Fiscal Year:	FY 2011	**Task Last Updated:**	FY 09/10/2010
PI Name:	Olson, Sandra Ph.D.		
Project Title:	Oxygen 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		
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City:	Cleveland	**State:**	OH
Zip Code:	44135	**Congressional District:**	9
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	Directed Research
Start Date:	10/02/2008	**End Date:**	12/20/2013
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: Title change to Oxygen Delivery System (previously Medical Oxygen Fire Safety), per M. Covington/JSC via S. Watkins/ExMC/JSC (Ed., 9/23/13)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):			
Grant/Contract No.:	Directed Research		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	The goal of the Medical Oxygen Concentrator for Spacecraft Emergencies (MOCSE) Project is to develop an oxygen concentrator that provides a reliable source of enriched oxygen from spacecraft cabin air for use in medical contingency operations for current and future spaceflight programs. The current medical oxygen requirement aboard ISS is being met using 100% oxygen from high pressure oxygen tanks, but the problem with this system is that it elevates the cabin oxygen concentration so that extended use will increase the fire hazard in an already contingency operation. The objective of the technology development is to produce a robust system that concentrates the air in the cabin and delivers that to the patient without adding oxygen to the cabin air and thus without increasing the fire hazard in the cabin. Work on this project contains three thrusts as defined below: CONCENTRATOR TECHNOLOGY THRUST While oxygen concentrators are available commercially, they do not meet NASA spaceflight requirements. Accordingly, NASA has undertaken steps to correct that situation. First, in the Fall of 2009, NASA selected Lynntech, Inc. for a Phase II SBIR award to develop electrochemical membrane technology for use as an oxygen concentrator. This promising concept could dramatically reduce the size from what is currently commercially available. In a second technology thrust, the National Space Biomedical Research Institute awarded a grant to Professor James Ritter of the University of South Carolina is developing techniques to modify commercial oxygen concentrators so that they are compatible with spaceflight. NASA’s role in this effort is to act as a collaborator: providing information on constraints associated with spaceflight hardware, particularly for oxygen systems, communicating requirements, and as a developer of ancillary technologies, such as batteries. FIRE SAFETY THRUST While the fire hazard associated with an oxygen concentrator is unquestionably lower than that present when oxygen from a storage bottle is released into the closed spacecraft environment, local fire hazards still exist around the patient and the concentrator equipment. NASA Glenn personnel analyzed the hazards associated with this medical treatment, and will continue to analyze the hazards associated with the hardware under development. BATTERY TECHNOLOGY THRUST Given the requirement for 24 hours of operation independent of vehicle power, commercially available batteries may not be able to meet the power requirements of these devices. Given their joint expertise in battery technology, a partnership of NASA GRC and industry personnel will advance the state of the art in metal-air batteries to be compatible with NASA requirements. A Phase I SBIR call was issued in 2010 for advanced battery technology to address this need, and 8 response proposals have been received and are under review.
Rationale for HRP Directed Research:	This research is directed because it contains highly constrained research, which requires focused and constrained data gathering and analysis that is more appropriately obtained through a non-competitive proposal.
Research Impact/Earth Benefits:	The development of a small, portable oxygen concentrator and batteries that can be used to run the oxygen concentrator would have widespread application for use in personal medical oxygen applications, providing patients with significant mobility improvements.
Task Progress:	Oxygen Concentrator Thrust In 2009, NASA awarded a Phase I SBIR contract to TDA, Inc. (PI: Alptekin), do further develop pressure swing absorption technology to produce oxygen enriched air. The contractor demonstrated technology that absorbed nitrogen from cabin air, producing a concentrated oxygen flow. While TDA submitted a Phase II proposal, it was not selected for award. At the same time as TDA’s award, NASA also awarded a Phase I contract to Lynntech, Inc (PI: Cisar). Lynntech’s technology is based on electrochemical membranes, similar to what is used in fuel cells. NASA awarded a Phase II SBIR contract to develop a small, portable oxygen concentrator for spaceflight use to Lynntech in early 2010. Lynntech has proposed to continue development of their technology with the expected result after 2 years of a TRL Level 6 prototype unit that can be performance tested. If successfully awarded and developed, Phase III proposals would take the product to flight ready. A National Space Biomedical Research Institute (NSBRI) task is also underway with the University of South Carolina (PI: Ritter) that will combine new air compressor designs with advances in Pressure Swing Adsorption (PSA) technology to develop an improved oxygen concentrator breadboard system that will supply 4 LPM of oxygen, weigh 7.2 pounds and require 106 watts of electric power. Spacecraft Fire Safety Thrust Future space missions will take us beyond Earth’s orbit to nearby asteroids, various moons, and Mars. The interplanetary spacecraft that will be used for these missions will have an internal atmosphere that is currently envisioned to be at reduced pressure and elevated oxygen to facilitate extra-vehicular activities. Due to the long duration of these exploration missions, medical support for the crew will include advanced life support equipment, including patient ventilation with oxygen. These increased levels of oxygen pose an increased risk of fire, especially in off-nominal procedures such as medical emergencies. Modeling results indicate that when a patient is on oxygen, the oxygen concentration aboard the International Space Station (ISS) rises very slowly due to the large volume and good mixing due to ventilation. In much smaller capsule type spacecraft, the oxygen concentration increases much more rapidly and the fire risk increases accordingly. Continuously Stirred Tank Reactor (CSTR) models of the oxygen concentration as a function of time for both the ISS and a capsule are presented as well as numerical models of the oxygen immediately around a patient in the US Lab aboard ISS under normal spacecraft ventilation and with the ventilation deactivated, as it might be in a fire emergency. Even in the ISS well-mixed scenario there is a pocket of elevated oxygen around an astronaut's head and torso that creates a higher risk situation. If an ignition source such as a friction device (drill or other tool), cautery tool, laser, or electric shock is introduced into this region, the resulting fire can rapidly spread through the oxygen-saturated clothing and hair as well as to other astronauts who are trying to treat the patient. Serious burns can occur in seconds.

