UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE PATENT TRIAL AND APPEAL BOARD

UNIFIED PATENTS INC.
Petitioner

v.

GE VIDEO COMPRESSION LLC
Patent Owner

IPR2019-00617
Patent 9,729,891

DECLARATION OF DR. ANDREW B. LIPPMAN

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I, Dr. Andrew B. Lippman, hereby declare the following:

I. BACKGROUND AND QUALIFICATIONS

1. My name is Andrew Lippman, and I am over 21 years of age and otherwise competent to make this Declaration. I make this Declaration based on facts and matters within my own knowledge and on information provided to me by others, and, if called as a witness, I could and would competently testify to the matters set forth herein.

2. I have been retained as a technical expert witness in this matter by Counsel for the Petitioner, Unified Patents, Inc. ("Petitioner") to provide my independent opinions on certain issues requested by Counsel for Petitioner relating to the accompanying Petition for *Inter Partes* Review of U.S. Patent No. 9,729,891 ("the '891 patent"). My compensation in this matter is not based on the substance of my opinions or on the outcome of this matter. I have been informed that GE Video Compression, LLC is the purported owner of the '891 patent. I note that I have no financial interest in GE Video Compression, LLC, or Petitioner, and I have no other interest in the outcome of this matter.

3. I have summarized in this section my educational background, career history, and other qualifications relevant to this matter. I have also included a current version of my curriculum vitae as Exhibit 1008.

A. Education

4. I earned my undergraduate degree in Electrical Engineering from MIT in 1971. I earned a Master of Science degree in Computer Graphics from MIT in 1978. I earned a Ph.D. in Electrical Engineering from the École Polytechnique Fédérale de Lausanne (Switzerland) in 1995. My thesis was on scalable video, a technique for representing visual data in a fluid and variable networking and processing environment, similar to what we call streaming today.

B. Career Synopsis

5. I am currently a Senior Research Scientist at the Massachusetts Institute of Technology ("MIT") and Associate Director of the MIT Media Laboratory, an approximately $50 Million per year research and teaching facility at MIT, which I helped establish in the early 1980s. I direct a special interest group called Ultimate Media, and am co-principal investigator of the Communications Futures Program, which unifies diverse research projects across MIT related to the technology, policy, and economics of communications most generally over the Internet.

6. At MIT, I have supervised over 50 Master's and Ph.D. theses in the Media Arts and Sciences program and have taught courses such as Digital Video and MIT's freshman physics seminar. Through the course of my career, I have directed and served as principal investigator of research projects supported by the Defense Advanced Research Projects Agency (DARPA), the Office of Naval Research (ONR), The National Science Foundation (NSF), and over 50 industrial companies.

I have never precisely calculated my net research volume, but it is in excess of $50 Million.

7. I am named as an inventor on six patents in the area of video and digital processing and have served on the advisory boards for technology companies in fields ranging from video conferencing to music analysis. I have authored or co-authored over 65 published papers in the fields of interactivity, communications, video coding, and television.

8. I served on the editorial board of the Image Communication Journal between 1989 and 2003.

9. I have worked generally on video interaction systems since the 1970's. In the early 1970's, I developed font representations that permitted high quality display of text on standard broadcast television receivers. In 1978, I directed a DARPA-funded project called the "Movie-Map" that used computing and optical video and image storage to create an "experiential map" that featured "surrogate travel," the ability to recreate the visual experience of traveling through a real place, a city. This is similar to Google's Street-View and mapping systems. In the 1980's, I was principal investigator of Office of Naval Research funded programs in video and graphics computer systems for interactive learning dedicated to maintenance and repair. I also developed networked video communications systems that included scripting languages for specifying audiovisual content and representing it on various monitoring terminals. In 1991, I created the "Media Bank" program in the Media

Lab the purpose of which was to allow a diverse set of networked devices to access appropriate forms of content for which they had the bandwidth and processing power to display. This entailed maintaining state information about terminal devices at a server and using that to determine the best representation of the audiovisual material to deliver to them. In addition, it included and developed cryptographic distribution methods that insured secure delivery of information on the network. Related to this work, I also supervised Masters theses on networked distribution of video and coding specifically for diverse uses on the Internet. Also in 1991, I created the Television of Tomorrow program at the MIT Media Lab. This program addressed the digital representation and delivery of video at diverse scales and through diverse networks. This program built on work on scalable representations of images that were standards-independent and interactive. In 1993, I was invited to be a member of Robert Kahn's "Cross Industry Working Group" the goal of which was to develop the ideas for a National Information Infrastructure. At DARPA, Kahn had initiated the research to develop the Arpanet and the Internet. Throughout this period, my students and I worked on distributed interactive systems for consumer use (television, electronic newspapers, learning) including the basic technology of the network and the client-server interactions.

