HUMANS TO MARS 2023

PHOEBE HENSON
SENIOR ADVANCED SYSTEMS ENGINEER
HUMAN SPACE R&D
HONEYWELL AEROSPACE

Honeywell

Honeywell’s history of spaceflight

Every U.S. human space mission

80% of all satellite missions

Honeywell products have been on every US human space mission and 80% of all satellite missions.

Momentum Control

Constellation Series RWAs
Control Moment Gyros
Small Satellite RWAs
Momentum Control System




Satellite Electronics

On Board Computers
Payload Processing
Solid State Data Storage
On Board Networks (SpaceVPX, TTE)

Actuation Mechanisms Isolation Systems

Thrust Vector Actuation
Docking System Actuators
Solar Array Gimbals

Environmental Control & Life Support Systems

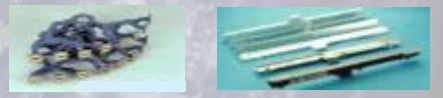
Cabin Pressurization Control Systems of N_2/O_2
Gas & Liquid Flow Control Valves
Heat exchangers, Pumps, Fans, Sensors
CO_2 Removal (LiOH, CDRA, CDRILS)
Oxygen Recovery (Methane Pyrolysis)

Human Space and Satellite Mission Heritage

Mercury	Orion Crew Vehicle	SpaceX Dragon	Satellites (LEO, MEO, GEO)
Gemini	Space Launch System	Boeing CST-100	Strategic Missiles/Interceptors
Apollo	Deep Space Gateway	NG Cygnus	Hubble Space Telescope
Skylab	Human Landing System	SNC Dream Chaser	James Webb Telescope
Space Shuttle	International Space Station	QEYSSAT	Interplanetary Probes

RF Products

LNA Switches
Beam Forming Networks
Isolators & Circulators
TWTA Combiners
Antennas



RadHard Microelectronics & Sensors

ASICs & Memories
Mixed Signal Devices
Magnetic Sensors
Pressure Sensors

Avionics, Navigation & Displays

Vehicle Management Computer
Space Intg GPS/INS (SIGI), FTINU, INCA & RRGU
C&DH IO products (i.e. PDUs, MDMs etc.)
Displays & Hand Controls, Control Panels

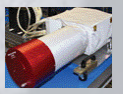
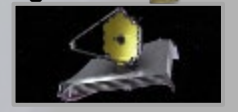
Inertial Measurement Units

Miniature Inertial Measurement Unit (MIMU)
Startracker Measurement Unit (StarMU)
SPIRIT – Satellite IRU/IMU & SRIMU
High Performance FOG IRU

Satellite/Payload Systems

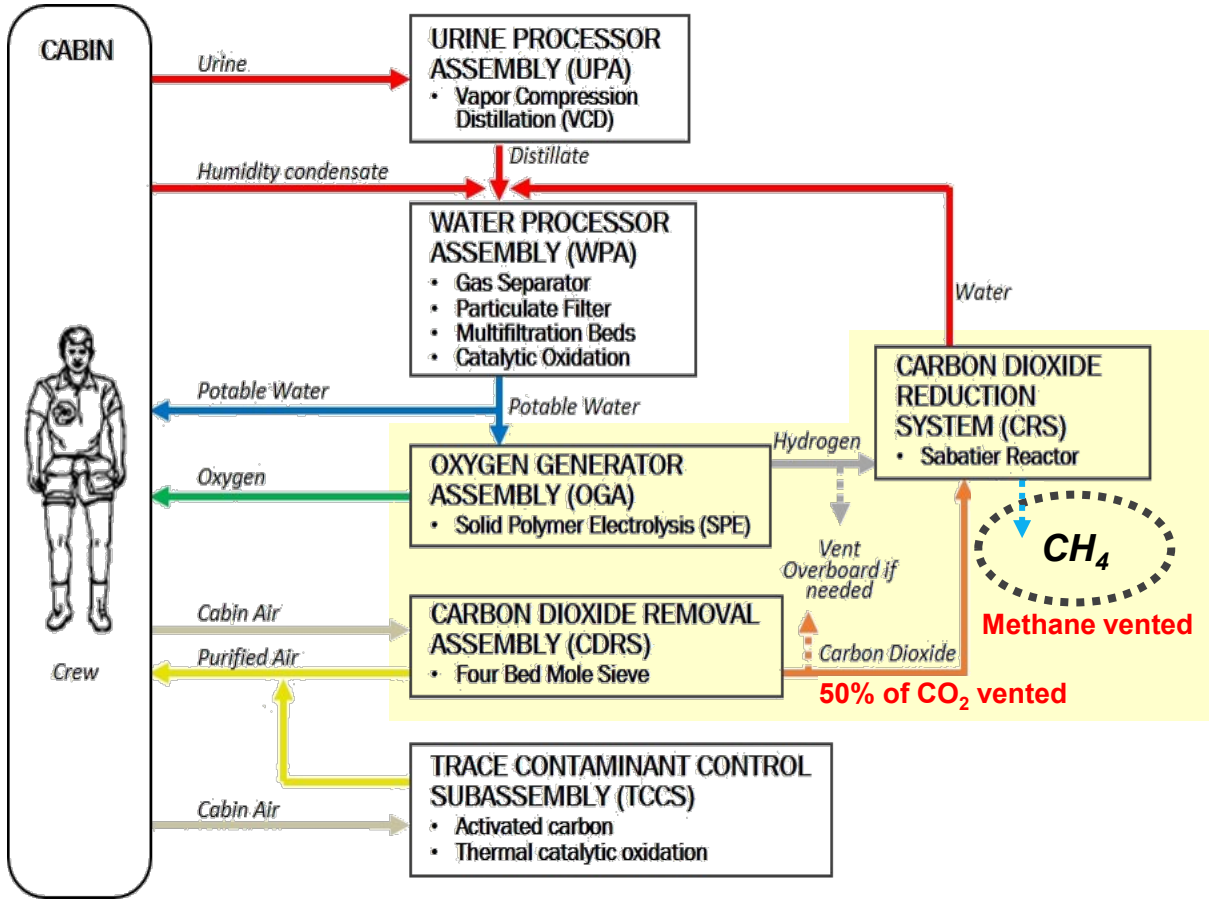
Secure Communication – QKD, Optical
Optical Imagery – Visible, IR
Space Situational Awareness
Astronomy – Fine pointing



