AerospaceDaily & DEFENSE REPORT

AVIATION WEEK Intelligence NETWORK

The Business Daily of the Global Aerospace and Defense Industry Since 1963

September 2, 2020

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Responsive Space

Smallsat launch provider Rocket Lab has received a five-year Launch Operator License from the FAA for Electron rocket flights from its Launch Complex 2 at the Mid-Atlantic Regional Spaceport on Wallops Island, Virginia. "Having FAA Launch Operator Licenses for missions from both Rocket Lab launch complexes enables us to provide rapid, responsive launch capability for small satellite operators," CEO Peter Beck says. "With our upcoming missions from Launch Complex 2, we're ushering in an era of even more flexibility and launch availability."

Daily Briefs

LOCKHEED MARTIN has $183.2m U.S. Army contract for M142 High Mobility Artillery Rocket System launchers.

LEIDOS INC. has $35.8m U.S. Army contract for special mission Mi-17/PC-12 aircraft fleets supporting Afghanistan.

SOUTH KOREA's defense ministry seeks record 52.9 trillion won ($44.72 billion) defense budget next year (5% increase), with boosts to personnel training, maintenance.

BELGIUM formally retired IAI RQ-5 B-Hunter UAV from Belgian military service Aug. 28.

ALLIANT TECHSYSTEMS has $81m U.S. Navy contract for new technology to increase capability of Advanced Anti-Radiation Guided Missile family.

FUNDING & POLICY

Chinese ICBM, Sensor Moves Suggest Nuke Posture Shift, DOD Says

STEVE TRIMBLE, steve.trimble@aviationweek.com

China may be shifting to a "launch on warning" posture for nuclear attack with a possible expansion of silo-based intercontinental ballistic missiles (ICBMs) and development of a space-based early warning capability, a new U.S. Defense Department report warns.

Nuclear weapons figured prominently among the revelations contained in the Pentagon's latest annual report on China's military capabilities, which was released Sept. 1.

Commercial imagery last year showed that China has constructed a silo on a Western training range with dimensions too small to support the DF-5 ICBM, and the report concludes the silo is "probably" being used to develop a concept of operations for adapting the road-mobile DF-41 ICBM to a silo launch system.

Further, Russia has agreed to help China develop an early warning system for missile attack, the report says. A potential development of space-based sensors would augment an existing ground-based network of large phase array radars similar to the U.S.-operated Precision Acquisition Vehicle Entry Phased Array Warning System.

The combination indicates a possible intent to develop a launch-on-warning posture for nuclear weapons, the report says.

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ICBM, From P. 1

Open source estimates of China's nuclear stockpile have ranged from 200 to 400, but the Pentagon's new report is the first in the annual series to include a U.S. military estimate.

"Over the next decade, China's nuclear warhead stockpile—currently estimated to be in the low 200s—is projected to at least double in size as China expands and modernizes its nuclear forces," the report states.

As the stockpile grows, China's nuclear enterprise also is diversifying. Adding to previous reports about the role of H-6N bomber unveiled last year, the Pentagon's analysts concluded the aircraft will be able to carry a nuclear-armed air-launched ballistic missile.

The report also describes new developments in China's conventional weapon capabilities. Previous versions of the annual assessment were silent on the size of China's inventory of DF-26 intermediate-range ballistic missiles (IRBMs), but the latest version sets the current stockpile at 200 launchers and more than 200 missiles.

At the same time, the report also downplayed the US military's assessment of China's inventory of short-range ballistic missiles, which declined from a range 750-1,500 missiles in last year's report to "over 600."

The Pentagon's annual report also offered new details of the Pentagon's assessment of China's anti-satellite capabilities.

"China has an operational ground-based Anti-Satellite (ASAT) missile intended to target low-Earth orbit satellites, and China probably intends to pursue additional ASAT weapons capable of destroying satellites up to geosynchronous Earth orbit," the report says.

That statement is likely a reference to the interceptor for the HQ-19, which is roughly equivalent to the Terminal High Altitude Area Defense system. China also is known to have tested the SC-19 as a direct-ascent ASAT weapon.

