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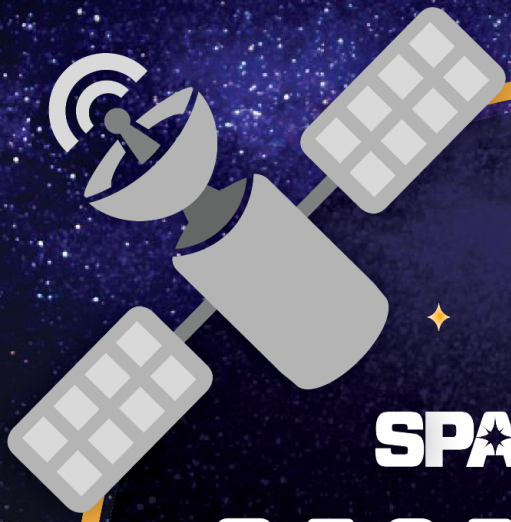

THE SPACENEWS AWARDS FOR EXCELLENCE & INNOVATION

INSIDE

- Space Policy Directive 1
- New Shepard flies again
- 5 bold predictions for 2018

Cobham congratulates the winners of the SpaceNews Awards for Excellence & Innovation

Cobham congratulates this year's finalists and awardees. Your examples of excellence and innovation are inspirational to us all.

- Company of the Year - SpaceX
- Corporate Leader of the Year
  - Gwynne Shotwell, SpaceX
- Startup of the Year - Kymeta
- Turnaround of the Year - ILS
- Deal of the Year
  - MDA buys DigitalGlobe
- Breakthrough of the Year
  - Planet completes Mission 1
- Government Agency of the Year - 45th Space Wing
- Government Leader of the Year: Civil
  - Etienne Schneider, Luxembourg
- Government Leader of the Year: Military
  - Gen. John Hyten, USSTRATCOM
- Unsung Hero of the Year - Jason Crusan, NASA

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2121 Crystal Drive, Suite 625, Arlington, Virginia, 22202 [USA]
T: +1 (703) 414-5300 E: CAES.BD@cobham.com

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We honor the 10 winners of the first annual *SpaceNews* awards.

***SpaceNews* will not publish an issue Jan. 1. Our next issue will be Jan. 15. Visit SpaceNews.com, follow us on Twitter and sign up for our newsletters at SpaceNews.com/newsletters.**

ON THE COVER: SPACENEWS ILLUSTRATION
THIS PAGE: SPACENEWS ILLUSTRATION

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SIGNIFICANT DIGITS

£200K

The British government is taking steps to make the country a haven for space startups. Earlier this month, the U.K. Space Agency announced it would provide £200,000 ($268,000) to kickstart four new space technology business incubators. The new incubators will bring the total number of U.K. space startup clusters to 15. The largest, in Harwell, currently hosts 80 companies, with a goal of growing to 200 companies by 2030.

$1,000

Satellite operator SES, in a recent meeting with FCC officials, said its C-band customers have little incentive to register their satellite dishes since registration is a voluntary process that can cost more than $1,000 per site. The FCC wants a more accurate database of C-band users to inform its decisions on allowing terrestrial use of part of C-band satellite spectrum, but SES and other operators argue that the existing database covers only a small fraction of actual C-band antennas in use.

500

Inflight-connectivity provider Gogo crested the 500 mark for planes equipped with its 2Ku satellite antenna. More than 400 of those installations took place this year. Gogo says it has cut average install times in half to around 30 hours, and has more than 2,000 2Ku contracts. More than 550 of those contracts came in this year.

An illustration of the lander and "micro-rover" ispace is developing for lunar missions. A $90 million funding round announced Dec. 13 will support work on two demonstration missions launching by the end of 2020.

MOON VENTURE RAISES $90M

A Japanese company planning a series of robotic missions to the moon announced Dec. 13 that it has raised more than $90 million in one of the largest Series A funding rounds for any emerging space venture. Tokyo-based ispace said the $90.2 million round, featuring a consortium of Japanese funds and companies, will be used to develop a pair of missions launching by the end of 2020 to orbit and land on the moon, precursors for a more regular series of lunar lander missions in following years.

The company will use the funds for two demonstration missions: a lunar orbiter launching in late 2019 and a lunar lander in 2020. It hopes to then fly a regular series of commercial lunar lander missions carrying payloads for customers. The company is also responsible for Team Hakuto, one of the finalists in the Google Lunar X Prize. It has completed a rover that will fly to the moon on the lander being developed by Team Indus.

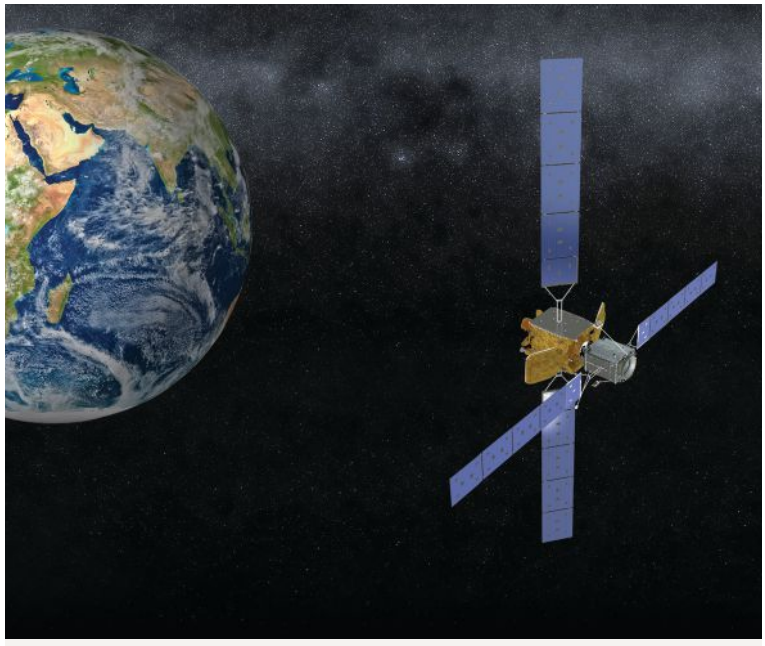
HELP WANTED

An advisory group for the new National Space Council will soon be seeking nominations for members. NASA announced Dec. 12 that the charter for the Users' Advisory Group, which NASA will operate on behalf of the council, had been approved. The group will consist of 15 to 30 people and include both representatives of non-federal aerospace organizations and subject matter experts. Nominations for the group will open this month.

ISPACE

WELCOME TO THE OCCUPATION

Blue Origin is starting to move into its new factory in Florida. The company received a temporary certificate of occupancy Monday for part of its new facility located just outside the gates of the Kennedy Space Center. The company will use the 70,000-square-meter factory to manufacture New Glenn rockets, which the company will launch from a pad at neighboring Cape Canaveral Air Force Station as soon as 2020.



FCC GIVES MISSION EXTENSION VEHICLE PRELIMINARY GO-AHEAD

Orbital ATK has received preliminary approvals from the FCC for its first satellite life extension mission. The FCC last week gave approval for Orbital ATK's Mission Extension Vehicle (MEV) to perform "rendezvous, proximity operations, and docking" with the Intelsat-901 satellite in geostationary orbit. The company still needs approvals from the FCC to relocate Intelsat-901 and then undock from it. The FCC's approvals involved the use of frequencies for telemetry, tracking and command of the MEV.

CLOSE ENCOUNTER

NASA's Dawn spacecraft will wrap up its mission next year by flying closer than ever to the dwarf planet Ceres. The spacecraft will move into an elliptical orbit around Ceres in the spring, taking it to altitudes as low as 30 kilometers above the surface. Scientists will use those close passes to collect high-resolution images of selected areas of the surface and collect more accurate chemical composition data. In the new orbit, the spacecraft will likely exhaust its remaining supply of hydrazine propellant, used for attitude control, in three or four months.

BLUE ORIGIN VIA TWITTER/ORBITAL ATK/NASA

ROSCOSMOS/U.S. POSTAL SERVICE/ELON MUSK VIA TWITTER

SOYUZ FAILURE PINNED ON BAD ALGORITHM

Russian officials said a programming error is to blame for last month's failed Soyuz launch. The Nov. 28 launch failed when the rocket's upper stage apparently fired in the wrong direction, causing it and its satellite payload to reenter over the North Atlantic Ocean. A Roscosmos statement said that "a hidden problem in the algorithm" caused the failure, which had gone undetected in past flights of the Fregat stage. Russian Deputy Prime Minister Dmitry Rogozin criticized the report for not assigning blame for the failure.

A FIRST-CLASS STAMP OF APPROVAL

The U.S. Postal Service will release a Sally Ride stamp next year. A preliminary design of the stamp unveiled Dec. 13 features a painting of Ride, the first American woman in space, with a shuttle launching in the background. The post office will also issue a four-stamp set next year for science, technology, engineering and mathematics (STEM) education, with engineering represented by a diagram of an Apollo spacecraft.

