It's Fast and It Hovers: The Next X-Plane

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What Doomed the F-8?

Vought XF8U-1

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BY MARK HUBER | PHOTOS BY JIM KOEPNICK

At the Howard Aircraft Foundation fly-in, members putter around Benny Howard's high-wing beauties.

JIM KOEPNICK

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"Hi! I'm from Earth!"

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Space Nerds

Sometimes a soldier's best friend is an IT guy with a satellite dish.

BY ED DARACK

Gunfighter

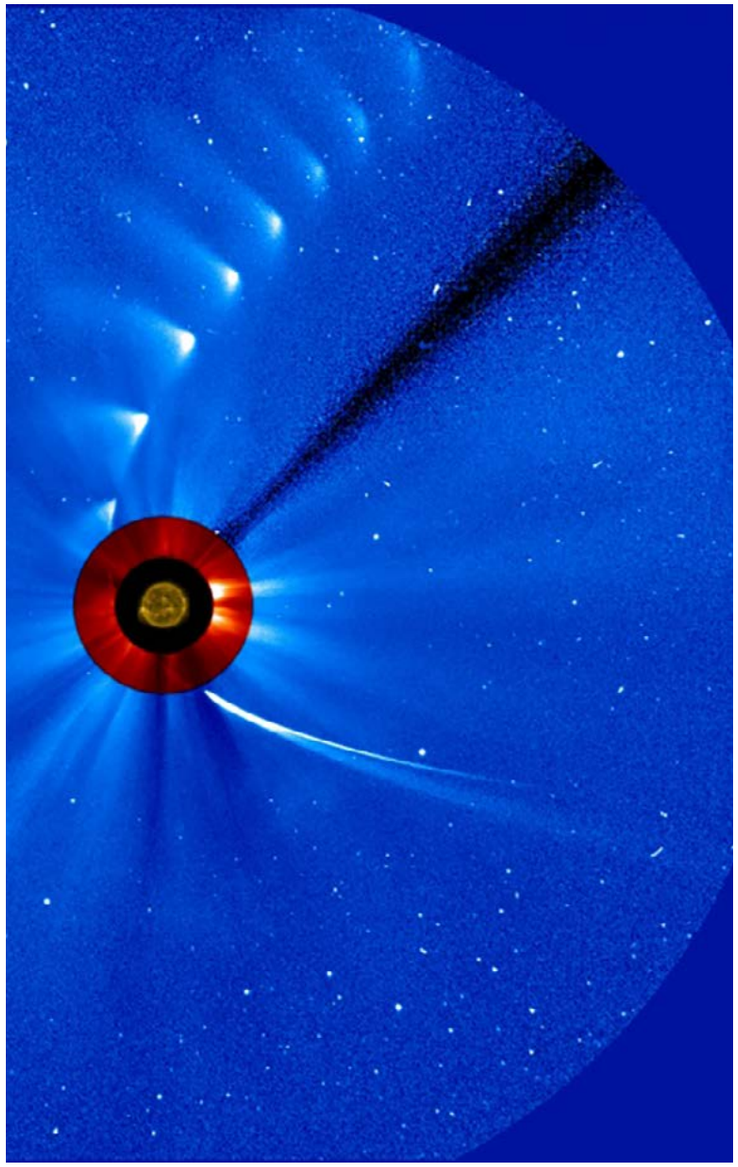
The Vought F-8 Crusader's motto: Have gun, will dogfight.

BY EILEEN BJORKMAN

If the Lockheed Martin F-35B Joint Strike Fighter is any guide, the companies competing for DARPA's vertical-takeoff-and-landing X-plane have their work cut out for them.

LEFT: TECH SGT. WOLFRAM M. STUMPF/USANG; RIGHT: LOCKHEED MARTIN/ANDY WOLFE

Departments



In a composite image made by the Solar and Heliospheric Observatory, Comet ISON is stopped (several times) in its swing around the sun.

One of a collection of bashed cockpit voice recorders, recovered from airliner crash sites.

ON THE COVER: On the 60th anniversary of the Crusader's first flight, the Museum of Flight in Seattle rolled out its XF8U-1 after a decades-long restoration. Last September, Museum photographer Ted Huetter snapped its portrait.

LEFT: NASA LANGLEY/DAVID C. BOWMAN; RIGHT: JEFFREY MILSTEIN

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Viewport

FROM THE DIRECTOR OF THE NATIONAL AIR AND SPACE MUSEUM

Flying Lessons

FOR THE NEXT THREE MONTHS, the National Air and Space Museum is hosting an exhibit unlike any that has appeared in the Museum before. Developed by Boeing and Evergreen Exhibitions, Above and Beyond features 20 interactive or dynamic displays that engage visitors in the many fields of aerospace, from designing aircraft to traveling to Mars (see In the Museum). This is a gallery where there are not just things to see—although there are artifacts and many videos—but things to do. When you plan your visit, you'll want to budget at least a couple of hours in order to take in all that is offered here.

Besides its interactivity, Above and Beyond is unusual in another way. At the same time it teaches our visitors about aerospace, we hope it will teach us about our visitors. As we begin to renovate our other galleries—work we are undertaking with a $30 million gift from Boeing—our curators and exhibit designers are using Above and Beyond as a test lab to learn about the kinds of activities that are most effective in holding visitors' interest.

Even as we update and transform our exhibit space, one hallmark of the National Air and Space Museum that will not change is the protection and display of authentic artifacts that played a signifi-

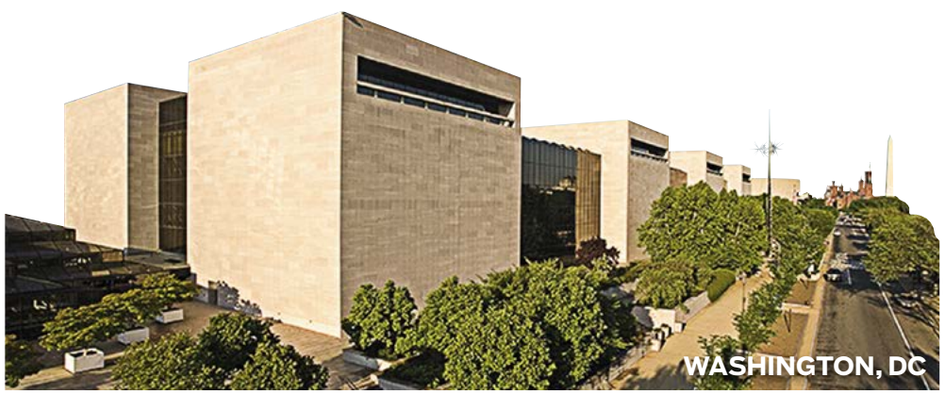
cant role in aerospace history. One of those artifacts, the subject of this issue's cover story, is the Vought F-8 Crusader, the first U.S. fighter to fly faster than 1,000 mph.

In 1966, I checked out in the F-8. There was no simulator, and there were no two-seaters. To get the feel of the airplane, on your first hop, you lined up on the runway, went into afterburner, and at 60 knots you came out of burner and tried to stop before the end of the runway.

Every F-8 pilot wanted to earn a thousand-mile-an-hour pin, but although the F-8 was an easy airplane to fly, it wasn't easy to get it to 1,000 mph. In the F-4, you can get your Mach 2 pin just by adding power and sitting there. In the F-8, you had to really work, particularly in the older ones. You climbed to about 43,000 feet, then went into afterburner, which you could use for only five minutes. Then you started down, accelerating, and when you got to 37,000 feet, you eased it back up to about 40,000 feet again. When you came back down the next time, you had to make it, because by then you'd run out of burner time and probably out of airspace.

In this issue's feature, you'll see the patch the F-8 pilots made: "When you're out of F-8s, you're out of fighters." A-4 Skyhawk pilots developed a different patch. It said, "When you're out of F-8s, it's no big deal." I'm glad I don't have to moderate that debate, but I'm also glad we have an F-8 Crusader in the National Air and Space Museum. You can learn a lot about fighter aircraft by studying that one.

J.R. DAILEY IS THE JOHN AND ADRIENNE MARS DIRECTOR OF THE NATIONAL AIR AND SPACE MUSEUM.



WASHINGTON, DC

CHANTILLY, VA

Letters

WRITE TO US

Look for Another Lunar Loss

Scientists should forget about tasking the Lunar Reconnaissance Orbiter to find Luna 9 ("ISO First Moon Lander," Soundings, Sept. 2015); instead, have it try to solve the mystery of Surveyor 4.

On July 17, 1967, at about two and a half minutes before touchdown, all contact with the Surveyor was lost. Some believe the retro-rocket exploded, blowing Surveyor to pieces. But it's possible something happened to the radio and Surveyor has been sitting on the moon's surface ever since. Pointing the LRO at Surveyor 4's Central Bay landing site would help solve the mystery of its loss.

THOMAS J. FRIELING
Tallahassee, Florida

Aces Missing

From "The Last American Aces" (Aug. 2015), the uninitiated might think there was only one pilot ace in the Vietnam War, Richard "Steve" Ritchie. There was another: Randy "Duke" Cunningham. Am I admitting some annoyance that the only Vietnam pilot mentioned was Air Force? Regrettably, yes. As a naval aviator of that era, I

want people to know that the Navy held its own in Vietnam.

C.W. "TODD" SCHRACK
Bethlehem, Pennsylvania

Editors' reply: Our photo-essay could include only those who attended the 2015 American Fighter Aces convention, which is mentioned in the introduction, or who were able to be within driving distance so that the photographer could reach them.

We Meet Again, Old Phriend

The Phrog went out in style (Viewport, Aug. 2015). At the farewell fly-in on August 1 at the Steven F. Udvar-Hazy Center in Virginia, BuNu no. 153369 made a low pass, an Osprey (the Phrog's replacement) on its wing. Afterward, the CH-46's logbooks were presented to General Jack "Zorro" Dailey, director of the National Air and Space Museum, which will display 153369 at the Udvar-Hazy Center.

Upon my return home, I checked my logbooks and found that, after 26 years of flying CH-46s, I made my last flight as a Marine Corps pilot on May 8, 1990, in that exact aircraft.

COL. JERALD GARTMAN, USMC (RET.)
Morehead City, North Carolina

Corrections

Sept. 2015 "Huey Pilots: Where the Heroes Were Made": The Marines' name for the UH-34 is Sea Horse, not Choctaw.

Aug. 2015 "Brought to You by Drones": On July 17, Flirtey delivered medications via drone to a clinic in western Virginia, not West Virginia.

June/July 2015 "War Within a War," p. 34, caption: The first bombing missions in Korea were flown a few days, not three weeks, after the war began. The error was introduced during copy editing.

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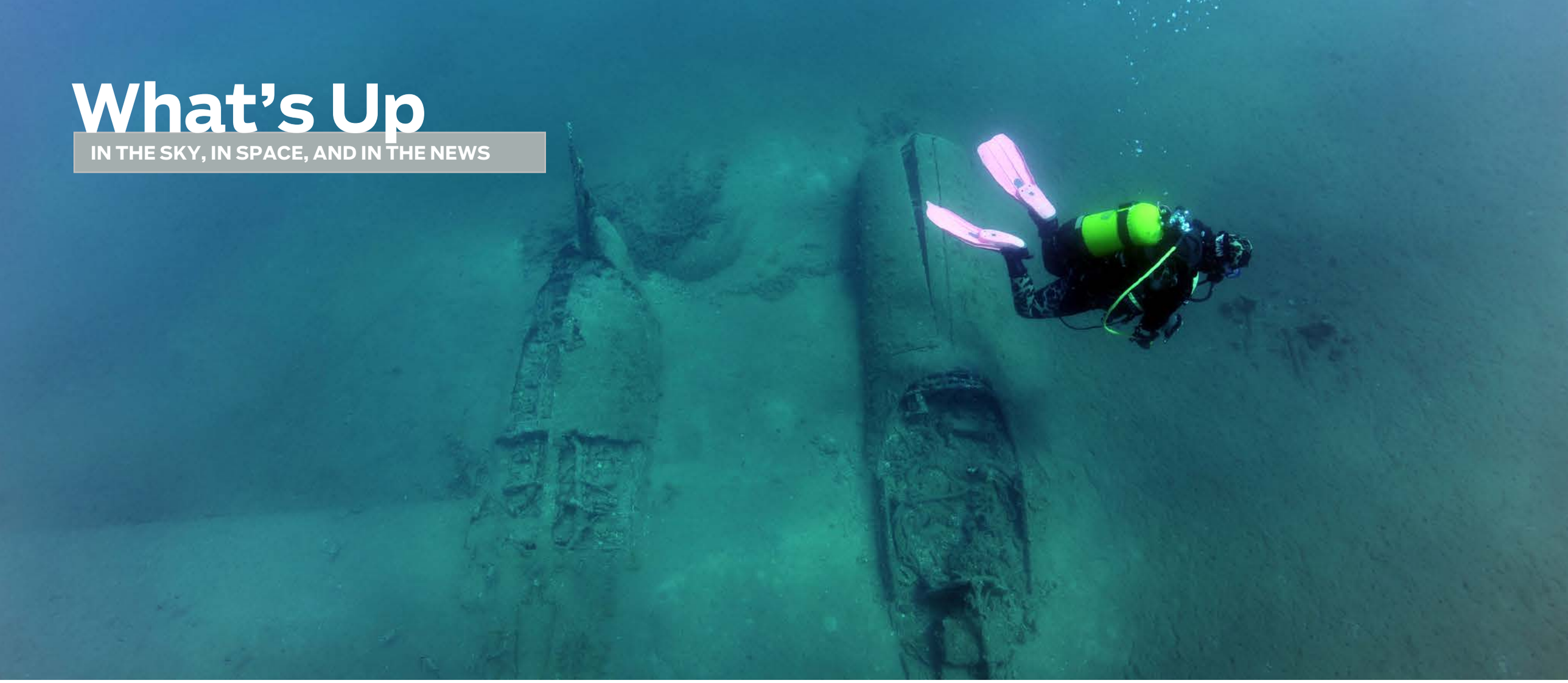
What's Up

IN THE SKY, IN SPACE, AND IN THE NEWS



Diver Sara Belluomini examines a wreck believed to be a 1943 Lockheed F-4 reconnaissance airplane that went down in the Tyrrhenian Sea, off the coast of Tuscany, during World War II. Sara and her father Dino, owners of the Cecina Diving Center in Cecina, Italy, met the airplane's pilot, David Toomey, in 2000 when he traveled to Italy to search for his airplane, named *Duckypoo,* the pet name of the aircraft's crew chief (see "Can This P-38 Be Saved?," Oct./Nov. 2009). According to underwater photographer Stefano Ruia, the Belluomini family was unable to help Toomey locate his aircraft in 2000 because his time in Italy was too short to conduct a thorough search. (Toomey died in January 2014.) The divers say that this wreck is in the area of the Tyrrhenian Sea where Toomey told them he believed his airplane sank.

On June 27, 1944, First Lieutenant David Toomey flew *Duckypoo* from his base in Tarquinia on a low-level reconnaissance mission over the Arno River valley. He ran straight into an ambush by German anti-aircraft guns, but managed to bring the damaged *Duckypoo* out over the water before he finally ditched.

The Belluominis, says Ruia, have spent three years searching for the F-4 along the bottom of the waters around their base. They are now waiting for permission from Italian archaeological authorities to examine the wreck and excavate around it to find the aircraft's name or serial numbers so they can confirm its identity.

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WORKS BY LEGENDARY HOLLYWOOD PHOTOGRAPHER

RICHARD SCUDDER

www.RichardScudderArt.com | 323-373-6483 | PO Box 17811 Beverly Hills, Ca. 90209

NASA Nosedives for Your Safety

A SMALL FLEET of Cessnas at NASA's Langley Research Center in Hampton, Virginia, has not been having a breezy summer. The first, a model 172, carrying two dummies in the cabin, suffered a hard landing on July 1; the second took a nosedive into the dirt on July 29; and a third airplane got a hard tail strike as it crashed on August 26. Had people been in these accidents, they potentially could have survived. What NASA wanted to know was: Would help come in time?

The agency's Search and Rescue Mission Office was testing the airplanes' emergency locator transmitters, or ELTs—instruments the Federal Aviation Administration requires every aircraft to carry. In modern ELTs, which transmit at 406 megahertz, a protected frequency band for personal distress calls, a gravity-activated switch

A Cessna sporting a speckled livery undergoes a controlled crash at the Langley center; the dots allow cameras to track crash loads.

NASA LANGLEY/DAVID C. BOWMAN

flips when the airplane experiences an impact. A fleet of satellites detects the signal and notifies a local search-and-rescue team. But ELTs have been notoriously unreliable (see "Lost in America," Oct./Nov. 2011). And the FAA doesn't give advice on where and how to install them so they best survive a crash.

"We're trying to mimic real-world crashes," says Lisa Mazzuca, NASA's search-and-rescue manager. The data from the tests will help in building and verifying models that can predict what happens to every part of the ELT instrument when it goes through an impact. "Obviously we can't keep buying airplanes and crashing them to see what happens," says Mazzuca. The team hopes to learn the best ways to mount the ELT in the aircraft, and more about the device itself: Are there better materials to use? Could the cables be designed better? Is the relay to the satellite working as best it can?

NASA will take the models to an international group that's designing the second generation of ELTs. These next-gen models should be available by 2019, just after an upgrade in the satellite system that detects them. Over the next few years, Cospas-Sarsat, the multi-national program that runs the search-and rescue system, plans to move its instruments from low-Earth-orbit and geosynchronous satellites onto GPS satellites in medium Earth orbit. The stronger beacons and higher satellite altitude will enable location detection to within 100 square meters, down from one square kilometer today.

HEATHER GOSS

MAYDAY: NASA TO THE RESCUE

A donated Cessna hits the pavement at NASA's Langley Research Center to set off four emergency beacons on board. The video will be used to create models of how beacons perform based on where they're installed.

Tap to watch video at *airspacemag.com/eltcrash*

NASA

Tell the Astronauts: The Law's Coming

LAST NOVEMBER, while the European Space Agency's Rosetta team celebrated landing its Philae probe on comet 67P/Churyumov-Gerasimenko, NASA's Asteroid Redirect Mission continued to plan how it would go about moving an asteroid into lunar orbit and send astronauts there before 2030. A month later, the Federal Aviation Administration told Bigelow Aerospace it could land an inflatable habitat on the moon at some future date and have exclusive rights to the land it occupies, in what seems like a bold expansion of the agency's jurisdiction.

Along with the immutable laws of physics, five international treaties govern space. The most important is the 1967 United Nations Outer Space Treaty, which forbids nations from claiming sovereignty over any celestial object. "I would say the chances of us backing out of the treaty so we could claim ownership of a celestial body are about zero," says James Dunstan, a space lawyer who founded Mobius Legal Group. "There are more important items" that the United States would prefer to keep intact, he says, "like no nuclear bombs in Earth orbit." (Although the treaty doesn't define "celestial body," the general consensus is that it doesn't include anything that can be moved from its natural orbit.)

Europe sends its Philae lander to Comet 67P (artist concept). Can we stake a claim in space? The lawyers are on it.

The treaty declares space and celestial bodies free for "exploration and use," but it also provides for zones of non-interference. Astronauts from one nation can't toss dust on the solar panels of another nation's asteroid probe, nor can moonwalkers enter Bigelow's future lunar park until they're invited inside the airlock. That's a type of ownership, and with the rise of companies that intend to go mining in space, like Washington State-based Planetary Resources, celestial property rights need to be addressed.

The FAA's letter to Bigelow pointed out that the 1967 treaty requires nations to regulate commercial activities in space, but U.S. federal law has no such framework. So in March,

THE COUNT

1,300

The number of Section 333 waivers for commercial drone operations the Federal Aviation Administration awarded through the end of August. Recent exemptions allowed drones to inspect cell phone towers, perform botany surveys, and conduct search-and-rescue missions.

ESA/ATG MEDIALAB

Bugatti Flies

SCOTT WILSON'S REPLICA of race car designer Etto Bugatti's only airplane ("French Racing Blue," Sept. 2014) made its first flight August 19, successfully but with a rough landing. **Watch the video at** *airspacemag.com*.

Congressman Bill Posey of Florida introduced the Space Resource Exploration and Utilization Act in the House of Representatives, which will likely vote on it in September. It's a start, says Dunstan, who is familiar with how to get governments and for-profit entities to work together in space—he brokered the lease of Mir for commercial projects, such as the filming of "Destination Mir," a reality show NBC wanted to produce before Russia scrapped the station. But, he says, the bill has some real problems that need to be addressed before Congress creates our first space mining laws.

Dunstan, along with Berin Szoka, president of the technology policy group TechFreedom, wrote an open letter to the House members calling for amendments that would encourage space mining without violating international law. Right now, the ambiguous language could allow companies to claim large swaths of territory—a whole asteroid or enormous sections of the moon, even if operations occupy only a small part—in clear violation of the treaty. But the bill is also not specific enough to declare that anything extracted becomes the sole property of whoever dug it up. International law on the matter was solidified decades ago when NASA brought home a sack of moonrocks and traded them with the Russians, who sold some on the market, proving an extracted resource has value for the one in possession of it, unlike celestial bodies as a whole.

Meanwhile, Planetary Resources recently got two grants from NASA to continue developing asteroid mining technologies, and in July sent one of its Arkyd spacecraft into orbit to test software and control systems. The company could be collecting asteroid resources in the next 10 years. Congress might just have a law passed by then.

PHIL SCOTT

ALDERT VAN NIEUWKOOP (2)

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Air & Space Interview

WHAT THE NEWSMAKERS ARE SAYING

Robert M. Farley

An assistant professor at the University of Kentucky's Patterson School of Diplomacy and International Commerce, Farley is the author of *Grounded: The Case for Abolishing the United States Air Force* (University Press of Kentucky, 2014).

Do you think there was ever a time when we needed an independent air force?

No. I think it was a serious mistake to give the Army Air Force its independence in 1947, just as it was a mistake to make the Royal Air Force independent in 1918. The experience of the U.S. Army Air Force in World War II demonstrated that American airpower could win decisive victories as a part of pre-existing military organizations.

What do you think the Air Force has gotten right?

The Air Force has gotten a lot right. Especially in the period between 1972 and 1991, when it identified many of the internal problems that

"We have the institutions that we built, and we can rebuild them if we need to," says Farley, who hopes his book will stimulate debate about the future of U.S. military forces.

ANN STROTH

had caused difficulties in Vietnam, and engaged in the slow, hard process of reform that was necessary to create an organization that could act as a partner for the Army and the Navy. This included training reform, procurement reform, and doctrinal reform.

Where do you think the Air Force could improve?

The Air Force can give up on the idea that airpower will, eventually, replace and subsume other forms of military power. This is an idea that has animated airpower thought since [Italian General Giulio] Douhet surveyed the carnage of the First World War, and it's baked into the DNA of the USAF. I'm not sure there's a more poisonous notion in the history of American military thought: It's caused doctrinal problems, training problems, procurement problems, and has been the source of tension between the services. The problem is that this idea is tied deeply to the reality of Air Force independence; it's what provided the justification for independence in the first place. Giving up on the idea that airpower is really the dominant form of military power means, in some sense, giving up on the ideas that the founders of the Air Force fought for.

Why do you think we should take the radical step of abolishing the Air Force?

Airpower is more important than ever, but it's also more integrated than ever with other forms of military power. B-1Bs provide small teams of U.S. soldiers and Marines with what amounts to close air support. This is a degree of integration that was difficult to imagine in 1947. Our institutions can, under pressure of war, adapt to this new need for force integration, but they don't adapt easily. The bureaucratic walls inevitably create distance, often in ways that no one expects. The resource advantage that the United States has enjoyed over its rivals since the end of the Cold War is waning. It's easy to overstate the threat, but it's imaginable within our lifetime that Chinese military spending will exceed American. This means that we won't always have the luxury of an unwieldy structure for managing our military.

Couldn't a similar argument be made for abolishing either the U.S. Navy or U.S. Army?

Not really. The U.S. Navy represents what I would like a military organization to look like: A coherent whole that has the tools it needs to exercise influence and force on a global scale. Naval airpower exists as part of this

integrated whole, no different than the surface or subsurface components of the fleet. Similarly, the Marine Corps has an organizational vision that integrates airpower, seapower, and landpower, and that can make doctrinal and procurement

Giving up on the idea that airpower is really the dominant form of military power means, in some sense, giving up on the ideas that the founders of the USAF fought for.

decisions based on that vision. The Army and the Air Force don't. They need each other in order to successfully wage war, yet they have different strategic visions, different cultures, and different priorities. The actual process of warfighting often smooths these differences down, but they recur when it's time to rebuild and restructure the force. This leaves both organizations inefficient at their jobs.

How long would it take to integrate the existing Air Force into the Navy and Army?

Years, but less than a decade. The Air Force was larger in 1947 than it is today, and faced a more serious set of procurement decisions, yet the military and civilian establishment pulled off major reforms in a fairly short period of time. Right now the Russians are reconfiguring their airpower institutions—in the wrong direction, I think—and it hasn't proven all that disruptive thus far. It will cost a lot, and the costs will be front-loaded. The Air Force will undoubtedly lose talented people, as will the Army and the Navy as the process uncovers redundancies. In the long run, however, I suspect that changes to the procurement process will save money, and in any case will make for more effective warfighting.

Would you do away with the Air Force Academy as well? Or keep it and funnel its graduates directly into the Navy and Army?

That's a level of detail that goes beyond what I've explored in the book, but the general thought would be to do our best to reduce the cultural barriers that have developed between the services over the years. In this case, it's hard to see how maintaining a separate institution for the undergraduate education of would-be aviators and aviation support personnel would fit into developing a coherent force. That said, I don't doubt that some use could be found for the Colorado Springs campus that maintained its connection with the history and traditions of American airpower.

Regarding air power, naval power, and ground forces, would you rank all three of equal importance? If not, how would you rate them?
This is the wrong question. Virtually every useful way of thinking about military force involves the cooperation of land, sea, and air assets. Even ships at sea depend on land sensors, land-based air, and—for some navies—land-based anti-ship missiles. That we're still asking the wrong question, 30 years after Goldwater-Nichols, is an artifact of how we've decided to organize our military forces. Ground, sea, and air aren't naturally in competition with one another, but when you decide to organize your military around an Army, a Navy, and an Air Force, you put them into competition.

Independent of your opinions about the Air Force, how do you foresee the future of air power?
I think that airpower will continue to play a critical role in American national power in the next century. Everything that the military does requires command of the air, from intelligence to basic logistics. I think, however, that some of the trends we've seen over the past decade or so will continue, particularly the shift from manned to unmanned platforms. I also worry that the cost of high-end, manned platforms will continue its upward trajectory, making it even more difficult to purchase aircraft in the numbers necessary to make the U.S. military function as it should. What effect will that have on the Air Force? The USAF has weathered the beginnings of the "unmanned" cultural crisis better than most have expected, but as more and more critical capabilities shift in the unmanned direction, that may change. I also wonder if the increasing need for technical integration between the three services will make more people see the light about how unnecessary bureaucratic boundaries make life harder for everyone.

What has been the reaction to your book?
The book has met a lot of resistance, but in general the resistance has been respectful and productive. The people pushing back against the argument have been willing to revisit and make clear some core assumptions about why we need an air force, and that's been a useful intellectual exercise. I've received a few private emails from connected people who find the argument compelling, but no one is waving the book on the floor of the Senate. My hope is that the book will find its way into the hands of think-tankers, low-level staffers, and students, who could eventually have an impact on policy.

