An opening for commercial space stations
ISS turns 20 next year. Is it ready for business class?

INSIDE
- Trump’s budget blueprint
- Bigelow’s inflationary scenario

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ABOVE: A “space cheeseburger” is seen floating inside the International Space Station with Expedition 50 flight engineer Peggy Whitson of NASA in the background. Astronauts routinely use tortillas instead of bread due to the latter’s tendency to crumble and float away in microgravity.

ON THE COVER: Astronaut Kate Rubins inspects the inside of the Bigelow Aerospace Expandable Activity Module attached to the ISS.
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SPACEX NOTCHES ANOTHER GPS WIN

In its first head-to-head competition with United Launch Alliance, SpaceX won an Air Force contract for a GPS satellite launch. The $96.5 million contract went to SpaceX March 14 for a GPS 3 satellite launch planned for 2019. SpaceX won a similar GPS launch contract last year, but ULA declined to submit a bid. ULA confirmed last September, when proposals were due for this contract, that it was bidding.

The Air Force told reporters that SpaceX won by offering a lower price. This award, and another GPS 3 launch contract SpaceX won last year, are the first of 15 “Phase 1A” launches being competed by the Air Force, and officials said they believe both SpaceX and ULA can be competitive on bids for future launches.

SIGNIFICANT DIGITS

$75M
The additional funding New Zealand’s Rocket Lab raised to scale up production of its Electron small rocket.

$786M
OHB’s total 2016 revenue. While the German satellite maker missed its 2016 revenue goal of $810 million, OHB is shooting for $860 million this year.

500
The number of seconds NASA fired an RS-25 engine March 23 to test a new engine controller that will be used on the Space Launch System’s late 2018 debut.

A SpaceX Falcon 9 rocket lifted off March 16 from Cape Canaveral to deploy a communications satellite for EchoStar Corp. EchoStar 23 will provide direct broadcast services for Brazil from 45 degrees west in geostationary orbit.
QUICK TAKES

SPACE DATA HIGHWAY

Airbus plans to add a third node to the European Data Relay System (EDRS) communications network. The company says it’s planning a 2020 or 2021 launch of the EDRS-D satellite, providing coverage over the Asia Pacific region. EDRS-D will join EDRS-A and the future EDRS-C satellite to provide near global coverage, relaying data from Earth science satellites in low Earth orbit. EDRS, also known as the SpaceDataHighway, uses laser links to provide much greater bandwidth than traditional systems.

SSL VS. ORBITAL ATK

Space Systems Loral has sued Orbital ATK over a breach of confidential documents. In the suit filed March 22, SSL said an Orbital ATK employee accessed confidential SSL documents about a satellite servicing technology project on a NASA server and shared those documents with other Orbital ATK employees. Orbital ATK told SSL the employee had been fired, but SSL wants more information on who had access to those documents and how they may have been used. The suit comes a month and a half after Orbital ATK sued DARPA over a contract it awarded to SSL for a satellite servicing program.

JUICE IS LOOSE

Europe’s first mission to Jupiter has passed its preliminary design review. The Jupiter Icy Moon Explorer, or Juice, is scheduled for launch in 2022 to go into orbit around Jupiter and make flybys of the moons Callisto, Europa and Ganymede. With the preliminary design review complete, prime contractor Airbus is starting work on an engineering prototype to be completed by late 2018.

SKIPPING SATELLITE

Global satellite operator SES was a virtual no-show at the Satellite 2017 conference in Washington the first week of March. The company lacked the high-profile presence in years past at the satellite industry conference, including skipping a panel of satellite operator chief executives, because of company decisions to focus resources on events where it can better connect with potential customers. “We have to make huge, enormous efforts to go deep into the markets in which we operate,” a company spokesman said.

“While we’re not at war in space, I don’t think we could say we’re exactly at peace, either.”


The European Data Relay System, also known as the SpaceDataHighway.

Artist’s impression of ESA’s Juice probe visiting Jupiter’s icy moons.
The fact is there’s hardly anything in orbit that doesn’t contain at least one component made by us. From platform data handling, solar arrays, power electronics, sensors and actuators to payload equipment for telecoms, Earth observation, navigation and science applications, our commitment to R&D and reputation for reliability has made us the go-to supplier. Find out more about our ever-expanding portfolio at airbusds.com/space-equipment
A ‘SKINNY’ BUDGET, THIN ON DETAILS

The White House Office of Management and Budget released March 16 a preview of the detailed 2018 spending request U.S. President Donald Trump is expect to send Congress by early May. The U.S. federal government’s 2018 budget year begins Oct. 1.

DEFENSE DEPARTMENT

Boosting Pentagon spending by $52 billion — as President Trump has proposed — doesn’t go far enough to please defense hawks in the House and Senate. Even so, a 9 percent bump for such a large component of the federal government’s discretionary budget forced across-the-board cuts for every other executive branch agency except for Veterans Affairs and Homeland Security.

NASA

Trump seeks to cancel NASA’s Asteroid Redirect Mission (ARM) and several Earth science missions in its budget proposal. The fiscal year 2018 budget blueprint proposes $19.1 billion for NASA, down one percent from the nearly $19.3 billion it received in 2016. The blueprint proposes canceling ARM and four Earth science missions, and also shutting down NASA’s Office of Education. The budget proposal would provide additional funding for NASA’s planetary science program, but would not allocate any money to a proposed Europa lander mission. The overall cut in NASA’s budget is far less than other agencies, which would receive cuts in some cases in excess of 30 percent over 2016 levels.

COMMERCE DEPARTMENT (INCLUDES NOAA)

Trump wants to cut 16 percent from next year’s budget for the Commerce Department, which includes NOAA. The blueprint doesn’t give figures for NOAA, but says Trump’s budget “maintains the development” of the Joint Polar Satellite System (JPSS) and Geostationary Operational Environmental Satellite (GOES) programs. However, the budget would take savings from the Polar Follow On program, which funds development of future JPSS satellites after JPSS-2, “by better reflecting the actual risk of a gap in polar satellite coverage.”
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‘Historic’ planetary science budget boost leaves researchers uneasy about other cuts

NASA officials praised “historic” funding levels for its planetary science programs in the administration’s fiscal year 2018 budget request, even as some scientists in attendance worried about how that budget would affect other agency programs.

A March 20 town hall meeting known as “NASA Night” at the Lunar and Planetary Science Conference in The Woodlands, Texas, was NASA’s first opportunity to discuss a budget blueprint released by the White House March 16 that seeks $1.9 billion for planetary science, part of an overall $19.1 billion request.