10. I was a member of the Motion Picture Experts Groups, an ISO standards committee effort that defined the standards for common distribution of "MP3" music and storage and distribution of "MPEG Video." I co-wrote the paper defining the

requirements for the MPEG-2 standard with Okubo and McCann in 1995. MPEG standards remain the predominant encoding for distribution of digital video to this day. I was also the principal investigator on industry-funded programs addressing digital motion pictures — the "Movies of the Future" program at MIT, and high definition television, "Television of Tomorrow." At the Media Lab at MIT, I created the "Digital Life" consortium the purpose of which was to explore and develop ideas relevant to an Internet-connected society.

11. A more detailed account of my work experience and qualifications, and a list of my publications, is included in my Curriculum Vitae, which can be found in Exhibit 1008. Based on my experiences described above, and as indicated in my Curriculum Vitae, I am qualified to provide the following opinions with respect to the '891 patent.

12. As part of my work and in forming my opinions in connection with this proceeding, I have reviewed the following materials, each of which I believe experts in my field would reasonably rely upon in forming opinions regarding the subject matter of this proceeding:

- U.S. Patent 9,729,891 (Ex. 1001);
- File History for U.S. Patent 9,729,891 (Ex. 1002);
- Patent Cooperation Treaty Publication No. WO 2011/042645 (Ex. 1004) ("*Pateux – FR*")
- English Translation of WO 2011/042645A1 (Ex. 1005) ("*Pateux*")
- U.S. Patent No. 9,467,699 (Ex. 1006) ("*Huang*")
- Richardson, The H.264 Advanced Video Compression Standard, Wiley (2010) (Ex. 1007) ("*Richardson*")

- Shi et al., Image and Video Compression for Multimedia Engineering, CRC Press (2000) (Ex. 1009) ("*Shi*")
- Shannon, Communication Theory of Secrecy Systems, Bell System Technical Journal, Vol. 28-4, pp. 656-715, Oct. 1949 (Ex. 1010) ("*Shannon*")
- Symes, Video Compression Demystified, McGraw-Hill (2001) (Ex. 1011) ("*Symes*")
- Poe, The Gold Bug, Project Gutenberg, (2008) (Ex. 1012) ("*Poe*")

II. LEGAL FRAMEWORK

A. Obviousness

13. I am a technical expert and do not offer any legal opinions. However, I have been informed about certain legal principles regarding patentability and related matters under United States patent law, which I have applied in performing my analysis and arriving at my technical opinions in this matter.

14. I have been informed that a person cannot obtain a patent on an invention if the differences between the invention and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art ("PHOSITA"). I have been informed that a conclusion of obviousness may be founded upon more than a single item of prior art. I have been further informed that obviousness is determined by evaluating the following factors: (1) the scope and content of the prior art, (2) the differences between the prior art and the claim at issue, (3) the level of ordinary skill in the pertinent art, and (4) secondary considerations of non-obviousness. In addition, the obviousness inquiry should not be done in hindsight. Instead, the obviousness

inquiry should be done through the eyes of a PHOSITA at the time of the alleged invention.

15. In considering whether certain prior art renders a particular patent claim obvious, I have been informed that I can consider the scope and content of the prior art, including the fact that one of skill in the art would regularly look to the disclosures in patents, trade publications, journal articles, conference papers, industry standards, product literature and documentation, texts describing competitive technologies, requests for comment published by standard setting organizations, and materials from industry conferences, as examples. I have been informed that for a prior art reference to be proper for use in an obviousness analysis, the reference must be "analogous art" to the claimed invention. I have been informed that a reference is analogous art to the claimed invention if: (1) the reference is from the same field of endeavor as the claimed invention (even if it addresses a different problem); or (2) the reference is reasonably pertinent to the problem faced by the inventor (even if it is not in the same field of endeavor as the claimed invention). In order for a reference to be "reasonably pertinent" to the problem, it must logically have commended itself to an inventor's attention in considering his problem. In determining whether a reference is reasonably pertinent, one should consider the problem faced by the inventor, as reflected either explicitly or implicitly, in the specification. I believe that all of the references I considered in forming my opinions in this IPR are well within the range of references a PHOSITA would have consulted

to address the type of problems described in the Challenged Claims.

16. I have been informed that, in order to establish that a claimed invention was obvious based on a combination of prior art elements, a clear articulation of the reason(s) why a claimed invention would have been obvious must be provided. Specifically, I am informed that, under the U.S. Supreme Court's *KSR* decision, a combination of multiple items of prior art renders a patent claim obvious when there was an apparent reason for one of ordinary skill in the art, at the time of the invention, to combine the prior art, which can include, but is not limited to, any of the following rationales: (A) combining prior art methods according to known methods to yield predictable results; (B) substituting one known element for another to obtain predictable results; (C) using a known technique to improve a similar device in the same way; (D) applying a known technique to a known device ready for improvement to yield predictable results; (E) trying a finite number of identified, predictable potential solutions, with a reasonable expectation of success; (F) identifying that 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; or (G) identifying an explicit 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 the prior art references to arrive at the claimed invention. I am also informed that where there is a motivation to combine, claims may be rejected as prima facie

obvious provided a PHOSITA would have had a reasonable expectation of success regarding the proposed combination.