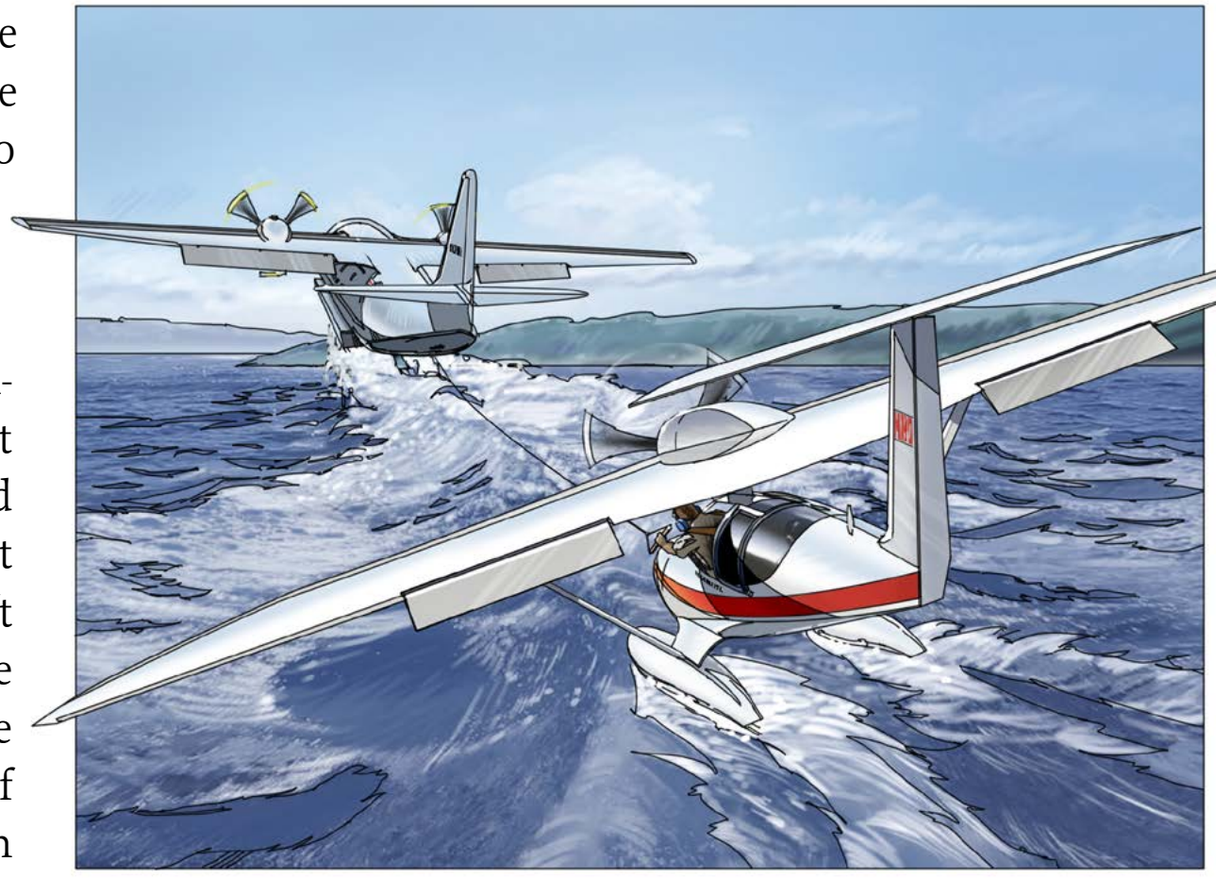
Bill Sweetman **Technically Speaking**

OBSERVATIONS FROM THE FRONT LINES OF AEROSPACE

World of Waterfowl

BURT RUTAN IS ONE OF THE MOST significant aircraft designers in history. Six of his creations are in the National Air and Space Museum. Rutan is also the man who predicted, on a 2003 panel convened by *Popular Science* magazine, that the porn industry would fund the development of virtual reality technology so life-like it'll eventually spell the end of air travel. So anyone who says he knows what to expect from Burt Rutan is either Burt Rutan or a liar.

But Rutan has been talking for a long time about personal aircraft that would not be tied to airports. At the Experimental Aircraft Association AirVenture in Oshkosh last July, he revealed a few details of Ski-Gull, his first design since his retirement from Scaled Composites. Ski-Gull is intended to go runway-free by operating from water, ice, and snow, as well as ground too soft for wheels.



HARRY WHITVER

In other recent news, one of Japan's first military aircraft sales—following its decision last year to permit defense exports—could be a batch of 10 ShinMaywa US-2 amphibious aircraft, the latest version of a 50-year-old design. The US-2 is at least 20 times larger than the Ski-Gull, but both designs have roots in the fertile ground of 1950s U.S. aviation—in particular, the aircraft developed to support the cold war at sea.

Back then, the U.S. Navy needed a counter to Soviet submarines that were based on the World War II-era German

Type XXI, with its snorkel and large battery capacity. One idea was to fit a large dipping sonar—an acoustic transmitter and receiver, lowered deep into the water on a cable—to a seaplane that could take off and land in the open ocean.

Previous seaplanes were best suited for sheltered water, but designers at Convair and Martin worked the problem from two directions: hulls with high length-to-beam ratios for better stability and lower water resistance, and auxiliary jet engines blowing high-pressure air across oversize wing flaps to cut landing and takeoff speeds. Neither got past the mockup stage, due to 1957 budget cuts and the fact that a highly secret project called SOSUS—Sound Surveillance System—turned out to work very well, particularly against new, noisy nuclear subs.

But Japan, vividly recalling how U.S. submarines decimated its merchant fleet in World War II, took up the idea of a blown-wing, sonar-carrying seaplane. The US-2's ancestor, the PS-1, was Japan's biggest and costliest postwar airplane when it first flew in 1967. Videos of the airplanes in operation and under testing are impressive, with the airplane plowing through 13-foot waves and at times almost disappearing from view—before lifting off at speeds of little more than 50 knots (58 mph).

The hydro-ski was another cold war innovation in marine aircraft. The U.S. Navy's first attempt to use skis was on the supersonic Convair Sea Dart fighter. In retrospect it is astounding that anyone thought it would work: The takeoff speed was 125 knots at a time when the world's water speed record was 150 knots, and more than one man died in the process of getting it there. But the Sea Dart was not the only hydro-ski aircraft of the 1950s.

Russian-born designer Michael Stroukoff had created the Fairchild C-123 military transport and worked on the same blown-wing, slow-flight technologies as Convair and Martin. His own company tested them in the YC-134, a much modified C-123. (NASA later tapped its YC-134 test experience in support of the Japanese PS-1 project.)

Stroukoff's hydro-ski experiment was focused on tactical transport rather than submarine warfare. His goal was to couple short-runway and off-runway performance with a patented ski system that he called Pantobase: a pair of broad shock-mounted skis located ahead of the main wheels. In tests done in 1955 on the Delaware River, a Pantobase-equipped C-123, its fuselage water-sealed but otherwise unmodified—no boat-shaped hull and no step—lifted cleanly from the water after a 30-second run. The Pantobase was designed to operate from soft ground or snow, but the project fell victim to the same budget crisis as the Navy's flying boats, and a lack of interest in things that weren't supersonic or nuclear.

Images of Rutan's Ski-Gull have so far been limited to photos of the screen in his Oshkosh presentation. But two features are quite clear: The body is not boat-shaped, and it has a broad, short ski on each side.

Just like the Pantobase.

"AERIAL DRAMA AT ITS BEST."

- ERIK LARSON, #1 *New York Times* bestselling author of *Dead Wake*

"GRIPPING"

- MICHAEL TOUGIAS, bestselling co-author of *The Finest Hours*

"EPIC"

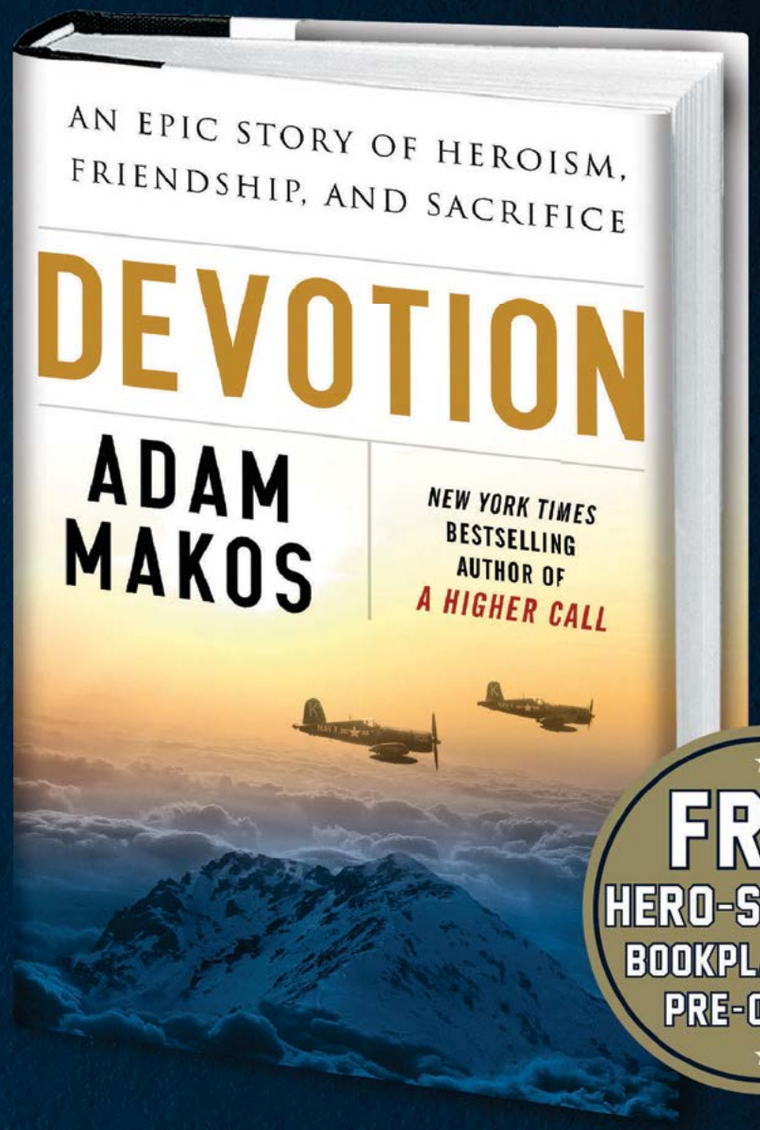
- ERIC BLEHM, bestselling author of *Fearless*

"A GEM"

- CAPT. DALE DYE, military advisor, *Band of Brothers*

"LOVINGLY RENDERED"

- HAMPTON SIDES, bestselling author of *Ghost Soldiers*



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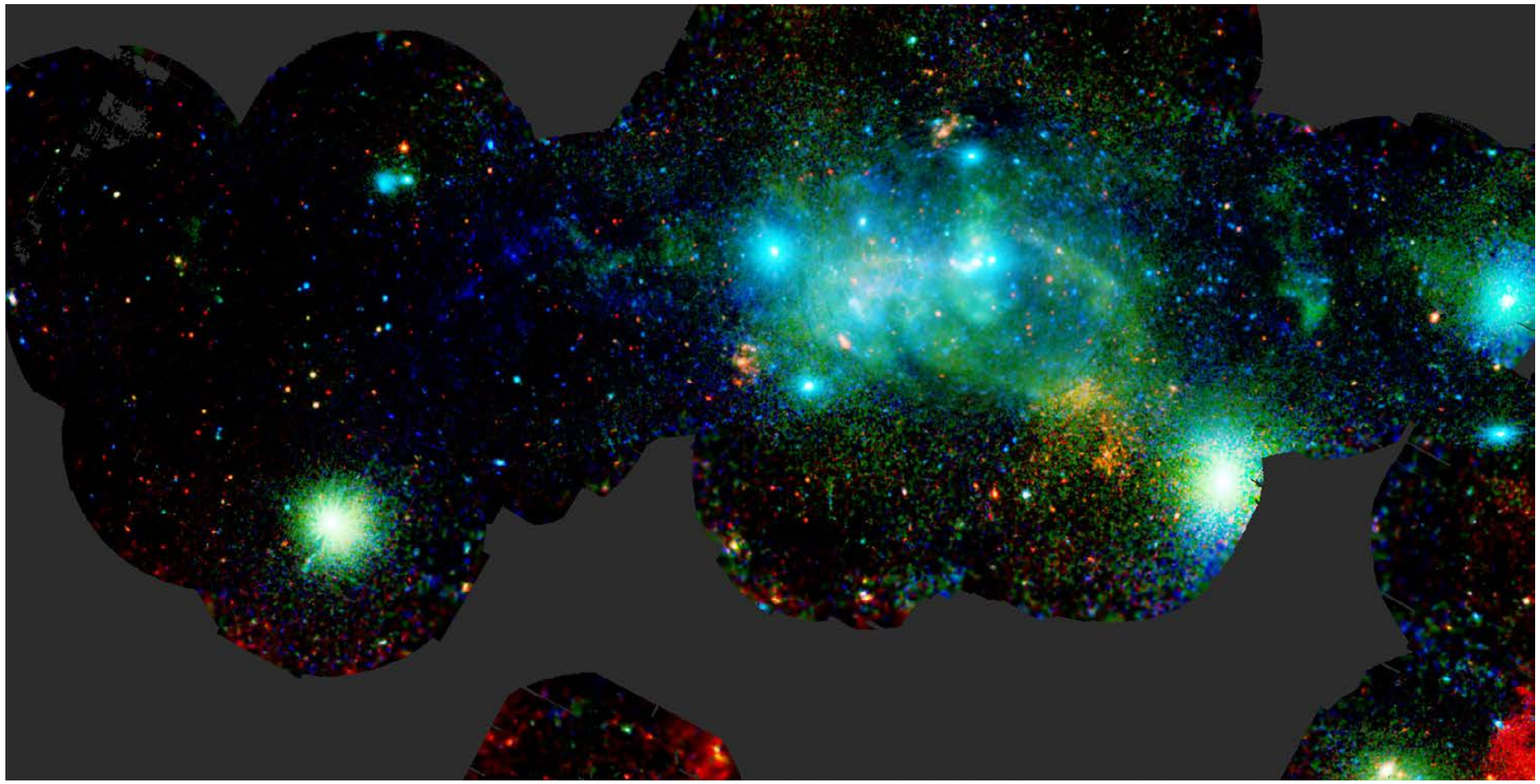
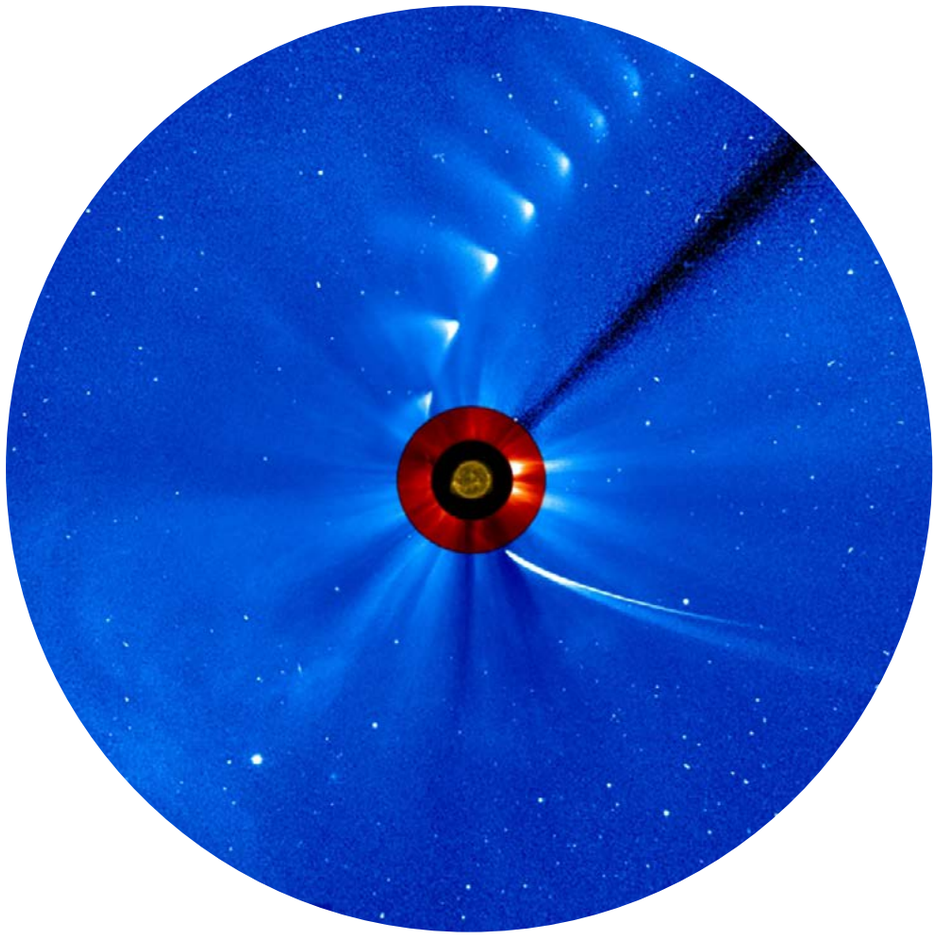


UNIVERSE

The Tumultuous Milky Way

SUPERNOVAS, NEUTRON STARS, stellar clusters: The center of our galaxy has it all. In this new image, the European XMM-Newton X-ray observatory revealed the chaos at the heart of the Milky Way. Sagittarius A∗ is a supermassive black hole on the far left; the immense gravitational pull on nearby matter causes it to emit X-rays, lighting up the space around the event horizon.

ESA/XMM-NEWTON/G. PONTI



SUN

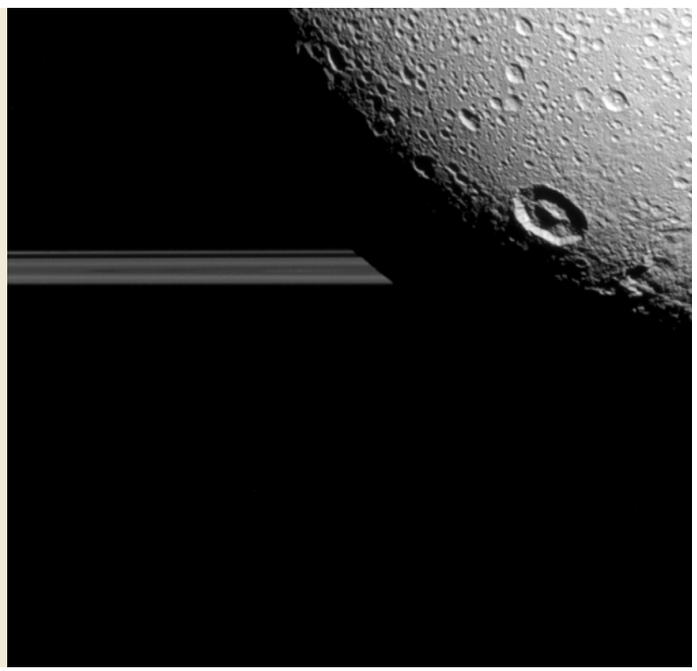
Comet Hunting Record

THE SOLAR AND HELIOSPHERIC Observatory (SOHO) is on track in September to discover its 3,000th comet, more than any other observatory in history. (That's Comet ISON zipping around the sun, left). Most have been spotted by amateur astronomers through the Sungrazer Project, run by the U.S. Naval Research Laboratory, which offers tips on how to find the comets.

PLANETS

Goodbye Dione

IT'S THE BEGINNING of the end for NASA's Cassini mission, which made its last flyby of Saturn's moon Dione on August 17. The rocky moon (Saturn's rings behind) is constantly showered by icy geysers from Enceladus. After 20 years in the Saturn system, Cassini will be sent to crash into the planet in 2017.

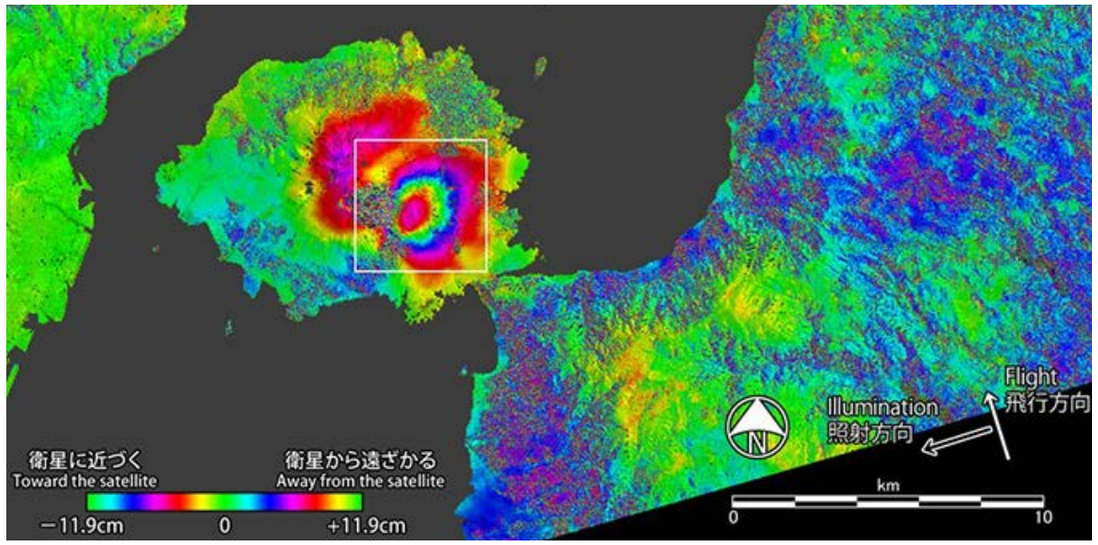


TOP: ESA/NASA/SOHO/SDO/GSFC; BOTTOM: NASA/JPL-CALTECH/SSI

EARTH

Volcano Emergency

WHEN JAPAN'S Sakurajima volcano showed signs of erupting on August 16, JAXA's DAICHI-2 satellite was sent to measure how the ground was moving (right) to assist with possible disaster preparation.



UNIVERSE

Closer to New Earth

NASA'S KEPLER has found the most Earth-like planet yet: It's just 60 percent larger, with a 385-day orbit within the habitable zone of a G2-type star, just like our sun. At left, an artist impression compares them.

ONCE MORE AROUND THE SUN

Rise and Shine, Comet 67P

On August 13, Comet 67P/Churyumov-Gerasimenko passed perihelion, the closest it gets to the sun in its 6.5-year orbit. Since July, ESA's Rosetta spacecraft has been sending back photos of outbursts from the comet as it began to heat up and icy materials under the surface changed to gas.

TOP: JAXA; CENTER: NASA/JPL-CALTECH/T. PYLE; BOTTOM: ESA/ROSETTA

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Blackbird Down

Top: The wreckage of "Rapid Rabbit," the SR-71 that pilot Dennis Bush crash-landed in 1972 at Kadena Air Base, Okinawa. Bottom: The same aircraft at Udorn Air Base, Thailand, two months earlier.

IN 1972, more than 50,000 troops were stationed throughout 32 U.S. military bases in Okinawa, Japan. Kadena Air Base, with two 12,100-foot runways, was their gateway to Southeast Asia.

In the wake of the Quang Tri massacre, which occurred when North Vietnamese forces captured that South Vietnamese provincial capital, Kadena's activity level was balls to the wall. As an aircraft maintenance technician there, you did as much as you could as fast as you could for as long as you could. And sleep? You got it when and where you could.

Kadena's parallel runways divided the base. My outfit, Military Airlift Command, was on one side. The other side was used by Tactical Air Command and Strategic Air Command. MAC "turned"—refueled and, if needed, repaired—the C-141s and C-5s that were hauling supplies into and out of the Vietnam theater. Lots of ammo went in. Lots of bodies came out. Most returning flights carried a few. Randomly an aircraft would have just one, or none. But I saw airplanes full of caskets, and you never forget that.

On the other side of the runways, SAC launched tankers in support of the B-52s en route from Guam to Vietnam. In those days the tankers

PHOTO ILLUSTRATION BY THÉO. CHART: UNIVERSITY OF TEXAS AT AUSTIN; CRASH: USAF; RUDDER: SHAYNE MEDER/MARCHFIELD.ORG; RAMP: COURTESY HABU.ORG

still had loud turbojet engines that produced gobs of smoke, made worse by the 630-gallon water injections each KC-135 used on takeoff, creating a two-mile cloud of black fog trailing each flight. During the 1972-1973 "Christmas bombing" of Hanoi, the tankers would take off from Kadena in four flights of four: Sixteen KC-135s at a time, packed tight. You'd have to have seen it to believe it.

Amid all that activity, occasionally a quiet would descend on the base: An SR-71 Blackbird was about to appear. Kadena and the airspace around it had to be secure. The spyplanes were housed in four hangars in the SAC area and never parked outside for the rest of the world to see.

To launch, the SR-71 would start its engines inside the hangar and, flanked by an entourage of trucks, creep its way to the end of the runway. After final prep and checks at the runway's threshold, the trucks would back off. Then this quiet, purring monster would let out a roar that seemed to drown out the world, then shoot down the runway as if it were fired from a gun. Lifting its nose to a 45-degree angle, it would disappear from view in less than 10 seconds. I witnessed dozens of launches, every one of them as spellbinding as the first.

An SR-71 coming in to land was another show entirely. Upon touchdown the nose would stay pointed in the air for a long time. Eventually, a giant orange drag chute would emerge and, at least 25 yards behind the airplane, fill out with dreamlike languor. Only then would the nose gear descend gently to the surface.

On the afternoon of July 20, 1972, I was in my maintenance truck, eavesdropping on the tower frequency. Word had gotten around that an SR-71 would be landing soon. Normally the Blackbird pilots weren't a chatty bunch, but I could hear the anxiety in the voice of this one.

I heard the tower warn him of a 90-degrees-to-the-runway crosswind of 35 knots gusting to 50 knots—a typhoon was on its way. I could've sworn I heard the tower advise him to consider an alternate airport. But landing anywhere else was out of the question. The SR-71 wouldn't have had the fuel, and everyone understood without discussion that the brass wanted that airplane on the ground and out of sight as quickly as possible.

I sought out a good vantage point to observe the landing: a small concrete building, which housed fuel pumps, about 50 yards from the runway the SR-71 was headed for. I climbed to the roof and settled in. I could see the landing lights before I could make out the airplane, perfectly lined up with the runway, three or four miles out. I couldn't have been more focused if I were landing the damn thing myself.

The main landing gear touched down, and despite the hellish crosswinds, the fuselage was aligned perfectly with the runway's centerline. It looked like the pilot was going to pull off a picture-perfect landing. But as soon as he deployed his drag chute, a wind gust blew it to port. I watched the nose shift to starboard.

Then one of the left main landing

gear tires exploded.

The pilot jettisoned the chute, poured the coals to the burner, and rotated away from the runway, climbing back into the sky to circle around.

I remember thinking, *What the hell is he gonna do now?* No drag chute.

As he touched down, a fireball engulfed the left landing gear. The airplane kept rolling, nose still high in the air, and then the right gear tires blew. The Blackbird skidded past me like that, nose up and tires on fire, for four or five seconds.

Blown tire. And a monster crosswind, increasing by the minute. Fortunately, an incoming or outgoing SR-71 had the entire base to itself.

The pilot made a second approach, dumping fuel the entire length of the runway, then came back around for his final.

As he touched down, a fireball engulfed the left landing gear. The airplane kept rolling, nose still high in the air, and then the right gear tires blew. The Blackbird skidded past me like that, nose up and tires on fire, for four or five seconds. When the left gear collapsed and the wing struck the runway, the left engine exploded and debris flew high into the air. The entire airframe began to spin, still traveling down the runway at probably 150 mph, and finally the right gear buckled.

The flaming wreck continued sliding down the runway, still on the centerline, until it finally drifted off to the left, into the grass. It came to rest about two-thirds of the way down the runway, about 4,000 feet from where I stood watching, jaw agape.

I watched the pilot and reconnaissance system operator in their bright orange flight suits leap from the remnants of their aircraft and run from it as fast as they could.

I jumped down from the building and several of us started running toward them, but a fire truck and a base security car cut us off. The officer in the car ordered us to stay back. (The pilot, Captain Dennis K. Bush, and the reconnaissance systems officer, Captain James W. Fagg, escaped without injury.)

Five hours later, the typhoon was upon us. Nothing moved at Kadena for three days. Once the weather returned to normal, a recovery crew began trying to lift the top-secret wreckage onto the back of a flatbed truck with a giant crane. The earth was so saturated that instead of the airplane coming up, the crane sank into the mud.

