THE AUTOMATION ISSUE

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ABOVE: People watch “The Great American Eclipse” through protective glasses in Madras, Oregon, on Aug. 21. A total eclipse was visible along a narrow swath of the United States stretching from Oregon to South Carolina.

ON THE COVER: SPACENEWS ILLUSTRATION. THIS PAGE: NASA/AUBREY GEMIGNANI
Prof. Dr.-Ing. Johann-Dietrich Wörner, Director General, European Space Agency (ESA)

Prof. Dr. Pascale Ehrenfreund, Chair of the Executive Board, DLR

Jean-Yves Le Gall, President, CNES

Sylvain Laporte, President, Canadian Space Agency (CSA)

Timothy Towney, NASA Europe Representative, NASA

Dr. Oliver Juckenäfels, Head of Site Bremen and Vice President On-Orbit Services and Exploration, Airbus Defence & Space

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The amount Descartes Labs, a startup that specializes in applying machine learning to geospatial data, raised in a Series B round led by March Capital. The Santa Fe firm plans to enhance its “data refinery,” the cloud-based supercomputing platform it uses to draw useful information and insight from disparate datasets.

+3 Mos.

The remaining teams in the Google Lunar X Prize competition have a little more time to win the $20 million grand prize. The X Prize Foundation says the five teams named as finalists earlier this year have until the end of March 2018 to complete their missions. It had become clear in recent months that most, if not all, of the teams were struggling to launch by the previous end-of-the-year deadline even though they had launch contracts to do so.

16

A new survey by Bloomberg and Bryce Space & Technology found that 16 of the 500 richest people in the world have made investments in space companies or associated ventures. Besides the familiar names of Jeff Bezos and Elon Musk, other billionaires with stakes in space ventures include Sheldon Adelson, who is supporting Google Lunar X Prize team Spacell; Eric Schmidt, an investor in Planetary Resources; and Ricardo Salinas, who has invested in OneWeb.

GETTING THEIR FEET WET

Two European astronauts have completed a training exercise with Chinese counterparts as a step towards in-space cooperation. Samantha Cristoforetti and Matthias Maurer joined 16 Chinese astronauts for nine days of sea survival training off the coast from the Chinese city of Yantai, practicing getting out of a Shenzhou spacecraft in the ocean. The training is part of a 2015 cooperative agreement between the European Space Agency and the China Manned Space Agency, with the long-term goal of flying ESA astronauts on China’s future space station.
QUICK TAKES

ICYE RAISES $13M FOR RADAR MICROSATELLITES

A Finnish company has raised $13 million to further development of synthetic aperture radar (SAR) microsatellites. Iceye said it raised a $8.5 million financing round from several investors, led by Draper Nexus, with the rest of the money coming from a Finnish government agency. Iceye plans to launch its first three SAR satellites in the next 12 months, to be followed by a constellation of 18 satellites to provide imagery with revisit times on the order of several hours.

SCHOOL OF HARD ROCKS

A Colorado university is preparing to launch the first graduate program in space resources. The Colorado School of Mines plans to start an interdisciplinary space resources program in 2018, pending approval by university leadership. The program will examine not just the engineering issues of extracting resources from celestial bodies but also economic and legal topics.

SPENGLER JOINS BROADBAND COMMISSION

The CEO of Intelsat is joining a United Nations commission that advocates for broadband internet access. Intelsat said that Stephen Spengler will become a commissioner on the United Nations Broadband Commission for Sustainable Development. He joins the CEO of Inmarsat and the director general and CEO of the International Telecommunications Satellite Organization as members of the commission with satellite backgrounds. The commission, with 50 members, calls for greater availability of broadband access to drive global development.

HYLAS HOLDUP

Avanti has set a new launch date for its Hylas-4 communications satellite. The company said last week it now expects Arianespace to launch the satellite in March 2018. That date is later than previously planned, but the company said Hylas-4 will still enter service next July thanks to a more favorable launch accommodation. That launch, the company said, will also allow the spacecraft to carry more fuel and extend its on-orbit life from 15 to 19 years.
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SPACEPORT STATUS

Backers of New Mexico’s Spaceport America are worried about competition from other states. The custom-built spaceport has been hampered by tight funding and delays in the operations of its anchor tenant, Virgin Galactic. The spaceport’s supporters say that without additional support from the state, including funding for operations and additional infrastructure, New Mexico risks being “overtaken” by other states that are now spending more on commercial spaceport facilities in their states. Critics of the spaceport have complained about a lack of return on the investment the state has already made on Spaceport America.

Meanwhile, a new study concludes that a proposed commercial spaceport in Georgia could have a “significant” economic impact for the region. Research by Georgia Southern University found that construction of Spaceport Camden, in Camden County on Georgia’s Atlantic coast, could generate more than $7 million in revenue, with annual operational revenues approaching $17 million. Critics of the planned spaceport argued that the summary of the report released by local officials offered little justification for those claims.

The British government said it got a strong response to a call for proposals regarding spaceports in the country. The UK Space Agency said it received 26 proposals for grants to support developing of suborbital and orbital launch capabilities in the country. The proposals covered sites throughout the country, hosting vehicles developed both in the country and from operators in the U.S. and Europe. The agency’s deputy CEO said there “may be a case for awarding a number of grants” to support those efforts.

SPACEX SUITS UP

Elon Musk has revealed the first image of the spacesuit that astronauts flying on the crewed version of the company’s Dragon spacecraft will wear. In an Instagram post early last week, Musk released the image of upper part of the suit, white with black accents. Musk said the suit pictured is an actual flight model, not a mockup, and has been tested to “double vacuum pressure.”

SIGNIFICANT DIGITS

$4M

The amount start up Helios Wire just raised to support development of a constellation of satellites that will relay information from sensors on the ground. The company, led by former Urthecast CEO Scott Larson, is planning to launch an initial demonstration satellite at the end of this year, with two operational satellites to follow next fall.

$9.1M

The price a Japanese joint venture plans to charge to launch a 100-kilogram payload aboard a small rocket they’re developing. Canon Electronics, IHI Aerospace, Shimizu and Development Bank of Japan created the JV to work on a launcher smaller than the existing Epsilon rocket but bigger than the SS-520 rocket that failed on a test flight earlier this year.

GLAVCOSMOS BAGS TWO-SATELLITE CONTRACT

Russia’s Glavcosmos has signed a contract for two launches of South Korean satellites. Glavcosmos, which markets Soyuz launches from Russia, announced Aug. 21 a contract with the Korea Aerospace Research Institute and Korea Aerospace Industries for two Soyuz-2 launches of the CAS500-1 and CAS500-2 Earth-observation satellites. The announcement did not disclose when the launches would take place, but noted that each launch would also carry secondary payloads.
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SpaceX notches 15th landing after long-overdue Formosat-5 launch

A long-delayed remote sensing satellite for the government of Taiwan Aug. 24, executing another first stage landing in the process.

The Falcon 9 lifted off from Vandenberg Air Force Base in California at 2:51 p.m. Eastern, at the beginning of a 42-minute launch window.

SpaceX reported no technical issues during the countdown, and foggy conditions at the launch site earlier in the morning partially cleared by launch time.

The rocket’s only payload, the Formosat-5 remote sensing satellite, separated from the upper stage a little more than 11 minutes after launch. The satellite was deployed into a sun-synchronous orbit at an altitude of 720 kilometers. SpaceX, during the launch webcast, declared the launch a success.

Formosat-5 was built by Taiwan’s space agency, the National Space Organization, known by the acronym NSPO. The 450-kilogram spacecraft was the first such satellite built domestically by Taiwan, and succeeds Formosat-2, retired a year ago.

The spacecraft carries cameras capable of producing panchromatic images at a resolution of two meters and color images at a resolution of four meters. It also carries an ionospheric science instrument developed by a Taiwanese university.

