Space Station 2.0: A Transformational Architecture for Space Development.

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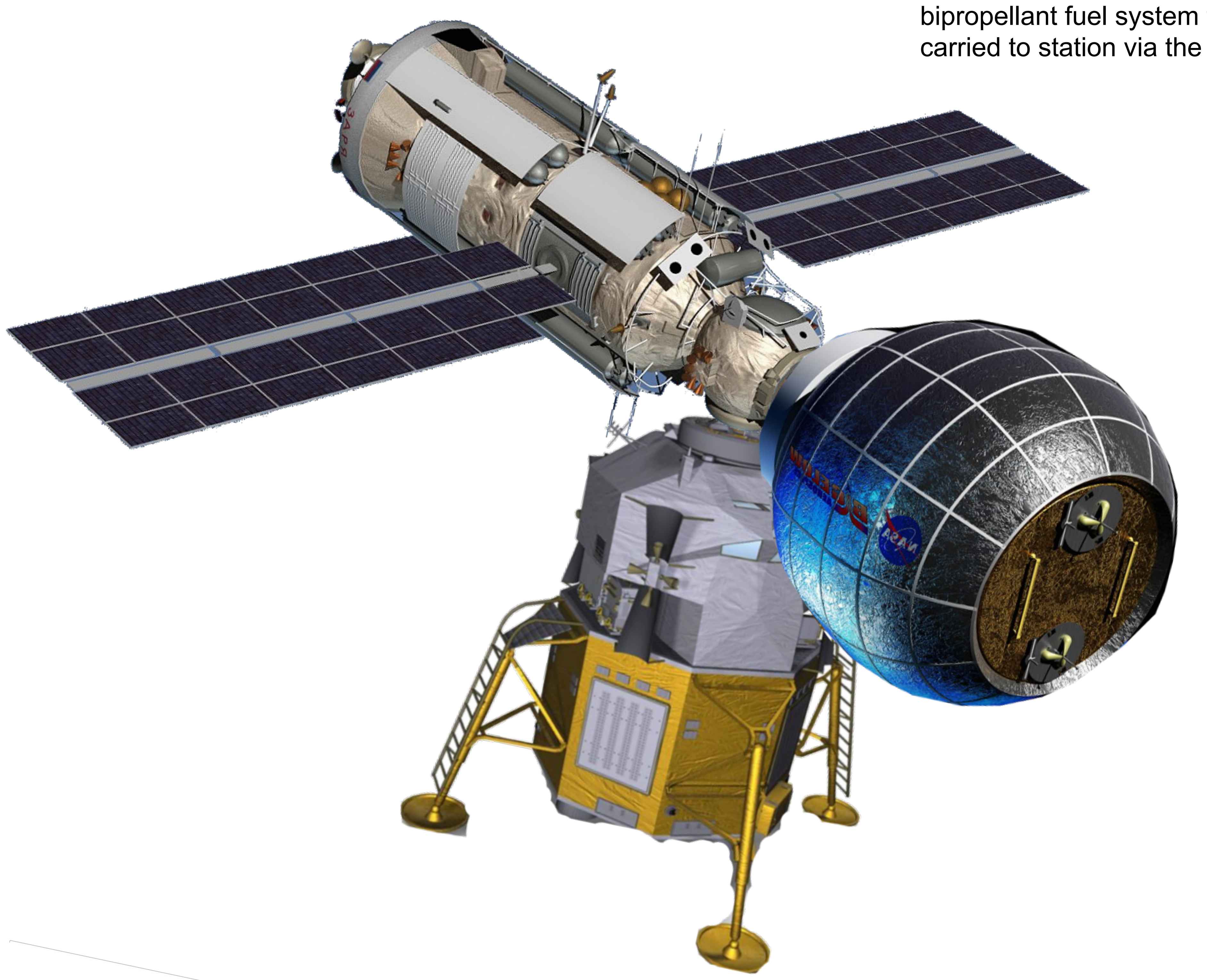
Abstract

The United States' 150 billion dollar investment in the International Space Station (ISS) has produced only of the fraction of the scientific value that was expected. The ISS, despite the best of intentions, is a somewhat esoteric underachievement. Recent successes in commercial launch vehicle acquisition programs and emerging technologies, however, may give way to a promising alternate approach for developing a successor station: Space Station 2.0. By leveraging a COTS-style acquisition strategy and commercial management paradigm, the next space station could be located at a destination of greater scientific interest and be far more productive then the ISS. Space Station 2.0 utilizes several emerging but mature technologies as well as non-governmental management partners to achieve unprecedented capabilities at lower or comparable cost to the construction and maintenance of ISS.

