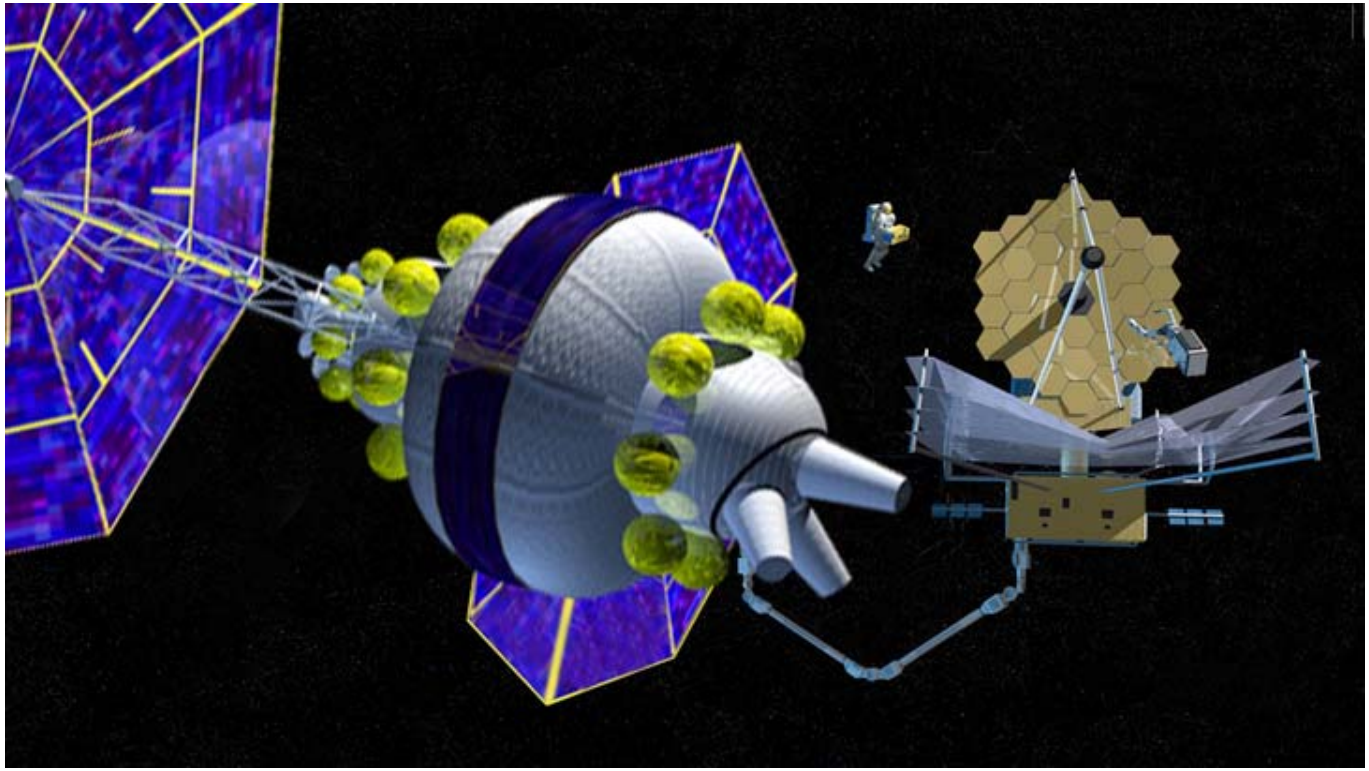
Enabling the Exploration Vision:

NASA Goals and a Libration Point Gateway



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Space Resources Roundtable VII
Houston, Texas

Contention: To achieve the highest priority national goals in space, NASA must develop substantial in-space capabilities within the next decade

Corollary: These capabilities will benefit significantly lunar surface operations, as well as being necessary to the human exploration of Mars.

The Challenge:

NASA has been given profound challenges over the next few decades: sustained operations on the lunar surface, extending human presence beyond the Earth-Moon system, and the search for life within the Solar System and beyond.

These goals will require capabilities that build upon and extend those required for the ESAS return-to-the-Moon architecture.

The Conclusion of this Presentation:

Elements of capable in-space operations can achieve multiple national goals in space. Indeed, it may be impossible to achieve major Agency goals without in-space capabilities not currently being developed.

This presentation emphasizes one scenario: a human-occupied "Gateway" at the Earth-Moon L1point that may be used to support lunar surface operations, bioastronautics and preparation for long human voyages, and servicing of complex science facilities.

Within about a decade, there will be numerous requirements -- and extensive opportunities -- for space operations (I)

Support for Lunar Surface Operations:

Comm systems: constant line-of-sight to surface

Management of space-based power systems

Robotic/telerobotic surface explorers: operations with little latency

Robotic ISRU and construction: line-of-sight to surface, intervention

Space depoting: cycling from surface to space depot and back to surface

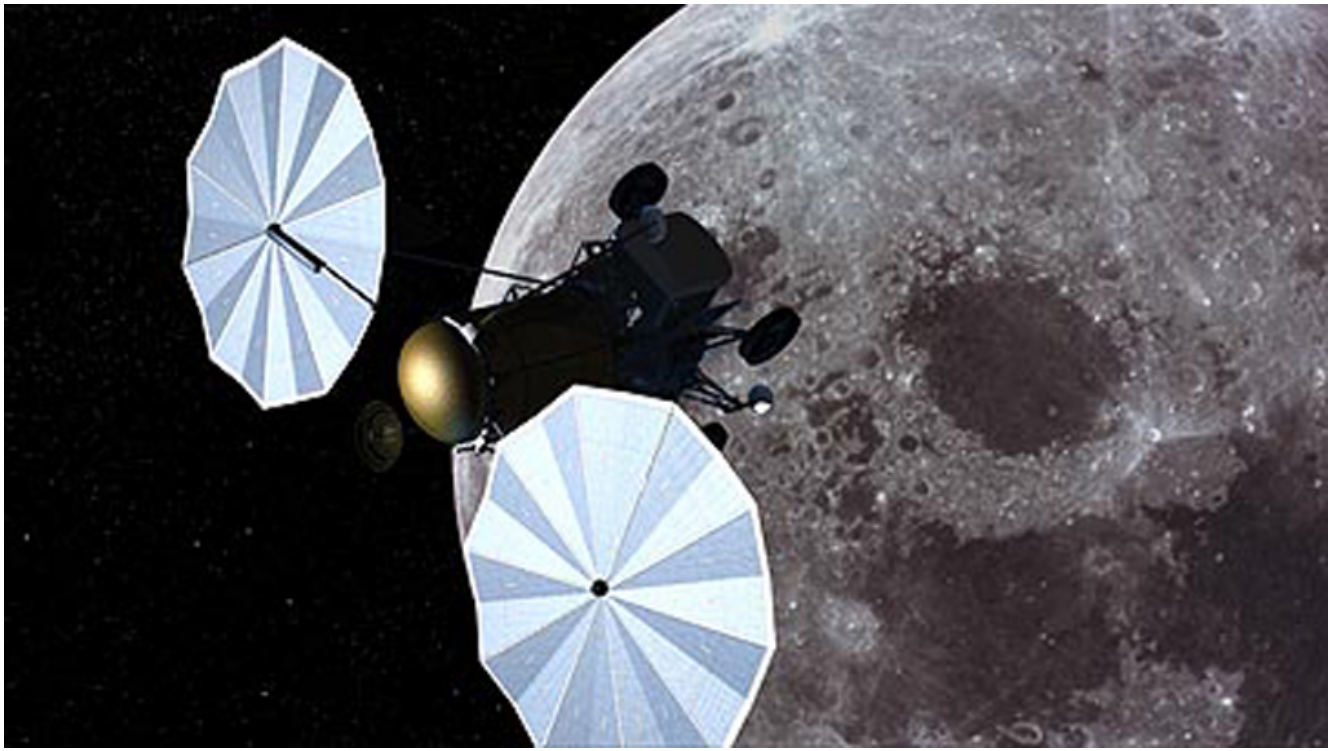
Capable support for human surface contingencies:

- **Send supplies/medical equipment to surface**
- **Coordinate rescue/recovery with constant line-of-sight comm**
- **Well-equipped and staffed orbiting ER/repair/resupply station**

Summary:

As a parallel to Antarctic occupation, in-space support for sustained lunar surface operations is likely to be an enabling capability.

In-space support for lunar surface operations



Controlled emplacement concept: robotic re-supply or ISRU capability, with direct orbiting line-of-sight comm. Contingency support may include upgrading, repair, or replacement of failed equipment, replacement lander or surface hab, or substantial medical support.

Within about a decade, there will be numerous requirements -- and extensive opportunities -- for space operations (II)

Post-ISS Preparation for Long Human Voyages to Mars:

Bioastronautics/crew safety/crew health: extend the work begun on ISS

Life-support systems, vehicle health maintenance

Operational systems for long voyages: repair, back-up, redundancy

Precursors/demos: safe 2030's voyages require capabilities in 2020's

Summary:

Preparation for the long human voyages to Mars is likely to be far more challenging and complex than the return to the Moon, with capabilities necessary well in advance of the first voyage: investments should begin in the near future.

Advanced bioastronautics, life support, and IVHM

Successful human exploration of Mars one day will <u>require</u> in-space capabilities that build upon, but extend significantly, those that are being developed via ISS

Within about a decade, there will be numerous requirements -- and extensive opportunities -- for space operations (III)

Servicing of Large Complex Science Facilities in Space:

Large optical systems for defense, astronomy, Earth science

Complex robotic science missions to the outer Solar System

- **Revived *JIMO* or other fission-powered systems?**

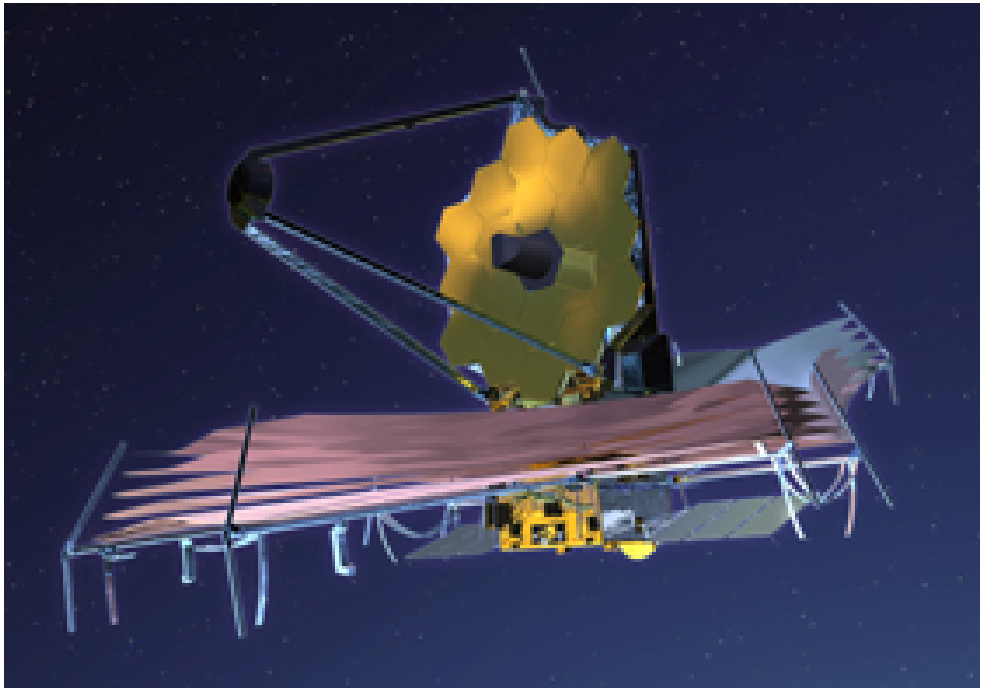
Accessible isolation sites for sample return

Assembly, support, repair, and recovery capabilities to build the human transfer vehicle to Mars

Summary:

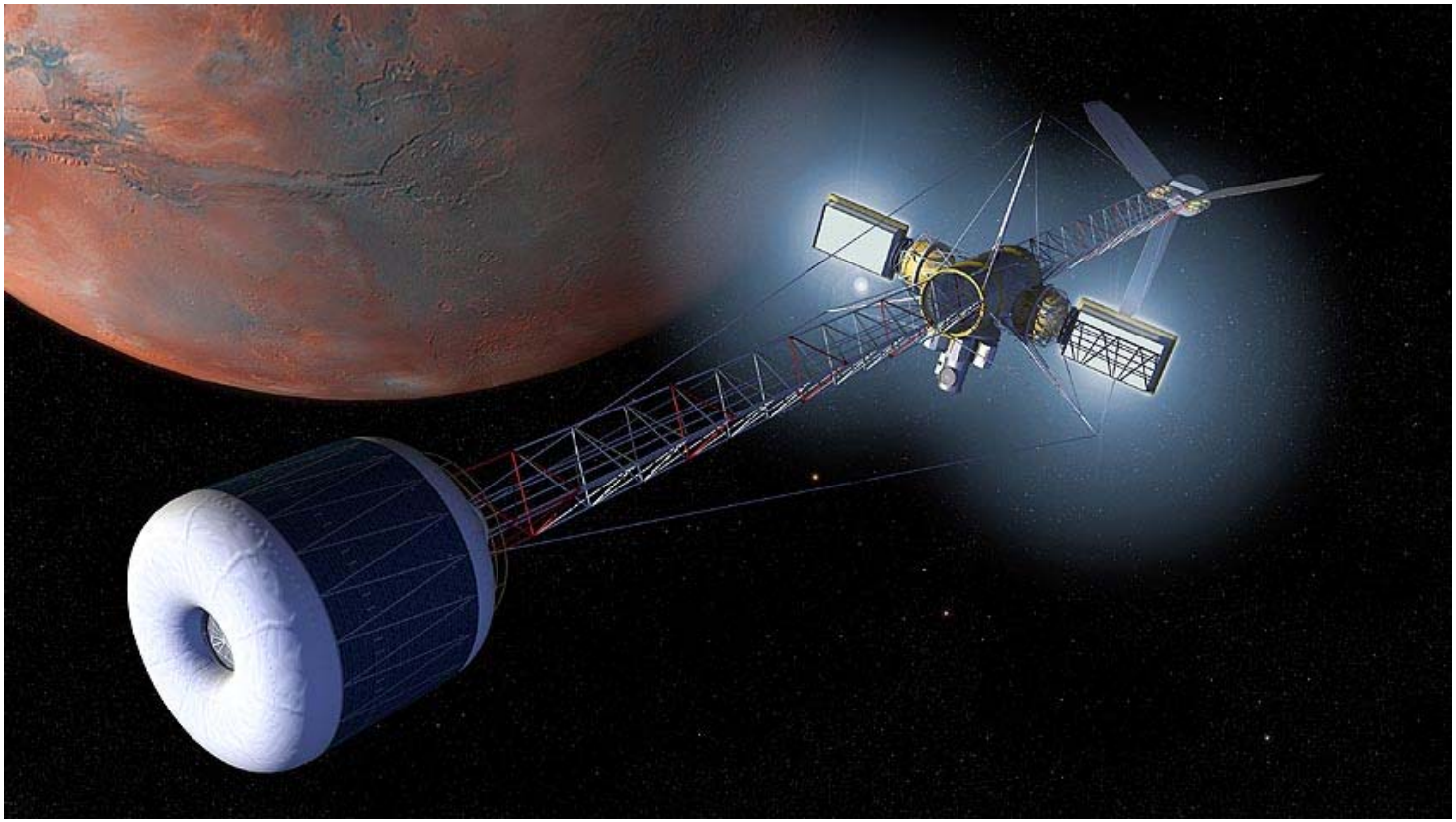
Significant goals in science and human exploration subsequent to the return to the Moon will require substantial operational capabilities in free space using both human and robotic systems.

Increasingly large and complex optical systems to achieve priority national goals



Optical systems larger than those currently under development (aka, JWST at ~6.5 m) appear to be beyond the limit of purely autonomous deployment. In addition, the cost and lengthy development periods of these missions argue in favor of on-orbit upgrade and repair capabilities.

Successful human missions to Mars are necessary to achieve major national goals

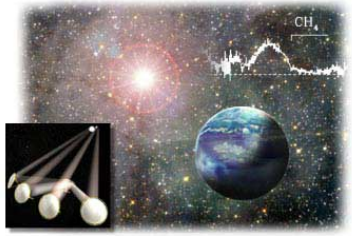


A Mars transfer vehicle using artificial gravity: approximately the length of a football field.
How will this be built, deployed, repaired, etc. in space? What are the plans for demos and precursors?
A 2030's mission will require extensive capabilities in space in the 2020's.

Enabling Multiple Goals

Human Mars Exploration

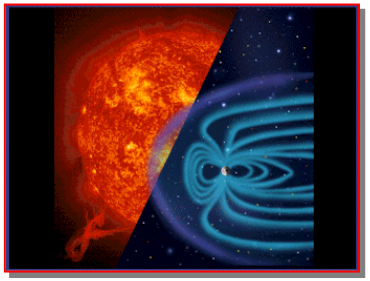
- **Technology Development**
- **Deep-Space Operational Experience**
- **Block 1 version of the Mars habitation system**



Construct, Deploy, and Service Advanced Science Facilities

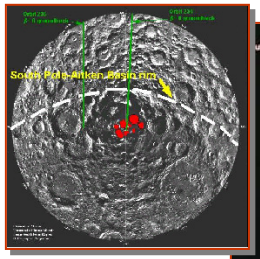
- **Large astronomical observatories**
- **Complex missions to the outer Solar System**

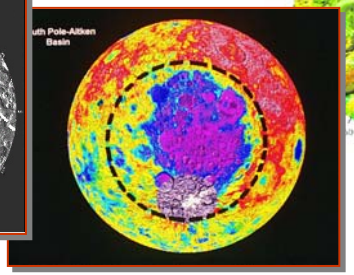
Multiple goals via a single facility

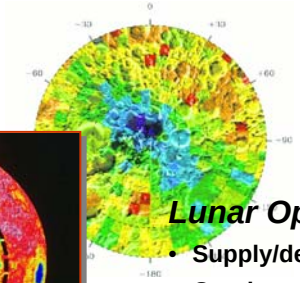


Public Engagement

- **Humans/robots achieving major national goals**
- **Multiple science/exploration goals**
- **Major stepping stone to Mars**
- **Major new direction for NASA**







Lunar Operations Support

- **Supply/depot station**
- **Contingency support for surface operations**
- **Robots/telerobots operations and supervision**
- **Comm/power systems support**

Is it possible to enable these critical and disparate national goals with a single facility?

