U.S. NUCLEAR REGULATORY COMMISSION
NOTICE OF GRANT/ASSISTANCE AWARD

1. GRANT/AGREEMENT NO.	2. MODIFICATION NO.	3. PERIOD OF PERFORMANCE	4. AUTHORITY
NRC-HQ-11-G-38-0073		FROM: 8/22/2011 TO: 8/21/2013	Pursuant to Section 31b and 141b of the Atomic Energy Act of 1954, as amended

5. TYPE OF AWARD	6. ORGANIZATION TYPE	7. RECIPIENT NAME, ADDRESS, and EMAIL ADDRESS
[X] GRANT [ ] COOPERATIVE AGREEMENT	Private Institution of Higher ED DUNS: 097394084 NAICS:611310	Georgia Tech Research Corporation 505 10th Street, NW Atlanta, GA 30332-0420

8. PROJECT TITLE:

"Risk/Reliability Analysis Technology Infusion in Support of Engineering Education and the Workforce"

9. PROJECT WILL BE CONDUCTED	10. TECHNICAL REPORTS ARE REQUIRED	11. PRINCIPAL INVESTIGATOR(S) NAME, ADDRESS and EMAIL ADDRESS
PER GOVERNMENT'S/RECIPIENT'S PROPOSAL(S) DATED See Program Description AND APPENDIX A-PROJECT GRANT PROVISIONS	[X] PROGRESS AND FINAL [ ] FINAL ONLY [ ] OTHER (Conference Proceedings)	Georgia Tech Research Attn: Dr. Seung-Kyum Choi 505 10th Street, NW Atlanta, GA 30332-0420 Email: schoi@me.gatech.edu (912) 966-6771

12. NRC PROGRAM OFFICE (NAME and ADDRESS)	13. ACCOUNTING and APPROPRIATION DATA	14. METHOD OF PAYMENT
NRC Attn: Tanya Parwani-Jaimes Office of Human Resources MS: GW5A06 (301) 492-2308 11545 Rockville Pike Rockville, Maryland 20852 Email: Tanya.Parwani-Jaimes@NRC.GOV	APPN. NO: 31X0200 B&R NO: 2011-84-51-K-134 JOB CODE: T8453 BOC NO: 4110 OFFICE ID NO: RFPA: HR-11-266 FAIMIS GR0054	[ ] ADVANCE BY TREASURY CHECK [ ] REIMBURSEMENT BY TREASURY CHECK [ ] LETTER OF CREDIT [X] OTHER (SPECIFY) Electronic ASAP.gov (See Remarks in Item #20 "Payment Information")

15. NRC OBLIGATION FUNDS		16. TOTAL FUNDING AGREEMENT		
THIS ACTION	$135.768.00	NRC	$135.768.00	This action provides funds for Fiscal Year in the amount of See Page Two
PREVIOUS OBLIGATION	$ 00.0	RECIPIENT	$ 0.00	
TOTAL	$135.768.00	TOTAL	$135.768.00	

17. NRC ISSUING OFFICE (NAME, ADDRESS and EMAIL ADDRESS)

U.S. Nuclear Regulatory Commission
Div. of Contracts
Attn: Shashi Malhotra Email: Shashi.Malhotra@NRC.GOV
Mail Stop: TWB-01-B10M
Rockville MD 20852

18.	19. NRC CONTRACTING OFFICER
Signature Not Required	Sheila Bumpass (Signature) 8/22/11 (Date) NAME (TYPED) Sheila Bumpass TITLE Contracting Officer TELEPHONE NO. 301-492-3484

20. PAYMENT INFORMATION

Payment will be made through the Automated Standard Application for Payment (ASAP.gov) unless the recipient has failed to comply with the program objectives, award conditions, Federal reporting requirements or other conditions specified in 2 CFR 215 (OMB Circular A110).

21. Attached is a copy of the "NRC General Provisions for Grants and Cooperative Agreements Awarded to Non-Government Recipients. Acceptance of these terms and conditions is acknowledged when Federal funds are used on this project.

22. ORDER OF PRECEDENCE

In the event of a conflict between the recipient's proposal and this award, the terms of the Award shall prevail.

23. By this award, the Recipient certifies that payment of any audit-related debt will not reduce the level of performance of any Federal Program.

TEMPLATE - ADM001

SUNSI REVIEW COMPLETE

ADM002

ATTACHMENT A - SCHEDULE

A.1 PURPOSE OF GRANT

The purpose of this Grant is to provide support to the "Risk/Reliability Analysis Technology Infusion in Support of Engineering Education and the Workforce" with Georgia Tech Research Corporation, as described in Attachment B entitled "Program Description."

A.2 PERIOD OF GRANT

1. The effective date of this Grant is August 22, 2011. The estimated completion date of this Grant is August 21, 2013.

2. Funds obligated hereunder are available for program expenditures for the estimated period: August 22, 2011 – August 31, 2013.

A. GENERAL

1. Total Estimated NRC Amount:	$135,768
2. Total Obligated Amount:	$135,768
3. Cost-Sharing Amount:	$0
4. Activity Title:	"Risk/Reliability Analysis Technology Infusion in Support of Engineering Education and the Workforce"
5. NRC Project Officer:	Tanya Parwani-Jaimes
6. DUNS No.:	097394084

B. SPECIFIC

RFPA No.:	HR-11-266
FAIMIS:	GR0054
Job Code:	T8453
BOC:	4110
B&R Number:	2011-84-51-K-134
Appropriation #:	31X0200
Amount Obligated:	$135,768

A.3 BUDGET

Revisions to the budget shall be made in accordance with Revision of Grant Budget in accordance with 2 CFR 215.25.

	Years 1 & 2
Direct Participant Cost	$ 90,211
Indirect Cost (F & A)	$ 45,557
Total Project Costs	**$135,768**

A.4 AMOUNT OF AWARD AND PAYMENT PROCEDURES

1. The total estimated amount of this Award is $135,768 for the two-year period.
2. NRC hereby obligates the amount of $135,768 for program expenditures during the period set forth above and in support of the Budget above. This grant program is fully funded. NRC is

not obligated to reimburse the Grantee for the expenditure of amounts in excess of the total obligated amount.

3. Payment shall be made to the Grantee in accordance with procedures set forth in the Automated Standard Application For Payments (ASAP) Procedures set forth below.

Attachment B – Program Description

PROGRAM DESCRIPTION

Title: Risk/Reliability Analysis Technology Infusion in Support of Engineering Education and the Workforce

PI: Seung-Kyum Choi, Ph.D.
George W. Woodruff School of Mechanical Engineering
Georgia Institute of Technology
Email: schoi@me.gatech.edu, Phone: 912-966-6771

Focus Area: Reliability and Risk Analysis
EDU Number: EDU11-016
Total Budget: $135,768

A series of courses will be created to cover core probabilistic risk assessment (PRA) techniques which is expected to increase and fuel rapid growth in various industries. Course titles include **Probabilistic Risk Assessment,** and **Reliability-based Systems Design.** The proposed courseware will be designed to be accessible to a broad engineering audience so that students will become familiar with statistical thinking, risk-informed decision making, and reliability/risk assessment technologies. Throughout the propose courses along with community outreach and collaborative environment, students will gain a better understanding of core PRA technologies and their integration at the level of design and implementation of nuclear or other engineering systems. The courseware developed will be adapted for use at multiple educational levels.

The proposed project will also utilize a comprehensive synthesis framework to systematically analyze complex engineering problems by accurately estimating the risk and reliability of the system under the consideration of uncertainty. The PI's previously developed decision support process and the multiscale modeling scheme will be adapted and utilized to achieve this goal. A significant benefit to society is expected by providing this demonstration example that utilizes risk and reliability assessment technologies much more efficiently than currently possible, leading to reduced risks for various industries.

Another outcome of this project is the development of a collaborative environment. The implemented grid portal will allow engineers to support different PRA technology services for practical risk assessment problems to be systematically designed at different scales. This collaborative design environment among distributed organizations will enable many benefits including faster product development and improved product quality while reducing costs and risks.

1. Vision and Goals

Vision

With the advent of new technologies, the exponential pace of engineering capabilities became too fast for product development. The educational period needed to effectively learn about the performance and perception of this new technology has not been reduced at an equal pace. These leaps forward bring greater complexity to designs and a larger number of decisions that need to be made. Specifically, increased complexity in a system adds an increased amount of uncertainty in design variables and product performance. Successful product innovation cannot be achieved without adequate instruments to analyze and manage these complexities and uncertainties. Moreover, it is critical to incorporate the effect from these complexities and uncertainties in the design process of nuclear facilities and materials to regulate safety and security. To address this requirement, Georgia Tech will develop a series of courses that introduce risk/reliability analysis and design concepts to undergraduate and graduate students under the direct satisfaction of NRC and ABET requirements [1].

The Nuclear Regulatory Commission (NRC) now utilizes Probabilistic Risk Assessment (PRA) in the process of decision making and regulations. Various industries, including chemical, medical and airline industries, use PRA tools in their decision making process to facilitate determining the value of their activities before making significant investments. The denotation of "Risk and Reliability Assessment (RRA)" is vast and represents a bold attempt within academia, supported by NRC, to address the enormous opportunities latent in this very fertile and indispensable field. This proposal seeks to educate the engineering community, especially the academic community, in making the best use of this little understood, yet greatly accessed infrastructure. To make the best use of the emerging RRA, engineers, technicians, and to lesser extents, nuclear scientists and professionals in all disciplines must have a working understanding of this methodology. The current environment already demands that engineers, technicians, and professionals work synergistically to assimilate and integrate RRA technology into nearly every engineering discipline, including electronics, chemistry, manufacturing, materials, biology, and mechanics. The effective deployment of RRA is expected to increase and fuel rapid growth in nuclear related industries, which will lead to rapid growth in the demand for engineers and technicians with core RRA skills.

To meet this demand, it is not enough to simply train more nuclear scientists and professionals. We must also equip engineers and technicians in all disciplines and at all levels with greater control over new and cross-cutting developments in RRA through education and supporting simulation toolkits. If engineers and technicians have a general understanding of core RRA technology and components and their integration at the level of design and implementation of products, a massive surge in productivity and creativity in their respective disciplines will be realized that will have a far-ranging impact.

Currently, the Nuclear and Radiological Engineering program at Georgia Tech does not have regular courses which cover the topic of risk and reliability analysis technologies. Therefore, there is an urgent need for creating a series of courses to cover various risk assessment

techniques. Our proposed courseware will be designed to be accessible to a broad engineering audience so that students will become familiar with statistical thinking, risk-informed decision making, and reliability/risk assessment technologies. Course titles include **Probabilistic Risk Assessment,** and **Reliability-based Systems Design.**

An integrated aspect of this effort will be the creation of a new framework that will integrate existing computational tools into a work space where students can manipulate and visualize their designs. The framework will facilitate the use of IT-infrastructure tools such as the National Design Repository (NSF-funded CIBER-U project [2]). Through their work on and with the framework, students will gain a better understanding of core PRA technologies and their integration at the level of design and implementation of nuclear engineering systems. The courseware developed will be adapted for use at multiple educational levels. To ensure the success of this initiative, we will work closely with our partner institute, i.e., Savannah State University (SSU) (HBCU), Armstrong Atlantic State University (AASU), and Georgia Southern University (GSU) to deliver the new course components and integrate them into the curriculum at Georgia Tech, SSU, AASU, GSU, and beyond.

The framework we propose will not only support our educational objectives, it will also greatly enhance the capabilities of engineering and technology students, their instructors, and engineers and technicians in the workforce.

