AerospaceDaily & DEFENSE REPORT

AVIATION WEEK Intelligence NETWORK

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

August 10, 2020

Inside:

PROGRAMS
Russian Special Forces' Mi-8AMTSh-VN Starts Flight Tests ..... PAGE 2
South Korea Unveils Prototype KF-X Radar ..... PAGE 3

OPERATIONS
SpaceX Resumes Starlink Deployments ..... PAGE 3

FUNDING & POLICY
Senators Draft Bill To Prohibit Certain UAS Exports ..... PAGE 4

TECHNOLOGY
Collins Close To Air Combat Training System Deal ..... PAGE 5
In-Situ Resources, 3D Printing Seen Enabling Deep-Space Exploration ..... PAGE 6

FLEET SNAPSHOT
North Korean Air Force ..... PAGE 8

Staying Nimble

The U.S. National Reconnaissance Office is pursuing an "integrated hybrid architecture" for its constellation of intelligence-gathering satellites, according to Director Chris Scolese. "This approach to our constellation leverages the unique capabilities of our larger satellites with smaller proliferated satellites that provide mission augmentation, regional emphasis and reconstitution, [and] commercial satellites that enable us to meet mission needs with unclassified, sharable imagery and allow us to reserve our national assets for the most sensitive missions," Scolese said during a kickoff even for this past week's virtual Small Satellite Symposium.

Daily Briefs

FAA awarded $3.3m in research, education and training grants to universities comprising the Alliance for System Safety of UAS through Research Excellence (ASSURE).

LOCKHEED MARTIN has $65.3m U.S. Navy contract for fiscal 2020 Aegis modernization, new construction of guided missile destroyers and Foreign Military Sales production for Spain, Japan.

ELBIT Hermes 900 UAV destined for the Swiss Army crashed in Israel during Aug. 6 test flight.

LOCKHEED MARTIN has $20.6m U.S. Navy contract for 30P05 capability upgrade materials for F-35 customers.

BALL AEROSPACE has $9.7m U.S. Air Force contract for Defense Experimentation Using Commercial Space Internet (DEUCSI) effort to establish ability to communicate with Air Force platforms via multiple commercial space internet constellations.

FUNDING & POLICY

Space Force, NRO Stick With ULA, SpaceX For Launch Services

LEE HUDSON, lee.hudson@aviationweek.com
IRENE KLOTZ, irene.klotz@aviationweek.com

WASHINGTON and CAPE CANAVERAL—The U.S. national security space agencies will stick with incumbents United Launch Alliance (ULA) and SpaceX for medium and heavy-lift launch services over the next five years, Air Force acquisition chief William Roper said Aug. 7.

The contracts awarded to the two companies are worth a combined $653 million, Roper told reporters via Zoom.

Concurrent with the firm-fixed-price, indefinite delivery requirement contracts, ULA was assigned missions USSF-51 and USSF-106, scheduled for launch in the second and fourth quarters of fiscal 2022, respectively.

SpaceX will fly USSF-67, scheduled for launch in fourth quarter 2022, under a contract worth $316 million, Roper said. ULA's task order is worth $337 million.

All three missions are classified, Roper added.

Over the next five years, ULA and SpaceX will divide an estimated 32-34 launches 60-40, according to the selections made under the National Security Space Launch Phase 2 Launch Service Procurement—the first such solicitation since 2005.

The program is designed to end dependence on Russian rocket engines for launches

SPACE FORCE, P. 2

SPACE FORCE, From P. 1

of U.S. military satellites, reduce launch costs and spur competition for current and future national security space launches.

In addition to ULA and SpaceX, Northrup Grumman and Blue Origin submitted Phase 2 proposals.

Roper declined to provide details about the bids, including how closely the proposals were scored.

"We are disappointed by this decision. We are confident we submitted a strong proposal that reflected our extensive space launch experience and provided value to our customer, and we are looking forward to our debriefing from the customer," Northrop Grumman wrote in an email to Aerospace DAILY.

In a separate statement Blue Origin said, "We are disappointed in the decision that New Glenn was not selected... We submitted an incredibly compelling offer for the national security community and the U.S. taxpayer. Blue Origin's offer was based on New Glenn's heavy-lift performance, unprecedented private investment of more than $2.5 billion, and a very competitive single basic launch service price for any mission across the entire ordering period.