That amount is a 16-percent increase over the $1.63 billion planetary science received in a 2016 spending bill. NASA is operating under a continuing resolution that funds programs in the 2017 fiscal year, which started last Oct. 1, at 2016 levels through April 28.

“Historic,” said Jim Green, director of NASA’s planetary science division. “We’ve never had a proposed budget this high. This also is the highest increase in any organization at NASA this year.”

Green offered few details about how that $1.9 billion would be allocated among various programs in his division, saying those details would be released in May in the detailed budget plan. The Trump administration’s budget blueprint also offered few specifics beyond support for the Mars 2020 and Europa Clipper missions, and stating it would not fund a Europa lander.

Green said little about a proposed new Mars orbiter mission to take over the imaging and communications roles currently filled by the Mars Reconnaissance Orbiter, launched in 2005. Work on such a mission would need to start soon in order to be ready for a 2022 launch. “What we’ll have to do is wait until all the budget details are released” in May, he said.

While the budget outlook for NASA’s planetary science programs was much brighter than just a few years ago, when scientists attending the NASA Night event worried about cuts in missions and research funding, many at this town hall instead objected to plans in the budget proposal to close NASA’s Office of Education and cut more than $100 million from the agency’s Earth science programs.

Green said closing the Office of Education does not directly affect education activities funded within the Science Mission Directorate, which were restructured a couple years ago. “I think we’ve made really great steps to hang on to our educational funding,” he said.

Several of those attending the town hall meeting used the question-and-answer session to criticize the cuts despite the windfall proposed for their own research areas. “I personally feel that it’s very shortsighted to be excited about this planetary science budget, because planetary science does not live in isolation,” said Nancy Chabot of the Johns Hopkins University Applied Physics Laboratory, a comment that generated applause from the audience.

“We cannot be just supporting planetary science,” she said. “This will be a short-term gain, potentially, but a long-term loss if the science community in the United States is not strong everywhere, all around.”

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Like all things ‘90s, the White House Space Council is making a comeback

U.S. Vice President Mike Pence said March 21 that he expects the Trump administration to reestablish the National Space Council, a move that has the backing of a key member of Congress.


“In very short order, the president will be taking action to re-launch the National Space Council,” Pence said. “He’s asked me to chair that, as vice presidents have in the past, and we’re going to be bringing together the best and the brightest in NASA and also in the private sector.” Trump nodded as Pence spoke and said, “Right.”

Pence’s comments were the strongest indication to date that the Trump administration plans to follow through on a statement made during the campaign that it would restore the National Space Council, an interagency body that last operated in the administration of President George H.W. Bush.

The Trump administration has said little about space in its first two months in office. On March 10, the office of Vice President Pence tweeted a photo of him meeting at the White House with Apollo 11 astronaut Buzz Aldrin “as we work to shape the space policy of our administration.” Aldrin said later that Pence didn’t offer any indications of what that policy might be, but “took note some suggestions and some offers of assistance” from him during what the former astronaut called a “very friendly, very satisfying” meeting.

At the signing ceremony for the authorization bill, President Trump offered few hints about what his administration’s space policy might be. “I’m delighted to sign this bill — it’s been a long time since a bill like this has been signed — reaffirming our national commitment to the core mission of NASA: human space exploration, space science and technology,” he said.

The bill is the first NASA authorization act to be signed into law since October 2010. The act passed the Senate by unanimous consent Feb. 17 and by a voice vote in the House March 7. The bill authorizes $19.5 billion for NASA in fiscal year 2017 and includes a broad array of policy provisions, from development of a detailed plan for NASA’s human exploration programs, with the long-term goal of sending humans to Mars, to giving NASA the ability to establish long-term medical monitoring of former astronauts.

Among those members of Congress who attended the signing ceremony was Rep. Jim Bridenstine (R-Okla.), a member of the House Science Committee who has been active on space policy issues. Speaking a short time later at a Washington Space Business Roundtable luncheon, he endorsed Pence’s statement about reestablishing the National Space Council.

“For legislators that are interested and involved in space, this gives us a tremendous amount of opportunity,” he said of the space council, by addressing the “stovepipes” that isolate civil, commercial and national security space programs.

Bridenstine said he wasn’t sure when the executive order reestablishing the National Space Council might be signed by President Trump. He thought, though, it might not come “immediately” in order to give the administration time to identify staff members that would support the office.

“The fact that the vice president is talking about it on television, during the signing of the NASA Transition Authorization Act, is something I think we should all be excited about,” he said. "The American public is really interested in space exploration, and the nation is ready for this.”
Act, indicates that it’s happening. They’re serious about it,” he said of the National Space Council. “I’m thrilled about it.”

In his speech, Bridenstine highlighted several policy topics he thought the space council could be well suited to address. They included shifting space situational awareness work from the U.S. Air Force to an agency like the Federal Aviation Administration, use of commercial weather satellite data to address gaps in government systems, creating an “America first” policy for launch that encourages the development and use of domestically-developed launch vehicles, updating regulations associated with the commercial remote sensing industry, and better integrating launch activities into the national airspace system.

Many of those issues are topics that Bridenstine sought to address last year with his overarching space policy bill, the American Space Renaissance Act. While the bill did not pass, some of its provisions were incorporated into other legislation.

He said he is working on an updated version of the act, but does not plan to introduce it immediately. He introduced the original version of the bill last April at the Space Symposium, but said that he’ll use a visit to that conference next month to instead seek feedback. “We’re not going to rush it,” he said of the new version of the act, “Our target would be before the end of the year.”

That assumes Bridenstine is still in Congress by then: he remains a leading candidate to be nominated to be NASA administrator. Asked after the speech if he thought the administration was getting closer to nominating someone for the position, he responded, “I think so. I'll leave it at that.” SN

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The International Space Station has been the cornerstone of NASA’s human spaceflight program for decades. However, the agency can envision a future where it is not, one where astronauts go on missions into deep space, while commercial ventures operate their own stations in low Earth orbit. The question, though, is how do you get there from here, and how long does it take?

A provision of the NASA Transition Authorization Act of 2017, signed into law by President Trump March 21, requires NASA to deliver a report that provides a ‘step-wise approach’ from the current state of ISS operations to a future where ‘NASA could be one of many customers of a low-Earth orbit non-governmental human space flight enterprise.’

If industry gets its way, that transition will be gradual, extending perhaps well beyond the station’s current end date of 2024. “The ISS should be sustained beyond 2024 to the extent that the space station is technically capable and safe to remain in orbit.”

