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FROM: A.A.D./P.O. Box 110382
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MOVERS & SHAKERS

An Interview with
BRIGADIER GENERAL RICHARD GIBBS
Ogden Air Logistics Center

AVIATION AFTERMARKET DEFENSE

SPRING/SUMMER 2023 Vol. 18, No. 1

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The Price of Freedom

At the time of this writing, the war in Ukraine is still raging, and I suspect that it will continue for some time to come. The thing to remember about the Russian military leaders is that they have an unyielding determination to continue a chosen course of action for the long haul, no matter how deadly the results of such actions on both sides of the conflict.

"I Stand with Ukraine" is now a popular slogan here in America. But slogans do not stop armies, weapons do. And there are few weapon systems available that are as reliable and effective as the F-16 Fighting Falcon. At $50 million per aircraft, this incredibly capable fighting machine is a bargain. Fifteen aircraft—provided with spare parts, support equipment, and training—would cost under $900 million and would help defend Ukraine against inevitable Soviet air strikes and future incursions.

We send this publication to the Ukrainian embassy and in-country armed forces. When U.S. and NATO powers agree to support the Ukrainians with sophisticated fighter aircraft such as the F-16, hopefully the information we provide will aid their efforts by identifying bona fide suppliers who provide parts, repairs, upgrades, sustainment, and support for the F-16 Fighting Falcons and other defense systems.

The Ukrainian people seek the freedoms we take for granted here in the West, and they are willing to die for them. Freedom of the press. Freedom of assembly. Freedom of speech. Freedom of religion. And justice, which comes with all being treated fairly. Incursions into what should be universal freedoms come in many shapes and sizes. And even though we are fortunate to not have to defend them with our lives every day, we still need to play our part.

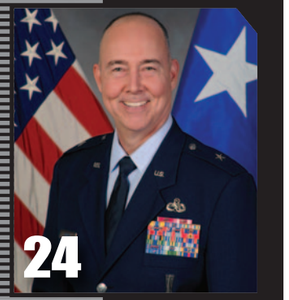
The sad truth is that even here, these rights, which we take for granted as U.S. citizens, can be denied to any one of us, at any time, without as much as a second thought from the powers that be. What has once again become apparent is how fragile our democracy is and how basic freedoms must be closely guarded—not just by the individual whose rights are in peril, but by all of us.

The United States began with a fight for the right of self-determination. Over the last 250 years, we have continued to support peoples throughout the world in their fight for the right to choose their own form of government. And yes, we always stand against unwarranted aggression, oppression, and genocide. The time has come to support the Ukrainian Air Force, doing what we can to enable them to put planes in the air to support those beliefs.

I wish "Svoboda" (Freedom) and "Myr" (Peace) for the Ukranian people.

Richard Greenwald

Richard Greenwald
Publisher



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by Patrick J. Walsh

The U.S. Air Force expects the Lockheed Martin F-16 Fighting Falcon, which was introduced in 1978, to remain part of its combat air force for several more decades. *(Image courtesy of the U.S. National Archives and Records Administration.)*

U.S. Air Force officials outline future plans for the F-16

The U.S. Air Force plans to continue to field the F-16 Fighting Falcon as a key part of its combat force into the 2040s. "We look at the F-16 as kind of the 'Big C' in capacity, so it's going to continue to be around for many, many years to come," said Brigadier General Dale White, Program Executive Officer for the Air Force Life Cycle Management Center's Fighters and Advanced Aircraft Directorate, at the Air Force's 2022 Life Cycle Industry Days event.

Originally developed by General Dynamics, of Reston, Virginia, the F-16 was introduced to U.S. Air Force service in 1978. When Lockheed Corporation acquired the aircraft manufacturing operations of General Dynamics in 1993, it took over production and upgrades. More than 4,600 F-16s have been built to date, and the fighter has been widely adopted by U.S. allies. Previously, U.S. Air Force plans envisioned a 2025 retirement of the F-16, with its role being subsumed by the Lockheed Martin's F-35A; however, multiple service life extension upgrades are expected to significantly expand the F-16's projected lifecycle.

In his remarks at the U.S. Air Force Life Cycle Industry Days event, which took place at the Dayton Convention Center in Ohio, August 10-12, White pointed to improvements in the F-16's electronic warfare capabilities and modifications to its radar system as examples of upgrades designed to keep the aircraft a key part of Air Force strategy in years to come. While noting that future modifications to the F-16 could prove costly, due to the large number currently in the U.S. Air Force fleet (nearly 900), White also stressed the likelihood that future improvements made to F-16s being acquired and operated by U.S. allies could be applied domestically, helping ensure the projected extension of the fighter's use.

Raytheon to Remanufacture F100 Engines for FMS

Raytheon Technologies has been awarded a $132.6 million contract modification to remanufacture F100 engine modules made by Pratt & Whitney (a subsidiary of Raytheon) for foreign military sales (FMS) partner countries. The twelve FMS nations slated to receive the remanufactured engine modules are Chile, Egypt, Greece, Indonesia, Iraq, Morocco, Pakistan, Poland, Romania, Saudi Arabia, Taiwan, and Thailand.

The F100 family of engines serves as the powerplant for the McDonnell Douglas F-15 Eagle and the General Dynamics F-16 Fighting Falcon. The contract calls for remanufacturing service across multiple generations of the F100, an afterburning turbofan whose first version was introduced in 1972, in an F-15 Eagle.

The work will be carried out at Raytheon's facilities in East Hartford, Connecticut; Midland, Georgia; and Midwest City, Oklahoma. The currently projected completion date is August 2023.

A U.S. Navy F/A-18 Super Hornet fitted with the Northrop Grumman LITENING advanced targeting pod. *(Image courtesy of Northrop Grumman.)*

F/A-18 Makes First flight with Northrop Grumman LITENING Targeting Pod

In September, the U.S. Navy completed the first flight test of the LITENING advanced targeting pod, supplied by Northrop Grumman of West Falls Church, Virginia, on a F/A-18 Super Hornet. The tests are part of the Navy's ongoing upgrade of the Super Hornet's legacy AN/ASQ-228 Advanced Targeting Forward-Looking Infrared (ATFLIR) pods.

"This first flight demonstrated LITENING's ability to rapidly add modern, upgradeable mission capabilities to the Super Hornet," said James Conroy, Vice President, Navigation, Targeting and Survivability, Northrop Grumman, in a statement announcing the completion of the initial flight tests.

Cooperatively developed by Northrop Grumman and Rafael Advanced Defense Systems of Israel, the LITENING pod is deployed on a diverse array of military aircraft in U.S. service and internationally. These platforms include the U.S. Air Force's F-15 Eagle and F-16 Fighting Falcon and the U.S Navy's F/A-18 Hornet, from which the high-performance F/A-18 E (single-seat) and F (two-seat) Super Hornet were developed. The Super Hornet tests of the LITENING pod included ground moving target tracking, air-to-air tracking, and target designation exercises.

According to Conroy, "The pod's digital video, autonomous target tracking, and laser sensors will give Naval aviators an entirely new set of capabilities for operations over land and sea today. And the growth capabilities built into LITENING's modular design ensure that the pod can evolve to meet changing requirements."

C-130s on the flight line at Little Rock Air Force Base, Arkansas. *(Image courtesy of the U.S. Air Force.)*

U.S. Air Force Selects Little Rock Air Force Base for Air National Guard Training

The U.S. Air Force has chosen Little Rock Air Force Base, Arkansas, as host of the Air National Guard Formal Training Unit supporting the ongoing transition from the Lockheed Martin C-130H to the C-130J Super Hercules.

Air National Guard pilots, navigators, flight engineers, and loadmasters currently receive C-130H training and certification at the base, which hosts the C-130H Formal Training Unit, under the Arkansas Air National Guard 189th Airlift Wing.

The 314th Airlift Wing, also located at the base, trains C-130 aircrew members from the U.S. Department of Defense (DOD), the U.S. Coast Guard, and 47 allied nations. It is the DOD's largest international flight training program.

"The 189th Airlift Wing looks forward to a continued strong partnership with the 314th, as we provide premier C-130 training to the Total Force and our allied partners," said Colonel Dean Martin, 189th Airlift Wing Commander. "Our aircrew and maintainers are top-of-the-line, and we are ready to take the next step in support to our nation and state."

Although the U.S. Air Force has replaced the majority of C-130H aircraft in active-duty inventory with the C-130J, the Air National Guard still primarily fields the C-130H. As the Air National Guard transition to the C-130J proceeds, training and certification will continue for the lifecycle of the C-130Hs.

"The wing will operate in a split-fleet configuration for many years to come, which will require all our aircrew and maintenance expertise to train airmen and support our mission," said Colonel Jay Geaney, 189th Operations Group Commander.

The first of four C-130J Hercules will be assigned to the C-130J Formal Training Unit at Little Rock in fiscal year 2023. Aircrew members have been selected and are being certified as experts in various aspects of C-130J systems and operations to instruct future C-130J trainees.

A Belgian Air Force C-130 during an exercise in 1998. The Pakistan Air Force has acquired seven of the C-130s formerly operated by the Belgian Air Component, which retired its C-130 fleet in December, 2021. *(Image courtesy of the U.S. National Archives and Records Administration.)*

Pakistan Takes Delivery of Former Belgian Air Force C-130H Hercules

The Pakistan Air Force has received the first of seven Lockheed Martin C-130H Hercules aircraft that were previously in the service of the Belgian Air Component, following Pakistan's purchase of the transports from a consortium led by Sabena Aerospace and Blue Aerospace.

The Belgium Air Component retired the last of its fleet of twelve C-130Hs in December, 2021, opting to replace the transport, which it had fielded for nearly 50 years, with the Airbus Defence and Space A400M Atlas. Belgium subsequently sold seven of its C-130H aircraft to the consortium, which, in turn, sold them to the Pakistan Air Force. Flying in Pakistan Air Force livery from Melsbroek Air Base, near Brussels, Belgium, the first of the C-130H Hercules was delivered to Pakistan on July 25.

This acquisition augments the Pakistan Air Force's existing C-130 fleet and leverages the force's long familiarity with the aircraft's maintenance and sustainment requirements. Pakistan has been an operator of the C-130 since 1962.

Boeing to Build KC-46A Tankers for the U.S. Air Force and Israel

Boeing Defense, Space & Security, a division of the Boeing Company, has been awarded a $2.2 billion contract modification at the end of August to produce fifteen KC-46A Pegasus aerial refueling aircraft for the U.S. Air Force. On the same day, the company was also awarded an undefinitized $927 million maximum contract to build four KC-46As for Israel.

The contract modification represents the exercise of an option to purchase the fifteen additional Pegasus tankers. This option is part of a larger plan for the U.S. Air Force to build its inventory from fifty-nine KC-46A aircraft in service in mid-2022 to a projected 179 by 2027.

The Israeli order for four aircraft will be the nation's first purchase of the KC-46A. In March 2020, the U.S. State Department granted approval of the sale of eight Pegasus tankers to Israel.

The work on the Israeli KC-46As also includes non-recurring design and test of the aircraft's Remote Vision System 2.0 and Air Refueling Operator Station 2.0. Modifications to the Remote Vision System—the interconnected system of cameras and sensors that boom operators use to guide the refueling boom into the aircraft being refueled—are expected to correct earlier difficulties in obtaining clear images under certain lighting conditions.

All work is to be done at Boeing's facilities in Seattle, Washington. The U.S. Air Force KC-46As are slated for completion by November 2025; the Israeli tankers are expected to be completed by December 2026.

Lockheed Awarded $7.6 billion Contract to Build 129 F-35s

Lockheed Martin Aeronautics, of Fort Worth, Texas, a unit of the Lockheed Martin Corporation, has been awarded a $7.6 billion contract modification to produce 129 F-35 Lightning II aircraft. The firm-fixed-price, fixed-price incentive contract modification was announced by the U.S. Department of Defense in August.

The contract award calls for the U.S. Air Force to acquire forty-nine F-35As, the U.S. Marine Corps to add three F-35B and ten F-35C aircraft, and the U.S. Navy to procure fifteen F-35Cs. The contract also designates thirty-two F-35A and four F-35B aircraft for non-U.S. Department of Defense participants and sixteen F-35As for foreign military sales.

The U.S. Naval Air Systems Command at Patuxent River, Maryland, is the contracting activity for the work, which is expected to be completed by October 2024.

(Image courtesy of the U.S. Air Force. Photo by Airman 1st Class Jose Miguel T. Tamondong.)

(Image courtesy of NASA.)

CLIMATE CHANGE

How our Industry Is Responding

By Tessa Axsom

The year 2021 introduced an estimated 36.4 billion metric tons of carbon dioxide ($C0_2$) into the worldwide atmosphere. Following the United Nations (UN) Climate Change Conference, known as COP26, held toward the end of that year, and this past November's COP27, increased commitments have been made by world governments and industries to address the climate crisis.

As part of these initiatives, national bodies and the global defense industry are working toward decarbonization strategies to achieve net-zero carbon emissions by 2050. Some governments are providing increased incentives and available funds to constituents, original equipment manufacturers (OEMs), and other industry parts and service providers in support of these efforts. At the same time, investors are pushing companies to provide proof of ongoing progress toward this goal.

The primary source of $C0_2$ emissions is the burning of fossil fuels, with most aviation applications being highly fuel-intensive users. An additional challenge facing worldwide militaries is the fact that they and supporting industries are continually pursuing technological advantages to strategically improve operational defense capabilities. From development and production through deployment of ever more equipment, this increases energy consumption, often counteracting carbon footprint reduction measures. Finally, despite ongoing efforts, the global defense industry lags behind in innovations to reduce emissions. Yet progress is being made.

NATIONAL COMMITMENTS

The United States has committed to the net-zero carbon emissions movement by creating net-zero goals, adding task forces, and exploring alternative energy sources. In 2022, the Biden Administration committed to achieving a 50 to 52 percent national reduction of carbon emissions (based on 2005 levels) by 2030; the overall plan specifies that companies initiate plans involving specific climate change efforts, with the target of a net-zero emissions economy-wide by 2050. This initiative was launched earlier with Executive Order (EO) 14030, Climate-Related Financial Risk (May 25, 2021, 86 FR 27967), which recognizes that the intensifying impacts of climate change present a set of growing risks to financial assets, companies, communities, and workers.

The U.S. National Climate Task Force works with domestic leaders, institutions, businesses, communities, and residents. In addition, the President's Emergency Plan for Adaptation and Resilience (PREPARE) was established in the past year to help people in developing countries adapt to and manage the impacts of climate change.

As part of the 2022 Inflation Reduction Act, President Biden secured the largest investment in energy security and climate change measures in American

CLIMATE CHANGE FAST FACTS

(Image courtesy of NASA's Goddard Space Flight Center.)

- According to the Intergovernmental Panel on Climate Change, carbon dioxide is at an unprecedented level not seen for the last 2,000 years.

- Since the late 1800s, the global temperature has increased by about 2 degrees Fahrenheit. The year 2020 tied with the year 2016 for the warmest year on record.

- Aviation represents around 3.5 percent of climate warming. The role of military aviation is currently estimated at between 8 percent to 15 percent of this total.

- Military jets fly at higher altitudes than commercial airplanes, which causes additional atmospheric heating effects due to the contrails left by aircraft. Plus, each sale of arms products contributes to the carbon cost of conflict.

- The U.S. military, the largest U.S. government user of fossil fuels and the single largest institutional source of greenhouse gas, emits more than 51 million tons CO2 annually.

- On a net basis, alternative fuels have the potential to reduce $C0_2$ emissions by up to 80 percent.

- There is a push for the defense use of electric versus gas non-combat vehicles; changes have been recommended to the Federal Acquisition Regulations about climate change.

A U.S. Air Force KC-135 Stratotanker, assigned to the 350th Expeditionary Aircraft Refueling Squadron, flies over Qatar. Through an innovative project, the Air Force is attempting to create new fuel options for aircraft use that involve carbon transformation, which has the potential of turning carbon dioxide from the air into nearly any chemical, material, or fuel. Truly space age stuff. *(Image courtesy of U.S. Air Force. Photo by Master Sgt. Joey Swafford.)*

history. And this year's fiscal budget builds on this proactive stance with yet more investment and plans to address the climate crisis.

GLOBAL EFFORTS

As the United Kingdom's Minister for Defence, Jeremy Quin stated, "In defense, we appreciate its [climate change] impact and how we must all work together to address it." Accordingly, a U.K. national and defense goal has been set to reduce net carbon emissions to zero by 2050.

According to some sources, the United Kingdom had been investing an estimated £17 billion (about $18.74 billion U.S.) annually toward this goal, with plans in place to more than double this figure.

Scientists for Global Responsibility (SGR) and Declassified UK (DUK) estimated the recent footprint of the U.K. military at more than 11 million tons of $C0_2$ per year. Among other ongoing measures to reduce emissions is testing of biofuels as an alternative to fossil fuels in Royal Air Force (RAF) aircraft and other military vehicles. It has been estimated that such substitution of conventional fuel by the U.K. national defense forces could reduce their $C0_2$ emissions by 18 percent.

The Canadian Department of National Defence also is investing in reducing its carbon footprint. According to Canada's Treasury Board President Jean-Yves Duclos, "The government is committed to cutting its operational carbon pollution 40 percent below 2005 levels by 2025." The Defence Energy and Environment Strategy for the 2020–2023 period calls for a $225 million Canadian (close to $180 million U.S.) investment in infrastructure to reduce the nation's military carbon footprint.

Finland's climate change policy, the Climate Change Act, enacted on June 1, 2015, states the goal of reducing greenhouse gas emissions by 80 percent (from 1990 levels) by 2050. The Act also provides a framework for a climate police planning system and the monitoring of Finland's climate objectives.