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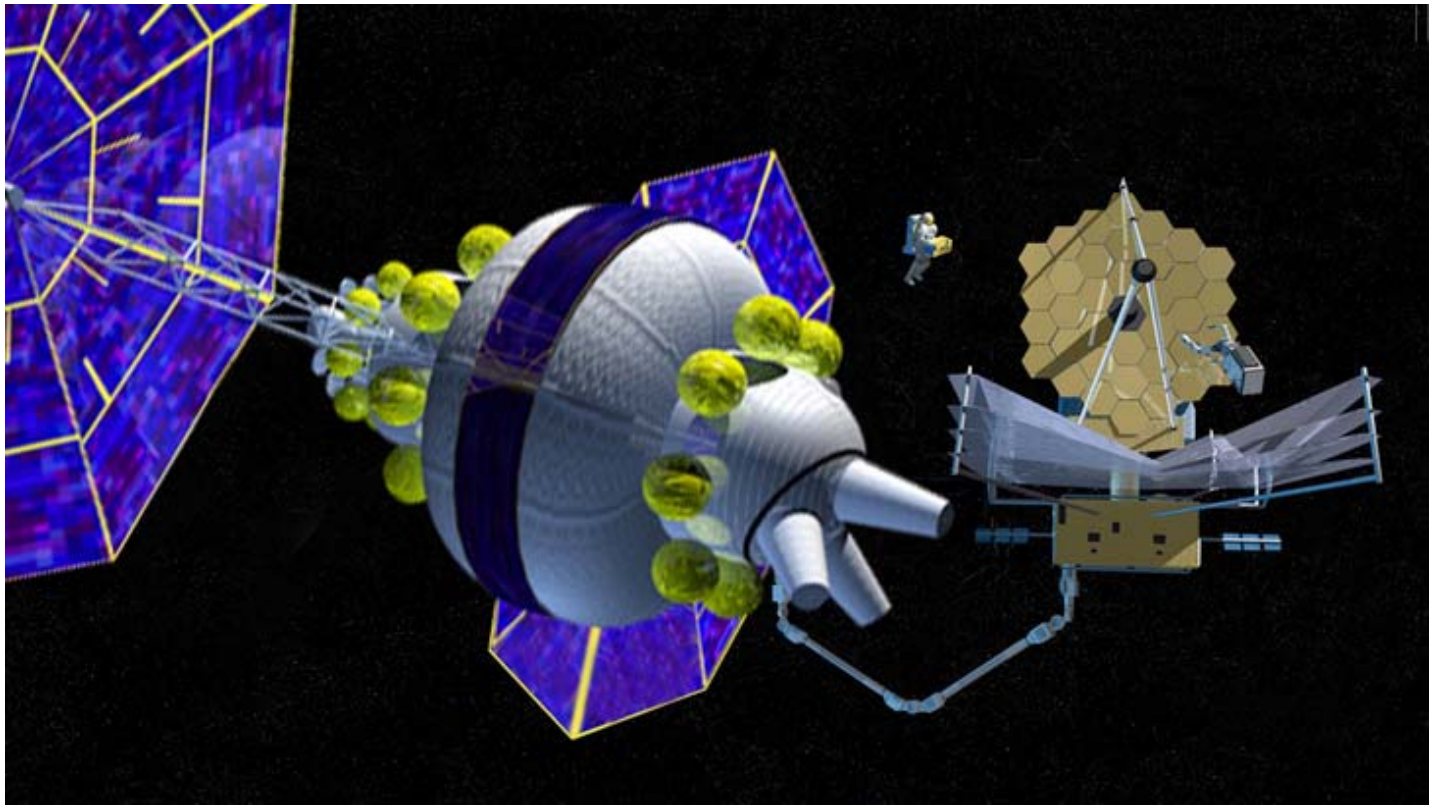
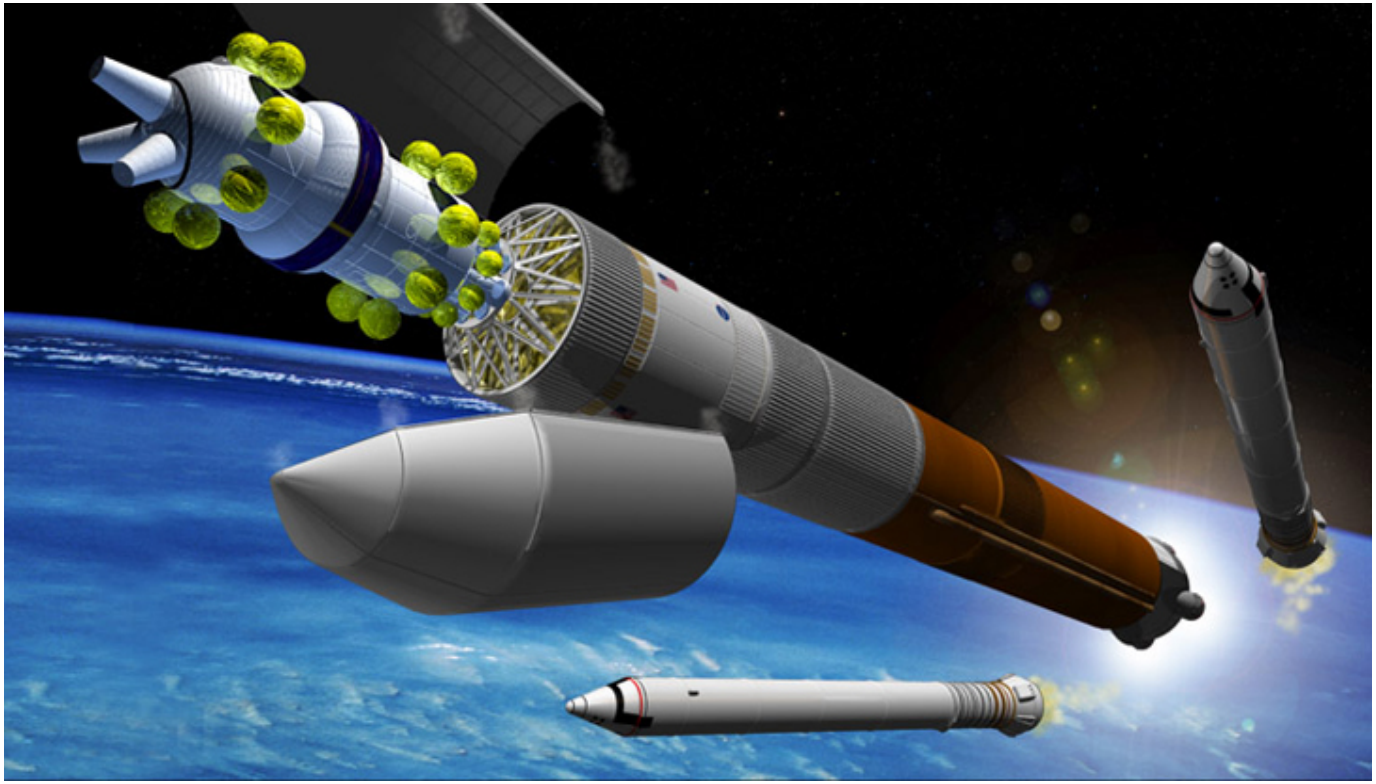


