NASAfacts

# Space Technology

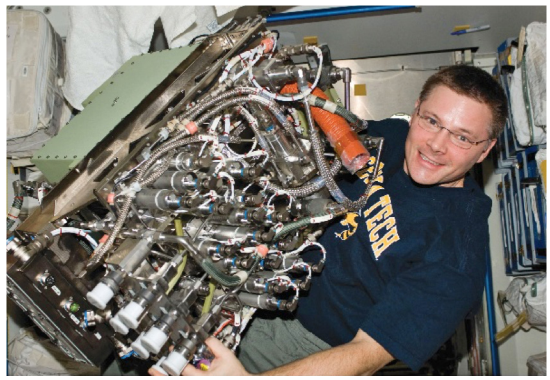
## Game Changing Development

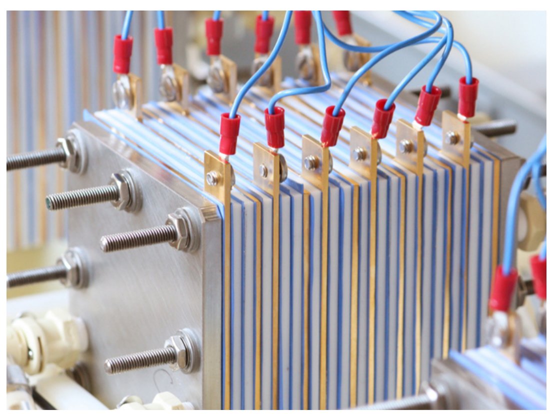
## SpaceCraft Oxygen Recovery (SCOR)

The SpaceCraft Oxygen Recovery (SCOR) Project is developing technologies that recover more oxygen from metabolically produced carbon dioxide than current hardware on the ISS. The goal is to make possible full recycling of the cabin atmosphere in space habitats and vehicles, enabling long duration human exploration.

The state-of-the-art system on the International Space Station uses Sabatier technology to recover oxygen from carbon dioxide, but only about 50 percent is recovered. The remaining oxygen required for the crew is resupplied from Earth. For long duration manned missions beyond low-Earth orbit, resupply of oxygen becomes economically and logistically prohibitive. To mitigate these challenges, the SCOR project is targeting development of technologies to increase the recovery of oxygen to more than 75 percent, with a stretch goal of 100 percent, reducing the total oxygen resupply required for future missions.

Through a phased development approach, four candidate technology approaches were evaluated during a 16-month period ending in 2016. Development teams included NASA scientists and engineers as well as members of industry and academia.


*NASA astronaut Douglas H. Wheelock, Expedition 25 commander, is photographed with the Sabatier Assembly on the ISS prior to installation.*


*A bank of electrochemical cells from the University of Delaware's ion exchange membrane electrolysis unit.*

Engineers at NASA's Glenn Research Center in Cleveland, Ohio, teamed with the University of Delaware to investigate an approach combining an ion exchange membrane electrolysis unit and a carbon formation reactor. The room temperature electrolysis unit, developed at the University of Delaware, utilizes ion exchange membranes in which oxygen is produced directly from carbon dioxide.

Engineers at Umpqua Research Company, Myrtle Creek, Oregon, developed continuous Bosch reactor technology in which oxygen is recovered from carbon dioxide, producing water and solid carbon as products. This unit would replace the Sabatier, utilizing hydrogen from an Oxygen Generation System.

A second group of engineers at Glenn teamed with a small business, pH Matter, LLC, Columbus, Ohio, to develop a system comprising a high-temperature solid oxide co-electrolyzer (SOCE) combined with a carbon formation reactor. The SOCE produces oxygen directly from the co-electrolysis of water and carbon dioxide.

Finally, the University of Texas at Arlington developed a microfluidic electrochemical reactor to recover oxygen from carbon dioxide via low temperature carbon dioxide electrolysis.

Following completion of the Phase I development efforts, the SCOR project competitively selected two Phase II technologies for further maturation. These include “Hydrogen Recovery by Carbon Vapor Deposition,” under development by Honeywell Aerospace, Des Plaines, Ill., and “Continuous Bosch Reactor,” under development by Umpqua Research. These efforts were initiated during the fall of 2017 and will continue into 2020.

The current flight Sabatier is limited in its ability to recover oxygen from carbon dioxide due to an insufficient amount of hydrogen available for its reaction. The Sabatier requires additional hydrogen due to the production of the byproduct methane. If hydrogen can be recovered from this byproduct, it can be sent back to the Sabatier to react with carbon dioxide to produce additional oxygen.

Honeywell Aerospace seeks to do just this. The company uses a high temperature process to recover hydrogen using a methane pyrolysis process. The company has long practiced this technique commercially to manufacture carbon-carbon composites for products like aircraft brakes. In cooperation with NASA, this terrestrial process is being applied to spaceflight. Solid carbon generated from the pyrolysis of methane is deposited within a high surface area substrate. When carbon is deposited under these conditions, the resulting material will be dense and easily handled by the crew.

Umpqua Research Company was selected to continue to develop and mature the continuous Bosch reactor technology. In this approach, carbon dioxide and hydrogen gases are combined and converted to solid carbon and water vapor in the presence of a specialized catalyst. Cylinders of the catalyst are introduced into one end of the reactor and pulverized into fine particles with high surface area by an attritor. Carbon forms on these particles and exits the other end of the reactor into a carbon collection system.

Water is recovered by a condensing heat exchanger, and delivered to the environmental control and life support system for production of oxygen or for use as potable water. Both Phase II technology efforts will be completed with prototype hardware delivered to NASA Advanced Exploration Systems, our NASA Mission Directorate customer, for evaluation and further maturation.

Concurrent with the technology development activities is a systems integration and analysis effort to develop mechanistic models and perform trade studies to elucidate how these technologies may best be implemented in a regenerative environmental control and life support system architecture for human exploration of deep space.

*Substrate loaded with carbon from Honeywell Aerospace’s Carbon Vapor Deposition process.*

*Sintered catalyst cylinder developed for Umpqua Research’s Continuous Bosch Reactor.*

The Game Changing Development (GCD) Program is part of NASA’s Space Technology Mission Directorate. The GCD Program aims to advance exploratory concepts and deliver technology solutions that enable new capabilities or radically alter current approaches.

For more information about GCD, please visit http://gameon.nasa.gov/

National Aeronautics and Space Administration

**Johnson Space Center**
Houston, Texas 77058

**www.nasa.gov**