Goals

Our initial objectives will be

- Creation of new curriculum components that emphasize risk and reliability analysis, and closely match the requirements of future engineers and technicians
- Development of a prototype of a risk-informed design framework comprising both visual and robust simulation environments

These goals are intended to improve the use of state-of-the-art risk and reliability assessment capabilities, not by introducing new courseware, but simply by empowering all engineers and technicians to become familiar with and adept in deploying core risk/reliability-informed design concepts. Success in the implementation of this program will enable non-experts to achieve effective management of large amounts of data and complex engineering processes, thus reducing their level of frustration and increasing their productivity and work satisfaction. At the same time, our goals will directly support the satisfaction of NRC and ABET requirements [1] within engineering and technology programs.

2. Implementation Plan

To accomplish our vision and goals, four components can be considered as our approaches:

- Create a new curriculum and courses which are suitable for future engineers and technicians (section 2.1)
- Foster identified research of risk and reliability analysis for complex engineered systems to facilitate a virtual and robust engineering environment (section 2.2)
- Build a community that encourages feedback, self-growth, and self-sustainment (section 2.3)
- Establish collaborative environment that can enrich RRA technologies (section 2.4)

The current proposal is for the initial 2-year demonstration phase of the project. A breakdown of the proposed work by year is located in section 2.4.

2.1 Create a New Curriculum and Courses

New Courseware Development

The objective of our new courseware is to enhance our students' knowledge and use of techniques for risk and reliability-informed engineering. Our courseware should review fundamental concepts and practical aspects of core RRA techniques so that the students develop the ability to learn and adapt new workflow operations in industry or business environments. Our courseware will be designed to be accessible to this broad engineering audience. Students will become familiar with statistical thinking, risk/reliability assessment, data exploration, and decision making technologies, and they will gain real-world skill sets to enhance their superior abilities and training.

In addition to courses that teach core RRA technologies, courses in fundamental stochastic or statistical methods for engineering systems will be added to the curriculum. Stochastic analysis is a technique for assessing the effects of uncertain input parameters and assumptions on engineered systems. It is an important component of reliability-based design, which is gaining wider recognition within the engineering community. The courses to be developed at Georgia Tech will emphasize risk/reliability-informed design while addressing the signature theme of nuclear engineering systems to directly satisfy NRC requirements:

- **NRE4xxx Probabilistic Risk Assessment (3 unit, elective course for undergraduate students)**: Students will gain an understanding of the basics of Probabilistic Risk Assessment in the broader sense of planning, analyzing, designing, and implementing complex engineered systems. This course reviews fundamental concepts and practical aspects of core PRA techniques including basic probabilistic descriptions, sampling methods, fault/event tree analysis, risk management, and nuclear safety. The course will be offered through the Nuclear and Radiological Engineering (NRE) program at Georgia Tech as a regular course. The target of the course is senior students and we expect to have at least 40-50 students every semester. The students from our partner institutes, including AASU, GSOU, and SSU will be able to attend this course. The graduate students can also register this for 4000 level course as an elective.

- **NRE/ME6xxx Reliability-based Systems Design (3 unit, elective course for graduate students):** Students will learn to view fundamentals and applications of system reliability, stochastic finite element methods, reliability/risk analysis, sampling methods and stochastic optimization methods. This course will cover the fundamental formalism with some attention given to its history, it describes basic applications for the formalism and it continues with a number of additional applications including the risk assessment of the nuclear energy system. Since the content of the course is general enough for many engineering disciplines, the course will be offered as a regular course for both the NRE and Mechanical Engineering (ME) program at Georgia Tech. Thus, this course will provide an opportunity for ME students to have good fundamental understanding of RRA and NRC's requirements. The target of the course is graduate students, and we expect a wide spectrum of students for this specific course. The typical number of participants for this course are anticipated to be at least 30-40 graduate students. The course will also be offered to the distance learning students.

- **NRE8xxx Risk-informed Decision Support Process (3 unit, special topics course for graduate students):** *This course is not included in the scope of the current 2 years proposed plan; however, it is planned to be offered as a long term goal without requiring*

additional resources from NRC. In this course, Students will learn and apply the decision support process to solve complex engineering problems including nuclear energy systems. This course is designed as a project-based learning course. The lectures will be provided for eight weeks to cover the fundamental process of the decision process. Lecture topics include decision analysis via multiattribute utility theory and conjoint analysis, risk management, and cost-benefit analysis. The rest of the classes are designed as a project-based learning course. Practical problems from our industrial partners and research institutes will be assigned to the students. The course will be offered to the NRE program as a special topics course. Once it is offered at least three times, the permanent course number will be assigned as a regular course. 20-30 students are expected per semester, and 2-3 students will be allowed to work together as a group depending upon the scope of the assigned project.

NRE4xxx Probabilistic Risk Assessment:

Probabilistic risk assessment (PRA) is a systematic method to estimate risks of complex engineering systems to ensure their safety [3]. The PRA technique quantifies risk and identifies the most significant components for system safety. It is critical to understand the basics of the PRA to satisfy the demand of a complex engineered technological entity, i.e., nuclear power plant, airliner, etc.

The main purpose of the proposed course is to provide a comprehensive introduction to PRA. As shown in Table 1, this course reviews fundamental concepts and practical aspects of core PRA techniques including basic probabilistic descriptions, sampling methods, fault/event tree analysis, risk management, and nuclear safety. The PI will spend much of the class time concentrating on fundamentals, but it is of paramount importance that everyone develops a good grasp on the underlying ideas and methods for the PRA, since many students may lack some prerequisites. There will be two midterm exams and a comprehensive final exam. Homework will normally be assigned once per week. The course is designed for senior level undergraduate students; however, graduate students can also register for this 4000 level course as an elective.

Table 1. Syllabus Example for NRE4xxx Probabilistic Risk Assessment

Catalog Description	Introduction to fundamental methods in probabilistic risk assessments. Topics covered are probabilistic description, sampling methods, risk assessment, and nuclear power plant safety.
Prerequisites	Elementary probability theory and statistics
Textbook	None, Lecture slides will be provided on T-square (www.t-square.gatech.edu)
Reference	Modarres, M., Risk Analysis in Engineering: Techniques, Tools, and Trends, CRC Press Ang, and Tang, Probability Concepts in Engineering Planning and Design, Wiley Choi, Grandhi, and Canfield, *Reliability-based Structural Design*, Springer, London, 2007.
Goals	To provide knowledge about risk assessment techniques and to enhance engineers and scientists' skills in the state-of-the art commercial software.
Topics Covered	1. Basic probabilistic descriptions 2. Sampling methods 3. Failure modes 4. Elements of risk assessment

	5. Probabilistic risk assessment (Levels I, II, and III) 6. Fault tree / event tree analysis 7. Bayesian belief networks 8. Regulation and risk management 9. Risk-informed Decision Making 10. Fundamental concept of nuclear safety 11. Reactor safety studies and accidents
Grading	Homework 30% Tests 70%

NRE/ME6xxx Reliability-based Systems Design:

This course provides students with an understanding of the fundamentals and applications of system reliability, reliability & risk analysis, stochastic sampling methods, probabilistic decision-based design, and optimization under uncertainty. This course will cover the fundamental formalism with some attention given to its history. It describes basic applications for the formalism, and it continues with a number of additional applications. Probability theory, statistic methods, and reliability analysis methods including Monte Carlo sampling, Latin hypercube sampling, first and second-order reliability methods, conjoint analysis, multiattribute utility theory, and stochastic optimization will be discussed [4]. In addition, the use of stochastic expansions, including polynomial chaos expansion and Karhunen-Loeve expansion [4], for the reliability analysis of practical engineering problems will also be examined. Detailed examples of practical engineering applications including nuclear power systems, aerospace systems, and other practical systems will be discussed to illustrate the effectiveness of these methods. The syllabus for the proposed NRE/ME6xxx Reliability-based Systems Design is shown in Table 2. The PI is the principal author of the textbook [4] selected. The participants will get the critical information and intuitive solutions directly from the author. In each homework assignment, students will develop a research module that will ultimately be used for the framework of the final project. The developed module of the homework/final project will be used to achieve goals related to the students' specific interests and needs.

Table 2. Syllabus Example for ME6xxx Reliability-based Systems Design

Catalog Description	Introduction to a wide range of deterministic and probabilistic design methods for systems design. Topics covered are uncertainty representation, reliability/risk assessment, design with design of experiments (DOE), reliability-based design, and robust design.
Prerequisites	Senior or graduate standing in engineering or related discipline
Textbook	Choi, Grandhi, and Canfield, *Reliability-based Structural Design*, Springer, 2007.
Reference	Hoyland, and Rausand, Systems Reliability Theory, Wiley Montgomery, *Design and Analysis of Experiments*, Wiley Ebeling, Introduction to Reliability and Maintainability Engineering,
Goals	To provide a sufficient understanding of probabilistic design techniques for variety of disciplines including energy, aerospace, mechanical, chemical, and biotechnical systems with emphasis on project-based learning.
Topics Covered	1. Introduction to probabilistic design 2. Basic probabilistic description 3. Random field 4. Simulation in design 5. Design with design of experiments 6. Analysis of variance

	7. First- and second-order reliability methods 8. Failure models 9. Fault tree / event tree analysis / Reliability block diagrams 10. Reliability-based systems design 11. Probabilistic Decision-based Design 12. Robust design (Taguchi method)
Grading	Homework 30% Tests 40% Final project 30%

NRE8xxx Risk-informed Decision Support Process:

The goal of the proposed course is to have students understand and apply concepts of the risk-informed decision support process to solve practical engineering problems. Lecture topics include decision analysis via multiattribute utility theory and conjoint analysis, risk management, and cost-benefit analysis. In this course, students are given real-world, open-ended, interdisciplinary challenges proposed by industrial and research project sponsors. They learn and apply the risk-informed decision support process. A group of 2-3 students will be allowed to work in a team to design and analyze given problems. Student groups will prepare and present their project work in class and orchestrate the ensuing class discussion. The project applications will demonstrate the interwoven nature of risk management and engineering design. This kind of project-based learning is identified as one of the best pedagogical practices for improving learning of design concepts [5]. Again, the development of this course is not included in the 2 year plan of the project plan. It is planned to be offered as a long term goal of this project.

Table 3. Syllabus Example for NRE8xxx Risk-informed Decision Support Process

Catalog Description	Introduction to common elements of risk and reliability assessment, management, and decision analysis. Topics covered are multiattribute utility theory, conjoint analysis, decision support process, and risk management.
Prerequisites	Senior or graduate standing in engineering or related discipline
Textbook	None/Lecture slides will be posted on T-square (www.t-square.gatech.edu)
Reference	Clemen, *Making Hard Decisions*, Duxbury Press Thuesen, and Fabrycky, *Engineering Economy*, Prentice-Hall
Goals	To learn the skills necessary to perform risk-informed decision support process of multidisciplinary systems using state-of-the-art analysis and computation techniques
Topics Covered	1. Multiattribute utility theory 3. Conjoint analysis 4. Decision analysis 5. Compromised decision support process 6. Risk management 7. Risk-informed decision making
Grading	Homework 40% Reading Assignment 20% (Readings will be assigned from various regulatory, industry, and scientific sources) Presentations 20% Final project 30%

2.2 Foster Identified Researches of Risk/Reliability Engineering

Risk/Reliability-informed Design Framework

In the traditional design process, engineering systems are designed with simplified rules to compensate for uncertainties and variabilities in modeling, simulation, and manufacturing processes. An example of this approach is safety factor design. However, this deterministic design process does not directly account for the random nature of most input parameters. Without realistic considerations of variabilities and tolerances in the design process, the design may induce catastrophic system failures. One objective for the proposed framework is to develop probabilistic decision-support tools to assist the management of complex engineering systems in the presence of uncertainty.