Advanced Battery Development

The need for advanced battery technology is driven by the oxygen concentrator power requirements as well as the mass and volume restrictions placed on the oxygen concentrators by the governing requirements. This means the energy requirements for the oxygen concentrator may be in excess of 1000 Watt-hours/kilogram (Wh/kg) and currently there are no commercially available primary batteries that have the ability to meet that requirement.

There are only a few chemistries with a reasonable chance of achieving specific energies in excess of 1000 Wh/kg within the next few years. Metal/air systems are the most likely candidates. These systems can achieve higher specific energy because they rely on ambient air as one of the reactants and thus realize a mass benefit by not having to include the mass of the oxygen used in the reaction. The highest theoretical specific energy for metal-air battery chemistry is lithium/air at 11,500 Wh/kg giving it the best potential to realize the highest specific energy values of any battery chemistry, possibly upwards of 10 times greater than a state-of-the-art lithium thionyl chloride battery. Although lithium/air batteries are not yet available commercially, the chemistry is very similar to both zinc/air and aluminum/air making it much easier to realize the technological advances needed to develop this battery chemistry and produce a working lithium/air battery with a practical specific capacity that would meet the oxygen concentrator’s battery power and mass requirements.

NASA does not currently sponsor any development efforts related to metal air systems. There is a good match between the current battery requirements for the oxygen concentrator and the capabilities of metal/air systems. This is an area that could ideally be addressed in the context of the SBIR awards would not only enable oxygen concentrators to meet their requirements, but also advance the technology so that these lightweight systems could spin off into other areas such as power for medical devices. Accordingly, a battery SBIR call, has been released, proposals have been received and are being reviewed.

Ideally, multiple phase I SBIR awards will be issued, funded, and closely monitored in the hope that at least one will lead to a phase II SBIR effort. The effort would be structured so that at the conclusion of the phase II SBIR effort a prototype battery or smaller, multiple prototype battery modules will be delivered in addition to the final report. These deliverable batteries will undergo validation and verification testing in the Electrochemistry Branch facility at GRC. Furthermore, a phase III SBIR effort may be utilized to purchase additional prototype battery units for TRL6 validation and verification testing.

Bibliography Type:	Description: (Last Updated: 04/17/2024)
Papers from Meeting Proceedings	Olson SL, Griffin DW, Urban DL, Ruff GA, Smith EA. "Flammability of Human Hair in Exploration Atmospheres." International Conference on Environmental Systems, Savannah, GA, July, 2009. ICES Paper number 09-01-2512. July 2009. , Jul-2009