Fiscal Year:	FY 2018	**Task Last Updated:**	FY 03/05/2018
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:	Flight,Ground	**Solicitation / Funding Source:**	Directed Research
Start Date:	10/02/2008	**End Date:**	12/31/2017
No. of Post Docs:	2	**No. of PhD Degrees:**	2
No. of PhD Candidates:	2	**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:	Antonsen, Erik	**Contact Phone:**	281.483.4961
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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:	NASA's Exploration Medical Capability (ExMC) is charged to reduce the risk of adverse health and mission outcomes due to limitations of in-flight medical capabilities. They have identified a number of technology gaps, one of which is: Current spaceflight oxygen delivery systems deliver pure oxygen to the crewmember from high pressure oxygen tanks, which results in a gradual increase in cabin oxygen levels and a localized area of increased oxygen concentration in the vicinity of the crewmember, posing an increased fire hazard. The Oxygen Concentrator Module (OCM) project is tasked with developing an oxygen delivery system with variable oxygen capability that minimizes localized oxygen build-up and meets the commercial crew vehicle evacuation requirements. Work focuses on the development of a supplemental oxygen delivery system for crewmembers that pulls oxygen out of the ambient environment instead of using compressed oxygen. This provides better resource optimization and reduces fire hazard by preventing the formation of localized pockets of increased oxygen concentration within the vehicle. The system will provide oxygen support in a closed cabin environment where the atmosphere may be at a reduced pressure and elevated oxygen percentage (compared to terrestrial standard atmosphere composition and pressure). Future space missions will take astronauts beyond Earth's orbit. These exploration missions may be long in duration (e.g., 36 months) and will have limited resources. It is vital that each piece of equipment serve as many functions as possible, with built in redundancy. A modular oxygen concentrator that uses the ambient cabin air can serve a number of functions (medical emergency, pre-breathing, atmospheric contamination, or leak) without taxing other spacecraft systems to compensate for an increase in ambient oxygen. This improves mission safety by not exacerbating fire risk, and minimizing system interdependencies. This gap aligns well with the International Space Station (ISS) Health Maintenance System (HMS) because HMS currently has no oxygen delivery system that can meet commercial crew vehicle evacuation requirements. Concentrating oxygen from cabin air eliminates the up mass associated with oxygen tanks and reduces fire hazard, as it prevents the formation of localized pockets of increased oxygen levels within the vehicle. An oxygen concentrator for crew medical support is considered vital to provide an ill crewmember with ventilation with oxygen. Providing a method of oxygen therapy that uses cabin air keeps the oxygen levels stable and avoids Environmental Control and Life Support System (ECLSS) intervention required to maintain the cabin oxygen levels. The medical conditions requiring oxygen supplementation include: Altitude sickness, Anaphylaxis, Burns, Choking/obstructed airway, Cough –URI, bronchitis, pneumonia, inhalation, De Novo cardiac arrhythmia, Decompression sickness, Headache (CO2, SAS, other), Infection – sepsis, Medication overdose/misuse, Neck injury, Radiation sickness, Seizure, Smoke inhalation, and Toxic exposure. The final flight system for an oxygen delivery system needs to be Food & Drug Administration (FDA) clearable device and should be designed to minimize mass, volume, and power. A demonstration unit for the International Space Station (ISS) should verify the technology and provide oxygen capability for ISS. There are two US oxygen delivery systems currently used onboard the 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 spaceflights 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 environmental control intervention required to reduce the cabin oxygen levels. Improved oxygen concentration technology could also find wide application on Earth.
Task Progress:	The oxygen concentrator project has been subsumed into the Space Technology Mission Directorate's (STMD) funded research and development for environmental control and life support (ECLS) oxygen – including metabolic breathing oxygen, emergency medical oxygen, and high pressure space suit grade oxygen. Monthly telecons to discuss Oxygen Generation and Recovery (OGRe) have begun between various members of Marshall Space Flight Center MSFC-ES62, Johnson Space Center JSC-EC311, and Glenn Research Center GRC-MSI, LTT, and LTX. A concept of operations document was baselined [1]. The ConOps provides a description of the Medical Oxygen Patient Interface (MOPI) in an easily understood format of narrative and illustration. The ConOps is a system level conceptual response to the requirements stated in the Engineering Requirements Document (ERD). It provides a description of the primary system functions, and concepts for integration, deployment, operations, and support. The purpose of this ConOps is to describe the system characteristics of the proposed Medical Oxygen Patient Interface from the user's viewpoint. As the MOPI evolves, the ConOps will be updated to reflect the current design and planning. The two year Phase II SBIR for a Vacuum Swing Adsorption (VSA) system that utilizes this 4 component parallel architecture was completed in December, 2017, and the final report received. TDA's VSA system uses a modified version of the lithium exchanged low silica X zeolite (Li-LSX), a state-of-the-art air separation sorbent extensively used in commercial Portable Oxygen Concentrators (POCs) to enhance the N2 adsorption capacity. The TDA, Inc. SBIR Phase II delivered four oxygen generator units. The units use ambient vehicle cabin air as the feed and delivers high purity oxygen. A laptop with control software to remotely operate the prototype was also delivered. The four units will be tested in the Spacecraft Exploration Atmospheres Test Lab at NASA Glenn Research Center (Bldg. 77- Rm.151) to evaluate the oxygen concentrator prototypes. The area of the lab used for the testing includes the test chamber, a vacuum exhaust system, a gas supply rack, chiller, power supplies, and a data acquisition system. [1] Calaway K. Zin Technologies, Inc. "Medical Oxygen Patient Interface (MOPI) Concept of Operations Document." NASA Concept of Operations document OCM-CONOPS-002 Internal document, July 2017.
Bibliography Type:	Description: (Last Updated: 02/26/2025)
NASA Technical Documents	Calaway K. Zin Technologies, Inc. "Medical Oxygen Patient Interface (MOPI) Concept of Operations Document." NASA Concept of Operations document OCM-CONOPS-002 Internal document, July 2017. , Jul-2017