Fiscal Year:	FY 2011	**Task Last Updated:**	FY 01/11/2011
PI Name:	Pisacane, Vincent L. Ph.D.		
Project Title:	Lunar EVA Dosimetry: Microdosimeter-Dosimeter Instrument		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Radiation Effects Team		
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)		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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City:	Annapolis	**State:**	MD
Zip Code:	21402-1314	**Congressional District:**	3
Comments:	PI retired October 2011 (Ed., 2/29/2012; information from NSBRI)		
Project Type:	Ground	**Solicitation / Funding Source:**	2007 Crew Health NNJ07ZSA002N
Start Date:	01/01/2009	**End Date:**	09/30/2011
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	3	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	4
No. of Bachelor's Candidates:	7	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:	NOTE: PI retired and end date changed to 9/30/2011 from original end date of 12/31/2012; task transferred to James Ziegler and continues through 3/31/2013, per NSBRI (Ed., 2/29/2012)		
Key Personnel Changes/Previous PI:	PI Vincent Pisacane retired and end date changed to 9/30/2011; James Ziegler is new PI effective 10/1/2011 and project continues through 3/31/2013, per NSBRI. See Ziegler for FY2012 and later reports (Ed., 2/29/2012)		
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Grant/Contract No.:	NCC 9-58-RE01601		
Performance Goal No.:			
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Task Description:	1. AIMS Objective is to advance the state-of-the-art of solid-state microdosimeters (SSMD) to design, develop, and test a flight-qualifiable engineering model by Dec 2012. This 4 year project started in 1 Jan 2009 with this report concluding the 2nd year. Aims include: 1.1 Develop a benchtop system to advance the state-of-the-art of SSDM incorporating proven advancements into the flight engineering model 1.2 Develop a flight engineering model suitable as a personal SSDM 1.3 Develop improved SSDM sensors 1.4 Utilize computer modeling to support instrument development and compare with observations 1.5 Explore opportunities to transition to a flight program 2. KEY FINDINGS 2.1 Benchtop System - Obtained and analyzed SSMD spectra for NASA Space Radiation Laboratory (NSRL) beams (protons & heavy ions) to identify particle types, energies, and mass-to-charge ratios in the beams and produced by intervening materials. Reduced instrument noise levels near a factor of 10 during our National Space Biomedical Research Institute (NSBRI) funding period. Best noise measurements at NSRL with 200 feet of cable is ~0.3keV/micron (~0.2 keV/micron-tissue). Compared SSMD spectra from our 1st generation sensors with silicon surface barrier detectors and also obtained spectra for neutrons, the most damaging particles. 2.2 Flight Engineering Model - The instrument developed in year 1 is MIcroDosimeter iNstrument (MIDN)-II (MIDN-II). We have designed an improved version, MIDN-III, reducing size and mass with an expanded set of remote commands that should be available by the end of 2010. MIDN-II tests showed good agreement with the benchtop system observations, radiation codes, and tissue equivalent proportional counter (TEPC) results used as references. Its noise cutoffs is ~ 1keV/micron. Continued development of our unique optical calibration system and applied for a patent in Sept 2010. This provides a continuous end-to-end test and confirms the calibration or recalibrates the SSMD while in operation accomplished without a problematic radiation source. 2.3 Sensor Development - Prior observations were with the 1st generation SSMD sensors. A 2nd generation SSMD sensor was produced and tests confirmed performance using the benchtop and flight engineering instruments. A 3rd generation sensor has been designed and fabricated; preliminary tests look promising with more testing to continue in year 3. 2.4 Modeling - Several versions of the Geant4 radiation code are employed to compare to our SSMD observations. Collaboration has produced detailed SSMD distributions for each particle type and energy, critical for interpreting observations, especially since individual components can be measured with the dose equivalent (DE) coincidence system. We obtain acceptable agreement between our observations and radiation transport codes. We also employ the SolidWorks tool to develop test fixtures and housings and Electronic Workbench tool to model electrical circuits. 2.5 Flight Opportunity - Completed a conceptual design to fit a NanoRacks configuration for the International Space Station (ISS) through the auspices of the Department of Defense (DoD) Space Test Program. Our system has been approved annually for several years for inclusion on DoD space missions. We declined a flight opportunity for a potential launch in 2012 due to insufficient funds and impact to the MIDN project. 3. IMPACTS Noise measurements with the bench-top system established that SSMDs are able to be operated with noise levels as good as or better than those obtained previously by TEPCs in space. This establishes the feasibility of building space qualifiable systems with sufficiently low noise so that complete SSMD spectra for high energy protons will be able to be obtained even in the lower-lineal energy region not detected previously with space-qualified systems, a major goal of this research project. Recent measurements of SSMD spectra with high-energy neutrons (~15 MeV), considered to be the most damaging particles in space, show that SSMD can operate in high-dose radiation fields for long time periods without failures. This establishes the radiation resistance of our SSDMs, a major goal of this project. Recent measurements with SSDM systems at the NSRL facility at Brookhaven National Laboratory (BNL) establish the practicality of using our new capability of identifying particle species, energy, and charge-to-mass ratio responsible for specific individual events. These measurements provide more stringent data for establishing quality factors and the accuracy of the transport codes and theoretical calculations, a major aim of this project. Development of an end-to-end system test and calibration of a personal SSMD while operational without the need for an ionizing radiation source is a critical achievement. The development and test of the MIDN-II and the design of the MIDN-III that are early versions of a flight qualifiable personal SSMD are important accomplishments. 