ULTIMATE ROAD TRIP

Elon Musk says the first flight of the Falcon Heavy rocket will carry a very unusual payload: his Tesla Roadster sports car. In tweets Dec. 1 , Musk said the launch, now scheduled for January, will feature "my midnight cherry Tesla Roadster playing Space Oddity. Destination is Mars orbit." After some confusion about whether Musk was joking, a company official, speaking on background, later confirmed the payload was real, but offered no additional details about it. Musk claimed earlier this year the test flight of the long-delayed heavy-lift rocket would carry the "silliest thing we can imagine."

Blue Origin flies next-generation New Shepard vehicle

The New Shepard crew capsule after landing. The capsule carried a dozen payloads and an instrumented test dummy, visible in one of the capsule's large windows.

Blue Origin quietly carried out a successful test flight of a new version of its New Shepard suborbital vehicle Dec. 12 and waited 11 hours to share the news.

"Today's flight of New Shepard was a tremendous success," Blue Origin CEO Bob Smith said in a statement released late that night along with photos and a video of the flight. "It marks the inaugural flight of our next-generation Crew Capsule as we continue step-by-step progress in our test flight program."

The vehicle lifted off from the company's test site in West Texas at 11:59 a.m. Eastern, reaching a peak altitude of nearly 100 kilometers and a top speed during ascent of Mach 2.94. The propulsion module made a powered vertical landing while the crew capsule descended under parachutes, touching down 10 minutes and 6 seconds after liftoff.

The Mission 7 flight was the first to use a new propulsion module, after Blue Origin retired the earlier module that flew five successful test flights from November 2015 through October 2016. It was also the first flight of an upgraded crew capsule, dubbed "Crew Capsule 2.0," that includes windows the company says are the largest ever flown on a spacecraft.

The capsule, Blue Origin said, carried 12 commercial, research and education payloads. Images released by the company show it also carried an instrumented test dummy identified as Mannequin Skywalker. "He had a good ride," tweeted company founder Jeff Bezos.

OUT OF THE BLUE

In a return to the secrecy that veiled earlier phases of New Shepard's development, Blue Origin did not provide any information about the flight until well after it ended. Last year, the company started providing advance notice of test flights and, later, live webcasts.

The only advance word about this flight came in the form of a Federal Aviation Administration airspace restriction, known as a Notice to Airmen (NOTAM), published Dec. 9, which closed airspace around the test site for several hours a day from Dec. 11 through 14. Blue Origin said it was planning "spaceflight operations" there and would cancel the NOTAM after the operations were complete.

During the day Dec. 12 there were rumors of a flight, but no official word from the company. The FAA's Office of Commercial Space Transportation, later in the day, listed the flight on its list of launches it licensed, and the FAA also removed the NOTAM from its website.

The flight was the first New Shepard launch to be carried out under a full-fledged launch license from the FAA, issued to Blue Origin in August. Previous launches took place under an experimental permit, which allows for suborbital flight testing but does not allow the vehicles to be used to carry payloads for hire. **SN**

JEFF FOUST

BLUE ORIGIN

NASA/AUBREY GEMIGNANI

President Trump announces the signing of Space Policy Directive 1 flanked by U.S. lawmakers, cabinet officials and various space dignitaries including Apollo astronauts Harrison "Jack" Schmitt and Buzz Aldrin, Coalition for Deep Space Exploration Executive Director Mary Lynne Dittmar (front row, second from right) and Mark Albrecht (front row, far right), the National Space Council's executive secretary from 1989-1992.

Trump formally establishes lunar landing goal, but without details

U.S. President Donald Trump signed an order Dec. 11 formally directing NASA to send humans back to the moon, but provided no information on schedules or budgets for such an initiative.

In a brief White House ceremony, Trump signed what the administration is calling Space Policy Directive 1, which enacts a recommendation made at the National Space Council meeting in October to make a return to the moon a step towards eventual human missions to Mars.

"The directive I'm signing today will refocus America's space program on human exploration and discovery," Trump said at the event, attended by several members of Congress, other government and industry officials, and current and former astronauts. "It marks an important step in returning American astronauts to the moon for the first time since 1972 for long-term exploration and use."

"This time, we will not only plant our flag and leave our footprint, we will establish a foundation for an eventual mission to Mars," Trump added.

Vice President Mike Pence, who also spoke at the ceremony, hailed the policy as an early success for the National Space Council, which unanimously approved that recommendation at its first meeting Oct. 5.

"Today's action by President Trump makes that recommendation official national policy," >

JEFF FOUST

Ivanka Trump handles a sample from the moon that Apollo 17 astronaut Harrison "Jack" Schmitt, left, collected during his 1972 mission. Trump's father has directed NASA to return to the moon, but his order provides no timetable or funding for the undertaking.

NASA/AUBREY GEMIGNANI

< > he said. "As everyone here knows, establishing a renewed American presence on the moon is vital to achieve our strategic objectives and the objectives outlined by our National Space Council."

Neither Trump nor Pence, however, offered additional details beyond that policy statement. That included no information on a timeline for a human return to the moon, or estimated costs or other budget information for the initiative.

NASA, in a statement issued after the ceremony, said that the policy directs the agency to "lead an innovative and sustainable program of exploration with commercial and international partners to enable human expansion across the solar system and to bring back to Earth new knowledge and opportunities." Work on the initiative, it stated, would be reflected in the agency's fiscal year 2019 budget proposal, to be released in February.

"NASA looks forward to supporting the president's directive strategically aligning our work to return humans to the moon, travel to Mars and opening the deeper solar system beyond," NASA Acting Administrator Robert Lightfoot said in the statement.

Other government and industry officials expressed general support for the new policy despite — or perhaps because of — the lack of details about how it will be carried out.

"After 45 years, it is time to return humans to the region of the Moon even as we look toward Mars," said Mary Lynne Dittmar, president and chief executive of the Coalition for Deep Space Exploration, an industry group. Dittmar was among the guests at the White House ceremony.

Eric Stallmer, president of the Commercial Spaceflight Federation and another attendee of the event, said he supported both the overall policy as well as the administration's willingness to consider commercial roles for the effort.

"They would like our input" on how to achieve that policy, Stallmer said in an interview after the event. "The White House and the National Space Council want to work with industry on this."

Individual companies also weighed in. "We support the president and vice president's vision and commitment to return America to the moon," Lockheed Martin said in a statement. "A lunar mission with today's technology would further our understanding of the moon's history and resources. And it will build a strong foundation that will not only accelerate the U.S. to Mars and beyond, it will foster a thriving new space economy that will create jobs and drive innovation here on Earth."

Sen. John Thune (R-S.D.), chairman of the Senate Commerce Committee, noted that the statement aligned with provisions of a NASA authorization bill enacted in March setting Mars as a long-term goal for human exploration. "I applaud the president for his engagement on sending a manned mission to the moon and, as underscored in the bipartisan reauthorization of NASA signed into law earlier this year, eventually to Mars," he said.

Among those in attendance at the event was Harrison "Jack" Schmitt, the Apollo 17 astronaut who landed on the moon exactly 45 years ago on the last human lunar landing to date. "Today, we pledge that he will not be the last," Trump said in his remarks, adding that humans will be landing elsewhere as well.

"What do you think, Jack? We'll find some other places out there? There are a couple of other places, right?" Trump asked.

"Yes, we should," Schmitt responded. "Learn from the moon." SN

THE SPACENEWS AWARDS FOR EXCELLENCE & INNOVATION

SpaceNews established these awards to honor the well-known champions and the unsung heroes shaping the global space industry. We endeavored to celebrate headline-grabbing breakthroughs as well as outside-the-limelight innovations.

The winners were chosen by the *SpaceNews* editorial team after an open nomination process that concluded with a reader poll that collected thousands of votes for the people and organizations recognized in the pages ahead.

✦ COMPANY OF THE YEAR ✦

SPACEX

For several years, SpaceX offered a number of promises to the space industry: frequent launches, reusable rockets, and a new heavy-lift vehicle.

And, for much of that time, SpaceX struggled to deliver, thanks to delays, technical problems, and two high-profile launch failures.

However, 2017 was the year SpaceX really started to carry through. The company entered the year still recovering from its last mishap, the September 2016 pad explosion. The company returned to flight in January, launching the first 10 Iridium Next satellites from California. A month later SpaceX brought Kennedy Space Center's Launch Complex 39A, last used at the end of the shuttle program, back to life launching Falcon 9 rockets while repairing the company's Cape Canaveral pad damaged in last year's explosion.

Bring 39A online allowed SpaceX to finally hit its stride. By the middle of December, SpaceX had carried out a record-high 17 launches in 2017. (One more launch, of a fourth batch of Iridium satellites, is scheduled to take place before the end of the year.) This year's pace included two launches two days apart on opposite coasts, and three launches within two weeks.

SpaceX also turned reusability from an experiment — one that, initially, resulted in a series of failed landings — into a regular part of its operations. With successful demonstrations of "flight-proven" first stages in 2017, SpaceX has been able to convince even relatively conservative customers, like NASA and Iridium, to fly on reused boosters to save money or time.

SpaceX will need the momentum it built up in 2017 for its even bigger plans in 2018. The company is planning to increase its launch rate by up to 50 percent in 2018, which will be assisted by the recent completion of repairs to its Cape Canaveral launch pad. The long-delayed Falcon Heavy rocket is slated to launch as soon as January, and SpaceX has two critical test flights of its commercial crew vehicle scheduled for later in 2018.