NSPO awarded the launch contract for Formosat-5 to SpaceX in 2010, at the time intending to launch the spacecraft on SpaceX’s smaller Falcon 1 rocket. SpaceX later discontinued the Falcon 1, moving Formosat-5 to a larger Falcon 9 vehicle. Terms of the contract were not disclosed, but NSPO is widely understood to be paying far less than the Falcon 9 list price of more than $60 million for this launch.

At the time of the contract, SpaceX expected to launch Formosat-5 by early 2014. The change in launch vehicles and delays in SpaceX’s launch schedules, including those caused by two Falcon 9 failures in 2015 and 2016, significantly delayed the launch.

SpaceX previously planned to fly a secondary payload, the Sherpa bus from Seattle-based Spaceflight Industries, which would have deployed nearly 90 small satellites after separating from the Falcon 9 upper stage.

However, Spaceflight announced in March that it had decided to find alternative rides for those secondary payloads because of “significant” delays it expected in the Formosat-5 launch.

The launch also features another landing of the Falcon 9 first stage, in this case on a droneship called “Just Read the Instructions” in the Pacific Ocean. This was the 15th successful landing of a Falcon 9 first stage in 40 liftoffs, and the ninth to land on a ship.

The launch was the 12th Falcon 9 mission of 2017, and the second in 10 days, after the launch of a Dragon cargo spacecraft Aug. 14 from the Kennedy Space Center in Florida.

The next Falcon 9 launch, of the U.S. Air Force’s X-37B spaceplane, is planned for early September from Florida.
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Until recently, SolAero Technologies had little incentive to automate solar panel manufacturing because their arrays were usually custom-made for satellites based on their orbits and missions. Sometimes a few panels were designed to be identical, but the orders weren’t large enough to offset the expense of investing in the type of specialty equipment the firm would need to automate panel production. What’s more, the panels, which often exceeded three meters on a side, were too large to produce with popular automation tools.

“There traditionally has not been enough standardization to justify automation,” said Brad Clevenger, chief executive of Albuquerque-based SolAero. “Within the last three years, that pendulum has swung pretty far. Now it looks as if the industry is going to support a certain level of standardization and volumes in the constellation programs that make investment in automation much more attractive than it has been in 20 years.”

Companies are investing in automation as they try to position themselves for work building commercial and government constellations of tens or hundreds of cookie-cutter satellites. In addition to the large quantities, the proposed constellations are filled with satellites small enough for companies to build with automation tools widely used in commercial industry.

The first constellation poised for production belongs to OneWeb. OneWeb Satellites, a joint venture of Airbus Defence and Space and OneWeb, plans to build an initial constellation of 900 broadband satellites that each weigh about 150 kilograms.

SolAero
SolAero, a firm that specializes in end-to-end solar panel production, is in the midst of a $10 million project to expand its New Mexico facility and invest in automation aimed at helping it produce solar panels for OneWeb and future constellations.

SolAero brought in robotic machines to handle many of the tasks associated with turning solar cells into Coverglass Interconnected Cells (CICs), which include the cells, glass, interconnects to route power and a bypass diode, and ultimately into solar panels. The firm already relied heavily on automation in its semiconductor wafer manufacturing operations which produce solar cells.

“We can now assemble CICs onto panels larger than a meter square in a semi-automated fashion,” Clevenger said.

The investment in automation is helping SolAero reduce costs, accommodate higher volume orders and improve quality.

“You get a large degree of repeatability with automation which helps with quality and reliability,” Clevenger said. “We would have automated this side of the business a decade ago if only the product designs allowed it.”
MDA

Work on OneWeb’s constellation is also prompting MDA Corp. to automate.

MDA announced plans in June to manufacture 3,600 communications antenna subsystems for OneWeb at its factory in Montreal. Thales Alenia Space also hired MDA to produce 96 communication antenna subsystems for O3B satellites and 486 Ka-band antennas for the Iridium Next constellation, but the OneWeb order dwarfs those.

MDA is filling the new order with the help of collaborative robots that work with pneumatic systems and test software. In addition, MDA will verify the radio frequency performance of antenna parts using completely autonomous test systems, Joanna Boshouwers, vice president and general manager of MDA’s satellite subsystems business, said by email.

Digital torque wrenches with automatic data recording will help MDA assemble subsystems and the firm will rely on automatic photogrammetry to confirm antenna dimensions and their geometric characteristics.

“Automation allows tighter process control and repeatability, ultimately yielding a consistently higher-quality product,” Boshouwers said.

Roccor

Roccor, a small business based in Longmont, Colorado, that specializes in deployable space structures, is investing in automation to compete for work on the large constellations that represent “a profound change in the market,” said Doug Campbell, Roccor chief executive. “It’s a whole new business.”

Although Roccor cannot disclose the name of a customer who coincidentally is building a constellation of 900 satellites destined for low Earth orbit, the firm is producing 1,800 composite booms to deploy solar arrays.

“We specialize in composites that are flexible, bendable,” Campbell said. “They don’t have discreet hinge lines, which means I can give you a system with the structural properties you need at substantially lower cost.”

To fulfill the 1,800 boom order, Roccor is expanding its factory, segregating the new production line from its ongoing research and development work, and investing in equipment.

Initially, Roccor fabricating booms by hand, but the surge in orders is prompting the firm to automate the process using large-scale manufacturing equipment similar to tools used by commercial fishing rod and golf club manufacturers. Roccor also is investing in large machines like CNC routers to finish the booms.

“You program the shape you want and it mills it out,” Campbell said. “None of that is done by hand.”

Those investments will give Roccor an edge in future competitions because anyone planning a constellation of tens or hundreds of satellites will focusing intently on the cost of subsystems, Campbell said. “These guys are looking for nontraditional vendors because they can’t pay a gazillion dollars for future systems. It’s a tremendous opportunity for small businesses.” SN

“Now it looks as if the industry is going to support a certain level of standardization and volumes in the constellation programs that make investment in automation much more attractive than it has been in 20 years.”

Brad Clevenger, SolAero CEO

OneWeb Satellites is building OneWeb’s first 10 satellites in Toulouse, France, before shifting production of the full 900 to a scratch-built factor outside the gates of Kennedy Space Center, Florida.

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Robots building satellites? Not quite, but maybe soon.

While robots began assisting and replacing assembly line workers in automobile and airplane factories years ago, humans still reign supreme in satellite manufacturing. But that’s slowly starting to change.

In contrast to the millions of cars and thousands of airplanes produced annually, satellites — and geostationary telecommunications satellites in particular — are produced in much lower numbers. In a good year, the world’s satellite manufacturers might book a combined commercial 25 orders. That low volume limits the efficiency gained from industrial robots, at least on the ground.

“In terms of today, the uses for us are somewhat minimal,” said Tom Wilson, vice president of Orbital ATK’s Space Systems Group.

Orbital ATK mostly uses robotics to fit electronic boards with computer chips, Wilson said, which isn’t new for space or most other industries.

Like Orbital ATK, Space Systems Loral sees limited application for robots, despite averaging more telecom satellites per year. “In our relatively low-volume, high-mix environment, the standard industrial robot doesn’t do you much good,” echoed Paul Estey, SSL’s chief operating officer. “You don’t have very many applications of it.”

Even OneWeb’s mega-constellation, whose first satellites are just now being built by the OneWeb-Airbus joint venture OneWeb Satellites in Toulouse, France, doesn’t provide the scale needed to justify the upfront expense of automating assembly.

“For routine assembly process, we didn’t see the return on that given the quantity of operations we were performing,” said Brian Holz, OneWeb Satellites chief executive. “It wasn’t high enough to really drive the need for too many robotics.”