Fleet Snapshot: Chinese Combat Aircraft 2020

Family	Type	Current Fleet
People's Liberation Army Air Force		
J-10	J-10A	218
	J-10B	55
	J-10C	132
	J-10S	46
J-20	J-20	36
	J-20A	2
JH-7	JH-7A	137
MiG-21 (J-7/8)	J-7 II	100
	J-7E	126
	J-7G	72
	J-8B	6
	J-8DH	46
	J-8F	48
	JZ-8F	24
Su-27	J-11A	105
	J-11B	107
	J-11BS	64
	J-16	92
	J-16D	4
	Su-30MKK	74
	Su-35S	24
H-6*	H-6H	48
	H-6K	94
	H-6M	28
	H-6N	4

Family	Type	Current Fleet
People's Liberation Army Navy		
J-10	J-10AH	16
	J-10SH	6
JH-7	JH-7	52
	JH-7A	71
MiG-21 (J-7/8)	J-8F	24
	J-8H	24
	JJ-7	100
	JZ-8F	4
Su-27	J-11B	40
	J-11BS	36
	J-15	41
	J-15T	1
	Su-30MK2	24
H-6*	H-6G	24
	H-6J	8
Grand Total		2163

***Note:** H-6 figures do not include tanker derivatives in PLAAF or PLAN service.

Source: Aviation Week's Fleet Discovery Database. To learn about our fleet data products and services, go to: pgs.aviationweek.com/FleetDataServices

Prepared by Matt Jouppi and Sam Archer

PROGRAMS

MAD FIRES Takes Next Step With Gun-Fired Missile Interceptors

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Raytheon will focus on developing the seeker for a naval gun-fired, guided missile interceptor under a $32.5 million order announced by the Defense Department (DOD) on Aug. 31.

The award opens Phase 3 of the Multi-Azimuth Defense Fast Intercept Round engagement System (MAD FIRES) program.

The Defense Advanced Research Projects Agency launched MAD FIRES to demonstrate that a rapid-firing naval gun could be used for a ship's self-defense against swarms of incoming cruise missiles.

The MAD FIRES interceptor would be fired out of a gun barrel, but unlike an unguided artillery round, can home in on an incoming missile and destroy it.

The new contract raises the overall value of the program to $100 million, according to the DOD.

Over the next 27 months, Raytheon will make improvements to the projectile developed during Phase 2. The company also will develop a functional illuminator and engagement manager, the DOD said. The combined projectile and seeker then will be used to engage, and if it works, defeat a representative target missile.

Phase 3 should be completed by November 2022, the DOD said.

OPERATIONS

Norway Begins SAR Operations With AW101

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Norway has inducted its fleet of Leonardo AW101 search-and-rescue (SAR) helicopters into service.

Sixteen AW101s are being purchased as part of the Norwegian All-Weather Search and Rescue Helicopter (NAWSARH) requirement that will see the three-engine helicopter replace the Westland-built Sea King, which has been in service since the early 1970s.

Norwegian government officials declared the AW101 as being in service on Sept.1, with a base at Sola near Stavanger becoming the first facility with the aircraft to become operational. Officials also announced that the AW101 would be named the "SAR Queen," in Norwegian services.

"The first of our new rescue helicopters have finally been put into operation," Norwegian Prime Minister Erna Solberg said. "With that, the rescue service has received a significant boost—both over sea and land."

The AW101s have better range, speed and improved performance in poor weather over the Sea King," officials stated.

Eight of the 16 helicopters have been delivered to Norway and three more will be delivered during the fall. All the helicopters will be in service in 2022, although their introduction to service could be impacted by the coronavirus pandemic. Delivery of the first aircraft was marred by an incident that saw the helicopte tip onto its side during a ground run in November 2017, meaning it had to be sent back to Leonardo for a rebuild.

The AW101s—built by Leonardo at its Yeovil, England, facility—are delivered in the Mk. 612 configuration, which includes the installation of the Leonardo-developed Osprey flat-panel active electronically scanned array radar installed into the nose and rear of the landing gear nacelles. This solution eliminates the need for a belly-mounted radar that could be damaged if the helicopter had to land in snow or rough terrain. The helicopter also is equipped to locate people using the signal from their cell phone, even when outside the area of cell tower coverage. The Norwegian configuration also has been selected by Canada to form the basis of a mid-life update for the country's CH-149 Cormorant SAR helicopters.