SpaceX still has ambitions for Mars, which company founder and CEO Elon Musk updated in a September conference address that attracted worldwide attention. Musk said the first launches of SpaceX's planned BFR rocket to Mars could take place in 2022, a timeline he admitted was "aspirational." However, SpaceX demonstrated in 2017 what was previously considered aspirational, like high flight rates and reusability, can be achieved, eventually.

✦ CORPORATE LEADER OF THE YEAR ✦

GWYNNE SHOTWELL

SpaceX is indelibly linked to its founder, Elon Musk, who has crafted a vision for the company of establishing humanity as a multiplanetary species. He has attracted rock-star levels of publicity that are unprecedented in the space industry. When Musk spoke at the International Astronautical Congress in Australia in September, organizers had to take significant crowd control measures, recalling the chaos of when he spoke at the same conference a year earlier in Mexico.

However, Musk is a busy man. In addition to SpaceX he also runs electric car company Tesla, has a startup called Neuralink that is developing brain-computer interfaces and another startup, The Boring Company, that wants to relieve traffic jams with tunnels. Needless to say, he can't devote all his time to SpaceX.

What helps keep SpaceX focused on carrying out its growing manifest of launches and various development projects is the company's president, Gwynne Shotwell. While she is not as famous as Musk, her leadership has been essential to SpaceX's success. Joining SpaceX in 2002 as vice president of business development (and one of its first employees), she has been overseeing the company's growth into a major force in the space industry.

"When I started I was the seventh employee at SpaceX, and we have almost 7,000 people now," she said in a November conference speech. She's sought to find the right mix of employees who work on the development of new vehicles as well as those who handle the operations of existing ones, like the Falcon 9 and Dragon.

"We need that launch cadence. That's the fuel for SpaceX's development."

She's helped ensure that SpaceX has plenty of fuel this year. The company has had a record year with nearly 20 launches, and Shotwell said in a November interview that she wants to increase that launch rate by 50 percent in 2018, eventually reaching 30 to 40 launches a year. Those launches are supporting the development of the Falcon Heavy, the crewed version of Dragon and, most recently, the company's proposed BFR vehicle.

But while she's focused on Spacex's operations, she shares Musk's vision of humans going to Mars. "What is all this leading to?" she asked in that November speech after recounting the recent company successes and near-term plans. "These are all stepping stones along the path of us developing a space transportation system capable of taking humans to other planets."

✦ GOVERNMENT LEADER OF THE YEAR (MILITARY) ✦

U.S. AIR FORCE GEN. JOHN HYTEN

It is hard to think of any recent government civilian or uniformed leader who has shaped the debate about military space more than Gen. John E. Hyten.

When Hyten was a colonel in the U.S. Air Force 20 years ago, he raised eyebrows with his prediction that there would be a war in space. "It just seemed obvious to me," the now four-star commanding general of U.S. Strategic Command said recently.

He also presciently warned that emerging competitors like China were preparing for the day when military conflict moved into space. "So our job was going to be like fighting war in any other domain: deter that conflict and if it does happen...figure out how to fight it and win."

Hyten was a "space warfighter" before the term was even part of the military lexicon.

Hyten led Air Force Space Command from 2014 to 2016, and served as its vice commander from 2012 to 2014. He now runs the nation's nuclear enterprise at STRATCOM but still keeps a close eye on space.

To give space forces greater visibility and status, Hyten reorganized STRATCOM and created a Joint Force Space Component Command led by Air Force Space Command chief Gen. John Raymond. Hyten called this a major development in evolution of space as a military

mission. By this time next year, STRATCOM will have air, land, maritime and space components.

Although Hyten is no longer directly overseeing military space operations, he intends to play a key role shaping future requirements for new satellite constellations.

He worries that the Pentagon is being complacent about U.S. space dominance and not preparing for a future when space will be contested.

Hyten recently issued a stark warning: "Our adversaries are building capabilities to change the balance of power in the world. We can't allow that to happen."

✦ GOVERNMENT LEADER OF THE YEAR (CIVIL) ✦

ÉTIENNE SCHNEIDER

A member of the Luxembourg Socialist Workers' Party would seem to be an unlikely champion of asteroid mining ventures. But Étienne Schneider, who represents his party in Luxembourg's coalition government as deputy prime minister and minister of the economy, has become the biggest proponent of the emerging space resources industry among government officials in any country.

Under Schneider's leadership, the country established its SpaceResources.lu initiative in 2016, offering 200 million euros — and promises of a friendly legal regime — to attract space resources companies to the country. That has lured companies including Deep Space Industries and Planetary Resources from the United States, and ispace from Japan, to set up offices in Luxembourg. In July, Luxembourg's parliament passed legislation that grants companies operating from the country rights to space resources they extract, similar to a U.S. law passed in 2015.

However, those efforts have attracted more than just lunar and asteroid mining companies. In November, Spire announced it would establish its European headquarters in the country, which will eventually host as many as 250 employees. In turn, the Luxembourg Future Fund would participate in Spire's $75 million Series C funding round. Schneider hailed the deal as the latest milestone in "our government's three-decade history of attracting ground-breaking companies in this sector," dating back to the formation of Luxembourg-based satellite operator SES in the 1980s.

There's more to come from Schneider and Luxembourg. In a speech in November at the NewSpace Europe conference in Luxembourg, he said the country was working to establish a national space agency that will act as a public-private partnership with venture capital funds to invest in more space companies. "Luxembourg is ready and eager to support and nurture the growing number of commercial space initiatives," he said.

The focus on space resources has not been without some controversy. "Some people in this country thought that I had become completely mad when I launched this initiative," he said at the conference. But he's playing a long game with the initiative. "There is a big chance that the official language of space will one day be Luxembourgish."

✦ GOVERNMENT AGENCY OF THE YEAR ✦

45TH SPACE WING

The 45th Space Wing at Patrick Air Force Base, Florida, spent a chunk of 2017 in the crosshairs of massive Atlantic hurricanes. But the wing has not let storms derail its plans.

As Hurricane Irma pounded the Florida coast in September, the SpaceX Falcon 9 launch vehicle was scheduled for its first flight with the Air Force X-37B Orbital Test Vehicle. While the wing continued to make storm preparations, the Falcon 9 successfully lifted off from the Kennedy Space Center's Launch Complex 39A.

"This phenomenal team makes the impossible possible," says Wing Commander Brig. Gen. Wayne Monteith.

The 45th Space Wing racked up more than two dozen launches and landings in 2017, placing over $6.5 billion of national security and commercial satellites in orbit and making Cape Canaveral the busiest spaceport in the world.

Monteith is rallying his troops as he embarks on what he calls a "Drive to 48." That's 48 launches a year by 2021, an average of roughly one a week.

This surge in East Coast launch operations is projected as Blue Origin begins to fly along with SpaceX, United Launch Alliance, Orbital ATK and others. The "Drive to 48" has led to multiple improvements for the space industry, the most important being the first use of autonomous flight safety systems for booster launches and landings.

The wing oversaw the first landing of the X-37B spaceplane, opening a gateway for the vehicle to land within easy reach of its refurbishment and

launch sites.

The unit has been lauded for its efficiency and its tight management of resources. A notable case study has been the Falcon Flight, an organization within the 5th Space Launch Squadron, 45th Launch Group of the 45th Space Wing. Launch vehicle expertise for legacy Atlas and Delta government missions was consolidated into the 5th Space Launch Squadron and that team is supporting the first SpaceX GPS-3 mission scheduled in May. The Falcon team has been instrumental in the certification of two SpaceX launch pads, evaluating more than 40 design reviews, 30 activation tests, and 13 ground systems per launch pad.

Once regarded as part of the problem, the 45th Space Wing is looking more and more like part of the solution.

We are enabling a new reach into deep space
and inspiring the next generation of explorers
to reach for the stars.

AEROJET ROCKETDYNE

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Wait till you see what we do next.

✦ DEAL OF THE YEAR ✦

MAXAR TECHNOLOGIES

After MacDonald Dettwiler and Associates revealed plans in February for a $2.4 billion merger with DigitalGlobe to create a joint company called Maxar Technologies, it was easy to see how the puzzle pieces fit together.

Since Canada's MDA bought satellite builder Space Systems Loral in 2012, the firm has been expanding its presence in the United States and looking for a foothold in the lucrative U.S. government market. As part of its U.S. Access Plan, MDA appointed American citizen Howard Lance, the former Harris Corp. chief executive, as its president and chief executive in 2016 and established SSL MDA Holdings Inc., which manages the company's global operations from its headquarters in San Francisco. Purchasing DigitalGlobe with its strong ties to U.S. defense and intelligence agencies was a logical progression.

DigitalGlobe, meanwhile, has been diversifying its business to share geospatial imagery and information with a wider pool of international government and commercial customers. Still, the company remained heavily reliant on a single contract: EnhancedView, which provides geospatial imagery and information to U.S. government customers through the U.S. National Geospatial-Intelligence Agency. About 45 percent of DigitalGlobe's revenue was tied to EnhancedView, which will account for about 15 percent of Maxar Technologies' business.

