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# AIR FORCE

MAGAZINE

**USAF has too many missions  
and not enough airmen**



**SOMETHING'S  
GOTTA GIVE** p.21



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See "Growing Pains," p. 21. ANG photo by Capt. Holli Nelson.

# Develop, Borrow, Steal: The Race for Tech

WRIGHT-PATTERSON AFB, OHIO—

One of the United States' undeniable advantages lies in its recurring ability to turn science fiction into reality. American innovators have repeatedly transformed the world with both revolutionary consumer goods and unmatched government-sponsored capabilities. Much of the technology the Air Force has sponsored has underpinned national security for decades.

During the Cold War, the US turned to technology as a way to offset the Soviet Union's enormous numerical advantages. It was a strategy that paid off handsomely.

Today, the nation is reaping the benefits of many technologies USAF was present for from the beginning. Unmatched stealth

**USAF is developing the next generation of revolutionary capabilities. Can it field them first?**

aircraft like the F-22 Raptor, the now-ubiquitous Global Positioning System, ever-evolving precision weapons, and remotely piloted aircraft like the MQ-9 Reaper all owe their existence in large measure to Air Force-inspired American ingenuity.

Maj. Gen. William T. Cooley, a mechanical engineer by education and now commander of the Air Force Research Laboratory (AFRL) here, has watched USAF's science and technology successes and struggles for nearly three decades. New technologies progress too slowly and emergent capabilities frequently stall when it comes time to transition to operational use. These are "enduring problems," Cooley said in an interview.

But what happens when an enemy—whether by watching the US publicly wage its wars for the past 27 years, or by taking advantage of rapidly advancing commercial technologies, or through a surreptitious hacking campaign—is able copy, steal, or just avoid America's technological advantages? This is a growing problem.

Many enemies, large and small, have effectively "gone to school" on modern war by carefully observing US operations since 1990. Regarding commercial capabilities, Cooley notes that industrial research and development funding first surpassed government R&D in the 1990s, and the private sector now outspends the government by two-and-a-half times.

Quickly developing the next generation of game-changing capabilities and successfully transitioning them into operational use is more important than ever. It is increasingly difficult to keep the nation's technological advantages. Some recent examples:

■ Images of China's J-20 stealth fighter first surfaced in 2010, when then-Defense Secretary Robert M. Gates was visiting the communist state. Gates had previously predicted that Chinese stealth fighters would not appear until 2020.

■ Two years later, China's J-31 flew for the first time. Top Defense officials say China's J-20 and J-31 stealth fighters were greatly aided by espionage. Indeed, head-on, a J-31 is almost indistinguishable from a Lockheed Martin F-35. Why start from



China's J-31 (top) is an F-35 knockoff, and DOD admits it.

scratch if you can steal major portions of the plans?

■ In 2014, the Justice Department indicted five members of China's Peoples Liberation Army for "economic offenses directed at ... the US nuclear power, metals, and solar products industries," according to a DOJ release. This was formal acknowledgement China had military hackers targeting the US.

The bottom line is that, in addition to protecting advantages the Air Force already has, USAF must keep the pedal to the metal.

Air Force Secretary Heather Wilson has asked AFRL to "clean the whiteboard," and take a fresh look at the Air Force's entire science and technology enterprise, said Cooley. The comprehensive S&T review will run the duration of 2018.

Overall, AFRL is staffed by outstanding scientists and engineers with "a lot going very well," he said, but AFRL cannot rest on its laurels.

"Organizations can sometimes get in a rut and not necessarily pay attention to emerging things. Every so often you need to view with new eyes the state of the environment," Cooley said.

"To be agile enough to maintain our advantage, the Air Force must reach for ... game-changing technologies," stated USAF's 30-year "A Call to the Future" strategy paper in 2014. Some of the more promising technologies cited were hypersonic speed, nanotechnology (to create lighter and stronger structures), directed energy, and unmanned systems. Three years on, Cooley says AFRL is "continuing to push those [and] make them militarily useful."

It is ever harder to stay in first place technologically, but with consistent support from DOD and Congress the Air Force is well positioned to do just that. This is never a given, however. As Cooley noted, when funds are tight, programmers will inevitably raid the future to pay for current needs.

Whether it is hypersonic weapons, scalable laser weapons that almost never run out of ammo, autonomous programs that take much of the toil out of intelligence processing (or capabilities too secret to be discussed yet), the race to develop the next generation of war winning capabilities is on—and it has no finish line.



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## Joint Punishment

Your editorial on joint assignments ["Giving Joint Assignments Their Due," December, p. 2] provided a good analysis of the dilemma of serving in joint assignments. I agree that the Air Force needs to "train, educate, develop, and reward folks" for joint assignments. In my 20-year Air Force career I had three joint assignments and one joint school for a total of seven years. After a defense agency assignment as a detachment commander and a one-year defense school, I was promoted to major, one year below the zone. After completing ACSC in residence and during a follow-on U&S command tour, I was passed over twice in the primary zone to lieutenant colonel. Several senior officers advised that promotion boards may have thought I had too many joint assignments. I was lucky to have been recruited by the subordinate Air Force component command (Majcom), which got me promoted a year above the zone. Despite such a tumultuous career, I believe Air Force personnel are needed in joint commands and agencies to provide the Air Force expertise, capabilities, and points of view to enhance both accomplishing the joint organization's and the Air Force's missions. This message should be taught to all Air Force personnel from Day 1 and reinforced by all selection and promotion boards. Joint assignments should not be detrimental to a career. My last assignment was at a defense agency whose two-star Air Force director was "fired" for security reasons, so my last OER was signed and endorsed by two Air Force colonels. No offense to the colonels, but I saw the handwriting on the wall, so I retired. I suggest all officer ratings be "automatically" forwarded to a

higher echelon when a defense agency director is a two-star officer or lower, or when the senior general officer billet is vacant. I say automatically because Air Force element commanders or personnel officers should not screen personnel of the same rank as themselves.

Lt. Col. Russel A. Noguchi,  
USAF (Ret.)  
Pearl City, Hawaii

It was great to see "Giving Joint Assignments Their Due," regarding Air Force efforts concerning joint operations, especially joint task force command positions, and to bring more purple into the force through better training. I was assigned to US Forces Korea as a senior major, and I am sure the fact that I was out of my normal supported command (what was then Air Intelligence Agency) and in a joint position contributed to my not being selected. As was stated in the article, some see the joint world as a parallel universe and unfortunately that includes some members of promotion boards. I hope Air Force efforts have the intended affect and joint assignments become less of a stigma for company and field grade officers.

Maj. Douglas W. McGuire,  
USAF (Ret.)  
Fredericksburg, Va.

"Giving Joint Assignments Their Due" certainly caught my attention. I found the position of Gen. [David] Goldfein, Chief of Staff, who purports to "strengthening joint leaders and teams" something I had heard during my career. The editorial reports that USAF considers some joint assignments will even be "considered equivalent to command positions at promotion time." Goldfein says he will ensure that folks get "rewarded" for serving in joint assignments.

I bought that same mantra, popular in the '80s. I volunteered for and attended the Armed Forces Staff College (AFSC), Norfolk, Va., and spent months being trained to work in a "purple" assignment. My major thesis was graded "distinguished" and used in a future course curriculum. Some AFSC students chose not to take a joint assignment, but worked the system so as to return to an Air Force cockpit, something I would have loved to have done, since my pre-

vious assignment had been in the F-15 Eagle. However, I remained true to my "calling" to serve in a joint assignment, as the "importance of joint work" was the propaganda of the times.