The new helicopters were ordered and funded by the Norwegian Ministry of Justice and Public Security but are flown by crews from the Royal Norwegian Air Force.

The NAWSARH program originally began in conjunction with Iceland, which would have bought an extra three helicopters to support its SAR requirements. But Iceland pulled out of the program in September 2012. The-then Eurocopter and AgustaWestland were shortlisted in July with their H225 and AW101. Other bidders were NHIndustries, offering the NH90, Sikorsky, offering the S-92, and Bell-Boeing, proposing a SAR version of the V-22 Osprey tiltrotor.

BUSINESS

Cubic Consolidates Defense Businesses, One Exec Departs

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Military training and C4ISR services provider Cubic has merged two defense business units into one, with one of the former unit chiefs planning to leave the company.

The consolidation, announced Aug. 28, combines Cubic Mission Solutions (CMS) with Cubic Global Defense (CGD) to form a new Cubic Mission and Performance Solutions segment under Michael Knowles, who led CGD. He joined Cubic in 2014 from Rockwell Collins and previously worked at Lockheed Martin. Michael Twyman, a senior vice president and president of CMS since 2016, will leave the company, Cubic said.

After the reorganization, Cubic's two business segments are Cubic Transportation Systems and Cubic Mission and Performance Solutions. The transportation unit is a major provider of public transit farecard and payment services worldwide.

"Cubic's unwavering commitment to 'winning the customer' requires us to continually evaluate our business structure and organize our talent and resources in a manner that best serves our customers," Chairman, CEO and President Brad Feldmann says. "This aligns with our key priority of 'Living One Cubic,' an ongoing dedication to effectively share resources across the company to achieve superior talent management, absolute customer focus, customer-centric innovation, cost-effective enterprise systems and impeccable ethics."

Both Cubic executives and financial analysts have remained confident in the company's defense prospects. Earlier in August, the company touted several recent multiyear awards, including a position on the $950 million U.S. Air Force Advanced Battle Management System, and a $38 million contract to deliver a High Capacity Backbone prototype, along with a $99 million U.S. Navy contract for Surface Training Immersive Gaming and Simulations. Cubic estimated COVID-19 had caused up to $41 million in lost sales and up to a $14 million hit to adjusted pretax earnings.

PROGRAMS

Lockheed, York Space Systems Win First SDA Contracts

LEE HUDSON, lee.hudson@aviationweek.com

Lockheed Martin and York Space Systems have 30 days to begin work on the first-ever contract for the National Security Space Architecture.

The duo won firm-fixed price contracts for the Tranche 0 Transport Layer, which consists of 20 satellites that will feed into the U.S.'s missile warning system. Lockheed Martin received approximately $187 million to build 10 satellites, while York Space Systems was awarded roughly $94 million. The plan is for 20 satellites to launch at the end of fiscal 2022, Space Development Agency (SDA) Director Derek Tournear told reporters Aug. 31.

SDA hosted a virtual industry day April 2, followed by a solicitation release May 1, and awarded contracts Aug. 31. Tournear said each vendor agreed to meet 10 payment milestones. These deliverables include program kickoff, preliminary design review, critical design review and progressing toward flight. Each company must complete all 10 milestones, but at different cadences, he said.

"As it stands, we rewarded them based completely on the technical merit and what we thought was their ability to be able to make schedule and provide a solution, and price was factored into those evaluation criteria" that were issued with the request for proposals, Tournear said.

Both Lockheed Martin and York Space Systems submitted a complete technical solution that includes different optical link providers, he said.

SDA issued an interface control document outlining the optical communications standard that was part of the solicitation.

Lockheed Martin and York Space Systems will demonstrate the optical links are interoperable using a government reference system that is being developed and run by the Naval Research Laboratory.

"That is our method to prevent any kind of vendor lock because we want to ensure that we have an open architecture standard that anyone could build an optical crosslink to be compatible with," Tournear said.

BUSINESS

Shell, DJI Partner To Develop Drone Inspection Technology

BILL CAREY, bill.carey@aviationweek.com

Shell Oil Co. and drone manufacturer DJI announced a partnership to develop new methods for industrial inspections at Shell's Deer Park Manufacturing Complex in Texas.