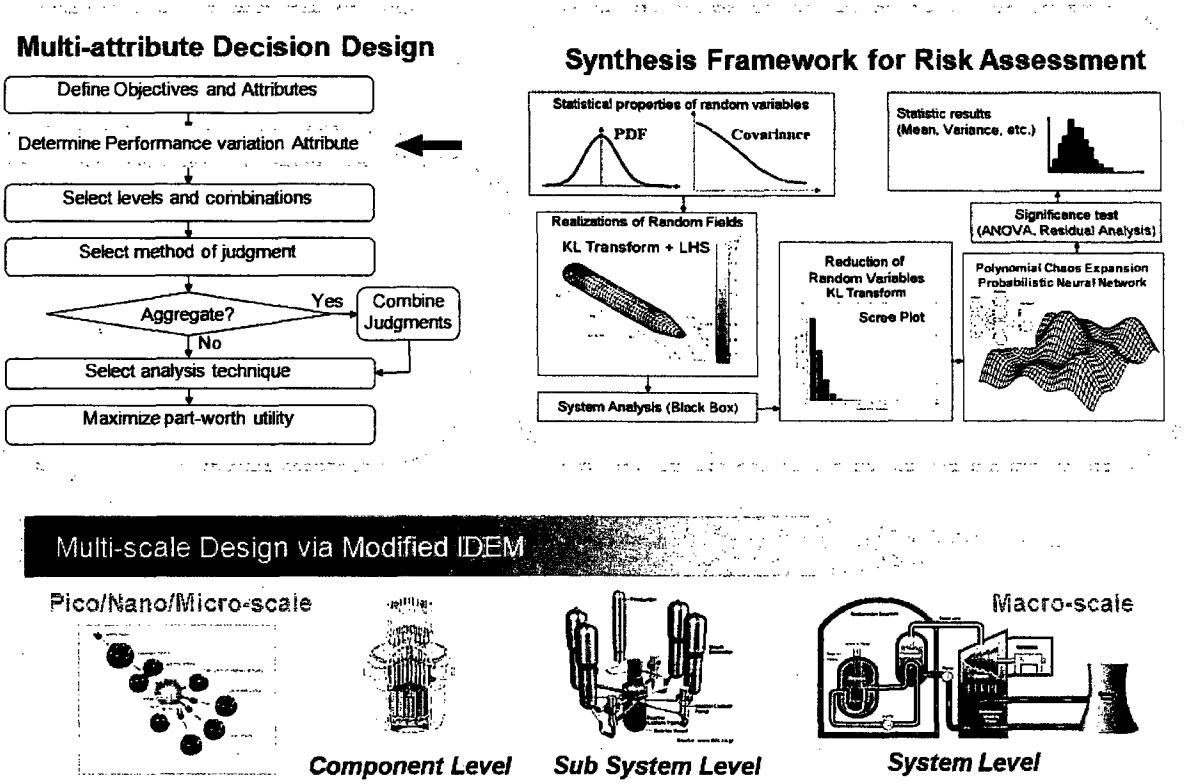


Figure 1. Risk/Reliability-informed Design Framework

The development of risk/reliability-informed design framework (Figure 1) that makes complex systems understandable has tremendous potential to provide robust design and to enhance productivity. As shown in Figure 1, the proposed framework includes the capability of the realistic descriptions of uncertainty which are critical for designing robust systems. If the parameters are randomly distributed and sufficient data is available, the form of uncertainty can be represented by a Probability Density Function (PDF). This type of uncertainty is called aleatory (random, inherent, or objective) uncertainty. A second category of uncertainty, epistemic (subjective) uncertainty, is due to a lack of information or a lack of knowledge. Since subjective uncertainty is viewed as reducible as more information is gathered–based on past experience or expert judgment–it requires more attention and careful judgment [4]. Figure 2 shows the most common uncertainty representations currently available. The probabilistic

approaches, i.e., stochastic FEM, FORM, and SORM, are based on the theoretical foundation of the PDF information and introduce the use of random variables, processes, and fields to represent uncertainty [4]. The non-probabilistic approaches, such as the evidence theory [6], imprecise probability [7]-[9], and fuzzy-intervals [10],[11], manage imprecise knowledge about the true value of parameters. Unfortunately, there is no clear guidance as to how to pick one from the others, and the choice between these methods is the sole responsibility of the analysts. The PI already has a well-established stochastic modeling procedure for both epistemic and aleatory uncertainty including random field representation and fuzzy set [12]-[17]. The two types of uncertainty are modeled in terms of the unified uncertainty analysis framework. Specifically, the concept of imprecise probability [9] is utilized to address the lack of information and ignorance, etc. The copulas [18]-[21] is introduced to formulate multivariate distributions instead of assuming the known joint PDF or joint Cumulative Distribution Function (CDF). Thus, the framework can provide users with a complete set of modeling schemes for both aleatory and epistemic uncertainty and moreover, capabilities of formulating various multivariate phenomena.

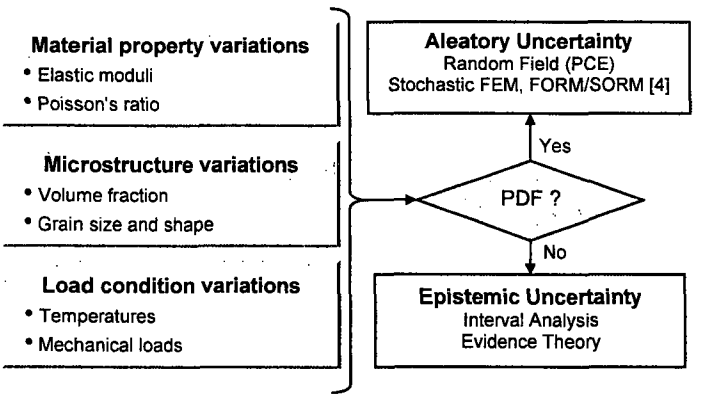


Figure 2. Types of uncertainty

Another significant feature of the framework is that it supports the multiattribute design problems by utilizing the multiattribute utility theory [22]-[24] and conjoint analysis [25]-[28]. In the decision support process, the ranking or rating of design alternatives is inconsistent from user to user, and it is often difficult to get customer responses in a timely fashion. The high number of alternative comparisons required for complex engineering problems can be exhausting for the decision maker. In addition, many design objectives can have interdependencies that can increase complexity and uncertainty throughout the decision making process. The uncertainties in the attainment of subjective data along with increased model uncertainties can reduce the reliability of decision analysis results. The PI recently integrated a decision support process into traditional design problems by enabling the modeling of designer preferences and trade-offs under the consideration of uncertainty [29]. The main advantage of the implemented method is the use of a simulation-based ranking scheme to replace the traditional customer survey for the modeling of DM's preferences via the use of stochastic simulation. The simulation-based ranking scheme is performed through known uncertainty data allowing for objective data to be accurately used to represent subjective data. As shown in Figure 2, the functionalities of the realistic representation of uncertainty and decision support process will be incorporated into the **multiscale design process**. Thus, a systematic and comprehensive framework will be achieved which can facilitate the multiscale systems design processes under the consideration of uncertainty. From the PI's previous work [30], the Inductive Design Exploration Method (IDEM) [31] will be adapted to represent the relationship of information gained from models at various scales to ensure coupling effects can be controlled. It is natural to anticipate that integrating the decision support process along with the realistic representation of uncertainty into the framework of the IDEM will assist in reducing the uncertainty in the design process of complex systems with multiple scales that may or may not be well separated. Ultimately, a framework for guiding a decision maker in the choice of the appropriate mathematical formalism for expressing a given multiscale decision problem will be implemented in this task. This framework will be helpful for balancing risks and benefits in complex engineered systems under large uncertainties. Moreover, it will provide perspective on the use of stochastic analysis in decisions.

The components of the developed framework can be directly used as teaching materials for the suggested new classes mentioned in Section 2.1. The source code of this prototype framework can be open to every engineer and technician through the web. Using open source promises to improve the quality of this key computing engine through peer review by thousands of professionals and students. In addition, each component of the developed framework can be used as the hands-on tutorial software for the teaching of the new courseware. The PI expects that moving from thousands to several millions of engineers and technicians will further change the nature of the design process. Eventually, commercial design tools can officially include compatibility with the proposed framework.

2.3 Community Outreach and Student Advisement

One of the key factors for motivating students to pursue advanced degrees and research careers in science and technology is a positive experience as an undergraduate. Unfortunately, one of the major hurdles encountered by undergraduate students is the lack of opportunities to explore research in fields that may interest them. To resolve this issue, an undergraduate research program will be developed that focuses on the RRA technologies. The program will have two components: an academic year research component and a summer component.

The **academic year program** would provide students at Georgia Tech (and our local partner institutions such as Georgia Southern Univ., Armstrong Atlantic State Univ., and Savannah State Univ.) the opportunity to conduct research in the area of the risk/reliability-informed synthesis method with the PI. The existing undergraduate research course, i.e., ME4699 or ME4698, will be adapted for the current project. The recent undergraduate students advised by the PI, their research areas, and the student outcomes are shown in Table 2. It is shown that the undergraduate students successfully conducted the research works under the PI's guidance, 4 of 7 research programs received the PURA (President's Undergraduate Research Award), and two students have decided to attend graduate school. The future research program, will specifically target underrepresented students to increase the number of minorities pursuing advanced degrees.

Table 2. List of Research Experience for Undergraduate Students advised by PI

Semester / Course No.	Student Name	Undergraduate Institution	Research Area	Outcome
Spring 2007 ME4699	Cheng Shu Ngoo Abhishek Kumar	Georgia Tech	Multidisciplinary Designing of Vehicle Chassis	Poster Presentation at 2007 GT Research Symposium
Summer 2007 ME4699	Steven Capes Tyson Taylor	Georgia Southern University*	Stochastic Modeling and Simulation of Vehicle Chassis	President's Undergraduate Research Award
Spring 2008 ME4698	Abhishek Kumar	Georgia Tech	Topology Optimization of Vehicle Chassis	President's Undergraduate Research Award
Summer 2008 ME4699	Scott Jorjenson	Georgia Southern University*	Structural Integrity Prediction of Automotive Vehicle	Implemented new laboratoryfor ME4053
Fall 2008 ME4699	Wes Bryan Thomas Brooks	Georgia Southern University*	Digital Manufacturing	Published a paper for ASEE journal
Spring 2010 ME4698	Caleb Mock	Georgia Southern University*	Optimal Tolerance Allocation using Fuzzy Sets	President's Undergraduate Research Award
Summer 2010 ME4698	David McNicoll	Georgia Tech	Design of Cellular Structures for Wind Turbine Blade	President's Undergraduate Research Award

* Students from our partner institutes can attend Georgia Tech courses

The academic year program will eventually be expanded to a **summer research program**. Georgia Tech (GT) Savannah has a NSF Funded summer research program, CREATE (Collaborative Research Experiences in Advanced Technology and Engineering), for non-GT sophomores, juniors, and seniors in engineering or engineering related disciplines. During this

program, the students would spend the summer at GT Savannah matched with a faculty member. The PI participated in the CREATE program and supervised three undergraduate students in 2010. This effort will expose state-of-the-art research to non-GT students and will create a multidisciplinary research program focused on RRA methods by collaborating with the faculty members from other departments. While the academic year undergraduate research program would focus primarily on the research project within this proposal, the summer research program will foster collaboration between diverse faculty and students by working in one of the numerous aspects of the risk/reliability-informed methods such as the following: 1) probabilistic design of renewable energy system, 2) structural integrity risk evaluation under environmental damage, and 3) statistical method of digital manufacturing tolerance.

GT Savannah outreach focuses on the cultivation of collaborations with businesses and school; and support of existing community-based initiatives. Table 3 shows demographic statistics for the primary outreach initiatives hosted by the GT Savannah campus. Two programs that highlight GT Savannah's collaborations with businesses and school outreach are the **Savannah Engineering Academy** and the **Savannah Science Seminar** (http://savsciensesem.org). Both exist as community collaborations and engage more than seventeen local companies and six professional organizations including the Army Corps of Engineers, Gulfstream Aerospace, local chapters of the American Institute of Aeronautics and Astronautics, the American Society of Civil Engineers, the Institute for Electrical and Electronics Engineers, the National Association of Women in Construction, the Society of American Military Engineers, and the newly formed Society of Women Engineers.