I was assigned as the only fighter pilot in the Intelligence Center Pacific (IPAC) and was first recognized for my analysis of the KAL 007 shoot down by the Soviets on Sept. 1, 1983. I was then chosen to be the executive officer for the J2, a one-star Air Force general in charge of intelligence for the Pacific Command (PACOM). Shortly thereafter, I was selected to be the deputy executive officer and speechwriter to Adm. [William J.] Crowe Jr., the commander in chief (CINC) of PACOM. I served in that capacity until Crowe was chosen to be the Chairman of the Joint Chiefs of Staff (CJCS), at which time it was important for me to return to the cockpit.

During my time as one of the only rated USAF officers in IPAC, an exec to the J2, and the assistant exec and speechwriter to CINCPACOM, I received "firewalled" officer efficiency reports (OERs). My last two were endorsed by the Secretary of Defense (SecDef) and every OER stated, "promote ahead of contemporaries." I fully hoped, based on my career and hard work, that I might make O-6 one or two years early.

But, when returning to an Air Force unit, though serving in key positions and continuing to get firewalled OERs, my report—a year ahead of the colonel's board—was sent to a three-star for endorsement (the wing commander wanted to "save" OERs for four-star endorsements, as he thought I didn't need it—that I was sure to get the early promotion). The Air Force promotion board cared less if I performed well in a joint assignment for a Navy four-star and was endorsed by SecDef. No early promotion.

Then, the Air Force had the gall to ask me to serve in another joint assignment, one that would have required me to quit flying early (and lose thousands of dollars in flight pay), sell my home, put my son in a boarding school (there were no DOD schools where I was to be assigned), and more. I had already served commendably in three joint jobs, but was not "rewarded" for such, as Goldfein (and Major General Killough,

## WRITE TO US

Do you have a comment about a current article in the magazine? Write to "Letters," *Air Force Magazine*, 1501 Lee Highway, Arlington, VA 22209-1198 or email us at [letters@afa.org](mailto:letters@afa.org). Letters should be concise and timely. We cannot acknowledge receipt of letters. We reserve the right to condense letters. Letters without name and city/base and state are not acceptable. Photographs cannot be used or returned.

—The Editors

the head of Goldfein's joint leaders task force) purport in the article.

I had a great USAF career and enjoyed my "joint" time, but if we really think that we need more officers and airmen to serve in "purple" jobs, then we need to stand behind the statement that doing so will be "rewarding."

Lt. Col. Bob Russell,  
USAF (Ret.)  
Lancaster, Calif.

### Namesake: Dyess

I learned of [Lt. Col. Edwin] Dyess and the other Davao prisoners, McCoy and Mellnik, in the book *Jersey Brothers* (December, p. 64). Of the three Navy brothers, the youngest, Barton, was assigned to the Philippines arriving days before the Japanese struck. He was wounded and endured life as a prisoner of the Japanese but was not one of the 12 who escaped the prison camp. Dyess was admonished not to speak of the conditions in the prison camps. However, after President [Theodore] Roosevelt finally gave approval, the account of the Japanese atrocities was made public and published.

Lt. Col. Robert Rogers,  
USAF (Ret.)  
Sudbury, Mass.

### Non Neutral on Neutron Bomb

I really enjoyed John Correll's article on "The Neutron Bomb" and his account of the physics and politics behind its history of development, production, and proposed, but never implemented, deployment (December, p. 58). As a physician I have been interested in the differences between the medical effects of fission versus enhanced radiation weapons (ERW) of similar yields. As Correll pointed out, the prompt radiation-to-blast ratio in an ERW is much greater than that of a fission device. He did not mention that the biological effects of neutron radiation (and hence mixed field radiation) differ from those of the primarily gamma radiation produced by a fission device. Mixed field radiation injuries have shorter survival times, a shorter latency period (time between exposure and manifestation of symptoms), increased mortality, and increased delayed healing times for concurrent blast and/or thermal injuries. For survivors, the risk of carcinogenesis from mixed field radiation is considerably elevated as well. The only good news is that the fission product fallout from an ERW is half that of a fission device of similar yield.

The phrase used by the Soviet Union, and certain Western media personnel and politicians, that the ERW is "the capitalist bomb" built to "kill people and preserve property," is (intentionally?) deceptive. If one states instead that an ERW bomb is built to "kill the aggressor's invading troops and decrease destruction of the defender's homeland," a different impression is created. This was in fact why the ERW was constructed, to defend the West against Warsaw Pact invasion through the Fulda Gap.

Col. Glen I. Reeves,  
USAF (Ret.)  
Weiser, Idaho

I appreciated learning about the strategy, politics, and presidential decision-making surrounding the "neutron bomb" from John Correll's article in the December 2017 issue of *Air Force Magazine*. I'm looking forward to reading a timely sequel on nuclear weapons plans and policy for the Korean Peninsula.

Col. J. Randall Johnson,  
USAF (Ret.)  
Batavia, Ill.

### Century Skepticism

As a lifetime member of AFA, and an avid reader of *Air Force Magazine*, I wanted to make you aware of an error in December's article entitled "Commemorating USAF's 100-Year Units" [p. 31]. The author of the article left out one squadron that is still supporting the USAF's global operation by flying the MQ-9 Reaper, the 111th Attack Squadron, Texas ANG. As a former member, I can assure you that the 111th started life at Kelly Field, Texas, in 1917, as the 111th Aero Squadron. The unit was transferred to the Texas National Guard in 1924 as the 111th Observation Squadron/36th Division. Over the many decades the 111th has seen action in the MTO, ETO, Korea, (first Air Guard unit to see action in Korea), Air Defense, Operation Noble Eagle, and Operation Enduring Freedom. The unit celebrated its 100th anniversary on August 12. Please add a correction in the next issue.

Capt. Randall Smith,  
USAF (Ret.)  
Katy, Texas

The "Commemorating USAF's 100-Year Units" article in December's *Air Force Magazine* is a valuable testament to the rich heritage of the service. The number of units that can trace their history back to that period of time should not be surprising, however, since the

Army Air Service grew from just one aero squadron in 1916 to 185 aero squadrons by the end of World War I, of which 45 deployed to the European conflict.

However, I noted one omission from the array of squadrons that are currently active and that can trace their ancestry to 1917—the 141st Air Refueling Squadron, a component of the 108th Wing, New Jersey Air National Guard. Although it did not receive the official designation as the 141st Aero Squadron until Jan. 2, 1918, as it was enroute to the European conflict, it was effectively organized on Oct. 8, 1917, at Rockwell Field, San Diego (today's North Island Naval Air Station).

As an undesignated provisional unit, it drew men from other units and trained on the ubiquitous Curtiss Jenny at Rockwell until they began their eastward trek across the country and then the Atlantic Ocean. After receiving further training in England and France, the 141st Aero Squadron (Pursuit) finally arrived at Gengault (Toul) Aerodrome on Oct. 19, 1918, and immediately entered combat as part of the Meuse-Argonne Offensive.

Commanded by Capt. Hobart Amory Hare (Hobey) Baker and equipped with SPAD S.XIIIs, the unit led the 4th Pursuit Group in the number of combat sorties flown, aerial engagements and German aircraft downed. About a month after the armistice, on Dec. 21, 1918, Captain Baker was tragically killed while post-maintenance testing a SPAD the day of his intended return to the United States. The squadron stayed in Europe a bit longer, forming part of the Third Army Air Service's 5th Pursuit Group's occupation force, until demobilization in June 1919.