Plus, both firms are geospatial-imagery experts: MDA is known for synthetic aperture radar while DigitalGlobe is known for electro-optical

imaging. DigitalGlobe boasts a fleet of high-resolution Earth-observation satellites and MDA operates many of the ground stations that collect, process and distribute those imagery products around the world.

Since the proposed merger was announced, more pieces have fallen into place. MDA SSL, a leading communications satellite manufacturer, is building WorldView-Legion, DigitalGlobe's next-generation Earth-imaging constellation.

It's too soon to see how the entire puzzle will look once its fully assembled, but with 6,500 employees in the United States, Canada and around the world, it's clear Maxar Technologies possesses some impressive capabilities in spacecraft manufacturing, satellite ground systems, space robotics, Earth imaging and geospatial-data analysis.

✦ BREAKTHROUGH OF THE YEAR ✦

PLANET COMPLETES MISSION 1

When Planet announced plans in 2013 to build the world's largest constellation of Earth-observing satellites capable of providing daily global imagery, it was hard to believe the tiny startup (or anyone for that matter) could accomplish that. Sure, cubesats were small and inexpensive, but they didn't produce high-quality images and had few reliable rides into orbit. Planet saw that firsthand when it lost 26 satellites in a 2014 launch failure and eight more in 2015.

Still, there was always something about the Planet team that made their claims impossible to dismiss. Maybe it was their engineering expertise and Silicon Valley-style ingenuity. After all, these were the same people who pushed commercial-off-the-shelf to the limit by sending smartphone technology into space when they worked at the NASA Ames Research Center. Plus, instead of following industry norms, they adopted an approach, now widely known as agile aerospace, that includes rapid prototyping, on-orbit testing and mass production.

Meanwhile, Planet kept growing organically and through smart acquisitions: it bought BlackBridge and its RapidEye Earth-observing satellites in 2015 and, earlier this year, purchased Google's Terra Bella and its SkySat high-resolution imaging fleet. In 2017 alone, Planet has launched 146 satellites on three continents.

With its current constellation, Planet is gathering 1.4 million images per day covering 300 million square kilometers. Planet's dataset has

been embraced by farmers, environmentalists, intelligence analysts, human rights activists, hedge fund managers and anyone else who wants to see changes happening on the ground. Planet's breakthrough is its ability to offer customers daily images of Earth's entire landmass, a goal it refers to as "Mission 1."

For an encore, Planet is building a platform that employs machine learning and object-recognition software to help customers find answers to their questions. How many ships are moving in and out of Shanghai's ports on a daily basis? How many buildings are under construction in Texas? The company plans to create an index of physical changes comparable to Google's internet index. It's another audacious goal and Planet has plenty of competition, but we'd be foolish to dismiss it.

✦ STARTUP OF THE YEAR ✦

KYMETA CORPORATION

Kymeta might not seem like your typical startup, but it was only five years ago that the company spun off from Intellectual Ventures, an intellectual property juggernaut often derided as a patent troll. With $12 million in early funding from Bill Gates and others, Kymeta set out to use metamaterials to build a better antenna for mobile applications.

This year, Kymeta delivered on that promise, finally shipping its eagerly awaited product: a flat, lightweight antenna terminal with no moving parts.

Customers ranging from railroads to farmers started using Kymeta's mTenna flat-panel antennas this year to support high-throughput communications on the go. The U.S. Federal Emergency Management Agency deployed Kymeta's antennas in Puerto Rico this fall after Hurricane Maria destroyed cellphone towers across the island.

Kymeta's product shipment cemented its position as the frontrunner of a new breed of flat-panel antennas that promise to open new markets, boost the capability of high-throughput satellites and enable low-Earth-orbiting mega-constellations to achieve their full potential.

The Redmond, Washington-based company's antennas use electronic steering instead of mechanical systems to track satellites and enabling continuous service while switching between beams.

Kymeta also completed a new connected car trial this year, taking a Toyota RAV4 on a two-week road trip across the United States to demonstrate KĀLO, a bundled service combining Kymeta's mTennas and KyWay terminal with Intelsat's satellite capacity that provided mobile internet access along every stretch of the crosscountry route.

Kymeta anticipates expanding the rollout of its antennas in 2018. Borrowing assembly lines from LCD television manufacturer Sharp, Kymeta is in the process of mass-producing antennas the satellite industry will use to connect the world's planes, trains and automobiles, not to mention plenty of ships, tractors and construction equipment.

✦ TURNAROUND OF THE YEAR ✦

INTERNATIONAL LAUNCH SERVICES

The year got off to an all-too-familiar start for International Launch Services. The U.S.-based commercial arm of Russian rocket maker Khrunichev hadn't launched a single satellite in six months thanks to a close call during Proton-M's launch of a commercial satellite the previous June.

The rocket's second-stage engine clocked out early during the misssion, forcing the vehicle's Briz-M upper stage to extend its burn to safely deliver Intelsat-31 to its destination. Given Proton's recent spotty track record, Khrunichev couldn't shrug this one off. Launches were suspended while investigators dug into Proton's close call with an intensity normally reserved for rocket explosions.

In January, just as Proton was about to be cleared to return to flight, Khrunichev encountered a bigger problem: a factory had used the wrong solder for a batch of engines, including the ones already installed on Protons assembled for upcoming missions.

Fixing the materials mixup consumed nearly half of 2017, pushing Proton's return to flight to June. Despite the late start, ILS completed all three commercial missions on this year's manifest.

With the late September launch of AsiaSat-9 — ILS's final mission of 2017 — Proton has 12 consecutive successes, passing the 1 in 10 failure rate insurers had crafted rates around. At 15 consecutive successes, ILS expects more underwriters to return to Proton as the rocket rebuilds trust.

Cheaper insurance should only help ILS grow its manifest, which withered as a result of Proton's failure-a-year performance between 2010 and 2015.

While the Russian government plans to use Proton five or six times next year, ILS itself currently has just one launch sold for 2018: a late-in-the-year

dual mission carrying Eutelsat 5 West B and Orbital ATK's satellite-servicing Mission Extension Vehicle-1.

Still, ILS delivered this year's customers safely to orbit while undertaking the introduction of two new well-timed products: a two-stage Proton Medium on tap for 2018 and a 5-meter payload fairing envisioned for 2020.

Proton Medium is designed to haul roughly five tons to geostationary transfer orbit at prices ILS President Kirk Pysher said will allow the rocket to compete head-to-head with SpaceX's Falcon 9. The 5-meter payload fairing, meanwhile, will accomodate bigger satellites as well as clusters of smallsats megaconstellation customers want to catapult into orbit all at once.

ILS is also planning a Proton Light intended for three-ton payloads, but that project is on hold until Proton Medium is complete.

ILS isn't out of the woods, but after a pivotal 2017 the company is heading in the right direction.

✦ UNSUNG HERO OF THE YEAR ✦

JASON CRUSAN

NASA's exploration budget is dominated by big programs: the Space Launch System, the Orion spacecraft and their associated ground systems. They attract the dominant share of public attention — as well as the angst when they encounter delays and other difficulties.

However, within NASA's Human Exploration and Operations Mission Directorate is a relatively small office addressing the question of what additional capabilities will be needed, beyond SLS and Orion, to enable human exploration of the moon and Mars. The Advanced Exploration Systems division, led since its establishment in 2012 by Jason Crusan, is working on a variety of projects to develop capabilities needed for future exploration.

One of the division's best-known efforts is Next Space Technologies for Exploration Partnerships, or NextSTEP. This started as a series of partnerships with industry to study the development of habitation modules that could be used either for NASA missions, like the Deep Space Gateway, or for commercial applications like future space stations. A second phase of that effort involves six companies studying or building ground prototypes of their modules.

NextSTEP has grown beyond habitation module studies, though. The program recently awarded studies to several companies on a power and propulsion module that would form the core of the Deep Space Gateway, incorporating electric propulsion technology that may also have commercial applications. Other NextSTEP efforts include development of 3-D printer prototypes that could be key for future exploration missions and, most recently, a call for proposals for the development of technologies to make use of resources on the moon and Mars.

Crusan's division oversees other projects associated with developing key exploration technologies and capabilities, often working cooperatively with companies and universities. One example is the Lunar Cargo Transportation and Landing by Soft Touchdown, or CATALYST, program, providing technical support to companies developing commercial lunar landers. That effort is likely to take on new prominence with President Trump's Dec. 12 directive ordering NASA's human spaceflight program back to the moon.

Advanced Exploration Systems may have a low profile compared to programs like SLS and Orion, but the projects it is carrying out under Crusan's leadership may be critical to making those larger programs a long-term success.