Table 3. Georgia Tech Savannah Primary Outreach Programs 2009-2010

	Students	% Minority	% Female
Creative Technology Camp	57	32%	21%
Savannah Engineering Academy[10+]	30	37%	13%
FIRST Lego League workshops, competition	73	26%	32%
Engineering Explorer Posts (career exploration program)[2]	13	54%	46%
Robotics Explorer Post (GTS sponsored team)[2]	8	25%	0%
Savannah Science Seminar[10+]	32		50%
Vex Robotics Competition	46		
Scratch & LEGO Robotics workshops	166		
Regional Science & Engineering Fair[10+, Serving 13 Counties]	178		
Total for all programs	603		

[2] Collaborative programs involving at least two business partners or organizations
[10+] Collaborative program involving ten or more business partners or organizations

The PI will also present the results of the proposed project to the **Savannah Science Seminar**. The interactive demos and presentations being developed from the funding of this proposal will provide excellent sources for a wide spectrum of participants. Thus, the PI anticipates increasing student' interest in and understanding of science, technology, engineering and math. Since the program targets to foster appreciation and understanding of science, mathematics, technology and medical practices, the PI's research outcomes from this proposal will enhance participants' professional knowledge on various statistical thinking and approaches.

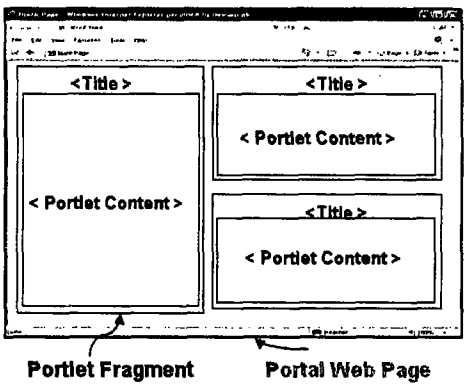
In addition, the results of the study will be disseminated to the engineering community by both conventional methods and through the internet. First, the disseminations will be done through annual reports, seminars, conferences, journal publications, etc. Developed materials will be posted on the current Systems Realization Laboratory website (http://www.srl.gatech.edu). A web page will be developed that contains the latest results from

the study, including reports, papers, and experimental data. Along with the test data, the corresponding analysis program will be made available to include Matlab codes or other programming sources. In this manner, other researchers can access the actual data and analysis programs for their own purposes, rather than just seeing the results presented by the reports. This will be particularly useful in the collaboration with the international investigators.

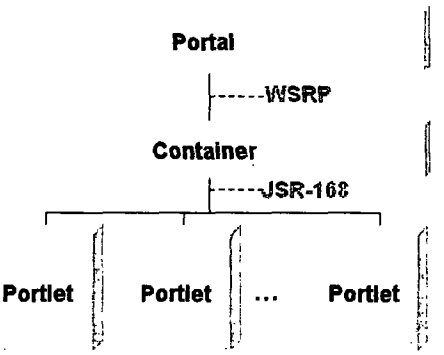
2.4 Build Collaborative Environment for Community

Collaborative product creation among distributed organizations enables various benefits including improved product quality and faster product development while reducing costs and risks. However, it requires careful management in communication, coordination, and conflict between different disciplines across all partners that participate in the product creation process. To reduce this complexity substantially, various computational environments address different aspects of the collaborative design environment [37]-[42]. The efforts in implementing the distributed collaborative environment resolved several important issues. For instance, users (virtual organizations) can exercise a web-based or simple client program to access services hosted on a server in order to conduct their tasks without installing or purchasing expensive standalone systems at their sites. This aspect can significantly reduce the costs and efforts for developing customized communication and coordination mechanisms.

In the long term, the PI is planning to establish a collaboration infrastructure that implements distance collaboration technologies so that PRA-related researchers would have open access to and use of our distributed facilities. The objective of the collaboration framework is to prevent tunnel vision and to share and gather knowledge on worldwide experiences with research and education innovation. The PI's intent is to provide and promote next-generation resources and tools to the Georgia Tech campuses and worldwide students/faculties who are involved in developing and implementing contemporary systemic innovations in education and research. The PI will promote this type of collaboration framework to other organizations and universities, including Georgia Tech's partner institutes.



(a) Portal Page with Three Portlets



(b) Web Portal Layers

Figure 3. Web Portal

A distinctive characteristic of the suggested collaboration framework is that the collaborators will focus on data collection and analysis. Consequently, there is interest to apply collaborative technologies to support data sharing as opposed to tool sharing. Collaboration is driven both by the need to share data and to share knowledge about data. Shared data is only useful if sufficient context is provided about the data such that collaborators may comprehend and effectively apply it. It is therefore imperative to know and understand how data sets relate to aspects of overall data space, applications, experiments, projects, and the scientific community, and then identify the critical features. Communication about experimental data is another important characteristic of a collaboratory. By focusing attention on the dynamics of information exchange, key challenges in creating a collaboratory may be social rather than technical. Similar

observations were made in the computer-supported collaborative learning case study [40]; the basic idea was that a successful computer-supported collaborative learning would need to draw the best lessons learned on both sides in computer-mediated communication and computer-supported cooperative work. The PI will build a larger community with other academic and non-academic institutions in order to ensure the success of research and teaching by sharing prototypes of the newly developed course materials and risk/reliability-informed design framework (Figure 1), which will be freely available through the web.

The PI plans to create a web portal as shown in Figure 3 for engineers, technicians, teachers, and students, which can be used to exchange course materials, software toolkits, etc. However, the proposed site goes beyond the typical website setup of MIT OpenCourseware <http://ocw.mit.edu/OcwWeb>. We will build an automated archival site that explores how global voluntary collaborations can be exploited for education. In this project, a grid infrastructure [38] will be utilized to develop distributed collaborative systems. A grid is a computing architecture that enables people to communicate with each other by sharing computing databases and computing power securely. A grid provides easy access to locally and remotely available information or data and support management of resource-intensive activities such as data sources, storage, applications and processing from different organizations. A grid portal is a standard web-based technology that is used to provide simple, intuitive user interfaces for accessing grid resources [38]. Using grid portals as middleware can reduce complexity in the process of product creation which requires a geographically distributed collaborative effort. Further, it can accelerate the process speed by carrying out intensive computing tasks over multiple servers. Grid portals have been developed as a secure, effective method for accessing computing resources, distributed systems and large models for people without them needing to know about the complexities of the underlying systems. In addition, grid portals provide complex solutions through the use of a web browser without the need to download or install any additional software or resources. This relatively new technology is becoming increasing popular as a platform for distributed collaboration in science, engineering, and other enterprises [42].

Figure 3 illustrates a typical web portal architecture. A portal is a web based application that serves as a unified gateway for information sources. It normally provides single sign-on and aggregation of content from different sources [41]. It contains several web components (portlets) to host the presentation layer of information as shown in Figure 3a. In a collaborative environment, a portal is normally customized to suit the specific engineer according to his/her role. For instance, only information and applications relevant to the engineer are displayed when he/she logs into the portal. Portlets are pluggable web-based components that are managed by a portlet container and displayed in a web portal. A portlet is specifically designed to produce fragments of markup that will be aggregated into other portlets to generate the overall markup for the portal page [41]. Email, discussion forums, and news in web pages are typical examples of portlets. As shown in Figure 3b, the web standards, Java Portlet Specification (JSR-168) and Web Services for Remote Portals (WSRP) support interoperability over different web portals [41],[43]. JSR-168 provides a universal way to integrate portlets into a portlet container. The WSRP sits between the portal and the container and is specified for communications with remote portlets [44].

Specifically, Gridsphere [37]-[39] and Apache Tomcat [45] will be utilized as the portlet and web containers respectively in this project. To construct a web site based on this grid portal technology, a GTA and a part-time student will be hired, and the detailed implementation plan is discussed in Section 3. The PI already has a high performance server (Sun Fire V890) for web applications. This SUN <http://www.sun.com> server will be mainly set aside for grid portal web hosting and for sharing computational data and teaching materials for the proposed project. The proposed collaborative tool will advance engineers' capability to design complex engineering systems by implementing a service oriented collaborative environment which can provide synthesis of risk and reliability assessment and decision support services. In addition, the

developed website should be able to interface easily and communicate with databases across various platform boundaries, such as UNIX and Windows. The website will also provide the capabilities for communicating with digital libraries, which is the storage of large collections of data in an electronic format [46], [47]. As soon as initial versions of our efforts are released to the community, initial feedback will be solicited and used to improve the teaching materials and the novel design framework. Once the web portal is successfully implemented, the synergetic results of the framework (Figure 1) and the portal (Figure 3) are substantial:

- User-friendly application to visualize and analyze data
- Analytical capabilities for both deterministic and stochastic problems
- Ability for rapid data retrieval, fusion, and decision-making
- Application with high-speed Network and Database platforms
- Ability to securely upload and transfer data files to external users

3. Project Management and Milestones

The courses to be developed at Georgia Tech will emphasize risk/reliability-informed design while addressing the signature theme of nuclear energy systems. The following are important activities of the project, and each component will be refined throughout the proposed period:

<Year 1>

- Implement a new undergraduate course, NRE4xxx Probabilistic Risk Assessment.
- Construct a web portal using the grid portal technology.
- Implement web-based learning materials for the proposed courses.
- Collection and analysis of the feedback about the implemented course from the first semester.

<Year 2>

- Implement a graduate level course, NRE/ME 6xxx Risk/Reliability-based Systems Design.
- Online feedback will be continuously gathered from the developed website.
- Share the successes and lessons-learned from the project nationally through conference attendance, journal publication, and the developed website.

Table 4. Course and Activity Schedule

Year / Semester		Course (Target)	Activity
Year 1	Summer Program	CREATE (Undergrad)	• Offer summer program for RRA • Implement course materials for NRE4xxx
	Fall Semester	NRE4xxx (Seniors)	• Offer ME4xxx • Collect initial feedback on ME4xxx
	Spring Semester	NRE4xxx (Seniors) NRE4699 (Undergrad)	• Refine the teaching materials of ME4xxx • Offer undergrad research program (NRE4699)
Year 2	Summer Program	CREATE (Undergrad)	• Continue to offer the summer program • Implement course materials for NRE/ME6xxx
	Fall Semester	NRE/ME6xxx (Grad)	• Offer NRE/ME6xxx • Collect initial feedback on NRE/ME6xxx
	Spring Semester	NRE/ME6xxx (Grad) NRE4xxx (Seniors)	• Refine teaching materials for NRE/ME6xxx • Permanent course number assigned on NRE4xxx

Year 3*	Summer Program	CREATE (Undergrad)	• Continue to offer the summer program • Implement course materials for NRE8xxx
	Fall Semester	NRE/ME6xxx (Grad) NRE8xxx (Grad)	• Permanent course number assigned on NRE6xxx • Offer NRE8xxx
	Spring Semester	NRE4xxx (Seniors) NRE4699 (Undergrad)	• Continue to offer NRE4xxx • Offer undergrad research program (NRE4699)

**Note: The activities of Year 3 will be conducted without the requirement of additional support from NRC.*

The proposed research will be performed by the PI and a graduate teaching assistant. The GTA will play a major role in the development of the IT-infrastructure tool for the proposed project under the PI's supervision. The graduate student will maintain the e-mail bins and message boards. Another part-time student will be hired from the Computer Science department. The student will mainly support the programming activities for constructing a grid portal based web server as described in Section 2.4. Once the grid portal-based site is created, the web portal will be easily maintained by the PI and the GTA. The data collected from this website forum will be used as feedback for training and will provide students with more information about courseware contents that cause difficulty.

Although the proposed project is planned for two year completion, the PI will continue the above activities without requiring additional costs. At Georgia Tech, it is recommended that the new courses be offered at least three times to be given a permanent course number. Therefore, Table 4 summarizes the course and activities scheduled for the next three years. In this way, the proposed courses, including two regular courses (NRE4xxx & NRE/ME6xxx) and one special topics course (NRE8xxx), will have the permanent course numbers at Georgia Tech. The PI also plans to apply for the NRC's student fellowship program in the near future.