"We are proceeding with New Glenn development to fulfill our current commercial contracts, pursue a large and growing commercial market, and enter into new civil space launch contracts. We remain confident New Glenn will play a critical role for the national security community in the future due to the increasing realization that space is a contested domain and a robust, responsive, and resilient launch capability is ever more vital to U.S security," the company said.

Blue Origin will be providing the BE-4 engines for ULA's Vulcan rockets.

PROGRAMS

Russian Special Forces' Mi-8AMTSh-VN Starts Flight Tests

PIOTR BUTOWSKI, butowski@post.pl

GDANSK, Poland—The new Mi-8AMTSh-VN military helicopter intended for Russian special forces has started flight tests, Rostec Corp. subsidiary Russian Helicopters says.

The first stage of evaluations will run through November, according to a late July message from Anatoly Serdyukov, industrial director of Rostec's aviation cluster. "In the future, two more helicopters of this type will join the flights," he said.

This is quite surprising, because the same helicopter, under the export designation Mi-171Sh-VN, has already been presented twice at the MAKS exhibition in July 2017 and again in September 2018. During MAKS, Leonid Belykh, CEO of the Ulan-Ude plant that produces these helicopters, said, "The helicopter is ready for flight tests and subsequent delivery to customers."

In June 2019, the Russian defense ministry ordered 10 Mi-8AMTSh-VN helicopters to be delivered in 2020-2021, making a mid-2020 start to test flights even more surprising.

The Mi-8AMTSh-VN (Mi-171Sh-VN) is framed as reflecting the experiences of the Syrian campaign. In fact, it is an extension of the line of counterinsurgency helicopters launched in the late 1990s by order of the Federal Security Service (FSB), to detect and destroy small rebel groups in Chechnya and Dagestan.

The first helicopters Mi-8MTKO and Mi-8GU had limited combat capability (unguided weapons) and were used for surveillance and target indication only. After several months of operations in Chechnya, the effectiveness of pure reconnaissance helicopters had been considerably reduced.

The helicopter designated the targets to artillery, which opened fire a few minutes later after allowing the helicopter to fly to a safe distance. The rebels were generally capable of moving to a safer location. The next Mi-8MN and MNP versions received Ataka anti-tank guided missiles (ATGM) for independent attack, and the OPS-24N day and night electro-optical aiming system.

The current Mi-8AMTSh-VN is being built as part of the Sapsan, or Peregrine, research and development program. It has many new features compared to the previous Mi-8MN/MNP variants. The main transmission gearbox is upgraded. It has a new main rotor with composite blades and an X-type tail rotor that were taken from the Mi-171A2 helicopter, the latest version of the Mi-8 family. Likewise, the newest ones available are the Klimov VK-2500-03 "hot and high" turboshafts producing 1,790 kW (2,400 shp) at takeoff and 2,013 kW (2,700 shp) in emergency mode.

The "V" in the helicopter's designation is for Vysotnyi, or high altitude. As a result, the cruising speed can reach 162 mph (260 km/hr.) and a maximum speed of 174 mph (280 km/hr.), 19 mph more than previously, and the maximum takeoff weight has been increased from 13,000 kg (28,660 lb.) to 13,500 kg.

The helicopter's guided weapon system was taken from the latest version of the Mi-35M combat helicopter, with the 9M120-1 Ataka-VM ATGMs guided by a laser. The laser missile guidance system has been added specifically to direct missiles in the OPS-24N-1L targeting payload.

The pilot has an opto-electronic GOES-321MK turret and can use night vision goggles. In addition to the Ataka ATGMs, the

MI-8AMTSH-VN, P. 5

PROGRAMS

South Korea Unveils Prototype KF-X Radar

KIM MINSEOK, themaxium@gmail.com

BRADLEY PERRETT, perrett@aviationweek.com

SEOUL, BEIJING—South Korea's defense ministry and Hanwha have rolled out a prototype for the radar of the Korea Aerospace Industries (KAI) KF-X fighter, following delivery of a ground-test unit in April.

The unit presented on Aug. 7 will be fitted to the first KF-X, itself due to be rolled out in April 2021.

The sensor, which has no known name, is not only South Korea's first fighter radar with an active electronically scanned array (AESA) and gallium-nitride technology; but also South Korea's first fighter radar of any kind.

