, **$200,000**, 10/1/17-9/30/18. OU Pink Sheet Credit: 40% ($80,000).
27. M. Atiquzzaman (PI), R.D. Barnes, and J.P. Havlicek, "SAFE-T Data Improvement Project," State of Oklahoma, Highway Safety Office, **$85,920**, 10/1/17-9/30/18. OU Pink Sheet Credit: 20% ($17,184).
28. R.D. Barnes (PI) and J.P. Havlicek, "Engineering and Design of Intelligent Transportation System," State of Oklahoma, Department of Transportation, **$635,000**, 10/1/16-9/30/17. OU Pink Sheet Credit: 50% ($317,500).
29. J.P. Havlicek (PI), R.D. Barnes, and M. Atiquzzaman, "Operation of Oklahoma Statewide Impaired Driver Database," State of Oklahoma, Highway Safety Office, **$39,811**, 1/1/17-9/30/17. OU Pink Sheet Credit: 34% ($13,536).
30. R.D. Barnes (PI), J.P. Havlicek, and M. Atiquzzaman, "Police Automated Records Information System and Collision Reporting System," State of Oklahoma, Highway Safety Office, **$233,977**, 10/1/16-9/30/17. OU Pink Sheet Credit: 40% ($93,591).
31. M. Atiquzzaman (PI), R.D. Barnes, and J.P. Havlicek, "Statewide Analysis for Engineering and Technology," State of Oklahoma, Highway Safety Office, **$88,877**, 10/1/16-9/30/17. OU Pink Sheet Credit: 20% ($17,775).
32. R.D. Barnes (PI) and J.P. Havlicek, "Intelligent Transportation System Engineering and Design," State of Oklahoma, Department of Transportation, **$668,819**, 10/1/15-9/30/16. OU Pink Sheet Credit: 50% ($334,410).
33. R.D. Barnes (PI), J.P. Havlicek, and M. Atiquzzaman, "Police Automated Records Information System and DUI Tracking Database," State of Oklahoma, Highway Safety Office, **$379,128**, 10/1/15-9/30/16. OU Pink Sheet Credit: 40% ($151,651).
34. M. Atiquzzaman (PI), J.P. Havlicek, and R.D. Barnes, "Statewide Analysis for Engineering

and Technology," State of Oklahoma, Highway Safety Office, **$88,877**, 10/1/15-9/30/16. OU Pink Sheet Credit: 20% ($17,775).

35. L. Ding (PI), J.P. Havlicek, and D.T. Liu, "RII Track-2 FEC: Innovative, Broadly Accessible Tools for Brain Imaging, Decoding and Modulation," National Science Foundation, **$1,357,173** (subcontract to the University of Rhode Island; prime contract award amount: $5,999,853), 8/1/15-7/31/19. OU Pink Sheet Credit: 33% ($447,867).
36. J.P. Havlicek (PI) and R.D. Barnes, "Oklahoma Bureau of Narcotics and Dangerous Drugs (OBNDD) PARIS System," Oklahoma Bureau of Narcotics and Dangerous Drugs, **$7,201**, 5/1/15-12/31/15. OU Pink Sheet Credit: 50% ($3,601).
37. R.D. Barnes (PI), J.P. Havlicek, and M. Atiquzzaman, "OU Intelligent Transportation Systems FY15," Oklahoma Department of Transportation, **$400,000**, 10/1/14-9/30/15. OU Pink Sheet Credit: 40% ($160,000).
38. J.P. Havlicek (PI), M. Atiquzzaman, and R.D. Barnes, "SAFE-T System Expert System Functionality: Option III," Oklahoma Department of Transportation, **$232,127**, 1/1/15-12/31/16. OU Pink Sheet Credit: 34% ($78,923).
39. M.B. Yeary (PI), R.D. Palmer, and J.P. Havlicek, "System and Software Support for CGI (Supplement)," CGI Federal, Inc., **$34,224**, 11/7/14-3/8/15, OU Pink Sheet Credit: 25% ($8,556).
40. M. Atiquzzaman (PI), R.D. Barnes, and J.P. Havlicek, "Enhancing Driver Safety During Severe Weather Conditions," Southern Plains Transportation Center, **$199,998**, 7/1/14-6/30/16. OU Pink Sheet Credit: 30% ($59,999).
41. R.D. Barnes (PI), J.P. Havlicek, and M. Atiquzzaman, "Police Automated Records and Information System," State of Oklahoma, Highway Safety Office, **$368,500**, 10/1/14-9/30/15. OU Pink Sheet Credit: 40% ($147,400).
42. M. Atiquzzaman (PI), J.P. Havlicek, and R.D. Barnes, "University of Oklahoma Crash Reporting and Analysis," State of Oklahoma, Highway Safety Office, **$74,825**, 10/1/14-9/30/15. OU Pink Sheet Credit: 20% ($14,965).
43. Joseph P. Havlicek, "PET Image Analysis Using a Novel Radioisotope Fluorothymidine for Identification of Bone Marrow Repopulation following Myeloablative Transplantation: Supplement," University of Oklahoma Health Sciences Center, Stephenson Cancer Center, **$16,966**, 10/1/14-4/30/15. OU Pink Sheet Credit: 100% ($16,966).
44. J.L. Holter Chakrabarty (PI), J.P. Havlicek, and S.K. Vesely, "PET Image Analysis Using a Novel Radioisotope Fluorothymidine for Identification of Bone Marrow Repopulation following Myeloablative Transplantation," Oklahoma Shared Clinical and Translational Resources pilot grant funded by US Dept. Health and Human Services, National Institutes of Health. **$50,000**. 1/8/14-6/30/14. Prime contractor: University of Oklahoma Health Sciences Center; subcontract awarded to OU Norman Campus: $25,788. Subcontract PI: J.P. Havlicek. OU Pink Sheet Credit: 100% ($25,788).
45. R.D. Barnes (PI), J.J. Sluss, Jr., M. Atiquzzaman, and J.P. Havlicek, "ITS System Engineering and Integration," Oklahoma Department of Transportation, **$344,000**. 10/1/13-9/30/14. OU Pink Sheet Credit: 35% ($120,400).
46. M. Atiquzzaman (PI), J.P. Havlicek, and R.D. Barnes, "University of Oklahoma SAFE-T Project," State of Oklahoma, Highway Safety Office, **$174,000**, 10/1/13-9/30/14. OU Pink Sheet Credit: 20% ($34,800).
47. R.D. Barnes (PI), M. Atiquzzaman, and J.P. Havlicek, "OU TraCS/PARIS Project," State of Oklahoma, Highway Safety Office, **$238,000**, 10/1/13-9/30/14. OU Pink Sheet Credit: 40% ($95,200).
48. R.D. Barnes (PI), J.J. Sluss, Jr., M. Atiquzzaman, and J.P. Havlicek, "ITS System Engineering and Integration," Oklahoma Department of Transportation, **$344,000**. 10/1/12-9/30/13. OU Pink Sheet Credit: 37% ($127,280).
49. R.D. Barnes (PI), M. Atiquzzaman, and J.P. Havlicek, "Police Automated Records Information System," State of Oklahoma, Highway Safety Office, **$155,000**, 10/1/12-9/30/13. OU Pink Sheet Credit: 40% ($62,000).
50. M. Atiquzzaman (PI), J.P. Havlicek, and R.D. Barnes, "University of Oklahoma Crash Reporting and Analysis," State of Oklahoma, Highway Safety Office, **$55,000**, 10/1/12-9/30/13. OU Pink Sheet Credit: 20% ($11,000).
51. R.D. Barnes (PI), J.J. Sluss, Jr., M. Atiquzzaman, and J.P. Havlicek, "ITS System Engi-

neering and Integration," Oklahoma Department of Transportation, **$312,150**. 10/1/11-9/30/12. OU Pink Sheet Credit: 35% ($109,253).

52. J.P. Havlicek (PI) and R.D. Barnes, "GPS Location Data Enhancement in Electronic Traffic Records," Oklahoma Transportation Center, **$100,000**, 10/1/11-12/31/12. OU Pink Sheet Credit: 50% ($50,000).
53. R.D. Barnes (PI) and J.P. Havlicek, "Fatality Analysis Reporting System and Roadway Inventory Correlation," Oklahoma Transportation Center, **$100,000**, 10/1/11-12/31/12. OU Pink Sheet Credit: 50% ($50,000).
54. R.D. Barnes (PI), M. Atiquzzaman, and J.P. Havlicek, "OU Software Development & Integration Project," State of Oklahoma, Highway Safety Office, **$220,000**, 10/1/11-9/30/12. OU Pink Sheet Credit: 40% ($88,000).
55. M. Atiquzzaman (PI), J.P. Havlicek, and R.D. Barnes, "University of Oklahoma Crash Reporting and Analysis," State of Oklahoma, Highway Safety Office, **$54,660**, 10/1/11-9/30/12. OU Pink Sheet Credit: 20% ($10,932).
56. R.D. Barnes (PI), J.J. Sluss, Jr., M. Atiquzzaman, J.P. Havlicek, J. Basara, and M.P. Tull, "A Mobile Intelligent Transportation System (ITS) Platform," Oklahoma Transportation Center, **$341,352**. 1/1/11-2/29/12. OU Pink Sheet Credit: 20% ($68,270).
57. R.D. Barnes (PI), J.J. Sluss, Jr., M. Atiquzzaman, J.P. Havlicek, and M.P. Tull, "ITS System Engineering Crash Diagram Supplement," Oklahoma Department of Transportation, **$17,645**. 10/1/10-6/30/12. OU Pink Sheet Credit: 25% ($4,411).
58. R.D. Barnes (PI), J.J. Sluss, Jr., M. Atiquzzaman, J.P. Havlicek, and M.P. Tull, "Intelligent Transportation System (ITS) Engineering and Integration Services," Oklahoma Department of Transportation, **$341,000**. 10/1/10-6/30/12. OU Pink Sheet Credit: 25% ($82,250).
59. R.D. Barnes (PI), M. Atiquzzaman, J.P. Havlicek, and M.P. Tull, "OU Software Development & Integration Project," State of Oklahoma, Highway Safety Office, **$234,573**, 10/1/10-9/30/11. OU Pink Sheet Credit: 30% ($70,372).
60. M. Atiquzzaman (PI), J.P. Havlicek, M.P. Tull, and R.D. Barnes, "University of Oklahoma Crash Reporting and Analysis," State of Oklahoma, Highway Safety Office, **$64,879**, 10/1/10-9/30/11. OU Pink Sheet Credit: 22% ($14,273).
61. R.D. Barnes (PI), J.J. Sluss, Jr., M. Atiquzzaman, J.P. Havlicek, and M.P. Tull, "Intelligent Transportation System (ITS) Engineering and Integration Services," Oklahoma Department of Transportation, **$220,000**. 10/1/09-9/30/10. OU Pink Sheet Credit: 25% ($55,000).
62. R.D. Barnes (PI), M. Atiquzzaman, J.P. Havlicek, and M.P. Tull, "OU Software Development & Integration Project," State of Oklahoma, Highway Safety Office, **$150,000**, 10/1/09-9/30/10. OU Pink Sheet Credit: 30% ($45,000).
63. M. Atiquzzaman (PI), J.P. Havlicek, M.P. Tull, and R.D. Barnes, "University of Oklahoma Crash Reporting and Analysis," State of Oklahoma, Highway Safety Office, **$55,000**, 10/1/09-9/30/10 OU Pink Sheet Credit: 22% ($12,100).
64. R.D. Barnes (PI), James J. Sluss, Jr., M. Atiquzzaman, J.P. Havlicek, and M.P. Tull, "Roadway Weather Information System and Automatic Vehicle Location (AVL) Coordination," Oklahoma Transportation Center (OTC), **$145,433**, 6/1/08-5/31/10. OU Pink Sheet Credit: 20% ($29,087).
65. R.D. Barnes (PI), James J. Sluss, Jr., M. Atiquzzaman, J.P. Havlicek, and M.P. Tull, "Roadway Weather Information System and Automatic Vehicle Location (AVL) Coordination (Matching Funds)," Oklahoma Department of Transportation, **$55,000**, 6/1/08-5/31/10. OU Pink Sheet Credit: 20% ($11,000).
66. R.D. Barnes (PI), J.J. Sluss, Jr., M. Atiquzzaman, J.P. Havlicek, M.P. Tull, and H. Refai, "ITS System Engineering and Integration Supplement," Oklahoma Department of Transportation, **$33,000**. 11/1/08-10/31/09. OU Pink Sheet Credit: 10% ($3,300).
67. R.D. Barnes (PI), J.J. Sluss, Jr., J.P. Havlicek, and M.P. Tull, "Intelligent Transportation System (ITS) Engineering and Integration Services," Oklahoma Department of Transportation, **$155,000**. 10/1/08-9/30/09. OU Pink Sheet Credit: 25% ($38,750).
68. J.P. Havlicek (PI) and G. Fan, "Multiple Domain Particle Filters for Integrated Tracking and Recognition in IR Imagery," Department of Defense, Army Research Office, **$474,000**, 7/1/08-6/30/11. OU Pink Sheet Credit: 100% ($474,000).
69. R.D. Barnes (PI), J.P. Havlicek, and M.P. Tull, "OU Software Development & Integration Project," State of Oklahoma, Highway Safety Office, **$150,000**, 10/1/08-9/30/09. OU Pink

Sheet Credit: 33% ($49,500).

70. R.D. Barnes (PI), J.P. Havlicek, and M.P. Tull, "OU Software Development & Integration Project Supplement," State of Oklahoma, Highway Safety Office, **$5,000**, 7/15/09-9/30/09. OU Pink Sheet Credit: 33% ($1,650).
71. M. Atiquzzaman (PI), J.P. Havlicek, M.P. Tull, and R.D. Barnes, "University of Oklahoma Crash Reporting and Analysis System," State of Oklahoma, Highway Safety Office, **$54,745**, 10/1/08-9/30/09. OU Pink Sheet Credit: 22% ($12,044).
72. J.P. Havlicek (PI), M.P. Tull, and R.D. Barnes, "OU Software Development & Integration Project (TraCS) Supplement," State of Oklahoma, Highway Safety Office, **$50,000**, 10/1/07-9/30/08. OU Pink Sheet Credit: 40% ($20,000).
73. J.P. Havlicek (PI), M.P. Tull, and R.D. Barnes, "OHP Troop S Civil Assessment System," State of Oklahoma, Department of Public Safety, **$50,000**, 4/15/08-4/14/09. OU Pink Sheet Credit: 34% ($17,000).
74. J.P. Havlicek (PI), M.P. Tull, and R.D. Barnes, "Automated Driver License Testing System," State of Oklahoma, Department of Public Safety, **$108,035**, 10/1/07-9/30/08. OU Pink Sheet Credit: 40% ($43,214).
75. J.P. Havlicek (PI), M.P. Tull, and R.D. Barnes, "OU Software Development & Integration Project (TraCS)," State of Oklahoma, Highway Safety Office, **$150,000**, 10/1/07-9/30/08. OU Pink Sheet Credit: 40% ($60,000).
76. J.P. Havlicek (PI), M. Atiquzzaman, M.P. Tull, and R.D. Barnes, "University of Oklahoma Crash Reporting and Analysis System (SAFE-T)," State of Oklahoma, Highway Safety Office, **$53,171**, 10/1/07-9/30/08. OU Pink Sheet Credit: 30% ($15,951).
77. M.P. Tull (PI), J.J. Sluss, Jr., J.P. Havlicek, and R.D. Barnes, "ITS System Engineering and Integration Services to be Provided by the OU ITS Lab as Part of the Oklahoma Transportation Center, FY 2008," Oklahoma Department of Transportation, **$219,976**, 10/1/07-9/30/08. OU Pink Sheet Credit: 30% ($65,993).
78. J.P. Havlicek (PI), J.J. Sluss, Jr., and M.P. Tull, "TraCS: Traffic and Criminal Software (continuation of OU Mobile Data Collection System Pilot Project)," State of Oklahoma, Highway Safety Office, **$182,467**, 10/1/06-9/30/07. OU Pink Sheet Credit: 40% ($72,987).
79. M.P. Tull (PI), J.J. Sluss, Jr., and J.P. Havlicek, "ITS System Engineering and Integration," Oklahoma Department of Transportation, **$208,000**, 10/1/06-9/30/07. OU Pink Sheet Credit: 45% ($93,600).
80. M.P. Tull (PI), J.J. Sluss, Jr., M. Atiquzzaman, J.P. Havlicek, and T. Runolfsson, "Advanced Voice and Multimedia Communications System for the ODOT ITS Network," State of Oklahoma, Department of Transportation (Oklahoma Transportation Center), **$81,000**, 10/1/06-9/30/07. OU Pink Sheet Credit: 30% ($24,300).
81. J.P. Havlicek (PI), J.J. Sluss, Jr., M. Atiquzzaman, M.P. Tull, and T. Runolfsson, "University of Oklahoma Crash Reporting and Analysis," State of Oklahoma, Highway Safety Office, **$50,000**. 10/1/06-9/30/07. OU Pink Sheet Credit: 25% ($12,500).
82. J.P. Havlicek (PI), J.J. Sluss, Jr., M.P. Tull, and T. Runolfsson, "OU Mobile Data Collection System Pilot Project (Continuation)," State of Oklahoma, Highway Safety Office, **$45,751**, 10/1/06-9/30/07. OU Pink Sheet Credit: 25% ($11,438).
83. J.J. Sluss, Jr. (PI), J.P. Havlicek, M.P. Tull, and T. Runolfsson, "Truck Weight Enforcement Using Advanced Weigh-in-Motion Systems," Oklahoma Transportation Center, **$78,223**, 5/1/06-4/30/07. OU Pink Sheet Credit: 25% ($19,556).
84. T. Landers (PI), with 19 Co-PI's including J.P. Havlicek, "Inter-Modal Containerized Freight Security: FY 06 Allocation," Oklahoma Department of Transportation, **$2,083,151**, 7/1/06-6/30/07. OU Pink Sheet Credit: 6% ($124,989).
85. J.P. Havlicek (PI), J.J. Sluss, Jr., M.P. Tull, and T. Runolfsson, "OU Mobile Data Collection Project (CDL)," State of Oklahoma, Highway Safety Office, **$105,277**, 3/1/06-9/30/06. OU Pink Sheet Credit: 25% ($26,319).
86. J.J. Sluss, Jr. (PI), J.P. Havlicek, M.P. Tull, and T. Runolfsson, "Intelligent Transportation System (ITS) Engineering and Integration Services," Oklahoma Department of Transportation, **$225,000**, 10/1/05-9/30/06. OU Pink Sheet Credit: 25% ($56,250).
87. J.P. Havlicek (PI), M.P. Tull, and J.J. Sluss, Jr., "SAFE-T: State-Wide Analysis for Enhancing Transportation," State of Oklahoma, Highway Safety Office, **$50,000**, 10/1/05-9/30/06. OU Pink Sheet Credit: 33% ($16,500).

88. R. Mc Pherson (PI), J.J. Sluss, Jr., J. Snow, J.P. Havlicek, J. Basara, M. Wolfinbarger, and C. Friebrich, "Clarus Weather System Design," Mixon/Hill, Inc. (prime contractor; flow-through from U.S. DoT – FHWA), **$411,769**, 6/1/05-2/28/07. OU Pink Sheet Credit: 10% ($41,177).
89. J.P. Havlicek (PI), J.J. Sluss, Jr., M.P. Tull, and T. Runolfsson, "OU Mobile Data Collection System Pilot Project," State of Oklahoma, Highway Safety Office, **$208,000**, 4/25/05-3/31/06. OU Pink Sheet Credit: 25% ($52,000).
90. J.P. Havlicek (PI) and J.J. Sluss, Jr., "University of Oklahoma Crash Reporting and Analysis System (FMCSA Supplement)," State of Oklahoma, Highway Safety Office, **$75,000**, 1/1/05-9/30/05. OU Pink Sheet Credit: 50% ($37,500).
91. J.P. Havlicek (PI) and J.J. Sluss, Jr., "University of Oklahoma Crash Reporting and Analysis System," State of Oklahoma, Highway Safety Office, **$50,000**, 10/1/04-9/30/05. OU Pink Sheet Credit: 50% ($25,000).
92. J.J. Sluss, Jr. (PI) and J.P. Havlicek, "Intelligent Transportation System Engineering and Integration Services," Oklahoma Department of Transportation, **$222,356**, 10/1/04-9/30/05. OU Pink Sheet Credit: 50% ($111,178).
93. J.P. Havlicek (PI) and G. Fan, "Integrated Detection, Tracking, Classification, and Learning for Dual-Band Infrared Imagery," Department of Defense, Army Research Office, **$465,897**, 7/1/04-6/30/07. OU Pink Sheet Credit: 100% ($465,897).
94. J.J. Sluss, Jr. (PI) and J.P. Havlicek, "Design and Integration of ITS (Intelligent Transportation Systems) Project in Oklahoma," Oklahoma Department of Transportation, **$164,500**, 10/1/03-9/30/04. OU Pink Sheet Credit: 50% ($82,250).
95. J.P. Havlicek (PI) and J.J. Sluss, Jr., "A Statewide Crash Reporting and Analysis System," State of Oklahoma, Highway Safety Office, **$50,000**, 10/1/03-9/30/04. OU Pink Sheet Credit: 50% ($25,000).
96. J.J. Sluss, Jr. (PI) and J.P. Havlicek, "Design and Integration of ITS (Intelligent Transportation Systems) Project in Oklahoma (Year 0)," Oklahoma Department of Transportation, **$41,000**, 7/1/03-9/30/03. OU Pink Sheet Credit: 50% ($20,500).
97. J.J. Sluss, Jr. (PI), J.P. Havlicek, and S. Radhakrishnan, "Development of a 511 Traveler Information Program Deployment Plan for Oklahoma," Oklahoma Department of Transportation, **$50,000**, 1/1/03-6/30/04. OU Pink Sheet Credit: 33% ($16,500).
98. J.P. Havlicek (PI) and J.J. Sluss, Jr., "A Statewide Accident Reporting and Analysis System," Oklahoma Transportation Center, **$30,000**, 1/1/03-9/30/03. OU Pink Sheet Credit: 50% ($15,000).
99. J.P. Havlicek (PI) and J.J. Sluss, Jr., "ITS Features for Enhanced Highway Safety in Work Zones," State of Oklahoma, Highway Safety Office, **$50,000**, 10/1/02-9/30/03. OU Pink Sheet Credit: 50% ($25,000).
100. J.J. Sluss, Jr. (PI) and J.P. Havlicek, "Design and Integration of ITS (Intelligent Transportation Systems) Project in Oklahoma," Oklahoma Department of Transportation, **$145,000**, 6/18/02-9/30/03. OU Pink Sheet Credit: 50% ($72,500).
101. J.E. Fagan (PI), J.P. Havlicek, and G.R. Schaumburg, "Determining the Required Navigational Performance of the GPS, WAAS, and LAAS Systems for Precision Simple and Complex Approaches and the Development of Models for the Prediction of the Operational Performance of these Navigation Systems," Federal Aviation Administration, **$545,000**, 5/1/02-6/30/03. OU Pink Sheet Credit: 30% ($163,500).
102. J.J. Sluss, Jr. (PI), J.P. Havlicek, and S. Radhakrishnan, "Oklahoma Statewide ITS Strategic Plan and ITS/CVO Plan," Federal Highway Administration/Oklahoma Department of Transportation subcontract; prime contractor: P.B. Farradyne, Inc., **$32,692**, 3/1/02-3/31/03. OU Pink Sheet Credit: 33% ($10,788).
103. J.E. Fagan (PI), J.P. Havlicek, and G.R. Schaumburg, "Determining the Required Navigational Performance of the GPS, WAAS, and LAAS Systems for Precision Simple and Complex Approaches and the Development of Models for the Prediction of the Operational Performance of these Navigation Systems in a Wide Variety of Aircraft (Global Positioning System Wide and Local Area Augmentation System)," Federal Aviation Administration, **$240,000**, 2/1/00-6/30/02. OU Pink Sheet Credit: 30% ($72,000).
104. J.P. Havlicek (PI), "Decentralized Image Retrieval for Education \(DIRECT\)," National Science Foundation subcontract; prime contractor: University of Virginia, PI: S.T. Acton,

$63,171, 1/1/02-12/31/03. OU Pink Sheet Credit: 100% ($63,171).

105. J.P. Havlicek (PI) and J.J. Sluss, Jr., "System Development and Testing for ITS," State of Oklahoma, Highway Safety Office, **$50,000**, 10/1/01-9/30/02. OU Pink Sheet Credit: 50% ($25,000).
106. M.P. Tull (PI), J.P. Havlicek, J.J. Sluss, Jr., and J. Cheung, "Artificial Intelligence Based Forecasting," Lucent Technologies, **$39,943**, 1/1/01-5/31/01. OU Pink Sheet Credit: 37% ($14,779).
107. P. Pulat (PI), J.J. Sluss, Jr., J.P. Havlicek, S. Radhakrishnan, and S.A. Moses, "Design and Evaluation of a Hierarchical Highway Network Structure and a Decision Support System with Surveillance Information to Enhance Business Partnerships in the E-Marketplace," National Science Foundation, **$100,001**, 8/15/00-8/14/01. OU Pink Sheet Credit: 20% ($20,000).
108. J.P. Havlicek (PI) and J.J. Sluss, Jr., "System Development, Integration, and Component Testing for Oklahoma City's Intelligent Transportation System," State of Oklahoma Highway Safety Office, **$50,000**, 10/1/00-9/30/01. OU Pink Sheet Credit: 50% ($25,000).
109. M.P. Tull (PI), J.J. Sluss, Jr., J.P. Havlicek, and S. Radhakrishnan, "Artificial Intelligence Based Inventory and Forecasting," Lucent Technologies, **$248,428**, 1/1/00-12/31/00. OU Pink Sheet Credit: 33% ($81,981).
110. J.P. Havlicek (PI) and J.J. Sluss, Jr., "System Development, Integration, and Component Testing for Oklahoma City's Intelligent Transportation System," State of Oklahoma Highway Safety Office, **$50,001**, 10/1/99-9/30/00. OU Pink Sheet Credit: 50% ($25,001).
111. J.J. Sluss, Jr. (PI) and J.P. Havlicek, "An Intelligent Transportation System for Oklahoma City," State of Oklahoma Department of Transportation, **$80,000**, 7/1/99-8/15/00. OU Pink Sheet Credit: 50% ($40,000).
112. J.E. Fagan (PI), J.P. Havlicek, J.J. Sluss, Jr., and G.R. Schaumburg, "A Proposal for Research to Determine the Required Navigational Performance of the GPS, WAAS, and LAAS Systems for Simple and Complex Approaches and the Development of Models for the Prediction of the Operational Performance of these Navigation Systems in a Wide Variety of Aircraft," Federal Aviation Administration, **$866,300**, 4/16/99-6/30/01. OU Pink Sheet Credit: 30% ($259,890).
113. M.P. Tull (PI), J.J. Sluss, Jr., and J.P. Havlicek, "Extended Artificial Intelligence Based Forecasting and Inventory Planning Models," Lucent Technologies, **$232,754**, 1/1/99-12/31/99. OU Pink Sheet Credit: 33.3% ($77,507).
114. J.J. Sluss, Jr. (PI) and J.P. Havlicek, "System Architecture Design for Oklahoma City's Intelligent Transportation System," State of Oklahoma Department of Transportation, **$49,776**, 5/13/98-10/31/98. OU Pink Sheet Credit: 50% ($24,888).
115. M.P. Tull (PI), J.J. Sluss, Jr., J.P. Havlicek, V.E. DeBrunner, L.S. DeBrunner, S.C. Lee, and S. Radhakrishnan, "Artificial Intelligence Based Forecasting and Inventory Planning Models," Lucent Technologies, **$229,298**, 11/1/97-12/31/98. OU Pink Sheet Credit: 21% ($48,153).

► **Total External Funding: $27,565,129**

► **Total Attributable to J.P. Havlicek (OU Pink Sheet Credit): $9,211,089**

► **Internally Funded Grants:**

1. H. Liu (PI), J. Holter Chakrabarty, and J.P. Havlicek, "Development of a Predictive Imaging Model for Prediction of Relapse Following Allogeneic Bone Marrow Transplantation," University of Oklahoma Bioengineering Center seed funding for interdisciplinary Research, $47,172. 12/15/13-12/14/14.
2. P.S. Harvey, R.W. Floyd, L. Gruenwald, J.P. Havlicek, Y. Li, and J.-S. Pei, "Safer School Buildings for Wind and Earthquakes: A Multidisciplinary Approach," University of Oklahoma College of Engineering seed funding for interdisciplinary Research, $10,000. 6/1/15-5/31/16.

Total Internal Funding: $57,172

▶ **Invited Lectures:**

1. J.P. Havlicek, "Designing Perceptually-Based Image Filters in the Modulation Domain," School of Electrical and Computer Engineering, Purdue University, West Lafayette, IN, May 3, 2011.
2. J.P. Havlicek, "Designing Perceptually-Based Image Filters in the Modulation Domain," Dept. Automation, Shanghai Jiao Tong University, Shanghai, China, September 25, 2010.
3. J.P. Havlicek, "Infrared Target Tracking in the Modulation Domain," Dept. Electrical & Computer Engineering, University of New Mexico, Albuquerque, NM, March 28, 2008.
4. J.P. Havlicek, "Multidimensional AM-FM Models with Image Processing Applications," School of Electrical and Computer Engineering, Purdue University, West Lafayette, IN, November 22, 2002.
5. J.P. Havlicek, "Image Texture Retrieval Using Joint Amplitude-Frequency Modulation Models," Dept. Electrical and Computer Engineering, University of Virginia, Charlottesville, VA, July 22, 2002.
6. J.P. Havlicek, "Modulation Models for Image Processing and Machine Vision," Dept. Electrical Engineering, The Ohio State University, Columbus, OH, March 31, 1998.
7. J.P. Havlicek, "Modulation Models for Image Processing and Machine Vision," School of Electrical & Computer Engineering, Oklahoma State University, Stillwater, OK, March 26, 1998.
8. J.P. Havlicek, "Wideband Frequency Excursions in Multicomponent AM-FM Models," School of Electrical & Computer Engineering Colloquium Seminar Series, the University of Oklahoma, Norman, OK, September 18, 1997.
9. J.P. Havlicek, "AM-FM Image Models," IEEE Oklahoma City Section meeting, Oklahoma City, OK, March 20, 1997.
10. J.P. Havlicek, "AM-FM Image Models," School of Electrical & Computer Engineering, the University of Oklahoma, Norman, OK, July 18, 1996.
11. J.P. Havlicek, "AM-FM Image Analysis," Dept. Electrical Engineering, University of Washington, Seattle, WA, May 14, 1996.
12. J.P. Havlicek, "AM-FM Image Analysis," Dept. Electrical Engineering, The Pennsylvania State University, University Park, PA, April 22, 1996.

▶ **Conference Presentations Without Proceedings:**

1. H. Soltani, M. Muraleetharan, and J. Havlicek, "Effects of ground improvement zone dimensions on the modal characteristics of pile founded structures," *Engineering Mechanics Institute Conference 2019*, California Institute of Technology, Pasadena, CA, Jun. 18-21, 2019.
2. K.M. Williams, J.L. Holter Chakrabarty, L. Lindenberg, S. Adler, J. Gea-Banacloche, B. Blacklock-Schuver, F.T. Hakim, D.D. Hickstein, J.N. Kochenderfer, J. Wilder, T. Chinn, K. Kurdziel, S.M. Steinberg, H. Khuu, F.I. Lin, D.H. Fowler, D. Halverson, D.N. Avila, G. Selby, T.N. Taylor, J. Mann, J. Hsu, R.B. Epstein, S.L. Anderson, C.T. Nguyen, J. Havlicek, S. Li, T. Pham, T. Kraus, S.K. Vesely, PhD, S.Z. Pavletic, C.M. Bollard, P. Choyke, and R.E. Gress, "FLT imaging reveals kinetics and biology of engraftment after myeloablative HSCT," *56'th American Society of Hematology (ASH) Annual Meeting and Exposition*, San Francisco, CA, Dec. 6-9, 2014.
3. K.M. Williams, J.L. Holter, L. Lindenberg, S. Adler, J. Gea-Banacloche, B. Blacklock-Schuver, F. Hakim, D. Hickstein, J. Kochenderfer, J. Wilder, T. Chinn, K. Kurdziel, S. Steinberg, H. Khuu, D. Fowler, F.I. Lin, D. Halverson, D.N. Avila, G. Selby, S.L. Anderson, C.T. Nguyen, J.P. Havlicek, T.N. Taylor, J. Mann, J. Hsu, R. Epstein, S.K. Vesely, S. Li, T. Kraus, T. Pham, S.Z. Pavletic, C. Bollard, P. Choyke, and R.E. Gress, "Novel imaging reveals early engraftment and stem cell homing," *NIH Blood and Marrow Transplant (BMT) Consortium: 20th Anniversary Allogeneic Stem Cell Transplant at NIH Conference and Celebration*, Washington, DC, Sep. 11-12, 2014.

Publications

A. Archival Journal Papers:

1. J.P. Wright, P.F. Tang, J.-S. Pei, F. Gay-Balmaz, and J.P. Havlicek, "On computing the analytic-signal backbone of the unforced harmonic oscillator," *J. Comput. Appl. Math.*, vol. 385, 16 pp., Article 113206, Mar. 15, 2021, published online Sep. 22, 2020.
2. E.D. Ross, S.S. Gupta, A.M. Adnan, T.L. Holden, J. Havlicek, and S. Radhakrishnan, "Neurophysiology of spontaneous facial expressions: II. Motor control of the right and left face is partially independent in adults," *Cortex*, vol. 111, pp. 164-182, Feb. 2019, published online Nov. 10, 2018.
3. K.M. Williams, J. Holter-Chakrabarty, L. Lindenberg, Q. Dong, S.K. Vesely, C.T. Nguyen, J.P. Havlicek, K. Kurdziel, J. Gea-Banacloche, F.I. Lin, D.N. Avila, G. Selby, C.G. Kanakry, S. Li, T. Scordino, S. Adler, C.M. Bollard, P. Choyke, and R.E. Gress, "Imaging of subclinical haemopoiesis after stem-cell transplantation in patients with haematological malignancies: A prospective pilot study," *The Lancet Haematology*, vol. 5, no. 1, pp. e44-e52, Jan. 2018, published online Dec. 13, 2017.
4. E.D. Ross, S.S. Gupta, A.M. Adnan, T.L. Holden, J. Havlicek, and S. Radhakrishnan, "Neurophysiology of spontaneous facial expressions: I. Motor control of the upper and lower face is behaviorally independent in adults," *Cortex*, vol. 76, pp. 28-42, Mar. 2016.
5. L. Yu, G. Fan, J. Gong, and J.P. Havlicek, "Joint infrared target recognition and segmentation using a shape manifold-aware level set," *Sensors*, special issue on sensors in new road vehicles, vol. 15, no. 5, pp. 10118-10145, Apr. 2015.
6. J. Gong, G. Fan, L. Yu, J.P. Havlicek, D. Chen, and N. Fan, "Joint target tracking, recognition and segmentation for infrared imagery using a shape manifold-based level set," *Sensors*, vol. 14, no. 6, pp. 10124-10145, Jun. 2014.
7. J. Gong, G. Fan, L. Yu, J.P. Havlicek, D. Chen, and N. Fan, "Joint view-identity manifold for infrared target tracking and recognition," *Comput. Vision, Image Understand.*, vol. 118, pp. 211-224, Jan. 2014.
8. N. Mould and J.P. Havlicek, "Neighborhood-level learning techniques for nonparametric scene models," *Signal, Image, Video Process.*, vol. 8, no. 6, pp. 1015-1029, Sep. 2014. doi: 10.1007/s11760-013-0571-x.
9. V. Venkataraman, G. Fan, J.P. Havlicek, X. Fan, Y. Zhai, and M. Yeary, "Adaptive Kalman filtering for histogram-based appearance learning in infrared imagery," *IEEE Trans. Image Process.*, vol. 21, no. 11, pp. 4622-4635, Nov. 2012.
10. V. Venkataraman, G. Fan, L. Yu, X. Zhang, W. Liu, and J.P. Havlicek, "Automated target tracking and recognition using coupled view and identity manifolds for shape representation," *EURASIP J. Advances Signal Process.*, v. 2011, doi: 10.1186/1687-6180-2011-124, 17 pp., Dec. 7, 2011.
11. P.C. Tay, J.P. Havlicek, S.T. Acton, and J.A. Hossack, "Properties of the magnitude terms of orthogonal scaling functions," *Digital Signal Process.*, vol. 20, no. 5, pp. 1330-1340, Sep. 2010.
12. X. Fan, G. Fan, and J.P. Havlicek, "Generative model for maneuvering target tracking," *IEEE Trans. Aerospace, Elect. Sys.*, vol. 46, no. 2, pp. 635-655, Apr. 2010.
13. Y. Zhai, M. Yeary, J. Havlicek, and G. Fan, "A new centralized sensor fusion-tracking methodology based on particle filtering for power-aware systems," *IEEE Trans. Instrumentation, Measurement*, vol. 57, no. 10, pp. 2377-2387, Oct. 2008.
14. V. DeBrunner, J.P. Havlicek, T. Przebinda, and M. Özaydın, "Entropy-based uncertainty measures for $L^2(\mathbb{R}^n)$, $\ell^2(\mathbb{Z})$, and $\ell^2(\mathbb{Z}/N\mathbb{Z})$ with a Hirschman optimal transform for $\ell^2(\mathbb{Z}/N\mathbb{Z})$," *IEEE Trans. Signal Process.*, vol. 53, no. 8, pp. 2690-2699, Aug. 2005.
15. S.T. Acton, D.P. Mukherjee, J.P. Havlicek, and A.C. Bovik, "Oriented texture completion by AM-FM reaction-diffusion," *IEEE Trans. Image Process.*, vol. 10, no. 6, pp. 885-896, Jun. 2001.
16. J.P. Havlicek and P.C. Tay, "Determination of the number of texture segments using wavelets," *Electron. J. Diff. Eqns.*, vol. Conf. 07, 2001, pp. 61-70, `http://ejde.math.swt.edu/conf-proc/07/toc.html`. Also published in *Proc. 16th Conf. Appl. Math.*, Edmond, OK, Feb. 23-24, 2001, pp. 61-70.
17. J.P. Havlicek, D.S. Harding, and A.C. Bovik, "Multidimensional quasi-eigenfunction approximations and multicomponent AM-FM models," *IEEE Trans. Image Process.*, vol. 9, no. 2,

pp. 227-242, Feb. 2000.

18. J.P. Havlicek, D.S. Harding, and A.C. Bovik, "Multicomponent multidimensional signals," *Multidimensional Syst. and Signal Process.*, vol. 9, no. 4, *invited paper*, pp. 391-398, Oct. 1998.
19. J.P. Havlicek, "The evolution of modern texture processing," *Elektrik, Turkish Journal of Electrical Engineering and Computer Sciences*, vol. 5, no. 1, special issue on image processing, pp. 1-28, 1997.
20. A.C. Bovik, J.P. Havlicek, M.D. Desai, and D.S. Harding, "Limits on discrete modulated signals," *IEEE Trans. Signal Process.*, vol. 45, no. 4, pp. 867-879, Apr. 1997.
21. J.P. Havlicek, D.S. Harding, and A.C. Bovik, "The mutlicomponent AM-FM image representation," *IEEE Trans. Image Process.*, special issue on nonlinear image processing, vol. 5, no. 6, pp. 1094-1100, Jun. 1996.
22. J.P. Havlicek, J.C. McKeeman, and P.W. Remaklus, "Networks of low-earth orbit store-and-forward satellites," *IEEE Trans. Aerospace and Elect. Sys.*, vol. 31, no. 2, pp. 543-554, Apr. 1995.
23. J.P. Havlicek, G.R. Katz, and J.C. McKeeman, "Even length median filters in optimal signal processing," *Electron. Letters*, vol. 28, no. 13, pp. 1258-1260, Jun. 18, 1992.
24. J.P. Havlicek, K.A. Sarkady, G.R. Katz, and J.C. McKeeman, "Fast efficient median filters with even length windows," *Electron. Letters*, vol. 26, no. 20, pp. 1736-1737, Sep. 27, 1990.

B. Book Chapters:

1. O. Alkhouli, V. DeBrunner, and J. Havlicek, "Hirschman Optimal Transform (HOT) DFT Block LMS Algorithm," in *Adaptive Filtering*, L. Garcia, ed., ISBN: 978-953-307-158-9, In-Tech, Sep. 2011, pp. 135-152.
2. G. Fan, V. Venkataraman, X. Fan, and J.P. Havlicek, "Appearance Learning for Infrared Tracking with Occlusion Handling," in *Machine Vision Beyond Visible Spectrum*, R.I. Hammoud, G. Fan, R.W. McMillan, and K. Ikeuchi, ed., Augmented Vision and Reality Series, Springer, Berlin, Heidelberg, Jun. 2011, pp. 33-64.
3. G. Fan, X. Fan, V. Venkataraman, and J.P. Havlicek, "Vehicle Tracking and Recognition," in *Intelligent Video Surveillance: Systems and Technology*, Y. Ma and G. Qian, ed., CRC Press - Taylor & Francis Group, Oxford, Dec. 2009, pp. 149-179.
4. G. Fan, V. Venkataraman, L. Tang, and J.P. Havlicek, "On Boosted and Adaptive Particle Filters for Affine-Invariant Target Tracking in Infrared Imagery," in *Augmented Vision Perception in Infrared: Algorithms and Applied Systems* (Advances in Pattern Recognition), R.I. Hammoud, ed., Springer-Verlag, London, 2009, pp. 441-466.
5. J.P. Havlicek, P.C. Tay, and A.C. Bovik, "AM-FM Image Models: Fundamental Techniques and Emerging Trends," in *Handbook of Image and Video Processing, 2 ed.*, A.C. Bovik, ed., Elsevier Academic Press, Burlington, MA, 2005, pp. 377-395.
6. M.S. Pattichis, J.P. Havlicek, S.T. Acton, and A.C. Bovik, "Multidimensional AM-FM Models with Image Processing Applications," in *Advances in Image Processing and Understanding: A Festschrift for Thomas S. Huang*, A.C. Bovik, C.W. Chen, and D. Goldgof, ed., Series in Machine Perception and Artificial Intelligence, vol. 52, World Scientific Publishing, Singapore, 2002, pp. 277-305.
7. M.P. Tull, J.J. Sluss, Jr., and J.P. Havlicek, "Product Demand Forecasting Using Genetic Programming," in *Fuzzy Engineering Expert Systems with Neural Network Applications,* A.B. Badiru and J.Y. Cheung, John Wiley & Sons, New York, 2002, pp. 274-281.
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C. Refereed Conference Papers:

1. B.D. Carson, F. Hurtado, J.P. Havlicek, L.J. Powers, L. Lindenberg, D.N. Avila, C.G. Kanakry, P. Choyke, K. Kurdziel, P. Eclarinal, K.M. Williams, and J. Holter Chakrabarty, "Approximate vertebral body instance segmentation by PET-CT fusion for assessment after hematopoietic stem cell transplantation," in *Proc. 23'rd IEEE Int'l. Conf. Bioinformatics and Bioengineering*, Dayton, OH, Dec. 4-6, 2023, pp. 62-69.
2. J.P. Havlicek, T.N. Arian, H. Soltani, T. Przebinda, and M. Özaydın, "A preliminary case for Hirschman transform video coding," in *Proc. IEEE Southwest Symp. Image Anal. & Interp.*, Santa Fe, NM, Mar. 29-31, 2020, pp. 104-107.
3. H. Soltani and J.P. Havlicek, "An improved subspace identification of a nonlinear soil-structure system," in *Proc. 12'th Int'l. Workshop Structural Health Monitoring*, Stanford, CA, Sep. 10-12, 2019, 8 pp.
4. H. Soltani, K.K. Muraleetharan, and J.P. Havlicek, "Characterizing dynamics of pile-supported structures using system and subsystem identification methods," in *Proc. 11'th Int'l. Workshop Structural Health Monitoring*, Stanford, CA, Sep. 12-14, 2017, 8 pp.
5. C.T. Nguyen, J.P. Havlicek, Q. Duong, S. Vesely, R. Gress, L. Lindenberg, P. Choyke, J. Holter Chakrabarty, and K. Williams, "An automatic 3D CT/PET segmentation framework for bone marrow proliferation assessment," in *Proc. IEEE Int'l. Conf. Image Process.*, Phoenix, AZ, Sep. 25-28, 2016, pp. 4126-4130.
6. C.T. Nguyen, J.P. Havlicek, J. Holter Chakrabarty, Q. Duong, and S.K. Vesely, "Towards automatic 3D bone marrow segmentation," in *Proc. IEEE Southwest Symp. Image Anal. & Interp.*, Santa Fe, NM, Mar. 6-8, 2016, pp. 9-12.
7. J.C. Fuenmayor Bello and J.P. Havlicek, "A state vector augmentation technique for incorporating indirect velocity information into the likelihood function of the SIR video target tracking filter," in *Proc. IEEE Southwest Symp. Image Anal. & Interp.*, Santa Fe, NM, Mar. 6-8, 2016, pp. 109-112.
8. C.T. Nguyen and J.P. Havlicek, "Color to grayscale image conversion using modulation domain quadratic programming," in *Proc. IEEE Int'l. Conf. Image Process.*, Québec City, Canada, Sep. 27-30, 2015, pp. 4580-4584.
9. J. Holter Chakrabarty, C.T. Nguyen, J. Havlicek, S.K. Vesely, L. Lindenberg, S. Adler, B.A.J. Blacklock-Schuver, K. Kurdziel, F. Lin, D. Avila, G.B. Selby, J. Mann, J. Hsu, A. Chai, R.B. Epstein, N.Q.T. Duong, S. Li, T. Kraus, S. Hopps, T. Pham, C.M. Bollard, P. Choyke, R. Gress, and K.M. Williams, "Novel imaging analysis of the marrow compartment after myeloablative HSCT reveals the kinetics and degree of myeloablation and cell Recovery," *Proc. 2015 American Society for Blood and Marrow Transplantation (BMT) Tandem Meetings*, San Diego, CA, Feb. 11-15, 2015. Published in *Biology of Blood and Marrow Transplantation*, vol. 21, no. 2, pp. S319-S320, Feb. 2015.
10. C.T. Nguyen, J.P. Havlicek, G. Fan, J.T. Caulfield, and M.S. Pattichis, "Robust dual-band MWIR/LWIR infrared target tracking," in *Proc. IEEE Asilomar Conf. Signals, Syst., Comput.*, Pacific Grove, CA, Nov. 2-5, 2014, pp. 78-83.
11. C.T. Nguyen and J.P. Havlicek, "On the amplitude and phase computation of the AM-FM image model," in *Proc. IEEE Int'l. Conf. Image Process.*, Paris, France, Oct. 27-30, 2014, pp. 4318-4322.
12. C.T. Nguyen and J.P. Havlicek, "Linear adaptive infrared image fusion," in *Proc. IEEE Southwest Symp. Image Anal. & Interp.*, San Diego, CA, Apr. 6-8, 2014, pp. 117-120.
13. P.A. Campbell and J.P. Havlicek, "Frequency guided phase unwrapping for improved AM-FM reconstruction," in *Proc. IEEE Southwest Symp. Image Anal. & Interp.*, San Diego, CA, Apr. 6-8, 2014, pp. 129-132.
14. E. Vorakitolan, J.P. Havlicek, R.D. Barnes, and A.R. Stevenson, "Simple, effective rate control for video distribution in heterogeneous intelligent transportation system networks," in *Proc. IEEE Southwest Symp. Image Anal. & Interp.*, San Diego, CA, Apr. 6-8, 2014, pp. 37-40.
15. J. Gong, G. Fan, J.P. Havlicek, N. Fan, and D. Chen, "Infrared target tracking, recognition and segmentation using shape-aware level set," in *Proc. IEEE Int'l. Conf. Image Process.*, Melbourne, Australia, Sep. 15-18, 2013, pp. 3283-3287.
16. L. Yu, G. Fan, J. Gong, and J.P. Havlicek, "Simultaneous target recognition, segmentation, and pose estimation," in *Proc. IEEE Int'l. Conf. Image Process.*, Melbourne, Australia,

Sep. 15-18, 2013, pp. 2655-2659.

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18. C.T. Nguyen and J.P. Havlicek, "AM-FM models, partial Hilbert transform, and the monogenic signal," in *Proc. IEEE Int'l. Conf. Image Process.*, Orlando, FL, Sep. 30 - Oct. 3, 2012, pp. 2337-2340.
19. N. Mould and J.P. Havlicek, "A stochastic learning algorithm for pixel-level background models," in *Proc. IEEE Int'l. Conf. Image Process.*, Orlando, FL, Sep. 30 - Oct. 3, 2012, pp. 1233-1236.
20. J. Gong, G. Fan, L. Yu, J.P. Havlicek, and D. Chen, "Joint view-identity manifold for target tracking and recognition," in *Proc. IEEE Int'l. Conf. Image Process.*, Orlando, FL, Sep. 30 - Oct. 3, 2012, pp. 1357-1360.
21. N. Mould and J.P. Havlicek, "A conservative scene model update policy," in *Proc. IEEE Southwest Symp. Image Anal. & Interp.*, Santa Fe, NM, Ap. 22-24, 2012, pp. 145-148.
22. C.T. Nguyen and J.P. Havlicek, "Gradient-based texture cartoon decomposition," in *Proc. IEEE Southwest Symp. Image Anal. & Interp.*, Santa Fe, NM, Apr. 22-24, 2012, pp. 85-88.
23. S. Peddireddy, N. Mould, and J.P. Havlicek, "AM-FM picture carrier beat type noise filters," in *Proc. IEEE Southwest Symp. Image Anal. & Interp.*, Santa Fe, NM, Apr. 22-24, 2012, pp. 209-212.
24. C.T. Nguyen, J.D. Williams, J.P. Havlicek, and M. Özaydın, "FM processing with generalized amplitude & phase: application to modulation domain geometric image transformations," in *Proc. IEEE Int'l. Conf. Image Process.*, Brussels, Belgium, Sep. 11-14, 2011, pp. 81-84.
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▶ **Short Vita:**

Joseph P. Havlicek is Gerald Tuma Presidential Professor of Electrical & Computer Engineering and Williams Companies Foundation Presidential Professor of Electrical & Computer Engineering at the University of Oklahoma. He is director and co-founder of the OU Center for Intelligent Transportation Systems. He is also a full member of the OU Institute for Biomedical Engineering, Science, and Technology. He received the B.S. degree in 1986 and the M.S. degree in 1988 in Electrical Engineering from Virginia Tech, Blacksburg, VA, and the Ph.D. degree in Electrical and Computer Engineering in 1996 from the University of Texas at Austin.

From 1984 to 1987, he was with Management Systems Laboratories, Blacksburg, VA, as a software engineer developing decision support software for US DoE nuclear materials management. From 1987 to 1989, he was affiliated with SFA, Inc., Landover, MD, and from 1987 to 1997 he was with the Naval Research Laboratory, Washington, DC, where he worked on infrared missile warning receivers for Navy aircraft, including the Navy's first two-color infrared system. In 1990 he was a recipient of the Department of the Navy Award of Merit for Group Achievement for this work which led to production combat systems deployed in both Afghanistan and Iraq. Throughout 1993 he was a programmer–analyst with Ralph Kirkley Associates, Austin, TX, developing image CODECS on-site in the multimedia division of IBM, Austin. He joined the University of Oklahoma as an assistant professor in January, 1997, where he currently holds the rank of Professor and the Gerald Tuma and Williams Companies Foundation Presidential Professorships. His research interests include signal, image, and video processing, modulation domain signal processing, target tracking, medical imaging, and intelligent transportation systems. He is author or co-author of over 130 scholarly publications in these areas. Since joining the University of Oklahoma in 1997, he has been PI or co-PI on more than 110 externally funded grants and contracts totaling over $27M.

Dr. Havlicek is a senior member of the IEEE. He served as a Senior Area Editor of IEEE Transactions on Image Processing from Nov. 2015 through Feb. 2018. Prior to that, he served as an Associate Editor for five years. He is also a past Associate Editor of IEEE Transactions on Industrial Informatics. He served as Publications Chair on the Organizing Committee of the 2007 IEEE International Conference on Image Processing (ICIP), as a Technical Area Chair for ICIP 2012 and ICIP 2013, and as a Technical Area Chair for the IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP) in 2012 and 2013. He has been a member of the Technical Program Committee and Organizing Committee of the IEEE Southwest Symposium on Image Analysis and Interpretation since 1998, serving as General Co-Chair (2010), Technical Program Co-Chair (2004, 2006, 2008), and Publicity Chair (2000, 2002). He was chairman of the Electrical and Computer Engineering Graduate Studies Committee at the University of Oklahoma from 2008 to 2013 and chairman of the Undergraduate Studies Committee from 2021 to 2023.

He was recipient of the University of Oklahoma College of Engineering Outstanding Faculty Advisor Award in 2006, the University of Oklahoma College of Engineering Brandon H. Griffith Faculty Award in 2003, the University of Oklahoma IEEE Favorite Instructor Award in 1998 and 2000, and the 1992 University of Texas Engineering Foundation Award for Exemplary Engineering Teaching while Pursuing a Graduate Degree. Dr. Havlicek is a member of Tau

Beta Pi, Phi Kappa Phi, and Eta Kappa Nu.

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Appendix A

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

AMAZON.COM, INC., AMAZON.COM SERVICES LLC,

Petitioner,

v.

NOKIA TECHNOLOGIES OY,

Patent Owner.

Case No. IPR2024-00604

U.S. Patent 10,536,714

Declaration of Charles D. Creusere

TABLE OF CONTENTS

I, Charles D. Creusere, declare as follows:

1. My name is Charles D. Creusere. I am a Full Professor in the Klipsch School of Electrical & Computer Engineering at New Mexico State University. I have prepared this report as an expert witness retained by Amazon.com, Inc and Amazon.com Services LLC. In this report I give my opinions as to whether certain claims of U.S. Patent No. 10,536,714 ("the '714 patent") are invalid. I provide technical bases for these opinions as appropriate.

2. This report contains statements of my opinions formed to date and the bases and reasons for those opinions. I may offer additional opinions based on further review of materials in this case, including opinions and/or testimony of other expert witnesses. I make this declaration based upon my own personal knowledge and, if called upon to testify, would testify competently to the matters contained herein.

I. OVERVIEW OF THE TECHNOLOGY

A. Video Compression Basics

3. Video comprises a sequence of pictures, called frames. If you look closely at a frame, for example by putting a magnifying glass up to your monitor, you will see that a frame is comprised of pixels. Groups of pixels are referred to as blocks, for example a square of 8 pixels by 8 pixels.

4. Video encoding, also referred to as video compression, exploits redundancies in video data to reduce the size of video. Since the 1990s, major

video coding standards, including MPEG, H.264 ("AVC"), and H.265 ("HEVC"), have applied the same block-based model: video frames are divided into blocks of pixels, a motion estimation and compensation front end exploits temporal patterns where a similar-looking block appears in the same frame or a nearby frame, and then a coded bitstream is produced in subsequent stages that include a transform stage and entropy encoding. Ex-1023, 000004. At the decoder, the inverse process is used to decode the video back into the original frames.[1] *Id.* A high-level conceptual diagram of encoder/decoder stages is illustrated below. *See e.g.*, Ex-1023, Fig. 2:

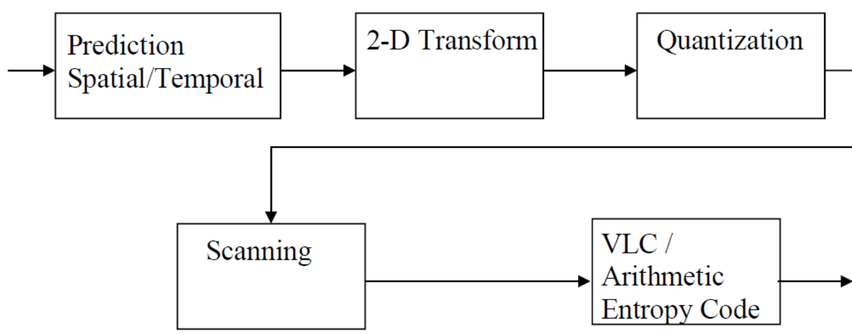


Fig. 2: Higher-level encoder block diagram

B. Motion Vectors and Motion Prediction

5. Blocks could be encoded using inter or intra-frame modes. *Intra-*frame encoding exploited redundant patterns within the same frame, with a block possibly being encoded with reference to another block in the same frame. *Inter-*

[1] Many of the video coding concepts, including HEVC concepts, described in this declaration still apply today.

frame coding allowed a block to be encoded with reference to similar blocks in other frames.

6. For example, inter-picture prediction was useful when an object moved across the screen in successive frames. In the example below, the same airplane on the bottom left of one frame appears on the top-right of the next frame. Ex-1021, 000002 (emphasis added):

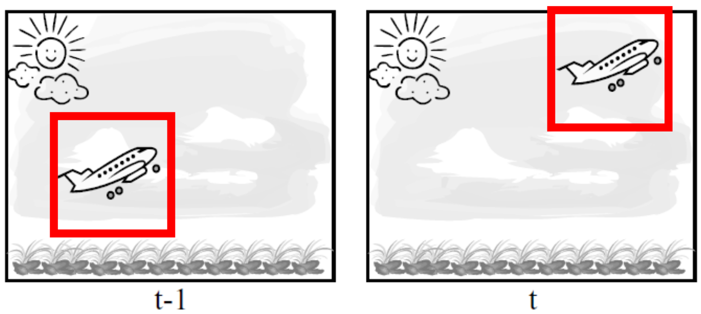
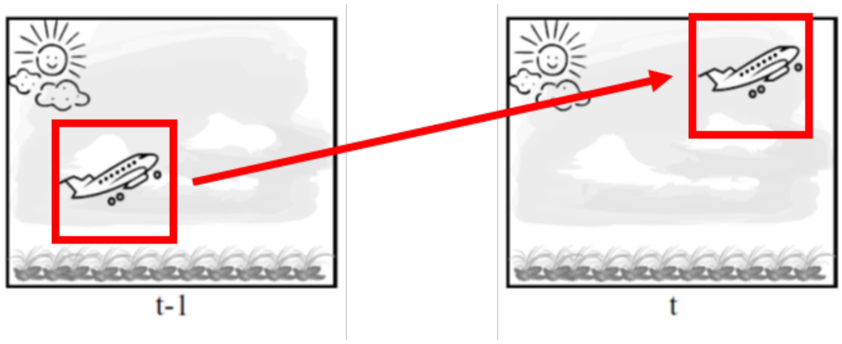


Fig. 3. Successive video frames

7. Since the block containing the airplane shifted to the right (in the X direction) and upwards (in the Y direction), a motion vector was used to describe this X-Y displacement. Ex-1021, 000002-4; Ex-1022, 000001-3. In other words, motion vectors described the motion of blocks between frames. Rather than transmit the pixels for this block twice (once for each frame), the video codecs instead transmitted the block once, for the first frame, and then signaled a motion vector, an index to a reference block in the first frame, and the residual difference between the motion compensated first frame block and the current frame block. The decoder would then use this information to reconstruct the second frame using

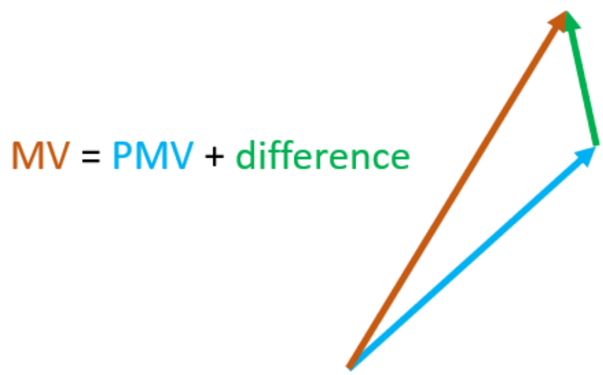
the block from the first frame. *See e.g.*, Ex-1021, 000004, Fig. 3 (emphasis added):



8. By sending a motion vector, a block index, and the residual difference, rather than an entire block of pixels, video codecs reduced the amount of data in the encoded video stream. Nonetheless, since each frame contained many thousands of blocks with frames streaming at 30 or 60 frames a second, the volume of data for transmitting motion vectors could be significant. *See* Ex-1022, 000001.

9. To reduce the amount of data used to signal motion vectors, the ITU utilized predicted motion vectors in its H.264 standard as well as in the successor standard that became H.265. Ex-1022, 000001-2. For example, early iterations of H.264 used the median values of motion vectors from three spatially-neighboring blocks as a Predicted Motion Vector ("PMV") or motion vector predictor ("MVP"). *Id.* Since the encoder and decoder could independently calculate this PMV, there was no need to transmit the entire vector; instead, a smaller difference

vector was inserted into the video stream to indicate the difference between the predicted and actual motion vector for a block. *Id.*



10. By 2010, neighboring blocks were commonly used to find PMV candidates. This was known for H.264. Ex-1004, ¶¶2-3. Since early drafts of H.265, by at least Working Drafts 3 and 4, multiple spatial motion vector prediction candidates were obtained from neighboring blocks, labelled A_0, A_1, B_0, B_1, B_2 below, to create a list of candidates. The encoder evaluated which motion vector candidate offered the best prediction for the current block, meaning the predicted pixel values were closest to the actual pixel values. Ex-1010, §8.4.2.1.8 (annotated with the current block):

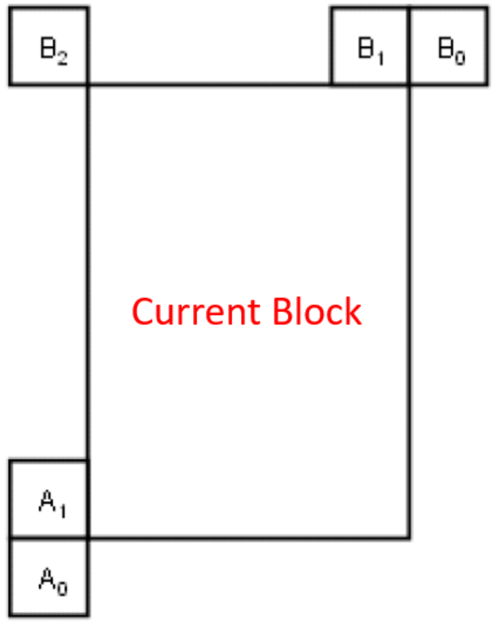


Figure 8-5 – Spatial motion vector neighbours

Since the encoder and decoder independently generated the same candidate list (using the same information from neighboring blocks), the encoder simply signaled to the decoder which candidate was chosen from the list, for example sending an index value of 2 to signal the second candidate from the list. This reduced data because the encoder did not need to transmit the candidate list or a motion vector; instead, the encoder transmitted a single, small number to signal which candidate was chosen, and the decoder referred to its independently-constructed candidate list, which was identical to that of the encoder, to look up the candidate using the index. *See e.g.*, Ex-1004, ¶37.

11. Motion vector candidates from the same frame, including those from neighboring blocks in the frame, were called spatial motion vector prediction

candidates. Ex-1022, 000001-3. Neighboring blocks were often good sources of motion vector candidates because neighboring blocks tend to have the same motion. For example, when a scene pans to the right, objects in the background will tend to have similar motion towards the left across the screen. Ex-1022, 000001-2. Predicted motion vectors take advantage of such patterns to decrease the amount of data used to encode motion vectors, as explained above.

12. Redundant motion vector prediction candidates, however, can increase the size of the index needed to signal which candidate was selected as the predictor for a given block. *E.g.*, Ex-1004, ¶7, ¶107 (explaining that more bits are "needed to specify the candidate vector" as the number of vectors grows). For example, if the neighboring blocks all have the same motion vector, it would be redundant to include all of them as motion vector predictor candidates. Therefore, H.264 and H.265 both analyzed spatial motion vector prediction candidates to remove redundant ones. In fact, it was common in the art to remove redundant motion vector candidates. For example, this was taught for H.264 and in working drafts of H.265. Ex-1004, ¶21, ¶62; Ex-1010, §8.4.2.1.1, §8.4.2.1.7.

13. For H.264, prior art that applied H.264 included methods for selecting PMV candidates from the set of all previously-coded blocks. Since "[l]imiting and/or reducing the number of candidates … can be helpful to reduce the overhead of signaling," it was known in the art to "avoid duplicate occurrences of the same

motion vector" by "comparing the candidates already in the list with the new vector that could be added[,]" which comprised a "subset" of candidates from blocks within an allowed distance from the current block, rather than the full set of previously-coded blocks. Ex-1004, Abstract, ¶¶70-71.

14. For H.265, presentations were made to the standards body regarding the exact manner in which redundant candidates might be removed. "When motion vectors have the same value, the motion vectors are removed from the list [of motion vector candidates.]" Ex-1010, §8.4.2.1.7, §8.4.2.1.1. As I will explain in more detail below, at the 6th HEVC meeting held on July 14-22, 2011, Nakamura presented a proposal, JCTVC-F419, to reduce the number of comparisons needed for removing redundant motion vector candidates. *Infra* §III.E; Ex-1007, Fig. 1. Nakamura proposed creating a subset of two spatial motion vector prediction candidates, so that redundant candidates could be identified and removed with fewer comparisons, without having to compare the full set of neighboring candidates. Ex-1007, 000003, Table 1, Fig. 1.

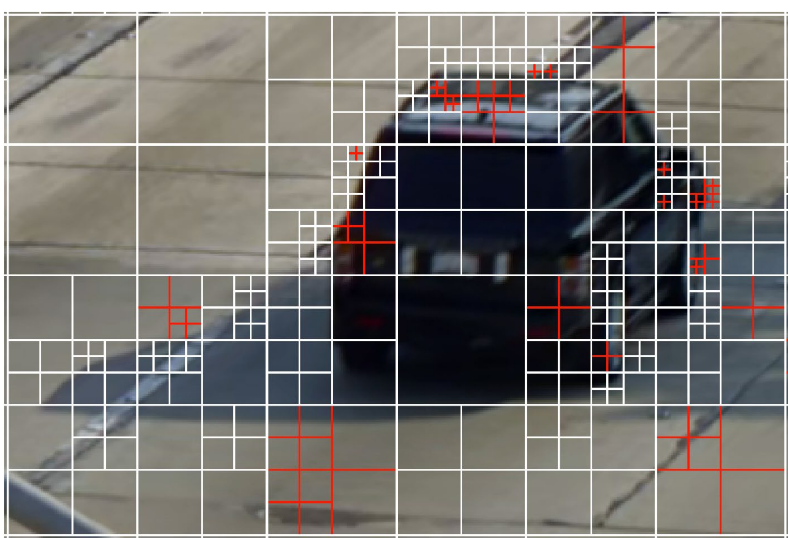
C. H.264 to H.265

15. The H.264 standard (also standardized by the ISO as MPEG Advanced Video Coding ("AVC")) was published in 2003. H.264 was widely used for compression of video at HD (high definition) resolutions and below, and from the beginning it was popular in consumer electronics and Internet streaming.

In 2010, the standardization process began for the successor video standard, which was called H.265 by the ITU and also referred to as the High Efficiency Video Coding ("HEVC") standard.

16. H.265 used H.264 as a starting point and incorporated many of the same concepts. Both standards followed the same overall architecture for block-based video coding, as explained above. Both also used predicted motion vectors for motion compensation. Ex-1004, ¶3; Ex-1005, ¶3; Ex-1006, ¶4.

17. HEVC introduced new terminology for a type of block called a "coding unit" or "CU," which was analogous to macroblocks in H.264. *See* Ex-1005, ¶¶32-33; Ex-1006, ¶4. CUs could be split into smaller CUs to fit visual patterns in the frame. "The basic partition geometry of all these elements is encoded by a scheme similar to the well-known quad-tree segmentation structure." *See* Ex-1019, 00005; Ex-1020 at 00002 (Fig. 1):



18. Motion vectors operated on the basis of a block called a "prediction unit" or "PU." Ex-1005, ¶35; Ex-1006, ¶25. In the simplest scenario, one CU would be covered by a PU of the same size, and a single motion vector would be assigned to the entire CU/PU. *See* Ex-1005, ¶35. This approach was used when the entire CU moved in the same direction, such as large blocks of road in the above image. Conversely, when different portions of a CU moved in different directions, the CU could be divided into multiple PUs, with different motion vectors assigned to each PU. *See id*.

19. HEVC referred to an undivided CU (consisting of one PU the same size) as being 2Nx2N. When a CU was split horizontally into two symmetric rectangular PUs, it was referred to as a 2NxN partition size. A vertically divided CU was referred to as an Nx2N partition size. Example partition modes are shown below. Ex-1006, ¶4; Ex-1018, ¶3, Fig. 2:

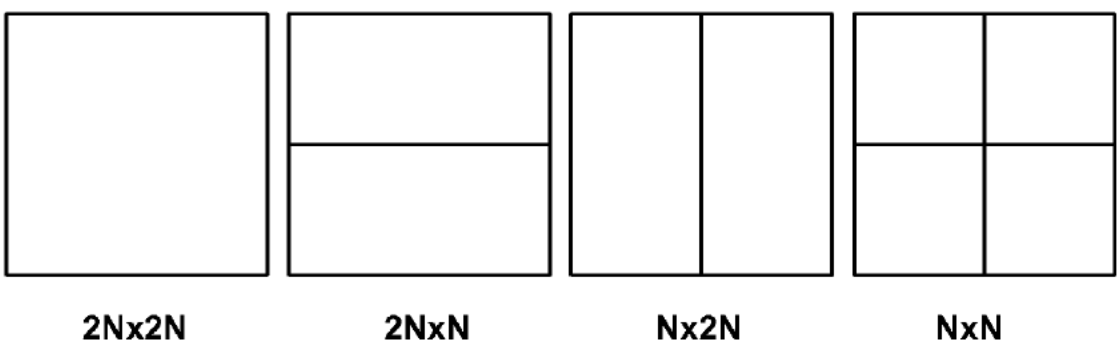


Fig. 2

II. THE ’714 PATENT

A. Overview

20. The ’714 patent is directed to video encoding and decoding in the context of H.263, H.264, and Working Draft 4 of H.265/HEVC, which the purported patent admits were pre-existing video codecs that pre-dated the ’714 patent. Ex-1001, 1:40-42, 2:21-25.

21. The patent admits that prior video codecs “create[d] motion vector predictions” (“MVP”) by “generat[ing] a list or a set of candidate predictions from blocks in the current frame and/or co-located or other blocks in temporal reference pictures and signalling[sic] the chosen candidate as the motion vector prediction.” Ex-1001, 3:5-19, 3:60-66. “A spatial motion vector prediction is a prediction obtained only on the basis of information of one or more blocks of the same frame than the current frame whereas temporal motion vector prediction is a prediction obtained on the basis of information of one or more blocks of a frame different from the current frame.” *Id.* “After the list is generated, some of the motion vector prediction candidates may have the same motion information. In this case, the identical motion vector prediction candidates may be removed to reduce redundancy.” *Id.*, 3:66-4:3. To find redundant MVP candidates, the candidates in the list must be compared to each other.

22. The ’714 patent seeks to “improv[e] the prediction accuracy and hence possibly reducing information to be transmitted in video coding systems.” Ex-1001, 8:24-28. To this end, the ’714 patent purports to introduce “a method for generating a motion vector prediction list” in “a way to reduce the complexity of the implementation.” Ex-1001, 4:18-23. According to the ’714 patent, “[t]his can be achieved by performing a limited number of motion information comparisons between candidate pairs to remove redundant candidates rather than comparing every available candidate pair.” Ex-1001, 4:18-27. In particular, the ’714 patent claims recite limitations for “determining a subset” of spatial MVP candidates and then “comparing motion information” of a selected candidate with the subset, “without making a comparison of each pair from the [full] set of spatial motion vector prediction candidates[.]” Ex-1001, claim 1.

23. However, as explained above, the prior art already included techniques for removing redundant MVP candidates without comparing each pair from the full set of candidates. *Supra* §I.

B. Prosecution History

24. I understand the ’714 patent is one of a chain of continuation patents beginning with U.S. Patent No. 9,571,833 (’833 patent) and including U.S. Patent No. 10,237,574 and U.S. Patent No. 9,743,105. Ex-1001, (63). It is my understanding that each of these parent patents shares the same specification as the

’714 patent because they are continuations, and that the prosecution histories of the patents in this chain provide context for the ’714 patent.

25. At the same time the ’714 family of patents was being prosecuted in the United States, a European counterpart, EP2774375 (the “EU Counterpart”), was being prosecuted in the EU. Ex-1017, 000246-256 (extended European search report dated March 14, 2016); Ex-1015, 000315-336 (Response after Final Action dated July 1, 2016).

26. However, an extended European search report issued on March 21, 2016 in which the European Patent Office issued a rejection in view of Nakamura. Ex-1017, 000246-256 (extended European search report). The Patent Owner did not dispute that Nakamura was prior art or that Nakamura taught the claims. Instead, the Patent Owner amended the claims with lengthy limitations that led to independent claim 1 being *three pages long* in the EP Counterpart. Ex-1017, 000335-351.

27. On April 25, 2016, the Applicant submitted an Information Disclosure Statement to the US Patent Office during the prosecution of the ’833 patent citing the extended European search report and Nakamura. Ex-1015, 000308. The Examiner did not consider this IDS before the Notice of Allowance. Ex-1015, 000476-477 (mailed 12/20/2016); Ex-1015, 000483. The ’833 patent was allowed

without any substantive discussion of Nakamura or amendments like those made in the EU counterpart. Ex-1015, 000378.

28. In the Notice of Allowance, the Examiner cited, as the reason for allowance, the limitation for comparing motion information of candidates "without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates[.]" Ex-1015, 000390. Likewise, for the '714 patent, the Examiner allowed the claims citing "limitations analogous to the claims of" the '833 patent for comparing motion information "without making a comparison of each pair from the set of spatial motion vector prediction candidates[.]" Ex-1002, 000118 (Notice of Allowance).

29. However, the European Patent Office had found a similar limitation to be taught by Nakamura (Ex-1017, 000253), *which the Patent Owner did not dispute.* Nakamura is presented here as Ground 3.

C. Priority Date

30. The '714 patent is one of a chain of continuation applications beginning with the '833 patent and claims priority to a provisional application filed on November 4, 2011. I have not conducted any analysis as to whether the '714 patent is entitled to its claim of priority. For the purposes of this declaration, I have applied a November 4, 2011 priority date for my opinions without regard to whether the '714 patent is entitled to such a priority date.

D. Challenged Claims

31. I understand that Petitioner is challenging the validity of claims 1-8, 15-22, and 29 of the ’714 patent in the Petition for Inter Partes Review to which this declaration will be attached. Those claims are reproduced in Appendix 3. While this Petition and declaration are directed to the challenged claims, I have considered all claims 1-8, 15-22, and 29 of the ’714 patent, as well as portions of the ’714 patent prosecution history in forming my opinions.

III. SUMMARY OF THE PRIOR ART

32. There are a number of patents and publications that constitute prior art to the ’714 patent. I have reviewed and considered the prior art discussed in this section, along with the materials listed in Appendix 2.

A. Invalidity Grounds

33. Based on my review and analysis of the materials cited herein, my opinions regarding the understanding of a POSITA in the relevant timeframe (*supra* §II.C), and my training and experience, it is my opinion that the challenged claims of the ’714 patent are invalid based on the following grounds:

Grounds	Claims	Statutory Basis	Prior Art
1	1-3, 5-8, 15-17, 19-22, 29	§103	Rusert and Karczewicz
2	1-8, 15-22, 29	§103	Rusert, Karczewicz, and Lin
3	1-8, 15-22, 29	§103	Nakamura and WD4

34. I understand that Rusert, Karczewicz, Lin, and WD4 were not cited or considered during prosecution of the ’714 patent. None of these four references or any related patents are listed on the face of the ’714 patent. In addition, I reviewed the file history for the ’714 patent and am not aware of these references being discussed in any office action or in the prosecution history generally. I understand that Nakamura was cited in an IDS that was signed after the examiner issued a Notice of Allowance for the ’833 patent. *Supra* §II.B.

B. Rusert (Ex-1004)

35. Rusert is U.S. Patent Application Publication No. 2011/0194609 to Rusert et al., entitled “Selecting Predicted Motion Vector Candidates.” Rusert was filed on February 7, 2011 and was published on August 11, 2011. I understand Rusert is prior art to the ’714 patents under at least pre-AIA §102(a) and §102(e).

36. I have reviewed the Rusert reference. I understand that Rusert was not cited or considered during prosecution of the ’714 patent based primarily on the fact that Rusert is not cited on the face of the ’714 patent and or discussed in the prosecution history.

37. Rusert teaches a method for selecting Prediction Motion Vector candidates (“PMV candidates”) for video encoding and decoding. Ex-1004, Abstract. Rusert reduces the number of candidates using a “subset of the set of previously coded motion vectors that were used for previous blocks[,]” e.g., by

limiting the candidates to those used "for previous blocks having an allowed distance from the current block." Ex-1004, ¶11. When the list of candidates is updated, duplicates and essentially "similar" vectors are excluded. *Id.* ¶¶70-73. A candidate is selected from the list and used for motion prediction by the encoder and decoder. *Id.* ¶¶12-13, ¶¶88-99.

38. The list of PMV candidates is called "PMV_CANDS." I note that Rusert includes some typographical errors where this name is mistyped as "PMV_SANDS." E.g., Ex-1004, ¶6, ¶39, ¶42, ¶44, ¶88. This is clearly a typo, which would have been clear to POSITA in the context of Rusert. Several paragraphs use both "PMV_SANDS" and "PMV_CANDS" to refer to the same list. *See*, *e.g.*, Ex-1004, ¶39 (describing how "[u]pdate means that one or more motion vectors are added to an existing PMV_SANDS list[]" and how "[a] PMV_CANDS list may be updated"), ¶42 (referring to "one or multiple PMV_CANDS lists" and "either a single or two different PMV_SAND"), ¶44 (describing how "[t]he PMV_CANDS list may be updated" and how "to update PMV_SANDS[]"), ¶88 (referring to "candidates in PMV_SANDS" and "candidates in the PMV_CANDS list."). Moreover, the places where Rusert refers to "PMV_SANDS" have corresponding discussions in Rusert's provisional application that correctly state "PMV_CANDS". *Compare* Ex-1004, ¶6 *with* Ex-1012, 000003-4. Furthermore, this name is easily mistyped because the letter "S"

is close to "C" on QWERTY keyboards and both appear in the name. Moreover, this type of typographical error is commonplace with Microsoft Word because it is all capital letters, which Microsoft Word often skips (there is a setting for the spell check to omit all-caps words).

39. Rusert is analogous art in the same field as the '714 patent (video encoding and decoding, *infra* §IV). For example, Rusert teaches a method for a video encoding and decoding apparatus (Ex-1004, ¶1), with motion vector teachings used to encode and decode video (*id.*, ¶¶23-25).

C. Karczewicz (Ex-1005)

40. Karczewicz is U.S. Patent Application Publication No. 2011/0249721 to Karczewicz, entitled "Variable Length Coding of Coded Block Pattern (CBP) in Video Compression." Karczewicz was filed on April 11, 2011 and was published on October 13, 2011. I understand Karczewicz is prior art to the '714 patent under at least pre-AIA §102(a) and §102(e).

41. I have reviewed the Karczewicz reference. I understand that Karczewicz was not cited or considered during prosecution of the '714 patent based primarily on the fact that Karczewicz is not cited on the face of the patent or discussed in the prosecution history.

42. Karczewicz provides video encoding/decoding teachings related to the High Efficiency Video Coding ("HEVC") video standard, also referred to as

H.265. Ex-1005, Abstract. Karczewicz teaches that H.265 is a new video coding standard. Ex-1005, ¶32. For example, Karczewicz teaches block types in H.265, e.g., coding units and prediction units. Ex-1005, ¶¶33-35.

43. Karczewicz is analogous art in the same field as the ’714 patent (video encoding and decoding, *infra* §IV). For example, Karczewicz teaches that its techniques relate to "coding video data." Ex-1005, Abstract.

D. Lin (Ex-1006)

44. Lin is U.S. Patent Application Publication No. 2014/0092981, entitled "Method and Apparatus for Removing Redundancy in Motion Vector Predictors." Lin was filed on June 12, 2012 and claims priority to provisional application 61/500,903, which was filed on June 24, 2011. I understand Lin is prior art to the ’714 patent under at least pre-AIA §102(e).

45. It is my understanding that a prior art patent application publication is entitled to its provisional application date if the subject matter relied upon in the reference published application is described in the provisional application, and at least one of the claims of the published application is supported by the written description of the provisional application. It is my opinion that Lin is entitled to its priority date of June 24, 2011 (the filing date of its provisional application), which is before the earliest possible priority date of November 4, 2011 of the ’714 patent. First, Lin’s provisional application provides support for all subject matter relied-

upon by this Declaration. Second, as set forth in the following table, the Lin Provisional provides sufficient details to enable one reasonably skilled in the art to make or use the invention claimed by Lin, including as stated in Lin's claim 1.

Lin's Claim 1	**Lin's Provisional Support**
1. A method of deriving a motion vector predictor (MVP) for a current block in an Inter, Merge, or Skip mode, the method comprising:	Ex-1013, 000007, 000009, 000012
determining neighboring blocks of the current block, wherein an MVP candidate set is derived from MVP candidates associated with the neighboring blocks;	Ex-1013, 000016 (Fig. 6)
determining at least one redundant MVP candidate according to a non-MV-value based criterion;	Ex-1013, 000009-11
removing said at least one redundant MVP candidate from the MVP candidate set; and	Ex-1013, 000009-11
providing a modified MVP candidate set, wherein the modified MVP candidate set corresponds to the MVP candidate set with said at least one redundant MVP candidate removed.	Ex-1013, 000008-11

46. I have reviewed the Lin reference. I understand that Lin was not cited or considered during prosecution of the '714 patent, based primarily on the fact that Lin is not cited on the face of the patent or discussed in the prosecution history. A different reference authored by Lin, directed to different teachings, is cited on the face of the '714 patent.

47. Lin provides teachings related to removing redundant motion vector predictors (MVPs). Lin teaches that, under the HEVC standard, each coding unit (CU) contains one or multiple prediction units (PUs). Ex-1006, ¶4; Ex-1013, 000007. When a CU is divided into two PUs, Lin teaches that the MVP candidate from the second PU can be removed because it is redundant. Ex-1006, ¶44, ¶25, Fig. 7A-7D; Ex-1013, 000010, 000017.

48. Lin is analogous art in the same field as the ’714 patent (video encoding and decoding, *infra* §IV). For example, Lin teaches that its disclosures relate to video coding, in particular, “coding techniques associated with derivation of motion vector predictors for motion vector coding.” Ex-1006, ¶2; *see also* Ex-1013, 000007.

E. Nakamura (Ex-1007, Ex-1008, Ex-1009) and WD4 (Ex-1010)

49. Nakamura is an HEVC proposal (numbered JCTVC-F419) presented at the 6th meeting of the Joint Collaborative Team on Video Coding (JCT-VC), held between July 14-22, 2011 in Torino, Italy. Nakamura is titled “Unification of derivation process for merge mode and MVP” and authored by Hiroya Nakamura et al. The Nakamura proposal comprises 6 files, which were part of the same proposal and uploaded to the JCT-VC website in one zip archive file. The 6 files in Nakamura include a main document describing the proposed techniques of the proposal (Ex-1007), a Working Draft description of the proposed techniques of the

proposal (Ex-1008), and a presentation slide deck illustrating the proposed techniques of the proposal (Ex-1009).

50. WD4 is version 3 of the Working Draft 4 of the HEVC standard (H.265) developed by the JCT-VC. WD4 was the output of the 6th JCT-VC meeting held July 14-22, 2011 in Torino, Italy. Ex-1010, 000001.

51. I understand that the Nakamura proposal and WD4 are prior art to the ’714 patent under at least pre-AIA §102(a). Nakamura was publicly available by at least the time of the 6th JCT-VC meeting on July 22, 2011. Ex-1007, 000001; Ex-1014, ¶15, ¶36; Ex-1049, ¶56. The input to the 6th meeting was Working Draft 3 (“WD3”), and the output was Working Draft 4. At that meeting, attendees drafted Working Draft 4, which was made publicly available through the JCT-VC website shortly after the meeting; version 3 of Working Draft 4 (“WD4”) was publicly available through the JCT-VC website by September 8, 2011. Ex-1010, 000001; Ex-1014, ¶15, ¶ 37; Ex-1049, ¶56. Nakamura and WD4 were made available to all meeting participants and were publicly accessible on the JCT-VC’s website. *See generally* Ex-1014, Ex-1049. Anyone with Internet access could download Nakamura and WD4 from the JCT-VC website. Ex-1014, ¶¶35-37; Ex-1049, ¶¶56-57.

52. The JCT-VC meetings were high-profile events that were widely known to those interested in video coding and were attended by individuals from

around the United States and the world, including professors from universities and engineers for a wide range of technology companies. It was common for individuals and companies of the industry to monitor these standards meetings to stay updated on changes and developments, as evidenced by several published papers citing Nakamura and WD4. *See, e.g.*, Ex-1024, Ex-1051, Ex-1025. Indeed, the paper "Non-fixed Quantization Considering Entropy Encoding in HEVC" by Gweon cites both Nakamura and WD4. Ex-1024, 000010.

53. Furthermore, the '714 patent admits that Nakamura and WD4 were prior art. First, the '714 patent references WD4 in its background. Ex-1001, 2:21-22 ("In some video codecs, such as High Efficiency Video Coding Working Draft 4…"). Second, Nakamura was cited as prior art against the '714 family of patents during prosecution of a European counterpart, EP2774375. *Supra* §II.B. The Patent Owner did not dispute that Nakamura was prior art and instead submitted Nakamura as prior art to the US Patent Office shortly before the parent of the '714 patent was allowed. *Supra* §II.B.

54. Therefore, for the reasons explained above, Nakamura and WD4 were publicly available before the provisional application for the '714 patent was filed on November 4, 2011.

55. Nakamura "presents simplifications of derivation process for merge mode and motion vector predictor (MVP)." Ex-1007, Abstract. The

simplifications include "reduc[ing] the number of candidates in the spatial derivation process to reduce the number of times of comparison in the removal process." Ex-1007, Abstract. Additionally, Nakamura proposes an "improvement of derivation method of the candidates for merge mode and motion vector predictor (MVP)" with a "unification of the location of spatial neighbors for merge mode and MVP." Ex-1007, §1. Nakamura is analogous art in the same field as the '714 patent (video encoding and decoding, *infra* §IV). For example, Nakamura teaches "simplifications" and "improvement[s]" to video encoding and decoding processes for H.265. Ex-1007, Abstract, §1. Indeed, Nakamura provides results showing improvements in video encoding time and decoding time. Ex-1007, Tables 7-12.

56. WD4 contains various teachings related to the encoding and decoding of video streams according to the in-development HEVC video standard. For example, WD4 provides syntax for various video elements, such as prediction units, specifying "syntax element[s]… parsed from the bitstream[.]" Ex-1010, §7.1. WD4 is analogous art in the same field as the '714 patent (video encoding and decoding, *infra* §IV). For example, WD4 describes aspects of video streams that were created by video encoders and decoded by video decoders, including the syntax of video bitstreams and video decoding processes. Ex-1010, §7.1, §8.4.

IV. LEVEL OF ORDINARY SKILL IN THE ART

57. I have analyzed the ’714 patent and determined that the field of the patent is video encoding and decoding. For example, the ’714 patent characterizes its alleged invention as “a method for encoding, a method for decoding,” and “an encoder and a decoder.” Ex-1001, 1:18-20. More specifically, the ’714 states “[t]he present invention introduces a method for generating a motion vector prediction list for an image block.” Ex-1001, 4:18-19.

58. In determining the characteristics of a hypothetical person of ordinary skill in the art (“POSITA”) of the ’714 patent at the time of the claimed invention, I considered several things, including various prior art techniques relating to video encoding and decoding, the type of problems that such techniques gave rise to, and the rapidity with which innovations were made. I also considered the sophistication of the technologies involved, and the educational background and experience of those actively working in the field at the time. I also considered the level of education that would be necessary to understand the ’714 patent. Finally, I placed myself back in the relevant period of time and considered the engineers and programmers that I have worked with and managed in the field of video encoding and video decoding.

59. I came to the conclusion that a person of ordinary skill in the field of art of the ’714 patent would have been a person with (1) a bachelor’s degree in

electrical engineering, computer engineering, computer science, or a comparable field of study such as physics, and (2) approximately two to three years of practical experience with video encoding/decoding. Additional experience can substitute for the level of education, and vice-versa. I at least qualify under the definition of a POSITA because I had a BS degree in electrical and computer engineering by 1985, with many years of experience in video encoding and decoding (more than three) by 2011, as explained in my qualifications section. *Infra* §VII.

V. CLAIM CONSTRUCTION

60. For purposes of this inter partes review, I have considered the claim language, specification, and portions of the prosecution history to determine the meaning of the claim language as it would have been understood by a person of ordinary skill in the art at the time of the invention. The "plain and ordinary meaning" or Phillips standard has traditionally been applied in district court litigation, where a claim term is given its plain and ordinary meaning in view of the specification from the view point of a person of ordinary skill in the art.

61. I have applied the *Phillips* standard in my analysis. Unless otherwise stated, I have applied the plain and ordinary meaning to claim terms.

A. "spatial motion vector prediction candidate"

62. Based on my review of the claims and specification of the '714 patent, it is my opinion that a POSITA would have understood a "spatial motion vector

prediction candidate" to mean a candidate motion vector obtained from one or more previously-encoded blocks in the current frame.

63. The specification of the '714 patent states that "a spatial motion vector *prediction* is a prediction obtained only on the basis of information of one or more blocks of the same frame than the current frame." Ex-1001, 3:9-14. Furthermore, the specification "defines candidate motion vectors for the current frame by using… one or more neighbour blocks and/or other blocks of the current block *in the same frame*…" Ex-1001, 12:51-56. Therefore, a spatial motion vector prediction *candidate* would be a candidate motion vector obtained only on the basis of information of one or more blocks of the current frame. *See* Ex-1001, 3:9-14, 12:51-56. The specification further states that spatial motion vector prediction candidates are obtained from "one or more already encoded block." Ex-1001, 12:58-59. That is, because spatial motion vector prediction candidates are "define[d]… by using one or more of the motion vectors of one or more neighbour blocks and/or other blocks of the current block in the same frame[,]" each spatial motion vector prediction candidate "represents the motion vector of one or more already encoded block." Ex-1001, 12:51-59.

B. "temporal motion vector prediction candidate"

64. Based on my review of the claims and specification of the '714 patent, it is my opinion that a POSITA would have understood a "temporal motion vector

prediction candidate" to mean a candidate motion vector obtained from a previously-encoded frame.

65. The specification of the '714 patent states that a "temporal motion vector *prediction* is a prediction obtained on the basis of information of one or more blocks of a frame different from the current frame." Ex-1001, 3:12-14. Furthermore, the specification that "for temporal prediction… motion vectors of a co-located block or other blocks in a previously encoded frame can be selected as candidate predictors for the current block." Ex-1001, 12:63-13:3.

C. "the block"

66. Limitation [1b] recites "the block," which could be interpreted to refer to either (a) the "block of pixels" introduced in [1a], or (b) the block from which the first spatial motion vector candidate is obtained. During prosecution of the parent patent (the '833 patent), the Examiner applied the first interpretation, where "based on the location of the block" was based on the location of the "current block," and finding that this limitation was satisfied by prior art teachings for "selecting one of the PMV from MVs of neighboring blocks" (Ex-1015, 000168 (Non-Final Office Action)), which the Applicant did not dispute (Ex-1015, 000241-244 (Reply to Office Action)). This Declaration applies the Examiner's interpretation, where "the block" finds antecedent basis in [1a]: "a *first spatial*

motion vector prediction candidate from a set of spatial motion vector prediction candidates *for a block of pixels*[.]"

D. "a subset of … candidates"

67. Limitation [1b] recites "a subset of … candidates," which means a subset of one or more candidates. The claims confirm that the subset may comprise one candidate. Limitation [1c] compares motion information of a potential candidate with motion information of "candidates in the determined subset" of limitation [1b]; dependent claim 3 further specifies that the potential candidate is compared with "at most one other" candidate. The specification includes embodiments where the subset is a single candidate. Ex-1001, 15:50-16:39 (e.g., block A1 is compared with block B1, block B0 is compared with block B1, block A0 is compared with block A1), Fig. 8b.

VI. INVALIDITY

68. Based on my review and analysis of the materials cited herein, my opinions regarding the understanding of a POSITA in the 2011 timeframe, and my training and experience, it is my opinion that a POSITA would have found the challenged claims 1-8, 15-22, and 29 of the '714 patent obvious in view of the invalidity grounds. The reasons for my conclusions are explained more fully below.

A. Grounds 1 and 2

69. It is my opinion that a POSITA would have found the Challenged Claims obvious based on Ground 1, i.e., the teachings of Rusert alone or in combination with Karczewicz. Rusert teaches and suggests the limitations of the challenged claims. Karczewicz provides additional teachings that update Rusert's terminology and teachings in accordance with the H.265 standard.

70. It is my opinion that a POSITA would have found the Challenged Claims obvious based on Ground 2, i.e., the teachings of Rusert, Karczewicz, and Lin. In addition to the teachings provided by Rusert and Karczewicz for Ground 1, Lin provides further teachings regarding excluding redundant motion vector candidates.