4. Assessment and Dissemination Plan

This project will be evaluated through a comprehensive outcome assessment plan. The PI will manage the evaluation process regarding development areas of the project, project strengths, and recommendations for improvement. During the curriculum development phase of the project, the teaching materials will be pilot-tested in classrooms of participating faculty. An estimated 200 students will participate. Using tests and survey instruments, student learning gains and student impressions will be collected. The PI plans to evaluate the project's progress and performance in the following ways:

- **Collection and analysis of the feedback from the proposed project will begin immediately during the first semester, and qualitative feedback will be obtained from student surveys for each course.** The PI and GTA will meet regularly to address problems and discuss things that worked, things that did not work, and directions for needed changes. Faculty and students from our partner institutes will be welcome to participate in these debriefing sessions. Notes from these sessions will form a part of the basis for an ongoing evaluation of the activities.

- **Online feedback will be gathered from the developed website.** The GTA will maintain the e-mail bins and message boards. The data collected from this website forum will also be used as feedback for training and will provide the students with more information about courseware contents that cause difficulty.

- **Questionnaires will be given to the students at least twice during the semester.** These questionnaires will inquire students concerning the usefulness of this experience with respect to their overall education. Thus, these questionnaires will be useful for improving our effort as it goes along. It should be noted that since there is a one-on-one relationship between a student and a teacher, assessment happens continually, and directions can be changed if necessary.

The successes and lessons-learned from the project will be shared nationally through several methods. First, the PI will include developed materials on the newly built website, <www.srl.gatech.edu/pra/>. The site will have extensive information on risk and reliability assessment technologies. Second, the PI will disseminate the project results and products by making presentations at local, regional, or national conferences of professional associations. The nature of the project, the processes used to create the materials, and segments will be provided through science and engineering presentations to the broader community. Examples of targeted associations include ANS, ASME, and the regional and state affiliates of the National Science Teachers Association, and the International Technology Education Association. The PI will also make data available in a timely manner by means of databases, digital libraries, or other venues. These activities will help to integrate research with education activities in order to communicate in a broader context.

5. Conclusion

A series of courses will be created to cover core PRA techniques; which is expected to increase and fuel rapid growth in various industries. The proposed courseware will be designed to be accessible to a broad engineering audience so that students will become familiar with statistical thinking, risk-informed decision making, and reliability/risk assessment technologies. Throughout the propose courses along with community outreach and collaborative environment, students will gain a better understanding of core PRA technologies and their integration at the level of design and implementation of nuclear or other engineering systems. The courseware developed will be adapted for use at multiple educational levels. To ensure the success of this initiative, the implemented course will also be offered to the Georgia Tech Regional Engineering Program so that the students from our partner institutes, i.e., Savannah State University (HBCU), Armstrong Atlantic State University, and Georgia Southern University will have opportunities to be exposed to these newly developed course components.

The proposed research will also develop a comprehensive synthesis framework to systematically design complex engineering problems by accurately estimating the risk and reliability of the system under the consideration of uncertainty. The decision support process and the multiscale modeling scheme will be adapted and utilized to achieve this goal. Specifically, the multiattribute utility theory and conjoint analysis will provide engineers with effective ways for handling various multi-attribute design problems. In addition, the multiscale approach will efficiently account for uncertainties that are apparent in different scales. The integration of the advanced simulation and decision support methods into the grid technology will enable industries to efficiently handle complex problems which cannot be readily solved today. A significant benefit to society is expected by providing this demonstration example that utilizes risk and reliability assessment technologies much more efficiently than currently possible, leading to reduced risks for various industries.

Another outcome of this project is the development of a collaborative environment. The implemented grid portal will allow engineers to support different PRA technology services for practical risk assessment problems to be systematically designed at different scales. This

environment can manage various risk assessment problems by providing more informed decisions to the distributed data across organizations. Therefore, this collaborative design environment among distributed organizations will enable many benefits including faster product development and improved product quality while reducing costs and risks.

References

[1] ABET (Accreditation Board for Engineering and Technology), Criteria for Accrediting Engineering Programs Effective for Evaluations During the 2009-2010 Accreditation Cycle, Baltimore, MD, 2008, http://www.abet.org/.

[2] Szykman, S., Racz, J., and Sriram, R., "The Representation of Function in Computer-Based Design," 1999 ASME Design Theory and Methodology Conference, Las Vegas, NV, DETC99/DTM-8742, 1999.

[3] Haimes, Y. Y., *Risk Modeling, Assessment, and Management*, John Wiley, 1998.

[4] Choi, S., Grandhi, R.V., and Canfield, R.A., *Reliability-Based Structural Design*, Springer, London, 2006.

[5] Dym, C.L., Agogino, A.M., Eris, O., Frey, D.D., and Leifer, L.J., "Engineering Design Thinking, Teaching, and Learning," Journal of Engineering Education, Vol. 94, No. 1, 2005, pp. 103-120.

[6] Oberkampf, W.L. and Helton, J.C., "Chapter 10: Evidence Theory for Engineering Applications," in *Engineering Design and Reliability Handbook*, eds. Nikolaidis, E., Ghiocel, D.M., and Singhal, S., CRC Press, 2005.

[7] Coolen, F.P.A., "An Imprecise Dirichlet Model for Bayesian Analysis of Failure Data including Right-censored Observations," *Reliability Engineering & System Safety*, Vol. 56, No. 1, pp.61-68, 1997.

[8] Coolen, F.P.A., "Low Structure Imprecise Predictive Inference for Bayes' Problem," *Statistics & Probability Letters*, Vol. 36, No. 4, pp. 349-359, 1998.

[9] Coolen, F.P.A., "On the Use of Imprecise Probabilities in Reliability," *Quality and Reliability Engineering International*, Vol. 20, No. 3, pp. 193-202, 2004.

[10] Viertl, R., *Statistical Methods for Non-Precise DATA*. CRC Press, New York, 1996.

[11] Viertl, R. and Filzmoser, P., "Testing hypotheses with fuzzy data: The fuzzy p-value," *Metrika*, Vol. 59, 2004, pp. 21-29.

[12] Choi, S., "Reliability Assessment using Stochastic Local Regression," *International Journal of Reliability and Safety*, Vol. 3, Nos 1/2/3, 2009, pp. 267-285.

[13] Choi, S., Grandhi, R.V., Canfield, R.A. and Pettit, C.L., "Polynomial Chaos Expansion with Latin Hypercube Sampling for Estimating Response Variability," *AIAA Journal*, Vol. 42, 2004, pp. 1191-1198.

[14] Choi, S., and Patel, J., "Optimal Design of Cellular Structures under Random Fields," *Journal of Engineering Design* (in press), 2010.

[15] Choi, S., Grandhi, R.V., and Canfield, R.A., "Structural Reliability under non-Gaussian Stochastic Behavior," *Computers and Structures*, Vol. 82, 2004, pp.1113-1121.

[16] Choi, S., Grandhi, R.V., and Canfield, R.A., "Robust Design of Mechanical Systems via Stochastic Expansion," *International Journal of Materials and Product Technology*, Vol. 25, 2006, pp. 127-143.

[17] Kumar, A., Goksel, L., and Choi, S., "Tolerance Allocation of Assemblies using Fuzzy Comprehensive Evaluation and Decision Support Processes," *Proceedings of 2010 ASME International Design Engineering Technical Conference*, Montreal, Quebec, Canada, August 15-18, 2010.

[18] Nelsen, R.B., *An Introduction to Copulas*, Springer, New York, 1999.

[19] Silva, R.S., and Lopes, H.F., "Copula, Marginal Distributions and Model Selection: a Bayesian Note," *Statistics and Computing*, Vol. 18, No. 3, 2008, pp. 313-320.

[20] Huard, D., Évin, G., and Favre, A.-C., "Bayesian Copula Selection," *Computational Statistics and Data Analysis*, COMSTA3137, Vol. 51, No. 2, 2006, pp. 809-822.

[21] Genest, C., Ghoudi, K., and Rivest, L.P., "A Semiparametric Estimation Procedure of Dependence Parameters in Multivariate Families of Distribution," *Biometrika*, Vol. 82, No. 3, 1995, pp. 543-552.

[22] Keeney, R.L., "A Decision Analysis with Multiple Objectives: The Mexico City Airport", Bell *Journal of Economics and Management Science*, 4(1), 1973, pp. 101-117.
[23] Keeney, R.L. and Raiffa, H., *Decisions with Multiple Objectives: Preferences and Value Tradeoffs*, Cambridge University Press, New York, NY, 1993.
[24] Thevenot, H.J., Steva, E.D., Okudan, G.E. and Simpson, T.W., "A Multiattribute Utility Theory-Based Method for Product Line Selection", *Journal of Mechanical Design*, 29(11), 2007, pp. 1179-1184.
[25] Amarchinta, H. and Grandhi, R.V. (2008), "Multi-Attribute Structural Optimization Based on Conjoint Analysis", *AIAA Journal*, 46(4), 884-893.
[26] Green, P., Carroll, J. and Goldberg, S., "A General Approach to Product Design Optimization via Conjoint Analysis", *Journal of Marketing*, 43(Summer), 1981, pp. 17-35.
[27] Orme, B.K., *Getting Started With Conjoint Analysis: Strategies for Product Design and Pricing Research*, Research Publishers LLC, Wisconsin, 2006.
[28] Reutterer, T. and Kotzab, H.W., "The Use of Conjoint Analysis for Measuring Preferences in Supply Chain Design", *Industrial Marketing Management*, 29(1), 2000, pp. 27-35.
[29] Ruderman, A., Choi, S., and Jiao, J., "A Framework for Multi-attribute Optimum Design with Improved Conjoint Analysis," *Journal of Intelligent Manufacturing* (accepted for publication).
[30] Ruderman, A., Choi, S., Patel, J., Kumar, A., and Allen J.K., "Simulation-based Robust Design of Multi-scale Products," *Journal of Mechanical Design*, Vol. 132, September, 2010, pp. 1-12.
[31] Choi, H., McDowell, D., Allen, J., Rosen, D., and Mistree, F., "An Inductive Design Exploration Method for Robust Multiscale Materials Design," *ASME Journal of Mechanical Design*, Vol. 130, No. 3., 2008, pp. 31-42.
[32] Hazelrigg, G. A., "A Framework for Decision-Based Engineering Design," *Journal of Mechanical Design*, Vol. 120, No. 4, 1998, pp. 653-658.
[33] Wassenaar, H. J., Chen, W., Cheng, J., and Sudjianto, A., "Demand Analysis for Decision-Based Design of Vehicle Engine," *SAE Transactions*, 113(5), 2003, pp. 677-684.
[34] Herrmann, J. W., *Decision-Based Design Processes*, Technical Report No. 2008-1, University of Maryland, College Park, MD.
[35] Lewis, K., Chen, W., and Schmidt, L. C., *Decision Making in Engineering Design*, ASME Press, New York, 2006.
[36] Clemen, R. T., *Making Hard Decision: An Introduction to Decision Analysis*, South-Western College Pub., 1997.
[37] Gridsphere Project, http://www.gridsphere.org
[38] Novotny, J., Russell, M., and Wehrens, O., "GridSphere: A Portal Framework For Building Collaborations," *EUROMICRO*, 2004, pp. 412-419.
[39] LEAD Project, https://portal.leadproject.org/gridsphere/gridsphere
[40] Cogburn, L., *HCI (HumanComputer Interaction) in the so-called Developing World: What's in it for Everyone*, Interactions, ACM Press, NY, 2003.
[41] SIMDAT Project, www.scai.fraunhofer.de/about_simdat.html
[42] Thomas, M., Burruss, J., Cinquini, L., Fox, G., Gannon, D., Gilbert, L., von Laszewski, G., Jackson, L., Middleton, D., Moore, R., Pierce, M., Plale, B., Rajasekar, A., Regno1, R., Roberts, E., Schissel D., Seth, A., and Schroeder, W., "Grid Portal Architectures for Scientific Applications," *Journal of Physics: Conference Series*, Vol. 16, 2005, pp. 596-600.
[43] What is a Portlet?, http://oreilly.com/java/archive/what-is-a-portlet.html
[44] Hesmer S., Fischer P., Buckner T., Schuster I., *Portlet Development Guide*, April, 2002, ftp://ftp.software.ibm.com/software/webserver/portal/V41PortletDevelopmentGuide.pdf
[45] Jakarta Tomcat Project, http://tomcat.apache.org/
[46] Borgman, C., "What Are Digital Libraries? Competing Visions," *Information Processing and Management*, Vol. 35, 1999, pp. 227-243.

