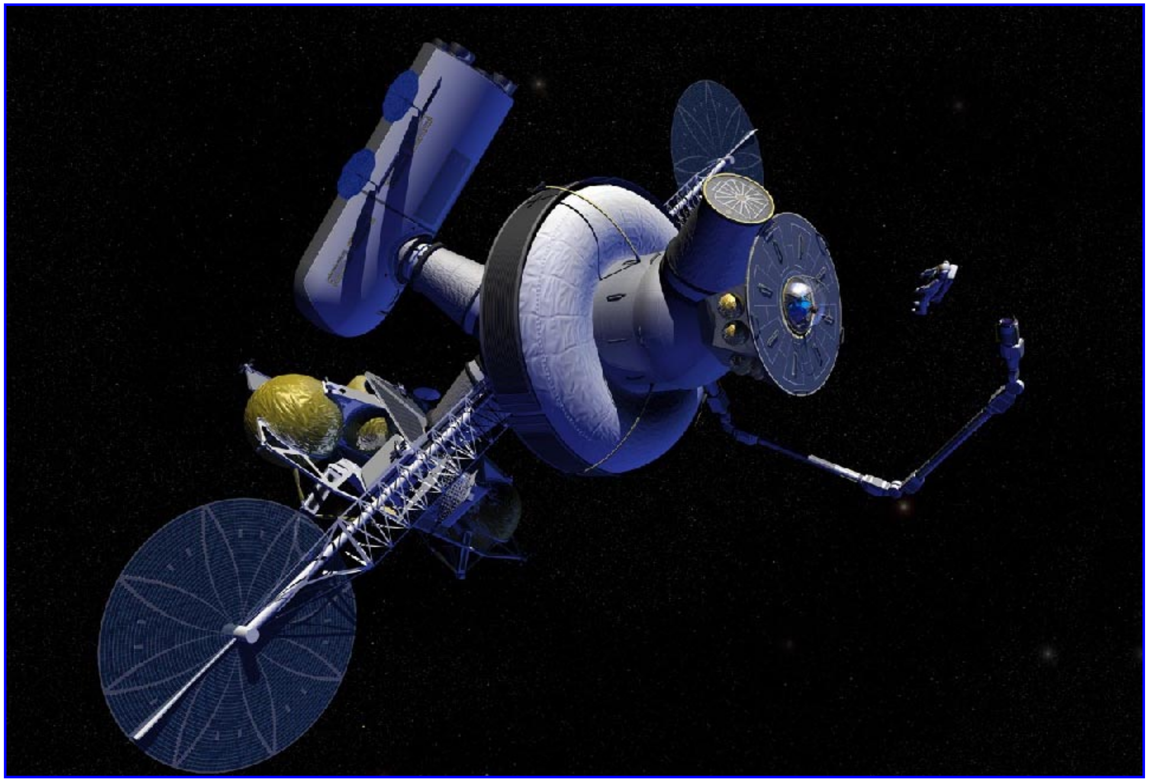
Gateway Concepts:

Thoughts on Construction of Future Science Facilities



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Concepts for Optimized Human/Robotic Construction of Advanced Science Facilities

The Challenge:

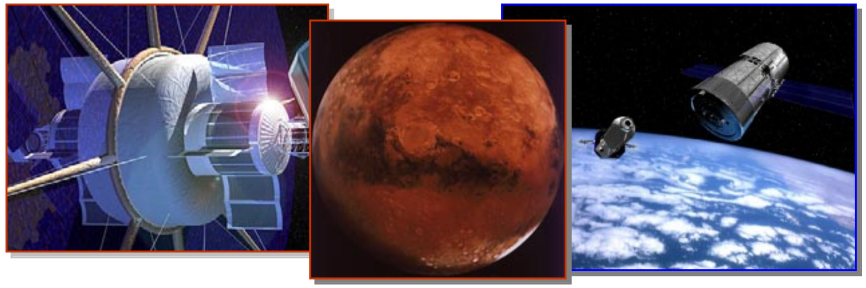
Ambitious science facilities, such as post-NGST astronomical telescopes, will be extremely difficult to deploy, construct, rescue, service, and repair in space without sophisticated capabilities for manipulation. Such capabilities might include advanced robots, autonomous or remotely-operated systems, and/or humans on-site.

The Goals of This Study:

We report here on a series of ongoing studies to evaluate alternative architectures for future space science facilities and how robots, humans, and autonomous systems might be optimally used to construct, support, recover, and repair them.