Significantly, on Sept. 8, 1973, the Secretary of the Air Force ordered the reconstitution of the 141st Aero Squadron and allotment to the New Jersey ANG, and consolidation with the then-existent 141st Tactical Fighter Squadron. The consolidated unit was also bestowed the lineage, history, honors, and colors of the 141st Aero Squadron. After flying high-performance fighter aircraft for its entire existence, the unit converted to the tanker mission in October 1991, becoming the 141st Air Refueling Squadron. Rick Porcelli, Barnetgat, N. J.

To my amazement, I found multiple units listed as having roots back over 100 years very hard to believe. For example, there are five (yes, five) air refueling units shown. Unfortunately, your article on air refueling on p. 45 indicates the first mil-



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itary air refueling occurred in June 1923. There is one "cyberspace" squadron shown. One space range squadron and finally, the USAF Thunderbirds, which only was founded in 1953, per their own web site.

Me thinks there was considerable "stretching" of the histories.

Col. Michael LaBeau,  
 USAF (Ret.)  
 Fort Worth, Texas

*As noted in the introduction, the 100 years is based on official Air Force lineage for currently active units. Most units have changed equipment, location, and mission several times, and may have been activated and inactivated more than once.—THE EDITORS*

I enjoyed perusing and researching your USAF 100-Year Units patch display in your December 2017 edition. I was impressed with the originality, creativity, and artistic skill that went in to creating these impressive historical images. Back in the "good old days" free spirits were allowed to be as expressive as they wanted.

I did some head scratching at some of the units I saw highlighted. A little internet surfing confirmed that each and every one had a story that started over a century or more ago and extends right up to today's Air Force.

All these units have long and illustrious lineage. Many traveled around more than FedEx trucks on Christmas Eve. For example, the 1st Reconnaissance Squadron has the distinction of being our military's oldest flying unit, established in March 1913. That unit has been re-designated 16 times and called 26 locations "home" while earning 12 campaign streamers.

It's good that today's "PC police" haven't imposed any social cleansing on any of these unit logos. Surely in today's patch approval process, mascots like Indian outlaws, hatchet men, red devils, Mohawk warriors, bomber barons, dice men, flying fiends, or Mr. Jiggs might get more bureaucratic scrutiny than they could survive. Likewise, slogans like "kickin' ass," "resistance is futile," and "hat in the ring gang" might be judged as offensive by some.

Back in those early days we had important things to focus on like a world war and no time for a lot of Trumped up things like today.

Col. Bill Malec,  
 USAF (Ret.)  
 O'Fallon, Ill.

## I'm Not Crying, You're Crying

I just finished reading the incredible story about "DT" [Israel Del Toro] "Like a Phoenix," December, p. 26. Shortly after starting the story I was crying like a baby. Just to say I served in the same uniform humbles me. As a former fighter pilot, my combat experience (in an air conditioned climate-controlled environment) pales in comparison to what he and so many others have done to defend our great nation.

Lt. Col Dennis L. Lombard,  
 USAF (Ret.)  
 Tucson, Ariz.

## Special Tactics

I appreciated the article on AFSOC's special tactics (ST) and its impressive combat record ["The Rise of AFSOC's Special Tactics," December, p. 40]. ST's rapid, flexible, and lethal force gives special operations planners many innovative force options. I was, however, surprised and disappointed that the AFSOC special tactics history missed some major historical events in the evolution of this force. Specifically, the seminal event to develop a standing national hostage rescue task force was the brilliant Israeli July 4, 1976, Operation Thunderbolt (aka Jonathan) rescuing the hijacked passengers of an Air France airliner at the Entebbe Airport, Uganda. For various reasons that require longer elaboration (but not in this space), Military Airlift Command (MAC) developed a capability to support those rapid reaction missions. This resulted in the prototype special tactics unit unofficially known as Brand X in late 1976. As a member of that unit we stood on the shoulders of combat control team (CCT) experiences from Southeast Asia where CCTs performed front line combat missions. Brand X supported the competing Army capabilities (Blue Light and Delta Force) culminating in the 1980 Eagle Claw "Desert One" failed hostage rescue attempt in Iran. The follow-on 1981 organization of the Joint Special Operations Command (JSOC) and the 1987 stand-up of US Special Operations Command provided strength to build and reinforce the current robust organization. Leaving out mention of the "Father" of special tactics Col. John Carney is a glaring error. Carney, with the cover and support of MAC Gen. Duane Cassidy, took on the military bureaucracy and corrected the structural organization. He provided for realistic training, added pararescue and other key operational

support, and developed an officer path that is enjoyed today with many senior special tactics officers in key special operations forces (SOF) positions. This also opened up senior NCO positions in key service and joint commands. Brand X veterans look proudly on the modern day inclusion of combat weather, TACP, and forward surgical care that were long overdue, making today's special tactics a unique and powerful Air Force and SOF capability.

Maj. John A. Koren,  
USAF (Ret.),  
Eules, Texas

### Fill 'Em Up—Worldwide

I was pleased to read the story ["Global Reach, Through Tankers," December, p. 44]. My first Active Duty assignment was with the 431st Air Refueling Squadron at Biggs Air Force Base in El Paso, Texas, 1962 to 1965, when the squadron was deactivated, retiring the KB-50J from service. To find a picture of one of our KB-50J's refueling the Thunderbirds brought back many fond memories. The KB-50 was an old workhorse, but it always got off the ground. That probably had something to do with it's four R4360 engines teamed up with two J47 jets. The squadron motto was "Anywhere, Anytime," and I still have my original flying red horse patch as seen on the tail of the two planes in the picture.

Our flight line always looked like World War II due to the resemblance to the B-29, but it was a SAC base and included B-52s and KC-135s. It's interesting to note that the KB-50J squadron was part of Tactical Air Command rather than SAC. Even with the added jet engines the KB-50J was slow, and it was sometimes difficult for modern jet fighters to slow down enough to refuel behind them. I noted it appears that the F-100s seem to have flaps down and spoilers extended. Thank you for this trip back in time.

MSgt. Ted Brown,  
USAF (Ret.)  
Jacksonville, Ore.

### More about One-Way Nukes

The October/November *Air Force Magazine* article, ["The One-Way Nuclear Mission, p. 104,"] covered much of a little-known Cold War mission, however, there was a rather large omission when talking about aircraft employed. From 1970 until 1991, the 20th Tactical Fighter Wing, flying the F-111E pulled Victor Alert at RAF Upper Heyford (with similar missions supported by the 48th Tactical

Fighter Wing at RAF Lakenheath with the F-111F). While the F-111s, with a large internal fuel capacity added to the wing tanks, could fly much longer distances than the other aircraft listed in the article, flight to target distances increased accordingly resulting in many missions, in essence, being one-way missions.

During my two tours at RAF Upper Heyford, crews "pulled alert duty" either Monday through Friday or Friday until Monday. The crews lived at the alert facility during that time but could "expand" to other parts of the base, using specially marked "alert vehicles" which allowed them to return to the alert facility rapidly. I left many dinners half eaten at the officers club when we'd be "scrambled" and have to return to the facility and our aircraft.

As indicated in the article, by that time, we had gone to strict "two-man" control procedures with the two-man crew or a crew member and the crew chief making up the two-man team allowed to enter the aircraft shelter area. Only assigned aircraft commanders and weapon system officers could enter the cockpit and that had to be accomplished simultaneously.