The companies will work together to develop advanced features such as an "AI Spot-Check" tool that combines visual machine learning capability with real-time kinematics (RTK). An RTK system corrects a drone's GPS position as it flies with a known secondary position reference on the ground to produce centimeter-level position data.

"Shell Deer Park is excited to become a Solution Development Partner with DJI as we continue to adopt drone technology," said John McClain, Shell chief drone pilot. "Through this partnership, Shell Deer Park will have access to some of the most advanced drone technology from DJI to help elevate workplace safety and improve efficiency across our operations in the world's largest industry."

Shell started using DJI's consumer-grade Phantom 4 and higher-end Inspire 1 quadcopters at the Deer Park complex, an oil refinery and chemical plant located 20 mi. east of Houston, in 2016. The company's drone fleet now has DJI commercial models including the Matrice 300 (M300) RTK with Zenmuse H20 multisensor payload.

The forward-fitted H20 payload is configured with wide and zoom cameras and an integrated laser rangefinder that measures distance to 1,200 m (3,937 ft.). Shell is using the M300 and H20 to conduct automated inspections of critical infrastructure that can be difficult to assess from ground level, such as flare tips and floating roof tanks—open-topped cylindrical structures used to store oil.

"Shell has provided us with valuable insight into the unique challenges of conducting aerial inspections at one of its largest facilities, where infrastructure exceeds the height of 250 ft. off the ground," said Cynthia Huang, DJI director of business development.

"Through our collaboration, DJI will receive valuable firsthand insight into the complexities of deploying drone technology at a world-class refinery, and co-develop new product features like AI Spot-Check that will allow Shell and other innovative energy companies to use drones to safely and easily conduct required inspections of critical infrastructure."

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Published daily except Saturdays, Sundays and holidays by Aviation Week, 2121 K Street, NW, Suite 210, Washington, DC 20037. (ISSN No. 0193-4597). Gregory Hamilton President, Aviation Week.

Vol. 273 • No. 42

AVIATION WEEK NETWORK
an informa business

FUNDING & POLICY

Exploring The Challenge Of A Commercial ISS Successor

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HOUSTON—When the national spotlight turns to NASA, it's often focused on the White House directive to return human explorers to the Moon's surface by 2024.

But NASA Administrator Jim Bridenstine and others are attempting to make it clear that the International Space Station (ISS), which will mark 20 years of a continuous human presence in November, still has the potential to light up a high-tech low Earth orbit (LEO) economy and support humanity's reach into deep space.

The challenge for national leadership and Congress is coming to an agreement on whether to authorize NASA-led ISS operations with major partners from Russia, Europe, Japan and Canada beyond 2024 while investing in a private sector alternative to the orbiting science lab. Such an alternative would need to meet the agency's own Moon/Mars research and development needs while nurturing an expanding space economy once the ISS reaches the end of its operational life.

"The ISS is an amazing tool," Bridenstine told the Aug. 27 opening session of the virtual 2020 ISS Research and Development Conference. "Of course, where we are right now is that we are going to utilize it to the maximum extent possible for however many years we have left. We don't know when it's going to end. We know it can't last forever. But between now and that day, we have to maximize its utility."

Much of the conference's theme was on how to avoid prematurely walking away from a more than two-decade, $100 billion global investment in the ISS, which has housed 240 different astronauts from 19 different countries and supported more than 3,000 science and technology initiatives backed by researchers from 108 countries.

"It will not be a turn-the-light-switch kind of situation," Phil McAlister, NASA's director of commercial spaceflight programs, told the forum. "It will be a gradual transition."

However, that's only if there is not a sudden, catastrophic loss, he acknowledged.

The conference featured a handful of experts with distinctive administrative and commercial ties to the ISS. They discussed current thinking on how to execute a successful transition to private sector oversight, with financial support from the investment community and NASA.

Among them was McAlister, who highlighted the agency's success in enabling the development of ISS commercial cargo and, most recently, commercial crew transportation services. In early August, SpaceX successfully completed a two-month Demo-2 test flight to the ISS with two astronauts as part of NASA's Commercial Crew Program, setting the stage for regularly scheduled commercial crew launches beginning in late October.

