



Spacecraft Life Support Systems

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Temperature

Radiation Protection

Air

Food

Waste Removal

Water

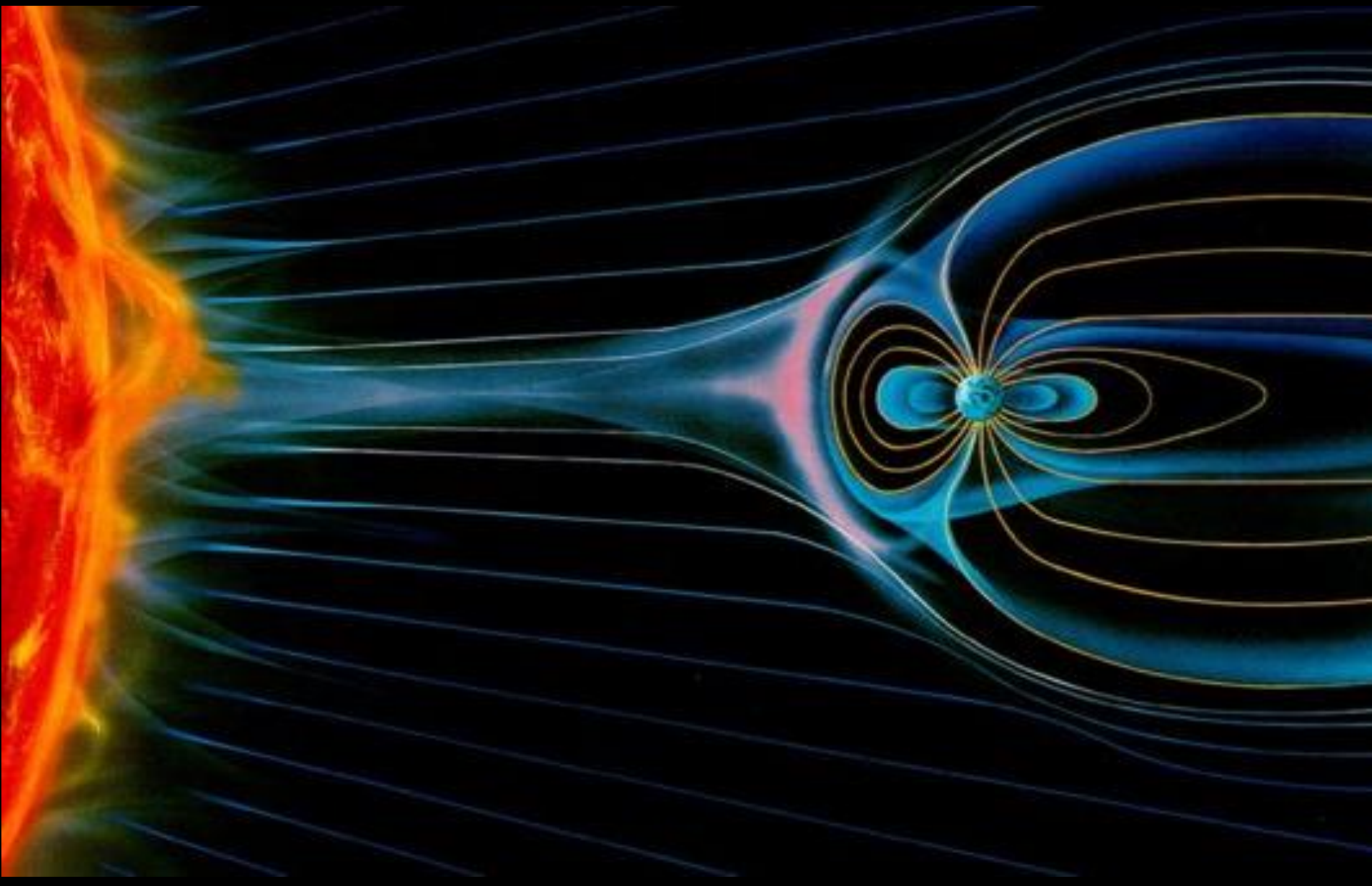
Gravity

Pressure





Earth's Life Support Systems (ELSS)