[47] Fox, E., Akscyn, R., Furuta, R., and Leggett, J., "Digital Libraries," *Communication of the ACM*, Vol. 38, No. 4, 1995, pp. 23-28.

Attachment C – Standard Terms and Conditions

The Nuclear Regulatory Commission's
Standard Terms and Conditions for U.S. Nongovernmental Grantees

Preface

This award is based on the application submitted to, and as approved by, the Nuclear Regulatory Commission (NRC) under the authorization 42 USC 2051(b) pursuant to section 31b and 141b of the Atomic Energy Act of 1954, as amended, and is subject to the terms and conditions incorporated either directly or by reference in the following:

- Grant program legislation and program regulation cited in this Notice of Grant Award.
- Restrictions on the expenditure of Federal funds in appropriation acts, to the extent those restrictions are pertinent to the award.
- Code of Federal Regulations/Regulatory Requirements - 2 CFR 215 Uniform Administrative Requirements For Grants And Agreements With Institutions Of Higher Education, Hospitals, And Other Non-Profit Organizations (OMB Circulars), as applicable.

To assist with finding additional guidance for selected items of cost as required in 2 CRF 220, 2 CFR 225, and 2 CFR 230 this URL to the Office of Management and Budget Cost Circulars is included for reference to:
A-21 (now 2 CFR 220)
A-87 (now 2 CFR 225)
A-122 (now 2 CFR 230
A-102:

http://www.whitehouse.gov/omb/circulars_index-ffm

Any inconsistency or conflict in terms and conditions specified in the award will be resolved according to the following order of precedence: public laws, regulations, applicable notices published in the Federal Register, Executive Orders (EOs), Office of Management and Budget (OMB) Circulars, the Nuclear Regulatory Commission's (NRC) Mandatory Standard Provisions, special award conditions, and standard award conditions.

Certifications and Representations: These terms incorporate the certifications and representations required by statute, executive order, or regulation that were submitted with the SF424B application through Grants.gov.

I. Mandatory General Requirements
The order of these requirements does not make one requirement more important than any other requirement.

1. Applicability of 2 CFR Part 215

a. All provisions of 2 CFR Part 215 and all Standard Provisions attached to this grant/cooperative agreement are applicable to the Grantee and to sub-recipients which meet the definition of "Grantee" in Part 215, unless a section specifically excludes a sub-recipient from coverage. The Grantee and any sub-recipients must, in addition to the assurances made as part of the application, comply and require each of its sub-awardees employed in the completion of the project to comply with Subpart C of 2 CFR 215 and include this term in lower-tier (subaward) covered transactions.

b. Grantees must comply with monitoring procedures and audit requirements in accordance with OMB Circular A-133. < http://www.whitehouse.gov/omb/circulars/a133_compliance/08/08toc.aspx >

2. Award Package

§ 215.41 Grantee responsibilities
The Grantee is obligated to conduct such project oversight as may be appropriate, to manage the funds with prudence, and to comply with the provisions outlined in 2 CFR 215.41 Within this framework, the Principal Investigator (PI) named on the award face page, Block 11, is responsible for the scientific or technical direction of the project and for preparation of the project performance reports. This award is funded on a cost reimbursement basis not to exceed the amount awarded as indicated on the face page, Block 16., and is subject to a refund of unexpended funds to NRC.

The standards contained in this section do not relieve the Grantee of the contractual responsibilities arising under its contract(s). The Grantee is the responsible authority, without recourse to the NRC, regarding the settlement and satisfaction of all contractual and administrative issues arising out of procurements entered into in support of an award or other agreement. This includes disputes, claims, protests of award, source evaluation or other matters of a contractual nature. Matters concerning violation of statute are to be referred to such Federal, State or local authority as may have proper jurisdiction.

Subgrants
Appendix A to Part 215—Contract Provisions

Sub-recipients, sub-awardees, and contractors have no relationship with NRC under the terms of this grant/cooperative agreement. All required NRC approvals must be directed through the Grantee to NRC. See 2 CFR 215 and 215.41.

Nondiscrimination
(This provision is applicable when work under the grant/cooperative agreement is performed in the U.S. or when employees are recruited in the U.S.)

No U.S. citizen or legal resident shall be excluded from participation in, be denied the benefits of, or be otherwise subjected to discrimination under any program or activity funded by this award on the basis of race, color, national origin, age, religion, handicap, or sex. The Grantee agrees to comply with the non-discrimination requirements below:

Title VI of the Civil Rights Act of 1964 (42 USC §§ 2000d et seq)
Title IX of the Education Amendments of 1972 (20 USC §§ 1681 et seq)
Section 504 of the Rehabilitation Act of 1973,as amended (29 USC § 794)
The Age Discrimination Act of 1975, as amended (42 USC §§ 6101 et seq)

The Americans with Disabilities Act of 1990 (42 USC §§ 12101 et seq)
Parts II and III of EO 11246 as amended by EO 11375 and 12086.
EO 13166, "Improving Access to Services for Persons with Limited English Proficiency."
Any other applicable non-discrimination law(s).

Generally, Title VI of the Civil Rights Act of 1964, 42 USC § 2000e et seq, provides that it shall be an unlawful employment practice for an employer to discharge any individual or otherwise to discriminate against an individual with respect to compensation, terms, conditions, or privileges of employment because of such individual's race, color, religion, sex, or national origin. However, Title VI, 42 USC § 2000e-1(a), expressly exempts from the prohibition against discrimination on the basis of religion, a religious corporation, association, educational institution, or society with respect to the employment of individuals of a particular religion to perform work connected with the carrying on by such corporation, association, educational institution, or society of its activities.

Modifications/Prior Approval
NRC's prior written approval may be required before a Grantee makes certain budget modifications or undertakes particular activities. If NRC approval is required for changes in the grant or cooperative agreement, it must be requested of, and obtained from, the NRC Grants Officer in advance of the change or obligation of funds. All requests for NRC prior approval should be made, in writing (which includes submission by e-mail), to the designated Grants Specialist and Program Office no later than 30 days before the proposed change. The request must be signed by both the PI and the authorized organizational official. Failure to obtain prior approval, when required, from the NRC Grants Officer may result in the disallowance of costs, or other enforcement action within NRC's authority.

Lobbying Restrictions
The Grantee will comply, as applicable, with provisions of the Hatch Act (5 U.S.C. §§1501-1508 and 7324-7328) which limit the political activities of employees whose principal employment activities are funded in whole or in part with Federal funds.

The Grantee shall comply with provisions of 31 USC § 1352. This provision generally prohibits the use of Federal funds for lobbying in the Executive or Legislative Branches of the Federal Government in connection with the award, and requires disclosure of the use of non-Federal funds for lobbying.

The Grantee receiving in excess of $100,000 in Federal funding shall submit a completed Standard Form (SF) LLL, "Disclosure of Lobbying Activities," regarding the use of non-Federal funds for lobbying within 30 days following the end of the calendar quarter in which there occurs any event that requires disclosure or that materially affects the accuracy of the information contained in any disclosure form previously filed. The Grantee must submit the SF-LLL, including those received from sub-recipients, contractors, and subcontractors, to the Grants Officer.

§ 215.13 Debarment And Suspension.
The Grantee agrees to notify the Grants Officer immediately upon learning that it or any of its principals:

(1) Are presently excluded or disqualified from covered transactions by any Federal department or agency;

(2) Have been convicted within the preceding three-year period preceding this proposal been convicted of or had a civil judgment rendered against them for commission of fraud or a criminal offense in connection with obtaining, attempting to obtain, or performing a public (Federal, State, or local) transaction or contract under a public transaction; violation of Federal or State antitrust statutes or commission of embezzlement, theft, forgery, bribery, falsification or destruction of records, making false statements, tax evasion, receiving stolen property, making false claims, or obstruction of justice; commission of any other offense indicating a lack of business integrity or business honesty that seriously and directly affects your present responsibility;

(3) Are presently indicted for or otherwise criminally or civilly charged by a governmental entity (Federal, State, or local) with commission of any of the offenses enumerated in paragraph (1)(b); and

(4) Have had one or more public transactions (Federal, State, or local) terminated for cause or default within the preceding three years.

b. The Grantee agrees that, unless authorized by the Grants Officer, it will not knowingly enter into any subgrant or contracts under this grant/cooperative agreement with a person or entity that is included on the Excluded Parties List System (http://epls.arnet.gov).

The Grantee further agrees to include the following provision in any subgrant or contracts entered into under this award:

'Debarment, Suspension, Ineligibility, and Voluntary Exclusion

The Grantee certifies that neither it nor its principals is presently excluded or disqualified from participation in this transaction by any Federal department or agency. The policies and procedures applicable to debarment, suspension, and ineligibility under NRC-financed transactions are set forth in 2 CFR Part 180.'

Drug-Free Workplace
The Grantee must be in compliance with The Federal Drug Free Workplace Act of 1988. The policies and procedures applicable to violations of these requirements are set forth in 41 USC 702.

Implementation of E.O. 13224 -- Executive Order On Terrorist Financing
The Grantee is reminded that U.S. Executive Orders and U.S. law prohibits transactions with, and the provision of resources and support to, individuals and organizations associated with terrorism. It is the legal responsibility of the Grantee to ensure compliance with these Executive Orders and laws. This provision must be included in all contracts/sub-awards issued under this grant/cooperative agreement.

Award Grantees must comply with Executive Order 13224, Blocking Property and Prohibiting Transactions with Persons who Commit, Threaten to Commit, or Support Terrorism. Information about this Executive Order can be found at: www.fas.org/irp/offdocs/eo/eo-13224.htm.

Procurement Standards. § 215.40-48
Sections 215.41 through 215.48 set forth standards for use by Grantees in establishing procedures for the procurement of supplies and other expendable property, equipment, real property and other services with Federal funds. These standards are furnished to ensure that

such materials and services are obtained in an effective manner and in compliance with the provisions of applicable Federal statutes and executive orders. No additional procurement standards or requirements shall be imposed by the Federal awarding agencies upon Grantees, unless specifically required by Federal statute or executive order or approved by OMB.

Travel
Travel must be in accordance with the Grantee's Travel Regulations or the US Government Travel Policy and Regulations at: www.gsa.gov/federaltravelregulation and the per diem rates set forth at: www.gsa.gov/perdiem, absent Grantee's travel regulation. Travel costs for the grant must be consistent with provisions as established in Appendix A to 2 CFR 220 (J.53). All other travel, domestic or international, must not increase the total estimated award amount.

Domestic Travel:
Domestic travel is an appropriate charge to this award and prior authorization for specific trips are not required, if the trip is identified in the Grantee's approved program description and approved budget. Domestic trips not stated in the approved budget require the written prior approval of the Grants Officer, and must not increase the total estimated award amount.

All common carrier travel reimbursable hereunder shall be via the least expensive class rates consistent with achieving the objective of the travel and in accordance with the Grantee's policies and practices. Travel by first-class travel is not authorized unless prior approval is obtained from the Grants Officer.