To build OneWeb’s order of 900 identical 150-kilogram satellites, Holz said the company is focusing more on the automation of repeatable processes, like placing cells onto solar arrays. Automating some manual procedures reduces the amount of touch labor involved and consequently, the risk of human error, but doesn’t mean a full-blown takeover by robotic builders.

“You’d get into more robotics maybe if you had another order of magnitude in terms of quantity of objects to build. We are not building one, but we’re not building a million either,” he said.
An SSL technician operates a machine that automatically mounts components onto circuit boards used for satellite systems such as data handling, telemetry, controls, command and digital radio-frequency units.

Making the case for robotics

These barriers to mainstream robotics don’t mean the industry isn’t investing in the technology, however. The European Space Agency has expressed great hope in bringing robotic capabilities to the clean rooms of satellite manufacturers.

“Within Europe, we see that the use of robots and automation is skyrocketing, especially in aeronautics,” said Paul Robert Nugteren, ESA’s technology and strategy coordinator for the agency’s Directorate of Telecommunications & Integrated Applications. “Robot suppliers specifically cater for the specific needs of these industries. The step to spacecraft manufacturing is happening now. Collaborative robots are good candidates to make their first appearance in spacecraft manufacturing. European industries are developing their capabilities in this area.”

Thales Alenia Space used a robot called Saphir to automate the installation of inserts for the spacecraft-bus panels of Bangladesh’s Bangabandhu telecom satellite. The French and Italian satellite manufacturer anticipates Saphir will slash the time for bonding an estimated 3,500 inserts per panel from three weeks to one week, and the number of employees needed for the task from two to one.

Lockheed Martin uses robotic arms to take some of the tedium out of solar array assembly. A $350 million satellite factory the company expects to open by 2020 near Denver could potentially employ robotic helpers that deliver tools to the humans building the satellites. “We’re also developing how larger robotic arms can 3-D print structures with both additive and subtractive capabilities at the same station,” Lockheed Martin spokesman Mark Lewis said. “[O]ne arm deposits material while the other can shave off and smooth surfaces so it all can be done in one station, versus two different processes currently.”

SSL, Estey said, has developed “an
industrial robot-like device” to assist with building satellite subsystems.

“We are beginning to use that now,” he said. “If that works out as we hope, we are going to expand the use of that type of a robot elsewhere in the factory.”

Frédéric Teston, head of ESA’s Systems Department Directorate of Technology, Engineering and Quality, said the agency expects a lot of automation from the aviation and automotive industries will “spin-in” over time to the satellite industry. Despite the challenges, constellations of tens, hundreds, or thousands of satellites are viewed by the agency as “the first candidates for extensive automation and use of robotics.”

“Experience build-up in constellations will then make its way to lower-volume production cases,” he said.

Downstream currents
Suppliers of satellite parts and subsystems are also guided by volume in determining whether or not robotics have any meaningful application.

Nuvotronics, a Durham, North Carolina-headquartered provider of amplifiers, space-qualified phased-array antennas, filters, diplexers, and other components, has been rapidly introducing robotics to create more reliable products, circumventing human error, said President David Sherrer.

“Over the last two years, we have moved most of the key steps in our manufacturing to use robotic handlers,” he said. “Human operators do not need to touch the work in process except to move batches from operation to operation.”

Sherrer said robotic handlers operate without human intervention for several of Nuvotronic’s machining processes, such as metal filling, removing disposable design molds from parts, and assembly of smaller parts into hardware.

“What used to take 10 minutes of human touch-time to fixture a substrate to grow metal into a layer is now done hands-off, including the pre-cleaning and post wash and dry steps,” he said. “The ability for these machines to run 24/7 without making errors translates into reduced cost and higher yield.”

That process used to take 10 minutes; it now takes about 30 seconds, he said.

In contrast, Melbourne, Florida-based Harris Corp.’s Space and Intelligence Systems division, a provider of large, unfurlable satellite antennas, builds only a couple of such antennas every year.

Over the past 50 years, the company has produced around 80 antenna reflectors, of which around 50 are unfurlable.

Tom Campbell, Harris Corp.’s director of program management for antennas and structures, said a typical antenna project takes 14 to 30 months to complete. Half of that time is design, he said, while the other half is the actual build process.

Campbell said automation has led to some decrease in the number of humans working on a project, but added that Harris has “been able to grow the business to take up the need for additional people.”

“It’s important to have a critical mass so that when customers call on us, we are ready to go,” he said.

Harris is using a lot of automation on the design side by adding antenna modeling code to computer-aided-design tools in order to better define final products, Campbell said. The company is also “very bullish” on 3-D printing to create structures “that are maybe an order of magnitude more optimized for the purpose at hand,” he said.

Robotics have limited use so far, but have found some applications in areas such as carbon-tube wrapping, he said, and in test equipment. Scale remains the biggest challenge.

“The instances of true high-volume manufacturing are still few and far between,” he said. “I think the industrial engineers are still favoring lean processes in most cases as we still tend to build most satellites one at a time.”

Robotics in space
Both Orbital ATK and SSL are developing robotic servicers for in-orbit repair and life extension. Toward the end of 2018, Wilson said, Orbital ATK subsidiary Space Logistics plans to launch its first mission-extension vehicle, or MEV-1, which will serve Intelsat for an initial five years. SSL parent company MDA Corp. >

Nuvotronics has embraced robotics and 3-D printing to streamline the production of space-qualified components, such as this piece of one of the company’s phased-array antennas.
is creating a company called Space Infrastructure Services, or SIS, that expects to launch a robotic servicer in 2021 based on a project with the U.S. Defense Advanced Research Projects Agency.

The two companies have different visions of how to approach in-orbit servicing as a business, and have quarreled in legal disputes over the technology in recent years, but both envision their products as kicking off what would rightly be called a paradigm shift if fully realized.

“Things like deep space gateways or large telecommunications satellites that you couldn’t fit in a launch vehicle fairing because of their size and the amount of power, [that’s what] we are talking about,” said Orbital ATK’s Wilson. “The idea is you can have a very-high-power system that can last for multiple decades that can be assembled on orbit with some of the technology we are developing. It’s more of a future look.”

Some of that critical technology is being produced through a NASA Tipping Point contract for the Commercial Infrastructure for Robotic Assembly and Services program, which Orbital ATK has been working on since September 2016.

Joe Anderson, leader of business development for Orbital ATK’s Advanced Programs Group, said NASA extended the project through to a ground demonstration in fall 2018, which will practice, among other things, how to add, remove and relocate structures such as solar panels.

“We are hopeful that next year NASA would come out with their phase two, which would be [a Request for Proposal] for an in-orbit demo,” he said. “We are looking forward to that. NASA seems to be very interested.”

In February, DARPA picked SSL to build the platform for the Robotic Servicing of Geosynchronous Satellites, which SSL’s Space Infrastructure Services subsidiary will market commercially after completing demonstrations for the agency. SSL also has a NASA Tipping Point contract for a program called Dragonfly meant to advance technology for the in-space assembly and repair of satellite antennas.

“Certainly in 10 years we are going to be using robotic assembly in orbit,” SSL’s Estey said. “The persistent platform is a good example where you’ve got modules you launch separately but are put together on orbit. That definitely in our opinion is going to happen.”

The persistent platform is a concept where a satellite bus stays in orbit indefinitely, and is updated using new payloads and technologies launched as parts. Robotic servicers would then plug in those payloads and remove broken or obsolete components to “refresh” the platform as needed.

“The application of robotics is much more applicable in the on-orbit assembly world and in [satellite] servicing ... once we get to being able to be very capable of that, we see a complete change in the satellite architecture,” said Estey.

Persistent platforms could grow to be substantially larger than what can fit in a rocket’s payload fairing, enabling gigantic satellites or other spacecraft to be constructed on orbit. SSL, 3-D printing startup Made In Space, and Orbital ATK are all working on robotic in-space manufacturing systems that could enable such structures.

