



Award Specific Terms and Conditions for the EEC-0812056 / 1159201, “Smart Lighting Engineering Research Center”, Rensselaer Polytechnic Institute Cooperative Agreement

The terms and conditions stated herein are the minimum requirements to fulfill the responsibilities to achieve the goals expected under ERC solicitation NSF 07-521. All referenced documents including websites are made a part of this Cooperative Agreement. The absence of a compelling strategy for achieving demonstrable impact in and of the key features of a Gen-3 ERC incorporated in this agreement and described in full details in NSF 07-521 is sufficient reason to deny continued funding.

The following includes revisions to the generic ERC terms and conditions that impact all ERCs since NSF 07-521 was issued.

1. Project Description:

The Smart Lighting ERC imagines a world where efficient, digital lighting makes us healthier and more productive, produces significant energy savings, and even provides wireless, optical access to the internet. The Center will develop new technologies and applications that will change the way society uses lighting. Engineered smart lighting systems will optically sense the environment to provide energy efficient, comfortable illumination when and where it is needed. Beyond illumination, smart lighting systems will simultaneously provide high speed data access, scan for biological and biochemical hazards and facilitate interfaces to developing capabilities in Smart Building and Smart Grid systems.

2. Project Governance and Governing Responsibilities:

The Awardee will ensure that an efficient and effective project governing structure is in place throughout the award period to support all critical significant project activities. The awardee will also ensure efficient and effective performance of all project responsibilities by the governing components throughout the award period.

3. Key Personnel:

The following positions are considered Key Personnel and are essential to the work of this ERC. Any contemplated changes in Key Personnel for these positions should be discussed with the NSF Program Officer. Written approval from the NSF Program Officer must be secured before any change is implemented. Any anticipated change in

the people serving as the Center Director or the Deputy Director to be effective within the next performance year must be disclosed in the ERC's annual report, and a succession plan must be provided in the report.

Director- Robert F. Karlicek
Deputy Director - Partha Dutta
Associate Directors - Tom Little, Steve Brueck
Administrative Director- Diane Veros
Education Program Director- Kenneth Connor
Pre-College Education Program Director – Elizabeth Herkenham
Technical Facilities Director- Morris Washington
Diversity Director - Barbara Ann Ruel
Systems Integration Committee co-Chairs - Art Sanderson, Partha Dutta, and Satyen Mukherjee (Phillips),
Innovation Ecosystem Director - Sylvia Mioc

In the case of the departure of the Center Director, the lead university and the affected university, in consultation with NSF, will find a replacement suitable to NSF. Before a change is implemented within the lead university, written approval from the NSF Program Officer must be secured. In the case of the departure of (a) the Center Director from the lead university, or (b) one of the members of the leadership team from a core partner university, and NSF does not find the person recommended by the Center to be suitable, the Foundation reserves the right to recommend termination of the ERC or the core partner's affiliation with the ERC.

4. Lead and Core Partner Universities:

The NSF Smart Lighting Engineering Research Center is configured as follows: Rensselaer Polytechnic Institute (RPI) is the lead university in the ERC, and Boston University (BU), and the University of New Mexico (UNM) are core partner universities. In the case of inadequate performance at the lead university or at any of the core partner universities, the Foundation reserves the right to recommend termination of, respectively, the ERC or the core partners.

5. Requirements for the Implementation of the Key Features (Revisions Since the Release of the ERC Solicitation:

- a. Strategic Research Planning and the Research Program:
 - (1) Support for the Research Experiences for Undergraduates Program (REU) program, at a minimum of \$42K per year, will be provided using ERC base budget funds. The ERC may seek an REU site award under the REU Program Solicitation to augment these funds. The ERC also may augment base REU Program support through a combination of REU supplemental awards to individual ERC faculty as long as those students have an interdisciplinary ERC experience

with exposure to industry.