2017 WINNERS & FINALISTS

» **Company of the Year:** SpaceX
Runner up: Planet
Finalists: Arianespace; Maxar Technologies; Nanoracks

» **Corporate Leader of the Year:** Gwynne Shotwell, SpaceX
Runner up: Jeffrey Manber, Nanoracks
Finalists: Rick Ambrose, Lockheed Martin; Jason Andrews, Andrews Space; Kirk Pysher, ILS

» **Government Leader of the Year (Military):** Gen. John Hyten
Runner up: Brig. Gen. Wayne Monteith, 45th Space Wing
Finalists: Robert Cardillo, National Geospatial-Intelligence Agency; Gordon Roesler and the DARPA Robotic Servicing of Geosynchronous Satellites team

» **Government Leader of the Year (Civil):** Étienne Schneider
Runner up: George Nield, FAA's Office of Commercial Space Transportation
Finalists: Jean-Yves Le Gall, CNES; Catherine Mealing-Jones, U.K. Space Agency

» **Government Agency of the Year:** 45th Space Wing
Runner up: Indian Space Research Organisation
Finalists: FAA's Office of Commercial Space Transportation, NOAA's National Environmental Satellite, Data, and Information Service

» **Deal of the Year:** Maxar Technologies
Runner up: Planet buys Terra Bella
Finalists: Speedcast buys UtilSat; Teledyne buys e2V; Virgin Group lands $1 billion Saudi investment

» **Breakthrough of the Year:** Planet completes Mission 1
Runner up: SpaceX's reusable Falcon 9 booster
Finalists: Spectrolab's XTJ Prime solar cell; Lockheed Martin's SPIDER flat optical instrument; Sodern's Auriga miniaturized star trackers; Space System Loral's Ultra High Density Satellite

» **Startup of the Year:** Kymeta
Runner up: Sky and Space Global
Finalists: LeoLabs; Made In Space; Rocket Lab

» **Turnaround of the Year:** International Launch Services
Runner up: Orbital ATK
Finalists: Alaska Aerospace Corp.; Spacecom; SpaceX

» **Unsung Hero of the Year:** Jason Crusan, NASA
Runner up: Frank "Ceppi" Cepollina, NASA
Finalists: R. Gilbert "Gil" Moore, Utah State University; Tom Mueller, SpaceX; Guy Perez, OHB; Eric Rehder, Boeing Spectrolab

COMMENTARY John Casani

An argument for space fission reactors

It's time for NASA to rebalance its power portfolio

America's space program has long held a special place in the public's imagination, but NASA missions are limited by budget constraints. NASA must use its funding wisely to implement balanced, cost-efficient programs to develop enabling technologies, such as technologies to power future NASA missions. Speaking as the former project manager of three successful missions — Voyager, Galileo, and Cassini — and the canceled Prometheus-Icy Moons Orbiter, I have a unique perspective to share.

Space nuclear power has long been recognized as an enabling technology for space science and exploration. Many of NASA's greatest achievements have relied on radioisotope nuclear power: Viking, Voyager, Galileo, Cassini, New Horizons, Curiosity. However, in 1988, the United States stopped making the plutonium-238 we need as a heat source in radioisotope thermoelectric generators (RTGs). With existing supplies likely to run out soon, NASA is planning to restart Pu-238 production with a sizable investment (about $100 million per year) that is expected to yield hundreds of grams over the next several years. Unfortunately, that is a very small amount compared to 24 kilograms of Pu-238 flown on Voyager or the 33 kilograms on Cassini.

While NASA's goal is a production rate of 1.5 kilograms per year, there are several major obstacles — both technical and political — that will not be easy to overcome, even with additional investment in Pu-238 production infrastructure. This, in turn, makes NASA reluctant to consider future Voyager- and Cassini-like missions.

Whatever production rate is achieved, every gram of Pu-238 will have significant value, but even at the most optimistic production levels NASA will not have enough Pu-238 to pursue future outer planet flagship-class missions such as exploring the surface of Titan or melting through the surface ice on Europa and powering a submarine in the ocean below. Clearly, it is risky for NASA to bank solely on Pu-238-supported space nuclear power without a backup.

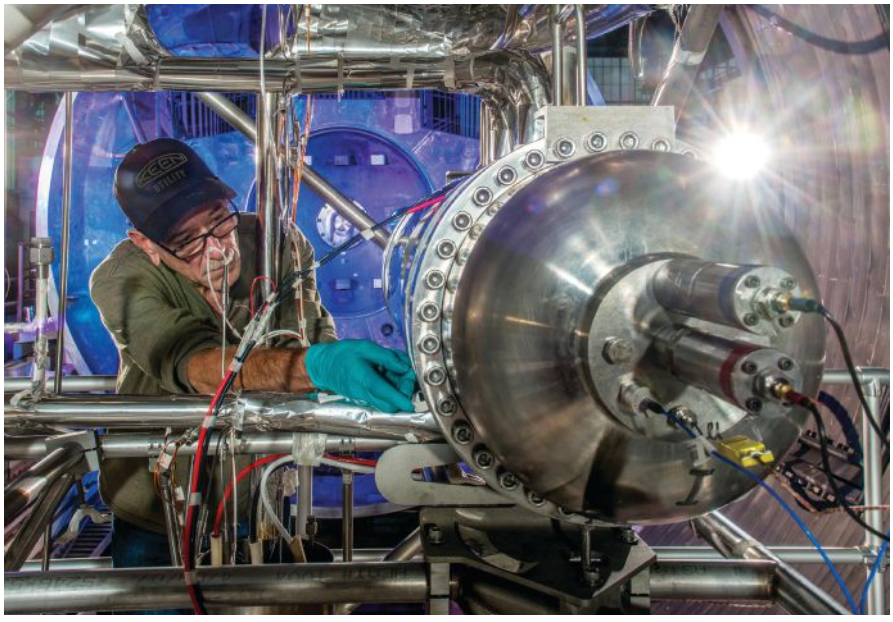
Beyond RTGs

NASA does not need to be content with simply trying to maintain radioisotope power capability, or to settle for less power for deep space exploration than was available for past missions. NASA can develop a balanced power portfolio that includes space fission power, which offers essentially unlimited power for space exploration.

While space fission won't compete on a mass basis with radioisotope systems at power levels below 500 watts (the break-even point might be between 500 and 1,500 watts), it will compete on a recurring cost-per-kilowatt basis at even lower power levels.

A small fission system would not only allow NASA to reconsider several-hundred-watt Cassini-like missions, but would also finally enable science missions that need kilowatts of power. A 10-kilowatt-electric (kWe) reactor could enable ambitious nuclear electric propulsion missions to orbit and explore the outermost planets and Kuiper belt objects.

Historically, the biggest obstacle to space fission power has been the perceived development cost, largely because development of advanced nuclear technology and new test facilities can be very expensive and take many years. NASA's Kilopower project addresses these concerns by showing that a simple space reactor can be developed



A NASA technician works on a 10-kilowatt Stirling Power Conversion Unit at Glenn Research Center.

NASA GLENN RESEARCH CENTER

for a few hundred million dollars and that facilities already exist to support the early development. The key difference between other programs (including the ill-fated Prometheus) and Kilopower is that Kilopower is demonstrating low cost by live testing of actual fission reactors — something that hasn't been done in the U.S. since the 1960s. Critics had said it was impossible to perform an affordable, simple nuclear-powered test in today's regulatory environment — but the Demonstration Using Flattop Fission experiment, conducted by Los Alamos National Laboratory in partnership with NASA in 2012, showed that it is possible.

Get KRUSTY

The Kilowatt Reactor Using Stirling Technology (KRUSTY) experiment, scheduled for completion in early 2018, will show that a flight-like space reactor can be designed, fabricated, and tested for only a few tens of millions of dollars. The remaining work to bring the entire system to flight status is significant but mostly nonnuclear (i.e. the remaining technical challenges exist in the power conversion system and spacecraft integration; an actual flight reactor could look and operate essentially the same as KRUSTY).

If KRUSTY is successful, the cost to bring a 1-kWe reactor to flight status should be relatively low: a few hundred million dollars, or well within the budget NASA is willing to spend on a limited amount of radioisotope power.

This is not to say that radioisotope power should be abandoned. It will always be essential for space exploration, and a significant investment in Pu-238 production is well warranted. If space reactors were used for missions that require significantly more than a hundred watts, a kilogram per year of Pu-238 would be sufficient for the smaller missions that benefit the most from the mass and packaging advantages of small RTGs as well as for spacecraft that require Pu-238 for thermal management.

Fission technology can also improve propulsion systems. Second-generation fission power systems could enable ambitious exploration of the outer solar system with 10- to 100-kW nuclear electric propulsion systems. Subsequent generations could then focus on propulsion for human spaceflight missions, where fission might have the greatest impact.

NASA is making a substantial investment in nuclear thermal propulsion, which offers up to double the capability of chemical rockets and which would greatly enhance human exploration. While NASA should be lauded for its bold vision, the leaps required in nuclear development and testing are reminiscent of previously failed programs that took too large a step. Even if ultimately successful, nuclear thermal propulsion benefits may not justify the price tag (tens of billions of dollars), especially if there is continued progress towards lower cost, higher capability launch vehicles.

Multi-megawatt nuclear electric propulsion systems can provide an order of magnitude improvement over chemical systems, thus providing far more potential than nuclear thermal propulsion. Multi-megawatt nuclear electric propulsion systems also have the advantage that the reactor technology can be developed via several incremental, achievable steps, of which Kilopower is the first. The balance of nuclear electric propulsion system development provides additional major challenges — but they are nonnuclear, can also be completed in steps, and build upon current solar electric propulsion efforts.