17. I am informed that the existence of an explicit teaching, suggestion, or motivation to combine known elements of the prior art is a sufficient, but not a necessary, condition to a finding of obviousness. This so-called "teaching-suggestion-motivation" test is not the exclusive test and is not to be applied rigidly in an obviousness analysis. In determining whether the subject matter of a patent claim is obvious, neither the particular motivation nor the avowed purpose of the patentee controls. Instead, the important consideration is the objective reach of the claim. In other words, if the claim extends to what is obvious, then the claim is invalid. I am further informed that the obviousness analysis often necessitates consideration of the interrelated teachings of multiple patents, the effects of demands known to the technological community or present in the marketplace, and the background knowledge possessed by a person having ordinary skill in the art. All of these issues may be considered to determine whether there was an apparent reason to combine the known elements in the fashion claimed by the patent.

18. I also am informed that in conducting an obviousness analysis, a precise teaching directed to the specific subject matter of the challenged claim need not be sought out because it is appropriate to take account of the inferences and creative steps that a PHOSITA would employ. The prior art considered can be directed to any need or problem known in the field of endeavor at the time of invention and can

provide a reason for combining the elements of the prior art in the manner claimed. In other words, the prior art need not be directed towards solving the same specific problem as the problem addressed by the patent. Further, the individual prior art references themselves need not all be directed towards solving the same problem. I am informed that, under the *KSR* obviousness standard, common sense is important and should be considered. Common sense teaches that familiar items may have obvious uses beyond their primary purposes.

19. I also am informed that the fact that a particular combination of prior art elements was "obvious to try" may indicate that the combination was obvious even if no one attempted the combination. If the combination was obvious to try (regardless of whether it was actually tried) or leads to anticipated success, then it is likely the result of ordinary skill and common sense rather than innovation. I am further informed that in many fields it may be that there is little discussion of obvious techniques or combinations, and it often may be the case that market demand, rather than scientific literature or knowledge, will drive the design of an invention. I am informed that an invention that is a combination of prior art must do more than yield predictable results to be non-obvious.

20. I am informed that for a patent claim to be obvious, the claim must be obvious to a PHOSITA at the time of the alleged invention. I am informed that the factors to consider in determining the level of ordinary skill in the art include (1) the educational level and experience of people working in the field at the time the

invention was made, (2) the types of problems faced in the art and the solutions found to those problems, and (3) the sophistication of the technology in the field.

21. I am informed that it is improper to combine references where the references teach away from their combination. I am informed that a reference may be said to teach away when a PHOSITA, upon reading the reference, would be discouraged from following the path set out in the reference, or would be led in a direction divergent from the path that was taken by the patent applicant. In general, a reference will teach away if it suggests that the line of development flowing from the reference's disclosure is unlikely to be productive of the result sought by the patentee. I am informed that a reference teaches away, for example, if (1) the combination would produce a seemingly inoperative device, or (2) the references leave the impression that the product would not have the property sought by the patentee. I also am informed, however, that a reference does not teach away if it merely expresses a general preference for an alternative invention but does not criticize, discredit, or otherwise discourage investigation into the invention claimed.

22. I am informed that even if a *prima facie* case of obviousness is established, the final determination of obviousness must also consider "secondary considerations" if presented. In most instances, the patentee raises these secondary considerations of non-obviousness. In that context, the patentee argues an invention would not have been obvious in view of these considerations, which include: (a) commercial success of a product due to the merits of the claimed invention; (b) a

long-felt, but unsatisfied need for the invention; (c) failure of others to find the solution provided by the claimed invention; (d) deliberate copying of the invention by others; (e) unexpected results achieved by the invention; (f) praise of the invention by others skilled in the art; (g) lack of independent simultaneous invention within a comparatively short space of time; (h) teaching away from the invention in the prior art.

23. I am further informed that secondary-considerations evidence is only relevant if the offering party establishes a connection, or nexus, between the evidence and the claimed invention. The nexus cannot be based on prior art features. The establishment of a nexus is a question of fact. While I understand that the Patent Owner here has not offered any secondary considerations at this time, I will supplement my opinions in the event that the Patent Owner raises secondary considerations during the course of this proceeding.

B. Claim Construction

24. I have been informed by counsel that the first step in an unpatentability analysis involves construing the claims, as necessary, to determine their scope. Second, the construed claim language is then compared to the disclosures of the prior art. I am informed that claims are generally given their ordinary and custom meaning as understood by one of ordinary skill in the art at the time of the invention, in light of the patent specification.

25. For purposes of this proceeding, I have applied the meaning of the claim terms of the ’891 Patent that is generally consistent with the terms’ ordinary and customary meaning, as a person of ordinary skill in the art would have understood them at the time of the invention. I have been instructed to assume for purposes of this proceeding that the time of the invention is July 15, 2011.