Using the ground-test prototype, the program has conducted 36% of testing on environmental effects on operation, said Shin Hyun-Ilk, the head of aircraft radar development at the ministry's Agency for Defense Development (ADD), which is leading the radar program. Hanwha is the manufacturing partner and is also contributing to development.

In addition, 92% of testing on electromagnetic interference has been done and the sensor's air-to-air mode is being evaluated, Shin said.

The program passed its system design review in August 2016 and critical design review in May 2019, with the ground-test prototype delivered to KAI 11 months later, Shin said.

The radar has about 1,000 transmitter-receiver modules, according to an official video. The exact number is 1,088, according to broadcaster OBS.

Such figures are normal for an AESA radar for a fighter of about the size of the KF-X, which will have an empty weight of 12 metric tons. The antenna is 70 cm (28 in.) wide and 25 cm (10 in.) deep, news service Money Today said.

A foreign company has asked to buy antennas of this design, Shin added.

Development of an earlier technology demonstrator was supported by Elta, which also may be contributing to the operational design. The whole radar program stems from U.S. refusal to supply technology on AESAs, among other systems, for the KF-X.

The first KF-X prototype is supposed to fly in 2022. Deliveries of production aircraft are due to begin in 2026. Indonesia is a junior partner in the program.

OPERATIONS

SpaceX Resumes Starlink Deployments

IRENE KLOTZ, irene.klotz@aviationweek.com

CAPE CANAVERAL—A SpaceX Falcon 9 rocket lifted off from Kennedy Space Center on Aug. 7 carrying 57 new Starlink broadband satellites—all outfitted with visors to cut Sun glint that interferes with astronomical observations—and two BlackSky Global imaging satellites.

Nine Merlin 1D engines on the rocket's first stage ignited at 1:12 a.m. EDT, sending the 229-ft.-tall booster out over the Atlantic Ocean to begin the 90th Falcon 9 mission and SpaceX's 13th launch of the year.

The rocket's first stage shut down and separated 3 min. later, leaving delivery of the Starlink and BlackSky satellites into orbit to the rocket's second stage, powered by a single Merlin vacuum-optimized engine.

As the upper stage neared its preliminary parking orbit, the core booster, making its fifth flight, touched down on a SpaceX drone ship stationed about 400 mi. northeast of Cape Canaveral. The booster is now one of three in the SpaceX fleet that have been launched five times.

The boosters are designed to be used on 10 missions with minimal refurbishment between flights. The first six-time flier is expected to be launched soon, SpaceX told Aerospace DAILY.

The company has been using its fleet leaders to deploy its Starlink broadband communications constellation, one of several fledging networks in low Earth orbit designed to provide high-speed, global, low-latency connectivity for commercial, residential, government and other users.

So far, the company has launched 595 satellites out of an initial constellation expected to number more than 1,584. Eventually, the Starlink network could consist of more than 40,000 spacecraft. SpaceX intends to begin rolling out initial beta service to select users in the northern U.S. and Canada this summer.

The Aug. 7 launch was the 10th devoted to deploying the Starlink constellation and the second to carry a piggyback payload. On June 13, SpaceX delivered three Earth-imaging SkySats for San Francisco-based Planet along with 58 Starlink websats. For the latest mission, a pair of Spaceflight's BlackSky Global satellites joined 57 Starlinks for the ride to orbit.

SPACEX, P. 7

FUNDING & POLICY

Senators Draft Bill To Prohibit Certain UAS Exports

JEN DIMASCIO, jen.dimascio@aviationweek.com

A bipartisan group of senators has introduced legislation to block President Donald Trump from loosening a treaty obligation that restricts the export of large U.S. unmanned aircraft systems (UAS).

It would close a door that Trump has tried to open for U.S. UAS manufacturers, codifying the prohibition of UAS exports except to the nation's closest allies.

Last month, Trump signed a policy determination that would reclassify UAS flying slower than 800 km/hr. (497 mph) as Category 2 aircraft under the Missile Technology Control Regime (MTCR), a consensus-based organization seeking to limit missile proliferation. This would reclassify certain UAS including the General Atomics Aeronautical Systems MQ-9 and Northrop Grumman MQ-4C that were previously in Category 1. Under the MTCR, Category 1 UAS that can carry payloads of 500 kg (1,100 lb.) have a "strong presumption of denial" for export licenses.