- (2) U.S. Student Involvement at Foreign University Partners: If there is a large number of U.S. ERC students who work in the foreign partner university(ies)' laboratories resulting in a large accrual of materials costs, the ERC may provide a subaward to that foreign partner to cover those costs.

b. University Education:

The ERC's university education program will function with a governing hypothesis of how to develop creative, innovative, and globally competitive engineers, will implement a set of activities and experiences designed to impart those characteristics to students, and will assess the impact of the program in achieving the desired characteristics in the impacted students.

c. Pre-college Education Program:

Support for the RET Program, at a minimum of \$42K per year, will be provided using ERC base budget funds. The ERC may seek an RET site award under the Program Solicitation to augment these funds. The ERC also may augment base RET Program support through a combination of RET supplemental awards to individual ERC faculty as long as those teachers work in ERC laboratories and have an interdisciplinary ERC experience. A short-term workshop designed only to inform pre-college teachers about engineering concepts may also be carried out but not in lieu of the required RET program.

d. ERC Innovation Ecosystem:

- (1) The ERC's industrial/practitioner partnership program will be governed by an ERC-wide membership agreement, including a uniform IP policy for ERC-generated IP at the lead and each of the ERC's partner universities. The membership agreement defines the scope and function of the ERC's partnership with industry/practitioner organizations, the types of membership such as full, affiliate, contributing, etc, the respective membership fees, and the ERC's Intellectual Property (IP) policy. The ERC will develop an IP policy that facilitates the roles of industrial partners in Gen-3 ERCs and be flexible in recognizing IP jointly developed by faculty in different universities or that developed by joint industry and university research.
- (2) Foreign firms may be members of the ERC as long as they participate in accordance with the same membership agreement as U.S. firms. Domestic and foreign member firms/practitioner organizations will contribute financially to the ERC and will have first rights of refusal for ERC-generated Intellectual property (IP)

- according to the terms of the agreement.
- (3) The ERC will function with an Industrial Advisory Board (IAB) involving all of its Industry/practitioner members. The IAB will meet at least twice a year, carry out an annual analysis of the ERC's strengths, weaknesses, opportunities and threats to survival (a SWOT analysis), and participate in the annual NSF review of the ERC's performance and plans. During the meeting with the NSF site visit team, the Chair of the IAB will present the IAB's SWOT analysis to the review team and discuss the findings. The SWOT will be updated annually and progress of the ERC in addressing the SWOT will be discussed with the NSF site visit team as well. The Chair and the IAB members also will discuss the annual SWOT analysis with the ERC Director and the ERC Leadership team to determine appropriate future strategies to deal with the weaknesses and threats.
 - (4) Industrial consortia may join the ERC, but benefits of membership do not accrue to firms that are consortia members, unless they are also paying membership fees to the ERC as members separate from the consortia.
 - (5) Throughout the course of the ERC's funding by NSF, the Center shall continue to develop and refine its technology transfer and innovation strategy and its Intellectual Property policy, the latter in accordance with NSF's Intellectual Property guidelines (NSF Award and Administration Guide, Chapter VI.D., "Intellectual Property") and the Awardee's policies.
 - (6) Industrial membership fees are treated as Program Income, and must be allocated for use for Center purposes. Industrial membership fees that are not expended in the year in which they are received must be placed in a Center account and reported to NSF and industry as 'unexpended funds' that are held in reserve for future use. Progress reports on the expenditure of these funds should be included in the Center's annual report and reported to IAB during the IAB meetings. Industrial members may provide additional support for activities such as sponsored research projects, equipment donations, intellectual property donations, or educational grants.
 - (7) Costs for organizing meetings with industry members will be borne by the ERC or the participants through a registration fee, as deemed appropriate. Costs for attending these meetings by industry members will be borne by their organizations.
 - (8) All ERCs will have member firms engaged in translational research through sponsored projects, and small firms carrying out translational research supported by funds from the ERC Program's Translational Research Fund or other non-ERC, non-member, non-university sources for ERC-generated Intellectual Property (IP) that member firms do not license.

