Water for Humans and Hardware in Space

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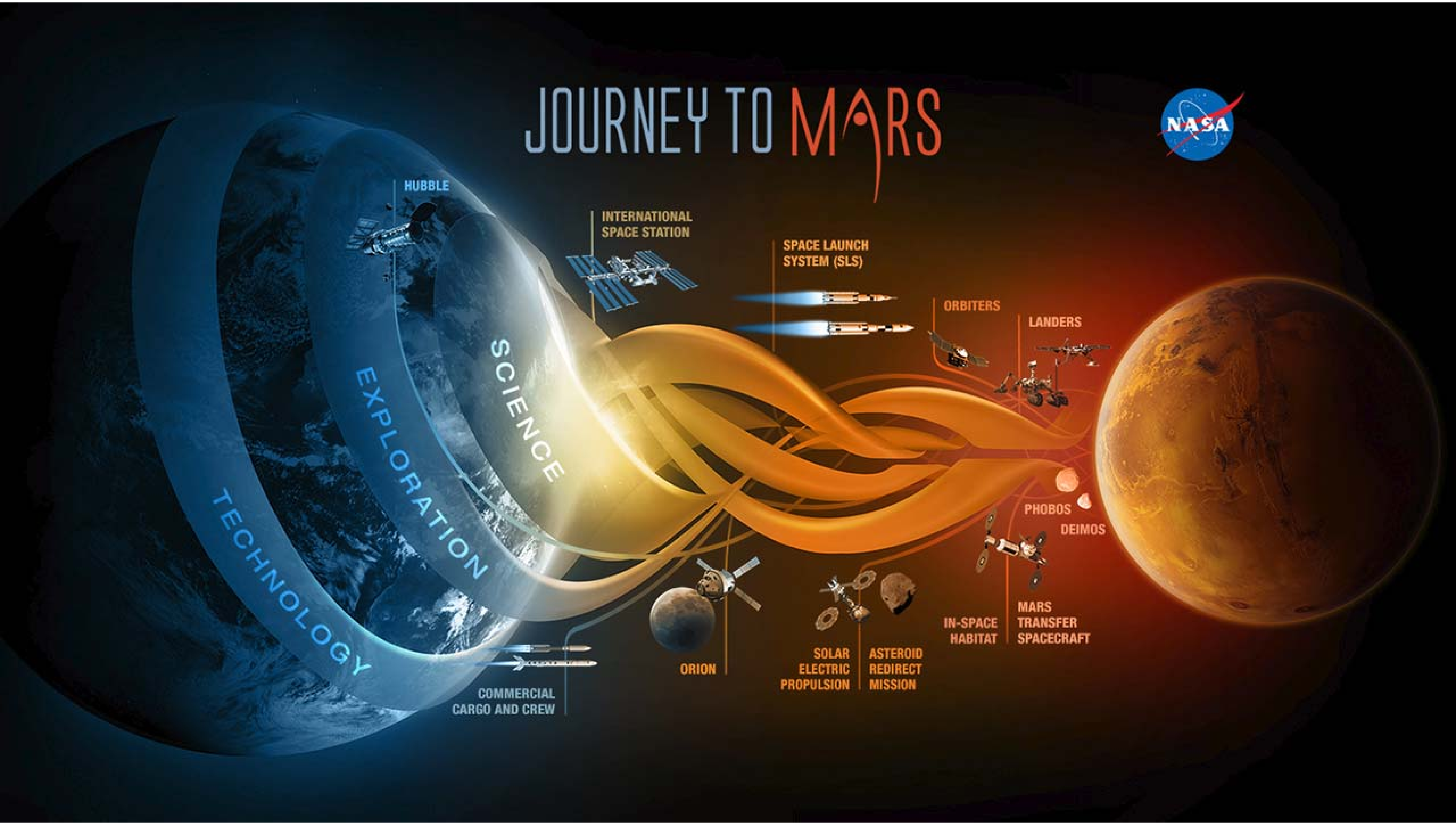
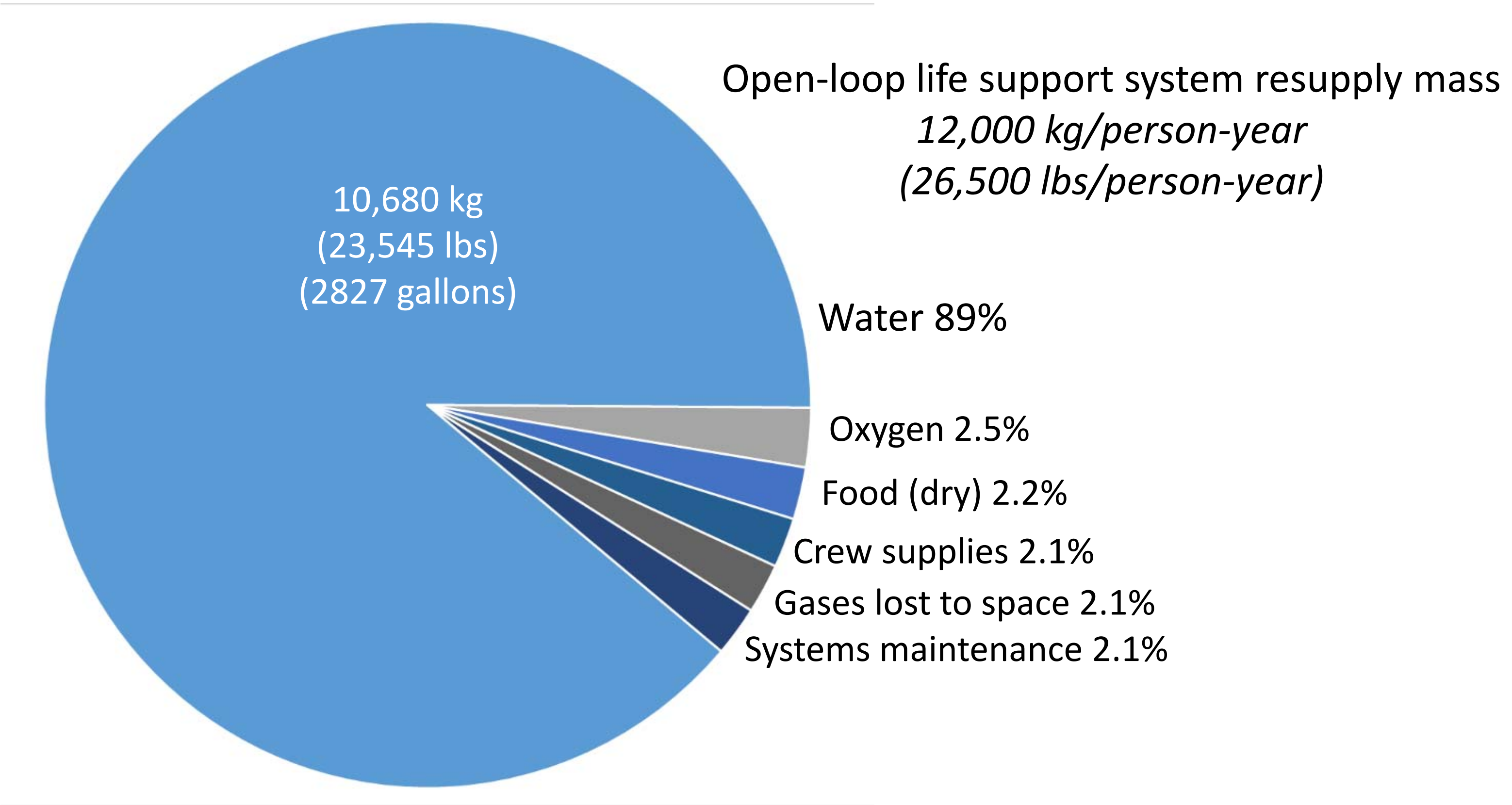
Presentation outline