The primary reason to invest in space fission power is the unique capability it would bring to NASA, with benefits well beyond the deep space missions it will enable. NASA will need space reactors to establish a robust power environment on the moon and Mars, where solar power is limited by day and night cycles, latitude, seasons, dust storms, buildup, degradation, etc. Ultimately, incremental advances could lead to higher power, lower specific-mass nuclear electric propulsion reactors that would revolutionize human travel throughout the solar system.

If the U.S. is serious about continuing to be a leader in space exploration, NASA must rebalance its power portfolio by adequately funding a simple system that establishes fission power in space. This simple system will allow the continuation of Voyager- and Cassini-class missions at the outermost planets and open up subsurface missions at Europa, Enceladus, and Titan. NASA can then use the expertise, technology, and infrastructure outflow from that development to achieve more ambitious capabilities, such as higher power surface reactors for human missions and, eventually, nuclear thermal propulsion and/or nuclear electric propulsion space reactor programs.

Americans have not lost enthusiasm for exploring the solar system and beyond. Now is the time to create the tools that will power that dream. **SN**

JOHN CASANI IS A RETIRED JET PROPULSION LABORATORY EMPLOYEE WHO SERVED AS PROJECT MANAGER FOR THE VOYAGER, GALILEO AND CASSINI MISSIONS, ALL OF WHICH USED RTG POWER SYSTEMS.

ON NATIONAL SECURITY Sandra Erwin

Cloud of uncertainty over military space programs

PARTISAN FIGHTS OVER FEDERAL SPENDING, TAX CUTS, SPELL TROUBLE FOR MILITARY AND SPACE BUDGETS

The U.S. military's ambitious space agenda faces big unknowns. Budgets top the list. Other looming issues are political and organizational.

Despite a commitment by the U.S. Air Force to increase military space budgets by 20 percent, larger fiscal pressures may derail those plans. The GOP-dominated Congress and the Trump White House promised a big boost in military spending but so far that vision looks more like a mirage.

Congress last week managed to keep the government open with temporary funding until Dec. 22 while lawmakers figure out the next steps. A bipartisan budget agreement will be needed to determine the final defense funding level but there are still many unresolved issues.

If the GOP tax reform bill gets passed, analysts predict the government will be cash-strapped in the coming years even more so than it is now — a scenario that makes it unlikely that the nation can afford to spend more on the military or on costly space ventures.

Budget uncertainty could hurt space programs even more so than other military priorities because space projects compete for funding with aviation procurements. "All those space programs that were going to start ramping up can't happen without a budget deal," budget analyst Todd Harrison of the Center for Strategic and International Studies told me last week. The next-generation satellite programs that the Air Force has been trying to push forward are not scheduled to start production any time soon but they still need funding to continue development and testing. "Absolutely there will be pressure on space programs," he said.

Harrison recalled that when he spoke with Air Force Secretary Heather Wilson in October, he asked her about the service's acquisition priorities. "She named a bunch of aircraft programs. There were no space progrxams in that list of priorities," he said. "If push comes to shove and they don't get all the resources they're looking for, I think the Air Force is going to focus on air power."

The Air Force "must-fund" items include the F-35A fighter jet, the B-21 bomber, the KC-46A tanker, the T-X trainer aircraft, a new intercontinental ballistic missile and a new nuclear-armed air-launched cruise missile.

In space, it's no so clear. The Air Force laid out plans to begin new programs for several satellite constellations, including a new missile-warning system, a modernized GPS, protected communications and wideband communications systems. If history is any guide, satellite procurements would be stretched out a few more years to free up funds for aviation.

Adding more uncertainty is last week's enactment of the National Defense Authorization Act for 2018, which reorganizes the Pentagon's space responsibilities. The law shifts space-related organizational, training and equipping powers from the Air Force secretary and Air Force chief of staff to the Air Force Space Command. The current head of Space Command, Gen. John "Jay" Raymond, said the reorganization will help set the conditions for the United States to get ahead of its enemies. The devil here will be in the details. The deputy secretary of defense has been assigned to lead the implementation of this law.

The NDAA also directed the Pentagon to study the possibility of deploying a space-based missile defense system, a complex and costly technology that the U.S. military has not pursued since the Reagan administration's Star Wars initiative. The technological, fiscal and political implications of a space-based missile defense are significant. Arms control experts have warned such a system would be destabilizing.

The NDAA suggests the Pentagon should aim for a "boost phase" interceptor which is the hardest to do from space, said Harrison.

"You'll need a massive constellation of satellites to do that. If you run the numbers, it's probably over 1,000 satellites to be able to intercept ballistic missiles one at a time," he said. "If a country launched two missiles from the same place at the same time you would need to double the size of your constellation."

Congressional interest in a space-based missile defense, like Trump's military buildup talk, illustrate today's reality: Everyone has big lofty ambitions that are not supported by strategy, policy or budgets. **SN**

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COMMENTARY U.S. Reps. Brian Babin and Ami Bera

We agree, Mr. President — America should return to the moon

President Trump's new space policy directive calling for American astronauts to return to the moon is welcome and encouraging news. The United States is entering a new era of space exploration. In the past, NASA and the federal government have led the way, but it is time we recognize the future of space travel will be a collaborative effort between NASA, the private sector, and the international community. As the chair and ranking member on the House of Representatives space subcommittee, we agree that the first step in this new era is crucial: America must return to the moon.

Decades after Apollo 17 left the moon, some may ask: Why go back? What more can we learn? With public and private interest in space growing, we have a unique opportunity to ignite a passion for scientific research and discovery, spur innovation in the private sector, and use the moon as a stepping stone to reach Mars.

Americans have benefited greatly from space exploration and scientific research. Medical advancements in drug treatment and vaccines can be traced back to research done in space. Technology used to filter and purify water on the International Space Station has been commercialized. Returning to the moon will allow scientists to complete unfinished lunar studies, including understanding the ice located at the lunar poles and the impacts of living in low gravity with intense solar radiation. This information could be critical to understanding future space exploration to Mars.

The commercial space industry has expressed interest in the moon as well. This September, our space subcommittee heard testimony on private lunar exploration. The commercial sector is developing new lunar landers and next-generation launch vehicles to return to lunar orbit.

The private sector has always been a partner in space exploration. From McDonnell Aircraft Corporation building the Mercury and Gemini capsules to Grumman building the Lunar Excursion Module for Apollo, government and the private sector have worked hand-in-hand since the very beginning of the space age. Going forward, a vibrant commercial space economy will drive down costs and increase competition along with innovation. But there is also a need for the government to maintain its own space exploration capabilities for strategic purposes. By leveraging logistical services, NASA could free up more resources for scientific research and development.

Decades after Apollo 17 left the moon, some may ask: Why go back? What more can we learn?

Returning to the moon would enable further scientific study and future exploration. The moon's resources could even supply and fuel missions deeper into our solar system. Lunar missions would also allow NASA to test capabilities within the vicinity of Earth before embarking on missions to Mars and other destinations.

It is clear we are approaching a renaissance of space exploration. America's return to the moon could lead to significant advancements in science, medicine, and technology that will enhance our lives here on Earth. We believe the next generation of astronauts, scientists, and engineers possess the passion and talent to re-establish America's presence on the moon and Mars. These next few years are key.

The revival of the National Space Council under Vice President Mike Pence is a welcome step. The council's goals are to reenergize American activity in space and to create a plan that will support human missions to the moon and beyond. As lawmakers, we must oversee their efforts. Congress has an obligation to ensure that America continues to lead the way in space exploration. Only by working together, Democrats and Republicans, private sector and public sector, can we achieve our goals.

We commend the president for making America's return to the moon a priority. Reaching beyond our horizons has been a hallmark of the American spirit and space exploration has always gone hand-in-hand with scientific discovery. Space exploration will facilitate economic growth and stimulate innovation. As John F. Kennedy once said, "man and his quest for knowledge and progress is determined, and cannot be deterred. The exploration of space will go ahead, whether we join in it or not. We mean to be a part of it; we mean to lead it." America must return to the moon. **SN**

U.S. REP. BRIAN BABIN (R-TEXAS) IS THE CHAIRMAN OF THE HOUSE SCIENCE SPACE SUBCOMMITTEE. **REP. AMI BERA** (D-CALIF.) IS THE SUBCOMMITTEE'S RANKING MEMBER.

COMMENTARY Rebecca Cowen-Hirsch

Paving a clear "Path" to interoperable SATCOM

It's time to allow trusted commercial operators to help government benefit from improved satellite operations

U.S. soldiers set up a tactical satellite communications system in Afghanistan.

U.S. ARMY/ SGT. RUSSELL GILCHREST

These are times when the only thing we can predict is unpredictability. From geopolitical threats to natural disasters – events emerge swiftly and unexpectedly, anywhere around the globe.

This event-driven reality provides an even more insistent imperative that U.S. government and military users must stand ready to deploy "anytime, anywhere." They must have access to resilient, robust and secure satellite communications (SATCOM) wherever they are, at a moment's notice, across the full spectrum of engagement. And, of course, this must be tempered with real expectations of cost-effectiveness and enhanced combat readiness delivered with agility.

There is a path to this state of SATCOM and, in fact, it exists. But, as with a lost hiker in the woods, the path is not quite clear to federal agency procurement officials or acquisition authorities. Following this analogy, for the hiker, fallen branches and other debris can block or hide the path, or a storm may wash away parts of it. Or perhaps, the painted markings on trees designating the trail suddenly stop appearing, and hikers find themselves lost.