III. OPINION

A. Level of Skill of a Person Having Ordinary Skill in the Art

26. I was asked to provide my opinion as to the level of skill of a person having ordinary skill in the art (“PHOSITA”) of the ’891 Patent at the time of the claimed invention, which I have been instructed to assume is July 15, 2011. In determining the characteristics of a hypothetical person of ordinary skill in the art of the ’891 Patent at the time of the claimed invention, I was told to consider several factors, including the type of problems encountered in the art, the solutions to those problems, the rapidity with which innovations are made in the field, the sophistication of the technology, and the education level of active workers in the field. I also placed myself back in the time frame of the claimed invention and considered the colleagues with whom I had worked at that time.

27. In my opinion, a person having ordinary skill in the art of the ’891 Patent at the time of its filing would have been a person having, as of July 15, 2011: (1) at least an undergraduate degree in computer science, computer engineering, electrical engineering or a similar technical field; and (2) a working knowledge of

video coding techniques; and (3) two or more years of experience (or with a graduate degree in the above-stated fields, one or more years of experience) in analysis, design, or development related to video encoding, with additional education substituting for experience and vice versa. Such a person of ordinary skill in the art would have been capable of understanding the ’891 Patent and the prior art references discussed herein.

28. Based on my education, training, and professional experience in the field of the claimed invention, I am familiar with the level and abilities of a person of ordinary skill in the art at the time of the claimed invention. Additionally, I met at least these as of July 15, 2011. Further, although my qualifications may exceed those of the hypothetical person having ordinary skill in the art defined above, my analysis and opinions regarding the ’891 Patent have been rendered from the perspective of a person having ordinary skill in the art at the time of the invention.

B. Background of the Technology

29. I was asked to briefly summarize the background of the prior art from the standpoint of a PHOSITA prior to the assumed date of invention of July 15, 2011. For the convenience of the reader, I refer to the Unified Exhibit page number located at the lower right-hand side for any non-patent or patent-application reference cited herein.

i. Background of Entropy Coding

30. The ’891 Patent relates to the coding of images, more particularly,

image sequences or video. *'891 Patent* at 1:15-16. One can refer to this in many ways. Since an image is an array of points, and video is a series of such images, one can more generally refer to coding of arrays. *Symes* at 49-50. A picture is an array intended to be viewed, or consumed, by a human observer. Within a natural image, there is redundancy. *Shi* at 66-76. Pictures consist of broad areas that are visually similar – large regions of shading or texture, punctuated by edges. This redundancy can be removed in coding, thus saving space needed to store the pictures or reducing transmission capacity. *Id*. In addition, there are elements of a picture or video sequence that are of less "importance" to the viewer or are not detected by the human visual system. These elements can often be discarded or represented with reduced accuracy with no loss of subjective quality. *Id.* A video stream is a sequence of pictures, called frames. As with individual images, there are correlations between frames that can be compressed with no loss, and aspects of moving images that can be discarded or represented with less accuracy with no loss of subjective quality. For example, at scene change borders or regions of high activity, humans are less sensitive to fine details in each frame. *Id*.

31. Video coding is a particular case of array coding where one can compress the information needed to represent the sequence by removing irrelevancy, and redundancy. The former is loss – some information is discarded. The latter is generally lossless and is merely an efficiency in transmission or storage. In picture coding, the likelihood of different array values varies with content. For example, a

dark scene has many more elements that are near black than a bright scene. Likewise, some images are highly detailed and have lots of sharp edges – a page of text, for example. Others may consist of broad areas of low detail – a soft-focus portrait, for example. In video, there are often succession of images that are similar so one may wish to code only the differences between them. In coding argot, one can use an earlier picture as a predictor of the current picture and code only the prediction differences, or prediction errors. *Symes* at 96-106. Since video usually contains some motion, one can also predict the current frame as a shifted version of parts of the previous one and thereby "motion compensate" the prediction. *Shi* at 66-76. For example, a slow pan is very much a series of shifted pictures. *Id*. Each previous picture can be estimated as a shifted version of the previous one. *Id*.

32. In the coders under consideration here, pictures are generally subdivided into "blocks" and groups of blocks. *Richardson* (Ex. 1007) at 15. Each block is processed to reduce the number of symbols needed to reconstruct it by a variety of techniques the specifics of which are not important here. In addition, blocks are grouped into "slices." *Id*. at 64-68. This reduces overhead and can allow slices to be decoded largely independently.

33. Entropy coding is an example of a means to reduce the information necessary to represent data. Entropy was described and named by Claude Shannon in seminal papers published in 1948 and 1949. *See, e.g.*, (Ex. 1010) *Shannon*. The essence of the idea is that a series of symbols can be represented without loss by

sending data (bits) at a rate equal to the underlying *entropy* or uncertainty associated with the data. *Id*. Data that is unlikely is coded with longer symbols (or sequence of bits) and data that is more likely is coded using fewer symbols. The symbols may be bits, binary digits, or something else. On average, with a perfect entropy coder, the data rate is equal to the entropy of the underlying data probabilities rather than being assigned a priori. *Id*. For example, there are 27 letters (including space) in the English alphabet, which would imply that five bits can be used to represent each letter (5 bits encodes 32 values, one value per specific letter). Clearly this is inefficient, since five codes are never used. But more important, the likelihood of each letter in English differs. Some are used rarely and others more frequently. Edgar Allen Poe used this to decode an encrypted letter in his story "the Gold Bug." *See Poe* (Ex. 1012) More scoring points are also given to infrequently used letters in Scrabble.

