

Developing Cislunar Space Using the COTS Model

BY BRUCE PITTMAN & DR. DANIEL J. RASKY

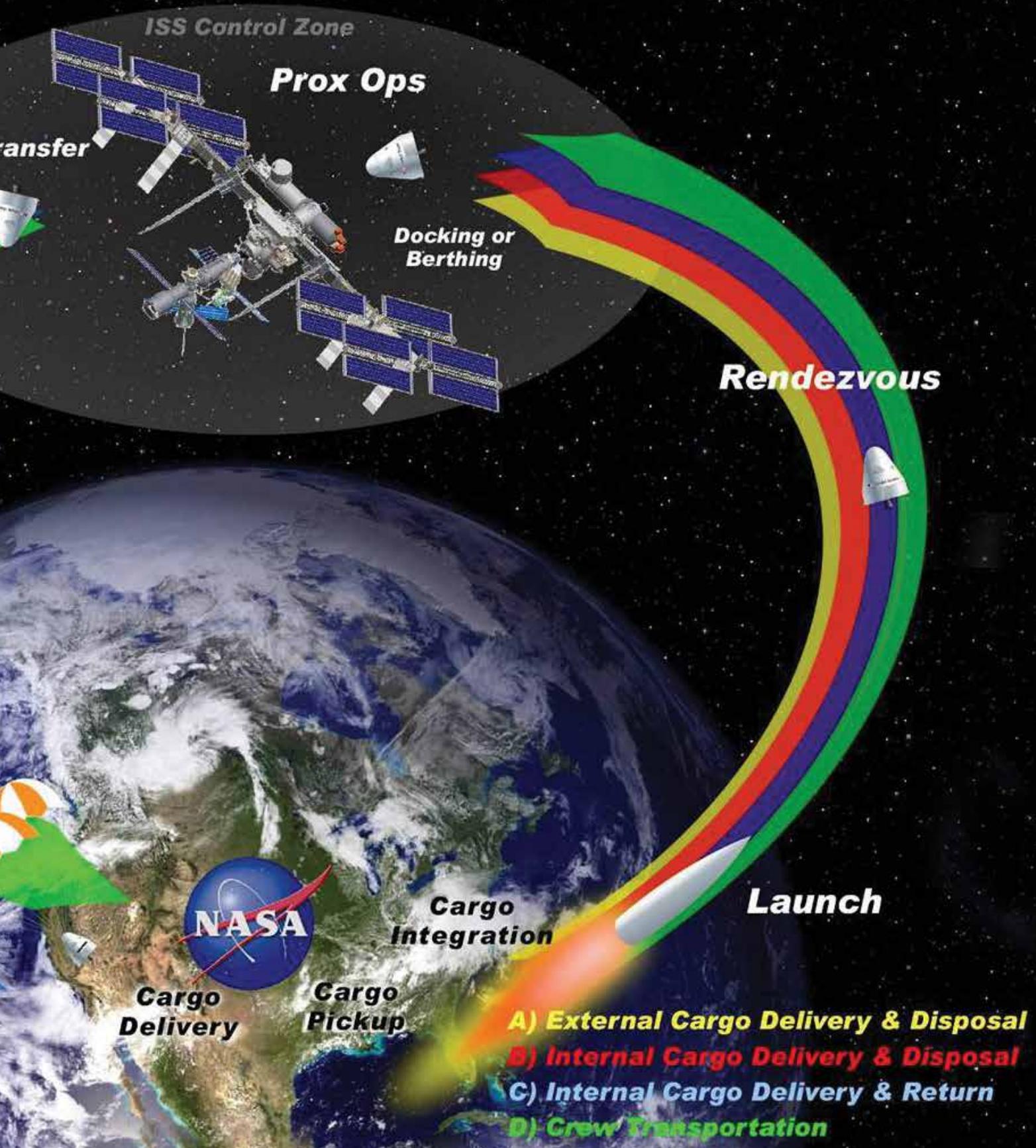
Cargo/Trash
Disposal

Cargo
Return

Crew
Return

Cargo Tr

Commercial Crew & Cargo Program Orbital Transportation Services



The legislation that established NASA (the National Aeronautics and Space Act of 1958) gave the agency special powers referred to as “other transaction authority,” or OTA.

To enter into and perform such contracts, leases, cooperative agreements, and other transactions as may be necessary in the conduct of its work and on such terms as it may deem appropriate, with any agency or instrumentality of the United States, or with any State, Territory, or possession, or with any political subdivision thereof, or with any person, firm, association, corporation, or education institution.