Anderson said Orbital ATK is evaluating a structure it calls the “GEO tower,” which would be a “multiple-decade-type application that would provide all of the backbone for communications payloads... just like a cell tower today.”

Multiple telecom operators could install payloads on the tower, and swap those payloads based on changes in technology and demand. GEO towers could also be used for Earth observation, assembling in orbit an aperture large enough to provide the resolution needed from the far away vantage point of GEO.

Wilson said Orbital ATK is still developing the technology and possible business plans for GEO towers, which could then be maintained using robotic servicing spacecraft. SN
Managing a flock of satellites

How Planet operates a big constellation with a small team

The concept of a satellite control center conjures up, in the minds of many, something resembling NASA’s Mission Control: dozens of people sitting at banks of consoles, intently monitoring the health of the spacecraft under their command 24 hours a day, seven days a week.

Planet, which has a constellation of nearly 200 Earth-imaging satellites, mostly Dove cubesats, does things a little differently. The company doesn’t have a big control center or a large team keeping watch on their satellite fleet.

“We have a small team of operators in San Francisco: actually only three satellite operators, including myself,” said Deanna Doan, who leads Dove operations for the company, in an Aug. 9 talk at the Conference on Small Satellites at Utah State University. “So, this week, it’s more like two, since I’m here.”

Planet is able to control its fleet with such a small team because of an emphasis on automation of spacecraft operations. “From the very beginning, we’ve concentrated on automation,” she said. “We always knew we would be operating a constellation of hundreds of satellites, so we need to scale appropriately. The only way to do that is to automate everything.”

To aid that automation, the company keeps satellite operations simple. When each spacecraft is over land during daylight, it takes images. When it passes in range of one of several ground stations, it transmits those images. The rest of the time, the spacecraft is idle, recharging its batteries and flying in a configuration that...
uses atmospheric drag to maintain spacing relative to the other satellites in the constellation.

Planet, since the company’s early days, has emphasized a concept it calls “agile aerospace” that brings the rapid technology refresh cycles of the electronics industry to space. That approach also applies to satellite operations, as the company applied the lessons learned from its early generations of satellites to more recent ones, frequently updating software.

That work is put to the test when the company launches a new batch of satellites. “We’ve never had 24/7 operations, including during commissioning,” Doan said. During those times, the company does bring in extra operators, calling on the team of five in Berlin that runs the RapidEye satellites Planet acquired in 2015. “We can take advantage of the time zone difference and stretch it out into essentially a 15-hour operations day.”

The company’s single biggest group of satellites, known as Flock 3p, featured 88 satellites launched on a single Indian Polar Satellite Launch Vehicle in February. Within two hours of launch, she said, the company had made initial contact with all 88 satellites, using a software package called “Megahealth” to quickly collect basic information on each satellite.

After that, the company worked on the rest of the satellites in batches, commissioning about eight satellites per week.

Of the 88 satellites, more than half of the satellites completed the commissioning process, from detumbling after deployment to calibrating the spacecraft’s camera, without human intervention. The rest required either a restart of the satellite’s computer or, in some cases, additional intervention from operators.

“This is the first time we commissioned a flock with end-to-end automation,” she said. “Overall, operator workload was reduced by at least a factor of four over previous flocks.”

Another example of the use of automation at Planet involves collecting the images those satellites generate. “Our ground stations are taking over 1,000 X-band passes every single day, and it’s only going to continue to go up,” said Kiruthika Devaraj, radiofrequency and communications lead for Planet, in a separate presentation at the conference.

That scale requires automation. “We couldn’t humanly look at passes and figure out which passes failed or what went wrong,” she said. “So we spent a lot of time automating ground station pass performance monitoring.”

That automated system looks at the data returned by the satellite and compares it to the amount expected given the characteristics of that pass. If a pass collects less than 80 percent of the expected data, it’s considered a failure. When that happens, Devaraj said, another system examines the data as well as spacecraft telemetry and, based on past experience, classifies what likely went wrong.

That system now receives more than five terabytes of data from the entire constellation each day, with each satellite transmitting at up to 200 megabits per second. Increased data rates are planned. “We think we can cross a gigabit per second soon,” she said.

That process of continuous improvement also applies to satellite commissioning. Planet’s latest batch of 48 satellites, called Flock 2k, launched in mid-July on a Soyuz. Less than a month later, Planet was more than halfway through the commissioning process for that group. “We transferred a lot of the lessons that we learned from Flock 3p into Flock 2k,” Doan said. “It’s been really smooth so far.” SN
IRIDIUM COMMUNICATIONS

THE IRIDIUM SATELLITE NETWORK OPERATIONS CENTER (SNOC) is in the process of swapping old satellites for new ones as it updates the constellation that carries voice and data traffic worldwide. But that doesn't mean there's a flurry of activity in the Leesburg, Virginia facility.

Thanks to automation, only about eight people per shift work in the SNOC, planning missions, sending commands and keeping tabs on 80 satellites in orbit, including spacecraft launched in the late 1990s that Iridium Communications is beginning to replace with Iridium Next satellites.

“We've automated almost everything or else we would have 10 times as many people,” said Scott Smith, Iridium Communications chief operating officer.

Iridium Communications’ commitment to automation dates from the beginning of the Iridium network operations in the late 1990s, Smith said, and the drive for automation continues.

Since January, SpaceX Falcon 9 rockets have sent 20 Iridium Next satellites into orbit. SpaceX plans to launch another batch of 10 in late September.

As SNOC personnel learn how the Iridium Next satellites function and behave, they are writing new scripts, or series of commands, to further automate satellite operations.

“Thats how you get things done, so you don’t have to sit and do it command by command,” Smith said.

For each Iridium Next satellite that joins the constellation, SNOC personnel move the new satellite into position directly behind an aging spacecraft and hook the new satellite into the constellation’s communications crosslinks. Then they move the old satellite out of the way and insert the new one in its slot.

Each step in that careful dance, known as slot swap, has pieces of automation and scripts involved. However, people oversee the entire process.

“There is not one button you push and say ‘Slot swap these satellites,’ because that is a very delicate operation,” Smith said.

In contrast, the process of pairing Iridium satellites with ground stations to share data as they pass over is fully automated.

Iridium Next satellites also rely heavily on automation to transmit 60,000 measurements multiple times per second on information like spacecraft voltages, temperatures and data rates. Computers process that data and alert SNOC personnel if they detect any anomalies.

“If something looks a little weird, we can turn on more data points in that particular piece of a payload,” Smith said. “The Iridium Next satellites are like supercomputers in the sky.”

Iridium Communications also relies heavily on automation in its collision avoidance activities. Since the 2009 collision of a defunct Russian Cosmos satellite with a working Iridium spacecraft, companies and government agencies have expanded data sharing and conjunction analysis dramatically.

Now, Iridium Communications shares the orbital position of each satellite with the Air Force every day. The Air Force runs the information through algorithms designed to look for possible collisions and shares its analysis with Iridium.

When the Air Force detects a possible collision, SNOC personnel turn to Iridium’s own algorithms to determine whether a satellite should be moved to a new orbital position and, if so, how and when.

“Most of the work that is done in collision avoidance is heavily automated,” Smith said. “Ten years ago it wasn’t.”

DEBRA WERNER
KERFUFFLE IN KOUROU

SPACEPORT STALL-OUT

WHY THE GUIANA SPACE CENTRE FOUND ITSELF AT THE EPICENTER OF A NATIONAL CRISIS

After being shut down for five weeks this spring, Europe’s Guiana Space Centre got back to business with the May 4 launch of an Ariane 5 rocket carrying two telecom satellites.
Hervé Tambour, a 30-year old French Guianese man born in the capital city of Cayenne, was shot and killed at a laundromat in early February after denying a robber his gold chain.