34. In Morse code, more likely letters are given a shorter code. "E," for example is a singled "dot" and "Z" is "dash-dash-dot-dot," significantly longer. *Symes* (Ex. 1011) at 46-48. For an average English message this means that less data is sent than would be by allocating an equal-length code for each letter. *Id*. Of course, this also ties the efficiency of the representation to the language, English. *Id*. The same might not be true for other languages. *Id*. Therefore, in entropy coding, it is important to have some estimate of the probabilities (commonly called the "probability estimate") of each symbol being coded. That is, one has to know that Z

is less frequent the E. Further, one could adapt Morse code to languages with different letter probabilities by changing the code table and signaling which is to be used. To complete the analogy, one could code English messages by a combination of lossy and lossless entropy coding. One could, for example, remove most of the vowels from a message, then entropy code the remainder. The reconstructed message would not be an accurate reproduction of the original, but it may suit the purpose and would be faster to transmit.

35. Even after the information in the picture is reduced and encoded, the symbols that represent it are not equally likely. For that reason, one generally applies entropy coding to those symbols to exploit their differing likelihood. However, even when doing so, the probabilities of symbols changes across an array, or frame, and across frames. Whereas early coders used a fixed probability table to entropy code the symbols, modern coders use adaptive entropy coders such as CABAC, described in the papers to adapt the entropy-coded representation of those symbols to their changing likelihood. *Richardson* (Ex. 1007) at 69-74.

C. **Pateux – WO 2011/042645**

36. *Pateux* relates to encoding and decoding images, including images within a video stream. *Pateux* at 4:4-5. This is the same field of endeavor of the ''891 Patent. *Pateux* notes that video encoders in use at the time, including widely used MPEG and H.264 video encoders, divide images into blocks called "macro-blocks" and encode each block using various algorithms, and the final algorithm applied is

entropy coding. *Id*. at 4:10-19. A common entropy coding method at the time was CABAC or "Context Adaptive Binary Arithmetic Encoder", which was included in both the MPEG4 and H.264 video coding standards in use at the time. *Id*. at 4:27-30. Entropy coding is a step that occurs after binarization, and binarization is the process of converting the relevant information into zeros and ones, that is, binary information that can be compressed using entropy coding. *Pateux* at 5:1-23. As described above in my explanation of entropy coding, *Pateux* similarly describes entropy coding as the process of developing a "probability estimate" and assigning codewords, which *Pateux* calls "symbols," to represent the information. *Id*. at 5:18-22. Like the '891 Patent, *Pateux* describes a similar problem that arises with entropy coding and parallel processing – delays due to the serial or "raster-scan" order of processing each slice, and the "lack of local adequacy of the learning of the probabilities" that make entropy coding less efficient. *Pateux* at 5:18-30.

37. *Pateux* describes the various steps involved in video processing, including dividing each image into distinct regions or "blocks" and then applying various algorithms such as intra-prediction, inter-prediction, and other compression algorithms that allow the digital images (i.e. sample arrays) to be encoded for efficient storage or transmission. *Pateux* at 4:10-30. According to *Pateux*, once these general algorithms are applied, one of the final steps involves encoding the binary data via entropy coding. *Id*. at 4:27-2:23. Based on the context in which *Pateux* describes entropy coding, and the sequence of steps *Pateux* describes for encoding

and decoding images in a video stream, it would have been obvious to a PHOSITA to further process the entropy decoded data to reconstruct an image (i.e. sample array). Given the state of the art at the time, reconstruction algorithms were not only ubiquitous but were built-in to video coding standards at the time such as MPEG and H.264, which are specifically noted as being useful for the methods taught in *Pateux*. *Id*. at 4:1-19. For example, *Pateux* teaches the "invention can thus, in particular, apply to the video encoding implemented in current (MPEG, H.264, etc.) or future (ITU-T/VCEG (H.265) or ISO/MPEG HVC) encoders." *Id*. at 4:6-8. From this teaching a PHOSITA would have understood the entropy coding disclosed in *Pateux* would be useful almost exclusively as a step toward reconstructing a sample array from entropy encoded data. Indeed, it would have defied common sense for a PHOSITA to process the entropy coded data according to *Pateux* and then elect not to proceed with the remaining steps outlined in MPEG, H.264, etc., or the actual encoding steps applied to the data in order to reconstruct a sample array from the data. Performing the reconstruction would have required little to no experimentation because the algorithms were precisely described in widely adopted standards in use at the time (MPEG, H.264, etc.), and the result of following these steps would have yielded the predictable reconstruction of an image.