A human-occupied “gateway” for sustained operations, in this case, at one of the Earth-Moon libration points.

Baseline "Gateway" mission profile

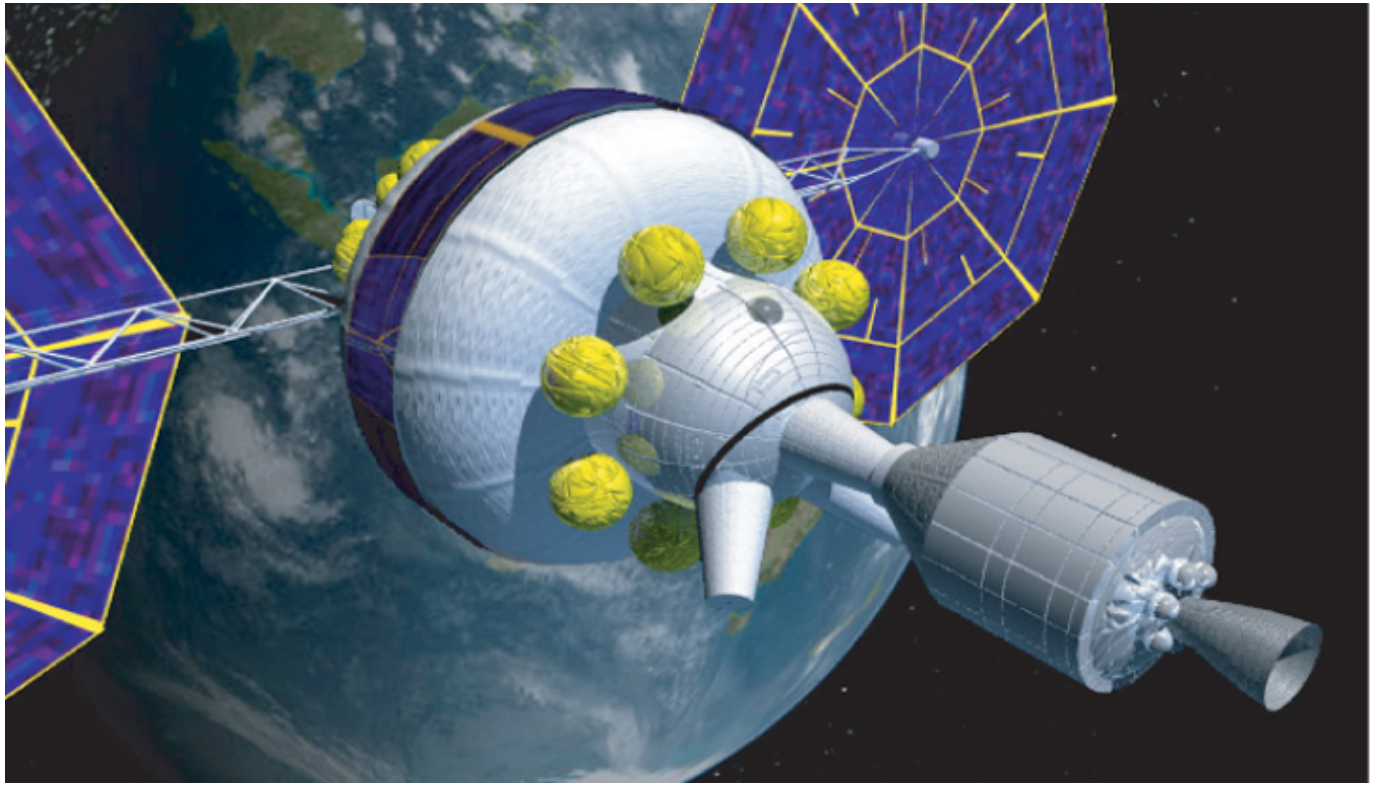
"If you in the astronomy community can't make use of the capabilities we're going to develop to go to the Moon and Mars, then shame on you!"