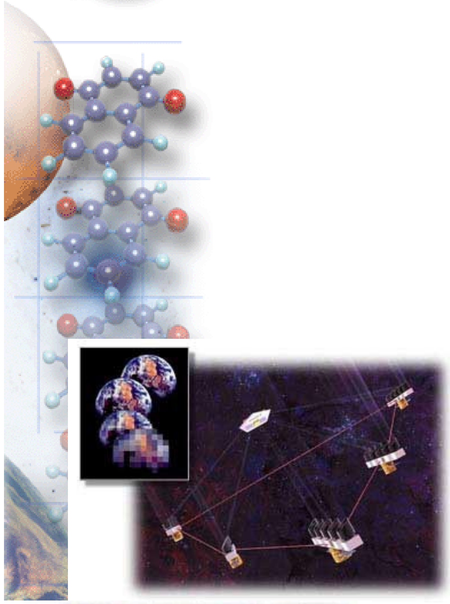
This presentation outlines one scenario -- a "Gateway" at the Earth-Moon L1 point for supporting multiple options beyond Low Earth Orbit -- plus our process for evaluating human/robotic activities to construct telescopes.

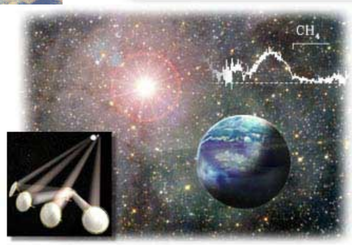
Exploration beyond LEO



Human Mars Exploration

- Technology Development
- Deep-Space Operational Experience
- Mission Staging





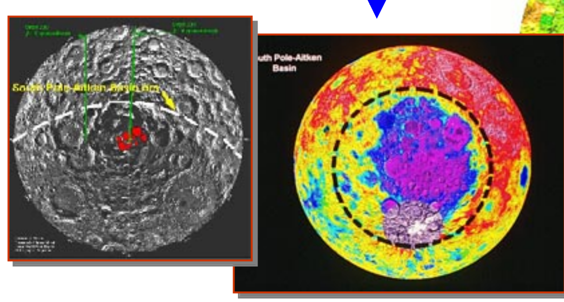
Construct, Deploy, and Service Advanced Astronomical Instruments

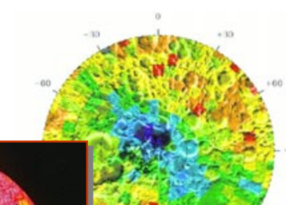
- Detect Biological Activity on Extra-Solar Planets
- Image Surfaces of Extra-Solar Planets

"Earth's Neighborhood" Capabilities

Construct and Deploy Solar Sentinels

- Search for Location and Mechanism of Solar Flares
- Increase Lead Time and Accuracy for Geospace Forecasts





Lunar Science

- Impact History in Near-Earth Space
- Composition of Lunar Mantle
- Past and Current Solar Activity
- Poles - History of Volatiles in Solar System

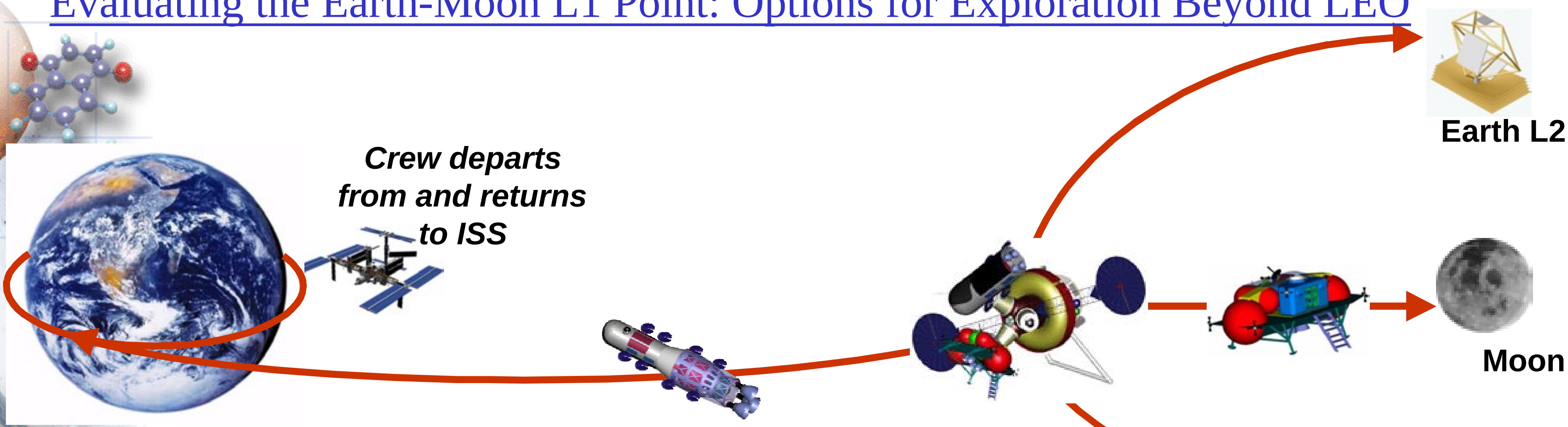
Major OSS Mission Concepts Under Study for 2010+: Candidates for Human-Robotic Support

