Fiscal Year:	FY 2011	**Task Last Updated:**	FY 10/12/2011
PI Name:	Ritter, James A Ph.D.		
Project Title:	Development of Pressure Swing Adsorption Technology for Spaceflight Medical Oxygen Concentrators		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Smart Medical Systems and Technology Team		
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:	Columbia	**State:**	SC
Zip Code:	29208-4101	**Congressional District:**	6
Comments:			
Project Type:	Ground	**Solicitation / Funding Source:**	2008 Crew Health NNJ08ZSA002N
Start Date:	09/01/2009	**End Date:**	08/31/2013
No. of Post Docs:	1	**No. of PhD Degrees:**	0
No. of PhD Candidates:	5	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	2	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:			
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Knox, James (NASA Marshall Space Flight Center) Edwards, Paul (SeQual Technologies) LeVan, Douglas (Vanderbilt University)		
Grant/Contract No.:	NCC 9-58-SMST02002		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	A source of medical oxygen will be needed at some point to keep an astronaut alive during a space mission. To meet this need, the ideal oxygen source would be a light, compact unit that uses minimal electricity, and can supply oxygen continuously for many days. No current technology meets these requirements. Traditional compressed-oxygen cylinders provide a limited amount of oxygen in a heavy, inconvenient package and are not suited for space missions. Oxygen concentrators, which extract oxygen from air using electricity, can eliminate the obvious problems with cylinder storage in space. These kinds of medical oxygen concentrators are already used in residential and military applications. However, existing systems are too big, use too much power, and are too heavy to be carried into space. For example, a unit that can produce oxygen continuously at 4 LPM, weigh less than 7 pounds and use less than 100 Watts of electric power requires a two-fold reduction in weight and power consumption, compared with the most advanced oxygen concentrators now in production by SeQual. As proposed herein, this requirement may be met by combining new air compressor designs with advances in Pressure Swing Adsorption (PSA) technology. SeQual and the team of researchers from the University of South Carolina (USC), Vanderbilt University (VU), and the Marshall Space Flight Center (MSFC) are uniquely positioned to achieve this next level of performance. To determine whether the proposed technology advances are indeed possible, during the second year of this four year project, the four teams of researchers have been busy carrying out extensive mathematical modeling studies (USC), measuring equilibrium and kinetic parameters for the modeling effort (VU), performing carefully planned experiments with an Eclipse medical oxygen system modified for testing at the bench scale (SeQual), and gearing up for testing an Eclipse medical oxygen system under different environmental conditions (MSFC). Results from numerous experiments were used successfully to validate USC's Dynamic Adsorption Process Simulator (DAPS). In particular, DAPS was specially modified and calibrated against a SeQual PSA module under controlled conditions with a decoupled compressor, and the process performance was analyzed with respect to cycle speed, temperature and high to low pressure ratio. Once validated, DAPS simulations focused on varying certain key process parameters to arrive at optimized PSA cycle designs. The learning from the design effort was implemented into a modified PSA module design operating a new PSA cycle, larger feed/exhaust ports, a backfill step, and larger recycle and purge ports. The new PSA module, associated compressor and other components were fabricated and assembled on a breadboard. The breadboard was connected to instrumentation and tested. The new PSA design successfully delivered 4 lpm of product in about an 8 lb assembly with a compressor shaft power of 130 Watts. This was a significant outcome, especially since the new PSA design was based entirely on predictions from the DAPS. Overall, in the first two years of this four year project, this program is ahead of schedule and definitely on track for improving even further the efficiency of the PSA separation, with the project potentially culminating in a breadboard system that will supply 4 LPM of oxygen, weigh 7.2 lbs, require 106 Watts, and satisfy any new constraints imposed by NASA. Year 3 will continue to follow the task outline presented in the original proposal. In this way, continually updated versions of DAPS will be used, along with carefully planned experiments, to further improve the performance of the PSA module. In addition, the compressor and other components will be evaluated based on new constraints imposed by NASA. Testing in a vacuum chamber with an Eclipse medical oxygen system will also be initiated to determine how it performs under International Space Station (ISS) environmental conditions.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	A major expectation of the research is the development of smaller medical oxygen concentrators, which will be of benefit not only for space flight but also for medical patients on Earth in need of oxygen enriched air.