- Why is water critical to NASA's mission?
- Water requirements for exploration
- Water recovery in space
- Current water monitoring technologies
- Technology needs for exploration



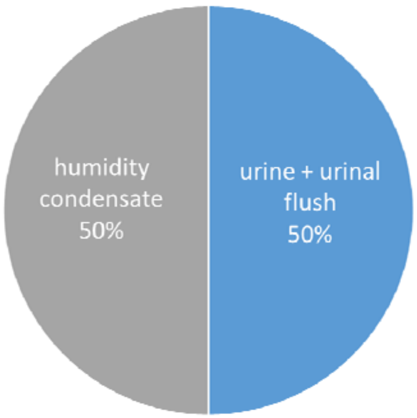
JOURNEY TO MARS
NASA
HUBBLE
INTERNATIONAL SPACE STATION
SPACE LAUNCH SYSTEM (SLS)
ORBITERS
LANDERS
SCIENCE
EXPLORATION
TECHNOLOGY
PHOBOS
DEIMOS
MARS TRANSFER SPACECRAFT
IN-SPACE HABITAT
SOLAR ELECTRIC PROPULSION
ASTEROID REDIRECT MISSION
ORION
COMMERCIAL CARGO AND CREW

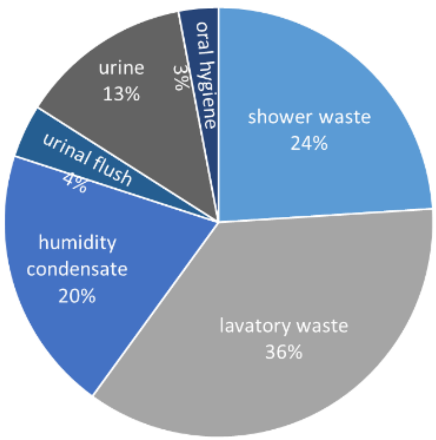
Human Life Support Requirements




Recovery of water
from wastewater is an
enabling technology to
explore beyond low
Earth orbit

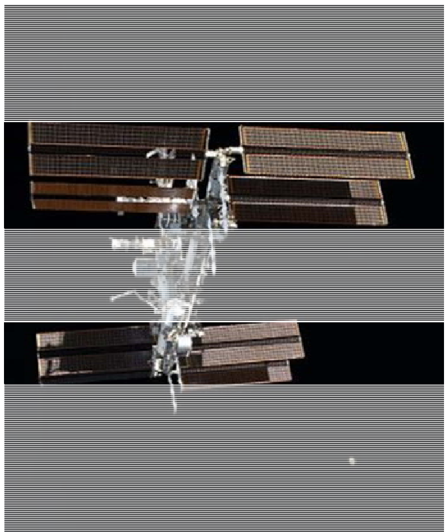
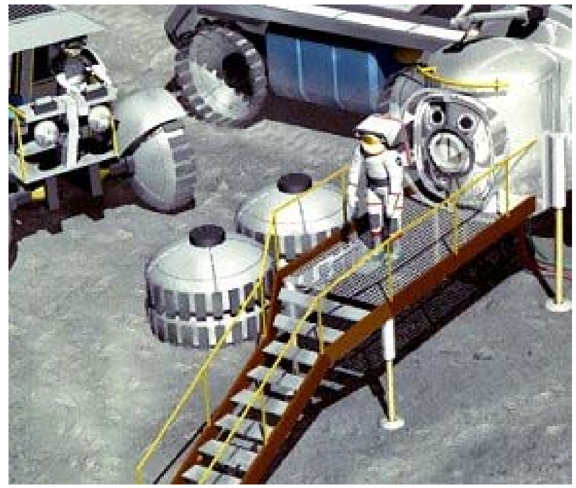
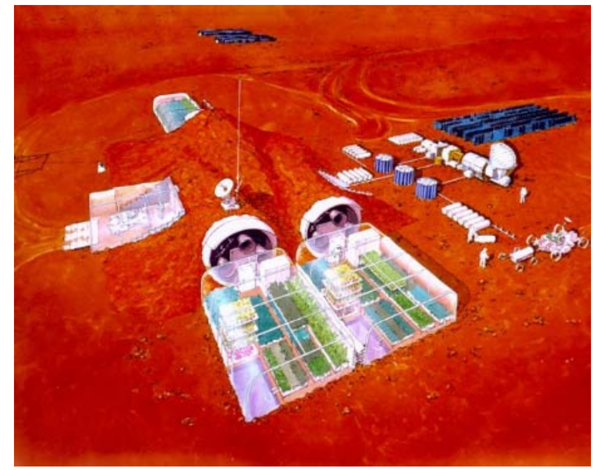
Wastewater Sources