CLOSING THE OXYGEN LOOP WITH METHANE PYROLYSIS

ECLSS Today



Current process is limited to <50% recovery of oxygen due to the hydrogen lost in the vented methane

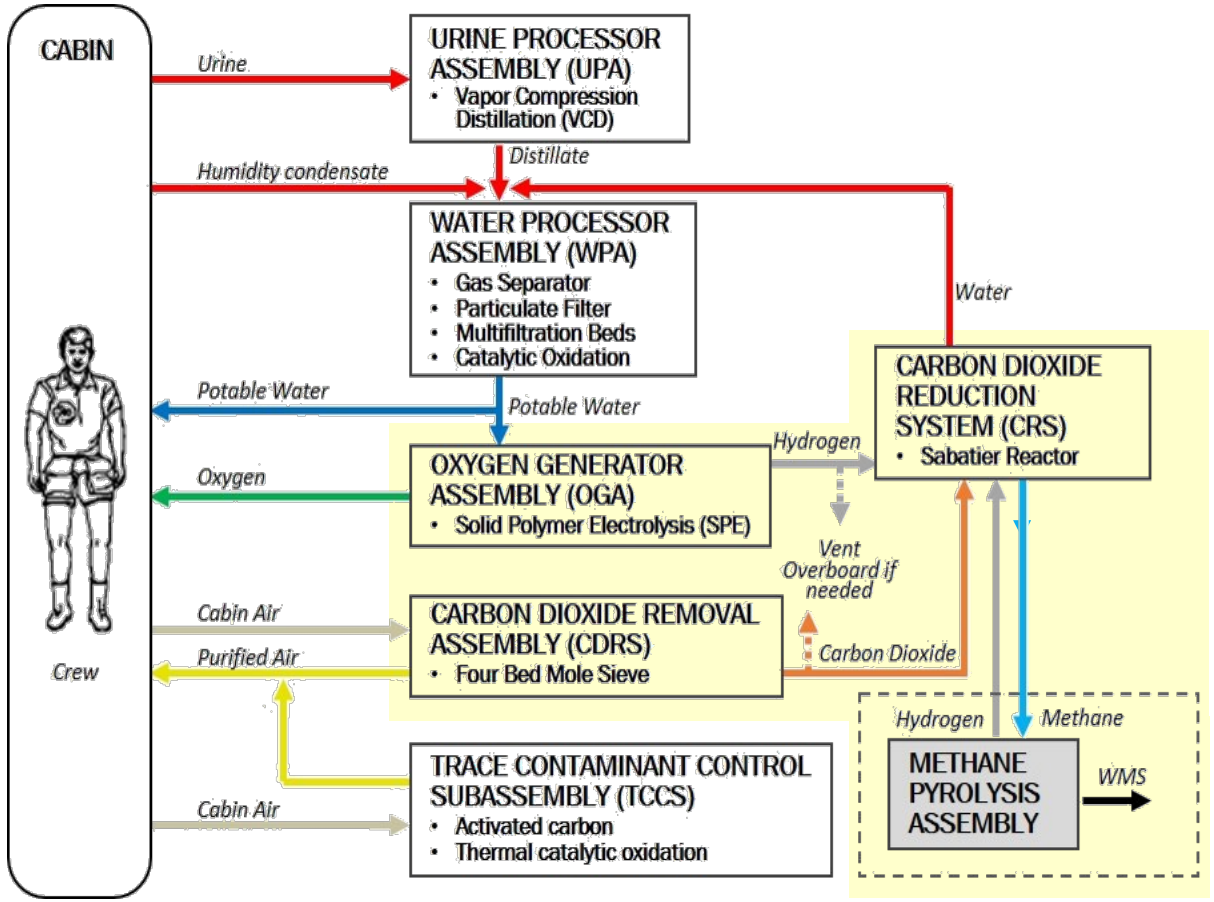
Not closing the loop will result in greater consumables on a trip to Mars