International Travel:
International travel requires PRIOR written approval by the Project Officer and the Grants Officer, even if the international travel is stated in the approved program description and the approved budget.

The Grantee shall comply with the provisions of the Fly American Act (49 USC 40118) as implemented through 41 CFR 301-10.131 through 301-10.143.

Property and Equipment Management Standards
Property and equipment standards of this award shall follow provisions as established in 2 CFR 215.30-37.

Procurement Standards
Procurement standards of this award shall follow provisions as established in 2 CFR 215.40-48

Intangible and Intellectual Property
Intangible and intellectual property of this award shall generally follow provisions established in 2 CFR 215.36.

Inventions Report - The Bayh-Dole Act (P.L. 96-517) affords Grantees the right to elect and retain title to inventions they develop with funding under an NRC grant award ("subject inventions"). In accepting an award, the Grantee agrees to comply with applicable NRC policies, the Bayh-Dole Act, and its Government-wide implementing regulations found at Title 37, Code of Federal Regulations (CFR) Part 401. A significant part of the regulations require that the Grantee report all subject inventions to the awarding agency (NRC) as well as include an acknowledgement of federal support in any patents. NRC participates in the trans-government Interagency Edison system (http://www.iedison.gov) and expects NRC funding Grantees to use this system to comply with Bayh-Dole and related intellectual property reporting

requirements. The system allows for Grantees to submit reports electronically via the Internet. In addition, the invention must be reported in continuation applications (competing or non-competing).

Patent Notification Procedures- Pursuant to EO 12889, NRC is required to notify the owner of any valid patent covering technology whenever the NRC or its financial assistance Grantees, without making a patent search, knows (or has demonstrable reasonable grounds to know) that technology covered by a valid United States patent has been or will be used without a license from the owner. To ensure proper notification, if the Grantee uses or has used patented technology under this award without license or permission from the owner, the Grantee must notify the Grants Officer. This notice does not necessarily mean that the Government authorizes and consents to any copyright or patent infringement occurring under the financial assistance.

Data, Databases, and Software - The rights to any work produced or purchased under a NRC federal financial assistance award are determined by 2 CFR 215.36. Such works may include data, databases or software. The Grantee owns any work produced or purchased under a NRC federal financial assistance award subject to NRC's right to obtain, reproduce, publish or otherwise use the work or authorize others to receive, reproduce, publish or otherwise use the data for Government purposes.

Copyright - The Grantee may copyright any work produced under a NRC federal financial assistance award subject to NRC's royalty-free nonexclusive and irrevocable right to reproduce, publish or otherwise use the work or authorize others to do so for Government purposes. Works jointly authored by NRC and Grantee employees may be copyrighted but only the part authored by the Grantee is protected because, under 17 USC § 105, works produced by Government employees are not copyrightable in the United States. On occasion, NRC may ask the Grantee to transfer to NRC its copyright in a particular work when NRC is undertaking the primary dissemination of the work. Ownership of copyright by the Government through assignment is permitted under 17 USC § 105.

Records Retention and Access Requirements for records of the Grantee shall follow established provisions in 2 CFR 215.53.

Organizational Prior Approval System

In order to carry out its responsibilities for monitoring project performance and for adhering to award terms and conditions, each Grantee organization shall have a system to ensure that appropriate authorized officials provide necessary organizational reviews and approvals in advance of any action that would result in either the performance or modification of an NRC supported activity where prior approvals are required, including the obligation or expenditure of funds where the governing cost principles either prescribe conditions or require approvals.

The Grantee shall designate an appropriate official or officials to review and approve the actions requiring NRC prior approval. Preferably, the authorized official(s) should be the same official(s) who sign(s) or countersign(s) those types of requests that require prior approval by NRC. The authorized organization official(s) shall not be the principal investigator or any official having direct responsibility for the actual conduct of the project, or a subordinate of such individual.

Conflict Of Interest Standards for this award shall follow OCOI requirements set forth in Section 170A of the Atomic Energy Act of 1954, as amended, and provisions set forth at 2 CFR 215.42 Codes of Conduct.

Dispute Review Procedures

a. Any request for review of a notice of termination or other adverse decision should be addressed to the Grants Officer. It must be postmarked or transmitted electronically no later than 30 days after the postmarked date of such termination or adverse decision from the Grants Officer.

b. The request for review must contain a full statement of the Grantee's position and the pertinent facts and reasons in support of such position.

c. The Grants Officer will promptly acknowledge receipt of the request for review and shall forward it to the Director, Office of Administration, who shall appoint an intra-agency Appeal Board to review a grantee appeal of an agency action, if required, which will consist of the program office director, the Deputy Director of Office of Administration, and the Office of General Counsel.

d. Pending resolution of the request for review, the NRC may withhold or defer payments under the award during the review proceedings.

e. The review committee will request the Grants Officer who issued the notice of termination or adverse action to provide copies of all relevant background materials and documents. The committee may, at its discretion, invite representatives of the Grantee and the NRC program office to discuss pertinent issues and to submit such additional information as it deems appropriate. The chairman of the review committee will insure that all review activities or proceedings are adequately documented.

f. Based on its review, the committee will prepare its recommendation to the Director, Office of Administration, who will advise the parties concerned of his/her decision.

Termination and Enforcement. Termination of this award by default or by mutual consent shall follow provisions as established in 2 CFR 215.60-62,

Monitoring and Reporting § 215.50-53

a. Grantee Financial Management systems must comply with the established provisions in 2 CFR 215.21

- Payment – 2 CFR 215.22
- Cost Share – 2 CFR 215.23
- Program Income – 2 CFR 215.24
    - Earned program income, if any, shall be added to funds committed to the project by the NRC and Grantee and used to further eligible project or program objectives or deducted from the total project cost allowable cost as directed by the Grants Officer or the terms and conditions of award.
- Budget Revision – 2 CFR 215.25

- The Grantee is required to report deviations from the approved budget and program descriptions in accordance with 2 CFR 215.25,and request prior written approval from the Program Officer and the Grants Officer.
- The Grantee is not authorized to rebudget between direct costs and indirect costs without written approval of the Grants Officer.
- The Grantee is authorized to transfer funds among direct cost categories up to a cumulative 10 percent of the total approved budget. The Grantee is not allowed to transfer funds if the transfer would cause any Federal appropriation to be used for purposes other than those consistent with the original intent of the appropriation.
- Allowable Costs – 2 CFR 215.27

b. **Federal Financial Reports**

The Grantee shall submit a "Federal Financial Report" (SF-425) on a quarterly basis for the periods ending March 31, June 30, September 30, and December 31, or any portion thereof, unless otherwise specified in a special award condition. Reports are due no later than 30 days following the end of each reporting period. A final SF-425 is due within 90 days after expiration of the award. The report should be submitted electronically to: Grants_FFR@NRC.GOV. ***(NOTE: There is an underscore between Grants and FFR).***

Period of Availability of Funds 2 CFR § 215.28

a. Where a funding period is specified, a Grantee may charge to the grant only allowable costs resulting from obligations incurred during the funding period and any pre-award costs authorized by the NRC.

b. Unless otherwise authorized in 2 CFR 215.25(e)(2) or a special award condition, any extension of the award period can only be authorized by the Grants Officer in writing. Verbal or written assurances of funding from other than the Grants Officer shall not constitute authority to obligate funds for programmatic activities beyond the expiration date.

c. The NRC has no obligation to provide any additional prospective or incremental funding. Any modification of the award to increase funding and to extend the period of performance is at the sole discretion of the NRC.

d. Requests for extensions to the period of performance should be sent to the Grants Officer at least 30 days prior to the grant/cooperative agreement expiration date. Any request for extension after the expiration date may not be honored.

Automated Standard Application For Payments (ASAP) Procedures

Unless otherwise provided for in the award document, payments under this award will be made using the Department of Treasury's Automated Standard Application for Payment (ASAP) system < http://www.fms.treas.gov/asap/ >. Under the ASAP system, payments are made through preauthorized electronic funds transfers, in accordance with the requirements of the Debt Collection Improvement Act of 1996. In order to receive payments under ASAP, Grantees are required to enroll with the Department of Treasury, Financial Management Service, and Regional Financial Centers, which allows them to use the on-line method of withdrawing funds from their ASAP established accounts. The following information will be required to make withdrawals under ASAP: (1) ASAP account number – the award number found on the cover sheet of the award; (2) Agency Location Code (ALC) – 31000001; and Region Code. Grantees

enrolled in the ASAP system do not need to submit a "Request for Advance or Reimbursement" (SF-270), for payments relating to their award.

Audit Requirements

Organization-wide or program-specific audits shall be performed in accordance with the Single Audit Act Amendments of 1996, as implemented by OMB Circular A-133, "Audits of States, Local Governments, and Non-Profit Organizations." http://www.whitehouse.gov/omb/circulars/a133/a133.html Grantees are subject to the provisions of OMB Circular A-133 if they expend $500,000 or more in a year in Federal awards.

The Form SF-SAC and the Single Audit Reporting packages for fiscal periods ending on or after January 1, 2008 must be submitted online.

1. Create your online report ID at http://harvester.census.gov/fac/collect/ddeindex.html
2. Complete the Form SF-SAC
3. Upload the Single Audit
4. Certify the Submission
5. Click "Submit."

Organizations expending less than $500,000 a year are not required to have an annual audit for that year but must make their grant-related records available to NRC or other designated officials for review or audit.

III. Programmatic Requirements

Performance (Technical) Reports

a. The Grantee shall submit performance (technical) reports electronically to the NRC Project Officer and Grants Officer on a semi-annual basis unless otherwise authorized by the Grants Officer. Performance reports should be sent to the Program Officer at the email address indicated in Block 12 of the Notice of Award, and to Grants Officer at: Grants_PPR.Resource@NRC.GOV. ***(NOTE: There is an underscore between Grants and PPR).***

b. Unless otherwise specified in the award provisions, performance (technical) reports shall contain brief information as prescribed in the applicable uniform administrative requirements 2 CFR §215.51 which are incorporated in the award.

c. The Office of Human Resources requires the submission of the semi-annual progress report on the SF-PPR, SF-PPR-B, and the SF-PPR-E forms. The submission for the six month period ending March 31st is due by April 30th, or any portion thereof. The submission for the six month period ending September 30th is due by October 31st or any portion thereof.

d. Grant Performance Metrics:

The Office of Management and Budget requires all Federal Agencies providing funding for educational scholarships and fellowships as well as other educational related funding to report on specific metrics. These metrics are part of the Academic Competitiveness Council's (ACC) 2007 report and specifically relates to Science, Technology, Engineering, and Mathematics (STEM) curricula.

As part of the FY 2010 HR grant awards, in addition to the customary performance progress report requested on the SF-PPR, SF-PPR-B, and SF-PPR-E forms, HR requires the following metrics to be reported on by the awardees as follows:

Curriculum Development Awards

1. Overall number of new courses developed in NRC designated STEM areas;
2. Number of students enrolled in new STEM courses;
3. Number of these enrolled students retained in STEM major.

Unsatisfactory Performance

Failure to perform the work in accordance with the terms of the award and maintain at least a satisfactory performance rating or equivalent evaluation may result in designation of the Grantee as high risk and assignment of special award conditions or other further action as specified in the standard term and condition entitled "Termination."

Failure to comply with any or all of the provisions of the award may have a negative impact on future funding by NRC and may be considered grounds for any or all of the following actions: establishment of an accounts receivable, withholding of payments under any NRC award, changing the method of payment from advance to reimbursement only, or the imposition of other special award conditions, suspension of any NRC active awards, and termination of any NRC award.

Other Federal Awards With Similar Programmatic Activities

The Grantee shall immediately provide written notification to the NRC Project Officer and the Grants Officer in the event that, subsequent to receipt of the NRC award, other financial assistance is received to support or fund any portion of the program description incorporated into the NRC award. NRC will not pay for costs that are funded by other sources.