The 20th TFW squadrons (55th, 77th, and 79th) are still in the same wing, however, they are now located at Shaw AFB, S.C. As a side note, the squadrons celebrated their 100th anniversary this year having been formed in 1917.

Lt. Col. Darrel DeLong,  
USAF (Ret.)  
Austin, Texas

### I Can See Clearly Now

Quit complaining about pilot shortages and begin thinking about how we solved that problem during the Vietnam era ["Air Force Association's Top Issues—2018," 2017 *Air, Space & Cyber Conference Special Edition*]. We strengthened the pilot-navigator aviation cadet program.

This program did not require just a college degree to enter either of the training programs. It took more than that. It required someone that had to prove themselves qualified to enter the programs.

Many airmen that had jobs as aircraft crew members, mechanics, and other technical positions turned out graduating a greater percentage of pilots than any other program.

And, having been an aviation cadet, I have learned that a larger percentage of us remain in the USAF than not.

Drop the 20/20-eyesight requirement! Maybe some high-performance aircraft

might require it—but most do not. I was a reconnaissance systems officer in the SR-71. Flew with several pilots wearing eyeglasses. If we recall pilots, I am sure that we will see eyeglasses!

Lt. Col. G. T. Morgan,  
USAF (Ret.)  
Hoodsport, Wash.

### Flying the Fishhook

I thoroughly enjoyed reading another one of John T. Correll's historical articles—my favorite section in the magazine. There was included a great deal of behind the scenes activity leading up to the Cambodian bombings that I'd not run across before ["The Shadow War in Cambodia," January, p. 54].

I would add a few minor clarifications. I was a B-52 navigator who participated in these early Cambodian raids. According to my private records, on Feb. 28, 1969, we made a 60-ship gaggle raid over four hours (the largest conducted before the Linebacker campaigns) in the Fishhook region just short of the Cambodian border and technically (barely) within South Vietnam. My post-mission private notes say approximately 350,000 pounds of bombs were dropped. It was a tremendous success, with great damage to the enemy. This obviously whetted the leadership's appetite for more of the same, which we all presumed led directly to the more aggressive first secret over-the-border attack on March 17-18, 1969, as stated by Correll. I was in that second attack as well, which my notes say was another 60-ship gaggle (not 48 as stated). Also, Correll reports that at Andersen AFB, Guam, only "the B-52 pilots and navigators" got the premission briefing. At U-Tapao, all six basic crewmen were included in the brief. Air police officers and men rather pointedly cleared the room of all extra crewmen and staff. The U-T wing commander personally presided over the ceremonies. Only the basic crews (in B-52C and D models only) were allowed to fly the March 17-18 mission.

Robert O. Harder  
Chicago

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DEC. 15, 2017—WASHINGTON, D.C.

**A PEEK AT THE NEW WORLD ORDER**

A new era of “great power competition” is underway, and the US will have to come to terms with the fact that it’s no longer the world’s sole superpower, but one of several. Accommodating that reality—and the likelihood of only modest increases in defense spending—means the US should fully train and equip the military it has and focus tightly on being able to “win our nation’s wars” without any warning time.

This assessment, delivered by former Deputy Defense Secretary Robert O. Work at the US Naval Institute in December, may be as close as the public gets to a glimpse of the new National Military Strategy, reportedly in its final stages of coordination in December. Work served as the No. 2 man at the Pentagon from April 2014 to July 2017, under both the Obama and Trump administrations. He directed all the Pentagon’s strategy reviews and weapons programs and was privy to the most classified assessments of US and adversary capabilities. More than perhaps anyone else, he knows how the US stacks up against its competition.

Work said the US will have to “unlearn the lessons” of the last 26 years when the post-Cold War world offered no existential military challenges to the US. This was a “period so strategically favorable to the US,” which had “uncontested ... supremacy” in all things military, leading to complacency in many areas.

That era ended in 2014 when China felt confident enough in its power—both “soft” economic and diplomatic power and “hard” military power—to embark on its South China Sea island-building campaign, directly challenging the US. Russia, in the same year, invaded Ukraine and annexed Crimea, apparently unconcerned about a US response.

These events were a clear sign of great powers trying to “secure their near-abroads” and challenge the US for power and influence, Work observed. The era might even have ended sooner, in 2008, when Russia threatened military consequences if NATO continued expanding, he allowed.

Today, US “hard power is declining ... with a vengeance” relative to its challengers, Work asserted.

“Don’t rule out the ideological component, either,” he added. While the US has not been as aggressive recently in its campaign to spread democracy, its challengers are vigorously trying to “make the world safe for authoritarianism.” Accompanying that is a “general intensification of world disorder,” with political and technological disruptions and a “pronounced uncertainty about the willingness and staying power of Western democracy.” For at least the next 25 years, the world will be in a “very, very chaotic period,” Work assessed.

During this era, the most important technologies will be in automation and artificial intelligence (AI), he predicted. These will enable militaries to function much faster, from the strategic and operational levels down to the tactical, and that will be the key to victory. For example, great strides are being made in “cognitive” electronic warfare, in which machine intelligence figures out what the enemy is doing, second by second, and counters it.



The Waverider hypersonic Scramjet just before its second test flight, in June 2011.

**CHINA HAS THE LEAD**

In recent defense white papers, China has boldly declared that it will pull even with the West in automation and AI by 2020, be better than anyone else in those disciplines by 2025, and be dominant in such technologies by 2030. China’s rapid rise in other technology pursuits suggests these aren’t idle boasts, Work added.

China is pursuing asymmetric strategies to counter US advantages and one of those is to exploit “near-space,” by taking a lead in hypersonics.

“China has said, ‘We’re going to compete and dominate in hypersonics,’” Work pointed out—flatly acknowledging that China is already the world leader in this area. “Our geo-strategic rivals ... are competing with us, hard.”

Work offered a checklist of challenges that must be addressed if the US is to remain militarily competitive in the coming decades; a period in which technological advantage will again seesaw between the great powers and in which there will be more of them.

First, the US must somehow both “compete with the other great powers while avoiding great power war,” he said. Second, this will require the ability to deter and respond to “old and new means of strategic attack,” including nuclear as well as cyber warfare. The latter can be practically as devastating as a nuclear attack if an enemy chose, for example, to crash the US electrical grid.

The third challenge will be to manage the “destabilization,

disintegration, and re-integration" of various alliances, nations, and regions of the world, Work said, specifically urging a focus on the potential rearrangement of alliances in the Middle East.

Fourth, the US needs to develop a new and credible concept for deterring and dealing with "nuclear-armed minor powers" such as North Korea and potentially Iran.

Fifth will be a push to "restore conventional overmatch" with competitors. Work said the US no longer enjoys a lopsided conventional advantage. "We are at parity now," he warned.

Rather than try to build more Air Force fighter squadrons, Army brigades, or Navy ships, Work said it will be more effective to "hone the force we have" and make sure the existing force structure is thoroughly manned, trained, and equipped. The US is, and will remain, "very, very good" militarily, and if it is well prepared—Work specifically urged that forces be "over-provisioned" and weapons inventories more than fully stocked—it will present a formidable deterrent to any adversary.

Organizationally, Work said the US has overindulged in training deployments. American power has been dissipated by sending an endless stream of ships, aircraft, and troops to war games around the world, pulling them away from other missions. Better to send "training teams" that can observe and offer guidance, Work said, because these deployments actually degrade readiness.