1. Motivation to Combine and Reasonable Expectation of Success

71. **Rusert and Karczewicz**. Rusert provides various teachings for selecting motion vector predictor candidates for video encoding and decoding. Ex-1004, ¶¶1-4, ¶¶11-15, ¶¶24-26, ¶¶34-44. Rusert uses H.264 to explain its teachings but explains that it is not limited to any particular video standard: "while examples have been given in the context of particular coding standards, these examples are not intended to be the limit of the coding standards to which the disclosed method and apparatus may be applied." Ex-1004, ¶116. While Rusert's teachings and embodiments were "given in the context of H.264/AVC, *the*

principles disclosed herein can also be applied to … other coding standard[s], and indeed any coding system which uses predicted motion vectors." *Id.*

72. The successor video standard to H.264 was called H.265. Ex-1005, ¶32. As Karczewicz teaches, by 2011, it had been widely known that H.265 was emerging as the successor video standard. *Id.* ("[t]he emerging HEVC standard… referred to as ITU-T H.265[.]"). Both H.264 and H.265 standards were drafted by ITU-T, the Telecommunication Standardization Sector of the International Telecommunication Union.

73. H.265 used H.264 as a baseline starting point and used the same concepts of block-based video encoding with predicted motion vectors for those blocks. Ex-1005, ¶35 ("[T]he PU may include data defining a motion vector for the PU."), ¶37 ("Each of the blocks may be predictively encoded based on blocks of previously coded pixels[.]"), ¶66, ¶71; Ex-1006, ¶5 ("[I]n HEVC, the motion vector competition (MVC) based scheme is applied to select one motion vector predictor (MVP) among a given MVP candidate set which includes spatial and temporal MVPs."). Therefore, H.265 is a coding standard that uses predicted motion vectors—precisely the type of coding standard for which Rusert provides express motivation to combine.

74. In short, given Rusert's express teachings to apply its teachings to other video coding standards, and the fact that the successor H.265 standard was

well known in the art and taught by Karczewicz, a POSITA would have been motivated to combine the teachings of Rusert and Karczewicz. This express teaching, suggestion, or motivation in the art was sufficient, on its own, to motivate a POSITA to combine Rusert and Karczewicz. Nonetheless, a POSITA would have been motivated to make this combination for a number of additional reasons, explained below.

75. A POSITA would have been motivated to make this combination because it would have combined prior art elements according to known methods to yield predictable results. For example, the combination would have combined Rusert's motion vector teachings, including for the selection of PMV candidates for blocks, with H.265 concepts (e.g., prediction units and related information for motion vectors), according to known methods (e.g., as taught by Karczewicz and known throughout the industry based on the widespread knowledge of H.265). Rusert explains its teachings in terms of blocks, with motion vectors assigned to or obtained from blocks. Ex-1004, ¶¶2-5, ¶36, ¶43. As Karczewicz explains, H.265 introduced new terminology for a type of block called a "prediction unit" ("PU"), with motion vectors being assigned to PUs and PUs comprising the blocks that are used for motion prediction. Ex-1005, ¶¶33-36, ¶¶64-66. Karczewicz also provides related teachings on the types of information conveyed by motion vectors. Ex-1005, ¶35. Therefore, it would have been obvious to apply Rusert's motion-vector

teachings to PUs in the H.265 context as a combination of prior art elements according to known methods, with predictable results as explained further below.

76. The combination would also have used Rusert's known techniques (e.g., for efficiently selecting PMV candidates) to improve similar devices and methods (e.g., for H.264 and H.265) in the same way. Rusert provides block-based motion vector teachings that were explained using H.264 as an example but were applicable to a variety of video coding standards. Ex-1004, ¶2, ¶116. This would have included the H.265 standard, which was similar to and in fact derived from H.264. Ex-1005, ¶3, ¶32 ("[T]he HEVC Test Model… presumes several capabilities of video coding devices over devices according to, e.g., ITU-T H.264/AVC."); *supra* §II.D. Karczewicz teaches aspects of the H.265 standard. Therefore, it would have been natural to apply Rusert's teachings regarding blocks to the H.265 context, including by applying Rusert's teachings to PUs as taught by Karczewicz, to improve the similar H.265 standard in the same way that Rusert explained for H.264. This would have applied a known technique to a known device/method that was ready for improvement, to yield predictable results as further explained below.

77. Furthermore, the combination of Rusert and Karczewicz was a simple substitution of a known element (e.g., Karczewicz's prediction unit teachings) into Rusert's teachings. Rusert explains its teachings in terms of the blocks that form

the basis for motion vector operations, and Karczewicz explains that, for H.265 video, those blocks (whose sizes are now allowed to vary) were called "PUs." Ex-1005, ¶6, ¶¶32-33, ¶64. Therefore, a POSITA would have been motivated to combine Rusert and Karczewicz by applying Karczewicz's teachings regarding PUs into Rusert's teachings for selecting PMV candidates for blocks in video frames.

78. Additionally, a POSITA would have found motivation in the similarity of the references. Both Rusert and Karczewicz are directed to video coding. Ex-1004, ¶1 ("The present application relates to … a video encoding apparatus, a video decoding apparatus …"); Ex-1005, Abstract ("This disclosure describes techniques for coding video data."). Both are discussed in the context of ITU standards, including H.264 and H.265. Ex-1004, ¶¶3-4, ¶67, ¶116 ("specific examples have been given in the context of H.264/AVC"); Ex-1005, ¶3, ¶5, ¶38, ¶¶32-33, ¶73. And while H.265 included new terminology for coding units ("CU") and prediction units ("PU"), Karczewicz explains that all of these are blocks of image pixels (Ex-1005, ¶64 ("block" generally "may refer to one or more of a macroblock, LCU, CU, sub-CU, TU, or PU.")), and "[i]n general, a CU" of H.265 "has a similar purpose to a macroblock of H.264[.]" Ex-1005, ¶33. In its simplest case, a CU was a PU, with the flexibility where a CU can be divided into multiple PUs. Ex-1005, ¶35 ("A CU… may include one or more prediction units (PUs).").

79. A POSITA would have been motivated because the combination of Rusert and Karczewicz would have yielded several advantages. For example, Rusert provides for "an improved method and apparatus for selecting PMV candidates" "to improve video coding efficiency[.]" Ex-1004, ¶7. Karczewicz provides teachings "used to improve efficiency in coding (e.g., encoding or decoding) video data." Ex-1005, ¶6.

80. Additionally, a POSITA would have been motivated to combine Rusert's teachings from its embodiments with Rusert's teachings regarding the operation of H.264 in its background section. Rusert explains that its teachings are given with examples in H.264 and therefore provides express teaching, suggestion, and motivation to combine the teachings of its embodiments with known concepts of the H.264 video standard. *See, e.g.*, Ex-1004, ¶¶3-4, ¶67, ¶77, ¶116.

81. Rusert teaches two options for initializing and updating PMV_CANDS: (1) PMV_CANDS is "dynamically generated specifically for the current motion compensation block" and (2) PMV_CANDS is "initialized once" and "updated according to a sliding window approach." Ex-1004, ¶41. A POSITA would have been motivated to use the first option in which PMV_CANDS is initialized and updated for each block because Rusert presents it as the first option. Furthermore, the first option is one of only two options, and a POSITA would have

been motivated to apply at least the first option as one of a finite number of options that Rusert teaches.

82. Karczewicz discusses H.264 and H.265 and applies its teachings to both. Therefore, Karczewicz's teachings regarding other features of H.265 would not have dissuaded a POSITA from combining with Rusert. For example, Karczewicz's coded block pattern teachings are applicable to both H.264 and H.265. Ex-1005, ¶5, ¶38. Furthermore, Rusert's teachings and Karczewicz's teachings are applicable to coding and decoding blocks of pixels, regardless of the nomenclature used to label them. A POSITA would have understood the features introduced by H.265 do not prevent teachings with respect to H.264 from being applied to H.265, and vice-versa.

83. Moreover, the combination would have had predictable results. Rusert already applies its teachings to block-based video encoding/decoding—i.e., where the operation of motion vectors is based on blocks. *See, e.g.*, Ex-1004, ¶2, ¶11. Karczewicz explains that a PU is a type of block, and that the operation of motion vectors in H.265 is based on PUs. Ex-1005, ¶35. Therefore, the concepts taught in Rusert were readily applicable to PUs, and the combination would have had the predictable result of selecting PMV candidates (as Rusert teaches) for PUs (as Karczewicz teaches). *See, e.g.*, Ex-1004, ¶116.

84. Furthermore, the combination would not have changed the principle of operation for any of the teachings of the references relied upon in the combination. The combination applies teachings from Rusert and Karczewicz in the manner taught by each reference: Rusert's teachings are still applied to the selected PMV candidates for block-based video encoding/decoding using predicted motion vectors, and Karczewicz's teachings are still used with motion vectors assigned to PUs, as explained above. Applying H.265 teachings to Rusert, and vice versa, would have been consistent with Rusert's statement that its principles are applicable to other video standards. *Id.*

85. A POSITA would have had a reasonable expectation of success when combining Rusert and Karczewicz. As explained above, the combination applies teachings from each reference according to their known purposes, in a conventional manner as taught by Rusert and Karczewicz, without changing their principle of operation. Furthermore, the teachings from Rusert and Karczewicz are complementary because both teach aspects of block-based video encoding from H.264 and H.265, respectively. Rusert provides examples using H.264, explaining it was not limited to that standard and its teachings apply to other coding standards, which naturally would have included the successor standard H.265. *Id*. Therefore, Karczewicz's teachings complement Rusert by teaching terminology and concepts from H.265. Ex-1005, ¶32.

86. Additionally, the combination had predictable results, as explained above, and Ground 1 does not modify Rusert or Karczewicz in a way that would render either reference inoperative. To the contrary, the similarities of the architectures and video standards—which both use block-based video encoding/decoding with predicted motion vectors assigned to blocks—would have given a POSITA a reasonable expectation of success in combining their teachings. *See, e.g.*, Ex-1004, ¶11 (discussing motion vectors used for coding blocks); Ex-1005, ¶2 ("[t]his disclosure relates to block-based video coding techniques...").

87. Given the education and experience of a POSITA (*supra* §IV), a POSITA would have been more than capable of applying Karczewicz's teachings to Rusert, and vice versa, because it would simply have applied Rusert's teachings from H.264 to the successor standard H.265. Additionally, motion estimation was commonplace, having been introduced by MPEG standards in the 1990s, and H.264 had introduced the use of predicted motion vectors by the early-mid 2000s. *Supra* §I. These were basic aspects of video encoding/decoding that a POSITA would have been knowledgeable about.

88. **Rusert, Karczewicz, and Lin.** The motivation to combine Rusert and Karczewicz was explained above. A POSITA would have been further motivated to apply Lin's teachings for removing redundant PMV candidates, for the reasons explained below.

89. Lin teaches a way to reduce the number of motion vectors that must be considered—particularly for the scenario where a block has been divided into two PUs. Ex-1006, ¶4, ¶25, ¶44. Applying these teachings would have furthered a stated goal of Lin and Rusert, by reducing the number of motion vector candidates. Rusert seeks to "reduce[] the number of previous motion vectors that must be considered" so "that less computation is needed, improving the processor efficiency of the coding." Ex-1004, ¶12; *see also* Ex-1004, ¶7, ¶13, ¶21, ¶70, ¶84. Lin likewise seeks to reduce the number of motion vector candidates. Ex-1006, ¶¶39-40 (teaching removing redundant MVP candidates to reduce complexity), ¶47; Ex-1013, 000009 (discussing removing redundant MVPs).

90. Additionally, Karczewicz provides motivation to combine with Lin. As explained above, the combination applies Karczewicz's PU teachings to Rusert. Karczewicz explains that CUs do not have to be divided—in the simplest case, if the block has uniform motion, the same motion vector can be assigned to the entire block. The entire CU block is a PU, and there is no reason to divide it into multiple PUs. Conversely, if different parts of the block are moving in different directions, the CU can be divided into multiple PUs so that each can have a different motion vector. Ex-1005, ¶35; Ex-1006, ¶35; Ex-1013, 000007. In other words, the block is divided into two PUs when each half of the block has different motion. If a block is divided into two PUs because its two portions have differing

motion vectors, then there is no way that the motion vector corresponding to one of these PUs can be a good predictor to the motion of the other PU. Therefore, when analyzing potential motion vectors for half of a block (that has been divided into two PUs), Lin explains that the motion vector from the other half can be removed. Ex-1006, ¶25, ¶44; Ex-1013, 000010. Lin explains that assigning the same motion vector to both halves of a divided block is redundant to the scenario where the block was not divided at all and the same motion vector was applied to the entire block comprising one PU. *See id.* Since Karczewicz already teaches that CUs can—but do not have to be—divided into PUs, a POSITA would have been motivated to reduce this redundancy as Lin teaches.

91. A POSITA would have been motivated to combine Lin with Rusert and Karczewicz because it would have used Lin's known technique of reducing candidates to improve similar devices/methods in the same way. After all, the combination already applied Karczewicz's PU teachings to Rusert. Adding Lin's further optimization of reducing candidates for this PU splitting scenario would have improved similar H.265 PU-based methods. A POSITA would have applied Lin's known technique to the known devices/methods as taught by Rusert and Karczewicz, which was ready for improvement to reduce the number of previous motion vectors that must be considered. Ex-1004, ¶12. Moreover, this would have

been a combination of prior art elements according to known methods to yield predictable results.

92. Furthermore, a POSITA would have been motivated by the similarity of the references. The coding units and prediction units taught by Lin are the same as those taught by Karczewicz—both refer to H.265 nomenclature. Ex-1006, ¶4 ("The basic unit for compression, termed Coding Unit (CU)… contains one or multiple Prediction Units (PUs)."); Ex-1005, ¶35 ("A CU… may include one or more prediction units (PUs). In general, a PU represents all or a portion of the corresponding CU[.]"). Both Lin and Karczewicz apply their teachings to H.265.

93. While Lin provides teachings in the context of merge mode, its teachings—e.g., for excluding redundant candidates when a block has been divided into multiple PUs—likewise apply to the combination of Rusert and Karczewicz, which seeks to efficiently select PMV candidates for a given block (as taught by Rusert) applied to PUs that can come from divided blocks (as taught by Karczewicz). The same underlying reasoning therefore applies because, even without merge mode, blocks are divided into multiple PUs to assign them different motion vectors, and it would not make sense to divide a block into separate PUs only to assign the same motion vector to both PUs. Ex-1005, ¶35; Ex-1006, ¶4; Ex-1013, 000007. Doing so would be less efficient than keeping the entire block

as a single PU and be contrary to the reason why the block was divided to begin with.

94. The combination would have had predictable results: when a block is divided into two PUs, the PMV candidate from one PU is excluded as a candidate for the other PU. Excluding the candidate would have been a predictable result consistent with the reason why a block is divided into PUs to begin with, as explained above.

95. Furthermore, the combination would not have changed the principle of operation for any of the teachings of the references. The combination applies teachings in the manner taught by each reference: Rusert and Karczewicz were explained above, and Lin's teachings are used to exclude candidates when a block is divided into two symmetric PUs, as taught and illustrated by Lin. Ex-1006, ¶44; Ex-1013, 000016. Since Ground 1 already applies H.265 PU concepts to Rusert, the application of Lin's PU teachings to this combination would have been entirely compatible with it and would not have changed its principle of operation. Ground 2 simply applies Lin's exclusion of PUs in certain scenarios.

96. A POSITA would have had a reasonable expectation of success when combining Lin with Rusert and Karczewicz. As explained above, the combination applies teachings from each reference according to their known purposes, in a conventional manner as taught by Rusert, Karczewicz, and Lin, without changing

their principle of operation. Furthermore, the teachings are complementary because all three references teach aspects of block-based video encoding from H.264 and H.265. *E.g.* Ex-1004, ¶25, ¶39; Ex-1005, ¶3, ¶5, ¶38; Ex-1006, ¶4, ¶25; Ex-1013, 000009-11. Lin's teachings apply a basic concept to further Rusert's stated goal of reducing the number of PMV candidates, by eliminating redundant ones as explained above. *E.g.*, Ex-1004, ¶25, ¶39, ¶¶42-44; Ex-1013, 000009-11.

97. Additionally, the combination would have had predictable results, as explained above, and Ground 2 does not modify Rusert, Karczewicz, or Lin in a way that would render any reference inoperative. To the contrary, the similarities of the architectures and video standards would have given a POSITA a reasonable expectation of success in combining their teachings. Ex-1004, ¶67, ¶116; Ex-1005, ¶32; Ex-1006, ¶¶4-5, ¶44; Ex-1013, 000007.

98. Given the education and experience of a POSITA (*supra* §IV), a POSITA would have been more than capable of applying Lin's teachings to Rusert and Karczewicz because it would simply have applied the concept of excluding candidates in a particular scenario as taught by Lin. Motion estimation and predicted motion vectors had been widespread for many years. *Supra* §I. These were basic aspects of video encoding/decoding that a POSITA would have been knowledgeable about.

2. Independent Claim 1

[1pre] A method comprising:

99. To the extent that the preamble is limiting, Ground 1 teaches limitation [1pre], as explained below.

100. Rusert teaches a **method**. For example, Rusert teaches "a *method* of selecting PMV candidates, wherein each PMV candidate corresponds to a motion vector used for coding of a previous block, said previous block having a distance from a current block." Ex-1004, Abstract, ¶1, ¶11. The method further comprises the steps and elements explained below. *Infra* §§VI.A.2[1a]-[1e].

[1a]	**selecting a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for a block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates and is utilized to identify motion vector prediction candidates of which one spatial motion vector prediction candidate from the motion vector prediction list is signaled as the motion information for the prediction unit;**

101. Ground 1 teaches limitation [1a], as explained below.

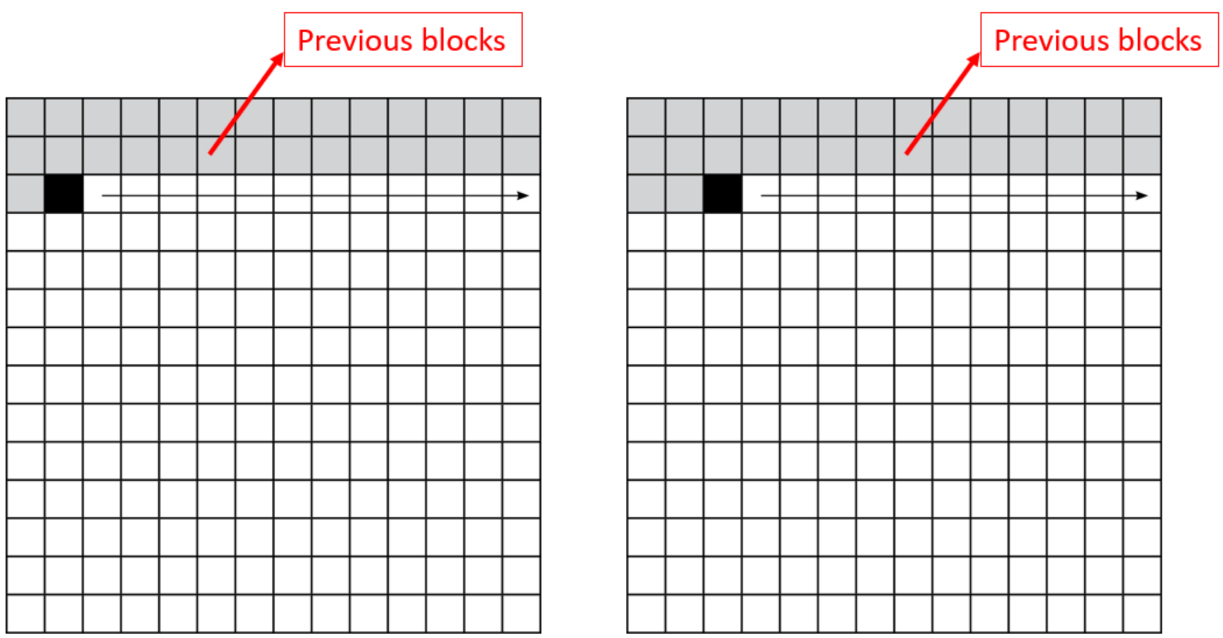
102. Ground 1 teaches **selecting a first spatial motion vector prediction candidate** (e.g., a PMV candidate) **from a set of spatial motion vector prediction candidates** (e.g., set of previously-coded motion vectors) **for a block of pixels.** For example, Rusert refers to a predicted motion vector as a "PMV" (Ex-1004, ¶3) and teaches "selecting … PMV candidates" from a "set of

previously coded motion vectors that were used for previous blocks[.]" Ex-1004, ¶11, ¶12, ¶15, ¶24, ¶25, ¶39, ¶113, Fig. 6. PMV_CANDS is a list of predicted motion vectors and is therefore a motion vector prediction list. *Id.*

103. Rusert's PMV candidates comprise spatial motion vector prediction candidates that are obtained from one or more previously-encoded blocks in the current frame. *Supra* §V.A. Rusert teaches that the PMV candidates include "*spatially* neighboring motion vectors" (Ex-1004, ¶6) with one of the PMV candidates being selected as a "*motion vector predictor*… for [a] vector to be coded" (Ex-1004, ¶3). *See also* Ex-1004, ¶¶4-5. Furthermore, Rusert teaches that PMV candidates are evaluated for inclusion in a PMV_CANDS list, which includes spatial and temporal motion vector prediction candidates, e.g., "[m]otion vectors" that "comprise *spatial* or temporal *neighbors of the current block*[.]" Ex-1004, ¶67. Since neighboring blocks are next to the current block in the current frame, Rusert's spatially neighboring motion vectors from those neighboring blocks are obtained only on the basis of information of one or more blocks of the current frame. Ex-1004, ¶¶4-6.

104. The PMV candidates are selected from a "set of previously coded motion vectors that were used for previous blocks[,]" which is a set of spatial motion vector prediction candidates for a block of pixels. *E.g.*, Ex-1004, ¶¶11-12. As Rusert iterates through blocks in a frame, each block will have its own set of

previously-coded motion vectors, specific for that block and different from others. As blocks of the frame are encoded, the number of blocks previous to the current block increases; therefore, the set of previously-coded motion vectors that were used for previous blocks expands with each encoded block. *See id.* Ex-1004, ¶59. Blocks were encoded/decoded in sequence, with a common approach being a raster scanning order (from top left to bottom right). *See, e.g.,* Ex-1004, ¶59 (teaching that "the blocks to the right and below the current block position have not been visited yet, and do not yet have motion vectors known for them"), Fig. 3g. I have illustrated this concept below where the current block is indicated in black. Each time the current block advances, the set of spatial motion vector prediction candidates increases by one.



Regardless of the scan pattern used, the sets of spatial motion vector prediction candidates are different for different blocks of pixels. Rusert's teachings are applied to "pixel blocks" or blocks of pixels, as further described below. Ex-1004, ¶2, ¶36.

105. Ground 1 further teaches **selecting a first… candidate… as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list** (e.g., PMV_CANDS). For example, Rusert teaches selecting candidate motion prediction vectors in "an outwards going scan… around the current block" for PMV candidates to potentially be included in a PMV_CANDS list. Ex-1004, ¶¶44, 51-66. Rusert teaches numerous examples (*see* Ex-1004, Figs. 3a-n), including Fig. 3c and the "search pattern shown in FIG. 3n" that "has been found to combine good compression efficiency (i.e., finding good motion vectors) with good computation performance." Ex-1004, ¶66, Figs. 3a-3n:

Fig. 3c

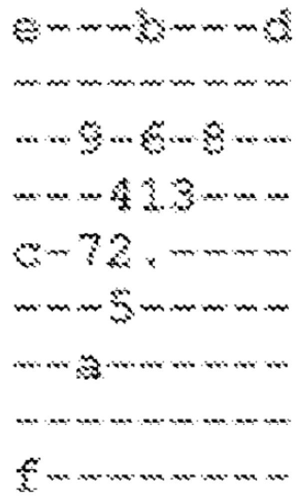


Fig. 3n

106. I note that Fig. 3c illustrates a scan pattern “in the following order: 1, 2, 9, h, j, l, m[]” with “1” (one) being the block located directly above the current block “.” and “l” (lowercase l) being the block located in the upper left corner. Ex-1004, ¶54. Fig. 3n illustrates a scan pattern with “an ordering as shown”: 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f with “a” being hexadecimal for 10, “b” being hexadecimal for 11, and so on. Ex-1004, ¶65.

107. Rusert selects candidates in the sequences taught by its search patterns, starting with a first candidate labelled “1” in its figures. Ex-1004, ¶¶51-66, Figs. 3a-n. Each candidate is selected from the set of previously-coded motion vectors that were used for previous blocks. Ex-1004, ¶11, ¶12, ¶15, ¶24, ¶25, ¶39, ¶44, ¶¶51-66. Rusert teaches visiting previously-coded blocks, in the sequences shown by its search patterns, and selecting the motion vector for that previously-coded block as a candidate for potential inclusion in PMV_CANDS. Ex-1004,

¶44, ¶¶51-66; *infra* §§VI.A.2[1c]-[1d] (explaining how the selected candidate is compared with candidates in PMV_CANDS for potential inclusion in PMV_CANDS). I have illustrated the start of the search patterns for Fig. 3c (horizontally):

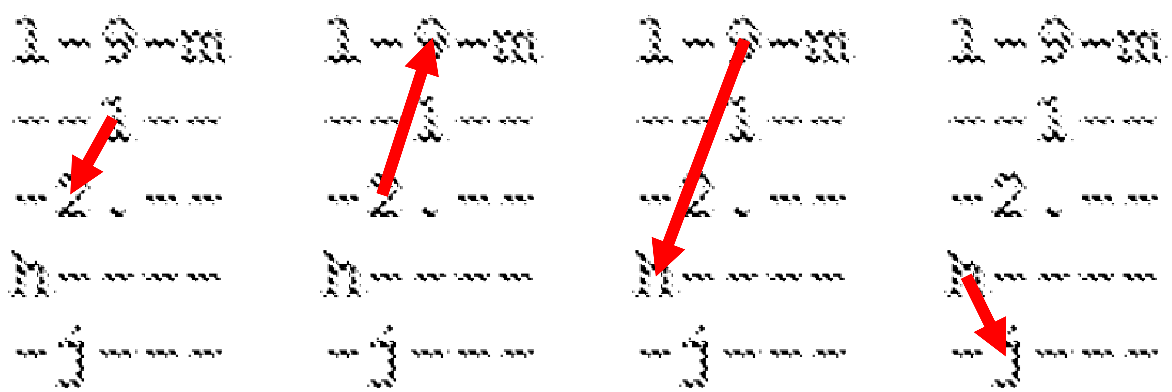


Fig. 3c Fig. 3c Fig. 3c Fig. 3c

and for Fig. 3n (horizontally):

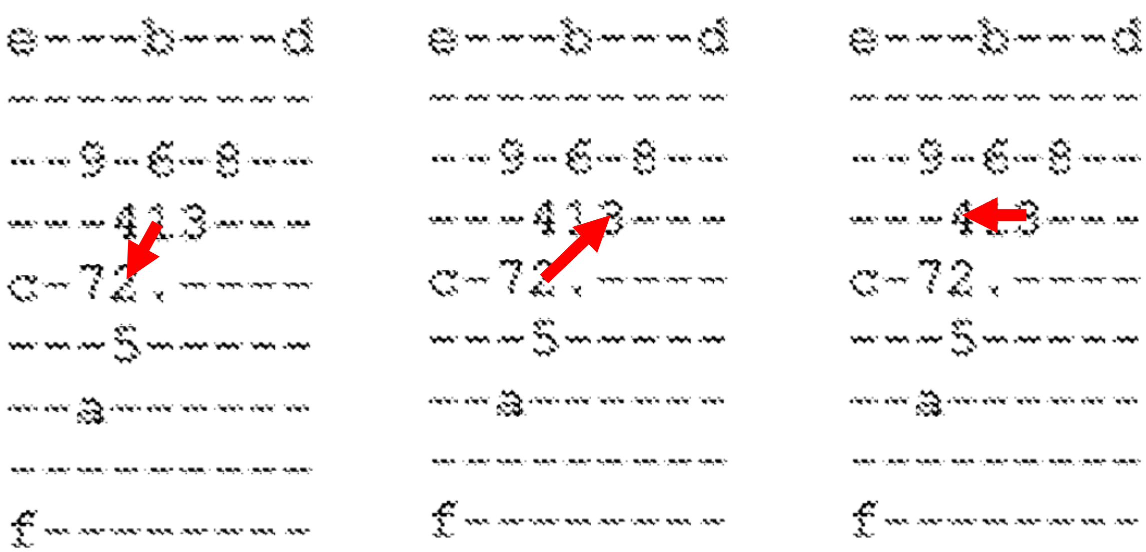


Fig. 3n Fig. 3n Fig. 3n

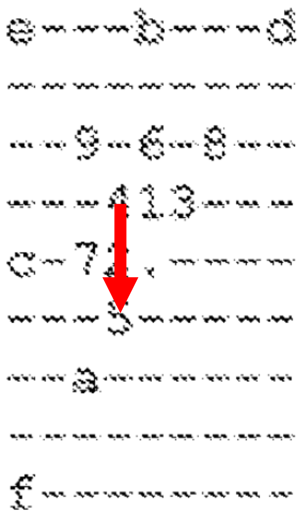


Fig. 3n

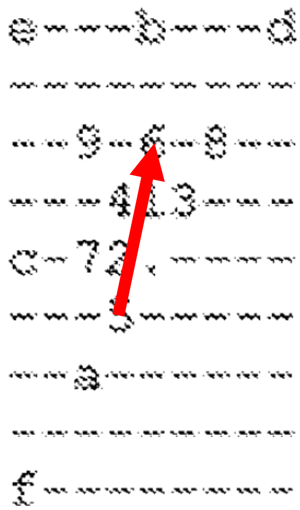


Fig. 3n

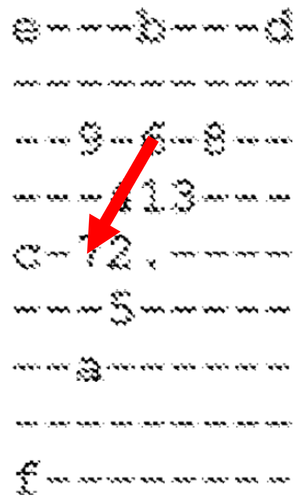


Fig. 3n

and for Fig. 3n again with directional annotation added:

Fig. 3n

108. PMV_CANDS is **a motion vector prediction list for a prediction unit of the block of pixels**. Rusert teaches that "[t]he PMV_CANDS list [is] used for coding a motion vector associated with a current motion compensation block[.]" Ex-1004, ¶41; *see also* Ex-1004, ¶4, ¶39, ¶42. PMV_CANDS is

"dynamically generated specifically for the current motion compensation block[.]" Ex-1004, ¶41. "In that case, before a block is processed, a PMV_CANDS list is initialized and then updated with a number of previously coded or pre-defined motion vectors." *Id*. When Rusert's PMV_CANDS list is updated (Ex-1004, ¶39 ("Update means that one or more motion vectors are added to an existing [PMV_CANDS] list")), it comprises a subset of the set of previously-coded motion vectors included in the PMV_CANDS list as part of the scan to that point. Ex-1004, ¶¶43-44, ¶¶51-66, ¶¶4-5, ¶¶36-39 ("A PMV_CANDS list may be updated to include previously coded motion vectors MV."). When Rusert's PMV_CANDS list is complete, a "predicted motion vector (PMV)" that "is used to predict a [motion vector]… is signaled" using PMV_CANDS and an index "to select a particular PMV candidate… from… PMV_CANDS[.]" Ex-1004, ¶36.

109. Rusert explains its teachings with references to blocks to which motion vectors are assigned. Ex-1004, ¶¶2-5, ¶36, ¶43. Therefore, in the context of Rusert's nomenclature, the prediction unit of Rusert's block of pixels is the block itself because Rusert's block is the unit for which a motion vector is assigned for motion prediction. Ex-1004, ¶2 ("Each motion compensation block is assigned one motion vector (for uni-predictive temporal prediction, such as in P frames) or two motion vectors (for bi-predictive temporal prediction, such as in B frames)."), ¶3 ("in recent video coding standards such as H.264/AVC where *small motion*

compensation block sizes are used"), ¶4, ¶36, ¶43 ("Before a motion vector associated with a current motion compensation block is processed, the PMV_CANDS list used for coding the current motion vector may be updated by using motion vectors associated with surrounding blocks."). For Rusert's teachings, a motion vector is provided for each "8x8 pixel block," also called a "sub-block" because it is a portion of a "macroblock." Ex-1004, ¶36. When Rusert looks for neighboring motion vectors, it scans nearby blocks where motion vectors have been assigned to those blocks. Ex-1004, ¶¶50-67, Figs. 3a-3n. Those blocks are therefore the prediction units in the context of Rusert's teachings.

110. Additionally, the combination of Ground 1 applies Rusert's teachings regarding "blocks" (in the H.264 context) to prediction units (following nomenclature in the H.265 context). *Supra* §VI.A.1 (explaining how and why Rusert and Karczewicz's teachings would have been combined). Rusert uses H.264 terminology, and a POSITA would have found it obvious and been motivated to apply Rusert's teachings to the successor standard H.265. *Id.* Rusert provides express motivation to do so. Ex-1004, ¶116.

111. Rusert's motion-vector teachings are explained on the basis of "blocks" because Rusert applies H.264 terminology, where motion vectors are assigned to "blocks." Ex-1004, ¶¶2-5, ¶36, ¶43. However, Rusert also explains that its teachings "can also be applied to… *any coding system which uses predicted*

motion vectors." Ex-1004, ¶116. As Karczewicz explains, the successor video standard H.265 introduced new terminology for a type of block called a "prediction unit" ("PU"), with motion vectors being assigned to PUs. Ex-1005, ¶¶33-36; *see also supra* §I. For H.265, "[i]n general, a CU has a similar purpose to a macroblock of H.264[.]" Ex-1005, ¶33. "A CU… may include one or more prediction units (PUs)"; "[i]n general, a PU represents all or a portion of the corresponding CU[.]" Ex-1005, ¶35. In its simplest case, a CU is commensurate with a PU. *Id.* "[T]he PU may include data defining a motion vector for the PU[,]" and "the motion vector may describe, for example, a horizontal component" and "a vertical component[.]" *Id*. This motion information is used for "prediction using a PU[.]" Ex-1005, ¶36; ¶66.

112. In short, Rusert explains its teachings in terms of blocks, with motion vectors assigned to or obtained from blocks in the H.264 context. Ex-1004, ¶¶2-5, ¶36, ¶43. Karczewicz explains that, for H.265, a PU is a type of block, and motion vectors are assigned to PUs. Ex-1005, ¶64 ("[T]he phrase 'block' refers to any size or type of video block" and "may refer to one or more of a macroblock, LCU, CU, sub-CU, TU, or PU."), ¶¶33-36. Therefore, based on these combined teachings, it would have been obvious to apply Rusert's motion vector teachings to PUs in the H.265 context, with PMV_CANDS being a motion vector prediction list for a prediction unit of the block of pixels. Ex-1005, ¶¶33-36, ¶66.

113. **Where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates**. For example, Rusert's PMV_CANDS list comprises motion information of the spatial motion vector prediction candidates. PMV_CANDS is a "list of PMV candidates[.]" Ex-1004, ¶37. Furthermore, "each PMV candidate corresponds to a motion vector used for coding of a previous block." Ex-1004, ¶11; *see also* Ex-1004, ¶¶24-25, ¶39, ¶41. The motion vectors of the PMV candidate include, for example, "x and y components." Ex-1004, ¶106, ¶36, ¶¶91-94, ¶100. Therefore, Rusert's PMV_CANDS list includes motion information, including motion vectors and their x and y components, of the PMV candidates. *See* Ex-1004, ¶¶2-3 (discussing motion vectors used for prediction of pixel blocks across frames); *see also* Ex-1001, 2:59-3:4 ("motion information is indicated by motion vectors associated with each motion compensated image block"). In short, Rusert teaches this limitation.

114. Additionally, Karczewicz teaches "the PU may include data defining a motion vector for the PU." Ex-1005, ¶35. The motion vector for the PU includes "a horizontal component" (e.g., x-component), "a vertical component" (e.g., y-component), "a resolution…, a reference frame… and/or a reference list[.]" *Id.* Therefore, Karczewicz confirms that the motion vectors of Rusert's PMV candidates include "x and y components" (Ex-1004, ¶¶106, 36, 91-94, 100) because Karczewicz teaches motion vectors include "a horizontal component" and

"a vertical component[.]" Ex-1005, ¶35. Moreover, based on the combined teachings of Karczewicz and Rusert, it would have been obvious to include the PU information described by Karczewicz (e.g., "a resolution…, a reference frame… and/or a reference list") in PMV_CANDS because the combination relies on Karczewicz's PU teachings and applies them to Rusert. *Supra* §VI.A.1 (explaining how the references would have been combined). Therefore, the combination of Ground 1 teaches the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates.

115. The PMV_CANDS list **is utilized to identify motion vector prediction candidates of which one spatial motion vector prediction candidate from the motion vector prediction list is signaled as the motion information for the prediction unit.**[2] For example, Rusert teaches using an index to signal "a particular PMV candidate… from [the] list of PMV candidates, PMV_CANDS" as the "predicted motion vector (PMV)… to predict a [motion vector]" for a block. Ex-1004, ¶36; *see also* Ex-1004, ¶4 (discussing approaches to "explicitly *signal a PMV to* be used out of a set of PMV candidates, PMV_CANDS"), ¶35 ("the generation of the *signaling bits* is done in the encoder"), ¶37 ("Using the

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[2] The '714 patent admits that it was known for "video codecs" to "generate a list of motion vector prediction[]" candidates, and that it was known for "[o]ne of the candidate motion vectors in the list" to be "signalled[sic] to be used as the motion vector prediction of the current block." Ex-1001, 3:60-66.

transmitted index, the decoder 150 can determine the PMV 220 as used in the encoder[.]"), ¶75 ("… use of one of the candidates in PMV_CANDS for prediction…"), ¶88, Table 1. This index is transmitted to a decoder, and the decoder uses this "transmitted index" to "determine the PMV… as used in the encoder" from PMV_CANDS to "reconstruct [a motion vector]." Ex-1004, ¶37. For example, Rusert teaches an example of using an index "3" or "0010" to signal "[PMV] candidate 3" in a PMV_CANDS list with seven PMV candidates. Ex-1004, ¶¶91-92. The index is transmitted to the decoder as the motion information for the block. Ex-1004, ¶¶35-37; *infra* §VI.A.2[1e] (providing further explanation). Therefore, Ground 1 teaches that PMV_CANDS is used to identify candidates, of which one is signaled as the motion information for the PU. As explained above, Ground 1 applies Rusert's teachings to PUs.

116. Rusert teaches exemplary codes used to signal which candidate from PMV_CANDS is used for the motion information for the current block. E.g., Ex-1004, ¶¶88-102 (exemplary codes for index values shown in various tables); *infra* §VI.A.2[1e].

117. Furthermore, Rusert illustrates in Figs. 2a and 2b below that a PMV candidate, PMV 220 (PMV_2 242 in the set), is signaled as the motion information for the block:

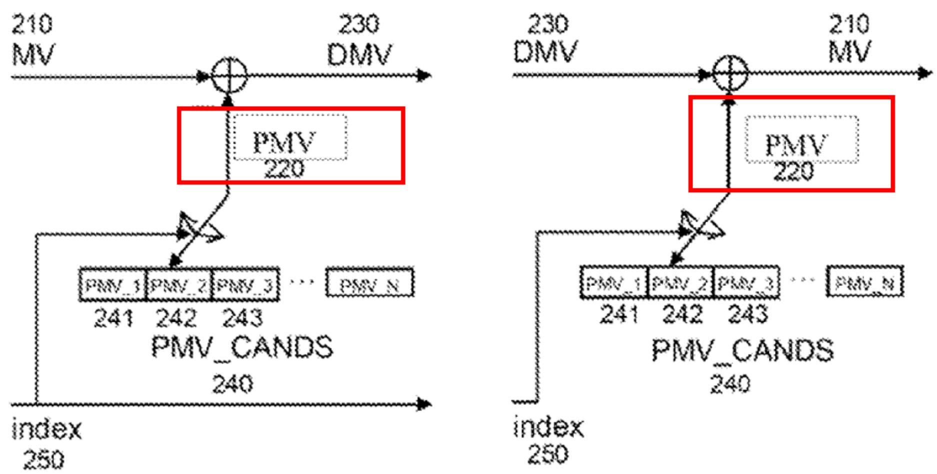

Fig. 2a Fig. 2b

Figs. 2a-2b teach examples of how a candidate from PMV_CANDS is signaled from encoder to decoder as the motion information for the current block; the decoder utilizes the index with PMV_CANDS to identify the motion vector prediction candidate. In these examples, the index 250 signals one PMV candidate (PMV_2 242) from PMV_CANDS, which includes a list of PMV candidates (PMV_1 241, PMV_2 242, PMV_3 243, PMV_N). Ex-1004, ¶36. The decoder uses the index 250 to identify PMV 220 as the PMV candidate to be used for the current block.

118. Ground 1 further applies Rusert's block-based teachings to PUs. *Supra* §VI.A.1 (explaining how and why the references would be combined). Based on the foregoing explanations, Ground 1 teaches limitation [1a].

[1b]	**determining a subset of spatial motion vector prediction candidates based on a location of the block associated with the first spatial motion vector prediction candidate;**

119. Ground 1 teaches limitation [1b], as explained below.

120. Rusert teaches **determining a subset of spatial motion vector prediction candidates** (e.g., based on Rusert's scan of previous PMV candidates within an allowed distance and pre-defined number). For example, Rusert teaches "selecting a set of PMV candidates as a *subset* of the set of previously coded motion vectors that were used for previous blocks[.]" Ex-1004, ¶11, ¶12 ("A PMV candidate list is created by *selecting a subset of the motion vectors* previously used for previous blocks[]"), ¶¶24-25; *supra* §V.D.

121. Rusert determines the subset of PMV candidates based on the locations of their corresponding blocks: "the selected set of PMV candidates comprises *a subset of the set of previously coded motion vectors* … having an allowed distance from the current block and an allowed position." Ex-1004, ¶15, ¶37, Figs. 2a-2b.

122. When Rusert's subset of PMV candidates, which is stored in PMV_CANDS, is updated with a PMV candidate (Ex-1004, ¶39 ("Update means that one or more motion vectors are added to an existing [PMV_CANDS] list")) using an outward scan from the current block, the subset of PMV candidates comprises the previously-coded PMV candidates obtained from blocks in previous

locations of Rusert's scan from the current block to that point. Ex-1004, ¶¶43-44, ¶¶51-66, ¶¶4-5, ¶¶36-39 ("A PMV_CANDS list may be updated to include previously coded motion vectors MV."). As the scan progresses outwards, the subset includes the PMV candidates obtained from blocks in previous locations of Rusert's scan order. Ex-1004, ¶44, ¶¶51-66, Figs. 3a-3n. For example, following the scan order of Fig. 3n, when block "3" is selected, the subset of PMV candidates includes PMV candidates obtained from blocks located at positions 1 and 2. *Id.* When block "4" is selected, the subset of PMV candidates includes PMV candidates obtained from blocks located at positions 1, 2, and 3. *Id.*

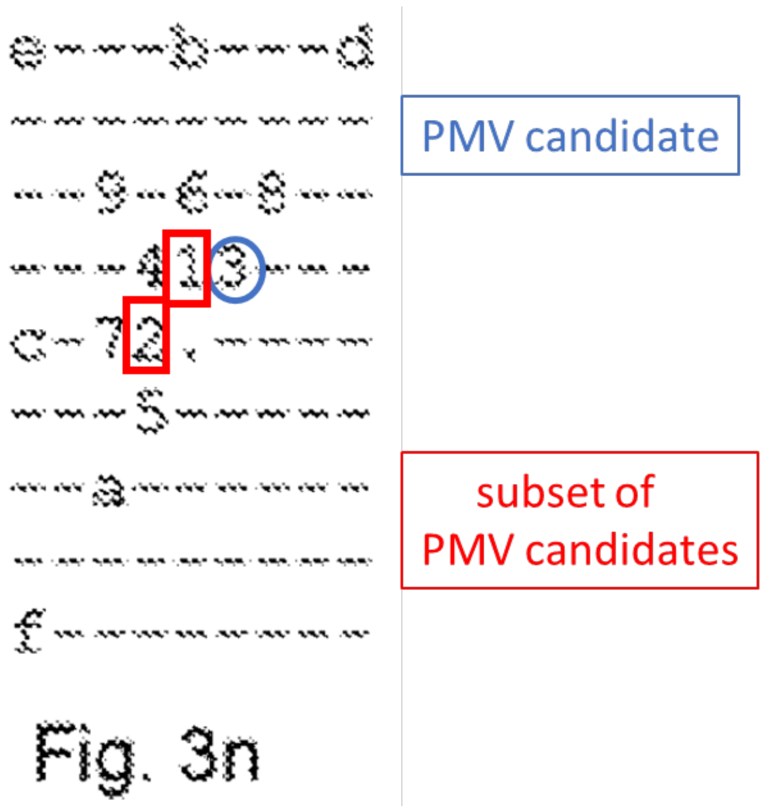

Fig. 3n

123. The PMV candidates in Rusert's subset of PMV candidates are a subset of the larger set of previously-coded motion vectors. Additionally, Rusert teaches terminating a scan "as soon as a pre-defined number of unique PMV candidates have been found[.]" Ex-1004, ¶48. Therefore, not all PMV candidates are considered. Even PMV candidates that are within "a certain distance" and part of "a predetermined scan pattern" are not considered if the "pre-defined number of unique PMV candidates have been found." Ex-1004, ¶¶44-49. For example, while Fig. 3n includes a scan of up to 15 blocks, Rusert terminates the scan with a subset of candidates from those blocks when a pre-determined number of candidates are obtained (e.g., 7), without using the remaining candidates in the scan sequence. Ex-1004, ¶48, ¶107. The subset of PMV candidates is therefore a subset of the set of PMV candidates that are within a certain distance and part of the scan pattern. As the scan progresses outwards and the subset of PMV candidates is updated, the subset is stored as a list of PMV candidates called PMV_CANDS. Ex-1004, ¶¶37-41, ¶¶44-49, ¶¶51-66; *infra* §VI.A.2.[1d]. The subset is determined for reducing the number of candidates, as explained for [1c].

124. Rusert improves coding efficiency by using this subset of spatial motion vector prediction candidates instead of all of previously-coded motion vectors. Ex-1004, ¶13 ("The size of the PMV candidate list is limited because a very large list would require long code words to identify which PMV candidate to

use.… This allows a candidate list to be produced using motion vectors from a wide range of previous blocks, but that is not excessively long.”), ¶12 (“*Restricting the previous blocks* that are considered reduces the number of previous motion vectors that must be considered *meaning that less computation is needed, improving the processor efficiency of the coding*.”).

125. The determination is **based on a location of the block associated with the first spatial motion vector prediction candidate**. Here, “the” block recited in [9b] has an antecedent basis in [9a]: “a *first spatial motion vector prediction candidate* from a set of spatial motion vector prediction candidates *for an encoded block of pixels*[.]” Therefore, “the block” refers to the “block of pixels” in [9a] and therefore refers to the current block for which motion vector prediction candidates are being analyzed.[3] *Supra* §V.C.

126. Rusert determines its subset based on the location of the current block. The subset of PMV candidates is updated by “an outwards going scan… around the current block[.]” Ex-1004, ¶44, ¶43 (“Before a motion vector associated with a current motion compensation block is processed, the PMV_CANDS list used for

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[3] This is further confirmed by the prosecution history of a parent patent, the ’833 patent. The Examiner interpretated “based on the location of the block associated with the first spatial motion vector prediction candidate” as based on the location of the “current block,” finding that this limitation was satisfied by prior art teachings for “selecting one of the PMV from MVs of neighboring blocks[.]” Ex-1015, 000168 (Non-Final Office Action). The Applicant did not dispute this plain reading of the claims. *See* Ex-1015, 000241-244 (Reply to Office Action).

coding the current motion vector may be updated by *using motion vectors associated with surrounding blocks*."). Because the "outwards going scan" is "performed around the current block[,]" the set of blocks that are scanned for potential inclusion in the subset of PMV candidates is based on the location of the current block. Ex-1004, ¶44.

127. Furthermore, the subset of PMV candidates is based on "an allowed distance from the current block and an allowed position. " Ex-1004, ¶15, ¶11, ¶13, ¶17, ¶¶24-25, ¶113, Fig. 6. The distance and position are relative to and therefore based on the location of the current block. *See, e.g.*, Ex-1004, ¶11 ("The method comprises identifying allowed distance values of distances between the current block and the previous block."), ¶16 (discussing identifying allowed positions relative to the current block). Rusert teaches several techniques for calculating distance values based on the locations of the current block and surrounding blocks, including Euclidean distance,[4] Manhattan distance, and Chebyshev distance. Ex-1004, ¶44. Within the allowed distance, Rusert teaches scanning surrounding blocks, starting with closest blocks and terminating the scan "once a certain distance has been reached." This prevents blocks from the set that are outside of the allowed distance from being scanned. Ex-1004, ¶13 (blocks with "certain

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[4] Rusert occasionally misspells "Euclidean distance" as "Euclidian distance". *See, e.g.*, Ex-1004, ¶44, ¶78, ¶87.

distance values" outside the allowed distance are not included in the subset), ¶43, ¶47. Rusert's figures include exemplary distance values of surrounding blocks relative to the current block, with the scan terminating when a certain distance value, such as 5 or 8, is reached. Ex-1004, Figs. 3a, 3d, 3f, 3g:

Fig. 3a

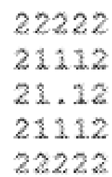


Fig. 3d

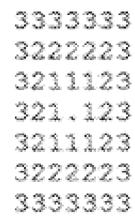


Fig. 3f

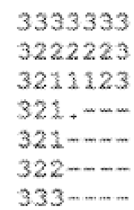


Fig. 3g

128. In each of Rusert's exemplary scans, the blocks are identified and ordered based on their location around the current block (indicated by "."). Ex-1004, ¶¶51-66, Figs. 3a-3n. Therefore, the subset of PMV candidates in PMV_CANDS is based on the location of the current block. Ex-1004, ¶11, ¶13, ¶15, ¶17, ¶¶24-25, ¶¶43-44, ¶¶51-66.

129. Additionally, Rusert teaches that only motion vector prediction candidates from blocks with allowed positions relative to the current block will be included in the subset. *See* Ex-1004, ¶15. Rusert explains:

> The allowed positions may be are *corner and middle block positions*. A previous block at a corner position is offset from a current block position by an equal distance in a horizontal direction and a vertical direction. A previous block at a middle position is either horizontally aligned or vertically aligned with a current block position. In a system

> where coding is performed by horizontal lines of pixels starting in the top left corner, the allowed block positions may comprise: *blocks horizontally aligned with and offset to the left of the current block; blocks vertically aligned with and offset above the current block; and blocks offset to the left and above the current block by the same distance*. The allowed distance values and/or the allowed positions may be predetermined.

Ex-1004, ¶16 (emphasis added). Here, Rusert teaches that PMV candidates of previous blocks that do not have an allowed position are excluded from the subset. For example, Rusert teaches excluding "all blocks other than the corner blocks and the blocks directly above and to the left of the current block[.]" Ex-1004, ¶65. This exclusion removes blocks that have not yet been encoded/decoded because the "blocks to the right and below the current block position have not been visited yet, and do not yet have motion vectors known for them[.]" Ex-1004, ¶59. Rusert teaches that excluding such blocks prevents "requir[ing] too many tests before growing the scan area big enough to capture distant blocks." Ex-1004, ¶65. Therefore, the subset of PMV candidates in PMV_CANDS is based on the location of the current block.

130. Alternatively, if "the" block were interpreted to mean the block of pixels from which the selected first candidate was obtained, Rusert also teaches this. *Supra* §V.C. For example, Rusert teaches that a "position" of a block of a PMV candidate is represented as (xpos, ypos), denoting a coordinate comprising an

x-coordinate and a y-coordinate of the block, i.e., **a location of the block associated with the first spatial motion vector prediction candidate**. *See, e.g.*, Ex-1004, ¶¶51-52. Based on the location of the block of the PMV candidate, Rusert teaches that the subset of PMV candidates with which the PMV candidate is compared includes the PMV candidates of blocks located in the scan pattern up to the PMV candidate. Ex-1004, ¶44. For example, following the scan pattern illustrated in Fig. 3n, the PMV candidate associated with the block located at "3" would be compared with a subset of PMV candidates that include the PMV candidates of blocks "1" and "2," which I illustrate below. *Id.,* ¶¶65-66, Fig. 3n:

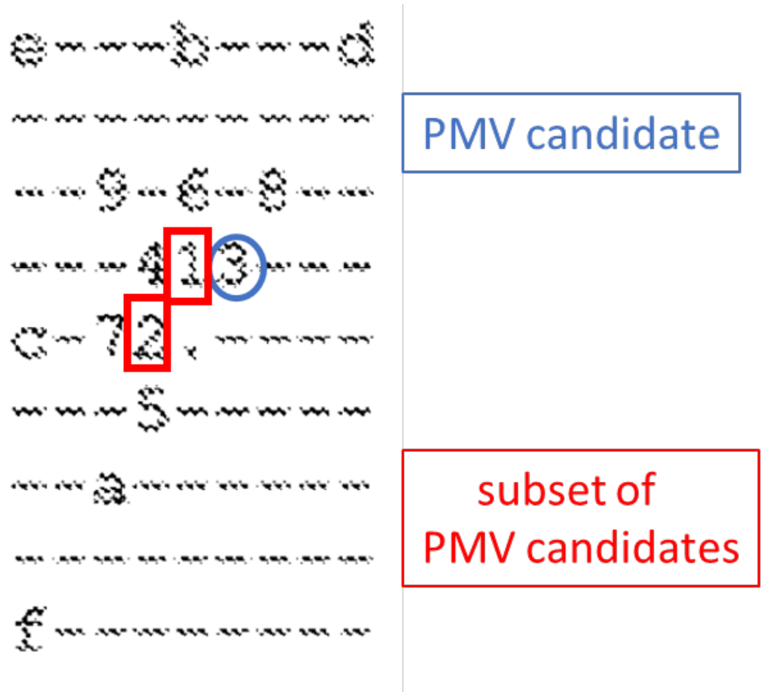


Fig. 3n

131. Based on the foregoing explanations, Ground 1 teaches limitation [1b].

[1c]	**comparing motion information of the first spatial motion vector prediction candidate with motion information of spatial motion vector prediction candidates in the determined subset of spatial motion vector prediction candidates without making a comparison of each pair from the set of spatial motion vector prediction candidates;**

132. Ground 1 teaches limitation [1c], as explained below.

133. Rusert teaches **comparing motion information of the first spatial motion vector prediction candidate with motion information of spatial motion vector prediction candidates in the determined subset of spatial motion vector prediction candidates** (e.g., subset of PMV candidates). For example, when updating the subset of PMV candidates, which is stored as a list in PMV_CANDS, Rusert teaches at least three comparisons for determining whether to include or skip a PMV candidate (Ex-1004, ¶¶71-72; *supra* §VI.A.2[1b]), any one of which is sufficient on its own to satisfy this limitation. When considering a PMV candidate for inclusion in the subset of PMV candidates, the "PMV candidate may be determined to be unnecessary if it at least one of the following conditions is fulfilled: [1] the PMV candidate is a duplicate of another PMV candidate in the set; [2] the PMV candidate is determined to be within a threshold distance of an existing PMV candidate; and [3] the PMV candidate would never be used because

at least one alternative PMV candidate will allow motion vectors to be coded using fewer bits." Ex-1004, ¶21.

134. First, Rusert teaches comparing whether "the PMV candidate is a duplicate of another PMV candidate" in the subset of PMV candidates. *Id.*, ¶71. "This ca[n] be done, when updating the list, by comparing the candidates already in the list with the new vector that could be added, and if a duplicate is found… [i]t is preferable to skip the new vector[.]" Ex-1004, ¶71. Skipping (thus excluding) duplicates is "[o]ne measure for reducing the number of candidates[.]" *Id.*; *see also* Ex-1004, ¶62 ("It has been identified as advantageous to discard such duplicates"). When a potential PMV candidate is selected and Rusert evaluates whether to update the subset of PMV candidates, the selected PMV candidate is compared with the current motion vectors of the PMV candidates that are already in the subset of PMV candidates. If it is a duplicate, then the potential PMV candidate is skipped and excluded. For example, two motion vectors are duplicates when their vector values (e.g., their x values and y values) are the same.

135. Second, Rusert teaches comparing whether "the PMV candidate is… within a threshold distance of an existing PMV candidate" in the subset of PMV candidates. Ex-1004, ¶21. This is accomplished using "a similarity measure" such as "Euclidian distance… or absolute distance." Ex-1004, ¶72, ¶87. For example, Euclidian distance is measured by "$(x_0-x_1)^2+(y_0-y_1)^2$" and absolute distance is

measured by "$|x_0 - x_1| + |y_0 - y_1|$, with (x_0, y_0) and (x_1, y_1) being the pair of motion vectors under consideration." Ex-1004, ¶72. Here, the x and y components of the motion vectors for the PMV candidate and each of the PMV candidates that are already in the subset of PMV candidates are compared to determine whether the distance between them is less than a threshold distance.[5] If the "similarity measure [is] smaller than a pre-defined threshold," then the PMV candidate is "[r]emov[ed] or skipp[ed][.]" Ex-1004, ¶72, ¶87.

136. Third, Rusert teaches comparing whether "at least one alternative PMV candidate will allow motion vectors to be coded using fewer bits." Ex-1004, ¶21. This is accomplished by "removing PMV candidates" that "will never be used" because another PMV candidate in the PMV_CANDS list facilitates "a bit sequence that is shorter or of the same length compared for all possible motion vectors." Ex-1004, ¶90. For example, Rusert teaches that "[i]f we want to encode a motion vector, such as MV= (0,2)," then "we can [] encode it using…" a first candidate "PMV=(0,2), plus a difference DMV=(0,0)" or a second candidate "PMV=(-1,2), plus a difference DMV=(1,0)[.]" Ex-1004, ¶¶91-94. In this example, the first candidate uses a "total number of… 6 bits" to code the motion vector because of its index costs (4 bits) and the difference cost to code the

[5] If the two PMV candidates are duplicates, the distance (such as the Euclidean distance and the absolute distance) between the two PMV candidates is zero.

difference between the motion vector and the first candidate (1 bit for the x component difference and 1 bit for the y component difference). Ex-1004, ¶93. The second candidate only uses "5 bits in total" because of its index costs (1 bit) and the difference cost (3 bits for the x component difference and 1 bit for the y component difference). From this example, Rusert teaches that "it will never be beneficial to use" the first candidate because the second candidate "will always be one [b]it cheaper or better." Ex-1004, ¶95. Therefore, when evaluating whether the subset of PMV candidates should be updated with a potential PMV candidate, Rusert teaches comparing the motion information of the potential PMV candidate with that of each PMV candidate that is already in the subset of PMV candidates, to determine if one will allow motion vectors to be encoded using fewer bits.

137. All three teachings compare a potential candidate with at least one other candidate from the subset of preceding candidates in Rusert's scan sequence. Since preceding candidates have smaller index values, they would be signaled more efficiently than later duplicates, and Rusert improves efficiency by determining this subset and comparing potential new candidates to the subset. Ex-1004, ¶¶88-98. For all three comparisons, the x and y components of Rusert's candidates are compared; this is motion information of the PMV candidates because the x and y components of the vector values describe the "motion of pixel blocks across frames." Ex-1004, ¶2. For example, "coding of a motion vector

consists of… a motion vector predictor… and … the difference… between the motion vector and the motion vector predictor." Ex-1004, ¶3, ¶¶36-37; *supra* §VI.A.2[1a] (explaining that the motion information is represented by vector values). Therefore, making any of the three comparisons is comparing the motion information of a PMV candidate with the motion information of another PMV candidate of the set of previously-coded motion vectors—in particular the PMV candidates currently in the subset of PMV candidates.

138. Additionally, for all three comparisons, Rusert teaches or at least suggests performing these comparisons when evaluating whether to update PMV_CANDS, which stores the subset of PMV candidates, with a PMV candidate. Ex-1004, ¶71, ¶75, ¶¶84-87, ¶90. Furthermore, this would have been obvious because Rusert teaches the advantages of reducing the number of candidates in PMV_CANDS, including with the use of these comparisons (Ex-1004, ¶12, ¶21, ¶70, ¶84, ¶90), and the natural time to perform these comparisons would have been when evaluating whether or not to add a PMV candidate to PMV_CANDS. As Rusert teaches, performing this check when PMV_CANDS is updated will prevent "unnecessary" candidates from being added, "because it may happen that some candidates… will never be used, since choosing a candidate with a shorter codeword and encoding the distance will give a bit sequence that is

shorter or of the same length compared for all possible motion vectors." Ex-1004, ¶90.

139. Rusert teaches **comparing … without making a comparison of each pair from the set of spatial motion vector prediction candidates**. For example, Rusert teaches that "[r]estricting the previous blocks that are considered reduces the number of previous motion vectors that must be considered meaning that less computation is needed, improving the processor efficiency of the coding." Ex-1004, ¶12. Each of the three comparisons explained above compares motion information from a selected candidate with the candidates in the subset of PMV candidates, without making a comparison of each pair from the set of motion vectors used for all previous blocks (i.e., the set of spatial motion vector prediction candidates). Ex-1004, ¶¶11-13, ¶¶15-16, ¶113. First, Rusert teaches comparing whether "the PMV candidate is a duplicate of another PMV candidate" (Ex-1004, ¶21) in the subset of PMV candidates "by comparing the candidates already in the list with the new vector that could be added" (Ex-1004, ¶71). Therefore, comparisons are made between pairs formed by the potential PMV candidate and the PMV candidates currently in the subset of PMV candidates and comparisons are not made of the potential PMV candidate with anything not in the subset of PMV candidates, such as motion vectors of previous blocks that have not been scanned yet or that were already excluded from the subset of PMV candidates. *Id*.

Second, Rusert teaches comparing whether "the PMV candidate is… within a threshold distance of an existing PMV candidate[]" in the subset of PMV candidates. Ex-1004, ¶21. Again, the comparisons made are for pairs formed by the potential PMV candidate and the PMV candidates in the subset of PMV candidates and not each motion vector for all previous blocks. *Id*. Third, Rusert teaches comparing whether "at least one alternative PMV candidate will allow motion vectors to be coded using fewer bits." *Id*. This involves comparisons of a potential PMV candidate with PMV candidates already in the subset of PMV candidates and not each motion vector for all previous blocks. *Id*. Even within the scan order, Rusert compares potential candidates with those already in the subset of PMV candidates, meaning Rusert avoids comparing each pair of candidates from the scan order. *See* Ex-1004, ¶¶11-13. Therefore, comparing motion information of a potential PMV candidate with motion information of the PMV candidates already in the subset of PMV candidates, uses less computation than comparing motion information of the PMV candidate with motion information of all previously encoded blocks and improves processor efficiency. Ex-1004, ¶12.

140. Additionally, when motion information of a PMV candidate is compared with motion information of the PMV candidates in the subset of PMV candidates, the motion information of the PMV candidate is not compared with each pair of candidates from the set of all previously-encoded blocks because the

subset of PMV candidates is limited to PMV candidates "having an allowed distance from the current block and an allowed position." Ex-1004, ¶15; *see supra* §VI.A.2.[1b]. The candidates of the previous blocks that are not within the allowed distance and not in an allowed position are not in the subset of PMV candidates and, therefore, are not compared.

141. Furthermore, Rusert teaches various scan patterns within the allowed distance, including scan patterns that exclude certain blocks within the allowed distance. *See*, *e.g.*, Ex-1004, ¶64 ("we could use only layers that are powers of two: 1, 2, 4, 8, ..."), ¶65 ("all blocks other than the corner blocks and the blocks directly above and to the left of the current block are excluded."), Figs. 3m, 3n. Because the allowed distance, the allowed position, and the scan pattern exclude candidates of blocks from consideration for potential inclusion in the subset of PMV candidates, a PMV candidate is not compared with these blocks, and there is no comparison of each pair of motion vectors from the set of all previously-encoded blocks.

142. Moreover, even within the various scan patterns that exclude certain blocks, Rusert teaches that a "scan may be terminated… as soon as a pre-defined number of unique PMV candidates have been found[.]" Ex-1004, ¶¶44-48. For example, Rusert teaches "us[ing] a maximum of four candidates in the [PMV_CANDS] list" or "us[ing] seven" as the maximum. Ex-1004, ¶107.

Limiting the maximum number of unique PMV candidates reduces "the number of bits needed to specify the candidate vector" and avoids "the problem that many vectors can be represented using several candidates, which is unnecessary." Ex-1004, ¶107. Therefore, Rusert does not compare each pair of candidates from the set of previously-encoded blocks, or even each pair of blocks within the scan order, because the scan of the previously-encoded blocks is terminated once a pre-defined number of unique PMV candidates are found. Rusert thus teaches claim 1 with the recited "set" being either (a) the previously-coded motion vectors for that frame, or (b) the full set of candidates from Rusert's scan order, because in both cases Rusert compares the selected candidate with a subset of candidates, without comparing each pair from the set of previously-coded motion vectors or the entire scan order.

143. Based on the foregoing explanations, Ground 1 teaches limitation [1c].

[1d]	**determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and**

144. Ground 1 teaches limitation [1d], as explained below.

145. Rusert teaches **determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list** (e.g., PMV_CANDS) **based on the comparing**. As I explained above, Rusert teaches at least three ways for comparing motion information of a PMV candidate with

motion information of PMV candidates in the PMV_CANDS list, which stores the subset of PMV candidates. *Supra* §VI.A.2[1c]. Rusert performs all three comparisons to determine whether to include or exclude the selected PMV candidate in the PMV_CANDS list. Ex-1004, ¶¶20-21.

146. Rusert teaches removing "unnecessary PMV candidates from the set of PMV candidates." Ex-1004, ¶20. "This ensures the length of the [PMV_CANDS] list is not unnecessarily long, which would reduce coding efficiency." Ex-1004, ¶21. "*A PMV candidate may be determined to be unnecessary* if it at least one of the following conditions is fulfilled: [1] the PMV candidate is a duplicate of another PMV candidate in the set; [2] the PMV candidate is determined to be within a threshold distance of an existing PMV candidate; and [3] the PMV candidate would never be used because at least one alternative PMV candidate will allow motion vectors to be coded using fewer bits." Ex-1004, ¶21. "Unnecessary PMV candidates are removed… because it may happen that some candidates in the list will never be used." Ex-1004, ¶90. A shorter PMV_CANDS list "allows the remaining PMV candidates to be signaled using shorter codes and so fewer bits[.]" Ex-1004, ¶¶22, 90 ("thereby making the list shorter and the average bit length of each index shorter.").

147. Rusert excludes unnecessary candidates, including the three categories explained above (duplicate PMV candidates, PMV candidates within a threshold

distance of PMV candidates in the PMV_CANDS list, and PMV candidates that have at least one alternative PMV candidate that will allow motion vectors to be coded using fewer bits), when deciding whether to add a new candidate to PMV_CANDS. Ex-1004, ¶21, ¶¶71-72; s*upra* §VI.A.2[1c]. As Rusert explains, the "PMV_CANDS list may be updated to include" PMV candidates. Ex-1004, ¶39, ¶44, ¶71, ¶87; *supra* §VI.A.2.[1c]. Here, "[u]pdate means that one or more motion vectors are added to an existing PMV_[C]ANDS list." Ex-1004, ¶39. For example, PMV candidates with "unique vectors" are inserted in the PMV_CANDS list based on an "outwards going scan[.]" Ex-1004, ¶50. As part of the "update" process whereby new candidates are added to PMV_CANDS, Rusert determines whether a selected PMV candidate should be included or skipped, meaning it is excluded because it is a duplicate, it is within a threshold distance of another PMV candidate in PMV_CANDS, or there is an alternative PMV candidate that will allow motion vectors to be coded using fewer bits. Ex-1004, ¶¶71-72; *supra* §§VI.A.2[1b]-[1c].

148. Additionally, this would have been obvious because Rusert teaches the advantages of reducing the number of candidates in PMV_CANDS using the three comparisons from [1c] (Ex-1004, ¶12, ¶21, ¶70, ¶84, ¶90), and the natural time to perform the comparisons would have been when evaluating whether or not to add a candidate to the subset of PMV candidates stored in PMV_CANDS. As

Rusert teaches, performing this check when PMV_CANDS is updated prevents "unnecessary" candidates from being added, "because it may happen that some candidates… will never be used[.]" Ex-1004, ¶90. Thus, Rusert teaches determining to include or exclude a PMV candidate in the PMV_CANDS list.

149. Based on the foregoing explanations, Ground 1 teaches limitation [1d].

[1e]	**causing information identifying the one spatial motion vector prediction candidate from the motion vector prediction list to be transmitted to a decoder or to be stored.**

150. Ground 1 teaches limitation [1e], as explained below.

151. Rusert teaches **causing information identifying the one spatial motion vector prediction candidate from the motion vector prediction list** (e.g., PMV_CANDS) **to be transmitted to a decoder or to be stored.** For example, Rusert teaches sending an index "to select a particular PMV candidate… from a list of PMV candidates, PMV_CANDS[.]" Ex-1004, ¶35. The index is stored in the video stream and transmitted "from the encoder… to the decoder[.]" *Id*.

152. As I explained above for limitation [1a], Rusert identifies and signals, using an "index," one PMV candidate from PMV_CANDS as the motion information for the current block. Ex-1004, ¶¶35-37, ¶75, ¶¶91-92, Figs. 2a-2b;

supra §VI.A.2[1a]. Rusert teaches transmitting the index to a decoder. Ex-1004, ¶¶35-37, Fig. 1:

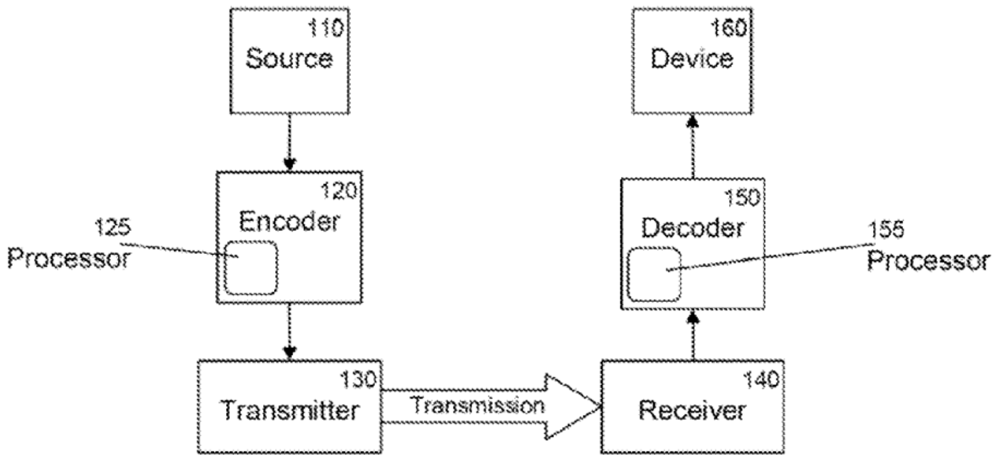


Fig. 1

For example, in Fig. 1, an "encoded video stream is sent to a transmitter… prior to transmission[,]" and "[a] receiver… receives the transmitted encoded video stream and passes this to a decoder[.]" Ex-1004, ¶34. In the encoded video stream, an "index… may be sent once together with each transmitted motion vector[.]" Ex-1004, ¶36, ¶34, Fig. 1. The decoder, "[u]sing the transmitted index,… can determine the PMV… as used in the encoder[.]" Ex-1004, ¶37.

153. Rusert teaches exemplary binary codes for the index used to identify a spatial motion vector prediction candidate from PMV_CANDS. E.g., Ex-1004, ¶¶88-102 (exemplary codes for index values shown in various tables):

Value	Index	Code
(−1,2)	0	1
(13, 4)	1	010
(12, 3)	2	011
(0, 2)	3	0010
(3, 4)	4	0011
(−4, 1)	5	0000
(4, 8)	6	0001

Table 1, for example, includes exemplary VLC codes depending on the maximum size of the PMV_CANDS list. *Id*. These types of binary codes were commonly used in video encoding to encode a value for storage in the video stream and transmission to the decoder because a video stream was a binary sequence of 1s and 0s. Therefore, index values needed to be converted from their numerical representations (e.g., 0, 1, 2, 3, 4, 5, 6) into binary codes. That is why Rusert teaches binary codes for its index values—it is information identifying a candidate from PMV_CANDS that is stored in the video stream and transmitted to the decoder. *Id.*, ¶¶91-102.

154. Furthermore, Rusert teaches "the respective lists of PMV candidates" are "stored in the encoder and decoder[.]" Ex-1004, ¶35. Corresponding indices that identify candidates from those lists would have obviously been stored as well. Representing bits in a computer fundamentally requires storage of the information in volatile or non-volatile memory, and Rusert's binary code in Table 1 above is an

example of the manner in which those indices could be stored in such memory.[6] That is how computers have operated for many decades.

155. The combination of Ground 1 applies Rusert's teachings from "blocks" (in the H.264 context) to PUs (following nomenclature in the H.265 context). *Supra* §VI.A.1 (explaining how and why Rusert and Karczewicz's teachings would have been combined).

156. Based on the foregoing explanations, Ground 1 teaches limitation [1e].

3. Dependent Claim 2

2.	**The method according to claim 1 further comprising selecting spatial motion vector prediction candidates from the set of spatial motion vector prediction candidates as the potential spatial motion vector prediction candidate in a predetermined order.**

157. Ground 1 teaches claim 2, as explained below.

158. As I have explained above, the combination of Rusert and Karczewicz teaches claim 1.

159. Rusert teaches **selecting spatial motion vector prediction candidates from the set of spatial motion vector prediction candidates as the potential spatial motion vector prediction candidate**. As I explained above for

[6] For example, to convert a digit to a binary code, the computer takes the input of a digit and stores it in the memory. After the digit is converted to a binary code, the binary code is also stored in the memory for transmission or further processing.

limitation [1a], Rusert teaches selecting a first spatial motion vector prediction candidate from the set of spatial motion vector prediction candidates for a block of pixels as a potential spatial motion vector prediction candidate. *Supra* §VI.A.2[1a]. Rusert also teaches selecting a sequence of spatial motion vector prediction candidates from the set of spatial motion vector prediction candidates by scanning "a plurality of blocks surrounding a current block." Ex-1004, ¶30, ¶40 ("an outwards going scan may be performed around the current block to obtain motion vectors to update PMV_[C]ANDS."), ¶¶51-66 (describing various scan patterns).

160. Rusert further teaches **selecting** … **in a predetermined order.** For example, Rusert teaches "a simple procedure to scan the candidates in order[.]" Ex-1004, ¶58. In particular, Rusert teaches "scan patterns… for a plurality of blocks surrounding a current block[.]" Ex-1004, ¶30, ¶40, ¶¶51-66. Rusert provides example scan patterns in Fig. 3a through Fig. 3n, with Fig. 3n shown below:

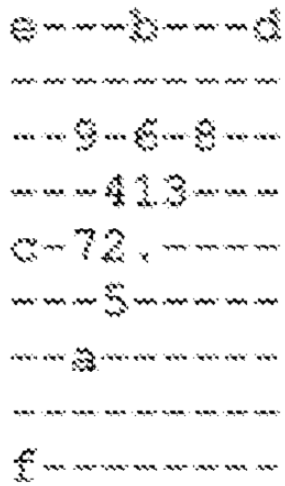


Fig. 3n

161. For example, for the scan pattern illustrated in Fig. 3c, Rusert teaches scanning "blocks in the following order: 1, 2, 9, h, j, l, m." Ex-1004, ¶54, Fig. 3c:

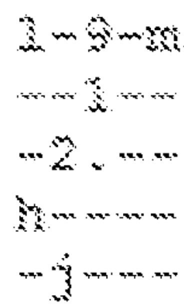


Fig. 3c

Rusert teaches this scan pattern "select[s] blocks in an order that took the closest ones first" with "considerations… that only a subset of blocks have valid motion vectors." Ex-1004, ¶¶53-54. As another example, Rusert teaches a search pattern with "an ordering as shown in FIG. 3n" which goes 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f. Ex-1004, ¶¶65-66, Fig. 3n. Rusert teaches this search pattern "has been found to combine good compression efficiency (i.e., finding good motion vectors) with good computation performance." Ex-1004, ¶66.

162. When discussing the scan patterns illustrated in Figs. 3a-3n, Rusert discusses the various known tradeoffs associated with these scan patterns. *See* Ex-1004, ¶¶51-65. In the end, Rusert teaches using its exemplary scan patterns, despite potential drawbacks, and a POSITA would have understood that each scan pattern was known and available to use as a predetermined scan pattern for scanning blocks. That Rusert teaches the approaches in view of known drawbacks is evidence that their benefit outweighs such drawbacks, and that various patterns were known and used in different scenarios. Thus, Figs. 3a-3n illustrate predetermined orders by which to scan "blocks surrounding a current block[.]" Ex-1004, ¶30.

163. Based on the foregoing explanation, Rusert teaches claim 2.

4. Dependent Claim 3

3.	**The method according to claim 1, further comprising comparing motion information of the potential spatial motion vector prediction candidate with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates.**

164. Ground 1 teaches claim 3, as explained below.

165. As I have explained above, the combination of Rusert and Karczewicz teaches claim 1, including [1c]: comparing motion information of the first spatial

motion vector prediction candidate with motion information of spatial motion vector prediction candidates in the determined subset of spatial motion vector prediction candidates without making a comparison of each pair from the set of spatial motion vector prediction candidates. *Supra* §VI.A.2[1c]. Rusert teaches at least three comparisons: (1) whether "the PMV candidate is a duplicate of another PMV candidate" in the PMV_CANDS list; (2) whether "the PMV candidate is… within a threshold distance of an existing PMV candidate[]"; and (3) whether "at least one alternative PMV candidate will allow motion vectors to be coded using fewer bits." *Id.*; e.g., Ex-1004, ¶21.

166. Rusert further teaches comparing motion information of the candidate with **at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates**. For example, Rusert teaches a scan sequence for evaluating whether to include or exclude spatial motion vector prediction candidates from neighboring blocks in PMV_CANDS. *Supra* §VI.A.2[1a]; Ex-1004, ¶44, ¶¶51-66, Figs. 3a-3n. Rusert teaches that the "PMV_CANDS list may be initialized e.g. as an empty list (zero entries)[.]" Ex-1004, ¶39. PMV_CANDS is then "updated to include previously coded motion vectors[.]" *Id*. This update is based on "an outwards going scan… around the current block to obtain motion vectors to update PMV_[C]ANDS." Ex-1004, ¶44.

Rusert performs its comparisons, e.g., checking for duplicates, "when updating the list[.]" Ex-1004, ¶71; *supra* §VI.A.2[1c].

167. Thus, Rusert begins the scan with a first PMV candidate, e.g., labelled "1" in Figs. 3a-3n, and considers whether to update PMV_CANDS with the first candidate. Ex-1004, ¶39. The scan then moves to the second PMV candidate, which is "compar[ed with] the candidates already in the list[.]" Ex-1004, ¶71. Here, for the second candidate, the PMV_CANDS list includes at most one other spatial motion vector prediction candidate: the first candidate. *See id.* Therefore, the motion information of the second PMV candidate in the sequence is compared with the motion information of at most one other PMV candidate (the first PMV candidate). Ex-1004, ¶21, ¶¶38-40, ¶44. Furthermore, Rusert teaches "the number of candidates in PMV_CANDS may be limited to a pre-defined or dynamically obtained number." Ex-1004, ¶73, ¶¶84-90. With a maximum number of two candidates, the scan would end once two PMV candidates are added to PMV_CANDS, so any potential PMV candidate would be compared with at most one other PMV candidate, the PMV candidate already in PMV_CANDS. It would have been obvious to a POSITA to choose two as a maximum number because it would allow the PMV candidate to use as motion information for the current block to be signaled with one bit (e.g., "0" or "1"). *See* Ex-1004, ¶77.

168. Based on the foregoing explanations, Ground 1 teaches claim 3.

5. Dependent Claim 4

4.	**The method according to claim 1 further comprising examining whether the block of pixels is divided into a first prediction unit and a second prediction unit; and if so, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the prediction unit is the second prediction unit.**

169. As I have explained above, Ground 1 teaches claim 1. Ground 2 further teaches claim 4. *Supra* §VI.A.1 (explaining how and why Lin's teachings would have been applied to the combination of Rusert and Karczewicz).

170. Ground 2 teaches **examining whether the block of pixels is divided into a first prediction unit and a second prediction unit.** For example, Lin teaches that, in H.265/HEVC, "[t]he basic unit for compression, termed Coding Unit (CU), is a 2Nx2N square block, and… [e]ach CU contains one or multiple Prediction Units (PUs)" with divisions "correspond[ing] to horizontal and vertical partition[s.]" Ex-1006, ¶4; Ex-1013, 000007. When a CU is not divided, the CU corresponds to a single PU. When a CU is divided horizontally, the 2Nx2N square is divided in half into two symmetric PU rectangles having dimensions of 2NxN. Likewise, when a CU is divided vertically, the 2Nx2N square is divided into two symmetric PU rectangles of Nx2N size. *Id.*; Ex-1013, 000016. Lin teaches both examples, where the block of pixels is divided into two prediction units: a first PU ("PU1") and a second PU ("PU2"). *Id.*; Ex-1006, ¶25, ¶44, Figs. 7A-7D; Ex-1013,

000010, 000017. This limitation is also satisfied the other way around, where the claimed "first" PU is PU2 and the claimed "second" PU is PU1.

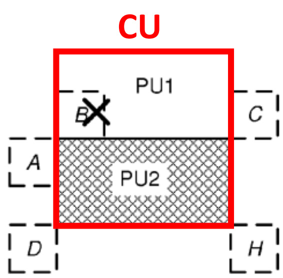


Fig. 7A

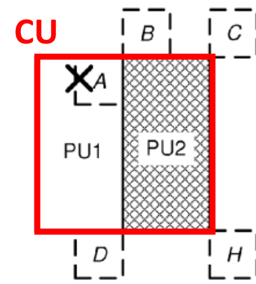


Fig. 7B

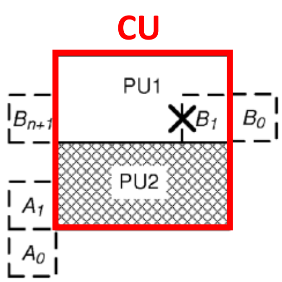


Fig. 7C

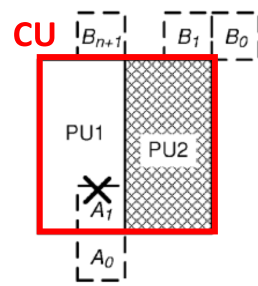


Fig. 7D

171. Lin "*identifies* and removes redundant MVP candidates" by examining the CU for "scenario[s] that multiple partitioned PUs… may cause the current PU to be… considered redundant and can be removed without comparing the [motion vector] values." Ex-1006, ¶44; Ex-1013, 000010, 000017. These scenarios include a CU divided horizontally into two prediction units ("2NxN") or vertically into two prediction units ("Nx2N") where, "for the second 2NxN,… Nx2N… PU, one or more of the MVP candidates are redundant and removed if

said one or more of the MVP candidates located within the previous (first) 2NxN,… Nx2N… PU." Ex-1006, ¶25; Ex-1013, 000009-11. Lin teaches examining whether a block of pixels is divided horizontally or vertically into two prediction units to exclude redundant motion vector predictor candidates, as further explained below.

172. Ground 2 teaches **and if so, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the prediction unit is the second prediction unit.** For example, Lin examines whether (i) the current block is divided into two PUs and (ii) the spatial motion vector prediction candidate is from the other PU; if so, Lin teaches excluding the candidate from the motion vector prediction list. As illustrated in Figs. 7A-7D below, "the second PU of 2NxN [and] Nx2N… can be removed without comparing the values of MVs[]" because "the MVP candidates of a current PU that may cause the current PU to be merged with other PUs… is considered redundant and can be removed without comparing the MV values." Ex-1006, ¶44, ¶25, Fig. 7A-7D; Ex-1013, 000010, 000017.

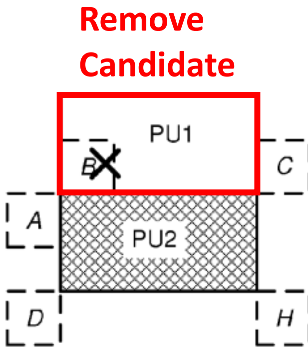


Fig. 7A

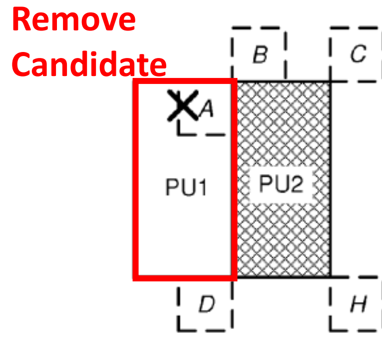


Fig. 7B

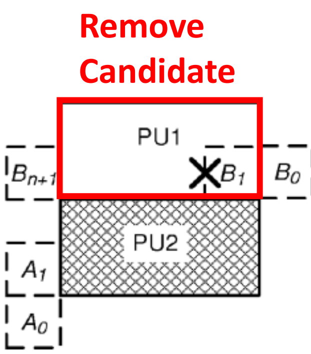


Fig. 7C

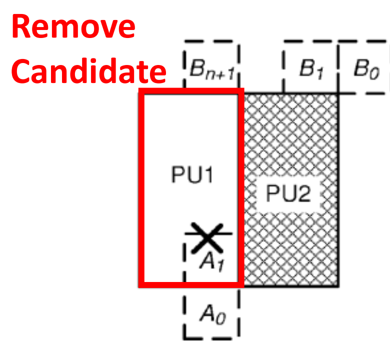


Fig. 7D

173. In particular, Lin teaches that, for "FIG. 7A, MVP B for the second 2NxN PU in the 2NxN… can be removed to avoid the duplication." Ex-1006, ¶44; Ex-1013, 000010. Likewise, "[i]n FIG. 7C, MVP B_1 for 2NxN PU2… is determined to be redundant and is removed from the MVP candidate set." *Id.*; Ex-1013, 000017. Similarly, MVP A for PU2 in the Nx2N in Fig. 7B and "MVP A_1 in FIG. 7D… are determined to be redundant and are removed from the MVP candidate set, respectively." *Id.* Therefore, Lin teaches examining whether the

block is divided into two PUs (e.g., 2NxN and Nx2N), and if so, removing the MVP candidate of the second PU from the MVP candidate set because it is redundant.

174. This concept was obvious in view of the reason why a CU is divided to begin with. CUs do not have to be divided—in the simplest case, one CU comprises one PU (they are commensurate in size). Ex-1006, ¶4 ("Each CU contains one or multiple Prediction Units (PUs)."); Ex-1013, 000007; Ex-1005, ¶35 ("A CU… may include one or more prediction units (PUs)."). If the block has uniform motion, there is no reason to divide it into multiple PUs. Conversely, if different parts of the block are moving in different directions, the CU can be divided into multiple PUs so that each can have a different motion vector. Ex-1006, ¶4. In other words, the block is divided into two PUs when each half of the block has different motion. If a block is divided into two PUs because its two portions have differing motion vectors, there is no way that the motion vector corresponding to one of these PUs can be a good predictor for the motion of the other PU. Therefore, when analyzing potential motion vectors for half of a block (that has been divided into two PUs), Lin explains that the motion vector from the other half can be removed. Ex-1006, ¶25, ¶44; Ex-1013, 000010. Lin explains that assigning the same motion vector to both halves of a divided block is redundant to the scenario where the block was not divided at all and the same

motion vector was applied to the entire block comprising one PU. That is why Lin teaches "remov[ing] redundant [motion vector predictor] candidates." Ex-1006, ¶44; Ex-1013, 000010.

175. In the combination of Ground 2, it would have been obvious to a POSITA to combine Lin's teachings with Rusert and Karczewicz to remove redundant PMV candidates from PMV_CANDS. *Supra* §VI.A.1 (explaining how and why the teachings of the references would have been combined). In particular, a POSITA would have been motivated to apply Lin's teachings of excluding candidates from the other PU when a block is divided into two PUs, as explained above, to Ground 1's process for selecting PMV candidates. *See id.*

176. Based on the foregoing explanations, Ground 2 teaches claim 4.

6. Dependent Claim 5

177. Ground 1 teaches claim 5, as explained below.

5[pre]. The method according to claim 1, further comprising

178. As I explained above, the combination of Rusert and Karczewicz teaches the method of claim 1. *Supra* §VI.A.2. Therefore, the combination teaches the preamble of claim 5.

[5a]	**determining a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list; and**

179. Ground 1 teaches limitation [5a], as explained below. The spatial motion vector prediction candidates (e.g., PMV candidates) and motion vector prediction list (e.g., PMV_CANDS) were explained for claim 1. *Supra* §VI.A.2[1a], §VI.A.3.

180. Rusert teaches **determining a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list** (e.g., PMV_CANDS). For example, Rusert teaches "the number of candidates in PMV_CANDS *may be limited* to a pre-defined or dynamically obtained number." Ex-1004, ¶73, ¶¶84-90. As some examples, Rusert teaches "a maximum of four candidates in the list" and "us[ing] seven" for a maximum. Ex-1004, ¶107. Rusert also teaches that "it is possible that PMV_CANDS list size is set to one, such that no bits need to be sent for index signaling." Ex-1004, ¶77.

181. Rusert teaches several benefits to determining a maximum number of candidates for PMV_CANDS. For example, "[l]imiting and/or reducing the number of candidates in PMV_CANDS can be helpful to reduce the overhead of signaling which PMV is used for motion vector prediction, since shorter lists require shorter code words." Ex-1004, ¶84, ¶70, ¶13 ("The size of the PMV candidate list is limited because a very large list would require long code words to

identify which PMV candidate to use[.]"). With "a bigger maximum,… the number of bits needed to specify the candidate vector also increases" and "many vectors can be represented using several candidates, which is unnecessary." Ex-1004, ¶107. By determining a maximum number of candidates, Rusert balances between "chances increas[ing] that a suitable vector can be found" and "redundant representation" that "grows the more vectors are added." Ex-1004, ¶107. In short, Rusert teaches determining a maximum number of candidates for PMV_CANDS, e.g., 4 candidates, to balance the increased chance of a suitable match with the increased cost of using longer code words. *Id.*

182. Rusert teaches variable-length coding ("VLC") examples for index values which vary based on the "Maximum list size C" of PMV_CANDS. Ex-1004, ¶88 (Table 1). "The VLC table used can depend on the maximum number of candidates in PMV_[C]ANDS (the list size), as e.g. dynamically adapted according to the methods above." Ex-1004, ¶88. "Table 1 below presents some examples for VLC codes for different maximum list sizes. The left column shows the maximum list size, also denoted as C. In the right column, the VLC codes are shown along with indexes to address candidates in the PMV_CANDS list." *Id.* Therefore, Rusert teaches determining a maximum number of candidates to be included in PMV_CANDS, e.g. as denoted by "C," which dictates the encoding table for index

values and controls the maximum number of candidates in the PMV_CANDS list. *Id.*

183. Based on the foregoing explanations, Rusert teaches limitation [5a].

[5b]	**limiting the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number.**

184. Ground 1 teaches limitation [5b], as explained below.

185. Rusert teaches **limiting the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number**. For example, Rusert teaches "an outwards going scan… to obtain motion vectors to update PMV_[C]ANDS… may be terminated… as soon as a pre-defined number of unique PMV candidates have been found[.]" Ex-1004, ¶¶44-48. By terminating the scan "as soon as a pre-defined number of unique PMV candidates have been found," the number of PMV candidates in PMV_CANDS is limited to the pre-defined number, which is the maximum number, because no additional PMV candidates are considered for inclusion in PMV_CANDS. *Id.*

186. In addition, Rusert teaches that "the candidate at the end of the PMV_CANDS list may be removed" in order to limit "the number of candidates in PMV_CANDS… to a pre-defined… number[.]" Ex-1004, ¶73. Thus, the number of PMV candidates in PMV_CANDS is smaller or equal to the maximum number

because candidates are removed in order to limit the number of PMV candidates to the maximum number. Moreover, by teaching a "maximum" number of candidates in the PMV_CANDS list, Rusert teaches a limit (the maximum) to the number of candidates in the list.

187. Rusert further teaches VLC examples based on the "Maximum list size C" of PMV_CANDS. Ex-1004, ¶88 (Table 1). "The VLC table used can depend on the maximum number of candidates in PMV_[C]ANDS (the list size), as e.g. dynamically adapted according to the methods above." Ex-1004, ¶88. "Table 1 below presents some examples for VLC codes for different maximum list sizes. The left column shows the maximum list size, also denoted as C. In the right column, the VLC codes are shown along with indexes to address candidates in the PMV_CANDS list." *Id.* Therefore, Rusert teaches limiting the number of candidates in PMV_CANDS to be smaller or equal to the maximum number, e.g. as denoted by "C," in accordance with the encoding tables in Table 1. *Id.* For example, when the maximum list size C is 4, Table 1 lists encodings for four index values to encode up to four values in PMV_CANDS. None of the encodings exceed the maximum list size C.

188. Based on the foregoing explanations, Rusert teaches limitation [5b].

7. Dependent Claim 6

6[pre]. The method according to claim 5 comprising:

189. Ground 1 teaches claim 6, as explained below.

190. As I explained above, the combination of Rusert and Karczewicz teaches the method of claim 5. *Supra* §VI.A.6. Therefore, the combination of Rusert and Karczewicz teaches the preamble of claim 6.