Prohibition Against Assignment By The Grantee

The Grantee shall not transfer, pledge, mortgage, or otherwise assign the award, or any interest therein, or any claim arising thereunder, to any party or parties, banks, trust companies, or other financing or financial institutions without the express written approval of the Grants Officer.

Site Visits

The NRC, through authorized representatives, has the right, at all reasonable times, to make site visits to review project accomplishments and management control systems and to provide such technical assistance as may be required. If any site visit is made by the NRC on the premises of the Grantee or contractor under an award, the Grantee shall provide and shall require his/her contractors to provide all reasonable facilities and assistance for the safety and convenience of the Government representative in the performance of their duties. All site visits and evaluations shall be performed in such a manner as will not unduly delay the work.

IV. Miscellaneous Requirements

Criminal and Prohibited Activities

a. The Program Fraud Civil Remedies Act (31 USC §§ 3801-3812), provides for the imposition of civil penalties against persons who make false, fictitious, or fraudulent claims to the Federal government for money (including money representing grant/cooperative agreements, loans, or other benefits.)

b. False statements (18 USC § 287), provides that whoever makes or presents any false, fictitious, or fraudulent statements, representations, or claims against the United States shall be subject to imprisonment of not more than five years and shall be subject to a fine in the amount provided by 18 USC § 287.

c. False Claims Act (31 USC 3729 et seq), provides that suits under this Act can be brought by the government, or a person on behalf of the government, for false claims under federal assistance programs.

d. Copeland "Anti-Kickback" Act (18 USC § 874), prohibits a person or organization engaged in a federally supported project from enticing an employee working on the project from giving up a part of his compensation under an employment contract.

American-Made Equipment And Products
Grantees are herby notified that they are encouraged, to the greatest extent practicable, to purchase American-made equipment and products with funding provided under this award.

Increasing Seat Belt Use in the United States
Pursuant to EO 13043, Grantees should encourage employees and contractors to enforce on-the-job seat belt policies and programs when operating company-owned, rented or personally-owned vehicle.

Federal Leadership of Reducing Text Messaging While Driving
Pursuant to EO 13513, Grantees should encourage employees, sub-awardees, and contractors to adopt and enforce policies that ban text messaging while driving company-owned, rented vehicles or privately owned vehicles when on official Government business or when performing any work for or on behalf of the Federal Government.

Federal Employee Expenses
Federal agencies are generally barred from accepting funds from a Grantee to pay transportation, travel, or other expenses for any Federal employee unless specifically approved in the terms of the award. Use of award funds (Federal or non-Federal) or the Grantee's provision of in-kind goods or services, for the purposes of transportation, travel, or any other expenses for any Federal employee may raise appropriation augmentation issues. In addition, NRC policy prohibits the acceptance of gifts, including travel payments for Federal employees, from Grantees or applicants regardless of the source.

Minority Serving Institutions (MSIs) Initiative
Pursuant to EOs 13256, 13230, and 13270, NRC is strongly committed to broadening the participation of MSIs in its financial assistance program. NRC's goals include achieving full participation of MSIs in order to advance the development of human potential, strengthen the Nation's capacity to provide high-quality education, and increase opportunities for MSIs to participate in and benefit form Federal financial assistance programs. NRC encourages all applicants and Grantees to include meaningful participations of MSIs. Institutions eligible to be considered MSIs are listed on the Department of Education website:
http://www.ed.gov/about/offices/list/ocr/edlite-minorityinst.html

Research Misconduct
Scientific or research misconduct refers to the fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results. It does not

include honest errors or differences of opinions. The Grantee organization has the primary responsibility to investigate allegations and provide reports to the Federal Government. Funds expended on an activity that is determined to be invalid or unreliable because of scientific misconduct may result in a disallowance of costs for which the institution may be liable for repayment to the awarding agency. The Office of Science and Technology Policy at the White House published in the Federal Register on December 6, 2000, a final policy that addressed research misconduct. The policy was developed by the National Science and Technology Council (65 FR 76260). The NRC requires that any allegation be submitted to the Grants Officer, who will also notify the OIG of such allegation. Generally, the Grantee organization shall investigate the allegation and submit its findings to the Grants Officer. The NRC may accept the Grantee's findings or proceed with its own investigation. The Grants Officer shall inform the Grantee of the NRC's final determination.

Publications, Videos, and Acknowledgment of Sponsorship

Publication of the results or findings of a research project in appropriate professional journals and production of video or other media is encouraged as an important method of recording and reporting scientific information. It is also a constructive means to expand access to federally funded research. The Grantee is required to submit a copy to the NRC and when releasing information related to a funded project include a statement that the project or effort undertaken was or is sponsored by the NRC. The Grantee is also responsible for assuring that every publication of material (including Internet sites and videos) based on or developed under an award, except scientific articles or papers appearing in scientific, technical or professional journals, contains the following disclaimer:

> "This [report/video] was prepared by [Grantee name] under award [number] from [name of operating unit], Nuclear Regulatory Commission. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the view of the [name of operating unit] or the US Nuclear Regulatory Commission."

Trafficking In Victims Protection Act Of 2000 (as amended by the Trafficking Victims Protection Reauthorization Act of 2003)

Section 106(g) of the Trafficking In Victims Protection Act Of 2000 (as amended as amended, directs on a government-wide basis that:

"any grant, contract, or cooperative agreement provided or entered into by a Federal department or agency under which funds are to be provided to a private entity, in whole or in part, shall include a condition that authorizes the department or agency to terminate the grant, contract, or cooperative agreement, without penalty, if the grantee or any subgrantee, or the contractor or any subcontractor (i) engages in severe forms of trafficking in persons or has procured a commercial sex act during the period of time that the grant, contract, or cooperative agreement is in effect, or (ii) uses forced labor in the performance of the grant, contract, or cooperative agreement." (22 U.S.C. § 7104(g)).

Executive Compensation

2 CFR 170.220 directs agencies to include the following text to each grant award to a non-federal entity if the total funding is $25,000 or more in Federal funding.

Reporting Subawards and Executive Compensation.

a. *Reporting of first-tier subawards.*

1. *Applicability.* Unless you are exempt as provided in paragraph d. of this award term, you must report each action that obligates $25,000 or more in Federal funds that does not include Recovery funds (as defined in section 1512(a)(2) of the American Recovery and Reinvestment Act of 2009, Pub. L. 111–5) for a subaward to an entity (see definitions in paragraph e. of this award term).

2. *Where and when to report.*

i. You must report each obligating action described in paragraph a.1. of this award term to *http://www.fsrs.gov.*

ii. For subaward information, report no later than the end of the month following the month in which the obligation was made. (For example, if the obligation was made on November 7, 2010, the obligation must be reported by no later than December 31, 2010.)

3. *What to report.* You must report the information about each obligating action that the submission instructions posted at *http://www.fsrs.gov specify.*

b. *Reporting Total Compensation of Recipient Executives.*

1. *Applicability and what to report.* You must report total compensation for each of your five most highly compensated executives for the preceding completed fiscal year, if—

i. the total Federal funding authorized to date under this award is $25,000 or more;

ii. in the preceding fiscal year, you received—

(A) 80 percent or more of your annual gross revenues from Federal procurement contracts (and subcontracts) and Federal financial assistance subject to the Transparency Act, as defined at 2 CFR 170.320 (and subawards); and

(B) $25,000,000 or more in annual gross revenues from Federal procurement contracts (and subcontracts) and Federal financial assistance subject to the Transparency Act, as defined at 2 CFR 170.320 (and subawards); and

iii. The public does not have access to information about the compensation of the executives through periodic reports filed under section 13(a) or 15(d) of the Securities Exchange Act of 1934 (15 U.S.C. 78m(a), 78o(d)) or section 6104 of the Internal Revenue Code of 1986. (To determine if the public has access to the compensation information, see the U.S. Security and Exchange Commission total compensation filings at *http://www.sec.gov/answers/execomp.htm.*)

2. *Where and when to report.* You must report executive total compensation described in paragraph b.1. of this award term:

i. As part of your registration profile at *http://www.ccr.gov.*

ii. By the end of the month following the month in which this award is made, and annually thereafter.

c. *Reporting of Total Compensation of Subrecipient Executives.*

1. *Applicability and what to report.* Unless you are exempt as provided in paragraph d. of this award term, for each first-tier subrecipient under this award, you shall report the names and total compensation of each of the subrecipient's five most highly compensated executives for the subrecipient's preceding completed fiscal year, if—

i. in the subrecipient's preceding fiscal year, the subrecipient received—

(A) 80 percent or more of its annual gross revenues from Federal procurement contracts (and subcontracts) and Federal financial assistance subject to the Transparency Act, as defined at 2 CFR 170.320 (and subawards); and

(B) $25,000,000 or more in annual gross revenues from Federal procurement contracts (and subcontracts), and Federal financial assistance subject to the Transparency Act (and subawards); and

ii. The public does not have access to information about the compensation of the executives through periodic reports filed under section 13(a) or 15(d) of the Securities Exchange Act of 1934 (15 U.S.C. 78m(a), 78o(d)) or section 6104 of the Internal Revenue Code of 1986. (To determine if the public has access to the compensation information, see the U.S. Security and Exchange Commission total compensation filings at *http://www.sec.gov/answers/execomp.htm.*)

2. *Where and when to report.* You must report subrecipient executive total compensation described in paragraph c.1. of this award term:

i. To the recipient.

ii. By the end of the month following the month during which you make the subaward. For example, if a subaward is obligated on any date during the month of October of a given year (*i.e.,* between October 1 and 31), you must report any required compensation information of the subrecipient by November 30 of that year.

d. *Exemptions*

If, in the previous tax year, you had gross income, from all sources, under $300,000, you are exempt from the requirements to report:

i. Subawards,

and

ii. The total compensation of the five most highly compensated executives of any subrecipient.

e. *Definitions.* For purposes of this award term:

1. *Entity* means all of the following, as defined in 2 CFR part 25:

i. A Governmental organization, which is a State, local government, or Indian tribe;

ii. A foreign public entity;

iii. A domestic or foreign nonprofit organization;

iv. A domestic or foreign for-profit organization;

v. A Federal agency, but only as a subrecipient under an award or subaward to a non-Federal entity.

2. *Executive* means officers, managing partners, or any other employees in management positions.

3. *Subaward:*

i. This term means a legal instrument to provide support for the performance of any portion of the substantive project or program for which you received this award and that you as the recipient award to an eligible subrecipient.

ii. The term does not include your procurement of property and services needed to carry out the project or program (for further explanation, see Sec. __ .210 of the attachment to OMB Circular A–133, "Audits of States, Local Governments, and Non-Profit Organizations").

iii. A subaward may be provided through any legal agreement, including an agreement that you or a subrecipient considers a contract.

4. *Subrecipient* means an entity that:

i. Receives a subaward from you (the recipient) under this award; and

ii. Is accountable to you for the use of the Federal funds provided by the subaward.

5. *Total compensation* means the cash and noncash dollar value earned by the executive during the recipient's or subrecipient's preceding fiscal year and includes the following (for more information see 17 CFR 229.402(c)(2)):

i. *Salary and bonus.*

ii. *Awards of stock, stock options, and stock appreciation rights.* Use the dollar amount recognized for financial statement reporting purposes with respect to the fiscal year in accordance with the Statement of Financial Accounting Standards No. 123 (Revised 2004) (FAS 123R), Shared Based Payments.

iii. *Earnings for services under non-equity incentive plans.* This does not include group life, health, hospitalization or medical reimbursement plans that do not discriminate in favor of executives, and are available generally to all salaried employees.

iv. *Change in pension value.* This is the change in present value of defined benefit and actuarial pension plans.

v. *Above-market earnings on deferred compensation which is not tax-qualified.*

vi. Other compensation, if the aggregate value of all such other compensation (e.g. severance, termination payments, value of life insurance paid on behalf of the employee, perquisites or property) for the executive exceeds $10,000.