Astronauts on the ISS captured these light trail images as they orbited the Earth at 28,000 kilometers per hour. Not as speedy? The transition to an era where commercial ventures operate private space stations, freeing government astronauts to explore deep space.

Transitioning from the ISS to commercial space stations will take time

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SPACE STATION TRANSITION

said Eric Stallmer, president of the Commercial Spaceflight Federation, at a March 22 hearing by the House space subcommittee on the long-term future of the ISS.

“Any ISS transition plan,” he added, “should prepare an evolutionary path in order to avoid disrupting science and operations on orbit, and any unnecessary economic upheaval.”

Other witnesses at the hearing agreed, noting the interest in commercial uses of the ISS. “Applications with strong market potential are emerging, which in turn leads to increased interest in commercial modules and follow-on platforms,” said Mary Lynne Dittmar, executive director of the Coalition for Deep Space Exploration. “Abandoning the ISS too soon will most certainly guarantee failure.”

NASA seems to agree. “We need to do a transition,” said Bill Gerstenmaier, NASA associate administrator for human exploration and operations. “There needs to be a smooth handoff.”

One reason for that smooth, but extended, handoff is the slow development of commercial applications for a space station. For decades, companies have sought the “killer app” for space station activities, from protein crystal growth to space manufacturing to tourism. So far, none have materialized.

“At present, there is no compelling economic driver apparent in LEO that can bridge the gap between current commercial activity and the revenues that can significantly offset ISS operations costs,” Dittmar said. “Given that markets frequently take decades to develop, this is not surprising.”

The problem some in Congress see with extending the station is its cost: more than $3 billion a year in NASA’s budget goes to the ISS, Gerstenmaier said. Of that, $1.7 billion a year goes towards transportation of cargo and crews to and from the station, $1 billion for operations, and $700 million to $800 million for research.

Continuing those costs beyond 2024 could mean making cuts elsewhere, such as programs to support human exploration to the moon and Mars. “If NASA stays on the ISS beyond 2024, we ought to be aware that remaining on the ISS will come at a cost,” warned Rep. Brian Babin (R-Texas), chairman of the space subcommittee. “What opportunities will we miss if we maintain this status quo?”

Babin mentioned a 2014 National Academies report on human space exploration that found that extending the ISS while keeping overall human spaceflight budgets flat would mean delaying other programs. “The longer we operate the ISS, the longer it will take to get to Mars,” he said.

Dittmar, who served on the committee that wrote that report, cautioned such a conclusion could be an oversimplification. “What I would say is that there is no question that, under a flat budget, you’re basically in a zero-sum game unless you’re able to find ways to offset that game with either a significant cost reduction or the influx of additional revenue,” she said.

Could commercial activities on the ISS provide revenue to help cover some, or all, of the costs of running the station and thus avoid that zero-sum game with exploration programs? One subcommittee member, Rep. Neal Dunn (R-Fla.), asked at the hearing whether it was feasible for commercial interests to handle the entire cost of the ISS by 2024.

“I think it would be hard to speculate that by 2024,” Stallmer responded. “The commercial sector is moving in the right direction with NASA, but to fully privatize the station would be difficult.”

If full private operations of the ISS weren’t feasible by 2024, Dunn asked, what fraction of station costs could be handed by commercial users? “I would love to see 50–50,” Stallmer responded.

Dittmar emphasized reducing costs, which she said could be done in part through greater use of public-private partnerships. “If the station is going to continue, you’re going to have to find ways to reduce costs,” she said.

Even if ISS takes on a greater commercial role as part of that transition, NASA will continue to make use of the station both to support its exploration plans as well as other research. “Station plays a pretty critical role” in testing technologies for human exploration, Gerstenmaier said. “We’re going to need some facility in space beyond 2024 to keep working on those items.”

“The ISS is a fully functional laboratory with trained personnel,” said Robert Ferl, director of the Interdisciplinary Center for Biotechnology Research at the University of Florida, who has flown experiments on the station. A shift of that research to commercial facilities, he said, would work only if “NASA stewardship of this research portfolio is maintained.”

Regardless of the nature of the transition, both NASA and the private sector acknowledge that, some day, the ISS will not be around. “I don’t think there’s any disagreement that we have to move off the station,” Dittmar said, even if it’s not clear how that will happen or how long it will take.

“I hate to counsel patience, but I’m going to counsel patience,” she added. “We need a little bit more time, I think, to allow these things to develop before we can get a real clear view of what that transition looks like.”
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Space available

Three firms are vying to lease a port on the ISS that could double as a springboard for a truly commercial space station.

ASA FACES THREE DRAMATICALLY DIFFERENT OPTIONS as it prepares for the transition from the government-owned and -operated International Space Station to one or more commercial facilities. The space agency is likely to announce this spring or summer whether to offer an available ISS port to Axiom Space, a team proposing to build a new module to serve government and commercial customers, Bigelow Aerospace and its expandable module or Ixion with its modified Centaur upper stage. Whoever wins is likely to have a leg up on the competition in the race to define the future of microgravity research, manufacturing, tourism and government operations in low Earth orbit.

AXIOM SPACE

As NASA and its international partners make plans for the eventual retirement of the ISS, Axiom Space is raising money for a commercial space station to cater to government astronauts, tourists, microgravity researchers, manufacturers and companies developing tools for future space exploration.

"We think we have an attractive plan that the customer base will support," said Michael Suffredini, Axiom president and chief executive, who formerly served as NASA’s International Space
Station program manager. "It is vitally important to have a commercial vehicle in low Earth orbit when ISS retires."

NASA and its international partners have agreed to support the ISS until at least 2024. In anticipation of the ISS retirement, NASA is seeking input from companies on ways the agency can continue to work in low Earth orbit.

Axiom plans to select a manufacturer this year to build a module to send to the ISS by 2021 that would later undock to form one element of a commercial facility. The module is designed to support seven people, including sovereign astronauts staying for 60 to 90 days at a time and tourists on seven- to 10-day visits.

Before traveling to the Axiom station, astronauts would go through extensive training provided by Axiom Space partner Stinger Ghaffarian Technologies (SGT), the company that trains NASA astronauts. Axiom Chairman Kam Ghaffarian is also SGT’s president and chief executive. Suffredini declined to say how much tourists would pay to vacation in orbit except to say it would be far less than the $20 million American businessman Dennis Tito paid in 2001 to travel to the ISS in a Russian Soyuz capsule.

