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

1. GRANT/AGREEMENT NO.	2. MODIFICATION NO.	3. PERIOD OF PERFORMANCE	4. AUTHORITY
NRC-27-10-1126		FROM: 09/30/10 TO: 09/29/15	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	DUNS: 044507085 State Controlled Higher Education	JACKSON STATE UNIVERSITY JSU 1400 J R LYNCH ST STE 206 JACKSON MS 392170001

8. PROJECT TITLE:
Risk Assessment and Risk Management of Nuclear Technology through Large Scale Simulation and Modeling

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 05/05/2010 AND APPENDIX A-PROJECT GRANT PROVISIONS	[X] PROGRESS AND FINAL [ ] FINAL ONLY [ ] OTHER (Conference Proceedings)	Dr. Shahrouz Aliabadi Jackson State University 1400 Lynch Street Jackson Mississippi 39217

12. NRC PROGRAM OFFICE (NAME and ADDRESS)	13. ACCOUNTING and APPROPRIATION DATA	14. METHOD OF PAYMENT
U.S. Nuclear Regulatory Commission Ms. Tuwanda Smith Mail Stop 03H8 (301) 415-7394 Office of Small Business & Civil Rights 6003 Executive Boulevard Rockville, MD 20852	APPN. NO: 31X0200 B&R NO: 07P-15-5C1-161 JOB CODE: L2284 BOC NO: 4110 OFFICE ID NO: SDB-27-10-1126	[ ] 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	$90,000.00	NRC	$450,000.00
PREVIOUS OBLIGATION		RECIPIENT	$0.00
TOTAL	$90,000.00	TOTAL	$450,000.00

This action provides funds for Fiscal Year 2010 in the amount of $90,000.00

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

U.S. Nuclear Regulatory Commission
Div. of Contracts
Attn: Mr. Michael Mills (301) 492-3621
Mail Stop: TWB-01-B10M
Washington, DC 20555
Michael.Mills@nrc.gov

18.
Acceptance of or objections to the Terms and Conditions of Award must be Emailed to the NRC Issuing Office (Block #17) within three (3) business days following the Award issue date. NRC considers lack of response as acceptance by the grantee of the terms and conditions of award.

19. NRC CONTRACTING OFFICER

Sheila Bumpass 9/27/2010
(Signature) (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.

SUNSI REVIEW COMPLETE

TEMPLATE - ADM001

ADM004

ATTACHMENT A - SCHEDULE

A.1 PURPOSE OF GRANT

The purpose of this Grant is to provide support to the "Jackson State University for research on radioactive aerosols.

A.2 PERIOD OF GRANT

1. The effective date of this Grant is September 30, 2010. The estimated completion date of this Grant is September 29, 2015.

2. Funds obligated hereunder are available for program expenditures for the estimated period: September 30, 2010 – September 29, 2011. Continued funding is subject to the availability of additional funding.

A. GENERAL

1. Total Estimated NRC Amount:	$450,000.00
2. Total Obligated Amount:	$ 90,000.00
3. Cost-Sharing Amount:	$ 0.00
4. Activity Title:	"Risk Assessment and Risk Management of Nuclear Technology through Large Scale Simulation and Modeling"
5. NRC Project Officer:	Tuwanda Smith
6. DUNS No.:	044507085

B. SPECIFIC

RFPA No.:	SDB-27-10-1126
FFS:	SBC10327
Job Code:	L2284
BOC:	4110
B&R Number:	07P-15-5C1-161
Appropriation #:	31X0200
Amount Obligated:	$ 90,000.00

A.3 BUDGET

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

	Year 1	Year 2	Year 3
Total Salaries & Wages Including Fringe Benefits	$42,056.00	$43,318.00	$44,617.00
Equipment	$10,000.00	$ 0.00	$ 0.00
Travel	$ 5,000.00	$ 5,000.00	$ 5,000.00
Participation/Trainee	$15,000.00	$15,000.00	$15,000.00

Support			
Other Direct Cost	$ 3,488.00	$10,001.00	$ 8,703.00
Indirect Direct Cost (28.6%)	$14,456.00	$16,679.00	$16,680.00
Total Direct Cost	$90,000.00	$90,000.00	$90,000.00

	Year 4	Year 5
Total Salaries & Wages Including Fringe Benefits	$45,956.00	$47,333.00
Equipment	$ 0.00	$ 0.00
Travel	$ 5,000.00	$ 5,000.00
Participation/Trainee Support	$15,000.00	$15,000.00
Other Direct Cost	$ 7,364.00	$ 9,000.00
Indirect Direct Cost (28.6%)	$16,680.00	$16,680.00
Total Direct Cost	$90,000.00	$90,000.00

A.4 AMOUNT OF AWARD AND PAYMENT PROCEDURES

1. The total estimated amount of this Award is $450,000.00 for a five (5) year period.

2. NRC hereby obligates the amount of $90,000.00 for program expenditures during the period set forth above and in support of the Budget above. The Grantee will be given written notice by the Contracting Officer when additional funds will be added. 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