[6a]	**examining, if the number of spatial motion vector prediction candidates in the motion vector prediction list smaller than the maximum number;**

191. Ground 1 teaches limitation [6a], as explained below.

192. Rusert teaches **examining, if the number of spatial motion vector prediction candidates in the motion vector prediction list [is] smaller than the maximum number**. As I explained above with respect to claim 5, Rusert teaches determining a maximum number of PMV candidates for PMV_CANDS and limiting the number of PMV candidates in PMV_CANDS to the maximum number. Ex-1004, ¶13, ¶¶44-48, ¶70, ¶73, ¶77, ¶¶84-90, ¶107; *supra* §VI.A.6 (claim 5). For example, Rusert examines if the number of candidates in PMV_CANDS is smaller than the maximum number when determining whether to continue its scan for additional PMV candidates. Rusert teaches "terminat[ing]" a scan for new candidates "as soon as a pre-defined number of unique PMV candidates have been found[.]" Ex-1004, ¶¶44-48. Here, "an outwards going scan… around the current block" is performed to obtain PMV candidates "to

update PMV_[C]ANDS[,]" and the number of PMV candidates in PMV_CANDS is examined to determine whether to continue or terminate the scan. *Id*. If the number of PMV candidates is less than the maximum number, or the "pre-defined number of unique PMV candidates[,]" then the scan continues; but if the number of PMV candidates is equal to the maximum number, then the scan is "terminated[.]" *Id*.

193. In addition, Rusert teaches that "the candidate at the end of the PMV_CANDS list may be removed" in order to limit "the number of candidates in PMV_CANDS… to a pre-defined… number." Ex-1004, ¶73. Thus, Rusert teaches examining if the number of PMV candidates in PMV_CANDS is smaller than the maximum number to determine whether to remove a PMV candidate for another PMV candidate or to add the other PMV candidate.

194. Based on the foregoing explanations, Ground 1 teaches limitation [6a].

[6b]	**if so, examining whether the prediction unit to which the potential spatial motion vector prediction candidate belongs is available for motion prediction;**

195. Ground 1 teaches limitation [6b], as explained below.

196. Ground 1 teaches **examining whether the prediction unit to which the potential spatial motion vector prediction candidate belongs is available for motion prediction.** While scanning blocks for new candidates, Rusert

examines whether the block to which a potential candidate belongs is available for motion prediction because motion vectors are not available for some blocks. For example, Rusert teaches three exemplary reasons why a block would be unavailable for motion prediction, any one of those teachings satisfies this limitation.

197. First, Rusert teaches that blocks "coded after the present block[]" "would never be available[.]" Ex-1004, ¶54. For example, blocks below and to the right of the current block would be coded after the present block. *Id.* Quite simply, these blocks are never available because they have not been coded yet and therefore do not have any motion information for motion prediction. No motion vector has been assigned to those blocks yet and therefore the blocks cannot provide a motion vector candidate.

198. Second, blocks are "sometimes… available depending upon the traversal pattern used[.]" Ex-1004, ¶54. Depending on the pattern used to reach the current block, some blocks would not be coded yet, and similar to the first condition explained above, these blocks do not have any motion information for motion prediction.

199. Third, Rusert teaches that blocks that have "no motion vector present" or have "the same [motion vector] as a block earlier in the sequence" are not available. Ex-1004, ¶54. Blocks that have no motion vector present do not have

motion information for motion prediction and cannot provide a motion vector candidate. Since Rusert seeks to avoid duplicates, blocks that have the same motion vector as a block earlier in the sequence are not available for motion prediction.

200. Thus, with any of these considerations, Rusert teaches examining whether a block is available for motion prediction.

201. In the context of Rusert's nomenclature, Rusert's block is a prediction unit because it is the unit for which a motion vector is assigned for motion prediction. Ex-1004, ¶¶2-5, ¶36, ¶43; *supra* §VI.A.2[1a] (explaining PUs and Rusert's blocks). Therefore, Rusert teaches this limitation.

202. Additionally, the combination of Ground 1 applies Rusert's motion vector teachings to Prediction Units. *Supra* §VI.A.1 (explaining how and why Rusert and Karczewicz's teachings would have been combined), §VI.A.2[1a] (explaining application of block and PU teachings); Ex-1004, ¶¶3-4, ¶36; Ex-1005, ¶¶33-36, ¶¶64-66. As Karczewicz explains, H.265 introduced terminology for a "prediction unit," which was a type of block, and motion vectors were assigned to PUs. Ex-1005, ¶¶33-36; *supra* §I. Therefore, it would have been obvious to apply Rusert's motion vector teachings to PUs, and the combination of Ground 1 teaches examining whether the prediction unit, to which the potential spatial motion vector prediction candidate belongs, is available for motion prediction.

203. Furthermore, this would have been obvious based on the teachings of Rusert and Karczewicz. As explained above, Rusert teaches three reasons for examining whether a block is available for motion prediction as part of its process for finding and evaluating potential spatial motion vector prediction candidates, and Karczewicz teaches that, in H.265, the block for which motion vectors are assigned is called a PU. Ex-1005, ¶¶33-36, ¶¶64-66. Therefore, when scanning for potential spatial motion vector prediction candidates as Rusert teaches, it would have been obvious to scan PUs in the H.265 context, and it would have been obvious to examine whether the PU is available for motion prediction, using the various criteria Rusert teaches.

204. Based on the foregoing explanations, Ground 1 teaches limitation [6b].

[6c]	**if so, performing at least one of the following:**
…	
[6k]	**for a potential spatial motion vector prediction candidate, which is below the potential spatial motion vector prediction candidate on the left side of the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit;**
…	

205. Limitation [6c] requires "performing at least one of the following." Therefore, I understand that this limitation is satisfied if the following claim requirement (limitation [6k]) is satisfied:

> **for a potential spatial motion vector prediction candidate, which is below the potential spatial motion vector prediction candidate on the left side of the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit;**

206. Ground 1 teaches this limitation, as explained below. As an initial matter, in the context of Rusert's nomenclature, Rusert's block is a prediction unit because it is the unit for which a motion vector is assigned for motion prediction. Ex-1004, ¶¶2-5, ¶36, ¶43. Additionally, the combination of Ground 1 applies

Rusert's motion vector teachings to Prediction Units. *Supra* §VI.A.1 (explaining how and why Rusert and Karczewicz's teachings would have been combined), §VI.A.2[1a] (explaining application of block and PU teachings); Ex-1004, ¶¶3-4, ¶36; Ex-1005, ¶¶33-36, ¶¶64-66. As Karczewicz explains, H.265 introduced terminology for a "Prediction Unit," which was a type of block, and motion vectors were assigned to PUs. Ex-1005, ¶¶33-36; *supra* §I. Therefore, when Rusert teaches its scanning and analysis process for motion vectors from various blocks, it would have been obvious to apply those teachings to PUs in the H.265 context because motion vectors were assigned on a PU basis in H.265. *Id.*

207. If Rusert's scan continues (the number of candidates in PMV_CANDS is less than a pre-defined number), Ground 1 applies the below-explained teachings **for a potential spatial motion vector prediction candidate, which is below the potential spatial motion vector prediction candidate on the left side of the prediction unit**. For example, Rusert teaches a scan pattern in Fig. 3n, illustrated below, that "has been found to combine good compression efficiency (i.e., finding good motion vectors) with good computation performance." Ex-1004, ¶66. As illustrated in Fig. 3n, the current block is "." (highlighted red below); the scan starts with a PMV candidate above the current block (e.g., block "1"), then scans a PMV candidate left of the current block (e.g., block "2") second, and so on, progressing through blocks "3," "4," and then "5."

Ex-1004, ¶¶65-66, Fig. 3n. The PMV candidate for block "5" (highlighted green below) is below the PMV candidate for block "2" (highlighted blue below), which is on the left side of the current block (in red). *Id.*:

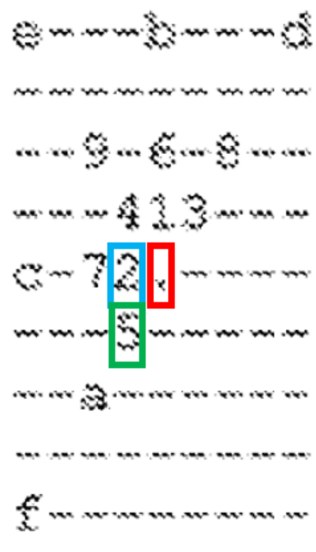


Fig. 3n

208. Therefore, Rusert analyzes a potential spatial motion vector prediction candidate (e.g., the PMV candidate from block "5" highlighted in green) which is below the potential PMV candidate on the left (e.g., from block "2" highlighted in blue) of the current block (e.g., block "." highlighted in red) for which candidates are being evaluated. Ex-1004, ¶66, Fig. 3n. As explained above, these blocks are prediction units, and Ground 1 applies these teachings to PUs in the H.265 context.

209. Ground 1 teaches **excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion**

information than the spatial motion vector prediction candidate on the left side of the prediction unit. For example, when analyzing a new PMV candidate, Rusert teaches "comparing the [PMV] candidates already in [PMV_CANDS] with the new [PMV candidate] that could be added, and if a duplicate is found,… skipping the new [PMV candidate]." Ex-1004, ¶¶71-72, ¶21, ¶62 ("It has been identified as advantageous to discard such duplicates.").

210. Rusert analyzes new PMV candidates following a scan order of nearby blocks, including the pattern of Fig. 3n illustrated below. Block 1 is analyzed first, then blocks 2, 3, and 4 in that order, adding candidates from those blocks to PMV_CANDS. When the 5th block is analyzed (highlighted green), Rusert will already have analyzed blocks 1, 2, 3, and 4. Ex-1004, ¶44, ¶¶65-66, Fig. 3n. Therefore, when Rusert evaluates whether to update PMV_CANDS with the spatial motion vector prediction candidate from block 5, Rusert compares the new candidate with the candidates already in PMV_CANDS, e.g., the candidates from blocks 1, 2, 3, and 4, to determine if it is a duplicate or within a threshold distance (meaning it is within a similarity measure) of an existing candidate in PMV_CANDS. Ex-1004, ¶¶71-72. This comparison includes a comparison of the PMV candidate from block 5 with the PMV candidate from block 2, and Rusert excludes the potential spatial motion vector prediction candidate for block 5 from PMV_CANDS if it is a duplicate or within a similarity threshold as compared to

the candidate on the left side of the PU (block 2). *Id.* In short, for the scan pattern of Fig. 3n, Rusert teaches excluding the PMV candidate below the PMV candidate to the left of the current block from PMV_CANDS if it is essentially similar (e.g., a duplicate or within a threshold distance) compared to the PMV candidate to the left. Ex-1004, Fig. 3n:

Fig. 3n

211. Rusert looks to whether the candidates are essentially similar by looking at whether they are duplicates or within a threshold distance. Indeed, Rusert uses its threshold comparison to "skip[] new motion vectors … that are similar but not equal, such as pairs of motion vectors *that have a similarity measure* smaller than a pre-defined threshold…" Ex-1004, ¶72. Therefore Rusert looks to whether candidates are essentially similar. *Id.*

212. Based on the foregoing explanations, Ground 1 teaches limitations [6c]-[6o].

8. Dependent Claim 7

7.	**The method according to claim 1 further comprising including a temporal motion prediction candidate into the motion vector prediction list.**

213. Ground 1 teaches claim 7, as explained below.

214. As I explained above, the combination of Rusert and Karczewicz teaches claim 1.

215. Rusert further teaches **including a temporal motion prediction candidate into the motion vector prediction list**. For example, Rusert teaches that "[m]otion vectors to be added to a PMV_CANDS list may comprise spatial or *temporal neighbors of the current block,* or combinations of spatial and/or temporal neighbors[.]" Ex-1004, ¶67. These teachings are consistent with "[e]xisting approaches" to motion prediction that "typically use motion vectors from spatially surrounding blocks or *temporally neighboring blocks* (co-located blocks in neighboring frames)." Ex-1004, ¶5. By including candidates from temporally-neighboring blocks in neighboring frames, e.g., frames that are close in time before and after the current frame, Rusert includes temporal candidates including candidate motion vectors obtained from a previously-encoded frame. *Supra* §V.B.

216. Based on the foregoing explanations, Ground 1 teaches claim 7.

9. Dependent Claim 8

8.	**The method according to claim 1 further comprising selecting one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the block of pixels.**

217. Ground 1 teaches claim 8, as explained below.

218. As I have explained above, the combination of Rusert and Karczewicz teaches claim 1.

219. Rusert further teaches **selecting one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the block of pixels**. For example, Rusert teaches "signaling which PMV [candidate] is used for motion vector prediction[.]" Ex-1004, ¶84; *supra* §§VI.A.2[1a], [1e]. "[A] code 'index'… is sent to *select* a particular PMV candidate… from a list of PMV candidates, PMV_CANDS" and the particular PMV candidate is used to "reconstruct MV=DMV+PMV" for the current block of pixels. Ex-1004, ¶¶36-37. Therefore, a PMV candidate is selected from PMV_CANDS using an index, and the selected PMV candidate represents the "predicted motion vector (PMV)" used to reconstruct the motion vector for a block. *Id.,* ¶36. Therefore, Rusert teaches selecting one motion vector prediction candidate from PMV_CANDS to represent a motion vector prediction for the block of pixels.

220. Additionally, Rusert teaches exemplary codes to signal the index of the selected candidate from PMV_CANDS. Ex-1004, ¶¶88-102 (exemplary codes for index values to signal which candidate from PMV_CANDS is used for motion information). For example, Table 1 includes codes for lists of various sizes including codes to indicate the first, second or third candidate in a list size of 3 candidates. *Id.,* ¶88.

221. Based on the foregoing explanations, Ground 1 teaches claim 8.

10. Independent Claim 15

[15pre] An apparatus comprising a processor and a memory including computer program code, the memory and the computer program code configured to, with the processor, cause the apparatus to:

222. To the extent that the preamble is limiting, Ground 1 teaches limitation [15pre], as explained below.

223. Rusert teaches an **apparatus comprising a processor and a memory including computer program code, the memory and computer program code is configured to, with the processor, cause the apparatus to.** For example, Rusert teaches "[t]he present application relates to … a video encoding apparatus, a video decoding apparatus, and a computer-readable medium." Ex-1004, ¶1; *see also* Ex-1004, ¶¶24-27, ¶114, ¶116, claim 17, claim 18. The "video encoding apparatus compris[es] a processor" and that the "video decoding apparatus compris[es] a processor[.]" Ex-1004, ¶¶24-25. Rusert further teaches "a

computer-readable medium, carrying instructions, which, when executed by computer logic," such as a processor, "causes said computer logic to carry out any of the methods disclosed herein." Ex-1004, ¶26. Therefore, Rusert teaches an "apparatus comprising a processor" and memory "carrying instructions" that cause the apparatus to "carry out any of the methods disclosed herein." Ex-1004, ¶¶24-26. At the very least, it would have been obvious to a POSITA for a video encoder and a video decoder to include a processor and a memory, such as a hard drive, to execute software because conventional computers have included processors and memory for this purpose for decades.

224. Based on the foregoing explanations, Ground 1 teaches the preamble of claim 15.

[15a]	**select a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for a block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates and is utilized to identify motion vector prediction candidates of which one spatial motion vector prediction candidate from the motion vector prediction list is signaled as the motion information for the prediction unit;**

225. Ground 1 teaches limitation [15a]. Limitation [15a] is identical to limitation [1a], except that limitation [15a] recites "select" while limitation [1a]

recites "selecting." For the same reasons I have discussed for limitation [1a], Ground 1 teaches limitation [15a]. *Supra* §VI.A.2[1a].

[15b]	**determine a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;**

226. Ground 1 teaches limitation [15b], as explained below.

227. Limitation [15b] is substantially similar to limitation [1b]. Their differences are shown below:

15[b]	**1[b]**
determine a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;	determining a subset of spatial motion vector prediction candidates based on a location of the block associated with the first spatial motion vector prediction candidate;

228. Limitation [15b] recites "*the* location of the block," which lacks an antecedent basis and refers to the only location of the block. This limitation is taught for the same reasons that "*a* location of the block" of limitation [1b] is taught, because both limitations reference the location of the block of pixels and neither claim requires a second location of the block.

229. At the very least, Ground 1 teaches limitation [15b] for the reasons I explained for limitation [1b]. *Supra* §VI.A.2[1b].

[15c]	**compare motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;**

230. Ground 1 teaches limitation [15c], as explained below.

231. Limitation [15c] is substantially similar to limitation [1c]. Their differences are shown below:

15[c]	**1[c]**
compare motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;	comparing motion information of the first spatial motion vector prediction candidate with motion information of spatial motion vector prediction candidates in the determined subset of spatial motion vector prediction candidates without making a comparison of each pair from the set of spatial motion vector prediction candidates;

232. As an initial matter, "*the* spatial motion vector prediction *candidate*" of limitation [15c] lacks antecedent basis. "*[T]he* spatial motion vector prediction *candidate*" is rendered obvious for the same reasons that "spatial motion vector prediction candidates" is rendered obvious, since both limitations reference a spatial motion vector prediction candidate in the determined subset.

233. As I explained above, the subset of spatial motion vector prediction candidates determined in limitation [1b]/[15b] is satisfied by a subset of one or

more spatial motion vector prediction candidates. *Supra* §V.D. Ground 1 teaches limitation [15c] for the same reasons limitation [1c] is taught. *Supra* §VI.A.2[1c].

234. Furthermore, "each *possible candidate* pair" is taught by Rusert for the same reasons that "each pair" is taught by Rusert, because a comparison of each pair from the set is a comparison of each possible candidate pair from the set.

235. At the very least, it would be obvious that Ground 1 teaches limitation [15c], for the same reasons I explained for limitation [1c]. *See* §VI.A.2[1c].

[15d]	**determine to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on comparison of the motion information of the first spatial motion vector candidate with motion information of the spatial motion vector prediction candidate; and**

236. Ground 1 teaches limitation [15d], as explained below.

237. Limitation [15d] is substantially similar to limitation [1d]. Their differences are shown below:

15[d]	1[d]
determine to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on comparison of the motion information of the first spatial motion vector candidate with motion information of the spatial motion vector prediction candidate; and	determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and

238. Limitation [1d] refers back to "the comparing" of limitation [1c]. Limitation [15d] is nearly identical to [1d], but instead of referring back to [15c], it simply repeats the language from [15c], which recites a step to "compare motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate."

239. Therefore, limitation [15d] is nearly identical to limitation [1d]. The minor differences, shown above, do not affect my analysis that Grounds 1 and 2 teach limitation [15d].

240. Therefore, for the same reasons I have discussed for limitation [1d], Ground 1 teaches limitation [15d]. *Supra* §VI.A.2[1d].

[15e]	**cause information identifying the one spatial motion vector prediction candidate from the motion vector prediction list to be transmitted to a decoder or to be stored.**

241. Ground 1 teaches limitation [15e]. Limitation [15e] is identical to limitation [1e], except that limitation [15e] recites "cause" while limitation [1e] recites "causing." For the same reason I have discussed for limitation [1e], Ground 1 teaches limitation [15e]. *Supra* §VI.A.2[1e].

11. Dependent Claim 16

242. Ground 1 teaches claim 16. Claim 16 is identical to claim 2, except that claim 2 recites "the method according to claim 1 further comprising selecting …," while claim 16 recites "the apparatus according to claim 15 wherein the

apparatus is further caused to select…" I addressed the apparatus of claim 15 above. *Supra* §VI.A.10. The rest of claim 16 is satisfied for the same reasons I explained for claim 2. *Supra* §VI.A.3.

12. Dependent Claim 17

243. Ground 1 teaches claim 17. Claim 17 is identical to claim 3, except that claim 3 recites "the method according to claim 1 further comprising comparing …," while claim 17 recites "the apparatus according to claim 15 wherein the apparatus is further caused to compare…" I addressed the apparatus of claim 15 above. *Supra* §VI.A.10. The rest of claim 17 is satisfied for the same reasons I explained for claim 3. *Supra* §VI.A.4.

13. Dependent Claim 18

244. Ground 1 teaches claim 18. Claim 18 is identical to claim 4, except that claim 4 recites "the method according to claim 1 further comprising examining …" and "excluding," whereas claim 18 recites "the apparatus according to claim 15 wherein the apparatus is further caused to examine…" and "exclude." I addressed the apparatus of claim 15 above (*supra* §VI.A.10), and the rest of claim 18 is satisfied for the same reasons I explained for claim 4. *Supra* §VI.A.5.

14. Dependent Claim 19

245. Ground 1 teaches claim 19. Claim 19 is identical to claim 5, except that claim 5 recites "the method according to claim 1 further comprising determining …" and "limiting," whereas claim 19 recites "the apparatus according

to claim 15 wherein the apparatus is further caused to determine…" and "limit." I addressed the apparatus of claim 15 above. *Supra* §VI.A.10. The rest of claim 19 is satisfied for the same reasons I explained for claim 5. *Supra* §VI.A.6.

15. Dependent Claim 20

246. Ground 1 teaches claim 20. Claim 20 is identical to claim 6, except that claim 6 recites "the method according to claim 1 further comprising examining …," followed by limitations using verbs in their gerund form, whereas claim 20 recites "the apparatus according to claim 15 wherein the apparatus is further caused to examine…," followed by the same limitations with the verbs in their base form. I addressed the apparatus of claim 15 above. *Supra* §VI.A.10. The rest of claim 20 is satisfied for the same reasons I explained for claim 6. *Supra* §VI.A.7.

16. Dependent Claim 21

247. Ground 1 teaches claim 21. Claim 21 is identical to claim 7, except that claim 7 recites "the method according to claim 1 further comprising including …," while claim 21 recites "the apparatus according to claim 15 wherein the apparatus is further caused to include…" I addressed the apparatus of claim 15 above. *Supra* §VI.A.10. The rest of claim 21 is satisfied for the same reasons I explained for claim 7. *Supra* §VI.A.8.

17. Dependent Claim 22

248. Ground 1 teaches claim 22. Claim 22 is identical to claim 8, except that claim 8 recites "the method according to claim 1 further comprising comparing …," while claim 22 recites "the apparatus according to claim 15 wherein the apparatus is further caused to compare…" I addressed the apparatus of claim 15 above. *Supra* §VI.A.10. The rest of claim 22 is satisfied for the same reasons I explained for claim 8. *Supra* §VI.A.9.

18. Independent Claim 29

[29pre]. A non-transitory computer readable medium having stored thereon a computer executable program code for use by an encoder, said program codes comprising instructions for:

249. To the extent that the preamble is limiting, Ground 1 teaches limitation [29pre], as explained below.

250. Rusert teaches **a non-transitory computer readable medium having stored thereon a computer executable program code for use by an encoder**, **said program codes comprising instructions for**. For example, Rusert teaches "a computer-readable medium, carrying instructions, which, when executed by computer logic, causes said computer logic to carry out any of the methods disclosed herein." Ex-1004, ¶26, ¶1 ("The present application relates to… a computer-readable medium."), claim 19. The computer-readable medium is used, for example, by "a video encoding apparatus[.]" Ex-1004, ¶24. At the very least, it would have been obvious to a POSITA for a video encoder to include a non-

transitory computer-readable medium, such as a hard drive, that stores computer executable program code, such as software, because conventional computers have included hard drives storing software for decades.

251. Based on the foregoing explanations, Ground 1 teaches the preamble of claim 29.

[29a]	**selecting a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for a block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates and is utilized to identify motion vector prediction candidates of which one spatial motion vector prediction candidate from the motion vector prediction list is signaled as the motion information for the prediction unit;**

252. Ground 1 teaches limitation [29a]. Limitation [29a] is identical to limitation [1a]. For the same reasons I have discussed for limitation [1a], Ground 1 teaches limitation [29a]. *Supra* §VI.A.2[1a].

[29b]	**determining a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;**

253. Ground 1 teaches limitation [29b], as explained below.

254. Limitation [29b] is nearly identical to limitation [1b]. As shown below, limitation [29b] recites "the location of the block," while limitation [1b] recites "a location of the block." This difference is identical to the difference

between limitation [15b] and limitation [1b]. For the same reasons I have discussed for limitation [15b], which references to limitation [1b], Ground 1 teaches limitation [29b]. *Supra* §VI.A.10[15b], §VI.A.2[1b].

29[b]	**1[b]**
determining a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;	determining a subset of spatial motion vector prediction candidates based on a location of the block associated with the first spatial motion vector prediction candidate;

[29c]	**comparing motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;**

255. Ground 1 teaches limitation [29c], as explained below.

256. Limitation [29c] is nearly identical to limitation [1c]. As shown below, the minor differences between limitation [29c] and limitation [1c] are identical to the differences between limitation [15c] and limitation [1c]. For the same reasons I have discussed for limitation [15c], which references to limitation [1c], Ground 1 teaches limitation [29c]. *Supra* §VI.A.10[15c], §VI.A.2[1c].

29[c]	1[c]
comparing motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;	comparing motion information of the first spatial motion vector prediction candidate with motion information of spatial motion vector prediction candidates in the determined subset of spatial motion vector prediction candidates without making a comparison of each pair from the set of spatial motion vector prediction candidates;

[29d]	**determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and**

257. Ground 1 teaches limitation [29d]. Limitation [29d] is identical to limitation [1d]. For the same reasons I have discussed for limitation [1d], Ground 1 teaches limitation [29d]. *Supra* §VI.A.2[1d].

[29e]	**causing information identifying the one spatial motion vector prediction candidate from the motion vector prediction list to be transmitted to a decoder or to be stored.**

258. Ground 1 teaches limitation [29e]. Limitation [29e] is identical to limitation [1e]. For the same reasons I have discussed for limitation [1e], Ground 1 teaches limitation [29e]. *Supra* §VI.A.2[1e]

B. Ground 3

259. It is my opinion that a POSITA would have found the Challenged Claims obvious based on Ground 3, i.e., the teachings of Nakamura and WD4. Nakamura teaches and suggests the limitations of the challenged claims. WD4 provides additional context for Nakamura's teachings, including additional details for limitations [1a] and [1e].

1. Motivation to Combine and Reasonable Expectation of Success

260. Nakamura is an HEVC proposal for "reduc[ing] the number of candidates in the spatial derivation process to reduce the number of… comparison[s] in the removal process." Ex-1007, Abstract. When applied to WD4, Nakamura's teachings satisfy the challenged claims. A POSITA would have been motivated to apply Nakamura's teachings to the draft HEVC standard because that was its express purpose. Nakamura is a proposal presented to the JCT-VC, the standards body responsible for the HEVC standard, at the 6th JCT-VC Meeting on July 14-22, 2011. Ex-1007, Header. The meeting started with WD3 as the then-current version of the standard. At the meeting, various proposals were made including Nakamura, and the JCT-VC drafted WD4, the draft HEVC standard. Ex-1007, 000001; Ex-1010, 000001. Nakamura proposed "simplifications" and "improvement[s]" to the then-current working draft (WD3). Ex-1007, Abstract, Introduction, §6 (References). In view of these simplifications

and improvements, WD4 "[i]ncorporated spatial merge candidate positions unification" from Nakamura. Ex-1010, Abstract. Therefore, the prior art provides express teaching, suggestion, and motivation to combine teachings from Nakamura and WD4.

261. Indeed, once the Nakamura proposal was made to the JCT-VC for inclusion into the HEVC standard, its teachings were known for HEVC. A POSITA would have found it obvious and been motivated to use Nakamura's teachings in the context of HEVC, including its working drafts. It would certainly not make sense for someone else to file for a patent many months later covering the application of Nakamura's teachings to the HEVC standard.

262. Nakamura was a proposal made at a JCT-VC meeting for the express purpose of applying its teachings to the HEVC standard, and WD4 was a draft version of the HEVC standard in the July 2011 timeframe. Nakamura teaches improvements to the HEVC standard and was intended to be used in the context of HEVC. Nakamura references aspects of the HEVC working drafts and uses HEVC terminology and concepts. Therefore, it would have been natural to apply Nakamura's teachings to draft HEVC standards; this would have applied a known technique to a known method ready for improvement to yield predictable results.

263. The combination of Nakamura and WD4 would have had predictable results. Nakamura teaches its "proposed technique is implemented into HM3.0

software", which was software implementation of the HEVC standard at that time. Ex-1007, §2.3.1. Furthermore, Nakamura provides results showing the actual application of its teachings to HEVC, including improvements from the combination. Ex-1007, §3 Therefore, Nakamura's teachings were readily applicable to HEVC and, indeed, were actually applied to HEVC. Thus, the combination of Nakamura and WD4 would have had predictable results. *See* Ex-1007, §3.

264. A POSITA would have been motivated to combine Nakamura and WD4 because it would have combined prior art elements according to known methods to yield predictable results. Nakamura teaches various improvements to HEVC, including "simplifications of derivation process for merge mode and motion vector predictor (MVP)[,]… unification of the location of spatial neighbors for merge mode and MVP[,]" and "improvement of derivation method of the candidates for merge mode and motion vector predictor (MVP)." Ex-1007, Abstract, §1. These improvements involve, for example, "reduc[ing] the number of candidates in the spatial derivation process to reduce the number of times of comparison in the removal process." Ex-1007, Abstract. These teachings are applied to HEVC, which WD4 teaches. Ex-1007, Abstract, Introduction, §6 (References); Ex-1010, Abstract. Therefore, it would have been obvious to apply

Nakamura's teachings to HEVC as a combination of prior art elements according to known methods, with predictable results.

265. In addition, a POSITA would have found motivation to combine Nakamura and WD4 because of the similarity of the references and the commonality of purpose. Nakamura and WD4 are both directed to video encoding and decoding, and are both meant for development of the HEVC standard. Both WD4 and Nakamura address motion vectors for block-based inter prediction. Ex-1010, §0.6; Ex-1007, Abstract. Nakamura teaches, for example, a "derivation process for merge mode and motion vector predictor (MVP)." Ex-1007, Abstract. WD4 also teaches the derivation process for motion vectors and adopts the techniques from Nakamura. Ex-1010, §8.4.2.1.1. Indeed, a POSITA would notice striking similarities between Nakamura's "[d]erivation process[es]" and WD4's "[d]erivation process[es]." *Compare* Ex-1008 §§8.4.2.1.1-8.4.2.1.3 *with* Ex-1010, §§8.4.2.1.1-8.4.2.1.3. For example, Nakamura's "Derivation process for spatial merging candidates" and WD4's "Derivation process for spatial merging candidates" share striking similarities with a difference in labelling (e.g., Nakamura's A, B, C, D, E blocks and WD4's A_1, B_1, B_0, A_0, B_2 blocks) and Nakamura's inclusion of a figure being the only differences. *Compare* Ex-1008 §8.4.2.1.2 *with* Ex-1010, §8.4.2.1.2. Furthermore, Nakamura's "Derivation process of reference indices for temporal merging candidate" and WD4's

"Derivation process of reference indices for temporal merging candidate" are identical. *Compare* Ex-1008 §8.4.2.1.3 *with* Ex-1010, §8.4.2.1.3.

266. Furthermore, a POSITA would have been motivated to combine because the teachings of WD4 and Nakamura are complementary. Nakamura provides detailed examples and explanations for deriving candidates for both merge mode and MVP mode. WD4 provides more context and details about how deriving candidates for merge mode and MVP mode work with the video encoding and decoding processes under the HEVC standard. *See generally* Ex-1010, §8. WD4 also explains the terminology and up-to-date background concepts of HEVC, especially on video encoding and decoding. *See generally, e.g.,* Ex-1010, §3. In understanding and implementing the teachings of Nakamura, a POSITA would have been motivated to look to WD4, which provides additional technical context and implementation details.

267. A POSITA would have been motivated to combine Nakamura and WD4 because the combination would have yielded several advantages. For example, Nakamura and WD4 share the same goal of improving efficiency of video coding. WD4 teaches that "the need has arisen for an industry standard for compressed video representation with substantially increased coding efficiency…" Ex-1010, §0.1. Nakamura teaches that its proposal "reduce[s] the number of candidates in the spatial derivation process to reduce the number of times of

comparison in the removal process." Ex-1007, Abstract. And Nakamura also provides actual results demonstrating the efficiency gains of its proposed techniques. Ex-1007, §3.

268. The combination of Nakamura and WD4 would not have changed the principle of operation for any of the teachings of the references relied upon in the combination. Nakamura was specifically proposed to be used with HEVC, which WD4 teaches, and that is precisely what the combination of Ground 3 is directed to. *See* Ex-1007, Abstract, §1, §6; Ex-1010, Abstract. The combination uses the teachings of Nakamura and WD4 in a conventional manner, as they were meant to be used. Moreover, both Nakamura and WD4 teach motion prediction for encoding and decoding blocks, with spatial motion vector prediction candidates. Both Nakamura and WD4 operate on the same principles of block-based motion prediction. Ex-1023, 000004. Therefore, Nakamura's teachings would not have changed the principle of operation of WD4.

269. That Nakamura references an earlier version of HEVC (e.g., WD3) would not have dissuaded a POSITA from combining Nakamura with WD4. Indeed, the output of the 6th JCT-VC meeting, where Nakamura was presented, was WD4. A POSITA would have understood that Nakamura's teachings were applicable to HEVC, including the working drafts in that timeframe such as WD3 and WD4.

270. A POSITA would have had a reasonable expectation of success when combining Nakamura with WD4. As explained above, the combination applies teachings from each reference according to their known purposes, in a conventional manner as taught by Nakamura and WD4, without changing their principle of operation. Furthermore, Nakamura implemented the combination and reported measurements from actual results showing performance increases when Nakamura's teachings were applied to HEVC. Ex-1007, §2.3.1, §3; Ex-1009, 000015-000018. The combination does not modify Nakamura or WD4 in a way that would render either reference inoperative. Given that Nakamura had successfully made and reported the combination, a POSITA would have had a reasonable expectation of success in doing so. *See id.*

271. Given the education and experience of a POSITA (*supra* §IV), a POSITA would have been more than capable of applying Nakamura's teachings to WD4, and vice versa, because it would simply have applied Nakamura's teachings, based on draft HEVC standards, to draft HEVC standards. Therefore, a POSITA would have had a reasonable expectation of success in applying Nakamura's teachings to draft HEVC standards, including WD4, which was after all the purpose of the Nakamura proposal for the HEVC standard.

272. Nakamura is a single proposal comprising multiple files. Each of those files is a component of the Nakamura proposal and therefore part of the

reference. To the extent it is argued that Nakamura is a collection of documents, a POSITA would have been motivated to combine the teachings of the three Nakamura files relied on by this Declaration: Nakamura Main Document (Ex-1007), Nakamura WD Description (Ex-1008), and Nakamura Presentation (Ex-1009). First, these files were jointly presented to the JCT-VC in a single proposal and were meant to be read together to understand the Nakamura proposal. Second, the files were packaged together in a single zip file for download (Ex-1014 (Sze Declaration), ¶16), and therefore HEVC attendees would have understood that the files were meant to be read together as part of the Nakamura proposal. Third, the files teach related aspects of Nakamura's proposal and therefore a POSITA would have understood from their context that their teachings were meant to be read and combined together. *See supra* §III.E.

273. A POSITA would also have had a reasonable expectation of success in combining the teachings of the files in the Nakamura proposal. As explained above, those files were drafted by the same author as part of the same proposal for the HEVC standard. Therefore, the teachings of Nakamura's files were meant to be read and used together, and a POSITA would have been capable of applying the teachings in the manner taught by the Nakamura files.

2. Independent Claim 1

[1pre] A method comprising:

274. To the extent that the preamble is limiting, Ground 3 teaches limitation [1pre], as explained below.

275. Nakamura teaches a **method**. For example, Nakamura teaches an "improvement of derivation method of the candidates for merge mode and motion vector predictor (MVP)." Ex-1007, §1, Abstract ("This contribution presents simplifications of derivation process for merge mode and motion vector predictor (MVP)."), §2.1, Fig. 1.

276. WD4 also teaches a method. For example, WD4 teaches a "[d]erivation process for spatial merging candidates" (Ex-1010, §8.4.2.1.2) and a "[d]erivation process for motion vector predictor candidates" (Ex-1010, §8.4.2.1.8).

277. Nakamura and WD4 further teach a method comprising the steps described below, with distinct teachings for merge mode and MVP mode that independently satisfy the limitations as explained below. *Infra* §VI.B.2[1pre]-[1e]. HEVC included two modes for predicting candidates: merge mode was optimal for areas of uniform motion, while MVP mode was more versatile but required more data. Generally, merge mode saved bits by utilizing the predicted motion vector without signaling difference vectors and other information used by MVP mode. Regardless, the detailed differences are not particularly relevant to the claim

analysis because the claims do not require one mode or the other. Both modes satisfy the claims, as explained in the sections below.

[1a]	**selecting a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for a block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates and is utilized to identify motion vector prediction candidates of which one spatial motion vector prediction candidate from the motion vector prediction list is signaled as the motion information for the prediction unit;**

278. Ground 3 teaches limitation [1a] in two independent ways: merge mode and MVP mode. Either teaching is sufficient by itself to satisfy the claims.

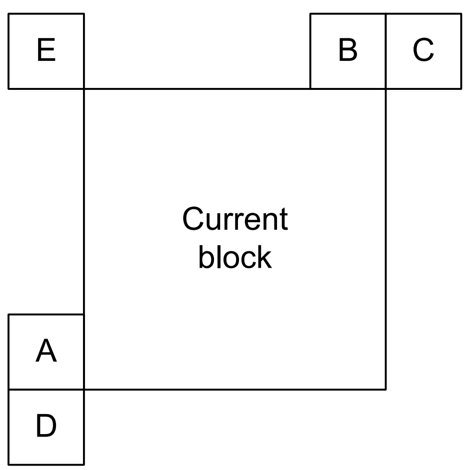
Merge Mode

279. Ground 3 teaches **selecting a first spatial motion vector prediction candidate** (e.g., for S_1) **from a set of spatial motion vector prediction candidates for a block of pixels.** For merge mode, Nakamura teaches a process for building a merge list that evaluates spatial motion vector prediction candidates, in sequence, from a set of five neighboring blocks (A, B, C, D, E). *E.g.*, Ex-1007, Tables 2-4; Ex-1009, 000008, 000010, 000012-14. Nakamura illustrates an example of the "[s]patial derivation order" on page 7 of Nakamura's presentation. Ex-1009, 000008.

280. Nakamura teaches a process for identifying two spatial motion vector prediction candidates (S_0 and S_1) for a merge list. Nakamura finds two "spatial candidate[s]" S_0 and S_1 from "the position[s] of the spatial neighbors A, B, C, D and E relative to the current prediction unit" which "can be used for… candidates[.]" Ex-1007, §2.2.1, Abstract, §1, Tables 2, 4, Fig. 1; Ex-1009, 000008, 000010, 000014. Nakamura steps through each of the spatially-neighboring blocks in sequence to select S_0 from one of the blocks; next, Nakamura steps through the remaining spatial neighbors to select a spatial motion vector prediction candidate from the next block in the sequence, until another candidate S_1 is found. Ex-1007, Tables 2, 4 ("Spatial derivation order"); Ex-1009, 000008. In particular, as explained further below, the selection of a candidate from a spatial neighbor for S_1 satisfies the claimed step for selecting a first spatial motion vector prediction candidate. It is irrelevant whether Nakamura applies its own "first" and "second" labels to describe the ordering of its spatial derivation process, or whether any other candidates come before S_1, because claim 1 merely recites "*a first* spatial motion vector prediction candidate" to distinguish that candidate from other spatial motion vector prediction candidates described in the claims, not as an absolute temporal requirement for that candidate. Therefore, it is my understanding that claim 1 does not impose a requirement for selecting the very first spatial motion vector prediction candidate for a video, frame, or particular block. Instead, this

language simply requires selecting *a* spatial motion vector prediction candidate, which is then designated the "first" spatial motion vector prediction candidate for the remainder of the claim. Here, the selected first spatial motion vector prediction candidate (as recited in claim 1) is Nakamura's S_1 for purposes of analyzing claim 1.

281. As I explained above, a "spatial motion vector prediction candidate" is a candidate motion vector obtained from one or more previously-encoded block in the current frame. *Supra* §V.A. The motion vector candidates from spatially neighboring blocks are spatial motion vector prediction candidates because each is a candidate motion vector obtained from one or more previously-encoded blocks in the current frame (A, B, C, D, and E). *E.g.*, Ex-1007, §2.2.1. As illustrated in Fig. 2(b), the spatial neighbors are blocks A, B, C, D, and E, which neighbor the current block of pixels. Ex-1007, Fig. 2(b):



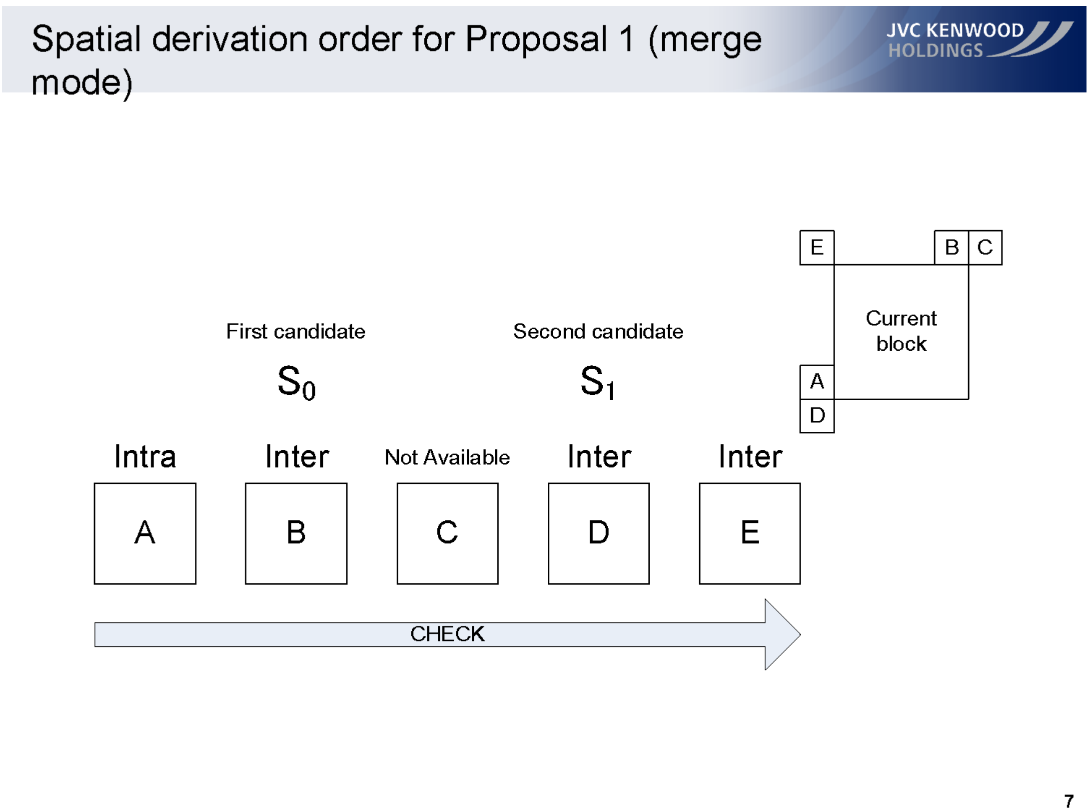
(b) Proposed technique

282. Since blocks are processed in raster scan order from top left to bottom right, blocks A-E represent the potential neighboring blocks that have already been encoded. Blocks below and to the right of the current block will not have been encoded yet and are not available as sources for spatial motion vector prediction candidates. *See* Ex-1010, §3.83 (explaining "raster scan"), §3.101. Furthermore, Nakamura and WD4's teachings "enable a high compression capability for a desired image or video quality" using "block-based inter prediction[,]" which teaches the blocks are blocks of pixels because images and videos are comprised of pixels. Ex-1010, §0.6

283. Each candidate comprises "availability flags… reference indices… prediction list utilization flags…" and "*motion vectors*" for prediction. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2.

284. Ground 3 teaches **selecting a first… candidate… as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list.** For example, Nakamura teaches a "merging candidate list is constructed of two spatial merging candidates" (S_0 and S_1) selected from the five spatial neighbor candidates "relative to the current prediction unit[.]" Ex-1007, §2.2.1, Table 2, §2.2.2, Table 3; Ex-1008, §8.4.2.1.1 ("The merging candidate list, mergeCandList…").

285. To select S_0 and S_1, Nakamura teaches a "[s]patial derivation order" in which candidates from the five spatially neighboring blocks are evaluated in sequence. Ex-1007, Table 2-4; Ex-1009, 000008, 000010, 000012-14. Nakamura illustrates an example of the "[s]patial derivation order" which starts from A and progresses to E. Ex-1009, 000008:



286. The above example illustrates the order in which the spatial neighbors are checked. Ex-1009, 000008. Following the spatial derivation order of A through E, Nakamura begins with block A and decides whether its candidate should be selected for S_0. Since A is an intra block and does not have a motion vector, Nakamura proceeds to the next block B, whose spatial motion vector

prediction candidate is selected as candidate S_0 for the merging candidate list because B is an inter block with motion vector prediction information. Nakamura proceeds in this manner, stepping through the spatial derivation order to select S_1, until two spatial candidates (S_0 and S_1) are selected for the merging candidate list. Ex-1009, 000008; Ex-1007, §2.2.1, Table 2. In this example, block C is skipped because it is not available. The spatial motion vector prediction candidate from Block D is then evaluated and selected for S_1. Block E is not checked because two spatial candidates have been found before the spatial derivation order reaches block E. Ex-1009, 000008. Therefore, Nakamura teaches selecting a first spatial motion vector prediction candidate (e.g., for S_1).

287. The merging candidate list is **a motion vector prediction list for a prediction unit of the block of pixels.** Nakamura teaches "[t]he merging candidate list, mergeCandList," (Ex-1008, §8.4.2.1.1; Ex-1010, §8.4.2.1.1) comprises "spatial merging candidates" found from "the position[s] of the spatial neighbors… relative to the current prediction unit" of the current block. Ex-1007, §2.2.1, Tables 2, 4, Fig. 2(b). One of the spatial candidates in the merging candidate list is assigned as the motion vector predictor for the current prediction unit. Ex-1008, §8.4.2.1.1 ("The following assignments are made with N being the candidate at position mergeIdx in the merging candidate list mergeCandList (N = mergeCandList[mergeIdx])…"); Ex-1010, §7.4.7 (explaining that merge_idx

"specifies the merging candidate index of the merging candidate list" for a prediction unit), §8.4.2.1.1, 000049, 000174 (showing "merge_idx" is associated with a prediction unit). Therefore, the merging candidate list is a motion vector prediction list for the PU corresponding to the block currently being processed. *See, e.g.,* Ex-1008, §8.4.2.1.1.

288. Nakamura teaches a "merging candidate list," which is referred to in WD4 as "mergeCandList." A POSITA reading Nakamura and WD4 would have understood this because Nakamura was a proposal for HEVC, and "mergeCandList" is an abbreviation for Merge Candidate List following a common computer programming style. Ex-1008, §8.4.2.1.1; Ex-1010, §8.4.2.1.1 ("The merging candidate list, mergeCandList…").

289. **Where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates.** Nakamura teaches that the "merging candidate list is constructed of" spatial candidates (Ex-1007, §2.2.1) and includes information of those candidates in the list, including "availability flags… reference indices… prediction list utilization flags…" and "motion vectors[.]" Ex-1008, §8.4.2.1.2.

290. The merging candidate list **is utilized to identify motion vector prediction candidates of which one spatial motion vector prediction candidate from the motion vector prediction list is signaled as the motion information**

for the prediction unit.[7] For example, Nakamura teaches "[t]he merging candidate list is constructed of two spatial… candidates" (Ex-1007, §2.2.1, Tables 2, 4) of which one is signaled by an index, mergeIdx, as the spatial candidate. The candidate is signaled as the motion information for the current PU and includes reference indices, prediction list utilization flags, and motion vectors. Ex-1008, §8.4.2.1.1 (emphasis added):

> The following assignments are made with *N being the candidate at position mergeIdx in the merging candidate list mergeCandList (N = mergeCandList[mergeIdx])* and X being replaced by 0 or 1:
>
> mvLX[0] = mvLXN[0] (8 73)
>
> mvLX[1] = mvLXN[1] (8 74)
>
> refIdxLX = refIdxLXN (8 75)
>
> predFlagLX = predFlagLXN (8 76)

See also Ex-1010, §8.4.2.1.1.

291. When the spatial candidate is assigned as the motion vector predictor for the current prediction unit, the motion vector information (e.g., mvLX),

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[7] The '714 patent admits that it was known for "video codecs" to "generate a list of motion vector prediction[]" candidates, and that it was known for "[o]ne of the candidate motion vectors in the list" to be "signalled[sic] to be used as the motion vector prediction of the current block." Ex-1001, 3:60-66. The patent also admits that merge mode was also used by HEVC. Ex-1001, 3:24-38.

reference index (e.g., refIdxLX), and prediction list utilization flags (e.g., predFlagLX) are set to those of the spatial candidate. Ex-1008, §8.4.2.1.1.

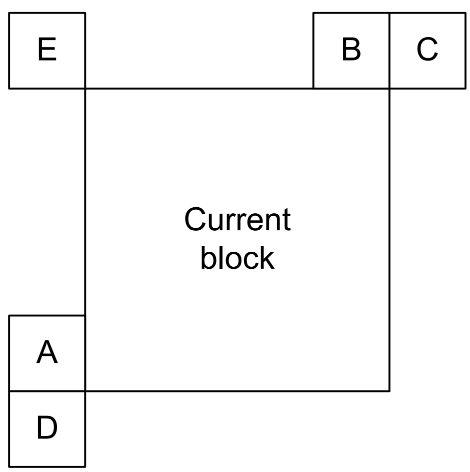
MVP Mode

292. For MVP mode, Ground 3 teaches limitation [1a] in a similar manner explained above for Merge Mode. Ex-1007, §2.2.2, Table 4; Ex-1009, 000005, 000014. Indeed, Nakamura proposed a "unification of the location of spatial neighbors for merge mode and MVP" and a "unification of the derivation process for merge mode and MVP." Ex-1007, Abstract.

293. Ground 3 teaches **selecting a first spatial motion vector prediction candidate** (e.g., S_1) **from a set of spatial motion vector prediction candidates for a block of pixels.** For MVP mode, Nakamura teaches a process for building an "MVP list" by evaluating a set of five spatially-neighboring blocks in sequence, following a "[s]patial derivation order," to select two candidates (S_0 and S_1) for the MVP list. Ex-1007, §2.2.2. Nakamura teaches a "first spatial candidate found" (S_0) and a "second spatial candidate found" (S_1) from "the spatial neighbors relative to the current prediction unit[.]" Ex-1007, §2.2.2, Abstract, §1, Tables 3-4, Fig. 1; Ex-1009, 000012-14. This process for stepping through the spatial derivation order and selecting spatial motion vector prediction candidates is explained below.

294. Here, the spatial candidates are "motion vector predictor[s]" (Ex-1007, §2.2.2, Abstract, §1, Tables 3-4, Fig. 1; Ex-1009, 000012-14) that include "motion vectors" and "availability flags[.]" Ex-1010, §8.4.2.1.8.

295. The motion vector candidates from the spatial neighbors are spatial motion vector prediction candidates because each is a candidate motion vector obtained from one or more previously-encoded block in the current frame (A, B, C, D, and E). *E.g.*, Ex-1007, §2.2.2; Ex-1009, 000011-000012. The spatial neighbors are blocks A, B, C, D, and E, which neighbor the current block of pixels. Ex-1007, Fig. 3(b):

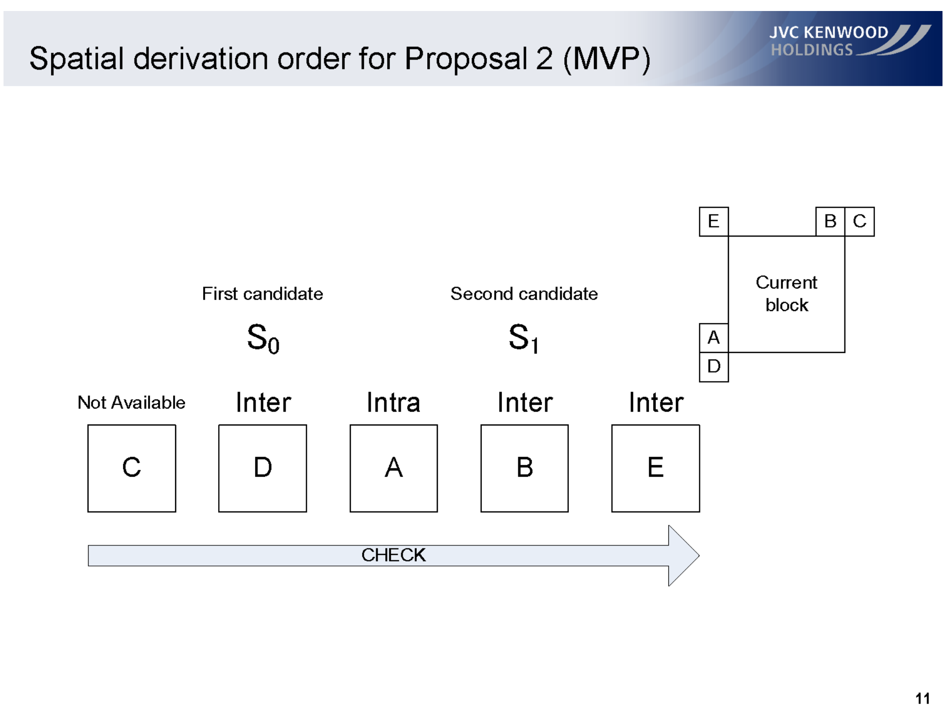


(b) Proposed technique

296. Since blocks are processed in raster scan order from top left to bottom right, blocks A-E represent the potential neighboring blocks that have already been encoded. Blocks below and to the right of the current block will not have been

encoded yet and are not available as sources for spatial motion vector prediction candidates. *See* Ex-1010, §3.83 (explaining "raster scan"), §3.101.

297. Ground 3 teaches **selecting a first… candidate… as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list.** For example, Nakamura teaches an "MVP list" with two spatial motion vector prediction candidates: S_0 and S_1. Ex-1007, Tables 3-4, §2.2.2; Ex-1009, 000012-14; Ex-1010, §8.4.2.1.10 ("motion vector predictor list mvpListLX"). Following a "[s]patial derivation order[,]" spatial neighbors of a current block are evaluated in sequence to select S_0 and S_1. Ex-1007, Tables 3-4; Ex-1009, 000012-14. Nakamura illustrates an example of the "[s]patial derivation order" on page 11 of Nakamura's presentation. Ex-1009, 000012:



298. This selection process is similar to the one explained above for Merge Mode. The above example illustrates how the spatial neighbors are checked for potential inclusion in the MVP list. Ex-1009, 000012. Following the spatial derivation order in the above example, block C is checked and not included because it does not have an available motion vector (it is "Not Available"). *Id*. Then, block D is evaluated; its spatial motion vector prediction candidate is selected for S_0 because it is an inter block with motion vector prediction information. Nakamura proceeds in this manner, stepping through the spatial derivation order to select S_1, until two spatial candidates (S_0 and S_1) are selected for the MVP list. Ex-1009, 000012; Ex-1007, §2.2.2, Table 3. In this example, those two candidates come from blocks D and B. Block A is intra and does not have a motion vector; block E is not checked because two spatial candidates were already found before the spatial derivation order reached block E. Ex-1009, 000008.

299. The MVP list is **a motion vector prediction list for a prediction unit of the block of pixels.** Nakamura teaches the motion vector predictor (MVP) list comprises two "spatial candidates" found from "the position[s] of the spatial neighbors relative to the current prediction unit" of the current block. Ex-1007, §2.2.2, Tables 3-4, Fig. 3(b). A "prediction mvpLX of the motion vector mvLX" is derived using the MVP list ("mvpListLX") and an index ("mvp_idx_lX"). Ex-1010, §8.4.2.1.7. One of the candidates from the MVP list (mvpLX) is assigned as

the motion vector prediction for the current prediction unit, as indicated by the index. *See id.* (explaining that the prediction mvpLX is the output of the derivation process for the motion vector prediction for the current prediction unit); Ex-1010, §7.4.7 (explaining that "mvp_idx_l0" and "mvp_idx_l1" "specif[y] the motion vector predictor index" of an MVP list for a prediction unit), §8.4.2.1.1; *see also* Ex-1010, §7.3.7, §9.3.1.1, Table 9-17 (showing that "mvp_idx_l0" "mvp_idx_l1" are associated with the initialization of a prediction unit). Therefore, the MVP list is a motion vector prediction list for the PU for the current block.

300. **Where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates.** For example, WD4 teaches that information of spatial candidates include "motion vectors" and "availability flags[.]" Ex-1010, §8.4.2.1.8. The "MVP list" includes two "spatial candidates" and thus includes this information. Ex-1007, Tables 3-4; §2.2.2.

301. The MVP list **is utilized to identify motion vector prediction candidates of which one spatial motion vector prediction candidate from the motion vector prediction list is signaled as the motion information for the prediction unit.**[8] For example, Nakamura teaches the MVP list comprises "two spatial candidates" (Ex-1007, §2.2.2, Tables 3-4) of which one is signaled by an

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[8] *See supra* n.7.

mvp index, (e.g., "mvp_idx_lX"[9]), as the spatial candidate assigned as the motion vector predictor for the current prediction unit. Ex-1007, §8.4.2.1.7 ("The motion vector of mvpListLX[mvp_idx_lX[xP, yP]] is assigned to mvpLX."). The candidate is signaled as the motion information for the current PU and includes motion vectors and availability flags. Ex-1010, §8.4.2.1.8.

302. Based on the foregoing explanations, Ground 3 teaches limitation [1a].

[1b]	**determining a subset of spatial motion vector prediction candidates based on a location of the block associated with the first spatial motion vector prediction candidate;**

303. Ground 3 teaches limitation [1b] in two independent ways: merge mode and MVP mode. Either teaching is sufficient by itself to satisfy the claims.

Merge Mode

304. Ground 3 teaches **determining a subset of spatial motion vector prediction candidates.** For example, for merge mode, Nakamura derives two candidates out of the candidates from five spatially-neighboring blocks. For example, Nakamura teaches that "[t]wo spatial merging candidates are derived in the spatial derivation process[]" from five "spatial neighbors A, B, C, D, and E

[9] The "X" in mvp_idx_lX can be 0 or 1; it indicates the mvp index can be mvp_idx_l**0** (using "list 0" for P prediction) or mvp_idx_l**1** (using "list 0" and "list 1" for B prediction). Ex-1010, §7.4.7.

relative to the current prediction unit[.]" Ex-1007, §2.2.1, Tables 1, 4; Ex-1009, 000010, 000014; Ex-1007, Table 2 ("2 in 5 [positions]", "S_0, S_1"); Ex-1009, 000008.

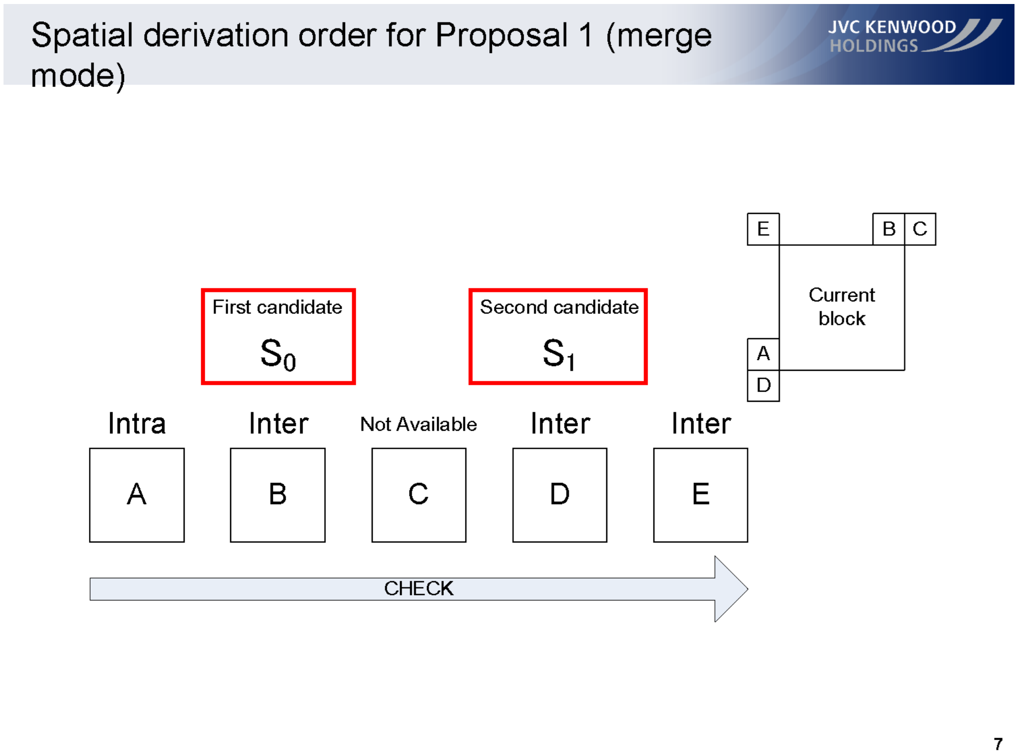
305. As explained further below, Nakamura teaches a removal process that compares S_0 with S_1 to check for redundancy when determining whether to include or exclude S_1. Ex-1007, Tables 2, 4 ("S_0 vs S_1"); Ex-1008, §8.4.2.1.1; Ex-1009, 000010, 13; Ex-1010, §8.4.2.1.1. Therefore, Nakamura determines a subset of spatial motion vector prediction candidates (e.g., S_0).

Table 2 Comparison between HM3.0 and proposed technique for merge mode

	HM3.0	Proposal 1
The number of spatial candidates	4 in 4 [positions]	2 in 5 [positions]
Spatial derivation order	A, B, C, D	A, B, C, D, E
The number of times of comparison of redundant candidates in the spatial derivation process	0 [time]	0 [time]
The number of temporal candidates	1	1
Merging candidate list order	A, B, Col, C, D	S_0, S_1, Col
The number of times of comparison in the removal process	10 [times] (A vs B, Col, C, D, B vs Col, C, D, Col vs C, D, and C vs D)	3 [times] (S_0 vs S_1, S_0 vs Col, and S_1 vs Col)

306. Additionally, as explained for [1a], Nakamura proceeds sequentially to select S_0 and then S_1. When S_1 is being selected, the merge list includes a subset of one spatial motion vector prediction candidate (S_0). *E.g.*, Ex-1009, 000008, 000010; Ex-1007, Table 2; *supra* §VI.B.2[1a]. This is a subset of spatial motion

vector prediction candidates (e.g., S_0). Ex-1009, 000008; *see also* Ex-1007, §2.2.1, Ex-1009, 000010:



307. The determination is **based on a location of the block associated with the first spatial motion vector prediction candidate.** Here, "the" block recited in [1b] has an antecedent basis in [1a]: "a *first spatial motion vector prediction candidate* from a set of spatial motion vector prediction candidates *for a block of pixels*[.]" Therefore, the block associated with the first spatial motion vector prediction candidate is the current block for which motion vector prediction candidates are being analyzed. *Supra* §V.C.

308. Nakamura determines its subset based on the location of the current block because the subset is determined from a set of "spatial neighbors A, B, C, D

and E relative to the current prediction unit" for the current block. Ex-1007, §2.2.1, Fig. 2(b). The spatial neighbors A, B, C, D and E are all determined from their position relative to the current block—they are the neighboring blocks above and to the left of the current block. Ex-1007, §2.2.1; Ex-1009, 000008. S_0 and S_1 are both selected from these spatial neighbors; therefore, S_0 and S_1 are also determined based on the location of the current block by analyzing candidates from spatial neighbors of the current block. Ex-1007, §2.2.1, Fig. 2(b).

309. Additionally, the subset comprising candidate S_0 is determined based on the location of the current block: it is the first available spatial motion vector prediction candidate from the neighboring blocks of the current block, following Nakamura's spatial derivation order which is defined based on the relative position of blocks around the current block. Ex-1009, 000008, 000010; Ex-1007, §2.2.1, Fig. 2; Ex-1008, §8.4.2.1.2, Fig. 8-3.

310. In the HEVC context, each PU corresponds with a block of pixels. Ex-1010, §6.3; *see also* Ex-1005, ¶33. The merge mode process iteratively steps through blocks in a frame, and in each step, evaluates spatial motion vector prediction candidates for the current block. Ex-1007, §2.2.1; Ex-1008, §8.4.2.1.1 (constructing mergeCandList in a specified order); Ex-1010, §8.4.2.1.1.

MVP Mode

311. For MVP mode, Ground 3 teaches limitation [1b] in a similar manner explained above for Merge Mode. Ex-1007, §2.2.2, Table 4; Ex-1009, 000005, 000014. Indeed, Nakamura proposed a "unification of the location of spatial neighbors for merge mode and MVP" and a "unification of the derivation process for merge mode and MVP." Ex-1007, Abstract.

312. Ground 3 teaches **determining a subset of spatial motion vector prediction candidates.** For example, Nakamura teaches that "[t]wo in five spatial candidates are derived… in the spatial derivation process." Ex-1007, §2.2.2, Tables 1, 4; Ex-1009, 000012-14; Ex-1007, Table 3 ("2 in 5 [positions]", "$mvLXS_0$, $mvLXS_1$"). Nakamura teaches that selecting "[t]wo in five spatial candidates" in MVP mode is a known process since earlier iterations of H.265 (e.g., HM3.0). Ex-1009, 000013 (comparing the MVP mode of HM3.0 and the proposed technique); *supra* §V.D.

313. As explained further below, Nakamura teaches a removal process that compares S_0 with S_1 to check for redundancy when determining whether to include or exclude S_1.[10] Ex-1007, Fig. 1 (describing a removal process), Table 3 ("$mvLXS_0$ vs $mvLXS_1$"), Table 4; Ex-1009, 000008, 000010, 000020. Therefore,

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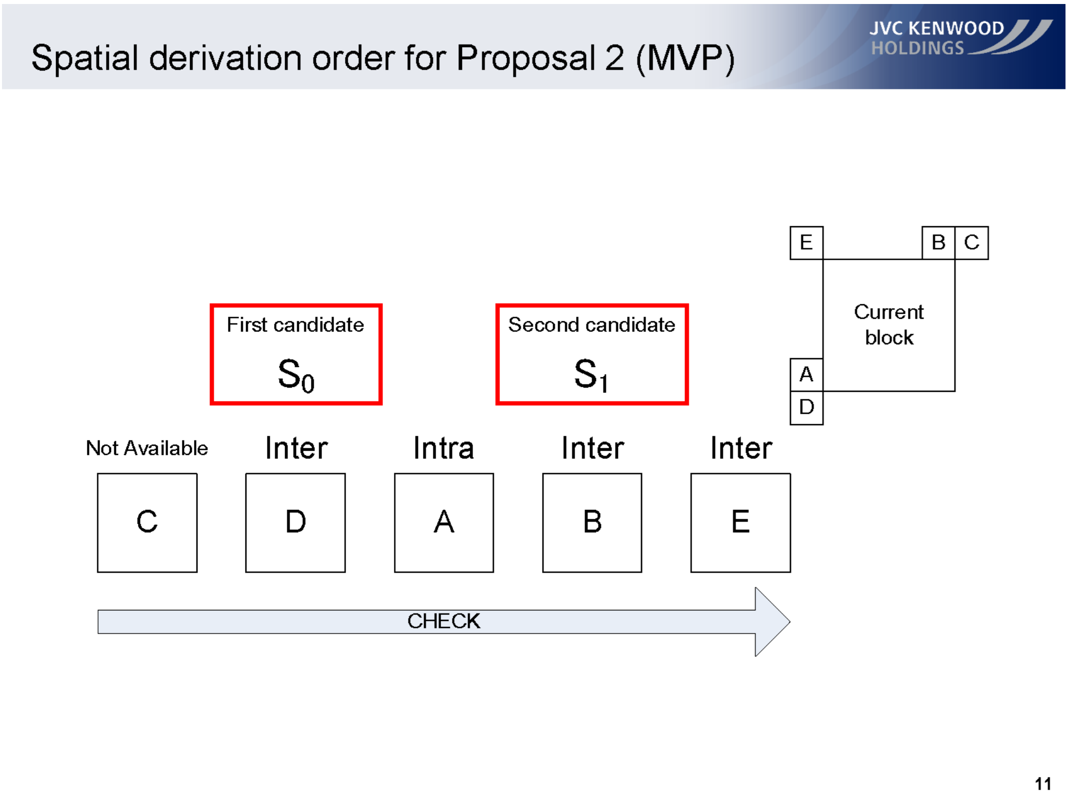
[10] Nakamura at times refers to S_0 as $mvLX\mathbf{S_0}$ and S_1 as $mvLX\mathbf{S_1}$.

Nakamura determines a subset of spatial motion vector prediction candidates (e.g., S_0, a.k.a. $mvLXS_0$).

Table 3 Comparison of HM3.0 between HM3.0 and proposed technique for MVP

	HM3.0	Proposal 2
The number of spatial candidates	2 in 5 [positions]	2 in 5 [positions]
Grouping of the neighbors in the spatial derivation process	Group A: Left (A_0, A_1) Group B: Upper (B_0, B_1, B_2)	without grouping
Spatial derivation order	Group A: A_0, A_1 Group B: B_0, B_1, B_2	C, D, A, B, E
The number of times of checking per spatial neighbors in the spatial derivation process	2 [times]	1 [time]
The number of times of comparison of redundant candidates in the spatial derivation process	6 [times] (mvLXA vs $mvLXB_0$, mvLXA vs $mvLXB_1$, and mvLXA vs $mvLXB_2$) x 2	0 [time]
The number of temporal candidates	1	1
MVP list order	mvLXA, mvLXB, mvLXCol	$mvLXS_0$, $mvLXS_1$, mvLXCol
The number of times of comparison in the removal process	2 [times] (mvLXA vs mvLXCol, and mvLXB vs mvLXCol)	3 [times] ($mvLXS_0$ vs $mvLXS_1$, $mvLXS_0$ vs mvLXCol, and $mvLXS_1$ vs mvLXCol)

314. Additionally, as explained for [1a], Nakamura proceeds sequentially to select S_0 and then S_1. When S_1 is being selected, the merge list includes a subset of one spatial motion vector prediction candidate (S_0). E.g., Ex-1009, 000012-000013; Ex-1007, Table 3; *supra* §VI.B.2[1a]. This is a subset of spatial motion vector prediction candidates (e.g., S_0). Ex-1007, Table 3, Table 4; Ex-1009, 000012-14:



315. The determination is **based on a location of the block associated with the first spatial motion vector prediction candidate.** Here, "the" block recited in [1b] has an antecedent basis in [1a]: "a *first spatial motion vector prediction candidate* from a set of spatial motion vector prediction candidates *for a block of pixels*[.]" Therefore, the block associated with the first spatial motion vector prediction candidate is the current block for which motion vector prediction candidates are being analyzed. *Supra* §V.C.

316. Nakamura determines its subset based on the location of the current block because the subset is determined from a set of "spatial neighbors relative to the current prediction unit" for the current block. Ex-1007, §2.2.2, Fig. 3(b). The

spatial neighbors A, B, C, D and E are all determined from their position relative to the current block—they are the neighboring blocks above and to the left of the current block. Ex-1007, §2.2.2, Fig. 3(b); Ex-1009, 000008. S_0 and S_1 are both selected from these spatial neighbors; therefore, S_0 and S_1 are also determined based on the location of the current block by analyzing candidates from spatial neighbors of the current block. *See id.*

317. Additionally, the subset comprising candidate S_0 is determined based on the location of the current block: it is the first available spatial motion vector prediction candidate from the neighboring blocks of the current block, following Nakamura's spatial derivation order which is defined based on the relative position of blocks around the current block. Ex-1007, Tables 3-4; Ex-1009, 000012-14.

318. In the HEVC context, each PU corresponds with a block of pixels. Ex-1010, §6.3; *see also* Ex-1005, ¶33. Nakamura and WD4 teach iteratively stepping through each block in a frame and, in each step, evaluating spatial motion vector prediction candidates for the current block. Ex-1007, §2.2.1; Ex-1010, §8.4.2.1.7 (constructing mvpListLX in a specified order).

319. Based on the foregoing explanations, Ground 3 teaches limitation [1b].

[1c]	**comparing motion information of the first spatial motion vector prediction candidate with motion information of spatial motion vector prediction candidates in the determined subset of spatial motion vector prediction candidates without making a comparison of each pair from the set of spatial motion vector prediction candidates;**

320. Ground 3 teaches limitation [1c] in two independent ways: merge mode and MVP mode. Either teaching is sufficient by itself to satisfy the claims.

Merge Mode

321. Ground 3 teaches **comparing motion information of the first spatial motion vector prediction candidate** (e.g., for S_1) **with motion information of spatial motion vector prediction candidates in the determined subset of spatial motion vector prediction candidates** (e.g., the subset comprising S_0). For merge mode, WD4 removed duplicate candidates from the merge list. Ex-1010, §8.4.2.1.1. Consistent with those teachings, Nakamura teaches comparing the two spatial candidates (S_0 and S_1) to "[r]emove candidates with the same motion information[.]" Ex-1007, Fig. 1, Table 4, Table 2:

Table 2 Comparison between HM3.0 and proposed technique for merge mode

	HM3.0	Proposal 1
The number of spatial candidates	4 in 4 [positions]	2 in 5 [positions]
Spatial derivation order	A, B, C, D	A, B, C, D, E
The number of times of comparison of redundant candidates in the spatial derivation process	0 [time]	0 [time]
The number of temporal candidates	1	1
Merging candidate list order	A, B, Col, C, D	S_0, S_1, Col
The number of times of comparison in the removal process	10 [times] (A vs B, Col, C, D, B vs Col, C, D, Col vs C, D, and C vs D)	3 [times] (S_0 vs S_1, S_0 vs Col, and S_1 vs Col)

322. As illustrated in Table 2, above, the overall removal process for WD3 required 10 comparisons because the merge list included 5 candidates (4 spatial candidates A-D plus a temporal candidate "Col"), and each pair from the set of 5 had to be compared to identify all redundant candidates. Since there were 10 possible pairings for the five candidates, 10 comparisons were needed for WD3 to determine if there were duplicates. Ex-1007, Fig. 1, Table 4, Table 2.

323. Nakamura reduced the number of spatial candidates to 2, meaning the merge list included 3 candidates total: two spatial candidates (S_0 and S_1) plus a temporal candidate "Col." Ex-1007, Fig. 1, Table 4, Table 2; Ex-1009, 000010. Since there were only 3 candidates, the removal process only required three comparisons: one comparison of the two spatial candidates (S_0 and S_1), one

comparison of the temporal candidate with S_0, and one comparison of the temporal candidate with S_1. Ex-1007, Table 2.

324. The comparison between the spatial candidates (S_0 and S_1) involves comparing their motion information, which includes "motion vectors" and "reference indices[.]" Ex-1010, §8.4.2.1.1 ("When merging candidates have the [same] motion vectors and the same reference indices, the merging candidates are removed from the list except the merging candidate which has the smallest order in the mergeCandList.").

325. In addition, while not required by the Challenged Claims, a POSITA would have found it obvious to apply Nakamura's teachings, for removing duplicates, when spatial motion vector prediction candidates (e.g., S_0 and S_1) are identified and considered for potential inclusion in the merge list. This would have been obvious because it is a straightforward way to prevent redundant candidates in the merge list, as Nakamura and WD4 teach. Ex-1007, Fig. 1. Moreover, Nakamura teaches comparing S_0 with S_1 and then comparing the temporal candidate with the spatial candidates (Ex-1007, Table2, Table 4; Ex-1009, 000010, 000013; Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2); this is consistent with an implementation that compares a potential candidate with those already in the merge list when the potential candidate is being considered. For example, when evaluating S_1, it is compared with the only candidate in the merge list S_0; when

evaluating the temporal candidate, it is compared with the two spatial candidates in the merge list, resulting in a maximum of the three comparisons, as Nakamura teaches. Ex-1007, Fig. 1, Table 4, Table 2.

326. Ground 3 teaches **comparing… without making a comparison of each pair from the set of spatial motion vector prediction candidates.** For example, Nakamura makes the above-described comparison (between S_0 and S_1) without making a comparison of each pair from the set of spatial candidates (from blocks A, B, C, D, and E). Ex-1007, Tables 1-2, 4. Indeed, that is the purpose of Nakamura's proposal, to reduce the number of comparisons by avoiding a comparison of each pair of candidates from blocks A, B, C, D, and E. *E.g.*, Ex-1007, Fig. 1, Table 4, Table 2. Nakamura teaches that reducing "[t]he number of candidates… in the spatial derivation process… reduce[s] the number of times of comparison in the removal process." Ex-1007, §2.2.1, Table 1. Thus, the application of these teachings from Nakamura improves coding efficiency by reducing the number of comparisons needed for removing duplicates.

MVP Mode

327. For MVP mode, Ground 3 teaches limitation [1c] in a similar manner explained above for Merge Mode. For example, Nakamura teaches comparing the two spatial candidates ($mvLXS_0$ and $mvLXS_1$) as part of a removal process that

"[r]emove[s] candidates with the same motion information[.]" Ex-1007, Fig. 1, Table 4, Table 3:

Table 3 Comparison of HM3.0 between HM3.0 and proposed technique for MVP

	HM3.0	Proposal 2
The number of spatial candidates	2 in 5 [positions]	2 in 5 [positions]
Grouping of the neighbors in the spatial derivation process	Group A: Left (A_0, A_1) Group B: Upper (B_0, B_1, B_2)	without grouping
Spatial derivation order	Group A: A_0, A_1 Group B: B_0, B_1, B_2	C, D, A, B, E
The number of times of checking per spatial neighbors in the spatial derivation process	2 [times]	1 [time]
The number of times of comparison of redundant candidates in the spatial derivation process	6 [times] (mvLXA vs $mvLXB_0$, mvLXA vs $mvLXB_1$, and mvLXA vs $mvLXB_2$) x 2	0 [time]
The number of temporal candidates	1	1
MVP list order	mvLXA, mvLXB, mvLXCol	$mvLXS_0$, $mvLXS_1$, mvLXCol
The number of times of comparison in the removal process	2 [times] (mvLXA vs mvLXCol, and mvLXB vs mvLXCol)	3 [times] ($mvLXS_0$ vs $mvLXS_1$, $mvLXS_0$ vs mvLXCol, and $mvLXS_1$ vs mvLXCol)

328. As illustrated in Table 3, above, the removal process involves one comparison of spatial candidates: $mvLXS_0$ vs $mvLXS_1$. Ex-1007, Table 3. Thus, Nakamura compares the first spatial motion vector prediction candidate (e.g., for S_1, a.k.a. $mvLXS_1$) with motion information of spatial motion vector prediction candidates in the determined subset of spatial motion vector prediction candidates (e.g., the subset comprising S_0, a.k.a. $mvLXS_0$).

329. The comparison between the spatial candidates involves comparing their motion information, which includes their "motion vectors[.]" Ex-1010, §8.4.2.1.7 ("When motion vectors have the same value, the motion vectors are removed from the list except the motion vector which has the smallest order in the mvpListLX.").

330. Here, WD4 uses "mvpListLX" to reference the MVP list taught by Nakamura. For example, Nakamura refers to the MVP list under HM3.0 which includes spatial candidates "mvLXA, mvLXB," which are the same spatial candidates in mvpListLX as taught by WD4. *Compare* Ex-1007, §8.4.2.1.7 (referring to spatial candidates mvLXA and mvLXB) *with* Ex-1010, §8.4.2.1.7 (referring to spatial candidates mvLXA and mvLXB).

331. Nakamura's MVP mode teaches **comparing… without making a comparison of each pair from the set of spatial motion vector prediction candidates.** For example, Nakamura teaches comparing the spatial candidates $mvLXS_0$ and $mvLXS_1$ without making a comparison of each pair from the set of spatial candidates, including blocks A, B, C, D, and E. Ex-1007, Tables 1, 3-4. Furthermore, Nakamura teaches that "[t]he number of times of comparison of redundant candidates in the spatial derivation process" is reduced to 0. Ex-1007, Table 3; Ex-1009, 000013. Thus, both the spatial derivation process and the

removal process do not make a comparison of each pair from the set of spatial candidates. Ex-1007, Table 3; Ex-1009, 000013.

332. In addition, while not required by the Challenged Claims, a POSITA would have found it obvious to apply Nakamura's teachings, for removing duplicates, when spatial motion vector prediction candidates (e.g., S_0 and S_1) are identified and considered for potential inclusion in the MVP list. This was explained for merge mode; that analysis applies here. *Supra* ¶325.

333. Based on the foregoing explanations, Ground 3 teaches limitation [1c].

[1d]	**determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and**

334. Ground 3 teaches limitation [1d] in two independent ways: merge mode and MVP mode. Either teaching is sufficient by itself to satisfy the claims.

<u>Merge Mode</u>

335. Ground 3 teaches **determining to include or exclude the first spatial motion vector prediction candidate** (e.g., S_1) **in the motion vector prediction list** (e.g., merging candidate list) **based on the comparing.** For example, for merge mode, Nakamura teaches "[r]emov[ing] candidates with the same motion information" in the removal process. Ex-1007, Fig. 1(a).

336. As explained above, Nakamura compares motion information for the first spatial motion vector prediction candidate (S_1) with a subset (S_0). Ex-1007, Fig. 1, Tables 2, 4; Ex-1010, §8.4.2.1.1; *supra* §VI.B.2[1c]. Nakamura determines whether to include or exclude S_1 in the merge list based on this comparison: if the motion information is different, then both S_0 and S_1 are included in the merging candidate list. Ex-1007, Fig. 1; Ex-1010, §8.4.2.1.1. Conversely, if the motion information is the same, then S_1 is redundant to S_0, and Nakamura excludes S_1 in the merging candidate list based on the comparison while S_0 is included because it has the smaller order (it is earlier in the spatial derivation order): "candidates are removed from the list except the merging candidate which has the smallest order in the mergeCandList[.]" Ex-1010, §8.4.2.1.1.

MVP Mode

337. For MVP mode, Ground 3 teaches limitation [1d] in a similar manner explained above for Merge Mode. Ex-1007, §2.2.2, Table 4; Ex-1009, 000005, 000014. Indeed, Nakamura proposed a "unification of the location of spatial neighbors for merge mode and MVP" and a "unification of the derivation process for merge mode and MVP." Ex-1007, Abstract.

338. Ground 3 teaches **determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based**

on the comparing. For example, for MVP mode, Nakamura teaches "[r]emov[ing] candidates with the same motion information" in the removal process. Ex-1007, Fig. 1(b).

339. As explained above, Nakamura compares motion information for the first spatial motion vector prediction candidate ($mvLXS_1$) with a subset ($mvLXS_0$). Ex-1007, Fig. 1, Tables 3-4; Ex-1010, §8.4.2.1.7; *supra* §VI.B.2[1c]. Nakamura determines whether to include or exclude $mvLXS_1$ in the MVP list based on this comparison: if the motion information is different, then both $mvLXS_0$ and $mvLXS_1$ are included in the merging candidate list. Ex-1007, Fig. 1; Ex-1010, §8.4.2.1.1. Conversely, if the motion information is the same, then $mvLXS_1$ is redundant to $mvLXS_0$, and Nakamura excludes $mvLXS_1$ in the MVP list based on the comparison while $mvLXS_0$ is included because it has the smaller order (it is earlier in the spatial derivation order): "motion vectors are removed from the list except the motion vector which has the smallest order in the mvpListLX[.]" Ex-1010, §8.4.2.1.7.

340. Based on the foregoing explanations, Ground 3 teaches limitation [1d].

[1e]	**causing information identifying the one spatial motion vector prediction candidate from the motion vector prediction list to be transmitted to a decoder or to be stored.**

341. Ground 3 teaches limitation [1e] in two independent ways: merge mode and MVP mode. Either teaching is sufficient by itself to satisfy the claims.

Merge Mode

342. Ground 3 teaches **causing information** (e.g., merge index) **identifying the one spatial motion vector prediction candidate from the motion vector prediction list to be transmitted to a decoder or to be stored**. For example, for merge mode, WD4 teaches a merge index (e.g., "merge_idx") that "specifies the merging candidate index of the merging candidate list[.]" Ex-1010, §7.4.7. Based on the merge_idx, one spatial "candidate at position merge_idx[xP][yP] in the merging candidate list mergeCandList" is assigned as the spatial candidate to use for prediction of the current block. Ex-1010, §8.4.2.1.1. Therefore, the merge_idx identifies the spatial candidate to be used for prediction of the current block. *Id.*

343. The merge_idx is stored as part of an encoded video that is transmitted to a decoder. For example, WD4 teaches a "[p]rediction unit syntax" that describes what information is encoded for a prediction unit. Ex-1010, §7.3.7 (red square highlights added; other markings in original):

} else { /* MODE_INTER */	
if(entropy_coding_mode_flag || PartMode != PART_2Nx2N)	
merge_flag[x0][y0]	u(1) | ae(v)
if(merge_flag[x0][y0]) {	
merge_idx[x0][y0]	ue(v) | ae(v)
} else {	

344. The prediction unit syntax describes information encoded for a prediction unit. For example, "merge_flag[x0][y0] specifies whether the inter prediction parameters for the current prediction unit are inferred from a neighbouring inter-predicted partition[,]" which is merge mode. Ex-1010, §7.4.7, §0.2, §3.11, §3.12, §3.34, §3.38. If merge_flag is set equal to 1, then "merge_idx[x0][y0] specifies the merging candidate index of the merging candidate list[.]" *Id*. Therefore, merge_idx is stored as part of the encoding for the prediction unit and transmitted along with the encoded video to a decoder. In summary, Nakamura and WD4 cause merge_idx, which identifies the one spatial motion vector prediction candidate from the motion vector prediction list, to be stored in the video stream and transmitted to a decoder.

345. Nakamura confirms its merge mode teachings are used in the encoding and decoding processes by providing actual results showing improvements at both the encoder and the decoder based on its teachings. Ex-1007, Tables 5-8, 11-12; Ex-1009, 000016, 000018. At the very least, a POSITA would have found it obvious for the encoder to store merge_idx in an encoded

video and transmit the video to a decoder, the decoder can use the merge_idx to decode the video. That is the purpose of merge_idx. *See id.*

MVP Mode

346. For MVP mode, Ground 3 teaches limitation [1e] in a similar manner explained above for Merge Mode. Ex-1007, §2.2.2, Table 4; Ex-1009, 000005, 000014. Indeed, Nakamura proposed a "unification of the location of spatial neighbors for merge mode and MVP" and a "unification of the derivation process for merge mode and MVP." Ex-1007, Abstract.

347. Ground 3 teaches **causing information identifying the one spatial motion vector prediction candidate from the motion vector prediction list to be transmitted to a decoder or to be stored**. For example, for MVP mode, WD4 teaches an mvp index (e.g., "mvp_idx_l0") that "specifies the motion vector predictor index[.]" Ex-1010, §7.4.7. Based on mvp_idx_l0, a "motion vector of mvpListLX… is assigned" as the spatial candidate to use for prediction of the current block. Ex-1010, §8.4.2.1.7; *supra* §VI.A.2[1a]. Therefore, the mvp_idx_l0 identifies the spatial candidate to be used for prediction of the current block. *Id.*

348. The mvp_idx_l0 is stored as part of an encoded video that is transmitted to a decoder. For example, WD4 teaches a "[p]rediction unit syntax"

that describes what information is encoded for a prediction unit. Ex-1010, §7.3.7 (red square highlights added; other markings in original):

else { /* Pred_L0 or Pred_BI */	
if(num_ref_idx_l0_active_minus1 > 0) {	
if(!entropy_coding_mode_flag) {	
if(combined_inter_pred_ref_idx == MaxPredRef)	
ref_idx_l0_minusX[x0][y0]	ue(v)
} else	
ref_idx_l0_minusX[x0][y0]	ue(v) | ae(v)
}	
mvd_l0[x0][y0][0]	se(v) | ae(v)
mvd_l0[x0][y0][1]	se(v) | ae(v)
mvp_idx_l0[x0][y0]	ue(v) | ae(v)
}	
if(inter_pred_flag[x0][y0] = = Pred_BI) {	
if(num_ref_idx_l1_active_minus1 > 0) {	
if(!entropy_coding_mode_flag) {	
if(combined_inter_pred_ref_idx == MaxPredRef)	
ref_idx_l1_minusX[x0][y0]	ue(v)
} else	
ref_idx_l1[x0][y0]	ue(v) | ae(v)
}	
mvd_l1[x0][y0][0]	se(v) | ae(v)
mvd_l1[x0][y0][1]	se(v) | ae(v)
mvp_idx_l1[x0][y0]	ue(v) | ae(v)
}	

349. The prediction unit syntax describes information encoded for a prediction unit. For example, for a "prediction_unit(x0, y0)" or a prediction unit located at x0, y0, an "inter_pred_flag[x0][y0] specifies… [t]he array indices[,]" which includes mvp_idx_l0, used for prediction of "the considered prediction block[.]" Ex-1010, §7.4.7, §0.2, §3.11, §3.12, §3.34, §3.38. Therefore, mvp_idx_l0 is stored as part of the encoding for the prediction unit and transmitted

along with the encoded video to a decoder. In summary, Nakamura and WD4 cause the MVP index (mvp_idx_l0), which identifies the one spatial motion vector prediction candidate from the motion vector prediction list, to be stored in the video stream and transmitted to a decoder.

350. Nakamura confirms its MVP mode teachings are used in the encoding and decoding processes by providing actual results showing improvements at both the encoder and the decoder based on its teachings. Ex-1007, Tables 5-6, 9-12; Ex-1009, 000017-18. At the very least, a POSITA would have found it obvious for the encoder to store mvp_idx_l0 in an encoded video and transmit the video to a decoder, the decoder can use the mvp_idx_l0 to decode the video. That is the purpose of mvp_idx_l0. *See id.*; Ex-1010, §8.4.2.1.7.

351. Based on the foregoing explanations, Ground 3 teaches limitation [1e].

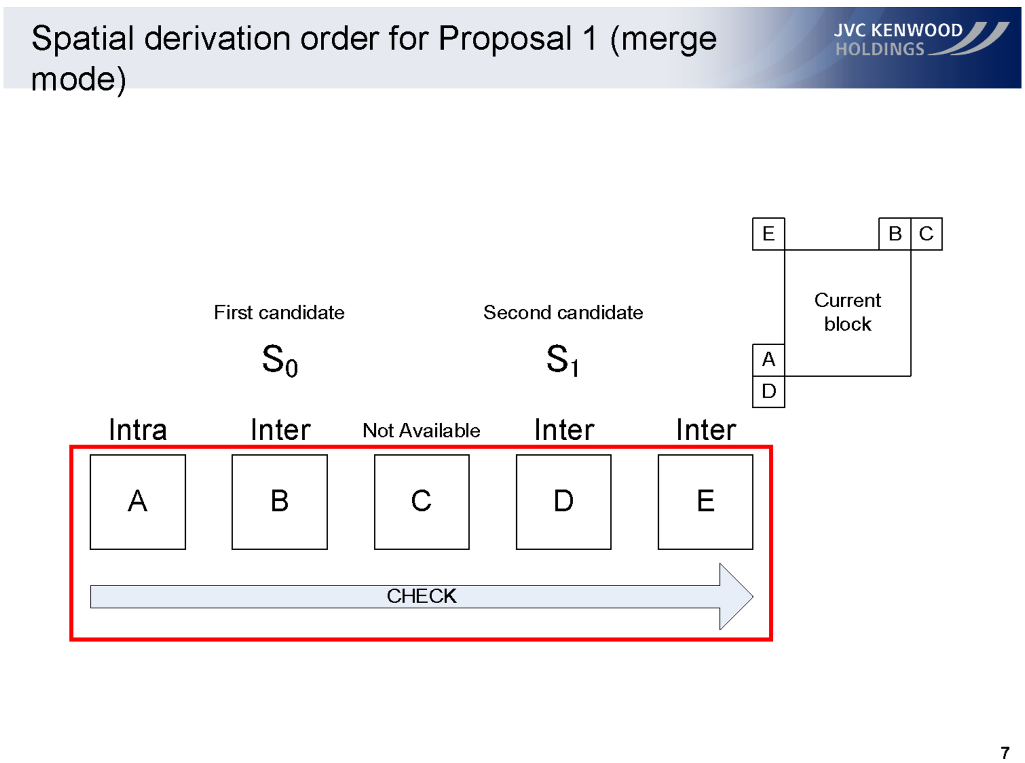
3. Dependent Claim 2

2.	**The method according to claim 1 further comprising selecting spatial motion vector prediction candidates from the set of spatial motion vector prediction candidates as the potential spatial motion vector prediction candidate in a predetermined order.**

352. Ground 3 teaches claim 2 in two independent ways: merge mode and MVP mode. Either teaching is sufficient by itself to satisfy the claims.

