Fiscal Year:	FY 2014	**Task Last Updated:**	FY 09/24/2013
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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Organization Name:	NASA Glenn Research Center		
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City:	Cleveland	**State:**	OH
Zip Code:	44135	**Congressional District:**	9
Comments:			
Project Type:	FLIGHT,GROUND	**Solicitation / Funding Source:**	Directed Research
Start Date:	10/02/2008	**End Date:**	12/31/2017
No. of Post Docs:	1	**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:**	2
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NASA JSC
Contact Monitor:	Watkins, Sharmi1a	**Contact Phone:**	281.483.0395
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Flight Program:	ISS		
Flight Assignment:	NOTE: End date changed to 12/31/2017 per transfer to ECLSS; information from ExMC element/JSC (Ed., 3/12/18) NOTE: End date changed to 9/30/2019 per HRP Technology Pipeline spreadsheet sent by B. Corbin (Ed., 9/9/14) 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) NOTE: End date changed to 12/31/17 per PI information (Ed., 7/26/13)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):			
Grant/Contract No.:	Directed Research		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	Future space missions will take astronauts beyond Earth's orbit. The spacecraft that will be used for these missions is currently envisioned to have an internal atmosphere that is at a reduced pressure and elevated oxygen percentage, which assists with extra-vehicular activities. These exploration missions may be long in duration (e.g. 36 months), which requires that medical support be available for the crew. This medical support will include advanced life support equipment, which includes patient ventilation with oxygen. There are many medical conditions listed on the Space Medicine Exploration Medicine Conditions List (SMEMCL) that involve either treatment with supplemental oxygen or full ventilator support. Medical conditions that the Oxygen Concentrator Module must address per decision of NASA's Exploration Medical Capabilities Advisory Board include those which may require oxygen or ventilation use including: smoke inhalation, sepsis, angina/myocardial infarction, hypovolemic shock, medication overdose, decompression sickness, stroke, head injury, choking/obstructed airway, chest injury, sudden cardiac arrest, altitude sickness, seizures, cardiogenic shock, radiation syndrome, neurogenic shock, toxic exposure to ammonia, and anaphylaxis. There are two US oxygen delivery systems currently used onboard the International Space Station (ISS); the Respiratory Support Pack (RSP) and the Portable Breathing Apparatus (PBA). The RSP uses the ISS 120 psi oxygen lines and delivers pure oxygen up to 12 L/min. The RSP is for medical O2 usage. The PBA consists of a non-refillable portable oxygen bottle that provides 15 minutes of oxygen and also includes a 30 foot hose to attach to the ISS oxygen lines for long term oxygen supply. The PBAs are distributed throughout the ISS, and a few are available in each module or node. Both the PBAs and the RSP can obtain their oxygen supply from high pressure tanks located on the ISS. The PBAs also attached to the ISS oxygen line for use during the pre-Extravehicular Activity (EVA) pre-breathe protocol (a method of decreasing the body's nitrogen load and the risk of decompression sickness). The PBAs are also used for emergency oxygen usage (e.g. in a tox hazard or fire situation). An alternative to the US oxygen mask is the Russian isolating gas mask that can be used during fire or atmospheric contamination events. It provides 70 minutes of oxygen, but has been reported to be bulky, hot, and uncomfortable to wear for long periods of time. The main challenge with the current systems is that when using either the RSP or PBAs, the cabin oxygen concentration is elevated which increases the fire hazard. Modeling results have shown that when a patient is receiving oxygen, the oxygen concentration aboard the ISS rises very slowly secondary to the large volume and good mixing due to ventilation. In a much smaller spacecraft, the oxygen concentration increases much more rapidly and the risk of fire increases accordingly. Even in the ISS well-mixed scenario there is a pocket of elevated oxygen around the astronaut's head and chest area that creates a high risk situation. If an ignition source is introduced into this area, the resulting fire can rapidly spread through the oxygen-saturated clothing and hair as well as to other astronauts who may be treating the patient. For exploration atmospheres, the ambient atmosphere may be at elevated oxygen and reduced pressure as the norm, increasing the flammability of materials in general. Ignition hazards for medical operations during future space flights may be similar to those encountered in a typical operating room: defibrillators, laser beams, and fiber optic light sources are already available on the ISS. These tools can cause sparks when the energy impacts a metallic surface. The sparks or even the glowing embers of charring materials can provide enough initial heat to ignite some fuels, especially in oxygen enriched atmospheres. Hot electrical components in an oxygen enriched environment can be a source of ignition also. The ignition hazard may exist for a few minutes after deactivation of the source. Heat transfer is different in microgravity. Hot surfaces are hotter in the absence of gravity, and cooling times are longer.