Our main goal in this project is to provide further enlightenment to communities, public, and scientific societies for the risk assessment and risk management of radioactive exposure through inhalation using state of the art multi-scale multi-physics computer simulation, *in silico*, methodologies. Linked to the main goal, our secondary goal will be to demonstrate a comprehensive *in silico* technology that can be used in many specific radioactive exposure problems such as medical applications, industrial processing, and fallouts from accidents, malicious incidents, and after military operations, trainings, or tests to mention a few. Our study will cover both public and occupational exposures and aim to fill a gap in understanding these kinds of exposures not possible, difficult, or expensive through experiments or measurements. To achieve these goals, our objectives;

- In regard to public exposure, for macro level studies, we will integrate a publicly available regional and global atmospheric model (Weather Research and Forecasting, WRF) into our general-purpose high fidelity Computational Fluid Dynamics (CFD) model (CaMEL^{CHH3}) including transport of radioactive particulate matters to estimate cumulative long term street level radioactive exposure in urban environment.
- In regard to occupational exposure in microenvironments, we will model complete work environments such as building rooms and instruments or machines with human subjects exposed respiratory tracks, and lungs including alveolus to track fate of radioactive particulate deposition.

- To understand adverse effects of the both kinds of exposures on human health, we will integrate simulated exposures for longer time period such that a cumulative exposure over years can be estimated and may be linked to certain health outcomes.

Introduction

Sources, exposures, and modeling

Radiation is part of our daily life ever since human existed on the Earth due to the fact that Earth's geo-structure naturally has radioactive elements and not all cosmic rays are trapped or reflected before they reach to Earth's surface. Exposure due to these natural radiations changes from soil and rock structure, elevation, and as well as latitude and longitude. We also have man-made radioactive sources as by products of our technological advancement in the fields of energy, manufacturing, health sector, and defense.

Most recent study of the National Council on Radiation Protection (NCRP) [1] found that in 2006 nearly half (48%) of the radiation to which the US population is exposed comes from medical sources such as CT scans, x-rays, and nuclear medicine. Amount of the individual exposure also increased to 620 mRem, nearly doubled in last three decades. The more medical radiation devices in use the higher accidental exposure of various kinds such as equipment malfunctions or human errors for both patients and technicians. A study of the International Commission on Radialogical Protection (ICRP) [2] addresses risk management issues in radiation therapy due to the fact that current approaches are "reactive" or "retrospective" hence confined to reported experience only rather than addressing the question of "what else could go wrong?" or "what are other potential hazards?"

While median public exposure of the nation increases significantly due to medical use of radioactive equipments over last couple of decades, regional- and local-scale radioactive incidents also need similar attention to understand and limit the associated risks. Such incidents may be related with natural disasters such as flooding, tornados, and ash spills due to heavy rains [3,4]. Though it is monitored, some national labs, such as Los Alamos National Laboratory, constantly vent out small amount of radioactive participles from plumes as part of their R&D operations [5]. Besides these, another major public concern is long term risks associated with radioactive contaminations and fallouts from weapon tests and military operations such as heavy use of Depleted Uranium (DU) rounds in military trainings within the country as well as in the recent warfare such as in Kosovo and Iraq [6].

Another form of exposure, which is more significant for individuals, is occupational. This kind of exposure is often coded as zero when the exposure dose is below the minimum detection level. This leads to an underestimation of the doses received by individuals over the years and can lead to underestimates of the risks in occupational epidemiologic studies. Beside the medical exposure, some examples include uranium mine extraction [7,8], industrial metal cutting activities such as the Department of Energy's (DOE) deactivation and decommissioning (D&D) activities involving cutting of radioactive materials, which pose problems associated with inhalation of radioactive aerosols [9-11].

Numerical modeling of radioactive particles both indoor and atmospheric dispersion has been studied extensively by many researchers. Various dispersion models have been employed including but not limited to Lagrangian, stochastic, discrete phase models with fine scale wind fields, and puff models [12-14]. CFD methodologies were used for real cases and scenarios to estimate risks and improve assessment procedures.

Health Aspects of Radioactive Particle Exposure

Though progress has been made in curtailing the radioactive pollution arising from various sources by operating with more safety standards, the permissible levels of radioactive

pollution are still debatable in terms of their long-term effect on public health. The intensity of the harmful effects of respirable radioactive particles varies based on the physical, chemical, and radioactive properties of inhaled particles. Reported Activity Median Aerodynamic Diameter for artificially produced radioactive aerosols have values about 1.5 μm [15], and 1 μm as recommended by ICRP in Publication 66.

The relationship between the size and shape of radioactive particles and their deposition, retention, and translocation in the upper and lower respiratory tracts and other micro- and nano-passages in the human body is very complex. Insoluble aerosols can settle in the respiratory mucosa, whereas gases and other soluble pollutants can spread throughout the body and can become fixed to organs for which there is preferential affinity. For large particles (> 0.5 micron) in lungs, impaction drives the deposition process. Whereas, for nano-sized particles, deposition is driven mainly by the Brownian motion. Solubility of the particles in bodily fluids is one of the crucial chemical properties, which can influence the particle deposition in the bronchial tubes.