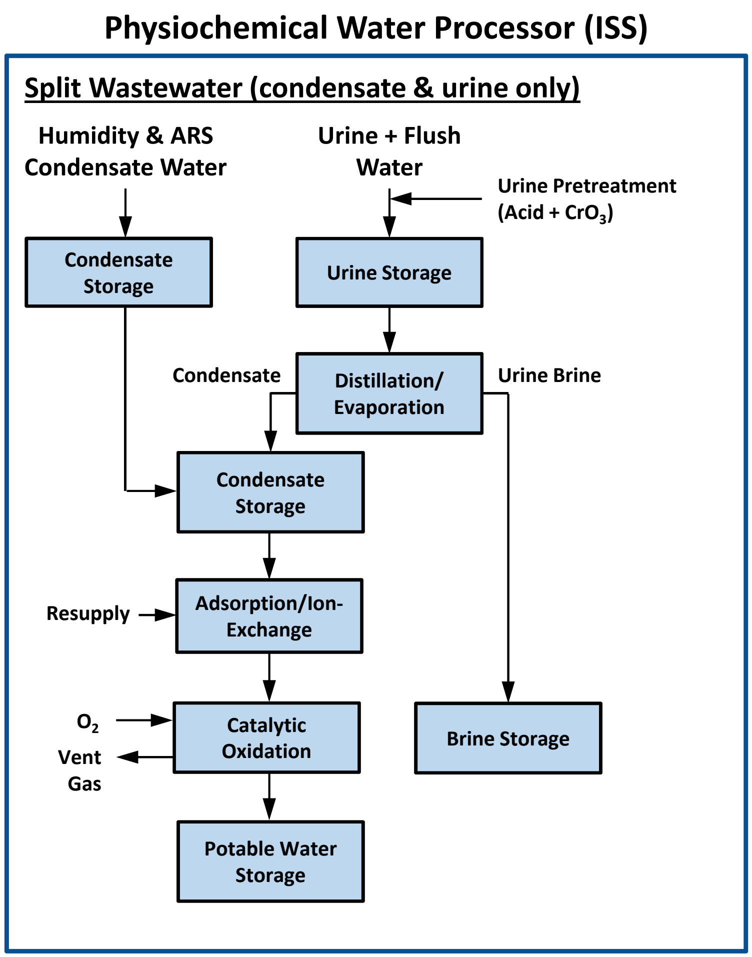
	ISS Wastewater	Exploration Wastewater (baseline)
pH	varies	8.9
Conductivity	170 µS/cm	5.8 mS/cm
Total organic carbon	60 mg/l	420 mg/l
Total nitrogen		1000 mg/l
Ammonium	20 mg/l	800 mg-N/l
Calcium		98 mg/l
Chloride		510 mg/l

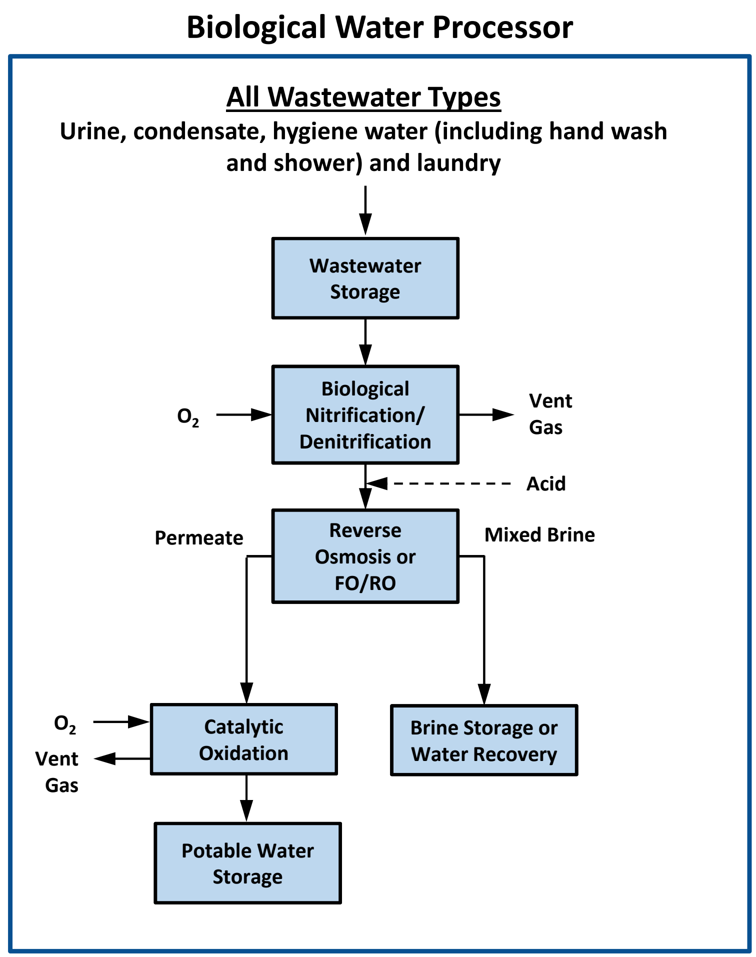
Wastewater sources increase as mission matures

Space Shuttle	ISS	Transit Mission	Permanent Base
N/A	Urine	Urine	Urine
	Humidity Condensate	Humidity Condensate	Humidity Condensate
		Hygiene	Hygiene
		Laundry (?)	Laundry
			Waste Leachate
			Hydroponics(?)

