Fiscal Year:	FY 2019	**Task Last Updated:**	FY 12/16/2019
PI Name:	Somers, Jeffrey M.S.		
Project Title:	ATD (Anthropomorphic Test Dummy) Injury Metric Development		
Division Name:	Human Research		
Program/Discipline:			
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Space Human Factors Engineering		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **HFBP**:Human Factors & Behavioral Performance (IRP Rev H)		
Human Research Program Risks:	(1) **Dynamic Loads**:Risk of In-Mission Injury and Performance Decrements and Long-term Health Effects due to 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:**	36
Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	Directed Research
Start Date:	07/01/2015	**End Date:**	09/30/2020
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
Contact Monitor:	Williams, Thomas	**Contact Phone:**	281-483-8773
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Flight Program:			
Flight Assignment:	NOTE: End date changed to 9/30/2020 per B. Gore/ARC HRP (Ed., 10/1/19) NOTE: End date changed to 9/30/2019 per E. Connell/HFBP/JSC (Ed., 11/17/17) NOTE: Element change to Human Factors & Behavioral Performance; previously Space Human Factors & Habitability (Ed., 1/19/17) NOTE: Change to start date per E. Connell/SHFH/HRP (Ed., 2/3/16) NOTE: Added "Development" to title, per E. Connell/SHFH/HRP (Ed., 10/7/15) NOTE: Change in title to "ATD Injury Metric" from "THOR Injury Metric Development" per E. Connell/SHFH HRP (Ed., 8/19/15) NOTE: Period of performance changed to 5/1/2015-9/30/2017 (previously 7/3/2014-10/31/2016) due to delayted start, per E. Connell/JSC SHFH element (Ed., 4/15/2015)		

Key Personnel Changes/Previous PI:	November 2019: Jacob Putnam removed as CoInvestigator and Preston Greenhalgh now CoInvestigator. May 2018: Remove Jessica Wells as Co-Investigator. June 2016 report--Additional CoInvestigators: Jessica Wells, Lockheed Martin Information Systems and Global Solutions, 2625 Bay Area Blvd, Houston, TX 77058, 281.483.7216. jessica.a.wells@nasa.gov ; Narayan Yoganandan, PhD, Medical College of Wisconsin, 9200 West Wisconsin Ave., Milwaukee, WI 53226. (414) 384-3453. yoga@mcw.edu ; John Humm, MS, Medical College of Wisconsin, 9200 West Wisconsin Ave., Milwaukee, WI 53226. jhumm@mcw.edu. ; Additional Key Personnel: Jacob Putnam, Wyle Science Technology and Engineering Group.
COI Name (Institution):	Yoganandan, Narayan Ph.D. (Medical College of Wisconsin) Humm, John M.S. (Medical College of Wisconsin) Greenhalgh, Preston M.S. (KBR/NASA Johnson Space Center)
Grant/Contract No.:	Directed Research
Performance Goal No.:	
Performance Goal Text:	
Task Description:	Data from the Hybrid III and THOR (Test Device for Human Occupant Restraint), anthropomorphic test devices (ATD) currently available to test the Occupant Protection requirements, are not well correlated to low-injury risk, as these ATDs were designed for automotive use. Automotive research is directed at preventing severe injuries in very low probability events. NASA vehicles require a lower risk of injury because the vehicles will land every time, making that a high probability event. The objective of this study is to develop injury risk functions for the Hybrid III and THOR ATDs. Matched pair tests between postmortem human surrogates (PMHS) and each ATD will be used to determine ATD-specific injury criteria. The merit of the matched pair design is the one-to-one correspondence of the results from external loads to both surrogates. Injury outcomes from PMHS tests will be used with region-specific data, such as forces and moments either individually or in combination, to derive ATD-specific injury criteria. Specific Aims 1. Identify appropriate datasets for ATD comparison 2. Test Hybrid III 50th percentile male and THOR in same conditions as historical testing 3. Use historical human data to establish tolerance and injury risk focusing on lateral responses and sex differences 4. Use Bayesian analysis combined with survival analysis along with human tolerance to estimate injury risk. Use results of prior data mining and existing literature as prior distribution 5. Develop new Injury Assessment Reference Values (IARVs) based on the new statistical analysis. Historical human data will be selected from the Medical College of Wisconsin (MCW) database. The data will be selected based on loading dynamics and subject demographics. Once these data are selected, the Hybrid III 50th percentile male and THOR ATDs will be tested in identical conditions. A Bayesian analysis along with survival analysis will be used to relate the resulting ATD responses to improve injury risk predictions. The results of the Occupant Protection (OP) Data Mining and Modeling Task will be used as prior distributions.