The radioactivity of the particles and how long they stay inside the respiratory system can explain the amount of damage that can be done to the lung. A particle which contains radioactive elements with shorter half-life can rapidly damage the lung before being cleared. In contrast, if the half-life of the radioactive particle is relatively long, it can be cleared from the respiratory system before causing considerable amount of damage. However, cumulative effect of these radiations can be significant if the lungs are subjected to the intake of these particles on regular basis for long time.

Recent studies [16,17] discussed the health effects of internal contamination with depleted uranium detected in British, Canadian, and United States Gulf War veterans as late as nine years after inhalation exposure to radioactive dust in the Persian Gulf War I. It was observed that inhalation pathway of internal contamination with DU was the most important route of entry to the extra cellular fluid via the bronchoalveolar tree. More than half of the uranium mobilized from lungs into systemic circulation was observed to be eventually deposited in bones and kidney [18].

Team Qualification

The researchers at the Northrop Grumman Center for High Performance Computing (NGC) at JSU have developed many computational technologies for use on high performance computational platforms. They have successfully developed a series of CaMEL family numerical flow solvers. The CaMEL flow solvers are highly optimized for solvers to large scale computations. These flow solvers have been implemented in parallel using the ParMETIS mesh partitioning and the Message Passing Interface (MPI) libraries. Very efficient non-blocking MPI functions are called to set up the inter-processor "gather" and "scatter" routines in the pre-processing stage. Thanks to the efficient communication subroutines, the scalability performance of CaMEL flow solvers is excellent on many computer platforms including Linux clusters. The $CaMEL^{CHH3}$ is an incompressible flow solvers based on cell-centered finite volume and node-based finite element method. The flow solver is extremely accurate and has been verified and validated in many documentations [19-23]. The $CaMEL^{CHH3}$ capabilities will be enhanced to carry out large-scale simulations required in this proposed research project.

Proposed Research Activities

Radioactive Exposure Modeling in Microenvironments

Fate of radioactive particles in pulmonary system

The motivation for this section of the proposed project is the significance of the health hazard posed by the inhalation of radioactive aerosols, especially when the exposure is long term and in small persistent doses. Simulation based, *in silico*, approaches are hampered by the fact that experimental, *in vivo or in vitro,* studies for flows in the small bronchial tubes are difficult and expensive due to their small scale and their inaccessibility deep in the chest.

Respiration in the pulmonary system produces surprisingly complex flow fields in the network of lung airways. The geometry of bronchial tubes of lung is highly non-planar and asymmetric with varying tubular size, total of 2^{17} (131,072) distinct tubes [24]. Characteristics of the flows in these tubes include secondary currents, in the form of vortices, which play a critical but poorly understood role in the filtration of entrained particles from inhaled air, consigning some to deposition on mucus-lined walls, others to a return trip through exhalation, and some to lodgings deep in the alveolar sacs of the terminal airways.

In the upper respiratory system, the airflow is mostly turbulent, Reynolds number as high as 8000 [25]. The bronchial tube walls here are ciliated with thick mucus layer [26] flowing upward. Particles that are deposited here get cleared by the ciliary action and either be removed from the mouth or swallowed in to the gastroinstatinal tract. However, in small bronchial tubes, the flow fields are laminar, Reynolds number up to 1000) [27]. Since there is no established thick mucus layer [26], particles trapped in the small bronchial tubes are likely to have high retention time. If the particles are soluble in bodily fluids they enter the systemic blood circulation rather quickly and can affect other organs such as liver and skeletons. Insoluble particles are finally cleared by phagocytosis [28]. Phagocytized particles (a type of cell within the body capable of engulfing and absorbing bacteria and other small cells and particles) may enter alveoli or enter the lymph nodes. Figure 1 shows our simulation results for pressure distribution and secondary flow velocities in a generic nine-generation (four-twelve) small bronchial tube model. The laminar flow was generated employing Reynolds number of 319 in the small bronchial tubes. The challenges and issues related to pulmonary systems are listed as following:

- Geometric modeling complexity during inhale-exhale cycle.
- Particle transport increases complexity for the secondary flows.
- Post particle deposition mechanisms are crucial for the particle retention time.

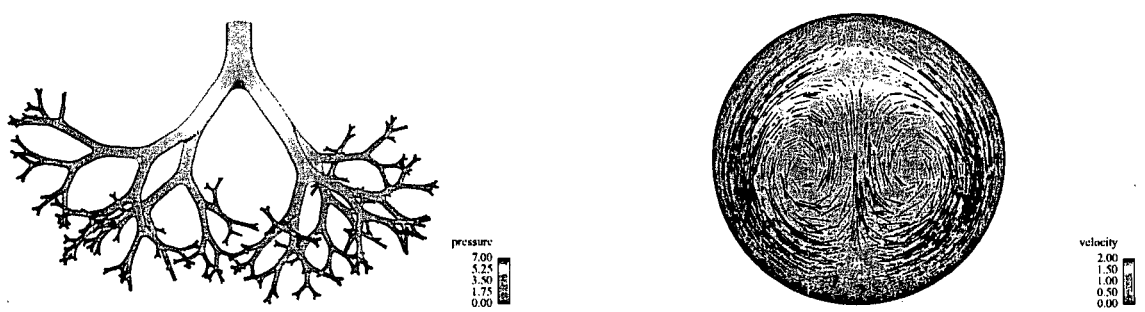

Figure 1: Pressure distribution and secondary flow in bronchial tube model by CaMEL^{CHH3}.

