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National Aeronautics and Space Administration

Accelerating Sustainable Solutions for Earth and Space

Closed-Loop Living System for Deep-Space ECLSS with Immediate Applications for a Sustainable Planet

Presenter: Darlene Mendoza Wiedemann, M.A.

FC: ARC

Date: 06/27/2017
TIME: 09:10 PST

***NOTE**: All presentations will undergo a review by the MDL and then by ITAR/EAR.*

Topic Overview

Dr. Dan Rasky, is the Chief of the Space Portal Office. His background is in mechanical engineering. Two of his most notable inventions are the Thermal Protection Systems that enabled the Stardust comet sample return mission enabled by the SBIR program, which was the fastest ballistic entry of a manned made object into the Earth's atmosphere in history, and has worked with SpaceX to develop, PICA, the thermal protection systems for their DragonLab.

Darlene M. Wiedemann, M.A., is the Sustainability Lead for Space Portal and adviser to the STTR T6.04 subtopic manager. Her background is in studying the adverse impacts of climate change on the global food system, particularly in developing countries. She believes sustainable technologies can help mitigate these impacts, but will require cross government agencies, industry and academia partners.

Sustainability Base

Sustainability Base

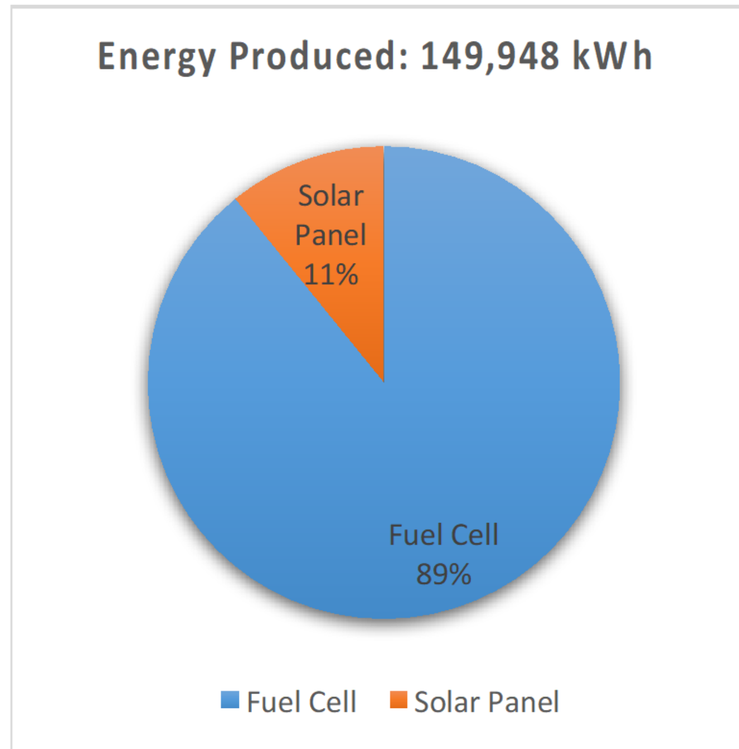
Alternative Energy

K.R. Sridhar

BloomBox

August 2016

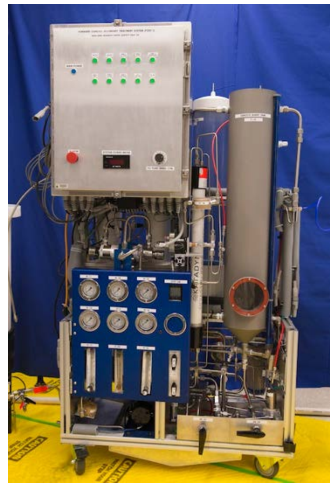
Energy Used: 40,750 kWh

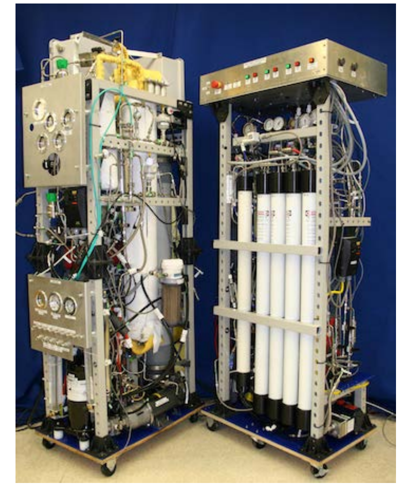


Sustainability Base

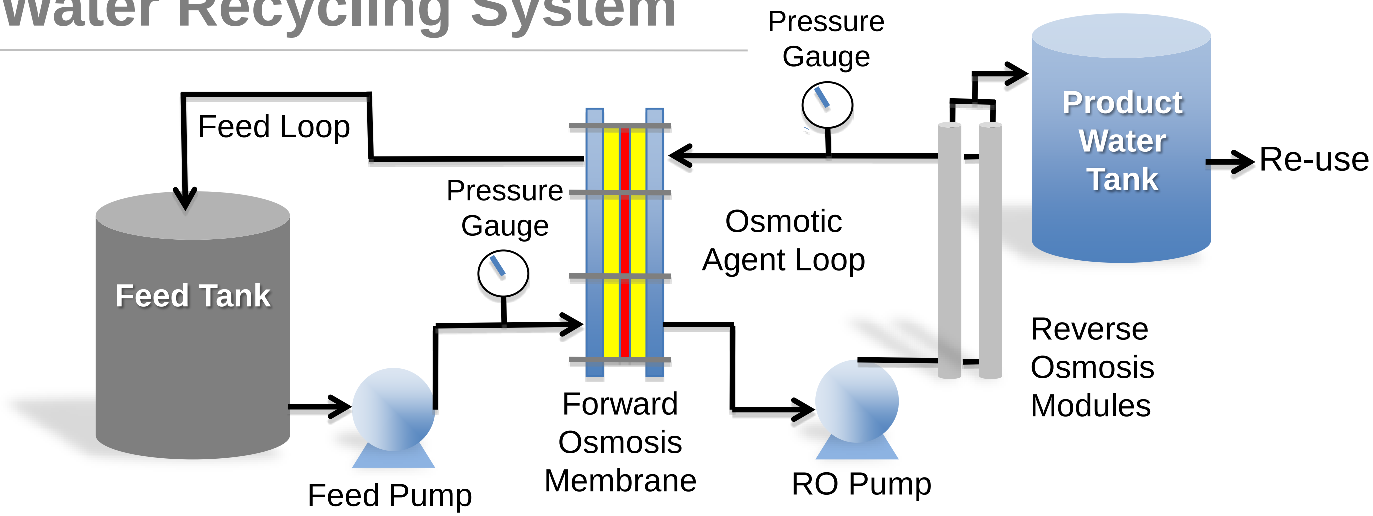
Water Recycling

Michael Flynn





Water Recycling System



Topic Overview

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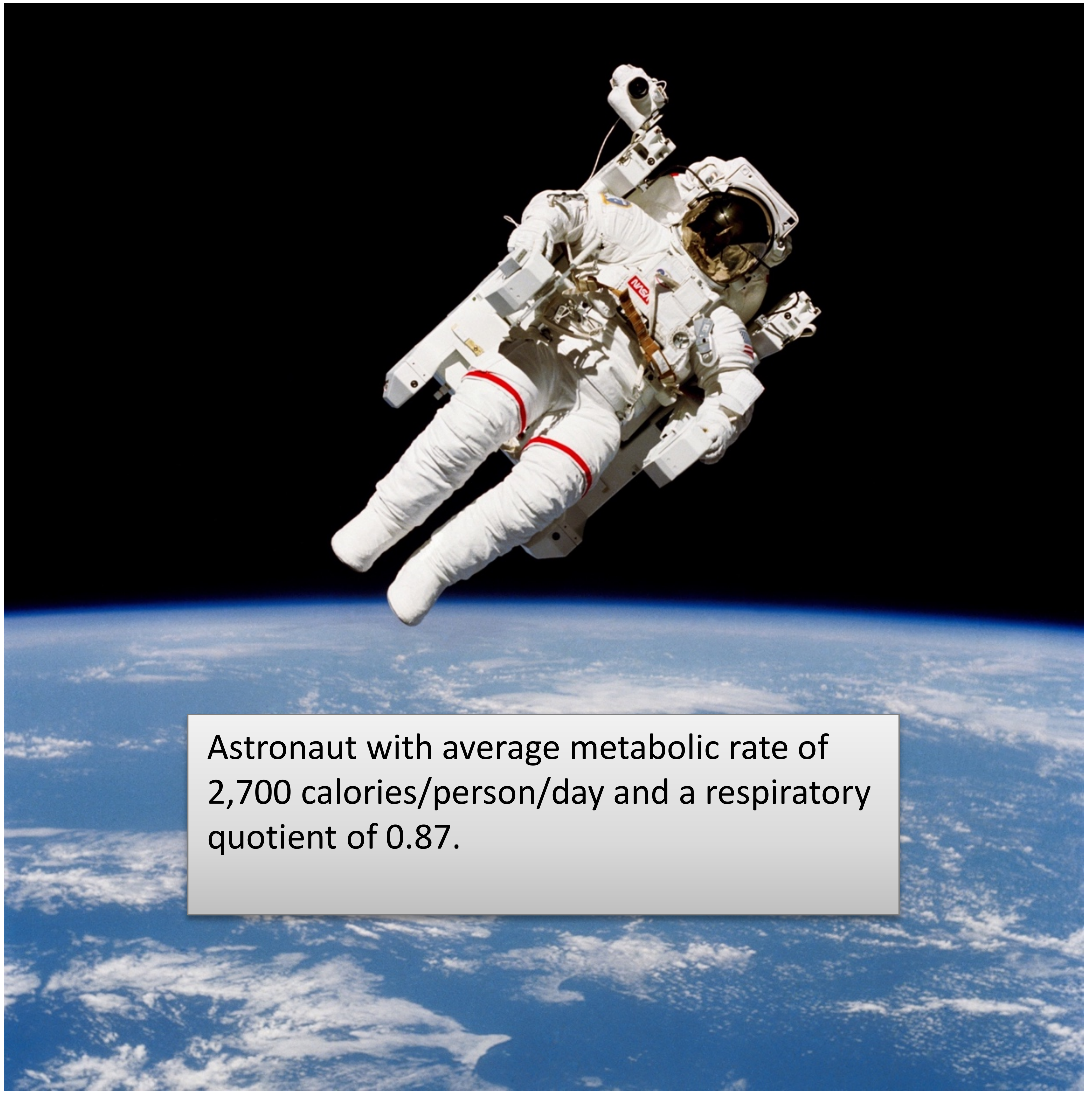