French Guiana’s 2016 murder rate, of 16.8 murders per 100,000 inhabitants, is more than 10 times higher than France’s national average. Local experts say that helps explain why Tambour’s unsolved murder — the first homicide of 2017 — touched such a nerve.

Coming on the heels of a year that saw 42 murders, Tambour’s death was the catalyst behind the formation of the 500 Brothers, a collective of former police officers and activists seeking to rein in the violence and improve local living standards. Disparate demonstrators, led by the masked and black-clad 500 Brothers, closed off access to the Guiana Space Centre, or CSG, on March 21, about five weeks after Tambour lost his life.

A week later, an estimated 10,000 to 12,000 people took to Cayenne’s streets amid a general strike and widespread blockades, forming the largest protest in French Guiana’s 71-year history. The CSG, located less than an hour away in the city of Kourou, sat blockaded and incapacitated.

Tambour’s death, said Damien Davy, an anthropologist at French Guiana’s Centre National de la Recherche Scientifique, “was like we say in French: ‘c’est la goutte d’eau qui a fait déborder le vase.’” Loosely translated: it was the drop of water that caused the vase to overflow.

The largest of France’s overseas territories, French Guiana spans some 83,000 square kilometers, making it roughly the same size as Austria, the United Arab Emirates or the U.S. state of Idaho. Bordered by Brazil along the south and east, Suriname to the west, and the Atlantic Ocean along the north, French Guiana’s 250,000 residents live in what is often considered to be the most dangerous part of France.

Didier Faivre, the director of the Guiana Space Center, knows this.

“According to official statistics, French Guiana is the worst for safety of all French lands,” said Faivre, a veteran of the French space agency CNES who began his career in 1983 at the spaceport. “I don’t want to deny that this is a problem.”

European rockets launch billions of dollars worth of satellites from French Guiana every year. At the same time, basic infrastructure like clean water and electricity aren’t reliable in many parts of the South American territory. Arguably, it was inevitable that a spaceport juxtaposed with poverty and insecurity would turned emblematic of the region’s challenges.

This spring, the troubles of French Guiana’s residents became those of the entire European launch sector and the space industry that relied on its services.

“The inhabitants of French Guiana are tired of this violence and these crimes, which every year are more numerous,” said Davy, the anthropologist. “In 2016, the French Guiana territory was the most murderous in France — 42 people were killed.”

Davy said French Guiana has proportionally more murders than the port city of Marseille, which has been trying to shake its reputation as the murder capital of France.

Initially, CNES, the spaceport’s operator, and Arianespace, the European company that uses the spaceport to launch Ariane 5, Vega and Europeanized Soyuz rockets, thought the spaceport would be offline for a day or two, not five weeks, but the facility turned into a bargaining chip for local residents.

THE PROTESTS THAT IDLED EUROPE’S SPACEPORT FOR FIVE WEEKS THIS SPRING BEGAN WITH A MURDER.
KERFUFFLE IN KOUROU

> to get the attention of mainland France.

FRENCH GUIANA’S RELATIONSHIP WITH THE SPACEPORT

“The problem is not with space, the problem is with the development between Western Europe and French Guiana,” said Faivre. “French Guiana is part of France and part of Europe, but is far from the European standard in terms of security, health, education, energy, employment, social welfare, and so on. We are much closer to Suriname or Brazil.”

The French government selected Kourou as the location of its spaceport in 1964. Fifteen years later, the first-ever Ariane launch lifted off from there on Christmas Eve 1979. Stéphane Israël, Arianespace’s CEO, described the event as “a magnificent Christmas gift for everybody,” and the territory’s economy reflects that sentiment. Davy said French Guiana’s gross domestic product was about $17,500 per inhabitant. By comparison, residents of nearby Guyana had a per capita GDP of $3,993 and Haitians just $752, he said.

“We generate 9,000 jobs direct and indirectly and it amounts to 15 percent of the GDP of French Guiana,” Israël said, adding that an estimated 40 percent of private wages in French Guiana come from the space industry.

Some 1,700 people are directly employed to operate the spaceport, and more come as “missionaires,” international workers with three- to six-year contracts, according to Israël. Those workers live, raise children, and pay taxes all in French Guiana, he said. Furthermore, around 70 percent of the the CSG staff are locals, Faivre said.

“CNES is not a bubble in French Guiana,” he said. “CNES has roots in Guiana.”

Having a spaceport in Kourou, French Guiana is a major boon for Europe. Located 5.3 degrees above the equator, the territory is 90 percent jungle, and despite times of heavy rain, rarely experiences tropical storms. The locational advantages mean more efficient launches (proximity to the equator increases launcher speeds by 460 meters per second, according to the European Space Agency), limited downtime from weather, and low risk of damage to nearby populaces. But while the benefits are clear to Europe, they are not always for locals.

“The people don’t understand the contrast between the high-tech space industry, and the poor development of French Guiana (delays for vital equipment, such as healthcare, school, roads, energy, etc.) in comparison with France,” said Stéphane Granger, a teacher of history and geography at the University of French Guiana and the Melkior-Garré school in Cayenne. “In reality, the Guiana Space Center takes part in the development, but there is some jealousy because it was a unilateral decision of the French government.”

Davy said lots of French Guianese residents know the importance of the space industry, including its major economic impact, but different points of view exist nonetheless.

“The problem is not with space, the problem is with the development between Western Europe and French Guiana. French Guiana is part of France and part of Europe, but is far from the European standard in terms of security, health, education, energy, employment, social welfare, and so on. We are much closer to Suriname or Brazil.” Didier Faivre
“The CSG gives a lot of grants in French Guiana for students, local enterprise, NGO’s... but on the other hand, when Europe and France launch high-tech satellites from Kourou, a lot of places in French Guiana don’t have drinking water yet or internet connections or telephones,” he explained. “We live in a place of high technological industry but with a lot of unemployment and a lot of social problems.

“So some inhabitants of French Guiana think that the French state must help much the social and economic development of our territory. For a minority of independency activists, the CSG is the symbol of neo-colonialism.”

French Guiana’s economy has also drawn immigrants mainly from Haiti, Brazil, Guyana and Suriname, which now account for a third of the population, he said. Some blame the violence on immigrants, he said, but “the majority of those families are victims of this violence like all the people living here.”

**FAIVRE AND THE 500 BROTHERS**

On April 4, the 500 Brothers and other French Guianese residents marched to the CSG. Previous demonstrations, including an interruption of the Cartagena Convention, an international environmental conference where Ségolène Royal, the former partner of France’s then-President François Hollande, was in attendance, had not elicited the attention of mainland France as intended. Now using the spaceport became a power move to once again, shout across the Atlantic.

“We had one demonstration with people walking to the CSG,” said Faivre. “They wanted to see me, so I told them: if you want to see me, you will see me. We [conferred] a meeting room here, and the objective of this meeting was to explain to the director of the launch base, which is the most important place in [French] Guiana, the problems of [French] Guiana, the needs, and hope that I take it, [and] transfer it to my authorities in Paris.”

Faivre said locally elected representatives, demonstration organizers and leaders from various social movements all participated in this meeting. Their hope was that the CSG would be an intermediary between mainland France and the now restive South American territory.

The mood of the meeting was “very serene,”

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**TIMELINE: FRENCH GUIANA’S SOCIAL MOVEMENT**

**FEBRUARY 11**

Cayenne resident Hervé Tambour is murdered during a robbery at a laundromat, sparking the formation of the 500 Brothers.

**MARCH 17**

The 500 Brothers interrupt the Cartagena Convention in Cayenne to draw attention to poor safety within the territory.

**MARCH 21**

Demonstrators and the 500 Brothers place blockades around the Guiana Space Centre, preventing an Ariane 5 launch.

**MARCH 27**

A territory-wide strike is launched following the formation of blockades at main roundabouts across French Guiana.