Science Missions currently under study for 2007 and beyond						
Mission	Description	Human Assembly	Human Servicing	Large Launch Vehicle	Fission Propulsion	RPS
ARISE	Advanced Radio Interferometry between Space and Earth	n	n	n		
CMBPOL	Cosmic Microwave Background Polarization	n	n	n		
Europa Subsurface	Penetration of frozen crust, and hunt for life below	n	n	y	probable	probable
EXIST	Energetic X-ray Imaging Survey Telescope	n	n	n		
FAIR	Filled-Aperture Infrared Telescope	y, L1	y, L1	y		
HSI	High Resolution X-ray Spectroscopy Mission	y, LEO	n	n		
Interstellar Probe	solar wind termination shock & heliopause;significant penetration into the loca	y, L1	n, L1	y	probable	
ITM Wave Imaging	Ionosphere-Thermosphere-Mesosphere (ITM)	n	n	n		
Life Finder	Detecting spectroscopic signs of life on nearby extrasolar planets.	y	y	y		
MAXIM Pathfinder	MicroArcsecond X-ray Imaging Mission Pathfinder	(y)	(y)	y		
Microscale Coronal Features	imaging and spectroscopic data able to resolve microscale coronal features.	n	n	n		
Neptune Orbiter	Neptune & Triton	n	n	y	probable	probable
OWL	Orbiting Wide-angle Light-collectors	n	n	n		
Planet Imager	An array of interferometers that each carried NGST-sized telescopes (about e	y	y	y		
Saturn Ring Observer	detailed investigations of complex dynamic processes in rings	n	n	y	possible	probable
Solar Polar Imager	data from above Sun's poles to complement data fromecliptic plane.	y*, LEO	n	y		
SPIRIT	Space Infrared Interferometric Telescope	y**, L1	n	y		
SUVO	Space Ultraviolet Optical Telescope	y, L1	y, L1	y		
Venus SSR	Venus Surface Sample Return	n	n	y		probable

* May use solar sail; potential human deployment of sail
**Possible human deployment of interferometer

Gateway Architecture

Evaluating the Earth-Moon L1 Point: Options for Exploration Beyond LEO



Crew Transfer Vehicle

- Transports crew between ISS and Gateway (4-6 day trip)
- Nominal return to ISS with contingency direct Earth return