- (9) In addition, the ERC will develop and nurture the innovation ecosystem for the purposes of accelerating the translation of knowledge into innovation, by:
- (i) Stimulating member firms to support sponsored projects for the purposes of translating center-generated IP to commercialization,
 - (ii) Forming collaborations with small firms for the purpose of translating ERC-generated IP to the marketplace, if member firms do not license the IP - (This should be done via licensing IP, knowledge transfer to the firm, and/or securing translational research funds to accelerate commercialization of the technology by the small business in partnership with the ERC. Translational research funds could be secured from the ERC Translational Research Fund and/or from funding from other non-ERC/non-member/non-university sources);
 - (iii) Building partnerships with federal, state, or local government programs designed to develop entrepreneurs, support start-up firms, and otherwise speed the translation of ERC-generated knowledge and technology into practice and products; and
 - (iv) Leveraging technology commercialization opportunities offered by the federal Small Business Innovation Research (SBIR)/Small Business Technology Transfer (STTR) programs. The ERC will include analyses to determine the most effective methodologies to use to achieve these innovation goals through these types of partnerships.
 - (v) In reference to 9(ii) above, ERCs will classify their IP generated from research under the scope of the ERC's strategic plan as core IP (IP resulting from center-controlled unrestricted funds) and Project IP (IP resulting from restricted funds that flow through the center or flow directly to a PI). For Core IP and Project IP, the full member firms/practitioner organizations or the sponsoring firm/practitioner organization, respectively, will be offered the first option to negotiate a license. If there is no license forthcoming in either case, the IP can be offered to a non-member small firm and a partnership formed between that firm and ERC faculty to carry out translational research to accelerate product development. Support for a translational research project to accelerate product development can be sought from NSF through the ERC Translational Research Fund; in that case, the small firm would be the submitting organization, with a subaward to the ERC faculty. In

addition, in that case, the university must screen the project for ERC faculty, Industrial Liaison Officers (ILO) and/or ERC Executive Management personnel conflicts of interest. When conflicts are disclosed for any of the above three categories of personnel, the university impacted must develop a conflict management plan for each disclosure.

(vi) In the case of a conflict, there will be a conflict of interest management plan. Progress and impacts of the project would be reported in the ERC's annual report. Because NSF would support such a project as an associated project outside the center's core funds, any additional IP developed from that project would not revert to the university or member firms.

e. Student Leadership Council. The SLC is responsible for organizing student activities to achieve the ERC's goals for research and education. The SLC will be comprised of undergraduate and graduate students and will have a Chair and a Co-Chair. The Chair will serve as a member of the ERC's Leadership Team. The SLC also is responsible for carrying out a SWOT analysis of the ERC and communicating the results to the ERC Director, the ERC's leadership team, and the NSF site visit team.

6. Programmatic Activity Requirements:

a. Joint NSF-Awardee Activities:

The ERC will participate in evaluation and other types of studies of the ERC Program initiated by NSF. Such studies include but are not limited to the outcomes and impacts of the ERC Program. The ERC will also participate in workshops organized by NSF to study various issues common to the system of centers. Costs for attending these meetings must be included in the budget submitted to NSF.

b. Electronic Access: The Awardee shall establish and maintain an electronic access capability via the Internet to transfer the quantitative and qualitative data to an NSF database. The access to this electronic information will be protected and only NSF will have and grant access. The Center will establish a WWW "Home Page" containing some elements with public access to make available any information about the Center's goals, activities, and accomplishments. The Center will develop and use an identifying logo that is consistent with the Awardee's policies and procedures and approved by the Awardee as a graphic identity to be used on brochures, newsletters, on the Center's WWW "Home Page," etc.