Historically, the government has perceived commercial SATCOM (COMSATCOM) as a gap filler, or simply a surge service to fill in for unavailable military capabilities. And yet, even in the U.S., approximately 73 percent of all SATCOM is provided by commercial providers, as reported by the Army's own Wideband Consolidated SATCOM System Expert just last year. Other allied and coalition nations have similar or even greater percentages of COMSATCOM use. So it is not surprising that governments have become increasingly reliant on COMSATCOM to support ongoing critical military operations and responses to catastrophes. With military and defense operations in the Middle East and elsewhere in the world, there remains a state of highly mobile, asymmetrical engagement. Coupled with the ever-advancing technological innovation in the SATCOM industry, we continue to see a surge in the use of, and even greater dependence upon, COMSATCOM.

For federal users, however, the path to optimal SATCOM has been muddled by piecemeal and antiquated military procurement practices, further complicated by budget and cultural impediments.

The "debris" of the government acquisition system means that multiple U.S. Department of Defense (DoD) branches are responsible for multiple parts of the package, turning to private industry generally on an "as needed" basis. The Navy supplies narrowband space segment, or Mobile User Objective System (MUOS). The Air Force supplies the wideband "space" part, i.e., the Wideband Global Satcom (WGS) – originally as a Wideband Gapfiller Satellite system. The Army provides the "land" part, i.e., both military-owned and commercial terminals for units, while >

< > the Defense Information Systems Agency is the storefront for commercial SATCOM. In each case, despite the maturity of commercial communications, there remains a disconnect where the focus is on use of spectrum: leasing MHz versus looking at the more relevant effects that SATCOM enables and leveraging SATCOM as a Service as a force multiplier, critical infrastructure and thus an operational imperative.

The fragmentation and overlap in space acquisition management and oversight have contributed to program delays and cancellations, cost increases and inefficient operations, with the terminal segment lagging far behind. Most of those programs began before some of today's concepts of operations – such as airborne Intelligence, Surveillance and Reconnaissance (ISR) – were even envisioned. As a result, there are programs like MUOS where only the legacy UHF capability is accessible. And even the wideband workhorse for the U.S. government and its allies, the WGS system with its nine satellites on orbit, cannot flexibly meet all operational requirements. What's more, in some geographies, there is often competing demand for WGS access for military mission-specific priorities.

Bottom line, this all brings a burden to the end user, who is not getting the needed mission-critical capability quickly and effectively.

At the "pointy end of the spear" or in the foxhole, users do not care about which branch of the military "owns" which part of the communication architecture, or whether the actual technology is supplied by a government or commercial provider. They only want results, in the form of maximum capability, flexibility and resilience. Simplicity is required, and SATCOM needs to be readily accessible wherever they go, with smaller, easy-to-use equipment and multiband, multimode terminals to ensure connectivity is fully mission capable regardless of how challenging the situational or geographic conditions, or priority of the mission.

This speaks to the urgency for a more agile, unified strategy to ensure the availability of reliable, resilient and seamless state-of-the-art SATCOM capabilities, which are fully interoperable with agency-owned systems. Taking an entirely integrated architecture approach that considers military SATCOM (MILSATCOM) and COMSATCOM as a holistic capability and that allows for rapid and cost-effective innovation relevant to government's ever-changing needs, this strategy would inspire "order-of-magnitude" improvements in SATCOM capabilities.

Fortunately, while still obscured, the path for the government is getting clearer, as events over the past year and beyond have demonstrated.

Moving forward

We have witnessed 2017 bringing significant developments as the commercial sector and government leaders have worked together to create a more protected and resilient space environment that will improve capabilities for our servicemen and women. Throughout this collaboration, greater support has emerged for the development of an integrated SATCOM architecture and strategy in the interest of rapid and cost-effective innovation and greater resilience and frequency diversity.

The official launch in January 2017 of a wideband Analysis of Alternatives (AoA) stands as a promising example of this trend. Through the AoA, leadership intends to build the next generation of infrastructure for the future wideband communication system to replace the dated WGS program. Currently underway, it provides an opportunity to define, arguably for the first time, a new approach that harnesses the scale, scope and innovation of COMSATCOM. A Commercial Working Group has formed to gather perspectives and input from industry leaders about the best ways to move forward. Our top executives work with their government counterparts to develop a "blueprint" to take the best of what industry has to offer – space, air and ground layer communication capabilities and ongoing innovations – and seamlessly integrate these capabilities into the future DoD architecture.

Furthermore, the Fiscal Year 2018 National Defense Authorization Act, which has been passed by both the House and the Senate and sent to the president's desk for signature, marks the first step toward a crucial space reorganization and leadership shift presenting a clear opportunity for COMSATCOM to become an integral part of the SATCOM architecture.

When we look at these developments as a collective whole, we can see that government leadership clearly recognizes that the desired integrated architecture depends upon the reach, resilience and technology modernization of COMSATCOM, as an essential element of mission assurance. Importantly, this is supported by evolving policies and a strategy that drives satellite communication acquisition away from a piecemeal and antiquated procurement model.

Path found: SATCOM as a Service

All of these positive dynamics come together enabling government to opt for newer business models, such as SATCOM as a Service, a readily available capability that comprehensively addresses the aforementioned needs for interoperability, efficiency, ease of use and responsiveness to the DoD requirements. Mobile government users are increasingly adopting this managed service model, seeking access to rapid,

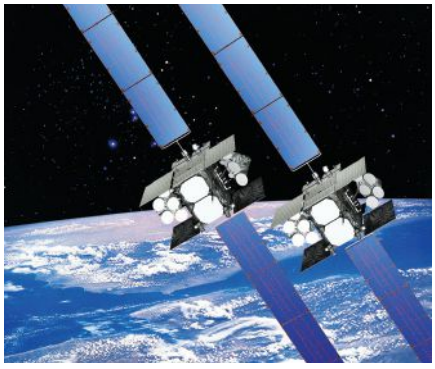
reliable, worldwide SATCOM wideband capability. This contrasts with historicaly leased satellite services, which require setting up fixed systems, one-by-one, every time a new network is required. To do that, government contractors must set up their own hubs at ground stations throughout the world, wire together their own network and create their own systems. SATCOM as a Service is an end-to-end model that provides wideband/fixed satellite services globally without the time and expense of building and maintaining a private network.

From a user's perspective, SATCOM as a Service establishes a mobile wideband experience that is no different from moving around the globe with a cellphone, without stopping to worry about where the cellphone towers are, who installed them and who wired everything together. SATCOM as a Service allows users to travel anywhere in the world with one-touch access. They never have to make a new investment whenever they set up a new SATCOM network – and it relieves the burden to manage these networks from end users, allowing them to fully focus on their mission.

SATCOM as a Service is a cost-efficient model in which users only pay to access the capability they need. A subscription or managed service, it delivers guaranteed data rates to satisfy mission needs at a moment's notice, worldwide. With solid service-level agreements and committed information rates, users get what they ask for and only use it when they must, and the quality of the acquired service is assured. In other words, no more guessing games or overleasing and underleasing.

Rapid augmentation in narrowband

Industry brings new advancements in critical technologies, such as narrowband to support the high-throughput



The Pentagon is evaluating alternatives to procuring additional Wideband Global Satcom satellites.

requirements of users. Inmarsat and its partners are deploying Wideband Streaming L-band (WiSL), an innovative connectivity service suited to specific government needs, further augmenting MILSATCOM resources and enhancing operations. It is a capability utilizing Inmarsat's reliable, worldwide L-band space and ground network, with higher throughputs from miniature form factor antennas to meet high-demand ISR and Process, Exploitation, Dissemination (PED) needs. WiSL is now flying on aircrafts, rapidly transforming from an idea to a new capability: During recent demonstrations in multiple user scenarios, it delivered data rates as high as 10Mbps x 10Mbps, via micro antennas as small as a 13 centimeters. Using high-order modulation, the demonstrations revealed efficiencies up to 4.5 bits per hertz for cost-efficient bandwidth utilization.

In addition, L-band Tactical Satellite (L-TAC) stands as another example of technology innovation built to mobile users requirements. It is a highly resilient, "UHF-like" tactical narrowband satellite capability for robust, low-cost, beyond-line-of-sight mobile communications when UHF is not available for existing radios. Via tactical radios, which are either portable or installed in vehicles, helicopters, ships and other mobile platforms, users acquire UHF tactical functionality that is extremely suitable for beyond-line-of-sight, push-to-talk networks, through which users in various coverage areas share access to transmit a signal that can be heard by everyone else in the network (just like a telephone conference call). The service is also designed for point-to-point data communications between terminals in theater. L-TAC is made possible by narrow spot beams, with satellites supporting about 200 such beams. With this, L-TAC extends capability over the satellites when UHF capacity is absent. The result: low-risk, resilient and easy-to-use connectivity which is accessible regardless of the local infrastructure, weather or terrain.