38. One of skill in the art would understand Element 1(a) of the '891 Patent to encompass an encoder that processes slice subsets (i.e. entropy slices) because the '891 Patent explains that "entropy slices" are simply a "splitting of the traditional

slice into additional sub-slices." *'891 Patent* at 21:16-18. From this teaching, a PHOSITA would understand a "traditional slice" is referring to the traditional way that images are sliced in image processing, and that an "entropy slice" is merely a subset of such slices, i.e., a slice subset. Further, the claim language of Element 1(a) following the word "comprising" specifies that the claimed slice subset is a portion of entropy encoded data representing portions of an image comprised of rows of blocks, where each row of blocks has the same number of blocks. Here again, the claim itself confirms that a "slice subset" is consistent with a PHOSITA's understanding of an entropy slice, or row of blocks.

39. Similarly, *Pateux* describes entropy coded data in Figure 5a, which shows entropy slices comprised of rows of blocks, where each row has the same number of blocks. *Pateux* at 26:10-24:4. My understanding is based in part on the description in *Pateux* that "Figure 5a illustrates an example of an embodiment wherein the same class is assigned to all the subsequences of the same line of the image, for example the class numbered 0 corresponds to the first line at the top of the image, class 1 to the second line, etc." I understand this to be describing lines of an image, and these lines are depicted in Figure 5a as rows of blocks, where each row has the same number of blocks. *Id*. at Figure 5a. In addition, *Pateux* notes that in "this embodiment, the various lines can therefore be decoded in parallel . . ." and I understand this description of decoding the blocks in Figure 5a to be consistent with *Pateux*'s description that its disclosure is focused on entropy coding, and

therefore the blocks in Figure 5a contain entropy coded data.

40. A PHOSITA would have understood the disclosure supporting Figure 5a in *Pateux* to be a description of entropy decoding because it refers to "decoding the sub-sequences," and refers to the "probabilities stored during the decoding of" neighboring superblocks. *Pateux* at 17:45-63. In context, a PHOSITA would understand these references to "decoding" and the storage of nearby "probabilities" as a reference to entropy decoding, which is the entire thrust and purpose of *Pateux*. *Pateux* at 5:6-19. In addition, *Pateux* indicates the blocks in Figure 5a "must be sequentially decoded, the block to the left to be decoded prior to decoding the routine block," which a PHOSITA would understand to be a description of left-to-right processing of blocks in the rows depicted in Figure 5a because the left block must be decoded before proceeding to the next block, and the decoding is described as "sequential" in this manner. Similarly, the '891 Patent describes decoding along "path order 16" with reference to Figure 9, which is shown in the figure as left to right processing along the rows of blocks, as described in the '891 Patent at Column 17, line 33. As shown in Figure 9, the probabilities p2, p3, p4 etc. used to initialize the probability of Pnew in Figure 9 are in a preceding and spatially neighboring row, as required by Claim Element 1(c). Thus, a PHOSITA would understand the language in Claim Element 1(c) to place the "second row" above the "first row," as graphically depicted in Figure 9 and annotated in the petition.

41. One explicitly stated goal of *Pateux* is to rely on the stored probability

estimates from nearby, previously decoded blocks. *Pateux* at 8:6-19. Claim Element 1(d) refers to "adapting the first probability estimation along the entropy coding path using a previously-decoded part of the slice subset." This element should also be understood in context of Element 1(c). There, a first probability estimate is established based on a probability estimation obtained by decoding a block in the row above the current block. In Element 1(d), the probability estimate from the preceding element is then adapted to include probability estimate data from a left block in the same row. As a result, the probability estimate that will be used to decode the current block uses the data from both the above block and the left block. A PHOSITA would have understood, based in part on the disclosure in the '891 Patent at Column 28, lines 52-59 that describe using probability estimations that depend on the probability estimation from the preceding portion along the entropy coding path, that this claim element requires additionally utilizing the probability estimate from the block to the left of the block currently being decoded. *Pateux* describes this same concept by explaining that it uses the "probabilities stored during the decoding of two adjacent super blocks, those respectively located above <u>and to the left</u>." *Pateux* at 23:56-62 (emphasis added). This description of using the probability of the block situated to the left involves using a previously decoded part of the current slice subset because the block to the left is <u>in the same slice subset</u> and has been decoded in advance according to the described raster scan order.

42. Similarly, *Pateux* describes how "probabilities of the symbols are

initialized from the values of at least two previously-obtained . . . probabilities stored during the preceding encoding of at least two super-blocks," and a PHOSITA would understand this to be a description of initializing using, or based on, these previously stored probabilities because *Pateux* expressly states "the learning of the probabilities of occurrence of the symbols is based on a partitioning of the image into subsequences of symbols, for which the probabilities of occurrence of the symbols are stored at the end of encoding and <u>used for the initialization</u> of the probabilities of occurrence of the symbols in a nearby vicinity," which is a description of "using" previous probability estimates for initializing subsequent probability estimates. *Pateux* at 18:27-19:2. This "using" of probabilities is also referred to as "adapting" the probability once the probability has been initialized because adapting simply means using the additional probability data along with other probability data in the current probability model. *See Marpe* at 16.