Rationale for HRP Directed Research:	This task meets the criteria for a Directed Task due to schedule constraints and the requirement of using the same test facilities used in the original human testing. Based on the approved Path to Risk Reduction, this task is required to be completed by the end of FY17 in order to meet the Orion schedule for EM-2. Because of this accelerated schedule, there is insufficient time to solicit this work. In addition, the testing in this task must be conducted to best replicate the original human test conditions. Because of this, testing will need to be conducted at the original test facility, excluding the ability to solicit the work.
Research Impact/Earth Benefits:	The outcome of this research will be improved Injury Assessment Reference Values (IARVs) for Anthropomorphic Test Devices or crash test dummies. By improving the quality of IARVs at low severity impacts in multiple directions, automotive vehicle designers can create safer cars and trucks and have the tools needed to show that a design is actually safer.
Task Progress:	For each phase of this study historical post-mortem human surrogate (PMHS) test cases are first selected from the Medical College of Wisconsin (MCW) database for match paired testing. Selection of these cases are made based on their similarity to spaceflight loading dynamics and Astronaut demographics. Once these data are selected, the Hybrid III 50th percentile male and THOR Anthropomorphic Test Device (ATD) are tested in identical conditions. A survival analysis is then used to relate the resulting ATD responses to identified PMHS injuries and develop injury risk correlation. This correlation will be used to improve upon the injury metrics previously developed in other research tasks. The resulting metrics will be used to update NASA standards and provided to the Orion and Commercial Crew Program to allow additional insight into verification, validation and risk analysis. Currently phase 1 – lower neck injury under rearward impact has been completed. A supplemental phase of this project, cervical spine injury under vertical contact loading, has also been completed. For this supplemental phase injury risk functions were developed from PMHS test only. It was determined that compressive contact loading, used in PMHS testing, had minimal value in matched paired ATD testing due to the inflexibility of the ATD head/neck structure in this loading configuration. The remaining lateral injury metrics for the neck, thorax, and pelvis are in various stages of completion and are on track to be finished by September 2020. The lateral lower neck metric development has completed the necessary ATD matched-pair testing, but due to a low number of those tests being applicable to spaceflight loading dynamics, additional cases are currently being run using finite element models to supplement the current data. In addition, tests using the GHBMC whole body finite element model are also being run in lateral neck loading conditions. ATD testing in the lateral acetabular loading cases showed that the ATDs are too stiff to match the input conditions of the cadaveric data. Therefore, an injury assessment reference value (IARV) is being created based on the cadaveric data, instead of the ATDs. The IARV for lateral chest compression is rib fracture. Correlation between cadaveric and ATD chest compression is

	difficult due to the mechanism to calculate fracture. The method for calculating fracture for the cadaveric and different ATDs are all different and do not necessarily correlated to the same points on the thorax and can not necessarily be used together. Current research includes finding the best way to create the IARV for rib fracture. Other current research includes finding the injury metrics for pelvis and examining the effect of sex differences in lower neck, lateral thorax, lateral pelvis injuries, as well as sex differences in lordosis.
Bibliography Type:	Description: (Last Updated: 12/29/2020)
Articles in Peer-reviewed Journals	Yoganandan N, Humm JR, DeVogel N, Banerjee A, Pintar FA, Somers JT. "Pelvis injury risk curves in side impacts from human cadaver experiments using survival analysis and Brier score metrics." Traffic Injury Prevention. 2019;20 Suppl 2:S137-S142. Published online: 25 Nov 2019. https://doi.org/10.1080/15389588.2019.1682565 ; PubMed PMID: 31762331 , Nov-2019