Commercial crew missions promise to increase the number of astronauts assigned to the ISS U.S. segment from three to four. This will raise the anticipated number of crew hours available each week for research and technology to 70 hr., a new high. Boeing is working to certify its CST-100 Starliner and begin regularly launching astronauts by the end of next year.

"Our strategy in my opinion is that we have to have safe, reliable and cost-effective free-flier platforms that are privately owned and operated," McAlister said. "That needs to be the focus of our near-term commercialization strategy. The thing I've learned in

ISS, P. 8

PROGRAMS

Perlan Plans Climate Science Role Expansion With New Sensor

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LOS ANGELES—The Airbus Perlan Mission II stratospheric glider project plans to dramatically expand its role in atmospheric and climate research by incorporating new sensors and working collaboratively with other high-altitude investigation agencies, companies, assets and projects.

As an initial step the Perlan 2 glider, which on Sept. 2, 2018, set a new world altitude record of 76,124 ft., will shortly be fitted with a radio occultation device to provide temperature and water vapor data in the upper atmosphere. The sensor, developed as part of Project Monark, an advanced global weather sensing initiative run by Silicon Valley-based innovation group Airbus A^3 (A-cubed), will collect data by measuring and analyzing differences in signal refractivity from GPS satellites.

Although the Perlan project originally aimed to spend 2020 continuing envelope expansion to a planned maximum operating altitude of 90,000 ft., these plans were put on hold by the COVID-19 pandemic. Instead, "the transition we're going through is moving from flight testing to becoming a reliable scientific platform," Perlan CEO Ed Warnock says.

"We are zero emissions and we are steerable. We can fly at sufficient speeds that we can penetrate upwind in the upper atmosphere and it makes the Perlan a unique scientific platform," Warnock says. "We are combining what the Perlan can do with the Egret aircraft [the Grob G 520 high-altitude turboprop used to tow the glider to higher release altitude]. which can carry 850 kg [1,900 lb.] of additional instrumentation and fly at over 50,000 ft. It can fly in the same area as the Perlan is flying, so we can have a double approach."

The Perlan also will operate in tandem with Canadian-based Stratodynamics Aviation, a company that in partnership with unmanned vehicle and autopilot specialist UAVOS in 2019 successfully demonstrated deployment of a stratospheric HiDRON UAV from a balloon at more than 111,000 ft. Together with the Egret, the combination could make "for a swarm of instrumentation," Warnock says. "We think we can pull together a cluster of scientific capabilities that is unique, and we're starting to advertise that for the science community around the world."

Perlan meteorologist Elizabeth Austin says the Monark sensor will be a key step toward understanding climate change and will aid in forecasting. "Water vapor is the most important greenhouse gas and it has tremendous variability. We don't have a good handle on measuring water vapor in the stratosphere at all and that has a huge impact on not just climate models but weather models."

The tests also could pave the way for broader installation of similar sensors on commercial aircraft as part of upgrades to the continuous global weather sensing system already in use, she says. "What I think Airbus envisions with these sensors is to eventually have them on all sorts of commercial aircraft, so that we are getting lots of data to feed into the weather and climate models," Austin adds, pointing to the growing importance of the global collection of weather data by commercial aircraft. This is reflected in the drop-off in forecasting accuracy during periods of reduced civil air activity such as after Sept. 11, 2001, and during the ongoing pandemic.

Austin adds that the partnership with Stratodynamics will enable Perlan and HiDRON gliders to carry identical instrumentation suites that will allow cross comparisons and verification of sensors, as well as collection of data to verify the predictive accuracy of the weather research and forecast (WRF), a widely used model supported by the U.S. National Center for Atmospheric Research.

Meanwhile, preparations continue toward a resumption of flight test programs in 2021, the first of which could be a three-month atmospheric sensing campaign over the Sierra Nevada mountains in the U.S. starting in February. The program, which also would involve NASA if funding is secured, will be followed by the next phase of testing in Argentina, which is due to run from July to September.