NASA Administrator Mike Griffin 10/12/05



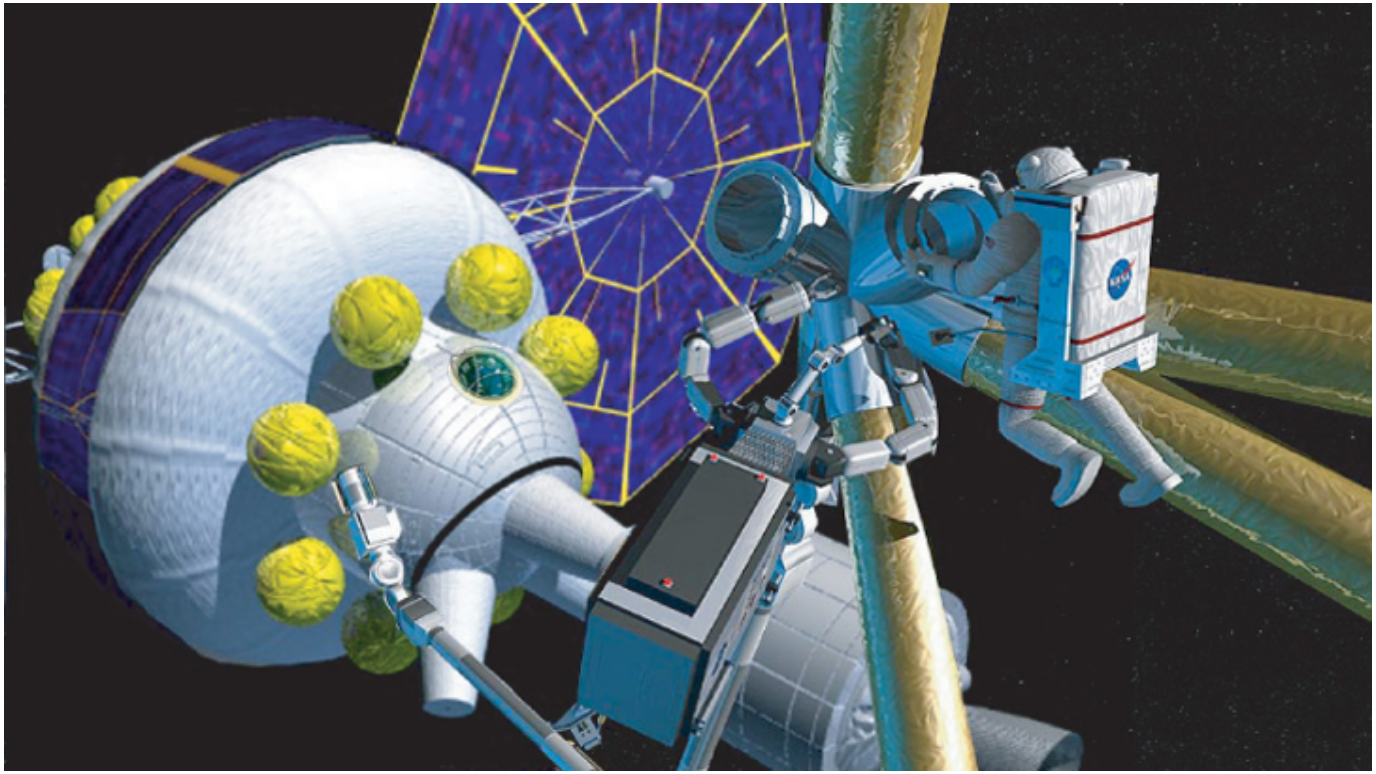
Launch of inflatable "gateway" via heavy lift (includes lunar transfer stage): a single launch makes available ~1/3 the volume of the completed ISS

Baseline "Gateway" mission profile



Outfitting the "Gateway" after launch, with the CEV at one of three available docking ports. Given the multiple uses of a "Gateway," there may be some uses for it in LEO, LLO, as well as the libration points.