Merge Mode

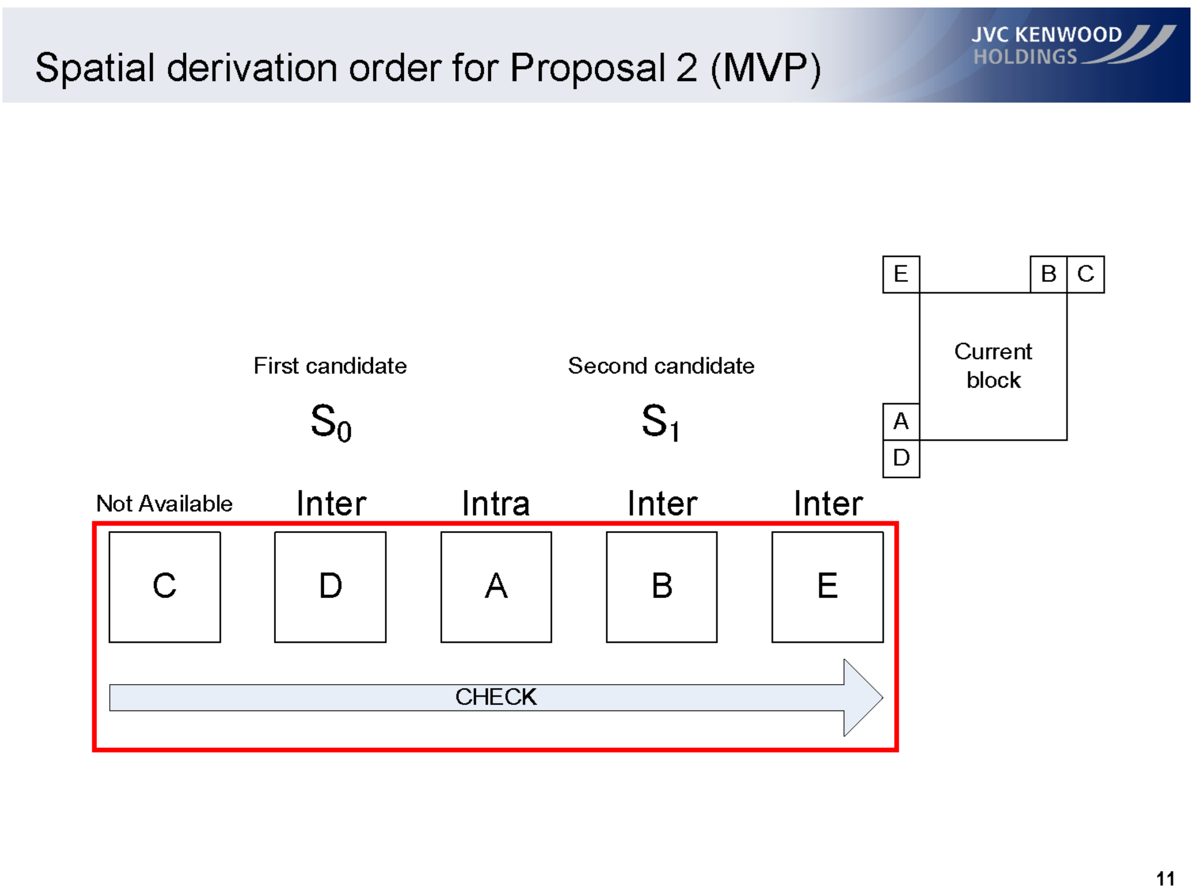
353. Ground 3 teaches **selecting spatial motion vector prediction candidates from the set of spatial motion vector prediction candidates as the potential spatial motion vector prediction candidate in a predetermined order.** For example, for merge mode, Nakamura teaches a "[s]patial derivation order" by which spatial candidates are selected as part of the spatial derivation process. Ex-1007, Tables 2-4; Ex-1009, 000008:



354. Nakamura selects spatial candidate S_0 and then S_1 following the spatial derivation order, with the spatial candidates adjacent to the current block being evaluated in the order A, B, C, D, E. Ex-1007, Tables 2, 4; Ex-1009, 000008; *supra* §VI.B.2[1a].

MVP Mode

355. Ground 3 teaches **selecting spatial motion vector prediction candidates from the set of spatial motion vector prediction candidates as the potential spatial motion vector prediction candidate in a predetermined order.** For example, for MVP mode, Nakamura teaches a "[s]patial derivation order" by which spatial candidates are checked as part of the spatial derivation process. Ex-1007, Tables 3-4; Ex-1009, 000012:



356. Nakamura selects spatial candidate S_0 and then S_1 following the spatial derivation order, with the spatial candidates adjacent to the current block

being evaluated in the order: C, D, A, B, E. Ex-1007, Tables 3-4; Ex-1009, 000012; *supra* §VI.B.2[1a].

357. Based on the foregoing explanations, Ground 3 teaches claim 2.

4. Dependent Claim 3

3.	**The method according to claim 1, further comprising comparing motion information of the potential spatial motion vector prediction candidate with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates.**

358. Ground 3 teaches claim 3 in two independent ways: merge mode and MVP mode. Either teaching is sufficient by itself to satisfy the claims.

<u>*Merge Mode*</u>

359. Ground 3 teaches **comparing motion information of the potential spatial motion vector prediction candidate** (e.g., S_1) **with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates** (e.g., S_0)**.** For example, Nakamura teaches comparing motion information of two spatial candidates (S_0 and S_1) as part of a removal process that "[r]emove[s] candidates with the same motion information[.]" Ex-1007, Fig. 1, Tables 2, 4; *supra* §VI.B.2[1c]. In the removal process, "[t]he number of times of comparison" is 3, with only one of the comparisons being between the two spatial candidates. Ex-1007, Tables 4, 2:

Table 2 Comparison between HM3.0 and proposed technique for merge mode

	HM3.0	Proposal 1
The number of spatial candidates	4 in 4 [positions]	2 in 5 [positions]
Spatial derivation order	A, B, C, D	A, B, C, D, E
The number of times of comparison of redundant candidates in the spatial derivation process	0 [time]	0 [time]
The number of temporal candidates	1	1
Merging candidate list order	A, B, Col, C, D	S_0, S_1, Col
The number of times of comparison in the removal process	10 [times] (A vs B, Col, C, D, B vs Col, C, D, Col vs C, D, and C vs D)	3 [times] (S_0 vs S_1, S_0 vs Col, and S_1 vs Col)

360. Potential spatial motion vector prediction candidate S_1 is only compared to one other spatial motion vector prediction candidate (S_0). Since "[t]he merging candidate list is constructed of two spatial merging candidates[,]" S_1 can be compared to at most one other spatial motion vector prediction candidate during the removal process. Ex-1007, §2.2.1. Table 2 confirms this: "comparison[s] in the removal process" are *S_0 vs S_1*, S_0 vs Col, and S_1 vs Col, with S_0 and S_1 being the "spatial candidate[s] found in the spatial derivation process" and Col being a co-located temporal candidate. Ex-1007, Table 2, §2.2.1; *see also* Ex-1008, §8.4.2.1.1. Since Col is a temporal candidate, it is not a spatial motion vector prediction candidate and is not part of the set of spatial motion vector prediction candidates.

361. Therefore, Nakamura teaches comparing motion information of the potential spatial motion vector prediction candidate (e.g., S_1) with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates (e.g., S_0).

MVP Mode

362. Ground 3 teaches **comparing motion information of the potential spatial motion vector prediction candidate with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates.** For example, Nakamura teaches comparing motion information of two spatial candidates ($mvLXS_0$ and $mvLXS_1$) as part of a removal process that "[r]emove[s] candidates with the same motion information[.]" Ex-1007, Fig. 1, Tables 3-4; *supra* §VI.B.2[1c]. In the removal process, "[t]he number of times of comparison" is "3 [times]", with only one of the comparisons being between the two spatial candidates. Ex-1007, Tables 4, 3:

Table 3 Comparison of HM3.0 between HM3.0 and proposed technique for MVP

	HM3.0	Proposal 2
The number of spatial candidates	2 in 5 [positions]	2 in 5 [positions]
Grouping of the neighbors in the spatial derivation process	Group A: Left (A_0, A_1) Group B: Upper (B_0, B_1, B_2)	without grouping
Spatial derivation order	Group A: A_0, A_1 Group B: B_0, B_1, B_2	C, D, A, B, E
The number of times of checking per spatial neighbors in the spatial derivation process	2 [times]	1 [time]
The number of times of comparison of redundant candidates in the spatial derivation process	6 [times] (mvLXA vs $mvLXB_0$, mvLXA vs $mvLXB_1$, and mvLXA vs $mvLXB_2$) x 2	0 [time]
The number of temporal candidates	1	1
MVP list order	mvLXA, mvLXB, mvLXCol	$mvLXS_0$, $mvLXS_1$, mvLXCol
The number of times of comparison in the removal process	2 [times] (mvLXA vs mvLXCol, and mvLXB vs mvLXCol)	3 [times] ($mvLXS_0$ vs $mvLXS_1$, $mvLXS_0$ vs mvLXCol, and $mvLXS_1$ vs mvLXCol)

363. Potential spatial motion vector prediction candidate $mvLXS_1$ is only compared to one other spatial motion vector prediction candidate ($mvLXS_0$). Since "[t]wo in five spatial candidates are derived… in the spatial derivation process[,]" there are at most two spatial candidates, and $mvLXS_1$ can be compared to at most one other spatial motion vector prediction candidate during the removal process. Ex-1007, §2.2.2. Table 3 confirms this: "comparison[s] in the removal process" are *$mvLXS_0$ vs $mvLXS_1$*, $mvLXS_0$ vs mvLXCol, and $mvLXS_1$ vs mvLXCol, with $mvLXS_0$ and $mvLXS_1$ being the "spatial candidate[s] found in the spatial derivation process" and mvLXCol being a co-located temporal candidate. Ex-1007, Table 3, §2.2.2; Ex-1008, §8.4.2.1.1. Since mvLXCol is a temporal

candidate, it is not a spatial motion vector prediction candidate and is not part of the set of spatial motion vector prediction candidates.

364. Therefore, Nakamura teaches comparing motion information of the potential spatial motion vector prediction candidate (e.g., $mvLXS_1$) with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates (e.g., $mvLXS_0$).

365. Based on the foregoing explanations, Ground 3 teaches claim 3.

5. Dependent Claim 4

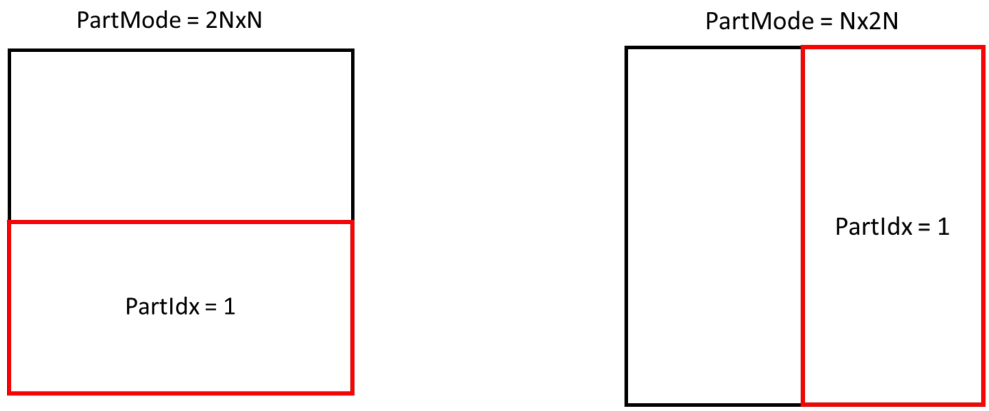
4.	**The method according to claim 1 further comprising examining whether the block of pixels is divided into a first prediction unit and a second prediction unit; and if so, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the prediction unit is the second prediction unit.**

366. Ground 3 teaches claim 4. Ground 3 teaches examining the block of pixels, which is the current block. Ex-1010, §0.2, §§3.11-3.12, §3.34, §3.38; Ex-1007, §2.2.1, Fig. 2; supra §§VI.B.2[1a], [1e].

367. For merge mode, Ground 3 teaches **examining whether the block of pixels is divided into a first prediction unit and a second prediction unit; and if so, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the prediction unit is the second prediction unit**. For example, Nakamura and WD4 teach excluding a spatial candidate, by setting it as unavailable with "availableFlagN is set equal to 0[,]" if "one of the

following conditions is true[:]… PartMode of the current prediction unit is PART_2NxN and PartIdx is equal to 1…" or "PartMode of the current prediction unit is PART_Nx2N and PartIdx is equal to 1[.]" Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. In these passages, Nakamura examines whether the block of pixels is divided into a first and second PU ("PartMode of the current prediction unit" is PART_2NxN or PART_Nx2N) and whether the current PU is the second PU ("PartIdx is equal to 1"). If so, Nakamura excludes the potential spatial motion vector prediction candidate from block B (for horizontally-divided blocks) or block A (for vertically-divided blocks) from the motion vector prediction list. This is further explained below.

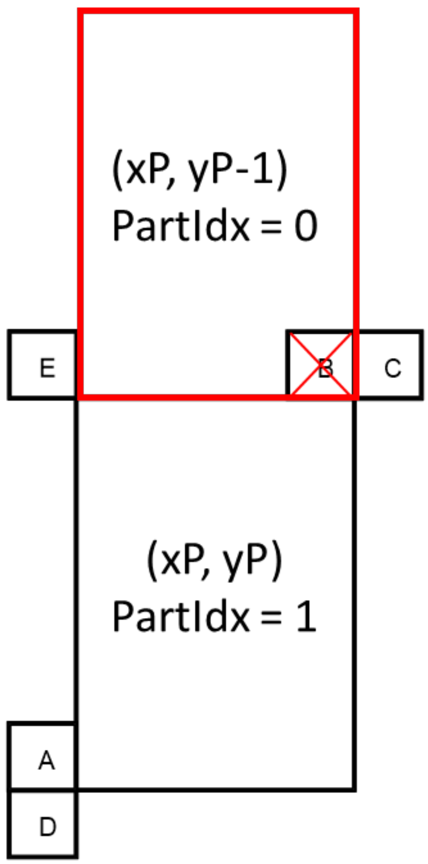
368. For HEVC, partition mode PART_2NxN refers to a block that is horizontally divided into two equal PUs; PART_Nx2N refers to a block vertically divided into two equal PUs. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2; *supra* §I.C (explaining partition notation). Each PU has a partition ID. The first PU has PartIdx = 0, while the second PU has PartIdx = 1. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. Nakamura checks if "PartIdx is equal to 1" meaning it checks if the PU is the second PU of the divided block. I have illustrated this below:



369. If the block is divided into a first and second PUs, then Nakamura excludes the potential spatial motion vector prediction candidate from the merge list if the current PU is the second PU. Ex-1008, §8.4.2.1.2. This is explained below for the horizontally-divided block (2NxN) and then the vertically-divided block (Nx2N).

370. For the 2NxN (horizontally-divided) scenario, when deciding the availability of neighboring blocks A-E, Nakamura sets the spatial candidate for block B and any spatial candidate that has "identical motion parameters[]" as block B to unavailable, meaning it is excluded from the merge list. Ex-1008, §8.4.2.1.2. Nakamura iterates through neighboring blocks, setting variable "N" to A, B, C, D or E in sequence. *Id.* ("the derivation of availableFlag N, with N being A, B, C, D or E"). For each block, including block B, Nakamura evaluates whether the block has "identical motion parameters" with block B. *Id.* ("PartMode of the current prediction unit is PART_2NxN and PartIdx is equal to 1 and *the prediction units covering luma location (xP, yP–1) (PartIdx=0)* and luma location (xN,yN) (Cand.

N) have *identical motion parameters*[.]"); Ex-1010, §8.4.2.1.2; Ex-1008, §8.4.2.1.2. Here, the coordinates "(xP, yP–1)" refers to the block above the current block because it has the same x coordinate but is 1 row up. The y coordinate has 1 subtracted from it, which results in the previous block in the vertical (y) direction. Since block B is the block above the current block, block B is a PU "covering… (xP, yP-1)." *Id.* I have illustrated this below, with a red box showing the block that Nakamura would exclude:



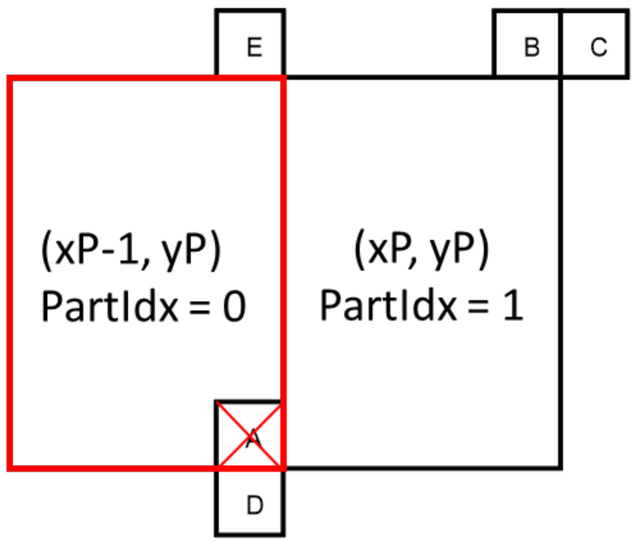
371. Block B has "PartIdx=0" because this is a horizontally-divided block (part mode 2NxN), and block B is above the current block, which has PartIdx=1. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. Therefore, when Nakamura iterates to

block B, then N is set to B (Ex-1008, §8.4.2.1.2 ("the derivation of availableFlag N, with N being A, B, C, D or E")), and Nakamura excludes block B's potential spatial motion vector prediction candidate from the merge list because, by the law of identity, block B has "identical motion parameters" with itself. *Id.*

372. By setting availableFlagB "equal to 0," block B is not available for, and therefore excluded from, the merging candidate list. Ex-1008, §8.4.2.1.2 ("The merging candidate list, mergeCandList, is constructed of… B, if availableFlagB is equal to 1[.]"); Ex-1010, §8.4.2.1.2.

373. For the Nx2N (vertically-divided) scenario, when deciding the availability of neighboring blocks A-E, Nakamura sets the spatial candidate for block A and any spatial candidate that has "identical motion parameters[]" as block A to unavailable, meaning it is excluded from the merge list. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. Nakamura iterates through neighboring blocks, setting variable "N" to A, B, C, D or E in sequence. Ex-1008, §8.4.2.1.2 ("the derivation of availableFlag N, with N being A, B, C, D or E"); Ex-1010, §8.4.2.1.2. For each block, including block A, Nakamura evaluates whether the block has "identical motion parameters" with block A. Ex-1008, §8.4.2.1.2 ("PartMode of the current prediction unit is PART_Nx2N and PartIdx is equal to 1 and *the prediction units covering luma location (xP–1, yP) (PartIdx=0)* and luma location (xN, yN) (Cand. N) have identical motion parameters[.]"); Ex-1010, §8.4.2.1.2. Here, the

coordinates "(xP-1, yP)" refers to the block to the left of the current block because its x coordinate has been decremented by 1, meaning it is the previous block in the horizontal (x) direction. Since block A is the block to the left of the current block, block A is a PU "covering luma location (xP–1, yP)." *Id.* I have illustrated this below, with a red box showing the block that Nakamura would exclude:



374. Block A has "PartIdx=0" because this is a vertically-divided block (part mode Nx2N), and block A is to the left of the current block, which has PartIdx=1. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. Therefore, when Nakamura iterates to block A, then N is set to A (Ex-1008, §8.4.2.1.2 ("the derivation of availableFlagN, with N being A, B, C, D or E")), and Nakamura excludes block A's potential spatial motion vector prediction candidate from the merge list because, by the law of identity, block A has "identical motion parameters" with itself. *Id.*

375. By setting availableFlagA "equal to 0," block A is not available for, and therefore excluded from, the merging candidate list. Ex-1008, §8.4.2.1.2 ("The merging candidate list, mergeCandList, is constructed of… A, if availableFlagA is equal to 1[.]"); Ex-1010, §8.4.2.1.2.

376. The reason why Nakamura and WD4 both teach claim 4 is because, as I explained above, blocks are divided into two PUs when each half of the block has different motion. *Supra* §VI.A.5 (explaining, for claim 4, why this was obvious based on the reason why a block is divided into two PUs to begin with). Therefore, it does not make sense to include the candidate from the other PU of a divided block because it will not reflect the motion of the current block. *See id.*

377. Based on the foregoing explanations, Ground 3 teaches claim 4.

6. Dependent Claim 5

378. Ground 3 teaches claim 5, as explained below.

[5pre]. The method according to claim 1, further comprising

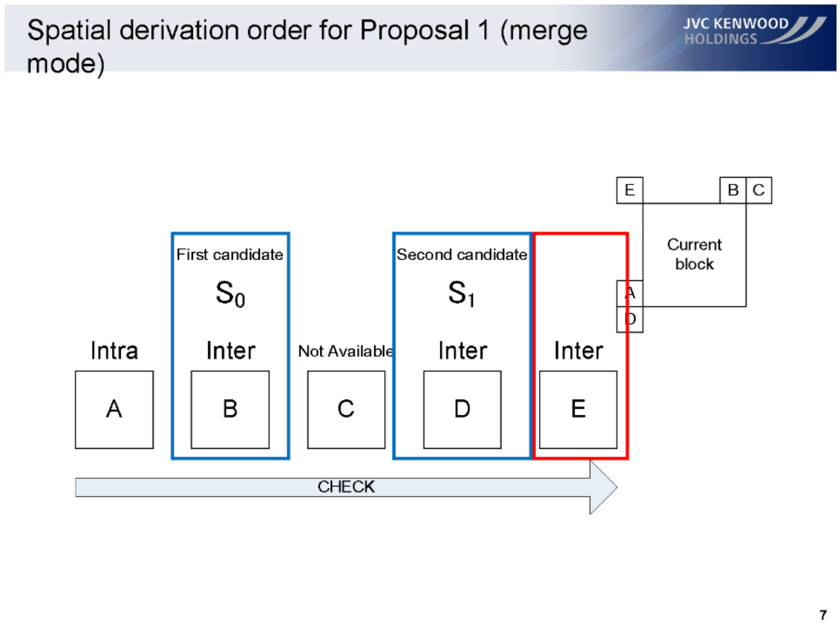
379. As I explained above, the combination of Nakamura and WD4 teaches the method of claim 1. *Supra* §VI.B.2. Therefore, the combination teaches the preamble of claim 5.

[5a]	**determining a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list; and**

380. Ground 3 teaches limitation [5a] independently with merge mode and MVP mode teachings.

Merge Mode

381. Ground 3 teaches **determining a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list** in at least two ways for merge mode. First, Nakamura teaches "[t]he merging candidate list is constructed of two spatial merging candidates[.]" Ex-1007, §2.2.1, Tables 1-2, 4; *supra* §VI.B.2[1b]. Therefore Nakamura teaches determining a maximum number of spatial candidates (2) in the merging candidate list because at most two candidates will be included in the list; no additional spatial candidates are added after two. Ex-1009, 000008:



382. As illustrated in the above example, after two spatial candidates S_0 and S_1 (highlighted with blue boxes), corresponding to blocks B and D respectively, are selected for the merging candidate list, block E (in red box) is not included in the merging candidate list even though block E is available for motion vector prediction. Ex-1009, 000008. Therefore, Nakamura teaches that two is the maximum number of spatial candidates in the merging candidate list.

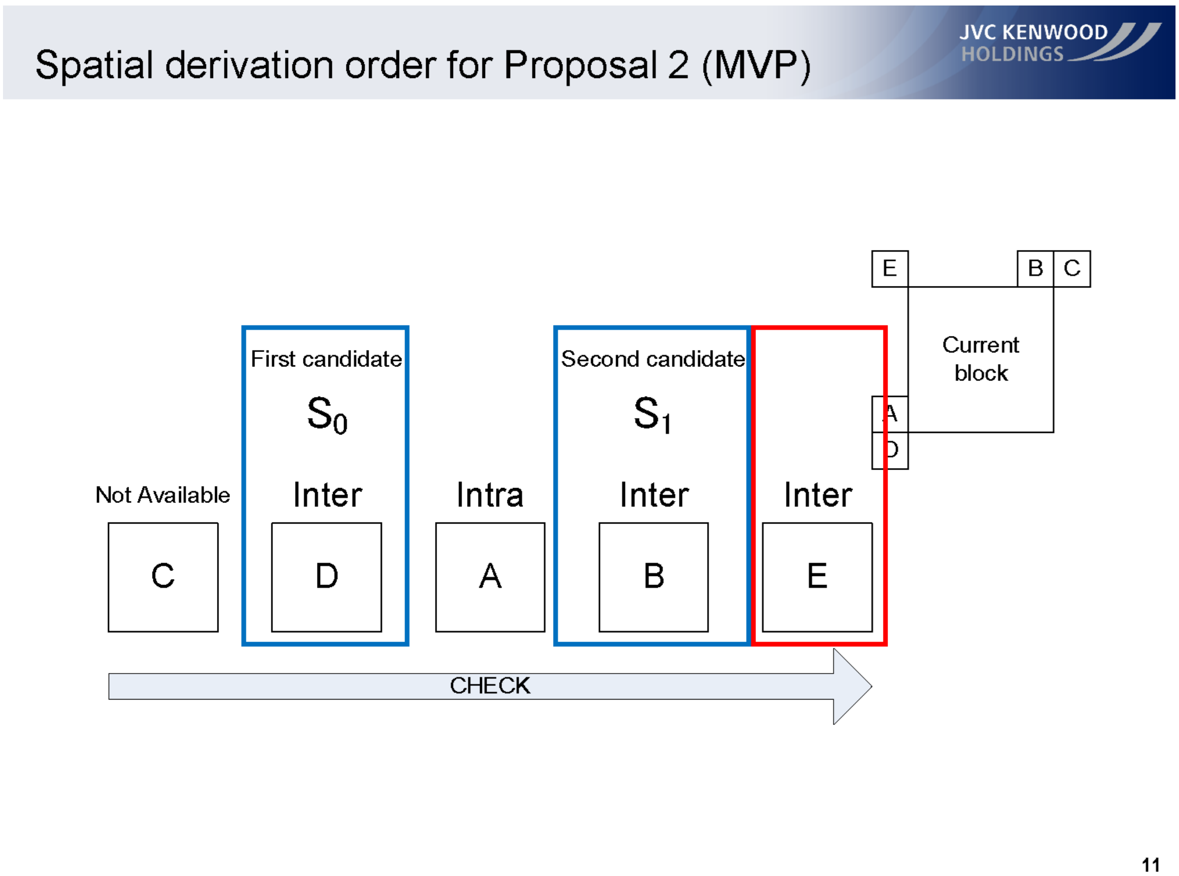
383. Second, Nakamura teaches a maximum number of spatial candidates checked for the merging candidate list. Ex-1008, §8.4.2.1.1 ("If the number of availableFlagM (with M being replaced by A, B, C or D) which is equal to 1 in order of A, B, C, D and E is equal to 4, the availableFlagN is set equal to 0. (Note: If availableFlagA, availableFlagB, availableFlagC and availableFlagD are equal to 1, availableFlagE is set to 0.)"); Ex-1010, §8.4.2.1.2 ("If one of the following

conditions is true, the availableFlagN is set equal to 0,… N is equal to B2 and availableFlagA0 + availableFlagA1 + availableFlagB0 + availableFlagB1 is equal to 4”). Here, Nakamura teaches that if four spatial neighbors are available as spatial candidates for the merging candidate list, then any additional spatial neighbor is set as unavailable, limiting the number of spatial candidates checked for the merging candidate list to four. For example, “[i]f availableFlagA” for block A, “availableFlagB” for block B, “availableFlagC” for block C, and “availableFlagD” for block D “are equal to 1,” indicating that blocks A, B, C, and D are available, then “availableFlagE” for block E “is set to 0.” Ex-1008, §8.4.2.1.1. By limiting the number of spatial candidates that are checked to four, the maximum number of spatial candidates to be included in the merging candidates list is four. Thus, for this additional reason, Nakamura teaches determining a maximum number (e.g., 4) of spatial motion vector prediction candidates to be included in the motion vector prediction list.

MVP Mode

384. Ground 3 teaches **determining a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list.** For example, Nakamura teaches “[t]wo in five spatial candidates are derived… in the spatial derivation process.” Ex-1007, §2.2.2, Tables 1, 3-4;

supra §VI.B.2[1b]. Two is the maximum number of spatial candidates in the MVP list because at most two candidates are in the list; no additional spatial candidates are added after two. Ex-1009, 000012:



385. As illustrated in the above example, after two spatial candidates S_0 and S_1 (in blue boxes) corresponding to blocks D and B respectively, are selected for the MVP list, block E (in the red box) is not included in the MVP list even though block E is available for motion vector prediction. Ex-1009, 000012. These teachings are confirmed in WD4, which teaches a variable "maxNumMVPCand is set to 2." Ex-1010, §8.4.2.1.7. If "[t]he variable numMVPCandLX" which "is set

to the number of elements within the mvpListLX… is equal to or greater than maxNumMVPCand[],” then “all motion vector predictor candidates… greater than maxNumMVPCand… are removed from the list.” Ex-1010, §8.4.2.1.7. Therefore, Nakamura teaches two is the maximum number of spatial candidates to be included in the MVP list.

386. Based on the foregoing explanations, Ground 3 teaches limitation [5a].

[5b]	**limiting the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number.**

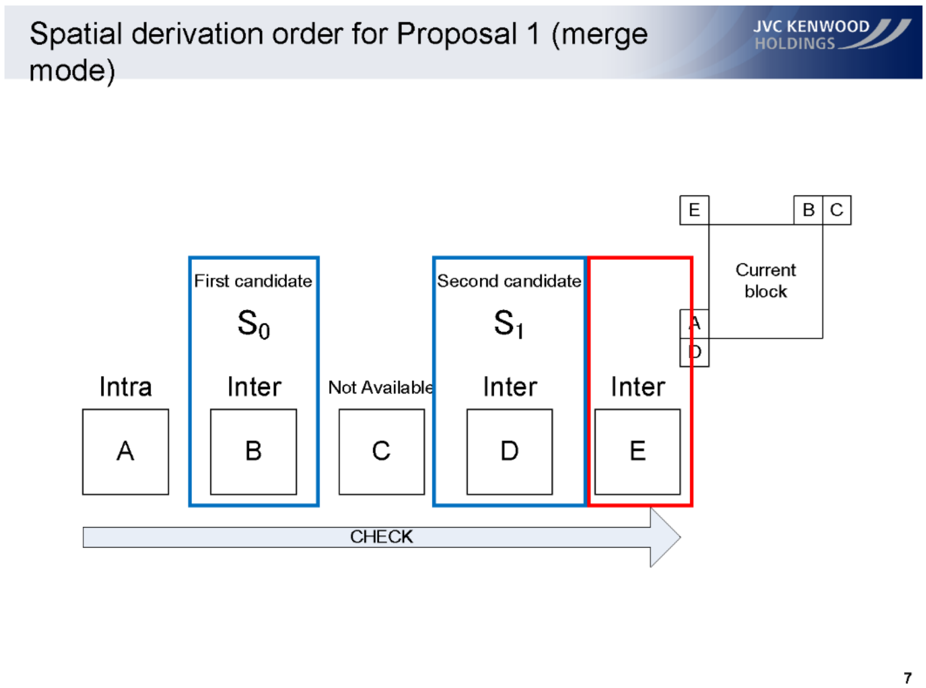
387. Ground 3 teaches limitation [5b] independently with merge mode and MVP mode teachings.

Merge Mode

388. Ground 3 teaches **limiting the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number** at least two ways for merge mode. These were explained above for limitation [5a].

389. First, Nakamura teaches that after two spatial candidates are selected for the merging candidate list, no additional spatial candidates are included in the merging candidate list. Thus, Nakamura limits the number of spatial motion vector

prediction candidates in the merging candidate list to be smaller or equal to the maximum number two. *Supra* §VI.B.6[5a]; Ex-1007, Tables 3-4; Ex-1009, 000008:



390. As illustrated in the above example, the spatial candidate for block E (in red box) is available for motion vector prediction but not included in the merging candidate list. Ex-1009, 000008. That is because two spatial candidates (in blue boxes), S_0 and S_1 corresponding to blocks B and D respectively, have already been found. *Id*. Therefore, Nakamura teaches limiting the number of spatial motion vector prediction candidates in the merging candidate list to being smaller or equal to two spatial candidates.

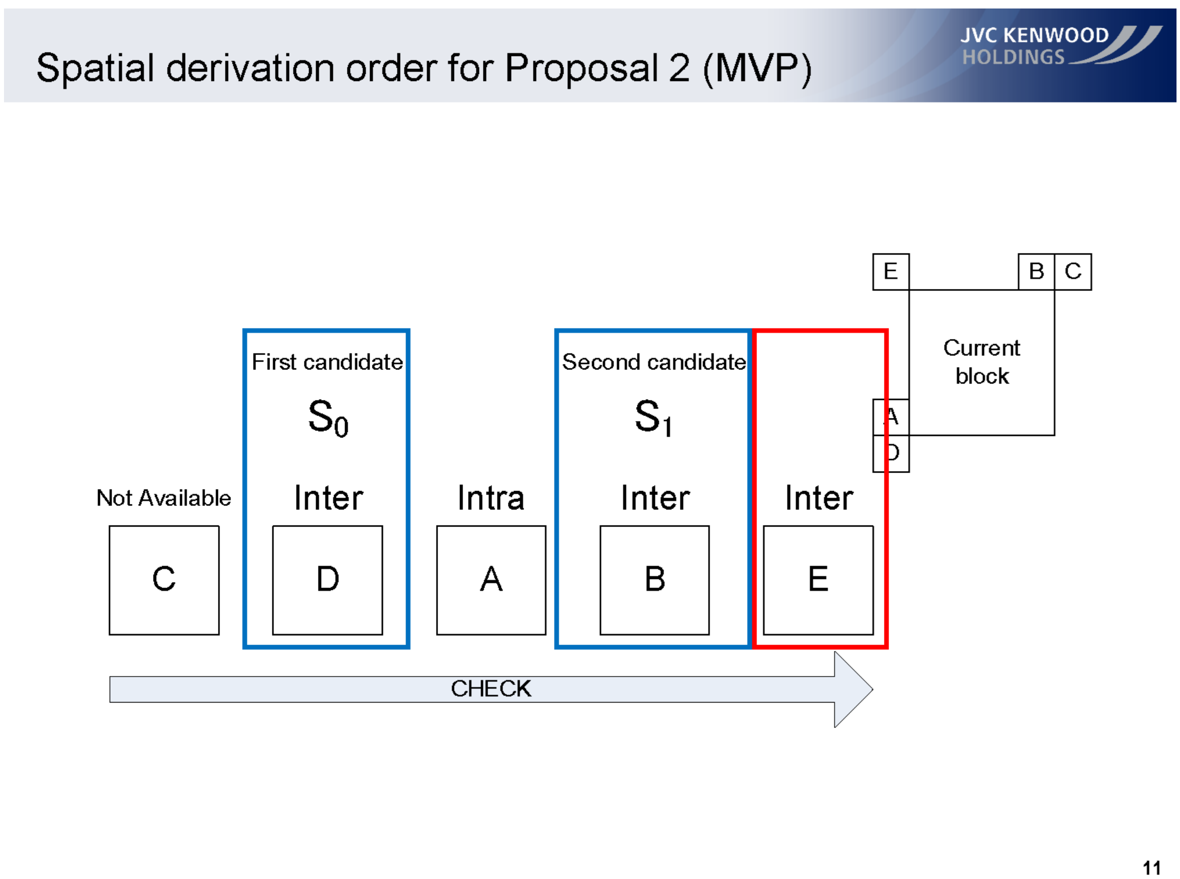
391. Second, Nakamura teaches limiting the number of spatial candidates checked for the merging candidate list to four. Ex-1008, §8.4.2.1.1 ("If the number

of availableFlagM (with M being replaced by A, B, C or D) which is equal to 1 in order of A, B, C, D and E is equal to 4, the availableFlagN is set equal to 0. (Note: If availableFlagA, availableFlagB, availableFlagC and availableFlagD are equal to 1, availableFlagE is set to 0.)"); Ex-1010, §8.4.2.1.2 ("If one of the following conditions is true, the availableFlagN is set equal to 0,… N is equal to B2 and availableFlagA0 + availableFlagA1 + availableFlagB0 + availableFlagB1 is equal to 4"); *supra* §VI.B.6[5a]. Here, Nakamura teaches that if four spatial neighbors are available as spatial candidates for the merging candidate list, then any additional spatial neighbor is set as unavailable, limiting the number of spatial candidates checked for the merging candidate list to four. For example, "[i]f availableFlagA" for block A, "availableFlagB" for block B, "availableFlagC" for block C, and "availableFlagD" for block D "are equal to 1," indicating that blocks A, B, C, and D are available, then "availableFlagE" for block E "is set to 0." Ex-1008, §8.4.2.1.1. By limiting the number of spatial candidates that are checked to four, the maximum number of spatial candidates included in the merging candidates list is at most four.

MVP Mode

392. Ground 3 teaches **limiting the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to**

the maximum number. For example, for MVP mode, Nakamura teaches "[t]wo in five spatial candidates are derived… in the spatial derivation process." Ex-1007, §2.2.2, Tables 1, 3-4; *supra* §VI.B.6[5a]. Thus, Nakamura limits the number of spatial motion vector prediction candidates in the MVP candidate list to be smaller or equal to the maximum number two; no additional spatial candidates are added after two. Ex-1009, 000012:



393. As illustrated in the above example, after two spatial candidates (in blue boxes), S_0 and S_1 corresponding to blocks D and B respectively, are selected for the MVP list, block E (in red box) is not included in the merging candidate list

even though block E is available for motion vector prediction. Ex-1009, 000012. These teachings are confirmed in WD4, which teaches a variable "maxNumMVPCand is set to 2." Ex-1010, §8.4.2.1.7. If "[t]he variable numMVPCandLX" which "is set to the number of elements within the mvpListLX… is equal to or greater than maxNumMVPCand[]," then "all motion vector predictor candidates… greater than maxNumMVPCand… are removed from the list." Ex-1010, §8.4.2.1.7. Therefore, Nakamura teaches limiting the number of spatial motion vector prediction candidates in the MVP list to being smaller or equal to two spatial candidates.

394. Based on the foregoing explanations, Ground 3 teaches limitation [5b].

7. Dependent Claim 6

395. Ground 3 teaches claim 6, as explained below.

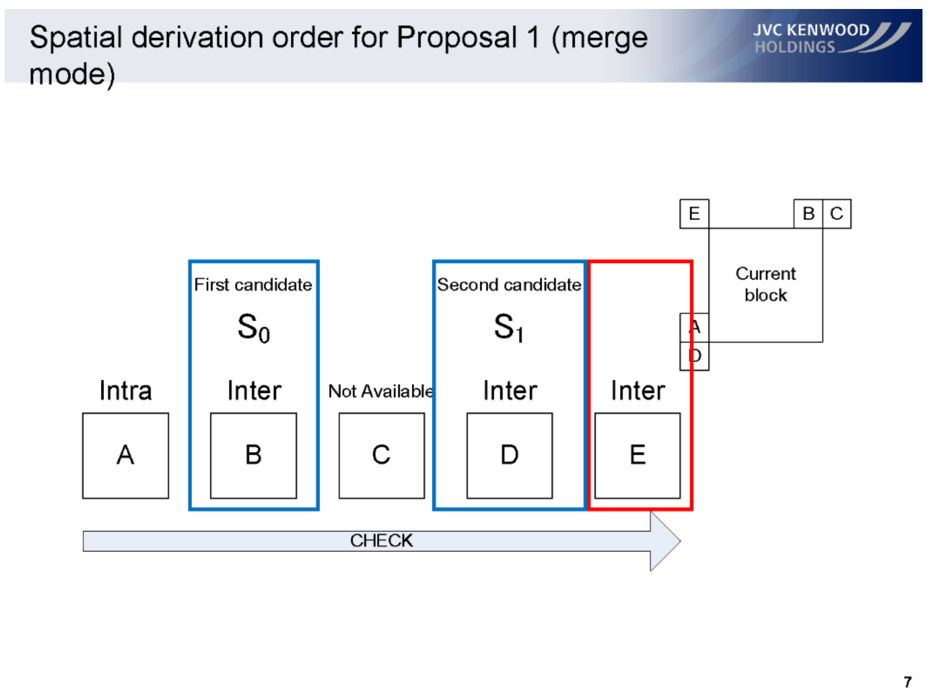
6[pre]. The method according to claim 5 comprising:

396. As I explained above, Ground 3 teaches the method of claim 5. *Supra* §VI.B.6. Therefore, Ground 3 teaches the preamble of claim 6.

[6a]	**examining, if the number of spatial motion vector prediction candidates in the motion vector prediction list smaller than the maximum number;**

397. Ground 3 teaches limitation [6a] for merge mode.

398. Ground 3 teaches **examining, if the number of spatial motion vector prediction candidates in the motion vector prediction list smaller than the maximum number**. For example, Nakamura teaches "[t]he merging candidate list is constructed of two spatial merging candidates" out of five spatial neighbors, with two as the maximum number of spatial candidates. Ex-1007, §2.2.1, Tables 1-2, 4; *supra* §VI.B.6[5a]. Nakamura further teaches examining if the number of spatial candidates in the merging candidate list is smaller than the maximum number (two) to limit the number to two. *Supra* §VI.B.6[5b]; Ex-1007, Table 3, Table 4; Ex-1009, 000008:



As illustrated in the above example, the spatial candidate for block D (e.g., S_1) is added when the number of spatial candidates in the merging candidate list is smaller than two, and the spatial candidate for block E is not included in the merging candidate list because the number of spatial candidates in the merging candidates list is no longer smaller than two. The variable "NumMergeCand" represents the "number of elements… within the mergeCandList[.]" Ex-1008, §8.4.2.1.1.

399. Based on the foregoing explanations, Ground 3 teaches limitation [6a].

[6b]	**if so, examining whether the prediction unit to which the potential spatial motion vector prediction candidate belongs is available for motion prediction;**

400. Ground 3 teaches limitation [6b] for merge mode.

401. Ground 3 teaches **examining whether the prediction unit to which the potential spatial motion vector prediction candidate belongs is available for motion prediction.** For example, Nakamura teaches that "[f]or the derivation of availableFlagN, with N being A, B, C, D or E… the availableFlagN is set equal to 0[,]" or unavailable, "[i]f one of the following conditions is true… [t]he prediction unit… is not available[.]" Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. The prediction unit may not be available, for example, because the prediction unit is intracoded (e.g., "PredMode is MODE_INTRA") or because it does not have an associated motion vector predictor. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. Therefore, Nakamura teaches examining whether the PU to which the potential

spatial motion vector prediction candidate belongs is available for motion prediction, so as to exclude the candidate if it is not available.

402. Based on the foregoing explanations, Ground 3 teaches limitation [6b].

[6c]	**if so, performing at least one of the following:**
[6d]	**for a potential spatial motion vector prediction candidate on a left side of the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:**
[6e]	**the received block of pixels is vertically divided into a first prediction unit and a second prediction unit;**
…	
[6g]	**for a potential spatial motion vector prediction candidate above the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:**
[6h]	**the received block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and the prediction unit is the second prediction unit;**

403. Limitation [6c] requires "performing at least one of the following:" and limitations [6d] and [6g] require "if any of the following conditions are fulfilled:". Therefore, I understand that limitations [6c]-[6o] are satisfied if limitations [6d]-[6e] are met. Alternatively, limitations [6c]-[6o] are also satisfied if limitations [6g]-[6h] are satisfied. Ground 3 teaches receiving a block of pixels,

which is the current block. Ex-1010, §0.2, §3.11, §3.12, §3.34, §3.38; Ex-1007, §2.2.1, Fig. 2; *supra* §§VI.B.2[1a], [1e].

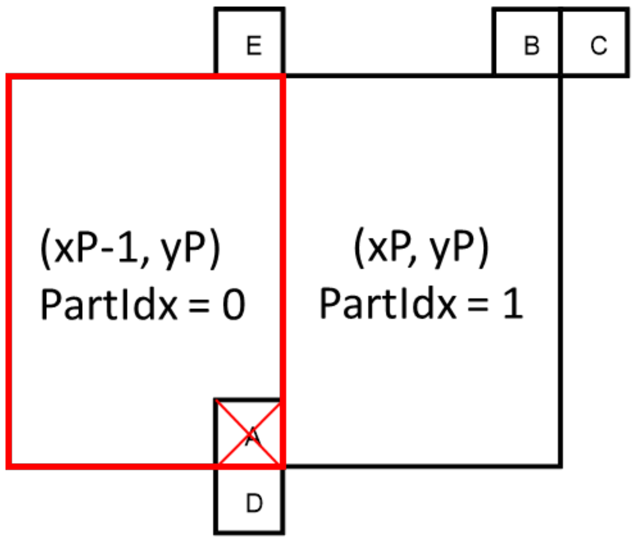
404. Ground 3 teaches limitations [6c], [6d]-[6e], [6g]-[6h] for merge mode.

405. For [6d]-[6e], Ground 3 teaches **for a potential spatial motion vector prediction candidate on a left side of the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled: the received block of pixels**[11] **is vertically divided into a first prediction unit and a second prediction unit.** For example, Nakamura excludes the potential spatial motion vector prediction candidate from the merging candidate list by setting the availableFlagN to 0. Nakamura teaches that "[i]f one of the following conditions is true, the availableFlagN is set equal to 0… PartMode of the current prediction unit is PART_Nx2N and PartIdx is equal to 1 and the prediction units covering luma location (xP-1, yP) (PartIdx=0) and luma location (xN, yN) (Cand. N) have identical motion parameters[.]" Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2.

406. Here, for a scenario where a block of pixels is a Nx2N vertically-divided block (e.g., PartMode is PART_Nx2N) and the PU for the current block is

[11] The "received block of pixels" appears to reference "a block of pixels" in [1a]. As explained above, the block of pixels is the current block for which motion vector prediction candidates are being analyzed. *Supra* §VI.B.2[1a].

the prediction unit on the right side (e.g., PartIdx=1), Nakamura teaches that the prediction unit on the left side (e.g., PartIdx=0) and any block that has "identical motion parameters" are set as unavailable and therefore excluded from the merging candidate list. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2; *supra* §VI.B.5 (explaining HEVC partition modes and ids for claim 4). This scenario is illustrated below:



407. Nakamura iterates through neighboring blocks, setting variable "N" to A, B, C, D or E in sequence. Ex-1008, §8.4.2.1.2 ("the derivation of availableFlagN, with N being A, B, C, D or E"); Ex-1010, §8.4.2.1.2. For each block, including block A, Nakamura evaluates whether the block has "identical motion parameters" with block A. Ex-1008, §8.4.2.1.2 ("PartMode of the current prediction unit is PART_Nx2N and PartIdx is equal to 1 and *the prediction units covering luma location (xP–1, yP) (PartIdx=0)* and luma location (xN, yN) (Cand.

N) have identical motion parameters[.]"); Ex-1010, §8.4.2.1.2. Here, the coordinates "(xP-1, yP)" refers to the block to the left of the current block because its x coordinate has been decremented by 1, meaning it is the previous block in the horizontal (x) direction. Since block A is the block to the left of the current block, block A is a PU "covering luma location (xP–1, yP)." *Id.* When Nakamura iterates to block A, N is set to A (Ex-1008, §8.4.2.1.2 ("the derivation of availableFlag N, with N being A, B, C, D or E")), and Nakamura excludes block A's potential spatial motion vector prediction candidate from the merge list because block A has "identical motion parameters" with itself. *Id.*

408. In the Nx2N scenario illustrated above, availableFlagA for block A is set "equal to 0," making block A unavailable for, and therefore excluded from, the merging candidate list. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. Block A is excluded because it is "the prediction unit[] covering… (xP-1, yP)" or the block on the left side of the prediction unit in a vertically divided block of pixels. Therefore, for a potential spatial motion vector prediction candidate on a left side of the current PU, Nakamura excludes the potential spatial motion vector prediction candidate from the merging candidate list if the current block is vertically divided into a first and second PU. This exclusions only occurs if the PU on the left (for vertically-divided blocks) is available for motion prediction because otherwise, it would already be marked as unavailable. *Supra* §VI.B.7[6b].

409. Therefore, as explained above, Nakamura satisfies claim 6.

410. For [6g]-[6h], Nakamura's merge mode teaches **for a potential spatial motion vector prediction candidate above the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled: the received block of pixels**[12] **is horizontally divided into a first prediction unit and a second prediction unit, and the prediction unit is the second prediction unit.** For example, Nakamura excludes the potential spatial motion vector prediction candidate from the merging candidate list by setting the availableFlagN to 0. Nakamura teaches that "[i]f one of the following conditions is true, the availableFlagN is set equal to 0… PartMode of the current prediction unit is PART_2NxN and PartIdx is equal to 1 and the prediction units covering luma location (xP, yP–1) (PartIdx=0) and luma location (xN, yN) (Cand. N) have identical motion parameters[.]" Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2.

411. Here, for a scenario where a block of pixels is a 2NxN horizontally divided block (e.g., PartMode is PART_2NxN) and the current prediction unit is the prediction unit on the bottom (e.g., PartIdx=1), Nakamura teaches that the prediction unit above the current prediction unit (e.g., PartIdx=0) and any block

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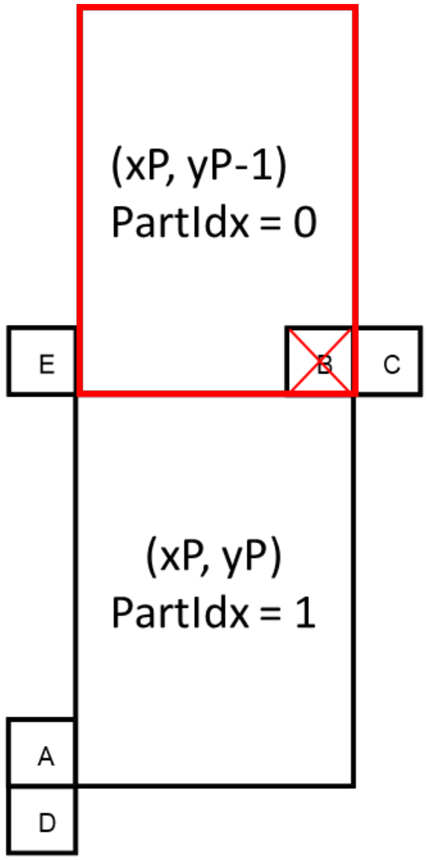
[12] The "received block of pixels" appears to reference "a block of pixels" in [1a]. As explained above, the block of pixels is the current block for which motion vector prediction candidates are being analyzed. *Supra* §VI.B.2[1a].

that has "identical motion parameters" are set as unavailable. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. This scenario is illustrated below:



412.   Nakamura iterates through neighboring blocks, setting variable "N" to A, B, C, D or E in sequence. Ex-1008, §8.4.2.1.2 ("the derivation of availableFlag N, with N being A, B, C, D or E"); Ex-1010, §8.4.2.1.2. For each block, including block B, Nakamura evaluates whether the block has "identical motion parameters" with block B. Ex-1008, §8.4.2.1.2 ("PartMode of the current prediction unit is PART_2NxN and PartIdx is equal to 1 and *the prediction units covering luma location (xP, yP–1) (PartIdx=0)* and luma location (xN,yN) (Cand. N) have *identical motion parameters*[.]"); Ex-1010, §8.4.2.1.2. Here, the coordinates "(xP,

yP–1)” refers to the block above the current block because it has the same x coordinate but is 1 row up. The y coordinate has 1 subtracted from it, which results in the previous block in the vertical (y) direction. Since block B is the block above the current block, block B is a PU “covering… (xP, yP-1).” *Id.* When Nakamura iterates to block B, then N is set to B (Ex-1008, §8.4.2.1.2 (“the derivation of availableFlag N, with N being A, B, C, D or E”)), and Nakamura excludes block B’s potential spatial motion vector prediction candidate from the merge list because block B has “identical motion parameters” with itself. *Id.*

413. In the 2NxN scenario illustrated above, availableFlagB for block B is set “equal to 0,” making block B unavailable for, and therefore excluded from, the merging candidate list. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. Block B is excluded because it is “the prediction unit[] covering… (xP, yP-1)” or the block above the current prediction unit in a vertically divided block of pixels. Therefore, for a potential spatial motion vector prediction candidate above the prediction unit, Nakamura excludes the potential spatial motion vector prediction candidate from the merging candidate list if the received block of pixels is horizontally divided into a first and second PU, and the PU is the second PU. This exclusion only occurs if the PU above (for horizontally-divided blocks) is available for motion prediction because otherwise, it would already be marked as unavailable. *Supra* §VI.B.7[6b].

414. Based on the foregoing explanations, Ground 3 teaches limitations [6c]-[6o].

8. Dependent Claim 7

7.	**The method according to claim 1 further comprising including a temporal motion prediction candidate into the motion vector prediction list.**

415. Ground 3 teaches claim 7 in two independent ways: merge mode and MVP mode. Either teaching is sufficient by itself to satisfy the claims.

Merge Mode

416. Ground 3 teaches **including a temporal motion prediction candidate into the motion vector prediction list.** For example, Nakamura teaches "[t]he merging candidate list is constructed of two spatial merging candidates and a temporal merging candidate." Ex-1007, §2.2.1, Tables 1-2 ("[t]he number of temporal candidates"), 4 ("[t]he number of temporal candidates"); Ex-1009, 000009-10, 000014; *supra* §V.B. Therefore, the merging candidate list includes a temporal motion prediction candidate.

MVP Mode

417. Ground 3 teaches **including a temporal motion prediction candidate into the motion vector prediction list.** For example, Nakamura

teaches “a temporal candidate [is] derived… in the spatial derivation process[.]” Ex-1007, §2.2.2, Tables 1, 3 (“[t]he number of temporal candidates”), 4 (“[t]he number of temporal candidates”); Ex-1009, 000009, 000013-14; *supra* §V.B. Therefore, the MVP list includes a temporal motion prediction candidate.

418. Based on the foregoing explanations, Ground 3 teaches claim 7.

9. Dependent Claim 8

8.	**The method according to claim 1 further comprising selecting one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the block of pixels.**

419. Ground 3 teaches claim 8 in two independent ways: merge mode and MVP mode. Either teaching is sufficient by itself to satisfy the claims.

<u>*Merge Mode*</u>

420. Ground 3 teaches **selecting one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the block of pixels.** For example, WD4 teaches a merge index (e.g., “merge_idx”) that “specifies the merging candidate index of the merging candidate list[.]” Ex-1010, §7.4.7; *supra* §VI.B.2[1e]. Based on the merge_idx, one spatial “candidate at position merge_idx[xP][yP] in the merging candidate list mergeCandList” is assigned as the spatial candidate to use for prediction of the current block. Ex-1010, §8.4.2.1.1.

421. As I also explained above with respect to limitation [1a], the merging candidate contains information such as motion vector information and reference picture index, which indicates the motion vector prediction for a prediction unit. *Supra* §VI.B.2[1a].

422. Therefore, WD4 teaches selecting one motion vector prediction candidate from the merging candidate list to represent a motion vector prediction for the current block of pixels. The selected merging candidate is assigned as the spatial candidate to use for prediction of the block of pixels, and therefore, represents the motion vector prediction used for the block of pixels. *Supra* §VI.B.2[1e]; Ex-1010, §8.4.2.1.1.

<u>*MVP Mode*</u>

423. Ground 3 teaches **selecting one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the block of pixels**. For example, WD4 teaches an mvp index (e.g., "mvp_idx_l0") that "specifies the motion vector predictor index[.]" Ex-1010, §7.4.7; *see supra* §VI.B.2[1e]. Based on mvp_idx_l0, a "motion vector of mvpListLX… is assigned" as the spatial candidate to use for prediction of the current block. Ex-1010, §8.4.2.1.7; *supra* §VI.B.2[1a]. Therefore, the mvp_idx_l0 identifies the spatial MVP candidate to be used for prediction of the current block.

424. As I also explained above, the MVP candidate includes information such as the motion vector and availability flag and indicates the motion vector prediction for the block. Ex-1010, §8.4.2.1.8; *supra* §VI.B.2[1a].

425. Therefore, WD4 teaches selecting one motion vector prediction candidate from the MVP list. The selected MVP candidate is assigned as the spatial candidate to use for prediction of the block of pixels, and therefore, represents the motion vector prediction used for the block of pixels. *Supra* §VI.B.2[1e]; Ex-1010, §8.4.2.1.7.

426. Based on the foregoing explanations, Ground 3 teaches claim 8.

10. Independent Claim 15

15[pre] An apparatus comprising a processor and a memory including computer program code, the memory and the computer program code configured to, with the processor, cause the apparatus to:

427. To the extent that the preamble is limiting, Ground 3 teaches limitation [15pre], as explained below.

428. Nakamura teaches an **apparatus comprising a processor and a memory including computer program code**. For example, Nakamura teaches an encoder "for encoding experiments" that comprises a "CPU" and "[m]emory[.]" Ex-1007, Table 5:

Table 5 Simulation environment for encoding experiments

CPU	Intel Core i7 870 2.93GHz
Memory	16GB (DDR3)
OS	Windows 7 Professional 64bit
Compiler	Microsoft Visual C++ 2008 Express edition SP1
Executable	x64

Furthermore, WD4 teaches "encoders" to perform the encoding process. Ex-1010, §0.5 (addressing the performance of encoders), §3.37 (defining an encoder as "[a]n embodiment of an encoding process").

429. Nakamura teaches **the memory and computer program code is configured to, with the processor, cause the apparatus to** perform the recited steps. *Infra* §§VI.A.2[23a]-[23e]. For example, Nakamura teaches "[t]his proposed technique is implemented into HM3.0 software[.]" Ex-1007, §2.3.1, §3.3.3, Tables 7-12 (reporting "[s]imulation results" with encoder runtime). At the very least, it would have been obvious to a POSITA for a video encoder to include a processor and a memory, such as a hard drive, to execute software because conventional computers have included processors and memory for this purpose for decades.

430. Based on the foregoing explanations, Ground 3 teaches limitation [15pre].

[15a]	**select a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for a block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates and is utilized to identify motion vector prediction candidates of which one spatial motion vector prediction candidate from the motion vector prediction list is signaled as the motion information for the prediction unit;**

431. Ground 3 teaches limitation [15a]. Limitation [15a] is nearly identical to limitation [1a]. *See Supra* §VI.A.10[15a]. The minor differences do not affect my analysis that, for the same reasons I have discussed for limitation [1a], Ground 3 teaches limitation [15a]. *Supra* §VI.B.2[1a]

[15b]	**determine a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;**

432. Ground 3 teaches limitation [15b], as explained below.

433. Limitation [15b] is nearly identical to limitation [1b]. *See supra* §VI.A.10[15b]. The minor differences, shown below, do not affect my analysis that Ground 3 teaches limitation [15b]. *Supra* §VI.A.10[15b], §VI.B.2[1b].

15[b]	**1[b]**
determine a subset of spatial moti on vector prediction candidates ba sed on the location of the block a ssociated with the first spatial m otion vector prediction candidate;	determining a subset of spatial mo tion vector prediction candidates based on a location of the block a ssociated with the first spatial m otion vector prediction candidate;

[15c]	**compare motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;**

434. Ground 3 teaches limitation [15c], as explained below.

435. Limitation [15c] is nearly identical to limitation [1c]. *See supra* §VI.A.10[15c]. The minor differences, shown below, do not affect my analysis that Ground 3 teaches limitation [15c]. *Supra* §VI.A.10[15c], §VI.B.2[1c].

15[c]	1[c]
compare motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;	comparing motion information of the first spatial motion vector prediction candidate with motion information of spatial motion vector prediction candidates in the determined subset of spatial motion vector prediction candidates without making a comparison of each pair from the set of spatial motion vector prediction candidates;

436. The limitation "each *possible candidate* pair" is taught by Ground 3 for the same reasons that "each pair" is taught by Ground 3, because a comparison of each pair from the set (e.g., for blocks A, B, C, D, E) is a comparison of each possible candidate pair from the set.

[15d]	**determine to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on comparison of the motion information of the first spatial motion vector candidate with motion information of the spatial motion vector prediction candidate; and**

437. Ground 3 teaches limitation [15d], as explained below.

438. Limitation [15d] is nearly identical to limitation [1d]. *See supra* §VI.A.10[15d]. The minor differences, shown below, do not affect my analysis that Ground 3 teaches limitation [15d]. *Supra* §VI.A.10[15d], §VI.B.2[1d].

15[d]	**1[d]**
determine to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on comparison of the motion information of the first spatial motion vector candidate with motion information of the spatial motion vector prediction candidate; and	determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and

[15e]	**cause information identifying the one spatial motion vector prediction candidate from the motion vector prediction list to be transmitted to a decoder or to be stored.**

439. Ground 3 teaches limitation [15e]. Limitation [15e] is nearly identical to limitation [1e]. *See Supra* §VI.A.10[15e]. The minor differences do not affect my analysis that, for the same reasons I have discussed for claim 7, Ground 3 teaches limitation [15e]. *Supra* §VI.B.2[1e].

11. Dependent Claim 16

440. Ground 3 teaches claim 16. Claim 16 is nearly identical to claim 2. *See Supra* §VI.A.11. The minor differences do not affect my analysis that, for the same reasons I have discussed for claim 2, Ground 3 teaches claim 16. *Supra* §VI.B.3.

12. Dependent Claim 17

441. Ground 3 teaches claim 17. Claim 17 is nearly identical to claim 3. *See Supra* §VI.A.12. The minor differences do not affect my analysis that, for the same reasons I have discussed for claim 3, Ground 3 teaches claim 17. *Supra* §VI.B.4.

13. Dependent Claim 18

442. Ground 3 teaches claim 18. Claim 18 is nearly identical to claim 4. *See Supra* §VI.A.13. The minor differences do not affect my analysis that, for the same reasons I have discussed for claim 4, Ground 3 teaches claim 18. *Supra* §VI.B.5.

14. Dependent Claim 19

443. Ground 3 teaches claim 19. Claim 19 is nearly identical to claim 5. *See Supra* §VI.A.14. The minor differences do not affect my analysis that, for the same reasons I have discussed for claim 5, Ground 3 teaches claim 19. *Supra* §VI.B.6.

15. Dependent Claim 20

444. Ground 3 teaches claim 20. Claim 20 is nearly identical to claim 6. *See Supra* §VI.A.15. The minor differences do not affect my analysis that, for the same reasons I have discussed for claim 6, Ground 3 teaches claim 20. *Supra* §VI.B.7.

16. Dependent Claim 21

445. Ground 3 teaches claim 21. Claim 21 is nearly identical to claim 7. *See Supra* §VI.A.16. The minor differences do not affect my analysis that, for the same reasons I have discussed for claim 7, Ground 3 teaches claim 21. *Supra* §VI.B.8.

17. Dependent Claim 22

446. Ground 3 teaches claim 22. Claim 22 is nearly identical to claim 8. *See Supra* §VI.A.17. The minor differences do not affect my analysis that, for the same reasons I have discussed for claim 8, Ground 3 teaches claim 22. *Supra* §VI.B.9.

18. Independent Claim 29

[29pre]. A non-transitory computer readable medium having stored thereon a computer executable program code for use by an encoder, said program codes comprising instructions for:

447. To the extent that the preamble is limiting, Ground 3 teaches limitation [29pre], as explained below.

448. Nakamura and WD4 teach **a non-transitory computer readable medium having stored thereon a computer executable program code for use by an encoder, said program codes comprising instructions for**. For example, Nakamura teaches that "[t]his proposed technique is implemented into HM3.0 software[.]" Ex-1007, §2.3.1. Therefore, Nakamura's teachings have been implemented using software executed on encoders and decoders. Ex-1007, Tables 5-12 (describing "the simulation environments for encoding and decoding experiments" and the "[s]imulation results"). WD4 confirms this, teaching its techniques are implemented on "a very large variation… of encoders and decoders[.]" Ex-1010, §0.5. At the very least, it would have been obvious to a POSITA for a video encoder to include a non-transitory computer-readable medium, such as a hard drive, that stores computer executable program code, such as software, because conventional computers have included hard drives storing software for decades.

449. Based on the foregoing explanations, Ground 3 teaches limitation [29pre].

[29a]	**selecting a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for a block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates and is utilized to identify motion vector prediction candidates of which one spatial motion vector prediction candidate from the motion vector prediction list is signaled as the motion information for the prediction unit;**

450. Ground 3 teaches limitation [29a]. Limitation [29a] is identical to limitation [1a]. For the same reasons I have discussed for limitation [1a], Ground 3 teaches limitation [29a]. *Supra* §VI.B.2[1a].

[29b]	**determining a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;**

451. Ground 3 teaches limitation [29b], as explained below.

452. Limitation [29b] is nearly identical to limitation [1b]. *See* §VI.A.10[29b]. The minor differences do not affect my analysis that, for the same reasons I have discussed for limitation [1b], Ground 3 teaches limitation [29b]. *Supra* §VI.B.2[1b].

29[b]	1[b]
determining a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;	determining a subset of spatial motion vector prediction candidates based on a location of the block associated with the first spatial motion vector prediction candidate;

[29c]	**comparing motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;**

453. Ground 3 teaches limitation [29c], as explained below.

454. Limitation [29c] is nearly identical to limitation [1c]. *See* §VI.A.10[29c]. The minor differences do not affect my analysis that, for the same reasons I have discussed for limitation [1c], Ground 3 teaches limitation [29c]. *Supra* §VI.B.2[1c].

29[c]	1[c]
comparing motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;	comparing motion information of the first spatial motion vector prediction candidate with motion information of spatial motion vector prediction candidates in the determined subset of spatial motion vector prediction candidates without making a comparison of each pair from the set of spatial motion vector prediction candidates;

[29d]	**determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and**

455. Ground 3 teaches limitation [29d]. Limitation [29d] is identical to limitation [1d]. For the same reasons I have discussed for limitation [1d], Ground 3 teaches limitation [29d]. *Supra* §VI.B.2[1d].

[29e]	**causing information identifying the one spatial motion vector prediction candidate from the motion vector prediction list to be transmitted to a decoder or to be stored.**

456. Ground 3 teaches limitation [29e]. Limitation [29e] is identical to limitation [1e]. For the same reasons I have discussed for limitation [1e], Ground 3 teaches limitation [29e]. *Supra* §VI.B.2[1e].

VII. BACKGROUND AND QUALIFICATIONS

457. This section contains a summary of my educational background, career history, publications, and other relevant qualifications. My full curriculum vitae is attached as Appendix 1 to this declaration.

458. I received a bachelor of science degree in Electrical and Computer Engineering from the University of California at Davis in 1985. I received a Master of Science degree in electrical and Computer Engineering from the University of California at Santa Barbara in 1990, and I received my PhD. in Electrical and Computer Engineering, also from the University of California at Santa Barbara in 1993.

459. I have more than 30 years of experience with data compression, decompression, and data storage.

460. I am currently a Full Professor in the Klipsch School of Electrical & Computer Engineering at New Mexico State University. I was an Assistant Professor at New Mexico State from January 2000 until I became an Associate Professor in 2004. I have been a Full Professor since August 2010. My research and coursework at New Mexico State have focused on digital signal and image and video processing. Much of the research I have done over the course of my career is in the area of image and video compression.

461. My first exposure to the field of signal compression came in the fall of 1989, when I took a course entitled Vector Quantization and Signal Compression at UCSB from Prof. Allen Gersho—an internationally renowned researcher in the area of speech compression. As my Ph.D. research progressed, I began to focus on transform-based compression as my main application area. My first paper dealing with image compression was published in 1991. I have since written 24 other journal and conference papers directly related to compression, and I am the named inventor on two issued United States patents related to compression.

462. Since joining the faculty of New Mexico State University in 2000, I have taught numerous classes at both the graduate and undergraduate levels. At the graduate level, I have taught the following: Signal Compression (EE573), Image Processing (EE596), Digital Signal Processing (EE545), Pattern Recognition (EE565), Advanced Linear Systems (EE555), Telemetering Systems (EE585), Information Theory (EE586), Adaptive Signal Processing (EE594), Multirate Signal Processing and Wavelets (EE595), and Neural Signal Processing (EE590). At the undergraduate level, I have taught the following courses: Linear Algebra & Probability (EE200), Signals and Systems I (EE312), Image Processing (EE446), Introduction to Digital Signal Processing (EE395), and Digital Communications (EE497).

463. From 1993 through 1999, I was a Researcher and Team Leader, at the Naval Air Warfare Center, China Lake. At China Lake, my research efforts focused on high speed image and video compression technologies including embedded wavelet video compression. I also developed a real-time video streaming system that efficiently operated over TCP/IP networks while retaining the highest possible fidelity.

464. From 1990 through 1993, I worked as a Research Assistant in the Department of Electrical and Computer Engineering at the University of California, Santa Barbara. In this position, I worked on subband coding (compression) and multirate filter bank theory. I also implemented real-time filter banks on a digital signal processor. In the summer of 1992, I worked at AT&T Bell labs where I developed and simulated new methods of extremely low bit rate video coding for video telephone applications.

465. From 1985 through 1989, I worked as a Design Engineer at the Naval Weapons Center, China Lake. In this role, I built and tested the guidance electronics for various laser guided munitions. This project included mixed analog and digital circuit design as well as the programming of an embedded digital signal processor. I also developed software for an advanced video processor and studied ground target tracking.

466. A full listing of my publications is found in my curriculum vitae. *See* Appendix 1.

467. I have published 17 peer-reviewed journal articles and 94 conference papers, including 9 journal articles and 30 conference papers directly related to data compression; the following are representative:

- C.D. Creusere, "A new method of robust image compression based on the embedded zerotree wavelet algorithm," IEEE Trans. on Image Processing, Vol 6, No. 10, Oct. 1997, pp. 1436-1442.
- C.D. Creusere, "Fast embedded compression for video," IEEE Trans. on Image Processing, Vol. 8, No. 12, pp. 1811-16, December 1999.
- C.D. Creusere, "Motion compensated video compression with reduced complexity encoding for remote transmission," Signal Processing: Image Communications, Vol. 16, pp. 627-42, April 2000.

468. I am a named co-inventor on two issued patents, both relating specifically to image and video compression. I am the listed inventor on U.S. Patent No. 6,148,111 entitled "Parallel digital image compression system which exploits zerotree redundancies in wavelet coefficients" and U.S. Patent No. 6,466,698 entitled "Efficient embedded image and video compression using lifted wavelets."

469. In addition to the experience and publications listed above, I have also received the following awards and distinctions that are relevant to the subject matter of this declaration. I am currently deputy Editor-in-Chief for IEEE Transactions on Image Processing as well as an Area Editor for IEEE Open Journal on Signal Processing. I have previously served as an Associate Editor for IEEE Transactions on Image Processing from 2010 through 2014. I have also served in this capacity from 2002 through 2005. From 2008-2013, I served as an Associate Editor for IEEE Transactions on Multimedia. I also served as a Senior Area Editor for IEEE Transactions on Image Processing from 2016-2022.

470. In 2004, I served as the co-general chair for the IEEE Digital Signal Processing Workshop in Taos, New Mexico. In 2012 and 2014, I served as the co-technical chair for the Southwest Symposium on Image Analysis and Interpretation held in Santa Fe, New Mexico and San Diego, CA, respectively. In addition, I served as the technical chair for the 2015 and 2021 International Telemetering Conference held in Las Vegas, NV in October. I am also a member of the technical program committees for the IEEE Data Compression Conference, IEEE International Conference on Image Processing and the IEEE Acoustics, Speech, and Signal Processing Conference.

B. Compensation

471. For my efforts in connection with the preparation of this declaration I have been compensated at my standard rate for this type of consulting activity. My compensation is in no way contingent on the results of these or any other proceedings relating to the above-captioned patent.

C. Materials and Other Information Considered

472. I have considered information from various sources in forming my opinions. I have reviewed and considered each of the exhibits listed in the attached Appendix 2 (Materials Considered in the Preparation of This Declaration) in forming my opinions.

VIII. UNDERSTANDING OF THE LAW

473. I am not an attorney. In forming my opinions in this Declaration, I applied the relevant legal principles provided to me by counsel, which are summarized in Appendix 4.

IX. RESERVATION OF RIGHTS

474. My opinions are based upon the information that I have considered to date. I am unaware of any evidence of secondary considerations with respect to the ’714 patent that would render any of the challenged claims non-obvious. I reserve the right, however, to supplement my opinions in the future to respond to any arguments raised by the owner of the ’714 patent and to take into account new information that becomes available to me.

475. I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed on April 8, 2024.

By:

Charles D. Creusere

APPENDIX 1: CURRICULUM VITAE OF CHARLES D. CREUSERE

VITA

CHARLES D. CREUSERE

Klipsch School of Electrical & Computer Engineering
Mailing Address:
MSC 3-0
New Mexico State University
P.O. Box 30001
Las Cruces, NM 88003-8001
Phone: 575-646-3919
Fax: 575-646-1435

email: ccreuser@nmsu.edu

DISSERTATION TITLE

"Perfect Reconstruction Modulated Polyphase Filter Banks Using Reverse-Time Subfilters."

ACADEMIC TRAINING

1980-1985: University of California at Davis, B.S. in Electrical and Computer Engineering.

1989-1990: University of California at Santa Barbara, M.S. in Electrical and Computer Engineering.

1990-1993: University of California at Santa Barbara, Ph.D. in Electrical and Computer Engineering.

PROFESSIONAL EXPERIENCE

2010-Present Holder of the Frank Carden Endowed Chair in Telemetering & Telecommunications and Full Professor. Current research interests include compressive sensing/sparse reconstruction for LIDAR and streaming sensor data as well as EEG brain analysis for audiovisual perceptual quality assessment and modeling.

October 2008 Selected for the International Foundation for Telemetering Endowed Professorship.

Jan. 2000-2008 Assistant/Associate professor in the Klipsch School of Electrical & Computer Engineering. My teaching areas include digital signal processing, image processing, pattern classification, and source coding (signal compression). I have done past research in areas of image, video, and audio compression as well as feature vector extraction for pattern classification. Currently, my research interests include distributed compression, polarimetric image processing for scene analysis, and nonstationary signal denoising.

1993-1999: Researcher & Team Leader, Naval Air Warfare Center, China Lake. My research efforts have focused on high speed image and video compression technologies which offer unique capabilities such as robustness to transmission errors and regional localization. My team (2 other people) and I have implemented a real-time (3 to 15 frames/second with 240x512 frames)

320C80-based system which uses a wavelet transform along with embedded coding techniques to compress a video input and stream it through the Internet via TCP/IP protocols. Our recent research focus has been to add more intelligence to the encoder so that the space-frequency information in the image that is most useful for image analysis is received with the highest fidelity. While most of my recent research has been in the area of embedded compression, I am still very much interested in other applications of time/space-frequency decompositions and of multirate digital signal processing concepts in general.

1999, Spring Quarter: Instructor at the University of California at Santa Barbara. Taught graduate class in Multirate Digital Signal Processing, ECE 258B.

1990-1993: Research Assistant, Department of Electrical and Computer Engineering, University of California, Santa Barbara. Worked under Prof. S.K. Mitra on subband coding and multirate filter bank theory. Also implemented real-time filter banks on a Motorola 56001 digital signal processor.

1992: Summer Employee, AT&T Bell labs, Murray Hill, NJ. Developed and simulated new methods of extremely low bit rate video coding for video telephone applications.

1985-1989: Design Engineer, Naval Weapons Center, China Lake. Designed, built, and tested the guidance electronics for the Laser Guided Training Round. This project included mixed analog and digital circuit design as well as the programming of an embedded DSP. Also developed software for an advanced video processor and studied ground target tracking.

FUNDED RESEARCH

- (2000) Office of Naval Research, *Compression of Digital Elevation Maps Using Non-linear Wavelets*, 2000-2003, $94K

- (2001) Sandia National Labs, *Intelligent Compression for Remote Sensing*, 2001-2003, $70K.

- (2002) National Science Foundation (Early Career Grant), *Efficient Audio Compression with Perceptually Embedded Scalability*, 2002-2007, $350K.

- (2004) National Geospatial-Intelligence Agency, *Passive Polarimetric Imagery Classification Study*, 2004-2006, $160K (joint with Dr. David Voelz).

- (2005) Los Alamos National Laboratories, *Signal Detection via Adapted Filter Banks and Geometric Dimensionality Reduction*, 2005-2006, $15K (unburdened).

- (2006) Los Alamos National Laboratories, *Signal Detection via Adapted Filter Banks and Geometric Dimensionality Reduction*, 2006-2007, $50K (unburdened).

- (2006) National Geospatial-Intelligence Agency, *Exploiting Polarization in Imaging Systems*, 2006-2009, $304K (joint with Dr. David Voelz).

- (2006) Army Research Office, *Distributed Source Coding Using Bitstream-based Detection and Classification*, 2006-2009, $326K.

- (2006) DARPA (Subcontract from LANL), *ADAM Project*, 2006-2007, $104K (joint with Dr. Joe Lakey and Dr. Jaime Ramirez)

• (2009) NMSU IRG, *Perceptual audio quality evaluation by direct measurement of human brain responses*, 2009-2010, $39K (joint with Dr. Jim Kroger, Psychology)

• (2011) National Science Foundation, *CIF:Medium:Assessment and modeling of temporal variation in perceived audio and video quality using direct brainwave measurement*, 2011-2015, $917K (lead PI with Dr. Jim Kroger and Dr. Joerg Kliewer as co-PIs)

• (2011) NASA EPSCOR, *Proximity Operations for Near Earth Asteroid Exploration,* 2011-2014, $750K (co-PI, with Dr. Eric Butcher (lead), others)

• (2012) National Geospatial Intelligence Agency (NGA), *Pulse Complexity Based LIDAR Scene Modeling for Sparse Reconstruction and Super-Resolution*, 2012-2013 (plus 3 1 year options), $150K ($75K/option year), co-PI Dr. David Voelz.

• (2018) Airforce Research Lab (AFRL), Software Radio Design in LabView FPGA, 2018-2019, $140K.

PATENTS

• Patent titled "Parallel digital image compression system which exploits zerotree redundancies in wavelet coefficients," Patent Number 6,148,111.

• Patent titled "Efficient embedded image and video compression using lifted wavelets," Number: 6,466,698, granted October 15, 2002.

OTHER DISTINCTIONS

• Awarded the International Foundation for Telemetering Professorship, October 2008.

• Received an educational fellowship from the Department of Defense, 1989-1992.

• Certificate of Merit for the outstanding technical paper awarded at the AIAA Missile Sciences Conference for the paper "Automatic target recognition directed image compression," Nov. 1998.

• Patent (classified) "Notice of Allowability" titled, "Microcontroller-Based Laser Pulse Decoder," granted October 7, 1991.

• Associate editor for IEEE Trans. on Image Processing, 2002-2005, 2010-2014

• Associate editor for IEEE Trans. on Multimedia , 2008-2013.

• Guest Editor, "Issue on Advances in Hyperspectral Data Processing and Analysis", IEEE Journal of Selected Topics in Signal Processing, Vol. 5, Numbers: 5 & 6, August-September 2015,

• Co-general chair, IEEE Digital Signal Processing Workshop, August 2004, Taos, NM.

• Co-technical chair for the 2012 and 2014 Southwest Symposium on Image Analysis and Interpretation.

• Student Paper Contest Chair, 40th Asilomar Conf. on Signals, Systems, and Computers, October 2006.

- Organized special session entitled "Applications of Multirate DSP" at the 40th Asilomar Conf. on Signals, Systems, and Computers, October 2006.
- Member of technical program committees for the IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), the IEEE International Conference on Image Processing (ICIP), and the IEEE Data Compression Conference (DCC).
- Senior Area Editor, IEEE Transactions on Image Processing, March 2016 to May 2022.
- Area Editor for IEEE Access, June 2022-Present.
- Deputy Editor-in-Chief, IEEE Transactions on Image processing, May 2023-present.

CONSULTING ACTIVITIES

- Video compression systems (technology consultant), Abba Tech, Albuquerque, NM, 2000.
- Expert witness in laser rangefinding technology, Asia Optical Inc. (through NY law firm of Osterlenk, Faber, Gerb & Soffen), Case: LTI versus Nikon/AOI, July 2001-2003. Case went to trial/ testified in court.
- Technical expert for defense; Case: Real-Time v. AT&T (byte.mobile), 2011-2012, case settled June 2012.
- Technical expert for defense; Case: Princeton Digital v. Dell, 2014-2015, case dismissed June 2015.
- Technical expert for defense; Noninfrigement & IPR (6,597,812), Real-time v. SAP, 1/2016-6/2016.
- Technical expert for defense; IPRs (7,378,992 & 8,643,513), Real-time v. Riverbed, et al., 2/2016-2017
- Technical expert for defense; IPRs (7,415,530, 9,116,908, 7,161,506, & 9,054,728), Real-time v. Dell, et al., 2/2016-2017
- Technical expert for defense; Noninfringement, Real-time v. HP Enterprises, 4/2016-2018.
- Technical expert for defense; IPR (7,358,867, 7,161,506, & 9,054,728), Real-time v. Teradata 11/2016-2017
- Technical expert for defense; IPRs (7,415,530, 8,643,513 & 7,378,992), Real-time v. Veritas 12/2016-2017.
- Technical expert for defense; IPRs (7,075,917 & 6,304,612), UNILOC v. Apple 9/2018-2019.
- Technical expert for defense; IPR (7,558,730), Advanced Voice Recognition Systems v. Apple 7/2019-2020.
- Technical expert for defense; District Court; Noninfringement, Realtime Adaptive Systems v. YouTube/Google, 2018-2020.
- Technical expert for defense; ITC case; Nokia v. Lenovo, Oct. 2020-2021.
- Technical expert for defense; IPR (10,176,848), Maxell v. Apple, 2019-2021.

• Technical expert for plaintiff (rebutting invalidity); East Texas District Court; USAA v. PNC Bank, 2021-present. Deposed in Case 1 and Case 2; Attended trial in May 2022 for Case 1 and September 2022 for Case 2 but was not called to testify (USAA won on all counts, patents upheld as valid); I have also opined as an expert in 3 related IPRs (deposed in one of those cases, so far).

• Technical expert for defense; District Court; Gesture Tech Partners v. Apple/Lenovo&Motorola, 2021.

JOURNAL PUBLICATIONS

1. **C.D. Creusere and S.K. Mitra**, "A simple method for designing high-quality prototype filters for M-band pseudo-QMF banks," *IEEE Trans. on Signal Processing*, Vol. 43, No. 4, April 1995, pp. 1005-1007.

2. **C.D. Creusere and S.K. Mitra**, "Efficient audio coding using perfect reconstruction noncausal IIR filter banks," *IEEE Trans. on Speech and Audio Processing,* Vol. 4, No. 2, March 1996, pp. 115-123.

3. **C.D. Creusere and S.K. Mitra**, "Image coding using wavelets based on perfect reconstruction IIR filter banks," *IEEE Trans. on Circuits and Systems for Video Technology,* Vol. 6, No. 5, Oct. 1996, pp. 447-458.

4. **C.D. Creusere**, "A new method of robust image compression based on the embedded zerotree wavelet algorithm," *IEEE Trans. on Image Processing*, Vol 6, No. 10, Oct. 1997, pp. 1436-1442.

5. **C.D. Creusere and A. Van Nevel**, "ATR-directed image and video compression," *Journal of Aircraft,* Vol. 36, No. 4, pp. 626-31, July-August 1999.

6. **C.D. Creusere**, "Fast embedded compression for video," *IEEE Trans. on Image Processing*, Vol. 8, No. 12, pp. 1811-16, December 1999.

7. **C.D. Creusere**, "Motion compensated video compression with reduced complexity encoding for remote transmission," *Signal Processing: Image Communications,* Vol. 16, pp. 627-42, April 2000.

8. **C.D. Creusere**, "Understanding perceptual distortion in MPEG scalable audio coding," *IEEE Trans. on Speech and Audio Processing,* Vol. 13, No. 3, pp. 422-431, May 2005.

9. **L. E. Boucheron and C.D. Creusere***,* "Lossless wavelet-based compression of digital elevation maps for fast and efficient search and retrieval," *IEEE Trans. on Geoscience and Remote Sensing,* Vol. 43, No. 5, pp. 1210-1214, May 2005.

10. **V. Thilak, D. Voelz, and C.D. Creusere**, "Polarization-based index of refraction and reflection angle estimation for remote sensing applications," *Applied Optics*, Vol. 46, Bo. 30, pp. 7427-7536, Oct. 2007.

11. **C.D. Creusere, K. Kallakuri, and R. Vanam**, "An Objective Metric of Human Subjective Audio Quality Optimized for a Wide Range of Audio Fidelities," *Audio, Speech, and Language Processing, IEEE Transactions on [see also Speech and Audio Processing, IEEE Transactions on]* , vol.16, no.1, pp.129-136, Jan. 2008

12. **S. Kandadai and C.D. Creusere**, "Scalable Audio Compression at Low Bitrates," *Audio, Speech, and Language Processing, IEEE Transactions on [see also Speech and Audio Processing, IEEE Transactions on]* , vol.16, no.5, pp.969-979, July 2008

13. **S. Kandadai and C.D. Creusere**, "Reverse engineering and repartitioning vector quantizers using training set synthesis," *Signal Processing,* August 2008.

14. **V. Thilak, C.D. Creusere, and D. Voel**z, "Passive Polarimetric Imagery-Based Material Classification Robust to Illumination Source Position and Viewpoint," *Image Processing, IEEE Transactions on ,* vol.20, no.1, pp.288-292, Jan. 2011.

15. **C.D. Creusere and J. Hardin**, "Assessing the Quality of Audio Containing Temporally Varying Distortions," *Audio, Speech, and Language Processing, IEEE Transactions on* , vol.19, no.4, pp.711-720, May 2011.

16. **Castorena, J.; Creusere, C.D.**, "The Restricted Isometry Property for Banded Random Matrices," *Signal Processing, IEEE Transactions on* , vol.62, no.19, pp.5073-5084, Oct.1, 2014 doi: 10.1109/TSP.2014.2345350.

17. **Castorena, J.; Creusere, C.D.**, "Sampling of Time-Resolved Full-Waveform LIDAR Signals at Sub-Nyquist Rates," *Geoscience and Remote Sensing, IEEE Transactions on* , vol.53, no.7, pp.3791-3802, July 2015. doi: 10.1109/TGRS.2014.2383839.

REFEREED CONFERENCE PUBLICATIONS

1. **H. Babic, S.K. Mitra, C.D. Creusere, and A. Das**, "Perfect reconstruction recursive QMF banks for image subband coding," *Proc. Asilomar Conf. Signals, Systems, and Computers*, Pacific Grove, CA, Nov. 1991, pp. 746-750.

2. **S.K. Mitra, C.D. Creusere, and H. Babic**, "A novel implementation of perfect reconstruction QMF banks using IIR filters," *Proc. IEEE Int. Symposium on Circuits and Systems*, San Diego, CA, May 1992, pp. 2312-2315.

3. **S.K. Mitra, C.D. Creusere, and H. Babic**, "Design of transmultiplexers using IIR filter banks," *Signal Processing VI: Theories and Applications*, Elsevier Science Publishers, 1992, pp. 223-226.

4. **C.D. Creusere and S.K. Mitra**, "Efficient image scrambling using polyphase filter banks," *Proc. International Conference on Image Processing*, Austin, TX, Nov. 1994, pp. 81-85.

5. **C.D. Creusere and G. Hewer**, "Wavelet-based nearest neighbor pattern classification using scale sequential matching," *Proc. Asilomar Conf. Signals, Systems and Computers*, Pacific Grove, CA, Nov. 1994, pp. 1123-1127.

6. **C.D. Creusere**, "Embedded zerotree image coding using low complexity IIR filter banks," *Proc. Int. Conf. on Acoustics, Speech, and Signal Processing*, Detroit, MI, May 1995, pp. 2213-16.

7 **C.D. Creusere and Gary Hewer**, "Digital video compression for weapons control and bomb damage indication," *AGARD Conference Proceedings 576*, Chapter 16, Sept. 1995.

8. **C.D. Creusere**, "Image coding using parallel implementations of the embedded zerotree wavelet algorithm," *Proc. of the Digital Video Compression Conference (Algorithms and Technologies 1996)*, San Jose, CA, Jan. 28-Feb. 2, 1996, pp. 82-93.

9. **C.D. Creusere**, "A family of image compression algorithms which are robust to transmission errors," *Proceedings of the SPIE*, Vol. 2825, Denver, CO, August, 1996, pp. 890-900.

10. **C.D. Creusere**, "Perfect reconstruction time-varying IIR filter banks," *Conf. Rec. Asilomar Conf. Signals, Systems, and Computers*, Pacific Grove, CA, Nov. 1996, pp. 1319-23.

11. **C.D. Creusere**, "Out-of-loop motion compensation for reduced complexity video encoding," *Proc. of the Data Compression Conf.* (pp. 428) *& Data Compression Industry Workshop* (pp.28-37), March 1997, Snowbird, UT.

12. **C.D. Creusere**, "Periodic pan compensation for reduced complexity video compression," *Proc. Int. Conf. on Acoustics, Speech, and Signal Processing,* Vol IV, pp. 2889-92, April 1997, Munich, Germany.

13. **C.D. Creusere**, "A new approach to global motion compensation which reduces video encoding complexity," *Proc. Int. Conf. on Image Processing*, Vol. III, pp. 634-7, October 1997, Santa Barbara, CA.

14. **C.D. Creusere**, "Spatially partitioned lossless image compression in an embedded framework," *Conf. Rec. 31st Asilomar Conf. on Signals, Systems, and Computers*, Nov. 1997, Pacific Grove, CA.

15. **C.D. Creusere**, "Adaptive embedding for reduced complexity image and video compression," *Proc.*

of the SPIE, Vol 3309 (Visual Communications and Image Processing), pp. 48-57, Jan. 1998, San Jose, CA.

16. **C.D. Creusere**, "Successive coefficient refinement for embedded lossless image compression," *Proc. of the Data Compression Conf.*, pp. 539, March 1998, Snowbird, UT.

17. **C.D. Creusere**, "Subband coding of speech and audio," *Proc. of the European Signal Processing Conf.* (invited paper), Sept. 1998, Isle of Rhodes, Greece.

18 **C.D. Creusere**, "Fast embedded video compression using cache-based processing," *Proc. of the European Signal Processing Conf.*, Sept. 1998, Isle of Rhodes, Greece.

19. **C.D. Creusere**, "Successive coefficient refinement for embedded lossless image compression," *Proc. Int. Conf. on Image Processing*, Oct. 1998, Chicago, IL.

20. **C.D. Creusere** and A. Van Nevel, "Autonomous target recognition directed image compression," *Proc. of the AIAA*, Nov. 1998.

21. **C.D. Creusere**," Improved successive refinement for wavelet-based embedded image compression," *Proc. of the SPIE*, Denver, CO, July 1999.

22. A. Van Nevel and **C.D. Creusere**, "Intelligent Bandwidth Compression," *Proc. of the SPIE*, Denver, CO, July 1999.

23. **C.D. Creusere,** "Optimal refinement/significance map tradeoffs in SPIHT-based image compression," *Conf. Rec., 34th Asilomar Conf. on Signals, Systems, & Computers, pp. 1026-30, Oct. 2000.*

24. **C.D. Creusere,** "Compression of digital elevation maps using nonlinear wavelets," *Proc. Int. Conf. on Image Processing*, pp. 824-7, October 2001.

25. **C.D. Creusere and G. Dahman**, "Object detection and localization in compressed video," *Conf. Rec. 35th Asilomar Conf. on Signals, Systems, and Computers*, Nov. 2001, Pacific Grove, CA.

26. **C.D. Creusere**, "An analysis of perceptual artifacts in MPEG scalable audio coding," *Proceedings of the Data Compression Conference*, pp. 152-161, April 2002, Snowbird, UT.

27. **C.D. Creusere and N. Tolk**, "Combining wavelets and GLICBAWLS to achieve resolution-progressive lossless compression," *Proc. of the International Conference on Image Processing*, pp. III-229-32, October 2002.

28. **L. Boucheron and C.D. Creusere**, "Compression of digital elevation maps for fast and efficient search and retrieval," *Proc. of the International Conference on Image Processing*, pp. 629-32, September 2003.

29. **S. Kandadai and C.D. Creusere**, "An experimental study of object detection in the wavelet domain," *Conf. Rec. 37th Asilomar Conf. on Signals, Systems, and Computers*, pp. 1620-4, Nov. 2003, Pacific Grove, CA.

30. **C.D. Creusere**, "Quantifying perceptual distortion in scalably compressed MPEG audio," *Conf. Rec. 37th Asilomar Conf. on Signals, Systems, and Computers*, pp. 265-9, Nov. 2003, Pacific Grove, CA.

31. **C.D. Creusere and L. Zhou**, "Spatial object detection and classification in JPEG bitstreams ," *Proceedings 11th Digital Signal Processing Workshop*, pp. 115-9, August 2004, Taos Ski Valley, NM,

32. **L. Zhou and C.D. Creusere**, "Spatial object detection in JPEG bitstreams," *Proceedings European Conference on Signal Processing*, pp. 949-52, September 2004, Vienna, Austria.

33. **V. Thilak and C.D. Creusere**, "Tracking of extended size targets in H.264 compressed video using the probabilistic data association filter," *Proceedings European Conference on Signal Processing*, pp. 281-4, September 2004, Vienna, Austria.

34. **S. Kandadai and C.D. Creusere**, Reverse engineering vector quantizers by training set synthesis," *Proceedings European Conference on Signal Processing*, pp. 789-92, September 2004, Vienna, Austria.

35. **V. Thilak, J. Saini, D. G. Voelz, C. D. Creusere** , "Pattern recognition for passive polarimetric data using nonparametric classifiers," *Proc. of the SPIE Vol. 5888*, p. 337-344, Polarization Science and Remote Sensing II; Joseph A. Shaw, J. Scott Tyo; Eds.

36. **R. Vanam and C.D. Creusere**, "Evaluating low bitrate scalable audio quality using advanced version of PEAQ and energy equalization approach ," *Proc. IEEE Int. Conf. on Acoustics, Speech, and Signal Processing*, Vol. III, pp. 189-92, March 2005.