During these flights, which will resume the attempt to reach the highest altitudes ever achieved in a piloted, unpowered aircraft, "the biggest challenge will be the change in true airspeed," Perlan chief pilot Jim Payne says. "As the density decreases as you go to higher altitude, the true airspeed has to go up. At 90,000 ft., the true airspeed is 6.7 times the indicated airspeed, and at 76,000 ft. it's about 4.5 [times]. So this causes the turn radius to be larger, and of course we are getting closer to our 'coffin corner' [a region of flight where the stall speed of a subsonic aircraft is near the critical Mach number].

"At 90,000 ft. our stall speed will be 40 kt. indicated airspeed and our maximum airspeed will be 54 kt. indicated, but that's a huge difference in true airspeed. So, as a pilot, we'll just be focusing ever harder on maintaining accurate airspeed somewhere around 48 kt. indicated airspeed so we get a little margin on both sides," Payne says.

BUSINESS

FAA OKs Amazon Part 135 Drone Deliveries

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E-commerce giant Amazon said it has received air carrier certification of its Prime Air drone delivery service from the FAA, making it the third U.S. company the agency has approved to deliver packages by drone.

Amazon Prime Air received Part 135 air carrier certification from the FAA on Aug. 29. The Seattle-based company explained that it does not plan to begin commercial deliveries imminently, and it did not identify where it will launch a drone service.

Alphabet Wing in April 2019 became the first proponent of a drone delivery system to obtain a Part 135 certificate from the FAA; the authorization allows it to transport packages by drone in Christiansburg, Virginia. The FAA awarded UPS Flight Forward a broader Part 135 Standard certification the following September. UPS conducted the first drone delivery flight with the certificate on Sept. 27 at the WakeMed Health campus in Raleigh, North Carolina.

Wing's original Part 135 single-pilot authorization was expanded to a Standard certification in October 2019, the FAA said.

Amazon's ambition to deliver packages by drone was revealed during a "60 Minutes" segment featuring CEO Jeff Bezos in December 2013. Since then, it has closely guarded information about the development effort. In 2016, the company hired former Alaska Airlines captain and Air Line Pilots Association national safety coordinator Sean Cassidy as its director of safety and regulatory affairs to interact with the FAA.

In a notice published in the Federal Register in August 2019, Amazon sought exemptions from the FAA to operate a Part 135 delivery service. A petition letter accompanying the notice and signed by Cassidy revealed that Amazon had started a type certification program for its MK27 drone with the FAA in 2017.

The letter described the MK27 as a battery-powered, shrouded, six-rotor drone with a maximum gross takeoff weight of 88 lb. that is capable of vertical takeoffs and landings and wing-borne flight. The craft is designed to carry an internal payload of 5 lb. to a roundtrip range of 15 nm.

In its latest announcement, Amazon described its delivery drone as fully electric and shrouded, with an "industry-leading" detect-and-avoid system. The company's goal is to deliver packages to customers in 30 min. or less from the time they order.

"This certification is an important step forward for Prime Air and indicates the FAA's confidence in Amazon's operating and safety procedures for an autonomous drone delivery service that will one day deliver packages to our customers around the world," Amazon Prime Air VP David Carbon said. "We will continue to develop and refine our technology to fully integrate delivery drones into the airspace, and work closely with the FAA and other regulators around the world to realize our vision of 30-minute delivery."

BUSINESS

Schiebel, Equinor Demo Offshore Platform Delivery

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Schiebel's Camcopter has flown to an offshore oil-and-gas platform to prove the rotary-wing unmanned aircraft systems (UAS) could be used for offshore delivery.

The offshore industry has been looking at alternative, more cost-effective means of urgently delivering parts to offshore platforms than by using manned helicopters.

The two companies claim the demonstration is the first UAS delivery to an operational offshore platform.

The demonstration, in conjunction with Norway's Equinor energy company, saw the Camcopter fly from the shore at Mongstad, near Bergen, to the company's Troll A platform.

The UAS flew 55 nm, performing a brief search-and-rescue mission using its onboard electro-optical camera before delivering an additively manufactured part to the platform. The 100-kg (220-lb.) Camcopter was then used to perform an aerial inspection of the platform before departing back to Mongstad.

"Drones could reinforce safety, boost production efficiency and contribute to lower CO2 emissions from Norwegian oil and gas," said Arne Sigve Nylund, Equinor's executive vice president for development and production in Norway.