7. NSF Ongoing Project Oversight:

The Awardee will ensure full commitment and cooperation among the governing structure components, and all project staff during ongoing NSF project management and oversight activities. The awardee will ensure availability of all key institutional partners during any desk or on-site review as well as timely access to all project documentation. As a minimum requirement, the Center Director will meet annually at NSF with the NSF ERC Program Officer assigned to the ERC for oversight to discuss progress and other issues. The timing of the visit is to be determined by mutual agreement between the Center Director and ERC Program Officer.

- a. Annual Review: NSF will carry out annual site visits to review the progress and plans of the Center. Renewal reviews will be carried out in years three and six. Based on the performance of the ERC, and in consultation with the ERC Director, the NSF Program Officer may determine that an annual site review is not necessary. In that case, the Center Director and a team of key individuals may visit NSF to update the NSF Program Officer and other NSF staff on progress and plans of the Center. For the purpose of the annual review, site visits will be conducted a minimum of six weeks prior to the anniversary date of the award to review performance and to provide advice to the ERC. The level of continued NSF support will be negotiated with the Awardee annually and will depend upon a review of progress through the annual site review or other means, the performance metrics, the industrial support level, the Program Officer's assessment of progress, and the availability of funds for the program.
- b. Renewal Proposal Review: If a renewal proposal is submitted during the sixth year of the Center's operation, the ERC will be evaluated in the manner described above to determine whether NSF will continue to support full ERC operations or provide decreased funding to phase out NSF support of the ERC over Years 7 and 8 of the Center's operation. If NSF decides to continue full ERC operations, a new level of funding support will be negotiated for years 7 and 8 and two years will be added to the agreement to extend it through year 10. If the Awardee chooses not to submit a renewal proposal, NSF support to the ERC will be phased down over the two-year period covering Years 7 and 8 of the Center's operation.
- c. NSF will specify the format of the progress report/renewal proposal, the review process, and review criteria approximately six months before the date agreed upon for submission.
- d. Termination of the Cooperative Agreement. NSF's agreement with a Center might be terminated as a result of an annual review indicating insufficient progress in organizing the ERC to achieve its vision, or not addressing one or more key features of the Center. In the case of

termination, NSF support to the Center will be phased down over the next one or two years.

- e. NSF may carry out a summative site visit at the end of the 10th year of support to determine the long-term value added by the ERC.
- f. After the end of the Cooperative Agreement with NSF, NSF expects the ERC to continue in a self-sufficient mode, maintaining the ERC culture with support from funds outside the ERC Program. Under no circumstances will the ERC receive ERC Program support to continue its full center operations after the Cooperative Agreement expires, although it may receive ERC Program support through subawards from other ERCs or through special purpose awards designed to capitalize on past ERC Program investments.

8. Reporting Requirements:

Awardee will provide *ad hoc* and regular reports as designated by the NSF cognizant Program Official, with content, format, and submission time line established by the NSF cognizant Program Official. The Awardee will submit all required reports via FastLane using the appropriate reporting category; for any type of report not specifically mentioned in FastLane, the Awardee will use the "Interim Reporting" function to submit reports.

a. Annual Report:

The Awardee shall submit an Annual Report which will contain specific information including, but not limited to, the following: the progress and plans of the ERC in all areas in achieving its vision with supporting data developed from the data submitted to the ERC Program's data base of indicators of progress and impact, information on revenues and expenditures, and proposed budgets. The annual report should also include plans, quantitative information on performance and the ERC's impact on diversity. The annual report is due at least five weeks prior to the annual site visit and at least 11 weeks prior to the anniversary date of the award. The annual report must be prepared according to the online document "Guidelines for Preparing ERC Annual Reports and Renewal Proposals," which is available at: <https://www.erc-reports.org>

b. Data Tables:

NSF maintains a database, ERCWeb, to collect and report quantitative and qualitative data for all of the ERCs. Each center is required to enter data into the database annually as instructed the "Guidelines for Preparing ERC Annual Reports and Renewal Proposals" and the "Guidelines for ERCWeb Data Entry." Both documents can be found at the website