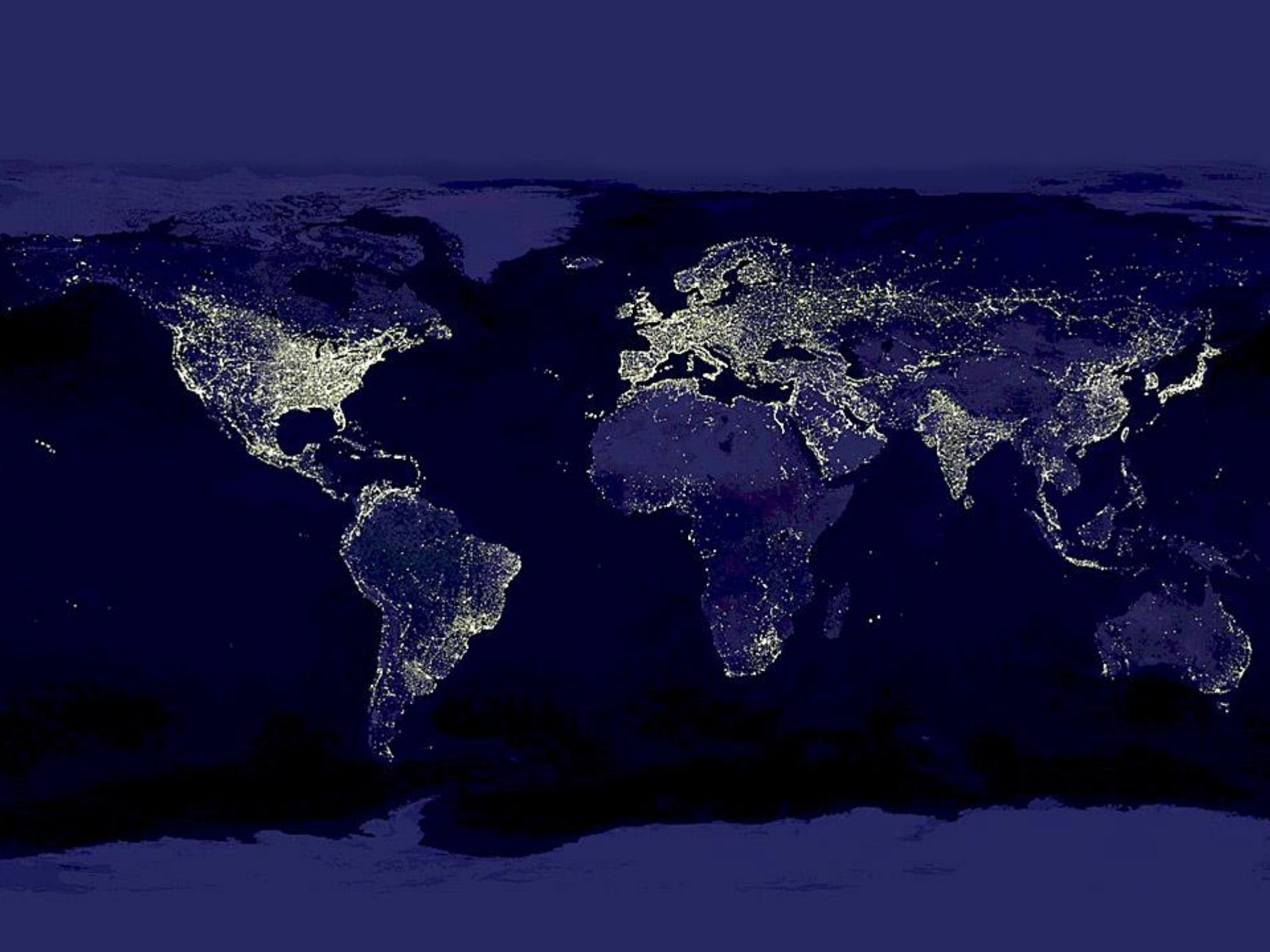
Human's Life Support Systems

Water/waste
purification

Air quality
regulation

Aesthetic/Spiritual values
Recreation/Ecotourism







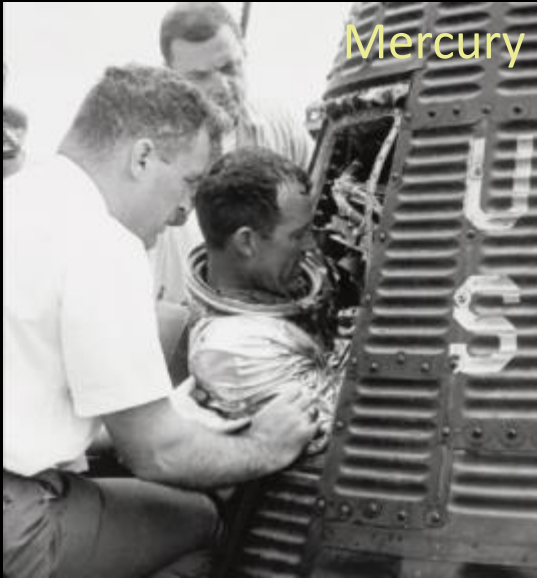
