Fiscal Year:	FY 2008	**Task Last Updated:**	FY 01/18/2009
PI Name:	Cucinotta, Francis A Ph.D.		
Project Title:	Space Radiation Risk Assessment		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Radiation health		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **SR**:Space Radiation		
Human Research Program Risks:	(1) **ARS**:Risk of Acute Radiation Syndromes Due to Solar Particle Events (SPEs) (2) **BMed**:Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders (3) **Cancer**:Risk of Radiation Carcinogenesis (4) **Cardiovascular**:Risk of Cardiovascular Adaptations Contributing to Adverse Mission Performance and Health Outcomes (5) **CNS**:Risk of Acute (In-flight) and Late Central Nervous System Effects from Radiation Exposure (6) **Degen**:Risk of Cardiovascular Disease and Other Degenerative Tissue Effects From Radiation Exposure and Secondary Spaceflight Stressors		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
PI Email:	not available	**Fax:**	FY
PI Organization Type:	NASA CENTER	**Phone:**	(702) 895-4320
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City:	Las Vegas	**State:**	NV
Zip Code:	89154-3037	**Congressional District:**	1
Comments:	Formerly at NASA Johnson Space Center, until summer 2013 (Ed., Oct 2013)		
Project Type:	GROUND	**Solicitation / Funding Source:**	Directed Research
Start Date:	06/01/2006	**End Date:**	05/31/2011
No. of Post Docs:	3	**No. of PhD Degrees:**	0
No. of PhD Candidates:	1	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:	Dr. Nikjoo has left the Project		
COI Name (Institution):	Pluth, Janice M (LBNL) Cornforth, Michael (U TX Medical Branch) George, Kerry (Wylie Labs) Ponomarev, Artem (USRA) Huff, Janice (USRA) Kim, Myung-Hee (USRA) Qualles, Garry (NASA Langley) Clowdsley, Martha (NASA Langley)		
Grant/Contract No.:			

Performance Goal No.:	
Performance Goal Text:	
Task Description:	The Risk Assessment Project at Johnson Space Center is responsible for the integration of results from NASA space radiobiology research into computational models used for astronaut radiation risk assessments. The purpose of the Project is fourfold: (1) evaluate the extent to which ongoing research leads to reduction in the uncertainty of risk assessments and provide, as a metric of program progress, the number of days in space during which the radiation exposure of astronauts remains below NASA limits within a 95% confidence interval ("safe days in space"); (2) perform mission planning studies to predict the number of safe days for any mission; (3) assess the radiation risk to astronauts for ongoing missions in real time; and, (4) provide recommendations for research directions most likely to reduce risk or improve the accuracy of risk predictions. The four categories of risks from radiation in space are defined by the NASA Bioastronautics Roadmap (BR). They are: 1) Carcinogenesis, 2) Acute and late effects to the Central Nervous System (CNS), 3) Degenerative Tissue Effects such as heart disease and cataracts, and 4) Acute Radiation risks. The number of safe days currently predicted for an astronaut's career is less than required by mission planning, due to the large uncertainties in risk prediction. In particular, a projection uncertainty below + or - 50% is the goal for the 1000-day Mars mission because the high level of risk will require high precision risk evaluations. The current approach used to project risk is based on epidemiology data and on phenomenological models used to derive risk prediction from them. This approach cannot lead to improvements in the accuracy of risk prediction beyond a factor of approximately 2. New approaches using molecular biology and genetics are the only viable ones for achieving the level of accuracy required by space exploration and a robust program to obtain the required data is supported by the Space Radiation Program. However, how to incorporate these data into risk prediction and assessment models is not well understood. This Project Plan describes the approaches that will be used to develop models of risk assessment based on mechanistic space radiobiology research funded by the Space Radiation Program, leading to incremental uncertainty reduction based on new experimental data, and to the development of application software to be used in the NASA operational radiation protection program. To accomplish these goals, we will establish new molecular based models of risk. The molecular pathways that are the hallmarks of genomic instability and cancer, and the perturbation of these pathways by radiation will be described using systems biology approaches and Monte-Carlo simulation. We will develop descriptive models of such pathways utilizing track structure models of biomolecular damage, and deterministic and stochastic kinetic models of dominant molecular pathways causative of BR radiation risks. These simulations will make maximum use of results from mechanistic space radiobiology, and will replace traditional hazard functions and their inherent uncertainties due to reliance on epidemiological or phenomenological approaches.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Radiobiology research provides many important qualitative descriptions of biological effects of radiation on biomolecules, cells, and tissues. The Space Radiation Risk Assessment Project provides an important link that integrates qualitative experimental observations into detailed quantitative biophysical models of radiations risks. This research benefits all humans that will be exposed to ionizing radiation. Models of cancer, acute and other risks developed by the Space Radiation Risk Assessment Project provide NASA with the ability to project risks and develop cost-effective mitigation approaches for future exploration missions.
Task Progress:	Extensive reviews of the field were made leading to the publication of Evidence Based Chapters for Cancer, CNS, Degenerative, and Acute risks to be included in the Human Research Program's Evidence Book. Also, a review of heavy ion carcinogenesis research was published in the journal, Nature Reviews Cancer. The NASA Cancer risk projection model was further developed to estimate organ specific cancer risks. A review of NASA Space Radiation sponsored publications, or other data on RBE's for solid cancer and leukemia including surrogate markers is underway to formulate organ specific quality factors. The anatomical human geometry model, CAMERA was compared to spaceflight agreement with overall consistency of <15% found for Space Shuttle and ISS results. A new CT-based VOXEL model was compared to the CAMERA model and agreed very well (<5% difference) for GCR and hard SPE spectra. The effects of background cancer rates and survival curves were estimated through comparison of space radiation cancer risks for each of the 50 states using multiplicative and weighted multiplicative and additive risk transfer models. System biology models were developed for the ATM and TGF-beta pathways. Mechanisms that could lead to differences between signaling between low and high dose or LET were identified and will be further investigated. Of interest are the biochemical description of non-targeted effects through inter-cellular signaling. Also new computational tools to understand DNA damage repair foci and flow cytometry results with heavy ion beams were developed. Work on molecular dynamics simulations of the Ku and Rad51 proteins interacting with DNA were completed and identified likely binding regions on these proteins, and predictions of binding energies were made. ITC and FRET methods are being considered to verify computational predictions. A Monte-Carlo track structure code, RITRACK was developed for relativistic heavy ion descriptions. The code includes the production and energy deposition of secondary electrons (delta-rays) with energies up to 10 MeV, and ions with energies from 0.1 MeV/u to 50 GeV/u. Track structure models of chromosomal aberrations using the random walk polymer models of the entire human genome were formulated and show good agreement with experiments. Probabilistic risk assessment (PRA) tools were developed for SPE risks including the Acute radiation syndromes. A data base for energy spectra of all SPE's in the space era was developed and Hazard functions and sampling schemes formulated to consider shielding designs under PRA. This is the first PRA tool developed that considers SPE frequency of occurence, event size, and event spectral characteristics. The results will be very informative to the NASA Constellation program and the assessment of shielding approaches and mission architectures.
Bibliography Type:	Description: (Last Updated: 02/11/2021)
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