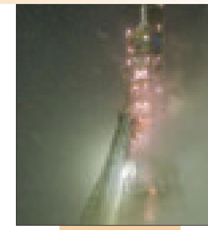


Exploration in an uncertain decade

You won't find an ATM on the international space station. Not much call for cash in orbit—there's no place to spend it. No Hilton hotel lounge, no Apollo Room club 'high atop everything,' no Starbucks—yet. So, just before leaving crew quarters for each of my shuttle launches, I'd turn over my wallet to Olan Bertrand, heading up the Astronaut Office engineering support team. The Astrovan would drop Olan off at the launch control center, with his promise that he'd see us on the runway just after wheels stop. His was one of the first faces greeting us after landing, through the open orbiter hatch. Soon after, 'the government'–Olan—would hand back my money. How rare is that?

In November, the Congress handed NASA its 'wallet' for 2012, and the nation's fiscal troubles ensured it was thinner than last year's. With the president's signature on the 'mini-bus' appropriations bill, NASA's FY12 budget fell to $17.8 billion. That's down from $18.5 billion in FY11, a reduction of $648 million, and $924 million below the president's budget request.

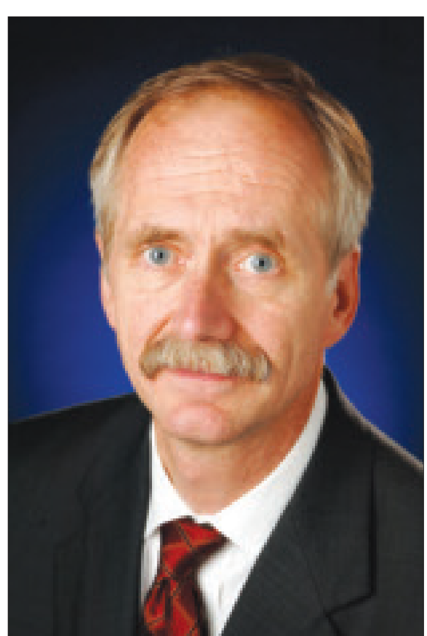
NASA Science received $5.1 billion, an increase of $155 million that continues development of the James Webb Space Telescope. Space Operations received $4.2 billion, down more than a billion dollars with shuttle retirement; those funds were reprogrammed to other NASA priorities. ISS operations were funded at $2.8 billion.

Human space exploration dropped $30 million from 2011. Most of its $3.8 billion will go to the Orion multipurpose crew vehicle ($1.2 billion) and the new Space Launch System ($1.86 billion). Congress has made clear that it expects NASA to move out smartly on both the deep-space Orion and the heavy lift booster.

The legislature, skeptical of industry progress and NASA's management of its commercial spaceflight program, cut the requested $850 million appropriation to $406 million. The commercial crew program is aimed at moving NASA astronauts off the Russian Soyuz and onto U.S.-built rockets and spacecraft by 2016.

Associate Administrator William Gerstenmaier, NASA chief of human exploration and operations, told Congress in October that those cuts would delay the advent of U.S. commercial crew transport to the ISS, and stretch U.S. reliance on the Soyuz to more than five years. His testimony warned that "NASA's initial analysis shows that an FY12 funding level of $500 million…would delay initial capability to ISS to 2017, assuming additional funding is available in the out-years. During that roughly one-year period of delay, NASA would be paying approximately $480 million to Russia for crew transportation services."

NASA received far less than that $500 million, so the agency must either extend its dependence on Russia or pump the remaining resources to one or two commercial suppliers in a bid to get rockets to the pad by 2016.



NASA Associate Administrator William Gerstenmaier.

Blending exploration into operations

Fate and funding have put Gerstenmaier in a key leadership role as NASA tackles major challenges in operations and exploration. He took over the helm of the new Human Exploration and Operations Mission Directorate (HEOMD) last fall.