Human Space Exploration



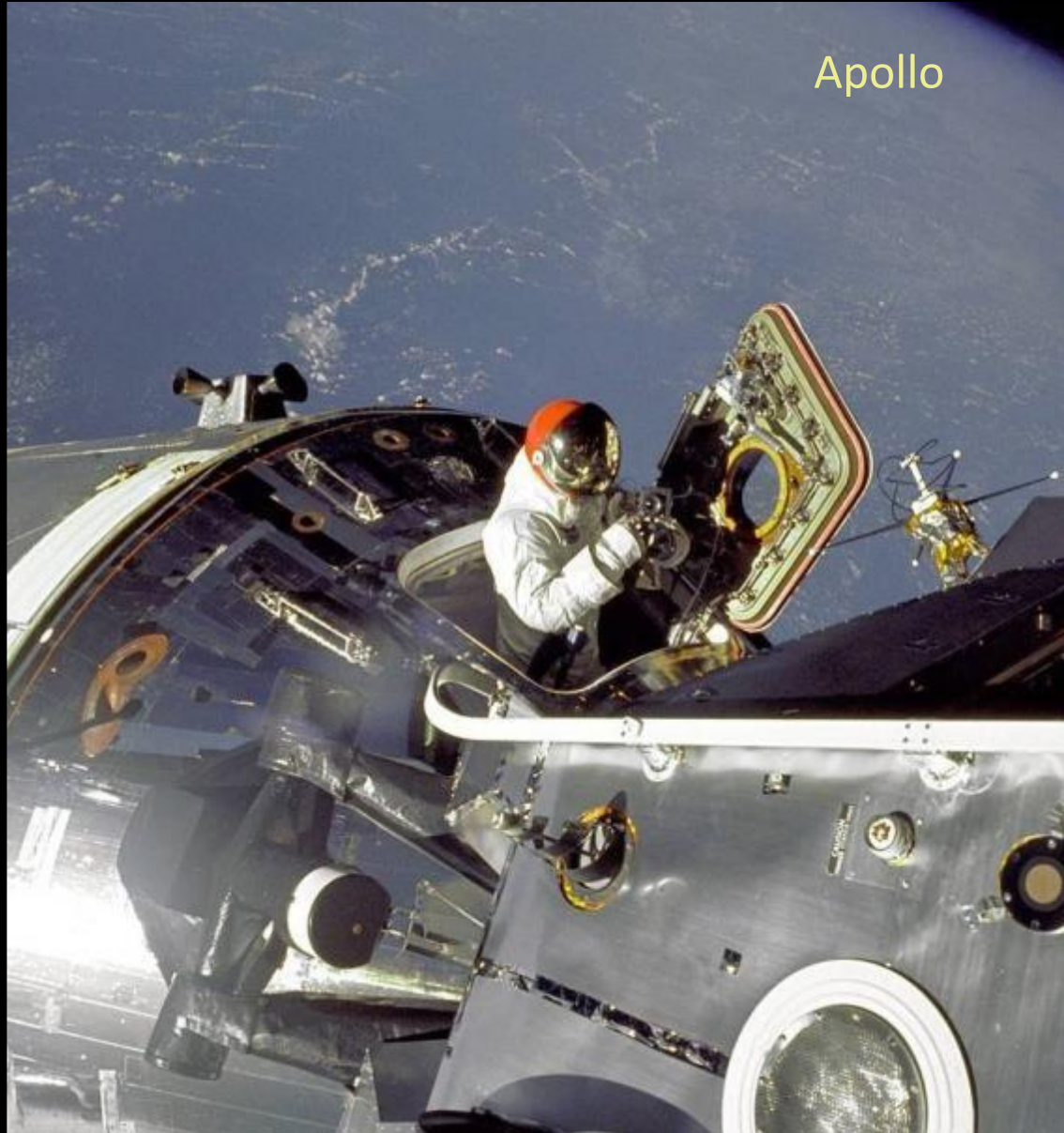


Early Missions

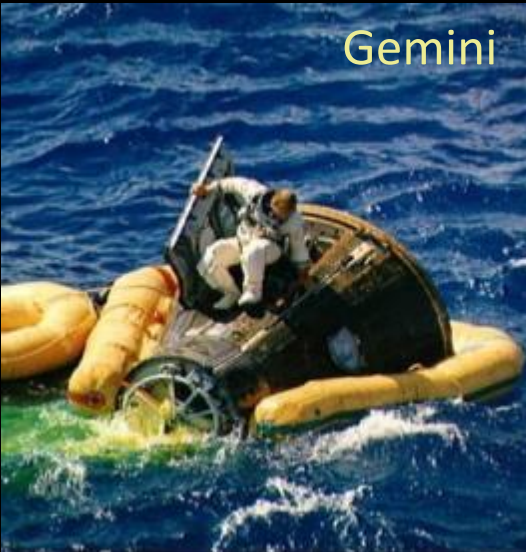
Mercury



Apollo



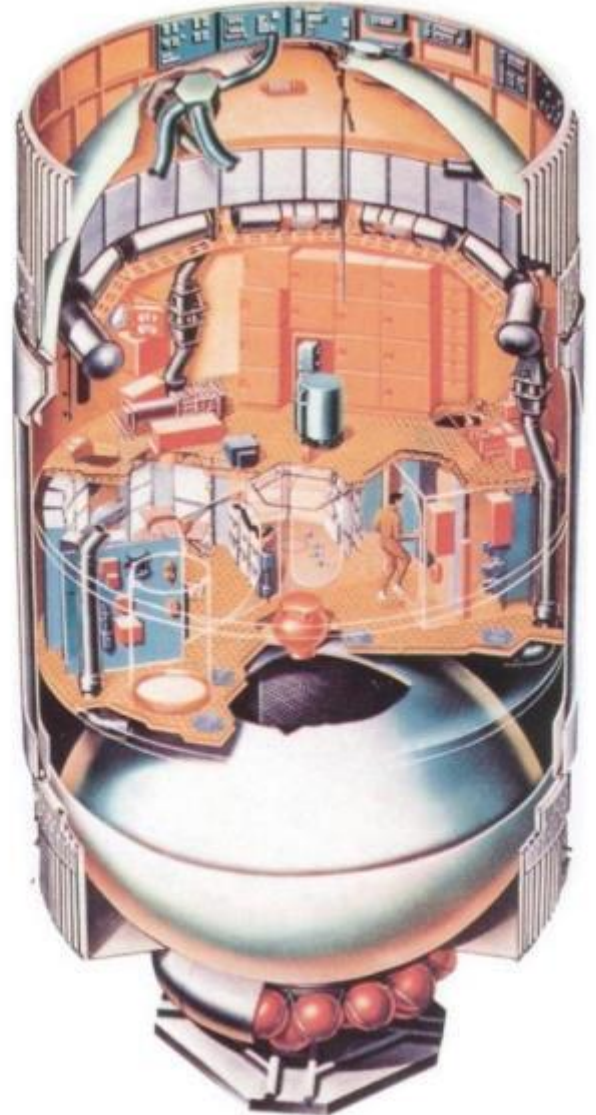
Gemini





SKYLAB

3 Missions - 28, 59, 84 days