Astronaut with average metabolic rate of 2,700 calories/person/day and a respiratory quotient of 0.87.

15 kg* of life-support consumables (air, food, and water) are needed per day

Supporting a single individual on a road trip to Mars would require approx. 9,900 kg/person

Very austere figure, that does not include additional resources.

Topic Overview

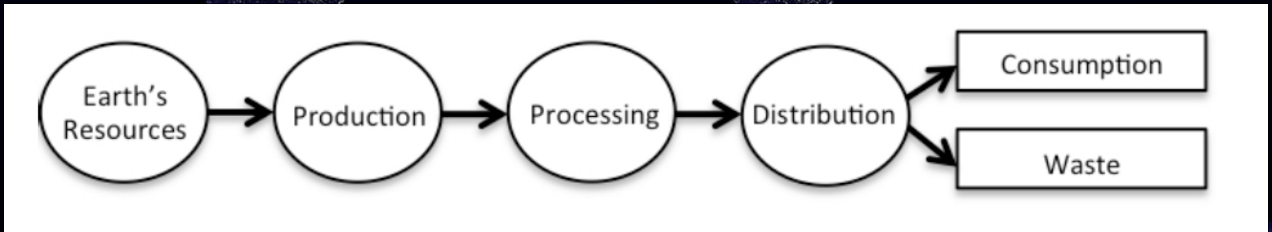
Supporting a single individual on a road trip to Mars would require approx. 9,900 kg/person

SpaceX's Falcon Heavy, maximum payload is 16,800kg

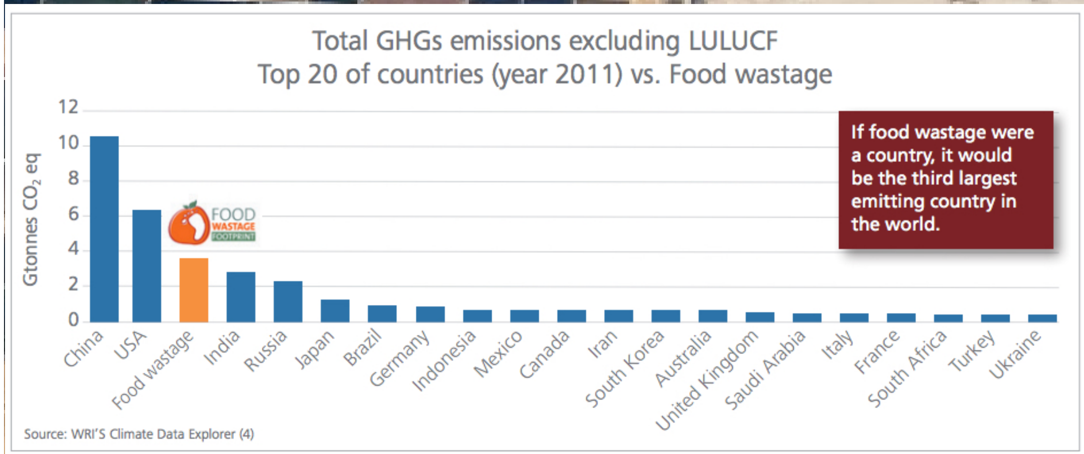
SpaceX advertises delivery of 8.0 mT to GTO for $90M, which is about $11.25M/metric ton on their Falcon Heavy.