NASA is likely to be an Axiom customer but not an anchor tenant, Suffredini said, as the space agency continues research aimed at mitigating the effects of microgravity on people and testing future exploration systems.

Axiom also will seek advertising revenue. For example, Axiom customers may purchase the right to advertise on its flight suits, Suffredini said.

Axiom could build, launch and activate the first commercial space station module “for something in the neighborhood of $600 million,” Suffredini said. The company has completed a seed investment round and plans to complete a Series A round by the end of February, said Amir Blachman, Axiom’s strategic development vice president, who declined to say how much money the firm has raised.

For customers, Axiom intends to simplify microgravity research and manufacturing by offering all necessary power and communications connections. In January, Axiom announced plans to work with Made in Space, the company that operates a commercial additive manufacturing facility on the ISS, to design an in-space factory with the equipment, utilities, power, and thermal management systems customers will need.

**BIGELOW’S XBASE**

Robert Bigelow began developing a commercial orbiting outpost 16 years ago when the International Space Station was still in its prime. As NASA looks for ways to start moving microgravity...
research off the ISS, the Bigelow Aerospace president is overseeing development of the Expandable Bigelow Advanced Station Enhancement, or XBASE, a 330-cubic-meter module that could attach to the ISS or fly independently.

"XBASE is the perfect, all-encompassing solution for NASA because it will be capable of being a stand-alone station," Bigelow said. "It doesn't need any other modules or attachments for power or anything else."

Bigelow is on schedule to produce two of the 330-cubic-meter modules, known as B330s, that will be ready for launch in 2020 on United Launch Alliance’s Atlas 5 552 — the only existing rocket with a fairing large enough to accommodate it, Bigelow said.

Once in orbit, NASA could attach XBASE to an ISS port and use it for many years. Or, NASA could opt to undock XBASE at some point and operate it as a free flyer in low Earth orbit. Still another option would be for NASA to outfit XBASE with equipment and supplies before moving it to Lagrange Point 1 (L1), cis-lunar orbit or another location outside of low Earth orbit, Bigelow said.

XBASE features an extensive environmental control and life support system as well as two dissimilar propulsion systems to enable the module to maintain its position in low Earth orbit. To move toward the moon or L-1, XBASE would need to rely on a transportation system like ULA’s next-generation upper stage engine, the Advanced Cryogenic Evolved Stage, Bigelow said.

With XBASE, Bigelow could serve NASA as well as new commercial and government customers. “If it were a free flyer, it would have fewer restrictions,” Bigelow said. “The station carries with it certain baggage, not the least of which is the expectations it will eventually be terminated.”

Many foreign nations that are not ISS partners are interested in sending their own astronauts to a space station, a business that will expand rapidly once commercial companies begin offering reliable transportation into low Earth orbit, Bigelow said.

Bigelow, an entrepreneur who made his fortune primarily through real estate investments including the hotel chain, Budget Suites of America, is not seeking outside investors for XBASE, but the company is “open to joint ventures, a relationship with NASA or with other companies thinking about expeditions to the moon or other destinations,” he said.

NASA began conducting tests in May of the Bigelow Expandable Activities Module (BEAM), an experimental module Bigelow built under a $17.8 million space agency contract. Through that program, Bigelow has confirmed with onboard radiation sensors that the multiple layers of high-strength materials comprising the inflatable hull provide “better radiation protection than other ISS modules,” Bigelow said.

Each B330 will have a hull that is thicker than BEAM’s. Still, the company would need to augment a B330’s radiation protection if NASA or another customer wants to send the module beyond low Earth orbit. “We would need to know that ahead of
time so we could make those changes,” Bigelow said.

**IXION**

Unlike the other teams, Ixion is not designing a new space station module. Instead, the team that includes NanoRacks, Space Systems Loral and United Launch Alliance proposes turning a spent Centaur upper stage into a man-tended habitat attached to the ISS.

“Now is not the time to build a state-of-the-art habitat from the ground up,” said Jeff Manber, NanoRacks chief executive, adding that a refurbished upper stage would cost far less than a new module. Ixion proposes using a refurbished Centaur as a “stepping stone from the government owned and operated space station to a commercial platform,” he said.

Ixion plans to draw on Space System Loral’s expertise in robotics to turn a Centaur into a “21st century space module,” Manber said. “NanoRacks and ULA are very confident that it is not a difficult transition.”

In addition to its ISS proposal, Ixion won a NASA contract in August to study the feasibility of converting a Centaur into a deep space habitat as part of NASA’s Next Space Technologies for Exploration Partnership. NanoRacks and Boeing also are building a commercial airlock to launch satellites from the ISS. That airlock could later be moved to Ixion’s commercial station, Manber said.

NanoRacks is in business to help customers gain access to the ISS. Its clients include NASA, international space agencies, high schools, universities and biopharmaceutical firms. “Our business model is not hardware, we are in the utilization business, so how do we keep our costs low? We reuse existing hardware,” Manber said.

A commercial module could serve additional customers. “We are in very mature talks with customers whose needs we are unable to meet on a NASA, manned space station,” Manber said.

Although NASA plans to select one firm to begin testing a commercial space station on the ISS, companies that are not selected may continue to develop commercial stations. “To me, it’s far more important that we focus on the hardware and the customer base and move forward,” Manber said.

Multiple stations will be coming down the pathway in the next 10 years,” he said. “You will have unmanned space stations, space hotels and government-dominated platforms, but you will never again see something as large in low Earth orbit as the ISS because it was a government, political solution.” SN
Robert Bigelow’s ideas on commercial space habitats have evolved since he established Bigelow Aerospace on 20 hectares in North Las Vegas, Nevada, in 1999. At the time space tourism looked promising, but Bigelow quickly realized that commercial space habitats like privately owned terrestrial structures could serve many different customers, including U.S. government agencies.

With that idea in mind, Bigelow is inviting NASA to become an early customer of the B330, the space habitat with 330 cubic meters of internal volume the firm plans to launch in 2020. Bigelow is inviting NASA to use one B330 as an Expandable Bigelow Advanced Station Enhancement, or XBASE that could be attached to the International Space Station or flown separately.

NASA is currently evaluating proposals offered by Bigelow Aerospace and competitors, including Axiom Space and Ixion, a consortium that includes NanoRacks, Space Systems Loral and United Launch Alliance, to attach a commercial module to a space station docking port.