37. **S. Kandadai and C.D. Creusere**, "Reverse engineering vector quantizers for repartitioned signal spaces," *Proc. 39th Asilomar Conference on Signals, Systems, and Computers*, pp. 1208-12, Pacific Grove, CA, Nov. 2005.

38. **R. Vanam and C.D. Creusere,** "Scalable perceptual metric for evaluating audio quality," *Proc. 39th Asilomar Conference on Signals, Systems, and Computers*, pp. 319-23, Pacific Grove, CA, Nov. 2005.

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4. **C.D. Creusere**, "Data Compression Project Final Report," NAWCWD Technical Paper, TP 8442.

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and white paper for the Motion Imagery Workshop, sponsored by the National Imagery and Mapping Agency (NIMA) and the National Science Foundation (NSF).

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APPENDIX 2: MATERIALS CONSIDERED IN THE PREPARATION OF THIS DECLARATION

Exhibit No.	Description
1001	U.S. Patent No. 10,536,714 to Bici, et al. ("the '714 patent")
1002	Prosecution File History for the '714 patent ("Prosecution History")
1004	U.S. Patent Application Publication No. 2011/0194609 to Rusert et al ("Rusert")
1005	U.S. Patent Application Publication No. 2011/0249721 to Karczewicz et al ("Karczewicz")
1006	U.S. Patent Application Publication No. 2014/0092981 to Lin et al ("Lin")
1007	Nakamura et al., "Unification of derivation process for merge mode and MVP," Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, 6th Meeting, Torino, Italy, Jul. 14-22, 2011, Document JCTVC-F419 ("Nakamura Document")
1008	Nakamura et al., "WD description of JCTVC-F419 Proposal 1" for "Unification of derivation process for merge mode and MVP," Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, 6th Meeting, Torino, Italy, Jul. 14-22, 2011, Document JCTVC-F419 ("Nakamura WD Description")
1009	Nakamura et al., "Unification of derivation process for merge mode and MVP" Presentation, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, 6th Meeting, Torino, Italy, Jul. 14-22, 2011, Document JCTVC-F419 ("Nakamura Presentation")
1010	Bross et al., "WD4: Working Draft 4 of High-Efficiency Video Coding," Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, 6th Meeting: Torino, IT, Jul. 14-22, 2011, Document JCTVC-F803 ("WD4")
1011	Prosecution File History for U.S. Patent No. 10,237,574 ("'574 Prosecution History")
1012	U.S. Provisional Application 61/301,649 ("Rusert Provisional")
1013	U.S. Provisional Application 61/500,903 ("Lin Provisional")
1014	Declaration of Vivienne Sze ("Sze Declaration")

Exhibit No.	Description
1015	Prosecution File History for U.S. Patent No. 9,571,833 ("'833 Prosecution History")
1016	Prosecution File History for U.S. Patent No. 9,743,105 ("'105 Prosecution History")
1017	European Prosecution File History for 12845839 ("European Prosecution History")
1018	U.S. Patent Application Publication No. 2012/0128067 to Liu ("Liu")
1019	Gary J. Sullivan, Recent Developments in Standardization of High Efficiency Video Coding (HEVC) ("Sullivan")
1020	Frank Bossen, HEVC Complexity and Implementation Analysis ("Bossen")
1021	Jian-Wei Chen et al, Introduction to H.264 advanced video coding. In: Proceedings of the 2006 Asia and South Pacific Design Automation Conference vol. 2006, pp. 736–741 (2006)
1022	Won, Kwanghyun et al, Motion vector coding using decoder-side estimation of motion vector. In 2009 IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB). IEEE, 2009.
1023	Gary J. Sullivan et al, The H.264/AVC Advanced Video Coding Standard: Overview and Introduction to the Fidelity Range Extensions, SPIE Conference on Applications of Digital Image Processing XXVII, 2004.
1024	Gweon, Ryeong-Hee, Non-Fixed Quantization Considering Entropy Encoding in HEVC, Journal of Broadcast Engineering. The Korean Institute of Broadcast and Media Engineers, 2011
1025	Hong, Chang-Yi, New Merge Mode Decision in High Efficiency Video Coding (HEVC), 2014 International Computer Science and Engineering Conference (ICSEC), IEEE (2014).
1026	JCT-VC - Joint Collaborative Team on Video Coding (https://www.itu.int/en/ITU-T/studygroups/2013-2016/16/Pages/video/jctvc.aspx)
1027	Terms of Reference of the Joint Collaborative Team on Video Coding Standard Development (https://www.itu.int/dms_pub/itu-t/oth/46/01/T46010000010001PDFE.pdf)
1028	Sullivan et al., "Meeting report of the sixth meeting of the Joint Collaborative Team on Video Coding (JCT-VC), Torino, IT, 14–22 July 2011," Joint Collaborative Team on Video Coding (JCT-

Exhibit No.	Description
	VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, 6th Meeting, Torino, Italy, Jul. 14-22, 2011, Document JCTVC-F800
1029	"All Meetings" web page (from the JCT-VC site) (http://phenix.int-evry.fr/jct/doc_end_user/all_meeting.php)
1030	"Torino Meeting - Document Register" web page (from the JCT-VC site) (http://phenix.int-evry.fr/jct/doc_end_user/current_meeting.php?id_meeting=149&search_id_group=1&search_sub_group=1)
1031	A portion of search screen for "merge mode" on the "Torino Meeting - Document Register" web page
1032	A portion of search screen for "MVP" on the "Torino Meeting - Document Register" web page
1033	Search result page for "merge mode" originated from the "Torino Meeting - Document Register" web page
1034	Search result page for "MVP" originated from the "Torino Meeting - Document Register" web page
1035	Search result page for "WD4" originated from the "Torino Meeting - Document Register" web page
1036	Search result page for "high-efficiency video coding" originated from the "Torino Meeting - Document Register" web page
1037	Search result page for "DRAFT" originated from the "Torino Meeting - Document Register" web page
1038	"Preview document JCTVC-F419 for Torino meeting" web page (http://phenix.int-evry.fr/jct/doc_end_user/current_document.php?id=2894)
1039	"Preview document JCTVC-F803 for Torino meeting" web page (http://phenix.int-evry.fr/jct/doc_end_user/current_document.php?id=3286)
1040	Sullivan et al., "Meeting report of the third meeting of the Joint Collaborative Team on Video Coding (JCT-VC), Guangzhou, CN, 7–15 October, 2010," Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, 3rd Meeting, Guangzhou China, Oct. 7-15, 2010, Document JCTVC-C400
1041	"All Meetings" web page (from the JCT-VC distribution website) (http://phenix.int-evry.fr/jct/doc_end_user/all_meeting.php)

Exhibit No.	Description
1042	"Torino Meeting - Document Register" web page (from the JCT-VC distribution website) (http://phenix.int-evry.fr/jct/doc_end_user/current_meeting.php?id_meeting=149&search_id_group=1&search_sub_group=1)
1043	Search result page for "merge mode" originated from the "Torino Meeting - Document Register" web page (from the JCT-VC distribution website)
1044	Search result page for "MVP" originated from the "Torino Meeting - Document Register" web page (from the JCT-VC distribution website)
1045	Search result page for "WD4" originated from the "Torino Meeting - Document Register" web page (from the JCT-VC distribution website)
1046	Search result page for "WD" originated from the "Torino Meeting - Document Register" web page (from the JCT-VC distribution website)
1047	"Preview document JCTVC-F419 for Torino meeting" web page (http://phenix.int-evry.fr/jct/doc_end_user/current_document.php?id=2894)
1048	"Preview document JCTVC-F803 for Torino meeting" web page (http://phenix.int-evry.fr/jct/doc_end_user/current_document.php?id=3286)
1049	Search result page for "Nakamura" originated from the "Torino Meeting - Document Register" web page (from the JCT-VC distribution website)
1050	Declaration of Clifford Reader
1051	Machine translation of Gweon, Ryeong-Hee, Non-Fixed Quantization Considering Entropy Encoding in HEVC, Journal of Broadcast Engineering. The Korean Institute of Broadcast and Media Engineers, 2011

APPENDIX 3: CHALLENGED CLAIMS

1. A method comprising:

[1a] selecting a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for a block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates and is utilized to identify motion vector prediction candidates of which one spatial motion vector prediction candidate from the motion vector prediction list is signaled as the motion information for the prediction unit;

[1b] determining a subset of spatial motion vector prediction candidates based on a location of the block associated with the first spatial motion vector prediction candidate;

[1c] comparing motion information of the first spatial motion vector prediction candidate with motion information of spatial motion vector prediction candidates in the determined subset of spatial motion vector prediction candidates without making a comparison of each pair from the set of spatial motion vector prediction candidates;

[1d] determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and

[1e] causing information identifying the one spatial motion vector prediction candidate from the motion vector prediction list to be transmitted to a decoder or to be stored.

2. The method according to claim 1 further comprising selecting spatial motion vector prediction candidates from the set of spatial motion vector prediction candidates as the potential spatial motion vector prediction candidate in a predetermined order.

3. The method according to claim 1, further comprising comparing motion information of the potential spatial motion vector prediction candidate with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates.

4. The method according to claim 1 further comprising examining whether the block of pixels is divided into a first prediction unit and a second prediction unit; and if so, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the prediction unit is the second prediction unit.

5. The method according to claim 1, further comprising

[5a] determining a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list; and

[5b] limiting the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number.

6. The method according to claim 5 comprising:

[6a] examining, if the number of spatial motion vector prediction candidates in the motion vector prediction list smaller than the maximum number;

[6b] if so, examining whether the prediction unit to which the potential spatial motion vector prediction candidate belongs is available for motion prediction;

[6c] if so, performing at least one of the following:

[6d] for a potential spatial motion vector prediction candidate on a left side of the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[6e] the received block of pixels is vertically divided into a first prediction unit and a second prediction unit;

[6f] the received block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and if the prediction unit is the second prediction

unit, and the potential spatial motion vector prediction candidate has essentially similar motion information than a spatial motion vector prediction candidate above the prediction unit;

[6g] for a potential spatial motion vector prediction candidate above the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[6h] the received block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and the prediction unit is the second prediction unit;

[6i] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit;

[6j] for a potential spatial motion vector prediction candidate, which is on a right side of the potential spatial motion vector prediction candidate above the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate above the prediction unit;

[6k] for a potential spatial motion vector prediction candidate, which is below the potential spatial motion vector prediction candidate on the left side of the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit;

[6l] for a potential spatial motion vector prediction candidate cornerwise neighbouring the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[6m] all the other potential spatial motion vector prediction candidates have been included in the motion vector prediction list;

[6n] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate above the prediction unit;

[6o] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit.

7. The method according to claim 1 further comprising including a temporal motion prediction candidate into the motion vector prediction list.

8. The method according to claim 1 further comprising selecting one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the block of pixels.

15. An apparatus comprising a processor and a memory including computer program code, the memory and the computer program code configured to, with the processor, cause the apparatus to:

[15a] select a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for a block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates and is utilized to identify motion vector prediction candidates of which one spatial motion vector prediction candidate from the motion vector prediction list is signaled as the motion information for the prediction unit;

[15b] determine a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;

[15c] compare motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;

[15d] determine to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on comparison of the motion information of the first spatial motion vector candidate with motion information of the spatial motion vector prediction candidate; and

[15e] cause information identifying the one spatial motion vector prediction candidate from the motion vector prediction list to be transmitted to a decoder or to be stored.

16. The apparatus according to claim 15 wherein the apparatus is further caused to select spatial motion vector prediction candidates from the set of spatial motion vector prediction candidates as the potential spatial motion vector prediction candidate in a predetermined order.

17. The apparatus according to claim 15, wherein the apparatus is further caused to compare motion information of the potential spatial motion vector

prediction candidate with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates.

18. The apparatus according to claim 15 wherein the apparatus is further caused to examine whether the block of pixels is divided into a first prediction unit and a second prediction unit; and if so, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if the prediction unit is the second prediction unit.

19. The apparatus according to claim 15, wherein the apparatus is further caused to:

[19a] determine a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list; and

[19b] limit the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number.

20. The apparatus according to claim 19 wherein the apparatus is further caused to:

[20a] examine, if the number of spatial motion vector prediction candidates in the motion vector prediction list smaller than the maximum number;

[20b] if so, examine whether the prediction unit to which the potential spatial motion vector prediction candidate belongs is available for motion prediction;

[20c] if so, perform at least one of the following:

[20d] for a potential spatial motion vector prediction candidate on a left side of the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[20e] the received block of pixels is vertically divided into a first prediction unit and a second prediction unit;

[20f] the received block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and if the prediction unit is the second prediction unit, and the potential spatial motion vector prediction candidate has essentially similar motion information than a spatial motion vector prediction candidate above the prediction unit;

[20g] for a potential spatial motion vector prediction candidate above the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[20h] the received block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and the prediction unit is the second prediction unit;

[20i] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit;

[20j] for a potential spatial motion vector prediction candidate, which is on a right side of the potential spatial motion vector prediction candidate above the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate above the prediction unit;

[20k] for a potential spatial motion vector prediction candidate, which is below the potential spatial motion vector prediction candidate on the left side of the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit;

[20l] for a potential spatial motion vector prediction candidate cornerwise neighbouring the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[20m] all the other potential spatial motion vector prediction candidates have been included in the motion vector prediction list;

[20n] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate above the prediction unit;

[20o] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit.

21. The apparatus according to claim 15 wherein the apparatus is further caused to include a temporal motion prediction candidate into the motion vector prediction list.

22. The apparatus according to claim 15 wherein the apparatus is further caused to select one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the block of pixels.

29. A non-transitory computer readable medium having stored thereon a computer executable program code for use by an encoder, said program codes comprising instructions for:

[29a] selecting a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for a block of pixels as a potential spatial

motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates and is utilized to identify motion vector prediction candidates of which one spatial motion vector prediction candidate from the motion vector prediction list is signaled as the motion information for the prediction unit;

[29b] determining a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;

[29c] comparing motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;

[29d] determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and

[29e] causing information identifying the one spatial motion vector prediction candidate from the motion vector prediction list to be transmitted to a decoder or to be stored.

APPENDIX 4: UNDERSTANDING OF THE LAW

I have applied the following legal principles provided to me by counsel in arriving at the opinions set forth in this report.

Legal Standard for Prior Art

I am not an attorney. I have been informed by attorneys of the relevant legal principles and have applied them to arrive at the opinions set forth in this declaration.

I understand that the petitioner for inter partes review may request the cancelation of one or more claims of a patent based on grounds available under 35 U.S.C. § 102 and 35 U.S.C. § 103 using prior art that consists of patents and printed publications.

Anticipation and Prior Art

I understand that § 102 specifies when a challenged claim is invalid for lacking novelty over the prior art, and that this concept is also known as "anticipation." I understand that a prior art reference anticipates a challenged claim, and thus renders it invalid by anticipation, if all elements of the challenged claim are disclosed in the prior art reference. I understand the disclosure in the prior art reference can be either explicit or inherent, meaning it is necessarily present or implied. I understand that the prior art reference does not have to use the same words as the challenged claim, but all of the requirements of the claim must be disclosed so that a person of ordinary skill in the art could make and use the claimed subject-matter.

In addition, I understand that § 102 also defines what is available for use as a prior art reference to a challenged claim.

Under § 102(a), a challenged claim is anticipated if it was patented or described in a printed publication in the United States or a foreign country before the challenged claim's date of invention.

Under § 102(b), a challenged claim is anticipated if it was patented or described in a printed publication in the United States or a foreign country more than one year prior to the challenged patent's filing date.

Under § 102(e), a challenged claim is anticipated if it was described in a published patent application that was filed by another in the United States before the challenged claim's date of invention, or was described in a patent granted to another that was filed in the United States before the challenged claim's date of invention.

I understand that a challenged claim's date of invention is presumed to be the challenged patent's filing date. I also understand that the patent owner may establish an earlier invention date and "swear behind" prior art defined by § 102(a) or § 102(e) by proving (with corroborated evidence) the actual date on which the named inventors conceived of the subject matter of the challenged claim and proving that the inventors were diligent in reducing the subject matter to practice.

I understand that the filing date of a patent is generally the filing date of the application filed in the United States that issued as the patent. However, I understand that a patent may be granted an earlier effective filing date if the patent owner properly claimed priority to an earlier patent application.

I understand that when a challenged claim covers several structures, either generically or as alternatives, the claim is deemed anticipated if any of the structures within the scope of the claim is found in the prior art reference.

I understand that when a challenged claim requires selection of an element from a list of alternatives, the prior art teaches the element if one of the alternatives is taught by the prior art.

Legal Standard for Obviousness

I understand that even if a challenged claim is not anticipated, it is still invalid if the differences between the claimed subject matter and the prior art are such that the claimed subject matter would have been obvious to a person of ordinary skill in the pertinent art at the time the alleged invention.

I understand that obviousness must be determined with respect to the challenged claim as a whole.

I understand that one cannot rely on hindsight in deciding whether a claim is obvious.

I also understand that an obviousness analysis includes the consideration of factors such as (1) the scope and content of the prior art, (2) the differences between the prior art and the challenged claim, (3) the level of ordinary skill in the pertinent art, and (4) "secondary" or "objective" evidence of non-obviousness.

Secondary or objective evidence of non-obviousness includes evidence of: (1) a long felt but unmet need in the prior art that was satisfied by the claimed invention; (2) commercial success or the lack of commercial success of the claimed invention; (3) unexpected results achieved by the claimed invention; (4) praise of the claimed invention by others skilled in the art; (5) taking of licenses under the patent by others; (6) deliberate copying of the claimed invention; and (7) contemporaneous and independent invention by others. However, I understand that there must be a relationship between any secondary evidence of non-obviousness and the claimed invention.

I understand that a challenged claim can be invalid for obviousness over a combination of prior art references if a reason existed (at the time of the alleged invention) that would have prompted a person of ordinary skill in the art to combine elements of the prior art in the manner required by the challenged claim. I understand that this requirement is also referred to as a "motivation to combine," "suggestion to combine," or "reason to combine," and that there are several rationales that meet this requirement.

I understand that the prior art references themselves may provide a motivation to combine, but other times simple common sense can link two or more prior art references. I further understand that obviousness analysis recognizes that market demand, rather than scientific literature, often drives innovation, and that a motivation to combine references may come from market forces.

I understand obviousness to include, for instance, scenarios where known techniques are simply applied to other devices, systems, or processes to improve them in an expected or known way. I also understand that practical and common-sense considerations should be applied in a proper obviousness analysis. For instance, familiar items may have obvious uses beyond their primary purposes.

I understand that the combination of familiar elements according to known methods is obvious when it yields predictable results. For instance, obviousness bars patentability of a predictable variation of a technique even if the technique originated in another field of endeavor. This is because design incentives and other market forces can prompt variations of it, and predictable variations are not the product of innovation, but rather ordinary skill and common sense.

I understand that a particular combination may be obvious if it was obvious to try the combination. For example, when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions, a person of ordinary skill has good reason to pursue the known options within his or her technical grasp. This would result in something obvious because the result is the product not of innovation but of ordinary skill and common sense. However, I understand that it may not be obvious to try a combination when it involves unpredictable technologies.

It is further my understanding that a proper obviousness analysis focuses on what was known or obvious to a person of ordinary skill in the art, not just the patentee. Accordingly, I understand that any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed.

It is my understanding that the Manual of Patent Examining Procedure §2143 sets forth the following as exemplary rationales that support a conclusion of obviousness:

- Combining prior art elements according to known methods to yield predictable results;
- Simple substitution of one known element for another to obtain predictable results;
- Use of known technique to improve similar devices (methods, or products) in the same way;

- Applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;
- Choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- Known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art;
- Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

A person of ordinary skill in the art looking to overcome a problem will often use the teachings of multiple publications together like pieces of a puzzle, even though the prior art does not necessarily fit perfectly together. Therefore, I understand that references for obviousness need not fit perfectly together like puzzle pieces. Instead, I understand that obviousness analysis takes into account inferences, creative steps, common sense, and practical logic and applications that a person of ordinary skill in the art would employ under the circumstances.

I understand that a claim can be obvious in light of a single reference, if the elements of the challenged claim that are not explicitly or inherently disclosed in the reference can be supplied by the common sense of one of skill in the art.

I understand that obviousness also bars the patentability of applying known or obvious design choices to the prior art. One cannot patent merely substituting one prior art element for another if the substitution can be made with predictable results. Likewise, combining prior art techniques that are interoperable with respect to one another is generally obvious and not patentable.

In order for a claim to be found invalid based upon a modification or combination of the prior art, there must be reasonable expectation that a person of ordinary skill would have successfully modified or combined the prior art to arrive at the claimed arrangement. This does not mean that it must be certain that a person of ordinary skill would have been successful – the law only requires that the person of ordinary skill in the art would have perceived a reasonable expectation of success in modifying or combining the prior art to arrive at the claimed invention.

In sum, my understanding is that obviousness invalidates claims that merely recite combinations of, or obvious variations of, prior art teachings using understanding and knowledge of one of skill in the art at the time and motivated by the general problem facing the inventor at the time. Under this analysis, the prior art references themselves, or any need or problem known in the field of endeavor at the time of the invention, can provide a reason for combining the elements of or attempting obvious variations on prior art references in the claimed manner.

Legal Standard for Claim Construction

I understand that before any invalidity analysis can be properly performed, the scope and meaning of the challenged claims must be determined by claim construction.

I understand that a patent may include two types of claims, independent claims and dependent claims. I understand that an independent claim stands alone and includes only the limitations it recites. I understand that a dependent claim depends from an independent claim or another dependent claim. I understand that a dependent claim includes all the limitations that it recites in addition to the limitations recited in the claim (or claims) from which it depends.

In comparing the challenged claims to the prior art, I have carefully considered the patent and its file history in light of the understanding of a person of skill at the time of the alleged invention.

I understand that to determine how a person of ordinary skill would have understood a claim term, one should look to sources available at the time of the alleged invention that show what a person of skill in the art would have understood disputed claim language to mean. It is my understanding that this may include what is called "intrinsic" evidence as well as "extrinsic" evidence.

I understand that, in construing a claim term, one should primarily rely on intrinsic patent evidence, which includes the words of the claims themselves, the remainder of the patent specification, and the prosecution history. I understand that extrinsic evidence, which is evidence external to the patent and the prosecution history, may also be useful in interpreting patent claims when the intrinsic evidence itself is insufficient. I understand that extrinsic evidence may include principles, concepts, terms, and other resources available to those of skill in the art at the time of the invention.

I understand that words or terms should be given their ordinary and accepted meaning unless it appears that the inventors were using them to mean something else or something more specific. I understand that to determine whether a term has special meaning, the claims, the patent specification, and the prosecution history are particularly important, and may show that the inventor gave a term a particular definition or intentionally disclaimed, disavowed, or surrendered claim scope.

I understand that the claims of a patent define the scope of the rights conferred by the patent. I understand that because the claims point out and distinctly claim the subject matter which the inventors regard as their invention, claim construction analysis must begin with and is focused on the claim language itself. I understand that the context of the term within the claim as well as other claims of the patent can inform the meaning of a claim term. For example, because claim terms are normally used consistently throughout the patent, how a term is used in one claim can often inform the meaning of the same term in other claims. Differences among claims or claim terms can also be a useful guide in understanding the meaning of particular claim terms.

I understand that a claim term should be construed not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the entire specification. I understand that because the specification is a primary basis for construing the claims, a correct construction must align with the specification.

I understand that the prosecution history of the patent as well as art incorporated by reference or otherwise cited during the prosecution history are also highly relevant in construing claim terms. For instance, art cited by or incorporated by reference may indicate how the inventor and others of skill in the art at the time of the invention understood certain terms and concepts. Additionally, the prosecution history may show that the inventors disclaimed or disavowed claim scope, or further explained the meaning of a claim term.

With regard to extrinsic evidence, I understand that all evidence external to the patent and prosecution history, including expert and inventor testimony, dictionaries, and learned treatises, can also be considered. For example, technical dictionaries may indicate how one of skill in the art used or understood the claim terms. However, I understand that extrinsic evidence is considered to be less reliable than intrinsic evidence, and for that reason is generally given less weight than intrinsic evidence.

I understand that in general, a term or phrase found in the introductory words or preamble of the claim, should be construed as a limitation if it recites essential structure or steps, or is necessary to give meaning to the claim. For instance, I understand preamble language may limit claim scope: (i) if dependence on a preamble phrase for antecedent basis indicates a reliance on both the preamble and claim body to define the claimed invention; (ii) if reference to the preamble is necessary to understand limitations or terms in the claim body; or (iii) if the preamble recites additional structure or steps that the specification identifies as important.

On the other hand, I understand that a preamble term or phrase is not limiting where a challenged claim defines a structurally complete invention in the claim body and uses the preamble only to state a purpose or intended use for the invention. I understand that to make this determination, one should review the entire patent to gain an understanding of what the inventors claim they invented and intended to encompass in the claims.

I understand that 35 U.S.C. § 112 ¶ 6 created an exception to the general rule of claim construction called a "means plus function" limitation. These types of terms and limitations should be interpreted to cover only the corresponding structure described in the specification, and equivalents thereof. I also understand that a limitation is presumed to be a means plus function limitation if (a) the claim limitation uses the phrase "means for"; (b) the "means for" is modified by functional language; and (c) the phrase "means for" is not modified by sufficient structure for achieving the specified function.

I understand that a structure is considered structurally equivalent to the corresponding structure identified in the specification only if the differences between them are insubstantial. For instance, if the structure performs the same function in substantially the same way to achieve substantially the same result. I further understand that a structural equivalent must have been available at the time of the issuance of the claim.

Appendix B

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

AMAZON.COM, INC., AMAZON.COM SERVICES LLC,

Petitioner,

v.

NOKIA TECHNOLOGIES OY,

Patent Owner.

Case No. IPR2024-00605

U.S. Patent 10,536,714

Declaration of Charles D. Creusere

TABLE OF CONTENTS

I, Charles D. Creusere, declare as follows:

1. My name is Charles D. Creusere. I am a Full Professor in the Klipsch School of Electrical & Computer Engineering at New Mexico State University. I have prepared this report as an expert witness retained by Amazon.com, Inc. In this report I give my opinions as to whether certain claims of U.S. Patent No. 10,536,714 ("the '714 patent") are invalid. I provide technical bases for these opinions as appropriate.

2. This report contains statements of my opinions formed to date and the bases and reasons for those opinions. I may offer additional opinions based on further review of materials in this case, including opinions and/or testimony of other expert witnesses. I make this declaration based upon my own personal knowledge and, if called upon to testify, would testify competently to the matters contained herein.

I. OVERVIEW OF THE TECHNOLOGY

A. Video Compression Basics

3. Video comprises a sequence of pictures, called frames. If you look closely at a frame, for example by putting a magnifying glass up to your monitor, you will see that a frame is comprised of pixels. Groups of pixels are referred to as blocks, for example a square of 8 pixels by 8 pixels.

4. Video encoding, also referred to as video compression, exploits redundancies in video data to reduce the size of video. Since the 1990s, major

video coding standards, including MPEG, H.264 ("AVC"), and H.265 ("HEVC"), have applied the same block-based model: video frames are divided into blocks of pixels, a motion estimation and compensation front end exploits temporal patterns where a similar-looking block appears in the same frame or a nearby frame, and then a coded bitstream is produced in subsequent stages that include a transform stage and entropy encoding. Ex-1023, 000004. At the decoder, the inverse process is used to decode the video back into the original frames.[1] *Id.* A high-level conceptual diagram of encoder/decoder stages is illustrated below. *See e.g.*, Ex-1023, Fig. 2:

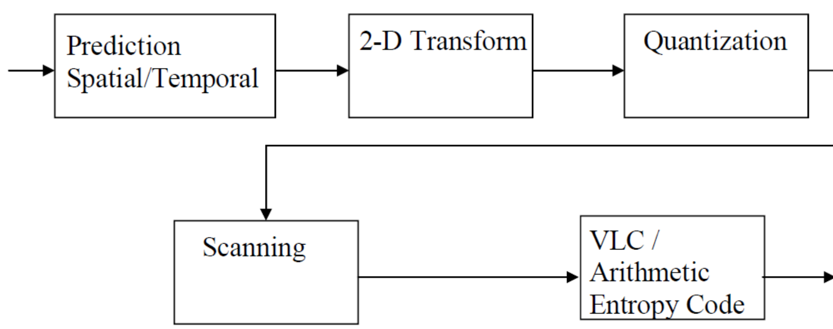


Fig. 2: Higher-level encoder block diagram

B. Motion Vectors and Motion Prediction

5. Blocks could be encoded using inter or intra-frame modes. *Intra*-frame encoding exploited redundant patterns within the same frame, with a block possibly being encoded with reference to another block in the same frame. *Inter*-

[1] Many of the video coding concepts, including HEVC concepts, described in this declaration still apply today.

frame coding allowed a block to be encoded with reference to similar blocks in other frames.

6. For example, inter-picture prediction was useful when an object moved across the screen in successive frames. In the example below, the same airplane on the bottom left of one frame appears on the top-right of the next frame. Ex-1021, 000002 (emphasis added):

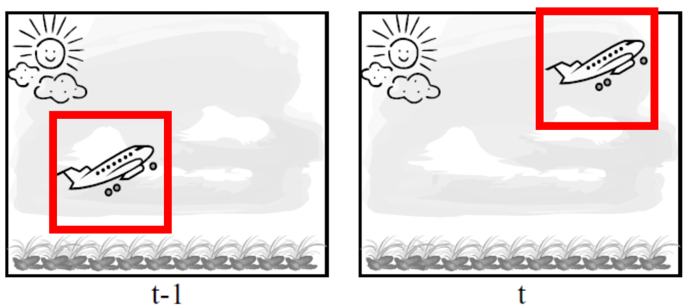
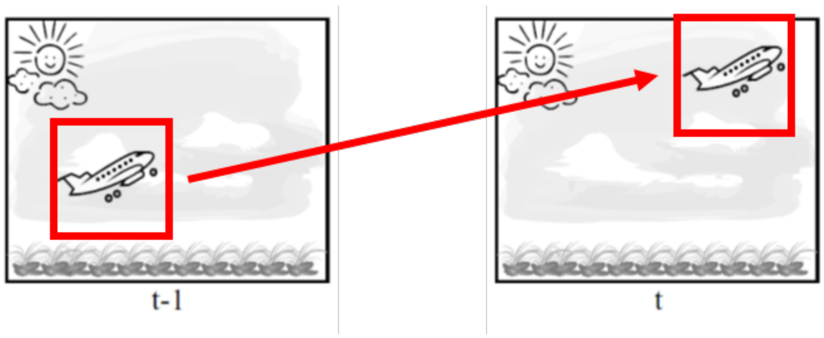


Fig. 3. Successive video frames

7. Since the block containing the airplane shifted to the right (in the X direction) and upwards (in the Y direction), a motion vector was used to describe this X-Y displacement. Ex-1021, 000002-4; Ex-1022, 000001-3. In other words, motion vectors described the motion of blocks between frames. Rather than transmit the pixels for this block twice (once for each frame), the video codecs instead transmitted the block once, for the first frame, and then signaled a motion vector, an index to a reference block in the first frame, and the residual difference between the motion compensated first frame block and the current frame block. The decoder would then use this information to reconstruct the second frame using

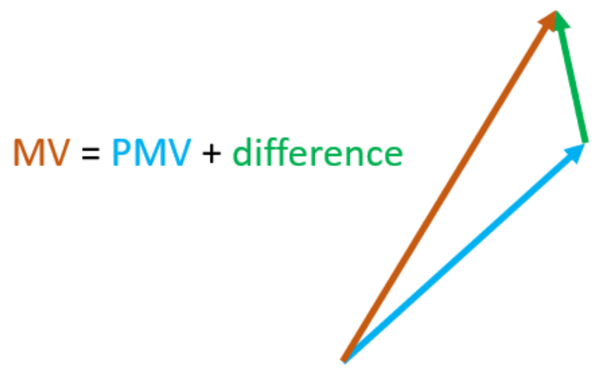
the block from the first frame. *See e.g.*, Ex-1021, 000004, Fig. 3 (emphasis added):



8. By sending a motion vector, a block index, and the residual difference, rather than an entire block of pixels, video codecs reduced the amount of data in the encoded video stream. Nonetheless, since each frame contained many thousands of blocks with frames streaming at 30 or 60 frames a second, the volume of data for transmitting motion vectors could be significant. *See* Ex-1022, 000001.

9. To reduce the amount of data used to signal motion vectors, the ITU utilized predicted motion vectors in its H.264 standard as well as in the successor standard that became H.265. Ex-1022, 000001-2. For example, early iterations of H.264 used the median values of motion vectors from three spatially-neighboring blocks as a Predicted Motion Vector ("PMV") or motion vector predictor ("MVP"). *Id.* Since the encoder and decoder could independently calculate this PMV, there was no need to transmit the entire vector; instead, a smaller difference

vector was inserted into the video stream to indicate the difference between the predicted and actual motion vector for a block, as illustrated below. *Id.*



10. By 2010, neighboring blocks were commonly used to find PMV candidates. This was known for H.264. Ex-1004, ¶¶2-3. Since early drafts of H.265, by at least Working Drafts 3 and 4, multiple spatial motion vector prediction candidates were obtained from neighboring blocks, labelled A_0, A_1, B_0, B_1, B_2 below, to create a list of candidates. The encoder evaluated which motion vector candidate offered the best prediction for the current block—meaning the predicted pixel values were closest to the actual pixel values. Ex-1010, §8.4.2.1.8 (annotated with the current block):

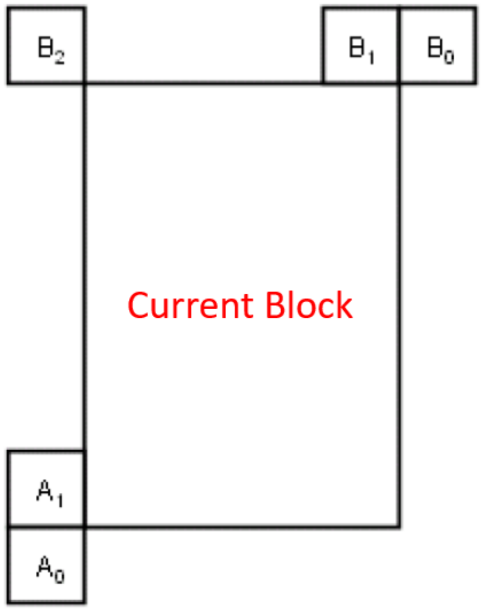


Figure 8-5 – Spatial motion vector neighbours

Since the encoder and decoder independently generated the same candidate list (using the same information from neighboring blocks), the encoder simply signaled to the decoder which candidate was chosen from the list, for example sending an index value of 2 to signal the second candidate from the list. This reduced data because the encoder did not need to transmit the candidate list or a motion vector; instead, the encoder transmitted a single, small number to signal which candidate was chosen, and the decoder referred to its independently-constructed candidate list, which was identical to that of the encoder, to look up the candidate using the index. *See e.g.*, Ex-1004, ¶37.

11. Motion vector candidates from the same frame, including those from neighboring blocks in the frame, were called spatial motion vector prediction

candidates. Ex-1022, 000001-3. Neighboring blocks were often good sources of motion vector candidates because neighboring blocks tend to have the same motion. For example, when a scene pans to the right, objects in the background will tend to have similar motion towards the left across the screen. Ex-1022, 000001-2. Predicted motion vectors take advantage of such patterns to decrease the amount of data used to encode motion vectors, as explained above.

12. Redundant motion vector prediction candidates, however, can increase the size of the index needed to signal which candidate was selected as the predictor for a given block. *E.g.*, Ex-1004, ¶7, ¶107 (explaining that more bits are "needed to specify the candidate vector" as the number of vectors grows). For example, if the neighboring blocks all have the same motion vector, it would be redundant to include all of them as motion vector predictor candidates. Therefore, H.264 and H.265 both analyzed spatial motion vector prediction candidates to remove redundant ones. In fact, it was common in the art to remove redundant motion vector candidates. For example, this was taught for H.264 and in working drafts of H.265. Ex-1004, ¶21, ¶62; Ex-1010, §8.4.2.1.1, §8.4.2.1.7.

13. For H.264, prior art that applied H.264 included methods for selecting PMV candidates from the set of all previously-coded blocks. Since "[l]imiting and/or reducing the number of candidates … can be helpful to reduce the overhead of signaling," it was known in the art to "avoid duplicate occurrences of the same

motion vector" by "comparing the candidates already in the list with the new vector that could be added[,]" which comprised a "subset" of candidates from blocks within an allowed distance from the current block, rather than the full set of previously-coded blocks. Ex-1004, Abstract, ¶¶70-71.

14. For H.265, presentations were made to the standards body regarding the exact manner in which redundant candidates might be removed. "When motion vectors have the same value, the motion vectors are removed from the list [of motion vector candidates.]" Ex-1010, §8.4.2.1.7, §8.4.2.1.1. As I will explain in more detail below, at the 6th HEVC meeting held on July 14-22, 2011, Nakamura presented a proposal, JCTVC-F419, to reduce the number of comparisons needed for removing redundant motion vector candidates. *Infra* §III.E; Ex-1007, Fig. 1. Nakamura proposed creating a subset of two spatial motion vector prediction candidates, so that redundant candidates could be identified and removed with fewer comparisons, without having to compare the full set of neighboring candidates. Ex-1007, 000003, Table 1, Fig. 1.

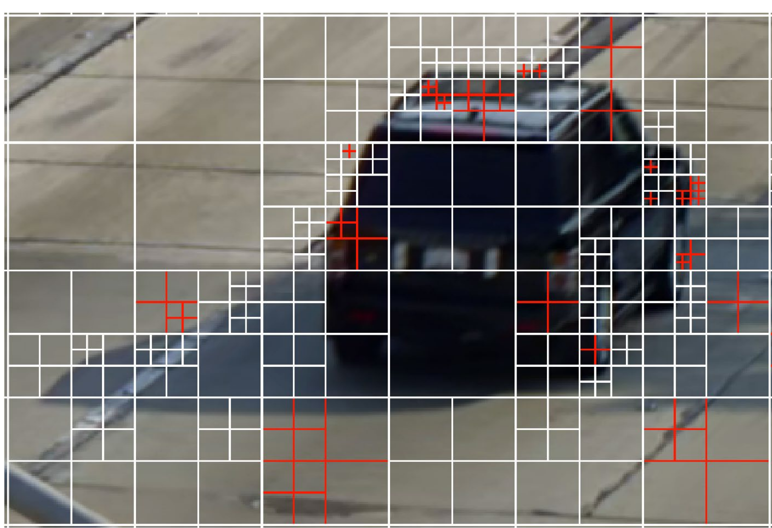
C. H.264 to H.265

15. The H.264 standard (also standardized by the ISO as MPEG Advanced Video Coding ("AVC")) was published in 2003. H.264 was widely used for compression of video at HD (high definition) resolutions and below, and from the beginning it was popular in consumer electronics and Internet streaming.

In 2010, the standardization process began for the successor video standard, which was called H.265 by the ITU and also referred to as the High Efficiency Video Coding ("HEVC") standard.

16. H.265 used H.264 as a starting point and incorporated many of the same concepts. Both standards followed the same overall architecture for block-based video coding, as explained above. Both also used predicted motion vectors for motion compensation. Ex-1004, ¶3; Ex-1005, ¶3; Ex-1006, ¶4.

17. HEVC introduced new terminology for a type of block called a "coding unit" or "CU," which was analogous to macroblocks in H.264. *See* Ex-1005, ¶¶32-33; Ex-1006, ¶4. CUs could be split into smaller CUs to fit visual patterns in the frame. "The basic partition geometry of all these elements is encoded by a scheme similar to the well-known quad-tree segmentation structure." *See* Ex-1019, 00005; Ex-1020 at 00002 (Fig. 1):



18. Motion vectors operated on the basis of a block called a "prediction unit" or "PU." Ex-1005, ¶35; Ex-1006, ¶25. In the simplest scenario, one CU would be covered by a PU of the same size, and a single motion vector would be assigned to the entire CU/PU. *See* Ex-1005, ¶35. This approach was used when the entire CU moved in the same direction, such as large blocks of road in the above image. Conversely, when different portions of a CU moved in different directions, the CU could be divided into multiple PUs, with different motion vectors assigned to each PU. *See id.*

19. HEVC referred to an undivided CU (consisting of one PU the same size) as being 2Nx2N. When a CU was split horizontally into two symmetric rectangular PUs, it was referred to as a 2NxN partition size. A vertically divided CU was referred to as an Nx2N partition size. Example partition modes are shown below. Ex-1006, ¶4; Ex-1018, ¶3, Fig. 2:

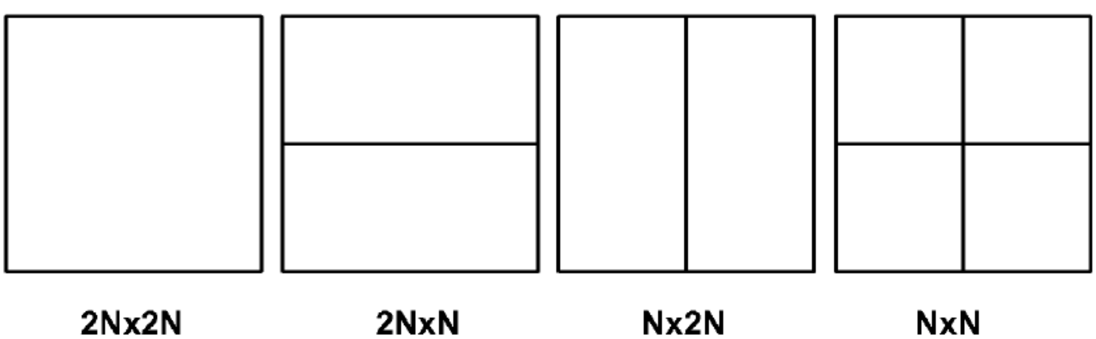


Fig. 2

II. THE ’714 PATENT

A. Overview

20. The ’714 patent is directed to video encoding and decoding in the context of H.263, H.264, and Working Draft 4 of H.265/HEVC, which the purported patent admits were pre-existing video codecs that pre-dated the ’714 patent. Ex-1001, 1:40-42, 2:21-25.

21. The patent admits that prior video codecs “create[d] motion vector predictions” (“MVP”) by “generat[ing] a list or a set of candidate predictions from blocks in the current frame and/or co-located or other blocks in temporal reference pictures and signalling[sic] the chosen candidate as the motion vector prediction.” Ex-1001, 3:5-19, 3:60-66. “A spatial motion vector prediction is a prediction obtained only on the basis of information of one or more blocks of the same frame than the current frame whereas temporal motion vector prediction is a prediction obtained on the basis of information of one or more blocks of a frame different from the current frame.” *Id.* “After the list is generated, some of the motion vector prediction candidates may have the same motion information. In this case, the identical motion vector prediction candidates may be removed to reduce redundancy.” *Id.*, 3:66-4:3. To find redundant MVP candidates, the candidates in the list must be compared to each other.

22. The ’714 patent seeks to “improv[e] the prediction accuracy and hence possibly reducing information to be transmitted in video coding systems.” Ex-1001, 8:24-28. To this end, the ’714 patent purports to introduce “a method for generating a motion vector prediction list” in “a way to reduce the complexity of the implementation.” Ex-1001, 4:18-23. According to the ’714 patent, “[t]his can be achieved by performing a limited number of motion information comparisons between candidate pairs to remove redundant candidates rather than comparing every available candidate pair.” Ex-1001, 4:18-27. In particular, the ’714 patent claims recite limitations for “determining a subset” of spatial MVP candidates and then “comparing motion information” of a selected candidate with the subset, “without making a comparison of each pair from the [full] set of spatial motion vector prediction candidates[.]” Ex-1001, claim 1.

23. However, as explained above, the prior art already included techniques for removing redundant MVP candidates without comparing each pair from the full set of candidates. *Supra* §I.

B. Prosecution History

24. I understand the ’714 patent is one of a chain of continuation patents beginning with U.S. Patent No. 9,571,833 (’833 patent) and including U.S. Patent No. 10,237,574 and U.S. Patent No. 9,743,105. Ex-1001, (63). It is my understanding that each of these parent patents shares the same specification as the

’714 patent because they are continuations, and that the prosecution histories of the patents in this chain provide context for the ’714 patent.

25. At the same time the ’714 family of patents was being prosecuted in the United States, a European counterpart, EP2774375 (the “EU Counterpart”), was being prosecuted in the EP. Ex-1017, 000246-256 (extended European search report dated March 14, 2016); Ex-1015, 000315-336 (Response after Final Action dated July 1, 2016).

26. However, an extended European search report issued on March 21, 2016 in which the European Patent Office issued a rejection in view of Nakamura. Ex-1017, 000246-256 (extended European search report). The Patent Owner did not dispute that Nakamura was prior art or that Nakamura taught the claims. Instead, the Patent Owner amended the claims with lengthy limitations that led to independent claim 1 being *three pages long* in the EP Counterpart. Ex-1017, 000335-351.

27. On April 25, 2016, the Applicant submitted an Information Disclosure Statement to the US Patent Office during the prosecution of the ’833 patent citing the extended European search report and Nakamura. Ex-1015, 000308. The Examiner did not consider this IDS before the Notice of Allowance. Ex-1015, 000476-477 (mailed 12/20/2016); Ex-1015, 000483. The ’833 patent was allowed

without any substantive discussion of Nakamura or amendments like those made in the EU counterpart. Ex-1015, 000378.

28. In the Notice of Allowance, the Examiner cited, as the reason for allowance, the limitation for comparing motion information of candidates "without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates[.]" Ex-1015, 000390. Likewise, for the '714 patent, the Examiner allowed the claims citing "limitations analogous to the claims of" the '833 patent for comparing motion information "without making a comparison of each pair from the set of spatial motion vector prediction candidates[.]" Ex-1002, 000118 (Notice of Allowance).

29. However, the European Patent Office had found a similar limitation to be taught by Nakamura (Ex-1017, 000253), *which the Patent Owner did not dispute.* Nakamura is presented here as Ground 3.

C. Priority Date

30. The '714 patent is one of a chain of continuation applications beginning with the '833 patent and claims priority to a provisional application filed on November 4, 2011. I have not conducted any analysis as to whether the '714 patent is entitled to its claim of priority. For the purposes of this declaration, I have applied a November 4, 2011 priority date for my opinions without regard to whether the '714 patent is entitled to such a priority date.

D. Challenged Claims

31. I understand that Petitioner is challenging the validity of claims 9-14, 23-28, and 30 of the ’714 patent in the Petition for Inter Partes Review to which this declaration will be attached. Those claims are reproduced in Appendix 3. While this Petition and declaration are directed to the challenged claims, I have considered all claims 9-14, 23-28, and 30 of the ’714 patent, as well as portions of the ’714 patent prosecution history in forming my opinions.

III. SUMMARY OF THE PRIOR ART

32. There are a number of patents and publications that constitute prior art to the ’714 patent. I have reviewed and considered the prior art discussed in this section, along with the materials listed in Appendix 2.

A. Invalidity Grounds

33. Based on my review and analysis of the materials cited herein, my opinions regarding the understanding of a POSITA in the relevant timeframe (*supra* §II.C), and my training and experience, it is my opinion that the challenged claims of the ’714 patent are invalid based on the following grounds:

Grounds	Claims	Statutory Basis	Prior Art
1	9-10, 12-14, 23-24, 26-28, 30	§ 103	Rusert and Karczewicz
2	9-14, 23-28, 30	§ 103	Rusert, Karczewicz, and Lin

3	9-14, 23-28, 30	§ 103	Nakamura and WD4

34. I understand that Rusert, Karczewicz, Lin, and WD4 were not cited or considered during prosecution of the ’714 patent. None of these four references or any related patents are listed on the face of the ’714 patent. In addition, I reviewed the file history for the ’714 patent and am not aware of these references being discussed in any office action or in the prosecution history generally. I understand that Nakamura was cited in an IDS that was signed after the examiner issued a Notice of Allowance for the ’833 patent. *Supra* §II.B.

B. Rusert (Ex-1004)

35. Rusert is U.S. Patent Application Publication No. 2011/0194609 to Rusert et al., entitled “Selecting Predicted Motion Vector Candidates.” Rusert was filed on February 7, 2011 and was published on August 11, 2011. I understand Rusert is prior art to the ’714 patents under at least pre-AIA §102(a) and §102(e).

36. I have reviewed the Rusert reference. I understand that Rusert was not cited or considered during prosecution of the ’714 patent based primarily on the fact that Rusert is not cited on the face of the ’714 patent and or discussed in the prosecution history.

37. Rusert teaches a method for selecting Prediction Motion Vector candidates (“PMV candidates”) for video encoding and decoding. Ex-1004,

Abstract. Rusert reduces the number of candidates using a "subset of the set of previously coded motion vectors that were used for previous blocks[,]" e.g., by limiting the candidates to those used "for previous blocks having an allowed distance from the current block." Ex-1004, ¶11. When the list of candidates is updated, duplicates and essentially "similar" vectors are excluded. *Id.* ¶¶70-73. A candidate is selected from the list and used for motion prediction by the encoder and decoder. *Id.* ¶¶12-13, ¶¶88-99.

38. The list of PMV candidates is called "PMV_CANDS." I note that Rusert includes some typographical errors where this name is mistyped as "PMV_SANDS." E.g., Ex-1004, ¶6, ¶39, ¶42, ¶44, ¶88. This is clearly a typo, which would have been clear to POSITA in the context of Rusert. Several paragraphs use both "PMV_SANDS" and "PMV_CANDS" to refer to the same list. *See*, *e.g.*, Ex-1004, ¶39 (describing how "[u]pdate means that one or more motion vectors are added to an existing PMV_SANDS list[]" and how "[a] PMV_CANDS list may be updated"), ¶42 (referring to "one or multiple PMV_CANDS lists" and "either a single or two different PMV_SAND"), ¶44 (describing how "[t]he PMV_CANDS list may be updated" and how "to update PMV_SANDS[]"), ¶88 (referring to "candidates in PMV_SANDS" and "candidates in the PMV_CANDS list."). Moreover, the places where Rusert refers to "PMV_SANDS" have corresponding discussions in Rusert's provisional

application that correctly state "PMV_CANDS". *Compare* Ex-1004, ¶6 *with* Ex-1012, 000003-4. Furthermore, this name is easily mistyped because the letter "S" is close to "C" on QWERTY keyboards and both appear in the name. Moreover, this type of typographical error is commonplace with Microsoft Word because it is all capital letters, which Microsoft Word often skips (there is a setting for the spell check to omit all-caps words).

39. Rusert is analogous art in the same field as the '714 patent (video encoding and decoding, *infra* §IV). For example, Rusert teaches a method for a video encoding and decoding apparatus (Ex-1004, ¶1), with motion vector teachings used to encode and decode video (*id.*, ¶¶23-25).

C. Karczewicz (Ex-1005)

40. Karczewicz is U.S. Patent Application Publication No. 2011/0249721 to Karczewicz, entitled "Variable Length Coding of Coded Block Pattern (CBP) in Video Compression." Karczewicz was filed on April 11, 2011 and was published on October 13, 2011. I understand Karczewicz is prior art to the '714 patent under at least pre-AIA §102(a) and §102(e).

41. I have reviewed the Karczewicz reference. I understand that Karczewicz was not cited or considered during prosecution of the '714 patent based primarily on the fact that Karczewicz is not cited on the face of the patent or discussed in the prosecution history.

42. Karczewicz provides video encoding/decoding teachings related to the High Efficiency Video Coding ("HEVC") video standard, also referred to as H.265. Ex-1005, Abstract. Karczewicz teaches that H.265 is a new video coding standard. Ex-1005, ¶32. For example, Karczewicz teaches block types in H.265, e.g., coding units and prediction units. Ex-1005, ¶¶33-35.

43. Karczewicz is analogous art in the same field as the '714 patent (video encoding and decoding, *infra* §IV). For example, Karczewicz teaches that its techniques relate to "coding video data." Ex-1005, Abstract.

D. Lin (Ex-1006)

44. Lin is U.S. Patent Application Publication No. 2014/0092981, entitled "Method and Apparatus for Removing Redundancy in Motion Vector Predictors." Lin was filed on June 12, 2012 and claims priority to provisional application 61/500,903, which was filed on June 24, 2011. I understand Lin is prior art to the '714 patent under at least pre-AIA §102(e).

45. It is my understanding that a prior art patent application publication is entitled to its provisional application date if the subject matter relied upon in the reference published application is described in the provisional application, and at least one of the claims of the published application is supported by the written description of the provisional application. It is my opinion that Lin is entitled to its priority date of June 24, 2011 (the filing date of its provisional application), which

is before the earliest possible priority date of November 4, 2011 of the ’714 patent. First, Lin’s provisional application provides support for all subject matter relied-upon by this Declaration. Second, as set forth in the following table, the Lin Provisional provides sufficient details to enable one reasonably skilled in the art to make or use the invention claimed by Lin, including as stated in Lin’s claim 1.

Lin’s Claim 1	**Lin’s Provisional Support**
1. A method of deriving a motion vector predictor (MVP) for a current block in an Inter, Merge, or Skip mode, the method comprising:	Ex-1013, 000007, 000009, 000012
determining neighboring blocks of the current block, wherein an MVP candidate set is derived from MVP candidates associated with the neighboring blocks;	Ex-1013, 000016 (Fig. 6)
determining at least one redundant MVP candidate according to a non-MV-value based criterion;	Ex-1013, 000009-11
removing said at least one redundant MVP candidate from the MVP candidate set; and	Ex-1013, 000009-11
providing a modified MVP candidate set, wherein the modified MVP candidate set corresponds to the MVP candidate set with said at least one redundant MVP candidate removed.	Ex-1013, 000008-11

46. I have reviewed the Lin reference. I understand that Lin was not cited or considered during prosecution of the ’714 patent, based primarily on the fact that Lin is not cited on the face of the patent or discussed in the prosecution

history. A different reference authored by Lin, directed to different teachings, is cited on the face of the ’714 patent.

47. Lin provides teachings related to removing redundant motion vector predictors (MVPs). Lin teaches that, under the HEVC standard, each coding unit (CU) contains one or multiple prediction units (PUs). Ex-1006, ¶4; Ex-1013, 000007. When a CU is divided into two PUs, Lin teaches that the MVP candidate from the second PU can be removed because it is redundant. Ex-1006, ¶44, ¶25, Fig. 7A-7D; Ex-1013, 000010, 000017.

48. Lin is analogous art in the same field as the ’714 patent (video encoding and decoding, *infra* §IV). For example, Lin teaches that its disclosures relate to video coding, in particular, “coding techniques associated with derivation of motion vector predictors for motion vector coding.” Ex-1006, ¶2; *see also* Ex-1013, 000007.

E. Nakamura (Ex-1007, Ex-1008, Ex-1009) and WD4 (Ex-1010)

49. Nakamura is an HEVC proposal (numbered JCTVC-F419) presented at the 6th meeting of the Joint Collaborative Team on Video Coding (JCT-VC), held between July 14-22, 2011 in Torino, Italy. Nakamura is titled “Unification of derivation process for merge mode and MVP” and authored by Hiroya Nakamura et al. The Nakamura proposal comprises 6 files, which were part of the same proposal and uploaded to the JCT-VC website in one zip archive file. The 6 files

in Nakamura include a main document describing the proposed techniques of the proposal (Ex-1007), a Working Draft description of the proposed techniques of the proposal (Ex-1008), and a presentation slide deck illustrating the proposed techniques of the proposal (Ex-1009).

50. WD4 is version 3 of the Working Draft 4 of the HEVC standard (H.265) developed by the JCT-VC. WD4 was the output of the 6th JCT-VC meeting held July 14-22, 2011 in Torino, Italy. Ex-1010, 000001.

51. I understand that the Nakamura proposal and WD4 are prior art to the '714 patent under at least pre-AIA §102(a). Nakamura was publicly available by at least the time of the 6th JCT-VC meeting on July 22, 2011. Ex-1007, 000001; Ex-1014, ¶15, ¶36; Ex-1049, ¶56. The input to the 6th meeting was Working Draft 3 ("WD3"), and the output was Working Draft 4. At that meeting, attendees drafted Working Draft 4, which was made publicly available through the JCT-VC website shortly after the meeting; version 3 of Working Draft 4 ("WD4") was publicly available through the JCT-VC website by September 8, 2011. Ex-1010, 000001; Ex-1014, ¶15, ¶37; Ex-1049, ¶56. Nakamura and WD4 were made available to all meeting participants and were publicly accessible on the JCT-VC's website. *See generally* Ex-1014, Ex-1049. Anyone with Internet access could download Nakamura and WD4 from the JCT-VC website. Ex-1014, ¶¶35-37; Ex-1049, ¶¶56-57.

52. The JCT-VC meetings were high-profile events that were widely known to those interested in video coding and were attended by individuals from around the United States and the world, including professors from universities and engineers for a wide range of technology companies. It was common for individuals and companies of the industry to monitor these standards meetings to stay updated on changes and developments, as evidenced by several published papers citing Nakamura and WD4. *See, e.g.*, Ex-1024, Ex-1051, Ex-1025. Indeed, the paper "Non-fixed Quantization Considering Entropy Encoding in HEVC" by Gweon cites both Nakamura and WD4. Ex-1024, 000010.

53. Furthermore, the '714 patent admits that Nakamura and WD4 were prior art. First, the '714 patent references WD4 in its background. Ex-1001, 2:21-22 ("In some video codecs, such as High Efficiency Video Coding Working Draft 4…"). Second, Nakamura was cited as prior art against the '714 family of patents during prosecution of a European counterpart, EP2774375. *Supra* §II.B. The Patent Owner did not dispute that Nakamura was prior art and instead submitted Nakamura as prior art to the US Patent Office shortly before the parent of the '714 patent was allowed. *Supra* §II.B.

54. Therefore, for the reasons explained above, Nakamura and WD4 were publicly available before the provisional application for the '714 patent was filed on November 4, 2011.

55. Nakamura "presents simplifications of derivation process for merge mode and motion vector predictor (MVP)." Ex-1007, Abstract. The simplifications include "reduc[ing] the number of candidates in the spatial derivation process to reduce the number of times of comparison in the removal process." Ex-1007, Abstract. Additionally, Nakamura proposes an "improvement of derivation method of the candidates for merge mode and motion vector predictor (MVP)" with a "unification of the location of spatial neighbors for merge mode and MVP." Ex-1007, §1. Nakamura is analogous art in the same field as the '714 patent (video encoding and decoding, *infra* §IV). For example, Nakamura teaches "simplifications" and "improvement[s]" to video encoding and decoding processes for H.265. Ex-1007, Abstract, §1. Indeed, Nakamura provides results showing improvements in video encoding time and decoding time. Ex-1007, Tables 7-12.

56. WD4 contains various teachings related to the encoding and decoding of video streams according to the in-development HEVC video standard. For example, WD4 provides syntax for various video elements, such as prediction units, specifying "syntax element[s]… parsed from the bitstream[.]" Ex-1010, §7.1. WD4 is analogous art in the same field as the '714 patent (video encoding and decoding, *infra* §IV). For example, WD4 describes aspects of video streams

that were created by video encoders and decoded by video decoders, including the syntax of video bitstreams and video decoding processes. Ex-1010, §7.1, §8.4.

IV. LEVEL OF ORDINARY SKILL IN THE ART

57. I have analyzed the ’714 patent and determined that the field of the patent is video encoding and decoding. For example, the ’714 patent characterizes its alleged invention as “a method for encoding, a method for decoding,” and “an encoder and a decoder.” Ex-1001, 1:18-20. More specifically, the ’714 states “[t]he present invention introduces a method for generating a motion vector prediction list for an image block.” Ex-1001, 4:18-19.

58. In determining the characteristics of a hypothetical person of ordinary skill in the art (“POSITA”) of the ’714 patent at the time of the claimed invention, I considered several things, including various prior art techniques relating to video encoding and decoding, the type of problems that such techniques gave rise to, and the rapidity with which innovations were made. I also considered the sophistication of the technologies involved, and the educational background and experience of those actively working in the field at the time. I also considered the level of education that would be necessary to understand the ’714 patent. Finally, I placed myself back in the relevant period of time and considered the engineers and programmers that I have worked with and managed in the field of video encoding and video decoding.

59. I came to the conclusion that a person of ordinary skill in the field of art of the ’714 patent would have been a person with (1) a bachelor’s degree in electrical engineering, computer engineering, computer science, or a comparable field of study such as physics, and (2) approximately two to three years of practical experience with video encoding/decoding. Additional experience can substitute for the level of education, and vice-versa. I at least qualify under the definition of a POSITA because I had a BS degree in electrical and computer engineering by 1985, with many years of experience in video encoding and decoding (more than three) by 2011, as explained in my qualifications section. *Infra* §VII.

V. CLAIM CONSTRUCTION

60. For purposes of this inter partes review, I have considered the claim language, specification, and portions of the prosecution history to determine the meaning of the claim language as it would have been understood by a person of ordinary skill in the art at the time of the invention. The “plain and ordinary meaning” or Phillips standard has traditionally been applied in district court litigation, where a claim term is given its plain and ordinary meaning in view of the specification from the view point of a person of ordinary skill in the art.

61. I have applied the *Phillips* standard in my analysis. Unless otherwise stated, I have applied the plain and ordinary meaning to claim terms.

A. "spatial motion vector prediction candidate"

62. Based on my review of the claims and specification of the '714 patent, it is my opinion that a POSITA would have understood a "spatial motion vector prediction candidate" to mean a candidate motion vector obtained from one or more previously-encoded blocks in the current frame.

63. The specification of the '714 patent states that "a spatial motion vector *prediction* is a prediction obtained only on the basis of information of one or more blocks of the same frame than the current frame." Ex-1001, 3:9-14. Furthermore, the specification "defines candidate motion vectors for the current frame by using… one or more neighbour blocks and/or other blocks of the current block *in the same frame*…" Ex-1001, 12:51-56. Therefore, a spatial motion vector prediction *candidate* would be a candidate motion vector obtained only on the basis of information of one or more blocks of the current frame. *See* Ex-1001, 3:9-14, 12:51-56. The specification further states that spatial motion vector prediction candidates are obtained from "one or more already encoded block." Ex-1001, 12:58-59. That is, because spatial motion vector prediction candidates are "define[d]… by using one or more of the motion vectors of one or more neighbour blocks and/or other blocks of the current block in the same frame[,]" each spatial motion vector prediction candidate "represents the motion vector of one or more already encoded block." Ex-1001, 12:51-59.

B. “temporal motion vector prediction candidate”

64. Based on my review of the claims and specification of the ’714 patent, it is my opinion that a POSITA would have understood a “temporal motion vector prediction candidate” to mean a candidate motion vector obtained from a previously-encoded frame.

65. The specification of the ’714 patent states that a “temporal motion vector *prediction* is a prediction obtained on the basis of information of one or more blocks of a frame different from the current frame.” Ex-1001, 3:12-14. Furthermore, the specification that “for temporal prediction… motion vectors of a co-located block or other blocks in a previously encoded frame can be selected as candidate predictors for the current block.” Ex-1001, 12:63-13:3.

C. “the block”

66. Limitation [1b] recites “the block,” which could be interpreted to refer to either (a) the “block of pixels” introduced in [1a], or (b) the block from which the first spatial motion vector candidate is obtained. During prosecution of the parent ’833 patent, the Examiner applied the first interpretation, with “the” block as the “current block” (Ex-1015, 000168), which the Applicant did not dispute (Ex-1015, 000241-244). For purposes of this IPR, Petitioner applies the Examiner’s interpretation, where “the block” finds antecedent basis in the “block of pixels” in [1a].

D. "a subset of … candidates"

67. Limitation [1b] recites "a subset of … candidates," which means a subset of one or more candidates. The claims confirm that the subset may comprise one candidate. Limitation [1c] compares motion information of a potential candidate with motion information of "candidates in the determined subset" of limitation [1b]; dependent claim 10 further specifies that the potential candidate is compared with "at most one other" candidate. The specification includes embodiments where the subset is a single candidate. Ex-1001, 15:50-16:39 (e.g., block A1 is compared with block B1, block B0 is compared with block B1, block A0 is compared with block A1), Fig. 8b.

VI. INVALIDITY

68. Based on my review and analysis of the materials cited herein, my opinions regarding the understanding of a POSITA in the 2011 timeframe, and my training and experience, it is my opinion that a POSITA would have found the challenged claims 9-14, 23-28, and 30 of the '714 patent obvious in view of the invalidity grounds. The reasons for my conclusions are explained more fully below.

A. Grounds 1 and 2

69. It is my opinion that a POSITA would have found the Challenged Claims obvious based on Ground 1, i.e., the teachings of Rusert alone or in combination with Karczewicz. Rusert teaches and suggests the limitations of the

challenged claims. Karczewicz provides additional teachings that update Rusert's terminology and teachings in accordance with the H.265 standard.

70. It is my opinion that a POSITA would have found the Challenged Claims obvious based on Ground 2, i.e., the teachings of Rusert, Karczewicz, and Lin. In addition to the teachings provided by Rusert and Karczewicz for Ground 1, Lin provides further teachings regarding excluding redundant motion vector candidates.

1. Motivation to Combine and Reasonable Expectation of Success

71. **Rusert and Karczewicz**. Rusert teaches all limitations of the independent claims. Rusert uses H.264 terminology and teaches the blocks that serve as prediction units in H.264. To the extent the claims require H.265 PUs, those were well-known in the art and for example taught by Karczewicz. A POSITA would have been motivated to apply Rusert's teachings to H.265 PUs and related concepts, as explained below. Rusert provides various teachings for selecting motion vector predictor candidates for video encoding and decoding. Ex-1004, ¶¶1-4, ¶¶11-15, ¶¶24-26, ¶¶34-44. Rusert uses H.264 to explain its teachings but explains that it is not limited to any particular video standard: "while examples have been given in the context of particular coding standards, these examples are not intended to be the limit of the coding standards to which the disclosed method and apparatus may be applied." Ex-1004, ¶116. While Rusert's

teachings and embodiments were "given in the context of H.264/AVC, *the principles disclosed herein can also be applied to … other coding standard[s], and indeed any coding system which uses predicted motion vectors*." *Id.*

72. The successor video standard to H.264 was called H.265. Ex-1005, ¶32. As Karczewicz teaches, by 2011, it had been widely known that H.265 was emerging as the successor video standard. *Id.* ("[t]he emerging HEVC standard… referred to as ITU-T H.265[.]"). Both H.264 and H.265 standards were drafted by ITU-T, the Telecommunication Standardization Sector of the International Telecommunication Union.

73. H.265 used H.264 as a baseline starting point and used the same concepts of block-based video encoding with predicted motion vectors for those blocks. Ex-1005, ¶35 ("[T]he PU may include data defining a motion vector for the PU."), ¶37 ("Each of the blocks may be predictively encoded based on blocks of previously coded pixels[.]"), ¶66, ¶71; Ex-1006, ¶5 ("[I]n HEVC, the motion vector competition (MVC) based scheme is applied to select one motion vector predictor (MVP) among a given MVP candidate set which includes spatial and temporal MVPs."). Therefore, H.265 is a coding standard that uses predicted motion vectors—precisely the type of coding standard for which Rusert provides express motivation to combine.

74. In short, given Rusert's express teachings to apply its teachings to other video coding standards, and the fact that the successor H.265 standard was well known in the art and taught by Karczewicz, a POSITA would have been motivated to combine the teachings of Rusert and Karczewicz. This express teaching, suggestion, or motivation in the art was sufficient, on its own, to motivate a POSITA to combine Rusert and Karczewicz. Nonetheless, a POSITA would have been motivated to make this combination for a number of additional reasons, explained below.

75. A POSITA would have been motivated to make this combination because it would have combined prior art elements according to known methods to yield predictable results. For example, the combination would have combined Rusert's teachings for generating/de-duplicating PMV candidate lists, including for the selection of PMV candidates for blocks, with H.265 concepts (e.g., prediction units and related information for motion vectors), according to known methods (e.g., as taught by Karczewicz and known throughout the industry based on the widespread knowledge of H.265). Rusert explains its teachings in terms of blocks, with motion vectors and motion prediction operating in terms of blocks. Ex-1004, ¶¶2-5, ¶36, ¶43. As Karczewicz explains, H.265 drafts introduced new terminology for a type of block called a "prediction unit" ("PU"), with motion vectors and motion prediction operating in terms of PUs, where PUs comprised the

blocks that are used for motion prediction. Ex-1005, ¶¶33-36, ¶¶64-66. Karczewicz also provides related teachings on the types of information conveyed by motion vectors. Ex-1005, ¶35. Therefore, it would have been obvious to apply Rusert's motion-vector teachings to PUs in the H.265 context as a combination of prior art elements according to known methods, with predictable results as explained further below.

76. The combination would also have used Rusert's known techniques (e.g., for efficiently selecting PMV candidates) to improve similar devices and methods (e.g., for H.264 and H.265) in the same way. Rusert provides block-based motion vector teachings that were explained using H.264 as an example but were applicable to a variety of video coding standards. Ex-1004, ¶2, ¶116. This would have included the H.265 standard, which was similar to and in fact derived from H.264. Ex-1005, ¶3, ¶32 ("[T]he HEVC Test Model… presumes several capabilities of video coding devices over devices according to, e.g., ITU-T H.264/AVC."); *supra* §II.D. Karczewicz teaches aspects of the H.265 standard. Therefore, it would have been natural to apply Rusert's teachings regarding blocks to the H.265 context, including by applying Rusert's teachings to PUs as taught by Karczewicz, to improve the similar H.265 standard in the same way that Rusert explained for H.264. This would have applied a known technique to a known

device/method that was ready for improvement, to yield predictable results as further explained below.

77. Furthermore, the combination of Rusert and Karczewicz was a simple substitution of a known element (e.g., Karczewicz's prediction unit teachings) into Rusert's teachings. Rusert explains its teachings in terms of the blocks that form the basis for motion vector operations, and Karczewicz explains that, for H.265 video, those blocks (whose sizes are now allowed to vary) were called "PUs." Ex-1005, ¶6, ¶¶32-33, ¶64. Therefore, a POSITA would have been motivated to combine Rusert and Karczewicz by applying Karczewicz's teachings regarding PUs into Rusert's teachings for selecting PMV candidates for blocks in video frames.

78. Additionally, a POSITA would have found motivation in the similarity of the references. Both Rusert and Karczewicz are directed to video coding. Ex-1004, ¶1 ("The present application relates to … a video encoding apparatus, a video decoding apparatus …"); Ex-1005, Abstract ("This disclosure describes techniques for coding video data."). Both are discussed in the context of ITU standards, including H.264 and H.265. Ex-1004, ¶¶3-4, ¶67, ¶116 ("specific examples have been given in the context of H.264/AVC"); Ex-1005, ¶3, ¶5, ¶38, ¶¶32-33, ¶73. And while H.265 included new terminology for coding units ("CU") and prediction units ("PU"), Karczewicz explains that all of these are blocks of

image pixels (Ex-1005, ¶64 ("block" generally "may refer to one or more of a macroblock, LCU, CU, sub-CU, TU, or PU.")), and "[i]n general, a CU" of H.265 "has a similar purpose to a macroblock of H.264[.]" Ex-1005, ¶33. In its simplest case, a CU was a PU, with the flexibility where a CU can be divided into multiple PUs. Ex-1005, ¶35 ("A CU… may include one or more prediction units (PUs).").

79. A POSITA would have been motivated because the combination of Rusert and Karczewicz would have yielded several advantages. For example, Rusert provides for "an improved method and apparatus for selecting PMV candidates" "to improve video coding efficiency[.]" Ex-1004, ¶7. Karczewicz provides teachings "used to improve efficiency in coding (e.g., encoding or decoding) video data." Ex-1005, ¶6.

80. Additionally, a POSITA would have been motivated to combine Rusert's teachings from its embodiments with Rusert's teachings regarding the operation of H.264 in its background section. Rusert explains that its teachings are given with examples in H.264 and therefore provides express teaching, suggestion, and motivation to combine the teachings of its embodiments with known concepts of the H.264 video standard. *See, e.g.*, Ex-1004, ¶¶3-4,¶67, ¶77, ¶116.

81. Rusert teaches two options for initializing and updating PMV_CANDS: (1) PMV_CANDS is "dynamically generated specifically for the current motion compensation block" and (2) PMV_CANDS is "initialized once"

and “updated according to a sliding window approach.” Ex-1004, ¶41. A POSITA would have been motivated to use the first option in which PMV_CANDS is initialized and updated for each block because Rusert presents it as the first option. Furthermore, the first option is one of only two options, and a POSITA would have been motivated to apply at least the first option as one of a finite number of options that Rusert teaches.

82. Karczewicz discusses H.264 and H.265 and applies its teachings to both. Therefore, Karczewicz’s teachings regarding other features of H.265 would not have dissuaded a POSITA from combining with Rusert. For example, Karczewicz’s coded block pattern teachings are applicable to both H.264 and H.265. Ex-1005, ¶5, ¶38. Furthermore, Rusert’s teachings and Karczewicz’s teachings are applicable to coding and decoding blocks of pixels, regardless of the nomenclature used to label them. A POSITA would have understood the features introduced by H.265 do not prevent teachings with respect to H.264 from being applied to H.265, and vice-versa.

83. Moreover, the combination would have had predictable results. Rusert already applies its teachings to block-based video encoding/decoding—i.e., where the operation of motion vectors is based on blocks. *See, e.g.*, Ex-1004, ¶2, ¶11. Karczewicz explains that a PU is a type of block, and that the operation of motion vectors in H.265 is based on PUs. Ex-1005, ¶35. Therefore, the concepts

taught in Rusert were readily applicable to PUs, and the combination would have had the predictable result of selecting PMV candidates (as Rusert teaches) for PUs (as Karczewicz teaches). *See, e.g.*, Ex-1004, ¶116.

84. Furthermore, the combination would not have changed the principle of operation for any of the teachings of the references relied upon in the combination. The combination applies teachings from Rusert and Karczewicz in the manner taught by each reference: Rusert's teachings are still applied to the selected PMV candidates for block-based video encoding/decoding using predicted motion vectors, and Karczewicz's teachings are still used with motion vectors assigned to PUs, as explained above. Applying H.265 teachings to Rusert, and vice versa, would have been consistent with Rusert's statement that its principles are applicable to other video standards. *Id*.

85. A POSITA would have had a reasonable expectation of success when combining Rusert and Karczewicz. As explained above, the combination applies teachings from each reference according to their known purposes, in a conventional manner as taught by Rusert and Karczewicz, without changing their principle of operation. Furthermore, the teachings from Rusert and Karczewicz are complementary because both teach aspects of block-based video encoding from H.264 and H.265, respectively. Rusert provides examples using H.264, explaining it was not limited to that standard and its teachings apply to other coding standards,

which naturally would have included the successor standard H.265. *Id*. Therefore, Karczewicz's teachings complement Rusert by teaching terminology and concepts from H.265. Ex-1005, ¶32.

86. Additionally, the combination had predictable results, as explained above, and Ground 1 does not modify Rusert or Karczewicz in a way that would render either reference inoperative. To the contrary, the similarities of the architectures and video standards—which both use block-based video encoding/decoding with predicted motion vectors assigned to blocks—would have given a POSITA a reasonable expectation of success in combining their teachings. *See, e.g.*, Ex-1004, ¶11 (discussing motion vectors used for coding blocks); Ex-1005, ¶2 ("[t]his disclosure relates to block-based video coding techniques...").

87. Given the education and experience of a POSITA (*supra* §IV), a POSITA would have been more than capable of applying Karczewicz's teachings to Rusert, and vice versa, because it would simply have applied Rusert's teachings from H.264 to the successor standard H.265. Additionally, motion estimation was commonplace, having been introduced by MPEG standards in the 1990s, and H.264 had introduced the use of predicted motion vectors by the early-mid 2000s. *Supra* §I. These were basic aspects of video encoding/decoding that a POSITA would have been knowledgeable about.

88. **Rusert, Karczewicz, and Lin.** The motivation to combine Rusert and Karczewicz was explained above. A POSITA would have been further motivated to apply Lin's teachings for removing redundant PMV candidates, for the reasons explained below.

89. Lin teaches a way to reduce the number of motion vectors that must be considered—particularly for the scenario where a block has been divided into two PUs. Ex-1006, ¶4, ¶25, ¶44. Applying these teachings would have furthered a stated goal of Lin and Rusert, by reducing the number of motion vector candidates. Rusert seeks to "reduce[] the number of previous motion vectors that must be considered" so "that less computation is needed, improving the processor efficiency of the coding." Ex-1004, ¶12; *see also* Ex-1004, ¶7, ¶13, ¶21, ¶70, ¶84. Lin likewise seeks to reduce the number of motion vector candidates. Ex-1006, ¶¶39-40 (teaching removing redundant MVP candidates to reduce complexity), ¶47; Ex-1013, 000009 (discussing removing redundant MVPs).

90. Additionally, Karczewicz provides motivation to combine with Lin. As explained above, the combination applies Karczewicz's PU teachings to Rusert. Karczewicz explains that CUs do not have to be divided—in the simplest case, if the block has uniform motion, the same motion vector can be assigned to the entire block. The entire CU block is a PU, and there is no reason to divide it into multiple PUs. Conversely, if different parts of the block are moving in different

directions, the CU can be divided into multiple PUs so that each can have a different motion vector. Ex-1005, ¶35; Ex-1006, ¶35; Ex-1013, 000007. In other words, the block is divided into two PUs when each half of the block has different motion. If a block is divided into two PUs because its two portions have differing motion vectors, then there is no way that the motion vector corresponding to one of these PUs can be a good predictor to the motion of the other PU. Therefore, when analyzing potential motion vectors for half of a block (that has been divided into two PUs), Lin explains that the motion vector from the other half can be removed. Ex-1006, ¶25, ¶44; Ex-1013, 000010. Lin explains that assigning the same motion vector to both halves of a divided block is redundant to the scenario where the block was not divided at all and the same motion vector was applied to the entire block comprising one PU. *See id.* Since Karczewicz already teaches that CUs can—but do not have to be—divided into PUs, a POSITA would have been motivated to reduce this redundancy as Lin teaches.

91. A POSITA would have been motivated to combine Lin with Rusert and Karczewicz because it would have used Lin's known technique of reducing candidates to improve similar devices/methods in the same way. After all, the combination already applied Karczewicz's PU teachings to Rusert. Adding Lin's further optimization of reducing candidates for this PU splitting scenario would have improved similar H.265 PU-based methods. A POSITA would have applied

Lin's known technique to the known devices/methods as taught by Rusert and Karczewicz, which was ready for improvement to reduce the number of previous motion vectors that must be considered. Ex-1004, ¶12. Moreover, this would have been a combination of prior art elements according to known methods to yield predictable results.

92. Furthermore, a POSITA would have been motivated by the similarity of the references. The coding units and prediction units taught by Lin are the same as those taught by Karczewicz—both refer to H.265 nomenclature. Ex-1006, ¶4 ("The basic unit for compression, termed Coding Unit (CU)… contains one or multiple Prediction Units (PUs)."); Ex-1005, ¶35 ("A CU… may include one or more prediction units (PUs). In general, a PU represents all or a portion of the corresponding CU[.]"). Both Lin and Karczewicz apply their teachings to H.265.

93. While Lin provides teachings in the context of merge mode, its teachings—e.g., for excluding redundant candidates when a block has been divided into multiple PUs—likewise apply to the combination of Rusert and Karczewicz, which seeks to efficiently select PMV candidates for a given block (as taught by Rusert) applied to PUs that can come from divided blocks (as taught by Karczewicz). The same underlying reasoning therefore applies because, even without merge mode, blocks are divided into multiple PUs to assign them different motion vectors, and it would not make sense to divide a block into separate PUs

only to assign the same motion vector to both PUs. Ex-1005, ¶35; Ex-1006, ¶4; Ex-1013, 000007. Doing so would be less efficient than keeping the entire block as a single PU and be contrary to the reason why the block was divided to begin with.

94. The combination would have had predictable results: when a block is divided into two PUs, the PMV candidate from one PU is excluded as a candidate for the other PU. Excluding the candidate would have been a predictable result consistent with the reason why a block is divided into PUs to begin with, as explained above.

95. Furthermore, the combination would not have changed the principle of operation for any of the teachings of the references. The combination applies teachings in the manner taught by each reference: Rusert and Karczewicz were explained above, and Lin's teachings are used to exclude candidates when a block is divided into two symmetric PUs, as taught and illustrated by Lin. Ex-1006, ¶44; Ex-1013, 000016. Since Ground 1 already applies H.265 PU concepts to Rusert, the application of Lin's PU teachings to this combination would have been entirely compatible with it and would not have changed its principle of operation. Ground 2 simply applies Lin's exclusion of PUs in certain scenarios.

96. A POSITA would have had a reasonable expectation of success when combining Lin with Rusert and Karczewicz. As explained above, the combination

applies teachings from each reference according to their known purposes, in a conventional manner as taught by Rusert, Karczewicz, and Lin, without changing their principle of operation. Furthermore, the teachings are complementary because all three references teach aspects of block-based video encoding from H.264 and H.265. *E.g.* Ex-1004, ¶25, ¶39; Ex-1005, ¶3, ¶5, ¶38; Ex-1006, ¶4, ¶25; Ex-1013, 000009-11. Lin's teachings apply a basic concept to further Rusert's stated goal of reducing the number of PMV candidates, by eliminating redundant ones as explained above. *E.g.*, Ex-1004, ¶25, ¶39, ¶¶42-44; Ex-1013, 000009-11.

97. Additionally, the combination would have had predictable results, as explained above, and Ground 2 does not modify Rusert, Karczewicz, or Lin in a way that would render any reference inoperative. To the contrary, the similarities of the architectures and video standards would have given a POSITA a reasonable expectation of success in combining their teachings. Ex-1004, ¶67, ¶116; Ex-1005, ¶32; Ex-1006, ¶¶4-5, ¶44; Ex-1013, 000007.

98. Given the education and experience of a POSITA (*supra* §IV), a POSITA would have been more than capable of applying Lin's teachings to Rusert and Karczewicz because it would simply have applied the concept of excluding candidates in a particular scenario as taught by Lin. Motion estimation and predicted motion vectors had been widespread for many years. *Supra* §I. These

were basic aspects of video encoding/decoding that a POSITA would have been knowledgeable about.

2. Independent Claim 9

[9pre]	**A method comprising:**

99. To the extent that the preamble is limiting, Ground 1 teaches limitation [9pre], as explained below.

100. Rusert teaches a **method**. For example, Rusert teaches "a *method* of selecting PMV candidates, wherein each PMV candidate corresponds to a motion vector used for coding of a previous block, said previous block having a distance from a current block." Ex-1004, Abstract, ¶1, ¶11. The method further comprises the steps and elements explained below. *Infra* §§VI.A.2[9a]-[9e].

[9a]	**selecting a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for an encoded block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the encoded block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates;**

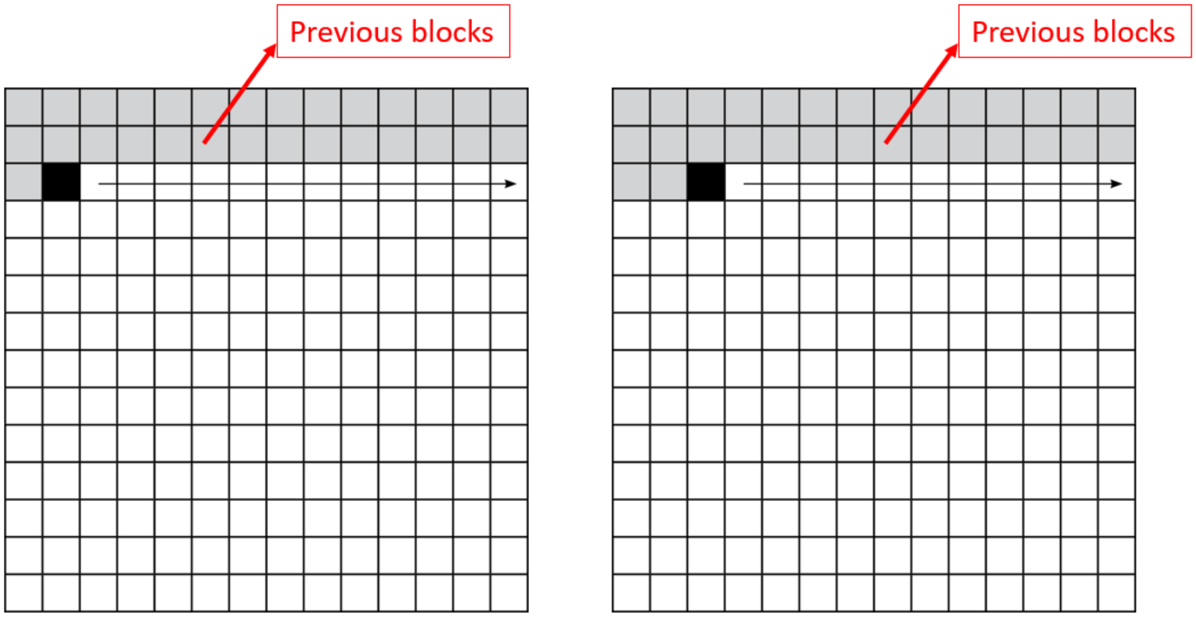
101. Ground 1 teaches limitation [9a], as explained below.

102. Ground 1 teaches **selecting a first spatial motion vector prediction candidate** (e.g., a PMV candidate) **from a set of spatial motion vector prediction candidates** (e.g., a set of previously coded motion vectors) **for an encoded block of pixels**. For example, Rusert refers to a predicted motion vector

as a "PMV" (Ex-1004, ¶3) and teaches "selecting … PMV candidates" for a current block from a "set of previously coded motion vectors that were used for previous blocks[.]" Ex-1004, ¶11, ¶12, ¶15, ¶¶24-25, ¶39, ¶113, Fig. 6. PMV_CANDS is a list of predicted motion vectors and is therefore a motion vector prediction list. *Id.* "[T]he encoder and decoder follow the same rules for creating and modifying" PMV_CANDS and "the respective lists of PMV candidates stored in the encoder and decoder maintain synchronization." Ex-1004, ¶35, ¶¶24-25.

103. Rusert's PMV candidates comprise spatial motion vector prediction candidates that are obtained from one or more previously-decoded blocks in the current frame. *Supra* §V.A. Rusert teaches that the PMV candidates include "*spatially* neighboring motion vectors" (Ex-1004, ¶6) with one of the PMV candidates being selected as a "*motion vector predictor*… for [a] vector to be coded" (Ex-1004, ¶3). *See also* Ex-1004, ¶¶4-5. Furthermore, Rusert teaches that PMV candidates are evaluated for inclusion in a PMV_CANDS list, which includes spatial and temporal motion vector prediction candidates, e.g., "[m]otion vectors" that "comprise *spatial* or temporal *neighbors of the current block*[.]" Ex-1004, ¶67. Since neighboring blocks are next to the current block in the current frame, Rusert's spatially neighboring motion vectors from those neighboring blocks are obtained only on the basis of information of one or more blocks of the current frame. Ex-1004, ¶¶4-6.

104. The PMV candidates are selected from a "set of previously coded motion vectors that were used for previous blocks[,]" which is a set of spatial motion vector prediction candidates for an encoded block of pixels. *E.g.*, Ex-1004, ¶¶11-12. As Rusert iterates through blocks of pixels in a frame, each block will have its own set of previously-coded motion vectors from which to select a PMV candidate, specific for that block and different from others. Ex-1004, ¶2 ("pixel blocks"), ¶¶11-12, ¶36, ¶59, Fig. 3g. As blocks of the frame are encoded, the number of blocks previous to the current block increases; therefore, the set of previously-coded motion vectors that were used for previous blocks expands with each encoded block. *See id.* Ex-1004, ¶59. Blocks were encoded/decoded in sequence, with a common approach being a raster scanning order (from top left to bottom right). *See, e.g.,* Ex-1004, ¶59. (teaching that "the blocks to the right and below the current block position have not been visited yet, and do not yet have motion vectors known for them"), Fig. 3g. I have illustrated this concept below where the current block is indicated in black. Each time the current block advances, the set of spatial motion vector prediction candidates increases by one.



Regardless of the scan pattern used, the sets of spatial motion vector prediction candidates are different for different blocks of pixels. Rusert's teachings are applied to "pixel blocks" or blocks of pixels, as further described below. Ex-1004, ¶2, ¶36. The decoder applies these teachings to an encoded block of pixels. As Rusert explains, the decoder receives encoded blocks from the encoder (Ex-1004, ¶34, ¶36, Fig. 1) and then "follow[s] the same rules" as the encoder to decode those blocks, building and using the same list of PMV candidates for each block. Thus Rusert receives the current block for which candidates are being evaluated.

105. Rusert further teaches **selecting a first … candidate … as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list** (e.g., PMV_CANDS). For example, Rusert teaches selecting candidate motion prediction vectors in "an outwards going scan… around

the current block" for PMV candidates to potentially be included in a PMV_CANDS list. Ex-1004, ¶44, ¶¶51-66. Rusert teaches numerous examples (*see* Ex-1004, Figs. 3a-n), including Fig. 3c and the "search pattern shown in FIG. 3n" that "has been found to combine good compression efficiency (i.e., finding good motion vectors) with good computation performance." Ex-1004, ¶66, Figs. 3a-3n:

Fig. 3c

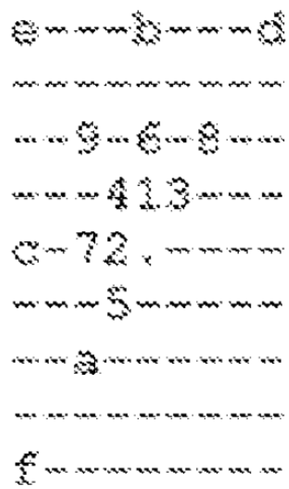


Fig. 3n

106. I note that Fig. 3c illustrates a scan pattern "in the following order: 1, 2, 9, h, j, l, m[]" with "1" (one) being the block located directly above the current block "." and "l" (lowercase l) being the block located in the upper left corner. Ex-1004, ¶54. Fig. 3n illustrates a scan pattern with "an ordering as shown": 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f with "a" being hexadecimal for 10, "b" being hexadecimal for 11, and so on. Ex-1004, ¶65.

107. Rusert selects candidates in the sequences taught by its search patterns, starting with a first candidate labelled "1" in its figures. Ex-1004, ¶¶51-66, Figs. 3a-n. Each candidate is selected from the set of previously-coded motion vectors that were used for previous blocks. Ex-1004, ¶11, ¶12, ¶15, ¶¶24-25, ¶39, ¶44, ¶¶51-66. Rusert teaches visiting previously-coded blocks, in the sequences shown by its search patterns, and selecting the motion vector for that previously-coded block as a candidate for potential inclusion in PMV_CANDS. Ex-1004, ¶44, ¶¶51-66; *infra* §§VI.A.2[9c]-[9d] (explaining how the selected candidate is compared with candidates in PMV_CANDS for potential inclusion in PMV_CANDS). I have illustrated the start of the search patterns for Fig. 3c (horizontally):

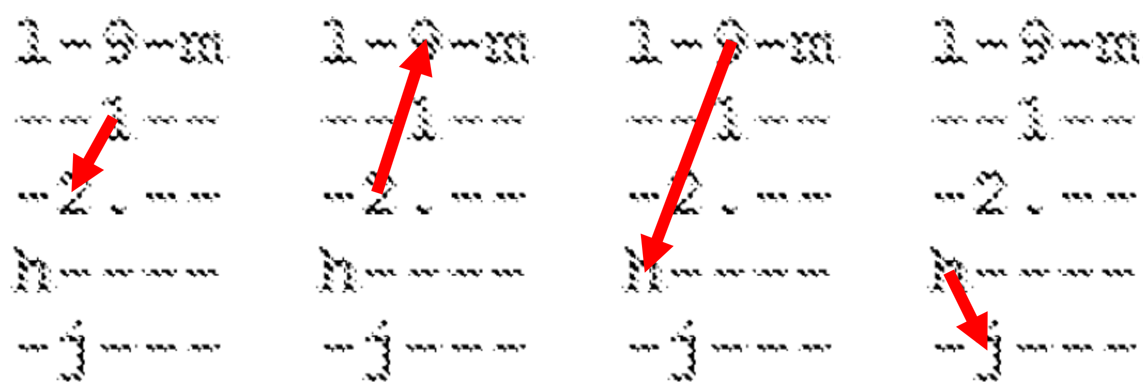


Fig. 3c Fig. 3c Fig. 3c Fig. 3c

and for Fig. 3n (horizontally):

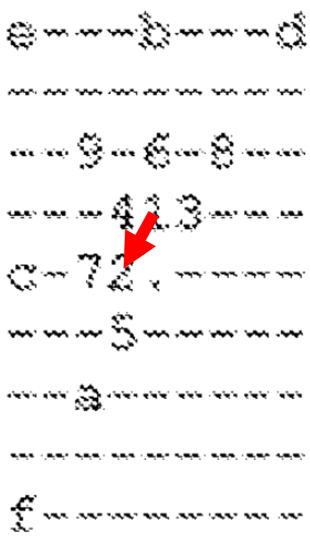


Fig. 3n

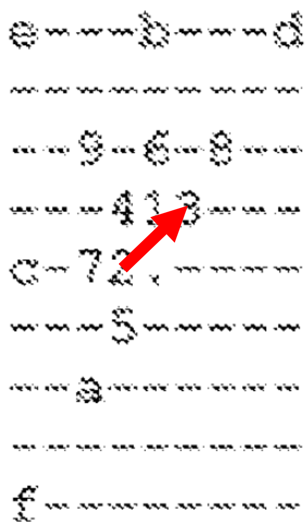


Fig. 3n

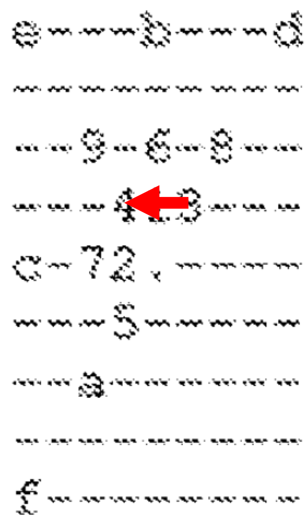


Fig. 3n

Fig. 3n

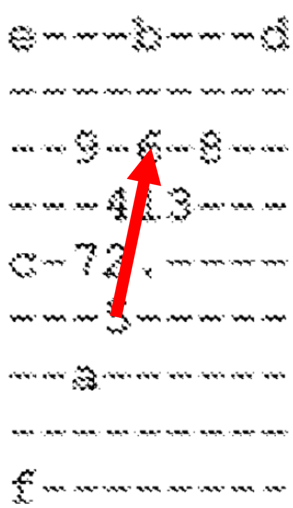


Fig. 3n

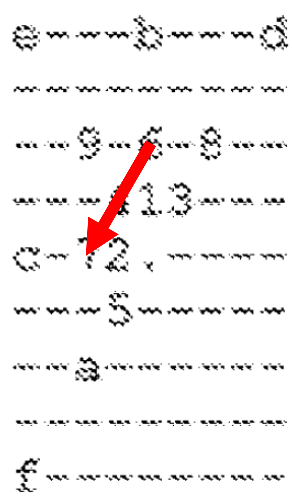


Fig. 3n

and for Fig. 3n again with directional annotation added:

Fig. 3n

108. PMV_CANDS is **a motion vector prediction list for a prediction unit of the encoded block of pixels**. Rusert teaches that "[t]he PMV_CANDS list [is] used for coding a motion vector associated with a current motion compensation block[.]" Ex-1004, ¶41; *see also* Ex-1004, ¶4, ¶39, ¶42. A decoder using "[t]he PMV_CANDS list… for" decoding an encoded block of pixels would "follow the same rules for creating and modifying" PMV_CANDS as the encoder that encoded the block of pixels to "maintain synchronization" of "the respective lists of PMV candidates stored in the encoder and decoder[.]" Ex-1004, ¶35, ¶¶24-25. PMV_CANDS is "dynamically generated specifically for the current motion compensation block[.]" Ex-1004, ¶41. "In that case, before a block is processed, a PMV_CANDS list is initialized and then updated with a number of previously coded or pre-defined motion vectors." *Id*. When Rusert's PMV_CANDS list is updated (Ex-1004, ¶39 ("Update means that one or more motion vectors are added

to an existing [PMV_CANDS] list")), it comprises a subset of the set of previously-coded motion vectors included in the PMV_CANDS list as part of the scan to that point. Ex-1004, ¶¶43-44, ¶¶51-66, ¶¶4-5, ¶¶36-39 ("A PMV_CANDS list may be updated to include previously coded motion vectors MV."). When Rusert's PMV_CANDS list is complete, a "predicted motion vector (PMV)" that "is used to predict a [motion vector]… is signaled" using PMV_CANDS and an index "to select a particular PMV candidate… from… PMV_CANDS[.]" Ex-1004, ¶36.