Similarly, the French Institute for International and Strategic Affairs (IRIS) launched the Observatory of Climate Change Impacts on Defense and Security to assess the looming security and political issues created by climate change. France is focusing on innovations involving dual technology (technology that benefits the defense and commercial industries alike) related to materials and energy consumption, favoring the use of eco-friendly military equipment to reduce its environmental impact.

CLIMATE CHANGE AND MISSION-READINESS

Master Sargeant Jeff Stack, loadmaster for the 53rd Weather Reconnaissance Squadron at Kessler Air Force Base, known as the "Hurricane Hungers," sits inside their WC-130J, holding a dropsonde. This tool is used to track and collect data about such tropical storms and hurricanes as Hurricane Katrina, which caused millions of dollars in damage to the base. *(Image courtesy of U.S. Air Force. Photo by Technical Sargeant Greg C. Biondo.)*

The U.S. National Aeronautics and Space Administration (NASA) estimates that a 13.1 percent declination of ice in the Arctic Sea is occurring per decade. In addition to municipal, commercial, and residential loss, exacerbated weather and conditions attributable to climate change already have caused horrendous and costly damage to major military installments.

In 2005, Hurricane Katrina caused $950 million in damages to Kessler Air Force Base in Biloxi, Mississippi. Hurricane Florence in 2018, caused $3.6 billion in taxpayer money and damages to three U.S. Marine Corps installations. Also in 2018, Hurricane Michael caused $4.7 billion in taxpayer money and damages to Tyndall Air Force Base in Panama City, Florida.

Sarah Fiocco, U.S. Air Force spokeswoman, stated, "The Department of the Air Force is actively working toward making our installations more resilient to the potential impacts of climate change and extreme weather." For example, construction in flood plains has been elevated 3 feet above the highest possible flood. At Tyndall Air Force Base, buildings are constructed 19 feet above sea level and can withstand winds of a minimum of 165 mph.

DEFENSE INDUSTRY EFFORTS IN SUPPORT OF CLIMATE CHANGE

In addition to the climate change efforts among governments, there has been significant defense support in climate change efforts. Many leading defense companies have joined the efforts in climate change by launching emission-reducing strategies.

According to Lockheed Martin's web pages entitled "Resource Efficiency: Energy and Carbon Management," the OEM has been implementing green strategies for a number of years now. For instance, it launched a "Go Green" strategy in 2007, focused on reducing carbon emissions through renewable energy, efficiency, and reduction of water usage.

Since launching this program, Lockheed Martin reportedly had reduced atmospheric carbon emissions by an impressive 47 percent by 2021, and overall energy-efficient improvements to date are estimated to have saved the company many millions in utility and

"The government is committed to cutting its operational carbon pollution 40 percent below 2005 levels by 2025."

Karen Kwong, U.S. Air Force Petroleum Agency chemist, prepares the Jet Fuel Thermal Oxidation Tester to run a sample in the Quality Surveillance Fuels Lab at Wright-Patterson Air Force Base, Ohio. This instrument models measures the conditions that fuel is exposed to inside of an aircraft during flight to determine the thermal stability of a fuel sample. Such research supports ongoing advances in reducing the carbon footprint of fleet engines. *(Image courtesy of U.S. Air Force. Photo by Michelle Gigante.)*

maintenance costs. The program currently aims to achieve a 70 percent reduction (from 2015 levels) in carbon emissions per dollar of gross profit by 2030, based on a science-based target methodology, established by the Center for Sustainable Development.

GE Aviation also has been a major player in the push to reduce carbon emissions. According to GE Aviation, the company's "commitment to innovation is [its] North Star in approaching sustainability." GE Aviation supports industry initiatives to approve and adopt 100 percent Sustainable Aviation Fuel (SAF). The GE9X engine is already said to be the most energy-efficient engine GE has ever built, but the OEM has not ended its efforts there.

GE Aviation's business Avio Aero, which designs, manufactures, and maintains components and systems for military and civil aviation, is investing in reducing $C0_2$ emissions through innovation. Among other efforts, the IRON (Innovative turbopROp configuratioN) project involves research and development of a diffused hybrid propulsion system.

Raytheon Technologies also has been active in climate change initiatives, already achieving an estimated reduction in greenhouse gas emissions of more than 20 percent since 2015. Accordingly, Pratt & Whitney, a Raytheon subsidiary, has trademarked the phrase "Powering Sustainable Innovation," as well as committed to the 2050 net-zero emissions goal.

The evolution of such innovative technologies as Pratt & Whitney's geared turbofan (GTF) engine design, which enables the fan and the turbine that drives it to spin at different optimal speeds, may very well fundamentally change how sustainable propulsion works. The GTF and other advanced military aircraft powerplant designs increasingly hold promise of primary or even full utilization of sustainable air fuel. In service for more than 11 million flight hours, this powerplant offers up to 20 percent reduction in $C0_2$ emissions, as well as reductions in its NOx (nitrous oxide) emissions and noise footprint.

Raytheon also is investigating hybrid electric technologies. It is hoped that such integrated technologies will help to deliver the fuel economy that will be needed for the next large aircraft engine program.

CLIMATE CHANGE AHEAD

Hopefully this short article has piqued your interest and provided insight into some of the regulations and efforts related to the multifold issues of climate change in the aerospace and defense industry.

Governments, industry and the aftermarket are joining forces, funding, and working together on the goal of achieving zero carbon emissions by 2050. But before even 2030, we surely will be seeing how related efforts and advances are altering the defense and broader aviation industries.

AAD

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Engineers at GE Aviation have been evaluating and testing the use of Sustainable Aviation Fuel (SAF) in aircraft engines for more than a decade. Today, GE Aviation and CFM International engines can be operated with approved SAF. *(Image courtesy of GE aviation.com.)*

BETTER ALTERNATIVES FOR A BIG IMPACT

In recent years, to help drive the net-zero goals, the U.S. Department of Defense has been working with industry to create alternatives to petroleum-based fuels, such as biofuels. Alternatives include gaseous fuels, such as hydrogen, natural gas, and propane; alcohols, such as ethanol, methanol, and butanol; vegetable and waste-derived oils; and electricity.

One such project is the Department of Defense's investment in Sustainable Aviation Fuels (SAFs). SAFs include biofuels, which are made from agricultural products that absorb carbon dioxide before being harvested. The benefit of SAF is that it has similar thermal and physical properties to conventional jet fuel but a much smaller carbon footprint. Some production pathways for SAF even result in a net-negative footprint. U.S. labs, including the National Renewable Energy Laboratory, Los Alamos National Laboratory and Pacific Northwest Laboratory, are heading research into SAF development and generation.

(Image courtesy of U.S. Air Force. Photo by Airman 1st Class Sebastian Romawac.)

FIGHTERS IN FILM

The True Story Behind the Making of *Top Gun: Maverick*

By Jeff Blundell

When Vincent Aiello took his seat in a movie theater to watch *Top Gun: Maverick*, he had a unique perspective.

"Number one, I wanted to see how close they got it. But number two, I wanted to feel special for a moment. If they're making a movie about this, we must be pretty cool," he said.

Aiello says "we," because for 25 years, he was a naval aviator just like Tom Cruise's character Pete Mitchell. Though, admittedly, he did not have as cool a call sign as "Maverick." During his time in the U.S. Navy, Commander Aiello was known as "Jell-O." That is just one example of how reality sometimes differs from what is shown on the big screen.

"They've got to make it compelling," says Aiello. "And let's face it, real life is not compelling. In military aviation, we spend hours preparing for a flight and debriefing a flight in excruciating detail. And, of course, they're not going to show that, because that's not the dramatic thing everyone wants to watch."

Aiello is now retired and hosts the popular "Fighter Pilot Podcast." In his thrice-monthly Internet radio show, he does not hesitate to point out places where movie producers take liberties with actual military practices or otherwise veer from the truth. Some of those factual fabrications are technical. For instance, he notes Maverick's signature move, well known from the first Top Gun: "Hit the breaks, and he'll fly right by."

"Well, there's this thing called physics. So that doesn't always work that well," Aiello says with a laugh. "Or the fact that it seems so hard to shoot another aircraft. It's really not that hard, especially if you're right behind them." He does grudgingly accept that in this and other films featuring defense aircraft, "A lot of the technical details are glossed over, because those details are not really what is important to the story."

What he does take serious issue with in such flicks is the way the pilots are portrayed. "Most of these stereotypes that Hollywood bestows on fighter pilots are wrong, frankly. A lot of the bravado, the arrogance, the lack of humility, are cringe-worthy for me."

He continues, "Most fighter pilots I know are just good, down-to-earth people, who have a particularly fascinating and amazing and consequential job."

Yet Aiello will not let such quibbles stop him from enjoying a great film. "Even if the story isn't exactly right, and the details are a little bit wrong, it's still a story that takes you out of your normal life for 2 hours. And that's enjoyable."

◀ Commander Vincent Aiello served 25 years as a naval aviator. *(Image courtesy of Fighter Pilot Podcast.)*

Commander Vincent Aiello flew F-18s from three different carriers: the USS *George Washington*, USS *Nimitz*, and USS *John F. Kennedy*. *(Image courtesy of Fighter Pilot Podcast.)* ▼

▲ U.S. Navy Aerial Advisor Captain Brian Ferguson and Aerial Coordinator/Lead Camera Jet Pilot Kevin LaRosa II on the set of *Top Gun: Maverick*. *(Image courtesy of Paramount Pictures.)*

◀ U.S. Navy Aerial Advisor Captain Brian Ferguson and Glen Powell on location for the filming. *(Image courtesy of Paramount Pictures.)*

◀ Monica Barbaro and Tom Cruise on the movie set of *Top Gun: Maverick*. Every plane was fitted with six cameras. *(Image courtesy of Paramount Pictures.)*

▼ Tom Cruise playing naval aviator Pete Mitchell in *Top Gun: Maverick*. Much of the film was shot on board the USS *Abraham Lincoln*. *(Image courtesy of Paramount Pictures.)*

GETTING IT RIGHT

From the U.S. Navy's perspective, the details do matter. The person in charge of getting as many of those details as correct as possible is Brian Ferguson. We talked with him about his role working on the 2023 *Top Gun* sequel.

"Hollywood sometimes likes to do things that are different than the way that we operate," says Ferguson. "For example, they might want a certain dialogue or a certain action to happen. And we would say, 'Hey, that's not how we would do it.'"

Discussing working on this new film, he notes, "We had to make sure that we weren't doing things that portrayed us in a dangerous or unprofessional light." He adds, "The Navy has an incredibly high standard of core values, and we had to maintain those."

In terms of his involvement in this project as U.S. Navy Aerial Advisor, Ferguson was not just a factchecker. He also was responsible for ensuring the safety of all of those involved in the flight scenes.

"The things that we did were robust and dynamic, not necessarily the things that we do on a regular basis. We do air-to-air, ground attack, night vision, low level—all those things. But for the film, we were doing it in formation with a civilian film airplane. And to make flying look good in a movie, you have to be much, much closer."

The U.S. Navy and Paramount Pictures were both committed to using "real" flying scenes, rather than computer-generated imagery (CGI). "You have a Navy pilot in the front and an actor in the back," explains Ferguson. "So, they're actually in the airplane, pulling 7 and a 1/2 Gs, low level, doing 600 knots. It was a distinct challenge, because we had to set up a training program to prepare the actors to be able to handle such intense physiological forces. It's a real workout, and they did it twice a day for a couple of hours at a time. So yes, it's real flying."

Sometimes, this kind of production can get a little too real, even for Hollywood. "There's a scene where an airplane goes over the top of a building that we built at the end of a runway. It's flying at a very low altitude and very high speed. We did a bunch of test passes. Then, the time we were actually filming it, the roof started to come off the building, flying up a little bit, and then slamming back down."

"The director said, 'I don't think I can use that, because it was too awesome. It'll never look real. Nobody will ever believe it. Everybody's going to think that's CGI,'" Ferguson recalls. "But it was not CGI. I was standing there and thought I was going to die." This thrilling scene made the final cut.

Between safety and technical concerns, and dealing with the competing interests of accuracy and storytelling, Ferguson's main job was facilitating joint decision-making between the U.S. Navy and Paramount Pictures. That was not easy. "Two very headstrong, very big organizations, that both wanted something very specific, presented a distinct challenge in meeting those goals."

Still, Ferguson concludes, "It worked. Yeah, there were rough spots. And there was a lot of interesting conversations about, 'How do we get from point A to point B together?' But it ended up being a fantastic partnership of industry and military."

COOPERATIVE EFFORT

Of course, if there are actors in the plane, there have to be cameras. "We did a tremendous amount of engineering and design testing, to put multiple cameras in the airplanes, which has never been done before," says Ferguson. "Some pilots have put a GoPro in their airplane. But these were large, 6K HD max cameras, and there were six in every plane."

Their size introduced a lot of concerns. "You've got to account for the weight. You've got to account for 'What if there's an ejection? Are all these camera parts going to come off? Can the camera sustain 7.5 Gs?'" explains Ferguson. "It took a tremendous amount of expensive engineering to make sure that these cameras could go in the airplane safely and operate and not compromise safety in an emergency."

THE NAVAL AVIATORS

Before he joined this project, Captain Ferguson had a long and illustrious career as a naval aviator. When the U.S. Navy tried to recruit him to serve as the technical advisor and aerial coordinator

"These are not the top fifty pilots in the Navy. These are not Blue Angel pilots or Top Gun instructors. They're fifty random fleet aviators."

- Brian Ferguson, U.S. Navy Aerial Advisor

THE (UNOFFICIAL) TOP FIVE FIGHTER PLANE MOVIES

1

Top Gun (1986)

The film was a huge commercial hit, grossing $356 million against a production budget of only $15 million, and became something of a cult classic.

(Image courtesy of Paramount Pictures.)

2

The Right Stuff (1983)

Often thought of as a film about astronauts, all the pilots in the program were U.S. Navy, U.S. Marine, and U.S. Air Force test pilots. The film was a box office bomb, losing money in theaters. But it did win four Oscars.

(Image courtesy of Warner Bros.)

3

Pear Harbour (2001)

A financial success, this movie brought in nearly $450 million. Yet it was panned by critics, mostly for its excessive run time (more than 3 hours).

(Image courtesy of Touchstone Pictures.)

4

Flight of the Intruder (1991)

Based on a novel with the same name written by Stephen Coonts, who drew from his own experience as a U.S. Navy pilot flying the Grumman A-6 Intruder, this film depicts Vietnam War fighter plane crews in action.

(Image courtesy of Paramount Pictures.)

5

Wings (1927)

Winner of the first Academy Award for Best Picture, this silent film was directed by William Wellman, a combat pilot who served in World War I. Its air combat scenes are incredibly realistic.

(Image courtesy of Paramount Pictures.)

A New Classic *Devotion* (2022)

Released in November 2022, this film tells the story of two U.S. Navy fighter pilots in the Korean War, flying Vought F4U Corsairs.

(Image courtesy of Columbia Pictures.)

▲ Monica Barbaro, Jay Ellis, and Danny Ramirez went through months of flight training to prepare for their roles as Naval aviators. *(Image courtesy of Paramount Pictures.)*

on this project, they also offered him the chance to be the lead pilot, sharing a plane with Tom Cruise. But Ferguson had a different idea.

"I said, 'Okay, I'll do it under one condition: I get to pick new aviators, and they have to be junior.'" That was the opposite of what had been planned. The original intention was to reward the longest standing and most decorated pilots with this exciting opportunity.

"And I said, 'How do you think that's going to play?" Ferguson recalls. "What do you think those lieutenants are going to say, sitting around the ready room, when they hear that a crusty old 30-year captain who's already done a lot of cool stuff, got thrown this bone to go be the superhero rock star, doing all the cool flying and movie stuff?'"

"So instead of using me and a bunch of other senior guys, we went the other direction. We used the younger people, who are doing all the hard work and all the great things. I wanted to highlight the fact that we can take any fleet-level crew and put them in a very dynamic, very challenging, very difficult, risk-managed position. And they will do spectacularly." Ferguson adds that he wanted that message to be crystal clear.

"These are not the top fifty pilots in the Navy. These are not Blue Angel pilots or Top Gun instructors. They're fifty random fleet aviators. The point is that all of our fleet aviators are incredibly skilled and ready to win in combat, anywhere in the world tonight."

A FILM WITH A PURPOSE

Supporting, encouraging, and retaining young pilots is a big part of why the U.S. Navy is so invested is this film. The other is recruiting.

"The reason that the Navy supported this venture was not, 'Hey, it's going to be another cool movie,'" Ferguson points out. "It had to have a return on investment for the American taxpayer and the Navy in the form of increased recruiting and retention."

You do not have to look far to find an example of how that could work. There is a clear precedent for using a Hollywood blockbuster as a recruiting tool.

"If you go back and look at 1986," says Aiello, referring to the time around the release of the first, highly successful *Top Gun* movie, "there was a huge spike in enlistments and in officer ascension programs. There was a story of a recruiter who set up his table right outside the theater. He had plenty of people that were interested."

"Let's face it," he adds. "This movie glamorizes the pilot role. The message is that we are members of a professional organization, where men and women, white and black, doesn't matter, can have a chance to be a pilot and do all sorts of incredible things."

Aiello is speaking from personal experience. He was 17 years old when that first film came out. As soon as the credits started rolling, he marched right down to the U.S. Navy office to sign up.

"I ended up doing five carrier deployments, over 700 carrier landings, over 3,000 flight hours," he says. "I served for 25 years and loved every minute of it."