43. A PHOSITA would understand the logic described in the '891 Patent of decoding the "second block" of the "second row" followed by the "first block" of the "first row" as the decoding of blocks in a temporal order that follows from the upper right to the lower left of grid of blocks. *See '891 Patent* at 16:58-67. The '891 Patent further confirms this by describing that some instances it may have "a slope of 1 y per 2x block positions." *Id*. at 17:5-7. This diagonal ordering of decoding blocks would be understood by a PHOSITA to be "angled" relative to the parallel paths along rows of blocks. Similarly, *Pateux* describes the blocks decoding

proceeding along an angled direction that follows, in one example, the blocks labelled "4" in Figure 5 and is an angled path relative the parallel direction that slice subsets are decoded in, as described above.

44. A PHOSITA would have understood the steps involved in entropy encoding data could be processed in reverse in order to perform entropy decoding. Indeed, entropy coded data would be useless unless the steps are followed in reverse order to obtain the original, unencoded data that could be used to reconstruct an image. Applying the steps in reverse order would have yielded predictable results because the methods described in *Pateux* provide everything that would have been necessary for a PHOSITA to understand how to implement the steps and no experimentation would have been required.

D. Huang – U.S. Pat. No. 9467, 699

45. Just like the '891 Patent, *Huang* describes an apparatus and method for parallel encoding and decoding of entropy slices. *Huang* at 1:19-22. It is in the same field of endeavor as the '891 Patent. And like the '891 Patent, *Huang* describes a similar problem that existed with conventional CABAC entropy coding, which was that processing each entropy slice in series leads to delays because each slice must be completed before the next slice can begin. This also leads to inefficient probability estimates because the end of one slice is relatively far away from the beginning of the next slice, and the image may contain very different information due to this large spatial difference, making the probability estimate less accurate.

46. The video coding standards in use at the time of *Huang*, including the MPEG and H.264 video coding standards, used the term "macroblock" to describe a small portion of an image that was typically a block of 8x8 pixels, although macroblocks could have other sizes as well. *Huang* describes a method of parallel coding using entropy slices. *Id.* at Abstract. The basic principle of *Huang* is to update the probability estimate used in entropy coding, also referred to as the "CABAC state," using nearby macroblocks that have already been processed. *Id*. at 7:10-20. *Huang* accomplishes this by establishing a "causal criterion" that ensure the upper left, upper, and upper right macroblocks have already been processed, in addition to the macroblock to the immediate left of the block currently being entropy coded. *Id*. at 5:49-65. This concept is also depicted in Figure 3 of *Huang* and its supporting disclosure, which describes a processing order that ensure the block to the left and the upper right have already been entropy coded. *Id*. at Figure 3; 4:10-67. A video stream is simply a series of images, and *Huang* describes its methods as operating on images (i.e. sample arrays) that are processed individually during entropy encoding and decoding. *Id*. 4:4-6; 5:15-17. A PHOSITA would understand the well-known concept of entropy slices, which are simply sliced portions of an image or sample array.

47. *Huang* teaches the general steps involved in entropy coding, and a PHOSITA would have understood that such steps would be generally applicable to both encoding and decoding, because each process is simply the mirror image of the

other. That is, the steps involved in encoding need to be followed in reverse order to decode the same data, and vice versa. One example of this is found in *Huang* at Figures 5 and 6, and their supporting disclosure. Specifically, the disclosure for Figure 5 describes a series of steps for parallel decoding entropy coded data. *Id*. at 5:29-6:7; Figure 5. Similarly, the description accompanying Figure 6 describes mirror image steps that would be applied for encoding the data using the same method. *Id*. at 6:25-40. Although the disclosure for Figure 6 is slightly truncated, this is simply because a PHOSITA would understand that the disclosure relating to Figure5 that describes the decoding process provides all of the necessary detail to understand the related encoding process.

48. When *Huang* describes that certain macroblocks or "MBs" are "parsed by CABAC," a PHOSITA would understand this to mean the steps involved in the well-known CABAC processing method have been completed. Included within CABAC is the step of initializing the probability estimate using MBs previously parsed by CABAC. *Huang* at 5:42-47. CABAC was a widely used processing method that would have been familiar to one of skill in the art, as it was described in detail as part of the widely used MPEG and H.264 video coding standards in use at the time of *Huang*. A PHOSITA would understand that using probability estimates is synonymous with "initializing" in the first instance and, when later data is added from another block, "adapting" the probability estimate because these words are all closely related in the art. *See, generally, Marpe* at 5-16; *Richardson* at 69-74.