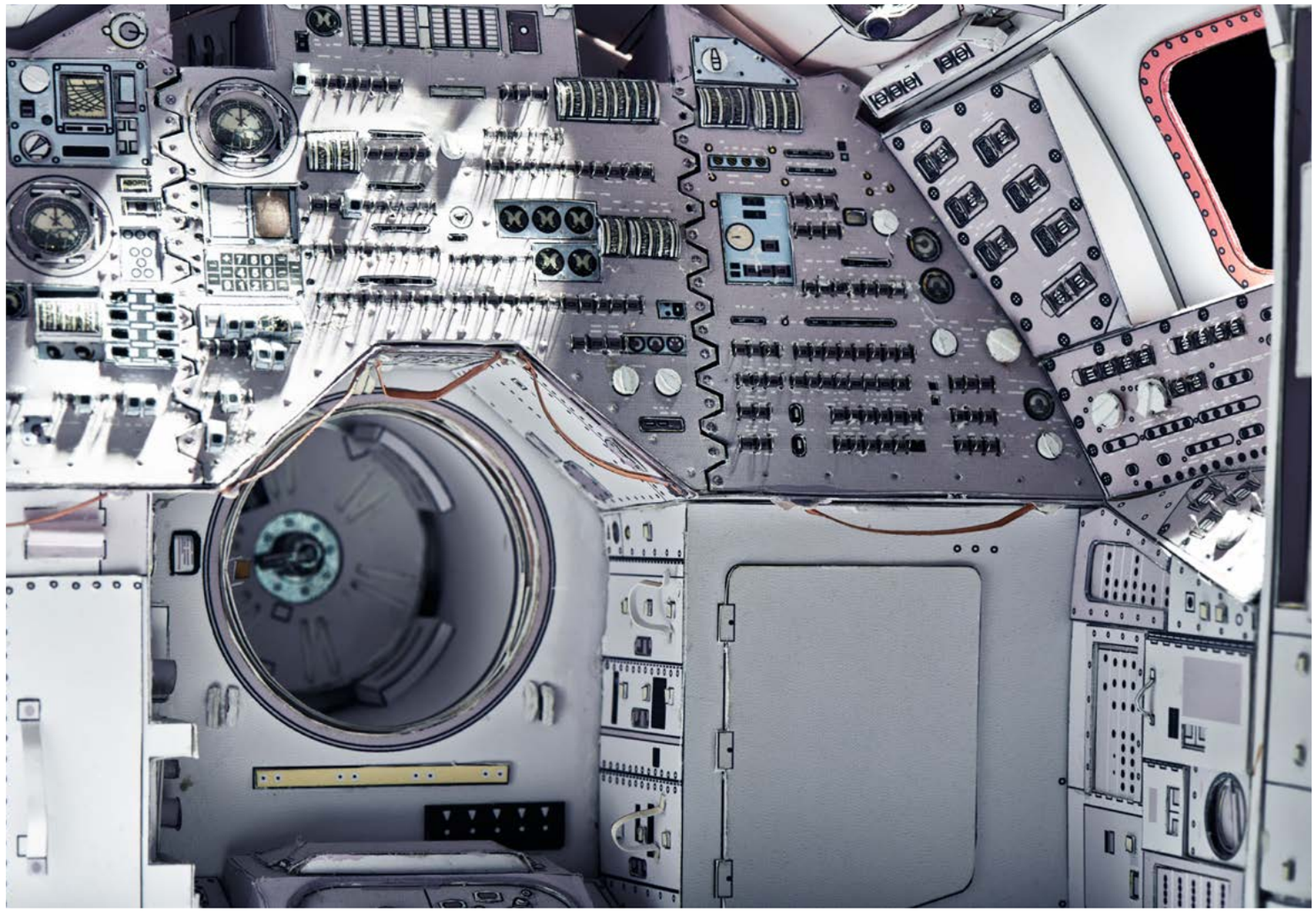
About a month later, I saw the fuselage being loaded into a C-5 headed Stateside. Forty-three years later, I still don't understand why getting that SR-71 inside while a typhoon was bearing down on us was so important. But those decisions were made far above my rank.

JODY LILIEDAHL

Paper, Scissors, Rocket

THE 2013 EURO SCALE MODELING exhibition in the Netherlands featured hundreds of meticulously detailed scale models from across the continent. One that dazzled many attendees was a five-foot-long Apollo command module separated into its components, each so realistic that it looked as though the actual spacecraft shrank to 1/12 its original size. Equally amazing was its building material: paper.

I started building space models in the 1960s, and back then, if you wanted your own "rocket garden," you had two choices: design and build your own or buy a plastic kit. The styrene models of the era varied in quality, some reasonably accurate, others not so much. Often the models represented prototypes or early concepts. Five years ago, I found an alternative: "Paper



Assembling Ken West's 1/12-scale paper Apollo Command Module is painstaking, but fixing errors is as easy as finding a printer. Try that with plastic!

BILLY LELIVELD

Aeronautics and Space Administration" at ***papermodelers.com.***

Models made from paper are hardly new. But in the mid-2000s, a confluence of factors gave them new life. "Digital technology, affordable design software, and the Internet with its inherent capacity for market distribution all came together," says Ken West, who designed the Apollo spacecraft that wowed Amsterdam. "Those things gave us a new opportunity to create subjects that are nearly impossible to duplicate in plastic for a reasonable price."

The sheer variety of scale model rockets and spacecraft in paper is remarkable. All the early U.S. and Russian manned spacecraft are available, along with a host of historic satellites and robotic explorers. If history's not your thing, you can download most of today's launch vehicles and planetary explorers, all but a handful for free. You can even get ahead of NASA and build your own Orion spacecraft.

The simplest paper launch vehicles are basically long tubes topped by a cone, with two-dimensional details printed on the parts. Space agencies NASA, Europe's ESA, and Japan's JAXA also offer free models of many robotic spacecraft that are relatively easy to build.

Typically, the more realistic a finished model looks, the more details it has and the higher degree of skill is needed. Many of the Russian boosters, for example, include detachable stages and engine details. NASA offers both simple and "challenging" versions of Cassini, the spacecraft now studying Saturn, and the space agency's Hubble Space Telescope model is museum-quality.

For the top-of-the-line kits, you'll have to open your wallet. (I have several and they're definitely worth it.) Ken West's 1/12-scale Apollo command module requires 127 pages of parts and 38 pages of instructions. At a length of 43 inches, AXM's 1/100-scale International Space Station takes up a lot of shelf space.

I consider the basic model as a starting point upon which to add whatever details will produce the most accurate possible replica. I don't limit myself to paper: Most of my finished models include plastic, wood, or metal.

Card modeling is a very forgiving hobby. When I worked on an expensive plastic or resin model, I would become frustrated whenever I screwed something up, but with paper models, I can fix an error just by getting another part on my computer and printing it out.

As technology evolves, 3D printers may become as ubiquitous as scissors and paper. But for now, the best and cheapest way to create your own space museum is to invest in a little ink, a few humble pieces of cardstock, and a bit of sweat equity.

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The Fun Part of Aerospace

WE FLEW IN A FLOCK—or, rather, our avatars did—following the lead bird as it plummeted toward Earth. At the last possible second, we flapped our wings—*we* moved our arms—and our bird selves soared into the sky. Our bodies had been transformed into virtual birds and, through motion-sensing technology, we manipulated our avatars as we learned about the forces of flight: lift, weight, thrust, and drag.

The "Spread Your Wings" simulation is just one of 20 activities in the new exhibit Above and Beyond, which opened August 1 at the National Air and Space Museum. Developed in conjunction with Evergreen Exhibitions and Boeing, the exhibit celebrates innovation

In "Spread Your Wings," part of the new exhibit Above and Beyond, three Museum visitors learn about flight by moving their bodies to control birds on a screen.

OSCAR WILLIAMS/ABOVE AND BEYOND

Would-be pilots who always wanted to be Top Guns test their skills by designing a jet fighter and competing against others (left).

in aerospace. Through augmented-reality technology, visitors can fly to Mars, design a jet (and race it against other pilots), and eliminate space junk orbiting Earth. While the exhibit is designed particularly for visitors ages seven to 14, everyone can find something challenging in this tech-heavy gallery.

"Above and Beyond is the most electronics-heavy exhibition ever housed at the National Air and Space Museum," said Roger Launius, the Museum's associate director, at the gallery opening. "And as such, it will help shape the future of this particular museum. We are engaged in serious efforts to understand how best to communicate with a range of people of diverse ages, backgrounds, and interests. In addition to being a superb exhibition in its own right, we hope to use the knowledge gained from how visitors interact with these displays to develop future exhibitry that will transform NASM into a 21st century museum."

Launius explained that in the next few years, the Museum plans to update all of its galleries, some of which haven't been redesigned since the Museum's opening in 1976.

What else is there to see? Visitors can step inside a capsule—surrounded by video screens—and experience a simulated ascent in a space elevator loosely based on the concept that cargo and people will one day be transported into space on a ribbon-like cable. During the ascent, visitors learn about the aircraft, spacecraft, and natural phenomena they would encounter along the way.

In "RoboFlyers," visitors equip an unmanned aerial vehicle for an imaginary mission while learning about UAVs flying real missions today. On display is the tiny RoboBee, with a wingspan of just 1.2 inch. The micro-drone, developed by Harvard

OSCAR WILLIAMS/ABOVE AND BEYOND

University's School of Engineering and Applied Science, is capable of tethered flight, but its designers hope that a swarm of robotic insects will one day autonomously pollinate a field of crops—or even conduct military surveillance.

At the other end of the spectrum, the ScanEagle, developed by Insitu, sports a 10-foot wingspan and can fly for 24 hours without landing or servicing. Built for the fishing industry but now used mainly by the military, it carries a high-resolution camera that provides users with reconnaissance and surveillance information.

Dreams Aloft, a series of video interviews with young aerospace engineers, could almost be considered a recruitment film for the aerospace industry. When the engineers describe what they do—"I'm Ana, and I get to break things"—and how they ended up in aerospace, anybody watching gets the message: This stuff is fun, and the people who do it are happy. One recalls: "I had an astronaut helmet that I made out of a cardboard box that I wore to an age where you certainly shouldn't have been wearing a cardboard box on your head." (The cardboard helmet paid off; the wearer is now a member of the research and development team at Boeing.)

At the exhibit opening, shuttle astronaut Chris Ferguson, now director of Crew and Mission Operations for Boeing's Commercial Crew Program, explained who Boeing would like to attract with this type of exhibit: "There are three kinds of young visitors to the Museum, in my view. Some go in and push the buttons and then go on to the next thing. Another group stands there in amazement and wonders, 'When that kid pushed the button, why did *that* happen?' And they're the ones we know we have. They're the ones who are going to help us get to Mars. It's the third group, the ones who think 'Do I really want to understand why this happens, or do I just want to take it for granted?'—that's the group we hope to grab with interactive exhibits like this."

Through augmented reality, visitors can experience the challenges (right) of the long and arduous journey to Mars.

OSCAR WILLIAMS/ABOVE AND BEYOND

Above and Beyond will run until January 3, 2016, then travel to the Saint Louis Science Center in Missouri; the National Maritime Museum in London; and the Museum of Flight in Seattle, Washington. You want your own Iron Man flying suit? Tell every seven- to 14-year-old you know to see it.

REBECCA MAKSEL

RECENT ARRIVAL AT THE MUSEUM

AERIAL ASSAULT

After a 50-year career in the U.S. Marine Corps, the CH-46 Sea Knight, better known as the Phrog, has become a museum piece. Accompanied by an MV- 22 Osprey, the aircraft taking over the Phrog's transport mission, and welcomed by the Purple Foxes of HMM-364, who restored it, Phrog # 153369 arrived at the National Air and Space Museum last August 1.

JOHN BRETSCHNEIDER

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THE NEXT X-PLANE

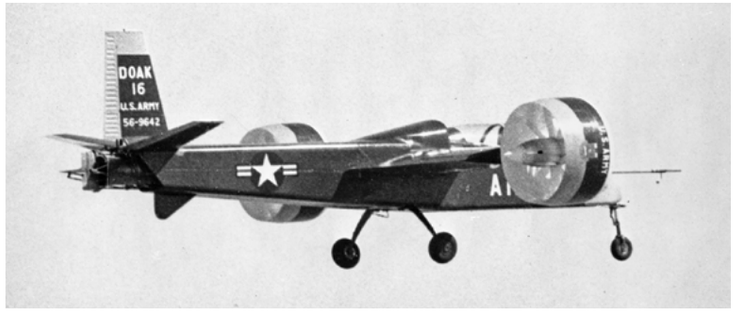
WHO WILL WIN THE COMPETITION TO BUILD AN AIRPLANE THAT CAN FLY FAST AND HOVER? ★ *BY RICHARD WHITTLE*

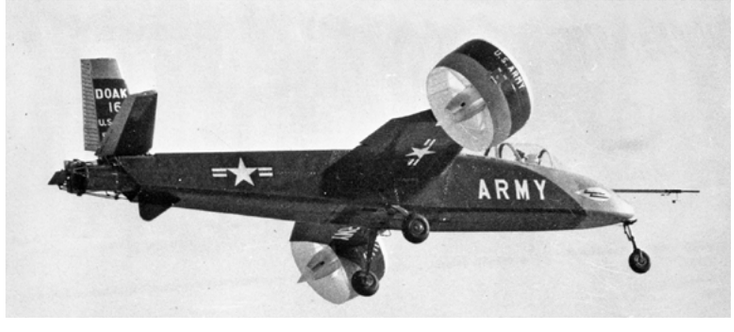
Boeing's Phantom Swift concept might look odd, but the idea is tried and true: A scale model "marketing tool" flew in 2013.

BOEING

NO ONE HAS EVER SET THE BAR for the dream machine of aviation higher than Alexander Klemin did on April 26, 1938. Testifying at a Congressional committee hearing on "Development of the Autogiro and Rotary-Winged Aircraft," the renowned chairman of the Daniel Guggenheim School of Aeronautics at New York University said that "[t]he conquest of the air in its broadest sense will only come when we can do in the air substantially everything that a bird can do in the air." Three-quarters of a century later, the Defense Advanced Research Projects Agency is preparing to announce which of four competing aircraft designers it thinks might come closest to fulfilling Klemin's vision. The winner will receive a $90 million contract to build and fly a technology demonstrator DARPA calls the Vertical Take-Off and Landing Experimental Aircraft, or VTOL X-Plane.

By "substantially everything a bird can do in the air," Klemin meant take off and land almost anywhere, fly fast, and hover. Some aircraft can do some of those things today; DARPA wants an X-plane that can do them all and do them better. The goal is not a production aircraft or a VTOL





It also echoes the Doak Model VZ-4, a 1958 prototype built for the U.S. Army. The Army stuck with conventional helicopters, but NASA kept the Doak for research flights.

craft suited to a specific mission, according to Ashish Bagai, DARPA's manager for the VTOL X-Plane. Instead, Bagai told the American Helicopter Society International last May at its annual conference, the aim is to "push the boundaries out of our dominant design space that we have today."

The invention of the helicopter transformed aviation. But in 1938, when Klemin spoke to Congress, the question he was addressing was whether taxpayer money spent on developing aircraft with rotors would be wasted. Klemin believed the investment would advance U.S. aviation, and his answer was quickly confirmed: In September 1939, Igor Sikorsky demonstrated his VS-300, the first useful American helicopter, and the age of vertical-lift aircraft began.

More than a decade passed before the first whirlybirds went into widespread use, but designers discovered almost immediately that the speed of any helicopter would be limited by the aerodynamics of rotors. Rotors work well in a hover, when their blades turn around a stationary axis, but in forward flight, air hits the rotor blades at dramatically different speeds as the blades advance in the direction the aircraft is traveling or retreat toward whence the aircraft came. This is the primary reason that, as Bagai told the AHS briefing, the fastest conventional helicopters top out at around 175 knots (200 mph). Fixed-wing airplanes can fly much faster, but the ones that can take off and land vertically—the AV-8 Harrier, the F-35B Lightning II, and the Russian Yak-38 Forger—can hover for only a short time, riding on small columns of rapidly moving air. An efficient hover is

NASM (SI-2006-618~A AND SI-2006-3820~A)

best achieved by moving a large volume of air downward relatively slowly.

Dozens of designers have tried to combine the agility of a helicopter with the speed of an airplane by marrying one or more methods of propulsion—rotors, propellers, turbojets, or ducted fans—with one of four ways to convert a craft from vertical to horizontal flight: tilting the whole aircraft, tilting the thrust, deflecting the thrust downward for vertical flight and rearward for horizontal flight, or using two thrust mechanisms on the same vehicle (such as rotors for vertical flight and prop fans or jet exhaust for horizontal flight). A graphic called the "V/STOL Wheel of Misfortune," its original creator lost to history, is easily found on the Internet; updated versions depict 45 vertical/short-takeoff-and-landing piloted concepts that actually were built, some of which look downright daft. "Time and again, the compromises necessary to combine the hover capability of a rotorcraft with the high forward flight speed of a fixed-wing aircraft were deemed to be unacceptable, particularly the costs of development, production, and operating these V/STOL concepts," writes Mike Hirschberg, who developed a modern V/STOL Wheel of Misfortune while working on the F-35 program and is now the executive director of AHS. The only four to go into production are the Harrier, the Yak-38 and F-35B jet fighters, and the V-22 Osprey tiltrotor troop transport, which swivels two large wingtip "proprotors" upward to take off and land like a helicopter and forward to fly like an airplane. That enables the Osprey, now in service with the United States and, soon, Japan, to cruise at 275 knots, roughly double the cruising speed of most military helicopters. Though the Osprey can hover, it doesn't do so very efficiently, in part because speedy forward flight requires the proprotors' blades to be short and heavily twisted, and in part because the craft has high disk loading (the total weight of the aircraft divided by the area of the circle its rotor blades describe). "Nearly all of the aircraft shown on the V/STOL Wheel—all of which were built and flown—could have been fielded, given enough time, money, and willingness to accept compromise," says Hirschberg. "But they needed to have a compelling capability over less expensive, less complicated conventional aircraft of their day." What the VTOL X-Plane program, also known as the VXP, is trying to do is to come at the problem by combining the lessons learned over the past 75 years with new technology and new ideas.

DARPA's Bagai says a key VXP requirement is "the ability to hover and to perform sustained hover. That's an attribute of vertical flight that's important. That's why we have helicopters today, because nothing else can do those missions that helicopters can do." Speed, he says, can be gotten pretty much just by adding power: "We know how to fly barn doors fast." He should know. When at Sikorsky, he was principal engineer on the X2 high-speed technology demonstrator, a compound helicopter—coaxial rotors with a pusher propeller—that won the Collier Trophy in 2011 for setting an unofficial helicopter speed record: 250 knots in level flight.

In March 2012 Bagai came to DARPA and started the VTOL X-Plane project, the sort of experimental project DARPA was made for. The agency doesn't produce military equipment; instead, it funds farsighted, sometimes far-fetched research to help keep the military on the cutting edge of technology. If DARPA's projects bear fruit,

THE TRIALS OF THE DOAK

A look at a typical "Wheel of Misfortune" aircraft.

Only one Doak VZ-4 was built, partly cobbled together using parts from other types. After 1958 test flights, the U.S. Army, the project sponsor, eventually decided to stick with helicopters, and put the Doak in a museum at Ft. Eustis.

Tap to watch video at *airspacemag.com/doak*

US ARMY VIA ELLA'S ARCHIVES

the results are handed over to the military for possible development. For example, the agency did some early work on the lift fan technology used in the F-35B, but has no direct role in F-35 production.

The VTOL project kicked off in 2013, when the agency awarded preliminary design contracts of $11 million to $17 million each to four competitors. Two of the awards went to some of America's top military aviation manufacturers: Boeing and a Sikorsky–Lockheed Martin team. The other contracts went to smaller companies headed by two of the country's most inventive aeronautical engineers: Aurora Flight Sciences, whose chief designer, John Langford, got his start heading a team that set a world record for human-powered flight, and Karem Aircraft, founded by Abraham Karem, who among other achievements invented the Predator drone.

The four contestants are offering dramatically different solutions—all unmanned, an option DARPA offered to speed the work.

Boeing ($17 million)

Boeing relied on its Phantom Works rapid prototyping facility to come up with its entry, Phantom Swift. The fuselage, roughly 44 feet long and 7.5 feet wide and shaped something like a surfboard, houses two large ducted fans, one fore and one aft of its centerpoint, and one smaller, swiveling ducted fan on each wingtip (Boeing declined to reveal the diameters of the fans). Project director Brian Ritter says the configuration echoes a Wheel of Misfortune aircraft called the Doak Model 16 VZ-4, an essentially conventional air-

THE NUMBERS: WHAT THE WINNER HAS TO HIT

DARPA's GOAL is an aircraft that can both hover efficiently and fly fast—abilities that have proved devilishly difficult to combine. To be successful the VXP will have to not only take off and land vertically and hover with agility, as only helicopters can, but also fly at sustained speeds of 300 to 400 knots (345 to 460 mph), as many airplanes can but helicopters can't. DARPA also set several weight requirements. Fully loaded, the VXP must weigh between 10,000 and 12,000 pounds—roughly the size of a Sikorsky S-76 commercial helicopter. At least 40 percent of the VXP's weight must be "useful load," what the craft can lift and carry besides itself, while its payload—useful load minus crew and fuel—has to equal at least 12.5 percent of total weight. The VXP will have to fly with 50 percent or less of the aerodynamic drag a standard helicopter flies with, meaning it will have to have a lift-to-drag ratio of 10:1 or more in cruise. DARPA is demanding a great leap forward in hover efficiency: at least 75 percent of the thrust a rotor could theoretically achieve from available engine power. A typical helicopter "figure of merit," as engineers know the term, is 60 percent. No mass production-ready aircraft will emerge from this contest, but the results may be used to design some.

craft that also had swiveling ducted fans on its wingtips. "We refer to them as wingtip thrusters and body lift fans," Ritter says, adding that Phantom Swift uses a "four-post lift approach" for vertical flight and hover. After vertical takeoff, louvers at the bottom of the lift fans in the fuselage can be used for maneuvering in a hover or closed entirely for forward flight. The body lift fans then shut down while the wingtip thrusters tilt forward to make the craft fly like a conventional airplane.

"We have the ability to control thrust [independently] on all four fans," Ritter says. "We have louvers in the bottoms of the body lift fans which can provide directional control. We have the ability to rotate our wingtip thrusters independently and help provide directional control. And then, by controlling the thrust out of each of those fans, all of those different things combined provide the means for low-speed directional control." At high speed "you've got full flying tails and flaperons on the aircraft as well," Ritter adds. "So we've got maneuverability and agility, in addition to just the wingtip thruster control in forward flight."

Power for Phantom Swift comes from two GE CT7-8 engines, a variant of GE's 700 series, which are used in Sikorsky's S-92 multi-role helicopter. Boeing built no subscale demonstrator to test its concept in flight, but Ritter says some "young engineers" at the Phantom Works built a six-foot model as "a marketing tool during the proposal stage"; a video of it flying in a lab can be found on YouTube.

It would be "very easy" to build manned

Aurora Flight Sciences' entry (left) tilts the entire wing—and the motors with it—much like the Vought XC-142 used to do (above). After the XC-142 was canceled in 1966, it too went to NASA for flight research.

or unmanned versions of the Phantom Swift, Ritter ventures, scaled down from the VXP's required 10,000 to 12,000 pounds to as little as 4,000 pounds. Scaling Phantom Swift up to 24,000 pounds also could be done, he says, though "it's going to take some engineering design." Nevertheless, Ritter adds, "when we look at this, we see a great X-plane and fun opportunity to demonstrate new technology—but also the makings of a new product line."

Aurora Flight Sciences ($14 million)

John Langford's company is developing the most unconventional entry: a hybrid electric tilt-wing aircraft using an avant-garde form of thrust called distributed electric propulsion, something NASA is also experimenting with. The thrust for LightningStrike, as Aurora calls its design, will be produced by 24 ducted fans, 18 embedded in the tilting wing and another six in a tilting canard. The fans are to be driven by three megawatts of electricity, equivalent to 4,023 horsepower, produced by three generators powered by a single Rolls-Royce AE 1107 turbine engine, the one used on the V-22 Osprey. No batteries required.

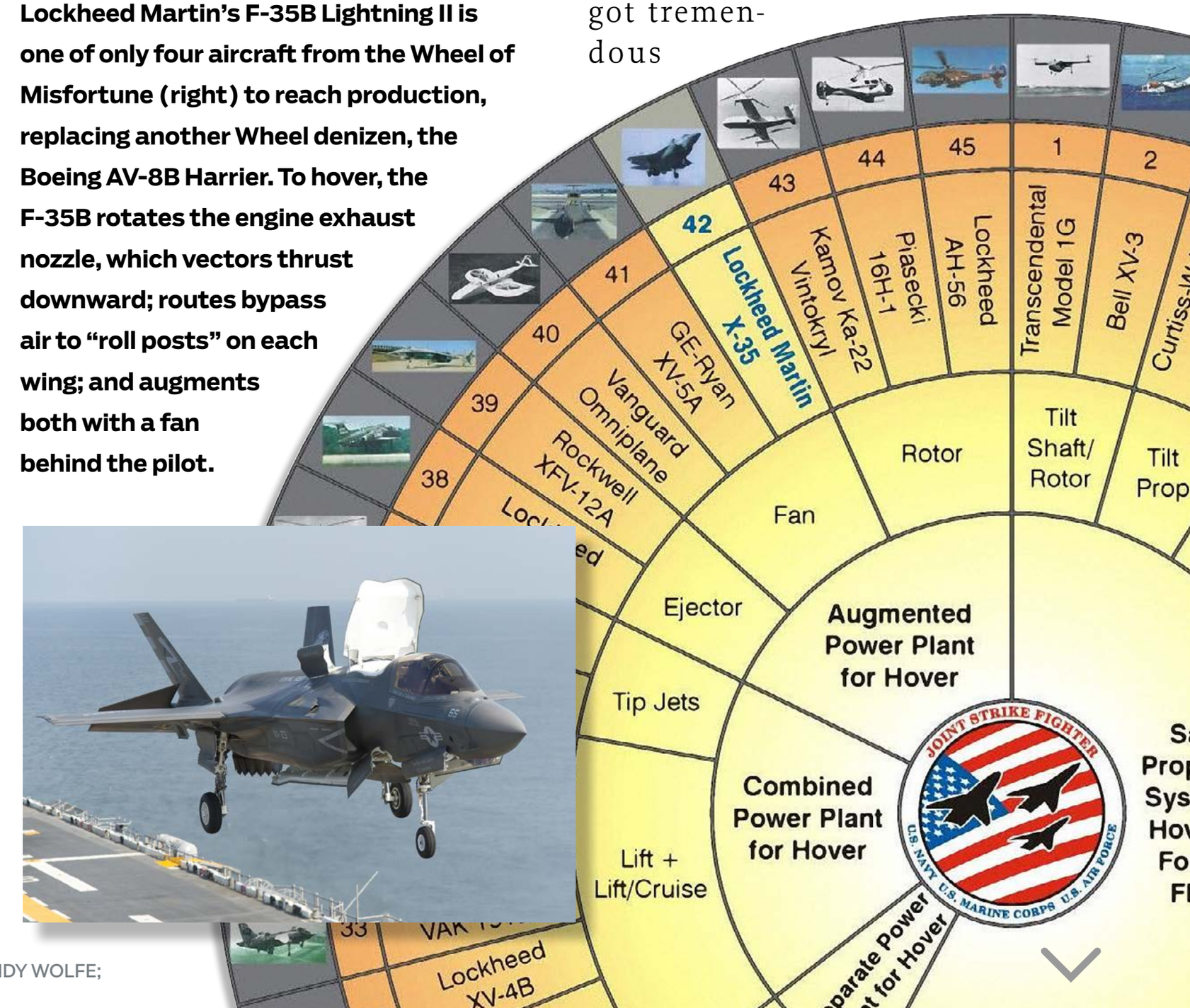
"It is a strange-looking airplane," Langford allows, but "one of the things distributed electric propulsion gives you is this incredible freedom to integrate the aerodynamics and propulsion together." The amount of power sent to each of the

LEFT: AURORA; RIGHT: US ARMY

18 wing fans (31 inches in diameter), and to the canard fans (21 inches in diameter), can be varied according to complex algorithms executed by triply redundant flight control computers. "There's essentially a nozzle at the back of each of these, and you can change the thrust of each of these individually, so you can change the lift distribution and you can get very powerful controls," Langford says. The configuration, he adds, "allows you to operate each piece of that wing at its maximum performance condition throughout the hover and the transition and the forward flight regime," so you avoid losing lift because, say, a rotor is blowing down on the wing.

For the VXP competition, the LightningStrike is unmanned and fully autonomous; no remote control pilot, as is used with the Predator and many other unmanned aircraft. But add a cockpit and the LightningStrike can be manned. It can also accommodate a cabin between the wing and canard, able to carry six troops or passengers. Langford adds that the design can be easily scaled up or down; the individual lift fans "almost become like Legos. You can add or subtract them."

Unlike the other entrants, Aurora built a one-fifth-scale model demonstrator—made largely with 3D printing—and as of press time planned test flights in September at Naval Air Station Patuxent River, Maryland, to validate data collected in wind tunnel tests. The LightningStrike will be "as maneuverable and agile as a helicopter, certainly," says Carl Schaefer, Aurora's program manager, "but I think where you'll see it most maneuverable and agile is in its forward flight regime. It's got tremendous



Lockheed Martin's F-35B Lightning II is one of only four aircraft from the Wheel of Misfortune (right) to reach production, replacing another Wheel denizen, the Boeing AV-8B Harrier. To hover, the F-35B rotates the engine exhaust nozzle, which vectors thrust downward; routes bypass air to "roll posts" on each wing; and augments both with a fan behind the pilot.