Industry has argued for years that the restrictions put U.S. manufacturers at a disadvantage, allowing companies in China and elsewhere to gain a foothold in the market.

But lawmakers concerned with the involvement of Saudi Arabia and the UAE in Yemen want to see restrictions continue.

Sens. Chris Murphy (D-Conn.), Mike Lee (R-Utah), Bernie Sanders (I-Vt.), Rand Paul (R-Ky.) and Chris Coons (D-Del.) are proposing a bill that would amend the Arms Export Control Act to block the sale of "advanced armed drones to countries not closely allied to the U.S." That would include UAS with a range greater than 300 km (190 mi.) or payload of 500 kg or greater—as the MTCR defines Category 1 UAS—without the speed exemption. The bill would exempt UAS exports to members of NATO, Australia, Japan, Israel, New Zealand and South Korea.

"The president's action will only further enable the Saudis to continue killing more innocent civilians in Yemen by supplying them with advanced U.S.-made drones," Murphy said. "Congress can stop Trump in his tracks by making some of the limits of the MTCR legally binding."

TECHNOLOGY

MTU, DLR To Flight Test Hydrogen Fuel-Cell Propulsion

GRAHAM WARWICK, graham.warwick@aviationweek.com

German aerospace center DLR and MTU Aero Engines plan to cooperate on development of a zero-emissions hydrogen fuel-cell power train for flight testing in a 19-passenger Dornier Do 228 regional aircraft, from 2026.

Under the MOU signed Aug. 5, German engine manufacturer MTU will develop the fuel-cell drive train, while DLR will provide and operate the Do 228 testbed and be responsible for integration and qualification of the power train.

One of DLR's Do 228s already is being converted into an electric flight demonstrator and is planned to fly first with a 500-kW-class all-electric drive train replacing one of its two Honeywell TPE331 turboprops and later with a hybrid-electric system.

"From today's perspective, the fuel cell in combination with sustainably produced hydrogen has the greatest long-term potential for enabling emission-free air travel, with sufficient performance and range for a regional aircraft," Lars Wagner, MTU board member for technology, said in a statement.

U.S. startup ZeroAvia is already planning to convert a Do 228 to hydrogen fuel-cell propulsion, aiming for supplement type certification by 2023. The 19-seater will follow a six-seat, single-engine Piper Malibu Mirage testbed, which is being converted to fuel-cell power and is expected to fly in the UK this year.

Fuel cells consuming sustainable hydrogen produced by electrolysis using renewable electricity are also among the potential options being explored by Airbus for a zero-emissions airliner it has committed to bring to market by 2035.

Germany's Liebherr-Aerospace is already developing both an emergency power system and an auxiliary power unit for aircraft using fuel cells, and Airbus says the technology could be used in either electric or hybrid-electric propulsion systems.

"Although great progress has been made in recent years on the performance and lifespan of fuel cells, there is still a considerable need for research in aviation," Rolf Henke, DLR board member for aeronautical research, said in a statement. "The planned joint project between researchers and industry is the first of many steps toward zero-emission aviation."

"The development of an airworthy fuel cell and the experience and data gained from it, including in the areas of regulation and aeronautical qualification, are of crucial importance for our further product development," Wagner said.

Staff

EDITORIAL
2121 K Street, NW, Suite 210, Washington, DC 20037
+1-202-517-1100 awin.aviationweek.com

EDITORIAL STAFF
Editor In Chief Jefferson Morris
Assistant Editor Andy Savoie
Editorial Director Joseph C. Anselmo
Military Reporters Michael Bruno, Bill Carey, Jen DiMascio, Lee Hudson, Guy Norris, Tony Osborne, Bradley Perrett, Steve Trimble, Graham Warwick
Space Reporters Mark Carreau, Irene Klotz
Associate Producers Amy Hardcastle, Donna Thomas

DATA & ANALYTICS
Director, Forecasts and Aerospace Insights Brian Kough
Manager, Military Data Operations Michael Tint
Senior Industry & Forecast Analyst Craig Caffrey
Military Program Analyst Mathew Jouppi
Regional Military Analysts Samuel Archer, Brandon Patrick, Sterling Richmond, Nate Taylor