**MARCH 28**

An estimated 10,000 to 12,000 demonstrators of all backgrounds protest in French Guiana against insecurity, a languishing economic situation and neglect by French ministers.

**MARCH 30**

Ericka Bareigts, France’s minister of overseas, apologizes to the French Guianese people for not taking into account the magnitude of their concerns, marking the start of negotiations.

**APRIL 4**

Thousands of people march to the Guiana Space Centre. Leaders from the movement met with Didier Faivre, head of the spaceport.

**April 5**

France forms a 1.85 billion aid package for French Guiana. Protestors reject it, demanding 2 billion more.

**APRIL 6**

A police officer is injured during a protest, marking the only known act of violence during the movement. The 500 Brothers, many of them former police officers, prevent further violence from occurring.

**APRIL 16**

Blockades are removed for the Easter holiday. They are restored by the 18th.

**APRIL 21**

The Accord de Guyane is signed, recognizing more of the protestor’s requests. The agreement allocated 1 billion euros to be followed by 2 billion euros over time to improve the security and welfare of French Guiana.

**MAY 4**

Arianespace resumes launches from the CSG.

**JUNE 1**

Arianespace completes all missions delayed by the demonstrations.

Source: Stéphane Granger, University of French Guiana
KERFUZZLE IN KOUROU

"They explained their position. They asked me to forward those messages to my boss in Paris, which I did, and we organized some meetings. In some areas I think our position was very useful," he said.

THE ACCORD DE GUYANE
Residents of French Guiana wanted Hollande to visit the territory, but that didn’t happen. Protests during the height of France’s president elections in April and May had a “very small impact,” according to Granger. French Guiana also rejected a 1.85-billion-euro aid package a day after meeting with Fairev, arguing for 2 billion more.

Through the Accord de Guyane agreement signed April 21, France committed to an aid package of 3 billion euros, starting with 1 billion now and 2 billion in the future. The 500 Brothers, then already starting to fray, and would fragment three days later over internal disagreements.

Arianespace resumed launches on May 4, orbiting a Brazilian satellite and a South Korean satellite on an Ariane 5 rocket. CNES returned the CSG to launch activity eight days after the protests ended, and used time previously allocated for maintenance to catch up on three delayed missions.

“In the space sector, many things are changing during the year, so it is a basic of our business to adapt the maintenance to the customer and not the customer to the maintenance," said Israel.

Arianespace caught up on all delayed launches by June 1, enabling the company to resume the launch schedule set out at the beginning of the year.

NEW UNDERSTANDINGS
Has anything changed with the CSG’s relationship to French Guiana? Faivre said the protests showed CNES it could benefit from communicating more clearly what the agency does there.

“This period has demonstrated that in some areas our duties are not fully understood by the local people, despite the fact that we are here since 1964,” he said. “It is an area of importance for sure.”

France founded the spaceport in South America “not to create a base totally decoupled from the country,” but to plant “a seed of socioeconomic development” in French Guiana while meeting national space goals, he said.

“Second, despite the fact that we cannot be the solution for Guiana — the budget of CNES is less than 200 million euro, when the needs of French Guiana are billions … what we can do is provide some support to the local economy in terms of education, [and] give some funds to help the economy,” he said.

“It is important for space, being a very strong activity in French Guiana, to have deep roots with the population in the territory,” added Israël. “When we make a launch, I think it is possible to have more of the young [French] Guianese people attending… We can see whether we can take more action in the schools, all that in a context where we cannot overspend because we have a difficult competitive environment as everyone knows, but maybe we can be more creative in what we are doing together.”

Granger said there’s been no further unrest since the spring, but warned “it could start again” if France’s newly elected government doesn’t respect the Accord de Guyane. SN
Does standardization drive investor value?

By all accounts, the smallsat market has never been hotter. As many as 6,000 small satellites will be launched in the next decade, according to Research and Markets, and the smallsat market should exceed $30 billion annually over that time frame.

I believe those estimates to be conservative once the true value creation from the data products they enable is widely known.

As the industry matures, however, there could be some natural impediments or accelerators that could impact these forecasts. Industry standards in manufacturing and in-space servicing are possible focal points.

To better understand this, it is best to see how industry standardization has driven value in other industries. Perhaps the most famous example was the national railroad system. When it was first created, railroads were territorial, proprietary and special gauge. This created value at the local level due to local monopolies but limited overall industry growth: no one operator could operate at scale; rail cars and the rails themselves couldn’t be produced in mass to a single standard; and passengers had to interface with different providers in different parts of the country if they wanted to travel or ship at any distance. There was no national connectivity and limited regional connectivity. Costs were high and demand was sluggish.

This all changed once a standard gauge was adopted. In fact, the value creation was so large that the anti-consumer elements were exposed and led to the first anti-trust legislation.

Another recent example of industry standards creating enormous value is the IEEE802.11 standard more commonly known as Wi-Fi. Imagine a world where you would have to configure your computer for a different wireless internet protocol in every city, country and perhaps even every building. Imagine the lost productivity and value that lack of interoperability would entail, not to mention the loss in reliability, security and other qualitative factors. Having a global Wi-Fi standard insured that wireless internet became the standard method of moving one and zeros and led to the explosion of industries such as streaming media.

So what are the analogs in space? I see two obvious ones: standards of manufacturing and standards in design. For example, Altius Space Machines is working on a standardized robotic interface known as a “dog tag” that would allow their proprietary grippers to capture and provide services to smallsats, be that refueling, de-orbiting or perhaps even upgrading smallsats capabilities in orbit. Imagine the possible value creation for the industry if a standardized method was developed and adopted for in-space servicing.

Another example of possible industry standardization is York Space Systems, which is developing an industrial-grade standardized bus system which they claim will both allow for lower price points and enable new data verticals to arise due to the reduced barriers to entry. There are early signs, given recent partnership agreements York has signed, that this bus system could become an industry standard.

There is value in manufacturing standardization as well. OneWeb is tooled up for very large volume manufacturing with a new factory expected to raise the bar for automated satellite manufacturing. If elements of their design was standard, these automated processes could be more readily leveraged by others, decreasing cost and cycle time and potentially benefiting the entire industry long term.

So what is the downside with industry standardization? Typically the arguments are twofold. One is that in a winner-take-all market, being proprietary, differentiated and unique is critical. In the case of smallsats, the differentiation mainly comes from the specialized tech and software within the smallsat envelope, helping to mitigate this concern. Furthermore, really none of the smallsat companies are currently operating at scale. By creating more ways to leverage additional scale, the whole industry should benefit both in terms of value and speed to market.

The second argument against industry standardization is that it stifles innovation; that by conforming around a standard, innovation is no longer the focus. This argument has some merit but only for the elements of design that are being standardized. That is to say, it wouldn’t keep smallsat manufacturers from innovating around other elements of their design that are non-standardized. In fact, one could argue it frees up more resources for companies to innovate around the design parameters that really matter for innovation and differentiation.

In summary, the smallsat market’s massive growth could be accelerated by additional industry standardization. Like in other industries, this standardization would lead to additional value creation in the overall supply chain and enable the industry to achieve additional scale.

The additional value created would benefit companies, customers and investors alike. SN

DYLAN TAYLOR IS A LEADING SPACE ANGEL INVESTOR AND PATRON CHAIR OF THE COMMERCIAL SPACEFLIGHT FEDERATION.
A growing chorus of voices advocate the adoption of norms of behavior for on-orbit space systems. It’s time to ask what are the purposes of such norms and how might they benefit the United States and private-sector commercial companies? Conversely, how might they constrain or harm us if poorly conceived or driven by competitors?

Merriam-Webster defines a norm as “an authoritative standard...a principle of right action binding upon the members of a group and serving to guide, control, or regulate proper and acceptable behavior.”