<https://www.erc-reports.org>. Many of the data tables required in the Annual Report are produced from the data submitted to the ERC database. The Center will print these tables directly from the database website and use them in their respective Annual Reports. Details, data collection requirements and procedures for entering data are available in the “Guidelines for ERCWeb Data Entry” document.

c. Renewal Proposal:

In lieu of the sixth-year annual report, the Awardee may submit a renewal proposal that contains a cumulative progress report covering the period from the beginning of the fourth year to the date of submission of the renewal proposal, a request for support for years seven through ten, and plans for center activities during that last four-year period of this Cooperative Agreement. The progress report/renewal proposal is due at NSF by a date agreed upon between NSF and the Awardee. If the Awardee chooses not to submit a renewal proposal, NSF support to the Center will be phased down over the two years remaining in the period of support provided by this Cooperative Agreement.

d. Summative Report.

If NSF decides to carry out a summative review of the long-term impact of the ERC, a summative preliminary final report covering the period from the beginning of the Center to the anniversary date shall be submitted to NSF at least five weeks prior to the final 10th year summative site visit. More details are available at <https://www.erc-reports.org> on the “ERC Library” link.

e. Final Report:

A final report prepared according to guidelines provided by the ERC will be due within 90 days of the expiration date of this Cooperative Agreement. Guidelines for the ERC final report are available on the following site: <https://www.erc-reports.org> on the “ERC Library” link.

In addition, to assist NSF in evaluating the ERC programs, the PI must also respond to the request for information about project outcomes following the end of the award period. These include the project’s impact on workforce needs, awards and other measures of the quality of the project’s products, including project technology transfer results not reported in prior years, but due to the ERC investment of prior years. NSF will provide guidelines for the collection and reporting of data and project information.

9. Diversity Strategic Planning:

The leadership, faculty, and students involved in an ERC shall be diverse in gender, race, ethnicity and persons with disabilities at levels that are benchmarked against the academic engineering-wide national averages. The faculty and staff of the ERC and the administrations of lead and partner universities receiving NSF funding shall devote the time and effort required to ensure that the diversity of the Centers' leadership teams, faculty, and students at all levels serves as a model for diversity within each institution and for the nation as a whole. The ERC will prepare and execute diversity strategic plans in collaboration with the home departments of the ERC-affiliated faculty. These plans shall articulate the ERC's diversity goals and intended actions but need not specify quantitative targets. The ERC also will be multicultural through the involvement of faculty and students from other countries by virtue of their role as faculty or students in the ERC's institutions and, through the involvement of faculty and students from the foreign partner universities. The involvement of foreign faculty and students also is expected to be diverse, representing a broad spectrum of cultures and countries. In fulfilling its obligations under the agreement and in compliance with the requirements of federal law, no university receiving federal funds will employ quotas or set-asides based on race.

Each ERC will:

- a. Demonstrate the existence of a partnership among the affiliated Deans of Engineering, other Deans, and the chairs of departments of the affiliated ERC faculty to increase the diversity of the Center's leadership team, faculty, undergraduate and graduate students, and graduates over the duration of NSF's support.
- b. Include as the lead or one of the domestic partner universities a university that serves large numbers of students predominantly underrepresented in engineering in the U.S. (i.e. women, African Americans, Pacific Islanders, Native Americans, Hispanic Americans, or persons with disabilities). The ERC may also develop non-core partner outreach connections with the same types of institutions.
- c. Develop and strengthen long-term core or outreach partnerships with predominantly female, African-American, Native-American, and Hispanic-American serving institutions and/or institutions serving large number of these underrepresented students who are majoring in engineering and science programs.
- d. The ERC may also, but is not required to, develop outreach connections with NSF programs focused specifically on increasing diversity of engineering students and faculty through the involvement of women, underrepresented racial minorities, and Hispanic-American students. This may include connections with one of the NSF's Louis Stokes Alliance for

Minority Participation (LSAMP), and/or with one or more of the NSF-sponsored awardees focused on diversity such as the NSF Alliances for Graduate Education and the Professoriate (AGEP), Colleges and Universities that serve predominantly Native American Populations, and other ongoing NSF programs serving underrepresented groups.