From wastewater to water: water recovery architectures





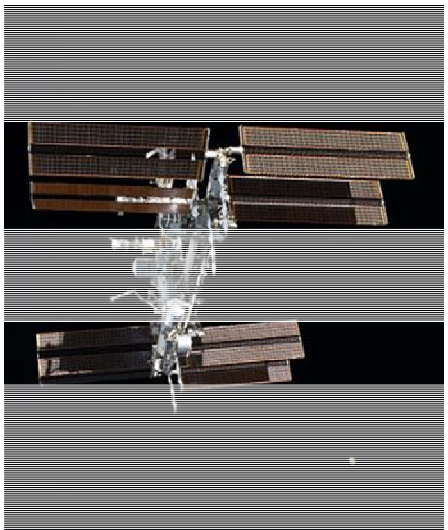
ARS = Atmosphere Revitalization System (CO_2 Reduction); FO/RO = Forward Osmosis/Reverse Osmosis

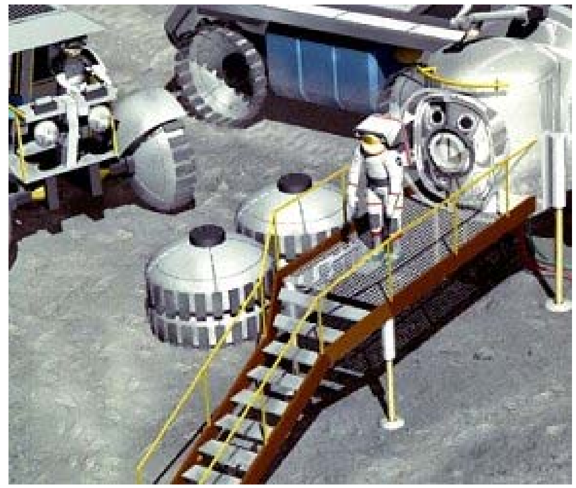
Product water quality

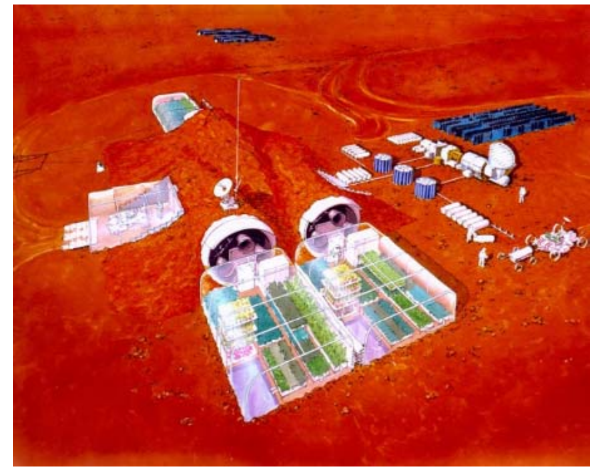
	NASA Potable Standards	NASA Hardware (Example)	EPA
Total organic carbon	3 mg/l	0.3 mg/l	Contaminant specific
Conductivity	N/A	1.0 µS/cm	Total dissolved solids: 500 mg/l
Chloride	N/A	500 µg/l	250 mg/l
Ammonia	1 mg/l	-	N/A
Surface tension	N/A	> 71.72 dynes/cm	N/A
Total silicon	N/A	500 µg/l	N/A
HPC	50 CFU/mL	<1CFU/mL	N/A

JSC-63414, Spacecraft Water Exposure Guidelines
JSC-66695, EMU Water Quality Specification