4.0 RESEARCH PLAN for 2011 4.1 Benchtop System - Having established the feasibility of particle identification with our SSMDs we shall: a. build a new prototype with smaller DE detectors with lower noise characteristics to reduce the number of random events. b. obtain data with protons and iron to investigate contributions from low-energy delta rays, typically responsible for 20-30% of the physical dose not seen by typical TEPCs. c. compare new sensor with the previous and with silicon sensors of the same thicknesses of a few microns but with larger cross-sectional areas. 4.2 Flight Engineering Model - Complete development of our flight engineering model, MIDN-III, and carry out radiation tests at the U.S. Naval Academy (USNA) and at NSRL. The remote command capability will be expanded. Further the optical calibration technique. 4.3 Sensor Development - Carry out detailed testing of 3rd generation SSMD sensors anticipating additional improved sensors from our collaborators. 4.4 Modeling - Add to our radiation transport codes by integrating the newly available GRAS (generally recognized as

	safe) module into our transport code suite. 4.5 Flight Opportunity - Continue to work with the DoD Space Test Program Office to obtain a future flight opportunity.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	To determine the risk from currently used radiation dosimeters requires knowledge of the species, energies, and frequencies of the radiation types or the frequency distributions as a function of linear energy transfer. The more frequently used passive dosimeters are also processed after the exposure and are not real-time instruments so the risk is inferred only after exposure. Microdosimeters are unique in that they can be used to directly determine the regulatory risk from radiation in real time when neither the species nor energies of the radiation are known. Thus it is a superior instrument for use in situations when the radiation environment is unknown and perhaps time varying. With sufficient investment in very-large-scale integration (VLSI) technology the solid-state microdosimeter can be integrated into a cell-phone sized instrument. Since microdosimetry provides the regulatory risks from radiation exposure in real time, it can be beneficially used by first responders in emergency situations when there is uncertainty in the radiation risk. The microdosimeter can be used in nuclear power plants and other facilities with radioactive materials to provide risk due to exposure. It can also be used to detected contraband radioactive material; because of its compact size and potentially relatively low cost, it can be used in situations where large numbers of sensitive detectors are needed. Development of Silicon on Insulator (SOI) microdosimeters has a potentially significant impact on applications to monitor the dose equivalent during proton therapy to reduce the possibility of secondary cancers generated in normal tissue by the radiation. Development of our calibration technique that does not use an ionizing radiation source will reduce the exposure of handlers of the microdosimeter. It will also eliminate the cost of satisfying the regulations on certification of users and on the handling, shipping, and facilities.
Task Progress:	The overall objective of this research project is to design, develop, and test an engineering model solid-state microdosimeter (SSMD) by December 2012 suitable for use in the new NASA spacesuit and robotic operation on rovers, tool boxes, and spacecraft. The benchtop instrument continues to be used to develop and investigate improvements to the state-of-the-art of SSMDs. This past year the focus has been on development of improved preamplifiers. Radiation sources available at the USNA have been used to carry out the test protocols. The benchtop system has been expanded to obtain and analyze microdosimetric spectra for incident NSRL beams of both protons and heavy ions with identification of particle types in the beam, their energies, and their mass-to-charge ratios and those produced by intervening materials. We carried out tests of our bench-top system with a neutron beam generated in the Nucleonics Laboratory at the USNA with favorable results. An improved version of the flight engineering model, MIDN-III, has been designed and is nearing completion. It has a reduced footprint and mass and expanded remote command capability. It will be available for test by the end of 2010. We processed data sets obtained at the NSRL/BNL from our benchtop system, flight engineering model MIDN-II, and two Far West HAWK tissue equivalent proportional counters. Inter-comparisons of the observations agreed well and also agreed with Geant4 simulations. These spectra have been added to our past data sets to update our extensive library of microdosimetric spectra. We continued development our unique optical calibration system for a SSMD that permits continual end-to-end system test and calibration while the instrument is operational deployed. This is an alternative to using a radiation source that is problematic in a personal dosimeter and eliminates handling and shipping restrictions and personnel and facility certifications required by international, federal, and local regulations. Our provisional patent application was superseded by a patent application in Sep 2010. We have tested our second generation microdosimeter sensors with our bench-top and flight engineering instruments and compared our results favorably with those obtained at the University of Wollongong. We received a sample of our third generation solid-state microdosimeter sensors in November and will begin testing at the beginning of the year. We completed an initial conceptual design of our instrument to fit within a NanoRacks configuration for deployment on the International Space Station through the auspices of the DoD Space Test Program. The NanoRacks configuration is modeled after the design of a cubesat. Our configuration would be 10cm x 10cm x 15cm with the majority of the volume dedicated to a rechargeable battery power supply. [Ed. note 2/29/2012: PI Vincent Pisacane retired and end date changed to 9/30/2011; James Ziegler is new PI effective 10/1/2011 and project continues through 3/31/2013, per NSBRI. See Ziegler for FY2012 and later reports]
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Awards	Janca EL, Ried NL. "2nd Place Student Paper, AIAA 40th International Conference on Environmental Systems, Barcelona, Spain, July 2010." Jul-2010
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