His new organization combines the old Space Operations and Exploration Systems Mission Directorates; the latter lost its independent portfolio when the White House cancelled the Constellation program in 2009. The directorate, 'HEO' in NASA shorthand, manages space operations related to human exploration in and beyond low Earth orbit. Its responsibilities encompass operations at the ISS, crew and cargo transport to the outpost, and plans for exploration beyond the station. HEO's activities include commercial space, advanced exploration systems, human spaceflight capabilities, and space life sciences research. The directorate also manages launch services, space transportation, and space communications that support robotic as well as human exploration. Details are at http://www.nasa.gov/directorates/heo/home/index.html.

Gerstenmaier is well-suited to lead NASA's station operations in the coming decade, and to prepare its people and technologies for eventual human exploration in deep space. In 1977, he joined NASA at Glenn to conduct wind tunnel tests for the nascent space shuttle. He subsequently headed up the Space Shuttle/Space Station Freedom Assembly Operations Office, and by the mid-1990s was the Shuttle/Mir Program's operations manager out of NASA Johnson.

Russian support personnel help crew exit the Soyuz TMA-02M shortly after the capsule landed with Expedition 29 Commander Mike Fossum and Flight Engineers Sergei Volkov and Satoshi Furukawa in a remote area of Kazakhstan, on November 22. Photo: NASA/Bill Ingalls.

I met Bill in 1997 aboard a jetliner packed with NASA engineers and program managers on our way to Moscow to 'engage' our new ISS partners. He was one of the few people aboard who seemed optimistic about the outcome of our negotiations, certainly more confident than I was. In 2000, as ISS construction commenced in earnest, he became the station program's deputy manager.

He rose to ISS program manager, then in 2005 was named to head the Space Operations Mission Directorate, overseeing both the shuttle and space station programs. Last year, Gerstenmaier managed the safe closeout of the space shuttle program, and now aims to carry NASA's operations skills and ambitions well beyond the station's orbit–launch date TBD.

Post-shuttle pace quickens

The new directorate immediately faced a series of challenges in LEO. A Soyuz booster carrying the Progress 44 cargo ship failed to reach orbit on August 24 when a faulty gas generator on the Soyuz' third stage engine caused premature thrust termination. The failure grounded the Progress/Soyuz crew capsule booster, cutting off access to the space station.

By late August, Roscosmos, the Russian space agency, identified the contaminants that caused the generator failure. The Russians shared the failure investigation results with NASA, said Gerstenmaier in an October 12 congressional hearing, and agency engineers performed a follow-up review of the findings.

"They did kind of a background check to make sure that the conclusions the Russians were drawing were reasonable….We agree with the basic Russian findings," he said.

After inspecting Soyuz's third-stage engines, the Russians launched Progress 45 on October 30, clearing the way for the launch of the Expedition 29 crew to the ISS on November 13. Commander Dan Burbank and flight engineers Anton Shkaplerov and Anatoly Ivanishin, aboard Soyuz TMA-22, docked with the ISS three days later.

After an abbreviated handover lasting less than a week, Burbank assumed command from outgoing Expedition 29 commander Mike Fossum, who had been in orbit since last June with cosmonaut Sergei Volkov and Japanese astronaut Satoshi Furukawa. Fossum and Furukawa, with Volkov at the controls, returned to Earth safely on November 21.

The Soyuz grounding had forced the ISS partners to reduce the onboard crew size to three, but the planned December launch of Soyuz TMA-03M, with Oleg Kononenko, ESA astronaut Andre Kuipers, and NASA's Don Petit, would restore the complement to six. They comprise Expedition 30, whose tenure began formally when Fossum's crew returned to Earth in November.

Easing the Soyuz monopoly

Last year's Soyuz failure illustrated the risks to the ISS engendered by dependence on a single launch system. While dealing with the Soyuz investigation, a rapid-fire logistical analysis to assess crew habitability, and planning for possible unmanned ISS operations, HEO and Gerstenmaier have been trying to accelerate efforts to re-

Atlas V would serve as the launch vehicle for both the Dream Chaser and the CST-100.

store a U.S.-based crew launch-to-LEO capability.

