Fiscal Year:	FY 2014	**Task Last Updated:**	FY 11/05/2013
PI Name:	Sandridge, Chris Ph.D.		
Project Title:	Integrated Radiation Analysis and Design Tools		
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) **Cancer**:Risk of Radiation Carcinogenesis (3) **CNS**:Risk of Acute (In-flight) and Late Central Nervous System Effects from Radiation Exposure (4) **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		
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PI Organization Type:	NASA CENTER	**Phone:**	757-864-2816
Organization Name:	NASA Langley Research Center		
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PI Web Page:			
City:	Hampton	**State:**	VA
Zip Code:	23681-2199	**Congressional District:**	1
Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	Directed Research
Start Date:	10/01/2005	**End Date:**	09/30/2015
No. of Post Docs:	2	**No. of PhD Degrees:**	0
No. of PhD Candidates:	0	**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 LaRC
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:	NOTE: End date changed to 9/30/2015 per 9/7/2012 HRP Master Task List information (Ed., 9/14/12)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Badavi, Francis (Old Dominion University) Blattnig, Steve (NASA Langley Research Center) Clowdsley, Martha (NASA Langley Research Center) Simonsen, Lisa (NASA Langley Research Center) Slaba, Tony (NASA Langley Research Center)		
Grant/Contract No.:	Directed Research		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	The Integrated Radiation Analysis and Design Tools (IRADT) Project develops and maintains an integrated tool set that collects the current best practices, databases, and state-of-the-art methodologies to evaluate and optimize human systems such as spacecraft, spacesuits, rovers, and habitats. IRADT integrates design models and methodologies in support of evaluation/verification of design limits and design solutions to meet As Low As Reasonably Achievable (ALARA) requirements (NASA STD 3001, Vol 2). IRADT provides the radiation community access to physics and transport capabilities and research improvements. The capabilities are developed under strict version control and are independently verified and validated (IV&V) to the extent possible. Current customers include ESMD's Directorate Integration Office studies (i.e. LAT, MAT, LSOS), Lunar Surface Systems as well as Constellation's Orion and Vehicle Integration Office, universities, industry, and SBIRs. IRADT is designed for utilization by future commercial customers concerned about transfer of proprietary data and results. Deliverables and access to the Integrated Radiation Design Tools fills identified gaps documented in the HRP Integrated Research Plan (HRP-47065, Rev. A) to support the evaluation of effective shielding options by the engineering community: · Cancer - 11: What are the most effective shielding approaches to mitigate cancer risks? · Cancer - 13: What are the most effective approaches to integrate radiation shielding analysis codes with collaborative engineering design environments used by spacecraft and planetary habitat design efforts? · Acute - 6: What are the most effective shielding approaches to mitigate acute radiation risks, how do we know, and implement? IRADT will specifically address the limitations associated with simplified geometry description (equivalent aluminum, three-layer transport interpolation, random orientation) and straight ahead transport. The design tools increases fidelity by incorporating common spacecraft and user specified materials in the geometry description with ray-by-ray transport to minimize the uncertainties due to range-scaling of material thicknesses and material ordering. Ray-by ray transport also establishes the basis to calculate the forward/backward neutron generation within vehicle/lunar surface geometries. The back-scattered neutron environment will be calculated from the opposite sides of the vehicle for a crew member's specific orientation at specific tissue locations. This will increase our ability to evaluate the effectiveness of shielding systems. In supporting the closure of these gaps, the Design Tool Project tools and models will support specification, implementation, verification, and monitoring of Spaceflight Human Systems Standard, Vol. 2 (NASA STD 3001, Vol. 2) radiation design and operational requirements with improved uncertainty quantification. The integrated tools and models will be supplied to the user community via a website called OLTARIS (On-Line Tool for the Assessment of Radiation in Space), which can be accessed at https:// .
