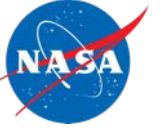


# Understanding Research Needs and Directions

National Aeronautics and  
Space Administration



## Committee on Biological and Physical Sciences in Space Washington, DC

Craig Kundrot  
Space Life and Physical Sciences  
Research and Applications Division  
Human Exploration & Operations Mission Directorate

27 March 2019



- **Collaboration with**
  - Environmental Control and Life Support Systems Systems Capability Leadership Team (ECLSS SCLT)
  - Space Technology Mission Directorate (STMD)
  - Human Exploration and Operations Mission Directorate Advanced Exploration Systems (HEOMD AES)
- **Provide**
  - Behavioral health benefits
  - Micronutrients that are not shelf stable
- **Research Challenges**
  - Plant selection / engineering
    - Plant watering
  - Microbiome management
- **In early formulation stage**

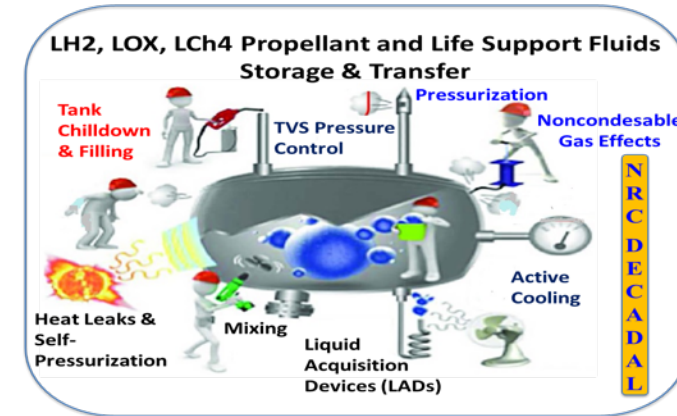
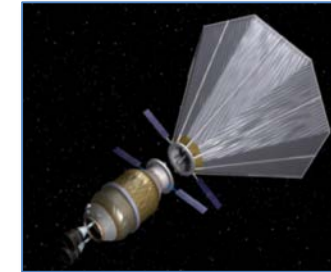




# Enabling Exploration: from Push to Pull

## Zero Boil-Off Tank (ZBOT) Experiment(s)

- **Cryogenic Fluids Management in microgravity**
  - Complex fluid and heat transfer
- **Zero Boil-Off**
  - Saves mass
  - Costs complex design
- **Cryogenic practitioners measure two scalars**
  - Pressure, temperature
- **ZBOT-1 imaged fluid flow and measured flow vector field**
  - Informs CFD models used for design of real world systems
- **STMD**
  - From mild interest
  - To incorporation into STMD CFM roadmap



- **ZBOT-1: Self-Pressurization & Jet Mixing (2017)**
- **ZBOT-NC: Effect of Non-Condensable Gases (2022)**
- **ZBOT-AC: Active Cooling Pressure Control (2025)**
- **ZBOT-FT: Filling & Transfer (Potential International Collaboration)**

Roadmap		2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Methane	Operational Cryogenic Valves	TRL 3									Ready for Flight (TRL 6)
	High Vacuum MLI	TRL 5									Ready for Flight (TRL 6)
	Low Conductivity Struts/Structure			TRL 6							
	Helium Pressurization										
	Broad Area Cooling										
	Pump Based Mixing										
	Thermodynamic Vent System										
	Liquid Acquisition Devices										
	Cryo-cooler (90K)										

- **Artificial Gravity (centrifugation) could protect crew against**
  - Bone loss
  - Muscle loss
  - Cardiovascular conditioning
  - Other conditions?
- **Modalities**
  - Whole vehicle
  - Part of vehicle
  - Within vehicle
    - e.g., 2 m radius centrifuge
- **HRP obtaining data to inform trade studies**
  - Duration
  - Intensity
  - Frequency

## 'Artificial Gravity' Bed-Rest Study to Track Space Travel's Effects on Human Body

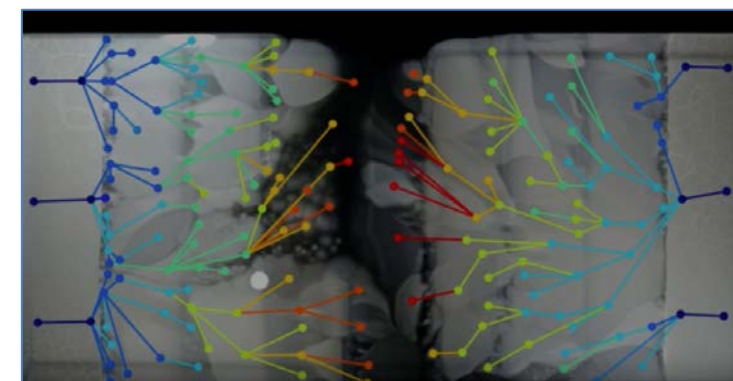
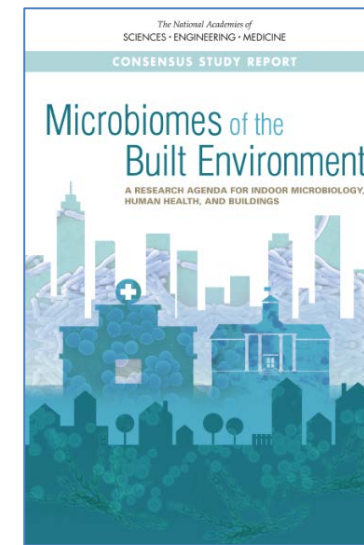
By Mike Wall 3 days ago Tech



The short-arm centrifuge at the German Aerospace Center's envihab facility in Cologne, Germany, will be used during the first joint long-term bed-rest study commissioned by the European Space Agency and NASA to investigate the potential of artificial gravity in mitigating the effects of spaceflight. The study begins March 25, 2019. (Image: © CC BY-SA 3.0 IGO)

[www.space.com/artificial-gravity-spaceflight-bed-rest-study](http://www.space.com/artificial-gravity-spaceflight-bed-rest-study)

- **Crew and plants will be reservoirs of microbes in a Mars mission**
- **“Clean well” may not be a good strategy for a Mars mission**
  - Antibiotic resistance in medicine
  - Bacterial growth in Superfund sites
- **Provocative Notion**
  - Maintain “designed” microbiomes in the built environment
- **Space Biology**
  - Monitoring state-of-the-art research
  - Convening a workshop to determine what NASA needs to know to decide how to manage (or not) the microbiomes of the built environment in a Mars mission



[www.youtube.com/watch?v=pIVk4NVIUh8](http://www.youtube.com/watch?v=pIVk4NVIUh8)



Thank you