Baseline “Gateway” mission profile

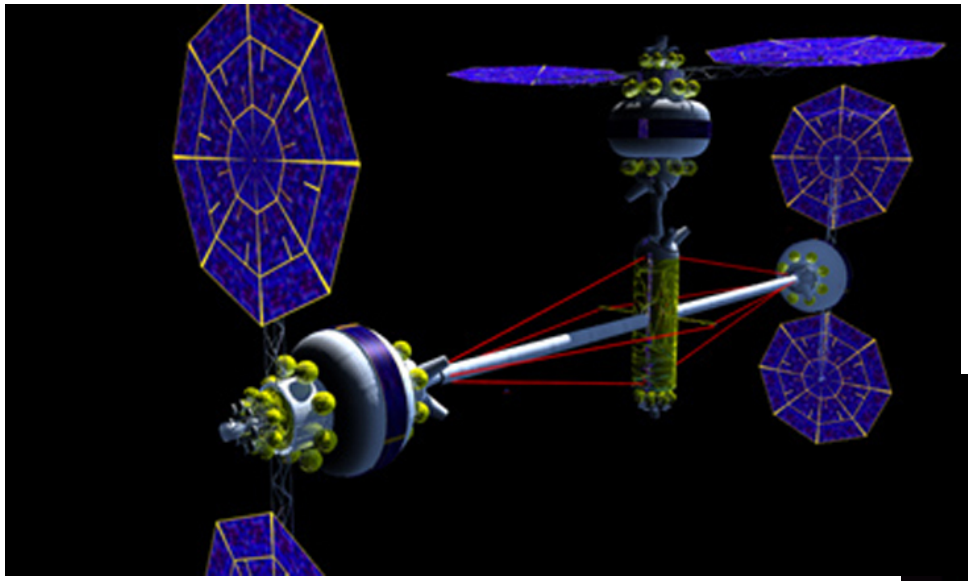


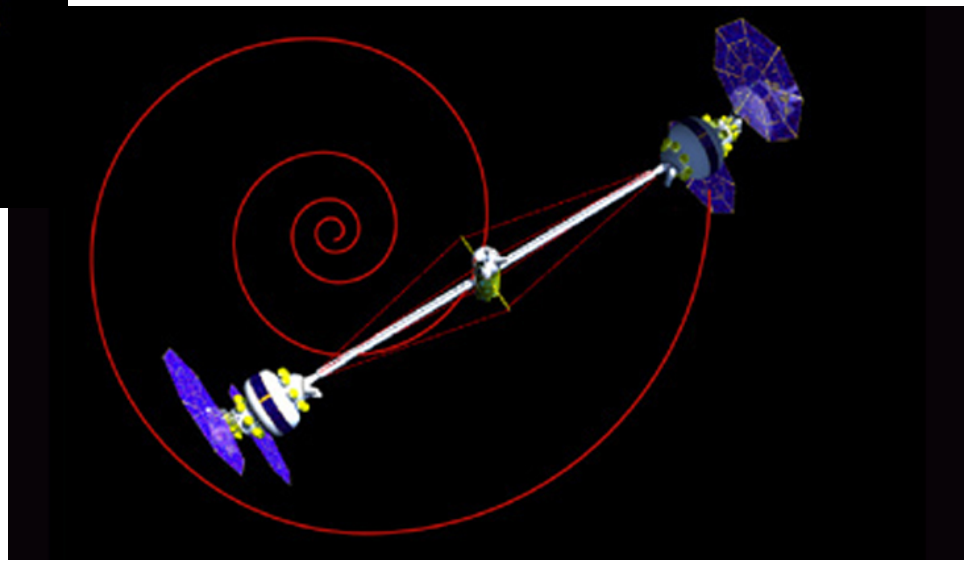
Major national goals in space -- in this case, large optical systems to search for Earth-like worlds beyond the Solar System -- will require deployment, assembly, repair, and upgrade. A “Gateway” can support human/robotic servicing of complex systems in space.

Baseline “Gateway” mission profile

In addition to supporting lunar surface operations and complex in-space science facilities, the “Gateway” is a site for post-ISS development of advanced bioastronautics, crew health and safety, and the systems necessary for long human voyages.

Baseline “Gateway” mission profile





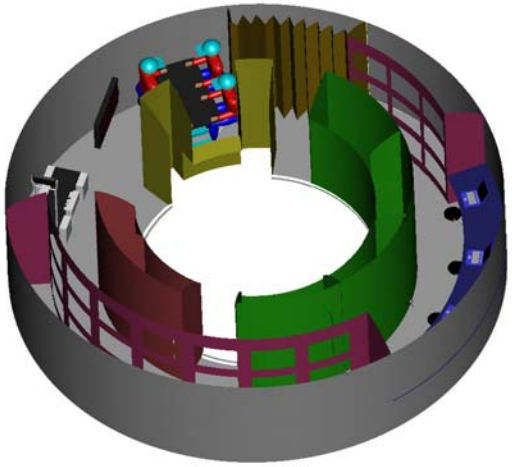
Evolved versions of the “Gateway” -- Block N’s -- may be used as the elements of the human transfer vehicle to Mars. In the concept shown here, an artificial gravity mission is assembled and is schematically represented on its way to Mars.

Gateway Concept Summary

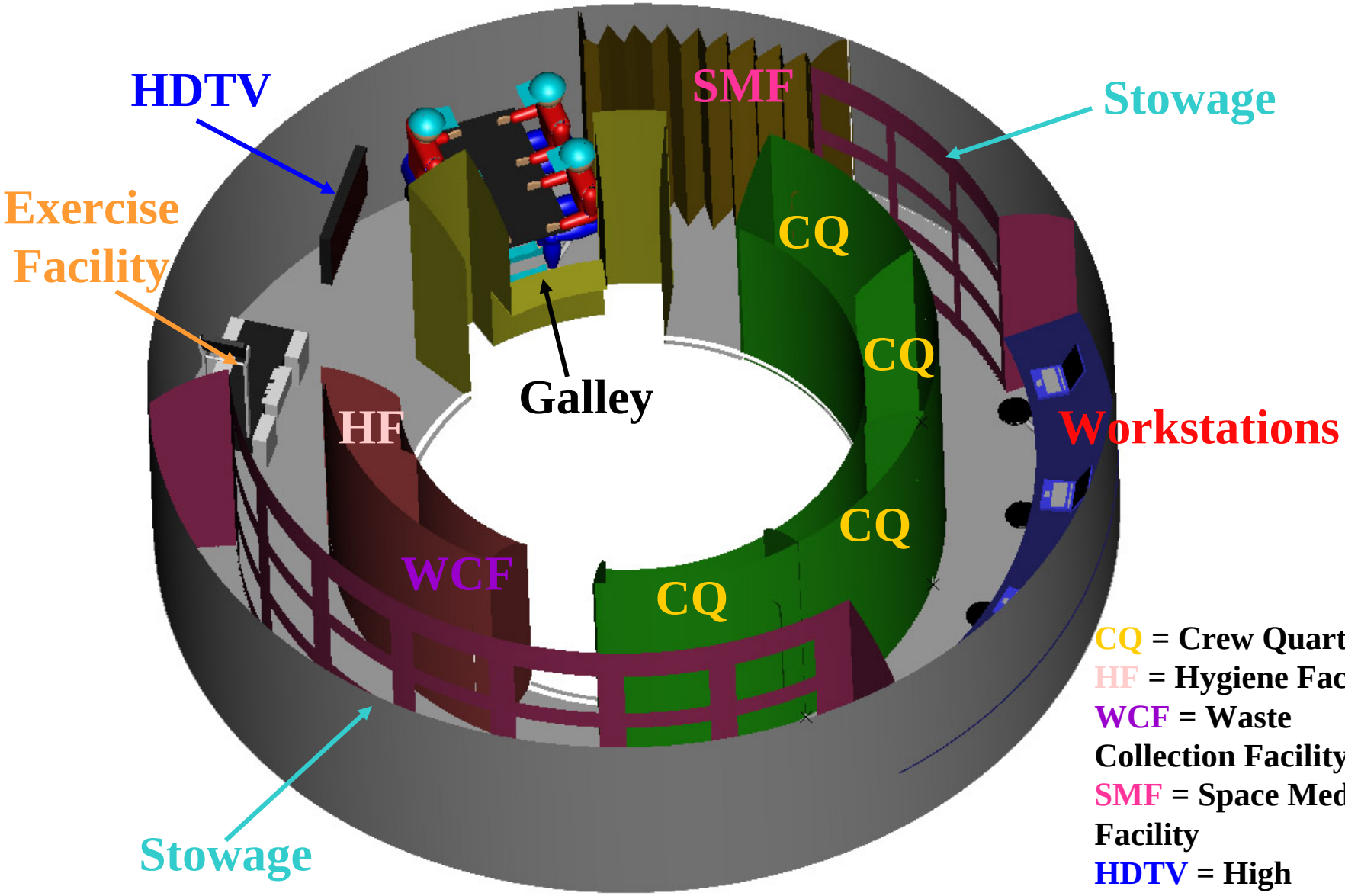
- **Destination:** **Earth-Moon L1**
- **Element Design Lifetime:** **15 yrs**
- **Crew Size:** **4 persons**
- **Habitable volume** **575 cu m (~47% of ISS complete)**
- **Docking** **3-port turret**
- **Mission Duration:** **10-30 days**
- **Launch** **integrated on SDV**
- **Total system mass** **95 mt**