The trial was performed in conjunction with Nordic Unmanned, a Norway-based drone services company, Norway's Civil Aviation Authority, Avinor Air Navigation Services and the Norwegian Communications Authority.

According to Equinor, UAS will also play a role in new energy solutions on the Norwegian Continental Shelf. The systems can inspect wind turbines, deploy equipment to be used by personnel performing maintenance and repairs, and deliver critical parts.

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overseeing both crew and cargo is that they take longer than you expect. So we have to get going now. Obviously, we have some budget challenges."

He pointed specifically to the $15 million Commercial LEO development budget line in NASA's 2020 budget, down from $40 million in 2019. The agency is seeking $150 million in its 2021 budget request, a step toward a goal of $200 million annually by 2023 and after.

"We need to do a better job there in telling our story," McAlister said.

In late February, NASA announced a potential $140 million, seven-year agreement with Axiom Space, a Houston-based startup, to initiate the development of a free-flying commercial station by docking at least one habitable module to the ISS U.S. segment Harmony module in 2024. Axiom plans to initiate the assembly of a free flier with up to four modules visited by commercial astronauts and prepared to depart as a free flier at the station's end of life.

As part of a strategy outlined in June 2019, NASA committed to supporting two commercial astronaut missions to the ISS annually, starting prior to 2024 and lasting up to 30 days.

NASA also was planning to select an actual commercial free flier research platform without a tie to the ISS but ended up holding back on a solicitation, according to Angela Hart, NASA's LEO commercialization manager.

"It's still a very important part of that overall strategy. We are re-evaluating how we want to do that solicitation. So we will be doing that in the future," Hart told the conference without providing additional details.

It seemed clear as the conference discussions continued that NASA infrastructure and budgets are deemed an essential catalyst in a challenging transition.

"We see a number of things along the way that we think would help build the LEO economy we want," said Mike Suffredini, Axiom co-founder, president and CEO. He also served as NASA's ISS program manager from 2005 until his retirement from the agency.

"In terms of the U.S. government, we are still challenged a little bit by the amount of money that is available to NASA and other government agencies to help push the effort along," Suffredini said. "The ISS program is funded, but there are other line items that are challenged like the LEO commercialization line that we need to work together with the agency to help explain to the government why this is important to transition from where we are to where we are trying to go."

Suffredini predicts a bright future for products with terrestrial applications that are manufactured in the absence of gravity. Examples discussed during the forum included artificial retinas to address human eyesight deficiencies and fiber optics for high-data-rate communications, two projects backed by LambdaVision and Made In Space and already underway on the ISS.

"I think manufacturing in space will be huge," Suffredini said.

With specific tax incentives, corporate board rooms across the U.S. and around the world will begin to seriously assess how more research and development, if not production, can be enhanced with access to LEO space platforms, Suffredini believes.

"The LEO economy is absolutely real and will develop and grow over time," Carissa Christenson, Bryce Analytics and Engineering CEO and a leading space economist, told the conference. "The big question is how soon."

Christenson emphasized the value of the ISS in providing access at modest scale to those interested through NASA and its international partners and the U.S. National Lab assets on the station available to other government agencies, academia and the commercial sector.

"One of the critical enablers for growth is to get more and more companies, researchers and innovators to easily have access to small ways of in-space experimentation," Christenson explained. "It's a funnel and you want to make the top end of that funnel really, really large. Before we see scalability at the bottom of the funnel, we need to see scalability at the top."

Though the global coronavirus pandemic has limited the cash available for near-term investment in space commerce, that capital has been preserved and is likely to resurface, she believes.

Richard DalBello, vice president of business development and government affairs at Virgin Galactic, urged the conference audience to consider whether greater access to commercial suborbital spaceflight might also serve to enlarge the funnel's top. DalBello was also an assistant director of space and aeronautics in the White House Office of Science and Technology Policy during the Obama administration.

Noting that both Virgin and suborbital competitor Blue Origin could be launching next year, DalBello suggested a taste of LEO microgravity from suborbital space could be a stepping-stone for a wide range of prospective investors.

"The ISS is the goal, and it's costly, complicated and requires lots of reviews," DalBello said. "Whereas, the suborbital will offer the opportunity to fly repeatedly, short duration and often. You will see more suborbital, which will lead to more demand for the ISS."