Fiscal Year:	FY 2014	**Task Last Updated:**	FY 04/24/2014
PI Name:	Gernhardt, Michael Ph.D.		
Project Title:	Occupant Protection Data Mining and Modeling Project		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Space Human Factors Engineering		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **SHFH**:Space Human Factors & Habitability (archival in 2017)		
Human Research Program Risks:	(1) **Dynamic Loads**:Risk of Injury from Dynamic Loads		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
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City:	Houston	**State:**	TX
Zip Code:	77058	**Congressional District:**	22
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	Directed Research
Start Date:	06/20/2012	**End Date:**	04/30/2015
No. of Post Docs:	0	**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 JSC
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Flight Program:			
Flight Assignment:	NOTE: End date changed to 4/30/2015 per P. Baskin/JSC HRP (Ed., 2/9/15) NOTE: to be extended to 12/30/2014 per CoI (Ed., 4/25/14)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Somers, Jeffrey M.S. (Wyle Science, Technology and Engineering Group) Untaroiu, Costin Ph.D. (Virginia Tech and Wake Forest University) Perry, Chris Ph.D. (Wright-Patterson Air Force Base) Newby, Nathaniel M.S. (Wyle Science, Technology and Engineering Group) Caldwell, Erin (Wyle Science, Technology and Engineering Group)		
Grant/Contract No.:	Directed Research		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Current National Aeronautics and Space Administration (NASA) Occupant Protection standards and requirements are based on extrapolations of biodynamic models, which were based on human tests performed during pre-Space Shuttle human flight programs. In these tests, occupants were in different suit and seat configurations than are expected for the Multi Purpose Crew Vehicle (MPCV) and Commercial Crew programs. As a result, there is limited statistical validity to the Occupant Protection standards. Furthermore, the current standards and requirements have not been validated in relevant spaceflight suit and seat configurations or expected loading conditions. To address the limitations of the current NASA standards, this study will address the following two objectives: 1) Develop a Finite Element (FE) model of Test device for Human Occupant Restraint (THOR) Anthropomorphic Test Device (ATD), and 2) Conduct data mining of existing human injury and response data using the THOR FE model. In order to develop updated standards, adequate injury assessment tools must be chosen and developed. In the case of dynamic loads, the THOR ATD was chosen as the appropriate human surrogate. For the data mining portion of the task, re-creation of the conditions of each impact case is needed to determine injury risk. Since physical re-creation of each case is not feasible, a numerical model of the THOR ATD is desired. An existing THOR FE model will be refined and validated. To supplement available THOR ATD validation data, additional THOR ATD testing will be conducted at two facilities and ATD response data will be collected. The FE model responses will then be assessed against the physical ATD responses. Once the ATD model is validated, it can be used for the data mining portion of the study. Because analogous space flight injury biomechanics data are very limited, data mining of other analogous environments will be used. These datasets are chosen as they have similarities with the landing environment expected in future vehicles. The existing human injury and response data from other sources include historical military volunteer testing, automotive Crash Injury Research Engineering Network (CIREN), IndyCar impacts, and NASCAR impacts. These data sources can allow better extrapolation of the ATD responses to off-nominal conditions above the nominal range that can safely be tested in humans. These elements will be used to develop injury risk functions for each of the injury metrics measured from the ATD. These risk functions would then be incorporated with the results of other Tasks to update the NASA standards. Task Description: The ultimate aim of this project is to develop Occupant Protection standards for NASA that would apply to all future crewed spacecraft. 1. Conduct ATD dynamic tests to relate human and ATD responses. 2. Mine existing human injury and tolerance data and simulate dynamic environments using Finite Element (FE) models. Relate human injury and responses to ATD estimated responses from FE models. 3. Develop injury risk functions based on ATD responses and develop NASA standards from these functions.
Rationale for HRP Directed Research:	This research is directed because NASA must define complete scientific activities in a short time and there is insufficient time to issue a solicitation.
Research Impact/Earth Benefits:	The results of this study have a significant impact on terrestrial applications in the automotive and aviation safety communities. This study has access to unique and previously unpublished human impact exposure data, which allows new insight into human tolerance to dynamic loads. This can have a direct benefit on future protection systems in automobiles and aircraft.
Task Progress:	Several of the Specific Aims have been completed and several are in progress. Below are details on the work completed for each specific aim. Specific Aim 1. Conduct Anthropomorphic Test Device (ATD) dynamic tests to relate human and ATD Responses a. Conduct impact testing of the Test device for Human Occupant Restraint (THOR). This portion of the specific aim is complete. Testing of the THOR ATD was completed in January of 2013. b. Mine existing human injury and tolerance data. This portion of the specific aim is ongoing. Several datasets have been mined and several more are in work. In addition, significant work has been accomplished to obtain the racing driver collision data from IndyCar. c. Correlate THOR ATD responses to historical human responses under the same impact conditions. This specific aim is complete. The results of the study were recently published in the Stapp Car Crash Journal. d. Develop a Finite Element (FE) model of the updated THOR ATD. This specific aim is complete. The Test Device for Human Occupant Restraint (THOR) Anthropomorphic Test Device (ATD) Finite Element (FE) model was updated in collaboration with the National Highway Traffic Safety Administration (NHTSA). The resulting model was then optimized using physical test data and validated with an alternate set of data. Specific Aim 2. After mining existing human injury and tolerance data, simulate dynamic environments using Finite Element (FE) models. a. Evaluate the accuracy of the model against the physical test data collected in Specific Aim 1. This specific aim is complete. Using a similar method used in Specific Aim 1c along with the data collected in Specific Aim 1a, the FE model was optimized and validated. b. Model human exposure data collected from IndyCar, NASCAR, and military volunteer data. This specific aim is planned to be completed by the end of the project. Now that the FE THOR model is validated, additional seating configurations will be developed. Specific Aim 3. Develop injury risk functions based on ATD responses and develop NASA standards from these functions. This specific aim is expected to be completed at the end of the project.

Bibliography Type:	Description: (Last Updated: 10/31/2019)
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NASA Technical Documents	Somers J, Caldwell E, Newby N, Maher J, Gernhardt M, Untaroiu C, Putnam J. "Test Device for Human Occupant Restraint (THOR) Multi-Directional Biodynamic Response Testing." Houston, Tex.: NASA Lyndon B. Johnson Space Center, 2014. NASA Technical Memorandum NASA/TM-2014-217387. , Feb-2014
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