Water needs change as mission matures

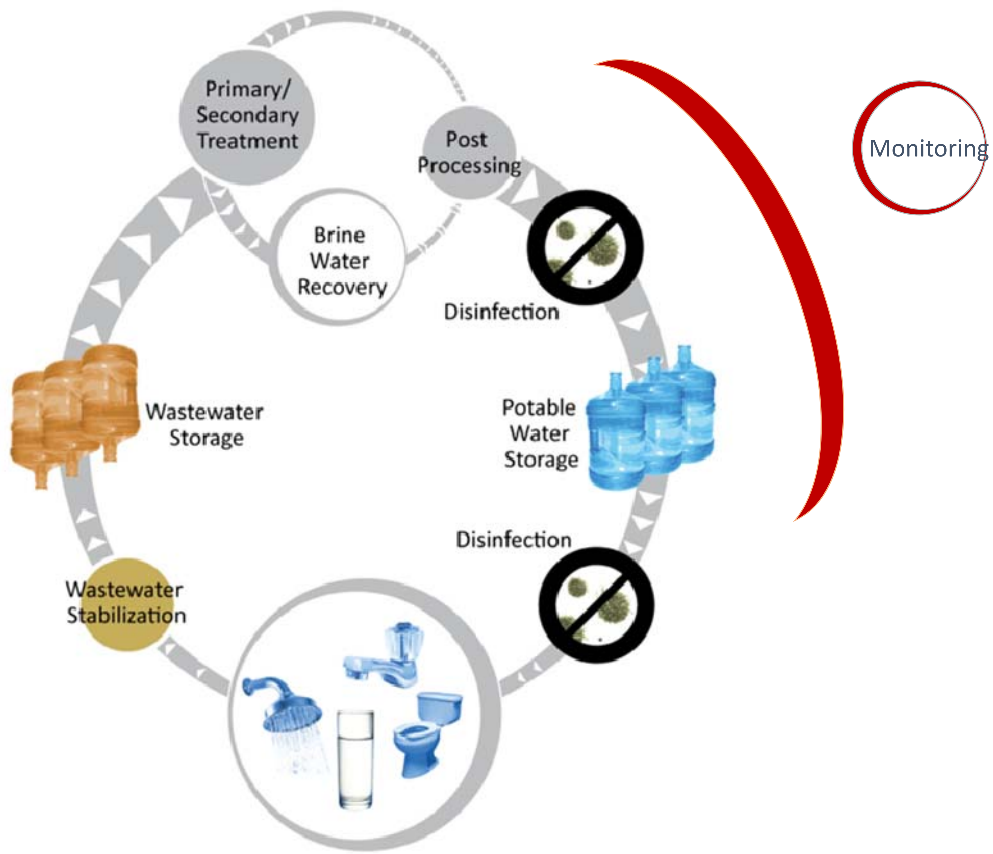






Space Shuttle	ISS	Transit Mission	Permanent Base
Consumption	Consumption	Consumption	Consumption
	Thermal coolant liquid (vehicle and suit)	Thermal coolant liquid(vehicle and suit)	Thermal coolant liquid (vehicle and suit)
	Hygiene activities	Hygiene activities	Hygiene activities
		Water for Injection	Water for Injection
			Laundry(?)
			Hydroponics(?)

Technology needs for exploration



Current water monitoring equipment

- TOC analyzer
- Conductivity probe
- HPC- modified spread plate method
  - No on-orbit identification capabilities
- Colorimetric solid phase extraction (C-SPE)
- OPA monitoring
  - Test strips
- Note: Water can be returned for more detailed analysis

Challenges for technology development

- Microgravity operation
- Phase separation
- Low flow = low shear forces = prolific biofilm formation
- Exploration missions have long periods between launch and operation

Answering the challenge

- In late 2014, stakeholders met to address gaps in current water monitoring technologies with the goal of developing, launching, and evaluating water monitoring technologies for exploration applications
- Technologies/methodologies discussed included:
  - Conductivity
  - Microbial enumeration/microbial identification
  - pH
  - TOC/organic identification
  - Total silicon
  - Free gas
  - Capacitance
  - Refractive index
  - Dissolved oxygen
- In January 2015, the ISS office initiated a program to fly technology prototypes to ISS by the end of the year to benefit future human space exploration
  - One of the projects selected: Water Monitoring Suite (WMS)

Water Monitoring Suite Project Background

- Water Monitoring Suite (WMS) combines three different types of instrumentation capable of demonstrating three different type of water monitoring technologies.