Work also urged a reorientation of assets toward more existential conflicts and competitions. He related that former NSA chief, USAF Gen. Michael V. Hayden, complained that when Russia invaded Ukraine, the US was practically blind in that area because "everything was tuned to ... low-frequency radio" transmissions in Afghanistan.

## STICK WITH "THIRD OFFSET"

Work pushed the "Third Offset" initiative he championed while in office, insisting the US must press hard to achieve leap-ahead technology advances just to keep up with its competition. As part of this, the US must move deliberately to be able to fight in space and have the resilience to "fight through" losses of satellite systems.

The Budget Control Act will persist until 2021, and he sees little sign of it being repealed, meaning a probable series of continuing resolutions or two-year budget deals. What the military urgently needs is a five-year assured plan to function properly, he asserted.

One option—and the one which Congress has resorted to for several years—is to fund essential needs with the Overseas Contingency Operations [OCO] account. One of Work's slides listed this option as "OCO the s#t out of it."

Under the defense budget proposed a year ago, Work said it's likely the services will wind up, practically, with about \$30 billion more in usable funds. That's far from what's needed, but, "You can do a lot—a lot—with \$30 billion" to fix readiness problems.

Rather than attempt to grow the military, the Pentagon should fill empty billets and "empty missile holes," Work said. Any adversary must look at well-stocked, well-trained US forces and conclude that "if they go after [us], it will be the worst day of their lives." US forces will be far more credible if they are viewed as having the capability to fight all-out without notice. Work said it's unfortunate the entire nuclear enterprise has atrophied so much that every element of it must be modernized all at once, but it must be done.

"We are way, way behind on recapitalization," he said, add-

ing "all the margin is gone." Every new nuclear program—from the Ohio-class ballistic submarine, to new B-21 bombers and missiles for the Air Force, to land-based ICBMs—has to be replaced, he insisted.

"About three percent" of the defense budget goes to nuclear forces, Work said, and modernization will double that figure to six percent. It's unlikely there will be "any extra money to do it," so that additional three percent will be "a decrement to the conventional forces;" another reason to resist trying to build a larger military.

## DUMPING JSTARS?

Once touted as the Air Force's fourth-highest modernization priority—after the F-35 strike fighter, the KC-46 tanker, and B-21 bomber—a replacement of the E-8 JSTARS ground moving target radar platform seemed headed toward cancellation in December.

Senior Air Force leaders acknowledged in September they were reconsidering the JSTARS Recap program, worried that a big intelligence, surveillance, and reconnaissance platform would be too lucrative a target for enemies in a future war. USAF Chief of Staff Gen. David Goldfein and Secretary Heather Wilson told reporters at AFA's Air, Space & Cyber Conference they were thinking instead about a disaggregated network of sensors on platforms already in the battlespace, which would be hard to knock out.

Air Combat Command chief Gen. James "Mike" Holmes told an AFA Mitchell Institute gathering in late November that, as envisioned, JSTARS Recap can't do the job originally anticipated.

"We don't think that a JSTARS Recap will give us the capability we need" in contested airspace, he said. At the time, the Air Force had not yet decided whether to simply dump the program—on the eve of selecting a contractor to build it—or go ahead, but with the proviso that it would only be used in more benign environments. In either case, USAF will need "a global capability that could do that [mission] on any battlefield," Holmes said. The service is reviewing with sister services and allies other ways it could do the less-demanding mission. Two alternatives might be the RQ-4 Global Hawk remotely piloted aircraft or the Navy's P-8 Poseidon patrol aircraft, Holmes said.

As originally envisioned, JSTARS reveals large enemy vehicle formations and their movements, but there are other ways of defining that information now, Holmes said. In recent years, JSTARS has been used increasingly to watch individual vehicles and "dismounted" people and is "frankly ... too expensive" to be used in such a way, he asserted.

In late November, the Air Force picked Northrop Grumman over Raytheon to develop the large radar that would be the core JSTARS sensor; a contract separate from that of outfitting and integrating a small fleet of airplanes for the mission. Raytheon, in a brief statement, said it believed "the evaluation process had significant flaws, and we have filed a protest accordingly." Typically, the Government Accountability Office is required to investigate and report back within 60 days as to whether an award was improperly made.

Three companies were in the running for the JSTARS contract, expected to be awarded in the spring of 2018: Boeing, with a version of its 737, in a configuration similar to that of the P-8; Lockheed Martin, with a solution hosted on a Global Express business jet; and Northrop Grumman, offering a system mounted on a Gulfstream G550 business jet. The new aircraft was to be in service by 2024.

Photo: Boeing



Capt. Paul Barbour

## ■ Airman Killed in T-38 Crash

A T-38 crashed at Laughlin AFB, Texas, on Nov. 20, killing Capt. Paul J. Barbour, 32. Barbour was the aircrew flight equipment commander with the 47th Operations Support Squadron and an instructor pilot (IP) with the 87th Flying Training Squadron.

Capt. Joshua Hammervold, also an IP for the 87th FTS, was injured in the crash.

"Tragic events like this are difficult for everyone—family, friends, coworkers, supervisors, and our entire Air Force," said Col. Charlie Velino, 47th Flying Training Wing commander. "Every day our pilots take a risk as they step into the cockpit, and every day they operate with the utmost skill, professionalism, and dedication to train the next generation of flying airmen and to ensure the safety of this great nation."

Laughlin temporarily grounded its aircraft after the crash, which took place during a training flight near the Texas-Mexico border. The 47th Flying Training Wing is responsible for undergraduate pilot training in the T-38, along with flying T-6s and T-1s. Flying operations resumed at Laughlin on Nov. 27.

## ■ JBER Airman Dies During Deployment to South Korea

A1C Darrick Jones, a JB Elmendorf-Richardson, Alaska, airman who was deployed to train Republic of Korea forces, collapsed and died on Nov. 6. Airmen attempted to resuscitate Jones, but were unable to revive him.

"The grief felt as a result of the loss of Airman 1st Class Jones cannot be overstated," said 673rd Air Base Wing Commander Col. George Dietrich. "On behalf of everyone at Joint Base Elmendorf-Richardson, I offer our most sincere condolences to the family and friends."

Jones, 23, enlisted in the Air Force in September 2015 and had been stationed at JBER since August 2016. He served as a water and fuels systems apprentice with the 773rd Civil Engineering Squadron. At press time, his death remained under investigation.



A1C Darrick Jones



An F-35 from Hill AFB, Utah, taxis at Kadena AB, Japan.

## ■ F-35As Deploy to Japan

Twelve F-35As and about 300 airmen touched down in Japan on Nov. 2 for the first Pacific deployment of the Air Force's newest fighter. The jets, from the 388th and 419th Fighter Wings at Hill AFB, Utah, deployed to Kadena AB, Japan. They were part of a US Pacific Command theater

security package. Two of the aircraft also participated in a Seoul, South Korea, air show in late October.

During the deployment, the F-35s will "integrate various forces into joint, coalition, and bilateral training across many different environments," according to Pacific Air Forces. The deployment is

"long-planned," according to the Air Force, and follows the deployment of US Marine Corps F-35Bs to MCAS Iwakuni, Japan. The F-35 is "ideally suited" for the Pacific and will be integrated both into training and "operations," PACAF Commander Gen. Terrence J. O'Shaughnessy said in the release.



T-6A Texans resumed flying operations Dec. 5.