Maybe other teenagers and twenty-somethings will see this latest *Top Gun* movie and decide to follow the same remarkable career path. AD

▲ All the in-plane filming in *Top Gun: Maverick* is authentic. That means no green screens were used. All the backgrounds are real. *(Image courtesy of Paramount Pictures.)*

▼ Making flying look good on film often involves tight formation flying. *(Image courtesy of Paramount Pictures.)*

These HH-60G Pave Hawk helicopters are being loaded into the back of a C-17 Globemaster at Patrick Space Force Base, Florida, in preparation for Hurricane Ian in September 2022. *(Image courtesy of U.S. Air Force. Photo by Master Sergeant Kelly Goonan.)*

C-17 GLOBEMASTER III

SUSTAINMENT AT THE ELEMENTAL LEVEL

By Donna J. Kelly

Aircraft sustainment involves far more than upgrades, modifications, inspections, and overall improvements. A system upgrade is not one item or component, but rather an amalgam of refined technologies and systems that relies on the dependable availability and application of specialized materials.

Consider the internal components of the Boeing C-17's four Pratt & Whitney F-117-110 turbofan engines. Their efficiency is due in large part to their ability to run at super-high temperatures. More efficient operation results in fuel savings, less wear on internal parts, and longer in-service times between extensive inspections and overhauls. So, what is it that makes these engines perform so well at high heat?

Forming the heart of these effective powerplants and central to many other of the C-17s capabilities are rare earth elements (REEs). For example, rhenium is a component of nickel-based alloys that can function in very high heat and extreme stress environments. It has an incredibly high melting point, 5,756 degrees Fahrenheit (3,180 degrees Celsius), exceeded in this property only by tungsten and carbon. It retains its ductility and will not change shape in temperatures ranging from absolute zero (–273.15C/–459.67 F) to its melting point. It also is resistant to "creep," which is the tendency to slowly deform permanently under applied stress.

To obtain 30 grams of rhenium requires refining 120 tons of copper. Thus, in order to ensure accessibility of this crucial element, Pratt & Whitney signed a contract in 2014 with Molymet (Molibdenos y Metales S.A.) of San Bernardo, Region Metropolitana, Chile, to supply rhenium to the engine producer for the foreseeable future.

Praseodymium, niobium, and cobalt are three more REEs used for high-temperature engines, as well as for fiber optic cables and magnets. Other such elements vital to the C-17's success include scandium used in alloys for the

A C-17 Globemaster III from the 145th Airlift Wing prepares to offload missile defense equipment for Exercise Arctic Edge 2022 at Eielson Air Force Base, Alaska, in March 2022. The largest such joint exercise in Alaska involves about 1,000 U.S. military personnel training alongside members of the Canadian Armed Forces. The C-17 is well-suited to operations in extremely cold environments. *Image courtesy of U.S. Air Force. Photo(by Senior Airman Joseph P. LeVeille.)*

Rare earth elements are vital to superior defense operations. (Image courtesy of the U.S. Army.)

aircraft structure; tantalum for capacitors, resistors, and other electronic equipment; indium for liquid crystal displays (LCDs); and gallium, which is used in integrated circuits, light-emitting diodes (LEDs), and semiconductors. Rare earth compounds also are found in traveling wave tubes (TWT) that generate and amplify microwaves and radio frequency signals. Erbium, found in fiber optic systems, aids in the transmission of vast amounts of digital data over distances in secure formats.

SOURCING CHALLENGES

China is currently the source of 90 to 95 percent of rare earth metals and also produces the majority of strong rare-earth magnets available globally. This predominance is based on China having some of the largest deposits of ore containing these elements, combined with loose environmental restrictions related to processing, low labor costs, and strong government support.

Aware that this sourcing poses a potential supply crisis, both the U.S. government and industry leaders have been making significant inroads into bolstering domestic production of REEs since 2019. The largest rare earth mine in the United States, the Mountain Pass Rare Earth Mine, owned by MP Materials and located in Mountain Pass, California, southwest of Las Vegas, Nevada, supplied approximately 16 per cent of the world's rare earth production in 2020. In 2021, it produced 46,752 tons of rare earth oxides, and in 2022, the company received U.S. Department of Defense grants to further develop production and processing of REEs.

However, the problem of refining REEs still leaves the balance of power in China's favor. Each step of the refinement process is extremely energy intensive—whether mechanical for mining and grinding, chemical for hydrometallurgy, or thermal for pyrometallurgy—plus the prevalent processes are enormously toxic.

The big question is whether there is a way to turn at least some of the dirty work of refining into more of a "green" process. Due to the anticipated pressure to upscale production, engineers at North American mining companies and scientific researchers, have made this one of their top priorities.

Promisingly, scientists at Cornell University in Ithaca, New York, are experimenting with a biological process that may achieve REE extrication without producing lethal residue. A bacterium named Gluconobacter oxydans has the ability to bioleach rare earth elements from raw ore. An acid within the bacterium called biolixiviant literally breaks down rock. The genome of G. oxydans has been pulled apart into its composite 2,733 genes, and each one is being tested to determine which components are the agents of disintegration. These components will be screened and developed to increase their ability to dissolve rock, hopefully to the point where toxic methods will no longer be needed for the extraction process.

Sustainable G. oxydans gets its energy from cheap, cellulose-derived sugars, and is being used in other research aimed at learning how to extract and recycle REES from discarded products. It already has been successfully used to leach out 49 per cent of the REEs in spent fluid catalytic cracking catalysts (SFCC).

INSIGHTS INTO LIGHTNING

Lightning strikes above a row of C-17 Globemaster IIIs assigned to the 97th Air Mobility Wing (AMW) at Altus Air Force Base, Oklahoma, April 11, 2020. Throughout spring and summer months, the chances of severe weather such as thunderstorms, flooding, hail and potentially tornados rises in Southwest Oklahoma. *(Image courtesy of U.S. Air Force. Photo by Airman 1st Class Breanna Klemm..)*

Though effective, current lightning protection methods all add at least some weight and impact performance. Searching for a better solution, Boeing has entered into a partnership with King Abdullah University of Science and Technology (KAUST) in Jeddah, Saudi Arabia, seeking to develop a more thorough explanation of the physics related to lightning strikes.

First, what are the mechanisms that quench deflagration waves? (Deflagration waves transfer heat layer by layer, and often result in explosions.) Second, what are the minimum electrical current conditions that result in ignition?

William Roberts, Director of Clean Combustion Research Center at KAUST reports: "These projects develop and apply cutting edge diagnostics in novel facilities to gain fundamental insight into the very real technical issues of flame quenching and ignition phenomena."

It is anticipated that new data garnered from such studies will provide a better understanding of the physical properties that govern lightning-related combustion. In turn, this may lead to new developments in carbon fiber reinforced polymers that may serve as both structural features and help reduce the danger of lightning damage for strategic transports like the C-17 and other aircraft.

In July 2020, a bolt of lightning caused extensive structural damage to a C–17 Globemaster while flying a routine mission near Ramstein Air Base, Germany. Technicians spent 18 days repairing the aircraft to where it could be certified for a one¬time flight to a structural repair facility for complete restoration. *(Image courtesy of U.S. Air Force. Photo by Staff Sergeant Devin Boyer.)*

LIGHTNING FROM AN ELEMENTAL VIEWPOINT

It is estimated that a lightning bolt contains more than 1 billion volts of electricity and produces heat five times hotter than the sun. This massive fury is delivered in energy packets that are remarkably narrow, between 1 to 7 inches in diameter, and the damage is done in less than 50 microseconds. It is widely accepted that aircraft can expect to encounter lightning once every 1,000 hours of flight time.

Mandated lightning protection in aviation began shortly after the 1963 crash of Pan Am flight 214, when a lightning strike blew off a wing tip and ignited fuel vapors in the Number 1 reserve tank, blowing the entire wing off the plane. Since that time, aircraft lightning protection has continued to develop to improve the chances of surviving a powerful blast.

The problem is that aircraft like the C-17 have over 10 percent of their surface covered in composite materials, with most

The sun rises over a C-17 Globemaster III on the flight line at March Air Reserve Base in California. (Image courtesy of U.S. Air Force. Photo by Technical Sergeant Carlton Creary.)

A Royal Australian Air Force C-17 Globemaster III flies in front of a U.S. Air Force C-17 during an aerial maneuver training mission around the Hawaiian Islands as part of Exercise Global Dexterity 2022 at Joint Base Pearl Harbor-Hickam in May 2022. *(Image courtesy of U.S. Air Force. Photo Airman 1st Class Makensie Cooper.)*

located in the outer extremities, wing tip, nose, and rudder, which are the areas with the highest chance of being hit by lightning. Composites do not transfer the energy of lightning like most metals do, so without some form of protection built in, lightning can be devastating.

For example, a C-17 flying a mission over Germany suffered a lightning strike to one of its winglets. The lightning traveled back to the aircraft tail, damaging both the winglet tips and one of the elevators. This brief contact resulted in 18 days of ground time, as technicians made temporary repairs for a one-time-flight to enable the aircraft to fly to a major depot for more extensive repairs.

A number of techniques are used to provide lightning protection for the Globemaster. The most common one uses expanded metal foil between 2 to 10 millimeters thick, which is cut and stretched into a diamond pattern and then placed on top of composite surfaces to transfer the electrical energy toward reinforced pathways. Copper, aluminum, and alloys, such as phosphor bronze, are commonly used in this effective, but weight-adding, method. Engineered Materials, a subsidiary of PPG Aerospace of Wallingford, Connecticut, manufactures this type of protection for all Boeing aircraft.

Microsemi of Aliso Viejo, California, manufactures a series of ultra-low capacitance transit voltage suppressors (TVS) that specifically protect avionics and other electrical devices during lightning strikes. Within a few nanoseconds of a lightning strike, TVS power diodes undergo an "avalanche breakdown," restricting the transient voltage and routing it to a ground point.

Another method of mitigating lightning damage is interwoven wire fabric (IWWF), where a carbon fiber or sometimes fiberglass material is interwoven with a carbon fiber ply. This is the most lightweight lightning protection, as the protective element is incorporated within the composite, requiring no added layer on the top surface. When lightning strikes the thin wires, they expand and erupt onto the surface, allowing the current to spread and be conducted away. TFP (Technical Fiber Products) of Schenectady, New York produce a variety of these materials for many defense aviation applications.

Another method is the use of highly conductive paints or films, generally made of copper and silver. LORD of Cary, North Carolina (recently acquired by Parker Aerospace of Mayfield Heights, Ohio), manufactures specialized UltraConductive films and paints. While these coatings provide a level of lightning protection, they usually are considered add-ons as a second layer of defense.

The last technique is an old one: plating fibers. By simply applying metal, nickel for example, to carbon fibers, conductivity is added to materials that already are mildly resistive. Lightning follows the conductive path, and, similar to IWWF, the nickel coating vaporizes and spreads the energy, lowering its density at that location.

IT'S THE LITTLE THINGS

Aviation began with cloth structures, transitioned to metals, and now includes a wide range of composites that possess strength and durability and weigh far less than traditional materials. Every step of this progress has had its problems, and some were overcome while others were abandoned. Yet we continue to strive for air superiority by building on what has been learned in the past.

It has been our ability to refine and produce superior materials that has brought us to this advanced stage in aviation history. As we continue to explore the atomic world, we can expect to discover more uses for specific elements, as well as physical properties of matter that will further advance our technical achievements.

Attention to the little things, such as the contribution of rare earth elements and the material mechanics of lighting damage mitigation, represent only two related aspects of overall development, improvement, and sustainment of such invaluable workhorses as the C-17. But it is so often those little things that become significant in ensuring safety, serviceability, and longevity.

AAD

(Image courtesy of U.S. Air Force.)

Brigadier General Richard Gibbs
U.S Air Force
Ogden Air Logistics Complex (ALC)
Hill Air Force Base, Utah

Movers & Shakers

Exceptional People Helping To Shape The Future

By Hank Hogan

SPOTLIGHT ON

Brigadier General Richard Gibbs

U.S Air Force, Ogden Air Logistics Complex, Hill Air Force Base, Utah

Hill Air Force Base in northern Utah is home to the Ogden Air Logistics Complex (ALC), where a team of 8,500 personnel performs depot repair, overhaul, and modification of the A-10, C-130, F-16, F-22, F-35, and T-38 aircraft, along with the Minuteman inter-continental ballistic missile system. Brigadier General Richard Gibbs assumed command of the ALC in July 2021, the latest stop in a 29-year U.S. Air Force career that has included numerous logistics and maintenance related assignments. He sat down to discuss with us his time in the Air Force, as well as some insights on current challenges in military aircraft maintenance. His lightly edited answers follow.

AAD: What lessons from your postings and assignments apply to your current position?

"There are lessons I take away from every single assignment," he responds. "One of the lessons is to appreciate where you are and who you are with."

Applying this concept to his latest posting, he notes, "I'm around airplanes every day. I get to talk to people from every walk of life. This is probably the dream job for me."

AAD: What are the biggest challenges facing the Ogden ALC? What are some solutions?

"Hiring and retention, I'll say that's number one," Gibbs replies. "If you look at our [U.S. Air Force] logistics complexes, our three depots, we, Ogden, are in the area with the lowest unemployment rate. So, it makes competition tough."

It helps to offer such personnel benefits as generous leave allowances, he says. Gibbs and his team also are working together on developing ways to attract highly skilled and sought-after civilian software professionals.

"The second challenge is delivering readiness on time, on budget. We have a measure called AA, aircraft availability. If you want to be prepared for combat tonight, you want to have the highest aircraft availability possible. If we're not delivering on time, then warfighters are not getting their airplanes when they need them."

Major Philip "Stonewall" Johnson, 514th Flight Test Squadron F-22 test pilot, departs Hill Air Force Base, Utah, in November 2020, on a functional check flight in the last F-22 Raptor to complete the F-22 Structural Repair Program. The 574th Aircraft Maintenance Squadron processed 135 F-22s through the program, performing structural modifications to increase total flying hour serviceability on the aircraft by 8,000 hours. *(Image courtesy of U.S. Air Force. Photo by Alex R. Lloyd.)*

1st Lt. David Whitfield, 605th Aircraft Maintenance Squadron Air Mobility Unit officer in charge, showcases the flight line layout to Brig. Gen. Richard W. Gibbs, Air Mobility Command, Logistics, Engineering and Force Protection director, at Joint Base McGuire-Dix-Lakehurst, N.J., Oct. 31, 2019. *(Image courtesy of U.S. Air Force. Photo by Airman 1st Class Ariel Owings.)*

After acknowledging some recent aircraft delivery issues, he continues, "We're figuring out, 'How do you get back on track?' We look a lot at the things that slow us down."

The third hurdle he lists is effectively meeting readiness goals in the context of an organic industrial base. "It's really about the facilities and the equipment of the depots," Gibbs explains. "We've got aging facilities." He identifies funding from the U.S. Congress, along with prudent use of those dollars, as one of the keys to overcoming this issue.

AAD: What have been some surprises in your first year of this job?

"I was surprised by how complex and dynamic it is," he quickly answers.

As an example, he outlines the complications of bringing on additional work at the ALC. Central to the success of supporting any new program is having effective personnel in place, and that process generally takes time due to training.

"I wind up having to do what I call investment hiring. But it's a little bit of a gamble," Gibbs reflects, citing budget uncertainty. "So, we have to figure out the right balance of risk for hiring versus risk for not hiring."

AAD: What about the problems, and solutions to those problems, of supporting aging aircraft?

"Aging aircraft. We've heard that for a number of years. That's just the reality," he responds.

Brig. Gen. Richard W. Gibbs, Air Mobility Command Logistics, Engineering and Force Protection director, steps onto a train at Joint Base Charleston, S.C., Jan. 28, 2020. *(Image courtesy of U.S. Air Force. Photo by Senior Airman Allison Payne.)*

U.S. Air Force Brig. Gen. Richard W. Gibbs, Air Mobility Command Logistics, Engineering and Force Protection director, speaks with Lt. Col. Michael Stefanovic, 19th Civil Engineer Squadron commander, left, and Col. Will Clark, 19th Airlift Wing vice commander, right, at Little Rock Air Force Base, Arkansas, Dec. 3, 2019. Gibbs toured the base to observe how the 19th AW successfully accomplishes combat airlift. *(Image courtesy of U.S. Air Force. Photo by Airman 1st Class Aaron Irvin.)*

Brig. Gen. Richard W. Gibbs, Air Mobility Command Logistics, Engineering and Force Protection director, examines the underside of a C-17 Globemaster III at Joint Base Charleston, S.C., Jan. 28, 2020. *(Image courtesy of U.S. Air Force. Photo by Senior Airman Allison Payne.)*

As he points out, "Regarding aging aircraft systems, when you bend a piece of metal a lot, eventually that metal can break."

Gibbs adds that work is underway to automate time-consuming manual tasks, such as drilling out bulkheads on the F-16. Coding software to handle this task is complicated, due to visual irregularities. But once finished, such projects benefit sustainment.

He observes, "As we incorporate such technology, a task like the bulkhead example is going to go from taking weeks to a couple of hours."

AAD: Speaking of aging airplanes, how do you deal with parts or processes that no longer exist, or institutional maintenance knowledge that disappears?

"We have to find alternate means," Gibbs states.

"First, we have to go to systems engineers to find ways to create old parts using new technology."

"Second, we have found—with an evolving workforce and no longer necessarily being able to call on as many years of experience—we are having to be a little bit more explicit in our technical data, for instance, on the work control cards. We just don't assume people have the experience and the knowledge. We have to write more down on those cards to make sure we don't induce errors."

AAD: You originally were commissioned through the Reserve Officers' Training Corps (ROTC). How has that impacted your career?

"I had a great experience," he recalls. "I was working, I was going to classes full time. On the weekends, I was doing ROTC. Thinking back, ROTC gave me a pretty solid foundation in figuring out how to do all these competing things and do them well."

"But there was the perpetual dilemma of figuring out that work/life balance, which I'm admittedly still working on. I haven't quite figured it out. I think most of us have that challenge."

"We all come from different walks of life, and we all have something to contribute..."