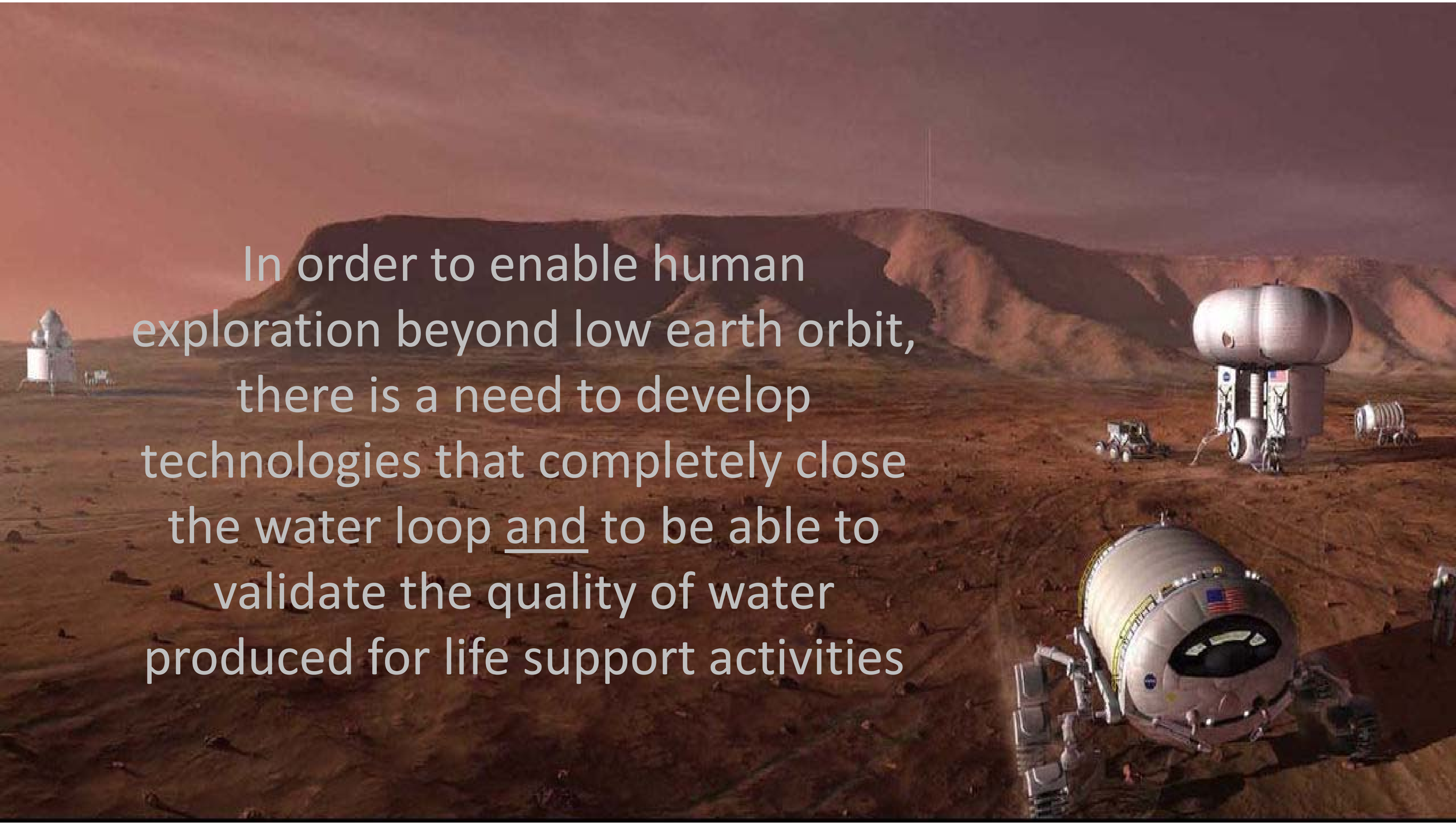
- Each instrument will also fly with unique sampling kits capable of use in microgravity.

- The instruments will be operated on orbit independently. The three instruments do not require integration with each other in order to function.
  1. Silica Analyzer System: Demonstrate the ability to analyze reactive silica content using the COTS HACH DR 900 Handheld Colorimeter

  2. Microbial Monitoring System: Demonstrate a microbial monitor that can perform real-time inflight microbial analysis using RAZOR EX PCR technology

  3. Organic Water Monitor: Demonstrate a water monitor to analyze organic contaminant content, using Gas Chromatography with miniaturized Thermal Conductivity Detector

WMS Hardware: SAS (L), MMS (R) and OWM (B)


In order to enable human
exploration beyond low earth orbit,
there is a need to develop
technologies that completely close
the water loop and to be able to
validate the quality of water
produced for life support activities