L_1 Gateway

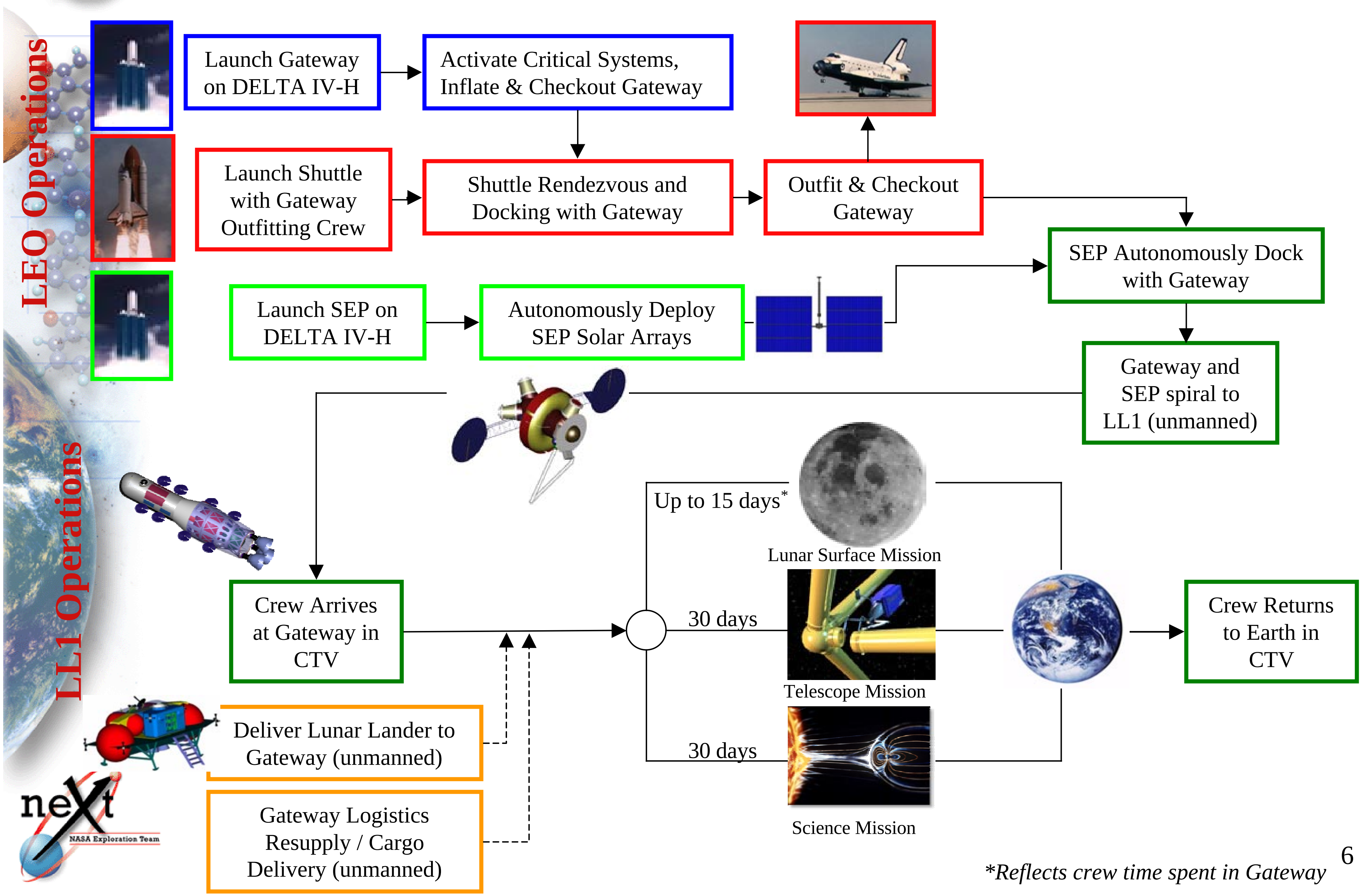
- "Gateway" to the Lunar surface
- Outpost for staging missions to Moon, Mars and science facility construction

Siting a human-occupied "Gateway" at the Earth-Moon L1 point has several advantages in the event that humans are important to support a major in-space science facility:

- After construction, such facilities may be transferred to Earth-Sun libration points (or beyond) with very modest Delta-Vs
- Humans may return to Earth relatively quickly in the event of emergency
- Long-term habitation at this site may be supported relatively easily from Earth
- Capabilities may be developed at this site for longer-term, deeper-space operations while still within short travel-time to Earth

NeXt NASA Exploration Team

Lunar L1 Gateway Mission Profile
[Baseline Concept]



*Reflects crew time spent in Gateway

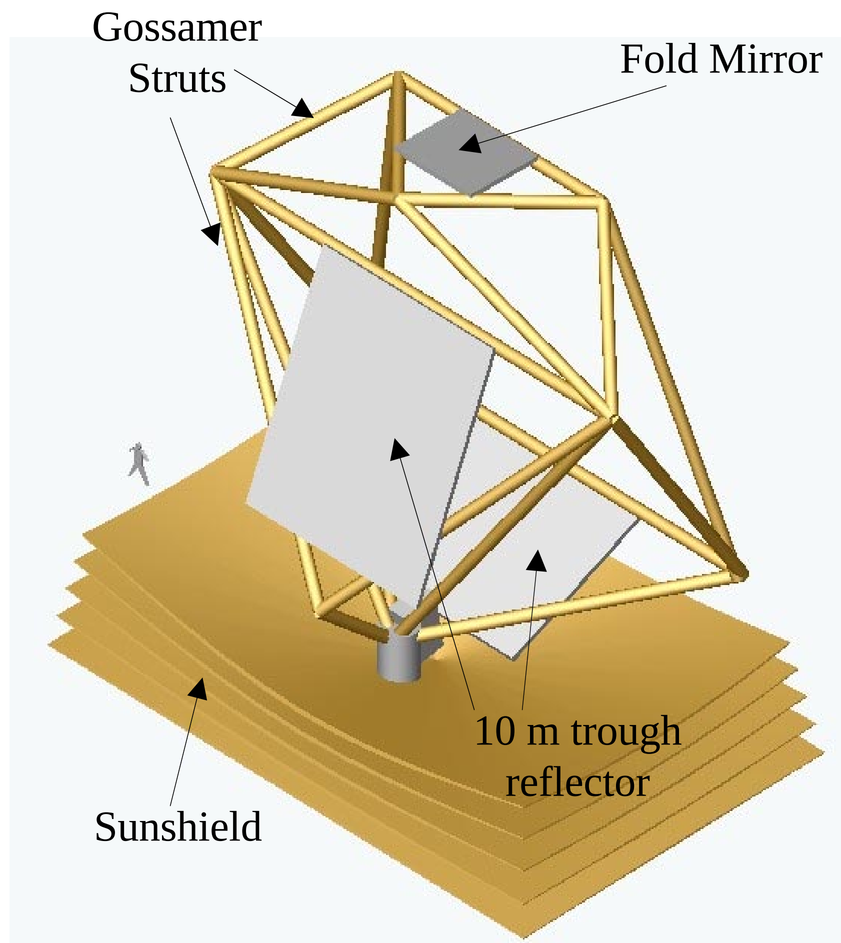
Far-IR Telescope Concept Construction
[Baseline Concept]