In the context of space systems, a set of agreed-upon norms of behavior can help guide or convince like-minded governments and companies to adopt and follow certain standards of conduct in the operation of space systems in order to promote predictable behavior and avoid potentially hazardous actions that threaten valuable on-orbit assets and undermine the long-term sustainability of space.

What benefits might attend the establishment of appropriate norms of behavior in space?

First, a U.S.-led effort to establish reasonable and appropriate norms of behavior can strengthen U.S. national security and promote innovative American businesses. We should find value in a coalition of states and companies that share broad interests about space sustainability and that can be relied upon to conduct space operations in predictable ways and benefit all states relying on space capabilities.

Second, a widely adopted set of norms of behavior can serve as a useful counter to Russian and Chinese efforts to promote unverifiable space arms-control measures — measures which are clearly designed to preclude the ability of the U.S. to defend itself against a variety of attacks on its satellites and create strategic advantages for our adversaries.

Third, norms of behavior may help alleviate potential problems associated with the growing number of commercial space systems set to be launched over the next decade. NewSpace companies are planning to deploy constellations of hundreds — and, in some cases, thousands — of satellites, which in turn places a premium on accurate tracking of such systems and predictability in their on-orbit operations. Adoption of and adherence to appropriate norms of on-orbit and de-orbiting behavior can reassure all owners and operators of satellite systems that governments and companies alike will make every effort to act responsibly.

Fourth, an American-led effort aimed at establishing appropriate norms of behavior would reinforce U.S. global leadership in space, at a time when China’s military-run space program is gaining significant momentum. The national security, economic, foreign policy and other benefits of U.S. leadership in space are manifold, and diplomatic measures that underscore U.S. global leadership in space can be particularly beneficial.

Establishment of norms of behavior in space must be closely linked with the fielding of improved capabilities to effectively monitor the location and behavior of on-orbit assets. Here, sophisticated space situational awareness (SSA) capabilities are vital. SSA capabilities can provide important “pattern of life” information about individual satellites, thereby enabling a move from simple acknowledgment of a satellite’s approximate location in space to a detailed understanding of that satellite’s precise position and its typical on-orbit behavior (taking into account that individual satellites can and oftentimes do operate in unique ways). Effective SSA also can help clarify ambiguities and establish predictable patterns of on-orbit operations, thereby improving the timely warning of unusual satellite behavior, reducing the likelihood of collisions, and enhancing the performance of individual space systems or satellite fleets or constellations. In turn, effective SSA helps reduce the risks of miscalculation or misperceptions.
At the same time, however, we must acknowledge that norms of behavior alone cannot solve the problem of the growing vulnerability of U.S. government and commercial space systems. Fundamentally, norms of on-orbit behavior should not be seen as a substitute for effective measures aimed at protecting and defending critical U.S. government and commercial space systems upon which our national security and economic well-being rely. Indeed, the states the U.S. worries most about cannot be said to be particularly impressed or restrained by Western norms. U.S. space systems and architectures must demonstrate greater resiliency in the face of extant and emerging counterspace threats and the U.S. national security establishment must devote greater attention to detecting, deterring and defeating any such attacks.

The United States can and should play the leading role in development, implementation, and monitoring of appropriate norms of behavior for space-faring nations and companies. This is especially true as new private-sector capabilities emerge. Just as the U.S. Navy serves to enforce the principle of safe passage on the high seas, the U.S. government can contribute significantly to making space a safe, predictable, and attractive environment in which to operate.

Still, norms of behavior are by no means a panacea; they have important limitations, including that they will not resolve the issue of the growing vulnerability of space systems. Furthermore, we should expect that some key nation-states (and possibly some companies) will refuse to follow such norms or guidelines. While recognizing such limitations, the U.S. government should work with like-minded states and private sector entities to create a more sustainable space environment for all.

“An American-led effort aimed at establishing appropriate norms of behavior would reinforce U.S. global leadership in space,” the author writes.

Christopher A. Williams is an independent consultant. He previously served in senior department of defense and congressional staff positions. He currently is an adviser to U.S. government organizations. The opinions expressed herein are solely the author’s.
Recent studies have concluded that the collision risk at geostationary orbit (GEO) is orders of magnitude higher than previously thought and today’s services, tools, and data insufficiently mitigate collision risk. Our community must act together decisively to safeguard and preserve the critical geostationary orbital resource for continued safe space operations.

Comprising the world’s leading satellite operators, accounting for over 60 percent of the active geostationary satellite population, the Space Data Association (SDA) leverages its members accumulated technical experience and knowledge to ensure flight safety; legal and technical protections enable fellow operators to efficiently and effectively collaborate. Our experience offering space traffic management (STM) services convinced us that only a next-generation system would provide the required safety of flight improvements.

Our approach is to build that system — the Space Data Center (SDC) 2.0 — in concert with Analytical Graphics Inc. (AGI). SDC 2.0, backed by AGI’s Commercial Space Operations Center (ComSpOC), will provide enhanced STM and Radio Frequency Interference (RFI) mitigation services to SDA members starting in 2018.

Everyone should understand the actual risks associated with operating at the geostationary regime, the potential permanent effects on the space operational environment, and why we must now act to acceptably mitigate these risks. Similar considerations apply at other orbital regimes, particularly in light of announced plans for large non-GEO constellations, where SDA intends to evolve its existing solutions.

SAFETY OF FLIGHT
For SDA, ensuring safety of flight means protecting satellites while also safeguarding the viability of the space environment for the long term. A collision in the geostationary arc could destroy an active spacecraft and create a debris field that could permanently render a large part of that arc effectively unusable. Operators typically agree in principle to preventing such events: Your neighbor’s problem has the potential to become your own enduring operational problem.

For decades, many deemed the risk of a meaningful collision remote — even as new space actors entered fielding more satellites. As we studied the issues our understanding evolved. Our technical team quantified GEO collision risk using five diverse and independent techniques, each of which consistently produced GEO collision risk estimates that are orders of magnitude higher than previously thought.
Everyone should understand the actual risks associated with operating at the geostationary regime, the potential permanent effects on the space operational environment, and why we must now act to acceptably mitigate these risks.

THE CHALLENGES IN SPACE

Satellite operators face major challenges to ensuring the ability to maintain safety of flight. Since 2010, SDA has operated the SDC, an automated system that receives data from SDA satellite operators and government catalogs, conducts analyses, and issues conjunction warnings. SDA collectively tasked member flight dynamics and radio-frequency management teams to define next-generation STM service requirements in light of our operational experience. Following extensive analysis and discussions, we identified the critical STM shortcomings of current operational systems:

1. Limitations in the availability and accuracy of data related to non-member satellites and debris objects, particularly those with sizes in the 20 centimeters to 1 meter range.

Our analysis concluded that a collision with objects as small as 20 centimeters in size could cause a significant debris generating event. However, the current public catalogs typically only include a GEO and GEO-crossing object population of (roughly) 1 meter and above in size. SDA estimates that incorporating these additional objects (between 20 centimeters and 1 meter) alone could account for a 50-percent increase in the number of objects being tracked at or near the geostationary arc. To protect the regime, these objects need to be sufficiently tracked and collisions with them avoided. Similar considerations apply at non-GEO orbital regimes.

In addition, existing public catalogs often fail to effectively and responsibly address orbit changes for objects performing maneuvers. The resulting time lag and inaccuracies following a maneuver frequently introduce days of unacceptable levels of increased operational risk. The increasing population of electric propulsion satellites compounds the situation. They are harder to track since they maneuver more frequently, and their inherently low thrust level means they need more timely conjunction notifications in order to be able to perform meaningful avoidance maneuvers.