Architecture

Station: Space Station 2.0 (SS2) architecture is based on scalable and upgradable modular segments. To reduce development cost and recurring sustainment expenses the modules(including habitation, storage and laboratory) will all be derivative of a common design heritage. The Station components are joined by linking nodes and are compatible with domestic as well as international components. Unlike the ISS, SS2 module will be acquired commercially reflecting the needs of anchor customers (i.e. NASA, Roscosmos, ESA).

Logistics: A commercially designed and operated Solar Electric Propulsion (SEP) tugboat will move modules and un-crewed cargo between LEO and SS2. Low-impulse electric propulsion can move greater masses then traditional chemical systems, ceteris paribus. High power SEP is currently an area of active investment by private companies including major commercial satellite developers and defense space technology suppliers. This mature technology is the most cost effective, and perhaps, practically speaking, the only way to deliver such massive payloads to destinations beyond low Earth orbit.



Architecture

Launch Vehicle: New aspirants to the launch vehicle market have made modest gains at reducing the price paid to deliver cargo to orbit. SS2 takes advantage of this development and shifts demand from medium-lift launch vehicles (needed for ISS logistics) to heavy-lift launch services. Both crew and cargo will require heavy-lift launch systems. Cargo will be hauled to a rendezvous point in LEO where an SEP tug stage will relocate the supplies to station. This configuration maximizes the mass-to-station that is achievable but this approach is slow and unsuitable for crewed transportation.

Crewed Vehicles: Human conveyance also utilize heavy-lift launch vehicles but will use the additional up-mass for chemical propellant allowing for quick transportation between LEO and Moon. A relatively small capsule and service module will be launched into a checkout orbit. The vehicle will then perform a trans-lunar injection burn to rendezvous with station after appropriate safety checks are performed.

Lunar Surface Operations: A combination lunar lander and accent vehicle can provide transportation to and from the lunar surface. The system will depend on a reusable liquid bipropellant fuel system that can be refueled from reserves carried to station via the SEP stage.

Acquisition and Management

Cost and performance benefits of SS2 architecture are primarily realized through the application of innovative procurement and management paradigms. Under the proposed model, NASA would obtain the necessary SS2 system elements by initiating a number of Space Act agreements to incentivize their development. Commercial bidding for station operations would be handled by a third party service provider. The first step in this process would be similar to that utilized for procurement of the Commercial Orbital Transportation System (COTS). NASA would share the development risk with commercial companies with the expectation that contracts would be solely awarded on a cost and performance basis. The development of multi-purpose modules suitable for human habitation beyond LEO can and should be developed this way because of the dual commercial-government demand for this capability. A NASA-Air Force Cost Model (NAFCOM) compared the SpaceX Falcon 9 development cost as a result of the COTS program with traditional government procurement options. The report demonstrates an order of magnitude in cost savings for the development of the same hardware.

The acquisition of an SEP transportation capability and lunar lander can be incentivized without government subsidy. These technologies can be cultivated via the commitment to a long-duration Moon program with the express guarantee that the government will pay some high price for services rendered.

Upgrades, day-to-day service and operational responsibilities will be managed by a third party service contractor. This vendor will be a lower cost custodian of SS2 by virtue of business vs. governmental operating efficiencies.

Lunar Science Benefits

- Routine Human Sorties to the Moon
- Persistent low-lunar orbit observation
- Mineralogy Mapping
- Meteorite Research
- Resource Identification
- Sample Return (including SPA basin)
- Geophysical Long-Lived Sensor Network
- General Purpose Exploration

Conclusion

New public-private space partnerships, acquisition and operating paradigms can be leveraged to implement a more capable space station at a lower cost and with improved research results for a larger community of users. The resulting station would be a down payment on an exploration infrastructure that would give lunar and planetary scientists unprecedented access to the lunar surface and beyond.

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