Hardware Support

- Docking for crew transfer vehicle and telescope component delivery module
- SSRMS-class large manipulator
- Small, dexterous robot to aid inspections and assembly/maintenance tasks
- EVA Airlock and teleoperator control station
- Unpressurized partially enclosed work area
- Structure/platform to restrain the telescope during work
- EVA and robotic-compatible storage areas for tools and telescope components

Mission Support

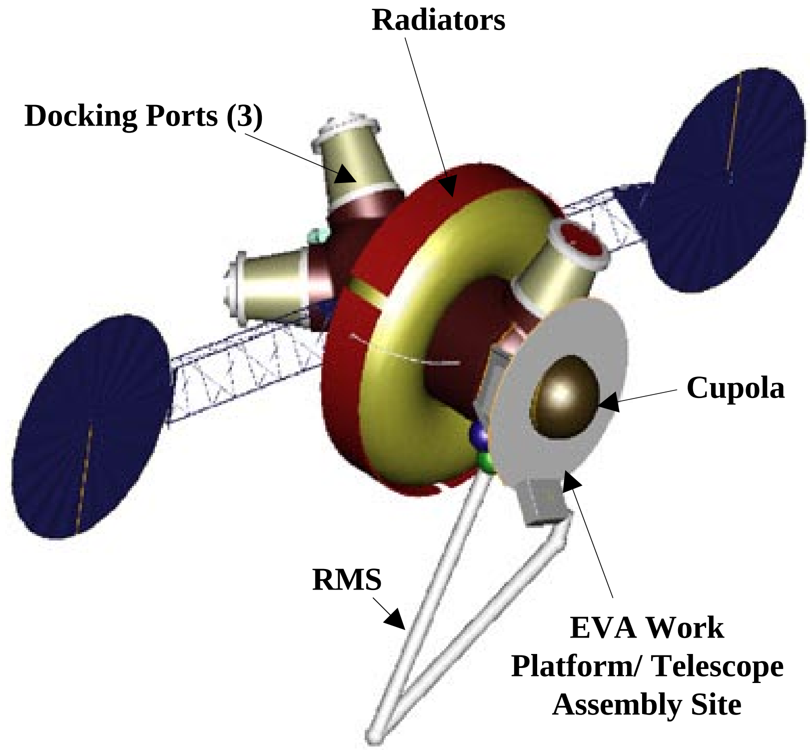
- Complete assembly at Lunar L1: **2 weeks** for **2 teams** of EVA crew; **6-8 EVA sorties**
- For telescope maintenance missions, assume **1 team** of EVA crew for **2 weeks**
- **Total Mission Time at Gateway: 25 days**