  (Integrated Gateway, chem & SEP propulsion)
- **3 x RL-10 LOX/methane main propulsion for insertion to 5900 km, above inner radiation belts**
- **6 x Hall Effect 50 kW SEP to reach Earth-Moon L1**

- **Support Missions:**
  - **Lunar surface:**
    - **Large supply and contingency capability**
    - **Constant regard of lunar hemisphere**
    - **Support for in-space depots**
  - **Bioastronautics experiment and development**
    - **Block 1 version of habitation module to Mars**
  - **Service of large, complex science facilities**

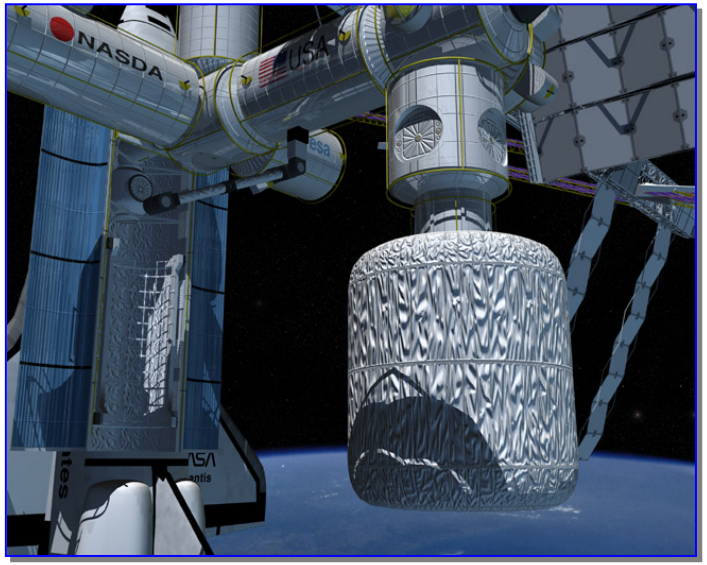


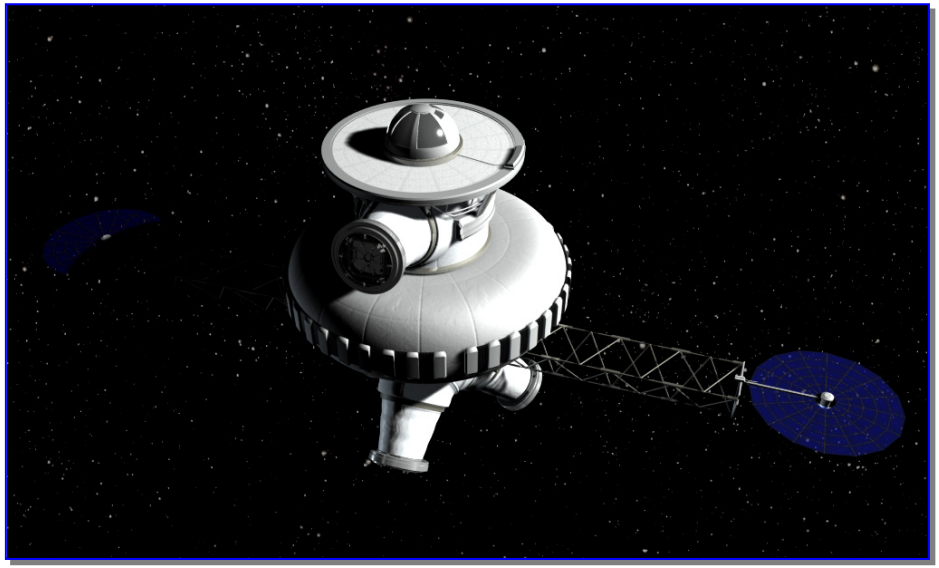
Habitability and Human Factors (HF&H) Cabin Layout



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 <u>materials</u> tested and <u>design knowledge</u> 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 (140 m^3/person -> roomy!)

Summary

NASA has been challenged to achieve extremely difficult, very high priority goals in space, including returning humans to the Moon, exploring the Solar System, seeking life's abodes on Mars and extra-solar worlds, and one day sending humans to Mars.

Over the past year, a small team from NASA HQ and the Centers, academia, and industry have built upon concepts originated by the NASA Exploration Team (NEXT).

In particular, this team has extended the "Gateway" concept, a human-occupied facility in space intended to achieve multiple national goals in space consistent with the *Vision for Space Exploration*, the recent ESAS architecture, and priorities from the National Science Foundation.

The "Gateway" concept described in this presentation is a habitation module to be operated at the Earth-Moon L1 point. It is proposed to be established to offer significant logistical and contingency support for lunar surface operations, while developing and demonstrating capabilities for long human voyages to Mars. This capability will also be useful for servicing large science facilities destined for other locations.