Unified SATCOM architecture

So, like the hiker in the woods who navigates past the debris to discover a distinct, well-laid path, the government-industry partnership brings much promise to steer agencies to a state of ready and responsive deployment of the most efficient, affordable, capable and interoperable SATCOM. Through this path forward, government users will greatly benefit from a completely integrated SATCOM architecture in which trusted commercial operators lead real innovation, empowering the DoD to consider MILSATCOM and COMSATCOM as a holistic capability to best support military missions.

The path exists and is available – now. And it is our duty to work together as industry and government leaders to forge ahead on it in the interest of achieving critical objectives and supporting the men and women who have dedicated their lives to these critical missions.

REBECCA M. COWEN-HIRSCH IS SENIOR VICE PRESIDENT FOR GOVERNMENT STRATEGY AND POLICY OF THE WASHINGTON-BASED U.S. GOVERNMENT BUSINESS UNIT AT INMARSAT.

U.S. AIR FORCE

CAPITAL CONTRIBUTIONS Dylan Taylor

5 bold predictions for an epic 2018

2017 WAS A GOOD YEAR FOR SPACE VENTURES. NEXT YEAR LOOKS EVEN BETTER

This year will be remembered for many milestones, not the least of which will be SpaceX's and Blue Origin's continued demonstration of reusable first-stage rockets. As we wrap up an extraordinary year for the space industry, there is reason to believe 2018 will be even better.

Here are five (admittedly bold) predictions for the year to come:

1. Space tourism finally takes flight

With last week's successful test flight of Blue Origin's New Shepard resuable rocket, it grows more likely that Jeff Bezos' suborbital vehicle carries its first crews above the Karman line early next year.

With Virgin Galactic close to doing the same, I predict more new astronauts will be minted in 2018 than any other year in the first six decades of spaceflight. Space tourism will finally become a mainstream topic and a profitable business.

2. More capital flows to space

Although 2017 was a landmark year, with angel and venture capital investments in space exceeding $2 billion for the first time, I believe 2018 will be even better. In particular, I expect international capital to become more active in the space industry.

Japan and the countries in the Middle East (the United Arab Emirates, in particular) are the most likely candidates for taking the lead on international capital. These investments will be on top of the $90 million Tokyo-based lunar robotic company iSpace raised this month, or the $1 billion that Saudi Arabia's sovereign wealth fund agreed to invest in Virgin Group's orbital and suborbital space ventures. I would anticipate the broader space industry to raise in excess of $5 billion in 2018 from all sources.

3. Blockbuster IPO

Of late, there have been no significant initial public offerings of stock by commercial space companies. I expect this to change in 2018. Likely candidates include Planet, Spire and Rocket Lab.

Theoretically, SpaceX could also be a candidate, but that is less likely given how successful they have been in attracting capital from the private markets.

A successful IPO will be instrumental in attracting additional capital to the industry, as well as encouraging even more new company formations.

4. Industry convergence

I predict 2018 will be the year where we will have full industry convergence between telecommunications, Internet of Things applications and Earth observation.

Glimpses of real-time information accessed via billions of connected devices with persistent high-speed bandwidth will be realized in late 2018. Its impact to the global economy will be significant and attract even more capital to space.

5. Commercial space shines

With the still-likely confirmation of Rep. Jim Bridenstine (R-Okla.) as NASA administrator, I predict commercial space partnerships will be further leveraged by the U.S. government.

Given a steady-state NASA budget coupled with ambitious policy goals to return humans to the moon, commercial space partnerships will emerge as the best approach for the U.S. space agency to achieve its objectives.

2018 should be the most significant year in the history of the industry since 1969. Reusable rocket will be commonplace, we will mint in excess to a hundred new astronauts, and billions more in capital will flow to the industry.

Assuming this all happens, we should be well positioned for an even more significant 2019 as humanity celebrates the 50th anniversary of the first Apollo moon landing in July. Buckle up. This is going to be a great ride. **SN**

DYLAN TAYLOR IS AN ANGEL INVESTOR AND PATRON CHAIR OF THE COMMERCIAL SPACEFLIGHT FEDERATION.

SHUTTERSTOCK

ON THE HORIZON

JANUARY

DATE	EVENT	PLACE
8-12	**SciTech Forum** scitech.aiaa.org	Kissimmee, FL
14-16	**CABSAT 2018** cabsat.com	Dubai, UAE
15-19	**Space Traffic Management Conference** commons.erau.edu/stm	Daytona Beach, FL
21-24	**Pacific Telecommunications Conference** ptc.org	Honolulu, HI

FEBRUARY

5-7	**SmallSat Symposium** smallsatshow.com	Silicon Valley, CA
21-23	**AFA Air Warfare Symposium** afa.org/airwarfare/home	Orlando, FL

MARCH

12-15	**Satellite 2018** 2018.satshow.com	Washington, D.C.
28-29	**Paris Space Week** paris-space-week.com	Paris, France

APRIL

DATE	EVENT	PLACE
3-5	**Space 2.0** infocastinc.com/event/space-2-0/	Silicon Valley, CA
9-12	**Earth and Space 2018** earthspaceconf.mst.edu	Cleveland, OH
16-19	**Space Symposium** spacesymposium.org	Colorado Springs, CO

MAY

15-16	**Space Forum** www.spaceforum.com	Luxembourg City
22-24	**Space Tech Expo 2018** www.spacetechexpo.com	Pasadena, CA
24-27	**International Space Development Conference** isdc.nss.org/2018/	Los Angeles, CA

JUNE

15-16	**Satellite & Space Missions Conference** satellite.conferenceseries.com	Rome, Italy

AUGUST

4-9	**Small Satellite Conference** satellite.conferenceseries.com	Logan, UT

FOUST FORWARD Jeff Foust

Third time's the charm?

FOR THE THIRD TIME IN THREE DECADES, A U.S. PRESIDENT HAS FORMALLY CALLED FOR A HUMAN RETURN TO THE MOON

THE TIMING OF THE ANNOUNCEMENT was a surprise. Its content, however, was not.

The fact that President Trump would be signing what the White House called Space Policy Directive 1 was announced just the day before the Dec. 11 ceremony. That date made sense in one aspect: it was the 45th anniversary of the landing of Apollo 17 lunar module, the last human mission to the moon to date.

The president made clear he wanted to change that. "It marks an important step in returning American astronauts to the moon for the first time since 1972 for long-term exploration and use," Trump said of his directive.

The administration, though, had been signaling for months that it wanted to go back to the moon. The directive was a recommendation unanimously approved at the National Space Council's first meeting in October, and officials such as Vice President Pence had been dropping hints for months before that about putting the moon back on the path to Mars.

But neither the directive nor comments at the brief signing ceremony — it lasted less than 10 minutes — offered details about just how the United States will send humans back to the moon. The directive simply replaces one paragraph of the 2010 National Space Policy developed by the Obama administration, with no details about timelines or budgets. Neither Trump nor Pence set deadlines, or made funding promises, in their remarks.

NASA, in a statement issued after the ceremony, said that implementation of the policy "will be reflected in NASA's Fiscal Year 2019 budget request" to be released early next year, and left it at that.

The timing of the announcement, some suggested, was intended as a signal to the White House Office of Management and Budget as it finalizes that budget proposal, given that it proposed cutting funding for exploration programs in its 2018 budget.

The directive is the third time in less than three decades that a president has formally called for a human return to the moon. The two Presidents Bush made similar declarations, 14 and a half years apart, only to see them falter, one undone when it was saddled with a $500 billion price tag and the other failing to survive a change in administrations.

This third proposal, arriving as if on cue nearly 14 years after the second President Bush announced the Vision for Space Exploration, will have to be different. There's no sign Congress is willing to significantly increase NASA's budget to pay for a conventional, NASA-led approach, or for raiding funding from other agency programs.

The directive offers a hint of what might work, though. The new paragraph added to the space policy directs NASA to lead "an innovative and sustainable program of exploration with commercial and international partners."

International interest in lunar exploration has been growing in recent years, such as the campaigning by the European Space Agency's leader, Jan Woerner, for his "Moon Village" proposal. Japan's government recently endorsed cooperating on NASA's proposed Deep Space Gateway as a way to send Japanese astronauts to the moon.

The commercial sector has demonstrated increasing capability for supporting a human return to the moon, and willingness in doing so. Blue Origin, for example, has proposed building a lander system for delivering cargo to the lunar surface to support human missions there.

Even SpaceX, which has long been focused on Mars, has a new interest in the moon. "If you want to get the public really fired up, I think we've got to have a base on the moon," Elon Musk said this summer.

Translating that commercial and international support into a sustainable program to send humans back to the moon will be a key challenge for NASA, the National Space Council and the White House.

If they fail this third time around, a future president may not bother with a fourth attempt. **SN**

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Contact Us Today

Paige McCullough
571-278-4090
pmccullough@spacenews.com

Kamal Flucker
571-402-5706
kflucker@spacenews.com

GO GALILEO! Arianespace capped off the year with its 11th mission on December 12, when an Ariane 5 flawlessly placed on orbit four more spacecraft of the Galileo constellation. This campaign for ESA and the European Commission was the 82nd successful flight in a row for the heavy lift launch vehicle from the Guiana Space Center. The Global Navigation Satellite System, which Europe entrusted to Arianespace for delivery, now numbers 22 satellites, and will make life better on Earth with its precision guidance services.

#missiontosuccess