### ■ T-6As Grounded at Vance after Physiological Incidents

The 71st Flying Training Wing at Vance AFB, Okla., grounded all T-6A trainers flying on Nov. 15 after pilots reported four physiological incidents there since Nov. 1. In each incident, "the aircraft's backup oxygen system operated as designed," and the pilot landed safely, according to a Vance press release. T-6A flying operations were halted while the wing analyzed the data from the reported events.

"Vance AFB is committed to ensuring aircrew safety is paramount, and [officials] are conducting a full investigation of the reported cases," said Col. Darrell Judy, 71st FTW commander, in the release. In the meantime, instructor pilots and students were briefed on the incidents to raise their awareness of the issue. Because all incidents were limited to the T-6A, training operations with the T-1A and T-38 continued as usual.



Lt. Gen. Steven Kwast addresses First Command for the first time as the new head of AETC.

### ■ Kwast Leaves Air University, Takes Charge at AETC

Lt. Gen. Steven L. Kwast assumed command of Air Education and Training Command in a ceremony at JBSA-Randolph, Texas, on Nov. 16, 2017. "When it was time to select the new AETC

commander, Gen. Steven Kwast was the obvious choice," said Chief of Staff Gen. David L. Goldfein, who presided over the ceremony. "In Kwast, we have an airman whose resume strikes a balance between combat warrior, intellectual, and leader. And perhaps most impor-

tantly, he exudes humility, credibility, and approachability."

Kwast served as commander and president of Air University at Maxwell AFB, Ala., since November 2014. He succeeds Lt. Gen. Darryl Roberson, who had led AETC since July 2015.

## ■ ACC Removes Logistics Chief

Air Combat Command's one-star general in charge of engineering, logistics, and force protection was removed from command on Nov. 27 for not maintaining a "healthy command climate." Brig. Gen. Carl Buhler was removed from command by ACC head Gen. James M. "Mike" Holmes following an inspector general investigation that found Buhler misused the official time of his subordinates, violated travel regulations, and abused his authority by improperly reassigning staff duties, according to an ACC statement to *Air Force Magazine*.



Brig. Gen. Carl Buhler

Buhler, who is now working as a special assistant to Holmes, had served in the position since September 2015 and previously commanded the Ogden Air Logistics Complex at Hill AFB, Utah. The deputy director of logistics, Marc Novak, is serving in the position until a new director is appointed, according to ACC.



USAF Thunderbirds Demonstration Squadron.

## ■ Thunderbirds Commander Relieved of Duty

The commander of the Air Force Thunderbirds was relieved of command following a loss of confidence in his "leadership and risk management style," Air Combat Command announced.

Lt. Col. Jason Heard was serving in his first season as commander of the US Air Force Air Demonstration Squadron and

Thunderbird 1. Heard was previously an F-15E expeditionary squadron commander with more than 3,000 flight hours.

Brig. Gen. Jeannie M. Leavitt, commander of the 57th Wing at Nellis AFB, Nev., relieved Heard effective Nov. 20. Leavitt determined a change was needed "to ensure the highest levels of pride, precision, and professionalism within the team," according to ACC.

## ■ Surge-Level Tempo Returns to Afghanistan as F-22 Debuts

US aircraft are striking targets in Afghanistan at a pace not seen since the peak of the surge seven years ago. In October, US aircraft conducted 653 strikes in Afghanistan. That tally is the highest total since aircraft conducted 866 air strikes in November 2010.

By the end of October, US aircraft had dropped 3,554 bombs in 2017—almost double 2016's final tally of 1,337.

The October total does not include the US and Afghan military's new offensive targeting of Taliban opium production. On Nov. 19, Operation Jagged Knife took advantage of new authorities to unleash a tidal wave of airpower including B-52s, F-22s, and A-29s targeting opium production in the mountains of the country.

The strikes marked the first time the

F-22 was publicly disclosed to have conducted a mission in Afghanistan. The F-22 Raptor "was used because of its ability to deliver precision munitions, in this case a 250-pound bomb, small diameter, that causes the minimal amount of collateral damage," said Army Gen. John W. Nicholson Jr., commander of US Forces-Afghanistan.

This high operations tempo in Afghanistan is possible because operations targeting ISIS in Iraq and Syria have eased recently. US efforts there "have gone well," Nicholson said, "so we're beginning to see the effects of a shift of resources, which will increase over the course of the winter, going into the spring, as the situation continues to improve there."

In October, US-led coalition aircraft conducted 1,642 strikes as part of Operation Inherent Resolve. That is the lowest total since November 2014.



An F-22 Raptor being refueled for Operation Jagged Knife in Afghanistan.

**■ Pilot Shortage Worsens**

The Air Force's pilot shortage is getting worse, and service efforts to stem the exodus have not yet paid off, Air Force Secretary Heather Wilson reported Nov. 9.

At the end of Fiscal Year 2017, the Air Force was 1,926 pilots short, across all categories. That, she said, represents nearly 10 percent of a pilot requirement of 20,000. The previous year, the shortage was 1,500.

The service is 1,300 fighter pilots short of requirements, Air Force spokeswoman Erika Yepsen added.

Yepsen also clarified that when Guard and Reserve pilots are included, the actual number is "approximately 2,000 Total Force" pilots USAF was short at the end of Fiscal 2017.



F-35 pilot 1st Lt. David Moore gets ready for flight.



An MQ-1 Predator's left tail is important for flight.

**■ Predator's Left Tail Broke Off, Causing 2015 Crash**

A mechanical failure of the left tail clamp on an MQ-1B Predator caused the remotely piloted aircraft to crash during a mission in an undisclosed area in the Middle East. On Nov. 8, 2015, an MQ-1B assigned to the 432nd Wing at Creech AFB, Nev.,—operated by a deployed launch and recovery element from the 46th Expeditionary Reconnaissance Squadron—crashed as it approached landing.

An Air Combat Command investigation found a left tail clamp or tail clamp bolt failure resulted in the airborne loss of the left tail. This caused an "unrecoverable departure from controlled flight," which happened as the pilot was conducting an arrival checklist. As the pilot alternated left and right inputs, mechanical and aerodynamic loads broke the weakened left tail clamp. The Predator was destroyed on impact, at a loss of \$5.3 million.



The new Block 5 MQ-9 Reaper.

**■ Air Force Picks Tyndall for New Reaper Wing**

The Air Force has selected Tyndall AFB, Fla., as the preferred location to host a new MQ-9 Reaper wing, including 24 aircraft. The new wing will include an operations group, mission control elements, a maintenance group, and launch and recovery capability. The Air Force picked Tyndall because the area has fewer aircraft competing for airspace, nearby training ranges, good weather, and lower up-front costs, Air Force Secretary Heather Wilson said.

**■ The War on Terrorism**

US Central Command Operations: Freedom's Sentinel and Inherent Resolve

**Casualties**

As of Dec. 13, a total of 46 Americans had died in Operation Freedom's Sentinel in Afghanistan, and 50 Americans had died in Operation Inherent Resolve, primarily in Iraq and Syria.

The total includes 92 troops and four Department of Defense civilians. Of these deaths, 43 were killed in action with the enemy while 52 died in noncombat incidents.

There have been 239 troops wounded in action during OFS and 58 troops in OIR.

Photos: USAF; Johnny Saldivar/USAF; TSgt. Gregory Brook; A1C Greg Erwin; SMSgt. Cecilio Ricardo; SrA. Christian Clausen

## BLUE FLAG IN ISRAEL

UVDA AIR FORCE BASE, ISRAEL—

US airmen in November had the chance to work with airmen from seven other nations during Blue Flag 2017, a multinational exercise in, and hosted by, Israel.