- e. Focus the Research Experiences for Undergraduates (REU) and Research Experiences for Teachers (RET) programs on increasing diversity.

10. ERC Key Features:

- a. Vision of the ERC:

Thus the vision of the Smart Lighting ERC is to enable the “Synthesis of Light for the Benefit of Humanity” by creating an immersive lighting environment that is vastly superior to that achievable with incandescent light bulbs and fluorescent tubes. The Smart Lighting ERC uniquely positioned itself as the leader of the “Second Wave” of the solid state lighting industry. SLERC refers to the “First Wave”, in layman’s terms, as the research, technology development, and deployment around such relatively common place devices as light emitting diode (LED) lighting fixtures and solid state liquid crystal displays. In contrast, the “Second Wave” is a new frontier that recognizes and leverages the fact that photons generate a tremendous amount of information that, if harvested and properly utilized, can provide significant value. The Center’s research plan and industrial partners program is built around the research and engineering opportunities that the ERC will attack in this “Second Wave.”

- b. ERC's Strategic Goals:

The goal of the Smart Lighting ERC is to develop the scientific foundation and knowledge base for smart lighting sources, sensors, and control electronics, and incorporate them into exemplary system testbed demonstrations of the technology to advance smart lighting functionality.

The ERC's integration of education, research, technology transfer, and innovation activities will be aimed at ensuring U.S. global leadership in smart lighting for years to come. The Smart Lighting Center will use the ERC Program's 3-plane strategic planning chart to display its strategic goals and the integration of its research program, accompanied by a milestone chart depicting the major deliverables through time and their interdependencies. The ERC will have a plan for partnering with small firms, as a subcontractor, to engage in translational research to speed innovation and technology transfer, when the members of the Industrial Advisory Board do not license ERC-generated Intellectual Property.

c. ERC's Research Program:

Thrusts S1 and S2 - Fundamental Science: Materials and Device Research at the bottom-tier, has two major thrusts, (i) Sources and (ii) Sensors.

Thrust S1 Sources: The S1 has multiple source development projects including color tunable sources, and a project to integrate the sources with MOSFET and HBT heterostructure device circuits in GaN to permit the integration of pre amplifier and control circuitry with state of the art LED devices project S1.3.

Thrust S2 Sensors: This thrust seeks to develop novel sensors for smart lighting systems that are more sensitive than current off the shelf technology and power- aware and power- conserving. This will be accomplished by exploring nano-photonics, nano-plasmonics, hybrid RF optical i.e. RF LED wireless transmitter and RF PD wireless receiver dual mode communication links.

Thrusts T1 and T2 - Enabling Technologies at the middle-tier of the 3-plane chart for the enabling technologies now contains a Systems Technology Thrust and the three enabling technology demonstration.

Thrust T1: Systems Technologies Thrust comprises to two projects. The Control Systems project focuses on developing the modeling, control, and estimation needed to achieve the desired spatial light field distribution when multiple light sources are used to illuminate a space. The Communications Systems projects has the goal of breaking the wireless traffic jam by providing an alternative communications medium to support the explosion of wireless devices such as smart phones, tablet computers, smart appliances, data connected computers, etc.

