Fiscal Year:	FY 2007	**Task Last Updated:**	FY 11/13/2007
PI Name:	Prisk, G. Kim Ph.D., D.Sc.		
Project Title:	Aerosol Deposition in the Lung in Fractional Gravity: Risk Mitigation for Lunar and Martian Habitats		
Division Name:	Human Research		
Program/Discipline:	NSBRI Teams		
Program/Discipline--Element/Subdiscipline:	NSBRI Teams--Technology Development Team		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **SHFH**:Space Human Factors & Habitability (archival in 2017)		
Human Research Program Risks:	(1) **Dust**:Risk of Adverse Health and Performance Effects of Celestial Dust Exposure		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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Zip Code:	92093-0852	**Congressional District:**	53
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2004 NSBRI NNH04ZUU003N Human Health in Space
Start Date:	07/01/2005	**End Date:**	06/30/2009
No. of Post Docs:	1	**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:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
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Key Personnel Changes/Previous PI:			
COI Name (Institution):			
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Performance Goal No.:			
Performance Goal Text:			

The deposition of aerosols from the environment in the lung presents a health risk. For particles larger than 0.5 micron, such deposition is strongly influenced by gravitational sedimentation. In microgravity, deposition by gravitational sedimentation is absent, and as a consequence, airway particle concentrations are higher than in 1G, enhancing aerosol transport to the alveolar region of the lung. The presence of previously unaccounted for complex mixing patterns in the periphery of the lung, combined with high alveolar aerosol concentrations, results in high deposition in this sensitive region of the lung in microgravity. Similar effects are expected in the fractional gravity environments of the moon and Mars.

The dust on the surface of Mars is highly oxidative in nature, due to the UV environment on the surface, and that on the Moon has properties comparable to that of fresh-fractured quartz on Earth, a highly toxic substance. The dust is also electro-statically charged, and so will tend to stick to the outside of spacesuits, and be tracked into habitats. The lung,

Task Description:	with its huge exposed surface area is highly vulnerable to adverse effects resulting from exposure to Mars and Moon dust. We are engaged in a multi-faceted approach involving human and animal experiments, combined with sophisticated modeling, to provide a path to assessing the health risk of dust exposure in habitats on both the Moon and Mars, addressing Risk #7 in the Bioastronautics Critical Path Roadmap. Such an assessment has profound implications on the degree of engineering (and thus cost) that will be required to limit the risk of such exposure to the inhabitants of these habitats. We will address the following hypotheses and objectives: 1: That total aerosol deposition in the human lung in fractional gravity will be higher than predicted by existing models (as is the case in microgravity), and that a higher than predicted alveolar deposition will result in these circumstances. Using the NASA Microgravity Research Aircraft, we will non-invasively measure both the total and regional deposition of inert particles (0.5 to 2 micron) in humans in fractional-G corresponding to that on the surface of the Moon and Mars. 2: That aerosol deposition in the lungs of spontaneously breathing rats in fractional-G will be more peripheral (closer to the alveoli) than in 1G. We will expose spontaneously breathing rats to fluorescent- and magnetically-labeled particles of varying sizes (between 0.5 and 2 micron) in 1G, and in fractional G corresponding to surface of the Moon and Mars, and measure the specific sites of regional deposition in the lungs using both fluorescent microscopy, and magnetic resonance imaging techniques. 3: We will couple existing sophisticated computational fluid dynamics (CFD) models of the upper airways of humans, to our model of the alveolar region of the lung, to predict aerosol deposition under conditions matching those of the experiments performed in humans. In rats we will use detailed 3D images of the rat bronchial tree to develop an upper airway CFD model which used in conjunction with an appropriately scaled alveolar model, will predict aerosol deposition under conditions matching those of the experiments performed in rats. Nearing the completion of year 2 of this project we have flown the human studies aboard the Microgravity Research Aircraft and the results have been presented in abstract form at the International Conference of the American Thoracic Society (SA #1). These studies showed that while deposition was reduced in fractional (lunar) gravity, that deposition which did occur was much more peripheral in the lung, with likely attendant increases in clearance time. The implications of this finding are that exposure models used for a lunar outpost cannot utilize terrestrial models. CFD modeling (SA #3) has progressed and we have shown that adequate transport estimates for particles can be made based on convective flow patterns, a result which greatly simplifies modeling in the central airways, as convective flow patterns are largely independent of gravity level. These results were also presented in abstract form at the International Conference of the American Thoracic Society. Proof of concept flights of the rat plethysmograph system necessary for SA #2 was successfully completed in this year, and the building of the system is currently in progress. In the upcoming year we see the first flights of the rat plehysmograph system with aerosol exposure in low gravity. The human studies will be published and CFD development and further simulations will be on-going in parallel.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The research funded by this grant has the potential to impact the setting of future standards for exposure to environmental particulate matter (PM). Setting such standards has a direct impact on the design (and hence the cost) of lunar and Martian habitat design, but many workers are routinely exposed to dusty environments, and will require similar protection standards.
Task Progress:	There are three major tasks. Progress under each is described below 1. Use human models to assess deposition patterns. The human studies, which were an extension of previous studies in microgravity performed by us, flew on the Microgravity Research Aircraft in this year. Data collection is complete is lunar gravity and results are in preparation for publication. No data were able to be collected in Martian gravity, but the results collected suggest a largely linear response to gravity, allowing adequate extrapolation to this condition. Results show that earth-based deposition models are inappropriate for use in the lunar environment. 2. Develop rat models to assess deposition patterns that can subsequently be used to directly assess lung damage. As part of the flights during this year, an engineering evaluation of the rodent aerosol exposure system was performed, and highlighted a number of potential issues to be addressed in the final design. However, overall the prototype system performed well, and we are now in the process of building the multi-animal exposure system to be flown in the upcoming year of the project. 3. Develop more comprehensive computational models of aerosol deposition under fractional-G consistent with these data. A new workstation dedicated to the computational simulations was installed and equipped with Computational Fluid Dynamics software allowing for aerosol transport simulations in the conducting airways as well as in the alveolar region of the lung. Comprehensive studies of aerosol transport in the conducting airways of the human lung have been conducted showing a strong dependence of aerosol transport on convective flow, a useful result in that ground based simulations and studies will be adequate for predicting the transport of aerosol to the periphery of the lung (although based on SA #1, the same cannot be said for peripheral deposition).
Bibliography Type:	Description: (Last Updated: 03/11/2021)
Abstracts for Journals and Proceedings	Darquenne C, van Ertbruggen C, Prisk GK. "Fine aerosol transport to lung segments is dominated by convective flow pattern." American Thoracic Society, San Francisco, CA, May 18-23, 2007. Am J Respir Crit Care Med. 2007;175:A936. , May-2007
Abstracts for Journals and Proceedings	Prisk GK, Darquenne C. "Aerosol deposition in the human lung is more peripheral in lunar gravity than in 1G." American Thoracic Society, San Francisco, CA, May 18-23, 2007. Am J Respir Crit Care Med. 2007;175: A936. , May-2007
Articles in Peer-reviewed Journals	Scadeng M, Rossiter HB, Dubowitz DJ, Breen EC. "High-resolution three-dimensional magnetic resonance imaging of mouse lung in situ." Invest Radiol. 2007 Jan;42(1):50-7. PMID: 17213749 , Jan-2007

Awards	Prisk GK. "Elected Senior Member, Institute of Electrical and Electronic Engineers, February 2007." Feb-2007
Awards	Prisk GK. "First-ever Honorary Member: Australian and New Zealand Society of Respiratory Scientists, March 2007." Mar-2007