Discussing the paths taken by his fellow officers, Gibbs comments, "I love the fact that we come from different commissioning sources." He notes that some of his colleagues come to the ALC via the ROTC route, while others come through officer training school or the U.S. Air Force Academy.

He adds that in his U.S. Air Force career, he has interacted with thousands of remarkably capable and intelligent enlisted personnel. That experience, in turn, has built upon something he learned to value back in those early days at the ROTC, which informs his successful approach to his current command.

"We all come from different walks of life, and we all have something to contribute," he says.

In his closing comments, Gibbs notes that his time at the Ogden ALC likely will last only a few years, based on the usual duration of U.S. Air Force posting for such roles. His stint at Ogden, though, brings with it a personal benefit that has nothing to do with logistics or airplanes.

"You cannot complain about being here at Hill Air Force Base, at the foothills of the Rocky Mountains. I love to ski. I grew up skiing. So, when I have some time, that's where you're going to find me, up on the ski slopes—if there's snow."

AAD

TRANSITION DEFENSE

What You Should Know About Selling Your Business

By Paul McDonnold

The U.S. Department of Justice headquarters, Robert F. Kennedy Department of Justice Building, in Washington, DC. *(Image courtesy of Wikimedia Commons, 2006.)*

In the defense aviation industry, hands-on business owners are a different breed. Their passion flies as high as the fighter jets, transports, and helicopters they help keep in the air.

To them, selling or merging their business may feel like giving up a grandchild. But sometimes this difficult decision must be made, whether due to health-related issues, retirement plans, or other financial, professional, or personal reasons.

Even if there are no plans for selling or merging their business in the offing, successful business owners should think about and prepare for the possibility sooner rather than later. That way, when the time comes, the transaction will be as seamless—and as profitable—as possible.

"A TRUE NIGHTMARE"

Though she is not in aviation, Jaclyn Johnson's experience can serve as a warning for business owners in any industry. As she recounts in the podcast Built to Sell, she founded and spent 6 years building her events and media company, Create and Cultivate, into a bustling operation with eight employees. Then one day in 2018, a large corporation approached her with a dream offer. They wanted to buy her out, at a price of $40 million.

Detailed negotiations followed. Signing day finally arrived on December 22. Unfortunately, the day would bring a Christmas surprise for Johnson, and not a

good one. After driving across Los Angeles to Santa Monica for what she thought was a meeting to finalize the acquisition, she learned the buyer had decided to pull the plug at the last minute.

While her personal drive, dedication, and daily involvement was key to the success of Create and Cultivate, it also became a dealbreaker for the buyer. "They felt I was too integral to the business." This abrupt turnaround left Johnson, who had already started planning her new life, in the lurch, to put it mildly.

BE PREPARED

Being deeply involved in the day-to-day workings of the company is something many entrepreneurs in aviation defense can relate to. In fact, most would hesitate to trade a leadership role in such a dynamic industry for anything else. But looking down the road, to a point where selling or merging the business may be desirable or even a necessity, highlights the importance of being prepared.

William Fry, the founder of Beacon, a company that works with owners of small-to-mid-size firms who want to sell their businesses, explains that one of the most frequent obstacles to a sale is heavy involvement by the owner and his or her family. "It creates a big risk for the new owner who is losing that." This can be particularly problematic when owners wait until the last minute before thinking about exit planning, an unfortunately common occurrence.

"I get it," Fry says, noting that it is human nature to put things off. "But this is so often one of the most important, if not the most important, transactions for a business owner, both emotionally and for their retirement."

In the case of many clients, he says he wishes he could go back in time 3 years to tell them, "Start getting all your books in order. Get your office manager to start organizing and scanning important documents and having them filed away, so that when the time comes you can put your best foot forward."

As Fry sees it, there is a two-fold cost to procrastinating. "One, the transaction gets more expensive, because you're paying these service advisors (lawyers, CPAs, and so on) to help figure out where the heck everything is. Two, it takes more time. There's a saying that time kills deals, and it's true."

THE DEVIL IS IN THE DILIGENCE

No one knows about deals being killed better than Johnson. She says the due diligence was the most challenging part of her 2018 negotiation trying to sell Create and Cultivate.

"It was very intense. I still joke with the PE (Private Equity) firm, it was the diligence of a billion-dollar company, the way that they approached it." She notes that this process involved a challenging amount of backtracking. "Especially because the business had been around for a while. You're digging back for receipts, having to figure out a lot of that stuff."

This difficult experience taught Johnson valuable lessons she now shares with other business owners. "People think someone emails you one day and is like, 'I'm going to pay you a lot of money for your business.' And sometimes that is how it happens. But it's a business in itself, selling your business."

"What I have told [other business owners] is: You've got to get a banker. You've got to do this. You've got to do this whole thing. Then you get an M&A lawyer. And they were like, 'Wait, what?' No one had told them about this."

SELLING A PIECE OF THEMSELVES

Comparatively speaking, serial entrepreneurs have it easy. They build businesses in order to sell them, planning and optimizing for that endpoint right from the start. But it is a different story for entrepreneurs who build their businesses to run and provide them with a livelihood and a career. These lifers are often hesitant to think about the day when they finally pass the baton, and what will come after that. Fry has seen the result many times, when an owner relinquishes that role as leader of a successful business, which has given him or her purpose for so long.

"On an interpersonal level, the hardest thing is letting go, and finding out how you fill that void," Fry says. "From a psychological standpoint, having a plan for what happens after the transaction closes is pretty important."

Some owners decide to stay on in a management, sales, or consulting role. Others make a clean break and throw themselves into hobbies. But this may not be enough.

"After all, there's only so much golfing or boating one can do," points out K. Srikrishna in his *Harvard Business Review* article "How to Make Selling Your Business a Fulfilling Experience." He writes that self-awareness is critical when owners sell a business. As part of moving on to the next stage of life, they need to make decisions about what their new purpose will be—focusing on hobbies, spending more time with family, giving back to their community, or even starting another career.

Srikrishna advises, "Identifying your purpose will take time, so it is best begun well before you're considering a sale." He also raises such questions as: "What excites you and gets you jumping out of bed each morning? What would you do if you had no constraints whatsoever? If you had only 1 year to live, what would you change and why?"

A HAPPY ENDING

Johnson's experience is not only an example of what can go wrong when trying to sell a business. It also illustrates what can go right when the correct lessons are learned. After her multi-million-dollar deal to sell Create and Cultivate fell through, she dusted herself off and began preparing for the next time a buyer came along.

"I immediately knew I had to hire a C-suite. I had to get people in the room that weren't me. I had to start kind of parsing out my responsibilities and how integral I was to every single thing that had happened." She also made financial changes. "We really focused on recurring revenue," she says, something most buyers want to see.

This better informed, proactive approach turned out to be a game changer for Johnson. In 2020, she sold her company for $22 million.

That kind of happy ending is how every successful entrepreneur should envision and plan for their eventual exit from the business, even if it is still many years away.

"Start getting all your books in order. Get your office manager to start organizing and scanning important documents and having them filed away, so that when the time comes you can put your best foot forward."

William Fry, Founder of Beacon. *(Image Courtesy of Beacon.)*

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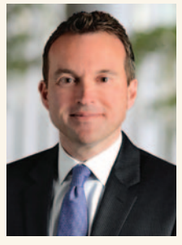
MERGER & ACQUISITION TRENDS: A SECTOR VIEW



Eric Fanning, President of Aerospace Industries Association. *(Image courtesy of Whitney Smith, Aerospace Industries Association.)*

When business owners in aviation defense decide to exit, they often sell to significantly larger players in the industry. But lately, the U.S. Department of Defense has expressed concerns about consolidation among the defense industrial base.

A 2022 Department of Defense report argues that decades of mergers and acquisitions (M&A) have reduced the level of competition to a point where regulators need to act. Among the report's recommendations are stricter oversight of M&A activity by both the Department of Justice and the Federal Trade Commission, as well as expanded opportunities for smaller businesses.

Eric Fanning, President and CEO of the Aerospace Industries Association, echoed the importance of the last recommendation in comments before the U.S. House Armed Services Committee last month. "I don't think consolidation is what's to blame for the shrinking number of companies doing business with the Department of Defense."

He testified that consolidation remains a valuable growth tool for both large and small companies, but that it should be accompanied by a healthy number of new firms coming into the industry. Fanning believes what is needed is to "find the way to let those new entrants in and grow the [defense industrial base]."

Regardless, M&A activity is not likely to dry up anytime soon. Bain and Company's Global M&A Report 2023 expects M&A activity in the aerospace and defense industry to continue strong, with private equity firms being especially active at the smaller end of the market "where margins can be attractive and there is fragmentation despite benefits to scale." Among the things private equity firms like about the sector include "enduring customer relationships, high backlog visibility, and stable cash flows." Suppliers with operational excellence and intellectual property, the report says, will make the most attractive targets.

In another 2023 report, HigherGov also takes a sanguine view, noting that while 2022 M&A activity in aerospace, defense, and government was down slightly (from an all-time record in 2021), it remained the second most active year on record. And among small to mid-size firms in the sector, there was actually increased M&A activity. Transactions involving firms with less than 50 employees rose from 250 in 2021 to 282 in 2022.

Wilbur and Orville Wright achieved the first manned heavier-than-air flight on December 17, 1903. The company they founded, The Wright Company, made the first-ever aircraft sale to the U.S. military when it sold its Wright Military Flyer to the Aeronautical Division of the U.S. Army Signal Corps in June 1909. *(Image courtesy of Curtiss-Wright Corporation.)*

NARROWING THE FIELD

A Brief History of Military Aviation Mergers and Acquisitions

By Patrick J. Walsh

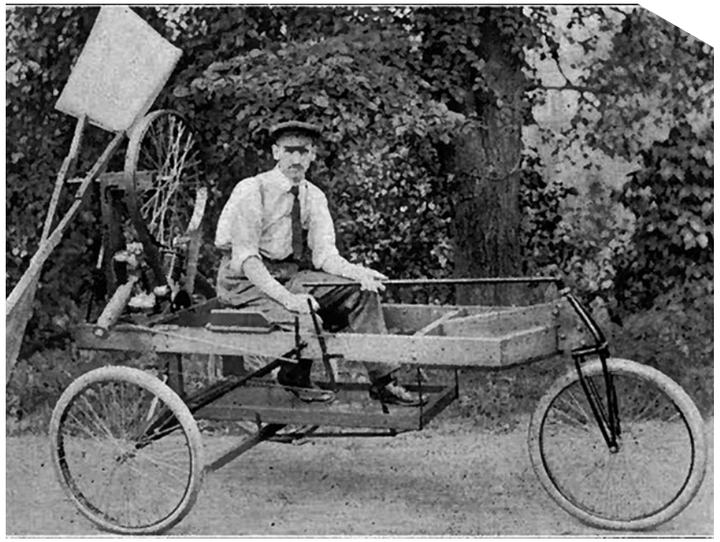
At the start of 1916, the year before the United States's entry into World War I, the nation's two preeminent military aircraft firms (by virtue of the patents they held) were the Wright Company, headquartered in New York City, and the Curtiss Aeroplane and Motor Company of Hammondsport, New York.

By the end of 1917, the corporate ownership of both companies had changed. Wright had merged with the Glenn L. Martin Company, of Santa Ana, California, in 1916. Curtiss was acquired in 1917 by automobile manufacturer Willys-Overland Motors, of Toledo, Ohio.

Both companies were subsequently the focus of a mega-merger that consolidated a host of related manufacturers and suppliers, which created the Curtiss-Wright Corporation in 1929. The merger made Curtiss-Wight the largest aviation company in the United States at the time, and served as a prime example of how mergers and acquisitions (M&A) would shape the industry.

MERGERS AND DEPARTURES

In the early years of the military aviation business, the pioneers who designed new aircraft often found the prospect of creating a workable corporate structure to be as daunting as designing new planes.



The challenges of integrating the skills of gifted inventor and savvy business executive were met by a rare group of early aircraft executives, including Glenn Curtiss, seen here as he demonstrates his "wind wagon" in 1904. Curtiss helped launch the military aviation business in the years leading up to World War I, via the Curtiss Aeroplane and Motor Company. *(The Curtiss Aviation Book by Glenn Curtiss, 1912.)*

Glenn Martin appears before the Naval Affairs Committee of the U.S. House of Representatives on February 28, 1938, to discuss the role his company's aircraft would play in President Franklin D. Roosevelt's Naval Expansion Program. *(U.S. Library of Congress.)*

In 1912, at the age of 26, Glenn Martin founded the first company bearing his name, to manufacture aircraft and provide flight training for the U.S. military. Within a year of the 1916 merger with the Wright Company, it became obvious to Martin that the new business arrangement would not work. He resigned and subsequently formed a second Glenn L. Martin Company, headquartered in Cleveland, Ohio, in 1917.

By 1926, when he founded the major corporation that would enshrine his name in the annals of U.S. military aviation history, Allan Lockheed had already created a successful aircraft business with his brother Malcolm. After seeing that first company fail in the aftermath of World War I, he had taken a hiatus from the industry for half a decade. His new venture, the Lockheed Aircraft Company, initially enjoyed substantial success.

Three years later in 1929, the company's majority stockholder, Fred Keeler, sold his interest in Lockheed to the Detroit Aircraft Corporation, of Detroit, Michigan, a holding company that owned a large portfolio of aviation businesses. Allan Lockheed resigned shortly after the sale.

Courtlandt Gross, President of Lockheed Aircraft Corporation (second from left), meets with Vice President Lyndon Johnson (left), President John F. Kennedy, and U.S. Secretary of Labor Arthur Goldberg (side view) at the White House on May 25, 1961. Courtlandt and his brother Robert led the group of investors who purchased Lockheed in 1932 and built it into a premier supplier of military aircraft. *(Abbie Rowe White House Photographs, John F. Kennedy Presidential Library and Museum, Boston)*

Shown is the Consolidated Aircraft Corporation's facility in Los Angeles in 1941. An important manufacturer of military aircraft during World War II, Consolidated merged with the Vultee Aircraft Corporation in 1943 to form Consolidated-Vultee Aircraft. General Dynamics acquired the company in 1953, and its Convair Division produced aircraft, missiles, and rockets until 1996. *(National Archives and Records Administration)*

Detroit Aircraft failed in 1931, and the Lockheed Aircraft Company was acquired by an investment group led by Robert and Courtland Gross. In 1934, the Gross brothers founded the Lockheed Aircraft Corporation in Burbank, California, and proceeded to guide the company's fortunes for more than 3 decades.

Similarly unexpected consequences followed the Curtiss-Wright merger. One of the other companies involved in the merger was Keystone Aircraft Corporation of Bristol, Pennsylvania. Keystone had been created by the brokerage firm Hayden, Stone & Company from the assets of the former Huff-Daland Aero Company. In 1928, it had acquired the Loening Aeronautical Engineering Corporation. The following year, when the securities firm transferred ownership of Keystone to Curtiss-Wright as part of the merger, the new owners decided to shutter Loening's facility in New York City and consolidate Keystone's operations at the former Huff-Daland headquarters in Pennsylvania.

The relocation plan did not appeal to several of Loening's longtime employees, who instead decided to remain in New York to begin their own company. Led by Leroy Grumman, they formed the Grumman Aircraft Engineering Corporation in Baldwin, New York, in 1929.

POST-WAR CONSOLIDATION

Acquisitions also played an important role in shaping the aviation defense industry in the aftermath of World War II. As orders for military aircraft dropped precipitously, many wartime suppliers reallocated their assets to focus on the commercial market. Others, including some of the manufacturers that had made important contributions to the war effort, were acquired by companies better positioned to survive the diminished demand for military aircraft.

Convair, in San Diego, California, was one example. After the 1943 wartime merger of the Consolidated Aircraft Corporation, also of San Diego, and Vultee Aircraft Corporation, of Downey, California, the manufacturer became known as Consolidated-Vultee Aircraft. It was acquired in 1947 by the Atlas Corporation, an investment firm with diverse holdings across multiple industries.

A key figure in the history of military aviation, John K. "Jack" Northrop was one of the founders of the Lockheed Aircraft Company in 1926. After forming two more companies that were acquired by others, in 1939 he founded the manufacturer that today embodies his legacy as the Northrop Grumman Corporation. *(Image courtesy of the U.S. Air Force.)*

In 1953, General Dynamics, of Reston, Virginia, acquired Consolidated-Vultee from Atlas, ensuring a future lineage for what became known as its Convair Division.

Another important supplier of World War II military aircraft, North American Aviation, of Los Angeles, California, was spun off by its corporate parent General Motors in 1948. North American merged with manufacturing conglomerate Rockwell-Standard, of Pittsburgh, Pennsylvania, in 1967 to form North American Rockwell. It would later play an important part in Rockwell International's emergence as a major aerospace contractor in the 1970s.

THE COLD WAR

The demands of the Cold War revitalized the military aviation sector and gave rise to a prolonged period of relative stability for the industry. This came at a time when its founding pioneers had largely given way to a new generation of corporate leaders.

The notable business developments of the era include the 1961 merger of the Martin Company (the name adopted by the Glenn L. Martin Company in 1957) with the American-Marietta Corporation of Chicago, Illinois, a conglomerate best known as a provider of industrial chemicals and building materials, to form the Martin Marietta Corporation.

The 1967 merger of the Douglas Aircraft Company and the McDonnell Aircraft Corporation, which resulted in the creation of the McDonnell Douglas Corporation, also proved a good fit for both companies. McDonnell's success as a supplier of military aircraft complemented Douglas's well established civil aviation business, enabling the new corporation to remain competitive in the military sector through the mid-1990s.

GROWTH BY ACQUISITION

The end of the Cold War brought about the most significant realignment of the defense aviation industry to date. The 1990s saw consolidation of the largest remaining competitors in the military aviation sector, in a series of transactions that in earlier eras would have been difficult to imagine.