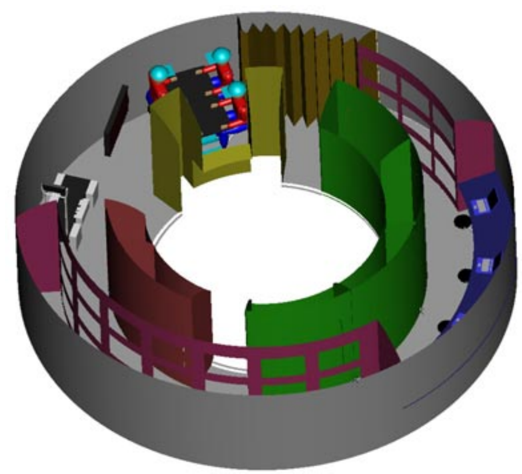


Gateway Concept Summary

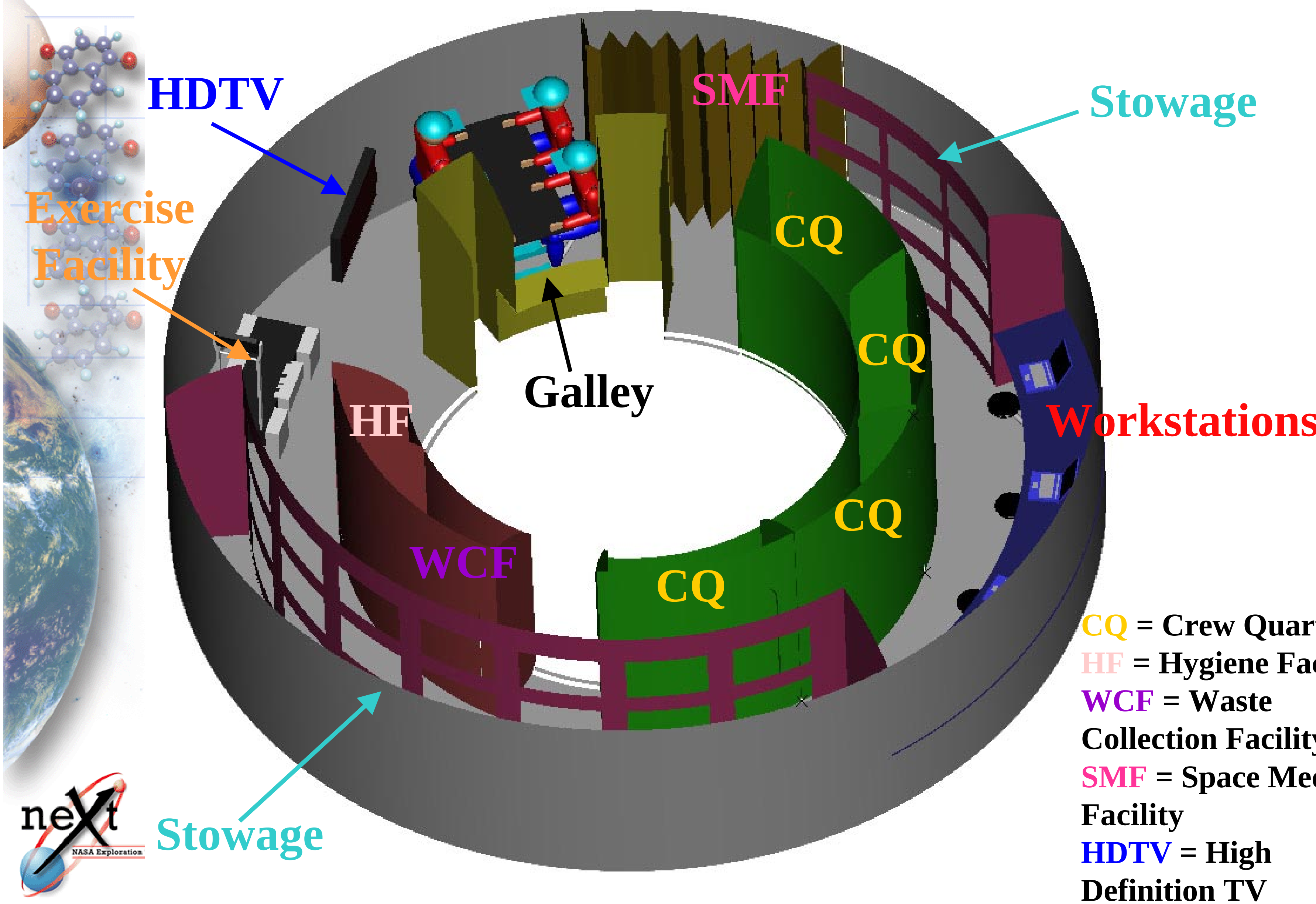
- **Destination:** Lunar L1
- **Element Design Lifetime:** 15 yrs
- **Crew Size:** 4 persons
- **Mission Duration:** 10-30 days
- **Element Mass:**
  - Launch: 22,827 kg
  - Outfitting: 588 kg
  - Post-outfitting: 23,415 kg
- **Element Volume:**
  - Launch: 145 m^3
  - Inflated: 275 m^3