We have the following capabilities and expertise to address issues/challanges related with this research.

- We modeled a generic, not patient specific, bronchial tubes of the lungs geometry.
- We have a computational capacity to handle mesh size over one billion elements.
- We have experience on particle destination maps visualization techniques [29,30].
- We have mesh moving capability to model fluid-structure interaction during inhale-exhale.

We propose the following in order to meet the challenges related to modeling the effects of radioactive particles on the bronchial tubes:

- The complete simulation will require modeling of mucus flow in the upper respiratory system and expansion and contraction of the tubes in the lower respiratory system.
- The modes of particle transport are mainly impaction and diffusion. A combination of various approaches such as Lagrangian and Brownian motion will be simulated.
- The mechanism of phagocytosis and solubility will also be considered to simulate the ultimate fate of the radioactive particles in the respiratory system.
- Indoor environments of professionals, patients, or workers, such as in metal-cutting facilities, hospitals, or radioactive material handling facilities, will be modeled to account for the accurate dispersion and intake of radioactive particles before they are inhaled into respiratory system.

Particles in Microscale Respiratory Systems

Deposition and translocation mechanisms in the lower respiratory tract, especially in the acinar region is much more critical and challenging. The acinus region of the lung contains the respiratory bronchioles, alveolar ducts, and the alveolar sacs [31-34]. The airflow and particle deposition mechanisms in the acinar region are different from those in the upper respiratory tract. Sedimentation, Brownian diffusion, and electrostatic precipitation are the dominant process in this zone [35]. At the alveoli level micro- and nano-fluidics comes into play and fundamental research in this area is lacking. Molecular transport mechanisms occurring across membranes through diffusion-controlled process are also very important. Understanding these process could enable us to more efficiently determine the damage caused to alveoli membrane and the amount of soluble radioactive pollutants diffusing into blood stream. We have following challenges and issues to address here:

- Accurate geometric modeling for the alveolar region is still challenging.
- Substantial volumetric changes during inhale/exhale cycle hence needs moving boundary .
- Most studies are based on steady or sinusoidal flow rates, not realistic flow rates.
- The acinar region involves multiphase particle transport.
- Disease in the acinar region such as Emphysema deforms the tissue structure.
- Diffusion process through alveoli is at micro- and nano-scale.

Modeling of flows at the alveoli level is an extremely challenging task mainly because of the micro dimensions involved and also due to lack of proper experimental data for validating the numerical results. For gaseous and liquid flows, the Navier stokes equations are still applicable as long as the flow regimes are not very far from continuum [36]. Fluid flow for almost all the generations (17-23) of the acinar region can very well be defined within the continuum hypothesis by the Navier-stokes equations. However blood flow through the alveolar sheets and capillaries may need to be described by slip flow boundary conditions [37].

Here at JSU, our existing codes, CaMEL^{CHH3}, can successfully simulate microscale gaseous and liquid flows within continuum and also in the slip flow regime where deviations from continuum are not very big. Extensive validations of the computational code have been

performed for microscale flows by comparing the numerical results with available analytical solutions, experimental data, and other published results in the literature as shown in Figure 2.

Measurement and simulation of flow phenomena, gas transport, and its influence on the particle deposition in the acinar zone is very challenging due to micro dimensions. Even though much work has been done in understanding the fluid dynamics of human respiratory system, fundamental research at the alveoli level is very scarce. Keeping in mind the various challenges together with the imperativeness of undertaking a detailed and fundamental study of fluid flow and particle deposition in the alveolar zone, we propose the following studies:

- Airflow and radioactive particle deposition in the alveolar passages: we aim to study the airflow and mixing in the alveolar passages in detail. We plan to extend our existing computational capabilities for simulating rigid alveolar ducts with circular cross section, surrounded with semi-spherical air sacs. Then, the goal would be to embark on much more complicated and challenging simulations such as more realistic alveoli geometry, moving alveoli boundary with fluid-structure interaction, and more realistic flow rates.
- Diffusion process of radioactive particles through alveolus: Our goal is to model this structure consisting of various individual constituents as a porous structure, membranes etc. Alternatively, macroscopic models would also be explored to simulate the three-dimensional, unsteady respiration process within the alveolar regions of the lungs.