The Lockheed Corporation merged with the Martin Marietta Corporation in 1995 to form the Lockheed Martin Corporation of North Bethesda, Maryland. The two companies had previously made separate purchases of divisions of General Dynamics Corporation in 1993, when Lockheed acquired General Dynamics's military aircraft division and Martin Marietta bought the company's Space Systems Division, and these legacy divisions became part of the new conglomerate.

In 1996, the Boeing Company purchased the military aviation and aerospace assets of Rockwell International. Boeing then merged with the McDonnell Douglas Corporation in 1997, absorbing the McDonnell Douglas corporate identity.

Meanwhile, the Northrop Corporation became the emblematic practitioner of growth by acquisition. In a signature move that also served as one in a long series of transactions, Northrop merged with the Grumman Aircraft Engineering Corporation in 1994 to form the Northrop Grumman Corporation of West Falls Church, Virginia.

AAD

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More than 300,000 parts from aerospace leaders across the industry go into the F-35's assembly. Here, the jet comes together at the Fort Worth, Texas, Lockheed Martin production facility. *(Courtesy of Lockheed Martin.)*

UNMANNED ROTORCRAFT ARE READY TO SOAR

By Hank Hogan

In 2022, unmanned helicopters, both large and small, are increasingly common. The larger, more capable of these unmanned aerial vehicles (UAVs) are being utilized by defense forces for search and rescue, intelligence, surveillance, and reconnaissance (ISR), and other missions.

Such unmanned vehicles generally fly under the control of a ground-based human operator. But with advances in technology, some unmanned rotorcraft are capable of operating in a wider range of operating conditions entirely on their own, both supporting the efforts of ground personnel and serving alongside traditional manned aircraft.

A Fire Scout prepares to land aboard the USS Jackson, a littoral combat ship, in the Pacific in April 2022. The unmanned rotorcraft can takeoff, travel, and land using automated systems. *(Image courtesy of U.S. Navy.)*

Looking at three examples of these rotorcraft from original equipment manufacturers (OEMs), headquartered in the United States, Switzerland, and Austria, reveals that sophisticated computing systems and avionics, added onboard sensors, improved navigation and control components, and better engine and rotor designs are making such unmanned aerial systems (UASs) ever more versatile and able to complement the efforts of traditional helicopter fleets.

ADVANTAGES OF UNMANNED SYSTEMS

We talked with Lance Eischeid, Director for the MQ-8 Fire Scout program at Northrop Grumman, based in Falls Church, Virginia, about this unmanned rotorcraft, with the MQ-8C being the latest version. First and foremost, he points out that one of the primary advantages of unmanned helicopters is keeping people out of harm's way.

"With the unmanned rotorcraft, it can now go in and support the manned aircraft in a manned-unmanned teaming fashion. [We can] send that unmanned aircraft to do the missions that are situations you don't want to put humans in," Eischeid notes. He categorizes such operations as, "the dull, the dirty, and the dangerous missions."

Detailing usage scenarios, Eischeid describes how the Fire Scout, a model actively deployed by the U.S. Navy aboard several ships, might be sent into an area suspected of harboring a potential target. Sensors aboard the unmanned rotorcraft would be used to confirm the presence and location of the target. Upon verification of the target, an armed manned aircraft then could be sent in to deal with it. "It really helps the Navy be safer and also operate their much more expensive manned assets only when they need them," Eischeid observes of this arrangement.

The MQ-8C autonomous rotorcraft is shown on a mission supporting the U.S Navy. *(Photo courtesy of Northrop Grumman.)*

Maritime surveillance operations for the European Maritime Safety Agency (EMSA) in Romania are conducted using the Camcopter unmanned helicopter. *(Photo courtesy of Schiebel.)*

Other OEMs of rotorcraft UAVs include UMS Skeldar of Möhlin, Switzerland and the Vienna-based Schiebel. Their rotorcraft, the Sweden-manufactured V-200 from UMS Skeldar and the Camcopter S-100 from Schiebel, are smaller than the Fire Scout. But as with Northrop Grumman's UAS, the unmanned rotorcraft developed by these companies are serving the international defense market.

A major selling point of such systems is the fact that the cost of flying an unmanned aircraft is about half that of a manned one. Unmanned rotorcraft also offer increased endurance, with some able to stay aloft for 6 or even 10 to 12 hours, instead of the 2 hours possible with a comparable manned helicopter. This increase in duration is due, in part, to carrying more fuel, possible because weight and space are not used for passengers or their support systems. Another reason for the greater time aloft is that an automated system does not tire as people do, and rotating ground-based operators, if used, does not require landing the helicopter.

Currently, many of the initial deployments of autonomous rotorcraft are naval. Ships at sea need an aircraft that fits within a small logistical footprint, and offers vertical takeoff and landing capabilities, requirements an unmanned helicopter satisfies. Also, operating an autonomous aircraft over water is easier, since there are fewer physical obstacles and no need to go through a rigorous regulatory approval of a flight plan.

"If you fly over sea, it's not as demanding in terms of ground risk considerations, because over sea it's not so crowded," notes Richard Hjelmberg, Vice President of Business Development for UMS Skeldar.

AUTOMATED CONTROL

There is another reason why autonomous rotorcraft are increasingly popular with the world's navies. Advances in technology have made them more capable. Innovations in controls, for instance, have made these aircraft safer and more useful.

Taking off and landing on a ship that may be pitching and rolling due to rough weather is a challenging task. In the case of the Fire Scout C, Northrop Grumman uses a radio frequency (RF)-based relative positioning system, developed by the Sierra Nevada Corp (SNC), headquartered in Sparks, Nevada. This system enables the aircraft to take off from and land on a ship in bad weather, where visibility is limited and maneuvering can be difficult. Eischeid notes that the radio frequency-based approach does require RF infrastructure on the ship to determine position of the rotorcraft relative to the ship. To eliminate this requirement, Northrop Grumman is looking at an optical landing system that uses deck patterns to guide an unmanned rotorcraft to a safe landing and takeoff.

The V-200 UAV is the larger of UMS Skeldar's two unmanned rotorcraft, and it is intended for the defense market. According to Hjelmberg, it performs fully automated takeoffs and landings,

▲ Unmanned helicopters, like this V-200 undergoing a flight check, are actively being deployed on naval vessels worldwide. *(Photo courtesy of UMS Skeldar.)*

◀ The U.S. Navy held flight trials of a Camcopter, an autonomous rotorcraft, in the Gulf of Mexico. *(Photo courtesy of Schiebel.)*

UNMANNED ROTORCRAFT AT A GLANCE

Northrop Grumman MQ-8C Fire Scout

Length: 24 feet (7.3 meters)

Payload: 600-plus pounds (272 kilograms). Depending on configuration, can be much heavier.

Web: www.northropgrumman.com/what-we-do/air/fire-scout

Schiebel Camcopter S-100

Length: 10 feet (3.11 meters)

Payload: 110 pounds (50 kilograms)

Web: https://schiebel.net/products/camcopter-s-100

UMS Skeldar V-200

Length: 13 feet (4.03 meters)

Payload: 88 pounds (40 kilograms)

Web: https://umsskeldar.aero/v-200-skeldar

requiring no human piloting, using the Airbus DeckFinder RF-based system and the Novotel Real-Time Kinematic (RTK) system. Gathering data from ground units spaced around the landing pad, both systems determine the position of the rotorcraft relative to the landing pad with an accuracy of better than 20 centimeters —that is, less than 8 inches.

In describing the operation of the V-200, Hjelmberg explains that once the aircraft takes off, it then goes to a holding location near the ship. There, it waits while the automatic system keeps it precisely positioned relative to the vessel, until the rotorcraft is released to follow its preprogrammed journey. Removing people from the control loop during takeoff and landing was a deliberate design decision.

"An automatic system takes care of the movement of the ship, pitch and roll, much better than any person can do. Also, the automatic input to the helicopter to maneuver is, of course, much quicker than any man can do by holding a joystick. This is a safety feature that we have integrated," Hjelmberg states.

The Schiebel Camcopter S-100 also uses an automated system, one that reportedly requires no prepared area or supporting launch or recovery equipment. Unlike some other autonomous systems, the S-100 can operate where a global positioning system (GPS) signal is not available. Walter Lindner, President and Chief Executive Officer of Schiebel Americas, recalls that this capability proved invaluable during a test at a U.S. military base involving jamming both communications and GPS signals, while fixed-wing unmanned aircraft and the S-100 flew a simulated mission.

"There were five aircraft in the air at the time, and four of them crashed. Ours did what it was supposed to do," Lindner says. "It went to a certain altitude and waited for a specified period of time. And when it couldn't reestablish communications, it flew home and landed."

BETTER SENSORS

Sensors form another area of innovation that is helping propel the use of autonomous rotorcraft. Schiebel does not make its own sensors, but it does offer integrated packages that combine a synthetic aperture radar (SAR), an electro-optical/infrared (EO/IR) sensor, and lightweight electronic support measures, forming a specialized system that provides the information typically needed in an ISR

▲ The U.S. Navy held flight trials of a Camcopter, an autonomous rotorcraft, in the Gulf of Mexico. *(Photo courtesy of Schiebel.)*

mission. In discussing this, Linder notes that the S-100 can deliver the power such sensors need. Radars systems, in particular, require significant amounts of electricity to operate.

Hjelmberg notes that UMS Skeldar also integrates multiple sensors into its aircraft. Possibilities include a combination of EO/IR sensors, radars, or laser-based light detection and ranging (LIDAR) systems for maritime missions, with an automatic identification system (AIS) providing ship identification and tracking. UMS Skeldar has installed at least ten different types of EO/IR sensors in its rotorcraft UAVs. As part of its development roadmap, the company plans to integrate signal intelligence and anti-submarine warfare sensors on the V-200.

However, having such onboard sensors gathering detailed information is not enough. An effective communication link is necessary, so that collected data can be transmitted to human command and acted upon if need be. For example, a mission's flight plan might be altered, rerouting the UAV to get a better look at something the sensors picked up.

UMS Skeldar's premium communication offering enables what Hjelmberg characterizes as extreme range and data bandwidth. "You can fly out to 200 kilometers (about 124 miles) from a ground control station, and you can download up to 15 megabits of data. Fifteen megabits is more than enough to download real-time, high-definition data from long distances," he says, noting that data transmission rates decrease the farther the aircraft gets from the ground station. "We are around 10 megabits at full distance."

Northrop Grumman also integrates a variety of sensors—some internally developed and some not—in its Fire Scout C, Eischeid reports. The list includes Leonardo's Osprey 30 electronically scanned array (AESA) multimode surveillance radar system, which has been optimized for naval operations; a forward-looking infrared (FLIR) EO/IR sensor; and an AIS. One of the company's systems, developed at Johns Hopkins University, pulls the data together and provides it in a more easily understood format to operators to help them evaluate what the unmanned aircraft is seeing in the visible, infrared, and other parts of the electromagnetic spectrum.

For naval vessels, such a sensor capability at an extreme range offers a significant benefit, especially for smaller ships that otherwise have no means to see over the horizon. "It gives the ship commanders the organic, real-time, ISR, and targeting capability, without having to rely on manned aircraft or other assets," Eischeid says.

MOTORS AND ROTORS

Motors, rotors, and other mechanical aspects represent yet another area where technological advances are aiding autonomous unmanned rotorcraft. The Fire Scout C, for instance, is built on the commercial Bell 407 helicopter, a mature platform, with more than 1,600 airframes produced and over 4.4 million flight hours logged. In addition to providing reliability of a proven platform, using this design also more than doubled the range and endurance and more than tripled the payload capacity of the Fire Scout C as compared to the B version, which was a proprietary Northrop Grumman design.

"The 407 is a much, much larger platform, which allows us to put larger fuel tanks inside the aircraft and then that allows for added endurance. It does leverage the vehicle management system and architecture from the B, which has been proved over the years," Eischeid notes.

Mechanical innovations also can be found in UMS Skeldar's V-200, which uses

A V-200 autonomous rotorcraft, equipped with a combination of sensors in a pod underneath the aircraft's body, takes off. *(Photo courtesy of UMS Skeldar.)*

the heavy aviation fuel favored by navies worldwide, due to it having lower flammability than the motor gasoline, or MOGAS, fuel used by some land-based aircraft. For the V-200, the OEM uses an engine originally developed by Hirth, an independent company that UMS bought some years back. "The benefit of the V-200 is the heavy fuel engine that has been proven over many years to work very well," Hjelmberg states. Because it uses the same fuel as manned aircraft, this UAV can be fueled by the same infrastructure, an efficiency for ships already supporting manned aircraft operations. Both the Fire Scout 8C and the Camcopter S-100 also have heavy fuel–capable engine options.

According to Lindner, Schiebel develops and builds its own engines in house. These are designed to have few moving parts, while still being able to generate significant power in a compact, lightweight form. The Camcopter's engine is a dual-rotor design, a proven and airworthy approach.

Lindner adds the fact that Scheibel has made some recent improvements to the aircraft's rotors, which, as is typical for rotorcraft, are made of composites. Discussing the innovation, he says, "They've actually put an anodized aluminum strip leading edge on those blades to prevent any damage or erosion from happening if it flies in a rainstorm or, worse yet, a hailstorm."

A FUTURE FLIGHT PATH

With these and other improvements, unmanned rotorcraft are attracting worldwide interest from defense forces, particularly navies. Some of the next markets will be land-based operations, both for the military and elsewhere.

Firefighters, for instance, work in rugged terrain, with the airspace above them frequently closed to manned aircraft due to intense flames and smoke. An unnamed rotorcraft could reach firefighters with needed supplies, thanks to its vertical takeoff and landing capability, risking no danger to a human pilot. Other applications involve inspecting critical infrastructure, such as pipelines, or maintaining round the clock surveillance for border security.

There is an overall trend toward larger unmanned rotorcraft to support such missions. The Fire Scout C, for example, is bigger than its predecessor, the B. The UMS Skeldar V-200 is also larger than the company's V-150, which was developed in parallel. And Schiebel is working on a next generation system that will be three times the size and payload capacity of its S-100.

As for flying alongside other manned and unmanned aircraft in a crowded airspace, that will require further development of sensors and systems that can take in a 360-degree view around an unmanned rotorcraft. These sense-and-avoid systems must be light enough and small enough to fit onto existing rotorcraft, and proven effective, with an acceptably small likelihood of a crash or collision.

Finally, regulatory agencies will have to decide upon and establish workable guidelines and ground rules for operation of UAVs in global airspace. Hjelmberg says the industry as a whole and UMS Skeldar in particular are working with the relevant authorities. Whenever and wherever the needed regulatory measures are in place, which may take some time, this will likely lead to far more demand and a much larger market for these UAVs.

In the meantime, there is a nearer term expansion of the naval market that will lead to substantial growth, one that Hjelmberg already sees unfolding. He predicts, "All NATO navies will have these kinds of systems on ships above patrol boat size. Patrol boats, corvettes, frigates, and destroyers, they will all have unmanned helicopter solutions in the future." And this may not be too far in the future, as Hjelmberg notes, "We see that in all new procurement of ships. There is a section talking about unmanned systems."

AAD

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(Photo courtesy U.S. Air Force . Photo by Airman 1st Class Alexis Redin.)

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Shown is a small decorative plaque depicting a man and griffin in combat, from the reign of King Shalmaneser II (858–824 B.C.E.). Part of the Nimrud ivories famed as examples of Phoenician art, this item was discovered in Iraq in 1951 by Sir Max Mallowan, husband of British author Agatha Christie. The mythological griffin was one of several names suggested for the Lockheed C-130 in a 1953 employee "Name the Plane" contest. (*Cleveland Museum of Art, Purchase from the J. H. Wade Fund, 1968.*)

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In the summer of 1953, readers of the *Southern Star*—Lockheed's weekly newspaper for employees at the company's plant in Marietta, Georgia—were given a unique opportunity. In a contest announced in the paper, workers were invited by management to submit potential nicknames for the firm's new military transport, the C-130.

Interest in the C-130 was particularly keen at the Marietta facility, which had been chosen to manufacture the new aircraft. Within two weeks, more than 9,000 entries were received in the "name the plane" contest. When the results were sorted and the best suggestions were selected, two winners were chosen.

A.A. Pommer had submitted the name "Griffin," in a nod to the mythical creature with the head and wings of an eagle and the body and rear legs of a lion. The name presumably fit the role envisioned for the new transport, as griffins traditionally are characterized in literature as guardians of great treasures.

The name that stuck, of course, was "Hercules," which had been proposed by more than 160 entrants in the contest. C.W. Flemister, Jr., was ultimately credited for the suggestion, sharing the top prize.

As appealing as it might seem to associate the strength of the legendary Hercules with the heavy lifting capability of the new transport—and as much as the C-130 has lived up to the heroic adventures of the legendary strongman—the original choice of the "Hercules" moniker was probably as much due to the company's tradition of naming its aircraft for heavenly bodies. In addition to being the name of the mythical hero and the legendary-in-its-own-right C-130, "Hercules" also is one of the 88 constellations recognized by the International Astronomical Union (IAU).

Sources: Friar, Stephen. *A New Dictionary of Heraldry*. London: Alphabooks, 1987.; International Astronomical Union, "The Constellations." www.iau.org.; Lockheed Martin Corp., "The Many Names of Hercules," www.lockheedmartin.com

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In the 1950s, transplanted members of the original C-130 design team were met by the wide open spaces of the Southern skies and the graciousness of lifestyle below. Here, a C-130 Hercules from the 165th Airlift Wing of the Georgia Air Guard finds a temporary home at Dobbins Air Force Base in Marietta, Georgia, after being evacuated from Savannah to escape tropical storm Andrea in June 2013. (U.S. Air Force photo.)