LEFT: LOCKHEED MARTIN/ANDY WOLFE; RIGHT: VSTOL.ORG

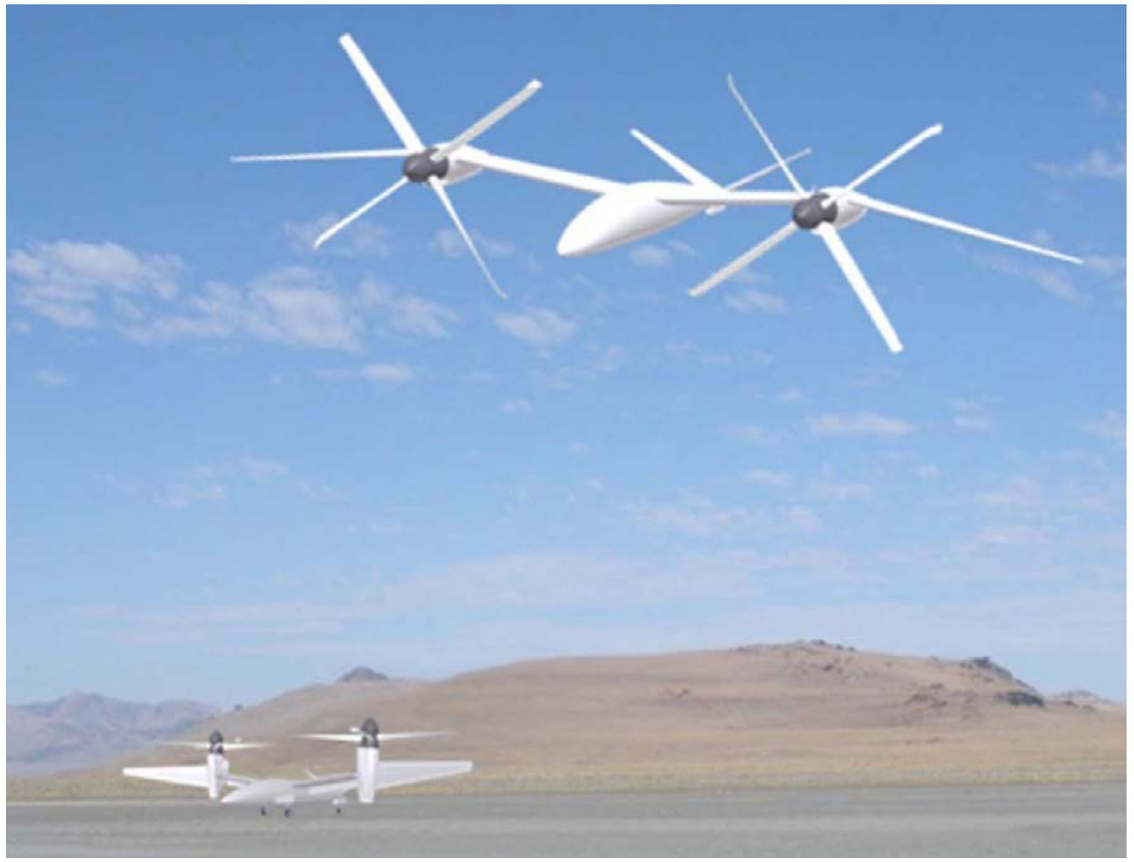
roll rates, very good pitch rates. It's a sports car, frankly."

Karem Aircraft ($11 million)

Also seeing a new product line: Abraham Karem, in his VXP entry. Along with the Predator UAV (see "The Drone Started Here," Apr./May 2013), Karem invented the Optimum Speed Rotor, a technology that enables a helicopter rotor to operate "at an optimal angular velocity in revolutions per minute (RPM) minimizing the power required to turn the rotor and thereby resulting in helicopter performance efficiency," as his patent explains. Karem has adapted that invention to design a series of Optimum Speed Tilt Rotors of various sizes, including his VXP entry, the TR36XP.

Named for the 36-foot diameter of its two rotors, the TR36XP is a willowy aircraft. It has a 40-foot fuselage with an upward V-tail and a long, slender wing—100 feet in span. The portions of the wing outboard of the rotors tilt with them. "The rotors are large compared with other configurations, and they move a lot of air, so the speed of the rotor downwash is quite modest," Karem says. Benjamin Tigner, Karem's director of advanced systems programs, says the TR36XP is "more maneuverable than most helicopters because the rotors are so rigid, and the pilot can yank the airplane around quite aggressively when needed."

The V-22's proprotor blades are short and twisted, a compromise between forward and vertical flight.



Karem's TR36XP's proprotor will improve efficiency in both modes by dramatically changing its rotation speed.

LEFT: US NAVY/KENAN O'CONNOR; RIGHT: KAREM

The craft's rotors, whose rpm can be reduced as much as 50 percent when less thrust is needed in forward flight, will be powered by two Turbomeca RTM 322 engines producing 2,540 shaft horsepower each. If one engine fails, a shaft connecting the rotors will keep them both turning. Karem says that's because its rotor diameter is large compared to the weight of the aircraft, the TR36XP could "very nicely" autorotate to a safe landing if both engines were lost.

Like the other entrants, Karem's tiltrotor, if selected, will be unpiloted, but the concept is "mainly designed with manned applications in mind," Karem says, and his company has been working on such designs for years. "We have designed and analyzed [optimum-speed tiltrotor] vehicles in many different sizes and many different applications, ranging all the way from around 10,000 pounds up to a 250,000 pounds takeoff weight. The risk reduction provided by a DARPA VTOL X-Plane demonstration could be leveraged for the benefit of both the military services and the VTOL industry to build new vehicle types with capabilities and utility well beyond today's helicopters."

Given all the work his company has done on the concept, Karem says, the team felt no need to build a subscale demonstrator. "Many of the challenging aspects of the OSTR [optimum-speed tilt rotor] technology have been proved in flight," he says.

Sikorsky/Lockheed ($14.4 million)

Working with Lockheed Martin's famed Skunk Works, the Sikorsky team is offering a design whose likeness can be found only on the Wheel of Misfortune. It's a tailsitter. The 1950s Convair XFY-1 and Lockheed XFV-1 were Navy-financed Pogos: Sitting on their tails, they pointed straight up for take off and landing. Big counter-rotating propellers on their noses did the lifting. "The poor pilot was looking over his shoulder trying to land the thing nose-up," says Linda O'Brien, Sikorsky's program manager. But that won't be a problem for Sikorsky's Unmanned Rotor Blown Wing, which won't carry a crew and will be flown by computers. "Autonomy gives a lot of flexibility in flying a vehicle like this," O'Brien says.

An artist's rendering shows an aircraft whose 36-foot wingspan holds two stationary proprotors, each 15 feet in diameter and positioned midway between wingtip and centerline. Between the rotors, the wing sports a pod, similar to the cockpit placed between the engine nacelles on a World War II P-38 Lightning. Unlike the P-38, the Sikorsky VXP lacks pylons leading to a horizontal tail. Instead, behind each of the proprotors—or under them when the aircraft sits on its tail—is a vertical tail at right angles to the wing that extends both up and down in horizontal flight.

O'Brien says a tailsitter is "the simplest way to capture VTOL and speed because there's no morphing of the aircraft. It takes off on its hind legs, so to speak, pitches over, and transitions into forward flight. You don't expend the weight and system complexity to morph or pivot or transform the airplane in any way." The Unmanned Rotor Blown Wing is meant to stay that way, but O'Brien says the companies have concepts for "tilt-wing versions of this that you could put a human in."

Mark Alber, manager of advanced concepts at Sikorsky and chief engineer on the project, says the aircraft is called the Rotor Blown Wing because, given the size

of the proprotors, "there is a very high percentage of the wing that's being blown by the rotor wash." This provides extra lift that enables the craft to have a smaller wing and greater speed. O'Brien predicts the aircraft will fly "significantly" faster than the minimum 300 knots DARPA requires.

DARPA project manager Bagai refuses to discuss how the winner of the competition will be chosen. Nor will he venture whether the result might meet the "substantially everything a bird can do in the air" standard. In some ways, Bagai argues, Klemin's vision was exceeded long ago. Not that many birds can hover, he notes, and none flies faster than the speed of sound. But birds far outclass manned aircraft in maneuverability and, he admits, in the way they can quickly land on a tree branch or telephone line.

As for the more practical question of how much the VTOL X-Plane project will advance vertical flight, Bagai says, "Whether the types that we're developing right now are the concepts that darken the skies or it's a spinoff from that that darkens the skies, I think either way it's a huge ramification." Were he alive, Klemin would surely be pulling for the designers to prove Bagai right.

Sikorsky/Lockheed's concept (above): The entire airplane tilts for vertical flight. Forebears like the Convair XFY-1 Pogo were tested and discarded in the 1950s.

LEFT: NASM (SI-75-14810~AM); RIGHT: SIKORSKY

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Ken Hyde's collection at his workshop (clockwise from top left): 1911 Model B; 1909 Military Flyer; 1910 transitional Flyer; 1902 glider; 1911 EX *Vin Fiz*; 1911 glider (not shown: a second 1909 Flyer). Pictured left to right: Bill Hadden, Scott Rawlings, David Mitchell, Ken Hyde, Greg Cone, Andrew King, and Cliff Gutridge.

AIRPLANES SEEKING GOOD HOME

A ONE-OF-A-KIND COLLECTION OF SCRATCH-BUILT WRIGHT AIRCRAFT IS UP FOR SALE.

by Paul Glenshaw | Photographs by Dane Penland

THERE ARE ONLY TWO GUYS who have built more Wright brothers' airplanes than Ken Hyde and his Wright Experience team: Orville and Wilbur. Hyde's count so far is 21. They include all the gliders built between 1900 and 1911, three 1903 Flyers, the long-lost 1908 Fort Myer Flyer, and four 1911 Model Bs (one with an original Wright engine).

While most of the airplanes Hyde has built belong to museums around the country, seven of them still reside in his shop in Warrenton, Virginia. He's hoping to find a museum to buy the airplanes and a second original engine (serial number 59), built in 1911 by Wright mechanic Charles Taylor himself.

"We've only done the first part of this—re-creating the airplanes," Hyde says. "It needs to go to the next phase, which is to keep the collection intact and housed some place where the public could enjoy it."

An original Wright engine, serial number 33, powers the 1911 Model B. The 35-horsepower, four-cylinder, water-cooled vertical engine was likely built by Charles Taylor. The red corduroy seat, partially visible at right, had no seat belt.

Hyde believes young people can get excited about aviation by learning the Wrights' story—two brothers building bicycles and playing with kites who go to the beach and invent one of the most transformative objects of the 20th century. He hopes re-creating their work will inspire future generations of aeronautical innovators. "[The Wrights] show a great practical application of mathematics," he says. "They're persistent. They're brave." And, he adds, they were so industrious and achieved so much, it's hard to figure out when they slept.

Hyde and his team know something about this. They've been learning intently, sometimes sleeplessly, about the Wrights' engineering for more than 25 years. Beginning in 2000, when I built a website for the group and worked with them to develop education projects, I've watched the activities in Hyde's shop, nestled in the Virginia countryside. As soon as I walked in, I could tell that it was different from other restoration shops I'd seen. It's a real Wright airplane factory, where almost everything is done in-house—from scratch-built Wright engines to hand-carved propellers. "We usually find it's best to make it ourselves," Hyde says. "That's what the Wrights did." And it's packed with projects squeezed in and around the maze of Wright machines. Here is a Jenny; over there a 1929 Parks PA-2 (a three-place biplane used in airmail service and flight training at Parks Air College). There's Wright engine no. 59.

Hyde believes young people can get excited about aviation by learning the Wrights' story—two brothers building bicycles and playing with kites who go to the beach and invent one of the most transformative objects of the 20th century.

Hyde and his team, sponsored by the Ford Motor Company, built the 1903 Flyer used in the December 2003 centennial of flight reenactment in Kitty Hawk, North Carolina. Weather and a misfiring engine prevented a successful flight on the big day, but the Flyer had flown before the December 17 ceremony. The team had succeeded in creating a Flyer that flew just as the original had flown for the Wrights: when conditions were right.

For most, the 2003 celebration was the culmination of interest in the Wright brothers, but Hyde had begun an investigation he felt compelled to continue. "There was no way to stop after 2003," he says today. "There were still so many questions. Orville and Wilbur couldn't wait to get to their shop every day. And that's what happened with us—it takes all of us to get our heads together to figure out what they did. We've still got a lot to learn."

Hyde's team has varied over the years, but there are several core craftsmen: Greg

Cone, the Charlie Taylor of the group and Hyde's longest-standing employee, has several Wright engines to his name; Cliff Guttridge handles the metalwork; Bill Hadden creates the drawings and does piecework in almost every phase of construction; and Scott Rawlings manages the woodshop and keeps the projects in line.

It all started in 1992, when the Army Aviation Museum in Fort Rucker, Alabama, commissioned Hyde, already renowned for restoring antique aircraft, to make a static Wright Model B for display. He figured he could simply get some plans from a museum and get to work, but he quickly discovered there were no plans. He began to look for clues. "It was six months before we cut the first piece of wood," he says. He realized that the Wrights' engineering had never been completely understood.

A close-up of the 1911 glider, which Orville used in experiments at Kitty Hawk. His diary entry for October 18, 1911, reads: "Made several glides. In last one, machine turned around in spite of all I could do and ran into hill, turning over. Broke both left wings and rear horizontal surface."

Most of the knowledge about their airplanes existed only in the Wrights' heads. They made drawings, but only fragments remain. How did they design and build their aircraft? How do they actually fly? Hyde and his team have spent thousands of hours in research: finding, copying, and scrutinizing every photo, letter, diary entry, newspaper article, film, and object they can find; making 3D scans of prop fragments; running dynamometer tests of original engines; developing a technique for creating AutoCAD models of the airplanes and matching them to photographs. (With this technique, if they have one reliable measurement for a component, they can get accurate measurements for the rest of the airplane.) The 1908 Fort Myer Flyer, which was destroyed in a crash, was rebuilt thanks to detailed photographs Carl Claudy took during the Army trials. "It's as if he knew we'd need them 100 years later," says Hyde.

They have re-created the famed Pride of the West muslin (based on fabric samples provided by the Wright family); they sent a sample of the original aluminum powder finish to a lab to be analyzed so they could get the exact grain size for the reproductions. They are fanatical craftsmen, from the superficial—getting the nickel-plated metal components to make

the Model B shine "like a fine piano"—to the critical, such as making sure the hand-carved propellers balance perfectly.

Today, the core of Hyde's collection is a group of seven airworthy aircraft, representing about 60 percent of the Wrights' experimental and commercial work. Like all Hyde reproductions, each is an exact duplicate of the original. The collection includes a 1902 glider, configured as Orville and Wilbur flew it in 1903; and two 1909 Military Flyers, one already outfitted for flight-testing, with places set up to record engine and propeller data, and the other configured as Wilbur had it at College Park, Maryland, in 1909. The engines on these 1909 machines are exact duplicates of the 1908 "US" engine, which is installed on the original 1909 Flyer at the National Air and Space Museum. (In 2007, Hyde's team was allowed to build a scaffold under the Flyer so they could access the engine interior; the engine hadn't been opened since 1911.)

Also for sale, the sole example of a 1910 "transitional" Flyer, which has both a forward canard and a rear elevator. Hyde's team configured it as Orville had at the Wrights' first training facility, in Montgomery, Alabama. Three more aircraft round out the collection: a 1911 Model B, which has flown and is ready to fly again, with an original engine (serial number 33); a 1911 glider, replicating the machine in which Orville set the first soaring record, in an October flight lasting 9 minutes, 45 seconds; and a 1911 Model EX, which is meticulously painted to duplicate the paint on Cal Rodgers' Model EX *Vin Fiz*. National Air and Space Museum chief curator Peter Jakab made it possible for Hyde's team to take a digital sample of the colors of the fabric on the original *Vin Fiz*, which hangs in the Museum.

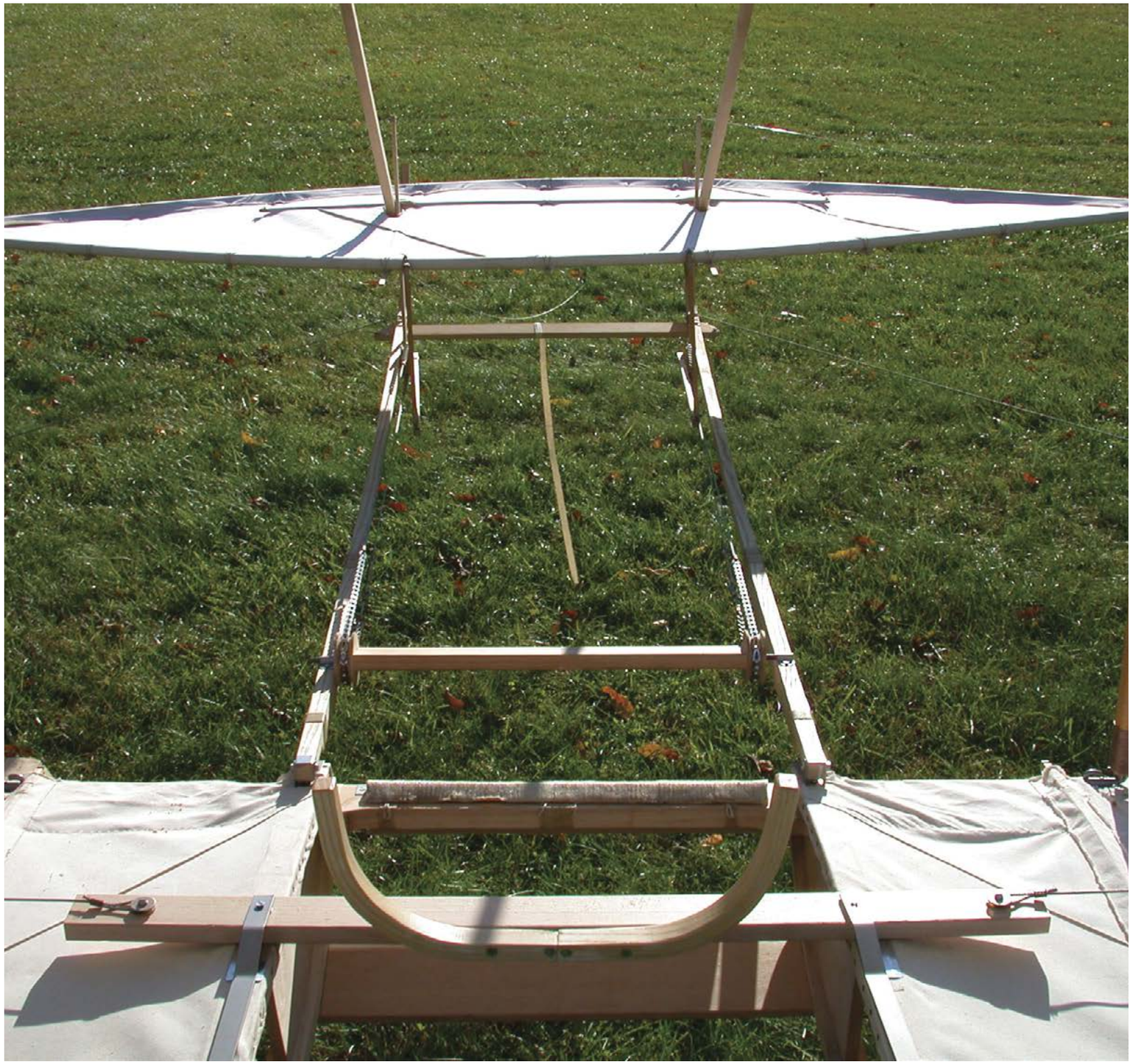
Because there have frequently been no drawings or written steps to follow, Hyde and the team have duplicated not only the machines the brothers built but their likely method of engineering and experimentation. At one point, for example, the builders needed to replicate the 1911 Model B's chain guides—the metal tubes that keep the chains driving the propellers on track. The tubes are oval in cross-section, and getting a manufacturer to produce them was prohibitively expensive. "So you go to bed wondering what to do, wondering what the Wrights did," says Hyde, "and you wake up in the middle of the night with the answer. You get a one-inch piece of tubing, put a 3/4-inch piece of bar stock in it, crank it in the vise, and it comes out perfect."

All of the aircraft in the collection are airworthy because that's how the brothers learned—through flight tests. "We need to do flight tests, get the data off the airplanes," says Hyde. The data would allow the brothers to build accurate simulators. Hyde also feels that demonstration flights (of the airplanes that are easier to fly) are important for public education about the Wright brothers and the progress they made from one model to the next.

Hyde insists on accurate re-creations because he is trying to retrace the steps the brothers took in learning about flight. "If you change things, any data that comes from testing reflects what we know now. So when we test an accurate airplane, we learn what they knew," he says. The team learns what Hyde calls the brothers' "secrets."

What's the biggest secret? "It's hard to say—there's a lot of small steps that improved the airplanes as they moved forward," Hyde says.

"They knew how to beat mean old Mr.



Hip cradle, 1902 glider: To fly the 1902 glider, the pilot lay on the lower wing. Moving the hip cradle actuated the wing warping for roll control. The same system was used on the next few Wright designs, including the 1903 Flyer. (WRIGHT EXPERIENCE)

Gravity," Greg Cone says. Cone restored engine #20, built about 1910 in the Dayton factory. There are all sorts of things to reduce weight—aluminum crankcase, simple fuel injection, tubular connecting rods, suction-operated intake valves, and strange little slots cut into the bottom of each cylinder. "[The slots] are auxiliary exhaust ports," says Hyde. Working with Delphi Labs and the University of Rochester, he ran a full set of dynamometer tests on the engine. The tests showed the exhaust slots helped lower the cylinder heads' temperature. "Too much heat leads to things like valve failures and detonation problems," he says.

So the engine was simple in order to be reliable, and provided modest power. It didn't need to do more. Hyde's wind tunnel tests show the Wrights' 1911 "bent end" propellers—the kind driven by engine #20—have a peak efficiency of 81.5 percent. (Propellers today are about 84-85 percent efficient.) "That's how they can get so much airplane into the air with just 35 horsepower," he says.

Other discoveries have been inferred from existing evidence: Flight test data from 2003 shows the 1903 Flyer was most

likely overpowered. The wooden dowels attached to the canard booms of the 1910 transitional Flyer were likely visual aids, showing Orville's students where to place the trailing edge of the canard in a climb. The engine's compression release system enabled the engine to be primed, but also served as the kill switch (rigged so if you fell forward in a hard landing, you'd trip a string and shut off the engine). There are countless other revelations in store.

Hyde stresses he's far from finished, and wants to see the collection grow. He has not yet re-created the 1904 Flyer II and the 1905 Flyer III. "They should be in the collection," he says. "I think the '04 is the most important of all, because that's one of the only times they were doing trial-and-error, trying to get the airplane to fly better."

Hyde imagines a place where it's all brought together: a facility with a grass strip where airplanes can be taken out and flown, where there's easy access for the public, where the data can be preserved and studied, and where young people can get their hands on real Wright machines. Brand-new ones. And with the knowledge passed on, there can be more on the way—airplanes and innovators both.

The 1911 Model EX (a reproduction of Cal Rodgers' *Vin Fiz*, the first airplane to fly across the U.S.) shows the unusual—for the Wrights—rectangular radiator.

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A Truly World-Wide Web

How aerial tech is bringing the Internet to everyone everywhere.

BY MARK ANDERSON

ONLY ONE OUT OF THREE inhabitants of this planet has regular access to the Internet. Its vast resources in education, industry, media, global communication, and culture—not to mention cat videos and selfies—are beyond the reach of most. A handful of companies and entrepreneurs are working on various ways to get the world's wired population to hit three out of three. Google, Facebook, and SpaceX have all recently announced initiatives to connect the world's unconnected three to four billion to the Internet. But to reach the world's most remote regions, the familiar combinations of cable TV wires, fiber optic lines, and cell phone towers won't be sufficient. Instead, Google wants to use high-altitude balloons, Facebook plans to fly solar-powered drones, and SpaceX is preparing to launch constellations of Internet-transmitting satellites into space. Plus, one satellite entrepreneur you've probably never heard of might beat them all to the punch.

Flying at 60,000 to 90,000 feet, the Aquila drone (above) will provide connectivity to remote users.

Whether the truly world-wide web

COURTESY FACEBOOK

arrives courtesy of one or some or all of them—or another, dark horse methodology no one is even talking about yet—within the next 10 to 15 years, it will happen. Most of the planet will be able to get online whenever they want to. "Gigabit-level access, 20- to 30-millisecond latency, everywhere on Earth" is how SpaceX founder Elon Musk described his vision earlier this year.

At Facebook's F8 conference in March — a usually-annual conference for developers who build applications for the social media site—Chief Technology Officer Mike Schroepfer laid out the fundamental problem. He posted a slide of Earth's wireless data coverage today, combining 4G, 3G, and 2G/EDGE networks. The image looks like that famous "Earth at night" NASA photo montage, revealing patches of the planet where artificial illumination shines brightly in the dark—and leaving vast stretches of Earth's landmass in darkness.

In densely populated regions of the world, Schroepfer said, telephone companies can afford to invest billions of dollars in fiber trunk lines, coaxial cable connections, and networks of cell phone towers. The subscriber base is big enough to cover the costs of such vast infrastructure investments. "As

Facebook's Mike Schroepfer.

you move to more rural areas of the world, you just can't recoup those costs," he said. "So what we're doing with [Facebook's] Connectivity Lab is we're investing...in radical new approaches to this problem. This basically means going to the sky. You have to have satellites, drones, and other things that don't require the massive investments in terrestrial infrastructure in order to affordably provide Internet access."

Meanwhile, Facebook's biggest rival in the Internet space race has been testing its visionary solution at a World War II-era hangar at Moffett Federal Airfield near Mountain View, California. Google's Project Loon was launched in June 2013 with the release of test balloons on New Zealand's South Island. The Loon project—the name is short for "balloon," but slyly acknowledges the perceived lunacy of the undertaking—is the latest of Google's so-called X-Projects. The X-Projects are now run by Alphabet, a conglomerate in which Google is only one division. Other prominent X-Projects include the self-driving car and Google Glass.

As Google spells it out in the terse web pages it devotes to Project Loon, the idea is simple but the execution will be complex. Helium balloons will carry solar-powered telecom payloads that essentially make the balloon a 4G/LTE-providing tower. The balloon itself contains a second balloon that will be used when the host reaches its destination in the stratosphere, 59,000 feet and more above Earth. This is nearly twice the altitude of airliners and the weather, putting it above many of the hazards lower-flying balloons could encounter. And thanks to the U.S. National Oceanic and Atmospheric Administration, Google also has access to detailed global forecasts of wind speed and

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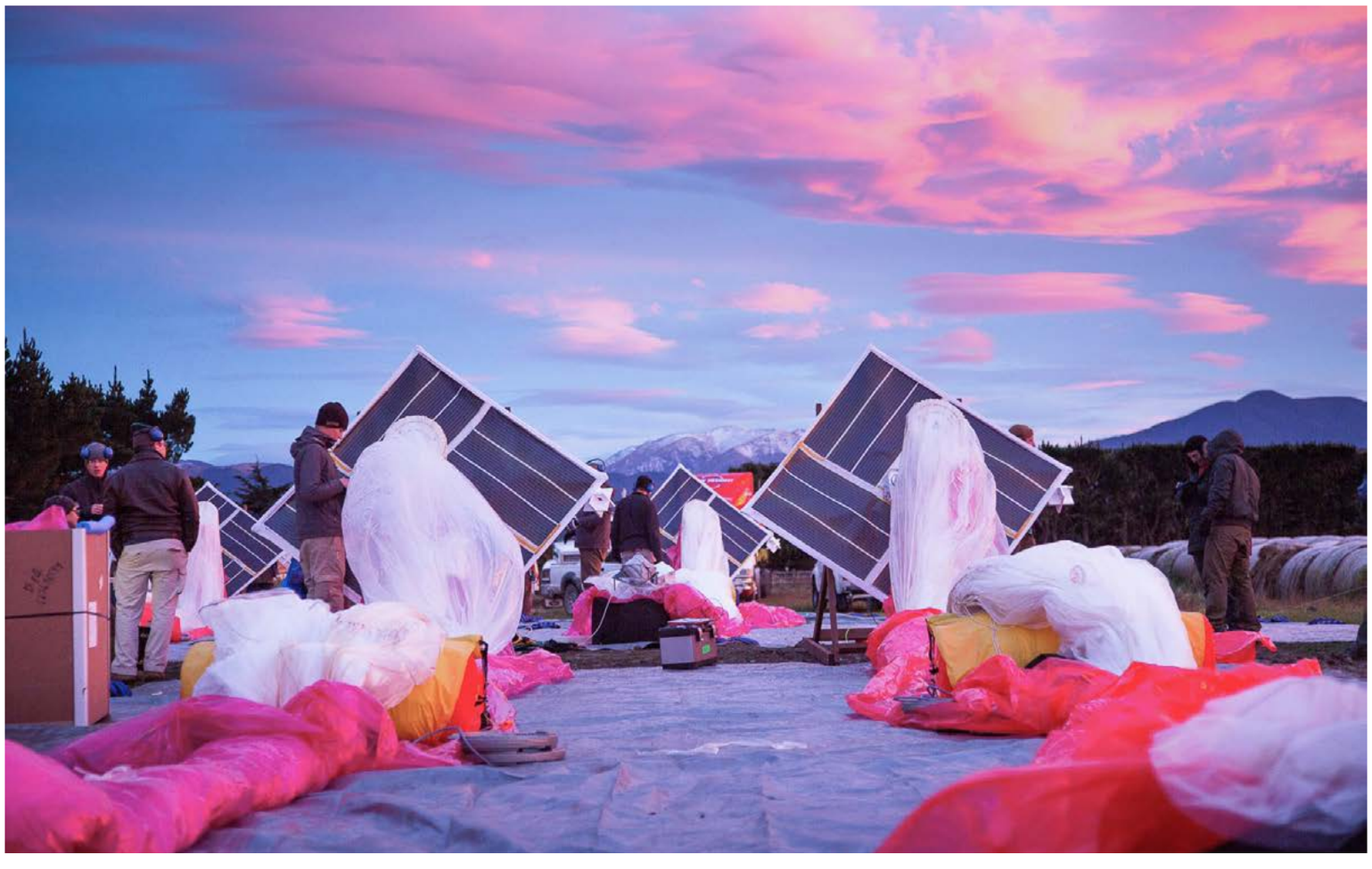
direction at various altitudes in the stratosphere.

