Fiscal Year:	FY 2012	**Task Last Updated:**	FY 01/08/2013
PI Name:	Dinges, David F. Ph.D.		
Project Title:	Countermeasures for Performance Deficits from Sleep Loss and Workload in Space Flight		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Human Factors and Performance Team		
Joint Agency Name:		**TechPort:**	No
Human Research Program Elements:	(1) **BHP**:Behavioral Health & Performance (archival in 2017)		
Human Research Program Risks:	(1) **BMed**:Risk of Adverse Cognitive or Behavioral Conditions and Psychiatric Disorders (2) **Sleep**:Risk of Performance Decrements and Adverse Health Outcomes Resulting from Sleep Loss, Circadian Desynchronization, and Work Overload		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
PI Email:	dinges@pennmedicine.upenn.edu	**Fax:**	FY
PI Organization Type:	UNIVERSITY	**Phone:**	215-898-9949
Organization Name:	University of Pennsylvania		
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City:	Philadelphia	**State:**	PA
Zip Code:	19104-4209	**Congressional District:**	2
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2007 Crew Health NNJ07ZSA002N
Start Date:	06/01/2008	**End Date:**	09/30/2012
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:**	20
No. of Bachelor's Candidates:	46	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:	NOTE: End date change to 9/30/2012 (from 5/31/2012) per NSBRI (Ed., 1/24/2012)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Banks, Siobhan (University of Pennsylvania Health System) Goel, Namni (University of Pennsylvania)		
Grant/Contract No.:	NCC 9-58-HFP01602		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	In order to be able to carry out mission-critical tasks at any time during a mission, astronauts must maintain a high level of performance in the face of demanding workloads and work-rest schedules that result in chronic sleep restriction. The proposed research used a laboratory-based study to acquire critically-needed information on the effects on performance of high cognitive workload and sleep restriction (Specific Aim 1). We tested the hypothesis that as sleep restriction accumulates, it would potentiate the performance-impairing effects of higher cognitive workload. Another key goal of the study was to provide astronauts with an objective way to identify performance changes and the need for countermeasures for fatigue from sleep restriction and high workload. To this end, the project completed validation of the sensitivity of the 3-minute PVT Self Test to high workload and sleep restriction. PVT Self Test feedback interfaces also have been evaluated, and the task was tested in analog operations to establish its technical feasibility (Specific Aim 2). Tertiary goals of the project include identification of biobehavioral predictors of differential vulnerability to the cognitive effects of sleep restriction and high workload (Specific Aim 3), and development of individualized biomathematical models that predict performance on the PVT Self Test during high workload (Specific Aim 4). The project has primary relevance to the strategic goals of the NSBRI Human Factors and Performance (HFP) Team. This project is finished with N=71 subjects completing the laboratory protocol: this number is sufficient to evaluate the effects of high cognitive workload and sleep restriction on performance.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	The research builds on an extensive body of work we have conducted to help manage the cognitive performance of astronauts in space while they undergo high workload and sleep restriction. The acquisition of critically needed knowledge on how these factors potentiate fatigue effects on performance will help set standards and improve individualized mathematical models that predict countermeasure needs. The continued development of the PVT Self Test will offer a tool by which astronauts can autonomously assess their performance fitness and make decisions about countermeasures. These deliverables will also have utility in a broad range of Earth-based applications in which sleep restriction and workload have major adverse impacts on human performance (e.g., transportation modes, power plants, military operations).
Task Progress:	The project is completed--data collection in the study occurred without incident. This year, N=12 healthy adults completed the 12-day experimental protocol (for a total of 144 laboratory days). Thus, collectively across 4 years, N=71 healthy adults completed the 11-day experimental protocol (for a total of 852 laboratory days). Throughout the 12-day experimental protocol, in which subjects were under continuous behavioral monitoring, we collected a large number of neurobehavioral and physiological tests to determine the effects of cognitive workload. These included the following: the 10-minute Psychomotor Vigilance Test (PVT) and the PVT Self Test, which assess vigilant attention; a modified version of the Maintenance of Wakefulness Test (MWT), which lasts 30 minutes and assesses sleep propensity during waking; the Karolinska Sleepiness Scale (KSS); VAS fatigue scales; executive function tests that relate to prefrontal cortex functioning; cardiac measurements of heart rate and heart rate variability; polysomnography; power spectral analysis of non-REM slow-wave activity; waking EEG; and blood draws for genetic biomarker identification.