109. Rusert explains its teachings with references to blocks to which motion vectors are assigned. Ex-1004, ¶¶2-5, ¶36, ¶43. Therefore, in the context of Rusert's nomenclature, the prediction unit of Rusert's block of pixels is the block itself because Rusert's block is the unit for which a motion vector is assigned for motion prediction. Ex-1004, ¶2 ("Each motion compensation block is assigned one motion vector (for uni-predictive temporal prediction, such as in P frames) or two motion vectors (for bi-predictive temporal prediction, such as in B frames)."), ¶3 ("in recent video coding standards such as H.264/AVC where *small motion compensation block sizes* are used"), ¶4, ¶36, ¶43 ("Before a motion vector associated with a current motion compensation block is processed, the PMV_CANDS list used for coding the current motion vector may be updated by using motion vectors associated with surrounding blocks."). For Rusert's

teachings, a motion vector is provided for each "8x8 pixel block," also called a "sub-block" because it is a portion of a "macroblock." Ex-1004, ¶36. When Rusert looks for neighboring motion vectors, it scans nearby blocks where motion vectors have been assigned to those blocks. Ex-1004, ¶¶50-67, Figs. 3a-3n. Those blocks are therefore the prediction units in the context of Rusert's teachings.

110. Additionally, the combination of Ground 1 applies Rusert's teachings regarding "blocks" (in the H.264 context) to prediction units (following nomenclature in the H.265 context). *Supra* §VI.A.1 (explaining how and why Rusert and Karczewicz's teachings would have been combined). Rusert uses H.264 terminology, and a POSITA would have found it obvious and been motivated to apply Rusert's teachings to the successor standard H.265. *Id.* Rusert provides express motivation to do so. Ex-1004, ¶116.

111. Rusert's motion-vector teachings are explained on the basis of "blocks" because Rusert applies H.264 terminology, where motion vectors are assigned to "blocks." Ex-1004, ¶¶2-5, ¶36, ¶43. However, Rusert also explains that its teachings "can also be applied to… *any coding system which uses predicted motion vectors*." Ex-1004, ¶116. As Karczewicz explains, the successor video standard H.265 introduced new terminology for a type of block called a "prediction unit" ("PU"), with motion vectors being assigned to PUs. Ex-1005, ¶¶33-36; *see also supra* §I. For H.265, "[i]n general, a CU has a similar purpose to a

macroblock of H.264[.]" Ex-1005, ¶33. "A CU… may include one or more prediction units (PUs)"; "[i]n general, a PU represents all or a portion of the corresponding CU[.]" Ex-1005, ¶35. In its simplest case, a CU is commensurate with a PU. *Id.* "[T]he PU may include data defining a motion vector for the PU[,]" and "the motion vector may describe, for example, a horizontal component" and "a vertical component[.]" *Id*. This motion information is used for "prediction using a PU[.]" Ex-1005, ¶36; ¶66.

112. In short, Rusert explains its teachings in terms of blocks, with motion vectors assigned to or obtained from blocks in the H.264 context. Ex-1004, ¶¶2-5, ¶36, ¶43. Karczewicz explains that, for H.265, a PU is a type of block, and motion vectors are assigned to PUs. Ex-1005, ¶64 ("[T]he phrase 'block' refers to any size or type of video block" and "may refer to one or more of a macroblock, LCU, CU, sub-CU, TU, or PU."), ¶¶33-36. Furthermore, both Karczewicz and Rusert teach the encoder and decoder use "reciprocal… techniques[,]" which confirms these teachings are applicable to both encoding and decoding. Ex-1005, ¶50; Ex-1004, ¶35, ¶¶24-25. Therefore, based on these combined teachings, it would have been obvious to apply Rusert's motion vector teachings to PUs in the H.265 context, with PMV_CANDS being a motion vector prediction list for a prediction unit of the block of pixels. Ex-1005, ¶¶33-36, ¶66. A decoder using PMV_CANDS for decoding an encoded block of pixels would "follow the same rules" as the encoder

that encoded the block of pixels to "maintain synchronization" of "the respective lists of PMV candidates stored in the encoder and decoder[.]" Ex-1004, ¶35, ¶¶24-25.

113. **Where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates**. For example, Rusert's PMV_CANDS list comprises motion information of the spatial motion vector prediction candidates. PMV_CANDS is a "list of PMV candidates[.]" Ex-1004, ¶37. Furthermore, "each PMV candidate corresponds to a motion vector used for coding of a previous block." Ex-1004, ¶11; *see also* Ex-1004, ¶¶24-25, ¶39, ¶41. The motion vectors of the PMV candidate include, for example, "x and y components." Ex-1004, ¶106, ¶36, ¶¶91-94, ¶100. Therefore, Rusert's PMV_CANDS list includes motion information, including motion vectors and their x and y components, of the PMV candidates. *See* Ex-1004, ¶¶2-3 (discussing motion vectors used for prediction of pixel blocks across frames); *see also* Ex-1001, 2:59-3:4 ("motion information is indicated by motion vectors associated with each motion compensated image block"). In short, Rusert teaches this limitation.

114. Additionally, Karczewicz teaches "the PU may include data defining a motion vector for the PU." Ex-1005, ¶35. The motion vector for the PU includes "a horizontal component" (e.g., x-component), "a vertical component" (e.g., y-component), "a resolution…, a reference frame… and/or a reference list[.]" *Id.*

Therefore, Karczewicz confirms that the motion vectors of Rusert's PMV candidates include "x and y components" (Ex-1004, ¶106, ¶36, ¶¶91-94, ¶100) because Karczewicz teaches motion vectors include "a horizontal component" and "a vertical component[.]" Ex-1005, ¶35. Moreover, based on the combined teachings of Karczewicz and Rusert, it would have been obvious to include the PU information described by Karczewicz (e.g., "a resolution…, a reference frame… and/or a reference list") in PMV_CANDS because the combination relies on Karczewicz's PU teachings and applies them to Rusert. *Supra* §VI.A.1 (explaining how the references would have been combined). Therefore, the combination of Ground 1 teaches the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates.

115. Ground 1 further applies Rusert's block-based teachings to PUs. *Supra* §VI.A.1 (explaining how and why the references would be combined). Based on the foregoing explanations, Ground 1 teaches limitation [9a].

[9b]	**determining a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;**

116. Ground 1 teaches limitation [9b], as explained below.

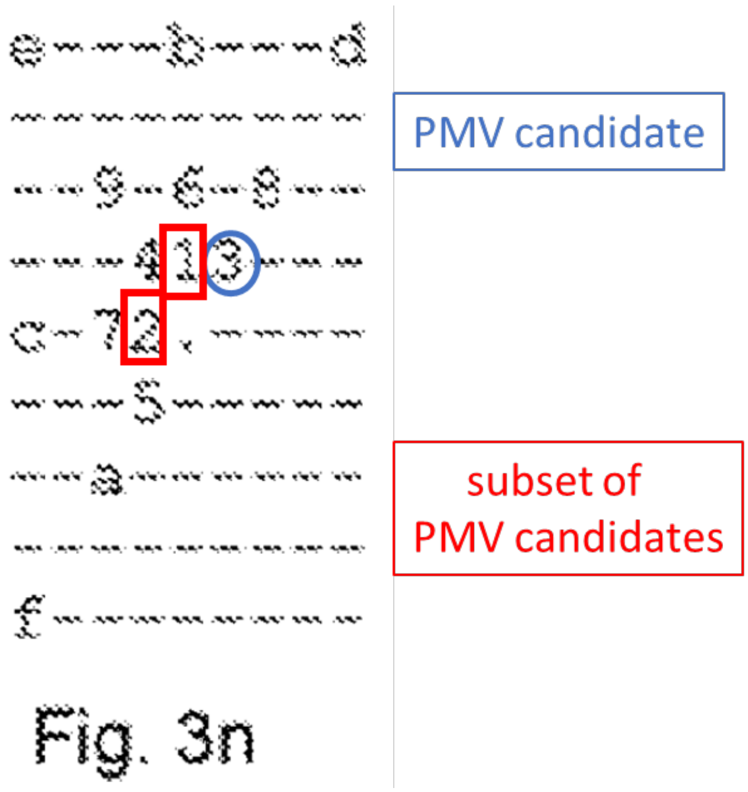
117. Rusert teaches **determining a subset of spatial motion vector prediction candidates** (e.g., based on Rusert's scan of previous PMV candidates within an allowed distance and pre-defined number). For example, Rusert teaches

"selecting a set of PMV candidates as a *subset* of the set of previously coded motion vectors that were used for previous blocks[.]" Ex-1004, ¶11, ¶12 ("A PMV candidate list is created by *selecting a subset of the motion vectors* previously used for previous blocks"), ¶¶24-25; *supra* §V.D.

118. Rusert determines the subset of PMV candidates based on the locations of their corresponding blocks: "the selected set of PMV candidates comprises *a subset of the set of previously coded motion vectors* … having an allowed distance from the current block and an allowed position[.]" Ex-1004, ¶15, ¶37, Figs. 2a-2b:

119. When Rusert's subset of PMV candidates, which is stored in PMV_CANDS, is updated with a PMV candidate (Ex-1004, ¶39 ("Update means that one or more motion vectors are added to an existing [PMV_CANDS] list")) using an outward scan from the current block, the subset of PMV candidates comprises the previously-coded PMV candidates obtained from blocks in previous locations of Rusert's scan from the current block to that point. Ex-1004, ¶¶43-44, ¶¶51-66, ¶¶4-5, ¶¶36-39 ("A PMV_CANDS list may be updated to include previously coded motion vectors MV."). As the scan progresses outwards, the subset includes the PMV candidates obtained from blocks in previous locations of Rusert's scan order. Ex-1004, ¶44, ¶¶51-66, Figs. 3a-3n. For example, following the scan order of Fig. 3n, when block "3" is selected, the subset of PMV candidates

includes PMV candidates obtained from blocks located at positions 1 and 2, as illustrated below. *Id.* When block "4" is selected, the subset of PMV candidates includes PMV candidates obtained from blocks located at positions 1, 2, and 3, and so on. *Id.*



120. The PMV candidates in Rusert's subset of PMV candidates are a subset of the larger set of previously-coded motion vectors. Additionally, Rusert teaches terminating a scan "as soon as a pre-defined number of unique PMV candidates have been found[.]" Ex-1004, ¶48. Therefore, not all PMV candidates are considered. Even PMV candidates that are within "a certain distance" and part of "a predetermined scan pattern" are not considered if the "pre-defined number of

unique PMV candidates have been found." Ex-1004, ¶¶44-49. For example, while Fig. 3n includes a scan of up to 15 blocks, Rusert terminates the scan with a subset of candidates from those blocks when a pre-determined number of candidates are obtained (e.g., 7), without using the remaining candidates in the scan sequence. Ex-1004, ¶48, ¶107. The subset of PMV candidates is therefore a subset of the set of PMV candidates that are within a certain distance and part of the scan pattern. As the scan progresses outwards and the subset of PMV candidates is updated, the subset is stored as a list of PMV candidates called PMV_CANDS. Ex-1004, ¶¶37-41, ¶¶44-49, ¶¶51-66; *infra* §VI.A.2.[9d]. The subset is determined for reducing the number of candidates, as explained for [9c].

121. Rusert improves coding efficiency by using this subset of spatial motion vector prediction candidates instead of all of previously-coded motion vectors. Ex-1004, ¶13 ("The size of the PMV candidate list is limited because a very large list would require long code words to identify which PMV candidate to use.… This allows a candidate list to be produced using motion vectors from a wide range of previous blocks, but that is not excessively long."), ¶12 ("*Restricting the previous blocks* that are considered reduces the number of previous motion vectors that must be considered *meaning that less computation is needed, improving the processor efficiency of the coding*.").

122. The determination is **based on the location of the block associated with the first spatial motion vector prediction candidate**. Here, "the" block recited in [9b] has an antecedent basis in [9a]: "a *first spatial motion vector prediction candidate* from a set of spatial motion vector prediction candidates *for an encoded block of pixels*[.]" Therefore, "the block" refers to the "block of pixels" in [9a] and therefore refers to the current block for which motion vector prediction candidates are being analyzed.[2] *Supra* §V.C.

123. Rusert determines its subset based on the location of the current block. The subset of PMV candidates is updated by "an outwards going scan… around the current block[.]" Ex-1004, ¶44, ¶43 ("Before a motion vector associated with a current motion compensation block is processed, the PMV_CANDS list used for coding the current motion vector may be updated by *using motion vectors associated with surrounding blocks*."). Because the "outwards going scan" is "performed around the current block[,]" the set of blocks that are scanned for potential inclusion in the subset of PMV candidates is based on the location of the current block. Ex-1004, ¶44.

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[2] This is further confirmed by the prosecution history of a parent patent, the '833 patent. The Examiner interpretated "based on the location of the block associated with the first spatial motion vector prediction candidate" as based on the location of the "current block," finding that this limitation was satisfied by prior art teachings for "selecting one of the PMV from MVs of neighboring blocks[.]" Ex-1015, 000168 (Non-Final Office Action). The Applicant did not dispute this plain reading of the claims. *See* Ex-1015, 000241-244 (Reply to Office Action).

124. Furthermore, the subset of PMV candidates is based on "an allowed distance from the current block and an allowed position. " Ex-1004, ¶15, ¶11, ¶13, ¶17, ¶¶24-25, ¶113, Fig. 6. The distance and position are relative to and therefore based on the location of the current block. *See, e.g.*, Ex-1004, ¶11 ("The method comprises identifying allowed distance values of distances between the current block and the previous block."), ¶16 (discussing identifying allowed positions relative to the current block). Rusert teaches several techniques for calculating distance values based on the locations of the current block and surrounding blocks, including Euclidean distance,[3] Manhattan distance, and Chebyshev distance. Ex-1004, ¶44. Within the allowed distance, Rusert teaches scanning surrounding blocks, starting with closest blocks and terminating the scan "once a certain distance has been reached." This prevents blocks from the set that are outside of the allowed distance from being scanned. Ex-1004, ¶13 (blocks with "certain distance values" outside the allowed distance are not included in the subset), ¶43, ¶47. Rusert's figures include exemplary distance values of surrounding blocks relative to the current block, with the scan terminating when a certain distance value, such as 5 or 8, is reached. Ex-1004, Figs. 3a, 3d, 3f, 3g:

[3] Rusert occasionally misspells "Euclidean distance" as "Euclidian distance". *See, e.g.*, Ex-1004, ¶44, ¶78, ¶87.

Fig. 3a

Fig. 3d

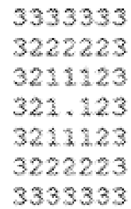


Fig. 3f

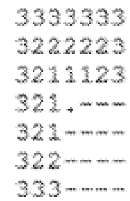


Fig. 3g

125. In each of Rusert's exemplary scans, the blocks are identified and ordered based on their location around the current block (indicated by "."). Ex-1004, ¶¶51-66, Figs. 3a-3n. Therefore, the subset of PMV candidates in PMV_CANDS is based on the location of the current block. Ex-1004, ¶11, ¶13, ¶15, ¶17, ¶¶24-25, ¶¶43-44, ¶¶51-66.

126. Additionally, Rusert teaches that only motion vector prediction candidates from blocks with allowed positions relative to the current block will be included in the subset. *See* Ex-1004, ¶15. Rusert explains:

> The allowed positions may be are *corner and middle block positions*. A previous block at a corner position is offset from a current block position by an equal distance in a horizontal direction and a vertical direction. A previous block at a middle position is either horizontally aligned or vertically aligned with a current block position. In a system where coding is performed by horizontal lines of pixels starting in the top left corner, the allowed block positions may comprise: *blocks horizontally aligned with and offset to the left of the current block; blocks vertically aligned with and offset above the current block; and blocks offset to the left and above the current block by the same*

> *distance*. The allowed distance values and/or the allowed positions may be predetermined.

Ex-1004, ¶16 (emphasis added). Here, Rusert teaches that PMV candidates of previous blocks that do not have an allowed position are excluded from the subset. For example, Rusert teaches excluding "all blocks other than the corner blocks and the blocks directly above and to the left of the current block[.]" Ex-1004, ¶65. This exclusion removes blocks that have not yet been encoded/decoded because the "blocks to the right and below the current block position have not been visited yet, and do not yet have motion vectors known for them[.]" Ex-1004, ¶59. Rusert teaches that excluding such blocks prevents "requir[ing] too many tests before growing the scan area big enough to capture distant blocks." Ex-1004, ¶65. Therefore, the subset of PMV candidates in PMV_CANDS is based on the location of the current block.

127. Alternatively, if "the" block were interpreted to mean the block of pixels from which the selected first candidate was obtained, Rusert also teaches this. *Supra* §V.C. For example, Rusert teaches that a "position" of a block of a PMV candidate is represented as (xpos, ypos), denoting a coordinate comprising an x-coordinate and a y-coordinate of the block, i.e., **the location of the block associated with the first spatial motion vector prediction candidate**. *See, e.g.*, Ex-1004, ¶¶51-52. Based on the location of the block of the PMV candidate,

Rusert teaches that the subset of PMV candidates with which the PMV candidate is compared includes the PMV candidates of blocks located in the scan pattern up to the PMV candidate. Ex-1004, ¶44. For example, following the scan pattern illustrated in Fig. 3n, the PMV candidate associated with the block located at "3" would be compared with a subset of PMV candidates that include the PMV candidates of blocks "1" and "2," which I illustrate below. *Id.,* ¶¶65-66, Fig. 3n:

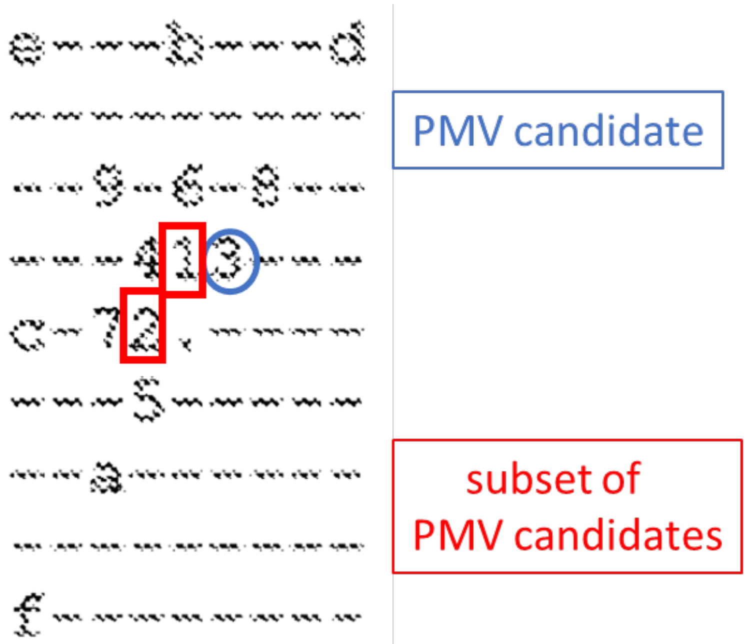


Fig. 3n

128. Based on the foregoing explanations, Ground 1 teaches limitation [9b].

[9c]	**comparing motion information of the first spatial motion vector prediction candidate with motion information of another spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;**

129. Ground 1 teaches limitation [9c], as explained below.

130. Rusert teaches **comparing motion information of the first spatial motion vector prediction candidate with motion information of another spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates** (e.g., a set of previously coded motion vectors). For example, when updating the subset of PMV candidates, which is stored as a list in PMV_CANDS, Rusert teaches at least three comparisons for determining whether to include or skip a PMV candidate (Ex-1004, ¶¶71-72; *supra* §VI.A.2[9b]), any one of which is sufficient on its own to satisfy this limitation. When considering a PMV candidate for potential inclusion in the subset of PMV candidates, the "PMV candidate may be determined to be unnecessary if it at least one of the following conditions is fulfilled: [1] the PMV candidate is a duplicate of another PMV candidate in the set; [2] the PMV candidate is determined to be within a threshold distance of an existing PMV candidate; and [3] the PMV candidate would never be used because at least one alternative PMV candidate will allow motion vectors to be coded using fewer bits." Ex-1004, ¶21.

131. First, Rusert teaches comparing whether "the PMV candidate is a duplicate of another PMV candidate" in the subset of PMV candidates. *Id.*, ¶71. "This ca[n] be done, when updating the list, by comparing the candidates already in the list with the new vector that could be added, and if a duplicate is found… [i]t is preferable to skip the new vector[.]" Ex-1004, ¶71. Skipping (thus excluding) duplicates is "[o]ne measure for reducing the number of candidates[.]" *Id.*; *see also* Ex-1004, ¶62 ("It has been identified as advantageous to discard such duplicates"). When a potential PMV candidate is selected and Rusert evaluates whether to update the subset of PMV candidates, the selected PMV candidate is compared with the current motion vectors of the PMV candidates that are already in the subset of PMV candidates. If it is a duplicate, then the potential PMV candidate is skipped and excluded. For example, two motion vectors are duplicates when their vector values (e.g., their x values and y values) are the same.

132. Second, Rusert teaches comparing whether "the PMV candidate is… within a threshold distance of an existing PMV candidate" in the subset of PMV candidates. Ex-1004, ¶21. This is accomplished using "a similarity measure" such as "Euclidian distance… or absolute distance." Ex-1004, ¶72, ¶87. For example, Euclidian distance is measured by "$(x_0-x_1)^2+(y_0-y_1)^2$" and absolute distance is measured by "$|x_0-x_1|+|y_0-y_1|$, with (x_0, y_0) and (x_1, y_1) being the pair of motion vectors under consideration." Ex-1004, ¶72. Here, the x and y components of the

motion vectors for the PMV candidate and each of the PMV candidates that are already in the subset of PMV candidates are compared to determine whether the distance between them is less than a threshold distance.[4] If the "similarity measure [is] smaller than a pre-defined threshold," then the PMV candidate is "[r]emov[ed] or skipp[ed][.]" Ex-1004, ¶72, ¶87.

133. Third, Rusert teaches comparing whether "at least one alternative PMV candidate will allow motion vectors to be coded using fewer bits." Ex-1004, ¶21. This is accomplished by "removing PMV candidates" that "will never be used" because another PMV candidate in the subset of PMV candidates facilitates "a bit sequence that is shorter or of the same length compared for all possible motion vectors." Ex-1004, ¶90.

134. For example, Rusert teaches that "[i]f we want to encode a motion vector, such as MV= (0,2)," then "we can encode… it using…" a first candidate "PMV=(0,2), plus a difference DMV=(0,0)" or a second candidate "PMV=(-1,2), plus a difference DMV=(1,0)[.]" Ex-1004, ¶¶91-94. Rusert teaches that the same process is followed when decoding an encoded block of pixels; therefore, the same set of candidates is constructed for decoding. Ex-1004, ¶35 ("the encoder and decoder follow the same rules for creating and modifying the set of PMV

[4] If the two PMV candidates are duplicates, the distance (such as the Euclidean distance and the absolute distance) between the two PMV candidates is zero.

candidates”). In this example, the first candidate uses a “total number of… 6 bits” to code the motion vector because of its index costs (4 bits) and the difference cost to code the difference between the motion vector and the first candidate (1 bit for the x component difference and 1 bit for the y component difference). Ex-1004, ¶93. The second candidate only uses “5 bits in total” because of its index costs (1 bit) and the difference cost (3 bits for the x component difference and 1 bit for the y component difference). From this example, Rusert teaches that “it will never be beneficial to use” the first candidate because the second candidate “will always be one [b]it cheaper or better.” Ex-1004, ¶95. Therefore, when evaluating whether the subset of PMV candidates should be updated with a potential PMV candidate, Rusert teaches comparing the motion information of the potential PMV candidate with that of each PMV candidate that is already in the subset of PMV candidates, to determine if one will allow motion vectors to be decoded using fewer bits.

135. All three teachings compare a potential candidate with at least one other candidate from the subset of preceding candidates in Rusert’s scan sequence. Since preceding candidates have smaller index values, they would be signaled more efficiently than later duplicates, and Rusert improves efficiency by determining this subset and comparing potential new candidates to the subset. Ex-1004, ¶¶88-98. For all three comparisons, the x and y components of Rusert’s candidates are compared; this is motion information of the PMV candidates

because the x and y components of the vector values describe the "motion of pixel blocks across frames." Ex-1004, ¶2. For example, "coding of a motion vector consists of… a motion vector predictor… and … the difference… between the motion vector and the motion vector predictor." Ex-1004, ¶3, ¶¶36-37; *supra* §VI.A.2.[9a] (explaining that the motion information is represented by vector values). Therefore, making any of the three comparisons is comparing the motion information of a PMV candidate with the motion information of another PMV candidate of the set of previously-coded motion vectors—in particular the PMV candidates currently in the subset of PMV candidates.

136. Additionally, for all three comparisons, Rusert teaches or at least suggests performing these comparisons when evaluating whether to update PMV_CANDS, which stores the subset of PMV candidates, with a PMV candidate. Ex-1004, ¶¶71, ¶75, ¶¶84-87, ¶90. Furthermore, this would have been obvious because Rusert teaches the advantages of reducing the number of candidates in PMV_CANDS, including with the use of these comparisons (Ex-1004, ¶12, ¶21, ¶70, ¶84, ¶90), and the natural time to perform these comparisons would have been when evaluating whether or not to add a PMV candidate to PMV_CANDS. As Rusert teaches, performing this check when PMV_CANDS is updated will prevent "unnecessary" candidates from being added, "because it may happen that some candidates… will never be used, since choosing a candidate with

a shorter codeword and encoding the distance will give a bit sequence that is shorter or of the same length compared for all possible motion vectors." Ex-1004, ¶90. This process is used when decoding an encoded block of pixels; therefore, the same set of candidates is constructed for encoding and decoding. Ex-1004, ¶35. Rusert teaches performing the same step in decoding an encoded block of pixels. Ex-1004, ¶24, ¶35.

137. Rusert teaches **comparing … without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates**. For example, Rusert teaches that "[r]estricting the previous blocks that are considered reduces the number of previous motion vectors that must be considered meaning that less computation is needed, improving the processor efficiency of the coding." Ex-1004, ¶12. Each of the three comparisons explained above compares motion information from a selected candidate with the candidates in the subset of PMV candidates, without making a comparison of each possible pair from the set of motion vectors used for all previous blocks (i.e., the set of spatial motion vector prediction candidates). Ex-1004, ¶¶11-13, ¶¶15-16, ¶113. First, Rusert teaches comparing whether "the PMV candidate is a duplicate of another PMV candidate" (Ex-1004, ¶21) in the subset of PMV candidates "by comparing the candidates already in the list with the new vector that could be added" (Ex-1004, ¶71). Therefore, comparisons are made between pairs formed

by the potential PMV candidate and the PMV candidates currently in the subset of PMV candidates and comparisons are not made of the potential PMV candidate with anything not in the subset of PMV candidates, such as motion vectors of previous blocks that have not been scanned yet or that were already excluded from the subset of PMV candidates. *Id*. Second, Rusert teaches comparing whether "the PMV candidate is… within a threshold distance of an existing PMV candidate[]" in the subset of PMV candidates. Ex-1004, ¶21. Again, the comparisons made are for pairs formed by the potential PMV candidate and the PMV candidates in the subset of PMV candidates and not each motion vector for all previous blocks. *Id*. Third, Rusert teaches comparing whether "at least one alternative PMV candidate will allow motion vectors to be coded using fewer bits." Ex-1004, ¶21. This involves comparisons of a potential PMV candidate with PMV candidates already in the subset of PMV candidates and not each motion vector for all previous blocks. *Id*. Even within the scan order, Rusert compares potential candidates with those already in the subset of PMV candidates, meaning Rusert avoids comparing each possible pair of candidates from the scan order. *See* Ex-1004, ¶¶11-13. Therefore, comparing motion information of a potential PMV candidate with motion information of the PMV candidates already in the subset of PMV candidates, uses less computation than comparing motion information of the

PMV candidate with motion information of all previously decoded blocks and improves processor efficiency. Ex-1004, ¶12.

138. Additionally, when motion information of a PMV candidate is compared with motion information of the PMV candidates in the subset of PMV candidates, the motion information of the PMV candidate is not compared with each pair of candidates from the set of all previously-encoded blocks because the subset of PMV candidates is limited to PMV candidates "having an allowed distance from the current block and an allowed position." Ex-1004, ¶15; *see supra* §VI.A.2[9b]. The candidates of the previous blocks that are not within the allowed distance and not in an allowed position are not in the subset of PMV candidates and, therefore, are not compared.

139. Furthermore, Rusert teaches various scan patterns within the allowed distance, including scan patterns that exclude certain blocks within the allowed distance. *See*, *e.g.*, Ex-1004, ¶64 ("we could use only layers that are powers of two: 1, 2, 4, 8, ..."), ¶65 ("all blocks other than the corner blocks and the blocks directly above and the left of the current block are excluded."), Figs. 3m, 3n. Because the allowed distance, the allowed position, and the scan pattern exclude candidates of blocks from consideration for potential inclusion in the subset of PMV candidates, a PMV candidate is not compared with these blocks, and there is

no comparison of each possible pair of motion vectors from the set of all previously-coded blocks.

140. Moreover, even within the various scan patterns that exclude certain blocks, Rusert teaches that a "scan may be terminated… as soon as a pre-defined number of unique PMV candidates have been found[.]" Ex-1004, ¶¶44-48. For example, Rusert teaches "us[ing] a maximum of four candidates in the [PMV_CANDS] list" or "us[ing] seven" as the maximum. Ex-1004, ¶107. Limiting the maximum number of unique PMV candidates reduces "the number of bits needed to specify the candidate vector" and avoids "the problem that many vectors can be represented using several candidates, which is unnecessary." Ex-1004, ¶107. Therefore, Rusert does not compare each pair of candidates from the set of previously-encoded blocks, or even each pair of blocks within the scan order, because the scan of the previously-encoded blocks is terminated once a pre-defined number of unique PMV candidates are found. Rusert thus teaches claim 9 with the recited "set" being either (a) the previously-coded motion vectors for that frame, or (b) the full set of candidates from Rusert's scan order, because in both cases Rusert compares the selected candidate with a subset of candidates, without comparing each pair from the set of previously-coded motion vectors or the entire scan order.

141. Based on the foregoing explanations, Ground 1 teaches limitation [9c].

[9d] determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and

142. Ground 1 teaches limitation [9d], as explained below.

143. Rusert teaches **determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list** (e.g., PMV_CANDS) **based on the comparing**. As I explained above, Rusert teaches at least three ways for comparing motion information of a PMV candidate with motion information of PMV candidates in the PMV_CANDS list, which stores the subset of PMV candidates. *Supra* §VI.A.2[9c]. Rusert performs all three comparisons to determine whether to include or exclude the selected PMV candidate in the PMV_CANDS list. Ex-1004, ¶¶20-21.

144. Rusert teaches removing "unnecessary PMV candidates from the set of PMV candidates." Ex-1004, ¶20. "This ensures the length of the [PMV_CANDS] list is not unnecessarily long, which would reduce coding efficiency." Ex-1004, ¶21. "*A PMV candidate may be determined to be unnecessary* if it at least one of the following conditions is fulfilled: [1] the PMV candidate is a duplicate of another PMV candidate in the set; [2] the PMV candidate is determined to be within a threshold distance of an existing PMV candidate; and [3] the PMV candidate would never be used because at least one alternative PMV candidate will allow motion vectors to be coded using fewer bits."

Ex-1004, ¶21. "Unnecessary PMV candidates are removed… because it may happen that some candidates in the list will never be used." Ex-1004, ¶90. A shorter PMV_CANDS list "allows the remaining PMV candidates to be signaled using shorter codes and so fewer bits[.]" Ex-1004, ¶¶22, 90 ("thereby making the list shorter and the average bit length of each index shorter.").

145. Rusert excludes unnecessary candidates, including the three categories explained above (duplicate PMV candidates, PMV candidates within a threshold distance of PMV candidates in the PMV_CANDS list, and PMV candidates that have at least one alternative PMV candidate that will allow motion vectors to be coded using fewer bits), when deciding whether to add a new candidate to PMV_CANDS. Ex-1004, ¶21, ¶¶71-72; s*upra* §VI.A.2[9c]. As Rusert explains, the "PMV_CANDS list may be updated to include" PMV candidates. Ex-1004, ¶39, ¶44, ¶71, ¶87; *supra* §VI.A.2[9c]. Here, "[u]pdate means that one or more motion vectors are added to an existing PMV_[C]ANDS list." Ex-1004, ¶39. For example, PMV candidates with "unique vectors" are inserted in the PMV_CANDS list based on an "outwards going scan[.]" Ex-1004, ¶50. As part of the "update" process whereby new candidates are added to PMV_CANDS, Rusert determines whether a selected PMV candidate should be included or skipped, meaning it is excluded because it is a duplicate, it is within a threshold distance of another PMV candidate in PMV_CANDS, or there is an alternative PMV candidate that will

allow motion vectors to be coded using fewer bits. Ex-1004, ¶¶71-72; *supra* §§VI.A.2[9b]-[9c]. Additionally, this would have been obvious because Rusert teaches the advantages of reducing the number of candidates in PMV_CANDS using the three comparisons from [9c] (Ex-1004, ¶12, ¶21, ¶70, ¶84, ¶90), and the natural time to perform the comparisons would have been when evaluating whether or not to add a candidate to the subset of PMV candidates stored in PMV_CANDS. As Rusert teaches, performing this check when PMV_CANDS is updated prevents "unnecessary" candidates from being added, "because it may happen that some candidates… will never be used[.]" Ex-1004, ¶90. Thus, Rusert teaches determining to include or exclude a PMV candidate in the PMV_CANDS list.

146. Based on the foregoing explanations, Ground 1 teaches limitation [9d].

[9e]	**selecting a spatial motion vector prediction candidate from the motion vector prediction list for use in decoding the encoded block of pixels, wherein the spatial motion vector prediction candidate is selected from the motion vector prediction list using information that was received identifying a respective spatial motion vector prediction candidate from the motion vector prediction list constructed by an encoder.**

147. Ground 1 teaches limitation [9e], as explained below.

148. Rusert teaches **selecting a spatial motion vector prediction candidate from the motion vector prediction list for use in decoding the encoded block of pixels**. For example, Rusert teaches "a code 'index'… to select

a particular PMV candidate… from a list of PMV candidates, PMV_CANDS[.]" Ex-1004, ¶36. Then, "[u]sing the transmitted index, the decoder… can determine the PMV… and thus may reconstruction [the motion vector.]" Ex-1004, ¶37. These techniques are "for video decoding, wherein the current block is the block being… decoded[.]" Ex-1004, ¶23, ¶35("The methods disclosed herein are performed… in the decoder during decoding."). The current block is part of an "encoded video stream" that is "passe[d] to a decoder… employed in decoding the encoded video stream." Ex-1004, ¶34. Therefore, Rusert teaches a decoder using an index to select a PMV candidate from PMV_CANDS for use in decoding an encoded block.

149. Rusert teaches **the spatial motion vector prediction candidate is selected from the motion vector prediction list using information that was received identifying a respective spatial motion vector prediction candidate from the motion vector prediction list constructed by an encoder**. For example, Rusert teaches "a particular PMV candidate" is selected "from a list of PMV candidates, PMV_CANDS[,]" using "a code 'index'" sent "from the encoder… to the decoder[.]" Ex-1004, ¶36, ¶37 ("Using the transmitted index, the decoder… can determine the PMV… as used in the encoder… and thus may reconstruct MV=DMV+PMV."), Fig. 1:

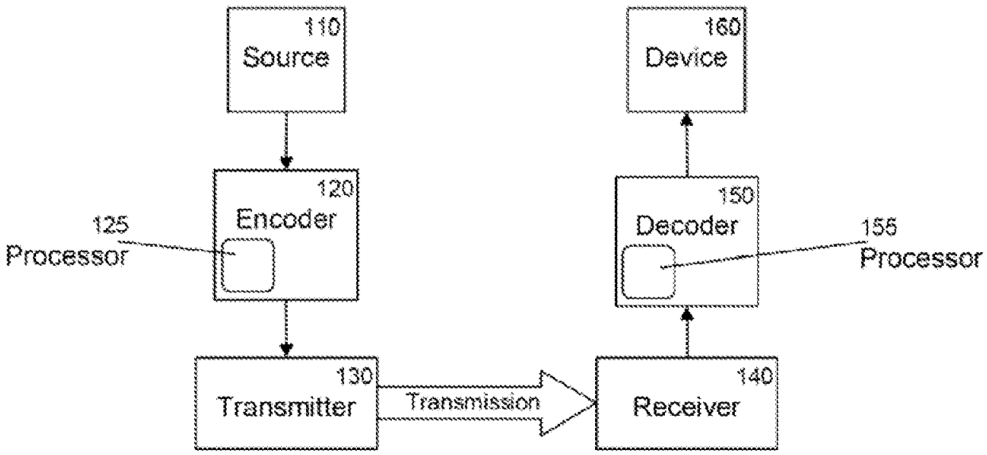


Fig. 1

The index is information received by Rusert's decoder to "select a particular PMV candidate… from a list of PMV candidates, PMV_CANDS" and the selected PMV candidate is used to reconstruct the motion vector for the current block. Ex-1004, ¶¶36-37. In this way, the received index is an index into the list by pointing to a particular candidate based on its position in the list. Rusert teaches zero-based indexing examples, starting with zero for the first candidate and ending with n-1 for a list of n candidates. Ex-1004, ¶¶88-95. PMV_CANDS is constructed by an encoder, and the decoder "mimics the encoder" to construct the same PMV_CANDS list. Ex-1004, ¶35, ¶37, ¶39. From PMV_CANDS, the decoder uses the index "signaled from the encoder" to "select a particular PMV candidate[.]" Ex-1004, ¶36. "Using the transmitted index, the decoder… can determine the PMV 220" to "reconstruct [the motion vector.]" Ex-1004, ¶27.

150. Rusert teaches that PMV_CANDS is constructed by an encoder. Rusert's decoder "mimics the encoder" and "follow[s] the same rules for creating and modifying the set of PMV candidates" so "the respective lists of PMV candidates stored in the encoder and decoder maintain synchronization." Ex-1004, ¶35, ¶37 ("The list PMV_CANDS 240 is identically available at both the encoder 120 and the decoder 150"), ¶39 ("[T]he decoder can derive the list PMV_CANDS in the same way as the encoder."). Therefore, the list of PMV candidates, PMV_CANDS, used by Rusert's decoder is the PMV_CANDS constructed by the encoder. Ex-1004, ¶35, ¶37, ¶39. From PMV_CANDS, Rusert's decoder uses the index "signaled from the encoder … to the decoder" to "select a particular PMV candidate[.]" Ex-1004, ¶36.

151. Rusert illustrates this process in Figs. 2a and 2b, reproduced below, where Fig. 2a shows the encoding process and Fig. 2b shows the decoding process:

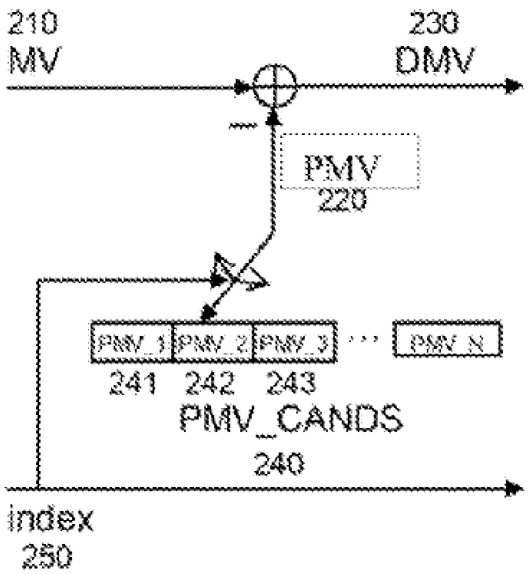


Fig. 2a

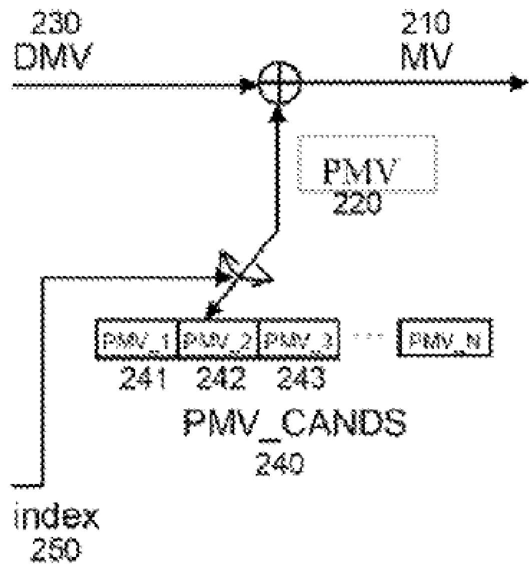


Fig. 2b

This example shows how "a code 'index' 250 is sent to select a particular PMV candidate, in this case 242 from a list of PMV candidates, PMV_CANDS 240[.]" Ex-1004, ¶36. Here, "PMV_CANDS 240 is identically available at both the encoder… and the decoder[]" and "[u]sing the transmitted index, the decoder… can determine the PMV 220" to "reconstruct [the motion vector.]" Ex-1004, ¶37.

152. Based on the foregoing explanations, Ground 1 teaches limitation [9e].

3. Dependent Claim 10

10.	**The method according to claim 9 further comprising comparing motion information of the potential spatial motion vector prediction candidate with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates.**

153. Ground 1 teaches claim 10, as explained below.

154. As I have explained above, the combination of Rusert and Karczewicz teaches claim 9, including [9c]: comparing motion information of the first spatial motion vector prediction candidate with motion information of another spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates. *Supra* §VI.A.2[9c]. Rusert teaches at least three comparisons: (1) whether "the PMV candidate is a duplicate of another PMV candidate" in the PMV_CANDS list; (2) whether "the PMV candidate is… within a threshold distance of an existing PMV candidate"; and (3) whether "at least one alternative PMV candidate will allow motion vectors to be coded using fewer bits." *Id.*; e.g., Ex-1004, ¶21.

155. Rusert further teaches comparing motion information of the candidate with **at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates**. For example, Rusert teaches a scan sequence for evaluating whether to include its spatial motion vector prediction candidate in PMV_CANDS. *Supra* §VI.A.2[9a]; Ex-1004, ¶44, ¶¶51-66, Figs. 3a-

3n. Rusert teaches that the "PMV_CANDS list may be initialized e.g. as an empty list (zero entries)[.]" Ex-1004, ¶39. PMV_CANDS is then "updated to include previously coded motion vectors[.]" *Id*. This update is based on "an outwards going scan… around the current block to obtain motion vectors to update PMV_[C]ANDS." Ex-1004, ¶44. Rusert performs its comparisons, e.g., checking for duplicates, "when updating the list[.]" Ex-1004, ¶71; *supra* §VI.A.2[9c].

156. Thus, Rusert begins the scan with a first PMV candidate, e.g., labelled "1" in Figs. 3a-3n, and considers whether to update PMV_CANDS with the first candidate. Ex-1004, ¶39. The scan then moves to the second PMV candidate, which is "compar[ed with] the candidates already in the list[.]" Ex-1004, ¶71. Here, for the second candidate, the PMV_CANDS list includes at most one other spatial motion vector prediction candidate: the first candidate. *See id.* Therefore, the motion information of the second PMV candidate in the sequence is compared with the motion information of at most one other PMV candidate (the first PMV candidate). Ex-1004, ¶21, ¶¶38-40, ¶44. Furthermore, Rusert teaches "the number of candidates in PMV_CANDS may be limited to a pre-defined or dynamically obtained number." Ex-1004, ¶73, ¶¶84-90. With a maximum number of two candidates, the scan would end once two PMV candidates are added to PMV_CANDS, so any potential PMV candidate would be compared with at most one other PMV candidate, the PMV candidate already in PMV_CANDS. It would

have been obvious to a POSITA to choose two as a maximum number because it would allow the PMV candidate to use as motion information for the current block to be signaled with one bit (e.g., "0" or "1"). *See* Ex-1004, ¶77.

157. Based on the foregoing explanations, Ground 1 teaches claim 10.

4. Dependent Claim 11

11.	**The method according to claim 9 further comprising examining whether the received encoded block of pixels is divided into a first prediction unit and a second prediction unit; and if so, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the prediction unit is the second prediction unit.**

158. As I have explained above, Ground 1 teaches the method according to claim 9. Rusert teaches receiving an encoded block of pixels (the current block).[5] Ex-1004, ¶34, ¶36, Fig. 1; *supra* §§VI.A.2[9a], [9e]. Ground 2 further teaches claim 11. *Supra* §VI.A.1 (explaining how and why Lin's teachings would have been applied to the combination of Rusert and Karczewicz).

159. Ground 2 teaches **examining whether the received encoded block of pixels is divided into a first prediction unit and a second prediction unit.** For example, Lin teaches that, in H.265/HEVC, "[t]he basic unit for compression, termed Coding Unit (CU), is a 2Nx2N square block, and… [e]ach CU contains one

[5] The "received encoded block of pixels" appears to reference "a block of pixels" in [9a]. As explained above, the block of pixels is the current block for which motion vector prediction candidates are being analyzed. *Supra* §VI.A.2[9a].

or multiple Prediction Units (PUs)" with divisions "correspond[ing] to horizontal and vertical partition[s.]" Ex-1006, ¶4; Ex-1013, 000007. When a CU is not divided, the CU corresponds to a single PU. When a CU is divided horizontally, the 2Nx2N square is divided in half into two symmetric PU rectangles having dimensions of 2NxN. Likewise, when a CU is divided vertically, the 2Nx2N square is divided into two symmetric PU rectangles of Nx2N size. *Id.*; Ex-1013, 000016. Lin teaches both examples, where the block of pixels is divided into two prediction units: a first PU ("PU1") and a second PU ("PU2"). *Id.*, Ex-1006, ¶25, ¶44, Figs. 7A-7D; Ex-1013, 000010, 000017. This limitation is also satisfied the other way around, where the claimed "first" PU is PU2 and the claimed "second" PU is PU1.

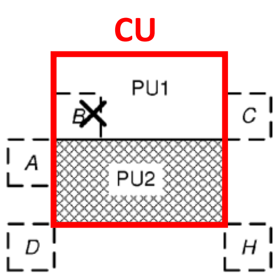


Fig. 7A

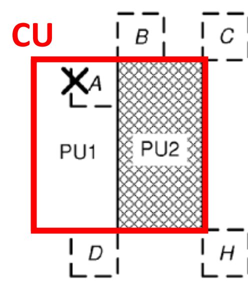


Fig. 7B

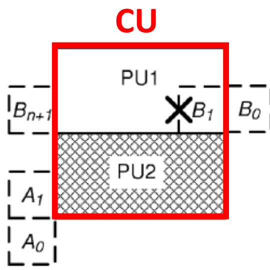


Fig. 7C

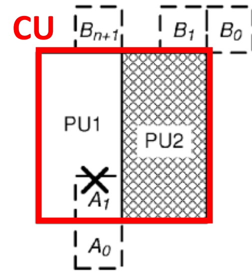


Fig. 7D

160. Lin "*identifies* and removes redundant MVP candidates" by examining the CU for "scenario[s] that multiple partitioned PUs… may cause the current PU to be… considered redundant and can be removed without comparing the [motion vector] values." Ex-1006, ¶44; Ex-1013, 000010, 000017. These scenarios include a CU divided horizontally into two prediction units ("2NxN") or vertically into two prediction units ("Nx2N") where, "for the second 2NxN,… Nx2N… PU, one or more of the MVP candidates are redundant and removed if said one or more of the MVP candidates located within the previous (first) 2NxN,… Nx2N… PU." Ex-1006, ¶25; Ex-1013, 000009-11. These teaching apply to an encoded block of pixels received by a decoder because Rusert and Karczewicz teach the decoder "mimics the encoder in order to achieve encoder/decoder synchronization. Ex-1004, ¶35, ¶¶24-35; Ex-1005, ¶50 ("[T]he decoder uses reciprocal… techniques to decode[.]"). Lin confirms these teachings because "a mismatch between the… encoder side and… the decoder side… may

result in parsing error… and cause the rest of the current picture parsed or decoded erroneously." Ex-1006, ¶22, ¶47; Ex-1013, 000002. Lin teaches examining whether a block of pixels is divided horizontally or vertically into two prediction units to exclude redundant motion vector predictor candidates, as further explained below.

161. Ground 2 teaches **and if so, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the prediction unit is the second prediction unit.** For example, Lin examines whether (i) the current block is divided into two PUs and (ii) the spatial motion vector prediction candidate is from the other PU; if so, Lin teaches excluding the candidate from the motion vector prediction list. As illustrated in Figs. 7A-7D below, "the second PU of 2NxN [and] Nx2N… can be removed without comparing the values of MVs[]" because "the MVP candidates of a current PU that may cause the current PU to be merged with other PUs… is considered redundant and can be removed without comparing the MV values." Ex-1006, ¶44, ¶25, Fig. 7A-7D; Ex-1013, 000010, 000017.

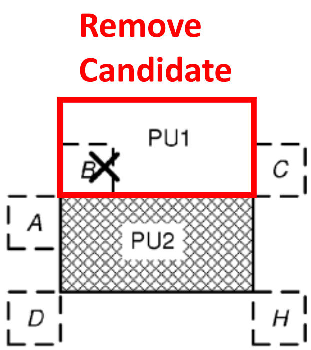


Fig. 7A

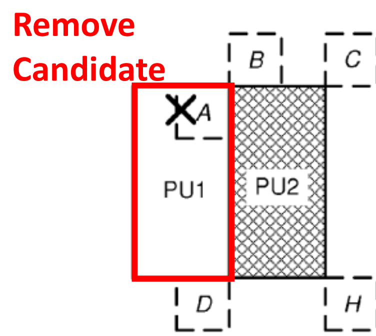


Fig. 7B

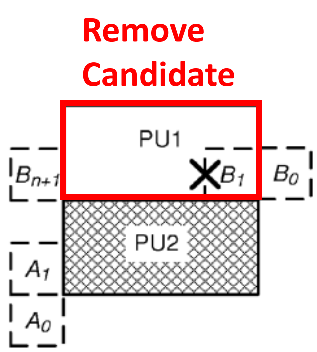


Fig. 7C

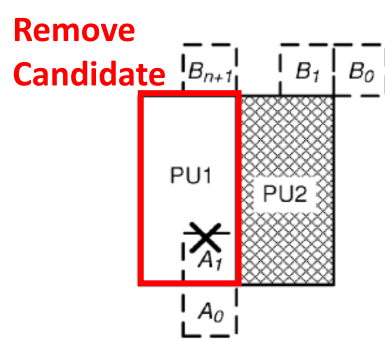


Fig. 7D

162. In particular, Lin teaches that, for "FIG. 7A, MVP B for the second 2NxN PU in the 2NxN… can be removed to avoid the duplication." Ex-1006, ¶44; Ex-1013, 000010. Likewise, "[i]n FIG. 7C, MVP B_1 for 2NxN PU2… is determined to be redundant and is removed from the MVP candidate set." *Id.*; Ex-1013, 000017. Similarly, MVP A for PU2 in the Nx2N in Fig. 7B and "MVP A_1 in FIG. 7D… are determined to be redundant and are removed from the MVP candidate set, respectively." *Id.* Therefore, Lin teaches examining whether the

block is divided into two PUs (e.g., 2NxN and Nx2N), and if so, removing the MVP candidate of the second PU from the MVP candidate set because it is redundant.

163. This concept was obvious in view of the reason why a CU is divided to begin with. CUs do not have to be divided—in the simplest case, one CU comprises one PU (they are commensurate in size). Ex-1006, ¶4 ("Each CU contains one or multiple Prediction Units (PUs)."); Ex-1013, 000007; Ex-1005, ¶35 ("A CU… may include one or more prediction units (PUs)."). If the block has uniform motion, there is no reason to divide it into multiple PUs. Conversely, if different parts of the block are moving in different directions, the CU can be divided into multiple PUs so that each can have a different motion vector. Ex-1006, ¶4. In other words, the block is divided into two PUs when each half of the block has different motion. If a block is divided into two PUs because its two portions have differing motion vectors, there is no way that the motion vector corresponding to one of these PUs can be a good predictor for the motion of the other PU. Therefore, when analyzing potential motion vectors for half of a block (that has been divided into two PUs), Lin explains that the motion vector from the other half can be removed. Ex-1006, ¶25, ¶44; Ex-1013, 000010. Lin explains that assigning the same motion vector to both halves of a divided block is redundant to the scenario where the block was not divided at all and the same

motion vector was applied to the entire block comprising one PU. That is why Lin teaches "remov[ing] redundant [motion vector predictor] candidates." Ex-1006, ¶44; Ex-1013, 000010.

164. In the combination of Ground 2, it would have been obvious to a POSITA to combine Lin's teachings with Rusert and Karczewicz to remove redundant PMV candidates from PMV_CANDS. *Supra* §VI.A.1 (explaining how and why the teachings of the references would have been combined). In particular, a POSITA would have been motivated to apply Lin's teachings of excluding candidates from the other PU when the received encoded block is divided into two PUs, as explained above, to Ground 1's process for selecting PMV candidates. *See id.*

165. Based on the foregoing explanations, Ground 2 teaches claim 11.

5. Dependent Claim 12

[12pre] The method according to claim 9 further comprising

166. As I explained above, the combination of Rusert and Karczewicz teaches the method of claim 9. *Supra* §VI.A.2. Therefore, the combination teaches the preamble of claim 12.

[12a] determining a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list; and

167. Ground 1 teaches limitation [12a], as explained below. The spatial motion vector prediction candidates (e.g., PMV candidates) and motion vector prediction list (e.g., PMV_CANDS) were explained for claim 9. *Supra* §VI.A.2[9a].

168. Rusert teaches **determining a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list** (e.g., PMV_CANDS). For example, Rusert teaches "the number of candidates in PMV_CANDS *may be limited* to a pre-defined or dynamically obtained number." Ex-1004, ¶73, ¶¶84-90. As some examples, Rusert teaches "a maximum of four candidates in the list" and "us[ing] seven" for a maximum. Ex-1004, ¶107. Rusert also teaches that "it is possible that PMV_CANDS list size is set to one, such that no bits need to be sent for index signaling." Ex-1004, ¶77.

169. Rusert teaches several benefits to determining a maximum number of candidates for PMV_CANDS. For example, "[l]imiting and/or reducing the number of candidates in PMV_CANDS can be helpful to reduce the overhead of signaling which PMV is used for motion vector prediction, since shorter lists require shorter code words." Ex-1004, ¶84, ¶70, ¶13 ("The size of the PMV candidate list is limited because a very large list would require long code words to

identify which PMV candidate to use[.]"). With "a bigger maximum,… the number of bits needed to specify the candidate vector also increases" and "many vectors can be represented using several candidates, which is unnecessary." Ex-1004, ¶107. By determining a maximum number of candidates, Rusert balances between "chances increas[ing] that a suitable vector can be found" and "redundant representation" that "grows the more vectors are added." Ex-1004, ¶107. In short, Rusert teaches determining a maximum number of candidates for PMV_CANDS, e.g., 4 candidates, to balance the increased chance of a suitable match with the increased cost of using longer code words. *Id.*

170. Rusert teaches variable-length coding ("VLC") examples for index values which vary based on the "Maximum list size C" of PMV_CANDS. Ex-1004, ¶88 (Table 1). "The VLC table used can depend on the maximum number of candidates in PMV_[C]ANDS (the list size), as e.g. dynamically adapted according to the methods above." Ex-1004, ¶88. "Table 1 below presents some examples for VLC codes for different maximum list sizes. The left column shows the maximum list size, also denoted as C. In the right column, the VLC codes are shown along with indexes to address candidates in the PMV_CANDS list." *Id.* Therefore, Rusert teaches determining a maximum number of candidates to be included in PMV_CANDS, e.g. as denoted by "C," which dictates the encoding table for index

values and controls the maximum number of candidates in the PMV_CANDS list. *Id.*

171. Based on the foregoing explanations, Rusert teaches limitation [12a].

[12b]	**limiting the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number.**

172. Ground 1 teaches limitation [12a], as explained below.

173. Rusert teaches **limiting the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number**. For example, Rusert teaches "an outwards going scan… to obtain motion vectors to update PMV_[C]ANDS… may be terminated… as soon as a pre-defined number of unique PMV candidates have been found[.]" Ex-1004, ¶¶44-48. By terminating the scan "as soon as a pre-defined number of unique PMV candidates have been found," the number of PMV candidates in PMV_CANDS is limited to the pre-defined number, which is the maximum number, because no additional PMV candidates are considered for inclusion in PMV_CANDS. *Id.*

174. In addition, Rusert teaches that "the candidate at the end of the PMV_CANDS list may be removed" in order to limit "the number of candidates in PMV_CANDS… to a pre-defined… number. Ex-1004, ¶73. Thus, the number of PMV candidates in PMV_CANDS is smaller or equal to the maximum number

because candidates are removed in order to limit the number of PMV candidates to the maximum number. Moreover, by teaching a "maximum" number of candidates in the PMV_CANDS list, Rusert teaches a limit (the maximum) to the number of candidates in the list.

175. Rusert further teaches VLC examples based on the "Maximum list size C" of PMV_CANDS. Ex-1004, ¶88 (Table 1). "The VLC table used can depend on the maximum number of candidates in PMV_[C]ANDS (the list size), as e.g. dynamically adapted according to the methods above." Ex-1004, ¶88. "Table 1 below presents some examples for VLC codes for different maximum list sizes. The left column shows the maximum list size, also denoted as C. In the right column, the VLC codes are shown along with indexes to address candidates in the PMV_CANDS list." *Id.* Therefore, Rusert teaches limiting the number of candidates in PMV_CANDS to be smaller or equal to the maximum number, e.g. as denoted by "C," in accordance with the encoding tables in Table 1. *Id.* For example, when the maximum list size C is 4, Table 1 lists encodings for four index values to encode up to four values in PMV_CANDS. None of the encodings exceed the maximum list size C.

176. Based on the foregoing explanations, Rusert teaches limitation [12b].

6. Dependent Claim 13

[13pre] The method according to claim 12 further comprising:

177. Ground 1 teaches claim 13, as explained below.

178. As I explained above, the combination of Rusert and Karczewicz teaches the method of claim 12. Therefore, the combination of Rusert and Karczewicz teaches the preamble of claim13.

[13a] examining, if the number of spatial motion vector prediction candidates in the motion vector prediction list smaller than the maximum number;

179. Ground 1 teaches limitation [13a], as explained below.

180. Rusert teaches **examining, if the number of spatial motion vector prediction candidates in the motion vector prediction list [is] smaller than the maximum number**. As I explained above with respect to claim 5, Rusert teaches determining a maximum number of PMV candidates for PMV_CANDS and limiting the number of PMV candidates in PMV_CANDS to the maximum number. Ex-1004, ¶13, ¶¶44-48, ¶70, ¶73, ¶77, ¶¶84-90, ¶107; *supra* §VI.A.6 (claim 5). For example, Rusert examines if the number of candidates in PMV_CANDS is smaller than the maximum number when determining whether to continue its scan for additional PMV candidates. Rusert teaches "terminat[ing]" a scan for new candidates "as soon as a pre-defined number of unique PMV candidates have been found[.]" Ex-1004, ¶¶44-48. Here, "an outwards going scan… around the current block" is performed to obtain PMV candidates "to

update PMV_[C]ANDS[,]" and the number of PMV candidates in PMV_CANDS is examined to determine whether to continue or terminate the scan. *Id*. If the number of PMV candidates is less than the maximum number, or the "pre-defined number of unique PMV candidates[,]" then the scan continues; but if the number of PMV candidates is equal to the maximum number, then the scan is "terminated[.]" *Id*.

181. In addition, Rusert teaches that "the candidate at the end of the PMV_CANDS list may be removed" in order to limit "the number of candidates in PMV_CANDS… to a pre-defined… number." Ex-1004, ¶73. Thus, Rusert teaches examining if the number of PMV candidates in PMV_CANDS is smaller than the maximum number to determine whether to remove a PMV candidate for another PMV candidate or to add the other PMV candidate.

182. Based on the foregoing explanations, Ground 1 teaches limitation [13a].

[13b] if so, examining whether the prediction unit to which the potential spatial motion vector prediction candidate belongs is available for motion prediction;

183. Ground 1 teaches limitation [13b], as explained below.

184. Ground 1 teaches **examining whether the prediction unit to which the potential spatial motion vector prediction candidate belongs is available for motion prediction.** While scanning blocks for new candidates, Rusert

examines whether the block to which a potential candidate belongs is available for motion prediction because motion vectors are not available for some blocks. For example, Rusert teaches three exemplary reasons why a block would be unavailable for motion prediction, any one of those teachings satisfies this limitation.

185. First, Rusert teaches that blocks "coded after the present block[]" "would never be available[.]" Ex-1004, ¶54. For example, blocks below and to the right of the current block would be coded after the present block. *Id.* Quite simply, these blocks are never available because they have not been coded yet and therefore do not have any motion information for motion prediction. No motion vector has been assigned to those blocks yet and therefore the blocks cannot provide a motion vector candidate.

186. Second, blocks are "sometimes… available depending upon the traversal pattern used[.]" Ex-1004, ¶54. Depending on the pattern used to reach the current block, some blocks would not be coded yet, and similar to the first condition explained above, these blocks do not have any motion information for motion prediction.

187. Third, Rusert teaches that blocks that have "no motion vector present" or have "the same [motion vector] as a block earlier in the sequence" are not available. Ex-1004, ¶54. Blocks that have no motion vector present do not have

motion information for motion prediction and cannot provide a motion vector candidate. Since Rusert seeks to avoid duplicates, blocks that have the same motion vector as a block earlier in the sequence are not available for motion prediction.

188. Thus, with any of these considerations, Rusert teaches examining whether a block is available for motion prediction.

189. In the context of Rusert's nomenclature, Rusert's block is a prediction unit because it is the unit for which a motion vector is assigned for motion prediction. Ex-1004, ¶¶2-5, ¶36, ¶43; *supra* §VI.A.2[9a] (explaining PUs and Rusert's blocks). Therefore, Rusert teaches this limitation.

190. Additionally, the combination of Ground 1 applies Rusert's motion vector teachings to Prediction Units. *Supra* §VI.A.1 (explaining how and why Rusert and Karczewicz's teachings would have been combined), §VI.A.2[9a] (explaining application of block and PU teachings); Ex-1004, ¶¶3-4, ¶36; Ex-1005, ¶¶33-36, ¶¶64-66. As Karczewicz explains, H.265 introduced terminology for a "prediction unit," which was a type of block, and motion vectors were assigned to PUs. Ex-1005, ¶¶33-36; *supra* §I. Therefore, it would have been obvious to apply Rusert's motion vector teachings to PUs, and the combination of Ground 1 teaches examining whether the prediction unit, to which the potential spatial motion vector prediction candidate belongs, is available for motion prediction.

191. Furthermore, this would have been obvious based on the teachings of Rusert and Karczewicz. As explained above, Rusert teaches three reasons for examining whether a block is available for motion prediction as part of its process for finding and evaluating potential spatial motion vector prediction candidates, and Karczewicz teaches that, in H.265, the block for which motion vectors are assigned is called a PU. Ex-1005, ¶¶33-36, ¶¶64-66. Therefore, when scanning for potential spatial motion vector prediction candidates as Rusert teaches, it would have been obvious to scan PUs in the H.265 context, and it would have been obvious to examine whether the PU is available for motion prediction, using the various criteria Rusert teaches.

192. Based on the foregoing explanations, Ground 1 teaches limitation [13b].

[13c]	**if so, performing at least one of the following:**
…	
[13k]	**for a potential spatial motion vector prediction candidate, which is below the potential spatial motion vector prediction candidate on the left side of the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit; and**
…	

193. Limitation [13c] requires "performing at least one of the following." Therefore, I understand that this limitation is satisfied if the following claim requirement (limitation [13k]) is satisfied:

> **for a potential spatial motion vector prediction candidate, which is below the potential spatial motion vector prediction candidate on the left side of the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit;**

194. Ground 1 teaches this limitation, as explained below. As an initial matter, in the context of Rusert's nomenclature, Rusert's block is a prediction unit because it is the unit for which a motion vector is assigned for motion prediction. Ex-1004, ¶¶2-5, ¶36, ¶43. Additionally, the combination of Ground 1 applies

Rusert's motion vector teachings to Prediction Units. *Supra* §VI.A.1 (explaining how and why Rusert and Karczewicz's teachings would have been combined), §VI.A.2[9a] (explaining application of block and PU teachings); Ex-1004, ¶¶3-4, ¶36; Ex-1005, ¶¶33-36, ¶¶64-66. As Karczewicz explains, H.265 introduced terminology for a "Prediction Unit," which was a type of block, and motion vectors were assigned to PUs. Ex-1005, ¶¶33-36; *supra* §I. Therefore, when Rusert teaches its scanning and analysis process for motion vectors from various blocks, it would have been obvious to apply those teachings to PUs in the H.265 context because motion vectors were assigned on a PU basis in H.265. *Id.*

195. If Rusert's scan continues (the number of candidates in PMV_CANDS is less than a pre-defined number), Ground 1 applies the below-explained teachings **for a potential spatial motion vector prediction candidate, which is below the potential spatial motion vector prediction candidate on the left side of the prediction unit**. For example, Rusert teaches a scan pattern in Fig. 3n, illustrated below, that "has been found to combine good compression efficiency (i.e., finding good motion vectors) with good computation performance." Ex-1004, ¶66. As illustrated in Fig. 3n, the current block is "." (highlighted red below); the scan starts with a PMV candidate above the current block (e.g., block "1"), then scans a PMV candidate left of the current block (e.g., block "2") second, and so on, progressing through blocks "3," "4," and then "5."

Ex-1004, ¶¶65-66, Fig. 3n. The PMV candidate for block "5" (highlighted green below) is below the PMV candidate for block "2" (highlighted blue below), which is on the left side of the current block (in red). *Id.*:

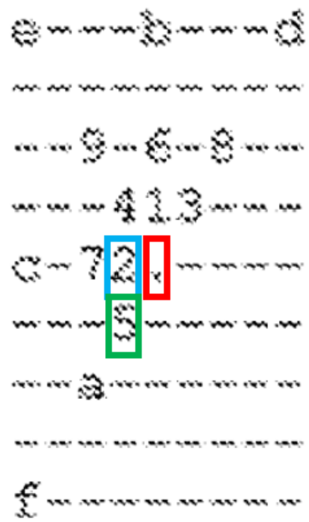


Fig. 3n

196. Therefore, Rusert analyzes a potential spatial motion vector prediction candidate (e.g., the PMV candidate from block "5" highlighted in green) which is below the potential PMV candidate on the left (e.g., from block "2" highlighted in blue) of the current block (e.g., block "." highlighted in red) for which candidates are being evaluated. Ex-1004, ¶66, Fig. 3n. As explained above, these blocks are prediction units, and Ground 1 applies these teachings to PUs in the H.265 context.

197. Ground 1 teaches **excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion**

information than the spatial motion vector prediction candidate on the left side of the prediction unit. For example, when analyzing a new PMV candidate, Rusert teaches "comparing the [PMV] candidates already in [PMV_CANDS] with the new [PMV candidate] that could be added, and if a duplicate is found,… skipping the new [PMV candidate]." Ex-1004, ¶¶71-72, ¶21, ¶62 ("It has been identified as advantageous to discard such duplicates.")

198. Rusert analyzes new PMV candidates following a scan order of nearby blocks, including the pattern of Fig. 3n illustrated below. Block 1 is analyzed first, then blocks 2, 3, and 4 in that order, adding candidates from those blocks to PMV_CANDS. When the 5th block is analyzed (highlighted green), Rusert will already have analyzed blocks 1, 2, 3, and 4. Ex-1004, ¶44, ¶¶65-66, Fig. 3n. Therefore, when Rusert evaluates whether to update PMV_CANDS with the spatial motion vector prediction candidate from block 5, Rusert compares the new candidate with the candidates already in PMV_CANDS, e.g., the candidates from blocks 1, 2, 3, and 4, to determine if it is a duplicate or within a threshold distance (meaning it is within a similarity measure) of an existing candidate in PMV_CANDS. Ex-1004, ¶¶71-72. This comparison includes a comparison of the PMV candidate from block 5 with the PMV candidate from block 2, and Rusert excludes the potential spatial motion vector prediction candidate for block 5 from PMV_CANDS if it is a duplicate or within a similarity threshold as compared to

the candidate on the left side of the PU (block 2). *Id.* In short, for the scan pattern of Fig. 3n, Rusert teaches excluding the PMV candidate below the PMV candidate to the left of the current block from PMV_CANDS if it is essentially similar (e.g., a duplicate or within a threshold distance) compared to the PMV candidate to the left. Ex-1004, Fig. 3n:

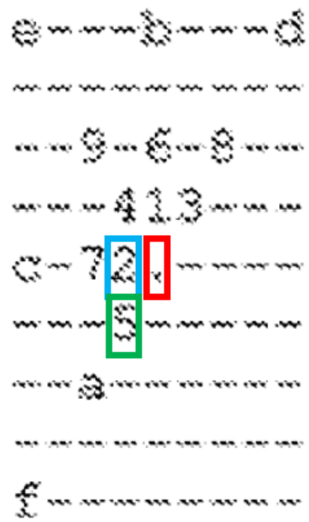


Fig. 3n

199. Rusert looks to whether the candidates are essentially similar by looking at whether they are duplicates or within a threshold distance. Indeed, Rusert uses its threshold comparison to "skip[] new motion vectors … that are similar but not equal, such as pairs of motion vectors *that have a similarity measure* smaller than a pre-defined threshold…" Ex-1004, ¶72. Therefore Rusert looks to whether candidates are essentially similar. *Id.*

200. Based on the foregoing explanations, Ground 1 teaches limitations [13c]-[13o].

7. Dependent Claim 14

14.	**The method according to claim 9 further comprising selecting one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the encoded block of pixels.**

201. Ground 1 teaches claim 14, as explained below.

202. As I have explained above, the combination of Rusert and Karczewicz teaches claim 1.

203. Rusert further teaches **selecting one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the encoded block of pixels**. For example, Rusert teaches "signaling which PMV [candidate] is used for motion vector prediction[.]" Ex-1004, ¶84; *supra* §§VI.A.2[1a], [1e]. "[A] code 'index'… is sent to *select* a particular PMV candidate… from a list of PMV candidates, PMV_CANDS" and the particular PMV candidate is used to "reconstruct MV=DMV+PMV" for the current block of pixels. Ex-1004, ¶¶36-37. Therefore, a PMV candidate is selected from PMV_CANDS using an index, and the selected PMV candidate represents the "predicted motion vector (PMV)" used to reconstruct the motion vector for a block. *Id.*, ¶36. Therefore, Rusert teaches selecting one motion vector

prediction candidate from PMV_CANDS to represent a motion vector prediction for the encoded block of pixels.

204. Additionally, Rusert teaches exemplary codes to signal the index of the selected candidate from PMV_CANDS. Ex-1004, ¶¶88-102 (exemplary codes for index values to signal which candidate from PMV_CANDS is used for motion information). For example, Table 1 includes codes for lists of various sizes including codes to indicate the first, second or third candidate in a list size of 3 candidates. *Id.,* ¶88.

205. Rusert teaches that the techniques of selecting a PMV candidate using an index are used for decoding an encoded block of pixels. For example, Rusert teaches that its teachings apply to "video decoding, wherein the current block is the block being… decoded[.]" Ex-1004, ¶23, ¶35 ("The methods disclosed herein are performed… in the decoder during decoding."). The current block is part of an "encoded video stream" that is "passe[d] to a decoder… employed in decoding the encoded video stream." Ex-1004, ¶34. The index that identifies a particular PMV candidate is also transmitted to the decoder as the motion information for the encoded block. The decoder thus selects a PMV candidate from PMV_CANDS using the transmitted index, and the selected PMV candidate represents the "predicted motion vector (PMV)" used to reconstruct the motion vector for the encoded block. Ex-1004, ¶36. Therefore, Rusert teaches a decoder using an index

to select a PMV candidate from PMV_CANDS to represent a motion vector prediction for the encoded block of pixels. *See supra* §VI.A.2[9e].

206. Based on the foregoing explanations, Ground 1 teaches claim 14.

8. Independent Claim 23

[23pre] An apparatus comprising a processor and a memory including computer program code, the memory and the computer program code configured to, with the processor, cause the apparatus to:

207. To the extent that the preamble is limiting, Ground 1 teaches limitation [23pre], as explained below.

208. Rusert teaches an **apparatus comprising a processor and a memory including computer program code, the memory and computer program code is configured to, with the processor, cause the apparatus to.** For example, Rusert teaches "[t]he present application relates to … a video encoding apparatus, a video decoding apparatus, and a computer-readable medium." Ex-1006, ¶1; see also Ex-1006, ¶24, ¶26, ¶27, ¶114, ¶116, claim 17, claim 18. The "video encoding apparatus compris[es] a processor" and that the "video decoding apparatus compris[es] a processor[.]" Ex-1006, ¶¶24-25. Rusert further teaches "a computer-readable medium, carrying instructions, which when executed by computer logic," such as a processor, "causes said computer logic to carry out any of the methods disclosed herein." Ex-1006, ¶26. Therefore, Rusert teaches an "apparatus comprising a processor" and memory "carrying instructions" that cause

the apparatus to "carry out any of the methods disclosed herein." Ex-1006, ¶¶24-26. At the very least, it would have been obvious to a POSITA for a video encoder and a video decoder to include a processor and a memory, such as a hard drive, to execute software because conventional computers have included processors and memory for this purpose for decades.

209. Based on the foregoing explanations, Ground 1 teaches the preamble of claim 23.

[23a]	**select a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for an encoded block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the encoded block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates;**

210. Ground 1 teaches limitation [23a]. Limitation [23a] is identical to limitation [9a], except that limitation [23a] recites "select" while limitation [9a] recites "selecting." For the same reasons I have discussed for limitation [9a], Ground 1 teaches limitation [23a]. *Supra* §VI.A.2[9a].

[23b]	**determine a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;**

211. Ground 1 teaches limitation [23b]. Limitation [23b] is identical to limitation [9b], except that limitation [23b] recites "determine" while limitation

[9b] recites "determining." For the same reasons I have discussed for limitation [9b], Ground 1 teaches limitation [23b]. *Supra* §VI.A.2[9b].

[23c]	**compare motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;**

212. Grounds 1 and 2 teaches limitation [23c], as explained below.

213. Limitation [23c] is substantially similar to limitation [9c]. Their differences are shown below:

[23c]	**[9c]**
comparing motion information of the first spatial motion vector prediction candidate with motion information of another spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;	compare motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;

214. As an initial matter, "*the* spatial motion vector prediction candidate" of limitation [23c] lacks antecedent basis. This limitation is rendered obvious for the same reasons that "*another* spatial motion vector prediction candidate" of

limitation [9c] is obvious because both limitations reference a spatial motion vector prediction candidate other than the first spatial motion vector prediction candidate.

215. Furthermore, "*in* the *determined subset*" is rendered obvious for the same reasons that "*of* the *set*" is obvious because a comparison between two spatial motion vector prediction candidates in a set teaches a comparison of two spatial motion vector prediction candidates in a subset of the set. Here, the "determined subset" references "a subset" in limitation [23b] which is a subset of "a set" in limitation [23a]. Likewise, "the set" of limitation [9c] is "a set" in limitation [9a].

216. At the very least, it would be obvious that Ground 1 teaches "comparing … with motion information of the spatial motion vector prediction candidate in the determined subset," because Rusert teaches, for example, comparing the selected PMV candidate with PMV candidates currently in PMV_CANDS. *See* §VI.A.2[9c]. For the reasons I explained for limitation [9c], Ground 1 teaches limitation [23c]. *Supra* §VI.A.2[9c].

[23d]	**determine to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on comparison of the motion information of the first spatial motion vector candidate with motion information of the spatial motion vector prediction candidate; and**

217. Grounds 1 and 2 teaches limitation [23d], as explained below.

218. Limitation [23d] is substantially similar to limitation [9d]. Their differences are shown below:

[23d]	[9d]
determine to include or exclude the first spatial motion vector predict ion candidate in the motion vector prediction list based on comparison of the motion information of the fi rst spatial motion vector candidate with motion information of the spat ial motion vector prediction candid ate; and	determining to include or exclude t he first spatial motion vector pred iction candidate in the motion vect or prediction list based on the com paring; and

219. Limitation [9d] refers back to "the comparing" of limitation [9c]. Limitation [23d] is nearly identical to [9d], but instead of referring back to [23c], it simply repeats the language from [23c], which recites a step to "compare motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate."

220. Therefore, limitation [23d] is nearly identical to limitation [9d]. The minor differences, shown above, do not affect my analysis that Grounds 1 and 2 teach limitation [23d].

221. Therefore, for the same reasons I have discussed for limitation [9d], Ground 1 teaches limitation [23d]. *Supra* §VI.A.2[9d].

[23e]	**select a spatial motion vector prediction candidate from the motion vector prediction list for use in decoding the encoded block of pixels, wherein the spatial motion vector prediction candidate is selected from the motion vector prediction list using information that was received identifying a respective spatial motion vector prediction candidate from the motion vector prediction list constructed by an encoder.**

222. Ground 1 teaches limitation [23e]. Limitation [23e] is identical to limitation [9e], except that limitation [23e] recites "select" while limitation [9a] recites "selecting." For the same reason I have discussed for limitation [9e], Ground 1 teaches limitation [23e]. *Supra* §VI.A.2[9e].

9. Dependent Claim 24

223. Ground 1 teaches claim 24. Claim 24 is identical to claim 10, except that claim 10 recites "the method according to claim 9 further comprising comparing …," while claim 24 recites "the apparatus according to claim 23 wherein the apparatus is further caused to compare…" I addressed the apparatus of claim 23 above. *Supra* §VI.A.8. The rest of claim 24 is satisfied for the same reasons I explained for claim 10. *Supra* §VI.A.3.

10. Dependent Claim 25

224. Ground 2 teaches claim 25. Claim 25 is identical to claim 11, except that claim 11 recites "the method according to claim 9 further comprising comparing …" and "excluding," whereas claim 25 recites "the apparatus according to claim 23 wherein the apparatus is further caused to compare…" and "exclude."

I addressed the apparatus of claim 23 above. *Supra* §VI.A.8. The rest of claim 25 is satisfied for the same reasons I explained for claim 11. *Supra* §VI.A.4.

11. Dependent Claim 26

225. Ground 1 teaches claim 26. Claim 26 is identical to claim 12, except that claim 12 recites "the method according to claim 1 further comprising determining …" and "limiting," whereas claim 19 recites "the apparatus according to claim 23 wherein the apparatus is further caused to determine…" and "limit." I addressed the apparatus of claim 23 above. *Supra* §VI.A.8. The rest of claim 26 is satisfied for the same reasons I explained for claim 12. *Supra* §VI.A.5.

12. Dependent Claim 27

226. Ground 1 teaches claim 27. Claim 27 is identical to claim 13, except that claim 13 recites "the method according to claim 12 further comprising examining …," followed by limitations using verbs in their gerund form, whereas claim 27 recites "the apparatus according to claim 26 wherein the apparatus is further caused to examine…," followed by the same limitations with the verbs in their base form. I addressed the apparatus of claim 23 above. *Supra* §VI.A.8. The rest of claim 27 is satisfied for the same reasons I explained for claim 13. *Supra* §VI.A.6.

13. Dependent Claim 28

28. The apparatus according to claim 23 wherein the apparatus is further caused to select one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the received encoded block of pixels.

227. Ground 1 teaches claim 28, as explained below.

228. Claim 28 is substantially similar to claim 14. Their differences are shown below:

[28]	[14]
The apparatus according to claim 23 wherein the apparatus is further caused to select one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the received encoded block of pixels.	The method according to claim 9 further comprising selecting one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the encoded block of pixels.

229. Claim 28 requires the apparatus to select one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the received encoded block of pixels. This is substantially the same as claim 14. As I have explained above for claim 14, the encoded block of pixels is transmitted from the encoder and received by the decoder. *See supra* §VI.A.7. For the reasons I explained for claim 14, Ground 1 teaches claim 28. *See id*.

14. Independent Claim 30

[30pre]. A non-transitory computer readable medium having stored thereon a computer executable program code for use by an encoder, said program codes comprising instructions for:

230. To the extent that the preamble is limiting, Ground 1 teaches limitation [30pre], as explained below.

231. As an initial matter, both limitation [30pre] and limitation [30e] recite "an encoder." This appears to be a typographical error arising from copying the preamble from claim 29. *Compare* Ex-1001, claim 29 *with* Ex-1001, claim 30. While limitation [30pre] states the limitations of claim 30 are for "an encoder", the limitations are inconsistent with an encoder because the limitations recite, for example, "selecting… for an encoded block of pixels" (limitation [30a]) and "decoding the encoded block of pixels" (limitation [30e]). Thus, it is my opinion that limitation [30pre] would be understood to be "for use by a decoder" not "for use by an encoder[.]" Regardless, Rusert teaches both "a video encoding apparatus" and "a video decoding apparatus[.]" Ex-1004, ¶1.

232. Rusert teaches **a non-transitory computer readable medium having stored thereon a computer executable program code for use by [a decoder], said program codes comprising instructions for**. For example, Rusert teaches "a computer-readable medium, carrying instructions, which, when executed by computer logic, causes said computer logic to carry out any of the methods disclosed herein." Ex-1004, ¶26, ¶1 ("The present application relates to… a video

encoding apparatus, a video decoding apparatus, and a computer-readable medium."), claim 19. The computer-readable medium is used, for example, by "a video encoding apparatus" and "a video decoding apparatus[.]" Ex-1004, ¶¶24-25. At the very least, it would have been obvious to a POSITA for a video encoder and a video decoder to include a non-transitory computer-readable medium, such as a hard drive, that stores computer executable program code, such as software, because conventional computers have included hard drives storing software for decades.

233. Based on the foregoing explanations, Ground 1 teaches the preamble of claim 30.

[30a]	**selecting a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for an encoded block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the encoded block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates;**

234. Ground 1 teaches limitation [30a]. Limitation [30a] is identical to limitation [9a]. For the same reasons I have discussed for limitation [9a], Ground 1 teaches limitation [30a]. *Supra* §VI.A.2[9a].

[30b]	**determining a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;**

235. Ground 1 teaches limitation [30b]. Limitation [30b] is identical to limitation [9b]. For the same reasons I have discussed for limitation [9b], Ground 1 teaches limitation [30b]. *Supra* §VI.A.2[9b].

[30c]	**comparing motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;**

236. Ground 1 teaches limitation [30c].

237. Limitation [30c] is nearly identical to limitation [9c]. As shown below, the minor differences between limitation [30c] and limitation [9c] are identical to the differences between limitation [23c] and limitation [9c]. For the same reasons I have discussed for limitation [23c], which references to limitation [9c], Ground 1 teaches limitation [30c]. *Supra* §VI.A.8[23c], §VI.A.2[9c].

[30c]	[9c]
comparing motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;	comparing motion information of the first spatial motion vector prediction candidate with motion information of another spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;

[30d]	determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and

238. Ground 1 teaches limitation [30d]. Limitation [30d] is identical to limitation [9d]. For the same reasons I have discussed for limitation [9d], Ground 1 teaches limitation [30d]. *Supra* §VI.A.2[9d].

[30e]	**selecting a spatial motion vector prediction candidate from the motion vector prediction list for use in decoding the encoded block of pixels, wherein the spatial motion vector prediction candidate is selected from the motion vector prediction list using information that was received identifying a respective spatial motion vector prediction candidate from the motion vector prediction list constructed by an encoder.**

239. Ground 1 teaches limitation [30e]. Limitation [30e] is identical to limitation [9e]. For the same reasons I have discussed for limitation [9d], Ground 1 teaches limitation [30e]. *Supra* §VI.A.2[9e].

B. Ground 3

240. It is my opinion that a POSITA would have found the Challenged Claims obvious based on Ground 3, i.e., the teachings of Nakamura and WD4. Nakamura teaches and suggests the limitations of the challenged claims. WD4 provides additional teachings on limitations [9a] and [9e].

1. Motivation to Combine and Reasonable Expectation of Success

241. Nakamura is an HEVC proposal for "reduc[ing] the number of candidates in the spatial derivation process to reduce the number of… comparison[s] in the removal process." Ex-1007, Abstract. When applied to WD4, Nakamura's teachings satisfy the challenged claims. A POSITA would have been motivated to apply Nakamura's teachings to the draft HEVC standard because that was its express purpose. Nakamura is a proposal presented to the JCT-VC, the standards body responsible for the HEVC standard, at the 6th JCT-

VC Meeting on July 14-22, 2011. Ex-1007, Header. The meeting started with WD3 as the then-current version of the standard. At the meeting, various proposals were made including Nakamura, and the JCT-VC drafted WD4, the draft HEVC standard. Ex-1007, 000001; Ex-1010, 000001. Nakamura proposed "simplifications" and "improvement[s]" to the then-current working draft (WD3). Ex-1007, Abstract, Introduction, §6 (References). In view of these simplifications and improvements, WD4 "[i]ncorporated spatial merge candidate positions unification" from Nakamura. Ex-1010, Abstract. Therefore, the prior art provides express teaching, suggestion, and motivation to combine teachings from Nakamura and WD4.

242. Indeed, once the Nakamura proposal was made to the JCT-VC for inclusion into the draft HEVC standard, its teachings were known for HEVC. A POSITA would have found it obvious and been motivated to use Nakamura's teachings in the context of HEVC, including its working drafts. It would certainly not make sense for someone else to file for a patent many months later covering the application of Nakamura's teachings to the HEVC standard.

243. Nakamura was a proposal made at a JCT-VC meeting for the express purpose of applying its teachings to the HEVC standard, and WD4 was a draft version of the HEVC standard in the July 2011 timeframe. Nakamura teaches improvements to the HEVC standard and was intended to be used in the context of

HEVC. Nakamura references aspects of the HEVC working drafts and uses HEVC terminology and concepts. Therefore, it would have been natural to apply Nakamura's teachings to draft HEVC standards; this would have applied a known technique to a known method ready for improvement to yield predictable results.

244. The combination of Nakamura and WD4 would have had predictable results. Nakamura teaches its "proposed technique is implemented into HM3.0 software", which was software implementation of the HEVC standard at that time. Ex-1007, §2.3.1. Furthermore, Nakamura provides results showing the actual application of its teachings to HEVC, including improvements from the combination. Ex-1007, §3 Therefore, Nakamura's teachings were readily applicable to HEVC and, indeed, were actually applied to HEVC. Thus, the combination of Nakamura and WD4 would have had predictable results. *See* Ex-1007, §3.

245. A POSITA would have been motivated to combine Nakamura and WD4 because it would have combined prior art elements according to known methods to yield predictable results. Nakamura teaches various improvements to HEVC, including "simplifications of derivation process for merge mode and motion vector predictor (MVP)[,]… unification of the location of spatial neighbors for merge mode and MVP[,]" and "improvement of derivation method of the candidates for merge mode and motion vector predictor (MVP)." Ex-1007,

Abstract, §1. These improvements involve, for example, "reduc[ing] the number of candidates in the spatial derivation process to reduce the number of times of comparison in the removal process." Ex-1007, Abstract. These teachings are applied to HEVC, which WD4 teaches. Ex-1007, Abstract, Introduction, §6 (References); Ex-1010, Abstract. Therefore, it would have been obvious to apply Nakamura's teachings to draft HEVC standards as a combination of prior art elements according to known methods, with predictable results.

246. In addition, a POSITA would have found motivation to combine Nakamura and WD4 because of the similarity of the references and the commonality of purpose. Nakamura and WD4 are both directed to video encoding and decoding, and are both meant for development of the HEVC standard. Both WD4 and Nakamura address motion vectors for block-based inter prediction. Ex-1010, §0.6; Ex-1007, Abstract. Nakamura teaches, for example, a "derivation process for merge mode and motion vector predictor (MVP)." Ex-1007, Abstract. WD4 also teaches the derivation process for motion vectors and adopts the techniques from Nakamura. Ex-1010, §8.4.2.1.1. Indeed, a POSITA would notice striking similarities between Nakamura's "[d]erivation process[es]" and WD4's "[d]erivation process[es]." *Compare* Ex-1008 §§8.4.2.1.1-8.4.2.1.3 *with* Ex-1010, §§8.4.2.1.1-8.4.2.1.3. For example, Nakamura's "Derivation process for spatial merging candidates" and WD4's "Derivation process for spatial merging

candidates" share striking similarities with a difference in labelling (e.g., Nakamura's A, B, C, D, E blocks and WD4's A_1, B_1, B_0, A_0, B_2 blocks) and Nakamura's inclusion of a figure being the only differences. *Compare* Ex-1008 §8.4.2.1.2 *with* Ex-1010, §8.4.2.1.2. Furthermore, Nakamura's "Derivation process of reference indices for temporal merging candidate" and WD4's "Derivation process of reference indices for temporal merging candidate" are identical. *Compare* Ex-1008 §8.4.2.1.3 *with* Ex-1010, §8.4.2.1.3.

247. Furthermore, a POSITA would have been motivated to combine because the teachings of WD4 and Nakamura are complementary. Nakamura provides detailed examples and explanations for deriving candidates for both merge mode and MVP mode. WD4 provides more context and details about how deriving candidates for merge mode and MVP mode work with the video encoding and decoding processes under the draft HEVC standard. *See generally* Ex-1010, §8. WD4 also explains the terminology and up-to-date background concepts of HEVC, especially on video encoding and decoding. *See generally, e.g.,* Ex-1010, §3. In understanding and implementing the teachings of Nakamura, a POSITA would have been motivated to look to WD4, which provides additional technical context and implementation details.

248. A POSITA would have been motivated to combine Nakamura and WD4 because the combination would have yielded several advantages. For

example, Nakamura and WD4 share the same goal of improving efficiency of video coding. WD4 teaches that "the need has arisen for an industry standard for compressed video representation with substantially increased coding efficiency…" Ex-1010, §0.1. Nakamura teaches that its proposal "reduce[s] the number of candidates in the spatial derivation process to reduce the number of times of comparison in the removal process." Ex-1007, Abstract. And Nakamura also provides actual results demonstrating the efficiency gains of its proposed techniques. Ex-1007, §3.