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	
Task Progress:	This task update will cover two years since there was no update submitted last year. The capability to create a LEO environment from a user-uploaded trajectory was added. User trajectories may either be analyzed as before (by integrating the environment over the trajectory) or on a point-by-point basis. When the job is submitted as an averaged trajectories, the external environment (boundary condition) is computed at each trajectory point and integrated to obtain an average environment. The average environment is then run as a single computation to provide total response quantities (and averaged per-day rates) for the entire trajectory. When the job is submitted as a point-by-point trajectory, the external environment is computed at each trajectory point and run as a separate job. The results are then combined and returned as a function of time along the trajectory. The capability to run ray-by-ray transport for vehicle thickness distributions was added. In this analysis, the transport is run along each ray in the thickness distribution and includes backward neutron transport (like slab calculations). This allows thickness distributions to have up to 100 different materials, in any order, along each ray. The Badhwar-O'Neill 2010 GCR model was added for freespace, Earth orbit, and surface environments. The user can still select the older Badhwar-O'Neill 2004 as well but the site now defaults to the 2010 model. The lunar surface environment has been updated to add the neutron albedo. Jobs that are submitted as an interpolation-based run will have the neutron albedo applied to surface-pointing rays, while the rest of the rays will receive the free-space environment. The GCR albedo is computed without the vehicle. The SPE albedo is considered negligible since the vehicle would shield the lunar surface in the 1-D transport, thus it is set to zero. In the case of ray-by-ray transport, an appropriate amount of lunar regolith is added to the surface pointing rays, which will automatically account for the neutron albedo in the bi-directional transport along each ray. Generalized spheres can now be created and used for project geometries. These spheres are defined similarly to slabs and can contain any number of layers and materials. These jobs are run using forward-only transport and effective dose calculations use an orientation-averaged, or spinning astronaut, phantom position. Mars surface environments (for SPE and GCR) have been added. The Mars environments can only be used with vehicle thickness distributions and are always executed using ray-by-ray transport. A surface-local-vertical vector needs to be defined to indicate which hemisphere is up and exposed to the atmosphere. The opposite hemisphere is assumed to be regolith. A Field-of-View (FOV) response has also been added for Mars surface projects to aid in comparisons to particle telescope-type instruments. OLTARIS currently has 170 active accounts. 70 accounts are government (including NASA, ORNL, JPL, AFRL, and FAA), 54 are university professors/researchers/students, and 46 are industry (including Boeing, Space X, Lockheed-Martin, ATK, Northrup Grumman, and Bigelow Aerospace). There have been 10,900 jobs run through OLTARIS since counting began in November 2009.
Bibliography Type:	Description: (Last Updated: 09/07/2020)

Articles in Peer-reviewed Journals	Slaba TC, Blattnig SR, Clowdsley MS. "Variation in lunar neutron dose estimates." Radiat Res. 2011 Dec;176(6):827-41. Epub 2011 Aug 22. PubMed PMID: 21859325 , Dec-2011
Articles in Peer-reviewed Journals	Walker SA, Slaba TC, Clowdsley MS, Blattnig SR. "Investigating material approximations in spacecraft radiation analysis." Acta Astronautica. 2011 Jul-Aug;69(1-2):6-17. http://dx.doi.org/10.1016/j.actaastro.2011.02.013 , Jul-2011
Articles in Peer-reviewed Journals	Singleterry RC. "Radiation engineering analysis of shielding materials to assess their ability to protect astronauts in deep space from energetic particle radiation." Acta Astronautica. 2013 Oct-Nov;91:49-54. http://dx.doi.org/10.1016/j.actaastro.2013.04.013 , Oct-2013
NASA Technical Documents	Slaba TC, Mertens CJ, Blattnig SR. "Radiation Shielding Optimization on Mars." Hampton, VA : NASA Langley Research Center, 2013. NASA technical publication 2013-217983. (NASA/TP–NASA/TP–2013-217983) https://spaceradiation.larc.nasa.gov/nasapapers/NASA-TP-2013-217983.pdf , Apr-2013