Bigelow already has an experimental module attached to the port NASA is offering. In 2013, NASA awarded Bigelow a $17.8 million contract for the Bigelow Expandable Activities Module (BEAM), which NASA sent to the space station on a SpaceX Dragon capsule in April 2016 and expanded to its full size in May 2016.

With that module in place, Bigelow has been able to test how well its hull, composed of strong, flexible materials, would protect astronauts or tourists from radiation and micrometeoroids.

In addition to running the company, Robert Bigelow is acting as the B330 program manager, which he says is an extension of the work he did during his previous career developing real estate and operating hotels, including his Budget Suites of America chain.

“In all the real estate projects I’ve built, I’ve been the general contractor,” Bigelow said. “I’m very used to dealing with engineers and architects. I’m not an armchair owner-operator; not in the least.”

Bigelow spoke recently with SpaceNews.

**Did you respond to the NASA’s request for information concerning a commercial module for the International Space Station?**

We did. We started work on this concept with NASA several years ago. We proposed the XBASE as the perfect all-encompassing solution for NASA because our B330 spacecraft is going to be capable of being a stand-alone station. You would obviously want taxis to handle the crew and resupply, but other structures are not necessary, which makes it unique.

**What is the schedule for building B330s?**

We are on schedule to produce two 330s in 2020 for shipping out to the launch facility. We have kept one eye very carefully focused on transportation because our B330 would be the largest payload ever flown. SpaceX’s Falcon 9 Heavy will probably have the heavy-lift capacity, but only the Atlas 5 552 stretch fairing can handle the length and size of our spacecraft.

**What are your plans for the first two B330s?**

Our choices would be to appropriate one to NASA either as a free flyer or attached to the station. There are certain pros and cons. If it were attached to the station, NASA might want to maintain it for quite some time and NASA might choose to also use the other one as a free flyer. Whether it is a free flyer or attached, we would like to conduct business onboard as well.

**What are the pros and cons of attaching to the space station?**

It would have fewer restrictions if it were not attached to the ISS. There are a number of different areas in which you would be less handcuffed for commercial use of the B330 as a free flyer because the station carries with it certain baggage, not the least of which is the expectation it will eventually be terminated. Our B330 is very capable of being used outside of low Earth orbit. I could attach a bus to it if it were a free flyer or NASA could attach a bus to it and move it out to L-1 or cislunar orbit. The spacecraft is very adaptable.
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So B330 could operate beyond low Earth orbit?
There are at least three different scenarios. If XBANE attaches to the station, it could serve that use for years and years. It could essentially go nowhere. Or, it could be disconnected, undocked and become a free flyer in LEO for a long time and NASA could continue to use it for testing. Or, once it is outfitted to NASA’s liking, it could be relocated. It could attach, for example, to the Advanced Cyrogentic Evolved Stage ULA is developing and move to L-1 or cislunar orbit or some other location.

What type of business activities do you envision for B330s?
I’ve been a developer, landlord and innkeeper most all of my life. Like a terrestrial structure, it will have various customers. Very early on, we said we will cater to foreign countries. Between 50 and 60 countries have a space agency or department. The ISS is off-limits to an awful lot of those countries. We were disappointed when the space station was extended beyond 2020 because we had two or three countries that were ready, willing and able to get very serious about being our clients.

Would you have corporate clients as well?
We have 30 Direct Reference Missions, discreet kinds of functions for B330s. Growing food or using it for a hospital are two Direct Reference Missions. There are so many because this is a stand-alone station, not just a habitat. It can be repurposed for a lot of different kinds of uses. We have competitors and can’t talk too much about certain things.

What does a B330 cost?
That’s proprietary. But the affordability of our spacecraft is going to be tremendous. It’s going to be terrific for customers and for NASA.

Are you funding all the work yourself?
Yes. We don’t need outside investors. I can handle the cost of building these spacecraft, but we are open to joint ventures and some kind of relationship with NASA or with companies thinking about expeditions to the moon. We are open to doing that so long as other folks contribute their fair share.

What have you learned from BEAM?
The BEAM is providing useful radiation information. Even though our B330 debris and radiation shields are far thicker than the BEAM, the BEAM is still providing better defense for radiation protection than the other ISS modules, especially from a background radiation standpoint.

Anything else?
The BEAM project helped us understand how to handle NASA safety issues. Something much larger than BEAM is going to be like BEAM on steroids for safety concerns.

Would you modify B330s for use beyond low Earth orbit?
We are radiation hardening everything from a LEO perspective. So NASA would have to tell us if the XBANE isn’t going to stay forever on the station.

Commercial space stations are on the horizon, but it’s taken a long time.
We all thought it would happen earlier. I’ve had to manage my company by advancing the throttle and putting on the breaks. It has been extremely frustrating because we are tied to the transportation. You can’t have an island nobody can get to. I stopped the throttling process a year or so ago. We are focused on 2020. There are no more pauses.

Robert Bigelow,
Bigelow Aerospace founder and president, B330 program manager
Wishful thinking collides with policy, economic realities in ‘Capitalism in Space’

On March 10, the Center for a New American Security released a report entitled “Capitalism in Space: Private Enterprise and Competition Reshape the Global Aerospace Launch Industry.”

A first glance at the title and the prestigious think tank sponsor certainly caught our attention as long-time analysts, managers, and engineers in the space community. It’s obvious that the U.S. launch industry has been changing and innovating with exciting demonstrations of new launch capabilities that are worrying foreign competitors.

The opening introduction briefly mentions traditional national interests in space, such as military strength, economic growth, and national prestige, but quickly goes off track in claiming there is a global race to establish “permanent colonies on the moon, Mars, and the asteroids.” Would that such fantasies were true, but wishing does not make it so.

The core problem is that based on this minimal experience the author poses a false binary choice between ‘government’ or ‘private sector’ approaches to space transportation, a choice in which he argues that the government should abandon traditional acquisition practices in favor of relying on “free enterprise.”

In effect, he makes an unsupported claim that commercial markets exist (or should exist) for the public goods of science, exploration, and security. In order to acquire these goods, the author argues that public funds should be provided to private actors with little accountability or oversight in order to realize cost savings. In his view, the most important purpose of space transportation policy is to economically benefit private space launch providers in the hopes that this will spur more space activity.

In public policy, it is
well-known that markets and governments each represent imperfect alternatives for acquiring goods and services. “Market failure” is a traditional justification for governments to step in and provide public goods that make no commercial sense (e.g., basic science, exploration).