This authority gives NASA special flexibility in structuring agreements when a normal contract or a grant are not appropriate. NASA has codified this authority through the use of Space Act Agreements (SAA).

This foundational authority will become more and more important as NASA pursues its space exploration goals. As pointed out in the recent NASA document entitled “Voyages: Charting the Course for Sustainable Human Space Exploration”:

This report articulates NASA's multi-destination human space exploration strategy using a capability-driven approach. NASA is ensuring that the United States fosters a safe, robust, affordable, sustainable, and flexible space program that is independent of dynamic political and economic changes.

By developing a set of core evolving capabilities instead of specialized, destination-specific hardware, NASA's innovative, capability-driven approach challenges the way we think about human space exploration and sets the stage for a new era of discovery. As we expand human presence throughout the Solar System, we increase our scientific knowledge, enable technological and economic growth, and inspire global collaboration and achievement.

The COTS Program Model

An excellent example of an SAA using NASA's other transaction authority is the Commercial Orbital Transportation Services (COTS) Program. COTS was initiated in 2006 to provide a development and demonstration path for commercial cargo services to the International Space Station. This was followed in 2009 with the Commercial Crew Development (CCDev)

Program providing a route for development of commercial crew transportation services to the ISS in order to take over the role from the decommissioned space shuttles. With these two programs, NASA has committed almost \$2 billion of its resources—a significant investment.

The COTS and CCDev programs both employ SAAs under NASA's other transaction authority. This is in contrast to use of Federal Acquisition Regulations (FAR) cost-plus based contracts that NASA has most often used for space hardware development. Employing SAAs in place of cost-plus contracts is an important new strategy for achieving NASA's sustainable space exploration and development goals.

Space Act Agreements Versus Cost-Plus Contracting

COTS' use of an SAA has several important implications. *First, it demonstrates the value of a milestone-based payment plan, where the government pays only upon successful completion of the milestone.* Further, in the COTS-SAA, the milestones and the dollars tied to those milestones were set by the proposing company, not by NASA. This provided the companies greater freedom for structuring a workable deal in terms of technical risk and cost. The government then used the proposed milestones as an evaluation criterion for awarding the agreements and held the companies to a firm acceptance assessment on the milestones before making payments. *Second, the COTS-SAA required commercial partners to put their own resources into the development effort, which helped ensure an alignment of business goals—that is, both the government and the companies were operating by the same set of incentives to speed development and reduce costs.*



Dragon became the first commercially developed space vehicle to be launched to the station to join Russian, European and Japanese resupply craft that service the complex while restoring a U.S. capability to deliver cargo to the orbital laboratory.

¹42 U.S.C. § 2473 (c)(5)

²see: <http://www.nasa.gov/exploration/whyweexplore/voyages-report.html>



The SpaceX Falcon 9 lifts off carrying the company's Dragon capsule on a mission to demonstrate the cargo spacecraft can dock with the International Space station.

This approach is very different from the traditional FAR-based cost-plus contracts where the government provides extensive written specifications to which industry responds with an extensive proposal. Any changes or modifications to the specifications then puts the government in the position of having to pay additionally for these changes. Also, any performance shortfalls and schedule slips by the company falls back on the government. This arrangement results in a significant misalignment of business goals, where the company typically has no financial incentives to speed up development or to minimize changes.

Finally, because the COTS-SAA structure only pays on successful completion of milestones, government oversight can be reduced and focused only on critical criteria such as milestone assessments. This has been shown to significantly reduce the cost when compared to FAR based, cost-plus contracts by as much as a factor of eight or more.

Large Cost Savings from Using COTS

NASA recently did a cost estimating comparison using its NAFCOM (NASA/Air Force Cost Model) estimating tool and uncovered some startling results. According to the NAFCOM model, if NASA had developed the Falcon 9 using traditional, FAR-based, cost-plus contracts and the usual oversight processes called for by NASA procedures (NASA 7120.5), the cost would have been almost \$4 billion.