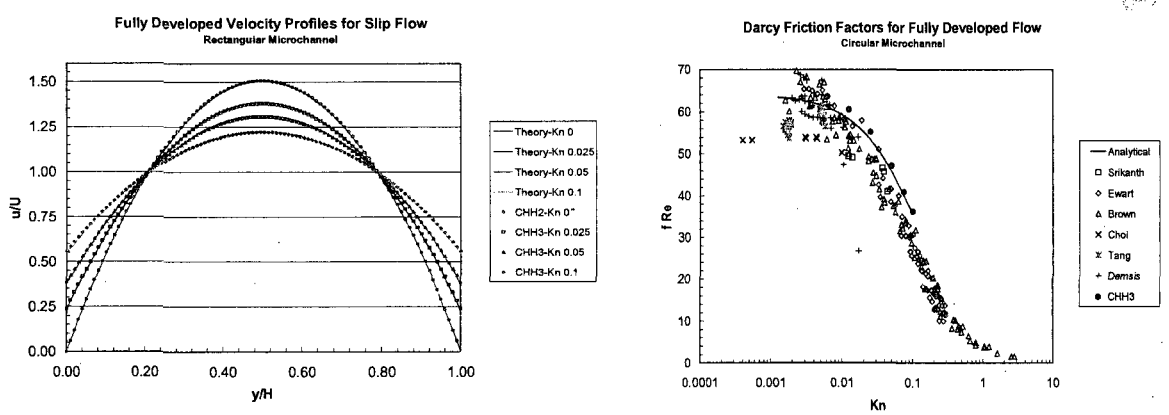

Figure 2: Validation studies of JSU fluid flow code, CaMEL^{CHH3}, for microscale flows. Knudsen number (Kn) is a measure of continuum defined as ratio of molecular mean free path and length scale

Public exposure modeling in Macro LEVEL approach

Global and regional fate modeling for radioactive particles

The particle dispersion models, such as Hybrid Single Particle Lagrangian Integrated Trajectory model (HYSPLIT) and AMS/EPA Regulatory Model (AERMOD) [51], are traditionally used to determine the short and long term fate of airborne particles. These dispersion models usually require steady and horizontally homogeneous hourly surface and vertical

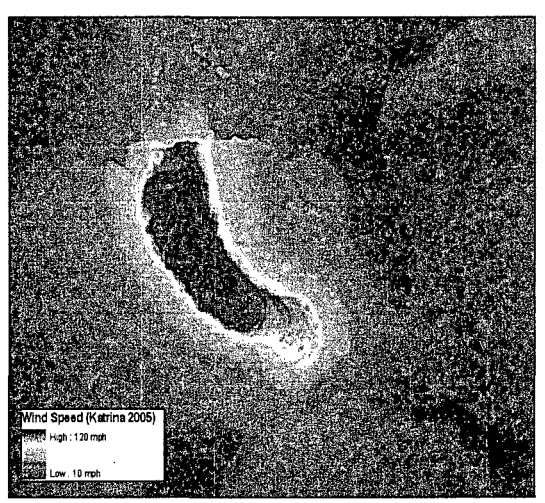

Figure 3: Numerical simulations of the hurricane Katrina (2005) using WRF carried out at Jackson State University. Wind speed along the hurricane path is shown

air meteorological observations. To get realistic regional and continental air flow field, the use of mesoscale Weather Research and Forecasting (WRF) model is very well suited [38-40], see http://wrf-model.org. WRF software architecture is designed to run on massive parallel computing environments and makes it very convenient for extensive and multi-physics model coupling. The coupled modeling of WRF and particle dispersion in the air is not something new. The WRF like mesoscale numerical weather models are usually executed with 1-4km grid spacing for this coupling purpose [41]. The outputs of those models are used to drive air quality, transport and dispersion models for urban areas. It is critical for weather models to capture influences of urban forcing on wind, temperature, and humidity in the atmospheric boundary layer structure. To bridge the gaps between traditional mesoscale modeling and microscale modeling, Chen et al. [41] have developed an integrated urban modeling system coupled to the WRF model as a community tool to address urban environmental issues. Other notable examples of WRF usage coupled with different air quality models for different cities or regions are - Houston, Texas [42], Pune, India [43], northern Taiwan [44], Beijing, China [45,46], etc.

WRF modeling system (with the 4-D VAR data assimilation module) has been extensively used by our research team to study high-resolution dynamic and thermodynamic processes of hurricanes such as Katrina, Dolly, and Gustav in the Gulf Coast Region. Recently, we have developed an integrated modeling scheme of a hurricane from its incipience to landfall (using WRF), associated water surge in ocean (using ADCIRC) and flooding in the coastal region (Using in-house CaMEL Overland model) [47,48]. This scheme is truly a multi-scale and multi-physics integration. Using the latest meteorological data 2-3 days before a hurricane strikes the ground track path, wind speed, pressure, rain, etc are predicted using WRF. The WRF outputs are used predict the storm surge and inland flooding to assess the infrastructure failure risk and setup the evacuation plan for the Mississippi coastal regions. Figure 3 shows an example of hurricane Katrina (2005) wind speed and hurricane track path hindcast in the Gulf of Mexico. This study is the major part of an on-going project in the Northrop Grumman Center for HPC at the Jackson State University regarding the homeland security in the state of Mississippi, funded by the Department of Homeland Security.

