Fiscal Year:	FY 2020	**Task Last Updated:**	FY 12/21/2020
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		
PI Email:	jeff.somers@nasa.gov	**Fax:**	FY
PI Organization Type:	NASA CENTER	**Phone:**	281-483-6010
Organization Name:	KBR/NASA Johnson Space Center		
PI Address 1:	2400 NASA Parklway		
PI Address 2:	MAILCODE: WYLE/HAC/37C		
PI Web Page:			
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:	1	**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
Contact Email:	thomas.j.will1@nasa.gov		
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 lower neck injury, lateral responses, and sex differences 4. Perform survival analysis with human tolerance to estimate injury risk and 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. For each phase of this study, historical PMHS test cases were first selected from the Medical College of Wisconsin (MCW) database for matched-pair testing. Selection of these cases was made based on their similarity to spaceflight loading dynamics and astronaut demographics. Once these data were selected, the Hybrid III 50th percentile male and THOR ATD are tested in identical conditions. The following injury criteria were evaluated: 1. Lower neck injury in rearward loading 2. Vertical neck loading 3. Upper and lower neck under lateral loading 4. Thorax in lateral loading 5. Pelvis in lateral loading A survival analysis was used to relate the resulting dynamic responses to identified PMHS injuries and develop injury risk correlation. This correlation was used to improve upon the injury metrics previously developed under the Occupant Protection (OP) Data Mining and Modeling Task. The resulting metrics will be used to update NASA standards and provided to the Orion and Commercial Crew programs to allow additional insight into verification, validation, and risk analysis.
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:	1 Lower Neck Injury in Rearward Loading. A total of 18 post mortem human surrogates (PMHS) were selected for this phase of the study. Each PMHS was exposed to accelerations inducing a combination shear force and extension moment of the neck. Matched pair testing of the Hybrid III and THOR Anthropomorphic Test Devices (ATDs) were also conducted in the same loading conditions, allowing direct comparison of the ATD responses and injury outcomes reported in the PMHS tests. A lower neck injury criteria (LNij) was calculated using parametric survival analysis for the PMHS, Hybrid III, and THOR using a critical intercept for both the shear force and extension moments. The resulting injury risk curves (IRCs) were calculated along with confidence intervals. The quality of the fit for each injury assessment reference values (IARVs) was evaluated using the normalized confidence interval size (NCIS). The LNij was evaluated at the 5% risk level (consistent with NASA standards for injury risk during dynamic phases of flight). For the PMHS and THOR ATD, the LNij was found to be a good fit. For the Hybrid III ATD, the LNij fit was found to be fair. 2 Vertical Neck Loading. A total of 36 PMHS were selected for this phase of the study. There were 2 groups used for testing, a group that was tested in an upright orientation, and the other tested in an inverted orientation. Each PMHS head-neck was loaded axially inducing a compression force. Because of the nature of the loading, and because ATD responses are not biofidelic, matched pair testing of the Hybrid III and THOR ATDs could not be conducted. As with the previous phase, the injury metric (axial force) was calculated using parametric survival analysis for the PMHS. The resulting IRCs were calculated along with confidence intervals with the same quality assessment used. The axial force was evaluated at the 5% risk level and found have a good fit quality in both the upright and inverted tests, as well as with the combined female data set of all ages. 3. Upper and Lower Neck under Lateral Loading. A total of 11 PMHS were selected for this phase of the study. There were 3 groups used for testing, with varying torso restraint used. Each PMHS was accelerated laterally, inducing a combined lateral moment, lateral shear force, and axial tension force in the neck of the PMHS. Matched pair testing of the Hybrid III and THOR ATD were also conducted in the same loading conditions, allowing direct comparison of the ATD responses and injury outcomes reported in the PMHS tests. As with the previous phase, the injury metric (lower lateral neck injury criteria, lower LatNij) was calculated using parametric survival analysis for the PMHS. The resulting IRCs were calculated along with confidence intervals with the same quality assessment used. The lower LatNij was evaluated at the 5% risk level. For the PMHS and THOR ATD, the lower LatNij was found to be an excellent fit. For the Hybrid III ATD, the lower LatNij fit was found to be a good. 4. Thorax in Lateral Loading. A total of 17 PMHS were selected for this phase of the study. Each PMHS was accelerated laterally, inducing chest deflection in the torso of the PMHS. Matched pair testing of the THOR ATD was also conducted in the same loading conditions; however, the instrumentation in the THOR chest did not respond significantly to the lateral deflections. The Hybrid III lacks lateral instrumentation required to respond to lateral loading and was not tested. As with the previous phase, the injury metric (lateral chest deflection) was calculated using parametric survival analysis for the PMHS. The resulting IRCs were calculated along with confidence intervals with the same quality assessment used. The lateral chest deflection was evaluated at the 5% risk level on the PHMS and was found to be an excellent fit. 5. Pelvis in Lateral Loading. A total of 22 PMHS were selected for this phase of the study. Each PMHS was loaded directly with a pendulum mass centered on the greater trochanter. Matched pair testing of the THOR ATD was also conducted in the same loading conditions; however, the instrumentation in the THOR acetabulum load cells reached their maximum range before reaching the injury conditions in the PMHS and thus the results were not able to be used to create IARVs. The Hybrid III lacks lateral instrumentation required to respond to lateral loading and was not tested. As with the previous phase, the injury metric (lateral greater trochanter force) was calculated using parametric survival analysis for the PMHS. The resulting IRCs were calculated along with confidence intervals with the same quality assessment used. The lateral greater trochanter force was evaluated at the 5% risk level on the PHMS and was found to be a good fit.
Bibliography Type:	Description: (Last Updated: 12/29/2020)