Cost $11,250/kg or $111,375,000.

Topic Overview



Topic Overview



Natural resources are not endless: droughts, environmental degradation, and natural disasters

UN's FAO: **one-third of all food produced in the world is wasted**, and if food waste was its own country it would be the third largest producer of greenhouse gas emissions.

Topic Overview

Closed-Loop Living System for Deep-Space ECLSS with Immediate Applications for a Sustainable Planet

NASA Needs

Earth Reliant

Research aboard the ISS.

- Mars mission class environmental control and life support systems.
- 3-D printing
- Material handling tests for space resource demonstration
- Space Farming

Proving Ground

Advance and validate capabilities required for deep space missions in cislunar space

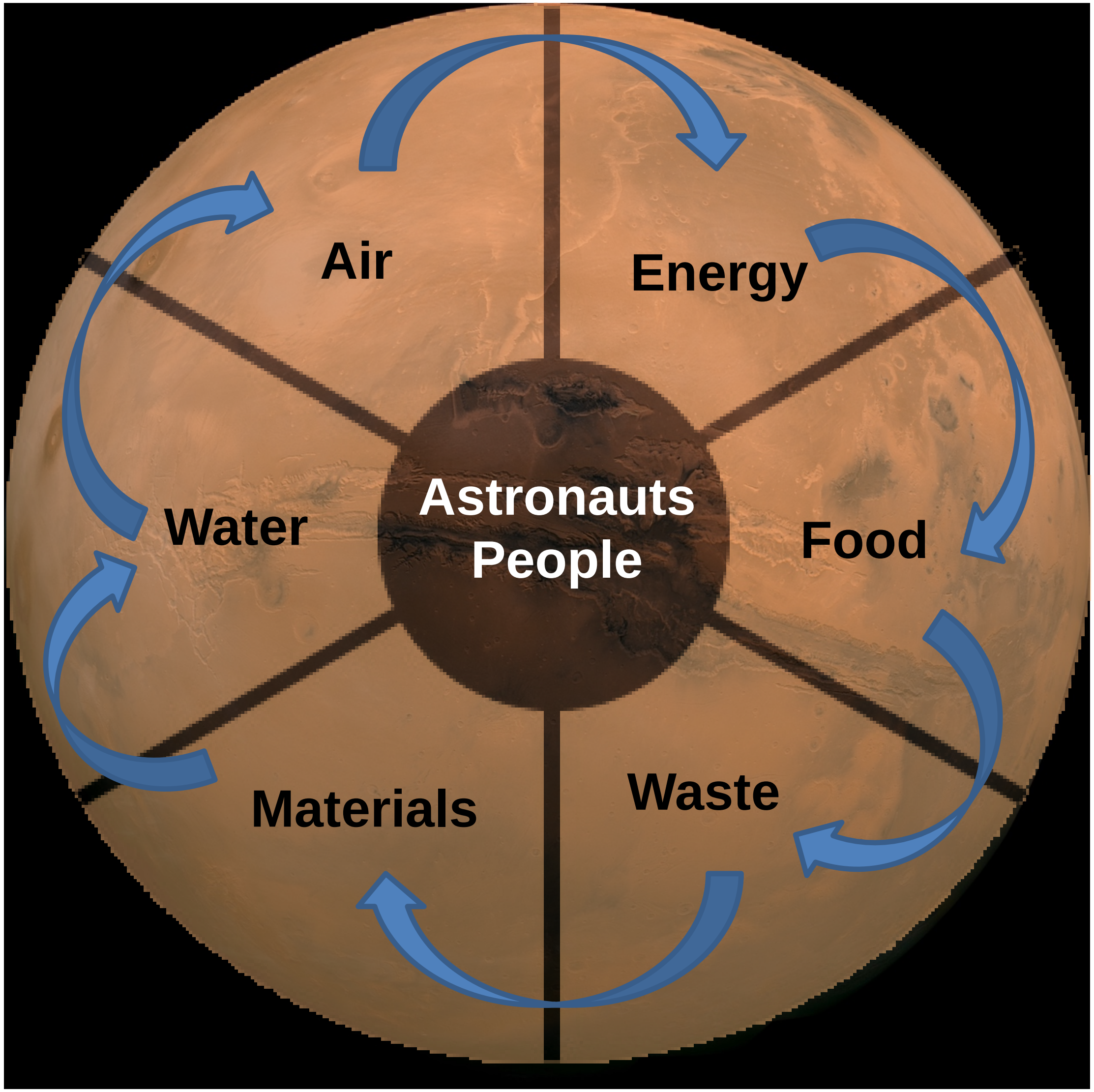
- An initial deep-space habitation facility for long-duration systems testing
- Concepts to minimize resupply needs through reduction, reuse, and recycling of consumables, packaging, and materials.