HOME OF THE HERCULES

When the Lockheed Corporation (now Lockheed Martin) moved into the government-owned U.S. Air Force Plant 6 at Dobbins Air Reserve Base in Marietta, Georgia, in 1951, its primary objectives were to ensure the continued viability of the B-29 and to begin production of the B-47 Stratojet long-range bomber, which it was manufacturing under license from Boeing. The move also positioned the Marietta facility as the logical choice for the production of the C-130. In September 1952, Lockheed announced that the new transport would be produced at the Georgia location.

News that the Hercules design team would soon be relocating from the firm's Burbank, California, location, was initially met with little enthusiasm. In a 2004 interview, legendary Lockheed engineer Willis Hawkins recalled the C-130 team members "kicking and screaming" about their transfer, which was necessitated by the company's need to iron out the details of the new airframe's production with U.S. Air Force officials.

As things worked out, Lockheed's team and the U.S. Air Force personnel involved ended up making relatively few changes to the basic design of the C-130. Generally, they settled on some modifications that served to lower production costs.

With the work complete, the members of the C-130 design team were recalled to California. After two years of living and working in Georgia, however, the group of Lockheed employees was even less enthusiastic to relocate than before. Hawkins recalled them once again "kicking and screaming" about returning to the West, after having enjoyed life in the gracious South.

Sources:
Rhodes, Jeff, "Willis Hawkins and The Genesis Of The Hercules," *Code One* magazine, November 2004.; Scott, Thomas A., "Lockheed Martin," *New Georgia Encyclopedia*, www.georgiaencyclopedia.org.

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A SHORT HOP: THE C-130 FROM PAGE TO PROTOTYPE

The design and production of a new aircraft for the U.S. Air Force is generally a complex business. Decisions, involving issues as weighty as financial calculations, safety considerations, and myriad engineering challenges, make the job of completing a new military aircraft seem overwhelmingly difficult. In the case of the Lockheed C-130 Hercules, however, the process was as streamlined and pragmatic as the aircraft it produced.

In the aftermath of the outbreak of the Korean War in June 1950, and through the subsequent intervention of U.S. forces in the conflict, U.S. Air Force planners recognized a need to upgrade their transport and cargo delivery capabilities. On February 2, 1951, the force issued its general operational requirement for a new transport to several contractors, including Lockheed.

By contrast with the many lengthy, highly detailed documents that often precede the procurement of complex systems, the formal Request for Proposal (RFP) that led to the creation of the C-130 was just seven pages. And a little more than 2 months after it received this notification, the Lockheed team had produced a detailed outline of the new transport's design.

Like the RFP, the Lockheed proposal was an easy read, at about 130 pages. It detailed an aircraft that met the U.S. Air Force's exact requirements for delivering troops and cargo, including large pieces of heavy equipment, to areas that could require landing and takeoff from unprepared airstrips in difficult terrain.

The subsequent presentation of the design was equally workmanlike and unpretentious. To introduce government officials responsible for procuring the new transport to the size and utility of their design, Lockheed engineers constructed a full-sized mockup of the C-130 fuselage and made their presentation to the officials within the mockup itself. With engineering drawings spread out on tables set up in the replica cargo area and projectors illumining the details of the airframe's design, amid the broad walls of the mockup, Lockheed's engineers successfully conveyed the pragmatic usefulness of what would become the Hercules.

Satisfied that the proposal met its requirements, on July 9, 1951, the U.S. Air Force formally awarded Lockheed a contract to build two prototype C-130s, just five months after making its initial request.

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Webb, William J. *The Korean War: The Outbreak, 27 JUNE — 15 September 1950*. Washington, DC: United States Army Center for Military History, 2000.

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A Luftwaffe ground crew loads a Meteor BVRAAM missile aboard a Eurofighter combat aircraft. The missile is being used on Eurofighter, Gripen, and Rafale fighter aircraft and is approved for application on other advanced fighters. (Photo courtesy of MBDA Missile Systems.)

METEOR BUSTER READY TO PROTECT EARTH

Dinosaurs may have been able to survive if they had MBDA Missile Systems' newest missile to shoot down the asteroid that landed in the Yucatán Peninsula 66 million years ago. While the Meteor missile might not be able to shoot down an asteroid quite that large, it certainly will enhance the German Air Force's air-to-air missile defenses.

In June 2021, the Luftwaffe's Tactical Air Wing 74, flying out of Neurberg Air Base in Bavaria, Germany, completed initial test flights of a Eurofighter Typhoon aircraft loaded with operational Meteor missiles. The Meteor is the next generation of beyond visual range air-to-air missile (BVRAAM) systems. The advanced missile features a unique ramjet propulsion system that enables it to fly farther and faster than other air-to-air missiles.

Unlike traditional air-to-air missiles that glide unpowered for most of their flight, limiting their ability to hit agile targets at long distances, Meteor's ramjet also provides sustained thrust at speeds in excess of Mach 4, all the way to the target. As it dynamically adjusts its velocity based on the target's maneuvers, the missile can successfully track and destroy maneuvering aircraft, unmanned aerial vehicles (UAVs), and cruise missiles, even at extreme ranges.

Measuring about 12 feet long and weighing 397 pounds, the Meteor missile has a combat range of 124 miles (200 kilometers). With its advanced active radar seeker, this armament is designed to engage current and future air targets, and it can do so day or night, in all weather conditions, even in severe electronic warfare environments.

MBDA provides missiles and systems for air, sea, and land forces. The company is a multinational group and joint venture of three European leaders in aerospace and defense: Airbus, BAE Systems, and Leonardo. According to Éric Béranger, CEO of MBDA, "The Meteor program can be considered Europe's most successful defense cooperation program, bringing together the best technologies from six European nations to deliver a common military capability that is truly revolutionary."

The Meteor has been cleared for frontline service with European domestic fighter aircraft, including models made by Eurofighter, Gripen, and Rafale. It also is compatible with other advanced platforms, such as the F-35 Lightning II Joint Strike Fighter.

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(Photo courtesy U.S. Air Force . Photo by Airman 1st Class Alexis Redin.)

SmartCan™: The ACE and Multi-Capable Airmen Enabler

MARVIN TEST SOLUTIONS

Munitions continue to evolve at a rapid pace incorporating lessons learned from the Korean,Vietnam and Gulf War era deployments. Since the introduction of the AIM-120 air to air missile in the 90s, munitions manufacturers have been pushing the boundaries, developing weapons that are not only highly lethal, but unaffected by environmental and enemy threats.

As the U.S. Air Force further refines what is needed to Fly, Fight, and Win, it has adopted a new operational doctrine called Agile Combat Employment (ACE). ACE, like the overarching directive to Accelerate Change or Lose from Gen. Charles Q. Brown, Jr., requires many elements to be successful. Two critical enablers of ACE are Multi-Capable Airmen and tailored force packages.

Achieving the ACE objectives can be especially challenging for armament system maintainers. To maintain fighter aircraft armament systems, over a dozen different test sets are currently used on the flightline and in the backshop. This task is further complicated by the limited capability of some test sets that only perform a single function within armament on a single aircraft, while others perform a single function, but on multiple aircraft. To illustrate this further, an F-16 unit can deploy with as many as five test sets, each required for a different function or mission, and some missions can require the use of all five.

THE CHALLENGES OF FIGHTER ARMAMENT TEST

Armament test is further complicated with the introduction of next generation Smart weapons that cannot be fully tested with the current generation of test sets. For example, testing a fighter aircraft's digital communications systems can be challenging, but when trained and equipped with legacy test equipment the task becomes nearly impossible. Current Air Force armament test sets can only test the aircraft they were fielded with, and often lack the ability to perform the functional tests required to support the next generation of Smart weapons.

Two major challenges face any unit employing these legacy test sets. First, the immense undertaking of training and becoming proficient with armament test utilizing a laundry list of test equipment. And secondly, correctly testing digital communication systems with these outdated test systems.

A key requirement for the successful execution of the ACE CONOPS is the Multi-Capable Airman, an individual cross-trained and proficient at multiple skills necessary for mission generation. However, it is important to understand the difference between successfully completing a training course and being deemed proficient. Training usually requires the completion of a prescribed course or a set of tasks. Becoming proficient can take a person's whole career in some cases, but typically requires a task to be repeated and accomplished numerous times after training is complete.

Testing armament systems with the current challenges can negatively impact operational performance and degrade the mission at hand. If test sets with extreme limitations are utilized to determine the armament system's reliability, aircraft can be deployed partially tested, thus jeopardizing overall mission success and potentially warfighter safety. The unfortunate truth is many munitions or armament system failures will not be identified and resolved with currently deployed test sets.

ACE ENABLER – ARMAMENT TEST

Fortunately, an ACE and Multi-Capable Airmen enabling solution is available now for armament test. The MTS-3060A SmartCan™ enables the successful execution of the ACE CONOPS by combining the required technology needed to properly test legacy analog circuitry and next generation digital systems. This is all accomplished in a ruggedized, handheld test set that is easy to deploy, use and maintain. The SmartCan weighs less than 4 lbs., yet delivers fast, comprehensive test capability at the flightline to ensure full mission capability for the warfighter.

The SmartCan has replaced legacy passive testing with advanced active testing and munition simulation; with active

simulation the maintainer becomes the pilot. If test procedures mimic munition expenditure procedures, the maintainer on the ground can duplicate the results the pilot experiences in flight. Latency and intermittent issues can be diagnosed by employing multiple SmartCan test sets on aircraft, resembling munitions loads and fully testing the aircraft's digital subsystem.

This innovative handheld instrument incorporates capabilities to test multiple interfaces and signal types such as MIL-STD-1760, MIL-STD-1553, RS-422, RS-232, CAN-Bus, MMSI, Ethernet, RS-485, Audio, RS-170 Video, and electronic loads. Combined with the ability to test all legacy measurement channels, the SmartCan is capable of testing any armament system. Thousands of test program sets (TPSs) and test reports can be stored, enabling trend analysis and providing the basis for predictive maintenance.

MTS-3060A SmartCan Universal Armament Test Set
(shown with adapter and cable kit)

Extensive cybersecurity features, both hardware and software, make the SmartCan the most cybersecure armament test set available. The removable SD card is the only memory available; when removed, the SmartCan is effectively sanitized and contains no TPS code or saved test data. External system access from other interfaces, such as USB drives, is not available. The ATEasy™ Test Executive and Development Environment, utilized for TPS development, is designed to comply with DOD Security Technical Implementation Guide (STIG) requirements. Access control, user privileges, DLL encryption, data encryption, as well as other safeguards, ensure a secure, reliable operating platform.

The SmartCan replaces multiple legacy test sets at the flightline.

ALL PLATFORMS, ALL ARMAMENT – THE ACE-ENABLED WARFIGHTER

A single, handheld, common menu-driven test set now enables Multi-Capable Airmen to support all armed aircraft platforms with ease, thus ensuring that current and future armament test needs are met across the USAF's inventory of armed aircraft. Commonality, capability and configurability should serve as the cornerstone for armament test equipment and the MTS-3060A SmartCan achieves all of these objectives. The SmartCan™ (SERD #75A77) is the most advanced handheld O-Level armament test set currently available, serving on the flightline today in 12 countries, replacing multiple current test sets. It was most recently purchased by the Air National Guard (ANG) to support all of their O-Level armament test needs on the A-10, F-16, and F-15 fleets.

The SmartCan, together with all cables, adapters and test set functionality are combined in a small, ruggedized transit case, greatly easing the support equipment logistics burden of combat mission support for agile, tailored force packages with a minimal footprint.

Our warfighters provide the first line of defense against a wide range of threats, and it is our mission to ensure they have the finest solutions available when placed in harm's way. The Nation's responsibility not only includes the weapons platforms, but also the test systems used to keep them fully operational. The MTS-3060A SmartCan is the premier O-Level armament test set available today enabling ACE and Multi-Capable Airmen.

We at MTS Make Test (and ACE) Easy!

ABOUT THE AUTHOR

Senior Master Sergeant Adam Wells, USAF, (Ret) is the Warfighter Support Solutions Manager for Marvin Test Solutions (MTS). He joined MTS in 2018 after retiring from the United States Air Force with 20 years of active duty service as an Armament Systems Specialist.

Adam's expertise extends to a number of aircraft platforms including the F-16, F-15C/D/E, F-22 and HH-60. He has extensive knowledge in conventional / nuclear munitions and operation, electrical testing and troubleshooting, intermediate and operational level of repair, training program creation and management, and strategic planning.

Company Highlights

The companies listed on the following pages are suppliers of parts, components, systems and repairs for the fighter aircraft aftermarket. Firms indicated in **BOLD** type with their logo and description have been vetted by the publishers as bona-fide sources of supply and are the best in the business, providing quality equipment and services at a price that reflects true value for the purchaser. We suggest you contact these businesses for all your supply and repair needs, since they are dedicated to your satisfaction as customers. If they do not have the exact part or repair you require, they can act on your behalf to locate a solution for you. For more information please contact Richard Greenwald at r.greenwald@abdonline.com

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THE LONG FLIGHT OF THE FIRST F-15B

The McDonnell Douglas (now Boeing) F-15 Eagle has played a memorable role in the history of modern fighter aircraft. But of all the Eagles that have flown, few have had as unique a lifespan as the first F-15B, the first of the original two-seat F-15s commonly used for training during the airframe's early years.

Intended from the start as a prototype devoted to test the real-world performance of subsequent production aircraft, the first F-15B (U.S. Air Force serial #71-0290) was initially assigned to the F-15 Joint Test Force at Edwards Air Force Base, where it first flew in 1973.

Along with other early versions of the F-15, #71-0290 was used to gather the data needed to put the Eagle into production. It also helped ensure that the then state-of-the-art fighter could safely and effectively assume the air superiority role for which it was designed.

Once that goal was achieved, the prototype F-15s seemed to have reached the end of their usefulness. But in 1984, #71-0290 became the centerpiece of an entirely different course of research, when the U.S. Air Force Aeronautical Systems Division, via the Flight Dynamics Laboratory, tapped McDonnell Douglas to provide a test aircraft for its Short Takeoff and Landing Maneuver Technology Demonstrator (STOL/MTD) program.

As a result, more than a decade after it was first assembled, the original F-15B was extensively modified so it could be used to test the suitability of a new kind of thrust vectoring nozzle, designed to provide enhanced maneuverability for the next generation of fighters. Decked out in its new red, white and blue livery, #71-0290 was outfitted with the innovative two-dimensional, thrust-vectoring, thrust-reversing nozzles, along with a digital fly-by-wire control system. It also was given canard surfaces essentially "borrowed" from the McDonnell Douglas F/A-18 Hornet.

The modified F-15 made its first flight in its new role on May 16, 1989. During the test program's run, it was used to gather extensive scientific data and information based on its practical experience. Among its achievements during the STOL/MTD program, the specially modified F-15 was used for landings on wet and damaged runways as short as 1,650 feet, as opposed to the 7,500 feet normally required. It also logged impressive performance in low-speed takeoffs and rapid deceleration.

When the STOL/MTD program ended in August 1991, it seemed the iconic F-15B prototype had made its final flight. But in 1993, the National Aeronautics and Space Administration (NASA)—an old friend of the F-15 that had contributed a great deal of scientific research to the fighter's development—acquired #71-0290 for use in a series of research programs that spanned the rest of the 1990s and continued well into the new century. The iconic, first-ever F-15B finally was retired on January 30, 2009.

Sources: Chambers, Joseph R. Partners in Freedom: Contributions of the Langley Research Center to U.S. Military Aircraft of the 1990s. Washington, DC: NASA History Division, Office of Policy and Plans, 2000.; NASA, www.nasa.gov.

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As welcome as it is in the U.S. military force's arsenal, the F-35 initially caused concern among some of its new neighbors at bases in heavily populated areas. This F-35A was warmly received at Oregon's Hillsboro Airport, where it took part in the Oregon International Air Show in May 2022. (U.S. Air Force photo.)

THE F-35: THE SOUND OF LIGHTNING

For all the unique advances it represents in comparison to previous generations of fighters, the Lockheed Martin F-35 Lightning II faced a hurdle familiar to its aircraft ancestors, when making its initial deployments at U.S. airfields.

In areas where large numbers of civilians reside close to bases where the F-35 was rumored to become a new neighbor, local political leaders found themselves faced with an ever-growing chorus of concerns about how loud the revolutionary new aircraft would sound. Many of the early worries about sound pollution arose from a 2009 environmental impact study requested by residents near Eglin Air Force Base in Florida.

Previous U.S. Air Force studies had already rated the McDonnell Douglas (now Boeing) F-15 as twice as loud as the General Dynamics (now Lockheed Martin)
F-16 Fighting Falcon, to which the local populace had long been accustomed. And the 2009 study projected the F-35 as sounding twice as loud at takeoff as the F-15 Eagles, and making as much as four times as much noise when landing. This raised fears that the F-35 could conceivably be too loud to bear.

Subsequent studies, as well as residents' experiences in the wake of the F-35's deployment, suggest that the sound profile of the Lightning II, while marginally louder than its predecessors, is within acceptable limits. A 2016 study in the Netherlands, for example, reported a perception that the newly-deployed F-35 sounded only slightly louder than the F-16s,

Sources
Alaimo, Carol Ann, "Noisy F-35 Still Without A Home," *Arizona Daily Star,* November 30, 2008.; "F-35, F-16 noise difference small, Netherlands study shows," *Aviation Week*, May 31, 2016.; Ledbetter, Stewart, "Wonder no more: F-35 jet noise levels finally confirmed at BTV," NBC 5 News, South Burlington, VT, May 31, 2019.; "Report on Jet Engine Noise Reduction." Arlington, VA: Naval Research Advisory Committee, April, 2009.

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2801 80th Street, Kenosha, WI 53143 U.S.A.

Sonaca Montreal 00 1 450-434-6114
13075 rue Brault, Mirabel (Québec), Canada QC J7J 0W2

Southwest Research Institute 210-684-5111
6220 Culebra Rd., San Antonio, TX 78238 U.S.A.