SUBSCRIBER SERVICES
Customer Service, New/Renewal Sales
Aerospace Daily & Defense Report,
P.O. Box 1175, Skokie, IL 60076-8175
Tel: +1-877-369-3706 (within the U.S.)
Tel: +1-913-850-6930 (outside the U.S.)
Fax: +1-800-455-3145
Email: tech_assistance@aviationweek.com

INTELLIGENCE AND DATA SERVICES
Managing Director Anne McMahon
Tel: +1-646-291-6353, anne.mcmahon@aviationweek.com
Senior Director, Business Development Thom Clayton
Tel: +44 (0) 20 7017 6106, thom.clayton@aviationweek.com

Discounted rates for multiple users and enterprise access available. Custom packages and additional services available including Intelligence/Research, Fleet Data, Forecasts.

User Engagement Laurie Grossman
Tel: +1-646-233-4434, laurie.grossman@aviationweek.com
Online access to Aerospace Daily & Defense Report is available at awin.aviationweek.com

ADVERTISING
Sales Director Melissa Crum
Tel: 913-284-2951, melissa.crum@informa.com

REPRINTS
Wright's Media
Tel: 1-877-652-5295 (within U.S.)
Tel: 1-281-419-5725 (outside U.S.)
informa@wrightsmedia.com

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. 25

AVIATION WEEK NETWORK
an informa business

TECHNOLOGY

Collins Close To Air Combat Training System Deal

LEE HUDSON, lee.hudson@aviationweek.com

Collins Aerospace is on the brink of closing a deal with its first international customer for a next-generation air combat training device that the U.S. Navy and Air Force will use for the F-35.

The Navy was the first customer and calls the technology the Tactical Combat Training System Increment II (TCT Inc. II), while the Air Force calls it the P6 Combat Training System. The Air Force recently decided to purchase the training platform and is leveraging investments already made by the Navy.

A glaring issue facing current air combat training devices is they do not have GPS encryption. TCT Inc. II will not only have encrypted GPS but will share in real time U.S. Top Secret and NATO secret data from the aircraft to troops on the ground, Chip Gilkison, integrated training solutions business development director at Collins Aerospace, told Aerospace DAILY.

This lays the foundation for bringing cross-service air combat and joint Live, Virtual and Constructive training to the U.S. and its allies in 2022. Gilkison said it is not only Five Eyes nations that are interested in TCT Inc. II but also many F-35 international partners.

TCT Inc. II can attach to fifth-generation aircraft via a pod, but the U.S. has opted for internal mounting on the F-35. The services can use the device to accelerate tactics, techniques and procedures development, he said.

"Instead of taking six to nine months to come up with a new tactic that can be flown by all F-35 pilots, for example, it can be a matter of weeks," Gilkison said. "You can take that new capability that the [original equipment manufacturer] has injected in the aircraft, and you could be using TCT Inc. II to gather all the test data from those aircraft."

Another feature is the processing power that allows the customer to load multiple waveforms so that they are not limited by antennas, Gilkison said.

The plan is for TCT Inc. II to enter milestone C in spring 2021, but before that happens the device will go on Navy jets for flight testing at Naval Air Station Patuxent River in Maryland this year.

MI-8AMTSH-VN, From P. 2

helicopter carries 80 mm unguided rockets, bombs and gun pods on its six pylons. Two 12.7 mm machine guns can be mounted on the sides of the helicopter's cabin; another two machine guns can be mounted on movable mounts in the side doors and in the hatch at the rear of the hold.

The helicopter is to receive the L370E8-6BV1 self-defense suite, which includes ultraviolet warning sensors, decoy launchers and directional infrared countermeasures. That suite was not present on the helicopter shown in 2017 and 2018, except for the decoy launchers on the sides of the fuselage. These launchers are intriguing, as they make up the previously unseen SV-370 system, combining in one block two 32-round 26 mm cassettes and one seven-round 50 mm cassette.

To protect troops, the cabin floor is covered with removable, lightweight Kevlar armor. Similar protection is installed along the sides to the level of the windows.

TECHNOLOGY

In-Situ Resources, 3D Printing Seen Enabling Deep-Space Exploration

MARK CARREAU, mark.carreau@gmail.com

HOUSTON—Here is an illuminating set of numbers when it comes to sustaining even a small crew of humans in Earth orbit aboard the International Space Station (ISS).