We will incorporate the WRF system into our comprehensive radioactive fallout regional and global dispersion study. Particle dispersion models provide the spatially resolved concentrations due to particle emission from variety sources. For our study we will use AERMOD. Wind information from WRF model will be fed into the AERMOD model. It is an advanced plume dispersion model for air quality assessments of emitted inert pollutants [45,50]. Based on an advanced characterization of the atmospheric boundary layer turbulence structure and scaling concepts, AERMOD is applicable to rural and urban areas, flat and complex terrain, surface and elevated releases, and multiple sources (including point, area, or volume sources). The model employs hourly sequential preprocessed meteorological data to estimate concentrations at receptor locations for averaging times from 1 hour to 1 year. Vertical profiles of wind speed, wind direction, turbulence, and temperature are estimated using all available meteorological observations.

Urban air flow modeling with radioactive particles deposition

Most radioactive particles from various sources once dissolved in liquid droplets or attached to airborne particulate matters demonstrate similar transport characteristics as other particulate matters such as PM2.5. Therefore, modeling of the radioactive aerosol particles' fate in urban environments can be estimated by the similar methodology and computational tools. Figure 4 highlights our urban CFD study for downtown Indianapolis.

Several pollutant and toxic gas dispersion models and exposure models have been approved/suggested by United States Environmental Protection Agency (U.S. EPA) for local and regional modeling. The models have several input and output data using environmental air quality measurements or simulations. AERMOD [51] and CALPUFF [52,53] models characterize

plumes with Gaussian distribution [54,55]. AERMOD is a straight- line steady plume while CALPUFF allows for time step changes in plume wind conditions. CMAQ [56] is a course grid model including all the elements of interest in air quality modeling but at general a larger than 4 km spatial resolution. APEX [57] and HAPEM6 [58,59] are human/society exposure models that use environmental concentrations from both measurements and dispersion models. While these models are practical and effective statewide as well as national scale air quality and exposure simulation using low-end computing resources even desktop computer, it should also be noted that there are several assumptions regarding the way they handles complex geometries, atmospheric parameters especially for urbanscapes.

Gaussian dispersion models based on regional atmospheric wind models are not the best fidelity models available for local scale as well as in community scale. In the presence of complex shapes such as topographical extrusions and intrusions, buildings, hills, riverside, ditches, vegetations, etc. wind turbulence becomes very important. Fine-scale CFD modeling can provide sophisticated details for dispersion of the particles, wind patterns, and change of several atmospheric properties.

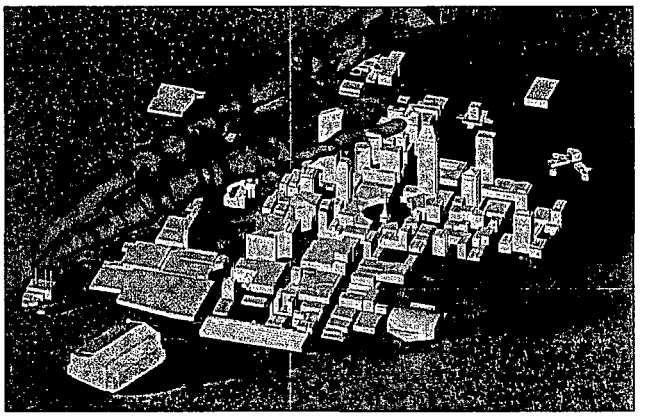

Figure 4: Plume over downtown Indianapolis. Simulations are carried out using CAMEL^{CHH3}.

Various research studies have been conducted using CFD modeling of urban terrains in fine scale. Two types of modeling have been in use to capture turbulent flow features in the simulation of transport and dispersion phenomena at the urban scale: Reynolds Averaged Navier-Stokes Equation (RANS), and Large Eddy Simulation (LES). LES has limitations resolving the flow near the surface [60]. As a response to some of these limitations, variations to these models have surfaced in the recent years, e.g., Very Large Eddy Simulation (VLES) [61,62], Detached Eddy Simulation (DES) [63], Monotonically Integrated Large Eddy Simulation (MILES) [64,65], Implicit turbulence modeling in LES [66,67], Hybrid LES/RANS [67,68,72].Most Commercial CFD packages, such as in [69-71] usually come both with RANS and LES turbulence modeling. While they are very well geared for commercial applications, they are not as powerful and convenient as research CFD codes for very large-scale applications on massively parallel computers.

In this project, we will use our CFD tool, CaMEL^{CHH3}, to predict local street level radioactive participle concentrations already in the atmosphere over the greater Indianapolis area. Regional atmospheric model, WRF, as explained in the previous section, will provide input to CaMEL^{CHH3}. Concentrations of the particles at street levels will be accumulated over longer time period and average public exposure will be estimated. To track the participles in a continuum model, we will use discrete phase model in Lagrangian frame. It is a force balance equation, which acts on the particles, such as gravity, aerodynamic force due to continuum flow field, pressure gradient, thermophoretic, rotating reference frame, Brownian motion, Saffman lift, and any user defined forces. Appropriate boundary condition on the particles such as being trapped, reflected, dissolved, evaporated, or aborted etc. will define fate of the particles.

Human Resource Development

In this program, Jackson State University (JSU) will provide educational and research opportunities for qualified undergraduate and graduate students to educate them for the

importance of Nuclear energy and how simulation methodologies can help to assess associated risks. In addition, to prepare them for employment in Science, Technology, Engineering, and Mathematics (STEM) specifically in nuclear energy related sectors in industry, government, and higher education through the establishment of: (1) an interactive summer research institute program for undergraduate students; (2) graduate student research residency.