Spectro, Inc. 978-486-0123
160 Ayer Rd., Littleton, MA 01460 U.S.A.

SRI International 609-734-2065
201 Washington Road, Princeton, NJ 08540 U.S.A.

ST Engineering 210-293-3200
9800 John Saunders Road, San Antonio, Texas 78216 U.S.A.

StandardAero 480-377-3100
6710 N. Scottsdale Road, Suite 250, Scottsdale, AZ 85253 U.S.A.

Strong Aerospace Consulting LLC 801-510-4009
1420 E. 2550 N., Layton, UT 84040 U.S.A.

Summit Aerospace, Inc. 305-267-6400
4000 NW 28th Street, Miami, FL 33142 U.S.A.

SUN AIR PARTS, INC. **661-257-7708**
26007 Huntington Lane
Valencia, CA 91355 U.S.A.
Contact: Dennis Nobile
info@sunairparts.com
www.sunairparts.com

Sun Air Parts specializes in supply of Pratt & Whitney piston engines, parts, tools (PWA & TAM Tools), and accessories for the R-985, R-1340, R-1830, R-2000, and R-2800 engines. We buy engines and inventories and have FAA/PMA approvals for many parts including R-1340 cylinders, cams, gears, and many others. See our advertisement on page 85.

Sunaero 33 (4) 72 08 12 12
70 Rue Ampere, Genay Cedex 69730 France

Sunaero by Aerowing 855-325-3835
Nashville, TN U.S.A.

Support Systems Associates, Inc. 478-922-9987
800 Park Dr., Warner Robins, GA 31088 U.S.A.

Tactair Fluid Controls 315-451-3928
4806 W. Taft Rd., Liverpool, NY 13088 U.S.A.

Task Aerospace, Inc. 480-279-3207
5755 S. Sossaman Rd., Ste. 101, Mesa, AZ 85212 U.S.A.

TAT Technologies 972-8-8628500
P.O. Box 80, Gedera 70750 Israel

Teledyne Technologies Incorporated 805-373-4545
1049 Camino Dos Rios, Thousand Oaks, CA 91360 U.S.A.

Terma A/S 45 87 43 60 00
Hovmarken 4, Lystrup 8520 Denmark

Terma North America, Inc. 478-333-2800
128 Osigian Boulevard, Suite 100, Warner Robins, GA 31088 U.S.A.

TestVonics, Inc. 603-924-5922
375 Jaffrey Road, Peterborough, NH 03458 U.S.A.

TEXSTARS, LLC. 972-647-1366
802 Ave. J E., Grand Prairie, TX 75050 U.S.A.

Textron Systems 401-457-2200
40 Westminster St., Providence, RI 02903 U.S.A.

Textron Systems- Support Solutions 410-666-1400
124 Industry Lane, Hunt Valley, MD 21030 U.S.A.

Thales Group 703-838-9685
2733 South, Crystal Dr., Arlington, VA 22202 U.S.A.

The PDI Group 216-271-7344
6225 Cochran Road, Solon, OH 44139 U.S.A.

The Shain Group, Inc. 215-353-8014
89 Militia Hill Rd., Warrington, PA 18976 U.S.A.

Total Quality Systems, Inc. 801-731-2150
4066 S. 1900 W., Suite A, Roy, UT 84067 U.S.A.

Transaero, Inc. 631-752-1240
35 Melville Park Rd., Suite 100, Melville, NY 11747 U.S.A.

TransDigm Group Inc. 216-706-2960
1301 East 9th St., Suite 3000, Cleveland, OH 44114 U.S.A.

Transworld Aviation USA, LLC. 919-234-0729
150-A Dominion Drive, Morrisville, NC 27560 U.S.A.

Trelleborg Sealing Solutions 260-749-9631
2509 Bremer Road, Ft. Wayne, IN 46803 U.S.A.

Triumph Group, Inc. 610-251-1000
899 Cassatt Road #210, Berwyn, PA 19312 U.S.A.

Turkish Aerospace Industries, Inc. 90 312 811 1800
Fethiye Mahallesi, Havaclk, Bulvar No: 17 Kahramankazan-Ankara
06980 Turkey

U.S. Dynamics Corporation 631-842-5600
425 Bayview Avenue, Amityville, NY 11701 USA

U.S. Turbine & Accessory, LLC. 734-485-8024
12668 Delta Drive, Taylor, MI 48180 U.S.A.

UDASH, Inc. 805-526-5222
4511 Ish Drive, Simi Valley, CA 93063 U.S.A.

UFC Aerospace Corp. 631-435-3535
100 Corporate Drive, Holtsville, NY 11742 U.S.A.

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Ultra Electronics Herley 717-397-2777
3061 Industry Drive, Lancaster, PA 17603 U.S.A.

Unical Defense, Inc. 909-348-1500
680 South Lemon Ave., Suite A, City of Industry, CA 91789 U.S.A.

United Dynamics, Inc. 812-506-4723
2555 Cannon St., New Albany, IN 47150 U.S.A.

Universal Synaptics Corp. 801-731-8508
4066 S. 1900 W. Ste. B, Roy, Utah 84067 U.S.A.

University of Dayton Research Institute 801-622-0064
2485 Grant Ave., #315, Ogden, UT 84401 U.S.A.

U.S. Air Tool Co. 631-471-3300
60 Fleetwood Court, Ronkonkoma, NY 11779 U.S.A.

UTC Aerospace Systems 860-654-6000
1 Hamilton Rd., Windsor Locks, CT 06096 U.S.A.

Veteran Equipment Systems And Sales 707-752-5278
2339 Courage Dr. #C, Fairfield, CA 94533 U.S.A.

VIAVI Solutions LLC 316-522-4981
Sales Office, Research and Development, Manufacturing
10200 W. York Street, Wichita, KS 67215 U.S.A.

VIAVI Solutions, Inc. 913-940-2610
10200 W. York St., Wichita, KS 67215 U.S.A.

Vision Systems International, LLC. 408-232-5300
641 River Oaks Pkwy, San Jose, CA 95134 U.S.A.

Vital Link Europe Ltd. 44 (0) 1276 401570
Unit 9, Stanhope Gate, Stanhope Rd., Camberley Surrey GU15 3DW UK

Vital Link, Inc. 979-885-4181
914 Bartlett Rd., Sealy, TX 77474 U.S.A.

W. L. Gore & Associates, Inc. 610-268-1000
380 Starr Rd., Landenberg, PA 19350 U.S.A.

Aurora Flight Sciences engineers are fine-tuning aircraft aerodynamics with new forms of active airflow control technology. The results are likely to enhance the efficiency and effectiveness of commercial and military aircraft. (Photo courtesy of Aurora Flight Sciences, a Boeing Company.)

VIRTUALLY INVISIBLE FIGHTERS

"Could it be a Romulan ship using their cloaking device?" uttered Captain Kirk in a 1966 episode of Star Trek. While we are a long way from the year 2285, when the USS Enterprise was traveling "Where no man has gone before," we are getting closer to successfully "cloaking" fighter aircraft with radar invisibility.

Currently, stealth aircraft, such as the B-2 Spirit bomber, are coated in a radar-absorbent material (RAM) designed to convert incoming electromagnetic radar waves into heat. RAM technology is not capable of deflecting all radar frequencies and is only about 70 percent effective in hiding from radar detection. Plus, it is too fragile to withstand temperatures above 480° F (250° C), and salt, moisture and friction can cause it to lose integrity. Due to these limitations, aircraft must be designed to protect the RAM, compromising maneuverability, air speed, and flight time.

Chengying "Cheryl" Xu, Associate Professor of Mechanical and Aerospace Engineering at North Carolina State University, along with her team, has been developing a new skin for stealth fighter jets. This carbon fiber–reinforced composite polymer skin will be more robust, durable, reliable, and effective. Able to withstand temperatures upwards of 3,275° F (1,800° C) and highly resistant to oxidation and corrosion, this "second skin" is expected to provide cloaking that will make the aircraft as close to invisible from radar detection as currently possible —absorbing more than 90 percent of incoming radar waves.

The new material will be spray-coated onto the surface of the aircraft at a thickness of only 3 mm, so it is expected to have little effect on flight performance. Other possible applications include submarines and ballistic missiles.

Wall Colmonoy-Aerobraze Engineered Technologies 405-672-1361
4700 S.E. 59th Street, Oklahoma City, OK 73135 U.S.A.

WESTEST ENGINEERING CORPORATION **385-423-7201**
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Layton, UT 84040 U.S.A.
Contact: Attila Shevket
attilas@westest.com
www.westest.com

WesTest provides a broad range of highly engineered test/diagnostic solutions from extensive experience on the F-16, F-15, ICBM and Power Supply ATE. WesTest 2000/DATS Test System is the U.S.A.F F-16 standard depot level tester. DATS is expressly designed for LRU & SRU avionics testing, with over 500 certified test programs.

WilliamsRDM, Inc. 817-872-1500
200 Greenleaf St., Ft. Worth, TX 76107 U.S.A.

Wings Aerospace LLC. 727-599-9287
8278 30th Avenue North, Saint Petersburg, FL 33710 U.S.A.

Woodward, Inc. 800-543-5811
1081 Woodward Way, Fort Collins, CO 80524 U.S.A.

WPI- Rubin Campus Center 508-831-6806
100 Institute Rd., Worcester, MA 01609 U.S.A.

Worldwide Warehouse Redistribution Services 937-522-6589
1940 Allbrook Drive, Bldg 1, WPAFB, OH 45433 U.S.A.

WRIGHT MEDIA, INC. **914-244-8899**
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Naples, FL 34108 U.S.A.
www.wrightmediainc.com
Contact: Richard Greenwald
r.greenwald@wrightmediainc.com

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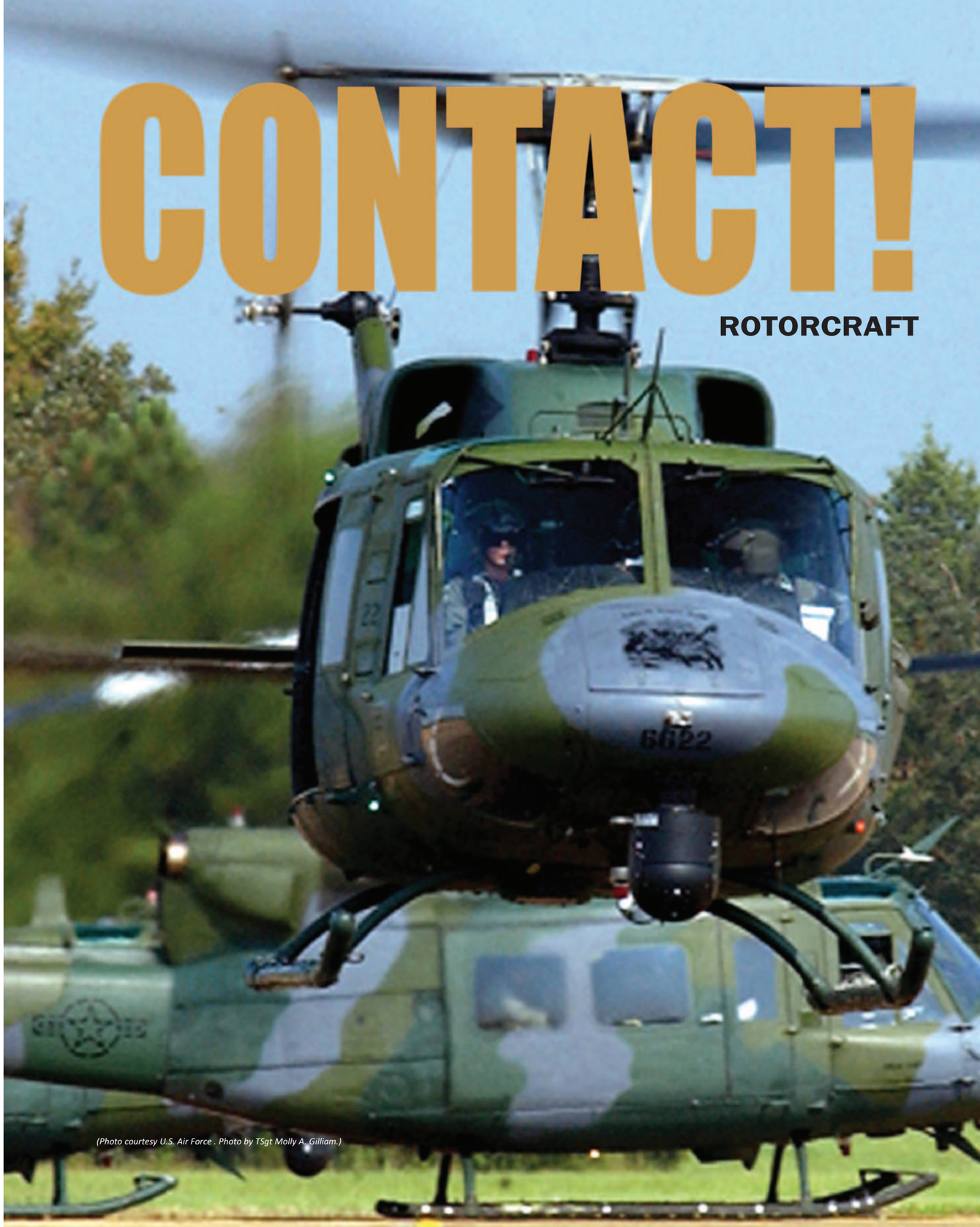
Wyvern Technologies, Inc. 714-966-0710
1205 E. Warner Ave., Santa Ana, CA 92705 U.S.A.

XTREME Semiconductor 858-230-6961
26304 Blue Cove Road, Marble Falls, TX 78654 U.S.A.

Zodiac Arresting Systems 610-494-8000
2550 Market Street, Aston, PA 19014-3426 U.S.A.



(Photo courtesy U.S. Air Force . Photo by TSgt Molly A. Gilliam.)

Company Highlights

The companies listed on the following pages are suppliers of parts, components, systems and repairs for the rotor-wing aircraft aftermarket. Firms indicated in **BOLD** type with their logo and description have been vetted by the publishers as bona-fide sources of supply and are the best in the business, providing quality equipment and services at a price that reflects true value for the purchaser. We suggest you contact these businesses for all your supply and repair needs, since they are dedicated to your satisfaction as customers. If they do not have the exact part or repair you require, they can act on your behalf to locate a solution for you. For more information please contact Richard Greenwald at r.greenwald@abdonline.com

20/20 Components 239-313-5458
5851 Jeffrey Lane, Ft. Myers, FL 33907 U.S.A.

AE Petsche Co, Inc. 844-237-7600
1401 Nolan Ryan Expressway, Arlington, TX 76011 U.S.A.

AAR Aircraft Component Services NY 516-222-9000
747 Zeckendorf Blvd., Garden City, NY 11530 U.S.A.

Abbott-Interfast Corporation 847-459-6200
190 Abbott Drive, Wheeling, IL 60090 U.S.A.

Accurate Precision Fasteners Corp. 201-567-9700
20 Honek Street, Englewood, NJ 07631 U.S.A.

ACG Systems, Inc. 410-224-0224
133 Defense Highway, Suites 206 / 207, Annapolis, MD 21401 U.S.A.

Action Aircraft 214-351-1284
10570 Olympic Drive, Dallas, TX 75220 U.S.A.

Adams Rite Aerospace 714-278-6500
4141 North Palm Street, Fullerton, CA 92835 U.S.A.

AEK Technology, Inc. 818-686-1445
13041 Bradley Ave., Sylmar, CA 91342 U.S.A.

AERO COMPONENT ENGINEERING CO. **818-841-9258**
28887 Industry Drive
Valencia, CA 91355 U.S.A.
Contact: David Bill
davidwbill@aerocomponent.com
www.aerocomponent.com

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See our advertisement on page 45.

Aero Controlex 216-291-6025
4223 Monticello Blvd, South Euclid, OH 44121 U.S.A.

AERO ENGINEERING & MFG. 661-295-0875
28217 Ave. Crocker
Valencia, CA 91355 U.S.A.
Contact: AJ Denogean
mail@aeroeng.com
www.aeroeng.com

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See our advertisement on page 47.

Aero Engineering Support Group, Inc.
3601 Commerce Blvd., Kissimmee, FL 34741 U.S.A.

Aero Hardware & Parts Co, Inc. 914-273-8550
130 Business Park Dr., Armonk, NY 10504 U.S.A.

AERO INSTRUMENTS & AVIONICS **818-800-6250**
3332 Walden Ave.
Depew, NY 14043 U.S.A.
Contact: Doug Jenkinson
djenkinson@aeroinst.com
www.aeroinst.com

Established in 1968, Aero Instruments & Avionics, Inc. proudly celebrates over 50 years as the leader in the testing and repair of Instruments, Avionics, and Accessories. Our extensive experience and superior capabilities offer you a reliable, cost-effective alternative to other avionics repair services.
See our advertisement on page 46.

Aero International, Inc. 571-203-8360
641 South Washington Street, Alexandria, VA 22314 U.S.A.

Aero Turbine, Inc. 209-983-1112
6800 S. Lindbergh Street, Stockton, CA 95206 U.S.A.

Aero-Dyne Supply Co, Inc. 510-562-0657
474 Whitney Street, San Leandro, CA 94577 U.S.A.

Aero-Missile Components, Inc. 215-245-5700
351 Camer Drive, Bensalem, PA 19020 U.S.A.

Aerospace Fasteners, Inc. 903-723-0693
255 N. US 287, Palestine, TX 75803 U.S.A.

AGC Acquisition, LLC 203-639-7125
106 Evansville Ave., Meriden, CT 06451 U.S.A.

Aircraft Lighting International, Inc. 631-474-2254
195 Engineers Road, Hauppauge, NY 11788 U.S.A.