Serving as home for up to seven astronauts and cosmonauts, the ISS is provisioned with about 28,600 lb. of spare parts. Another 39,600 lb. of spares are stowed on Earth ready for timely launches aboard resupply missions. But based on a predicted mean time between failures, the components that fail each year aboard the ISS amount to about 990 lb.

The numbers were provided by Jennifer Edmunson, a planetary geologist and the Jacobs Space Exploration Group In-Situ Resource Utilization (ISRU) lead for In-Space Manufacturing at NASA's Marshall Space Flight Center. The quantities are likely to increase as the separation between Earth and future explorers rises as they reach out to settle the Moon and Mars.

The numbers also are a testament to the potential value of seeking out resources on other planetary bodies and developing technologies—such as additive manufacturing, better known as 3D printing—to make use of those homegrown assets to reduce the need for costly cargo mission launches.

"ISRU is the only economical way to enable a sustainable human presence off the Earth," Edmunson said after laying out the ISS logistics accounting before a July 28 virtual ISS National Laboratory Additive Manufacturing in Space Workshop. "If we have the opportunity to manufacture our spare parts on demand using piece parts made from ISRU, just imagine the time and money we could save as well as the small amount of space the feedstock would take up relative to 13,000 kg (28,600 lb.) of spare parts on the ISS."

Edmunson touched on the large quantities of water ice believed to reside at the lunar poles and within the Martian subsurface, the red planet's carbon dioxide atmosphere, and the soil-like regolith strewn across the surface of the Moon and

IN-SITU, P. 7

TECHNOLOGY

Test Set For High-Performance Fuel For Hypersonic Weapons

GRAHAM WARWICK, graham.warwick@aviationweek.com

A Purdue University spinoff is to test an improved propellant for solid-fuel ramjet propulsion systems in hypersonic weapons under more than $1.1 million in contracts from the U.S. military.

Adranos is developing a solid rocket fuel, called Alitech, that uses aluminum-lithium (Al-Li) powder instead of aluminum in the propellant mix, increasing fuel efficiency and reducing corrosive effects.

The West Lafayette, Indiana-based startup has flight tested the fuel in a solid rocket motor. But "Alitec's performance increases can be applied to both traditional solid-rocket motors and air-breathing systems," Brandon Terry, chief technology officer, said in a statement.

Aluminum powder is used in solid propellants as an additive to increase their density and combustion temperatures and stabilize the burn. But the metallic fuel forms large molten droplets that burn slowly. This results in a performance loss of up to 10% that prevents a rocket from realizing its full range and payload capacity. The fuel also emits hydrochloric acid, which damages the environment and corrodes launch equipment.

Aluminum-lithium fuel has demonstrated increased performance through better combustion and higher efficiency. The large difference in boiling point between aluminum and lithium causes microexplosions of the metallic drops, reducing agglomerates. In addition, Al-Li virtually eliminates hydrochloric acid production while also improving theoretical specific impulse. Adranos calculates that Alitec could increase missile range by up to 68% and booster payload by 65%.

In 2019, the startup won the U.S. Army's first xTechSearch competition, receiving a total of $325,000 for conducting a flight demonstration of its solid propellant powering a prototype rocket. The flight demo confirmed Alitec could substantially increase the range of ballistic missiles and support the Army's Long Range Precision Fires modernization priority. Early in 2020, Adranos raised $1 million in funding.

The latest contracts have been awarded by the Army's Aviation and Missile Center and the Defense Department's Rapid Reaction Technology Office. Under the contracts, tests at Purdue's Zurcrow Labs will use a heated air system capable of simulating a Mach 4 flight environment to determine Alitec's functionality within a solid-fuel-ramjet hypersonic propulsion system.

Alitec is processed in the same way as traditional solid propellants, allowing it to be used in any existing or future missile system. "We mix it the same way. We cast it the same way. We cure it the same way. The only difference is we're replacing one metal powder with another metal powder in the processing," Terry said.

IN-SITU, From P. 6

Mars as perhaps the most obvious of raw materials waiting to be mined, processed, and even recycled.

So ISRU, combined with advances in additive manufacturing, could provide the materials and technologies for the construction of human habitats, shelters and factories as well as spare parts and other crew supplies on the Moon and Mars.