249. The combination of Nakamura and WD4 would not have changed the principle of operation for any of the teachings of the references relied upon in the combination. Nakamura was specifically proposed to be used with HEVC, which WD4 teaches, and that is precisely what the combination of Ground 3 is directed to. *See* Ex-1007, Abstract, §1, §6; Ex-1010, Abstract. The combination uses the teachings of Nakamura and WD4 in a conventional manner, as they were meant to be used. Moreover, both Nakamura and WD4 teach motion prediction for encoding and decoding blocks, with spatial motion vector prediction candidates. Both Nakamura and WD4 operate on the same principles of block-based motion prediction. Ex-1023, 000004. Therefore, Nakamura's teachings would not have changed the principle of operation of WD4.

250. That Nakamura references an earlier version of HEVC (e.g., WD3) would not have dissuaded a POSITA from combining Nakamura with WD4. Indeed, the output of the 6th JCT-VC meeting, where Nakamura was presented, was WD4. A POSITA would have understood that Nakamura's teachings were applicable to HEVC, including the working drafts in that timeframe such as WD3 and WD4.

251. A POSITA would have had a reasonable expectation of success when combining Nakamura with WD4. As explained above, the combination applies teachings from each reference according to their known purposes, in a conventional manner as taught by Nakamura and WD4, without changing their principle of operation. Furthermore, Nakamura implemented the combination and reported measurements from actual results showing performance increases when Nakamura's teachings were applied to draft HEVC standards. Ex-1007, §2.3.1, §3; Ex-1009, 000015-000018. The combination does not modify Nakamura or WD4 in a way that would render either reference inoperative. Given that Nakamura had successfully made and reported the combination, a POSITA would have had a reasonable expectation of success in doing so. *See id.*

252. Given the education and experience of a POSITA (*supra* §IV), a POSITA would have been more than capable of applying Nakamura's teachings to WD4, and vice versa, because it would simply have applied Nakamura's teachings,

based on draft HEVC standards, to draft HEVC standards. Therefore, a POSITA would have had a reasonable expectation of success in applying Nakamura's teachings to draft HEVC standards, including WD4, which was after all the purpose of the Nakamura proposal for the HEVC standard.

253. Nakamura is a single proposal comprising multiple files. Each of those files is a component of the Nakamura proposal and therefore part of the reference. To the extent it is argued that Nakamura is a collection of documents, a POSITA would have been motivated to combine the teachings of the three Nakamura files relied on by this Declaration: Nakamura Main Document (Ex-1007), Nakamura WD Description (Ex-1008), and Nakamura Presentation (Ex-1009). First, these files were jointly presented to the JCT-VC in a single proposal and were meant to be read together to understand the Nakamura proposal. Second, the files were packaged together in a single zip file for download (Ex-1014 (Sze Declaration), ¶16), and therefore HEVC attendees would have understood that the files were meant to be read together as part of the Nakamura proposal. Third, the files teach related aspects of Nakamura's proposal and therefore a POSITA would have understood from their context that their teachings were meant to be read and combined together. *See supra* §III.E.

254. A POSITA would also have had a reasonable expectation of success in combining the teachings of the files in the Nakamura proposal. As explained

above, those files were drafted by the same author as part of the same proposal for the HEVC standard. Therefore, the teachings of Nakamura's files were meant to be read and used together, and a POSITA would have been capable of applying the teachings in the manner taught by the Nakamura files.

2. Independent Claim 9

[9pre] A method comprising:

255. To the extent that the preamble is limiting, Ground 3 teaches limitation [9pre], as explained below.

256. Nakamura teaches a **method**. For example, Nakamura teaches an "improvement of derivation method of the candidates for merge mode and motion vector predictor (MVP)." Ex-1007, §1, Abstract ("This contribution presents simplifications of derivation process for merge mode and motion vector predictor (MVP)."), §2.1, Fig. 1.

257. WD4 also teaches a method. For example, WD4 teaches a "[d]erivation process for spatial merging candidates" (Ex-1010, §8.4.2.1.2) and a "[d]erivation process for motion vector predictor candidates" (Ex-1010, §8.4.2.1.8).

258. Nakamura and WD4 further teach a method comprising the steps described below, with distinct teachings for merge mode and MVP mode that independently satisfy the limitations as explained below. *Infra* §VI.B.2[1pre]-[1e].

HEVC included two modes for predicting candidates: merge mode was optimal for areas of uniform motion, while MVP mode was more versatile but required more data. Generally, merge mode saved bits by utilizing the predicted motion vector without signaling difference vectors and other information used by MVP mode. Regardless, the detailed differences are not particularly relevant to the claim analysis because the claims do not require one mode or the other. Both modes satisfy the claims, as explained in the sections below.

[9a]	**selecting a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for an encoded block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the encoded block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates;**

259. Ground 3 teaches limitation [9a] in two independent ways: merge mode and MVP mode. Either teaching is sufficient by itself to satisfy the claims.

<u>*Merge Mode*</u>

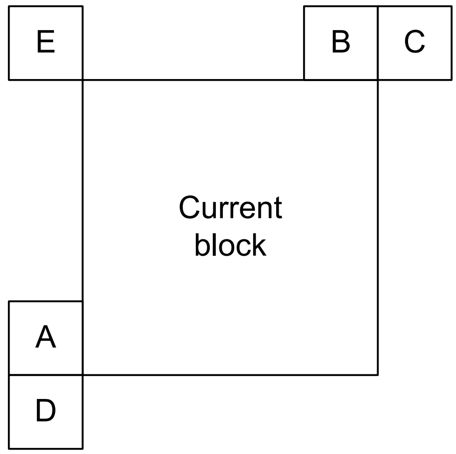
260. Ground 3 teaches **selecting a first spatial motion vector prediction candidate** (e.g., for S_1) **from a set of spatial motion vector prediction candidates for an encoded block of pixels**. For merge mode, Nakamura teaches a process for building a merge list that evaluates spatial motion vector prediction candidates, in sequence, from a set of five neighboring blocks (A, B, C, D, E).

E.g., Ex-1007, Tables 2-4; Ex-1009, 000008, 000010, 000012-14. Nakamura illustrates an example of the "[s]patial derivation order" on page 7 of Nakamura's presentation. Ex-1009, 000008.

261. Nakamura teaches a process for identifying two spatial motion vector prediction candidates (S_0 and S_1) for a merge list. Nakamura finds two "spatial candidate[s]" S_0 and S_1 from "the position[s] of the spatial neighbors A, B, C, D and E relative to the current prediction unit" which "can be used for… candidates[.]" Ex-1007, §2.2.1, Abstract, §1, Tables 2, 4, Fig. 1; Ex-1009, 000008, 000010, 000014. Nakamura steps through each of the spatially-neighboring blocks in sequence to select S_0 from one of the blocks; next, Nakamura steps through the remaining spatial neighbors to select a spatial motion vector prediction candidate from the next block in the sequence, until another candidate S_1 is found. Ex-1007, Tables 2, 4 ("Spatial derivation order"); Ex-1009, 000008. In particular, as explained further below, the selection of a candidate from a spatial neighbor for S_1 satisfies the claimed step for selecting a first spatial motion vector prediction candidate. It is irrelevant whether Nakamura applies its own "first" and "second" labels to describe the ordering of its spatial derivation process, or whether any other candidates come before S_1, because claim 1 merely recites "*a first* spatial motion vector prediction candidate" to distinguish that candidate from other spatial motion vector prediction candidates described in the claims, not as an absolute

temporal requirement for that candidate. Therefore, it is my understanding that claim 1 does not impose a requirement for selecting the very first spatial motion vector prediction candidate for a video, frame, or particular block. Instead, this language simply requires selecting *a* spatial motion vector prediction candidate, which is then designated the "first" spatial motion vector prediction candidate for the remainder of the claim. Here, the selected first spatial motion vector prediction candidate (as recited in claim 1) is Nakamura's S_1 for purposes of analyzing claim 1.

262. As I explained above, a "spatial motion vector prediction candidate" is a candidate motion vector obtained from one or more previously-encoded block in the current frame. *Supra* §V.A. The motion vector candidates from spatially neighboring blocks are spatial motion vector prediction candidates because each is a candidate motion vector obtained from one or more previously-coded blocks in the current frame (A, B, C, D, and E). *E.g.*, Ex-1007, §2.2.1. As illustrated in Fig. 2(b), the spatial neighbors are blocks A, B, C, D, and E, which neighbor the current block of pixels. Ex-1007, Fig. 2(b):



(b) Proposed technique

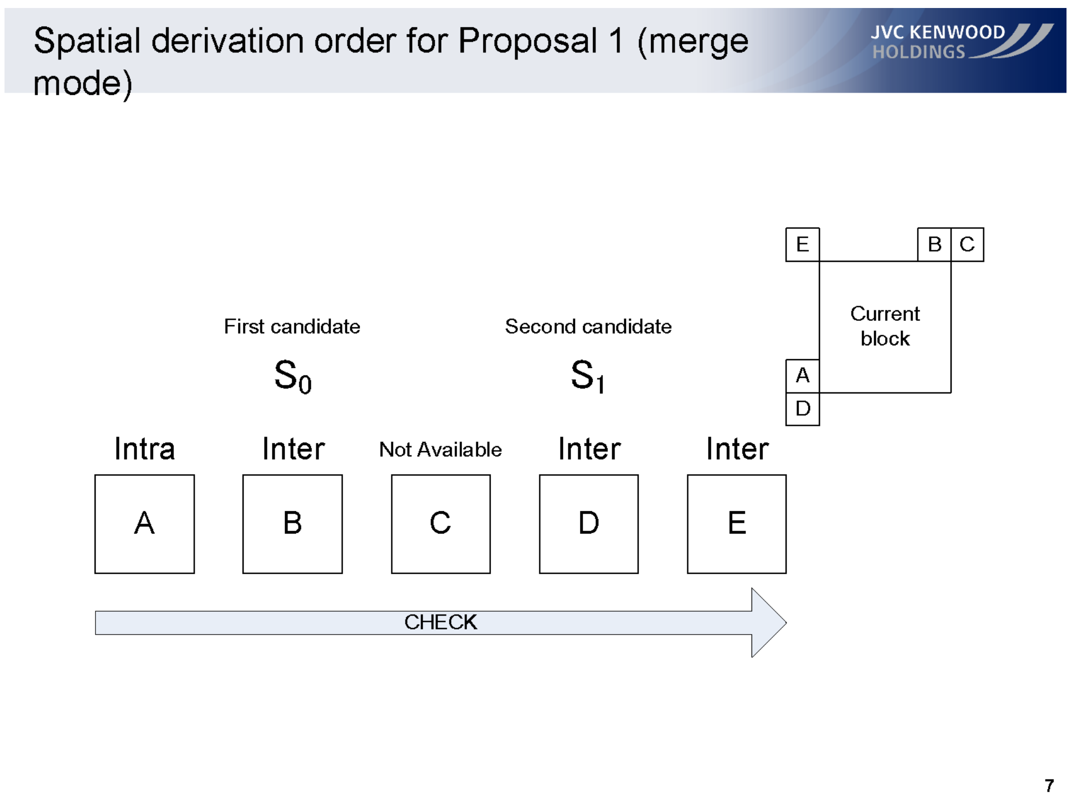
263. Since blocks are processed in raster scan order from top left to bottom right, blocks A-E represent the potential neighboring blocks that have already been encoded. Blocks below and to the right of the current block will not have been encoded yet and are not available as sources for spatial motion vector prediction candidates. *See* Ex-1010, §3.83 (explaining "raster scan"), §3.101. Furthermore, Nakamura and WD4's teachings "enable a high compression capability for a desired image or video quality" using "block-based inter prediction[,]" which teaches the blocks are blocks of pixels because images and videos are comprised of pixels. Ex-1010, §0.6

264. Each candidate comprises "availability flags… reference indices… prediction list utilization flags…" and "*motion vectors*" for prediction. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2.

265. WD4 teaches that a "decoding process specified in this Recommendation | International Standard that reads a bitstream and derives decoded pictures from it" and an "encoding process… that produces a bitstream conforming to this Recommendation | International Standard." Ex-1010, §3.34, §3.38. Therefore, the teachings of Nakamura and WD4 for encoding a video and decoding the video are applicable to both processes so that a bitstream encoded based on these teachings would be correctly decoded. Indeed, Nakamura's teachings are applied to decode an encoded block of pixels (the "current block") received in a bitstream from the encoder. Ex-1007, §2.2.1, Fig. 2; Ex-1009, 000005, 000007-8; Ex-1010, §§8.4.2.1.1-8.4.2.1.2. Those bitstreams are "transmitted and received" and include encoded blocks that are decoded according to the teachings of Nakamura and WD4. Ex-1010, §0.2, §3.11, §3.12, §3.34, §3.38, §§8.4.2.1.1-8.4.2.1.2; Ex-1007, §2.2.1, Fig. 2.

266. Ground 3 teaches **selecting a first… candidate… as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list**. For example, Nakamura teaches a "merging candidate list is constructed of two spatial merging candidates" (S_0 and S_1) selected from the five spatial neighbor candidates "relative to the current prediction unit[.]" Ex-1007, §2.2.1, Table 2, §2.2.2, Table 3; Ex-1008, §8.4.2.1.1 ("The merging candidate list, mergeCandList…").

267. To select S_0 and S_1, Nakamura teaches a "[s]patial derivation order" in which candidates from the five spatially neighboring blocks are evaluated in sequence. Ex-1007, Table 2-4; Ex-1009, 000008, 000010, 000012-14. Nakamura illustrates an example of the "[s]patial derivation order" which starts from A and progresses to E. Ex-1009, 000008:



268. The above example illustrates the order in which the spatial neighbors are checked. Ex-1009, 000008. Following the spatial derivation order of A through E, Nakamura begins with block A and decides whether its candidate should be selected for S_0. Since A is an intra block and does not have a motion vector, Nakamura proceeds to the next block B, whose spatial motion vector

prediction candidate is selected as candidate S_0 for the merging candidate list because B is an inter block with motion vector prediction information. Nakamura proceeds in this manner, stepping through the spatial derivation order to select S_1, until two spatial candidates (S_0 and S_1) are selected for the merging candidate list. Ex-1009, 000008; Ex-1007, §2.2.1, Table 2. In this example, block C is skipped because it is not available. The spatial motion vector prediction candidate from Block D is then evaluated and selected for S_1. Block E is not checked because two spatial candidates have been found before the spatial derivation order reaches block E. Ex-1009, 000008. Therefore, Nakamura teaches selecting a first spatial motion vector prediction candidate (e.g., for S_1).

269. The merging candidate list is **a motion vector prediction list for a prediction unit of the encoded block of pixels.** Nakamura teaches "[t]he merging candidate list, mergeCandList," (Ex-1008, §8.4.2.1.1; Ex-1010, §8.4.2.1.1) comprises "spatial merging candidates" found from "the position[s] of the spatial neighbors… relative to the current prediction unit" of the current block. Ex-1007, §2.2.1, Tables 2, 4, Fig. 2(b). One of the spatial candidates in the merging candidate list is assigned as the motion vector predictor for the current prediction unit. Ex-1008, §8.4.2.1.1 ("The following assignments are made with N being the candidate at position mergeIdx in the merging candidate list mergeCandList (N = mergeCandList[mergeIdx])…"); Ex-1010, §7.4.7 (explaining that merge_idx

"specifies the merging candidate index of the merging candidate list" for a prediction unit), §8.4.2.1.1, 000049, 000174 (showing "merge_idx" is associated with a prediction unit). Therefore, the merging candidate list is a motion vector prediction list for the PU corresponding to the block currently being processed. *See, e.g.,* Ex-1008, §8.4.2.1.1.

270. Nakamura teaches a "merging candidate list," which is referred to in WD4 as "mergeCandList." A POSITA reading Nakamura and WD4 would have understood this because Nakamura was a proposal for HEVC, and "mergeCandList" is an abbreviation for Merge Candidate List following a common computer programming style. Ex-1008, §8.4.2.1.1; Ex-1010, §8.4.2.1.1 ("The merging candidate list, mergeCandList…").

271. **Where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates.** Nakamura teaches that the "merging candidate list is constructed of" spatial candidates (Ex-1007, §2.2.1) and includes information of those candidates in the list, including "availability flags… reference indices… prediction list utilization flags…" and "motion vectors[.]" Ex-1008, §8.4.2.1.2.

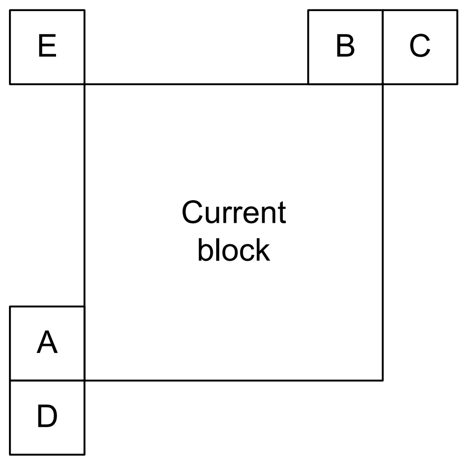
MVP Mode

272. For MVP mode, Ground 3 teaches limitation [9a] in a similar manner explained above for Merge Mode. Ex-1007, §2.2.2, Table 4; Ex-1009, 000005, 000014. Indeed, Nakamura proposed a "unification of the location of spatial neighbors for merge mode and MVP" and a "unification of the derivation process for merge mode and MVP." Ex-1007, Abstract.

273. Ground 3 teaches **selecting a first spatial motion vector prediction candidate** (e.g., S_1) **from a set of spatial motion vector prediction candidates for an encoded block of pixels**. For MVP mode, Nakamura teaches a process for building an "MVP list" by evaluating a set of five spatially-neighboring blocks in sequence, following a "[s]patial derivation order," to select two candidates (S_0 and S_1) for the MVP list. Ex-1007, §2.2.2. Nakamura teaches a "first spatial candidate found" (S_0) and a "second spatial candidate found" (S_1) from "the spatial neighbors relative to the current prediction unit[.]" Ex-1007, §2.2.2, Abstract, §1, Tables 3-4, Fig. 1; Ex-1009, 000012-14. This process for stepping through the spatial derivation order and selecting spatial motion vector prediction candidates is explained below.

274. Here, the spatial candidates are "motion vector predictor[s]" (Ex-1007, §2.2.2, Abstract, §1, Tables 3-4, Fig. 1; Ex-1009, 000012-14) that include "motion vectors" and "availability flags[.]" Ex-1010, §8.4.2.1.8.

275. The motion vector candidates from the spatial neighbors are spatial motion vector prediction candidates because each is a candidate motion vector obtained from one or more previously-encoded block in the current frame (A, B, C, D, and E). *E.g.*, Ex-1007, §2.2.2; Ex-1009, 000011-000012. The spatial neighbors are blocks A, B, C, D, and E, which neighbor the current block of pixels. Ex-1007, Fig. 3(b):

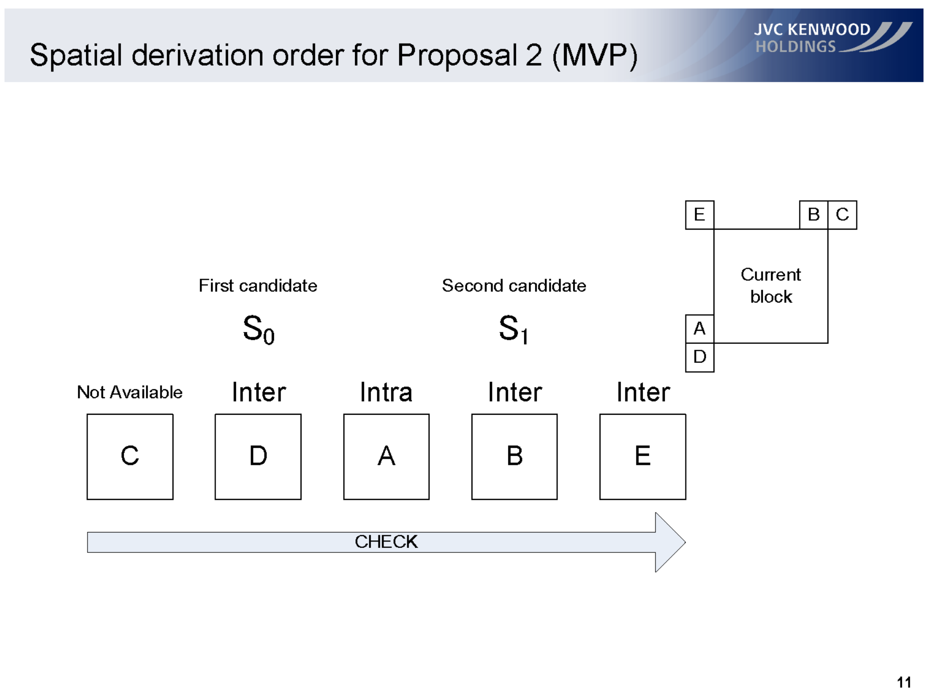


(b) Proposed technique

276. Since blocks are processed in raster scan order from top left to bottom right, blocks A-E represent the potential neighboring blocks that have already been encoded. Blocks below and to the right of the current block will not have been encoded yet and are not available as sources for spatial motion vector prediction candidates. *See* Ex-1010, §3.83 (explaining "raster scan"), §3.101.

277. Ground 3 teaches **selecting a first… candidate… as a potential spatial motion vector prediction candidate to be included in a motion vector**

prediction list. For example, Nakamura teaches an "MVP list" with two spatial motion vector prediction candidates: S_0 and S_1. Ex-1007, Tables 3-4, §2.2.2; Ex-1009, 000012-14; Ex-1010, §8.4.2.1.10 ("motion vector predictor list mvpListLX"). Following a "[s]patial derivation order[,]" spatial neighbors of a current block are evaluated in sequence to select S_0 and S_1. Ex-1007, Tables 3-4; Ex-1009, 000012-14. Nakamura illustrates an example of the "[s]patial derivation order" on page 11 of Nakamura's presentation. Ex-1009, 000012:



278. This selection process is similar to the one explained above for Merge Mode. The above example illustrates how the spatial neighbors are checked for potential inclusion in the MVP list. Ex-1009, 000012. Following the spatial derivation order in the above example, block C is checked and not included

because it does not have an available motion vector (it is "Not Available"). *Id*. Then, block D is evaluated; its spatial motion vector prediction candidate is selected for S_0 because it is an inter block with motion vector prediction information. Nakamura proceeds in this manner, stepping through the spatial derivation order to select S_1, until two spatial candidates (S_0 and S_1) are selected for the MVP list. Ex-1009, 000012; Ex-1007, §2.2.2, Table 3. In this example, those two candidates come from blocks D and B. Block A is intra and does not have a motion vector; block E is not checked because two spatial candidates were already found before the spatial derivation order reached block E. Ex-1009, 000008.

279. The MVP list is **a motion vector prediction list for a prediction unit of the encoded block of pixels.** Nakamura teaches the motion vector predictor (MVP) list comprises two "spatial candidates" found from "the position[s] of the spatial neighbors relative to the current prediction unit" of the current block. Ex-1007, §2.2.2, Tables 3-4, Fig. 3(b). A "prediction mvpLX of the motion vector mvLX" is derived using the MVP list ("mvpListLX") and an index ("mvp_idx_lX"). Ex-1010, §8.4.2.1.7. One of the candidates from the MVP list (mvpLX) is assigned as the motion vector prediction for the current prediction unit, as indicated by the index. *See id.* (explaining that the prediction mvpLX is the output of the derivation process for the motion vector prediction for the current prediction unit); Ex-1010, §7.4.7 (explaining that "mvp_idx_lc," "mvp_idx_l0,"

and “mvp_idx_l1” “specif[y] the motion vector predictor index” of an MVP list for a prediction unit), §8.4.2.1.1; *see also* Ex-1010, §7.3.7, §9.3.1.1, Table 9-17 (showing that “mvp_idx_lc,” “mvp_idx_l0,” and “mvp_idx_l1” are associated with the initialization of a prediction unit). Therefore, the MVP list is a motion vector prediction list for the PU for the current block.

280. **Where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates.** For example, WD4 teaches that information of spatial candidates include “motion vectors” and “availability flags[.]” Ex-1010, §8.4.2.1.8. The “MVP list” includes two “spatial candidates” and thus includes this information. Ex-1007, Tables 3-4; §2.2.2.

281. Based on the foregoing explanations, Ground 3 teaches limitation [9a].

282. (This paragraph number intentionally skipped.)

[9b]	**determining a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;**

283. Ground 3 teaches limitation [9b] in two independent ways: merge mode and MVP mode. Either teaching is sufficient by itself to satisfy the claims.

Merge Mode

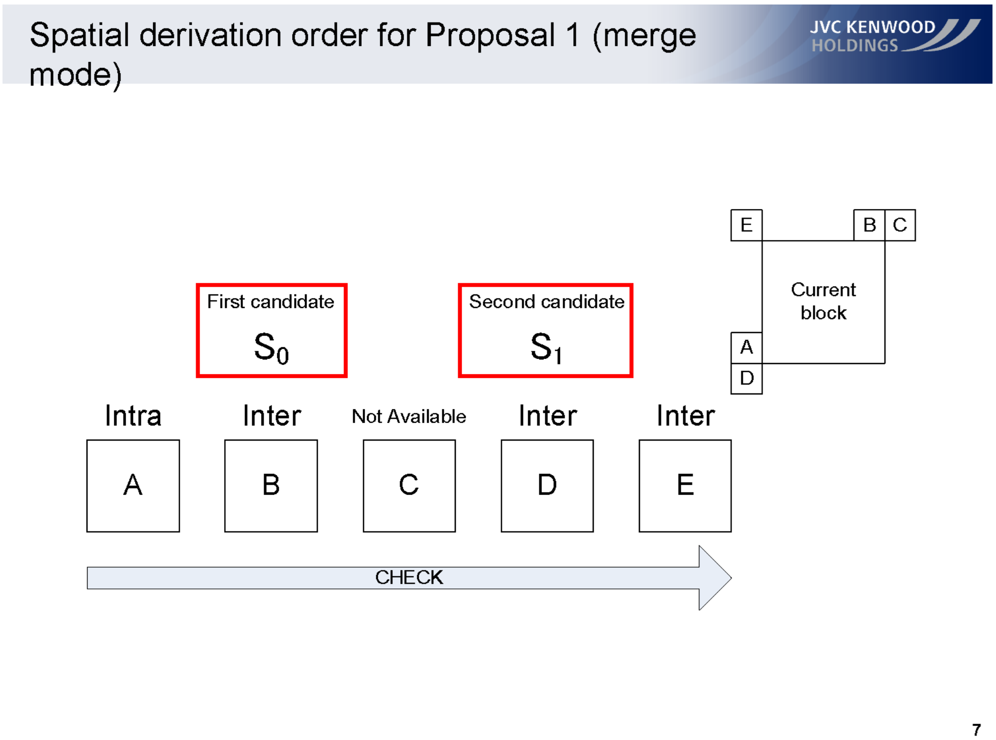
284. Ground 3 teaches **determining a subset of spatial motion vector prediction candidates.** For example, for merge mode, Nakamura derives two candidates out of the candidates from five spatially-neighboring blocks. For example, Nakamura teaches that "[t]wo spatial merging candidates are derived in the spatial derivation process[]" from five "spatial neighbors A, B, C, D, and E relative to the current prediction unit[.]" Ex-1007, §2.2.1, Tables 1, 4; Ex-1009, 000010, 000014; Ex-1007, Table 2 ("2 in 5 [positions]", "S_0, S_1"); Ex-1009, 000008; *supra* §V.D.

285. As explained further below, Nakamura teaches a removal process that compares S_0 with S_1 to check for redundancy when determining whether to include or exclude S_1. Ex-1007, Tables 2, 4 ("S_0 vs S_1"); Ex-1008, §8.4.2.1.1; Ex-1009, 000010, 13; Ex-1010, §8.4.2.1.1. Therefore, Nakamura determines a subset of spatial motion vector prediction candidates (e.g., S_0).

Table 2 Comparison between HM3.0 and proposed technique for merge mode

	HM3.0	Proposal 1
The number of spatial candidates	4 in 4 [positions]	2 in 5 [positions]
Spatial derivation order	A, B, C, D	A, B, C, D, E
The number of times of comparison of redundant candidates in the spatial derivation process	0 [time]	0 [time]
The number of temporal candidates	1	1
Merging candidate list order	A, B, Col, C, D	S_0, S_1, Col
The number of times of comparison in the removal process	10 [times] (A vs B, Col, C, D, B vs Col, C, D, Col vs C, D, and C vs D)	3 [times] (S_0 vs S_1, S_0 vs Col, and S_1 vs Col)

286. Additionally, as explained for [9a], Nakamura proceeds sequentially to select S_0 and then S_1. When S_1 is being selected, the merge list includes a subset of one spatial motion vector prediction candidate (S_0). *E.g.*, Ex-1009, 000008, 000010; Ex-1007, Table 2; *supra* §VI.B.2[9a]. This is a subset of spatial motion vector prediction candidates (e.g., S_0). Ex-1009, 000008; *see also* Ex-1007, §2.2.1, Ex-1009, 000010:



287. The determination is **based on the location of the block associated with the first spatial motion vector prediction candidate.** Here, "the" block recited in [9b] has an antecedent basis in [9a]: "*a first spatial motion vector prediction candidate* from a set of spatial motion vector prediction candidates for *an encoded block of pixels*[.]" Therefore, the block associated with the first spatial motion vector prediction candidate is the current block for which motion vector prediction candidates are being analyzed. *Supra* §V.C.

288. Nakamura determines its subset based on the location of the current block because the subset is determined from a set of "spatial neighbors A, B, C, D and E relative to the current prediction unit" for the current block. Ex-1007, §2.2.1, Fig. 2(b). The spatial neighbors A, B, C, D and E are all determined from

their position relative to the current block—they are the neighboring blocks above and to the left of the current block. Ex-1007, §2.2.1; Ex-1009, 000008. S_0 and S_1 are both selected from these spatial neighbors; therefore, S_0 and S_1 are also determined based on the location of the current block by analyzing candidates from spatial neighbors of the current block. Ex-1007, §2.2.1, Fig. 2(b).

289. Additionally, the subset comprising candidate S_0 is determined based on the location of the current block: it is the first available spatial motion vector prediction candidate from the neighboring blocks of the current block, following Nakamura's spatial derivation order which is defined based on the relative position of blocks around the current block. Ex-1009, 000008, 000010; Ex-1007, §2.2.1, Fig. 2; Ex-1008, §8.4.2.1.2, Fig. 8-3.

290. In the HEVC context, each PU corresponds with a block of pixels. Ex-1010, §6.3; *see also* Ex-1005, ¶33. The merge mode process iteratively steps through blocks in a frame, and in each step, evaluates spatial motion vector prediction candidates for the current block. Ex-1007, §2.2.1; Ex-1008, §8.4.2.1.1 (constructing mergeCandList in a specified order); Ex-1010, §8.4.2.1.1.

MVP Mode

291. For MVP mode, Ground 3 teaches limitation [9b] in a similar manner explained above for Merge Mode. Ex-1007, §2.2.2, Table 4; Ex-1009, 000005,

000014. Indeed, Nakamura proposed a "unification of the location of spatial neighbors for merge mode and MVP" and a "unification of the derivation process for merge mode and MVP." Ex-1007, Abstract.

292. Ground 3 teaches **determining a subset of spatial motion vector prediction candidates.** For example, Nakamura teaches that "[t]wo in five spatial candidates are derived… in the spatial derivation process." Ex-1007, §2.2.2, Tables 1, 4; Ex-1009, 000012-14; Ex-1007, Table 3 ("2 in 5 [positions]", "$mvLXS_0$, $mvLXS_1$"). Nakamura teaches that selecting "[t]wo in five spatial candidates" in MVP mode is a known process since earlier iterations of H.265 (e.g., HM3.0). Ex-1009, 000013 (comparing the MVP mode of HM3.0 and the proposed technique); *supra* §V.D.

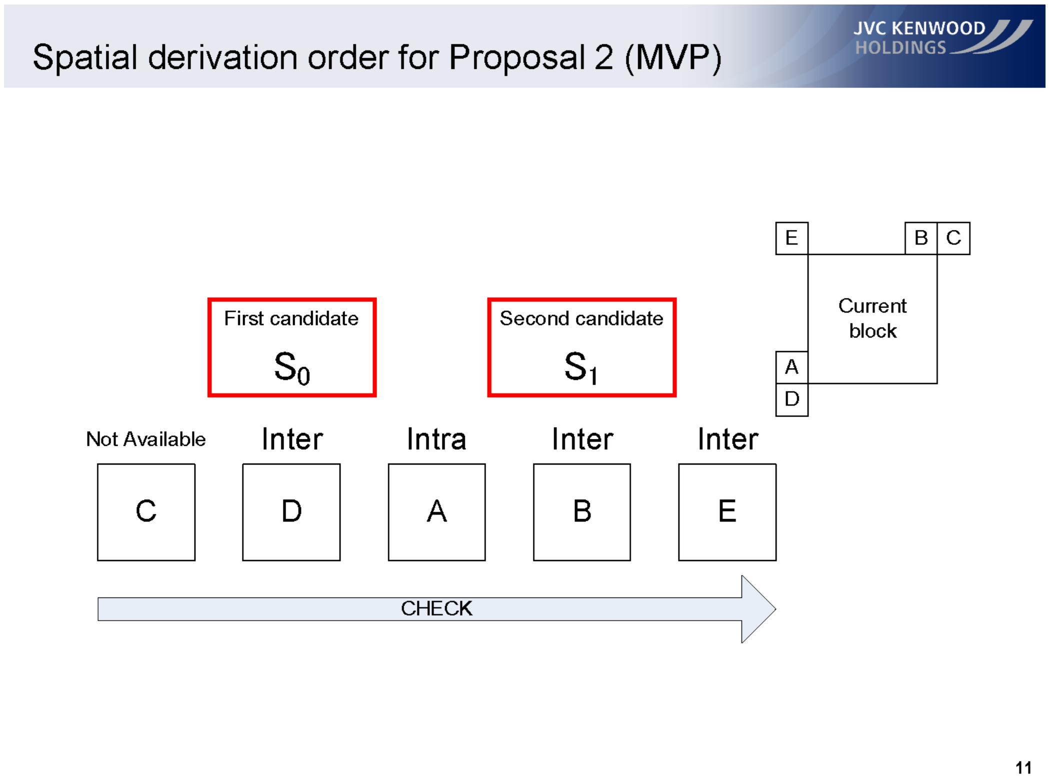
293. As explained further below, Nakamura teaches a removal process that compares S_0 with S_1 to check for redundancy when determining whether to include or exclude S_1. Ex-1007, Fig. 1 (describing a removal process), Table 3 ("$mvLXS_0$ vs $mvLXS_1$"), Table 4; Ex-1009, 000008, 000010, 000020.[6] Therefore, Nakamura determines a subset of spatial motion vector prediction candidates (e.g., S_0, a.k.a. $mvLXS_0$).

[6] Nakamura at times refers to S_0 as $mvLX\mathbf{S_0}$ and S_1 as $mvLX\mathbf{S_1}$.

Table 3 Comparison of HM3.0 between HM3.0 and proposed technique for MVP

	HM3.0	Proposal 2
The number of spatial candidates	2 in 5 [positions]	2 in 5 [positions]
Grouping of the neighbors in the spatial derivation process	Group A: Left (A_0, A_1) Group B: Upper (B_0, B_1, B_2)	without grouping
Spatial derivation order	Group A: A_0, A_1 Group B: B_0, B_1, B_2	C, D, A, B, E
The number of times of checking per spatial neighbors in the spatial derivation process	2 [times]	1 [time]
The number of times of comparison of redundant candidates in the spatial derivation process	6 [times] (mvLXA vs $mvLXB_0$, mvLXA vs $mvLXB_1$, and mvLXA vs $mvLXB_2$) x 2	0 [time]
The number of temporal candidates	1	1
MVP list order	mvLXA, mvLXB, mvLXCol	$mvLXS_0$, $mvLXS_1$, mvLXCol
The number of times of comparison in the removal process	2 [times] (mvLXA vs mvLXCol, and mvLXB vs mvLXCol)	3 [times] ($mvLXS_0$ vs $mvLXS_1$, $mvLXS_0$ vs mvLXCol, and $mvLXS_1$ vs mvLXCol)

294. Additionally, as explained for [9a], Nakamura proceeds sequentially to select S_0 and then S_1. When S_1 is being selected, the merge list includes a subset of one spatial motion vector prediction candidate (S_0). *E.g.*, Ex-1009, 000012-000013; Ex-1007, Table 3; *supra* §VI.B.2[9a]. This is a subset of spatial motion vector prediction candidates (e.g., S_0). Ex-1007, Table 3, Table 4; Ex-1009, 000012-14:



295. The determination is **based on the location of the block associated with the first spatial motion vector prediction candidate.** Here, "the" block recited in [9b] has an antecedent basis in [9a]: "a *first spatial motion vector prediction candidate* from a set of spatial motion vector prediction candidates for *an encoded block of pixels*[.]" Therefore, the block associated with the first spatial motion vector prediction candidate is the current block for which motion vector prediction candidates are being analyzed. *Supra* §V.C.

296. Nakamura determines its subset based on the location of the current block because the subset is determined from a set of "spatial neighbors relative to the current prediction unit" for the current block. Ex-1007, §2.2.2, Fig. 3(b). The

spatial neighbors A, B, C, D and E are all determined from their position relative to the current block—they are the neighboring blocks above and to the left of the current block. Ex-1007, §2.2.2, Fig. 3(b); Ex-1009, 000008. S_0 and S_1 are both selected from these spatial neighbors; therefore, S_0 and S_1 are also determined based on the location of the current block by analyzing candidates from spatial neighbors of the current block. *See id.*

297. Additionally, the subset comprising candidate S_0 is determined based on the location of the current block: it is the first available spatial motion vector prediction candidate from the neighboring blocks of the current block, following Nakamura's spatial derivation order which is defined based on the relative position of blocks around the current block. Ex-1007, Tables 3-4; Ex-1009, 000012-14.

298. In the HEVC context, each PU corresponds with a block of pixels. Ex-1010, §6.3; *see also* Ex-1005, ¶33. Nakamura and WD4 teach iteratively stepping through each block in a frame and, in each step, evaluating spatial motion vector prediction candidates for the current block. Ex-1007, §2.2.1; Ex-1010, §8.4.2.1.7 (constructing mvpListLX in a specified order).

299. Based on the foregoing explanations, Ground 3 teaches limitation [9b].

[9c]	**comparing motion information of the first spatial motion vector prediction candidate with motion information of another spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;**

300. Ground 3 teaches limitation [9c] in two independent ways: merge mode and MVP mode. Either teaching is sufficient by itself to satisfy the claims.

Merge Mode

301. Ground 3 teaches **comparing motion information of the first spatial motion vector prediction candidate** (e.g., for S_1) **with motion information of another spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates** (e.g., the subset comprising S_0). For merge mode, WD4 removed duplicate candidates from the merge list. Ex-1010, §8.4.2.1.1. Consistent with those teachings, Nakamura teaches comparing the two spatial candidates (S_0 and S_1) to "[r]emove candidates with the same motion information[.]" Ex-1007, Fig. 1, Table 4, Table 2:

Table 2 Comparison between HM3.0 and proposed technique for merge mode

	HM3.0	Proposal 1
The number of spatial candidates	4 in 4 [positions]	2 in 5 [positions]
Spatial derivation order	A, B, C, D	A, B, C, D, E
The number of times of comparison of redundant candidates in the spatial derivation process	0 [time]	0 [time]
The number of temporal candidates	1	1
Merging candidate list order	A, B, Col, C, D	S_0, S_1, Col
The number of times of comparison in the removal process	10 [times] (A vs B, Col, C, D, B vs Col, C, D, Col vs C, D, and C vs D)	3 [times] (S_0 vs S_1, S_0 vs Col, and S_1 vs Col)

302. As illustrated in Table 2, above, the overall removal process for WD3 required 10 comparisons because the merge list included 5 candidates (4 spatial candidates A-D plus a temporal candidate "Col"), and each pair from the set of 5 had to be compared to identify all redundant candidates. Since there were 10 possible pairings for the five candidates, 10 comparisons were needed for WD3 to determine if there were duplicates. Ex-1007, Fig. 1, Table 4, Table 2.

303. Nakamura reduced the number of spatial candidates to 2, meaning the merge list included 3 candidates total: two spatial candidates (S_0 and S_1) plus a temporal candidate "Col." Ex-1007, Fig. 1, Table 4, Table 2; Ex-1009, 000010. Since there were only 3 candidates, the removal process only required three comparisons: one comparison of the two spatial candidates (S_0 and S_1), one

comparison of the temporal candidate with S_0, and one comparison of the temporal candidate with S_1. Ex-1007, Table 2.

304. The comparison between the spatial candidates (S_0 and S_1) involves comparing their motion information, which includes "motion vectors" and "reference indices[.]" Ex-1010, §8.4.2.1.1 ("When merging candidates have the [same] motion vectors and the same reference indices, the merging candidates are removed from the list except the merging candidate which has the smallest order in the mergeCandList.").

305. In addition, while not required by the Challenged Claims, a POSITA would have found it obvious to apply Nakamura's teachings, for removing duplicates, when spatial motion vector prediction candidates (e.g., S_0 and S_1) are identified and considered for potential inclusion in the merge list. This would have been obvious because it is a straightforward way to prevent redundant candidates in the merge list, as Nakamura and WD4 teach. Ex-1007, Fig. 1. Moreover, Nakamura teaches comparing S_0 with S_1 and then comparing the temporal candidate with the spatial candidates (Ex-1007, Table2, Table 4; Ex-1009, 000010, 000013; Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2); this is consistent with an implementation that compares a potential candidate with those already in the merge list when the potential candidate is being considered. For example, when evaluating S_1, it is compared with the only candidate in the merge list S_0; when

evaluating the temporal candidate, it is compared with the two spatial candidates in the merge list, resulting in a maximum of the three comparisons, as Nakamura teaches. Ex-1007, Fig. 1, Table 4, Table 2.

306. Ground 3 teaches **comparing… without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates.** For example, Nakamura makes the above-described comparison (between S_0 and S_1) without making a comparison of each pair from the set of spatial candidates (from blocks A, B, C, D, and E). Ex-1007, Tables 1-2, 4. Indeed, that is the purpose of Nakamura's proposal, to reduce the number of comparisons by avoiding a comparison of each pair of candidates from blocks A, B, C, D, and E. *E.g.*, Ex-1007, Fig. 1, Tables 2, 4. Nakamura teaches that reducing "[t]he number of candidates… in the spatial derivation process… reduce[s] the number of times of comparison in the removal process." Ex-1007, §2.2.1, Table 1. Thus, the application of these teachings from Nakamura improves coding efficiency by reducing the number of comparisons needed for removing duplicates.

MVP Mode

307. For MVP mode, Ground 3 teaches limitation [9c] in a similar manner explained above for Merge Mode. For example, Nakamura teaches comparing the

two spatial candidates ($mvLXS_0$ and $mvLXS_1$) as part of a removal process that "[r]emove[s] candidates with the same motion information[.]" Ex-1007, Fig. 1, Table 4, Table 3:

Table 3 Comparison of HM3.0 between HM3.0 and proposed technique for MVP

	HM3.0	Proposal 2
The number of spatial candidates	2 in 5 [positions]	2 in 5 [positions]
Grouping of the neighbors in the spatial derivation process	Group A: Left (A_0, A_1) Group B: Upper (B_0, B_1, B_2)	without grouping
Spatial derivation order	Group A: A_0, A_1 Group B: B_0, B_1, B_2	C, D, A, B, E
The number of times of checking per spatial neighbors in the spatial derivation process	2 [times]	1 [time]
The number of times of comparison of redundant candidates in the spatial derivation process	6 [times] (mvLXA vs $mvLXB_0$, mvLXA vs $mvLXB_1$, and mvLXA vs $mvLXB_2$) x 2	0 [time]
The number of temporal candidates	1	1
MVP list order	mvLXA, mvLXB, mvLXCol	$mvLXS_0$, $mvLXS_1$, mvLXCol
The number of times of comparison in the removal process	2 [times] (mvLXA vs mvLXCol, and mvLXB vs mvLXCol)	3 [times] ($mvLXS_0$ vs $mvLXS_1$, $mvLXS_0$ vs mvLXCol, and $mvLXS_1$ vs mvLXCol)

308. As illustrated in Table 3, above, the removal process involves one comparison of spatial candidates: $mvLXS_0$ vs $mvLXS_1$. Ex-1007, Table 3. Thus, Nakamura compares the first spatial motion vector prediction candidate (e.g., for S_1, a.k.a. $mvLXS_1$) with motion information of spatial motion vector prediction candidates in the determined subset of spatial motion vector prediction candidates (e.g., the subset comprising S_0, a.k.a. $mvLXS_0$).

309. The comparison between the spatial candidates involves comparing their motion information, which includes their "motion vectors[.]" Ex-1010, §8.4.2.1.7 ("When motion vectors have the same value, the motion vectors are removed from the list except the motion vector which has the smallest order in the mvpListLX.").

310. Here, WD4 uses "mvpListLX" to reference the MVP list taught by Nakamura. For example, Nakamura refers to the MVP list under HM3.0 which includes spatial candidates "mvLXA, mvLXB," which are the same spatial candidates in mvpListLX as taught by WD4. *Compare* Ex-1007, (referring to spatial candidates mvLXA and mvLXB) with Ex-1010, §8.4.2.1.7 (referring to spatial candidates mvLXA and mvLXB).

311. Nakamura's MVP mode teaches **comparing… without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates.** For example, Nakamura teaches comparing the spatial candidates $mvLXS_0$ and $mvLXS_1$ without making a comparison of each pair from the set of spatial candidates, including blocks A, B, C, D, and E. Ex-1007, Tables 1, 3-4. Furthermore, Nakamura teaches that "[t]he number of times of comparison of redundant candidates in the spatial derivation process" is reduced to 0. Ex-1007, Table 3; Ex-1009, 000013. Thus, both the spatial derivation process

and the removal process do not make a comparison of each pair from the set of spatial candidates. Ex-1007, Table 3; Ex-1009, 000013.

312. In addition, while not required by the Challenged Claims, a POSITA would have found it obvious to apply Nakamura's teachings, for removing duplicates, when spatial motion vector prediction candidates (e.g., S_0 and S_1) are identified and considered for potential inclusion in the MVP list. This was explained for merge mode; that analysis applies here. *Supra* ¶305.

313. Based on the foregoing explanations, Ground 3 teaches limitation [9c].

[9d]	**determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and**

314. Ground 3 teaches limitation [9d] in two independent ways: merge mode and MVP mode. Either teaching is sufficient by itself to satisfy the claims.

Merge Mode

315. Ground 3 teaches **determining to include or exclude the first spatial motion vector prediction candidate** (e.g., S_1) **in the motion vector prediction list** (e.g., merging candidate list) **based on the comparing**. For example, for merge mode, Nakamura teaches "[r]emov[ing] candidates with the same motion information" in the removal process. Ex-1007, Fig. 1(a).

316. As explained above, Nakamura compares motion information for the first spatial motion vector prediction candidate (S_1) with a subset (S_0). Ex-1007, Fig. 1, Tables 2, 4; Ex-1010, §8.4.2.1.1; *supra* §VI.B.2[9c]. Nakamura determines whether to include or exclude S_1 in the merge list based on this comparison: if the motion information is different, then both S_0 and S_1 are included in the merging candidate list. Ex-1007, Fig. 1; Ex-1010, §8.4.2.1.1. Conversely, if the motion information is the same, then S_1 is redundant to S_0, and Nakamura excludes S_1 in the merging candidate list based on the comparison while S_0 is included because it has the smaller order (it is earlier in the spatial derivation order): "candidates are removed from the list except the merging candidate which has the smallest order in the mergeCandList[.]" Ex-1010, §8.4.2.1.1.

<u>*MVP Mode*</u>

317. For MVP mode, Ground 3 teaches limitation [9d] in a similar manner explained above for Merge Mode. Ex-1007, §2.2.2, Table 4; Ex-1009, 000005, 000014. Indeed, Nakamura proposed a "unification of the location of spatial neighbors for merge mode and MVP" and a "unification of the derivation process for merge mode and MVP." Ex-1007, Abstract.

318. Ground 3 teaches **determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based**

on the comparing. For example, for MVP mode, Nakamura teaches "[r]emov[ing] candidates with the same motion information" in the removal process. Ex-1007, Fig. 1(b).

319. As explained above, Nakamura compares motion information for the first spatial motion vector prediction candidate ($mvLXS_1$) with a subset ($mvLXS_0$). Ex-1007, Fig. 1, Tables 3-4; Ex-1010, §8.4.2.1.7; *supra* §VI.B.2[9c]. Nakamura determines whether to include or exclude $mvLXS_1$ in the MVP list based on this comparison: if the motion information is different, then both $mvLXS_0$ and $mvLXS_1$ are included in the merging candidate list. Ex-1007, Fig. 1; Ex-1010, §8.4.2.1.1. Conversely, if the motion information is the same, then $mvLXS_1$ is redundant to $mvLXS_0$, and Nakamura excludes $mvLXS_1$ in the MVP list based on the comparison while $mvLXS_0$ is included because it has the smaller order (it is earlier in the spatial derivation order): "motion vectors are removed from the list except the motion vector which has the smallest order in the mvpListLX[.]" Ex-1010, §8.4.2.1.7.

320. Based on the foregoing explanations, Ground 3 teaches limitation [9d].

[9e]	**selecting a spatial motion vector prediction candidate from the motion vector prediction list for use in decoding the encoded block of pixels, wherein the spatial motion vector prediction candidate is selected from the motion vector prediction list using information that was received identifying a respective spatial motion vector prediction candidate from the motion vector prediction list constructed by an encoder.**

321. Ground 3 teaches limitation [9e], as explained below.

<u>Merge Mode</u>

322. The teachings of merge mode in Nakamura in view of WD4 teach **selecting a spatial motion vector prediction candidate from the motion vector prediction list for use in decoding the encoded block of pixels**. For example, WD4 teaches a merge index (e.g., "merge_idx") that "specifies the merging candidate index of the merging candidate list[.]" Ex-1010, §7.4.7. Based on the merge_idx, one spatial "candidate at position merge_idx[xP][yP] in the merging candidate list mergeCandList" is assigned as the spatial candidate to use for prediction of the current block. Ex-1010, §8.4.2.1.1. As I also explained above, the spatial merging candidate contains motion information such as the motion vector and reference index and is used for the prediction of a block. *See supra* §VI.B.2[9a]. Therefore, WD4 teaches using merge_idx to select the spatial candidate from the motion vector prediction list for use in decoding the encoded block of pixels.

323. The teachings of merge mode in Nakamura and WD4 teach **the spatial motion vector prediction candidate is selected from the motion vector prediction list using information that was received identifying a respective spatial motion vector prediction candidate from the motion vector prediction list constructed by an encoder**. For example, WD4 teaches that the merge_idx is received by the decoder from the encoder. WD4 teaches a "[p]rediction unit syntax" that describes what information is encoded for a prediction unit. Ex-1010, §7.3.7 (red square highlights added; other markings in original):

prediction_unit(x0, y0~~, log2PUWidth, log2PUHeight, PartIdx~~) {	**Descriptor**
if(skip_flag[x0][y0]) {	
merge_idx[x0][y0]	ue(v) | ae(v)
} else if(PredMode = = MODE_INTRA) {	
if(PartMode == PART_2Nx2N && log2CUSize~~PUWidth~~ >= Log2MinIPCMCUSize)	
pcm_flag	u(1) | ae(v)
if(pcm_flag) {	
while (!byte_aligned( ))	
pcm_alignment_zero_bit	u(v)
for(i = 0; i < 1 << (log2CUSize << 1); i++)	
pcm_sample_luma[i]	u(v)
for(i = 0; i < (1 << (log2CUSize << 1)) >> 1; i++)	
pcm_sample_chroma[i]	u(v)
} else {	
prev_intra_luma_pred_flag[x0][y0]	u(1) | ae(v)
if(prev_intra_luma_pred_flag[x0][y0])	
if(NumMPMCand > 1)	
mpm_idx[x0][y0]	u(1) | ae(v)
else	
rem_intra_luma_pred_mode[x0][y0]	ce(v) | ae(v)
if(IntraPredMode[x0][y0] == 2)	
planar_flag_luma[x0][y0]	u(1) | ae(v)

<table>
<tr><td>intra_chroma_pred_mode[x0][y0]</td><td>ue(v) | ae(v)</td></tr>
<tr><td>SignaledAsChromaDC =
(chroma_pred_from_luma_enabled_flag ?
intra_chroma_pred_mode[x0][y0] == 3 :
intra_chroma_pred_mode[x0][y0] == 2)</td><td></td></tr>
<tr><td>if(IntraPredMode[x0][y0] != 2 &&
IntraPredMode[x0][y0]!=34 && SignaledAsChromaDC)</td><td></td></tr>
<tr><td>planar_flag_chroma[x0][y0]</td><td>u(1) | ae(v)</td></tr>
<tr><td>}</td><td></td></tr>
<tr><td>} else { /* MODE_INTER */</td><td></td></tr>
<tr><td>if(entropy_coding_mode_flag || PartMode != PART_2Nx2N)</td><td></td></tr>
<tr><td>merge_flag[x0][y0]</td><td>u(1) | ae(v)</td></tr>
<tr><td>if(merge_flag[x0][y0]) {</td><td></td></tr>
<tr><td>merge_idx[x0][y0]</td><td>ue(v) | ae(v)</td></tr>
<tr><td>} else {</td><td></td></tr>
<tr><td>if(slice_type == B) {</td><td></td></tr>
<tr><td>if(!entropy_coding_mode_flag) {</td><td></td></tr>
<tr><td>combined_inter_pred_ref_idx</td><td>ue(v)</td></tr>
<tr><td>if(combined_inter_pred_ref_idx == MaxPredRef)</td><td></td></tr>
<tr><td>inter_pred_flag[x0][y0]</td><td>ue(v)</td></tr>
<tr><td>} else</td><td></td></tr>
<tr><td>inter_pred_flag[x0][y0]</td><td>ue(v) | ae(v)</td></tr>
<tr><td>}</td><td></td></tr>
<tr><td>if(inter_pred_flag[x0][y0] == Pred_LC) {</td><td></td></tr>
<tr><td>if(num_ref_idx_lc_active_minus1 > 0) {</td><td></td></tr>
</table>

The prediction unit syntax describes information encoded for a prediction unit. For example, for a "prediction_unit(x0, y0)" or a prediction unit located at x0, y0, a "skip_flag[x0][y0] equal to 1 specifies that for the current coding unit… no more syntax elements except the motion vector predictor indices[,]" which is merge_idx, "are parsed[.]" Ex-1010, §7.4.6. As another example, "merge_flag[x0][y0] specifies whether the inter prediction parameters for the current prediction unit are inferred from a neighbouring inter-predicted partition[,]" which is merge mode. Ex-1010, §7.4.7. If merge_flag is set equal to 1, then "merge_idx[x0][y0] specifies the merging candidate index of the merging candidate list[.]" Ex-1010, 7.4.7. The prediction unit is encoded into the bitstream that is received by a decoder. Ex-1010, §7.3.7, §0.2, §3.11, §3.12, §3.34, §3.38.

324. A POSITA would have known, and it would have been obvious, that the merging candidate list, mergeCandList, is constructed by the encoder. As seen from above, merge_idx is generated in the encoding process and is stored as part of an encoded video, since it is part of information encoded for a prediction unit. The encoder generates the list of spatial motion vector prediction candidates so that the merge_idx points to a specific merging candidate used for predicting the motion vector for the current block. Ex-1008, §8.4.2.1.1; Ex-1010, §7.3.7, §7.4.7, §8.4.2.1.1.

325. As merge_idx identifies the merging candidate index of the merging candidate list, it is for use in decoding the encoded block by the decoder. WD4 teaches that, in the derivation process for luma motion vectors, the decoder uses merge_idx to select a merging candidate as the spatial candidate assigned as the motion vector predictor for the current prediction unit. WD4 teaches that this is achieved by setting the motion vector information (e.g., mvLX), reference index (e.g., refIdxLX), and prediction list utilization flags (e.g., predFlagLX) to those of the spatial candidate.:

> The following assignments are made with N being the candidate at position merge_idx[xP][yP] in the merging candidate list

mergeCandList (N = mergeCandList[merge_idx[xP][yP]]) and X being replaced by 0 or 1:

mvLX[0] = mvLXN[0] (8 88)

mvLX[1] = mvLXN[1] (8 89)

refIdxLX = refIdxLXN (8 90)

predFlagLX = predFlagLXN (8 91)

§8.4.2.1.1.

326. Therefore, WD4 teaches using merge_idx to select a merging candidate from the merging candidate list, which is constructed by the encoder. Accordingly, merge_idx is information received by WD4's decoder to identify a respective spatial motion vector prediction candidate from the motion vector prediction list constructed by an encoder. WD4 teaches using merge_idx to select spatial motion vector prediction candidate from the motion vector prediction list for use in decoding the encoded block of pixels. Nakamura and WD4 teach, or at least suggest, that the decoder receives merge_idx from the encoder because it is used by the encoder to create the video bitstream and saved as a syntax element into the bitstream, which is then received by the decoder. Ex-1010, §3.11, §3.12, §3.34, §3.38, §8.4.2.1.1. The encoder and decoder independently construct identical merge lists (mergeCandList) and use merge_idx to identify which candidate in the list was used for a particular PU. Ex-1008, §8.4.2.1.1; Ex-1010, §7.3.7, §7.4.7, §8.4.2.1.1.

327. Nakamura confirms that its merge mode teachings are used in the encoding and decoding processes by providing experimental results showing improvements at both the encoder and the decoder based on its teachings. Ex-1007, Tables 5-8, 11-12; Ex-1009, 000016, 000018. Nakamura also presents the substantially similar teachings for the derivation of luma motion vectors in the decoder like WD4. Ex-1018, §8.4.2.1.1; *see also* §VI.B.1 (explaining that the teachings of motion vector derivation are similar in Nakamura and WD4). At the very least, a POSITA would have found it obvious that the decoder would receive the merge_idx with an encoded video so that, when the decoder receives the video transmitted from the encoder, the decoder can use the merge_idx to decode the video.

<u>MVP Mode</u>

328. The teachings of the MVP mode in Nakamura in view of WD4 teach **selecting a spatial motion vector prediction candidate from the motion vector prediction list for use in decoding the encoded block of pixels**. For example, WD4 teaches an MVP index (e.g., "mvp_idx_l0") that "specifies the motion vector predictor index[.]" Ex-1010, §7.4.7. Based on mvp_idx_l0, a "motion vector of mvpListLX… is assigned" as the spatial candidate to use for prediction of the current block. Ex-1010, §8.4.2.1.7; *supra* §VI.B.2[9a]. Therefore, WD4 teaching

using mvp_idx_l0 to identify the spatial candidate from the motion vector prediction list to be used for decoding the encoded block of pixels

329. The teachings of the MVP mode in Nakamura in view of WD4 also teach **the spatial motion vector prediction candidate is selected from the motion vector prediction list using information that was received identifying a respective spatial motion vector prediction candidate from the motion vector prediction list constructed by an encoder**. For example, WD4 teaches that the mvp_idx_l0 is received by the decoder from the encoder. For example, WD4 teaches a "[p]rediction unit syntax" that describes what information is encoded for a prediction unit. Ex-1010, §7.3.7 (red square highlights added; other markings in original):

else { /* Pred_L0 or Pred_BI */	
if(num_ref_idx_l0_active_minus1 > 0) {	
if(!entropy_coding_mode_flag) {	
if(combined_inter_pred_ref_idx == MaxPredRef)	
ref_idx_l0_minusX[x0][y0]	ue(v)
} else	
ref_idx_l0_minusX[x0][y0]	ue(v) | ae(v)
}	
mvd_l0[x0][y0][0]	se(v) | ae(v)
mvd_l0[x0][y0][1]	se(v) | ae(v)
mvp_idx_l0[x0][y0]	ue(v) | ae(v)
}	
if(inter_pred_flag[x0][y0] = = Pred_BI) {	
if(num_ref_idx_l1_active_minus1 > 0) {	
if(!entropy_coding_mode_flag) {	
if(combined_inter_pred_ref_idx == MaxPredRef)	
ref_idx_l1_minusX[x0][y0]	ue(v)
} else	
ref_idx_l1[x0][y0]	ue(v) | ae(v)
}	
mvd_l1[x0][y0][0]	se(v) | ae(v)
mvd_l1[x0][y0][1]	se(v) | ae(v)
mvp_idx_l1[x0][y0]	ue(v) | ae(v)
}	

The prediction unit syntax describes information encoded for a prediction unit. For example, for a "prediction_unit(x0, y0)" or a prediction unit located at x0, y0, an "inter_pred_flag[x0][y0] specifies… [t]he array indices[,]" which includes mvp_idx_l0, used for prediction of "the considered prediction block[.]" Ex-1010, §7.4.7, §0.2, §3.11, §3.12, §3.34, §3.38. Therefore, mvp_idx_l0 is transmitted along with the encoded video to a decoder.

330. A POSITA would have known, and it would have been obvious, that the MVP candidate list is constructed by the encoder. As is clear from above,

MVP indices such as mvp_idx_10 are generated in the encoding process and is stored as part of an encoded video, since they are part of information encoded for a prediction unit. The encoder generates the list of MVP candidates so that the MVP indices such as mvp_idx_10 point to a specific MVP candidate used for predicting the motion vector for the current block.

331. Nakamura confirms that its MVP mode teachings are used in the encoding and decoding processes by providing experimental results showing improvements at both the encoder and the decoder based on its teachings. Ex-1007, Tables 5-6, 9-12; Ex-1009, 000017-18. For example, Nakamura teaches that the decoder performs decoding in accordance with the techniques it teaches. At the very least, a POSITA would have found it obvious that the decoder uses the mvp_idx_l0 transmitted by the encoder to decode the video.

332. Based on the foregoing explanations, Ground 3 teaches limitation [9e].

3. Dependent Claim 10

10.	**The method according to claim 9 further comprising comparing motion information of the potential spatial motion vector prediction candidate with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates.**

333. Ground 3 teaches claim 10 in two independent ways: merge mode and MVP mode. Either teaching is sufficient by itself to satisfy the claims.

Merge Mode

334. Ground 3 teaches **comparing motion information of the potential spatial motion vector prediction candidate** (e.g., S_1) **with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates** (e.g., S_0). For example, Nakamura teaches comparing motion information of two spatial candidates (S_0 and S_1) as part of a removal process that "[r]emove[s] candidates with the same motion information[.]" Ex-1007, Fig. 1, Tables 2, 4; *supra* §VI.B.2[9c]. In the removal process, "[t]he number of times of comparison" is 3, with only one of the comparisons being between the two spatial candidates. Ex-1007, Tables 4, 2:

Table 2 Comparison between HM3.0 and proposed technique for merge mode

	HM3.0	Proposal 1
The number of spatial candidates	4 in 4 [positions]	2 in 5 [positions]
Spatial derivation order	A, B, C, D	A, B, C, D, E
The number of times of comparison of redundant candidates in the spatial derivation process	0 [time]	0 [time]
The number of temporal candidates	1	1
Merging candidate list order	A, B, Col, C, D	S_0, S_1, Col
The number of times of comparison in the removal process	10 [times] (A vs B, Col, C, D, B vs Col, C, D, Col vs C, D, and C vs D)	3 [times] (S_0 vs S_1, S_0 vs Col, and S_1 vs Col)

335. Potential spatial motion vector prediction candidate S_1 is only compared to one other spatial motion vector prediction candidate (S_0). Since "[t]he

merging candidate list is constructed of two spatial merging candidates[,]" S_1 can be compared to at most one other spatial motion vector prediction candidate during the removal process. Ex-1007, §2.2.1. Table 2 confirms this: "comparison[s] in the removal process" are *S_0 vs S_1*, S_0 vs Col, and S_1 vs Col, with S_0 and S_1 being the "spatial candidate[s] found in the spatial derivation process" and Col being a co-located temporal candidate. Ex-1007, Table 2, §2.2.1; *see also* Ex-1008, §8.4.2.1.1. Since Col is a temporal candidate, it is not a spatial motion vector prediction candidate and is not part of the set of spatial motion vector prediction candidates.

336. Therefore, Nakamura teaches comparing motion information of the potential spatial motion vector prediction candidate (e.g., S_1) with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates (e.g., S_0).

<u>*MVP Mode*</u>

337. Ground 3 teaches **comparing motion information of the potential spatial motion vector prediction candidate with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates**. For example, Nakamura teaches comparing motion information of two spatial candidates ($mvLXS_0$ and $mvLXS_1$) as

part of a removal process that "[r]emove[s] candidates with the same motion information[.]" Ex-1007, Fig. 1, Tables 3-4; *supra* §VI.B.2[9c]. In the removal process, "[t]he number of times of comparison" is "3 [times]", with only one of the comparisons being between the two spatial candidates. Ex-1007, Tables 4, 3:

Table 3 Comparison of HM3.0 between HM3.0 and proposed technique for MVP

	HM3.0	Proposal 2
The number of spatial candidates	2 in 5 [positions]	2 in 5 [positions]
Grouping of the neighbors in the spatial derivation process	Group A: Left (A_0, A_1) Group B: Upper (B_0, B_1, B_2)	without grouping
Spatial derivation order	Group A: A_0, A_1 Group B: B_0, B_1, B_2	C, D, A, B, E
The number of times of checking per spatial neighbors in the spatial derivation process	2 [times]	1 [time]
The number of times of comparison of redundant candidates in the spatial derivation process	6 [times] (mvLXA vs $mvLXB_0$, mvLXA vs $mvLXB_1$, and mvLXA vs $mvLXB_2$) x 2	0 [time]
The number of temporal candidates	1	1
MVP list order	mvLXA, mvLXB, mvLXCol	$mvLXS_0$, $mvLXS_1$, mvLXCol
The number of times of comparison in the removal process	2 [times] (mvLXA vs mvLXCol, and mvLXB vs mvLXCol)	3 [times] ($mvLXS_0$ vs $mvLXS_1$, $mvLXS_0$ vs mvLXCol, and $mvLXS_1$ vs mvLXCol)

338. Potential spatial motion vector prediction candidate $mvLXS_1$ is only compared to one other spatial motion vector prediction candidate ($mvLXS_0$). Since "[t]wo in five spatial candidates are derived… in the spatial derivation process[,]" there are at most two spatial candidates, and $mvLXS_1$ can be compared to at most one other spatial motion vector prediction candidate during the removal process. Ex-1007, §2.2.2. Table 3 confirms this: "comparison[s] in the removal process"

are *$mvLXS_0$ vs $mvLXS_1$*, $mvLXS_0$ vs mvLXCol, and $mvLXS_1$ vs mvLXCol, with $mvLXS_0$ and $mvLXS_1$ being the "spatial candidate[s] found in the spatial derivation process" and mvLXCol being a co-located temporal candidate. Ex-1007, Table 3, §2.2.2; Ex-1008, §8.4.2.1.1. Since mvLXCol is a temporal candidate, it is not a spatial motion vector prediction candidate and is not part of the set of spatial motion vector prediction candidates.

339. Therefore, Nakamura teaches comparing motion information of the potential spatial motion vector prediction candidate (e.g., $mvLXS_1$) with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates (e.g., $mvLXS_0$).

340. Based on the foregoing explanations, Ground 3 teaches claim 10.

4. Dependent Claim 11

11.	**The method according to claim 9 further comprising examining whether the received encoded block of pixels is divided into a first prediction unit and a second prediction unit; and if so, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the prediction unit is the second prediction unit.**

341. Ground 3 teaches claim 11. Ground 3 teaches examining the received encoded block of pixels, which is the current block. Ex-1010, §0.2, §§3.11-3.12, §3.34, §3.38; Ex-1007, §2.2.1, Fig. 2; *supra* §§VI.B.2[9a], [9e].

342. For merge mode, Ground 3 teaches **examining whether the received encoded block of pixels**[7] **is divided into a first prediction unit and a second prediction unit; and if so, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the prediction unit is the second prediction unit**. For example, Nakamura and WD4 teach excluding a spatial candidate, by setting it as unavailable with "availableFlagN is set equal to 0[,]" if "one of the following conditions is true[:]… PartMode of the current prediction unit is PART_2NxN and PartIdx is equal to 1…" or "PartMode of the current prediction unit is PART Nx2N and PartIdx is equal to 1[.]" Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. In these passages, Nakamura examines whether the block of pixels is divided into a first and second PU ("PartMode of the current prediction unit" is PART_2NxN or PART Nx2N) and whether the current PUis the second PU ("PartIdx is equal to 1"). If so, Nakamura excludes the potential spatial motion vector prediction candidate from block B (for horizontally-divided blocks) or block A (for vertically-divided blocks) from the motion vector prediction list. This is further explained below.

343. For HEVC, partition mode PART_2NxN refers to a block that is horizontally divided into two equal PUs; PART_Nx2N refers to a block vertically

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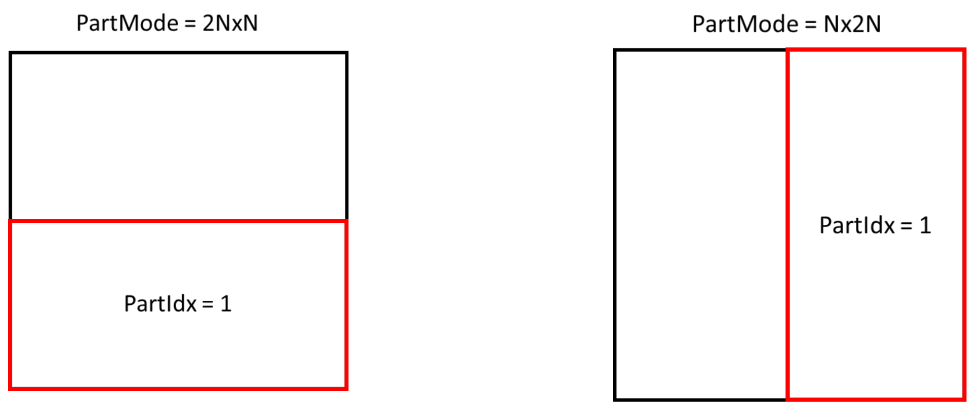
[7] The "received encoded block of pixels" appears to reference "a block of pixels" in [9a]. As explained above, the block of pixels is the current block for which motion vector prediction candidates are being analyzed. *Supra* §VI.B.2[9a].

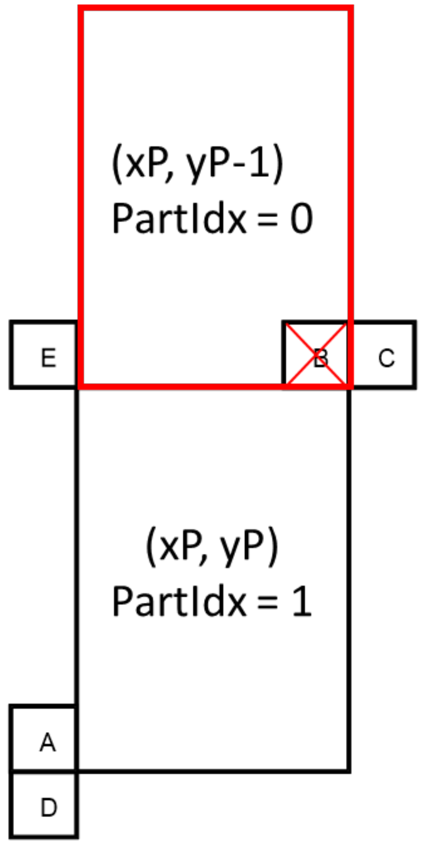
divided into two equal PUs. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2; *supra* §I.C (explaining partition notation). Each PU has a partition ID. The first PU has PartIdx = 0, while the second PU has PartIdx = 1. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. Nakamura checks if "PartIdx is equal to 1" meaning it checks if the PU is the second PU of the divided block. I have illustrated this below:



344. If the block is divided into a first and second PUs, then Nakamura excludes the potential spatial motion vector prediction candidate from the merge list if the current PU is the second PU. Ex-1008, §8.4.2.1.2. This is explained below for the horizontally-divided block (2NxN) and then the vertically-divided block (Nx2N).

345. For the 2NxN (horizontally-divided) scenario, when deciding the availability of neighboring blocks A-E, Nakamura sets the spatial candidate for block B and any spatial candidate that has "identical motion parameters[]" as block B to unavailable, meaning it is excluded from the merge list. Ex-1008, §8.4.2.1.2. Nakamura iterates through neighboring blocks, setting variable "N" to A, B, C, D

or E in sequence. *Id.* ("the derivation of availableFlag N, with N being A, B, C, D or E"). For each block, including block B, Nakamura evaluates whether the block has "identical motion parameters" with block B. *Id.* ("PartMode of the current prediction unit is PART_2NxN and PartIdx is equal to 1 and *the prediction units covering luma location (xP, yP–1) (PartIdx=0)* and luma location (xN,yN) (Cand. N) have *identical motion parameters*[.]"); Ex-1010, §8.4.2.1.2; Ex-1008, §8.4.2.1.2. Here, the coordinates "(xP, yP–1)" refers to the block above the current block because it has the same x coordinate but is 1 row up. The y coordinate has 1 subtracted from it, which results in the previous block in the vertical (y) direction. Since block B is the block above the current block, block B is a PU "covering… (xP, yP-1)." *Id.* I have illustrated this below, with a red box showing the block that Nakamura would exclude:

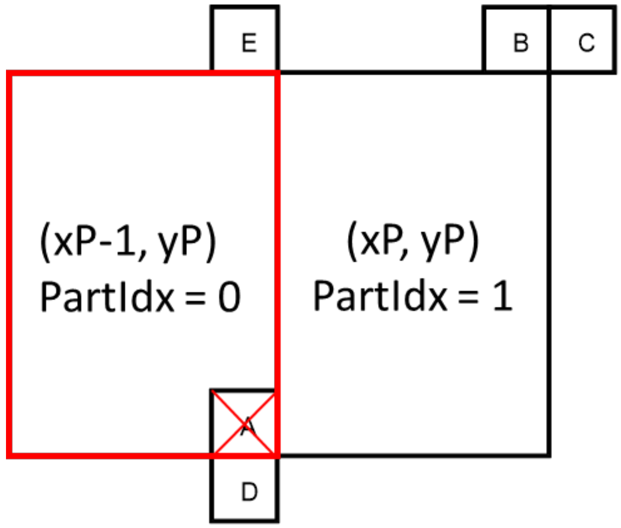


346. Block B has "PartIdx=0" because this is a horizontally-divided block (part mode 2NxN), and block B is above the current block, which has PartIdx=1. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. Therefore, when Nakamura iterates to block B, then N is set to B (Ex-1008, §8.4.2.1.2 ("the derivation of availableFlag N, with N being A, B, C, D or E")), and Nakamura excludes block B's potential spatial motion vector prediction candidate from the merge list because, by the law of identity, block B has "identical motion parameters" with itself. *Id.*

347. By setting availableFlagB "equal to 0," block B is not available for, and therefore excluded from, the merging candidate list. Ex-1008, §8.4.2.1.2

("The merging candidate list, mergeCandList, is constructed of… B, if availableFlagB is equal to 1[.]"); Ex-1010, §8.4.2.1.2.

348. For the Nx2N (vertically-divided) scenario, when deciding the availability of neighboring blocks A-E, Nakamura sets the spatial candidate for block A and any spatial candidate that has "identical motion parameters[]" as block A to unavailable, meaning it is excluded from the merge list. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. Nakamura iterates through neighboring blocks, setting variable "N" to A, B, C, D or E in sequence. Ex-1008, §8.4.2.1.2. ("the derivation of availableFlag N, with N being A, B, C, D or E"); Ex-1010, §8.4.2.1.2. For each block, including block A, Nakamura evaluates whether the block has "identical motion parameters" with block A. Ex-1008, §8.4.2.1.2 ("PartMode of the current prediction unit is PART_Nx2N and PartIdx is equal to 1 and *the prediction units covering luma location (xP–1, yP) (PartIdx=0)* and luma location (xN, yN) (Cand. N) have identical motion parameters[.]"); Ex-1010, §8.4.2.1.2. Here, the coordinates "(xP-1, yP)" refers to the block to the left of the current block because its x coordinate has been decremented by 1, meaning it is the previous block in the horizontal (x) direction. Since block A is the block to the left of the current block, block A is a PU "covering luma location (xP–1, yP)." *Id.* I have illustrated this below, with a red box showing the block that Nakamura would exclude:



349. Block A has "PartIdx=0" because this is a vertically-divided block (part mode Nx2N), and block A is to the left of the current block, which has PartIdx=1. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. Therefore, when Nakamura iterates to block A, then N is set to A (Ex-1008, §8.4.2.1.2 ("the derivation of availableFlag N, with N being A, B, C, D or E")), and Nakamura excludes block A's potential spatial motion vector prediction candidate from the merge list because, by the law of identity, block A has "identical motion parameters" with itself. *Id.*

350. By setting availableFlagA "equal to 0," block A is not available for, and therefore excluded from, the merging candidate list. Ex-1008, §8.4.2.1.2 ("The merging candidate list, mergeCandList, is constructed of… A, if availableFlagA is equal to 1[.]"); Ex-1010, §8.4.2.1.2.

351. The reason why Nakamura and WD4 both teach claim 4 is because, as I explained above, blocks are divided into two PUs when each half of the block has different motion. *Supra* §VI.A.5 (explaining, for claim 4, why this was obvious based on the reason why a block is divided into two PUs to begin with). Therefore, it does not make sense to include the candidate from the other PU of a divided block because it will not reflect the motion of the current block. *See id.*

352. Based on the foregoing explanations, Ground 3 teaches claim 11.

5. Dependent Claim 12

353. Ground 3 teaches claim 12, as explained below.

[12pre] The method according to claim 9 further comprising

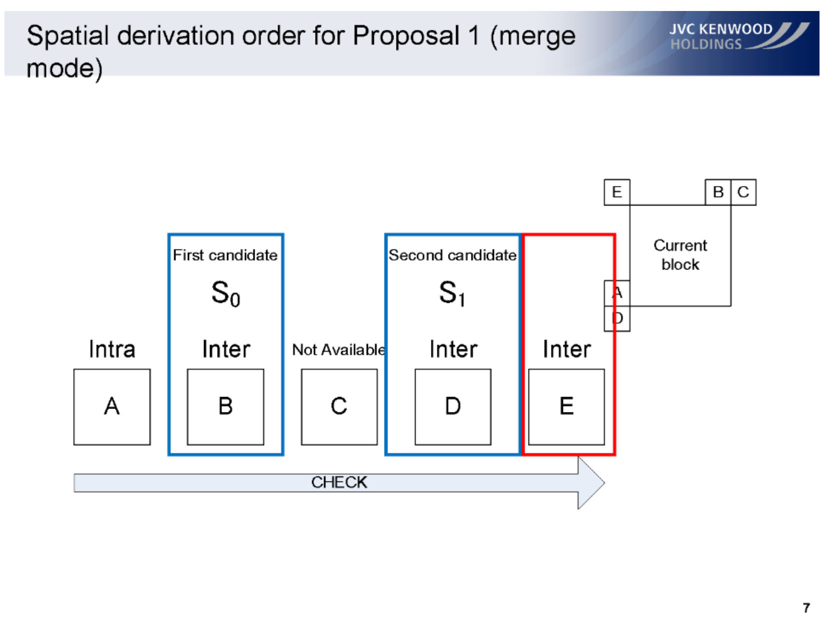
354. As I explained above, the combination of Nakamura and WD4 teaches the method of claim 1. *Supra* §VI.B.2. Therefore, the combination teaches the preamble of claim 5.

[12a]	**determining a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list; and**

355. Ground 3 teaches limitation [12a] independently with merge mode and MVP mode teachings.

Merge Mode

356. Ground 3 teaches **determining a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list** in at least two ways for merge mode. First, Nakamura teaches "[t]he merging candidate list is constructed of two spatial merging candidates[.]" Ex-1007, §2.2.1, Tables 1-2, 4; *supra* §VI.B.2[9b]. Therefore Nakamura teaches determining a maximum number of spatial candidates (2) in the merging candidate list because at most two candidates will be included in the list; no additional spatial candidates are added after two. Ex-1009, 000008:



357. As illustrated in the above example, after two spatial candidates S_0 and S_1 (highlighted with blue boxes), corresponding to blocks B and D respectively, are selected for the merging candidate list, block E (in red box) is not

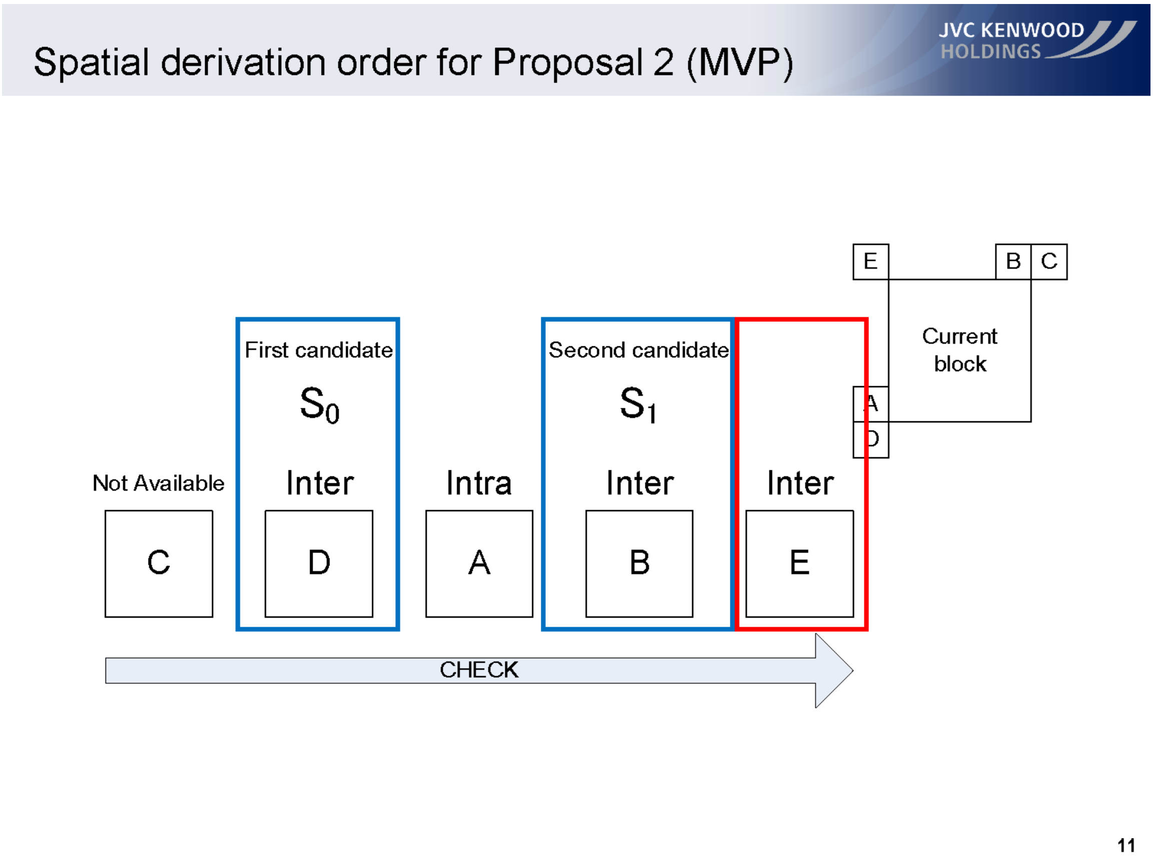
included in the merging candidate list even though block E is available for motion vector prediction. Ex-1009, 000008. Therefore, Nakamura teaches that two is the maximum number of spatial candidates in the merging candidate list.

358. Second, Nakamura teaches a maximum number of spatial candidates checked for the merging candidate list. Ex-1008, §8.4.2.1.1 ("If the number of availableFlagM (with M being replaced by A, B, C or D) which is equal to 1 in order of A, B, C, D and E is equal to 4, the availableFlagN is set equal to 0. (Note: If availableFlagA, availableFlagB, availableFlagC and availableFlagD are equal to 1, availableFlagE is set to 0.)"); Ex-1010, §8.4.2.1.2 ("If one of the following conditions is true, the availableFlagN is set equal to 0,… N is equal to B2 and availableFlagA0 + availableFlagA1 + availableFlagB0 + availableFlagB1 is equal to 4"). Here, Nakamura teaches that if four spatial neighbors are available as spatial candidates for the merging candidate list, then any additional spatial neighbor is set as unavailable, limiting the number of spatial candidates checked for the merging candidate list to four. For example, "[i]f availableFlagA" for block A, "availableFlagB" for block B, "availableFlagC" for block C, and "availableFlagD" for block D "are equal to 1," indicating that blocks A, B, C, and D are available, then "availableFlagE" for block E "is set to 0." Ex-1008, §8.4.2.1.1. By limiting the number of spatial candidates that are checked to four, the maximum number of spatial candidates to be included in the merging

candidates list is four. Thus, for this additional reason, Nakamura teaches determining a maximum number (e.g., 4) of spatial motion vector prediction candidates to be included in the motion vector prediction list.

MVP Mode

359. Ground 3 teaches **determining a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list**. For example, Nakamura teaches "[t]wo in five spatial candidates are derived… in the spatial derivation process." Ex-1007, §2.2.2, Tables 1, 3-4; *supra* §VI.B.2[9b]. Two is the maximum number of spatial candidates in the MVP list because at most two candidates are in the list; no additional spatial candidates are added after two. Ex-1009, 000012:



360. As illustrated in the above example, after two spatial candidates S_0 and S_1 (in blue boxes) corresponding to blocks D and B respectively, are selected for the MVP list, block E (in the red box) is not included in the MVP list even though block E is available for motion vector prediction. Ex-1009, 000012. These teachings are confirmed in WD4, which teaches a variable "maxNumMVPCand is set to 2." Ex-1010, §8.4.2.1.7. If "[t]he variable numMVPCandLX" which "is set to the number of elements within the mvpListLX… is equal to or greater than maxNumMVPCand[]," then "all motion vector predictor candidates… greater than maxNumMVPCand… are removed from the list." Ex-1010, §8.4.2.1.7.

Therefore, Nakamura teaches two is the maximum number of spatial candidates to be included in the MVP list.

361. Based on the foregoing explanations, Ground 3 teaches limitation [12a].

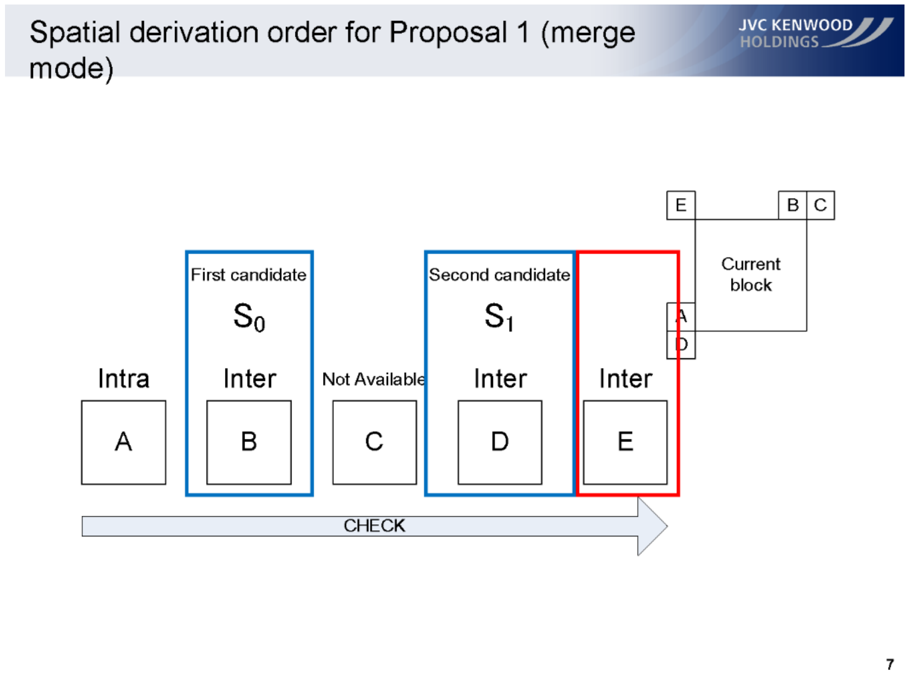
[12b]	**limiting the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number.**

362. Ground 3 teaches limitation [12b] independently with merge mode and MVP mode teachings.

<u>*Merge Mode*</u>

363. Ground 3 teaches **limiting the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number** at least two ways for merge mode. These were explained above for limitation [12a].

364. First, Nakamura teaches that after two spatial candidates are selected for the merging candidate list, no additional spatial candidates are included in the merging candidate list. Thus, Nakamura limits the number of spatial motion vector prediction candidates in the merging candidate list to be smaller or equal to the maximum number two. *Supra* §VI.B.5[12a]; Ex-1007, Tables 3-4, Ex-1009, 000008:



365. As illustrated in the above example, the spatial candidate for block E (in red box) is available for motion vector prediction but not included in the merging candidate list. Ex-1009, 000008. That is because two spatial candidates (in blue boxes), S_0 and S_1 corresponding to blocks B and D respectively, have already been found. *Id*. Therefore, Nakamura teaches limiting the number of spatial motion vector prediction candidates in the merging candidate list to being smaller or equal to two spatial candidates.

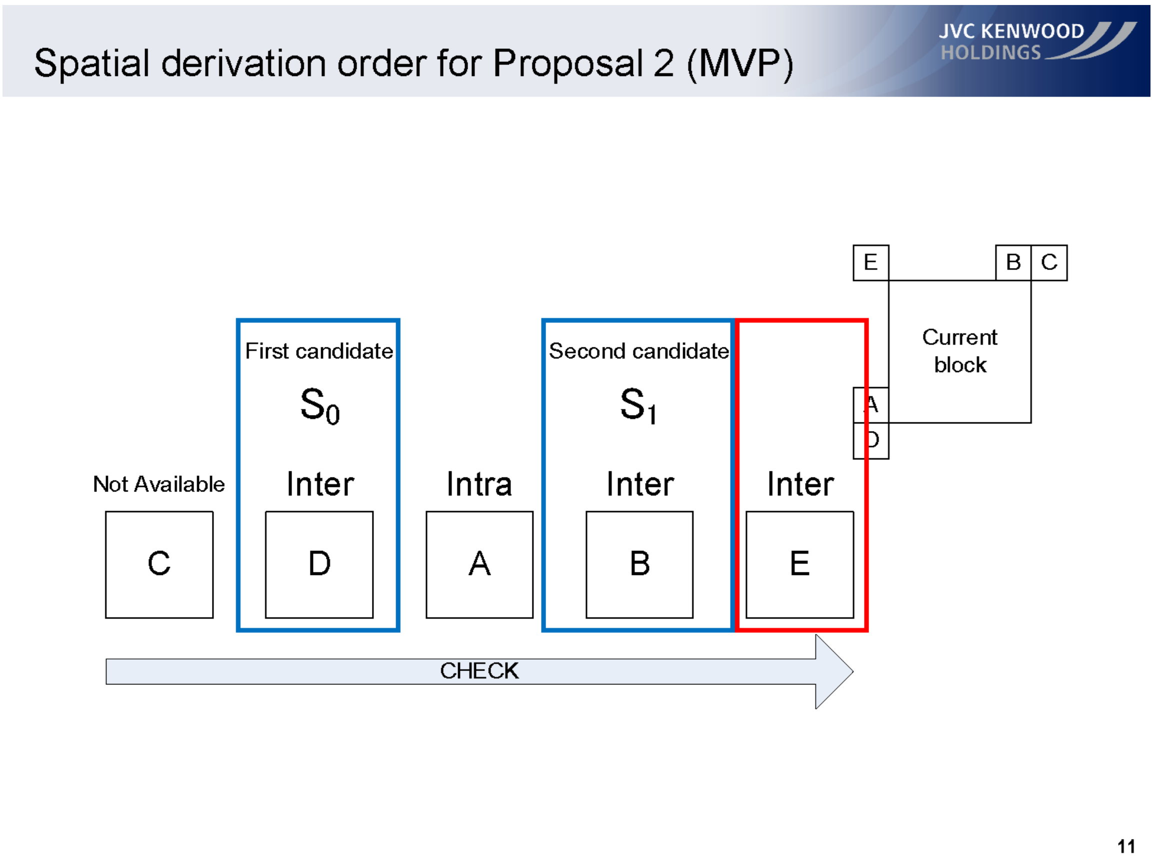
366. Second, Nakamura teaches limiting the number of spatial candidates checked for the merging candidate list to four. Ex-1008, §8.4.2.1.1 ("If the number of availableFlagM (with M being replaced by A, B, C or D) which is equal to 1 in order of A, B, C, D and E is equal to 4, the availableFlagN is set equal to 0. (Note: If availableFlagA, availableFlagB, availableFlagC and availableFlagD are equal to

1, availableFlagE is set to 0.)"); Ex-1010, §8.4.2.1.2 ("If one of the following conditions is true, the availableFlagN is set equal to 0,… N is equal to B2 and availableFlagA0 + availableFlagA1 + availableFlagB0 + availableFlagB1 is equal to 4"); *supra* §VI.B.5[12a]. Here, Nakamura teaches that if four spatial neighbors are available as spatial candidates for the merging candidate list, then any additional spatial neighbor is set as unavailable, limiting the number of spatial candidates checked for the merging candidate list to four. For example, "[i]f availableFlagA" for block A, "availableFlagB" for block B, "availableFlagC" for block C, and "availableFlagD" for block D "are equal to 1," indicating that blocks A, B, C, and D are available, then "availableFlagE" for block E "is set to 0." Ex-1008, §8.4.2.1.1. By limiting the number of spatial candidates that are checked to four, the maximum number of spatial candidates included in the merging candidates list is at most four.