  (TransHab: ~340 m^3 for 7 persons)
- **Power provided:**
  - Photovoltaic Array: 12 kW Nominal
  - Energy Storage: Li-ion Batteries
- **Support Missions:**
  - Outfitting at LEO: One mission/architecture
  - Human Consumables: Two missions/year
  - Life Support resupply: One mission/two years



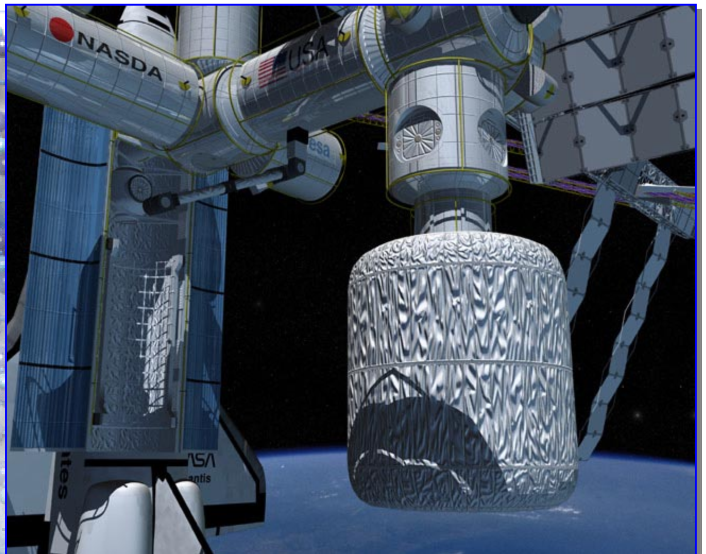


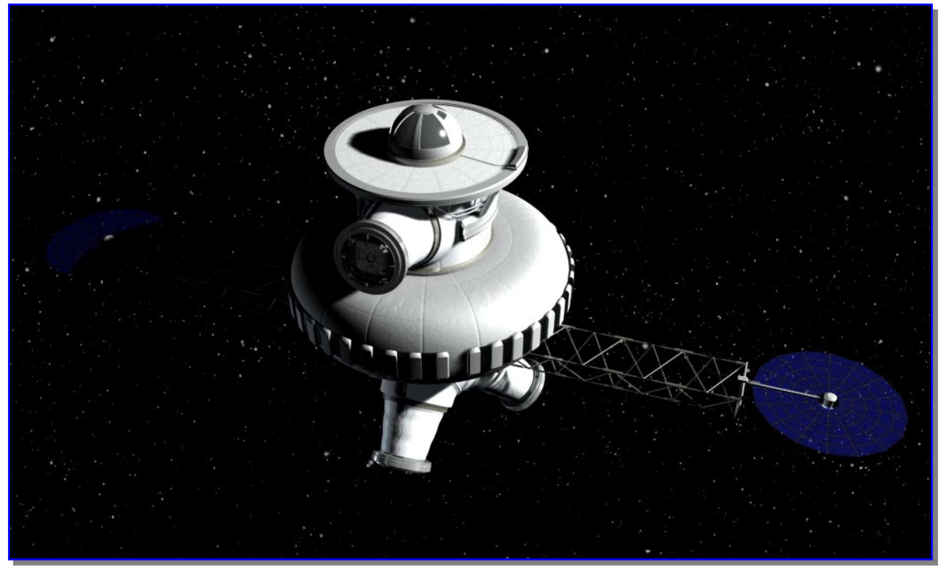
Habitability and Human Factors (HF&H) Cabin Layout



CQ = Crew Quarters
HF = Hygiene Facility
WCF = Waste Collection Facility
SMF = Space Medical Facility
HDTV = High Definition TV