49. *Huang* describes a zigzag pattern that proceeds from the upper right to the lower left corner of a grid of blocks. *Huang* at Figure 3; 2:44-47. Further, *Huang* depicts both in Figure 3 and 4 that each row has the same number of blocks. It would have been obvious to a PHOSITA to adopt this proposal in *Huang* of using the same number of blocks in each row because it would enable the zigzag pattern to initialize and terminate in a repeatable and predictable way, without the loss of efficiency that would be present if the rows of blocks were unequal. For example, if any row of blocks were to be shorter or longer than adjacent rows, the zigzag pattern would be interrupted in some instances and the benefits of the parallel processing in *Huang* would be reduced. Moreover, it would have been easier to simply implement the rows of blocks with equal numbers as shown in *Huang* rather than develop a new system that relies on an unequal number of blocks. In addition, uneven rows of blocks would not have matched well with rectangular images that typically have straight edges on the left and right sides, and therefore would require additional "make up" blocks to even the rows to match the image dimensions, which would be inefficient.

50. Figures 5 and 7 in *Huang* show the entropy slices arranged in parallel to each other proceeding in a horizontal direction. *Id*. at Figure 5, 7. The x-axis in Figures 5 and 7 clearly indicates that "CABAC Decoding" proceeds in the x-direction along the direction of each entropy slices. Thus, a PHOSITA would understand that according to "Proposal B" the entropy slices in *Huang* are processed

along entropy coding paths leading in the x-direction in parallel to each other because that is the direction indicated in the graph by the words "CABAC Decoding" with arrows point to the left and right, and each row of blocks would follow this same direction.

51. Claim Element 1(e) refers to "adapting the first probability estimation along the entropy coding path using a previously-decoded part of the slice subset." A PHOSITA would have understood, based in part on the disclosure in the '891 Patent at Column 28, lines 52-59 that describes using probability estimations depending on the probability estimate from the preceding portion along the entropy coding path, that this claim element requires utilizing the probability estimate from the block to the left of the block currently being decoded. *Huang* describes this concept explicitly because it the CABAC parsing "requires its left MB," which means the probability estimate uses a previously decoded part of the current slice subset since the block to the left is in the same slice subset and has previously been decoded. To implement this process of CABAC parsing, where CABAC includes updating the probability estimate using the CABAC state of previously decoded blocks, it would have been obvious to a PHOSITA that such CABAC states must be stored, at least temporarily, in order to be accessed during subsequent processing in order to update the probability estimate as required by the CABAC process. *Huang* teaches such storage would be necessary by explaining that "<u>during CABAC parsing</u> of all macroblocks, prediction residues and motion vector differences of the entire

picture <u>have to be stored</u> and accessed for further decoding." *Id*. at 1:40-43. A PHOSITA understand that this disclosure of storing information during CABAC parsing for "further decoding" would include storing the CABAC states, particularly because this concept was part of the CABAC process that was well-known at the time. *See, e.g., Richardson* at 69-74.

52. As described above and shown in Figures 5 and 7 of *Huang*, each entropy slice is arranged in parallel to each other and the entropy coding or "CABAC processing" proceeds along the entropy slices in the x-direction. *Huang* at Figure 5, 7. According to "proposal B" in *Huang*, each entropy slice begins decoding after a specified time delay. *Huang* at 5:53-6:20. A PHOSITA would recognize that this time delay, combined with parallel processing of each slice simultaneously, results in a path of encoding each individual block that is angled relative to the parallel paths along each individual entropy slice because each upper slice is processing ahead of the next lower slice which provides a path angled relative to the parallel paths.

53. A PHOSITA would have understood the steps involved in entropy encoding data could be processed in reverse in order to perform entropy decoding. Indeed, entropy coded data would be useless unless the steps were followed in reverse order to obtain the original, unencoded data that could be used to reconstruct an image. Applying the steps in reverse order would have yielded predictable results because the methods described in *Huang* provide everything that would have been necessary for a PHOSITA to understand how to implement the steps and no

experimentation would have been required.

54. *Huang* teaches its methods are intended to provide benefits "for software or hardware implementations." *Huang* at 1:48-50. In addition, generalized computing and processing systems were widely available at the time, and it would have been obvious to a PHOSITA to implement the methods described in Huang in as software instructions stored on a non-transitory medium. *See, e.g., Shi* at 423-424.

<u>Marpe – Context-Based Adaptive Binary Arithmetic Coding in the H.264/AVC Video Compression Standard</u>

55. *Marpe* describes the basic operation of Context-Based Adaptive Binary Arithemtic Coding or "CABAC," which is a well-known component of entropy coding such that *Marpe* is analogous art to the '891 Patent. *Marpe* discusses the operation of CABAC, including the "adapting" of probability estimates that are used in CABAC, part of the H.264 coding standard. A PHOSITA would have been familiar with CABAC, and would have looked to a well-known reference such as *Marpe* to confirm their understanding of the operating principles of CABAC. I understand that *Marpe* was a well-known reference for this purpose. *Marpe* describes updating the CABAC state by using or updating its working probability model using statistics from previously entropy coded portions of the image. *Marpe* at 5-15. In view of Marpe, a PHOSITA would understanding that initializing a probability estimate is synonymous with initializing or updating a CABAC state. *Id*.

IV. CONCLUSION

56. 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.

Date: 29 January, 2019

By: ______________________________

Andrew B. Lippman, Ph.D.