Thrust T2: Testbeds - Within the enabling plane there are three testbeds: (i) Smart Spaces (T2.1), (ii) Communications (T2.2), and (iii) Biosensors (T2.3). The Communications testbed focuses on the development and demonstration of hybrid RF-optical communications systems instead of pure visible light communications (VLC). The Biosensor testbed endeavors to develop several types of biosensor systems: (1) plasmonic sensors that rely on a shift in wavelength or intensity which occurs upon analyte binding, (2) the use of interference at several fixed wavelengths to measure layer thickness which changes upon analyte binding, and (3) the use of ultraviolet light to detect and classify microorganisms based upon intrinsic fluorescence. The Smart Spaces testbed is to be an interactive platform into which all of the enabling technologies will be integrated.

Thrusts A1- Translational Applications: At the top-tier, the following four

concepts (three applications and one economic impact study) are used to define the real world systems level goals of Smart Lighting Center. The aim is to help translate the technology developed and demonstrated in the middle-tier testbeds across the valley of death and into commercialization. The four concepts are:

- (1) Lighting for rooms and buildings to impact productivity and efficiency of human occupants (A1.1);
- (2) Infrastructure lighting and with dual uses in communications (smart grid) (A1.2);
- (3) Health and bio-sensing of bio-hazards and for bio-analysis (A1.3);
- (4) Drivers of Success in Research, Commercialization, and Diffusion of Smart Lighting (A1.4).

d. ERC's University Education Program:

The ERC's educational hypothesis is that to be creative and adaptive, Smart Lighting graduates will:

- (1) Be grounded in technical knowledge, analytical skills, and systems perspective of Smart Lighting;
- (2) Have positive attitudes and strategies for continuing their education through lifelong learning;
- (3) Contribute to the core research and broader mission of the ERC
- (4) Demonstrate skills in effective collaboration in technically and culturally diverse circumstances, and
- (5) Be prepared to develop ideas from their research into entrepreneurial opportunities.

To achieve this, the Center will develop a comprehensive, interactive educational program that will imbue both undergraduate and graduate students with innovative and creative skills and carry out a longitudinal assessment program to determine if the attributes offered by the ERC achieve that goal. As part of the effort, the ERC will develop course modules which comprise an "Illumineering" curriculum leading to a lighting concentration as part of an undergraduate engineering degree. The ERC will develop highly modular core Smart Lighting courses for graduate and undergraduate training. To guarantee easy access, course material will be available through the web, and both industry and remote students will have the opportunity to learn the Smart Lighting subject through distance learning courses. A 3-day workshop on "Topics beyond Research" will be used to extend the students' knowledge base to practical issues such as funding, ethics, inventions, intellectual property, etc.

To further broaden their experience base, Ph.D students will have the

opportunity to participate in an international experience through any of the international partner universities such as: Meijo University-Nagoya (Japan), Federal University of Rio de Janeiro- (UFRJ) (Brazil), Institute of Molecular Recognition (ICRM) Milan (Italy), University of Roma-Tre (Italy), University of Roma-Sapienza (Italy), and Vilnius University (Lithuania).

Both graduates and undergraduates will gain experience with innovation through partnerships with small firms engaged in translational research in the proposed ERC's research program and through courses in entrepreneurship.

e. Pre-college Education Program:

The Center will form long-term pre-college outreach partnerships with multiple K-12 schools and two school systems located in upstate New York, Boston, Massachusetts, the Board of Cooperative Educational Services (BOCES) New Visions Engineering program in Troy, New York, Baltimore, MD, Washington DC, and Terre Haute, IN areas. These programs have been established through each ERC University education partner school and will be supported through the Engineering Ambassador undergraduate (or similar) programs. UNM will be working to develop partner middle and high schools in the Albuquerque, NM area during Year-4. Smart Lighting graduate students will work with classroom teachers to bring concepts from physics, optics, and engineering into elementary and middle and high school education. Through Learn by Teaching complemented by the ERC Research Experience for Teachers (RET) program, the ERC will impact elementary through secondary education. Technological tools such as the Mobile Studio, development of hands-on modules and exposure to the ERC facilities such as the Science You Can See program will continue to attract more young people to science and technology via the development and dissemination of hands-on solid-state optics and photonics kits to classroom teachers and museums. The ERC will provide a Young Scholars Program for advanced high school students to carry out research in the university partner's laboratories.