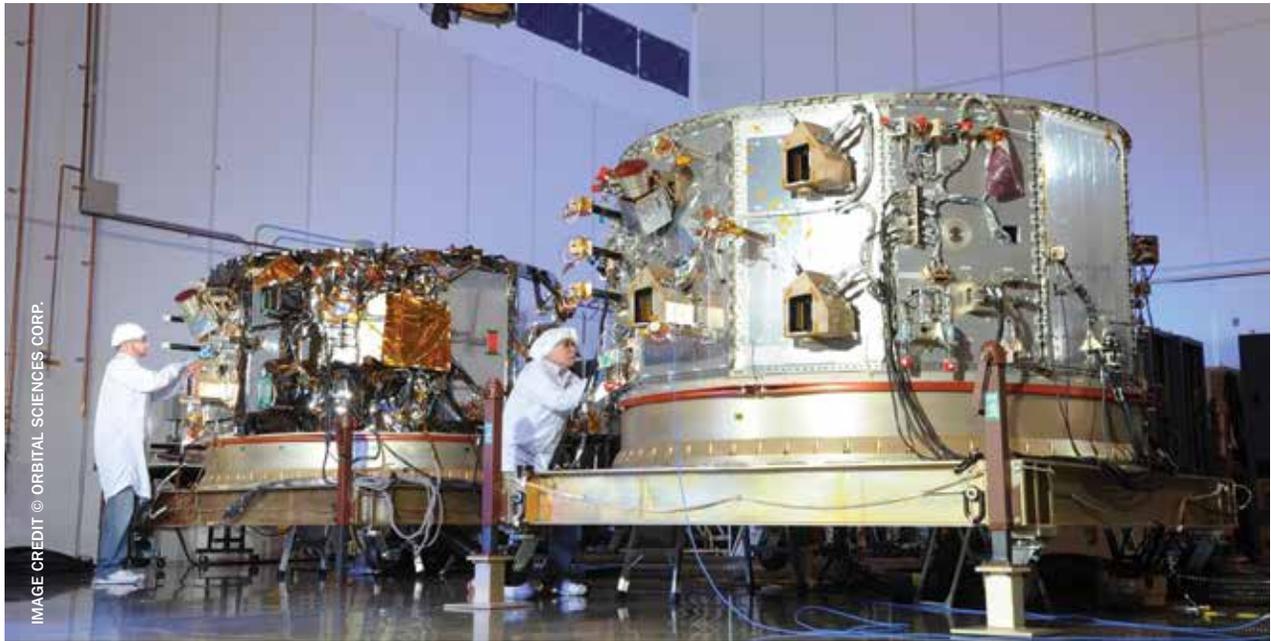
In comparison, SpaceX's actual expenses for the Falcon 1 and Falcon 9 combined were less than \$400 million. This analysis points to a potential route to sustainable development of the Moon and cislunar space through public/private partnerships modeled after the COTS-SAA. This is referred to as the Commercial Leverage Model (CLM).

It should be noted however that the CLM is not applicable in all situations. There are several criteria that should be considered in evaluating the applicability of the CLM for a particular project. These criteria include the level of maturity of the relevant technologies, which must be relatively high; the existence or potential for customers beyond the government; a sufficient level of commercial interest in entering into such an agreement; the ability and willingness of the commercial partner to finance their portion of the development effort; and the reasonable probability of a follow-on government procurement for these services or data.

What's Next?

In May 2012, SpaceX successfully docked their Dragon capsule with the ISS, delivering cargo to the station and returning payload back to Earth. This completed the final COTS milestone for SpaceX and in October 2012 they successfully carried out the first of their 12 Commercial Resupply Services (CRS) flights to ISS, which they won

³www.nasa.gov/pdf/586023main_8-3-11_NAFCOM.pdf



Orbital Sciences Corp., one of two companies under contract to resupply the ISS with vehicles developed under NASA's Commercial Orbital Transportation Services (COTS) seed-money effort, hopes to meet its final COTS milestone with a Cygnus berthing at the station in the fall.

under a FAR-based fixed price contract valued at \$1.6 billion. Orbital Sciences, which is the other COTS partner, has been making steady progress on their Antares rocket and Cygnus capsule and expects to complete COTS milestones by mid-2013. Orbital also won a CRS contract valued at \$1.9 billion for eight flights to ISS. These follow-on service contracts are an important element in providing the incentives to have the commercial companies invest with the government in the SAA process.

So, we have at least one recent example where NASA successfully used the CLM to great advantage; are there other areas where this model could be applied?

This question is currently under serious consideration by senior NASA managers. This is partly being motivated by recent White House direction in an executive memorandum entitled: "Accelerating Technology Transfer and Commercialization of Federal Research in Support of High-Growth Businesses." The White House memorandum stated:

I direct that the following actions be taken to establish goals and measure performance, streamline administrative processes, and facilitate local and regional partnerships in order to accelerate technology transfer and support private sector commercialization...
—Barack Obama

One nearby space destination that looks to be quite attractive from a technical and economic perspective is the Moon and surrounding region (cislunar space). This has not escaped NASA's attention. A recent article describes an L2 Gateway exploration strategy under consideration :

"NASA is serious about sending astronauts back to the Moon's neighborhood and will likely unveil its ambitious plans soon now that President Barack Obama has been re-elected, experts say."