The agency has been providing development funds to several commercial firms, with the goal of launching astronauts on U.S. vehicles by 2016. Last April, NASA gave $270 million to four companies to push development of rockets and spacecraft. (See "What's next for U.S. human spaceflight?," page 24).

Blue Origin is working on a reusable orbital spacecraft, a biconic capsule design recovered via parachute. Sierra Nevada is pursuing its Dream Chaser lifting body crew transport, modeled after NASA's HL-20 design. Atlas V would serve as the launcher; Dream Chaser would glide back for a runway landing. Space Exploration Technologies (SpaceX) is developing a launch escape system for a crewed version of its Dragon cargo capsule, and Boeing is designing its CST-100 capsule, also riding atop an Atlas V.

In October, Boeing announced it had signed a 15-year lease to use Kennedy Space Center's Orbiter Processing Facility-3 (OPF-3) to manufacture and test the CST-100. NASA had used the three OPFs to refurbish and maintain the shuttle orbiters. The Apollo-shaped CST-100 can carry up to seven crewmembers, or an equivalent combination of people and cargo, to the ISS or the proposed Bigelow space tourism habitat. Boeing says it is on track to provide services to the station by 2015, although funding shortfalls put that date in doubt.

SpaceX, another NASA Commercial Crew Development (CCDev) partner, has rescheduled Falcon 9 Flight 3, a cargo flight demonstration to the ISS, to February 7. Falcon 9 has achieved orbit twice; on Flight 3 the company hopes to demonstrate operation of its Dragon capsule and service module, the latter flying for the first time. With solar arrays and maneuvering thrusters, the Dragon/service module test should culminate with a grapple and berthing at the ISS. SpaceX attributed the delay partly to the November crew handover, and to lack of a full crew aboard the outpost; three astronauts would be stretched too thin to monitor the arrival and berthing of a new robotic vehicle. Testing of the booster software was also a factor. SpaceX hopes to launch Flight 3 before March.

The White House and NASA are gambling that commercial launch services could replace the canceled Constellation program's Ares I booster, and do so at lower cost. NASA will be under strong congressional pressure to show progress, even with reduced funding.

Beyond Earth orbit

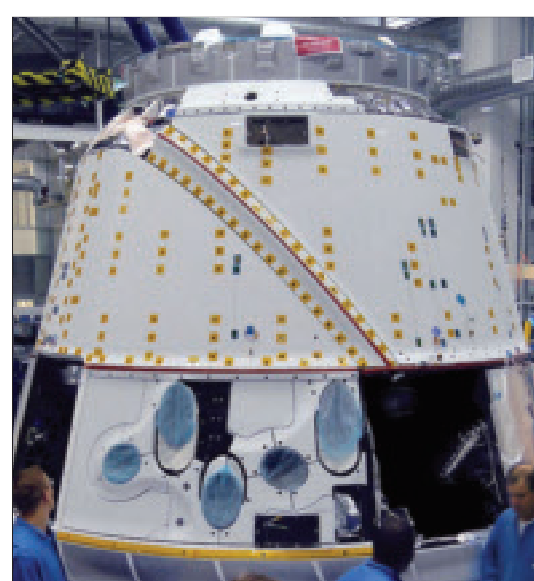
A flat or declining budget is also the major obstacle to HEO's plans for propelling humans beyond ISS. The new Space Launch System, unveiled by the agency in September after repeated delays, is a bid to provide the necessary rocket muscle. With a first launch goal of 2017, the new booster blends shuttle and Constellation technology to lift 70 metric tons to LEO. The design is capable of evolving to 130 metric tons of payload, a performance specification deemed so important by Congress that it was written into November's appropriations bill.