Interactive Summer Research Program for Undergraduate Students

This research program is geared toward preparing our undergraduate students for graduate programs in computational science. STEM students will be recruited from the departments of Environmental Engineering, Civil Engineering, Computer Engineering, Computer Science, Chemistry, Physics, Mathematics and Biology. The program will involve: 1) research projects (supervised by faculty and graduate students); 2) weekly seminars (with invited speakers); 3) weekly mini-courses; 4) weekly student presentations (concerning progress and difficulties); and 5) a final report. We will host 2 undergraduate students within the College of Science, Engineering and Technology at JSU in a summer long concentrated research project. The research projects will be selected based on the project requirements and student interest. The undergraduate students recruited for this program will receive a stipend of $1200 per month for 2 ½ months period ($3000 per summer per student).

Graduate Student Residency at NGC

One selected students registered in the graduate program with an emphasis area in a STEM discipline will be offered graduate student research residency. The intention is to provide an interdisciplinary experience with integrated education, and training and research components. These students will work closely with researchers and participate in all aspects of the research projects, including conducting research, documentation of the results, presentation of the results in scientific meetings and conferences, writing reports, etc. Selected student will receive up to $1600 stipends per month (for 2.5 months a year) plus tuition assistance of up to $5,000 per year.

Student Progress Tracking

The evaluation and self-assessment will be results driven. A database will be created to document the number of students recruited and supported through this project. Generally, the database will have three components: (1) Education and Human Resource Development; (2) Research; and (3) Broader Impacts.

The Education and Human Resources Development database will include: 1) Number of undergraduate and graduate students; 2) Student performance in core science courses; 3) Performance in all courses taken; 4) Skills development (oral, written, etc.); 5) Presentations at workshops, symposiums, and professional conferences and meetings; and 6) Students recruited for research.

The project director will continuously assess student advisement and mentoring. Weekly team meetings will always have student mentoring and performance as an agenda item. All student-related activities will be continuously assessed and tracked:

The project research activities will be documented in the Research database through internal and external reports, proposal development, journal publications, conference proceedings and abstracts, and collaborations. The participation of the students in national and international meetings and conferences will be reported. Each graduate student visiting our partner institutions will submit a final report, which documents the student's research activity. The research productivity assessment will necessarily be longer-term; however, process and progress metrics will be documented.

The Broader Impacts database will be a composite assessment of the research and education results. However, it will contain other elements such as interactions with industry and other universities, leveraging proposals submitted, etc.

NOTE: We will obtain NRC service agreements from students who receive scholarship.

Management and Evaluation

The principal investigator (PI) and the Project Director (PD) will be Dr. Shahrouz Aliabadi. Dr. Aliabadi is a distinguished professor in the School of Engineering at JSU and the Director of the NGC. Dr. Aliabadi is experienced in coordinating interdisciplinary research projects across scientific disciplines. Dr. Aliabadi has successfully managed various multi-million dollar research and educational projects in the past. He is familiar with the security and reporting requirements of various agencies and is well qualified to manage and execute this project. He is the recipient of various awards and honors and has more than 150 publications in computational engineering and high performance computing. He is nationally and internationally recognized for his contributions in the field of finite element method, high performance computing, and large-scale computations.

Dr. Aliabadi (PI) will report directly to Dean of the Jackson State University College of Science, Engineering and Technology. Dr. Aliabadi will manage educational component of the projects. He has vast experience in conducting and delivering summer institute programs, training students in high performance computing, and recruiting talented undergraduate and graduate students. Dr. Erdal Yilmaz (CoPI) will engage in research management for individual components' modeling. He has many years of experience and in conducting computational modeling and parallel computing for various projects.

FACILITIES AND Computational Resources

The Northrop Grumman Center for High Performance Computing (NGC-HPC) is located in the modern Jackson State University e-Center, a 17-acre complex with 300,000 sqft of modern space. The NGC-HPC has more than 5000 sqft of research space, including 5 offices, 5 cubicles, a large conference room and a 20-seat state-of-the-art training classroom.

Recently, NGC-HPC installed a 592-core computing engine cluster with 1.4 terabytes of memory for research and education. The system is configured into two partitions, one with 80 Intel Xeon quad-core processing unit and the other with 512 core AMD Opteron based processors. Our computing engine provides tremendous computing power to simulate real-world engineering applications with highest degrees of accuracy. This computing power will be available only to researchers at the Center and the faculty of the School of Engineering at JSU.