<u>*MVP Mode*</u>

367. Ground 3 teaches **limiting the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number**. For example, for MVP mode, Nakamura teaches "[t]wo in five spatial candidates are derived… in the spatial derivation process." Ex-1007, §2.2.2, Tables 1, 3-4; *supra* §VI.B.5[12a]. Thus, Nakamura limits the

number of spatial motion vector prediction candidates in the MVP candidate list to be smaller or equal to the maximum number two; no additional spatial candidates are added after two. Ex-1009, 000012:



368. As illustrated in the above example, after two spatial candidates (in blue boxes), S_0 and S_1 corresponding to blocks D and B respectively, are selected for the MVP list, block E (in red box) is not included in the merging candidate list even though block E is available for motion vector prediction. Ex-1009, 000012. These teachings are confirmed in WD4, which teaches a variable "maxNumMVPCand is set to 2." Ex-1010, §8.4.2.1.7. If "[t]he variable

numMVPCandLX" which "is set to the number of elements within the mvpListLX… is equal to or greater than maxNumMVPCand[]," then "all motion vector predictor candidates… greater than maxNumMVPCand… are removed from the list." Ex-1010, §8.4.2.1.7. Therefore, Nakamura teaches limiting the number of spatial motion vector prediction candidates in the MVP list to being smaller or equal to two spatial candidates.

369. Based on the foregoing explanations, Ground 3 teaches limitation [12b].

6. Dependent Claim 13

370. Ground 3 teaches claim 13, as explained below.

[13pre] The method according to claim 12 further comprising:

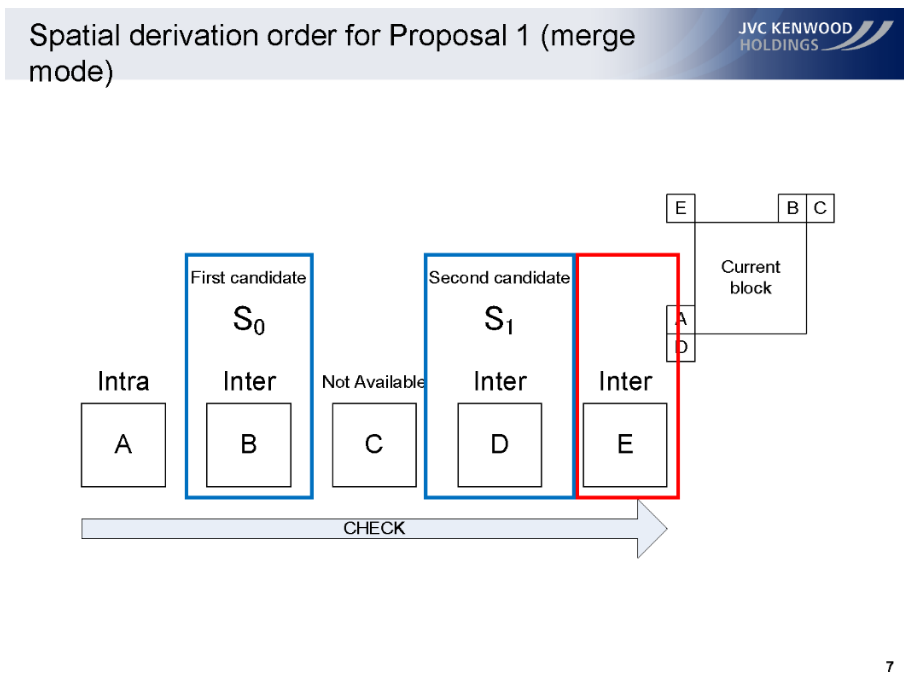
371. As I explained above, Ground 3 teaches the method of claim 12. *Supra* §VI.B.5. Therefore, Ground 3 teaches the preamble of claim 13.

[13a]	**examining, if the number of spatial motion vector prediction candidates in the motion vector prediction list smaller than the maximum number;**

372. Ground 3 teaches limitation [13a] for merge mode.

373. Ground 3 teaches **examining, if the number of spatial motion vector prediction candidates in the motion vector prediction list smaller than the maximum number**. For example, Nakamura teaches "[t]he merging candidate list is constructed of two spatial merging candidates" out of five spatial

neighbors, with two as the maximum number of spatial candidates. Ex-1007, §2.2.1, Tables 1-2, 4; *supra* §VI.B.5[12a]. Nakamura further teaches examining if the number of spatial candidates in the merging candidate list is smaller than the maximum number (two) to limit the number to two. *Supra* §VI.B.5[12b]; Ex-1007, Table 3, Table 4; Ex-1009, 000008:



374. As illustrated in the above example, the spatial candidate for block D (e.g., S_1) is added when the number of spatial candidates in the merging candidate list is smaller than two, and the spatial candidate for block E is not included in the merging candidate list because the number of spatial candidates in the merging candidates list is no longer smaller than two. The variable "NumMergeCand" represents the "number of elements… within the mergeCandList[.]" Ex-1008, §8.4.2.1.1.

375. Based on the foregoing explanations, Ground 3 teaches limitation [13a].

[13b]	**if so, examining whether the prediction unit to which the potential spatial motion vector prediction candidate belongs is available for motion prediction;**

376. Ground 3 teaches limitation [13b] for merge mode.

377. Ground 3 teaches **examining whether the prediction unit to which the potential spatial motion vector prediction candidate belongs is available for motion prediction**. For example, Nakamura teaches that "[f]or the derivation of availableFlagN, with N being A, B, C, D or E… the availableFlagN is set equal to 0[,]" or unavailable, "[i]f one of the following conditions is true… [t]he prediction unit… is not available[.]" Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. The prediction unit may not be available, for example, because the prediction unit is intracoded (e.g., "PredMode is MODE_INTRA") or because it does not have an associated motion vector predictor. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. Therefore, Nakamura teaches examining whether the PU to which the potential spatial motion vector prediction candidate belongs is available for motion prediction, so as to exclude the candidate if it is not available.

378. Based on the foregoing explanations, Ground 3 teaches limitation [13b].

[13c]	**if so, performing at least one of the following:**
[13d]	**for a potential spatial motion vector prediction candidate on a left side of the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:**
[13e]	**the received encoded block of pixels is vertically divided into a first prediction unit and a second prediction unit;**
…	
[13g]	**for a potential spatial motion vector prediction candidate above the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:**
[13h]	**the received encoded block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and the prediction unit is the second prediction unit;**

379. Limitation [13c] requires "performing at least one of the following:" and limitations [13d] and [13g] require "if any of the following conditions are fulfilled:". Therefore, I understand that limitations [13c]-[13o] are satisfied if limitations [13d]-[13e] are met. Alternatively, limitations [13c]-[13o] are also satisfied if limitations [13g]-[13h] are satisfied. Ground 3 teaches receiving an encoded block of pixels, which is the current block. Ex-1010, §0.2, §3.11, §3.12, §3.34, §3.38; Ex-1007, §2.2.1, Fig. 2; *supra* §§VI.B.2[9a], [9e].

380. Ground 3 teaches limitations [13c], [13d]-[13e], [13g]-[13h] for merge mode.

381. For [13d]-[13e], Ground 3 teaches **for a potential spatial motion vector prediction candidate on a left side of the PU for the current block, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled: the received encoded block of pixels[8] is vertically divided into a first prediction unit and a second prediction unit**. For example, Nakamura excludes the potential spatial motion vector prediction candidate from the merging candidate list by setting the availableFlagN to 0. Nakamura teaches that "[i]f one of the following conditions is true, the availableFlagN is set equal to 0… PartMode of the current prediction unit is PART_Nx2N and PartIdx is equal to 1 and the prediction units covering luma location (xP-1, yP) (PartIdx=0) and luma location (xN, yN) (Cand. N) have identical motion parameters[.]" Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2.

382. Here, for a scenario where the current block of pixels is a Nx2N vertically-divided block (e.g., PartMode is PART_Nx2N) and the PU for the current block is on the right side (e.g., PartIdx=1), Nakamura teaches that the prediction unit on the left side (e.g., PartIdx=0) and any block that has "identical motion parameters" are set as unavailable and therefore excluded from the merging

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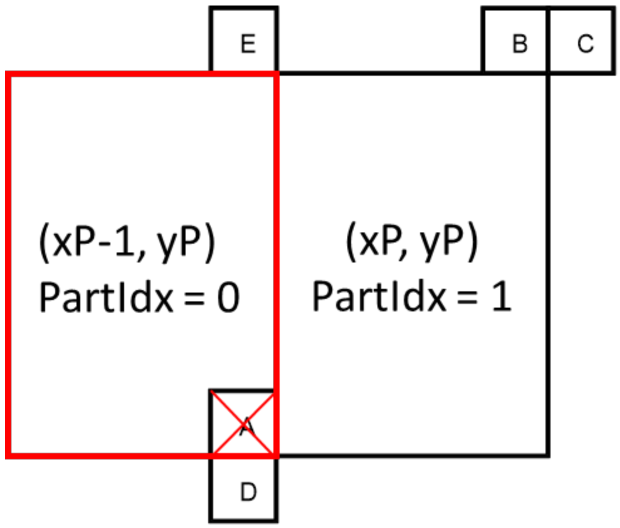
[8] The "received encoded block of pixels" appears to reference "a block of pixels" in [9a]. As explained above, the block of pixels is the current block for which motion vector prediction candidates are being analyzed. *Supra* §VI.B.2[9a].

candidate list. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2; *supra* §VI.B.4 (explaining HEVC partition modes and ids for claim 11). This scenario is illustrated below:



383. Nakamura iterates through neighboring blocks, setting variable "N" to A, B, C, D or E in sequence. Ex-1008, §8.4.2.1.2 ("the derivation of availableFlagN, with N being A, B, C, D or E"); Ex-1010, §8.4.2.1.2. For each block, including block A, Nakamura evaluates whether the block has "identical motion parameters" with block A. Ex-1008, §8.4.2.1.2 ("PartMode of the current prediction unit is PART_Nx2N and PartIdx is equal to 1 and *the prediction units covering luma location (xP–1, yP) (PartIdx=0)* and luma location (xN, yN) (Cand. N) have identical motion parameters[.]"); Ex-1010, §8.4.2.1.2. Here, the coordinates "(xP-1, yP)" refers to the block to the left of the current block because its x coordinate has been decremented by 1, meaning it is the previous block in the

horizontal (x) direction. Since block A is the block to the left of the current block, block A is a PU "covering luma location (xP−1, yP)." *Id.* When Nakamura iterates to block A, N is set to A (Ex-1008, §8.4.2.1.2 ("the derivation of availableFlag N, with N being A, B, C, D or E")), and Nakamura excludes block A's potential spatial motion vector prediction candidate from the merge list because block A has "identical motion parameters" with itself. *Id.*

384. In the Nx2N scenario illustrated above, availableFlagA for block A is set "equal to 0," making block A unavailable for, and therefore excluded from, the merging candidate list. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. Block A is excluded because it is "the prediction unit[] covering… (xP-1, yP)" or the block on the left side of the prediction unit in a vertically divided block of pixels. Therefore, for a potential spatial motion vector prediction candidate on a left side of the current PU, Nakamura excludes the potential spatial motion vector prediction candidate from the merging candidate list if the current block is vertically divided into a first and second PU. This exclusions only occurs if the PU on the left (for vertically-divided blocks) is available for motion prediction because otherwise, it would already be marked as unavailable. *Supra* §VI.B.6[13b].

385. Therefore, as explained above, Nakamura satisfies claim 6.

386. For [13g]-[13h], Nakamura's merge mode teaches **for a potential spatial motion vector prediction candidate above the PU for the current block,**

excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled: the received encoded block of pixels[9] **is horizontally divided into a first prediction unit and a second prediction unit, and the prediction unit is the second prediction unit**. For example, Nakamura excludes the potential spatial motion vector prediction candidate from the merging candidate list by setting the availableFlagN to 0. Nakamura teaches that "[i]f one of the following conditions is true, the availableFlagN is set equal to 0… PartMode of the current prediction unit is PART_2NxN and PartIdx is equal to 1 and the prediction units covering luma location (xP, yP–1) (PartIdx=0) and luma location (xN, yN) (Cand. N) have identical motion parameters[.]" Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2.

387. Here, for a scenario where a block of pixels is a 2NxN horizontally divided block (e.g., PartMode is PART_2NxN) and the PU for the current block is on the bottom (e.g., PartIdx=1), Nakamura teaches that the prediction unit above the current prediction unit (e.g., PartIdx=0) and any block that has "identical motion parameters" are set as unavailable. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. This scenario is illustrated below:

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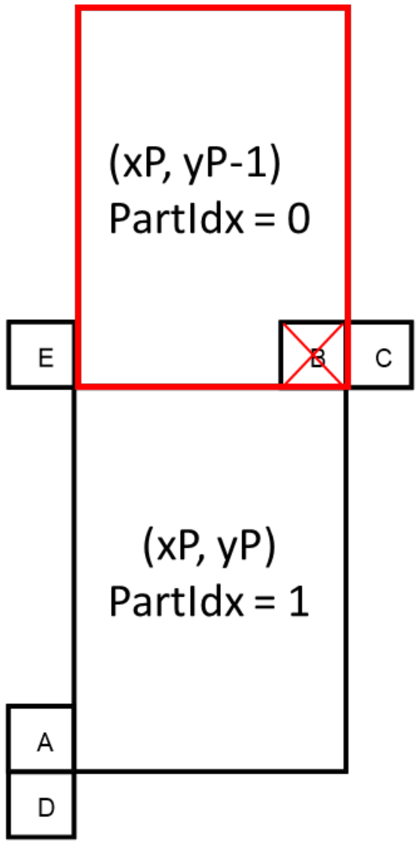
[9] The "received encoded block of pixels" appears to reference "a block of pixels" in [9a]. As explained above, the block of pixels is the current block for which motion vector prediction candidates are being analyzed. *Supra* §VI.B.2[9a].



388. Nakamura iterates through neighboring blocks, setting variable "N" to A, B, C, D or E in sequence. Ex-1008, §8.4.2.1.2 ("the derivation of availableFlag N, with N being A, B, C, D or E"); Ex-1010, §8.4.2.1.2. For each block, including block B, Nakamura evaluates whether the block has "identical motion parameters" with block B. Ex-1008, §8.4.2.1.2 ("PartMode of the current prediction unit is PART_2NxN and PartIdx is equal to 1 and *the prediction units covering luma location (xP, yP–1) (PartIdx=0)* and luma location (xN,yN) (Cand. N) have *identical motion parameters*[.]"); Ex-1010, §8.4.2.1.2. Here, the coordinates "(xP, yP–1)" refers to the block above the current block because it has the same x coordinate but is 1 row up. The y coordinate has 1 subtracted from it, which

results in the previous block in the vertical (y) direction. Since block B is the block above the current block, block B is a PU "covering… (xP, yP-1)." *Id.* When Nakamura iterates to block B, then N is set to B (Ex-1008, §8.4.2.1.2 ("the derivation of availableFlag N, with N being A, B, C, D or E")), and Nakamura excludes block B's potential spatial motion vector prediction candidate from the merge list because block B has "identical motion parameters" with itself. *Id.*

389. In the 2NxN scenario illustrated above, availableFlagB for block B is set "equal to 0," making block B unavailable for, and therefore excluded from, the merging candidate list. Ex-1008, §8.4.2.1.2; Ex-1010, §8.4.2.1.2. Block B is excluded because it is "the prediction unit[] covering… (xP, yP-1)" or the block above the current prediction unit in a vertically divided block of pixels. Therefore, for a potential spatial motion vector prediction candidate above the prediction unit, Nakamura excludes the potential spatial motion vector prediction candidate from the merging candidate list if the received block of pixels is horizontally divided into a first and second PU, and the PU is the second PU. This exclusion only occurs if the PU above (for horizontally-divided blocks) is available for motion prediction because otherwise, it would already be marked as unavailable. *Supra* §VI.B.6[13b].

390. Based on the foregoing explanations, Ground 3 teaches limitations [13c]-[13o].

7. Dependent Claim 14

14.	**The method according to claim 9 further comprising selecting one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the encoded block of pixels.**

391. Ground 3 teaches claim 14 in two independent ways: merge mode and MVP mode. Either teaching is sufficient by itself to satisfy the claims.

Merge Mode

392. Ground 3 teaches **selecting one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the block of pixels**. For example, WD4 teaches a merge index (e.g., "merge_idx") that "specifies the merging candidate index of the merging candidate list[.]" Ex-1010, §7.4.7; *supra* §VI.B.2[9e]. Based on the merge_idx, one spatial "candidate at position merge_idx[xP][yP] in the merging candidate list mergeCandList" is assigned as the spatial candidate to use for prediction of the current block. Ex-1010, §8.4.2.1.1.

393. As I also explained above with respect to limitation [9a], the merging candidate contains information such as motion vector information and reference picture index, which indicates the motion vector prediction for a prediction unit. *Supra* §VI.B.2[9a].

394. Therefore, WD4 teaches selecting one motion vector prediction candidate from the merging candidate list to represent a motion vector prediction for the current block of pixels. The selected merging candidate is assigned as the spatial candidate to use for prediction of the block of pixels, and therefore, represents the motion vector prediction used for the block of pixels. *Supra* §VI.B.2[9e]; Ex-1010, §8.4.2.1.1.

<u>*MVP Mode*</u>

395. Ground 3 teaches **selecting one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the block of pixels**. For example, WD4 teaches an mvp index (e.g., "mvp_idx_l0") that "specifies the motion vector predictor index[.]" Ex-1010, §7.4.7; *see supra* §VI.B.2[9e]. Based on mvp_idx_l0, a "motion vector of mvpListLX… is assigned" as the spatial candidate to use for prediction of the current block. Ex-1010, §8.4.2.1.7; *supra* §VI.B.2[9a]. Therefore, the mvp_idx_l0 identifies the spatial MVP candidate to be used for prediction of the current block.

396. As I also explained above, the MVP candidate includes information such as the motion vector and availability flag and indicates the motion vector prediction for the block. Ex-1010, §8.4.2.1.8; *supra* §VI.B.2[9a].

397. Therefore, WD4 teaches selecting one motion vector prediction candidate from the MVP list. The selected MVP candidate is assigned as the spatial candidate to use for prediction of the block of pixels, and therefore, represents the motion vector prediction used for the block of pixels. *Supra* §VI.B.2[9e]; Ex-1010, §8.4.2.1.7.

398. Based on the foregoing explanations, Ground 3 teaches claim 14.

8. Independent Claim 23

[23pre] An apparatus comprising a processor and a memory including computer program code, the memory and the computer program code configured to, with the processor, cause the apparatus to:

399. To the extent that the preamble is limiting, Ground 3 teaches limitation [23pre], as explained below.

400. Nakamura teaches an **apparatus comprising a processor and a memory including computer program code**. For example, Nakamura teaches a decoder "for decoding experiments" that comprises a "CPU" and "[m]emory[.]" Ex-1007, Table 6:

Table 6 Simulation environment for decoding experiments

CPU	Intel Core i7 870 2.93GHz
Memory	16GB (DDR3)
OS	Windows 7 Professional 64bit
Compiler	Microsoft Visual C++ 2008 Express edition SP1
Executable	x64

Furthermore, WD4 teaches "video decoders" with various "processing load and memory capability[]" capable of implementing its teachings. Ex-1010, Annex A.

401. Nakamura teaches **the memory and computer program code is configured to, with the processor, cause the apparatus to** perform the recited steps. *Infra* §§VI.A.2[23a]-[23e]. For example, Nakamura teaches "[t]his proposed technique is implemented into HM3.0 software[.]" Ex-1007, §2.3.1, *See, e.g.*, Ex-1007, §3.3.3, Tables 7-12 (reporting "[s]imulation results" with decoder runtime). At the very least, it would have been obvious to a POSITA for a video decoder to include a processor and a memory, such as a hard drive, to execute software because conventional computers have included processors and memory for this purpose for decades.

402. Based on the foregoing explanations, Ground 3 teaches the preamble of claim 23.

[23a]	**select a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for an encoded block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the encoded block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates;**

403. Ground 3 teaches limitation [23a]. Limitation [23a] is nearly identical to limitation [9a]. *See Supra* §VI.A.8[23a]. The minor differences do not affect

my analysis that, for the same reasons I have discussed for limitation [9a], Ground 3 teaches limitation [23a]. *Supra* §VI.A.8[23a], §VI.B.2[9a].

[23b]	**determine a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;**

404. Ground 3 teaches limitation [23b], as explained below.

405. Limitation [23b] is nearly identical to limitation [9b]. *See supra* §VI.A.8[23b]. The minor differences, shown below, do not affect my analysis that Ground 3 teaches limitation [23b]. *Supra* §VI.A.8[23b], §VI.B.2[9b].

[23c]	**compare motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;**

406. Ground 3 teaches limitation [23c], as explained below.

407. Limitation [23c] is nearly identical to limitation [9c]. *See supra* §VI.A.8[23c]. The minor differences, shown below, do not affect my analysis that Ground 3 teaches limitation [23c]. *Supra* §VI.A.8[23c], §VI.B.2[9c].

[23c]	[9c]
comparing motion information of the first spatial motion vector prediction candidate with motion information of another spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;	compare motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;

408. The limitation "each *possible candidate* pair" is taught by Ground 3 for the same reasons that "each pair" is taught by Ground 3, because a comparison of each pair from the set (e.g., for blocks A, B, C, D, E) is a comparison of each possible candidate pair from the set.

[23d]	**determine to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on comparison of the motion information of the first spatial motion vector candidate with motion information of the spatial motion vector prediction candidate; and**

409. Ground 3 teaches limitation [23d], as explained below.

410. Limitation [23d] is nearly identical to limitation [9d]. *See supra* §VI.A.8[23d]. The minor differences, shown below, do not affect my analysis that Ground 3 teaches limitation [23d]. *Supra* §VI.A.8[23d], §VI.B.2[9d].

[23d]	[9d]
determine to include or exclude the first spatial motion vector predict ion candidate in the motion vector prediction list based on comparison of the motion information of the fi rst spatial motion vector candidate with motion information of the spat ial motion vector prediction candid ate; and	determining to include or exclude t he first spatial motion vector pred iction candidate in the motion vect or prediction list based on the com paring; and

[23e]	**select a spatial motion vector prediction candidate from the motion vector prediction list for use in decoding the encoded block of pixels, wherein the spatial motion vector prediction candidate is selected from the motion vector prediction list using information that was received identifying a respective spatial motion vector prediction candidate from the motion vector prediction list constructed by an encoder.**

411. Ground 3 teaches limitation [23e]. Limitation [23e] is nearly identical to limitation [9e]. *See Supra* §VI.A.8[23e]. The minor differences do not affect my analysis that, for the same reasons I have discussed for limitation [9e], Ground 3 teaches limitation [23e]. *Supra* §VI.A.8[23], §VI.B.2[9e].

9. Dependent Claim 24

412. Ground 3 teaches claim 24. Claim 24 is nearly identical to claim 10. *See Supra* §VI.A.9. The minor differences do not affect my analysis that, for the same reasons I have discussed for claim 10, Ground 3 teaches claim 24. *Supra* §VI.B.3.

10. Dependent Claim 25

413. Ground 3 teaches claim 25. Claim 25 is nearly identical to claim 11. *See Supra* §VI.A.10. The minor differences do not affect my analysis that, for the same reasons I have discussed for claim 11, Ground 3 teaches claim 25. *Supra* §VI.B.4.

11. Dependent Claim 26

414. Ground 3 teaches claim 26. Claim 26 is nearly identical to claim 12. *See Supra* §VI.A.11. The minor differences do not affect my analysis that, for the same reasons I have discussed for claim 12, Ground 3 teaches claim 26. *Supra* §VI.B.5.

12. Dependent Claim 27

415. Ground 3 teaches claim 27. Claim 27 is nearly identical to claim 13. *See Supra* §VI.A.12. The minor differences do not affect my analysis that, for the same reasons I have discussed for claim 13, Ground 3 teaches claim 27. *Supra* §VI.B.6.

13. Dependent Claim 28

416. Ground 3 teaches claim 28. Claim 28 is nearly identical to claim 14. *See Supra* §VI.A.13. The minor differences do not affect my analysis that, for the same reasons I have discussed for claim 14, Ground 3 teaches claim 28. *Supra* §VI.B.7.

14. Independent Claim 30

[30pre] A non-transitory computer readable medium having stored thereon a computer executable program code for use by an encoder, said program codes comprising instructions for:

417. To the extent that the preamble is limiting, Ground 3 teaches limitation [30pre], as explained below.

418. As I explained for Ground 1, the preamble likely contains a typographical error, where "a computer executable program code for use by *a decoder*" is recited as "a computer executable program code for use by *an encoder*." *Supra* §VI.A.14[30pre].

419. Based on this understanding, Nakamura and WD4 teach **a non-transitory computer readable medium having stored thereon a computer executable program code for use by an decoder, said program codes comprising instructions for**. For example, Nakamura teaches "software" by which its "technique is implemented[.]" Ex-1007, §2.3.1. Nakamura's teachings were applied in software "for encoding and decoding experiments[.]" Ex-1007, §3.2. WD4 teaches an decoder. Ex-1010, §0.5 (addressing the performance of decoders), §3.31 (defining a decoder as "[a]n embodiment of a decoding process"), Annex A (describing the capability of the decoder required to perform video decoding functions). WD4's teachings were tested on software. *See*, *e.g.,* Ex-1010, 000003 (noting minor difference between software and text), §8.3.3.1.8 (noting minor bug in software).

420. To the extent that Patent Owner argues that Nakamura or WD4 does not explicitly state a non-transitory computer readable medium having stored thereon a computer executable program code for use by an decoder, it would have at least been obvious to a POSITA that the video decoder taught in WD4 includes a non-transitory computer-readable medium, such as a hard drive, that stores the computer executable program code comprising instructions for use by an encoder to perform the recited steps. It was well known for a computer, such as one that functions as a decoder in WD4, to include a non-transitory storage medium such as hard drive, where computer codes are stored, in order to perform the recited functionalities.

421. To the extent that the preamble "a computer executable program code for use by *a decoder*" of claim 30 is not a typographical error, Ground 3 also teaches the preamble. *See* Ex-1010, §0.5 (addressing the performance of encoders), §3.37 (defining an encoder as "[a]n embodiment of an encoding process."). In addition, it would have at least been obvious to a POSITA that the video decoder taught in WD4 includes a non-transitory computer-readable medium, such as a hard drive, that stores the computer executable program code comprising instructions for use by a decoder to perform the recited steps.

422. Based on the foregoing explanations, Ground 3 teaches the preamble of claim 30.

[30a] selecting a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for an encoded block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the encoded block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates;

423. Ground 3 teaches limitation [30a]. Limitation [30a] is identical to limitation [9a]. For the same reasons I have discussed for limitation [9a], Ground 3 teaches limitation [30a]. *Supra* §VI.B.2[9a].

[30b] determining a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;

424. Ground 3 teaches limitation [30b]. Limitation [30b] is identical to limitation [9b]. For the same reasons I have discussed for limitation [9b], Ground 3 teaches limitation [30b]. *Supra* §VI.B.2[9b].

[30c] comparing motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;

425. Limitation [30c] is nearly identical to limitation [9c]. *See* §VI.A.10[30c]. The minor differences do not affect my analysis that, for the same reasons I have discussed for limitation [9c], Ground 3 teaches limitation [30c]. *Supra* §VI.B.2[9c].

[30c]	[9c]
comparing motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;	comparing motion information of the first spatial motion vector prediction candidate with motion information of another spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;

[30d] determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and

426. Ground 3 teaches limitation [30d]. Limitation [30d] is identical to limitation [9d]. For the same reasons I have discussed for limitation [9d], Ground 3 teaches limitation [30d]. *Supra* §VI.B.2[9d].

[30e] selecting a spatial motion vector prediction candidate from the motion vector prediction list for use in decoding the encoded block of pixels, wherein the spatial motion vector prediction candidate is selected from the motion vector prediction list using information that was received identifying a respective spatial motion vector prediction candidate from the motion vector prediction list constructed by an encoder.

427. Ground 3 teaches limitation [30e]. Limitation [30e] is identical to limitation [9e]. For the same reasons I have discussed for limitation [9e], Ground 3 teaches limitation [30e]. *Supra* §VI.B.2[9e].

VII. BACKGROUND AND QUALIFICATIONS

428. This section contains a summary of my educational background, career history, publications, and other relevant qualifications. My full curriculum vitae is attached as Appendix 1 to this declaration.

429. I received a bachelor of science degree in Electrical and Computer Engineering from the University of California at Davis in 1985. I received a Master of Science degree in electrical and Computer Engineering from the University of California at Santa Barbara in 1990, and I received my PhD. in Electrical and Computer Engineering, also from the University of California at Santa Barbara in 1993.

430. I have more than 30 years of experience with data compression, decompression, and data storage.

431. I am currently a Full Professor in the Klipsch School of Electrical & Computer Engineering at New Mexico State University. I was an Assistant Professor at New Mexico State from January 2000 until I became an Associate Professor in 2004. I have been a Full Professor since August 2010. My research and coursework at New Mexico State have focused on digital signal and image and video processing. Much of the research I have done over the course of my career is in the area of image and video compression.

432. My first exposure to the field of signal compression came in the fall of 1989, when I took a course entitled Vector Quantization and Signal Compression at UCSB from Prof. Allen Gersho—an internationally renowned researcher in the area of speech compression. As my Ph.D. research progressed, I began to focus on transform-based compression as my main application area. My first paper dealing with image compression was published in 1991. I have since written 24 other journal and conference papers directly related to compression, and I am the named inventor on two issued United States patents related to compression.

433. Since joining the faculty of New Mexico State University in 2000, I have taught numerous classes at both the graduate and undergraduate levels. At the graduate level, I have taught the following: Signal Compression (EE573), Image Processing (EE596), Digital Signal Processing (EE545), Pattern Recognition (EE565), Advanced Linear Systems (EE555), Telemetering Systems

(EE585), Information Theory (EE586), Adaptive Signal Processing (EE594), Multirate Signal Processing and Wavelets (EE595), and Neural Signal Processing (EE590). At the undergraduate level, I have taught the following courses: Linear Algebra & Probability (EE200), Signals and Systems I (EE312), Image Processing (EE446), Introduction to Digital Signal Processing (EE395), and Digital Communications (EE497).

434. From 1993 through 1999, I was a Researcher and Team Leader, at the Naval Air Warfare Center, China Lake. At China Lake, my research efforts focused on high speed image and video compression technologies including embedded wavelet video compression. I also developed a real-time video streaming system that efficiently operated over TCP/IP networks while retaining the highest possible fidelity.

435. From 1990 through 1993, I worked as a Research Assistant in the Department of Electrical and Computer Engineering at the University of California, Santa Barbara. In this position, I worked on subband coding (compression) and multirate filter bank theory. I also implemented real-time filter banks on a digital signal processer. In the summer of 1992, I worked at AT&T Bell labs where I developed and simulated new methods of extremely low bit rate video coding for video telephone applications.

436. From 1985 through 1989, I worked as a Design Engineer at the Naval Weapons Center, China Lake. In this role, I built and tested the guidance electronics for various laser guided munitions. This project included mixed analog and digital circuit design as well as the programming of an embedded digital signal processor. I also developed software for an advanced video processor and studied ground target tracking.

437. A full listing of my publications is found in my curriculum vitae. *See* Appendix 1.

438. I have published 17 peer-reviewed journal articles and 94 conference papers, including 9 journal articles and 30 conference papers directly related to data compression; the following are representative:

- C.D. Creusere, “A new method of robust image compression based on the embedded zerotree wavelet algorithm,” IEEE Trans. on Image Processing, Vol 6, No. 10, Oct. 1997, pp. 1436-1442.
- C.D. Creusere, “Fast embedded compression for video,” IEEE Trans. on Image Processing, Vol. 8, No. 12, pp. 1811-16, December 1999.
- C.D. Creusere, "Motion compensated video compression with reduced complexity encoding for remote transmission," Signal Processing: Image Communications, Vol. 16, pp. 627-42, April 2000

439. I am a named co-inventor on two issued patents, both relating specifically to image and video compression. I am the listed inventor on U.S. Patent No. 6,148,111 entitled "Parallel digital image compression system which exploits zerotree redundancies in wavelet coefficients" and U.S. Patent No. 6,466,698 entitled "Efficient embedded image and video compression using lifted wavelets."

440. In addition to the experience and publications listed above, I have also received the following awards and distinctions that are relevant to the subject matter of this declaration. I am currently deputy Editor-in-Chief for IEEE Transactions on Image Processing as well as an Area Editor for IEEE Open Journal on Signal Processing. I have previously served as an Associate Editor for IEEE Transactions on Image Processing from 2010 through 2014. I have also served in this capacity from 2002 through 2005. From 2008-2013, I served as an Associate Editor for IEEE Transactions on Multimedia. I also served as a Senior Area Editor for IEEE Transactions on Image Processing from 2016-2022.

441. In 2004, I served as the co-general chair for the IEEE Digital Signal Processing Workshop in Taos, New Mexico. In 2012 and 2014, I served as the co-technical chair for the Southwest Symposium on Image Analysis and Interpretation held in Santa Fe, New Mexico and San Diego, CA, respectively. In addition, I served as the technical chair for the 2015 and 2021 International Telemetering

Conference held in Las Vegas, NV in October. I am also a member of the technical program committees for the IEEE Data Compression Conference, IEEE International Conference on Image Processing and the IEEE Acoustics, Speech, and Signal Processing Conference.

A. Compensation

442. For my efforts in connection with the preparation of this declaration I have been compensated at my standard rate for this type of consulting activity. My compensation is in no way contingent on the results of these or any other proceedings relating to the above-captioned patent.

B. Materials and Other Information Considered

443. I have considered information from various sources in forming my opinions. I have reviewed and considered each of the exhibits listed in the attached Appendix 2 (Materials Considered in the Preparation of This Declaration) in forming my opinions.

VIII. UNDERSTANDING OF THE LAW

444. I am not an attorney. In forming my opinions in this Declaration, I applied the relevant legal principles provided to me by counsel, which are summarized in Appendix 4.

IX. RESERVATION OF RIGHTS

445. My opinions are based upon the information that I have considered to date. I am unaware of any evidence of secondary considerations with respect to

the ’714 patent that would render any of the challenged claims non-obvious. I reserve the right, however, to supplement my opinions in the future to respond to any arguments raised by the owner of the ’714 patent and to take into account new information that becomes available to me.

446. I declare that all statements made herein of my knowledge are true, and that all statements made on information and belief are believed to be true, and that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code.

Executed on April 8, 2024.

By:

____
Charles D. Creusere

APPENDIX 1: CURRICULUM VITAE OF CHARLES D. CREUSERE

VITA

CHARLES D. CREUSERE

Klipsch School of Electrical & Computer Engineering
Mailing Address:
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Fax: 575-646-1435

email: ccreuser@nmsu.edu

DISSERTATION TITLE

"Perfect Reconstruction Modulated Polyphase Filter Banks Using Reverse-Time Subfilters."

ACADEMIC TRAINING

1980-1985: University of California at Davis, B.S. in Electrical and Computer Engineering.

1989-1990: University of California at Santa Barbara, M.S. in Electrical and Computer Engineering.

1990-1993: University of California at Santa Barbara, Ph.D. in Electrical and Computer Engineering.

PROFESSIONAL EXPERIENCE

2010-Present Holder of the Frank Carden Endowed Chair in Telemetering & Telecommunications and Full Professor. Current research interests include compressive sensing/sparse reconstruction for LIDAR and streaming sensor data as well as EEG brain analysis for audiovisual perceptual quality assessment and modeling.

October 2008 Selected for the International Foundation for Telemetering Endowed Professorship.

Jan. 2000-2008 Assistant/Associate professor in the Klipsch School of Electrical & Computer Engineering. My teaching areas include digital signal processing, image processing, pattern classification, and source coding (signal compression). I have done past research in areas of image, video, and audio compression as well as feature vector extraction for pattern classification. Currently, my research interests include distributed compression, polarimetric image processing for scene analysis, and nonstationary signal denoising.

1993-1999: Researcher & Team Leader, Naval Air Warfare Center, China Lake. My research efforts have focused on high speed image and video compression technologies which offer unique capabilities such as robustness to transmission errors and regional localization. My team (2 other people) and I have implemented a real-time (3 to 15 frames/second with 240x512 frames)

320C80-based system which uses a wavelet transform along with embedded coding techniques to compress a video input and stream it through the Internet via TCP/IP protocols. Our recent research focus has been to add more intelligence to the encoder so that the space-frequency information in the image that is most useful for image analysis is received with the highest fidelity. While most of my recent research has been in the area of embedded compression, I am still very much interested in other applications of time/space-frequency decompositions and of multirate digital signal processing concepts in general.

1999, Spring Quarter: Instructor at the University of California at Santa Barbara. Taught graduate class in Multirate Digital Signal Processing, ECE 258B.

1990-1993: Research Assistant, Department of Electrical and Computer Engineering, University of California, Santa Barbara. Worked under Prof. S.K. Mitra on subband coding and multirate filter bank theory. Also implemented real-time filter banks on a Motorola 56001 digital signal processor.

1992: Summer Employee, AT&T Bell labs, Murray Hill, NJ. Developed and simulated new methods of extremely low bit rate video coding for video telephone applications.

1985-1989: Design Engineer, Naval Weapons Center, China Lake. Designed, built, and tested the guidance electronics for the Laser Guided Training Round. This project included mixed analog and digital circuit design as well as the programming of an embedded DSP. Also developed software for an advanced video processor and studied ground target tracking.

FUNDED RESEARCH

- (2000) Office of Naval Research, *Compression of Digital Elevation Maps Using Non-linear Wavelets*, 2000-2003, $94K

- (2001) Sandia National Labs, *Intelligent Compression for Remote Sensing*, 2001-2003, $70K.

- (2002) National Science Foundation (Early Career Grant), *Efficient Audio Compression with Perceptually Embedded Scalability*, 2002-2007, $350K.

- (2004) National Geospatial-Intelligence Agency, *Passive Polarimetric Imagery Classification Study*, 2004-2006, $160K (joint with Dr. David Voelz).

- (2005) Los Alamos National Laboratories, *Signal Detection via Adapted Filter Banks and Geometric Dimensionality Reduction*, 2005-2006, $15K (unburdened).

- (2006) Los Alamos National Laboratories, *Signal Detection via Adapted Filter Banks and Geometric Dimensionality Reduction*, 2006-2007, $50K (unburdened).

- (2006) National Geospatial-Intelligence Agency, *Exploiting Polarization in Imaging Systems*, 2006-2009, $304K (joint with Dr. David Voelz).

- (2006) Army Research Office, *Distributed Source Coding Using Bitstream-based Detection and Classification*, 2006-2009, $326K.

- (2006) DARPA (Subcontract from LANL), *ADAM Project*, 2006-2007, $104K (joint with Dr. Joe Lakey and Dr. Jaime Ramirez)

• (2009) NMSU IRG, *Perceptual audio quality evaluation by direct measurement of human brain responses*, 2009-2010, $39K (joint with Dr. Jim Kroger, Psychology)

• (2011) National Science Foundation, *CIF:Medium:Assessment and modeling of temporal variation in perceived audio and video quality using direct brainwave measurement*, 2011-2015, $917K (lead PI with Dr. Jim Kroger and Dr. Joerg Kliewer as co-PIs)

• (2011) NASA EPSCOR, *Proximity Operations for Near Earth Asteroid Exploration,* 2011-2014, $750K (co-PI, with Dr. Eric Butcher (lead), others)

• (2012) National Geospatial Intelligence Agency (NGA), *Pulse Complexity Based LIDAR Scene Modeling for Sparse Reconstruction and Super-Resolution*, 2012-2013 (plus 3 1 year options), $150K ($75K/option year), co-PI Dr. David Voelz.

• (2018) Airforce Research Lab (AFRL), Software Radio Design in LabView FPGA, 2018-2019, $140K.

PATENTS

• Patent titled "Parallel digital image compression system which exploits zerotree redundancies in wavelet coefficients," Patent Number 6,148,111.

• Patent titled "Efficient embedded image and video compression using lifted wavelets," Number: 6,466,698, granted October 15, 2002.

OTHER DISTINCTIONS

• Awarded the International Foundation for Telemetering Professorship, October 2008.

• Received an educational fellowship from the Department of Defense, 1989-1992.

• Certificate of Merit for the outstanding technical paper awarded at the AIAA Missile Sciences Conference for the paper “Automatic target recognition directed image compression,” Nov. 1998.

• Patent (classified) “Notice of Allowability” titled, "Microcontroller-Based Laser Pulse Decoder," granted October 7, 1991.

• Associate editor for IEEE Trans. on Image Processing, 2002-2005, 2010-2014

• Associate editor for IEEE Trans. on Multimedia , 2008-2013.

• Guest Editor, “Issue on Advances in Hyperspectral Data Processing and Analysis”, IEEE Journal of Selected Topics in Signal Processing, Vol. 5, Numbers: 5 & 6, August-September 2015,

• Co-general chair, IEEE Digital Signal Processing Workshop, August 2004, Taos, NM.

• Co-technical chair for the 2012 and 2014 Southwest Symposium on Image Analysis and Interpretation.

• Student Paper Contest Chair, 40th Asilomar Conf. on Signals, Systems, and Computers, October 2006.

- Organized special session entitled "Applications of Multirate DSP" at the 40th Asilomar Conf. on Signals, Systems, and Computers, October 2006.
- Member of technical program committees for the IEEE International Conference on Acoustics, Speech, and Signal Processing (ICASSP), the IEEE International Conference on Image Processing (ICIP), and the IEEE Data Compression Conference (DCC).
- Senior Area Editor, IEEE Transactions on Image Processing, March 2016 to May 2022.
- Area Editor for IEEE Access, June 2022-Present.
- Deputy Editor-in-Chief, IEEE Transactions on Image processing, May 2023-present.

CONSULTING ACTIVITIES

- Video compression systems (technology consultant), Abba Tech, Albuquerque, NM, 2000.

- Expert witness in laser rangefinding technology, Asia Optical Inc. (through NY law firm of Osterlenk, Faber, Gerb & Soffen), Case: LTI versus Nikon/AOI, July 2001-2003. Case went to trial/ testified in court.

- Technical expert for defense; Case: Real-Time v. AT&T (byte.mobile), 2011-2012, case settled June 2012.

- Technical expert for defense; Case: Princeton Digital v. Dell, 2014-2015, case dismissed June 2015.

- Technical expert for defense; Noninfrigement & IPR (6,597,812), Real-time v. SAP, 1/2016-6/2016.

- Technical expert for defense; IPRs (7,378,992 & 8,643,513), Real-time v. Riverbed, et al., 2/2016-2017

- Technical expert for defense; IPRs (7,415,530, 9,116,908, 7,161,506, & 9,054,728), Real-time v. Dell, et al., 2/2016-2017

- Technical expert for defense; Noninfringement, Real-time v. HP Enterprises, 4/2016-2018.

- Technical expert for defense; IPR (7,358,867, 7,161,506, & 9,054,728), Real-time v. Teradata 11/2016-2017

- Technical expert for defense; IPRs (7,415,530, 8,643,513 & 7,378,992), Real-time v. Veritas 12/2016-2017.

- Technical expert for defense; IPRs (7,075,917 & 6,304,612), UNILOC v. Apple 9/2018-2019.

- Technical expert for defense; IPR (7,558,730), Advanced Voice Recognition Systems v. Apple 7/2019-2020.

- Technical expert for defense; District Court; Noninfringement, Realtime Adaptive Systems v. YouTube/Google, 2018-2020.

- Technical expert for defense; ITC case; Nokia v. Lenovo, Oct. 2020-2021.

- Technical expert for defense; IPR (10,176,848), Maxell v. Apple, 2019-2021.

• Technical expert for plaintiff (rebutting invalidity); East Texas District Court; USAA v. PNC Bank, 2021-present. Deposed in Case 1 and Case 2; Attended trial in May 2022 for Case 1 and September 2022 for Case 2 but was not called to testify (USAA won on all counts, patents upheld as valid); I have also opined as an expert in 3 related IPRs (deposed in one of those cases, so far).

• Technical expert for defense; District Court; Gesture Tech Partners v. Apple/Lenovo&Motorola, 2021.

JOURNAL PUBLICATIONS

1. **C.D. Creusere and S.K. Mitra**, "A simple method for designing high-quality prototype filters for M-band pseudo-QMF banks," *IEEE Trans. on Signal Processing*, Vol. 43, No. 4, April 1995, pp. 1005-1007.

2. **C.D. Creusere and S.K. Mitra**, "Efficient audio coding using perfect reconstruction noncausal IIR filter banks," *IEEE Trans. on Speech and Audio Processing,* Vol. 4, No. 2, March 1996, pp. 115-123.

3. **C.D. Creusere and S.K. Mitra**, "Image coding using wavelets based on perfect reconstruction IIR filter banks," *IEEE Trans. on Circuits and Systems for Video Technology,* Vol. 6, No. 5, Oct. 1996, pp. 447-458.

4. **C.D. Creusere**, "A new method of robust image compression based on the embedded zerotree wavelet algorithm," *IEEE Trans. on Image Processing*, Vol 6, No. 10, Oct. 1997, pp. 1436-1442.

5. **C.D. Creusere and A. Van Nevel**, "ATR-directed image and video compression," *Journal of Aircraft,* Vol. 36, No. 4, pp. 626-31, July-August 1999.

6. **C.D. Creusere**, "Fast embedded compression for video," *IEEE Trans. on Image Processing*, Vol. 8, No. 12, pp. 1811-16, December 1999.

7. **C.D. Creusere**, "Motion compensated video compression with reduced complexity encoding for remote transmission," *Signal Processing: Image Communications,* Vol. 16, pp. 627-42, April 2000.

8. **C.D. Creusere**, "Understanding perceptual distortion in MPEG scalable audio coding," *IEEE Trans. on Speech and Audio Processing,* Vol. 13, No. 3, pp. 422-431, May 2005.

9. **L. E. Boucheron and C.D. Creusere***,* "Lossless wavelet-based compression of digital elevation maps for fast and efficient search and retrieval," *IEEE Trans. on Geoscience and Remote Sensing,* Vol. 43, No. 5, pp. 1210-1214, May 2005.

10. **V. Thilak, D. Voelz, and C.D. Creusere**, "Polarization-based index of refraction and reflection angle estimation for remote sensing applications," *Applied Optics*, Vol. 46, Bo. 30, pp. 7427-7536, Oct. 2007.

11. **C.D. Creusere, K. Kallakuri, and R. Vanam**, "An Objective Metric of Human Subjective Audio Quality Optimized for a Wide Range of Audio Fidelities," *Audio, Speech, and Language Processing, IEEE Transactions on [see also Speech and Audio Processing, IEEE Transactions on]* , vol.16, no.1, pp.129-136, Jan. 2008

12. **S. Kandadai and C.D. Creusere**, "Scalable Audio Compression at Low Bitrates," *Audio, Speech, and Language Processing, IEEE Transactions on [see also Speech and Audio Processing, IEEE Transactions on]* , vol.16, no.5, pp.969-979, July 2008

13. **S. Kandadai and C.D. Creusere**, "Reverse engineering and repartitioning vector quantizers using training set synthesis," *Signal Processing,* August 2008.

14. **V. Thilak, C.D. Creusere, and D. Voel**z, "Passive Polarimetric Imagery-Based Material Classification Robust to Illumination Source Position and Viewpoint," *Image Processing, IEEE Transactions on ,* vol.20, no.1, pp.288-292, Jan. 2011.

15. **C.D. Creusere and J. Hardin**, "Assessing the Quality of Audio Containing Temporally Varying Distortions," *Audio, Speech, and Language Processing, IEEE Transactions on* , vol.19, no.4, pp.711-720, May 2011.

16. **Castorena, J.; Creusere, C.D.**, "The Restricted Isometry Property for Banded Random Matrices," *Signal Processing, IEEE Transactions on* , vol.62, no.19, pp.5073-5084, Oct.1, 2014 doi: 10.1109/TSP.2014.2345350.

17. **Castorena, J.; Creusere, C.D.**, "Sampling of Time-Resolved Full-Waveform LIDAR Signals at Sub-Nyquist Rates," *Geoscience and Remote Sensing, IEEE Transactions on* , vol.53, no.7, pp.3791-3802, July 2015. doi: 10.1109/TGRS.2014.2383839.

REFEREED CONFERENCE PUBLICATIONS

1. **H. Babic, S.K. Mitra, C.D. Creusere, and A. Das**, "Perfect reconstruction recursive QMF banks for image subband coding," *Proc. Asilomar Conf. Signals, Systems, and Computers*, Pacific Grove, CA, Nov. 1991, pp. 746-750.

2. **S.K. Mitra, C.D. Creusere, and H. Babic**, "A novel implementation of perfect reconstruction QMF banks using IIR filters," *Proc. IEEE Int. Symposium on Circuits and Systems*, San Diego, CA, May 1992, pp. 2312-2315.

3. **S.K. Mitra, C.D. Creusere, and H. Babic**, "Design of transmultiplexers using IIR filter banks," *Signal Processing VI: Theories and Applications*, Elsevier Science Publishers, 1992, pp. 223-226.

4. **C.D. Creusere and S.K. Mitra**, "Efficient image scrambling using polyphase filter banks," *Proc. International Conference on Image Processing*, Austin, TX, Nov. 1994, pp. 81-85.

5. **C.D. Creusere and G. Hewer**, "Wavelet-based nearest neighbor pattern classification using scale sequential matching," *Proc. Asilomar Conf. Signals, Systems and Computers*, Pacific Grove, CA, Nov. 1994, pp. 1123-1127.

6. **C.D. Creusere**, "Embedded zerotree image coding using low complexity IIR filter banks," *Proc. Int. Conf. on Acoustics, Speech, and Signal Processing*, Detroit, MI, May 1995, pp. 2213-16.

7 **C.D. Creusere and Gary Hewer**, "Digital video compression for weapons control and bomb damage indication," *AGARD Conference Proceedings 576*, Chapter 16, Sept. 1995.

8. **C.D. Creusere**, "Image coding using parallel implementations of the embedded zerotree wavelet algorithm," *Proc. of the Digital Video Compression Conference (Algorithms and Technologies 1996)*, San Jose, CA, Jan. 28-Feb. 2, 1996, pp. 82-93.

9. **C.D. Creusere**, "A family of image compression algorithms which are robust to transmission errors," *Proceedings of the SPIE*, Vol. 2825, Denver, CO, August, 1996, pp. 890-900.

10. **C.D. Creusere**, "Perfect reconstruction time-varying IIR filter banks," *Conf. Rec. Asilomar Conf. Signals, Systems, and Computers*, Pacific Grove, CA, Nov. 1996, pp. 1319-23.

11. **C.D. Creusere**, "Out-of-loop motion compensation for reduced complexity video encoding," *Proc. of the Data Compression Conf.* (pp. 428) *& Data Compression Industry Workshop* (pp.28-37), March 1997, Snowbird, UT.

12. **C.D. Creusere**, "Periodic pan compensation for reduced complexity video compression," *Proc. Int. Conf. on Acoustics, Speech, and Signal Processing,* Vol IV, pp. 2889-92, April 1997, Munich, Germany.

13. **C.D. Creusere**, "A new approach to global motion compensation which reduces video encoding complexity," *Proc. Int. Conf. on Image Processing*, Vol. III, pp. 634-7, October 1997, Santa Barbara, CA.

14. **C.D. Creusere**, "Spatially partitioned lossless image compression in an embedded framework," *Conf. Rec. 31st Asilomar Conf. on Signals, Systems, and Computers*, Nov. 1997, Pacific Grove, CA.

15. **C.D. Creusere**, "Adaptive embedding for reduced complexity image and video compression," *Proc.*

of the SPIE, Vol 3309 (Visual Communications and Image Processing), pp. 48-57, Jan. 1998, San Jose, CA.

16. **C.D. Creusere**, "Successive coefficient refinement for embedded lossless image compression," *Proc. of the Data Compression Conf.*, pp. 539, March 1998, Snowbird, UT.

17. **C.D. Creusere**, "Subband coding of speech and audio," *Proc. of the European Signal Processing Conf.* (invited paper), Sept. 1998, Isle of Rhodes, Greece.

18 **C.D. Creusere**, "Fast embedded video compression using cache-based processing," *Proc. of the European Signal Processing Conf.*, Sept. 1998, Isle of Rhodes, Greece.

19. **C.D. Creusere**, "Successive coefficient refinement for embedded lossless image compression," *Proc. Int. Conf. on Image Processing*, Oct. 1998, Chicago, IL.

20. **C.D. Creusere** and A. Van Nevel, "Autonomous target recognition directed image compression," *Proc. of the AIAA*, Nov. 1998.

21. **C.D. Creusere**," Improved successive refinement for wavelet-based embedded image compression," *Proc. of the SPIE*, Denver, CO, July 1999.

22. A. Van Nevel and **C.D. Creusere**, "Intelligent Bandwidth Compression," *Proc. of the SPIE*, Denver, CO, July 1999.

23. **C.D. Creusere,** "Optimal refinement/significance map tradeoffs in SPIHT-based image compression," *Conf. Rec., 34th Asilomar Conf. on Signals, Systems, & Computers, pp. 1026-30, Oct. 2000.*

24. **C.D. Creusere,** "Compression of digital elevation maps using nonlinear wavelets," *Proc. Int. Conf. on Image Processing*, pp. 824-7, October 2001.

25. **C.D. Creusere and G. Dahman**, "Object detection and localization in compressed video," *Conf. Rec. 35th Asilomar Conf. on Signals, Systems, and Computers*, Nov. 2001, Pacific Grove, CA.

26. **C.D. Creusere**, "An analysis of perceptual artifacts in MPEG scalable audio coding," *Proceedings of the Data Compression Conference*, pp. 152-161, April 2002, Snowbird, UT.

27. **C.D. Creusere and N. Tolk**, "Combining wavelets and GLICBAWLS to achieve resolution-progressive lossless compression," *Proc. of the International Conference on Image Processing*, pp. III-229-32, October 2002.

28. **L. Boucheron and C.D. Creusere**, "Compression of digital elevation maps for fast and efficient search and retrieval," *Proc. of the International Conference on Image Processing*, pp. 629-32, September 2003.

29. **S. Kandadai and C.D. Creusere**, "An experimental study of object detection in the wavelet domain," *Conf. Rec. 37th Asilomar Conf. on Signals, Systems, and Computers*, pp. 1620-4, Nov. 2003, Pacific Grove, CA.

30. **C.D. Creusere**, "Quantifying perceptual distortion in scalably compressed MPEG audio," *Conf. Rec. 37th Asilomar Conf. on Signals, Systems, and Computers*, pp. 265-9, Nov. 2003, Pacific Grove, CA.

31. **C.D. Creusere and L. Zhou**, "Spatial object detection and classification in JPEG bitstreams ," *Proceedings 11th Digital Signal Processing Workshop*, pp. 115-9, August 2004, Taos Ski Valley, NM,

32. **L. Zhou and C.D. Creusere**, "Spatial object detection in JPEG bitstreams," *Proceedings European Conference on Signal Processing*, pp. 949-52, September 2004, Vienna, Austria.

33. **V. Thilak and C.D. Creusere**, "Tracking of extended size targets in H.264 compressed video using the probabilistic data association filter," *Proceedings European Conference on Signal Processing*, pp. 281-4, September 2004, Vienna, Austria.

34. **S. Kandadai and C.D. Creusere**, Reverse engineering vector quantizers by training set synthesis," *Proceedings European Conference on Signal Processing*, pp. 789-92, September 2004, Vienna, Austria.

35. **V. Thilak, J. Saini, D. G. Voelz, C. D. Creusere** , "Pattern recognition for passive polarimetric data using nonparametric classifiers," *Proc. of the SPIE Vol. 5888*, p. 337-344, Polarization Science and Remote Sensing II; Joseph A. Shaw, J. Scott Tyo; Eds.

36. **R. Vanam and C.D. Creusere**, "Evaluating low bitrate scalable audio quality using advanced version of PEAQ and energy equalization approach ," *Proc. IEEE Int. Conf. on Acoustics, Speech, and Signal Processing*, Vol. III, pp. 189-92, March 2005.

37. **S. Kandadai and C.D. Creusere**, "Reverse engineering vector quantizers for repartitioned signal spaces," *Proc. 39th Asilomar Conference on Signals, Systems, and Computers*, pp. 1208-12, Pacific Grove, CA, Nov. 2005.

38. **R. Vanam and C.D. Creusere,** "Scalable perceptual metric for evaluating audio quality," *Proc. 39th Asilomar Conference on Signals, Systems, and Computers*, pp. 319-23, Pacific Grove, CA, Nov. 2005.

39. **S. Kandadai and C.D. Creusere**, "Perceptually-weighted audio coding that scales to extremely low bitrates," *Proc. IEEE Data Compression Conference*, pp. 382-391, Snowbird, UT, March 2006.

40. **V. Thilak, D. Voelz, C. Creusere, S. Damarla,** "Estimating the refractive index and reflected zenith angle of a target using multiple polarization measurements," Proc. SPIE Vol. 6240, 624004, Polarization: Measurement, Analysis, and Remote Sensing VII; Dennis H. Goldstein, David B. Chenault; Eds., May 2006.

41. **V.M. Prasad and C.D. Creusere**, "Analyzing reversible lapped transformations using Reng probing," *Proc. 40th Asilomar Conference on Signals, Systems, and Computers*, pp. 873-877, Oct. 2006.

42. **N. Balachandran and C.D. Creusere**, "Chirp classification using hidden Markov models," *Proc. 40th Asilomar Conference on Signals, Systems, and Computers*, pp. 545-549, Oct. 2006.

43. **V. Thilak and C.D. Creusere**, "Estimating the complex index of refraction and view angle of an object using multiple polarization measurements," *Proc. 40th Asilomar Conference on Signals, Systems, and Computers*, pp. 1067-1071, Oct. 2006.

44. **V. Thilak, C.D. Creusere, and D.G. Voelz**, "Material classification using passive polarmetric imagery," Proc. IEEE Int. Conf. on Image Proc., Vol. 4, pp. IV-121-124, Sept., 2007.

45. **A. Pamba, V. Thilak, D. G. Voelz, C. D. Creusere** "Estimation of incidence and reflection angles from passive polarimetric imagery: extension to out-of-plane scattering," Proc. SPIE Vol 6682, 66820O, Polarization Science and Remote Sensing III, Joseph A. Shaw; J. Scott Tyo, Editors, September 2007.

46. **V. Thilak, D. G. Voelz, C. D. Creusere**, "Image segmentation from multi-look passive polarimetric imagery, Proc. SPIE 6682, 668206, Polarization Science and Remote Sensing III, Joseph A. Shaw; J. Scott Tyo, Editors, October 2007.

47. **S. Kandadai and C.D. Creusere**, "Optimal Bit Layering for Scalable Audio Compression Using Objective Audio Quality Metrics," *Signals, Systems and Computers, 2007. ACSSC 2007. Conference Record of the Forty-First Asilomar Conference on* , pp.560-564, 4-7 Nov. 2007.

48. **C.D. Creusere and I. Mecimore**, "Bitstream-based overlap analysis for multi-view distributed video coding," *Proc. IEEE Southwest Symposium on Image Analysis and Interpretation*, pp. 93-96, March 2008.

49. **V. Thilak, C.D. Creusere, and D.G. Voelz**, "Passive Polarimetric Imagery Based Material Classification For Remote Sensing Applications," *Proc. IEEE Southwest Symposium on Image Analysis and Interpretation*, pp. 153-156 March 2008.

50. **V. Thilak, Q. Wang, D. G. Voelz, C. D. Creusere**, "Estimation of target geometry from Mueller matrix imagery," *Proc. SPIE 6972*, March 2008.

51. **C.D. Creusere and I. Mecimore**, "Bitstream-based correlation detector for multi-view distributed video coding applications," *Proc. Int. Conf. on Accoustics, Speech, and Signal Processing*, pp. 1001-1004, April 2008, Las Vegas, NV.

52. **S. Kandadai, J. Hardin, and C.D. Creusere**, "Audio quality assessment using the mean structural similarity measure," *Proc. Int. Conf. on Accoustics, Speech, and Signal Processing*, pp. 221-224, April 2008, Las Vegas, NV.

53. **S. Matta and C.D. Creusere**, "Efficient correlation extraction for distributed audio coding," *Signals, Systems and Computers, 2008 42nd Asilomar Conference on* , vol., no., pp.1272-1276, 26-29 Oct. 2008 .

54. **J.C. Hardin and C.D. Creusere**, "Objective analysis of temporally varying audio quality metrics," *Signals, Systems and Computers, 2008 42nd Asilomar Conference on* , vol., no., pp.1245-1249, 26-29 Oct. 2008 .

55. **S. Matta and C.D. Creusere**, "Distributed audio coding with efficient source correlation extraction," *Proceedings 13th Digital Signal Processing Workshop*, pp. 16-20, January 2009, Marco Island, FL.

56. **I. Mecimore and C.D. Creusere**, "Unsupervised bitstream based segmentation of images," *Proceedings 13th Digital Signal Processing Workshop*, pp. 642-647, January 2009, Marco Island, FL.

57. **Q. Wang, C.D. Creusere, V. Thilak, and D.G. Voeltz**, "Active polarimetric imaging for estimation of scene geometry," *Proceedings 13th Digital Signal Processing Workshop*, pp. 659-663, January 2009, Marco Island, FL.

58. **J.C. Hardin and C.D. Creusere**, "A temporally varying objective audio quality metric," *Proceedings 13th Digital Signal Processing Workshop*, pp. 21-25, January 2009, Marco Island, FL.

59. **I. Mecimore, W. Fahrenkrog, and C.D. Creusere**, "On bitstream based edge detection techniques," ITEA Conference, January 2009, El Paso, TX (best graduate student paper award).

60. **Mecimore, Ivan; Creusere, Charles D.**; , "Low complexity multi-view distributed video coding based on JPEG," *Image Analysis & Interpretation (SSIAI), 2010 IEEE Southwest Symposium on* , vol., no., pp.165-168, 23-25 May 2010.

61. **Creusere, C.D.; Mehta, K.; Voelz, D.G.**; , "Model-based estimation of surface geometry using passive polarimetric imaging," *Geoscience and Remote Sensing Symposium (IGARSS), 2010 IEEE International* , vol., no., pp.4557-4560, 25-30 July 2010.

62. **Castorena, J.; Creusere, C.D.; Voelz, D.**; , "Modeling lidar scene sparsity using compressive sensing," *Geoscience and Remote Sensing Symposium (IGARSS), 2010 IEEE International* , vol., no., pp.2186-2189, 25-30 July 2010.

63. **Castorena, J.; Creusere, C.D.; Voelz, D.**; , "Using finite moment rate of innovation for LIDAR waveform complexity estimation," *Signals, Systems and Computers (ASILOMAR), 2010 Conference Record of the Forty Fourth Asilomar Conference on* , vol., no., pp.608-612, 7-10 Nov. 2010

64. **Creusere, C.D.; Siddenki, S.; Hardin, J; Kroger, J**; , "Early investigations into subjective audio quality assessment using brainwave responses," *Signals, Systems and Computers (ASILOMAR), 2011 Conference Record of the Forty Fifth Asilomar Conference on* , vol., no., pp., Nov. 2011.

65. **Castorena, J.E.; Creusere, C;**, "Remote-sensed LIDAR using random sampling and sparse reconstruction," *Proc. International Telemetering Conference*, Las Vegas, NV, October 2011.

66. **Davis, P; Creusere, C.**; "Quantifying the gains of compressive sensing for telemetering application," *Proc. International Telemetering Conference*, Las Vegas, NV, October 2011.

67. **Creusere, C.D.; Kroger, J.; Siddenki, S.R.; Davis, P.; Hardin, J.**; , "Assessment of subjective audio quality from EEG brain responses using time-space-frequency analysis," *Signal Processing Conference (EUSIPCO), 2012 Proceedings of the 20th European* , vol., no., pp.2704-2708, 27-31 Aug. 2012.

68. **Castorena, J.; Creusere, C.D.;** , "Compressive sampling of LIDAR: Full-waveforms as signals of finite rate of innovation," *Signal Processing Conference (EUSIPCO), 2012 Proceedings of the 20th*

European , vol., no., pp.984-988, 27-31 Aug. 2012.

69. **Castorena, J.; Creusere, C.D.;** "Random impulsive scan for LIDAR sampling," Proc. IEEE Int. Conf. on Image Proc., October 2012.

70. **Creusere, C. ,Nelson, E., Critz, T., Butcher, E.**; "Analysis of communication interconnectedness in the proximity of near-earth asteroids," *Proc. International Telemetering Conference*, San Diego, CA, October 2012.

71. **Castorena, J.E.; Creusere, C;**, "Remote-sensed LIDAR using random impulsive scans," *Proc. International Telemetering Conference*, San Diego, CA, October 2012.

72. **Castorena, J.; Creusere, C.D.**, "Sub-spot localization for spatial super-resolved LIDAR," *Acoustics, Speech and Signal Processing (ICASSP), 2013 IEEE International Conference on* , vol., no., pp.2227,2231, 26-31 May 2013.

73. **Charles D. Creusere ; Juan Castorena**, "A unified framework for 3rd generation lidar pulse processing based on finite rate of innovations," *Proc. SPIE 8858, Wavelets and Sparsity XV*, 88580T (September 26, 2013); doi:10.1117/12.2022447.

74. **Nelson, E., Creusere, C., Critz, T., Butcher, E.**; "Analysis of communication rates in the proximity of near-earth asteroids," *Proc. International Telemetering Conference*, Las Vegas, NV, October 2013.

75. **Castorena, J.E.; Creusere, C;**, "Full-waveform LIDAR recovery at sub-Nyquist rates," *Proc. International Telemetering Conference*, Las Vegas, NV, October 2013.

76. **Davis, P.; Creusere, C.D.; Kroger, J.**, "EEG and the human perception of video quality: Impact of channel selection on discrimination," *Global Conference on Signal and Information Processing (GlobalSIP), 2013 IEEE* , vol., no., pp.9,12, 3-5 Dec. 2013, doi: 10.1109/GlobalSIP.2013.6736798.

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83. **Newtson, Kathy; Creusere, Charles D.**, "Histogram oriented gradients and map seeking circuits pattern recognition with compressed imagery," *Proc. Southwest Symposium on Image Analysis and Interpretation*, Santa Fe, NM, March 2016.

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3. **C.D. Creusere**, "Creating a compressed and embedded image representation which is robust to transmission errors," presented at the Office of Naval Research Workshop on Error Resilient Compression, San Diego, CA, February, 1996.

4. **C.D. Creusere**, "Data Compression Project Final Report," NAWCWD Technical Paper, TP 8442.

5. **C.D. Creusere**: "Applications of multirate digital signal processing to communications systems," NATO/RTA lecture series 216 on *Applications of M*athematical *Signal Processing Techniques to Mission Systems*, presented in Paris, France; Cologne, Germany; and Monterey, CA, November 1999.

6. **C.D. Creusere**, "Object detection and recognition in compressed video," invited presentation

and white paper for the Motion Imagery Workshop, sponsored by the National Imagery and Mapping Agency (NIMA) and the National Science Foundation (NSF).

7. **C.D. Creusere**, "Application specific compression: digital elevation map browsing, video surveillance, and scalable audio," invited seminar at the University of Arizona, Tucson, AZ, March 2003.

8. **C.D. Creusere**, "Compressing Digital Elevation Maps for Efficient Search and Retrieval," presented at the Office of Naval Research Workshop on Image Processing, Minneapolis, MN, May 2003.

APPENDIX 2: MATERIALS CONSIDERED IN THE PREPARATION OF THIS DECLARATION

Exhibit No.	Description
1001	U.S. Patent No. 10,536,714 to Bici, et al. ("the '714 patent")
1002	Prosecution File History for the '714 patent ("Prosecution History")
1004	U.S. Patent Application Publication No. 2011/0194609 to Rusert et al ("Rusert")
1005	U.S. Patent Application Publication No. 2011/0249721 to Karczewicz et al ("Karczewicz")
1006	U.S. Patent Application Publication No. 2014/0092981 to Lin et al ("Lin")
1007	Nakamura et al., "Unification of derivation process for merge mode and MVP," Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, 6th Meeting, Torino, Italy, Jul. 14-22, 2011, Document JCTVC-F419 ("Nakamura Document")
1008	Nakamura et al., "WD description of JCTVC-F419 Proposal 1" for "Unification of derivation process for merge mode and MVP," Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, 6th Meeting, Torino, Italy, Jul. 14-22, 2011, Document JCTVC-F419 ("Nakamura WD Description")
1009	Nakamura et al., "Unification of derivation process for merge mode and MVP" Presentation, Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, 6th Meeting, Torino, Italy, Jul. 14-22, 2011, Document JCTVC-F419 ("Nakamura Presentation")
1010	Bross et al., "WD4: Working Draft 4 of High-Efficiency Video Coding," Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, 6th Meeting: Torino, IT, Jul. 14-22, 2011, Document JCTVC-F803 ("WD4")
1011	Prosecution File History for U.S. Patent No. 10,237,574 ("'574 Prosecution History")
1012	U.S. Provisional Application 61/301,649 ("Rusert Provisional")
1013	U.S. Provisional Application 61/500,903 ("Lin Provisional")
1014	Declaration of Vivienne Sze ("Sze Declaration")

Exhibit No.	Description
1015	Prosecution File History for U.S. Patent No. 9,571,833 ("'833 Prosecution History")
1016	Prosecution File History for U.S. Patent No. 9,743,105 ("'105 Prosecution History")
1017	European Prosecution File History for 12845839 ("European Prosecution History")
1018	U.S. Patent Application Publication No. 2012/0128067 to Liu ("Liu")
1019	Gary J. Sullivan, Recent Developments in Standardization of High Efficiency Video Coding (HEVC) ("Sullivan")
1020	Frank Bossen, HEVC Complexity and Implementation Analysis ("Bossen")
1021	Jian-Wei Chen et al, Introduction to H.264 advanced video coding. In: Proceedings of the 2006 Asia and South Pacific Design Automation Conference vol. 2006, pp. 736–741 (2006)
1022	Won, Kwanghyun et al, Motion vector coding using decoder-side estimation of motion vector. In 2009 IEEE International Symposium on Broadband Multimedia Systems and Broadcasting (BMSB). IEEE, 2009.
1023	Gary J. Sullivan et al, The H.264/AVC Advanced Video Coding Standard: Overview and Introduction to the Fidelity Range Extensions, SPIE Conference on Applications of Digital Image Processing XXVII, 2004.
1024	Gweon, Ryeong-Hee, Non-Fixed Quantization Considering Entropy Encoding in HEVC, Journal of Broadcast Engineering. The Korean Institute of Broadcast and Media Engineers, 2011
1025	Hong, Chang-Yi, New Merge Mode Decision in High Efficiency Video Coding (HEVC), 2014 International Computer Science and Engineering Conference (ICSEC), IEEE (2014).
1026	JCT-VC - Joint Collaborative Team on Video Coding (https://www.itu.int/en/ITU-T/studygroups/2013-2016/16/Pages/video/jctvc.aspx)
1027	Terms of Reference of the Joint Collaborative Team on Video Coding Standard Development (https://www.itu.int/dms_pub/itu-t/oth/46/01/T46010000010001PDFE.pdf)
1028	Sullivan et al., "Meeting report of the sixth meeting of the Joint Collaborative Team on Video Coding (JCT-VC), Torino, IT, 14–22 July 2011," Joint Collaborative Team on Video Coding (JCT-

Exhibit No.	Description
	VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, 6th Meeting, Torino, Italy, Jul. 14-22, 2011, Document JCTVC-F800
1029	"All Meetings" web page (from the JCT-VC site) (http://phenix.int-evry.fr/jct/doc_end_user/all_meeting.php)
1030	"Torino Meeting - Document Register" web page (from the JCT-VC site) (http://phenix.int-evry.fr/jct/doc_end_user/current_meeting.php?id_meeting=149&search_id_group=1&search_sub_group=1)
1031	A portion of search screen for "merge mode" on the "Torino Meeting - Document Register" web page
1032	A portion of search screen for "MVP" on the "Torino Meeting - Document Register" web page
1033	Search result page for "merge mode" originated from the "Torino Meeting - Document Register" web page
1034	Search result page for "MVP" originated from the "Torino Meeting - Document Register" web page
1035	Search result page for "WD4" originated from the "Torino Meeting - Document Register" web page
1036	Search result page for "high-efficiency video coding" originated from the "Torino Meeting - Document Register" web page
1037	Search result page for "DRAFT" originated from the "Torino Meeting - Document Register" web page
1038	"Preview document JCTVC-F419 for Torino meeting" web page (http://phenix.int-evry.fr/jct/doc_end_user/current_document.php?id=2894)
1039	"Preview document JCTVC-F803 for Torino meeting" web page (http://phenix.int-evry.fr/jct/doc_end_user/current_document.php?id=3286)
1040	Sullivan et al., "Meeting report of the third meeting of the Joint Collaborative Team on Video Coding (JCT-VC), Guangzhou, CN, 7–15 October, 2010," Joint Collaborative Team on Video Coding (JCT-VC) of ITU-T SG16 WP3 and ISO/IEC JTC1/SC29/WG11, 3rd Meeting, Guangzhou China, Oct. 7-15, 2010, Document JCTVC-C400
1041	"All Meetings" web page (from the JCT-VC distribution website) (http://phenix.it-sudparis.eu/jct/doc_end_user/all_meeting.php)

Exhibit No.	Description
1042	"Torino Meeting - Document Register" web page (from the JCT-VC distribution website) (http://phenix.it-sudparis.eu/jct/doc_end_user/current_meeting.php?id_meeting=149&search_id_group=1&search_sub_group=1)
1043	Search result page for "merge mode" originated from the "Torino Meeting - Document Register" web page (from the JCT-VC distribution website)
1044	Search result page for "MVP" originated from the "Torino Meeting - Document Register" web page (from the JCT-VC distribution website)
1045	Search result page for "working draft" originated from the "Torino Meeting - Document Register" web page (from the JCT-VC distribution website)
1046	Search result page for "WD" originated from the "Torino Meeting - Document Register" web page (from the JCT-VC distribution website)
1047	"Preview document JCTVC-F419 for Torino meeting" web page (http://phenix.it-sudparis.eu/jct/doc_end_user/current_document.php?id=2894)
1048	"Preview document JCTVC-F803 for Torino meeting" web page (http://phenix.it-sudparis.eu/jct/doc_end_user/current_document.php?id=3286)
1049	Search result page for "Nakamura" originated from the "Torino Meeting - Document Register" web page (from the JCT-VC distribution website)
1050	Declaration of Clifford Reader
1051	Machine translation of Gweon, Ryeong-Hee, Non-Fixed Quantization Considering Entropy Encoding in HEVC, Journal of Broadcast Engineering. The Korean Institute of Broadcast and Media Engineers, 2011

APPENDIX 3: CHALLENGED CLAIMS

[9pre] A method comprising:

[9a] selecting a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for an encoded block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the encoded block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates;

[9b] determining a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;

[9c] comparing motion information of the first spatial motion vector prediction candidate with motion information of another spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;

[9d] determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and

[9e] selecting a spatial motion vector prediction candidate from the motion vector prediction list for use in decoding the encoded block of pixels, wherein the spatial motion vector prediction candidate is selected from the motion vector prediction list using information that was received identifying a respective spatial motion vector prediction candidate from the motion vector prediction list constructed by an encoder.

10. The method according to claim 9 further comprising comparing motion information of the potential spatial motion vector prediction candidate with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates.

11. The method according to claim 9 further comprising examining whether the received encoded block of pixels is divided into a first prediction unit and a second prediction unit; and if so, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the prediction unit is the second prediction unit.

[12pre] The method according to claim 9 further comprising

[12a] determining a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list; and

[12b] limiting the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number.

[13pre] The method according to claim 12 further comprising:

[13a] examining, if the number of spatial motion vector prediction candidates in the motion vector prediction list smaller than the maximum number;

[13b] if so, examining whether the prediction unit to which the potential spatial motion vector prediction candidate belongs is available for motion prediction;

[13c] if so, performing at least one of the following:

[13d] for a potential spatial motion vector prediction candidate on a left side of the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[13e] the received encoded block of pixels is vertically divided into a first prediction unit and a second prediction unit;

[13f] the received encoded block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and if the prediction unit is the second prediction unit, and the potential spatial motion vector prediction candidate has essentially similar motion information than a spatial motion vector prediction candidate above the prediction unit;

[13g] for a potential spatial motion vector prediction candidate above the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[13h] the received encoded block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and the prediction unit is the second prediction unit;

[13i] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit;

[13j] for a potential spatial motion vector prediction candidate, which is on a right side of the potential spatial motion vector prediction candidate above the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate above the prediction unit;

[13k] for a potential spatial motion vector prediction candidate, which is below the potential spatial motion vector prediction candidate on the left side of the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction

candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit; and

[13l] for a potential spatial motion vector prediction candidate cornerwise neighbouring the prediction unit, excluding the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[13m] all the other potential spatial motion vector prediction candidates have been included in the motion vector prediction list;

[13n] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate above the prediction unit;

[13o] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit.

14. The method according to claim 9 further comprising selecting one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the encoded block of pixels.

[23pre] An apparatus comprising a processor and a memory including computer program code, the memory and the computer program code configured to, with the processor, cause the apparatus to:

[23a] select a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for an encoded block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the encoded block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates;

[23b] determine a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;

[23c] compare motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;

[23d] determine to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on comparison of the motion

information of the first spatial motion vector candidate with motion information of the spatial motion vector prediction candidate; and

[23e] select a spatial motion vector prediction candidate from the motion vector prediction list for use in decoding the encoded block of pixels, wherein the spatial motion vector prediction candidate is selected from the motion vector prediction list using information that was received identifying a respective spatial motion vector prediction candidate from the motion vector prediction list constructed by an encoder.

24. The apparatus according to claim 23 wherein the apparatus is further caused to compare motion information of the potential spatial motion vector prediction candidate with motion information of at most one other spatial motion vector prediction candidate of the set of spatial motion vector prediction candidates.

25. The apparatus according to claim 23 wherein the apparatus is further caused to examine whether the received encoded block of pixels is divided into a first prediction unit and a second prediction unit; and if so, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if the prediction unit is the second prediction unit.

[26pre] The apparatus according to claim 23 wherein the apparatus is further caused to:

[26a] determine a maximum number of spatial motion vector prediction candidates to be included in the motion vector prediction list; and

[26b] limit the number of spatial motion vector prediction candidates in the motion vector prediction list smaller or equal to the maximum number.

[27pre] The apparatus according to claim 26 wherein the apparatus is further caused to:

[27a] examine if the number of spatial motion vector prediction candidates in the motion vector prediction list smaller than the maximum number;

[27b] if so, examine whether the prediction unit to which the potential spatial motion vector prediction candidate belongs is available for motion prediction;

[27c] if so, perform at least one of the following:

[27d] for a potential spatial motion vector prediction candidate on a left side of the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[27e] the received encoded block of pixels is vertically divided into a first prediction unit and a second prediction unit;

[27f] the received encoded block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and if the prediction unit is the second prediction unit, and the potential spatial motion vector prediction candidate has essentially similar motion information than a spatial motion vector prediction candidate above the prediction unit;

[27g] for a potential spatial motion vector prediction candidate above the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[27h] the received encoded block of pixels is horizontally divided into a first prediction unit and a second prediction unit, and the prediction unit is the second prediction unit;

[27i] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit;

[27j] for a potential spatial motion vector prediction candidate, which is on a right side of the potential spatial motion vector prediction candidate above the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction

candidate has essentially similar motion information than the spatial motion vector prediction candidate above the prediction unit;

[27k] for a potential spatial motion vector prediction candidate, which is below the potential spatial motion vector prediction candidate on the left side of the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit; and

[27l] for a potential spatial motion vector prediction candidate cornerwise neighbouring the prediction unit, exclude the potential spatial motion vector prediction candidate from the motion vector prediction list if any of the following conditions are fulfilled:

[27m] all the other potential spatial motion vector prediction candidates have been included in the motion vector prediction list;

[27n] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate above the prediction unit;

[27o] the potential spatial motion vector prediction candidate has essentially similar motion information than the spatial motion vector prediction candidate on the left side of the prediction unit.

28. The apparatus according to claim 23 wherein the apparatus is further caused to select one motion vector prediction candidate from the motion vector prediction list to represent a motion vector prediction for the received encoded block of pixels.

[30pre] A non-transitory computer readable medium having stored thereon a computer executable program code for use by an encoder, said program codes comprising instructions for:

[30a] selecting a first spatial motion vector prediction candidate from a set of spatial motion vector prediction candidates for an encoded block of pixels as a potential spatial motion vector prediction candidate to be included in a motion vector prediction list for a prediction unit of the encoded block of pixels, where the motion vector prediction list comprises motion information of the spatial motion vector prediction candidates;

[30b] determining a subset of spatial motion vector prediction candidates based on the location of the block associated with the first spatial motion vector prediction candidate;

[30c] comparing motion information of the first spatial motion vector prediction candidate with motion information of the spatial motion vector prediction candidate in the determined subset of spatial motion vector prediction candidates without making a comparison of each possible candidate pair from the set of spatial motion vector prediction candidates;

[30d] determining to include or exclude the first spatial motion vector prediction candidate in the motion vector prediction list based on the comparing; and

[30e] selecting a spatial motion vector prediction candidate from the motion vector prediction list for use in decoding the encoded block of pixels, wherein the spatial motion vector prediction candidate is selected from the motion vector prediction list using information that was received identifying a respective spatial motion vector prediction candidate from the motion vector prediction list constructed by an encoder.

APPENDIX 4: UNDERSTANDING OF THE LAW

I have applied the following legal principles provided to me by counsel in arriving at the opinions set forth in this report.

Legal Standard for Prior Art

I am not an attorney. I have been informed by attorneys of the relevant legal principles and have applied them to arrive at the opinions set forth in this declaration.

I understand that the petitioner for inter partes review may request the cancelation of one or more claims of a patent based on grounds available under 35 U.S.C. § 102 and 35 U.S.C. § 103 using prior art that consists of patents and printed publications.

Anticipation and Prior Art

I understand that § 102 specifies when a challenged claim is invalid for lacking novelty over the prior art, and that this concept is also known as "anticipation." I understand that a prior art reference anticipates a challenged claim, and thus renders it invalid by anticipation, if all elements of the challenged claim are disclosed in the prior art reference. I understand the disclosure in the prior art reference can be either explicit or inherent, meaning it is necessarily present or implied. I understand that the prior art reference does not have to use the same words as the challenged claim, but all of the requirements of the claim must be disclosed so that a person of ordinary skill in the art could make and use the claimed subject-matter.

In addition, I understand that § 102 also defines what is available for use as a prior art reference to a challenged claim.

Under § 102(a), a challenged claim is anticipated if it was patented or described in a printed publication in the United States or a foreign country before the challenged claim's date of invention.

Under § 102(b), a challenged claim is anticipated if it was patented or described in a printed publication in the United States or a foreign country more than one year prior to the challenged patent's filing date.

Under § 102(e), a challenged claim is anticipated if it was described in a published patent application that was filed by another in the United States before the challenged claim's date of invention, or was described in a patent granted to another that was filed in the United States before the challenged claim's date of invention.

I understand that a challenged claim's date of invention is presumed to be the challenged patent's filing date. I also understand that the patent owner may establish an earlier invention date and "swear behind" prior art defined by § 102(a) or § 102(e) by proving (with corroborated evidence) the actual date on which the named inventors conceived of the subject matter of the challenged claim and proving that the inventors were diligent in reducing the subject matter to practice.

I understand that the filing date of a patent is generally the filing date of the application filed in the United States that issued as the patent. However, I understand that a patent may be granted an earlier effective filing date if the patent owner properly claimed priority to an earlier patent application.

I understand that when a challenged claim covers several structures, either generically or as alternatives, the claim is deemed anticipated if any of the structures within the scope of the claim is found in the prior art reference.

I understand that when a challenged claim requires selection of an element from a list of alternatives, the prior art teaches the element if one of the alternatives is taught by the prior art.

Legal Standard for Obviousness

I understand that even if a challenged claim is not anticipated, it is still invalid if the differences between the claimed subject matter and the prior art are such that the claimed subject matter would have been obvious to a person of ordinary skill in the pertinent art at the time the alleged invention.

I understand that obviousness must be determined with respect to the challenged claim as a whole.

I understand that one cannot rely on hindsight in deciding whether a claim is obvious.

I also understand that an obviousness analysis includes the consideration of factors such as (1) the scope and content of the prior art, (2) the differences between the prior art and the challenged claim, (3) the level of ordinary skill in the pertinent art, and (4) "secondary" or "objective" evidence of non-obviousness.

Secondary or objective evidence of non-obviousness includes evidence of: (1) a long felt but unmet need in the prior art that was satisfied by the claimed invention; (2) commercial success or the lack of commercial success of the claimed invention; (3) unexpected results achieved by the claimed invention; (4) praise of the claimed invention by others skilled in the art; (5) taking of licenses under the patent by others; (6) deliberate copying of the claimed invention; and (7) contemporaneous and independent invention by others. However, I understand that there must be a relationship between any secondary evidence of non-obviousness and the claimed invention.

I understand that a challenged claim can be invalid for obviousness over a combination of prior art references if a reason existed (at the time of the alleged invention) that would have prompted a person of ordinary skill in the art to combine elements of the prior art in the manner required by the challenged claim. I understand that this requirement is also referred to as a "motivation to combine," "suggestion to combine," or "reason to combine," and that there are several rationales that meet this requirement.

I understand that the prior art references themselves may provide a motivation to combine, but other times simple common sense can link two or more prior art references. I further understand that obviousness analysis recognizes that market demand, rather than scientific literature, often drives innovation, and that a motivation to combine references may come from market forces.

I understand obviousness to include, for instance, scenarios where known techniques are simply applied to other devices, systems, or processes to improve them in an expected or known way. I also understand that practical and common-sense considerations should be applied in a proper obviousness analysis. For instance, familiar items may have obvious uses beyond their primary purposes.

I understand that the combination of familiar elements according to known methods is obvious when it yields predictable results. For instance, obviousness bars patentability of a predictable variation of a technique even if the technique originated in another field of endeavor. This is because design incentives and other market forces can prompt variations of it, and predictable variations are not the product of innovation, but rather ordinary skill and common sense.

I understand that a particular combination may be obvious if it was obvious to try the combination. For example, when there is a design need or market pressure to solve a problem and there are a finite number of identified, predictable solutions, a person of ordinary skill has good reason to pursue the known options within his or her technical grasp. This would result in something obvious because the result is the product not of innovation but of ordinary skill and common sense. However, I understand that it may not be obvious to try a combination when it involves unpredictable technologies.

It is further my understanding that a proper obviousness analysis focuses on what was known or obvious to a person of ordinary skill in the art, not just the patentee. Accordingly, I understand that any need or problem known in the field of endeavor at the time of invention and addressed by the patent can provide a reason for combining the elements in the manner claimed.

It is my understanding that the Manual of Patent Examining Procedure §2143 sets forth the following as exemplary rationales that support a conclusion of obviousness:

- Combining prior art elements according to known methods to yield predictable results;
- Simple substitution of one known element for another to obtain predictable results;
- Use of known technique to improve similar devices (methods, or products) in the same way;

- Applying a known technique to a known device (method, or product) ready for improvement to yield predictable results;
- Choosing from a finite number of identified, predictable solutions, with a reasonable expectation of success;
- Known work in one field of endeavor may prompt variations of it for use in either the same field or a different one based on design incentives or other market forces if the variations are predictable to one of ordinary skill in the art;
- Some teaching, suggestion, or motivation in the prior art that would have led one of ordinary skill to modify the prior art reference or to combine prior art reference teachings to arrive at the claimed invention.

A person of ordinary skill in the art looking to overcome a problem will often use the teachings of multiple publications together like pieces of a puzzle, even though the prior art does not necessarily fit perfectly together. Therefore, I understand that references for obviousness need not fit perfectly together like puzzle pieces. Instead, I understand that obviousness analysis takes into account inferences, creative steps, common sense, and practical logic and applications that a person of ordinary skill in the art would employ under the circumstances.

I understand that a claim can be obvious in light of a single reference, if the elements of the challenged claim that are not explicitly or inherently disclosed in the reference can be supplied by the common sense of one of skill in the art.

I understand that obviousness also bars the patentability of applying known or obvious design choices to the prior art. One cannot patent merely substituting one prior art element for another if the substitution can be made with predictable results. Likewise, combining prior art techniques that are interoperable with respect to one another is generally obvious and not patentable.

In order for a claim to be found invalid based upon a modification or combination of the prior art, there must be reasonable expectation that a person of ordinary skill would have successfully modified or combined the prior art to arrive at the claimed arrangement. This does not mean that it must be certain that a person of ordinary skill would have been successful – the law only requires that the person of ordinary skill in the art would have perceived a reasonable expectation of success in modifying or combining the prior art to arrive at the claimed invention.

In sum, my understanding is that obviousness invalidates claims that merely recite combinations of, or obvious variations of, prior art teachings using understanding and knowledge of one of skill in the art at the time and motivated by the general problem facing the inventor at the time. Under this analysis, the prior art references themselves, or any need or problem known in the field of endeavor at the time of the invention, can provide a reason for combining the elements of or attempting obvious variations on prior art references in the claimed manner.

Legal Standard for Claim Construction

I understand that before any invalidity analysis can be properly performed, the scope and meaning of the challenged claims must be determined by claim construction.

I understand that a patent may include two types of claims, independent claims and dependent claims. I understand that an independent claim stands alone and includes only the limitations it recites. I understand that a dependent claim depends from an independent claim or another dependent claim. I understand that a dependent claim includes all the limitations that it recites in addition to the limitations recited in the claim (or claims) from which it depends.

In comparing the challenged claims to the prior art, I have carefully considered the patent and its file history in light of the understanding of a person of skill at the time of the alleged invention.

I understand that to determine how a person of ordinary skill would have understood a claim term, one should look to sources available at the time of the alleged invention that show what a person of skill in the art would have understood disputed claim language to mean. It is my understanding that this may include what is called "intrinsic" evidence as well as "extrinsic" evidence.

I understand that, in construing a claim term, one should primarily rely on intrinsic patent evidence, which includes the words of the claims themselves, the remainder of the patent specification, and the prosecution history. I understand that extrinsic evidence, which is evidence external to the patent and the prosecution history, may also be useful in interpreting patent claims when the intrinsic evidence itself is insufficient. I understand that extrinsic evidence may include principles, concepts, terms, and other resources available to those of skill in the art at the time of the invention.

I understand that words or terms should be given their ordinary and accepted meaning unless it appears that the inventors were using them to mean something else or something more specific. I understand that to determine whether a term has special meaning, the claims, the patent specification, and the prosecution history are particularly important, and may show that the inventor gave a term a particular definition or intentionally disclaimed, disavowed, or surrendered claim scope.

I understand that the claims of a patent define the scope of the rights conferred by the patent. I understand that because the claims point out and distinctly claim the subject matter which the inventors regard as their invention, claim construction analysis must begin with and is focused on the claim language itself. I understand that the context of the term within the claim as well as other claims of the patent can inform the meaning of a claim term. For example, because claim terms are normally used consistently throughout the patent, how a term is used in one claim can often inform the meaning of the same term in other claims. Differences among claims or claim terms can also be a useful guide in understanding the meaning of particular claim terms.

I understand that a claim term should be construed not only in the context of the particular claim in which the disputed term appears, but in the context of the entire patent, including the entire specification. I understand that because the specification is a primary basis for construing the claims, a correct construction must align with the specification.

I understand that the prosecution history of the patent as well as art incorporated by reference or otherwise cited during the prosecution history are also highly relevant in construing claim terms. For instance, art cited by or incorporated by reference may indicate how the inventor and others of skill in the art at the time of the invention understood certain terms and concepts. Additionally, the prosecution history may show that the inventors disclaimed or disavowed claim scope, or further explained the meaning of a claim term.

With regard to extrinsic evidence, I understand that all evidence external to the patent and prosecution history, including expert and inventor testimony, dictionaries, and learned treatises, can also be considered. For example, technical dictionaries may indicate how one of skill in the art used or understood the claim terms. However, I understand that extrinsic evidence is considered to be less reliable than intrinsic evidence, and for that reason is generally given less weight than intrinsic evidence.

I understand that in general, a term or phrase found in the introductory words or preamble of the claim, should be construed as a limitation if it recites essential structure or steps, or is necessary to give meaning to the claim. For instance, I understand preamble language may limit claim scope: (i) if dependence on a preamble phrase for antecedent basis indicates a reliance on both the preamble and claim body to define the claimed invention; (ii) if reference to the preamble is necessary to understand limitations or terms in the claim body; or (iii) if the preamble recites additional structure or steps that the specification identifies as important.

On the other hand, I understand that a preamble term or phrase is not limiting where a challenged claim defines a structurally complete invention in the claim body and uses the preamble only to state a purpose or intended use for the invention. I understand that to make this determination, one should review the entire patent to gain an understanding of what the inventors claim they invented and intended to encompass in the claims.

I understand that 35 U.S.C. § 112 ¶ 6 created an exception to the general rule of claim construction called a “means plus function” limitation. These types of terms and limitations should be interpreted to cover only the corresponding structure described in the specification, and equivalents thereof. I also understand that a limitation is presumed to be a means plus function limitation if (a) the claim limitation uses the phrase "means for"; (b) the "means for" is modified by functional language; and (c) the phrase "means for" is not modified by sufficient structure for achieving the specified function.

I understand that a structure is considered structurally equivalent to the corresponding structure identified in the specification only if the differences between them are insubstantial. For instance, if the structure performs the same function in substantially the same way to achieve substantially the same result. I further understand that a structural equivalent must have been available at the time of the issuance of the claim.