The booster core, resembling Constellation's Ares V concept, will use liquid oxygen and hydrogen as propellants. Shuttle main engines power the core, and a single J-2X engine, derived from the Saturn IB and Saturn V, will insert the upper stage into LEO. Two five-segment solid rocket boosters will help lift the early SLS; NASA will compete proposals for higher performance liquid-fueled boosters as SLS moves toward the 130-metric-ton goal.

Incorporating much flight-proven hardware and Constellation technology, the biggest unknowns facing SLS are its mission and costs. Its first mission is to back up commercial services in reaching the ISS, but a first launch in 2017 may be too late to help much.

SLS's deep-space mission remains nebulous. The generic heavy payload capability clearly includes the Orion MPCV, but what will be its destination? The administration has taken lunar exploration off the table, so NASA at present can shoot only for the distant goal of near-Earth asteroid missions in the 2020s.

Despite full 2012 funding, a flat or declining NASA budget over the next



With its next Falcon 9 flight, SpaceX hopes to demonstrate operations of its Dragon capsule.

five years will certainly squeeze the agency's ability to develop and fly a Saturn V-class booster. Then there are worries about operations costs. Critics point out that even when operational, an asteroid expedition would fly, on average, only every other year. With tepid White House support for the booster, and projected costs of a billion dollars or more per launch, will SLS even survive to see first flight?

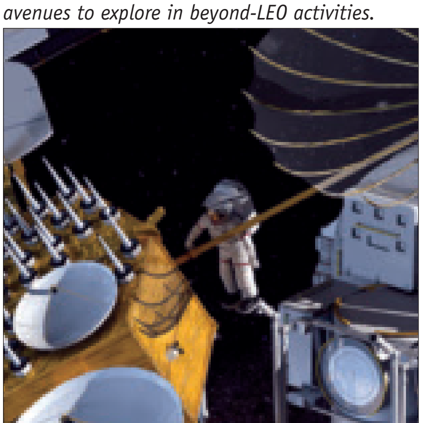
NASA should weigh alternatives like orbital propellant depots, touted by the agency last fall as a 'game-changing' technology. Despite their operational complexity and the cryogenic boil-off problem, depot economics with low-cost commercial rockets might be attractive in fueling heavy payloads for missions beyond Earth orbit.

Orion now appears much closer to actual flight. In November, Lockheed-Martin and NASA announced plans for an unmanned orbital mission, Exploration Flight Test-1. A Delta 4 will insert Orion into a high-apogee Earth orbit, resulting after two revolutions in a high-energy reentry designed to subject its heat shield to near-deep-space velocities, structural loads, and temperatures. Recovery would take place off the California coast. Target date for EFT-1 is early 2014.

Elevating relevance

If NASA is to keep human spaceflight from sliding further down the list of national priorities, it should propose and execute near-term achievements that build steadily toward lunar and asteroid exploration a decade hence. Sketchy outlines of using Orion and SLS in the 2020s are not sufficient. NASA should look to practical demonstrations within 5-10 years at the ISS and in cislunar space of how robotic and human exploration can open up new areas of commercial and industrial activity—exploration payback.

GEO satillite servicing is one of the promising avenues to explore in beyond-LEO activities.



The configuration of NASA's new SLS was unveiled last September.

Examples include having astronauts experiment with promising commercial processes in space: GEO satellite servicing, solar power beaming demonstrations, and resource extraction from extraterrestrial materials. Crews can also test vital exploration technologies at ISS: inflatable habitats, new spacesuits, free-flying personal exploration craft, even shirt-sleeve assembly hangars. Both avenues would provide highly visible near-term evidence that human deep space presence is relevant to our national economic vitality.

These technologies are all demonstrable within the decade, and are modest enough to be affordable in an uncertain budget environment. Such commercial and technical successes could pave the way for the deep space expeditions of the 2020s, a subject best saved for the next column.

Thomas D. Jones
Skywalking1@gmail.com
www.AstronautTomJones.com