Fiscal Year:	FY 2011	**Task Last Updated:**	FY 12/13/2011
PI Name:	Weaver, Aaron Ph.D.		
Project Title:	Spaceflight Injectable Delivery System		
Division Name:	Human Research		
Program/Discipline:	HUMAN RESEARCH		
Program/Discipline--Element/Subdiscipline:	HUMAN RESEARCH--Operational and clinical research		
Joint Agency Name:		**TechPort:**	Yes
Human Research Program Elements:	(1) **ExMC**:Exploration Medical Capabilities		
Human Research Program Risks:	(1) **Medical Conditions**:Risk of Adverse Health Outcomes and Decrements in Performance Due to Medical Conditions that occur in Mission, as well as Long Term Health Outcomes Due to Mission Exposures		
Space Biology Element:	None		
Space Biology Cross-Element Discipline:	None		
Space Biology Special Category:	None		
PI Email:	Aaron.S.Weaver@nasa.gov	**Fax:**	FY
PI Organization Type:	NASA CENTER	**Phone:**	(216) 433-3757
Organization Name:	NASA Glenn Research Center		
PI Address 1:	21000 Brookpark Road		
PI Address 2:	Mail Stop 110-3		
PI Web Page:			
City:	Cleveland	**State:**	OH
Zip Code:	44135	**Congressional District:**	10
Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	Directed Research
Start Date:	10/01/2008	**End Date:**	12/30/2011
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:	Watkins, Sharmi1a	**Contact Phone:**	281.483.0395
Contact Email:	sharmila.watkins@nasa.gov		
Flight Program:			
Flight Assignment:	NOTE: Per the Human Research Roadmap and HRP Master Task List, the project is currently in an archived state. End date changed to 12/30/2011; original end date was 9/30/2014 (Ed., 9/20/2012)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):			
Grant/Contract No.:	Directed Research		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	In the event of an emergency during spaceflight, it may be necessary for the crew to find extended safety in their Extra-Vehicular Activity (EVA) spacesuits. During this EVA contingency, NASA requires the capability to deliver liquid medications via intramuscular injection to ill or injured crewmembers. The delivery of liquid medication in a damaged vehicle unable to maintain a habitable environment poses unique challenges. Some of these challenges include the behavior of the fluid in a low-pressure and off-nominal-temperature environment, the formation of bubbles in microgravity, and the ability to physically use the medical delivery device at the desired anatomical location while the astronaut is suited. Under the auspices of NASA's Human Research Program, the In-Suit Injection System project (ISIS) at the Glenn Research Center (GRC) aims to develop an injection device capable of delivering necessary medications during an EVA contingency.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	This technology development project aims to design a medical injection device for the harsh environment of space. This technology could translate to harsh Earth environments such as during underwater diving or during a hazardous materials/chemicals scenarios requiring the user to be in a containment suit.
Task Progress:	In the event of an emergency during spaceflight, it may be necessary for the crew to find extended safety in their Extra-Vehicular Activity (EVA) spacesuits. During this EVA contingency, NASA requires the capability to deliver liquid medications via intramuscular injection to ill or injured crewmembers. The delivery of liquid medication in a damaged vehicle unable to maintain a habitable environment poses unique challenges. Some of these challenges include the behavior of the fluid in a low-pressure and off-nominal-temperature environment, the formation of bubbles in microgravity, and the ability to physically use the medical delivery device at the desired anatomical location while the astronaut is suited. Under the auspices of NASA's Human Research Program, the In-Suit Injection System project (ISIS) at the Glenn Research Center (GRC) aims to develop an injection device capable of delivering necessary medications during an EVA contingency. During this task book reporting period, preliminary testing was performed to determine appropriate components for a device. After this testing, a prototype device was designed, fabricated, and tested. In order to design and build a prototype injection device, preliminary testing was completed to determine key components. This testing included human factors elements, computational modeling, and vacuum chamber testing. To determine the best geometry for ease of device use, many different sized and shaped commercially available syringes were taken to the Johnson Space Center (JSC) for testing. There, they were placed in a glovebox, which creates a pressure differential equal to what astronauts would experience in while in their EVA suits. To interface with the syringes, the operator donned standard EVA gloves. While in the glovebox, the operator then unpacked, assembled, and mock injected the syringes into a ballistic gel to simulate the use of the syringe from start to finish. From this testing, it was determined that any commercial style syringe would be too difficult to use in a gloved situation. This testing also helped determine the appropriate diameter for the injection device. Another challenge for the injection device will be the thermal environment to which it will be subjected. To examine how long it will take liquid medication to reach a temperature point outside of acceptable limits, computational fluids models were developed using COMSOL Multiphysics Software (Burlington, MA). From the developed models, it was determined that some of the medication will reach its viability limit within 25 seconds of being exposed to the environment, and that it would take 7-7.5 hours for it to reach 99% steady state without thermal conditioning. Finally, to determine how best to interface a needled injection device with an EVA suit, testing was performed on rubber septa. Medicinal vials, sealed by differing combinations of septa material were punctured by a needle. Using either force gauges or a vacuum chamber, the septa were tested in an ambient environment, a low-temperature environment, and a low-pressure environment. From this testing, it was determined that an 1/8-inch-thick septa with two possible coatings would be most effective for the device interface. Informed by the preliminary testing and by consultation with Johnson Space Center (JSC) flight medical staff, a prototype injection system was designed and fabricated. The main goal of the prototype was to demonstrate the capability to deliver liquid medication while emphasizing crew safety and protecting the medication from the outside environment. Key components of the device include: • Spring-loaded design to allow for push-button operation • Simple operation to allow crew to inject themselves or crewmates • External housing to enclose an internal syringe and needle • Two-layer safety mechanism to prevent inadvertent deployment • Mechanical design to ensure medication is not delivered until needle has penetrated the muscle • Optional adapter to allow for operation outside of the EVA suit. Solid models of the device before it has been triggered ("Ready" state), when the needle has been deployed ("Injected" state), and when the medication has been delivered ("Delivered" state) have been demonstrated. From the "Ready" state, a push button is depressed releasing the first set of springs. These springs translate the syringe through the external housing until the needle has penetrated the muscle. After hitting a mechanical stop, a second spring depresses the plunger of the syringe, delivering the medication. The external housing protects the medication from the external environment. After fabrication of the prototype, testing was performed to validate design characteristics. The injector, filled with liquid, was placed in a vacuum (0.04 psia) and showed no evidence of leakage. The device was also tested in a chamber to simulate the pressure of the EVA suit. From this testing it was shown that the needle will be able to penetrate the injection interface, and that the medication does not prematurely deploy before the needle has entered the muscle. Finally, operation using a gloved hand was tested to explore ease of operation.

Bibliography Type:	Description: (Last Updated:)