DELIVERABLES AND TIMELINE

Total time of the proposed study will be five years. The deliverables will include the following tasks as specified annually (Y1, Y2,..):

Tasks	Description	Y1	Y2	Y3	Y4	Y5
Task #1	Radioactive source and intensity identification: A microenvironment where workers or professionals are exposed to radioactive particles will be identified and quantified. For public exposure, potential sources around part of the Midwest region, Indiana, will be identified and quantified for regional and city modeling.	X				
Task #2	Atmospheric particles deposition modeling for existing CFD solver, CaMEL^{CHH3}. Discrete phase particle model will be implemented.	X	X			
Task #3	Particle deposition modeling in bio-systems for existing CFD solvers. Physics of particle deposition on mucus layer of lung and alveolus surface will be modeled and implemented into the codes.	X	X	X		
Task #4	Mesh modeling for:					
a	Microenvironment simulations with our CaMEL^{CHH3} solver: Occupational environments such as interior rooms of building, tools and equipments of workers who are exposed to radioactive particles will be modeled.	X	X			
b	Upper respiratory systems and lungs simulations: This will include mucus layer movement (two phase flow) using CaMEL^{CHF3} code.	X	X	X		
c	Alveolar duct and sacs including alveolus simulations for micro-fluidic studies: Modeling will be done for one alveolar branching only due to extremely high computing resource requirements for complete alveolus of the lungs using CaMEL^{CHH3}.	X	X	X		
d	City dispersion simulations by CaMEL^{CHH3}: Currently we have Indianapolis model for wind and air pollution modeling. We will extend it to metropolitan Indianapolis area to cover more residential zones.		X	X	X	
e	Regional atmospheric modeling with WRF. To provide realistic atmospheric boundary to the city model, part of Midwest region Indiana, including potential radioactive sources will be modeled.		X	X	X	
Task #5	CFD simulations on High Performance Computing Environments. Above five models will be simulated using CaMEL codes for various flow and atmospheric conditions and post-processed.				X	X
Task #6	Interactive summer research program for undergraduate students at NHC-HPC. Topic will include: Nuclear energy fundamentals, modeling and simulation techniques, and health effects.	X	X	X	X	X
Task #7	Make outcome and all models available to public. Web portal development for research dissemination.					X
Task #8	Present research in scientific communities	X	X	X	X	X
Task #9	Publish research in international journals	X	X	X	X	X
Task #10	Documentation and technical reports	X	X	X	X	X

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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 these URLs to the Office of Management and Budget Cost Circulars are included for reference:

A-21 (now 2CFR 220):	http://www.whitehouse.gov/omb/circulars/a021/print/a021.html
A-87 (now 2CFR 225:	http://www.whitehouse.gov/omb/circulars/a087/print/a087-all.html
A-122 (now2 CFR 230	http://www.whitehouse.gov/omb/circulars/a122/print/a122.html
A-102, SF 424:	http://www.whitehouse.gov/omb/circulars/a102/print/a102.html
Form 990:	http://www.irs.gov/pub/irs-pdf/i990-ez.pdf

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.

By drawing funds from the Automated Standard Application for Payment system (ASAP), the recipient agrees to the terms and conditions of an award.

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 Part 180 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

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.

Service Agreement

A signed service agreement and resume are required for all student recipients of scholarships or fellowships funded by the US Nuclear Regulatory Commission. The Service Agreement is attached to the Terms and Conditions.

§ 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 215.180 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 VII 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 VII, 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 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 must 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, termination of the award, 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
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 is an appropriate charge to this award and prior authorization for specific trips are not required, as long as the trip is identified in the Grantee's original program description and original budget. All other travel, domestic or international, must not increase the total estimated award amount. Trips that have not been identified in the approved budget require the written prior approval of the Grants Officer.

Travel will be in accordance with the US Government Travel Regulations at: www.gsa.gov/federaltravelregulation and the per diem rates set forth at: www.gsa.gov/perdiem.

Travel costs to the grant must be consistent with provisions as established in Appendix A to 2 CFR 220 (J.53)

Property Management Standards
Property standards of this award shall follow provisions as established in 2 CFR 215.30.

Equipment procedures shall follow provision established in 2 CFR 215.34.

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

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 title and retain ownership 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 of this award shall follow provisions as established in 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 a review committee consisting of a minimum of three persons.

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,

Monitoring and Reporting § 215.51

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.
- Budget Revision – 2 CFR 215.25
  - In accordance with 2 CFR 215.25(e), the NRC waives the prior approval requirement for items identified in sub-part (e)(1-4).

- The Grantee is not authorized to rebudget between direct costs and indirect costs without written approval of the Grants Officer.
- Allowable Costs – 2 CFR 215.27

b. **Federal Financial Reports**

Effective October 1, 2008, NRC transitioned from the SF–269, SF–269A, SF–272, and SF–272A to the Federal Financial Report (SF-425) as required by OMB:
http://www.whitehouse.gov/omb/fedreg/2008/081308_ffr.pdf
http://www.whitehouse.gov/omb/grants/standard_forms/ffr.pdf
http://www.whitehouse.gov/omb/grants/standard_forms/ffr_instructions.pdf

The Grantee shall submit a "Federal Financial Report" (SF-425) on a quarterly basis for the periods ending 3/31, 6/30, 9/30, and 12/31 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 shall be submitted within 90 days after expiration of the award.

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 shall 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 shall 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 as specified in the special award conditions in the same frequency as the Federal Financial Report unless otherwise authorized by the Grants Officer.

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 submission for the six month period ending March 31st is due by April 30th. The submission for the six month period ending September 30th is due by October 31st.

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 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."