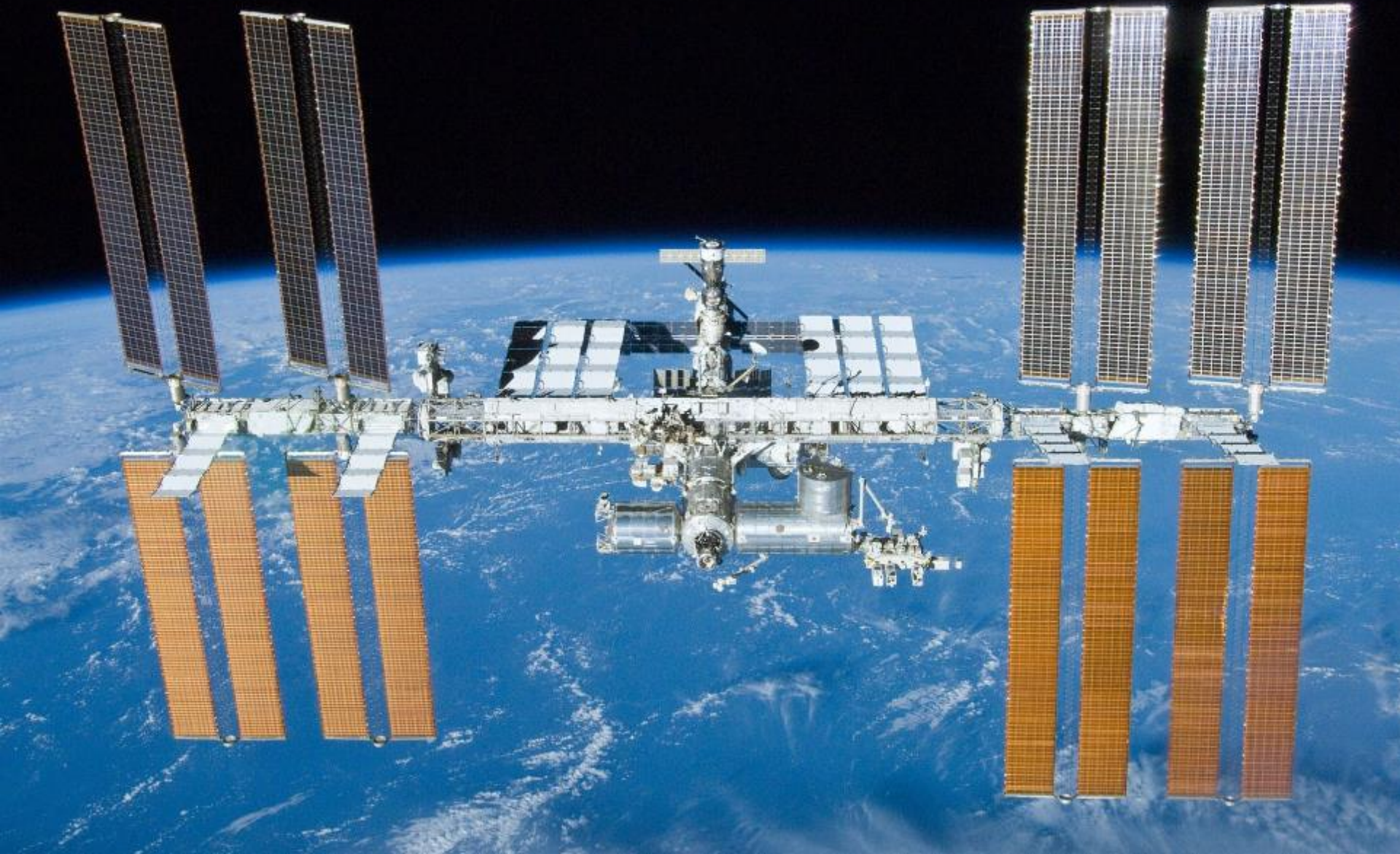


STS



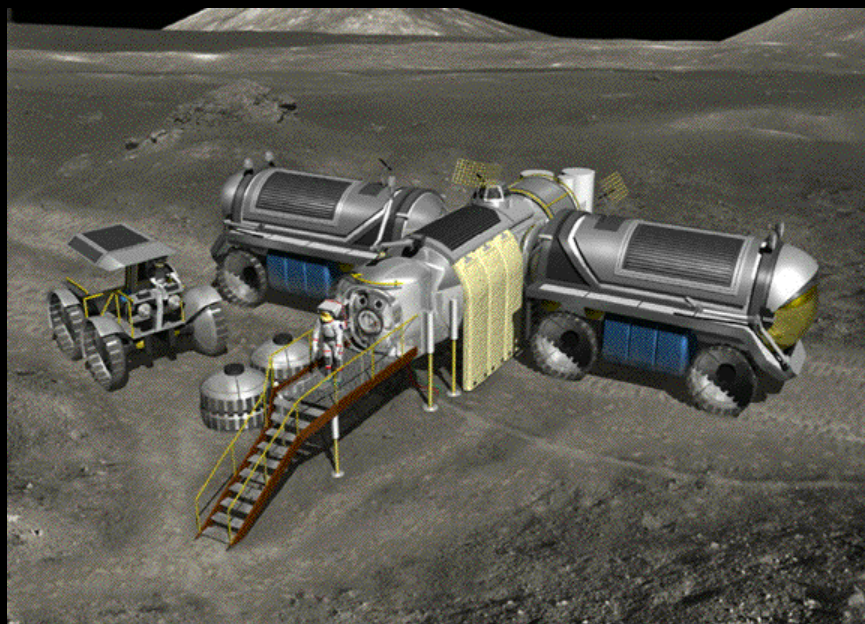


International Space Station



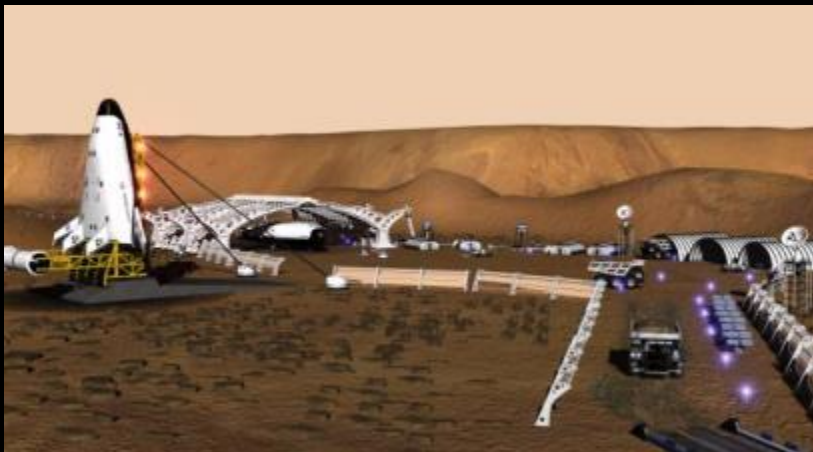
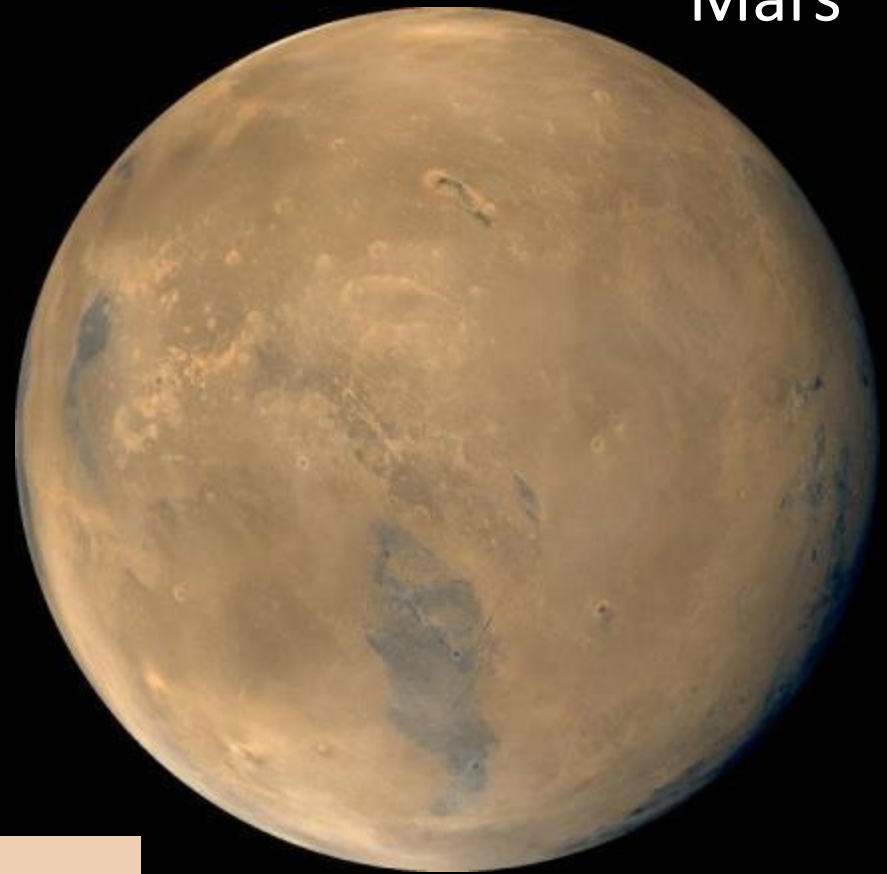