For instance, suppose that a given Loon — one 69,000 feet above Santiago, Chile, say — needs to travel east to Buenos Aires. NOAA's forecast might predict that at its current altitude, winds are unstable and southerly, but at 65,000 feet, they're easterly. So the Loon would need to descend by about two-thirds of a mile, then ride the currents toward its destination.

An onboard pump can inflate the Loon's inner balloon with air to cause it to slowly sink—and should it need later to climb, the inner balloon can pump the air back out. This gives the Loon balloon the ability to steer itself. Informed by data-crunching algorithms that enable it to use NOAA's forecasts, the Loon could climb up and down in the stratosphere and ultimately sail its way across the planet.

Google says it has so far launched more than 30 Project Loon test balloons, in New Zealand, California's Central Valley, and northeast Brazil. According to an announcement in March, a Loon launched from New Zealand, traveled 5,600 miles over the Pacific, then found calmer wind patterns (one-quarter the speed of its trans-Pacific

One of Google's Project Loon balloons (right) launched in June 2013 over New Zealand's south island. Below, workers in Christchurch inspect the balloons' monocrystalline solar cells, each of which Google says generates 100 watts of power in full sunlight.



COURTESY GOOGLE/LOON RISING (2)

crossing) over Chile to connect Chilean Loon testers to the Internet. It crossed the Atlantic at a top speed of 87 mph and finally, eight days later, lingered within half a mile of its target over eastern Australia, providing a further two hours of Internet connection there.

Google's big idea is to use a few thousand Loon balloons to knit together a world-blanketing quilt of 4G connectivity. "The Loon is a great magic trick," says Vern Fotheringham, former CEO of the satellite internet company LeoSat LLC. "God bless 'em. They can populate the stratosphere with very intelligent balloons.... Can you do it? It looks like you can. Does it make good economic sense to do it? I have no idea."

The three big players in the Internet space race—Google, Facebook, and SpaceX—are all tight-lipped about their detailed plans. (*Air & Space/Smithsonian* contacted representatives of all three, and while none agreed to an interview, a Facebook spokesperson later responded to questions via email.) However, space industry consultant Neil Mackay of Mile Marker 101 LLC has studied public announcements and conference presentations and believes Google appears well positioned to give existing satellite-based Internet providers some competition. Geostationary telecom satellites orbit Earth at more than 1,000 times the distance of a balloon; thus the Internet signal transmitted from these satellites has a latency, or lag time, more than 1,000 times that of a balloon-sent signal. So compared to a GEO satellite Internet connection that had shaved its latency time down to a dial-up modem-like half a second, an Internet connection in the stratosphere could trim the lag time back to several milliseconds or even less. That's the kind of near-zero lag results you might see in terrestrial T1 lines—the high-data-rate, extremely reliable Internet connection via (primarily) fiber optic cable many first-world businesses and offices rely on. One advantage of Google's plan is that "putting a balloon up is not a costly thing: It's only tens of thousands of dollars," Mackay says. "Therefore upgrading a system is not hard to do. You can constantly refresh it with new technology.... Their ability to stay in the technological forefront is greater than folks who put satellites up, and [those satellites will stay] up for five or 10 years."

However, Mackay says companies like Facebook and Google must remember that just because a technology works does not guarantee it will be adopted. Recall the tribulations of Google Glass, whose tiny base of tech-enthusiast users was drowned out by the complaints of regular folks not happy to be unwittingly filmed by "Glassholes" on the street, in the workplace, on the beach, in the grocery store, etc., without their consent. Mackay wonders how the tenderfoot Internet connectors will fare when dealing with the peculiar telecommunications regulations of individual countries. "Not every country wants some American company to provide [Internet] service there," he says. "The challenge is: Can they deal with all these different countries, each with its own regulations and economic climate, and get landing rights and all the other things that count?"

In a Q&A with the North American Bureau of the Internet Society conducted last year, Michael Cassidy, manager of Project Loon, said, "I wish I could say everything I know. But unfortunately I can't. We have been extremely successful with getting overflight permissions from basically almost everywhere in the world, including places you'd think maybe wouldn't [allow it]. Similarly with countries that some might think are maybe not as open to providing

Google Project Loon leader Michael Cassidy, with a prototype of a balloon's signal-distributing payload. Right: In April 2014, Google acquired Titan Aerospace, whose Solara-class drones could each potentially replace 100 cell towers.

information: [They] are actually eager to provide information to people in their rural areas who don't have access."

Greg Wyler is a serial entrepreneur who has wired parts of Rwanda—the old-fashioned, dig-trenches-and-lay-miles-of-fiber-optic-line way—and has offered satellite-based Internet connectivity to remote islands and other out-of-the-way locations. Now he is taking on Google and Facebook in the race to bring the world online. But rather than using untested technologies, Wyler thinks it can be done with a fresh approach to a very familiar industry.

Wyler plans to launch 648 Internet-providing satellites into low Earth orbit initially, and later launch about 250 more. And his constellation—which he maintains would be the largest devoted constellation of satellites in history—will, he says, be able to connect the planet to the Internet in just a few years, rather than a decade or longer.

Wyler's company, OneWeb, plans to launch its first satellites in 2017. Partnerships with Virgin Galactic (for launching), Qualcomm (for the chips in the satellites), and Airbus Defence and Space (for design and manufacturing help) have already been announced.

Each low-Earth-orbiting satellite (which Wyler says will cost around $400,000) will act as an intermediary for solar-powered OneWeb ground stations on Earth. And of

LEFT: COURTESY GOOGLE/LOON RISING; RIGHT: TITAN AEROSPACE

Scaled Composites' pilot-optional Proteus aircraft, seen in 1999 over Mojave, California, was intended to loiter over Los Angeles as an airborne cell tower. The plan was too ambitious for its era.

course unlike geosynchronous satellites, whose position can be fixed once like a satellite TV dish, any LEO satellite that the ground station tracks won't be in the sky for very long before it sets below the horizon—at which point the ground station must find a new one. Such never-ending tracking problems are the Achilles' heel of the LEO industry and have traditionally been the reason why LEO satellite ground stations (boasting expensive movable dishes and tracking hardware) cost ten times or more the price tag that Wyler projects for his stations. Keeping secret OneWeb's fix for this problem, Wyler points only to the track record of his partners.

"You have satellites moving overhead, with tremendous amounts of bandwidth, continuously handing over from beam to beam and satellite to satellite, to a terminal that's sitting on the roof of a school," he says. "Building chips that do that is really hard. Qualcomm is doing the heavy lifting, as they have deep technology in these types of handovers. Their handover technology is in 95 percent of the cell phones around the world." So, he says, Qualcomm is up to the challenge.

Wyler expects to sell his ground stations for a few hundred dollars each, a price that's competitive with satellite TV setups today. This price may put one out of range of most households in the developing world, Wyler acknowledges, but it's easily within reach of schools, community centers, local government buildings, and other NGO and non-profit centers. "That school district on an island in Indonesia can get a solar-powered terminal that a local girl would be paid to manage," he says. "It'd then bring high-speed Internet connectivity to the area around the school and to those kids.

"We're building—not researching," says Wyler. "We know how to build all the components, and we're in design and develop-

NASA

ment of all the components."

Of course, cheap, reliable, and global connectivity has been promised before. Teledesic, Iridium, and Globalstar all attempted to use constellations of satellites to connect billions of people around the world. None succeeded, and Iridium and Globalstar declared bankruptcy. They've since emerged from it, though not in any way that has Wyler looking at them as possible competition.

Wyler says that these companies all hit the market when technology couldn't support such ambitious goals. Now, he says, it can. Moore's Law has ensured that since the late 1990s, when companies like Teledesic last tried, computing speed has undergone some seven or eight doublings.

Industry consultant Tim Farrar of TMF Associates saw Wyler's keynote presentation this year at the Satellite 2015 confer-

A SpaceX Falcon 9 rocket lifts off from Cape Canaveral in July 2014 carrying ORBCOMM communications satellites. Elon Musk plans to use the rocket to haul a constellation of satellites that will transmit Internet connections to remote regions.

SPACEX

ence. And, as a consultant to Teledesic in the late 1990s, Farrar says he knows from first-hand experience that the viability of Wyler's plan depends on the ground stations. "He showed a mockup with solar arrays which themselves cost several hundred dollars," Farrar says. "Then he said he'd include a cellular base station in every terminal, which again you can't do for a few hundred dollars. And that's without solving the problem of having an antenna that tracks the satellite."

With current technology, Wyler can't expect to make money in selling the terminals, Farrar says. Indeed, it's possible the base stations would act as a loss-leader. But if the Internet signal is free, where does the profit come from?

I asked Wyler that question. He pointed out that five years ago the broadband-boosting base station Femtocell dropped below $100. "There is definitely some special sauce internally to design this, but we have all the technology pieces to really drive affordability," he says. "With our partners, we have an incredibly deep bench of technology to build a low-cost system that can provide remote Internet access."

While Wyler and Google are somewhat cards-to-the-vest about their plans for wiring the rest of the planet, Elon Musk surely wins the secrecy prize. His announcement of SpaceX's plans were vague and, Farrar says, confusing.

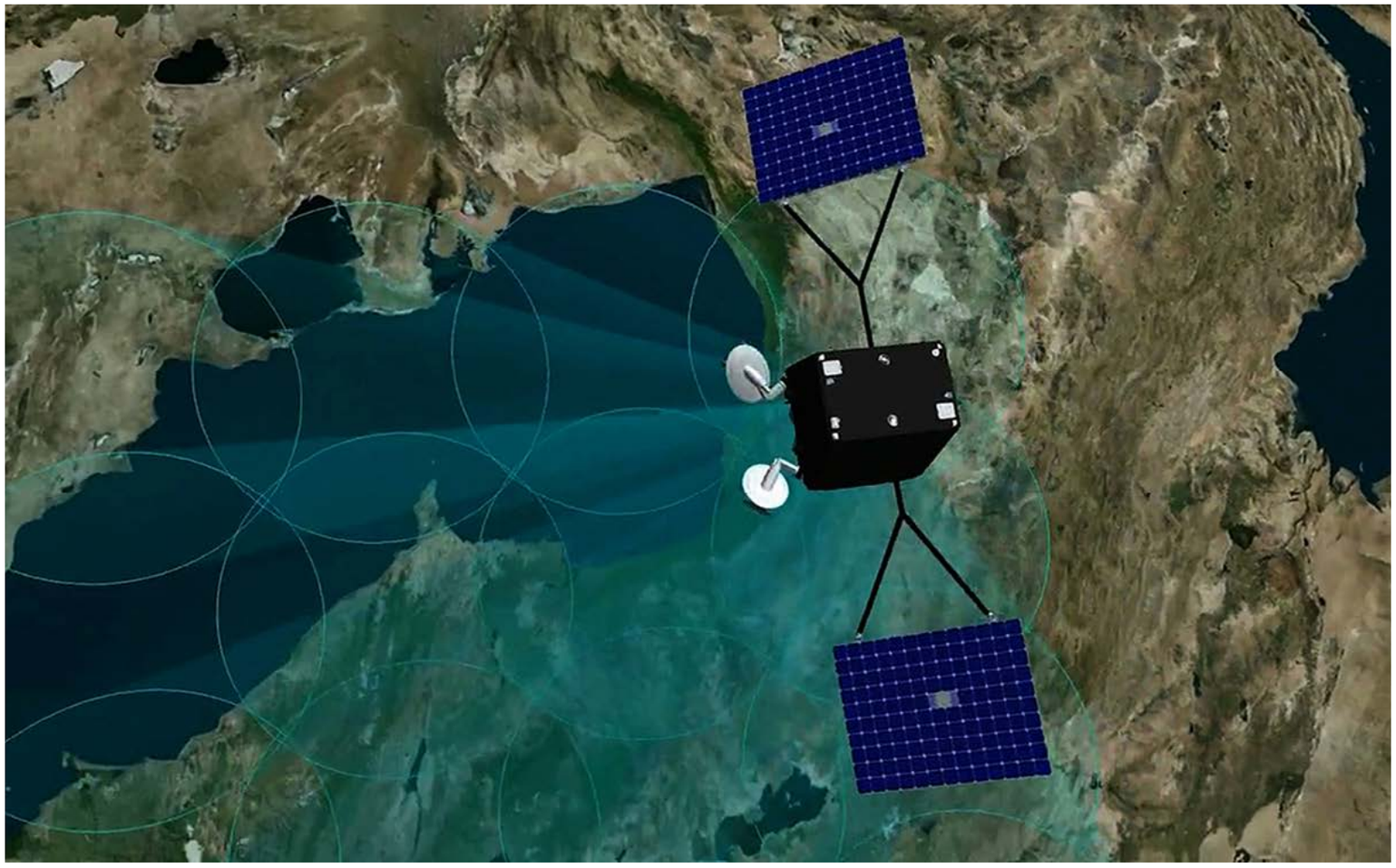
Crucially, SpaceX has filed a claim with the U.S. Federal Communications Commission that, if successful, could require OneWeb to share the broadband spectrum with SpaceX once their separate satellite constellations are launched. And that could mean that even if OneWeb is the first into orbit with its satellites, SpaceX could still take its time with its own system and also win access to half of the spectrum OneWeb seeks to claim.

On his company's blog, Farrar analyzed both Wyler's keynote and the speech Musk gave two months earlier outlining the SpaceX plan. "Elon's speech was not terribly well thought through; it was not technically coherent," Farrar says. "It suggests it was something rushed out to try and preempt Wyler's announcement."

As for Facebook's global Internet-connecting plans, the company (and its partner organization, internet.org) has announced that it plans to connect the planet via fleets of unmanned, solar-powered drones that roam the stratosphere and beam down data coverage. Facebook's 2014 purchase of the U.K. solar drone maker Ascenta enabled the world's leading social network to become, in one swoop, the world's leading maker of solar-powered "connectivity aircraft," in Facebook CEO Mark Zuckerberg's phrase.

In a July 30 blog post, Facebook Vice President of Global Engineering and Infrastructure Jay Parikh announced that a full-scale version of the company's Aquila drone was ready for flight testing. The solar-powered aircraft has the wingspan of a 737 but the weight of only a small car. Operating from 60,000 to 90,000 feet, it will remain above weather and air traffic. Each drone will have the ability to circle a remote region and beam down an Internet signal for up to 90 days at a time. Working together, the fleet is intended to provide uninterrupted Internet access to users and stations on the ground. Parikh also announced that Facebook's laser communications team had successfully lab-tested a beam that can transmit data at 10 gigabits per second, a 10-fold speed increase over prior lasers. He said the laser is accurate enough to hit a target the size of a dime from more than 10 miles away, and that the laser communications network this research will enable will

Artist's rendering of one of the hundreds of broadband-providing satellites OneWeb founder Greg Wyler wants to put into low Earth orbit.



allow Facebook's drones to communicate with one another and with stations on the ground.

Facebook's scheme is reminiscent of a 1999 plan to loiter an aircraft called Proteus above Los Angeles to serve as a high-altitude cell phone antenna tower. Its High Altitude Long Operation (HALO) Network was another grand idea from the late '90s tech bubble that proved to be starry-eyed.

Fotheringham thinks Facebook, Google, OneWeb, and Space X may not realize quite how many regulatory hurdles lie ahead: "The trade-off of not having a pilot on board," for example, "is you've got to wait on the [Federal Aviation Administration] and regulations and insurance companies to let you go and fly that aircraft over populated areas."

Moreover, Fotheringham says, keeping a solar-powered aircraft in the air for months on end requires a lot of power; at night, the drone must rely on stored power alone. Although Facebook has not disclosed specs for their drones, Fotheringham says, "I don't think the power budget is going to leave enough to have a very powerful telecommunications relay platform. I just think they need more power in the telecom payload."

Still, he says, it's easy to be a naysayer. "In any field, all the old jaded guys say, 'That'll never work.' And yet the 27-year-old brilliant guy says, 'Why don't we try this?' And the old guy says, 'No, no, no.' And they say, 'Screw it, we'll do this anyway.' That's the beauty of progress.

"It's a fun time," he adds. "There are entrepreneurially motivated companies that are taking their money and investing it in things that are hard. Hard things are important. And for America to lead the technology wave into the next century, we've got to be on our game. It's up to the entrepreneurs to do it."

COURTESY ONEWEB

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Meet the Howards

THE RESPECTABLE SIDE OF THE FAMILY, DESCENDED FROM A RACEPLANE.

by Mark Huber | Photographs by Jim Koepnick

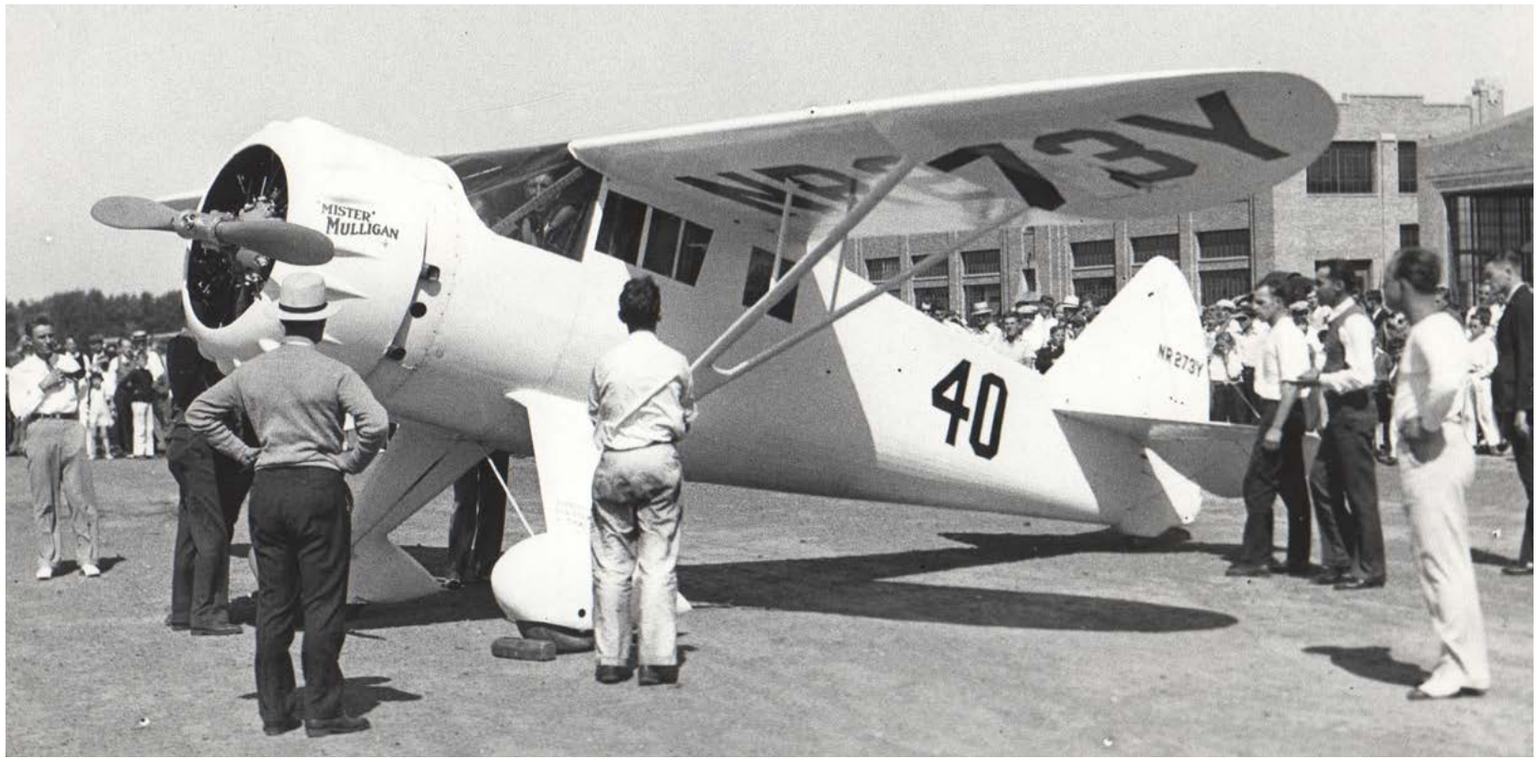
At the Howard Aircraft Foundation's 2014 Wisconsin fly-in, a dozen of the broad-back, high-wing cruisers look at home on grass, the surface most landed on originally.

HAPPY HOUR at the Siren airport in far northwest Wisconsin. On the ramp, sitting beneath the high wings of half a dozen 1940s Howard airplanes, a growing, graying, and security-badge-less gang is imbibing. It's an homage of sorts. Long before he gained fame building racers in the 1930s, including the revered Mr. Mulligan, Benny Howard got his start in the airplane business by modifying a World War I biplane trainer to carry extra cases of hooch for Prohibition-era bootleggers. One very impressed customer dubbed it a "damned good airplane," and from then on, Howard used the designation "DGA" for all his designs.

The assembled tipplers are DGA disciples. As the sun sets, more of the vintage tail draggers arrive, bounce down the runway, and park. Hearty greetings are extended, and it's bottoms up.

This is the first day of the Howard Aircraft Foundation's 2014 summer fly-in. The gathering is an annual event traditionally held in late July on the weekend before the Experimental Aircraft Association's massive yearly conclave in Oshkosh, about an hour's flight to the southeast. Howards from across the country have been gathering here for more than two decades, thanks to the largesse of Howard enthusiast Al Lund, 84, who lives not far away on Stone Lake, outside Hayward. Lund owns two flyable Howards, and his hangar at the Hayward airport is stuffed with enough fuselages, wings, engines, and assorted parts to build a half-dozen more. In a couple of days, foundation members will hop in their airplanes and fly over to Hayward, get shuttled out to Al's house for lunch, and then ride back to Hayward airport for an enormous pig roast dinner he throws once a year for everyone even tangentially associated with Howards or his home field.

Tonight on the ramp at Siren's Burnett County Airport, most of the airplanes are Howard DGA-15s. Howard Aircraft manufactured a lot of them—520—between 1940 and 1944. Almost all were



Fans swarm Benny Howard's famous raceplane, Mr. Mulligan, at the Cleveland Airport before it takes off for Los Angeles to start the 1934 cross-country Bendix Race. (It made it as far as Nevada.) In 1935, the racer won the Bendix and the Thompson Trophy.

COURTESY HOWARD AIRCRAFT FOUNDATION

built for the U.S. Navy, which flew them as officer transports, instrument trainers, and air ambulances; after World War II, they were sold as surplus to the civilian market. The contract wasn't profitable for Howard Aircraft; after the war, the suburban Chicago company was liquidated and the proceeds reinvested in an electric motor plant in Racine, Wisconsin. Benny Howard left the company he founded to join Douglas Aircraft as a test pilot. When he died in 1970, Donald Douglas

Al Lund (below) was one of the founders of the Howard club. His son Jim prepares to land one of the family's Howards at the fly-in (left); Mike Merritt's airplane (foreground) is already parked.

RIGHT: COURTESY LUND FAMILY

Sr. wrote, "There probably never was, nor will there ever be, another human being as interesting as Benny, as intelligent, as exasperating, or as lovable."

Ben Odell Howard was one of those "grease-stained entrepreneurs," in the words of *Time* reporter Paul O'Neil, who learned by doing during the golden age of aviation in the United States—an era of races and records between Charles Lindbergh's 1927 Atlantic crossing and the early 1940s, when airplane makers' shops sprouted in small towns and air exhibitions drew crowds 50,000 strong. Almost all of the golden age entrepreneurs, wrote O'Neil, "had absorbed what they knew of aeronautical science by tinkering with Jennies and Standards as barnstormers and by building, and risking their necks in, later models of their own." Instead of enrolling in flight school, Howard read a book on how to fly, then bought a second-hand Standard biplane and quickly crashed it. (His passenger died in the crash.) When Howard got out of the hospital, he "made a deal," as he put it, with a flight instructor. He later raced Roscoe Turner and Walter Beech and beat them both.

Today, some 200 Howard airplanes remain on the Federal Aviation Administration's registry, but only a few dozen are flying. Of those, most have undergone extensive restoration. Rebuilding just a set of wings for a DGA-15—wooden frame, mahogany plywood, and fabric—can be an eight-month, $100,000 adventure; overhauling the big, nine-cylinder, 450-horsepower Pratt & Whitney R-985 Wasp Junior engine can tack on up to another $50,000; add to this updating the electrical system, rewelding and recovering the metal-tube fuselage, new paint and interior, and a few modern conveniences such as an electric fuel pump and new radios, and the total can soar to $250,000—or a lot more.

"You'd be counting your blessings if you were just a quarter-million into it," says Jim Kreutzfeld of Castle Rock, Colorado. Kreutzfeld has had a hand in several Howard restorations and owns a 1940 DGA-15P. So does his brother Ken, an internationally known Howard specialist who owns K & M Restorations in Marblehead, Ohio.

Working with designer Gordon Israel, Howard specialized in very-limited-production racing aircraft, the most famous being the DGA-6 also known as Mr. Mulligan, winner in 1935 of both the Bendix distance race and the Thompson trophy for closed-course racing. In 1936, Howard crashed the airplane near Crownpoint, New Mexico, during his last stretch in the Bendix New York-to-Los Angeles race, seriously injuring himself and his wife Maxine, known as Mike. As a result of the crash, Howard lost a leg. Most of the Howard Foundation members who showed up in Siren learned about Mr. Mulligan after they became interested in Howards, as opposed to being drawn to the brand because of the racer. As colorful as Benny Howard's history is, his airplane still sells because it's a damned good airplane.

In 1970, parts from the original Mulligan were salvaged from the crash site and used as patterns to build three replicas, each a little different from the others. The first crashed in 1977 during a speed run over Tonopah, Nevada, killing builder Bob Reichardt. A second replica was built by Jim Younkin of Springdale, Arkansas, in 1985. (Younkin, who invented a solid-state autogyro system, got his first air-

Above: Restorer Rick Atkins test flies Craig Bair's DGA-15P, which became the 2015 Oshkosh Vintage Grand Champion. Far left: Howard and wife Maxine in 1935. Left: Most Howards wear the name on their tails.

plane ride in a Ford Trimotor in 1934 and is the father of the late Bobby Younkin, an airshow legend. He was a kid when Howard crashed the original.) His replica, powered by a Pratt & Whitney R-1340, took more than 8,000 hours to build and is displayed at the Arkansas Air Museum. Younkin also collaborated with a friend, the late Bud Dake of Creve Coeur airport near St. Louis, to build three Mullicoupes, loosely based on Mr. Mulligan but with the smaller R-985 engine and a modern steel-tube fuselage. In 2009 Howard enthusiast Bruce Dickenson of Santa Paula Airport in California built a hybrid of a DGA-6 and a DGA-15 that he called the DGA-21. Howards seem to attract what might be called a second generation of "grease-stained entrepreneurs," a gang of DIYers who stayed true to aviation after the world moved on.

Howard used Mr. Mulligan as the template for a series of aircraft designed for the general public. The four-seat DGA-8 that emerged in 1936 was the first in a family that used the same fuselage

LEFT: COURTESY HOWARD AIRCRAFT FOUNDATION; TOP RIGHT: DAN MCNEIL

WINGMAN

Wooden components, made by hand.

IT'S NOT QUICK AND IT'S NOT CHEAP, but if you want the wings on your Howard restored, Marc Stamsta is the man. He operates Max Aero in Hartford, Wisconsin, just down the road from Oshkosh.

His fascination with wood wings began at age seven, when he started assembling balsa wood airplanes. Now he does the real deal. "I've never been rich, so I've always had to build my own airplanes," Stamsta says. "If you're handy and you have a snowmobile engine and a bottle of glue, it's not that hard."

Howards have been a good business for Stamsta. He came away from Siren in 2014 with orders for three shipsets; that's two and half years' worth of work and around $64,000 each before the customer adds fabric, paint, and hardware.

Although good blueprints are available for the DGA-15, thanks to its military heritage, the process of rebuilding Howard wings is arduous and complex. For each set of wings, Stamsta says, "there are 8,000 to 10,000 parts, if you count the gussets. Each rib alone has 60 components. And I have to handle each part about 10 times; picking the boards, running them on the CNC [computer numeric controlled router], hand sanding it, gluing it, hand sanding some more, varnishing, and hand sanding again. And that's before I attach the mahogany plywood cover."

This is the age of carbon fiber, but Stamsta thinks wood is still the best material for wings. "A tree flexes in the wind for 600 years.

It will take master craftsman Marc Stamsta about eight months to rebuild this set of Howard wings. "They're big wings," he says.

Now you add more adhesives and epoxy to that wood and you really have something. These rebuilt wings will easily last 100 years."