"Regolith covers the surfaces of rocky planets and the vast majority of asteroids. So there is a lot of materials out there we can use," Edmunson said, breaking down the mineral content of the soil-like regolith material on the Moon and Mars into silicates, such as feldspar, olivine, and pyroxene. Those plus anorthite offer sources of iron, titanium, aluminum, silicon, oxygen, calcium and magnesium.

As testament to the concept, NASA has made the mining of deep-space resources a focus of its Artemis Accords, a set of principles of conduct among spacefaring nations unveiled by the agency in May. NASA proposes that each nation that choses to partner with it for future deep-space exploration sign and abide by the accords.

Though rooted in the 1967 Outer Space Treaty, the accords have sparked criticism from Dmitry Rogozin, head of the Russian space agency, a potential rival and partner.

Russia's cosmonauts aboard the station have had an opportunity to catch at least a glimpse at two of the ISS National Lab's research participants. They are Tethers Unlimited, Inc., headquartered near Seattle; and Made in Space, Inc., of Mountain View, California. They are pioneering new approaches to manufacturing such items as hand tools, as well as a commercial fiber-optic material of higher quality than can be manufactured under the influence of gravity for sale to customers on Earth.

"Overall, our objective at Tethers Unlimited is to help stand up a space economy to make mankind truly spacefaring," Rob Hoyt, the company's president and co-founder, told the workshop audience. "You need to stand up the demand and supply side at the same time. We see in-space manufacturing as one of the keystones that can tie them together."

Tethers Unlimited is currently focused on recycling ISS plastics, like the packing materials that protect equipment and supplies launched in containers. Samples of recycled material on the ISS are returned to Earth for analysis to see which packing materials are best suited for recycling, and how many times the material can be recycled with the company's Refabricator without losing key structural properties.

Tethers Unlimited also is developing FabLab for recycling metals into implements suitable for food processing and health care needs. Each device could find homes on the ISS, NASA's planned lunar-orbiting, human-tended Gateway, a planetary habitat or a deep space transport.

Meanwhile, Made in Space owns a commercial Additive Manufacturing Facility aboard the ISS. Since demonstrating the 3D printing of a small hand wrench more than four years ago, it has moved on to produce more than 200 tools, including a hand tool used by NASA astronauts on the ISS earlier this month.

"We are quickly early-innovating at scales to make initial products to see what works and what does not as quickly as possible," Justin Kugler, Made in Space vice president for business development, told the workshop.

In addition to its commercial manufacturing of space tools and hardware as well as a fiber-optic material aboard the ISS, the company plans to assess high-quality metal alloy, ceramic and industrial crystallization for a range of future high-tech markets.

The ISS promises to be a crucial proving ground as NASA's future exploration efforts look to ISRU and materials to recycle for the manufacture of a range of tools, equipment and supplies for future human explorers that would otherwise have to be launched frequently on long journeys, Edmunson said.

"The ISS is our example of how humans can live off the Earth. It's our testbed for sustainable environmental control and life support systems and for what works in constant less-than-Earth gravity," she said. "A lot of the processes we have on Earth are dependent on gravity, including the way the human body operates. So we have a lot of work to do."

The gravities of the Moon and Mars fall between the Earth's and the near absence of gravity on the ISS. That makes them suitable extremes for evaluating how ISRU materials sampled from the Moon and Mars and newly developed in-space manufacturing processes might fare at the Moon and Mars under different conditions. These include thermal extremes, radiation levels, atmospheric pressures, electrostatic changes and even micrometeorite impacts, Edmunson said.

SPACEX, From P. 3

SpaceX has more than 100 rideshare satellites preparing for flight on upcoming missions, said launch commentator John Insprucker, principle integration engineer.

The 10th Starlink mission had been on hold since June due to weather delays and undisclosed additional technical checkouts of the payload.

Fleet Snapshot

North Korean Air Force

Family	Type	Current Fleet
Fighter		
MiG-29/35	MiG-29 (9.12B)	8
	MiG-29 (9.13B)	2
	MiG-29UB (9.51)	1
Su-25	Su-25	15
	Su-25UBK	2
MiG-23/27	MiG-23ML	12
MiG-21 (J-7/8)	J-7	4
	MiG-21PFM	16
	MiG-21bis N	23
	MiG-21UM	3
MiG-19	F-6	60
MiG-15/17	J-5	5
Il-28 (H-5)	H-5	11
Trainer		
CJ-6	CJ-6	180
Transport		
An-2	Y-5	75
Cessna 172	Cessna 172E	1
Il-62	Il-62M	2
Rotary Wing - Scout		
MD 500/H-6	MD500D (369D)	18
	MD500E (369E)	72
Rotary Wing - Transport		
Mi-2	Mi-2	6
Mi-24/35	Mi-35P	4
Mi-26	Mi-26	4
Mi-8/14/17	Mi-17	2
	Mi-8T	12
UAV		
Pchela	Pchela-1T	*
Fleet Total		**538**