Earth Independent

Build on what we learn on ISS and cislunar space.

- Living and working within transit and surface habitats that support human life for years, with only routine maintenance
- Harvesting Martian resources to create fuel, water, oxygen, and building materials

NASA Needs

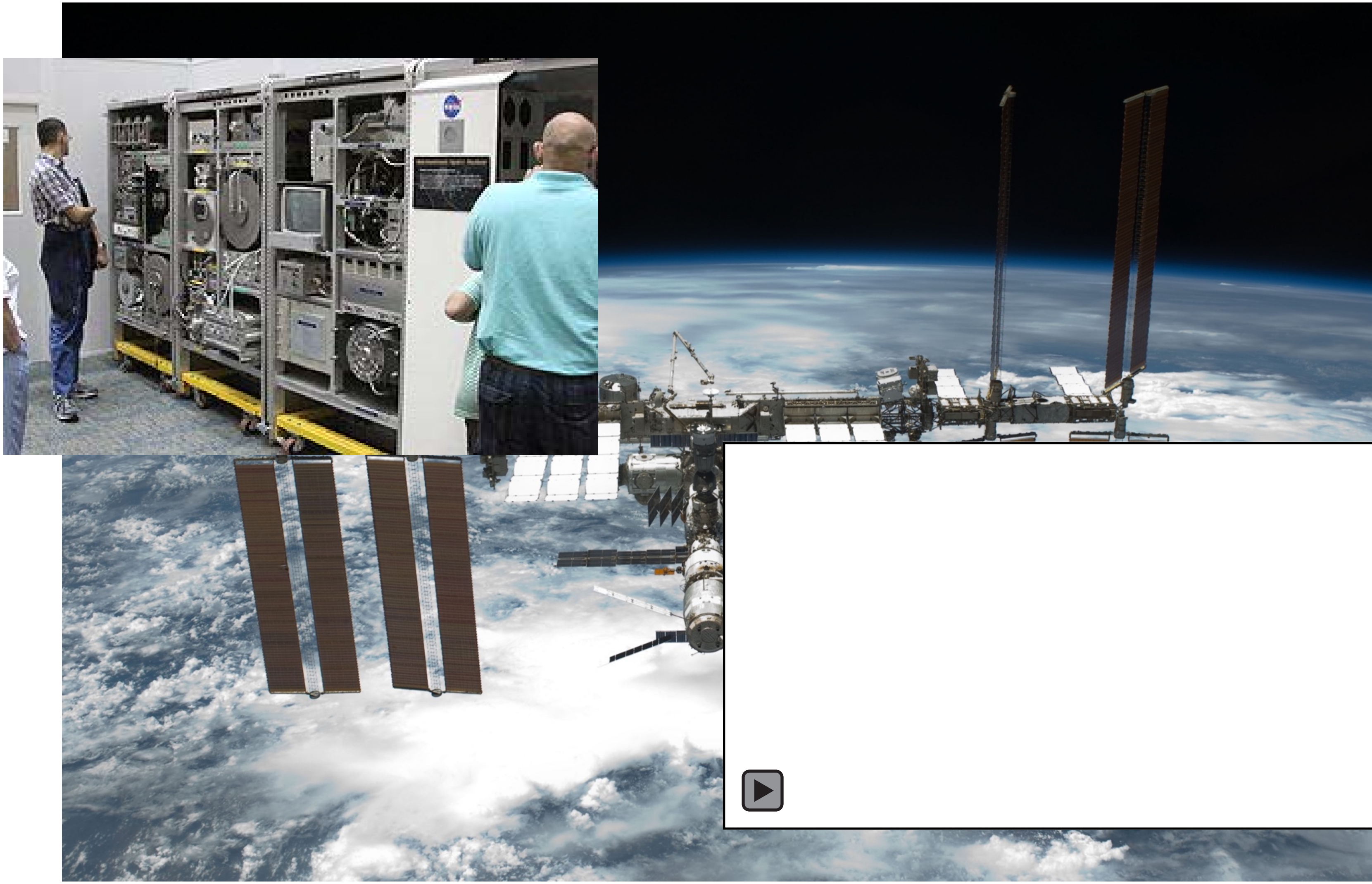


What are we looking for?

Technologies & Companies

1) . . . interested in producing any of these resources in space, while understanding the concept of a closed-loop system
2) . . . interested in minimizing our dependence on natural resources
3) . . . seeing by-products, waste, or GHGs as a resource

NASA Needs



Role of Small Businesses

1. The private industry and academia have invested heavily in sustainable technologies that can support some of NASA's life support subsystems (e.g. water recycling, energy, food production, additive manufacturing) and have become leaders in their field, eventually outpacing some of NASA's technologies.

2. In addition, the private industry and academia are interested in expanding their sustainable technologies into space.

- Why reinvent the wheel?
  - NASA in collaboration with these leaders can reduce cost in research and development and accelerate sustainable solutions for Earth and space.

Success Story

GLOBAL OPPORTUNITY

Mango Materials' technology helps solve global environmental challenges

"PERSISTENT" PLASTICS

Plastic products that end up in the natural environment persist for hundreds of years, negatively impacting wildlife and the surrounding ecosystem.

INFERIOR ALTERNATIVES

The increasingly high demand for low-cost, biodegradable materials cannot be met with current technologies and products.

GREENHOUSE GAS EMISSIONS

Methane is a greenhouse gas up to 25x more potent than carbon dioxide over a 100-year time frame.