Howard wings employ a variety of woods; ash in the wing strut area, basswood, mahogany plywood, birch plywood, and Sitka spruce. The spruce is becoming pricey in the wake of accelerated demand from foreign buyers, about $100 a board foot. Fortunately, the stronger and cheaper Douglas fir is an acceptable substitute.

Max Aero is a one-man operation, but Stamsta says he usually has help from "the old guys who hang out at the Hartford airport."

COURTESY MARC STAMSTA

but different engines. Howard sold 18 DGA-8s, powered by the Wright R-760; seven DGA-9s with the Jacobs L-5; four DGA-11s with the Pratt & Whitney Wasp Junior; and two DGA-12s with the Jacobs L-6. Between 1936 and 1939, the company built a total of just 31 in the series.

The DGA-15 was a different story. Launched in 1940 and designed to compete with the cabin-class single-engine business aircraft of the day—airplanes like Beechcraft's B-17 Staggerwing and the Stinson V77 Reliant—the aircraft sold well until the U.S. entry into World War II, when the factory began producing military variants. Howard's brochure for the Model 15 boasted of a rear seat with "motor car comfort for three" and a cabin with "scientific soundproofing" and "only the finest broad-cloth and leather."

Frank Rezich, 92, remembers building the airplanes that had to live up to those promises. At 17, he was the assistant to the factory superintendent. In 1940 Howard was a shoestring operation, with only 50 employees, individually making aircraft to order for high-profile customers like Jimmy Doolittle and actor Wallace Beery. "There was no assembly line, we did not build on a production basis," says Rezich. "Customers would send a deposit and we would start building an airplane." Rezich remembers Howard as "intense, demanding, and a perfectionist." Before releasing an aircraft for first flight, Rezich says, Howard would examine the smoothness of the finish; he'd run his hand over the fuselage, then "put his handkerchief on top of the fuselage and see if it would slide down."

HOWARDS IN REVIEW

A parade of lovelies at the worlds' biggest fly-in: Oshkosh, Wisconsin.

You can't appreciate the grace of Benny Howard's DGA-15s just by seeing a static display. In this brief video, a series of airplanes show off the elegance of Howard's design. Bonus: the sound of that Pratt & Whitney Wasp Junior.

Tap to watch video at *airspacemag.com/howards*

JULIA ARTZ

"IT'S THE BEST RIDE OUT THERE," says Dennis Lyons, a former American Airlines pilot who prefers the Howard to the Beech Bonanza he owned earlier. "It's not as fast as the Bonanza and it's more challenging to land, but it rides turbulence better." Lyons and his wife Susan have owned their blue DGA-15P, named Archibald B, for 10 years. Lyons says he can fly it from the airport near their home in San Miguel, California, to Chicago with just one stop for gas.

"You know this airplane doesn't know whether it's 1945 or 1995 or 2015," says Lyons. "Flying across Wyoming, nothing down there, you get the same feeling as the guy who first flew it."

"I'm not interested in going anywhere fast," says Mike Merritt, of Kennesaw, Georgia, owner of a 1944 DGA-15P, who retired after spending 20 years in the Air Force and later working as a civilian test pilot for Lockheed Martin. He's flown the F-117 stealth fighter and the F-22/A Raptor, but today he's happy to poke along in his Howard at 130 knots—about 150 mph. For its time, Merritt points out, the DGA-15 was pretty fast, with a top speed of 175 knots. "And expensive—more than

In 2014, the lineup of Howards at the Siren, Wisconsin airport eventually reached 14.

$17,000," he says. "But it is very solid. It has a great useful load—you can really put in four people and their luggage and go places. Range with full fuel is almost 1,000 miles."

The -15 has plenty of idiosyncrasies, and landing it is not easy, even for pilots with lots of tailwheel experience. The main gear carriage is fairly narrow, and if you hit it hard there is no give. If you don't nail your landing speed just right, you're going to bounce—rapidly. The only way to recover is to go around or move your feet on the rudder pedals faster than a ballerina on hot coals. The best way to land a Howard is to pitch up into a perfect three-point landing—much easier said than done.

One reason Howards are so stable, particularly in turbulence, is that there is no fuel in the wings to create an imbalance. The gas is stored in a series of three belly tanks that collectively can hold up to 151 gallons. The tanks have to be filled individually, and gassing a dry Howard can take up to 30 minutes. "A curved filler tube is used to get to the top of each tank," Merritt says. "You have to pump in the fuel slowly or it will spit it right back out at you." Unless the aircraft has been modified with a modern electric fuel pump, on startup you pump fuel to the engine with a mechanical "wobble pump." Merritt recommends landing and taking off with the selector switched to the forward tank, the one closest to the engine.

On an overcast morning, Merritt takes me along for a ride. You enter the aircraft through a right-hand cabin door between the sumptuous rear bench seat and the front pilot buckets and navigate up the incline. On the instrument panel, one switch is marked "flare dispenser," signaling the era during which the airplane first flew. Howards could be fitted with an aft flare dispenser, which illuminated the ground below for night landings on unlighted grass strips. It also started more than just a few fires. Says Merritt:

Alex Vickroy is the owner of the only Howard on floats. When he was a boy, says Vickroy, his father had a photo of the DGA-15 taped to the refrigerator.

"Pyrotechnics and airplanes generally don't mix."

For a single-engine tail dragger of this vintage, the Howard is a heavy beast—4,350 pounds—and speeds are higher all around—takeoff, stall, cruise, and approach—than those of many of its contemporaries. Taxiing side to side for visibility requires deft throttle application, as the Howard's relatively small rudder needs a fair amount of blow over the surface to maintain directional control on the ground.

Peripheral vision is the lead sense required on takeoff; that is, until the tail wheel comes up at 50 mph and you get your first glimpse of one of the features that makes this airplane special: that amazing panorama out the windscreen. At 70 mph, you're airborne, climbing at 1,800 feet per minute. Then you feel a second feature, that amazing stability: Take your hands off the yoke and it just stays put.

Merritt and I head north from Siren to Lake Superior's Apostle Islands, weaving between the bluffs and beaches, banking around the restored lighthouses, and enjoying the views from the elegance in the air.

At the hangar party, Howard owners catch up with one another. Dennis Lyons says his airplane has introduced him "to the most interesting people."

HOWARD OWNERS all have stories about how they found their airplanes and the multi-year sagas of rebuilding and restoration that followed. In 2001, current Howard Foundation president Presley Melton, a courtly, retired casket wholesaler from North Little Rock, Arkansas, found his 1943 DGA-15P in pieces in Washington state. He didn't know much about Howards; he just knew he wanted something with a 450-hp Pratt & Whitney R-985 engine. After the war, the airplane had been used by the tony Greenbrier hotel in West Virginia to shuttle guests,

then had a succession of owners from Alaska to North Dakota. When Melton got it, it hadn't flown since 1975. He had it trucked back to Arkansas. The showpiece restoration took until 2010, and Melton freely admits he exceeded his budget, but his airplane did win the 2010 EAA award for Antique Reserve Grand Champion.

Craig Bair first saw a Howard when he was eight and visiting the Denton, Texas airport, near Dallas. "I thought: That is the coolest airplane ever," he says today. About 40 years later, he feels the same way. He bought his first Howard, a DGA-15P, in 1997.

When his father died in 2000, Bair sold the -15 to raise the money needed to buy his dad's old Cessna 195. "As a kid, I grew up in that airplane," Bair explains, and the thought of the 195 going to someone else was unthinkable. But, he says, "After I bought the 195, I missed the Howard—bad."

Bair puts his admiration in automotive terms: The Cessna 195 is like a family sedan; a Howard, that's a limousine. He found his second Howard two years ago in North Dakota. Although he once ran an aircraft restoration business and is a licensed aircraft mechanic, his day job kept him too busy to restore the second Howard himself. He took it to Howard specialist Rick Atkins of Ragtime Aero in Placerville, California. Two years and $400,000 later, Bair is the proud owner of what could be the finest ground-up restoration of a DGA-15P ever. Bair and Atkins consulted old Howard brochures and documents to make the final product look like the original, right down to the patterns on the map pockets. While everyone else's airplane sat out overnight, Bair tucked his into a hangar. You really can't blame him.

Dennis Lyons was at Santa Paula Airport one day when he saw a Stearman biplane with a big Pratt & Whitney engine take off, then, not long after, return. "One of the cylinders on the engine was missing, gone, not on the engine anymore," recalls Lyons. The pilot had flown almost

Tim Weston restored his Howard himself. It won Antique Reserve Grand Champion.

The instrument paneal from Weston's DGA-15 indicates why it was an Oshkosh champion.

15 miles back to the airport with a cylinder missing. Lyons remembers thinking, "I want to fly behind an engine like that." A friend of Bruce Dickenson, Lyons knew about Howards and the big Pratt & Whitney that powered them, and a short time later he bought one.

Alex Vickroy wanted a Howard before he could drive. In 2006, when he was 18, he saw an ad for one on floats in *Trade-A-Plane*. Alex lives in Wisconsin; the airplane was in Alaska. He tore out the ad and kept it—for six years—before calling the owner, who still had the airplane. By 2012, Vickroy was a commuter airline pilot and had saved a little money. He went to Alaska, bought the airplane, and flew it home. It still looks very much like the working airplane it was in Alaska for more than three decades after receiving the Jobmaster cargo conversion and being mounted to a pair of enormous Edo 6470 aluminum floats. Vickroy likes to fly it to his fishing cabin on Lake Superior in Ontario, 40 miles from anything and accessible only by boat...or floatplane.

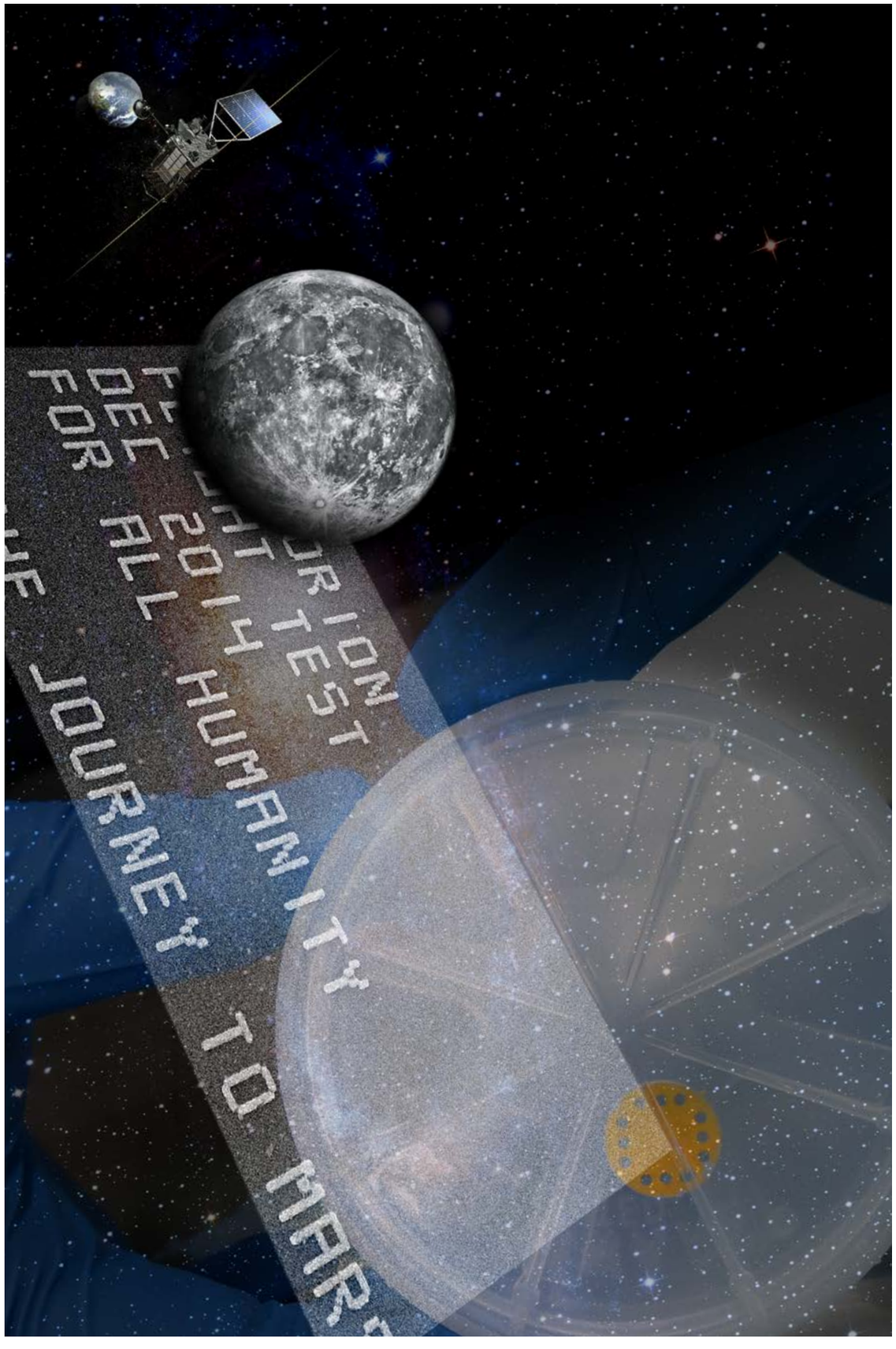
When it comes time to visit Al Lund, Vickroy taxis into Lund's lagoon and parks next to his float-equipped de Havilland Beaver. Everyone else catches a ride from the airport.

The lunch with Al is bittersweet. He's dying and everyone knows it. In less than five months he will be gone. He's mentored just about everyone in the Howard Foundation, and they have come to share a few laughs and say goodbye. Lund made his fortune in a series of businesses, but in his study there is no trace of any of them. He is surrounded by memorabilia and photographs of a life in aviation and of family. The two have been intertwined as long as his children can remember. Several of them are pilots and they can't discuss their father without talking about airplanes. (At this year's gathering, Al's wife Lois opened the hangar to the club, and the family once again hosted the lunch and dinner.)

The DGA-15's ample windscreen is especially welcome during air-to-air photo shoots. Howard Aircraft Foundation president Presley Melton shows off his airplane's pretty lines for the camera.

Al tells me that his Howard parts stash is for the benefit of the foundation's members and he doesn't want anyone making money from it. He was one of serveral who pooled money and effort to acquire the Howard DGA-15 type certificate in 2003, assuring that parts would be available to keep the Howards flying.

We go outside on the deck overlooking the lake where everyone has gathered. It is a flawless summer afternoon—brilliant sunlight, a few scattered clouds, and a light breeze. Painfully short, summer in northern Wisconsin doesn't get any better than this. Al sits down. The radials from the lagoon fire up. Al's son Jim taxis out in the Beaver. Vickroy pulls up alongside him in the Howard. Throttles advance and the race is on. Vickroy lifts a float first. Al Lund leans back in his chair. There is a glisten in his eye and he is smiling. For the DGA disciples, it is a Damned Good Afternoon.



“Hi! I’m from Earth!”

When sending spacecraft, it’s customary to include a note.

BY DAMOND BENNINGFIELD

WHEN THE PHOENIX LANDER touched down on the high northern plains of Mars in 2008, it carried a heavy load. In addition to cameras, weather instruments, and a chemical laboratory for studying the Martian dirt and ice, the craft toted 80 novels and short stories about Mars, a gallery of more than 60 paintings and illustrations, several radio programs, and the names of a quarter-million people. Marvin the Martian was aboard too.

Messages have been tucked away on spacecraft ranging from Japan’s Kaguya lunar probe (left, at top) to NASA’s Orion test article, which last year carried a coin-size microchip etched with 1.3 million names, poems, songs, and more.

JAXA

All were crammed into a mini-DVD mounted atop the desk-size lander's deck. It was made of silica glass to last at least 500 years—long enough for 26th century astronauts to find it and decode its messages from the past. "This was a gift for the future, for the humans we hope will one day live on Mars," says Jon Lomberg, the space artist and writer who directed the DVD project, known as Visions of Mars. "Finding these artifacts would be like us finding a piece of the *Mayflower*—it'll be a part of their history."

Phoenix isn't the only robotic explorer to bear messages from the Old Country. Many of the solar system missions launched in the last two decades have brought along some sort of calling card. For some, it's as basic as a list of names. Others offer greetings, works of art, or collections of small artifacts.

The Mars-orbiting MAVEN, for example, launched in 2013 to study the Martian atmosphere, carries thousands of haiku submitted by poets around the world. Kaguya, a Japanese orbiter that was intentionally crashed into the moon in 2009, bore short wishes from thousands more (astronomer Neil deGrasse Tyson wrote: "The Moon: Once a dream, Now our backyard"). And New Horizons, which skimmed past Pluto in July, carries such mementos as a small sprinkling of the ashes of Clyde Tombaugh, the Kansas farmboy-turned-astronomer who discovered Pluto in 1930, and a piece of *SpaceShipOne*, the first privately developed vehicle to reach space.

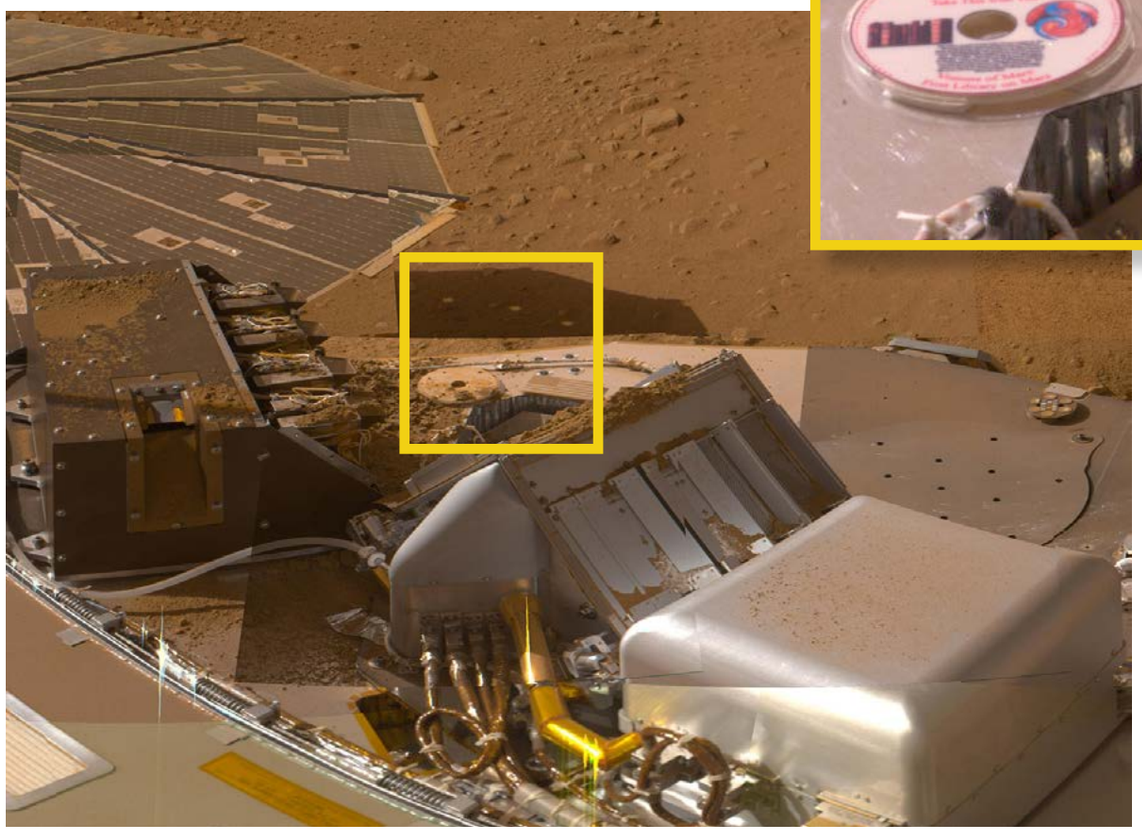
"It's a way for the public to establish a connection to these missions," says Tom Mason, outreach director for MAVEN, which entered Mars orbit last year. "In the early days, engineers at the lab would often laser-engrave their names on the spacecraft. Now the public can do the same thing—they can send something of themselves into space."

"It's a way for the public to establish a connection to these missions. Now the public can do the same thing—they can send something of themselves into space."

NASA created its first high-profile messages from home in the late 1960s and early '70s, attaching plaques to the Apollo lunar modules and to the Pioneer 10 and 11 probes, which explored Jupiter and Saturn, then swept out of the solar system. The agency upped the ante with the twin Voyagers of the late 1970s, which carried gold phonograph records with music, digitized images, and recorded greetings to any alien civilization that might happen upon the craft in the distant future.

The interplanetary message business opened to the public in a big way with the Cassini mission, launched to Saturn in 1997. The

Planetary Society, which has subsequently partnered with mission teams on many of these message projects, organized a "Send your name to Saturn" campaign that asked would-be Saturnians to submit their signatures on postcards. The names—616,400 of them—were scanned and stored on a



A mini-DVD fixed to the upper deck of the Phoenix lander left the clean room pristine (above, inset) but got a little dusty on the surface of Mars. A disk included on the Mars-orbiting MAVEN spacecraft (above, right) included student artwork and haiku.

mini-DVD, which will continue to orbit Saturn until Cassini's mission ends in 2017.

Since then, more than a dozen planetary missions have carried their own lists of names—more than 12 million in all, mainly submitted online—stored on CDs, DVDs, or microchips, or etched on wafers or ribbons of aluminum or other materials. (Many more are on Earth-orbiting spacecraft, which also have joined in the send-your-name craze.) Japan's Hayabusa mission dropped almost 900,000 names to the surface of the asteroid Itokawa; another 650,000 were vaporized when they slammed into Comet Tempel 1 as part of NASA's Deep Impact project. And about four million names are aboard *Opportunity*, the rover creeping around the Martian crater Endeavour. (*Opportunity*'s now-dead twin, *Spirit*, carries a duplicate list.)

These messages-from-home projects usually begin with either

LEFT AND INSET: NASA/JPL-CALTECH/UNIVERSITY OF ARIZONA; RIGHT: COURTESY MAVEN

the mission team or a suggestion from a designated "outreach" partner. "Each one is unique," says Bruce Betts, director of science and technology for The Planetary Society. "Sometimes the mission team wants more involvement, sometimes it doesn't. You have to propose to the principal investigators and the space agencies, and get [NASA] headquarters approval. There are lots of hoops to jump through."

"When we did the Visions of Mars DVD, we had to comply with a lot of rules," notes Lomberg, who has been at this game since he helped put together the Voyager record 40 years ago. "You don't want something that will melt or shatter or in any way interfere with the science instruments. And we tested to make sure that it would last for centuries. We even put it in a nuclear reactor to see how it would be affected by radiation."

"You don't want something that will melt or shatter or in any way interfere with the science instruments. And we tested to make sure that it would last for centuries."

If the DVD survives the rigors of the Martian environment long enough for future explorers to find it—and if they can decipher the centuries-old technology—they'll find the most extensive collection of words and pictures yet launched to another world. The disk, which evolved from a similar project for Russia's failed Mars 96 mission, includes Ray Bradbury's *Martian Chronicles*, Edgar Rice Burroughs' *A Princess of Mars*, and H.G. Wells' *War of the Worlds* plus Orson Welles' radio adaptation of the novel, as well as paintings by legendary space artists Chesley Bonestell and Bob McCall.

"It's a collection of science fiction that inspired people to build a spacecraft to go to Mars," says Lomberg. "It's not necessarily the most scientifically accurate look at Mars, but it's sci-fi that got people interested in Mars in the first place. We even included Marvin the Martian, because the first notion of Mars that a lot of people got came from those cartoons."

While the Phoenix lander may contain the most words, the New Horizons mission to Pluto and beyond carries the most stuff. Its payload of artifacts includes the usual list of names (434,738 on a CD), two American quarters (featuring Maryland, where the mission's control center is located, and Florida, where New Horizons was launched), and a 1991 postage stamp with a painting of Pluto and the caption "Not Yet Explored." One thing New Horizons does not include is a Pioneer- or Voyager-style message to the rest of the galaxy. "It was a very political activity for Voyager," says Alan Stern, the New Horizons principal investigator. "It was so complex,

Astronauts left several mementos on the moon in the 1960s and 1970s, including metal plates inscribed with the names of astronauts and world leaders. Right: New Horizons carried a container of ashes of Pluto discoverer Clyde Tombaugh three billion miles to Pluto.

and we were just trying to keep our eye on the ball, that we decided not to do it."

Lomberg still hopes to change that, even with the spacecraft three billion miles from Earth and moving away at 83,000 mph. He has proposed transmitting a Voyager-like library of images and greetings for storage in the craft's computer memory. He talked to Stern, who supported the idea, and received initial encouragement from NASA—but no money. So he assembled an advisory committee, started an online crowd-funding campaign, and started thinking about how to create a note from Earth in the Internet age. "I thought: Why not crowd-source the message," Lomberg says. "We can tell people that we want to send a picture of a family or a forest or a building, have them submit pictures, then the public can vote on them. That would be a better self-portrait of Earth."

Such a project is likely to take years to plan, and the message will take hours to reach New Horizons out in the far reaches of the solar system. By then, scientists and engineers may be planning new missions of exploration, and the public will no doubt come up with new kinds of messages to the universe, something nobody has sent before. "Never underestimate human creativity," says Lomberg.

LEFT AND INSET: NASA (2); RIGHT: JHU APL

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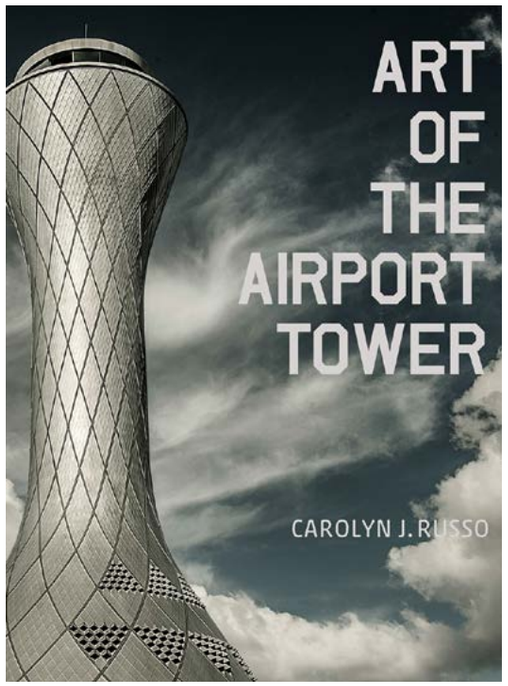
Towers

In a new book and exhibition, photographer Carolyn Russo transforms the ordinary into art.

NOT EVERYONE WOULD look at the "creamy concrete texture and circular windows" of the now-defunct LaGuardia air traffic control tower and think of Swiss cheese. Or glance at the Paris-Orly tower and be reminded of a birdie from a badminton game. Fortunately, National Air and Space Museum photographer Carolyn Russo looks at things in a different way. Since 2006 Russo has been photographing contemporary and historic air traffic control towers around the world. Her lush, compelling images have now been gathered into a new book, *Art of the Airport Tower*, and can be seen in an exhibition with the same title, which opens at the Museum on November 11, 2015, and runs through November 2016.

NEW YORK'S John F. Kennedy International Airport is one of only two airports in North America that has scheduled direct flights to all six inhabited continents. The new control tower, built in 1992, stands 321 feet high.