Luna





Mars





Atmosphere Management



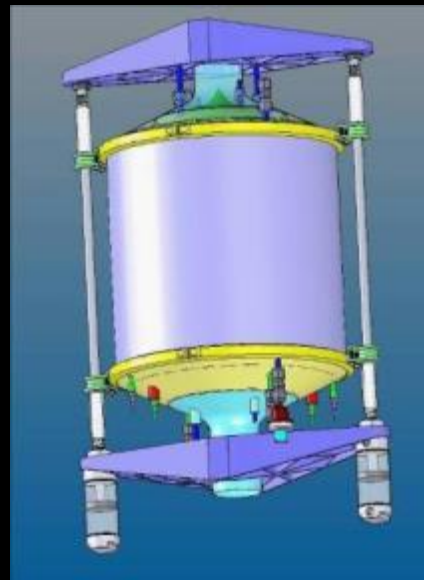
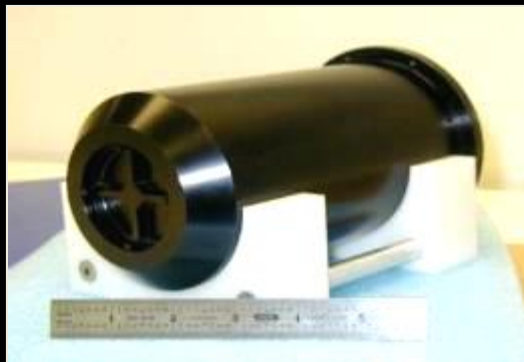
Air Revitalization