The goal of the two-week exercise was “to simulate extreme combat scenarios and coalition fights as realistically as possible,” according to the Israeli Air Force.

Air forces from Poland, Italy, Greece, India, France, Germany, Israel, and the US participated.

Seven F-16Cs and about 200 airmen from the 31st Fighter Wing at Aviano AB, Italy, engaged in the live-fly exercise.

“Anytime we participate in a multinational exercise with many different partners and players, it builds our interoperability. It builds our ability to communicate, it builds our common understanding of culture, and it builds our common understanding of capabilities and tactics,” said Brig. Gen. Lance Landrun, commander of the 31st FW.

An Israeli pilot said the exercise was designed to find common ground for each air force, so missions were planned and executed together, and everyone shared how they would fight each mission.

Some of the sorties involved flying against the Israeli Air Force’s “Flying Dragon” aggressor squadron.

“This is a significant milestone in our relationship with the international air forces, some of which are arriving in Israel to train for the first time. This exercise will allow us to continue cooperating with these forces in the future as well,” said Lt. Col. Nadav, commander of the 133rd Squadron, the Israeli squadron that led the exercise.

During Blue Flag 2017, four USAF crew chiefs participated in a two-day exchange with air force crew chiefs from Germany. SrA. Cody Linholm, a crew chief with the 510th Aircraft Maintenance Unit (AMU), said he spent the first day of the exchange explaining his routine to his German counterpart.

“We showed them a step-by-step launch, the danger areas of the jet, where to go if hydrazine was to spill on the jet, and things like that,” he said.

The next day, US airmen shadowed the Germans as they got Eurofighter Typhoons ready for a day of flying.

“It was a great experience to go over and actually work with the Germans. While the US Air Force does not fly or maintain the Eurofighter, it was still an opportunity to get out and experience something different, especially for our young maintainers,” said Capt. Jonathan Tolman, 510th AMU officer in charge.

## YEMEN QUESTIONS

Also in November, the House of Representatives passed a resolution (HR 599) stating that American assistance to the Saudi war against Iranian-backed Houthi rebels in Yemen is not covered by the authorizations for use of military force covering operations Inherent Resolve and Freedom’s Sentinel.

The resolution noted that the US “has participated in intelligence cooperation since 2015” with the Saudi-led coalition and has refueled coalition planes flying bombing missions



Then-A1C Cody Linholm (right, USAF) observes as German air force crew chiefs prepare a Eurofighter Typhoon.

in Yemen. It urged political solutions to the ongoing conflict, which intensified in early December after the death of the former Yemeni president, Ali Abdullah Saleh.

The resolution is nonbinding and does not attempt to end America’s participation in the war in Yemen. However, it acknowledged that Congress had not authorized participation and called for increased efforts to prevent civilian casualties and increase access to humanitarian assistance. At least 10,000 Yemenis have been killed since the war began in 2015, according to the resolution, and the World Food Program warned the country was on the brink of “full-scale famine” in April 2017, even before a Saudi blockade in early November.

US forces “routinely” fly aerial refueling missions “in support of US and partner operations targeting terrorists in the region that the Royal Saudi Air Force can use for training and for operational missions,” US Air Forces Central Command spokesman Lt. Col. Damien Pickart told *Air Force Magazine*.

US Central Command “has authorities to conduct a variety of missions in Yemen, all ultimately focused on bringing stability to the region and halting the spread of terrorism,” he explained. “The US does not provide targeting guidance or targeting intelligence to the Saudis in their fight with Yemeni rebels, and we don’t participate in Saudi missions that are outside the scope of specified authorities.”

The US maintains a small train, advise, and assist presence in Saudi Arabia, and in a separate mission, monitors and tracks terrorist networks and activities “to ensure the US and its partners have the most reliable intelligence to mitigate and target threats.”

The US has conducted more than 110 strikes in Yemen against al Qaeda in the Arabian Peninsula and against ISIS, according to the spokesman.

**Jennifer Hlad** is a freelance journalist based in the Middle East and a former *Air Force Magazine* senior editor. ✪



Airmen prep an F-35 for a night flight at Luke AFB, Ariz.

# LIGHTNING AND THUNDER

The F-35 and F-22 are teaching each other new tricks.

By John A. Tirpak, Editorial Director

**A**t the outset of the F-35 Joint Strike Fighter program, there were high expectations that it would benefit from lessons learned from its elder stablemate, the F-22 Raptor, also made by Lockheed Martin.

Now, a dozen years after the F-22's operational debut and two years after the F-35 was declared ready for combat, the flow of lessons learned is running both ways. The two fifth generation fighter programs are working together to reduce costs and make both systems more effective.

The F-22 has been a pathfinder for

the F-35: Its formations and methods of employment are a model for the junior fighter. In return, the small F-22 fleet is gaining economy-of-scale benefits by getting in on parts buys with the far larger—and growing—F-35 fleet. More advanced and hardier stealth features on the F-35 are working their way back to the F-22, the two aircraft share radar features, and operational and manufacturing experience with the F-35 are helping define upgrades for the Raptor.

“The F-35 and F-22 were always meant to operate alongside one another, so it makes a lot of sense to apply that same logic to the programmatic side of both platforms,” said Lockheed Martin F-35 program manager Jeff A. Babione. “We’re constantly taking

advantage of newer, more advanced technologies and processes. If we can apply the same advances to the F-35 and F-22, we drive costs down and pull schedules to the left on both programs.”

The F-22 pioneered fifth generation tactics and those are being applied straight to the F-35, according to Col. Paul “Max” Moga, commander of the 33rd Fighter Wing at Eglin AFB, Fla. The 33rd trains new F-35 pilots, but Moga spent years in the F-22, as an instructor and demonstration pilot and later as a squadron commander, after starting out in F-15s.

Regarding employment techniques on the F-22 and F-35, “I would describe them as a direct transfer,” Moga said. In the F-22, the key to employment

is “managing signature, sensor, and what we refer to as ‘flow,’” which he explained is how the plane and pilot sense the battlespace, steer between threats, and get into the optimum position to engage. That same concept applies to the F-35, he said.

Though fourth generation aircraft pilots have to manage visual and infrared signatures, “it’s not until you get in the fifth gen world that you really concern yourselves with radar signature management. ... That is a core competency of any fifth gen platform, and that is a direct transfer over from the F-22 to the F-35.” Pilots of both jets must “manage our signature as we employ the aircraft and optimize our survivability and lethality,” Moga said.

The F-22 was a “generational leap” over fourth gen fighters such as the F-15 and F-16, and it took a conscious shift in culture to shed old tactics that were no longer relevant when the F-22 came online, he noted.

In a fourth generation jet, a wingman must provide “mutual support” within visual range, “welded” to the flight lead just a few miles away. But “pretty early on in Raptor tactics development, we realized that, based on the capabilities of the airplane, we didn’t need visual mutual support. We needed a mutual support by presence, which, for us, can be upward of 10, 15, 20 nautical miles away from one another,” said Moga.

For a former fourth gen pilot who has always depended on someone close by having his back, “it takes a while to get used to that,” Moga said.

### GROWING UP FAST

Now, in the F-35 as well as the F-22, “we train our younger wingmen to operate outside the visual [support] environment, which means they have more responsibilities on their shoulders.” They have to grow up fast, Moga said.

In both jets, “our young wingmen are making tactical decisions and executing accordingly at a level that historically, in our fourth gen fleet, we would not expect out of them until they were a seasoned flight lead, if not a mission commander or instructor pilot,” he assessed.