Similarly, there are non-market failures of government in which markets are superior means of delivering goods and services. Neither is ideal in all cases, and even the most cursory look at space activities shows how diverse they are. Satellite communications are fully market-driven and remote sensing is becoming more market-driven with the rise of location-based services, while space launch remains driven by government revenues. Fully commercial markets that provide return on investment in endeavors such as orbital tourism, mining, and others are unfortunately still in the future.

In discussing NASA’s commercial cargo program, the author makes a series of technical and cost comparisons with the Space Launch System (SLS) and Orion. The comparisons are misleading as they have very different purposes, one focused on deliveries of government supplies to the International Space Station (ISS) and the other on deep space exploration beyond low Earth orbit. Regarding SLS/Orion, the author states, “The rocket therefore essentially belongs to NASA, whose goals — exploring space — have nothing to do with reducing cost or obtaining profit.... No satellite company can afford it.”

This is an obvious and intended result, as the vehicle is not designed for launching satellites, a task which the private sector can already do. The vehicle is being created for non-commercial deep space exploration missions. That’s why it’s a NASA program. The SLS might be used to launch multiple satellites, but if it did so, companies could easily argue this was unfair government competition.

The author states that, “... SpaceX’s own heavy-lift rocket, the Falcon Heavy, suggests it is possible to build a heavy-lift rocket for much less money and far less time than it has taken NASA to build (the) SLS.”

This is a false comparison of vastly different capabilities; the reported first stage Falcon Heavy thrust is approximately 1.71 million pounds. SLS thrust is 8.87 million pounds of thrust. The SLS is designed to place more than twice as much payload into a low Earth orbit and over three times as much into a trans-Mars injection orbit. Again, these are government requirements, not commercial requirements, and that’s why SLS is a NASA program.

Human spaceflight programs such as SLS, Orion and the International Space Station shoulder most NASA overhead costs. The author shows a lack of understanding on how the Obama administration, through the Office of Management and Budget, treated favored over disfavored programs and impacted costs and schedules. For example, SLS and Orion budgets were routinely burdened with termination liability costs and institutional taxes that were not imposed on the commercial crew and cargo programs.

Exploration programs did not receive funding freed up by the shuttle’s retirement as originally planned. The cancellation of human exploration programs in 2010, and the resulting congressional backlash took years to recover from and slowed development.

The author makes the valid point that the acquisition approaches for SLS/Orion and commercial cargo are fundamentally different. It’s also hard to disagree with the argument that traditional government acquisition processes are inefficient, expensive, and in need of reform.

However, such reform is not achieved through the abdication of responsibility for the proper stewardship of taxpayer funds. SpaceX is executing its NASA work with heavy reliance on public funds, and as such should be subject to NASA oversight and control to provide stewardship of funding and assurance of safety for NASA assets and lives, just as any other company would experience.

The fact that such government oversight and controls need improvement is not a
reason for exempting some projects and not others from a level playing field.

The commercial cargo effort, while privately managed, was only partially privately capitalized. NASA subsidies created the private sector capabilities that NASA later paid additional funds to use.

Commercial programs were not charged their proportional share of NASA overhead. Instead, they were provided no-cost NASA help and use of facilities, ultimately paid for by other NASA programs, raising their overhead and cost. Arguably, it was in NASA’s interests to ensure the commercial cargo effort was successful, but the work needed for success did not come free.

Privatization of a previous government function (e.g., cargo transport to ISS) is not the same as commercialization. The latter requires non-government customers to spread fixed costs over a larger base so that government is merely one customer among many.

Space launch today is about as commercial as a private shipyard that builds aircraft carriers and an occasional yacht.

The price competition created by SpaceX has not resulted in new demand coming to the market, merely a reallocation of market share among suppliers, largely to the detriment of the European Ariane launcher and the Russians. This is good for the United States, but it doesn’t mean there’s a commercially viable launch market without government supports.

To date, no investment in a new launch system has returned that investment in real terms. This is consistent with historical experience with other transportation systems such as railroads and airlines. Having transportation systems is immensely valuable to the national economy but companies in these businesses have difficulty making money for their owners.

Past studies have predicted that launch demand would remain inelastic (i.e., not changing in response to lower prices) until prices fell enough to trigger a new source of demand. Typically, launch prices below $1,000, and approaching $400, per pound are thought to be needed.

The bigger challenge is that launch and return systems would also have to demonstrate historically unprecedented levels of safety at these lower prices. Suborbital launch and balloon missions are valuable pathfinder efforts for the space tourism market, but their success or failure is not a government responsibility.

When speaking about civil space programs, candidate Donald Trump said, “A cornerstone of my policy is we will substantially expand public private partnerships to maximize the amount of investment and funding that is available for space exploration and development.”

This is a laudable and necessary action, but careful analysis is needed to know which partnership deals make sense and which do not. Partnerships can make sense when fixed costs can be shared with non-government customers, as for example when Falcon 9 vehicles can be used for delivering communications satellites or cargo to the International Space Station. They don’t make sense when the government is the only source of demand, as in the case of deep space exploration.

The United States does not face a stark choice between markets or governments in space, but rather the need for clear thinking on how to pursue a mixed strategy, using a variety of tools, to serve national interests. It would be wise to mistrust any purist strategy, that is, one which is all-government or all-private, where taxpayer dollars are needed.

What the CNAS study unintentionally shows is the deep desire of some space advocates to believe that a path to the stars exists independent of political and economic realities. We need to dream, but with our eyes wide open, so we can make wise choices on the use of markets and governments for exploring and developing space.

SCOTT PACE is the Director of the Space Policy Institute at the George Washington University’s Elliott School of International Affairs in Washington.
The elusive ‘why’ of space exploration

For those of us in the space sector, we rarely spend time asking “why go to space.” The answer is so obvious, so much a part of our DNA, that we don't need to spend time articulating, or even discussing amongst ourselves the “why.”

Unfortunately, as a community, we take the “why” so much for granted that when we reach out to connect with those outside of our space tribe — such as our national leadership (whether that is Congress or the administration), or our colleagues from other economic spheres, or to the public — we stumble to deliver a coherent narrative to explain the importance of human expansion into space.

Instead, we dive straight into the gory details of the “how” and describe with passion and excruciating detail all the hardware we need and are building to achieve our endeavors. We talk about rockets, space stations, space vehicles, habitats, fueling depots, resource extraction equipment, life support, and so on. And then we don’t understand why our audiences are not as excited or inspired about the concept of humans venturing, permanently, beyond our planet’s boundaries. Failing to inspire the same excitement in our listeners, we inevitably change conversational tactics to highlight the practical, expounding on the economic benefits society reaps when we push the limits of what humans and technology can do. Sometimes we receive a flicker of interest in this argument, sometimes not.