- O₂ Generation
- CO₂ Removal
- Contaminant Control
- Particulate Control



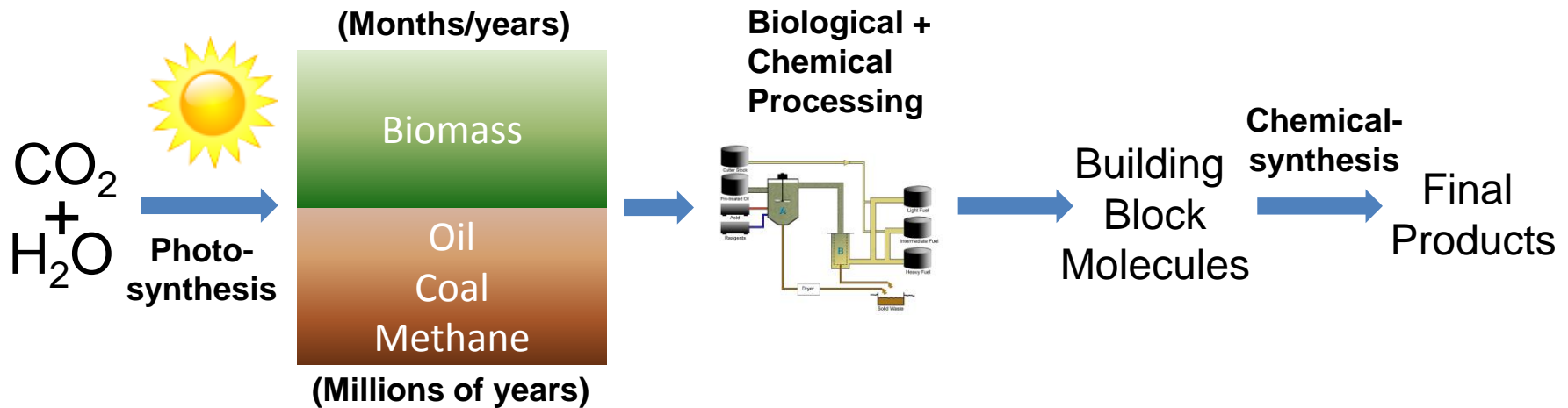
CO₂ Capture and Sequestration



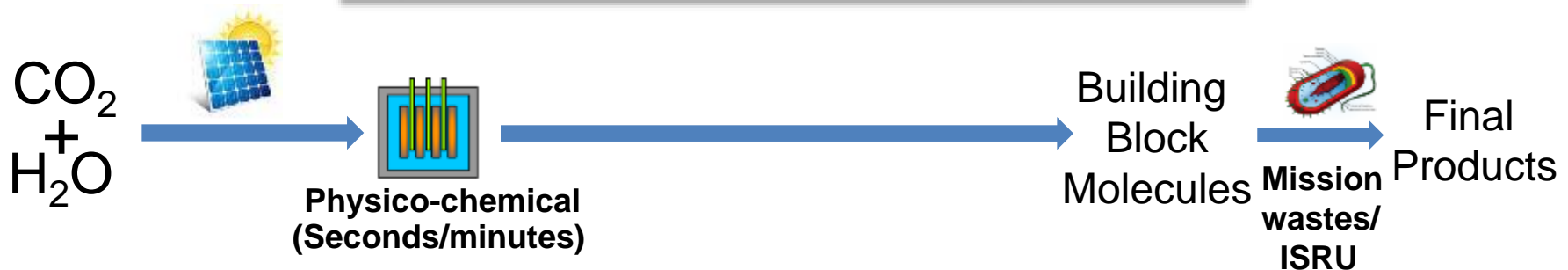


CO₂-Based Manufacturing Approaches

Current Terrestrial Biorefinery Model

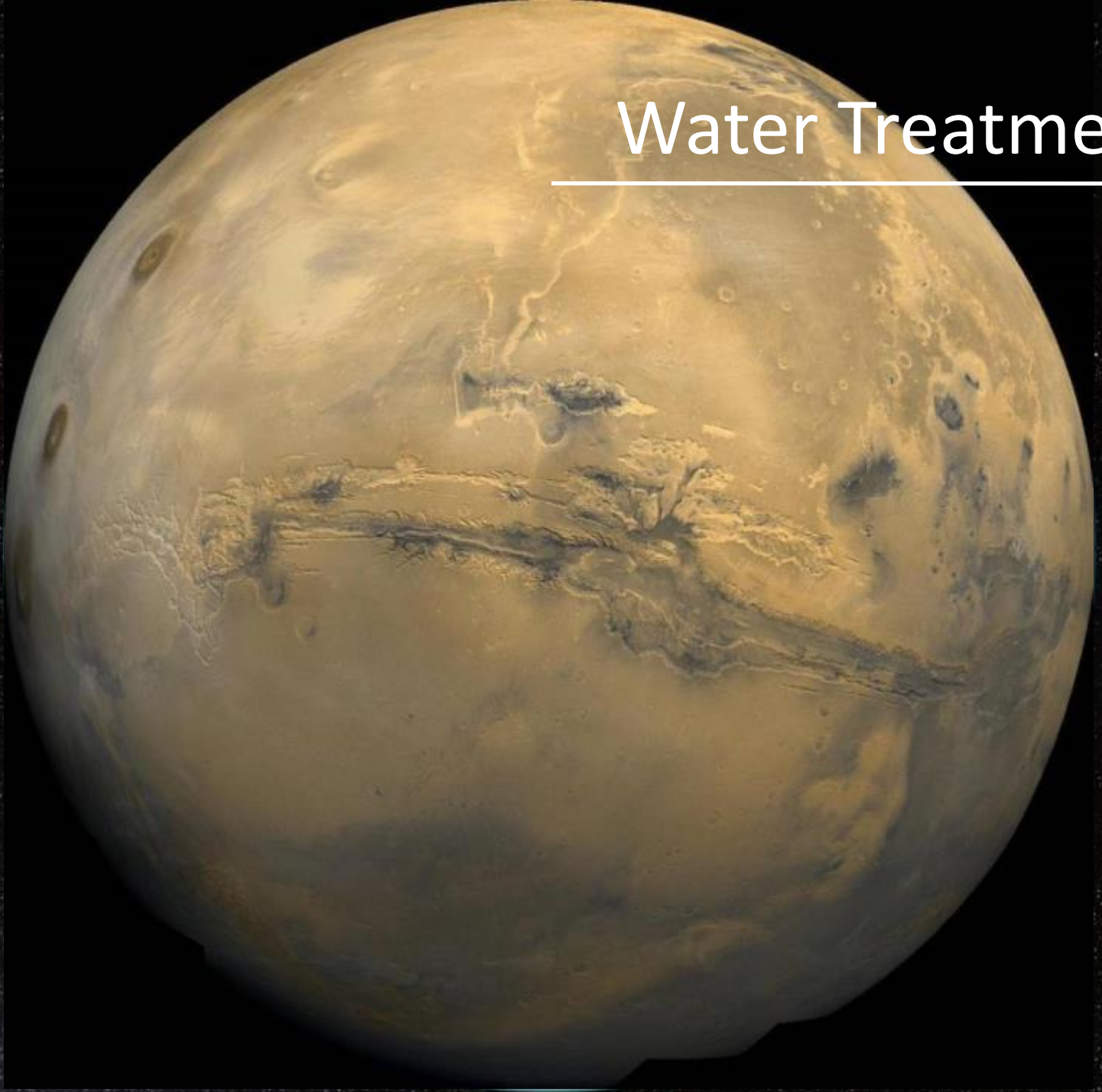


Space Bio-Manufacturing Model



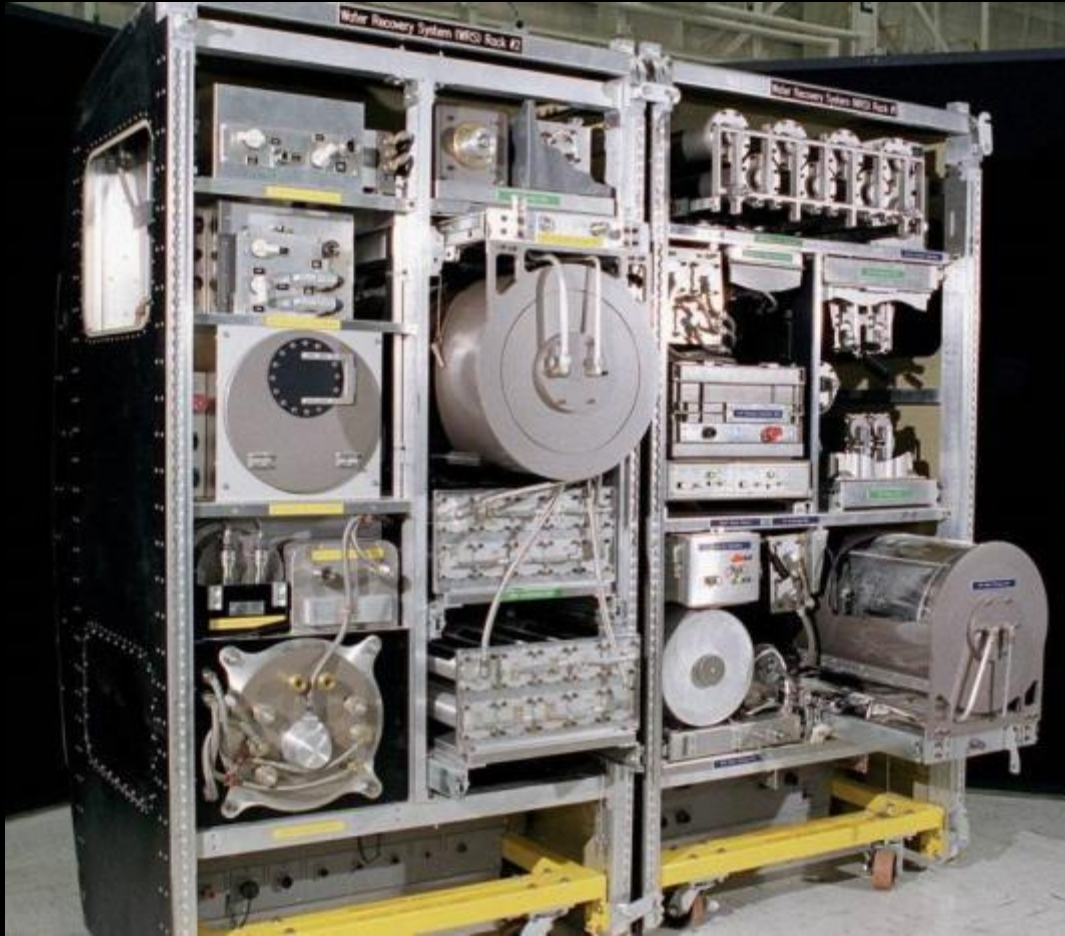


Water Treatment





Wastewater to Drinking Water

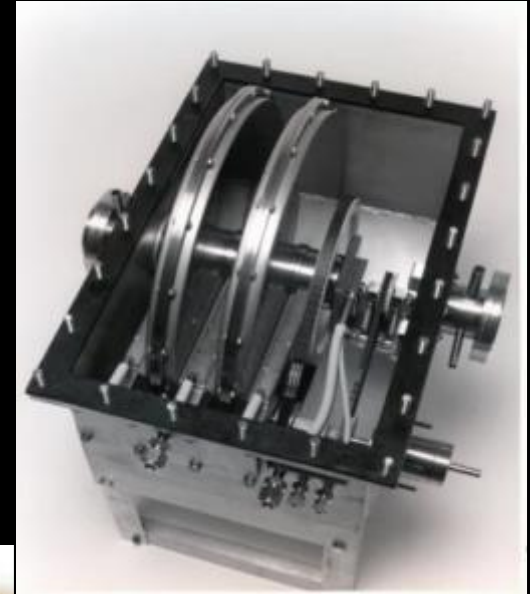
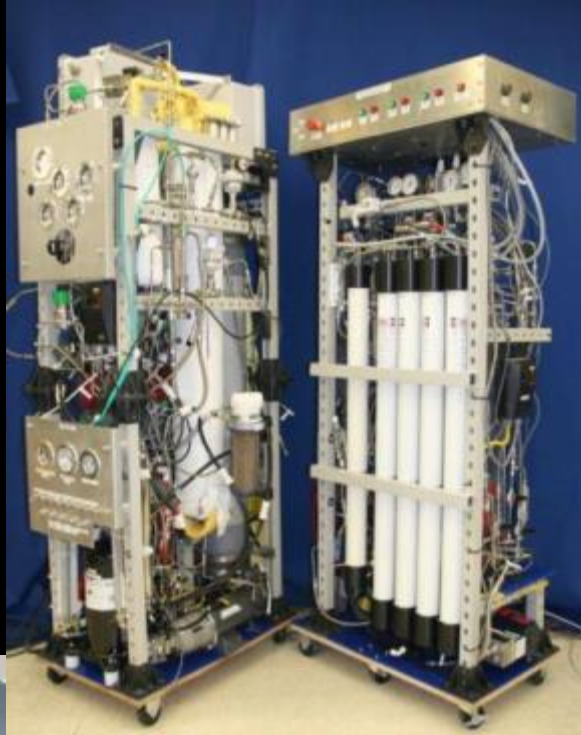


- Disinfection
- Organic Removal
- Inorganic Removal
- Maximize Recovery

ISS Water Recovery Subsystem



Closed-Loop Water Treatment





Waste Management





“Waste” Conversion and Reuse (“Cradle to Cradle” Approaches)



- Volume Reduction
- Odor Control
- Sanitize
- Generate H_2O , O_2 , CO_2 , Fuel, Nutrients, Building Materials

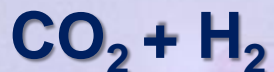


In Situ Manufacturing

Utilize unusable mission materials and *In situ* resources to generate products needed for sustainable systems.



Concept Example:



P/C Conversion
System



Microbial
Medium

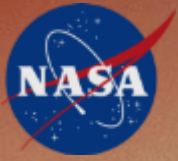


Growth System

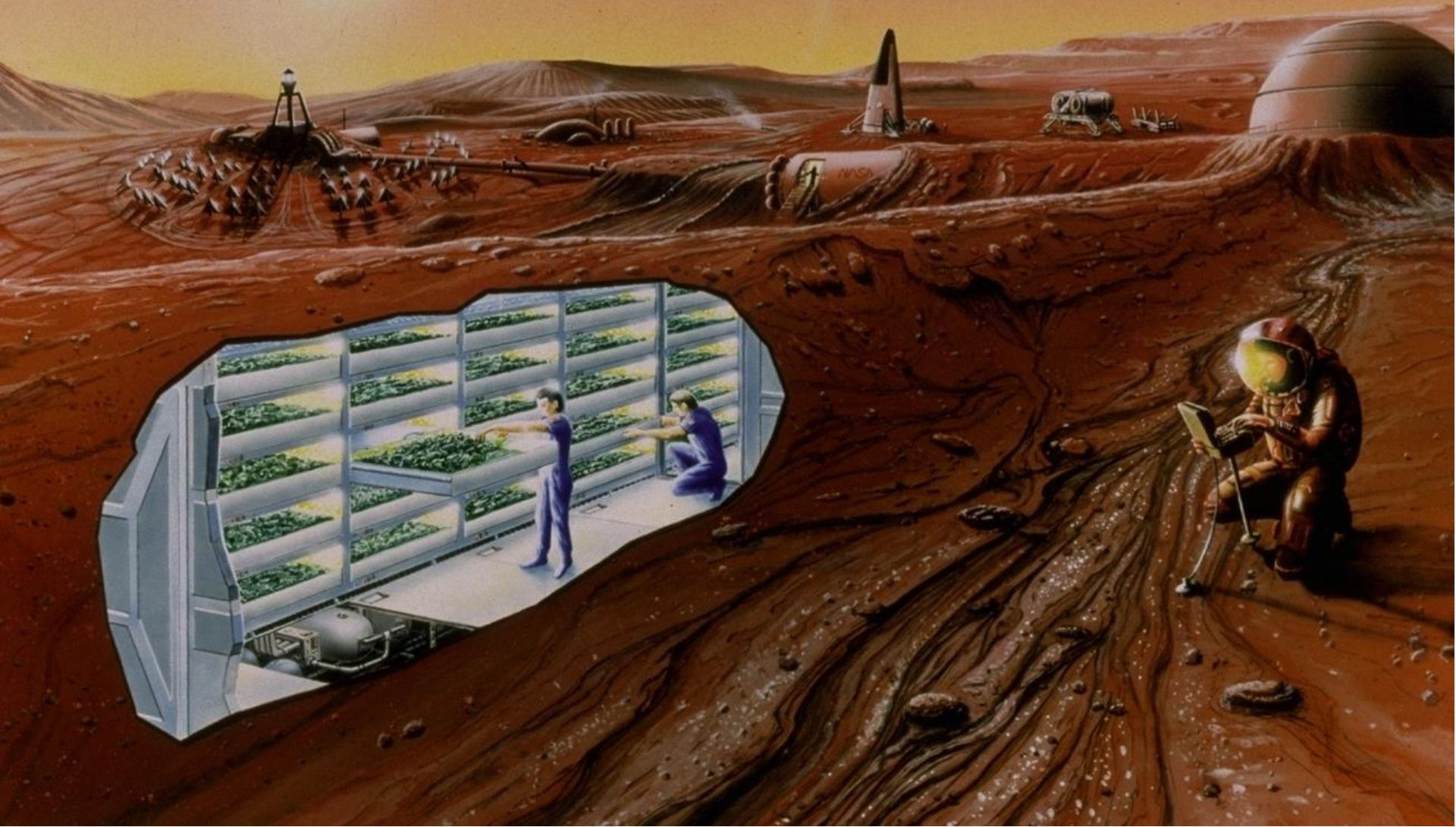


Products





Food Production





Closed System Agriculture



- Maximize Yield
- Low Water
- Efficient Lighting
- Use recovered nutrients



*Wheat - 3-4 x World Record
Potato - 2 x World Record
Lettuce-Exceeded Commercial
Yield Models*





Systems Engineering





Systems Engineering

ELSS-RQ35484-C

Earth Systems Program

Earth Life Support Systems Requirements Document

ESD – 34794

Earth Systems Directorate
Requirements Division

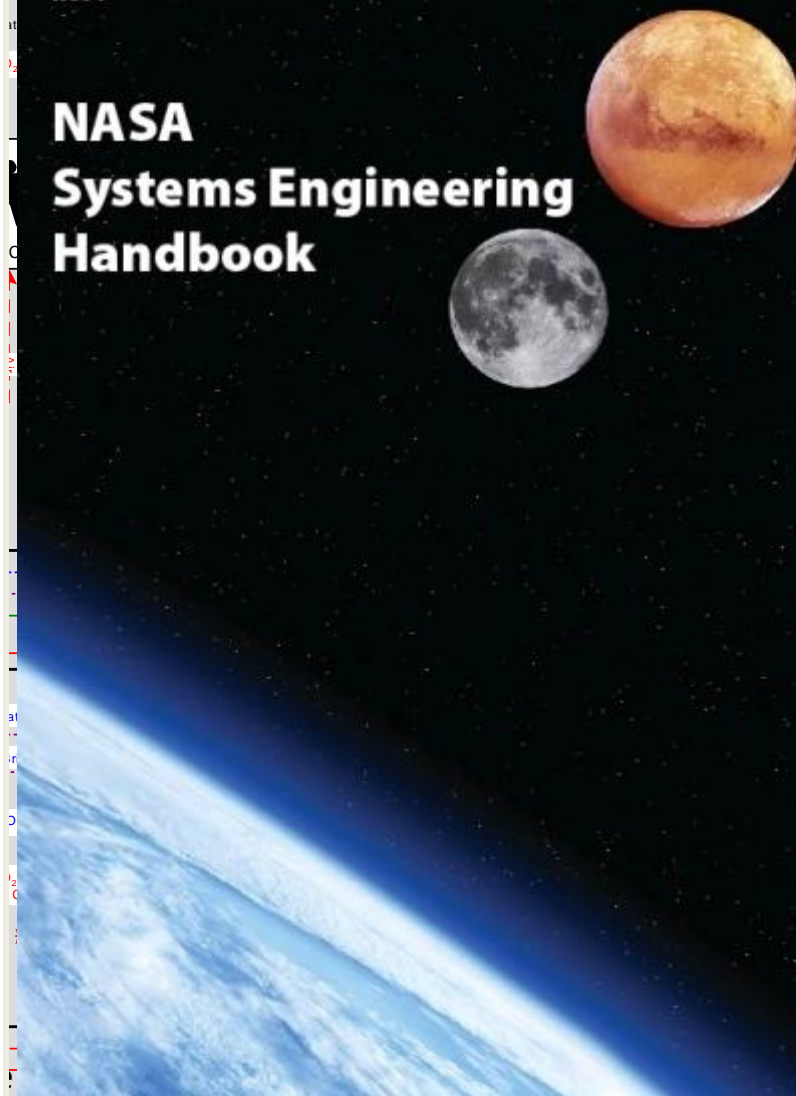
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Thank You