Tap to order

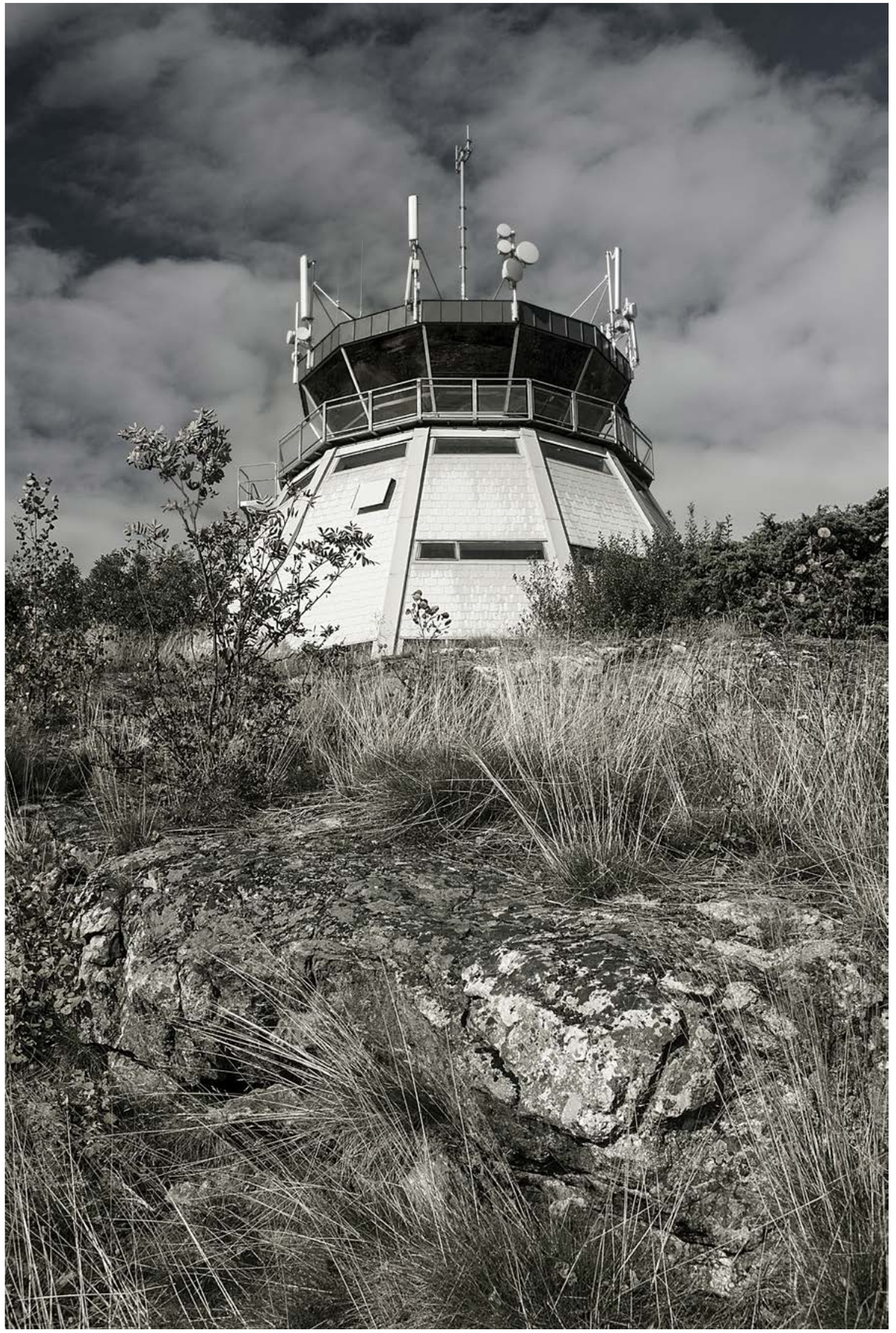
BANGKOK-SUVARNABHUMI Airport in Thailand was developed to accommodate Thailand's rapid air traffic growth. Although initially proposed in 1961, the planning process took 30 years. The site chosen for the airport was known as Nong Ngu Hao—"Cobra Swamp."

The main terminal was designed by Helmut Jahn of Murphy/Jahn Architects with structural elements that appear wave-like and float over the concourse to express the essence of the former site. The building also saves on energy by allowing natural light to flood the interior. It is the largest passenger terminal ever constructed in one phase and the fourth largest in the world.

The 433-foot control tower, built in 1995, is almost as tall as the Great Pyramid of Giza and also serves as a tourist attraction.

1

1/DUBAI'S AVIATION HISTORY began in 1937 with the establishment of a flying-boat base for Imperial Airways. In 2014 Dubai set a record for world's busiest airport. The contemporary airport tower is crowned with a multi-level control center. **2/**SWEDEN'S TORSLANDA AIRPORT opened in 1923; the last of its three towers was built in the late 1960s. In October 1977 the airport closed; the restored tower is now a café.



2

3

3/ AUSTRALIA'S SYDNEY AIRPORT tower houses all of its staff areas and bathrooms on its exterior, in pods. **4/** THE UNITED ARAB EMIRATES airport opened in 1968 on the island of Abu Dhabi. The 1982 tower design integrates the climate and local culture. **5/** BUILT IN 1929 for the Royal Air Force, Singapore's Seletar Airport served as a military base and civil airport until 1937.

4

5

6

7

6/ WITH ITS PINK TOWER, Flamingo International Airport is located on Bonaire, a Dutch Caribbean island roughly 60 miles off Venezuela. **7/** THE TOWER AT FORT WORTH ALLIANCE AIRPORT in Texas was designed by Albert Halff Associates and built in 1992. The cone hides the tower's microwave-signal relay equipment.

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SPACE NERDS

When troops need satellite info in a hurry, they contact the 117th. BY ED DARACK

Geospatial engineer Private Miranda Yost of the 117th Space Battalion works with software that helps troops and emergency response teams target locations.

CAPT. BENJAMIN GRUVER/10TH MOBILE PUBLIC AFFAIRS DEPARTMENT

FOR TWO YEARS, beginning in 2011, the U.S. Naval Criminal Investigative Service (NCIS) had been building a case against a group of Somali pirates operating in the western Indian Ocean. Just off the coast of Somalia, the group held two vessels: the *Albedo*, a 520-foot container ship they took captive in November 2010, and the *Naham 3*, a 160-foot fishing ship they commandeered in March 2012. Demanding millions in ransom, they held dozens of the ships' crew members hostage, starving, torturing, and in some cases killing them.

In May 2013, after amassing evidence against the pirates, NCIS personnel needed up-to-date satellite imagery of the

Sergeant Nathan Faith (below) checks a satellite dish gathering information to direct aircraft fighting Colorado's 2013 West Fork fire, like a Boeing Vertol 234 dumping water (right).

TECH SGT. WOLFRAM M. STUMPF/USANG (2)

ships, providing enough detail to clearly identify them and their exact positions. But the imagery had to be taken from unclassified systems so that during a future criminal trial, prosecutors could show the photographs to those without security clearances.

Unable to task the top-secret satellites of the U.S. National Reconnaissance Office, NCIS personnel contacted a seven-person team of specialists who provided the investigators exactly what they needed. Given a roughly-60-square-mile area of the Indian Ocean where NCIS believed the pirates may have anchored the ships, the team requested imagery from the WorldView-1 commercial satellite, operated by Colorado-based DigitalGlobe. "We were lucky to get several clear images free from fog, clouds, and weather, and started looking for anything that could possibly be the target," explains team member John Colin. With a resolution of 0.5 meter (at just under 20 inches, the highest the U.S. government allowed at the time for commercial imagery), Colin and Amanda Gibson, another team member, scanned the recent black-and-white images. Three faint white pixels caught Gibson's eye, and she zoomed in on them. "We found the boat!" Gibson said. The images revealed not only the *Albedo* but also the *Naham 3*, tethered with a mooring line to the larger container ship. The team passed the digital image files and geographic information to NCIS. "It took us just three hours!" says Colin of the satellite-based search.

Stationed at Naval Support Activity Bahrain, a U.S. Navy base in Manama, Bahrain, from May 2013 to January 2014, the team wasn't part of the U.S. government's intelligence agencies, nor any special operations group. Colin, a lieutenant, and Gibson, a sergeant, were members of a one-of-a-kind unit in the U.S. military: the 117th Space Battalion of the Colorado Army National Guard.

Unlike an Air Force squadron, a Marine Corps battalion, or an Army regiment, the 117th exists not for a single combat role or group of related roles but to provide the various capabilities of space-based assets—from communication to imaging. Lieutenant Colonel Martin Bortolutti, who was the 117th's commanding officer when the operation to locate the pirates took place, explains that "Army space capability" includes space-based assets not necessarily owned by the U.S. Army. "We can use those of other parties and agencies," he says, including imagery from commercial satellites, like DigitalGlobe's WorldView-1. Each of the team has a specific job, from geospatial engineer to computer network specialist.

During their 2013-2014 tour, the 117th's Commercial Imagery Team, designated CIT 4, stayed busy. "Our mission was to support all of United States Central Command [a military operations area spanning 4.6 million square miles and comprising 20 nations, including nearly all of the Middle East] with commercial satellite imagery," says Major Ben Howe, CIT 4's team leader for that deployment. "A big advantage of commercial imagery is that it is unclassified and sharable with other government agencies, civilians, and host nations." He notes that for most missions, half-meter resolution, although far bested by top-secret surveillance and reconnaissance satellites operated by the United States, is almost always sufficient.

Another mission had CIT 4 looking at every oil platform in

A member of the 117th wears a Space Operations badge (below an Army Aviation badge), which is awarded to those who have served 24 months in a space billet.

the Persian Gulf to determine which, if any, were operating illegally, a request made by the six-nation Gulf Cooperation Council. The team first undertook a broad search, one that wouldn't be suitable for the WorldView-1 satellite. "That's like looking through a soda straw toward the ground and water; it would take an untenable number of images to cover the entire gulf," says Howe. For the initial survey, CIT 4 worked with the National Geospatial-Intelligence Agency, which, among other tasks, procures commercial, unclassified imagery for the U.S. military. Through the NGA, the team tasked a commercial synthetic aperture radar satellite to scan the Persian Gulf, the first time the whole body of water was scanned. Once they'd mapped the oil platforms, the team employed the WorldView-1 to view each one up close.

The scan showed something the team hadn't been looking for: that the Iranian government had extended a runway for its military aircraft and had constructed a number of bunkers on the island of Abu Musa, which sits at a critical point along the Strait of Hormuz. The 117th's work also proved critical for the construction of a clean water project in Yemen; the imagery they provided helped locate potential wells. The unit created an up-to-date series of detailed maps of the Somali coast for the French navy, and after a bombing, quickly provided time-critical imagery of the area surrounding the U.S. Embassy at Bani Jamra, Bahrain.

Although commercially sourced, some of CIT 4's products are used for classified purposes. Howe recalled the work CIT 4 performed for the Nelson Mandela funeral procession in December 2013: "I was talking with an extremely high-level Army staff member who was not going to be using the imagery directly. He was going to be giving it to someone else. And I didn't ask or even speculate just who that was. That's not my job."

I wondered out loud if the high visibility of the funeral made the procession a tempting target for terrorists, and hence created an international interest in placing counterterrorism units, such as those of the U.S. Army Special Forces or Navy SEALs, along the route.

Howe stared blankly and waited for a question he could answer.

ED DARACK

In addition to the CITs, the 117th deploys teams that typically work with secret and top-secret space-based assets to support deployed U.S. military units. Called Army Space Support Teams, these groups assist troops in a number of ways. They provide accurate, highly detailed, laminated folding maps for field use. They monitor the military's global positioning system to advise on its reliability. Sergeant Jules Tallant, a geospatial engineer in the 117th who deployed to Afghanistan in 2012-2013, explains that GPS satellites' geometry is constantly changing, so the efficacy of the system for any location constantly changes. "We know where all the satellites will be at any time, so we can give a 24- or 48-hour model," she says. "Operations planners can know that if the GPS isn't going to be so great, maybe they don't want to drop JDAMs [GPS-guided bombs]."

Tallant's team also provided the Marines with a continuously operating system warning of a threat many might find surprising: incoming ballistic missiles. Nations such as China, Russia, and North Korea may not have all their missiles aimed at the United States; they may have at least some aimed where U.S. forces are massed, like the Marines in Afghanistan.

Because the Marine Corps does not possess its own dedicated space units, the 117th has been supporting Marines in Afghanistan and Iraq continuously over the past 10 years. "We're one of the most frequently deployed National Guard units in the context of organized units for a full-tour, boots-on-the-ground, combat theater deployment," says Lieutenant Colonel Bortolutti.

In addition to directly supporting U.S. and coalition forces, the teams train others in using unclassified space assets. They've trained Afghan forces to create maps and other imagery products for security and combat operations so the nation will have these skills after Americans leave. Captain Jeff Wilson, a member of CIT 4, spent nearly 150 days traveling throughout five countries training local forces, including those of Iraq and Afghanistan, in using commercial imagery.

Radio and satellite communication is vital for effective combat operations. At Camp Bastion, in Afghanistan's Helmand Province, right.

ED DARACK

A live fire training exercise in Yuma, Arizona. Space conditions—such as solar storms—can affect the quality of radio communications.

Because the 117th is a National Guard unit, specifically a Colorado unit, its members also provide expertise for domestic operations, including disaster relief, recovery, and emergency response planning. The 117th sent teams to help with the 2013 West Fork wildfires as well as flooding within the state.

Regardless of how it's deployed, the 117th has a vantage useful to any combatant. "Space is the new high ground," says Tallant, a reference to the centuries-old axiom that to win a conflict—be it against a human or adversary or nature—a force fights best from above.

ED DARACK

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GUNFIGHTERS

On its 60th anniversary, pilots remember the Vought F-8 Crusader.

BY EILEEN BJORKMAN

Vought F-8J Crusaders based on the carrier *Oriskany* fly in formation in 1971. The F-8 was a beloved dogfighter, but its day in the sun was short.

US NAVY

"THE LAST OF THE GUNFIGHTERS" sounds like a Gary Cooper movie or a Zane Grey novel. But the top result in a Google search for that phrase is the Wikipedia page for a six-decade-old jet fighter, the Vought F-8 Crusader. Adopted by the U.S. Navy in 1957, this single-engine, 1,000-mph dogfighter downed 19 MiGs during the Vietnam War and was an accurate, deadly strafer. Yet despite its service record, speed, and recognition for excellence—it won the 1956 Collier Trophy—the Crusader has fallen into obscurity. Why?

In a word that isn't even a word: F-4.

Retired Marine Corps General Jack Dailey, the director of the National Air and Space Museum, flew the F-8 in the mid-1960s. "Everybody who flew that airplane loved it," he says. "It was a single-seater, the way fighter pilots thought a fighter was supposed to be." But upon Dailey's arrival in Vietnam, he was assigned to an RF-4. He says the Crusader missed its war: It was too late for Korea, and by the time the Vietnam conflict got going, U.S. naval aviation was already well into its transition to the twin-engine, multi-role F-4 Phantom (see "Any Mission at Mach 2," Feb./Mar. 2015).

In the Tonkin Gulf in 1965, aviation ordnancemen of VF-194 load an AIM-9 Sidewinder onto an F-8 aboard the *Ticonderoga* (above, right). The Crusader's high wings challenged all but the tallest armorers. Right: An RF-8G on the deck of the *John F. Kennedy* in 1976. The Crusader's surveillance variant served longer than its fighter sibling.

TOP: NATIONAL NAVAL AVIATION MUSEUM; BOTTOM: LORENCE R. FIZIA

John Miottel (left) with the F-8 he flew into a barricade (above) aboard the *Hancock* in June 1958, after the airplane's tailhook broke.

With a top speed of Mach 2.2, the F-4 could intercept airborne threats to the fleet faster and farther from the ships than the Crusader could, and it had the ability to fire at an enemy head on. Also, that second engine gave the F-4 better survivability—critical for pilots flying in combat and over wide stretches of ocean.

Of course, the F-8 still had something F-4 pilots desperately wanted but didn't get for several years: guns. Four of them, firing 20mm rounds.

"There was this strange idea in the Department of Defense that the gun was passé," says military aviation historian Richard P. Hallion. "And the gun has never been passé." Compared to the missiles of today, he says, the air-to-air missiles arming F-4s and F-8s during Vietnam were primitive and unreliable.

Peter Mersky, the author of *F-8 Crusader Units of the Vietnam War*, says that even though only two of the Crusader's 19 MiG kills in Vietnam were made solely with guns, the F-8's cannon were more than just a confidence booster for pilots. "The two official F-8 gun kills have since been augmented by other unofficially credited kills that used a combination of 20mm fire and a well-placed Sidewinder hit," Mersky says.

The single-engine, single-seat F-8—originally the F8U-1 under the old Navy numbering system—was one of several aircraft born of the lessons of Korea, according to Hallion.

Former Senator John Glenn flew the F-8 as a U.S. Marine Corps major and test pilot at the naval air base at Patuxent River, Maryland, in the mid-1950s, and was an immediate fan. "I'd like to think what I could have done had I had it in

COURTESY W. JOHN MIOTTEL (2)

Above: A Crusader intercepts a Tu-95 Bear over the *Oriskany* in the western Pacific, 1974. Rear Admiral Bob Shumaker (right) deployed to Vietnam in an F-8 squadron aboard the *Coral Sea*. After his F-8 was shot down over Chanh Hoa in 1965, he spent eight years as a POW.

Korea when we were flying against the MiGs, compared to the F-86s," he says. "With four 20mm cannons, it would have been better armed than the MiG. In dogfights I don't know that it would have been much better in ability to turn, but it would have been better at controlling the battle because it could go higher and faster."

The higher, faster F-8 was the Navy's answer to the Air Force's supersonic air superiority stud, the F-100 Super Sabre. You could almost hear Vought lead engineer Russell Clark and the rest of the design team say "Oh yeah?" on March 25, 1955, when test pilot John Konrad took the prototype, XF8-U, supersonic on its first flight. The following year, Navy test pilot R.W. "Duke" Windsor took the Crusader to 1,015 mph, a national speed record and an achievement that took the postwar Thompson Trophy away from the F-100.

Glenn, who was in charge of F-8 armament testing, recalls early problems with the cannons mounted on the side of the

LEFT: US NAVY/LT. FESSENDEN; RIGHT: NASM (WEB 11784-2011)

engine duct at the front of the aircraft. "When we fired the gun on the ground at a target it did okay, but when we did a two-second burst-fire with all four guns, the duct would flex and you had a big circular random pattern." Vought beefed up the duct for later aircraft, but the initial solution was to send a cross-eyed airplane to the fleet. Glenn says, "To make up for that flexing we [made it] so when you looked down the boresight on the ground it was cross-eyed to the other side. We [adjusted the boresight by taking] the average of how far they were off-target when we did the two-second burst-fire."

In 1957, Glenn famously completed Project Bullet, briefly stealing the transcontinental speed record back from the Air Force by flying an F-8 nonstop coast to coast in afterburner the entire trip, except during the three aerial refuelings required.

Slowing the first fighter capable of flying faster than 1,000 mph to a safe speed for landing on a carrier deck required ingenuity, and the solution to that problem is one of the reasons that the National Aeronautic Association awarded the Collier Trophy to Vought and the Navy in 1956. Vought's team designed a "variable-incidence wing": Hinged at the rear, it adjusted its angle relative to the fuselage. The ability to increase the wing's angle of attack while keeping the fuselage level gave the pilot good visibility for takeoff and landing, and the increased lift needed for the slower speeds those regimes demanded. Even with the braking effect of this design innovation, the Crusader landed fast, and putting it down safely on the deck of a carrier required great skill.

Fleet pilots couldn't wait to fly the F-8, although their initial experiences ranged from sheer exhilaration to sheer terror. Don "Frazz" Fraser, a Marine pilot who

TAP TO SEE 360° VIEW

Explore the cockpit of this restored XF8U-1, at Seattle's Museum of Flight.

For other 360-degree cockpit views, visit *airspacemag.com/panoramas*

LYLE JANSMA

Before his famous cross-country flight, future Apollo astronaut John Glenn and a fellow F-8 pilot take turns getting fuel from an AJ-2 Savage tanker.

US NAVY

started flying the F-8 in 1959, remembers his first flight: "There were no simulators in those days. You strapped it on and hoped you had it all right. I was just so excited to fly an afterburner aircraft, hitting the burner and getting airborne like a jackrabbit. You had to be very careful... you had to roll in trim to keep the nose down. If you didn't do that and bring your wing down before accelerating, you could shed your wing right off."

But if takeoffs were exciting, landings were another thing altogether. The Crusader quickly gained a reputation as an "ensign killer." Pilot Joe Phaneuf recalls the tension raised by the F-8's high landing speed: "The [aircraft carrier] always had to make maximum knots to get the most wind across the deck to make the relative landing speed slower than the actual aircraft speed. The old carriers burned coal, and the blackest, stinkiest smoke would settle right behind the ship so you couldn't see." Flying toward the flight deck and listening to the landing signal officer say "Keep it coming" was an exercise in trust.

In 1957 John "Crash" Miottel transitioned from the FJ-2 Fury (a beefed-up, carrier-capable version of the Air Force F-86) to flying the F-8 off *Hancock*. He says the early aircraft had lightweight landing gear that broke a lot. To make matters worse, "the port strut served as a reservoir for hydraulic fluid, so if you lost the landing gear and got airborne again, you had to go to the backup ram air turbine [to keep your flight controls working]. Trying to land with a broken landing gear was not really desirable."

Miottel had a tailhook malfunction during landing, flying his disabled F-8 into a barricade erected on the flight deck. He describes the barricade as a "heavy-duty 20-foot-high tennis net" and the aircraft as a "multi-ton tennis ball on a 150-mph bad serve." Everything went fine until the barricade tore off his left landing gear; the aircraft pivoted on its left wingtip and headed off the port side of the carrier. Miottel managed to jettison his canopy and yank a handle that released him from the ejection seat as he plunged into the water, and he jokes,

Why did this RF-8G rocket skyward in a vertical climb? Because—with the 18,000-pound-thrust (with afterburner) Pratt & Whitney J57 turbojet—it could.

"The old aviators' maxim that 'Any landing you can walk away from is a good landing' was amended to incorporate the words 'or swim.' "

Rear Admiral Bob Shumaker (ret.) also had an adventure involving a recalcitrant tailhook and a night landing during a Mediterranean cruise on the *Saratoga* in 1960. After making three landing attempts with a tailhook that wouldn't come down, he says, "they told me to head to Italy, but I didn't have enough fuel so they said to join the tanker. I found the tanker and my heart was beating a little faster by then and the tanker said, 'I'm flipping every switch in here but I can't get the hose to come out.' That was strike number two."

For strike number three, *Saratoga*'s flight deck barricade wouldn't deploy. Shumaker was running out of options: "I was down to 200 pounds of fuel. I climbed to 3,000 feet and punched out and strike number four was the parachute didn't

US NAVY/MARK ALDRICH

open.... I pulled the D-ring to manually deploy the chute and nothing happened, but pulled harder and it finally opened." A nearby destroyer picked him up and ingloriously returned him to the carrier.

F-8 operations could be scary for the ground crew as well. John Borry, a plane captain and jet mechanic with VF-13 aboard *Shangri La*, didn't like crawling down the engine intake. "That's a good 20 feet long on the inside," he says. "Sometimes someone would stand behind the airplane and start whistling through the tailpipe like the engine was starting and you'd scramble out of there real quick!"

The F-8's giant air intake earned it another nickname: Gator. "That intake is down so low you couldn't walk anywhere near the front of the airplane," says Borry. "One day another guy got too close and it started to suck him in, but I grabbed his ankles and signaled the pilot to shut the engine down."

Still, mechanics loved the F-8. Jay Powelson remembers his favorite job was engine runs: "Nothing can compare to an F-8 afterburner shot because it just jars the whole airplane and you hope the chain is going to hold." The afterburner on the F-8 was an all-or-nothing affair, unlike the staged afterburners on newer aircraft. When F-8s arrived on the *Constellation* to the care of plane captains and mechanics who had worked only around F-4s, says Powelson, "Four or five guys hit the deck when the F-8 lit the afterburner. They thought something had blown up."

Louis Zezoff, a maintainer on the *Coral Sea* in 1961-1962, remembers watching the aircraft maneuver: "There wasn't a lot of rules and regulations back then.... The pilots taught themselves. The pilots couldn't wait to get in the seat and fly off the carrier. They called it the sports car of the Navy."

But even great fighters can be pushed too far, as Shumaker learned on his sixth flight in the F-8: "We were over Gainesville, Florida. There were a lot of clouds and we got up to 55,000 feet. As we started to turn around, we were slow, and the airplane spun on me and I went into the clouds. I got out of it after I think 14 rotations and I lost about 25,000 feet so it was pretty exciting."

Intercepting targets in the F-8 involved art, not just finding a blob on a radar. According to Shumaker, the F-8 radar could see a target at only about eight miles. "A controller on the ship would call out the direction and distance of a bogey and we would manually figure out how to intercept. It took a lot of technique. Our weapons were forward firing, you had to get in the rear hemisphere of the target to launch."

By the early 1960s, most of the bugs in the F-8 had been worked out and the fighter was ready for war. (Two unarmed reconnaissance variants, the RF-8A and RF-8G, saw action beginning with the Cuban Missile Crisis in 1962 and throughout the Vietnam War.) The E model could carry 4,000 pounds of external weapons such as bombs, so it served as an air-to-ground attack platform as well as a fighter.

Not everyone was enamored of bombs on a high-wing aircraft. Jem Golden, an ordnance man on the *Shangri La* in the late 1960s, says, "We only had two guys in the shop who were tall; the rest of us were five-eight, five-nine, standing on tiptoes trying to get these 500- or 750-pound bombs up there. The other

An F-4 Phantom and an RF-8A fly over the *Franklin D. Roosevelt* in 1973. Above right: Friendly rivalries among F-8 jocks and F-4 crews inspired this patch.

squadron would come over and help, and there'd be 10 guys trying to get one bomb loaded. We were cussing the whole time at the guy in the Pentagon that thought this one up."

The F-8 saw early action in Vietnam, including the February 1965 Flaming Dart operation, two strikes to retaliate against the Viet Cong for attacks on air bases and a hotel that housed Americans. Shumaker, flying off the *Coral Sea*, got the call for his first combat sortie: attack barracks at Chanh Hoa, just north of the demilitarized zone. "I rolled in on the target," he recalls; "I was flying low because of the weather and they nailed me in the tail section and the plane flipped upside down and nose down and I got out and the parachute opened about 35 feet above the ground." He was captured and spent eight years as a POW. He never flew the F-8 again.

Phaneuf flew 208 combat missions off both the *Ticonderoga* and the *Oriskany*. He says the diciest missions he flew were Iron Hand—escorting attacks on surface-to-air-missile sites. "[We'd] fly wing for an A-4 attack pilot who was armed with anti-radiation missiles. I was armed with anti-personnel rockets as well as Sidewinders. [We'd] fly off the ship [and] drop down low on top of the water to avoid the enemy radars until feet dry [over land] and zoom climb to 18 or 20 thousand feet. [Then our] anti-radar warning gear started chirping. An A-4 would lock his missile onto the radar site and launch. I would hit the afterburner and follow the missile as it looked at the SAM site. The missile would take out the radar van and then my job was to shoot my rockets so

LEFT: NATIONAL MUSEUM OF NAVAL AVIATION; RIGHT: US NAVY/CAPT. WILLIAM B. ECKER COLLECTION

it saturated the whole missile site to put it out of commission." But "our squadron was always first on the target," he says. "The first group in absorbed the flak and the SAMs and we never saw a MiG. The second group bagged quite a few."

Commander Hal Marr, flying off the *Hancock*, got the first F-8 kill, knocking down a MiG-17 with a Sidewinder on June 12, 1966. Nine days later, Lieutenant (JG) Phil Vampatella hit a MiG-17 with a Sidewinder and Lieutenant Eugene Chancy got the first MiG kill with a gun. All three pilots were in fighter squadron VF-211.

Marr described his MiG engagement in Mersky's *F-8 Crusader Units of the Vietnam War.* Flying with Vampatella on his wing, "We pull hard into them and the fight's on," he recalls. "Two MiGs split off, and we pass the other head on." After missing twice with his cannon, he was 1,000 feet above the MiG when he tried firing a Sidewinder, "but the missile can't hack it and falls to the ground. The MiG has been in 'burner for four or five minutes now and is mighty low on fuel, so he rolls and heads straight for his base. I roll in behind, stuff it in 'burner, and close at

The F-8's big air intake earned it the nickname Gator. The inscription on this RF-8A refers to the recon missions it flew during the Cuban Missile Crisis.

500 knots. At a half-mile, I fire my last 'Winder, and it chops off his tail and starboard wing."

Marr's kill was a typical F-8 engagement: The aircraft was a true dogfighter from the rear. Again, the F-8 had to be within visual range to engage, unlike the newer F-4, which could engage the enemy from longer ranges with its radar-beam-following Sparrow missiles. In addition, the F-4 required two crew members. Mersky says that Vought marketers dreamed up "Last of the Gunfighters" when they learned of the F-4's lack of internal gun and its two-crew concept, and fleet pilots quickly picked up the name and developed a friendly rivalry with their F-4 counterparts.

Although both Air Force and Navy F-4s were eventually equipped with guns, the nickname stuck. By the end of Vietnam, F-8 pilots claimed the highest kill ratio of any aircraft of the war: 19 MiGs downed to only three F-8 losses.

Of course, those statistics also reflected the relatively low numbers of F-8s in the fight. "F-8 pilots, although ready and able, did not see as many MiGs throughout the war as their F-4 compatriots," Mersky says. "There were many more Phantom squadrons than Crusader squadrons in action in Vietnam. Certainly by 1971, there were only three Crusader squadrons."

But the F-8 had a record outside of Vietnam as well. John Borry recalls slinging unusual ordnance one day in the Mediterranean in 1967: "The Russians

US NAVY/CAPT. WILLIAM B. ECKER COLLECTION

had a trawler dogging us all the time, especially when we were launching aircraft, to try to mess us up. The skipper got angry one day and told us to get 13 rolls of toilet paper. He lowered the speed brake, which is underneath the belly of the airplane, and it held the toilet paper [in holes in the metal]. He flew over the trawler and opened the speed brake and 13 rolls of toilet paper came streaming down. They had antenna arrays everywhere and it looked like someone's house at Halloween, but they loved it! They were waving and hollering at us because they didn't have toilet paper on their boat."

In the literal sense, the "Last Gunfighter" nickname was a misnomer. The F-4 was modified to carry guns, and subsequent U.S. fighters all have internal guns. But those aircraft also have multiple weapons that can kill an enemy the air crew never see, except on a radar scope. The F-8 was something else.