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:	Long duration exploration missions require that medical support be available for the crew. This medical support will include advanced life support equipment, which includes patient ventilation with oxygen. The current medical oxygen requirement onboard the International Space Station (ISS) is met using 100 percent oxygen from high pressure oxygen tanks. Using 100 percent oxygen can increase the risk of fire. Providing a method of oxygen therapy that keeps the oxygen levels below the vehicle fire limit will allow extended duration of oxygen therapy without intervention required to reduce the cabin oxygen levels. Improved oxygen concentration technology could also find wide application on Earth.
Task Progress:	We currently have two oxygen concentrator technologies under development. The Small Business Innovation Research (SBIR) Phase II unit was delivered in the fall of 2012, and the final report will be delivered by February, 2014. The National Space Biomedical Research Institute (NSBRI) unit will be complete in late 2013. We are currently testing the SBIR prototype units in the lab to evaluate how well it performs to meet the requirements. Similar testing will occur with the NSBRI unit when it is received. In addition, an assessment of their applicability to microgravity operation will also be performed. At the end of these evaluations, one of the technologies will be selected for flight development. The two technologies being pursued are: 1) the Pressure Swing Adsorption (PSA) method, and 2) the Electrochemical Proton Exchange Membrane technology. The PSA method extracts oxygen from the air by filtering out the nitrogen and then providing the oxygen to the patient. Under high pressure gas tends to be attracted to solid surfaces, or adsorbed. The higher the pressure the more gas is adsorbed; when the pressure is reduced the gas is released. In typical oxygen concentrators, air is passed under pressure through a vessel containing material which adsorbs nitrogen, allowing the enriched oxygen to pass through to the patient. The nitrogen can be released by reducing the pressure and then the system is ready for another cycle of producing enriched oxygen from air. The Electrochemical Proton Exchange Membrane technology relies on liquid water. The Proton Exchange Membrane uses electrical energy to transport O2 from the Cathode to the Anode in the form of H2O. Recent input from the Human Research Program Exploration Medical Capabilities (ExMC) element Advisory Board requested the inclusion of a closed loop oxygenation monitoring system that would monitor the patient's blood saturation level via pulse oximetry, and adjust the oxygen flow accordingly through medically certified protocols. Also, the board requested an increase in the flow rate range of the oxygen concentrator module to 2-15 SLPM, which the project is evaluating. Lastly, the Integrated Medical Model was used to predict the likelihood of crew medical issues requiring oxygen, and found that the most likely event by over a factor of 10 was the treatment of smoke inhalation. Thus an inlet filter on the oxygen concentration will be needed to cleanse the ambient atmosphere prior to delivery of oxygen to the patient.

	In addition to providing oxygen during medical emergencies, the Oxygen Concentrator Module could also be an option for use for pre-breathing by the crew in preparation for Extravehicular Activities (EVA). The portability of the system could allow the astronaut the ability to move freely within the spacecraft while completing the pre-breathing protocol and not be confined to the airlock. It could also be used as a first stage of an oxygen tank repressurization system. It could also be used in fire-fighting in lieu of oxygen bottles or simple respirators. The current plan is to fly a prototype unit aboard ISS to verify the technology, and then build and fully qualify an exploration system.
Bibliography Type:	Description: (Last Updated: 05/01/2023)
Abstracts for Journals and Proceedings	Olson SL. "A Portable Oxygen Concentrator Module for Exploration Mission Scenarios." 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	Ritter JA, LeVan MD, Edwards P, Knox JC. "Development of Pressure Swing Adsorption Technology for Spaceflight Oxygen Concentrators." 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	Balasubramanian A, Reeh J, Lange J, Teurman C, Cisar A. "Portable cathode-air vapor-feed electrochemical medical oxygen concentrator." 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