* Signifies a questionable in service fleet, meaning North Korea possesses an unknown number of the UAVs in question

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

Prepared by Sam Archer

Calendar

To list an event, send information in calendar format to Amy Hardcastle at amy.hardcastle@informa.com. For a complete list of Aviation Week Network's upcoming events, and to register, visit www.aviationweek.com/events (Bold type indicates new calendar listing.)

[Virtual Event] Aug. 10-13—Space Tech Expo Connect. For more information go to http://www.spacetechexpo.com

Aug. 12-13—Civil Avionics International Forum 2020. Chinese Society of Aeronautics and Astronautics, Shanghai Marriott Hotel Hongqiao, Shanghai, China. For more information go to http://galleon.eventbank.cn/event/9th-annual-civil-avionics-international-forum-2020-25450

[Virtual Event] Aug. 20-21—Space Warfighting Industry Forum (SWIF). For more information go to https://www.ndia.org/events/2020/8/20/space-warfighting-industry-forum

[Virtual Event] Aug. 24-26—AIAA Propulsion and Energy Forum. For more information go to https://www.aiaa.org/propulsionenergy#

[Virtual Event] Aug. 25-26—SpeedNews Aerospace Manufacturing Conference. For more information go to https://amc.speednews.com

[Virtual Event] Aug. 25-27—Bombardier Safety Standdown 2020. For more information go to https://safetystanddown.com/en

[Virtual Event] Aug. 25-28—UAS West Virtual Symposium. For more information go to asdnews.com/news/defense/2020/06/26/uas-west-virtual-symposium

Aug. 29-30—New York International Air Show, NY Stewart Int'l Airport, Hudson Valley, NY. For more information go to https://airshowny.com

[Virtual Event] Aug. 31-Sept. 3—2020 Humans to Mars Summit, The National Academy of Sciences Building, Washington, DC. For more information go to https://www.exploremars.org/summit

[Virtual Event] Sept. 2-3—Military Robotics and Autonomous Systems 2020 Conference. For more information go to http://www.smi-online.co.uk/defence/uk/conference/robotic-autonomous-systems

[Virtual Event, New Dates To Be Announced] Sept. 2-3—Aviation Week 2020 Military Aviation Logistics & Maintenance Symposium (MALMS). For more information go to https://mroamericas.aviationweek.com/en/military-symposium.html

[Virtual Event] Sept. 3-4—Military Space Situational Awareness Conference 2020. For more information go to https://smi-online.co.uk/defence/uk/milspace

[Virtual Event] Sept. 15-16—SpeedNews Commercial Aviation Industry Suppliers Conference. For more information go to https://ace.speednews.com

[Virtual Event] Sept. 22-24—Modern Day Marine. For more information go to https://www.marinemilitaryexpos.com/modern-day-marine/home

[Virtual Event] Oct. 12-14—IAC 71st International Astronautical Congress - The CyberSpace Edition. For more information go to http://iac2020.org

Oct. 19—Aviation Week Network's 63rd Annual Laureate Awards, The Ritz-Carlton Tysons Corner, McLean, VA. For more information go to https://laureates.aviationweek.com/en/home.html

[Virtual Event] Oct. 19-29—SPACECOM, For more information go to https://spacecomexpo.com

Oct. 20-21—Aviation Week DefenseChain Conference, The Ritz-Carlton Tysons Corner, McLean, Virginia. For more information go to https://defensechain.aviationweek.com/en/home.html

Oct. 21—Aviation Week Program Excellence Awards and Banquet, The Ritz-Carlton Tysons Corner, McLean, Virginia. For more information go to https://defensechain.aviationweek.com/en/home.html

Oct. 27-28—Mexico's Aerospace Summit, Querétaro Congress Center, Santiago de Querétaro , Mexico. For more information go to https://www.mexicoaerospacesummit.com