It is time to shift the conversation a bit — to be more unapologetically inspirational and aspirational from the get-go and only then follow with the practical, positive outcomes.

Humans are meant to explore; it is the core of who and what we are as a species. We explore to gain knowledge and satisfy our curiosity, to expand our boundaries, whether those are intellectual, geographical, economic, or spiritual. We have, over thousands of years, explored and spread our presence across the planet. It is time to move off the Earth and continue that dynamic throughout the solar system. Space is the next frontier. The “why” is that simple; it is enough to capture anyone’s imagination.

Next, we must consider the “what.” If we are to expand across the solar system, what should we be doing? Should we focus on the age-old, fundamental questions that speak to our origin and place in the cosmos? (for example, where do we come from and are there others like us in the galaxy?) These are truly monumental questions that should be addressed by the American space program in partnership with international and commercial partners. Adopting a fundamental question — the importance of human expansion, for its own sake as well as the ongoing search for our place and life in the universe — as the motivation for space exploration is key to a sustainable space program. These questions drive investigations of multiple destinations over many decades, the development of advanced technologies, and opportunities for commercial exploitations of space-based resources.

The search for how life began on Earth is addressed on our planet and our nearby companion, the moon, which formed following a collision (or collisions) of a Mars-sized body with the proto-Earth around 4.5 billion years ago. Nearly 700 million years later, the outer planets in the solar system underwent a major repositioning and resulted in a large influx of asteroids raining down upon the Earth and moon. About this same time, the first single-celled life began on Earth. Is this a coincidence or was this “late, heavy bombardment” the genesis of life of Earth? All evidence of these impacts has been erased by our planet’s active atmosphere and geology. But on the moon, the history of
this bombardment is preserved as a “witness plate.” Within the South Pole-Aitken Basin, in particular, there is primordial material on or near the surface that can be excavated during the first exploration of the moon’s far side with robots and humans.

For nearly a century, writers have speculated that Mars is a possible location where life may have formed independently. NASA’s Maven and Curiosity missions indicate that large bodies of water once existed on Mars billions of years ago and that conditions for life may have existed. Finding evidence of microbial life with different DNA/RNA constructions would lead to breakthroughs in our understanding of how life formed and might also point to advances in biomedicine. This solar system destination might address our creation in quite novel ways.

Going further outward in a sustainable space exploration program to address these fundamental questions are the “water worlds” around Jupiter and Saturn. Moons like Europa and Enceladus appear to have oceans of water below layers of ice that are probably tens of kilometers thick. Could life, even macroscopic life, exist in briny seas that are analogous to Earth’s primordial oceans heated by tidal forces from these moons’ gas giant planets? Beyond the solar system lies newly discovered exoplanets. Who knows what we will find on these unexplored bodies — life forms like us, or different?

Finally the “how” needs to be addressed. It is here where the conversation can turn to the practical. The “how” should address not only the equipment and methodologies that will be utilized but also the desired outcomes. Ideally, a well-designed and executed, inspirational, sustained space program will:

- Drive advances in science and technology
- Expand opportunity for everyone, everywhere in space
- Enhance and expand knowledge, education, innovation and economic vitality
- Advance the understanding of Earth and develop technologies to improve the quality of life on our home planet

The “how” is important. In order to achieve these outcomes we must look strategically at the complete picture, knowing the “why” and “what” in order to examine and identify the appropriate roles for all of the various entities that want to engage in the enterprise. There is room for everyone — all countries, government and private actors of all sizes, and individuals. We must do this together. We will do this together. SN

SANDRA MAGNUS is executive director of the American Institute of Aeronautics and Astronautics. Jack Burns is professor of astrophysics and planetary science at the University of Colorado Boulder. He served on the Trump transition’s NASA landing team.
Making America’s space program great again

Rumors are circulating that the Trump team is considering a return to the moon as the basis for its space policy. If done properly, this could be a very good thing.

NASA needs a clear near-term goal, but that goal should be humans to Mars. Mars is where the science is, it is where the challenge is, and it is where the future is. Because it once had oceans, rivers and lakes, Mars is the Rosetta Stone for telling us the truth about the potential prevalence and diversity of life in the universe. It is also the thrilling challenge that would draw millions of bold, young people into science and engineering, creating massive amounts of intellectual capital that will strengthen the nation in peace and war for decades. It is also the closest world that has all the resources needed for life and technological civilization, the new frontier to an open future for humanity as a multi-planet spacefaring species.

A return to the moon offers, at best, a pale reflection of such extraordinary benefits. It is thus the wrong plan for NASA. But at least it is a plan, and as such is far superior to the option of continuing with the chaotic aimlessness of Obama space policy, which, not being a plan, is not even wrong.

But we can do better. From a technological point of view, we are far closer today to being able to send humans to Mars than we were to sending men to the moon when President Kennedy started the Apollo program — and we were there eight years later. Furthermore, that was done by a nation with barely more than half the population and one quarter the gross national product of America today. Given the will, we could certainly land humans on Mars by the end of the current administration’s prospective second term.

So, the argument frequently advanced by hard-core lunar advocates that the moon should be our goal because we are supposedly incapable of going to Mars is simply wrong. Moreover, adopting such a declaration of impotence is hardly a way to make America great again. Furthermore, it is a prescription for program failure, as demonstrated by the collapse of the Bush administration’s moon-base program shortly after Obama took the reins. A return to the moon did not capture the public’s imagination, and consequently had no public support. When Obama moved to kill it, it died utterly defenseless, and barely mourned.

But a Mars-only effort can easily be turned by timid bureaucrats from a program into a “vision,” a strictly nominal goal whose primary purpose is to provide an excuse for endless spending on an assortment of futuristic technologies. The requirements for such technologies are then written into the Mars mission plan, thereby making it impossible.

This is where a moon program can help. We clearly know how to go to the moon, and a properly designed lunar transportation system can also be used as the basis for sending human to Mars. Not only that, but the existence of such operational hardware will very forcefully incentivize Mars mission planners to use it, rather than grandiose futuristic vaporware, as the basis of their thinking. This is a complete game changer.

