Fiscal Year:	FY 2013	**Task Last Updated:**	FY 04/22/2013
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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Zip Code:	77058	**Congressional District:**	22
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	Directed Research
Start Date:	06/20/2012	**End Date:**	06/30/2014
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:			
Key Personnel Changes/Previous PI:			
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Grant/Contract No.:	Directed Research		
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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:	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: 1. Conduct ATD dynamic tests to relate human and ATD responses. a. Conduct impact testing of the Test device for Human Occupant Restraint (THOR). There were some schedule delays related to borrowing the THOR ATD from NHTSA and also in coordinating with the test facility at Wright Patterson Air Force Base (WPAFB). Testing was ultimately completed in January 2013. A total of 46 tests were conducted in collaboration with WPAFB, 28 tests more than the original 18 tests planned. These additional tests, in the –X orientation, allow for enhanced assessment of the THOR in dynamics similar to expected spaceflight conditions. b. Mine existing human injury and tolerance data. The OP team received IRB approval of a de-identification protocol for IndyCar driver data in early October and subsequently received the de-identified dataset a few weeks later. Other datasets that have been received and analyzed this past year include additional data from the Air Force Research Laboratory (AFRL) and NASCAR data previously obtained through a Space Act Agreement. The OP team is also in discussions with U.S. Army Aeromedical Research Laboratory personnel to obtain Naval Biodynamics Laboratory data collected over a 25 year period. c. Correlate THOR ATD responses to historical human responses under the same impact conditions. This work started in January 2013 and is expected to complete in May 2013. An abstract describing the results was accepted by the Stapp Car Crash Conference and the results will be submitted to the Stapp Car Crash Journal in May 2013. d. Develop a Finite Element (FE) model of the updated THOR ATD. Although an earlier version of the ATD (THOR-NT) was validated previously, the team is working to update the current ATD (THOR-K) in collaboration with the National Highway Traffic Safety Administration, Toyota, University of Virginia and the Partnership for Dummy Biomechanics (PDB). The OP team was specifically tasked with updates to the head and neck and the other collaborators have agreed to update other parts of the model. This work is expected to be completed in early May 2013. 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. Once an updated THOR FE model is completely assembled in May 2013, a model of the WPAFB configuration will be created to allow assessment of the FE model against the physical test data collected in Specific Aim 1. This work is expected to be completed by the end of October 2013. b. Model human exposure data collected from IndyCar, NASCAR, and military volunteer data. Simulations of injury and non-injury cases will be conducted. These simulations will be driven by the dynamics recorded onboard the vehicle or sled. This allows estimates of the responses of the humans exposed to the same conditions. This work is expected to be completed by June 2013. 3. Develop injury risk functions based on ATD responses and develop NASA standards from these functions. Using the estimated responses from Specific Aim 2, statistical models will be developed to relate the responses to injury outcomes. The resulting statistical models will allow estimates of injury risk related to the THOR response parameters. Using these injury risk functions, Injury Assessment Reference Values (IARVs) can be determined for off-nominal conditions for future spacecraft. This work is planned for completion by study end (late June 2014), but it is possible that a small extension of the study may be required due to limitations in personnel availability to complete the work.
Bibliography Type:	Description: (Last Updated: 10/31/2019)
Abstracts for Journals and Proceedings	Newby N, Somers J, Caldwell E, Perry C, Littell J, Gernhardt M. "Assessing Biofidelity of the Test Device for Human Occupant Restraint (THOR-K) Against Historic Human Data." 57th Stapp Car Crash Conference, Orlando, FL, November 11-13, 2013. Stapp Car Crash Journal. Abstract submitted, April 2013. , Apr-2013
Abstracts for Journals and Proceedings	Somers J, Gernhardt M, Caldwell E, Newby N. "Assessing the Risk of Crew Injury Due to Dynamic Loads During Spaceflight." 2013 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-14, 2013. 2013 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-14, 2013 , Feb-2013
Abstracts for Journals and Proceedings	Caldwell E, Somers J, Newby N, Gernhardt M. "Investigation of the THOR Anthropomorphic Test Device for Predicting Injury to Crewmembers During Landing Impact." 2013 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-14, 2013. 2013 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-14, 2013. , Feb-2013
Abstracts for Journals and Proceedings	Newby N, Somers J, Caldwell E, Gernhardt M. "A Novel Approach for Defining a NASA Risk Posture for Occupant Injuries from Spacecraft Launch, Abort, and Landing." 2013 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-14, 2013. 2013 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-14, 2013. , Feb-2013
Abstracts for Journals and Proceedings	Somers JT. "Correlation of Hybrid III Numerical Models with Physical ATD Responses in Various Loading Directions." 2013 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-14, 2013. 2013 NASA Human Research Program Investigators' Workshop, Galveston, TX, February 12-14, 2013. , Feb-2013