Methane pyrolysis can recover this hydrogen and close the oxygen loop

$$Sabatier:\ CO_2 + 4\,H_2 \rightarrow CH_4 + 2\,H_2O$$
$$Electrolysis:\ 2\,H_2O \rightarrow 2\,H_2 + O_2$$
$$\underline{Pyrolysis:\ CH_4 \rightarrow 2\,H_2 + C}$$
$$Net\ reaction:\ CO_2 \rightarrow O_2 + C$$

CLOSING THE OXYGEN LOOP WITH METHANE PYROLYSIS

ECLSS Tomorrow



Advantages of Methane Pyrolysis:

- Increases oxygen recovery to near 100%
- Leverages NASA's investment in Sabatier technology
- Product is clean, easily handled carbon – no separations steps, soot, or hazardous gases
- Robust technology

A MORE EFFICIENT, EFFECTIVE AND RELIABLE
CARBON DIOXIDE REMOVAL BY IONIC LIQUID SYSTEM

Advantages of CDRILS:

- Maintains a lower CO_2 partial pressure
- More reliable and robust due to continuous system and tolerance to water
- Lower size, weight and power especially when integrating with downstream Sabatier
- Removes numerous trace contaminants

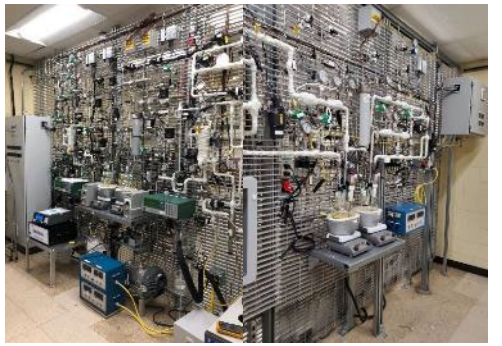
How it works:

- Exchange of EMIM Ac ionic liquid with promoter between a scrubber (CO2 capture by the ionic liquid) and a stripper (CO2 release)

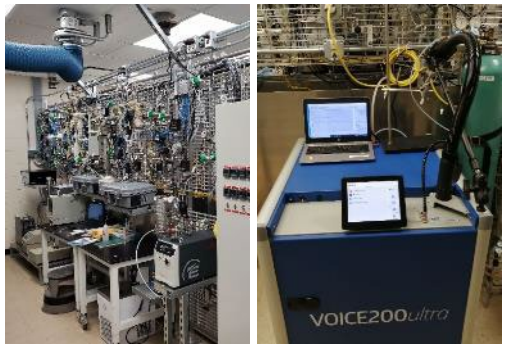
Status:

- Six separate ground demonstrations built and under test

Laboratory CDRILS test stand

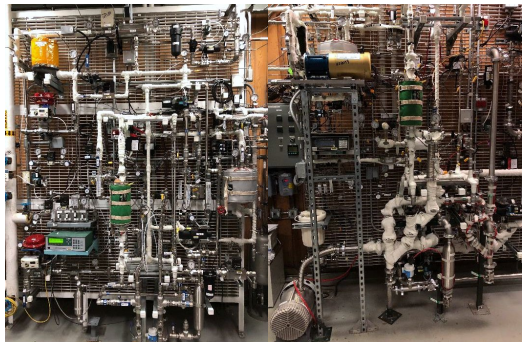


NASA CDRILS breadboard



NASA CDRILS contamination breadboard

Membrane durability test stand



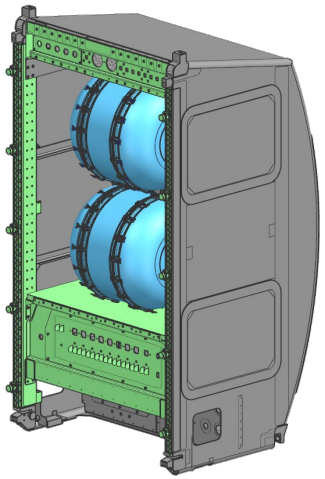
CDRILS brassboard

CDRILS prototype

STATUS OF ADVANCED ECLSS TECHNOLOGIES

NASA/Honeywell Methane Pyrolysis

- Brassboard reactor delivered to NASA for integrated system testing in 2022
- Flight-like reactor completing Preliminary Design Review in 2023



NASA/Honeywell CDRILS

- Six separate ground demonstrations built and under test
- Flight demonstration unit design in progress

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