The propulsion requirements to go from low Earth orbit to low lunar orbit are identical to that needed to go from LEO to a trans-Mars trajectory. So, any heavy-lift
system that could, for example, deliver 40 tons to lunar orbit could also send a 40-ton payload on its way to Mars. If the Mars mission plan is designed around a concept of using existing propulsion technology to send a few such discrete payloads to the red planet, rather than waiting for the age when we can build gigantic Battlestar Galactica spaceships at orbital spaceports, then conducting human Mars exploration in parallel with lunar operations becomes possible.

Furthermore, because orbital mechanics dictate that we can only launch to Mars every other year, this is the best way for us to proceed. A launch vehicle program costs almost as much to maintain as an idle force-in-being as it does to conduct active flight operations. If we had a heavy-lift launch system capable of six flights per year, and a well-designed Mars mission plan requiring three launches every two years, we would be well-advised to use the other nine launch options to support a robust program of lunar and near-Earth asteroid exploration, rather than waste our funds through inaction.

The American human spaceflight program is in very bad shape right now. It is operating without a coherent and rational goal, and unless such a goal is embraced and an intelligent plan set forth to achieve it, the drift and waste will only continue until the taxpayers, losing patience, put it out of its misery.

We must, and can, do better. We really can have a space program worthy of the American pioneer spirit. We don’t need to just keep going nowhere, or returning to places we explored a half century ago. We don’t need to disappoint yet another generation by failing to accept the challenge of attempting inspiring deeds. Instead of endlessly pretending that we are preparing to go somewhere, we can actually go, and become the first explorers, pioneers, and settlers of new worlds filled with wonders waiting to be discovered and history waiting to be made. Instead of accepting the view of our detractors that we no longer have what it takes, we can once again step forth boldly and astonish the world with what free people can do.

To make America’s space program great again, we need to make it brave again. The entire inner solar system is now within our reach. We should seize the time. SN

ROBERT ZUBRIN is PRESIDENT OF PIONEER ASTRONAUTICS AND THE MARS SOCIETY AND THE AUTHOR OF “THE CASE FOR MARS: THE PLAN TO SETTLE THE RED PLANET AND WHY WE MUST.”
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### April

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Place</th>
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<tbody>
<tr>
<td>3-6</td>
<td>33rd Space Symposium</td>
<td>Colorado Springs, CO</td>
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<tr>
<td>24-28</td>
<td>11th IAA Symposium on Small Satellites for Earth Observation</td>
<td>Berlin, Germany</td>
</tr>
<tr>
<td>26-27</td>
<td>Military Space Situational Awareness</td>
<td>London, UK</td>
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### May

<table>
<thead>
<tr>
<th>Date</th>
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<tbody>
<tr>
<td>9-11</td>
<td>Humans to Mars Summit 2017</td>
<td>Washington, DC</td>
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<tr>
<td>15-16</td>
<td>MilSatCom Asia-Pacific</td>
<td>Singapore</td>
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<tr>
<td>15-19</td>
<td>5th IAA Planetary Defense Conference</td>
<td>Tokyo, Japan</td>
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<tr>
<td>23-24</td>
<td>LATSAT</td>
<td>Mexico City, Mexico</td>
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<tr>
<td>23-25</td>
<td>Space Tech Expo USA</td>
<td>Pasadena, CA</td>
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### June

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<thead>
<tr>
<th>Date</th>
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<tr>
<td>6-8</td>
<td>Global Space Exploration Conference</td>
<td>Beijing, China</td>
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<tr>
<td>20-22</td>
<td>Earth Observation Summit 2017</td>
<td>Montreal, Canada</td>
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<tr>
<td>28-29</td>
<td>MilSatCom USA</td>
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### September

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<tbody>
<tr>
<td>11-15</td>
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### October

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<tr>
<td>24-26</td>
<td>Space Tech Expo Europe</td>
<td>Bremen, Germany</td>
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Anyone interested in the exploration of Jupiter’s icy moon Europa is familiar with the line from Arthur C. Clarke’s 1982 novel 2010: Odyssey Two: “All these worlds are yours except Europa. Attempt no landing there.” That was the message delivered to the Soviet-American crew that observed Jupiter become a star, turning its moons into a miniature solar system.

Engineers and scientists at NASA have no intent of following that directive. With the encouragement of some in Congress, NASA has been developing initial plans for a Europa lander mission, which would be a follow-on to the Europa Clipper orbiter under development for launch as soon as 2022.

In February, NASA released a report by a science team that identified the goals of such a mission, including searching for evidence of present-day life in that moon’s subsurface oceans. “Europa may hold the clues to one of NASA’s long-standing goals — to determine whether or not we are alone in the universe,” the report stated.

The lander mission, though, may be facing an obstacle bigger than 2001’s monolith: the White House. On March 16, the Trump administration released its budget blueprint for fiscal year 2018, which offered a record-high $1.9 billion for NASA’s planetary science program. The catch? The proposal does not fund a lander mission.

“To preserve the balance of NASA’s science portfolio and maintain flexibility to conduct missions that were determined to be more important by the science community, the Budget provides no funding for a multi-billion-dollar mission to land on Europa,” the document stated. That hints at the fact that the latest planetary science decadal report, published in 2011, highly ranked a Europa orbiter mission, but not a lander.

At a town hall meeting three days later about the Europa lander science report, held just before the start of the Lunar and Planetary Science Conference near Houston, project officials didn’t want to talk about the budget. “If you’re here to talk about something other than the science of this report, the science of this mission, you are unfortunately in the wrong town hall,” said Curt Niebur, the mission’s program scientist at NASA Headquarters, at the start of a five-hour meeting that avoided any discussion of budgets.

What it means, though, is that the lander mission is now in a state of limbo. Jim Green, director of NASA’s planetary science division, said in an interview after another town hall meeting at the conference March 20 that future plans for the lander mission depend on not just that fiscal year 2018 budget proposal, but also whether Congress passes a full-fledged appropriations bill for 2017 or simply extends the current continuing resolution through the rest of the fiscal year.

“If we get a continuing resolution this fiscal year, then we’re pretty much done with the Europa lander, because we’ve done everything we can do within the budget limitations that we have,” he said when asked what the next step for the lander concept was. Studies would continue, he added, if Congress does pass a bill with specific language about the mission.

That’s certainly not out of the question, since the mission’s biggest advocate in Congress is Rep. John Culberson (R-Texas), who chairs the appropriations subcommittee that funds NASA and, in past years, has funded Europa Clipper at levels far above any administration request. If Congress can pass an appropriations bill, it’s likely Culberson will see that the Europa lander gets additional funding to continue studies.

There are, though, no guarantees: the appropriations process, particularly in the current political environment, can be an enigmatic as the monoliths. SN
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