Aircraft On Ground, Inc. 214-350-5334
310 Regal Row, Dallas, TX 75247 U.S.A.

Airspares International 516-334-0900
504 East Meadow Ave., East Meadow, NY 11554 U.S.A.

AllClear Aerospace & Defense
15501 SW 29th St., Suite 101, Miramar, FL 33027 U.S.A.

Alturair 619-749-9867
1937 B Friendship Dr., El Cajon, CA 92020 U.S.A.

American Valley Aviation, Inc. 530-283-0711
550 Orion Way, Quincy, CA 95971 U.S.A.

AMETEK Aerospace and Defense 978-988-4235
50 Fordham Road, Wilmington, MA 01887 U.S.A.

Anillo Industries, Inc. 714-637-7000
2090 N. Glassell Street, Orange, CA 92865 U.S.A.

AOG Reaction 817-439-0700
526 Aviator Drive, Ft. Worth, TX 76179 U.S.A.

ARMEL ELECTRONICS, LLC **954-889-6611**
1601 75th St.
North Bergen, NJ 07047 U.S.A.

See our advertisements on pages 37, 73 and 89.

Astronautics Corp of America 414-449-4000
135 W. Forest Hill Ave., Oak Creek, WI 53154 U.S.A.

Autopilots Central, Inc. 918-836-6418
3112 N. 74th E. Ave., Tulsa, OK 74115 U.S.A.

AVIATION AFTERMARKET DEFENSE **914-242-8700**
P.O. Box 110382
Naples, FL 34108 U.S.A.
Contact: Richard Greenwald
r.greenwald@abdonline.com
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Serving the defense aviation aftermarket, AAD is recognized worldwide as the industry periodical for military aircraft. Published semi-annually, AAD magazine combines engaging articles with directory-type listing information for transports, fighters and rotorcraft. Also publishers of "Wright Prospector", "Contact!" magazine, and "The Program Guide".

AVNET Electro Air 800-241-7530
400 Franklin Road, Marietta, GA 30067 U.S.A.

AVOX Systems 716-683-5100
225 Erie St., Lancaster, NY 14086 Afghanistan

Av-Tech Industries 817-385-0130
1180 Corporate Drive W #100, Arlington, TX 76006 U.S.A.

Beaver Aerospace 734-853-5003
11850 Mayfield, Livonia, MI 48130 U.S.A.

Benchmark Connector Corp 954-746-9929
4501 N.W. 103rd Ave., Sunrise, FL 33351 U.S.A.

Bestek Industries, Inc. 210-434-1071
5710 Greyrock Drive, San Antonio, TX 78228 U.S.A.

Blue Aerospace 954-718-4404
6211 N. Nob Hill Road, Tamarac, FL 33321 U.S.A.

Boeing Distribution, A Boeing Company 972-586-6626
P.O. Box 619048, Dallas, TX 75261 U.S.A.

Bralco Metals 505-345-0959
6718 Jefferson St. N.E., Albuquerque, NM 87109 U.S.A.

Brown Helicopters 850-455-0971
10100 Aileron Ave., Pensacola, FL 32506 U.S.A.

Canfield Electronics, Inc. 631-585-4100
90 Remington Blvd., Ronkonkoma, NY 11779 U.S.A.

Cobham Communications 7720 640137
580 Deansleigh Road, Bournemouth, BH7 7DT United Kingdom

Concorde Battery Corp. 626-813-1234
2009 W. San Bernardino Road, West Covina, CA 91790 U.S.A.

Connector Distribution Corp 310-632-2466
2985 E. Harcourt Street, Compton, CA 90221 U.S.A.

CONSOLIDATED AIRCRAFT SUPPLY CO., INC. **631-981-7700**
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Ronkonkoma, NY 11779 USA
Contact: Steven Matza
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Consolidated Aircraft Supply Co., Inc. is a large FAA- and EASA Part 145-certified repair station that specializes in the maintenance, repair, overhaul, exchange and/or sale of aircraft accessories and rotables.
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Continental Cable Company 800-229-5131
253 Monument Road, Hinsdale, NH 03451 U.S.A.

D&D ENTERPRISES, LLC **954-791-9577**
3350 Enterprise Ave.
Weston, FL 33331 U.S.A.
Contact: David Ettlinger
david@dd-aviation.com
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D&D Enterprises, LLC. is trusted by C130A-J, L-100, P-3 operators, MRO's and major distributors worldwide to provide "Nose to tail" spares, repairs and technical requirements. D&D has one of the largest privately-owned C-130/L100 inventories in the world, ranging from engines, OEM product upgrades, Components, Consumables. D&D is certified ISO9001:2015/AS9120.
See our advertisements on pages 5 and 52.

Dayton-Granger, Inc. 954-463-3451
3299 SW 9th Ave., Ft. Lauderdale, FL 33315 U.S.A.

Dimo Corp. 302-324-8100
46 Industrial Blvd., New Castle, DE 19720 U.S.A.

Ducommun Technologies, Inc. 657-335-3665
200 Sandpointe Ave., Santa Ana, CA 92707 U.S.A.

Electroflight and Rolls-Royce hope their Electric NXT aircraft will break the world speed record for an electrically powered aircraft by reaching 300 mph (480 km/h). The technology they are developing also is expected to benefit the emerging electronic aircraft market. (Photo courtesy of Rolls-Royce.)

CHARGING UP TO BREAK THE AIRSPEED RECORD

Technical advances in the transportation industry often start with breaking performance records. The development of electric aircraft is no different.

UK-based Electroflight and Rolls-Royce are working together on beating the world speed record for an electrically powered aircraft. The current record is 213 mph (342 km/h), and Electroflight's Electric NXT aircraft will attempt to top speeds of 300 mph (480 km/h).

At the time of this writing, Rolls-Royce had been working with Electroflight on the project for three years, spending an estimated $8.3 million. While breaking the speed record is up front on the agenda, the larger goal of this ambitious project is developing technology that will reduce the environmental impact of flying.

As the Bristish are considered world leaders in niche automotive technology, especially motorsports electrification or Formula E, many members of the engineering team have backgrounds in motorcar racing. Their collective experience is being applied to the E-NXT, in the context of new aerospace electrification technology, with designing a battery-powered aircraft posing even more challenges than an electrified race car.

For example, to break the speed record, the battery will have to sustain close to full power output for about eight minutes and provide power to take off and land the aircraft. The battery system for the E-NXT weighs 650 pounds, close to half its total weight. To reduce weight, the battery system is housed in a carbon fiber shell strong enough to also attach the electric motor. The system has 6,400 individual battery cells, slightly larger than AA batteries, cooled by a mixture of water and glycol. Electroflight hopes the engineering know-how it has acquired for this project will provide a head start in the emerging market for batteries designed for electrically-powered aircraft. Governments around the world are committed to making aviation greener, and numerous electric aircraft initiatives are under development with aerospace manufacturers and their partners in the aftermarket.

Dynatech International 631-521-8027
2350 Commercial Park Drive, Palm Bay, FL 32905 U.S.A.

Electronic Expediters, Inc. 805-987-7171
3700 Via Pescador, Camarillo, CA 93012 U.S.A.

Enersys 610-208-1831
2366 Bernville Road, Reading, PA 19605 U.S.A.

Essential Turbines, Inc. 514-633-4458
443 Meloche Ave., Dorval, Qu H9P 2W2 Canada

Excel Aerospace Supply, Inc. 818-767-6867
11855 Wicks St., Sun Valley, CA 91352 U.S.A.

Floats & Fuel Cells 901-842-7110
4010 Pilot Drive, Memphis, TN 38118 U.S.A.

FRAZIER AVIATION, INC. **818-898-1998**
445 North Fox St.
San Fernando , CA 91340 U.S.A.
Contact: Rob Frazier
rob@frazieraviation.com
www.frazieraviation.com

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See our advertisement on pages 27 & 53.

Hawker Pacific Aerospace 818-765-6201
11240 Sherman Way, Sun Valley, CA 91352 U.S.A.

HC Pacific 818-425-8331
5536 Ontario Mills Parkway, Ontario, CA 91764 U.S.A.

Herber Aircraft Service 310-322-9575
1401 East Franklin Ave., El Segundo, CA 90245 U.S.A.

Honeycomb Company of America 941-756-8781
1950 Limbus Ave., Sarasota, FL 34243 U.S.A.

IAI North America 703-875-3771
13873 Park Center Rd., Suite 400N, Herndon, VA 20171 U.S.A.

IMP Aerospace & Defence 902-873-2250
693 Barnes Road, Enfield, NS B2T 1K3 Canada

Innovative Solutions & Support 610-646-9800
720 Pennsylvania Drive, Exton, PA 19341 U.S.A.

Inventory Locator Service - A Boeing Co. 901-433-1539
8001 Centerview Parkway, Memphis , TN 38018 U.S.A.

ISO Group 877-330-1580
2350 Commerce Park Drive, Palm Bay, FL 32905 U.S.A.

Jacon Fasteners and Electronics 800-700-2901
9539 Vasser Ave., Chatsworth, CA 91311 U.S.A.

Janco Corporation 818-846-1800
3111 Winona Ave., Burbank, CA 91504 U.S.A.

K & R Fasteners, Inc. 727-842-9222
8216 Kristel Circle, Port Richey, FL 34668 U.S.A.

Kampi Components 215-736-2000
88 Canal Road, Fairless Hills, PA 19030 U.S.A.

Kitco Defense 801-491-2447
3577 S. Mountain Vista Parkway, Suite B, Provo, UT 84606 U.S.A.

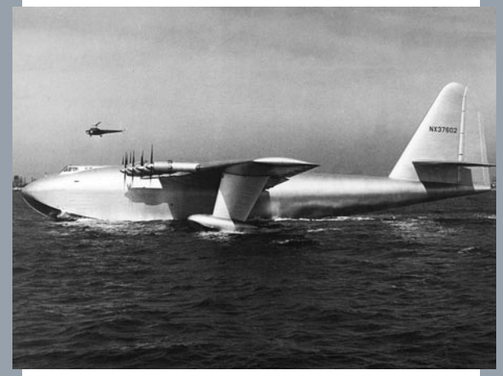
Loos & Company, Inc. 860-630-4242
16B Mashamoquet Rd., Pomfret Center, CT 06259 U.S.A.

Mecanex USA, Inc. 860-828-6531
119 White Oak Drive, Berlin, CT 06037 U.S.A.

Miraj Corporation 201-288-8877
345 Route 17, Hasbrouck Heights, NJ 07604 U.S.A.

Monogram Aerospace Fasteners 626-855-7144
3423 S. Garfield Ave., Commerce, CA 90040 U.S.A.

Moog, Inc. 716-687-7039
Seneca Street at Jamison Road, East Aurora , NY 14052 U.S.A.



H-4 Hercules "Spruce Goose". (Courtesy wikimedia.com)

75TH ANNIVERSARY OF THE 'SPRUCE GOOSE'

Today we're looking back to a time when an eccentric billionaire's dream of reaching new heights was still a novel idea. It was 75 years ago today that Howard Hughes' 'flying boat,' dubbed the 'Spruce Goose,' made its one and only flight. Officially named the Hughes H-4 Hercules, the press persisted in calling it the 'Spruce Goose' even though it was constructed almost entirely of birch wood. The plane was commissioned in 1942 by American industrialist Henry Kaiser, who supplied ships to the U.S. during World War II. Kaiser recruited Hughes—the film producer turned pilot, engineer, and business magnate—to build a flying cargo ship that could avoid German submarines while transporting troops and war supplies across the Atlantic. The contract called for three of the planes to be built within two years. Hughes was still working on the design when the war ended—in the end, he delivered only the one in our photo, two years after V-E Day.

Adjusted for inflation, the Spruce Goose cost roughly $213 million. It remains the largest flying boat ever built and when it was finished, it had the longest wingspan of any previously built aircraft at 320 feet, 11 inches. Even though the plane was no longer needed for the war effort, Hughes was committed to seeing it fly, which it did, but just barely. After liftoff, it flew at 135 mph roughly 70 feet above the water. It cruised for about a mile for a whopping 26 seconds. 'I put the sweat of my life into this thing,' Hughes had said just a few months prior, vowing to leave the country if it was a failure. Failure is in the eye of the beholder, however, as Hughes never left and his spending of government funds was considered reasonable, because, technically, the Spruce Goose did fly.

Ann G. Baumgartner Carl, a member of the Women Airforce Service Pilots (WASP), became the first American woman to fly a jet-powered aircraft when she piloted a variant of the XP-59A Airacomet. *(Courtesy of Smithsonian's National Air and Space Museum.)*

U.S. FIGHTER JET NUMBER 1

In fall 1942, the U.S. Army Air Force rolled out an aircraft that was oddly shrouded to hide everything but its very obvious front-mounted propeller. That day at Muroc Army Air Field (today, Edwards Air Force Base) was to see the first tests of the Bell XP-59A Airacomet, the U.S.'s first jet-powered fighter. The XP-59A wore its propeller and shawl costume to protect its secret joint development by Bell Aircraft Corporation and General Electric (GE).

General Henry "Hap" Arnold, Commanding General of the U.S. Army Air Force brought the project together relying heavily on British experience and assistance, especially on Frank Whittle's engine design expertise. The plane itself was conventional: straight-wing main foils; a traditional tail unit with its single-rudder, low-mounted stabilizers; and a forward cockpit. The two GE I-A jet engines, producing 1,250 pounds thrust each, were flush-mounted beneath the wings.

The Airacomet, in its original 59-A form, was not a notable success. Although it flew well, it was unable to outperform other highly developed propeller fighters of its day. The jet never saw combat, but it served as an advanced trainer, providing an invaluable platform for U.S. Army and U.S. Navy fighter pilots to gain experience with jet propulsion.

The XP-59A also provided another first. Ann G. Baumgartner Carl, a member of the Women Airforce Service Pilots, became the first American woman to fly a jet-powered aircraft as part of her highly varied aviation service career.

Sources: GE Aviation, www.geaviation.com; Military Factory, www.militaryfactory.com; Smithsonian National Air and Space Museum, https://airandspace.si.edu/;

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Photo courtesy of U.S. Army Private First Class Gabriel Sliva.

DROP SHIP DRONES

We have been hearing about Amazon and other bit retailers potentially developing drone drop ship networks for deliveries of small packages. "Joint Tactical Autonomous Aerial Resupply System" (JTARV) is military-speak for a drone that delivers supplies to combat teams in the field. The U.S. Army Futures Command's Sustainment Capabilities Development and Integration Directorate along with the U.S. Marine Corps' Capabilities Development and Integration Offices are taking a serious look at the concept, with the hope of having a capabilities development document signed by 2024 and an operational system in place by 2026.

According to the Request for Information (RFI), the drone should weigh around 1,300 pounds and be able to haul up to 800 pounds of supplies. Other requirements include day or night all-weather operation, a 110-mile radius, and the ability to communicate with current and future tactical command-and-control systems. The RFI went on to state that two to four soldiers should be able to lift the aircraft from a transport container and assemble it in 15 minutes. Other requirements for the drone include automatic launch, navigation in GPS-denied environments, and the abilities to self-select optimal flight paths, choose landing sites, and return to its point of origin—all the while avoiding all obstacles.

A company actively doing research and development for such un-manned vertical takeoff and landing technology is Malloy Aeronautics (www.malloyaeronautics.com). Based in the United Kingdom, with testing facilities in the United States, Malloy is creating a family of heavy-lift, unmanned vehicles, designed to solve so-called "last mile' logistics. The company has been working with the U.S. Army to develop concepts and designs for mission-specific airborne systems that can handle the most extreme and demanding operations.

TESTED IN SPACE, SAVING LIVES ON EARTH

From the start, the ability to adapt has been an advantage of the Lockheed Martin C-130 Hercules. And as the versatile airframe has moved from one role to another, its systems and equipment have been transformed to fit a wide array of missions.

The evolution of the HC-130H variant, for example, demonstrated the ability of specially modified C-130E aircraft to be deployed for combat search and rescue (CSAR) operations during the Vietnam War. Among the modifications made to the C-130E for such missions, one key component, the AN/ARD-17 aerial tracking system, had a unique lineage.

In its CSAR context, the job of the AN/ARD-17 was straightforward: it was used to locate beacons that downed aircrew deployed after they had reached the ground. Once the airman was located, CSAR forces, deployed in various aircraft, would take steps to suppress enemy fire, enter the contested terrain and complete the rescue.

By the time the HC-130H was deployed on its first CSAR mission in Vietnam in December 1965, the AN/ARD-17 device had been in development for several years, but not for use in combat. The system had its origins in the early years of the U.S. space program, where it was envisioned as a means of tracking and retrieving spacecraft returned to Earth.

During the final flights of the Mercury space program in 1962 and 1963, an early direction-finding device installed on a U.S. Air Force C-130B was able to successfully track the Mercury spacecraft in orbit. Buoyed by the successful test, Air Force officials and their counterparts at the National Aeronautics and Space Administration (NASA) made plans to acquire what would become the AN/ARD-17, with the intent of installing the system on as many as sixty HC-130s. The specially equipped aircraft could then be used to track and recover crewed spacecraft that veered off course from the intended return point.

As things worked out, NASA's ability to accurately predict where its pioneering astronauts would return to Earth mitigated the need for using the system to find wayward spacecraft during the manned Gemini and Apollo flights. But like the aircraft in which it was installed, the AN/ARD-17 system quickly adapted to its new role in the skies of Southeast Asia. Over the course of the war, it played a central part in the U.S. Air Force's CSAR capability, helping establish the Hercules's reputation for transforming its systems and equipment as it moves from role to role.

Sources: Chase, William R. and William A. Middleton, "Apollo Experience Report: The AN/ARD-17 Direction-Finding System." Washington, DC: NASA, March, 1975. Kaminski, Tom, "The Last Days of the King," Key Aero, July 4, 2019.

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