SDC 2.0 collision-avoidance services will be based on a high-accuracy and independently generated ComSpOC catalog of objects in and traversing the GEO arc. This catalog will evolve to include all objects larger than 20 centimeters, which we expect will be the most extensive available catalog available for flight safety services. SDC 2.0 uses advanced non-cooperative maneuver detection and characterization algorithms for all active catalog objects ensure the rapid determination of orbits during and after maneuvers. The same maneuver-detection capability will independently audit and verify operator-supplied maneuver plans, ensuring the highest quality of future maneuver information and collision-avoidance products.

2. Operator-specific biases.

All SDA members currently provide data related to their orbits and planned maneuvers into the SDC. Typically, operators use ranging data to estimate their positions. The nature of operator antenna networks makes the removal of absolute ranging biases very difficult, often resulting in kilometers of difference between the estimated and true satellite positions. These biases can only be effectively removed by using independent sensors, sensor networks and/or ‘truth’ reference orbits (e.g. cross-calibrating against the highly accurate ephemerides provided for satellites operating with navigation augmentation payloads). Thus, simply combining operator-provided positional estimates results in a faulty catalog.

The large number of diverse flight dynamics systems used by the operator community yields inconsistencies between orbit estimates, products, formats reference frames, and timing systems. While these differences may appear small, they can have a profound impact when trying to generate a comprehensive catalog to calculate accurate and reliable probability of collision metrics across multiple satellite operator fleets.

To overcome these issues, an effective space situational awareness (SSA) system must validate and calibrate the operator-provided information. This permits operators to remove individual bias measurements, yielding significantly more accurate orbit knowledge. Achieving realistic collision probability estimates and actionable conjunction warnings demands that covariances for catalog objects in turn be realistic. These covariances may also be instrumental in obtaining realistic geo-localization error ellipses. SDC 2.0 unified catalog >
processing eliminates inter-system biases, which is of critical importance for flight-safety warnings.

3. Lack of transparency and consistent availability of public catalog data. Government-provided data has been, and continues to be, crucial for enabling space situational awareness. However, it has its limitations, the most significant being the lack of complete and consistently available data. As the end users of conjunction notifications, operators ideally require assurance that warnings shall be timely, complete, and actionable. Today’s government-provided systems, which provide the public service only as a secondary mission, do not meet this requirement nor do they issue warnings for 20-centimeter to 1-meter objects at GEO. All operators benefit from the public services provided by government professionals, but it is time the operators start treating SSA information in the same way they do for other services required for safe and responsible fleet operations: as a critical, mandatory, audited resource.

SDC 2.0 will use a fully independently generated debris and satellite catalog with system performance level requirements provided under a binding service level agreement with the SDA.

4. Difficulty coordinating information for interference management between satellite operators. The legal and technical framework of the SDA has enabled ongoing communication and data pooling between unrelated, typically competitive operators. However, not every operator is a part of the SDA, and even for those that are, manual processes still delay RFI mitigation. For instance, if a geo-localization is needed to determine the source of RFI and the operator experiencing that RFI does not have within its fleet an adjacent satellite with which to perform the geo-localization, it typically undertakes a lengthy evaluation to determine a suitable neighboring satellite that is compatible and available. Once that neighboring satellite is identified, ephemerides and RF parameters are often required, and the manual exchange and coordination of this data between operators can take several days. This becomes further complicated and delayed by reference emitter availability, time dependence of geo-localization accuracy, and geo-localization equipment availability. A highly automated, machine-to-machine process should reduce the RFI mitigation process from multiple days (if not weeks) to mere hours.

SDC 2.0 includes RFI functionality that will allow the construction of geo-localization scenarios, facilitating higher-accuracy solutions in substantially shorter time frames. This functionality enables machine-to-machine data exchange with SDA member geo-localization systems. A Carrier ID database supports management and coordination of Carrier ID reference numbers, streamlining the process of identifying the interferer and resolving interference.

PROMOTING RESPONSIBLE OPERATIONS
Space is a shared environment and we all have a responsibility to ensure that it is maintained for long-term access and use. SDA members already recognize this and use the best tools and data currently available. However, these come with the limitations previously described. All responsible operators should, at a minimum, ensure:

• Development of and adherence to space standards, best practices and established norms of responsible behavior;
• Reliance on STM systems that always seek the best, most actionable and timely collision avoidance data, techniques and mitigation strategies;
• Collaborative, mutual and transparent sharing of key satellite operations information elements, including planned maneuvers, spacecraft characteristics and RF information;
• Adherence to station-keeping boxes, authorized RF levels and national, international and organizational space debris and RFI mitigation policies and practices.

Naturally, joining the SDA, and more specifically subscribing to SDC 2.0 STM services, will enable operators to achieve these goals. Fortunately, even competing operators from different nations recognize the value of working together. I truly believe that all operators should be part of this initiative if we want to ensure the future of space safety for all. If operators don’t do that, ultimately we jeopardize the very foundation of our activities.
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<td>Space Technology &amp; Investment Forum</td>
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<td>SmartPlane</td>
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*offer not valid for existing subscribers
One of NASA’s biggest planetary science missions is coming to an end. In the early morning hours of Sept. 15, the Cassini spacecraft will plunge into Saturn’s atmosphere, the final act of this long-lived spacecraft. The maneuver is designed to ensure that Cassini, its maneuvering fuel nearly depleted, doesn’t one day crash into and contaminate Enceladus or Titan, two moons that are at least potentially habitable.

Cassini is one example of what the scientific community calls a “flagship” mission. Such spacecraft, which include Curiosity, Galileo and Hubble, among others, can be incredibly powerful, enabling breakthroughs in our understanding of the solar system and the universe. They can also be incredibly expensive, with cost overruns that can jeopardize smaller missions.

Conscious of both the benefits and expense of such missions, NASA approached the National Academies in 2014 to ask them to evaluate what the agency prefers to call “large strategic” missions. Is it really worth spending billions of dollars on a single mission?

That report by an academy committee, released Aug. 24, offered few surprises. To the presumed relief of both NASA and scientists, the committee concluded that flagship missions should continue. Such missions, the final report stated, “have demonstrated some of the greatest science advances and the capabilities of the United States as a leader in scientific discovery and the exploration of space.”

A major emphasis of the report was on managing costs, understandable given the legacy of major overruns on missions like the James Webb Space Telescope. It concluded that new cost-control tools and approaches by NASA have helped JWST stay on track in recent years and avoided problems on other programs.

NASA, though, shouldn’t be complacent. “New technologies will require new methods of estimating costs,” said Kathryn Thornton, the co-chair of the committee and a former astronaut who now runs the aerospace engineering program at the University of Virginia, in a statement about the report. “Although NASA has gotten better at developing such tools, the agency will have to adapt its ways as technology evolves.”

Hand-in-hand with cost control is the need for balance between flagship and smaller missions, a point emphasized throughout the report. The committee recommended that each of NASA’s science divisions — astrophysics, Earth science, heliophysics and planetary science — rely on their individual decadal surveys to figure out what that balance should look like, and what decisions to make when there’s not enough money to do everything those surveys recommend.

That balance may be sorely tested in the next few years, particularly in planetary science. NASA currently has two planetary science flagships under development, the Mars 2020 rover and Europa Clipper. A House appropriations bill would direct NASA to ramp up development of a third, a Europa lander that would launch as soon as two years after Europa Clipper and likely cost even more.

Even more budget pressure could soon follow. Mars 2020 is intended to be the first step in a larger Mars sample-return effort, which will require two more missions: one to launch the samples the 2020 rover collects into Mars orbit and another to return them to Earth. Each will probably be a flagship-class mission. NASA is expected to provide more details on its Mars exploration plans as soon as Aug. 28, when agency officials brief another National Academies committee.

The report doesn’t provide specific guidance on how to plan for this potential wave of flagships and how to keep them from draining funding from smaller planetary missions. As tough as it may be to say goodbye to a flagship like Cassini after a long and successful mission, it may be even more difficult to figure out how to get more of them started. SN
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