Task Progress:	There are 8 tasks associated with this project: 1. Refine model parameters; 2. Validate dynamic adsorption process simulator (DAPS); 3. Optimize and understand the SeQual PSA cycle; 4. Examine alternative PSA cycles; 5. Redesign and build improved PSA module for 4 LPM system; 6. Define compressor specifications and build feasibility prototype for 4 LPM system; 7. Assemble and test breadboard systems; and 8. Verify DAPS predictions of new PSA modules. The project is on or ahead of schedule. In the first year, Tasks 1, 2, and 6 were initiated. In the second year, in addition, Tasks 3 and 4 were initiated, and Task 5 was initiated ahead of schedule. Progress has been made for each of these tasks. More detail is provided below. Task 1. Refine Model Parameters VU and USC): LeVan and his team have been working with Ritter and his team to update the dynamic cyclic adsorption process simulator (DAPS) with the most up to date thermodynamic and kinetic parameters. This task is on schedule. Task 2. Validate DAPS (USC and SeQual): Ritter and his team have been working with SeQual to obtain system dimensions, operating conditions and extensive experimental performance data of SeQual's Eclipse system and then using it to calibrate and validate DAPS. Significant progress has been made with respect to DAPS quantitatively predicting the performance of the Eclipse system. This task is on schedule. Task 3. Optimize and Understand the SeQual PSA Cycle (USC and SeQual): Using the refined and validated DAPS, Ritter and his team, with input from SeQual, have been carrying out extensive parametric studies of SeQual's PSA cycle to determine if it is possible to improve oxygen recovery, productivity or both while maintaining the oxygen purity and without redesigning the PSA module. There have been some key findings with DAPS. Some of these findings were recently verified experimentally by SeQual. This task is ahead of schedule. Task 4. Examine Alternative PSA Cycles (USC): Using the refined DAPS, Ritter and his team, with input from SeQual, are just beginning to explore new PSA cycle designs and cycle schedules to determine if it might be possible to improve the oxygen recovery, productivity or both while maintaining the oxygen purity by redesigning the PSA module. This task is ahead of schedule. Task 5. Redesign and Build Improved PSA Module (SeQual): Based on DAPS predictions, SeQual designed a new PSA module that successfully delivered 4 lpm of product in about an 8 lb assembly with a compressor shaft power of 130 Watts. This task is ahead of schedule. Task 6. Define Compressor Specifications and Build Feasibility Prototype for 4 LPM System (SeQual): SeQual has an operating compressor suitable for a 3 LPM oxygen PSA system through a different funding source. Specifications and requirements have been identified and a feasibility prototype is being built to provide sufficient pressure and vacuum to supply the 4 LPM system. This task is on schedule.

Bibliography Type:	Description: (Last Updated: 08/28/2015)
Articles in Peer-reviewed Journals	Ebner AD, Gray ML, Chisholm NG, Black QT, Mumford DD, Nicholson MA, Ritter JA. "Suitability of a solid amine sorbent for CO2 capture by pressure swing adsorption" Industrial & Engineering Chemistry Research 2011 May 4; 50(9):5634-41. http://dx.doi.org/10.1021/ie2000709 , May-2011
Articles in Peer-reviewed Journals	Mehrotra A, Ebner AD, Ritter JA. "Simplified graphical approach for complex PSA cycle scheduling." Adsorption. 2011 Apr;17(2):337-45. http://dx.doi.org/10.1007/s10450-011-9326-6 , Apr-2011
Articles in Peer-reviewed Journals	Ritter JA, Bhadra SJ, Ebner AD. "On the use of the dual-process Langmuir model for correlating unary equilibria and predicting mixed-gas adsorption equilibria." Langmuir. 2011 Apr 19;27(8):4700-12. Epub 2011 Mar 17. PubMed PMID: 21413784 ; http://dx.doi.org/10.1021/la104965w , Apr-2011
Articles in Peer-reviewed Journals	Wang Y, Helvensteijn B, Nizamidin N, Erion AM, Steiner LA, Mulloth LM, Luna B, Levan MD. "High pressure excess isotherms for adsorption of oxygen and nitrogen in zeolites." Langmuir. 2011 Sep 6;27(17):10648-56. Epub 2011 Jul 28. http://dx.doi.org/10.1021/la201690x ; PubMed PMID: 21744870 , Sep-2011