Gateway Design Heritage

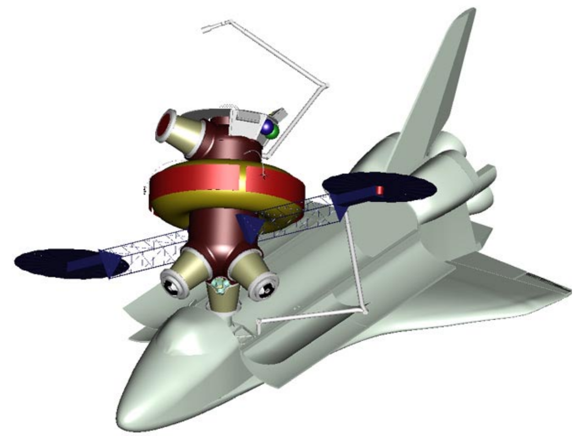




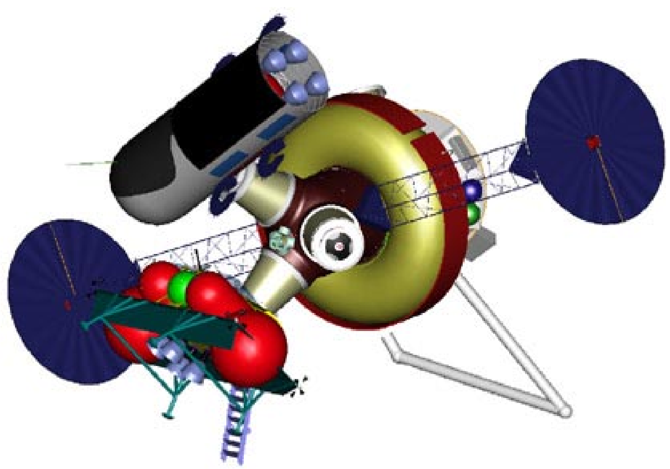
- Initial Gateway design was a carbon copy of TransHab
- Gateway and TransHab support different missions
  - TransHab relied upon ISS resources for ECLSS, TCS, Power, etc.; supports crew of seven
  - Gateway is a self-contained spacecraft and requires additional structural hardpoints for interior and exterior hardware packaging
- Gateway uses materials tested and design knowledge gained from TransHab study to minimize development cost
- Gateway features a hybrid structure design
  - Rigid core for hardware mounting
  - Inflatable crew quarters for large total pressurized volume (69 m^3/person -> roomy!)

Gateway Configurations

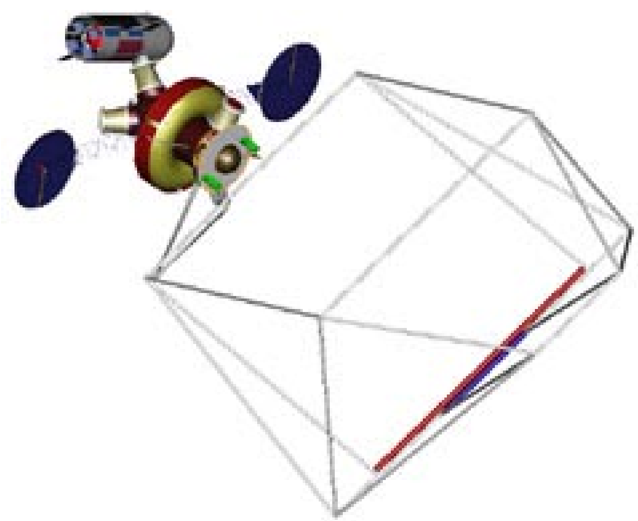
Launch Configuration



Gateway Outfitting in LEO

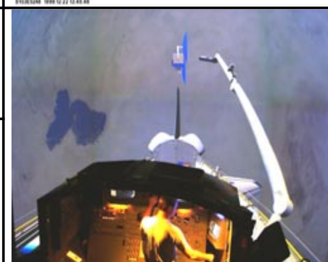
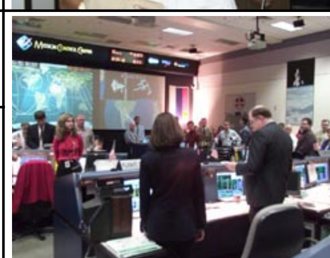


Lunar Surface Expedition



Telescope Assembly Mission

Tools Available for Space Telescope Support

Humans		Robots	
1. EVA Astronaut Pairs of astronauts work in conjunction with robotic agents to assemble space telescopes. Two pairs of two EVA crew assumed on alternating EVAs.		**1. Robonaut** Dexterous anthropomorphic robot to complement human assembly agents. Provides fine motor skills, telerobotically controlled.	
2. RMS Operator RMS controlled from vehicle interior by IVA crewmember. Also controls RMS cameras and Mini-AERCam.		**2. Remote Manipulator System (RMS)** Shuttle/Gateway-based robotic arm for worksite support and payload manipulation	
3. Robonaut Operator Dexterous robot controlled via telepresence equipment. Operator may be IVA crewmember or Earth-based operator.		**3. Assembly Table** Notional concept for aiding telescope assembly. Robotic features may include worksite tilt, rotation, and elevation capabilities.	
4. Mission Control Provides mission support, guidance, and additional problem solving capability. May be used for telerobotic control in conjunction with IVA crewmember control.		**4. Mini-AERCam** Free-flying camera for close-proximity inspection. Controlled by IVA crewmember. Utilizes inert Xenon propulsion system to minimize contamination.