The reach of Science You Can See will also extend to their college outreach affiliates Howard University and Morgan State University, both Historically Black Colleges and Universities (HBCUs), and the Rose-Hulman Institute of Technology, a primarily undergraduate institution.

Through these vehicles as well as the ERC's Research Experiences for Undergraduates Program the ERC will afford opportunities for large numbers of women and underrepresented minority students to engage in this new, rapidly growing field.

f. Innovation Ecosystem:

The ERC will develop a membership program consisting of paying members made up of a mix of large and medium-sized firms that are leaders in this field and smaller firms that are entering the field. The Industrial Advisory Board (IAB) will meet twice a year to review the ERC's research, education, technology transfer and innovation programs and assist in speeding technology transfer. This program will be complemented by the entrepreneurship and innovation partnerships the ERC has established with organizations such as the Center for Economic Growth in Albany, NY, the RPI Emerging Ventures Ecosystem Incubator, STC.UNM in Albuquerque, NM, and the Photonics Center in Boston, MA.

g. Special Deliverables:

The ERC will (i) define quantitative performance goals at the testbed level to help drive the testbed development; and (iii) develop and implement a plan for the Center to acquire a fuller knowledge of how different lighting parameters affect human health and comfort.

RPI will document that they have either already hired or have a plan in motion to hire the additional faculty member in a research area directly related to Smart Lighting, over the time of the ERC, within the School of Engineering.

The Co-Chairs of the Systems Integration Committee (SIC) will provide the leadership to define goals for interactive lighting systems that are clearly transformational to reviewers and others outside the ERC. The effectiveness of the SIC Co-Chairs in defining and executing clear transformational goal for the testbeds will be closely monitored as part of the post-award oversight process.

The ERC will develop collaborative projects examining the societal impact of smart lighting on the end user community (e.g. understanding the conditions under which people negatively and positively react to dual-use lighting-communications/signaling sources). The handling of societal impact issues on the Smart Lighting charter will be closely monitored as part of the post-award oversight process.

The issues below were raised in the external reviews and during the internal NSF review of the funding recommendation. They will be addressed initially during the first year and progress will be reviewed at the first annual review and subsequently thereafter as needed. The issues are:

- i. The ERC will continue to directly involve the faculty from the affiliate minority serving institutions in the research program as per the commitment in the PI's memo dated May 27, 2008.
- ii. The ERC will continue to implement mechanisms to recruit more Hispanics, Native Americans, and African Americans into the research program from UNM, Howard University, and Morgan State University as per the PI memo dated May 27, 2008. This diversity has been augmented by diversity provided by faculty and students from RPI and BU.

h. Headquarters

RPI will continue to provide at least 7500 square feet on the 7th floor of the George Low Building to establish the ERC Central Laboratories. This space will be used for the ERC headquarters, the core laboratories, and office space as follows. Of that space, roughly 1,500 square feet are dedicated to existing offices and 5,000 square feet to this effort, which will house the Central Laboratories proposed for the ERC (2,500 is existing and 2,500 will be renovated for new faculty). The remaining 1,000 square feet will be renovated into a headquarters suite for the ERC. In addition, the NSF Smart Lighting ERC will have access to lab facilities at its partners, BU and UNM, as well as many of the extensive state-of-the-art processing facilities at the Sandia National Laboratory and practitioner facilities at the New York State Wadsworth Center.

i. Institutional Support

The lead and core partner institutions will provide institutional support over Years 4 through 8 of the ERC as follows: Rensselaer: \$3,400,000; Boston University: \$1,600,000; The University of New Mexico: estimates providing 15% of the NSF funding received. The amount of these institutional commitments will be reported to the NSF Program Officer and documented in the annual and final reports.