As Zezoff says, "you had to be well within sight [of the target] and it was you against that other pilot and it was like you were standing on the streets of Dodge, eye to eye."

Powelson is more blunt: "F-8s were designed for dogfighting. The F-4 wasn't."

In his book *MiG Master: The Story of the F-8 Crusader,* historian Barrett Tillman elaborates: "Of the American aircraft which flew regularly over the north from 1965 on, only the F-8 could be called a true air-superiority fighter.... Interceptors and fighter-bombers can each successfully perform the [dogfighting] role, but not as well as an aircraft dedicated solely to that mission. This was the difference between the F-8 and every other American aircraft that operated over North Vietnam."

PETER MERSKY

Members of VFP-206, the last Crusader squadron, restore the XF8U for the squadron's 1987 decommissioning ceremony.

The first and the last: At Andrews Air Force Base the XF8U-1 prototype shares the tarmac with the last Crusader operated by the U.S. Navy (at left).

Tillman concludes, "Crusader pilots were *fighter* jocks, by God, with no ifs, ands or hyphens."

Today, the Crusader lives on in museums and websites devoted to its legacy. Craig Wall, a retired Air Force mechanic, is restoring the prototype, XF8U-1, in which John Konrad made the first flight 60 years ago. The aircraft came from the Smithsonian in the mid-1990s and sat outside at the Museum of Flight in Seattle for a number of years, picking up corrosion. Wall has worked on the airplane since 2001, and it is now painted exactly as it was during the first flight.

But the sun set relatively quickly on the F-8. With two engines, the F-4 paved the way for air superiority aircraft like the F-15, the F/A-18, and the F-22.

Meanwhile, rapid advances in ship design—longer, angled decks and steam catapults that could launch heavier aircraft than hydraulic cats could—made it possible for supercarriers like the *Forrestal*, commissioned in 1955, to carry squadrons of F-4s, faster and more powerful, if less agile, than the gunfighting Crusaders. Ultimately, the F-8's tenure as an American war-fighting aircraft was only about half as long as the career of the F-4, which served through the first Gulf War and wasn't retired until 1996.

Had it not been succeeded by a more adaptable and longer-lived aircraft, the F-8 would likely be a lot more famous today. But its legacy is haunted—by a Phantom.

LEE ALEXANDER

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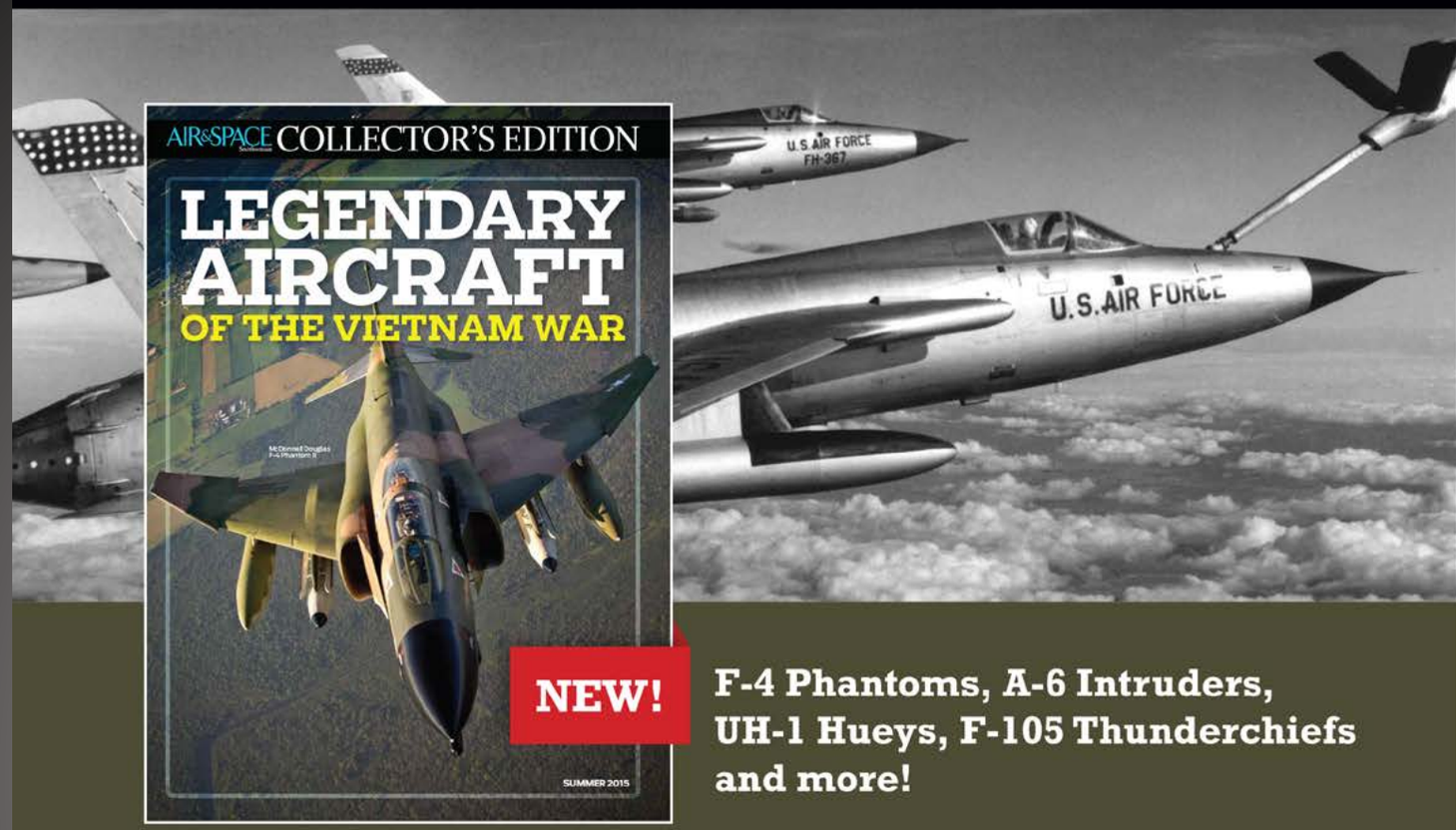
AIR&SPACE Smithsonian COLLECTOR'S EDITION



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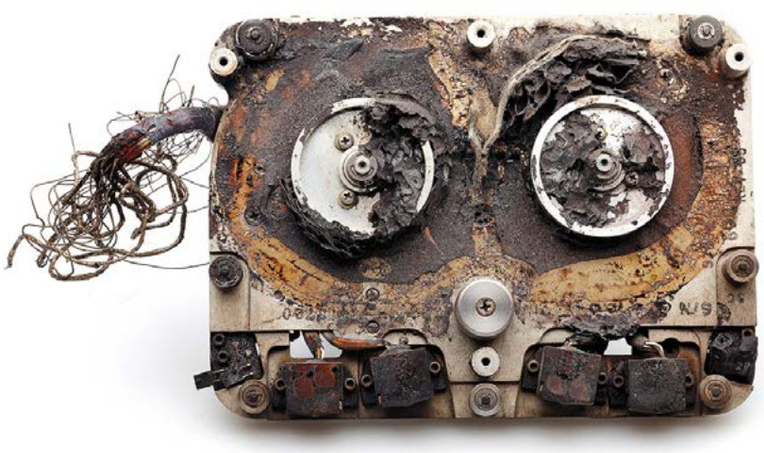
Sightings

PICTURES WORTH A SECOND LOOK



AFTER A TRIAL BY FIRE, or sudden impact, or submersion, a black box is sometimes the only thing that can explain what caused an aircraft to fall from the sky. Usually the device is made of two instruments: the flight data recorder, which logs the pilots' actions and aircraft systems status, and the cockpit voice recorder.

Photographer Jeffrey Milstein, a pilot himself, was at the Transportation Safety Board of Canada in Gatineau, Quebec, to take pictures of a helicopter's black box when he was led into a room with shelves filled with recorders recovered from other crashes. "Many were really old and used wire or foil to record," says Milstein, who was fascinated by them both visually and "emotionally as records of tragedies." He asked to photograph the entire collection.

Milstein then contacted the National Transportation Safety Board in the United States to see more, but the agency denied him access, so he tried Australia, whose Transport Safety Bureau allowed him to photograph the recorders stored there. These photos are of the Canadian and Australian black boxes. Milstein previously published a book of stunning airliner portraits titled *Aircraft: The Jet as Art* in 2007.

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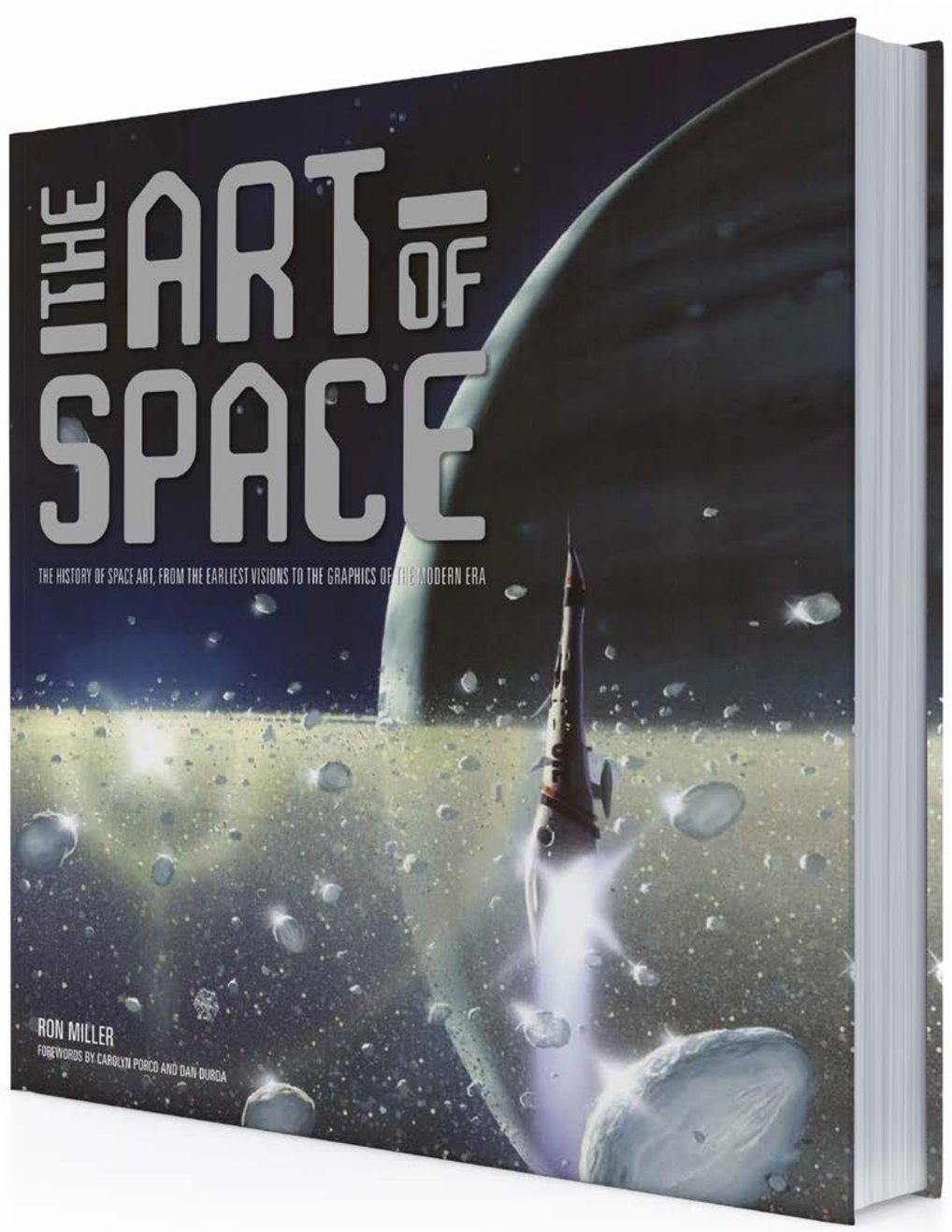
ASTRONOMICAL BEAUTY



The Art of Space

by Ron Miller. Zenith Press, 2014. 224 pp., $35.

THE BOOK A highly browsable history of space art, featuring 350 images from 26 artists who offer their visions of the solar system, the universe, space colonies, and alien life.

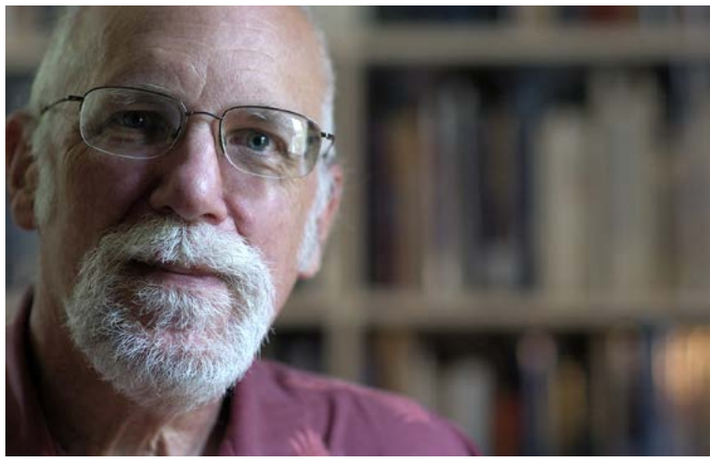
WHY THE AUTHOR DECIDED TO WRITE IT "It was kind of a spinoff of wanting to do a new book about classic space artist Chesley Bonestell. In talking this over with the publisher, the book gradually evolved into an overview of space art generally, especially as it's practiced by artists around the world today."

A CHAT WITH RON MILLER

What artists were you influenced by?
In space art, Chesley Bonestell, of course. I'd been fascinated by his art since I was in grade school. Later, other great space artists inspired me, such as Ludek Pesek.

What is your favorite genre of space art?
There are two basic kinds: the "Rock and Ball" and "Swirly" schools. The former creates art like Bonestell's: realistic landscapes with strange planets and moons in the sky. The latter approaches the art from more impressionistic or abstract directions. I'd say I'm firmly in the Rock and Ball camp.

Was space art more alluring when it was based on the artists' imaginations?
Even with the vast knowledge we now have of other worlds, space artists can still take viewers places satellites, probes, and landers have never been. For instance, I've recently taken some of the Pluto flyby images and interpreted what I thought it would look like to stand on the surface of the planet and see the same features from the viewpoint of a future tourist. That requires a mixture of knowledge and imagination.



Ron Miller is an *Air & Space* contributing editor.

Any advice for someone who would like to earn a living as a space artist?
I think a solid grounding in art is essential. You need to be a good artist before you can be a good space artist. And you should learn as much about astronomy as you can.

DIANE TEDESCHI IS AN ASSOCIATE EDITOR AT *AIR & SPACE/SMITHSONIAN.*

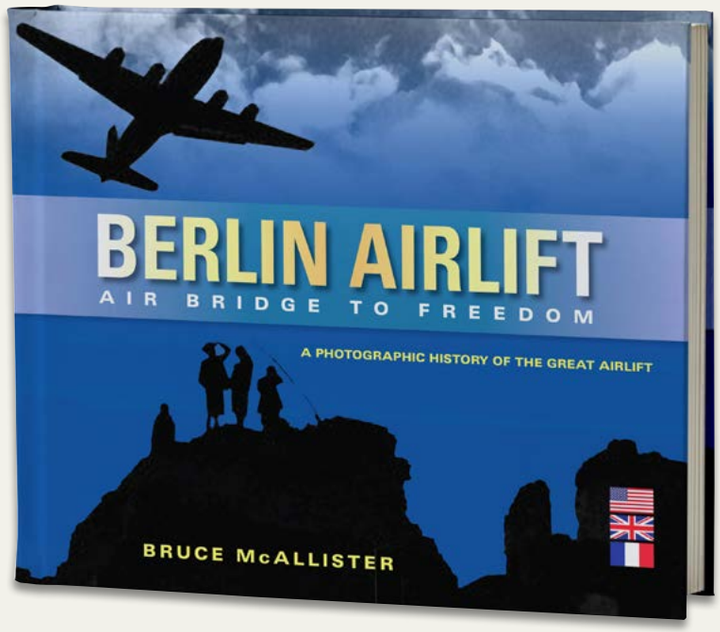
Read the entire interview at
airspacemag.com/miller

LEE SANDSTEAD

Berlin Airlift: Air Bridge to Freedom

by Bruce McAllister. Roundup Press, 2015. 216 pp., $49.95.

THE AUTHOR HAS ASSEMBLED a photographic history of the famed air supply mission that enabled the survival of West Berlin during a Soviet-imposed blockade that began in June 1948. We see not just the cargo aircraft involved but the people who helped carry out the mission: two men loading bottles of milk; Lieutenant Gail S. Halvorsen, known as the "Candy Bomber" for his deliveries of gum and chocolate; air traffic controllers wrangling rows of Douglas C-54 transports. More than 250 archival photographs document the destitution of West Berlin, and the military triumph that saved the city.



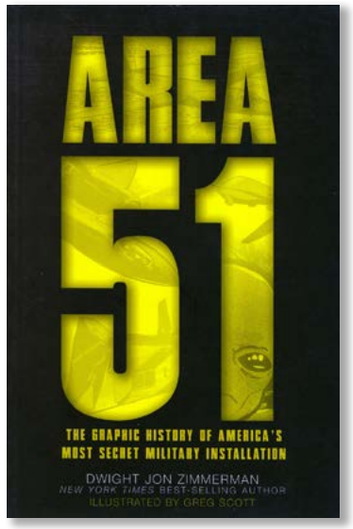
German children playing with U.S. Air Force transport models. (COURTESY BRUCE MCALLISTER)

A pilot tosses candy to children after landing at Tempelhof Airfield. (NARA)

U.S. Navy airlift pilots checking their course before flying into West Berlin. (NARA)

Area 51: The Graphic History of America's Most Secret Military Installation

by Dwight Jon Zimmerman. Illustrated by Greg Scott. Zenith Press, 2014. 91 pp., $19.99.



AREA 51 IS NOT A MYTH. Named after a section on an old government map, it's in the middle of Nevada and includes the dry Groom Lake bed, several runways, and dozens of buildings. It is where the U.S. government performs highly classified aviation research. And it has been the subject of speculation and conspiracy theories for decades. Look it up on Google.

Dwight Zimmerman and artist Greg Scott have now produced *Area 51: The Graphic History of America's Most Secret Military Installation*. It's sort of an odd topic for a graphic treatment. But *Area 51* is clearly intended as an introductory book aimed at a young adult audience. It addresses the topic seriously, recounting Groom's history, from its origins in the 1950s as the testing site for the CIA's U-2 spyplane through the development of the F-117 stealth fighter in the 1980s and up to today. Notably, it also addresses a bunch of lesser-known (and smaller) projects such as stealthy cruise missiles. At times the books seems too packed full of stuff for its audience. And not everything in the book was developed at Area 51.

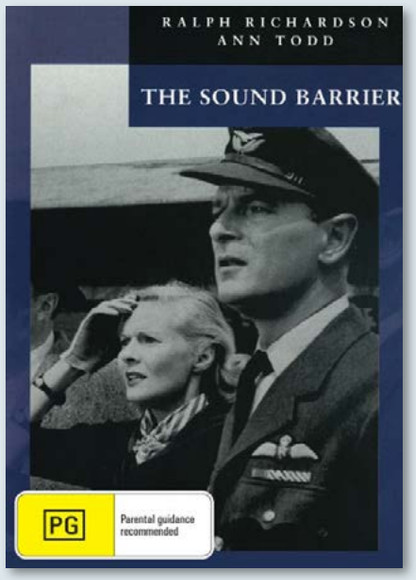
For years, people have claimed that aliens and their spaceships were examined at Groom. Anyone expecting a deep exploration of such sensational tales will be disappointed: Zimmerman and Scott dismiss the rumors as hokum. The artwork follows a realist style and is surprisingly accurate. Considering that several major aerospace contractors are currently conducting top-secret work on the next strategic bomber, maybe in a few years the authors can update this book with a few more secret aircraft.

FREQUENT CONTRIBUTOR DWAYNE DAY IS A SENIOR PROGRAM OFFICER AT THE NATIONAL ACADEMIES OF SCIENCE, ENGINEERING, AND MEDICINE.

The Sound Barrier

London Film Productions, 1952. DVD, 118 minutes, black & white. Rated PG, $17.

TODAY, SURPASSING MACH 1 is an everyday event for those flying high-performance jet- and rocket-powered aircraft. But back in the early 1950s, the sound barrier was dark and mysterious. Just the kind of thing to warrant a feature film.



Directed by two-time academy award winner David Lean, *The Sound Barrier* (also released as *Breaking the Sound Barrier*) is the fictionalized account of a British aviation industrialist, John Ridgefield (played by Ralph Richardson), who seems willing to offer up to the gods of Mach 1 anyone within reach in his quest to surmount said barrier. Problem is, those within reach include his aeronautically ungifted son and son-in-law, both of whom die in the line of duty before Ridgefield finds a test pilot with mad engineering skills to take the Prometheus (portrayed by a Supermarine Swift) past the treacherous barrier.

While the film is a product of its age (including some cringe-worthy exposition and even more cringe-worthy piloting advice), it is fun for fans of aviation celluloid. *The Sound Barrier* has nice footage displaying some of the most notable airframes from the flagging days of the British Empire: the de Havilland Vampire and the Vickers-Supermarine Attacker. Even the de Havilland Comet airliner—square windows and all—makes an appearance.

When his pilots go up, Lean takes us along for the ride, with cutting-edge (for its day) point-of-view photography. To evoke the power and majesty of a low-level flyby, Lean doesn't show us the airplane. But we hear the roar of a jet engine and see a field of wheat recoiling from the blast. And a run-of-the-mill Vampire delivery to Cairo demonstrates the power and poetry of the beginning of the Jet Age.

D.C. AGLE IS A FREQUENT *AIR & SPACE* CONTRIBUTOR WHO IS BASED IN SOUTHERN CALIFORNIA.

Contributors

World of Waterfowl. Bill Sweetman, senior international defense editor for *Aviation Week & Space Technology,* has written on almost every aspect of aerospace and military technology.

Solar System Chatter. Heather Goss is *Air & Space/Smithsonian*'s departments editor.

Blackbird Down. Jody Liliedahl, a well-traveled writer and photographer, lives in Monterey, California.

Paper, Scissors, Rocket. Les Dorr Jr. is a spokesperson for the Federal Aviation Administration in Washington, D.C.

The Next X-Plane. Richard Whittle is author of *The Dream Machine: The Untold History of the Notorious V-22 Osprey* and *Predator: The Secret Origins of the Drone Revolution*.

Airplanes Seeking Good Home. Paul Glenshaw is a frequent *Air & Space* contributor. Dane Penland is a photographer at the National Air and Space Museum.

A Truly World-Wide Web. Mark Anderson is a journalist and technology copywriter based in Northampton, Massachusetts. His website is *markawriter.com.*

Meet the Howards. Mark Huber has written about eccentric aircraft and their fascinating owners for *Air & Space* since 2000. Jim Koepnick's photographs have appeared in *Time*, *Life*, and other national magazines.

"Hi! I'm from Earth!" Damond Benningfield is a freelance science writer and audio producer in Austin, Texas.

Space Nerds. Ed Darack's forthcoming book, *Highest Valor* (Smithsonian Books, 2017), covers the downing of Extortion 17, the deadliest helicopter crash in the history of U.S. special operations. The book grew out of his article in the Feb./Mar. 2015 issue.

Gunfighters. Eileen Bjorkman, a retired U.S. Air Force flight test engineer, is working on a book about the history of homebuilt aircraft.

Forecast

IN FUTURE ISSUES

Turn on the Juice!

When NASA engineers replace two gas-guzzling engines with 16 small electric ones, they may change airplane design forever.

Coming soon to a sky near you: NASA will fly a radically altered Tecnam P2006T.

Space Fence

With space debris such a problem, how to see a three-inch object over a thousand miles away becomes very important.

At the U.S. joint space operations center in California, controllers track space junk.

The Eagle Hasn't Landed

The F-15 Eagle has flown in every major U.S. conflict since the Vietnam War, and is set to do so for decades more.

F-15C, doing what it does best, fires an AIM-7 over the Gulf of Mexico.

The Man Who Made Apollo If you were to take Bob Gilruth out of the U.S. space program of the 1960s, there's a good chance Americans wouldn't have made it to the moon.

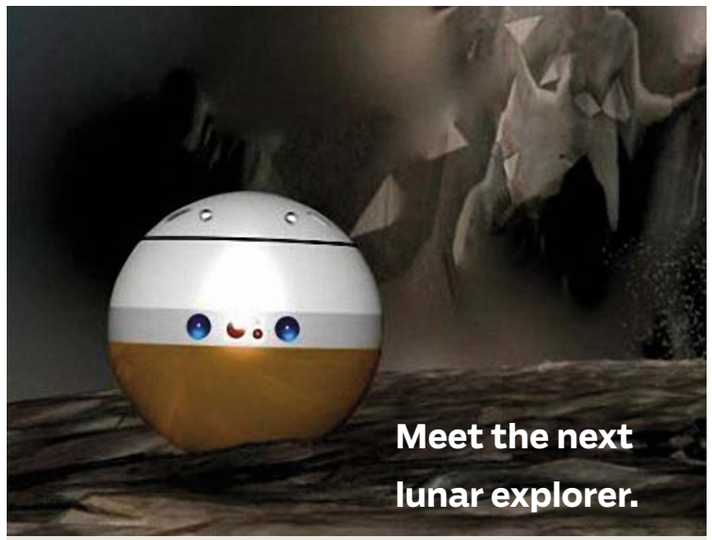
LEFT: NASA; CENTER: LOCKHEED MARTIN; RIGHT: U.S. AIR FORCE PHOTO/ MASTER SGT. MICHAEL AMMONS

Online and on the iPad

INSIDE THE XF8U-1

Slide into the cockpit of the prototype of Vought's F-8 Crusader, 1956 Collier Trophy winner and beloved Vietnam-era dogfighter. This is a 360-degree, high-res interior view of the Museum of Flight's fully restored XF8U-1, as seen on the cover of this issue. And click around; you might recognize the aircraft parked nearby.

The driver's seat of the first of the "Last Gunfighters," 60 years old and holding.



DRONES ON THE MOON

Humankind hasn't been back in over four decades, but a new proposal would use a trio of flying "pit-bots" to explore lunar lava tubes.

AIR & SPACE 2015 PHOTO CONTEST

There's still time. You have until November 15 to enter our 2015 photo contest in any of four categories: Civilian, People & Planes, Military, and Astronomy.

THE GHOST ARMY OF WORLD WAR II

Just after D-Day, four Army Engineer and Signal units used inflatable vehicles, fake radio transmissions, and sound effects to confuse Nazi forces. A new book by Rick Beyer and Elizabeth Sayles, featuring art-work by the men of the "ghost army," tells the tale.

Illustration from *The Ghost Army of World War II*: G.I.s lift a fake tank.

LEFT: LYLE JANSMA; CENTER: THANGAVELAUTHAM ET AL.; RIGHT: ARTHUR SHILSTONE/COURTESY PRINCETON ARCHITECTURAL PRESS

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One More Thing

FACTS ABOUT ARTIFACTS IN THE NATIONAL AIR AND SPACE MUSEUM

Pitts Special S-1C Little Stinker

The first object to greet visitors to the National Air and Space Museum's Steven F. Udvar-Hazy Center, the Pitts biplane is a welcome party of one conveying the message "Flight is fun."

Designer Curtis Pitts was renowned for his small, light, nimble aerobatic biplanes, the first of which weighed less than 500 pounds and first flew in 1945. It was wrecked only a few years later. A rare sight in the 1950s, Pitts Specials became mainstays of flying competitions in the 1960s and '70s—once Pitts was persuaded to sell construction drawings for his design, which was never mass produced, for $125 a set. His second airplane, the S-1C, completed around 1946–'47, was the world's smallest aerobatic aircraft, with a 16-foot, 10-inch wingspan. Today, it's the oldest Pitts Special that survives.

A Continental 85-horsepower engine provided more than enough oomph for this peppy show-stealer. Pitts sold the aircraft in 1948 to aerobatic star Betty Skelton, who named it *Little Stinker Too.* Earlier that year, she had flown *Little Stinker,* her 1929 Great Lakes 2TIA biplane, to victory in the International Feminine Aerobatic Championship.

One of Skelton's modifications to her new S-1C was to install a second, upside-down ball-bank indicator in the instrument panel, for use during inverted flight. In 1949 and 1950, Skelton flew the Pitts in the IFAC, capturing the title again both years.

DANE PENLAND

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Smithsonian

Editorial Offices
MRC 513, PO Box 37012,
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(202) 633-6070

e-mail: editors@si.edu

website: airspacemag.com

Circulation and advertising offices
420 Lexington Ave., Suite 2335
New York, NY 10170;
(212) 916-1300

Subscriptions:
PO Box 62170,
Tampa, FL 33662-2170
call (800) 513-3081
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