Bibliography Type:	Description: (Last Updated: 03/24/2024)
Abstracts for Journals and Proceedings	Abe T, Goel N, Braun ME, Dinges DF. "Effect of cognitive workload on polysomnographic measures under sleep restricted and non-sleep restricted conditions." 26th Annual Meeting of the Associated Professional Sleep Societies, Boston, MA, June 9-13, 2012. Sleep. 2012 Sleep. 2012;35 Suppl:A118-9. http://www.journalsleep.org/Resources/Documents/2012abstractsupplement.pdf , Jun-2012
Abstracts for Journals and Proceedings	Abe T, Goel N, Braun ME, Dinges DF. "Sleep Risks in Space: Effect of Cognitive Workload on Sleep Measures Under Sleep Restricted and Non-Sleep Restricted Conditions." 2012 NASA Human Research Program Investigators' Workshop, Houston, TX, February 14-16, 2012. 2012 NASA Human Research Program Investigators' Workshop, Houston, TX, February 14-16, 2012. , Feb-2012
Abstracts for Journals and Proceedings	Basner M, Mollicone DJ, Dinges DF. "Development of Briefer Versions of the Psychomotor Vigilance Test (PVT) as Sensitive Assays of Fatigue-Related Decrements in Vigilant Attention." 2012 NASA Human Research Program Investigators' Workshop, Houston, TX, February 14-16, 2012. 2012 NASA Human Research Program Investigators' Workshop, Houston, TX, February 14-16, 2012. , Feb-2012
Abstracts for Journals and Proceedings	Braun ME, Goel N, Abe T, Dinges DF. "Fatigue Risks in Space: Neurobehavioral and Physiological Effects of High Cognitive Workload and Chronic Sleep Restriction." 2012 NASA Human Research Program Investigators' Workshop, Houston, TX, February 14-16, 2012. 2012 NASA Human Research Program Investigators' Workshop, Houston, TX, February 14-16, 2012. , Feb-2012
Abstracts for Journals and Proceedings	Braun ME, Goel N, Dinges DF. "Neurobehavioral and physiological effects of high cognitive workload and chronic sleep restriction." 26th Annual Meeting of the Associated Professional Sleep Societies, Boston, MA, June 9-13, 2012. Sleep. 2012 Sleep. 2012;35 Suppl:A107. http://www.journalsleep.org/Resources/Documents/2012abstractsupplement.pdf , Jun-2012
Abstracts for Journals and Proceedings	Goel N, Banks S, Lin L, Mignot E, Dinges DF. "Genetic Markers for Differential Vulnerability to Chronic Sleep Restriction: Applications to Space." 2012 NASA Human Research Program Investigators' Workshop, Houston, TX, February 14-16, 2012. 2012 NASA Human Research Program Investigators' Workshop, Houston, TX, February 14-16, 2012. , Feb-2012
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Articles in Peer-reviewed Journals	Goel N. "Genetics of sleep timing, duration and homeostasis in humans." Sleep Medicine Clinics. 2011 Jun;6(2):171-82. http://dx.doi.org/10.1016/j.jsmc.2011.03.004 , Jun-2011

Articles in Peer-reviewed Journals	Basner M, Dinges DF. "An adaptive-duration version of the PVT accurately tracks changes in psychomotor vigilance induced by sleep restriction." Sleep. 2012 Feb 1;35(2):193-202. http://dx.doi.org/10.5665/sleep.1620 ; PubMed PMID: 22294809 , Feb-2012
Articles in Peer-reviewed Journals	Basner M, Mollicone DJ, Dinges DF. "Validity and sensitivity of a brief psychomotor vigilance test (PVT-B) to total and partial sleep deprivation" Acta Astronautica. 2011 Dec;69(11-12):949-59. http://dx.doi.org/10.1016/j.actaastro.2011.07.015 ; PubMed PMID: 22025811 , Dec-2011
Articles in Peer-reviewed Journals	Goel N, Banks S, Lin L, Mignot E, Dinges DF. "Catechol-O-methyltransferase Val158Met polymorphism associates with individual differences in sleep physiologic responses to chronic sleep loss." PLoS One. 2011;6(12):e29283. Epub 2011 Dec 27. http://dx.doi.org/10.1371/journal.pone.0029283 ; PubMed PMID: 22216231 , Dec-2011
Articles in Peer-reviewed Journals	Goel N, Dinges DF. "Behavioral and genetic markers of sleepiness." Journal of Clinical Sleep Medicine. 2011 Oct 15;7(5 Suppl):S19-21. Review. http://dx.doi.org/10.5664/JCSM.1348 ; PubMed PMID: 22003324 , Oct-2011
Articles in Peer-reviewed Journals	Goel N, Dinges, DF. "Predicting risk in space: Genetic markers for differential vulnerability to sleep restriction." Acta Astronautica. 2012 Aug-Sep;77:207-13. http://dx.doi.org/10.1016/j.actaastro.2012.04.002 , Aug-2012
Articles in Peer-reviewed Journals	Spaeth AM, Goel N, Dinges DF. "Managing neurobehavioral capability when social expediency trumps biological imperatives." Progress in Brain Research. 2012;199:377-98. http://dx.doi.org/10.1016/B978-0-444-59427-3.00021-6 ; PubMed PMID: 22877676 , Aug-2012
Articles in Peer-reviewed Journals	Dennis LE, Wohl RJ, Selame LA, Goel N. "Healthy adults display long-term trait-like neurobehavioral resilience and vulnerability to sleep loss. " Sci Rep. 2017 Nov 2;7(1):14889. https://doi.org/10.1038/s41598-017-14006-7 ; PubMed PMID: 29097703; PubMed Central PMCID: PMC5668275 , Nov-2017