MANGOMATERIALS

PILOT PLANT

Production team creates customer samples and prototypes

Location	Redwood City, CA
Methane Partner	Silicon Valley Clean Water
Facility Type	Wastewater treatment plant
Initial Year of Operation	2015
PHA Production Capacity	500 lbs/year
Number of Fermentation Runs	40

MANGOMATERIALS

DISPOSAL ENVIRONMENTS

PHA biodegrades in many natural and industrial environments

Compost and Soil

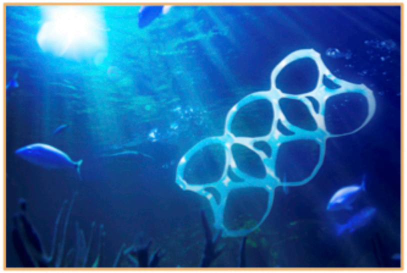
PHA can be composted in home compost and industrial compost facilities, and can break down in aerobic environments like natural soils.

Landfills

PHA can be broken down by microorganisms found in modern landfills.

Anaerobic Digestion

At wastewater treatment plants and agricultural facilities, PHA is consumed by microorganisms present in biosolids.



Oceans

PHA is consumed by microorganisms found in lakes, rivers, oceans, and other natural waterways.

MANGOMATERIALS

Resources

- References to other strategies or documents that provide more information and context for this topic.
  - sbir.nasa.gov (subtopic T6.04: Closed-Loop Living System for Deep-Space ECLSS with Immediate Applications for a Sustainable Planet)
  - *Human Exploration of Mars Design Reference Architecture 5.0* https://www.nasa.gov/pdf/373667main_NASA-SP-2009-566-ADD.pdf
  - *Life Support for a Low-Cost Lunar Settlement: No Showstoppers* http://www3.nd.edu/~cneal/CRN_Papers/Harper16_NS_LifeSupportLunarSettelment.pdf
  - NASA's Journey to Mars: Pioneering Next Steps in Space Exploration https://www.nasa.gov/sites/default/files/atoms/files/journey-to-mars-next-steps-20151008_508.pdf

The End

THANK YOU FOR YOUR PARTICIPATION!

NOTE: *This presentation will be accessible through the Industry Day website.*