"The space agency has apparently been thinking about setting up a manned outpost beyond the Moon's far side, both to establish a human presence in deep space and to build momentum toward a planned visit to an asteroid in 2025."

A NASA L2 gateway would be stationed about 60,000 km above the surface of the Moon on the opposite side from the Earth. There it would provide a unique opportunity for studying the far side of the Moon and offer many potentials for commercial partnerships. This would include providing cargo transportation to the gateway or to the lunar surface. One possible gateway operational scenario is to provide a deep space habitat for astronauts to practice tele-operations of robotic vehicles on the lunar surface. This would be a prelude to eventual tele-operations of robotic vehicles on the Martian surface, operated by astronauts on one of Mars' moons,

⁴NASA Figures Show That Commercial Rocket Costs Less Than Half as Much as Government-Run Effort Would, John Matson, Scientific American, September 28, 2011
⁵see: <http://www.whitehouse.gov/the-press-office/2011/10/28/presidential-memorandum-accelerating-technology-transfer-and-commercial>

Phoebus or Demos, in preparation for humans to travel to the Martian surface. Development and demonstration of in-situ resource utilization on the lunar surface for production of liquid oxygen or other useful materials for the gateway would be another potential commercial opportunity, as would development and supply of resource depots and crew habitats at L2, on the lunar surface and other locations.

In addition to potential future NASA efforts for a L2 gateway, right now there are 24 active teams competing to win the Google Lunar X PRIZE and figuring out low-cost ways to not only get the Moon, but to land safely and operate on the surface for extended periods. The first prize in this competition is \$20 million. Many of these companies are looking at not just winning the prize but at developing a successful business model that enables them to return to the Moon on a regular basis. Several members of the international community are also planning lunar landings including Russia, China, Japan, and the European Space Agency.

To leverage the commercial investments being made by the U.S. Google Lunar X PRIZE teams, in 2010 NASA awarded six Innovative Lunar Demonstration Data contracts with a total value of \$30.1 million. These contracts allow NASA to purchase data from these six companies regarding their efforts to develop vehicle capabilities and demonstrate end-to-end robotic lunar landing missions. This data will be used to inform the development of future human and robotic lander vehicles and exploration systems. Each contract has a maximum award of \$10.01 million over a period of five years.

Capability Driven Exploration

The NASA Voyages document outlines the suite of capabilities required to enable NASA to explore 1) cislunar space including the Lagrange points, 2) near Earth asteroids, 3) Earth's Moon, and 4) Mars and its moons:

- Low Earth orbit crew and cargo access
- Beyond Earth orbit crew and cargo access
- In-space propulsion
- Ground operations
- In-space operations
- Long-duration habitation
- Mobile exploration module
- Extravehicular activity systems
- Precursor robotics
- Human-robotic interfaces
- Destination systems

The document also states that affordability, sustainability, and interoperability are key principles for these capabilities.

There are a growing number of private sector entities that are being established to operate in this arena as well. Some of the more high-profile projects include Planetary Resources' plans to mine asteroids, the B612 Foundation Sentinel initiative to catalog asteroids, and most recently the Golden Spike Company's plans to return humans to the Moon by 2020. This is in addition to the Google Lunar X PRIZE teams and SpaceX CEO Elon Musk's goal of sending people to Mars within 10-20 years and reducing the cost of such a journey to \$500,000. Musk's ultimate goal is to establish a colony on Mars supporting tens of thousands of people. He believes that at this \$500k/person price point, such a colony will be feasible and the possibilities for both public and private exploration and development of the Solar System will truly be wide open.

With commercial and government interest in developing new space capabilities, it would seem likely that the CLM could be effectively applied to demonstrating at least some of the required capabilities listed above. This would be a win/win for both NASA and industry by leveraging scarce resources, accelerating development, and providing the anchor customer base that is required for successful commercial operations.

Bruce Pittman is a contractor in the space portal in the NASA Research Park and the emerging space office at NASA Ames and is on the board of NSS. Dr. Daniel J. Rasky is a co-founder and director of the space portal in the NASA Research Park and director of the emerging space office at NASA Ames.



R2, the first humanoid robot created by GM / NASA was sent to the space station with the intention of eventually taking over tasks too dangerous or mundane for astronauts

⁶see: <http://www.space.com/18380-nasa-moon-missions-obama-election.html>