Fifth gen pilots have to “get up to speed a lot quicker because when they’re by themselves, the consequences can get dire if they make an improper or incorrect tactical decision.” There’s no “safety net” of “some-



An F-15 (top), two F-35s, and two F-22s fly in formation over the Nevada Test and Training Range. USAF is looking to field systems that will aid communications between fourth and fifth generation fighters.



Airmen ready an F-22 for a Red Flag mission at Nellis AFB, Nev.

## Talking Past Each Other

The biggest area of fifth generation synergy that has yet to materialize is in the area of communications. To be stealthy, F-22s talk to each other and share data via the Intra-Flight Data Link (IFDL), while F-35s transmit and receive data among themselves via the Multifunction Advanced Data Link (MADL). Both systems are low probability of detection and intercept—meaning it’s hard for an enemy to listen in and triangulate the jets’ positions by their communications traffic—but the systems can’t talk to each other. The Air Force has been scrambling to solve the problem.



A technician works on an F-35 at Hill AFB, Utah.

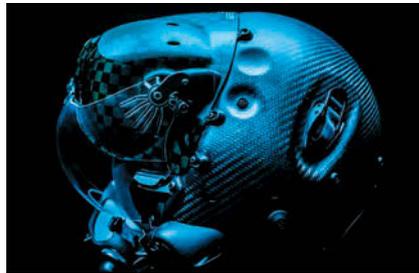
body being two miles away from them that can clean somebody off their six o'clock," he noted.

This is all made possible by the extraordinary sensor capability in both aircraft that draws information from both onboard and offboard sensors and from the sensors of their wingmen's jets. "You no longer need four ... or eight sets of eyeballs to scan the horizon and look for threats and put together the tactical picture that you need to execute. ... The aircraft does all that for you," he explained. In fact, it's so much data that sometimes "it's more than you need."

The airplanes' missions are complementary. The F-22 is primarily an air superiority fighter with ground attack capability, while the F-35 is optimized for attack, with dogfighting capability as well. By remaining unseen and undetected, the F-35 can use the stealth dogfight tactics already well-established by the F-22, though perhaps not to the same speeds and altitudes.

One mission not shared between the two is close air support. Moga said CAS is a new one for him to learn. Though early on the F-22 units did try to practice CAS, Moga admitted that "we kind of got off track back in those years." Since then, the F-22 operators "got back in our lane and realized there were other platforms that were really optimized for that mission far more efficiently and effectively."

The F-22 has been a success story in Operation Inherent Resolve, Moga asserted. Though its high-end dogfight capabilities have never been tested in combat, "I think the F-22 has performed tactically better than most people thought it was going to in theater." When not "gainfully employed,"



The new F-35 helmet offers a wealth of information—and options—to pilots.

dropping bombs or escorting packages of other aircraft, the F-22 has proved stellar in other ways, putting together "the electronic order of battle, ... the airborne order of battle," and then conveying that information "back to the platforms it may be more applicable to."

A lesson learned—and one certainly being applied on the F-35—is "the importance of maintaining accurate and up-to-date mission data files," Moga noted. This is another area where exhaustive information on regional threats is applicable to both airplanes. The software facility that loads both aircrafts' mission data files is at Eglin. USAF and partner nations collaborate to populate the databases with every threat known to intelligence.

"There's a lot of work to be done, and it's a fast-moving ball game, but we're making a lot of progress," he said. Still, "we've got a little ways to go before we can raise the flag and say we're where we want to be," Moga added.

The F-35 pilot wears a helmet that shows practically all aircraft, environment, and target data, but this capability came along after the F-22 was designed. While it would be impractical and expensive to backfit the F-22 fleet with the "see through the floor"

electro-optical systems on the F-35, "most of the pilots flying [the F-22] would like ... some version of a helmet" that displays data and allows the full use of more advanced weapons, Moga asserted. Both jets can carry the AIM-9X short-range dogfight missile, for example, but only the F-35 can aim the missile far off-boresight (at a high angle off the nose of the airplane), because the missile can be cued by the pilot simply looking at the target and designating it. Lacking a targeting helmet, the F-22 can't employ that tactic.

The F-35 helmet is "a game-changer," Moga asserted. Besides offering the off-boresight shooting capability, "there's also other utilities they can use it for now that they have an air-to-ground-mapping SAR (synthetic aperture radar) ... capability."

The helmet and cockpit displays in the F-35 also offer "many more options" for calling up and displaying information. Though for an "old guy" like him, the wealth of displays and information can be "overwhelming," Moga said, young pilots take to it quite naturally.

"When I watch their tapes in the debrief and I see how quickly they're changing their displays from this to that and spending half a second to get just what they need and then flipping back ... it's pretty phenomenal." The young pilots were reared on "Windows and Playstation," he noted. A new helmet is on the short list for F-22 upgrades.

## STEALTH ARMOR

The stealth coatings transfer between the jets is "one of the larger success stories" in the crossplay of the F-22 and F-35, Moga said. "The coatings and surfaces on the F-35 are a direct result of the lessons we learned with the ... LO (low observability) management on the F-22."

The coatings on the F-22 were "very problematic" for a number of years because the F-22's stealthy surfaces still require a degree of putty and tape to smooth the surfaces. On the F-35, though, the stealth treatments "are exponentially easier to maintain, sustain, and restore," he pointed out.

"It's easier for the maintainers to fix the aircraft, it's quicker, and we have a much more accurate tool" to assess the normal degradation of stealth surfaces and its effect on signatures. Now, Lockheed is looking at ways that it can apply the F-35's resilient stealth coatings to

the F-22. If successful, it could sharply reduce maintenance man hours per flight hour and result in more jets being available for action at any given time; a significant benefit considering the smallness of the F-22 fleet, which numbers only 187 airplanes, including test and training birds.

“We’re now making a more concerted effort to apply what we’ve learned on the F-35 to the Raptor,” Babione said, “as we continue to develop and upgrade both platforms.”

The F-35’s stealth coatings have held up far better than those of the F-22 in the “salt spray, ocean environment, high humidity” conditions of the Florida coast, said Ken Merchant, Lockheed’s vice president for the F-22 program, in an interview with *Air Force Magazine*.

“We’re looking at taking Jeff (Babi-one’s) topcoat from the F-35 and bring that over to the F-22,” he said. This would “add a bit of weight, because it’s a little heavier material, but it’s spread evenly over the airplane so it doesn’t cause me a CG (center of gravity) issue.” Whether the Air Force will approve the change in materials is still “pre-decisional,” Merchant said, but it offers a potential payoff in substantially reduced maintenance costs.

Though the F-22 would still need some caulking and taping, it’s already benefitting from a new leading-edge material. The old stuff “got real brittle over time,” Merchant said, but the new material is “just more flexible and durable.” It goes by the name “maximum toughness boot.” It was partly developed at the F-35 program, “and they’ve got something very similar.” Lockheed has opened a “speed line” at its Marietta, Ga., facility to replace the old material with the new.

Getting the F-22 and F-35 sharing technologies is “a drum I’ve been beating since I got here,” said Merchant, who retired from the Air Force as a major general in 2014. He worked on F-22 utilities development in the mid-1990s and headed the Air Armament Center at Eglin AFB, Fla., among many program management duties in his career.

He sees opportunities in common software—made possible by an open systems architecture for both the F-35 and F-22—new common processors, the new radar waveform, and in economies-of-scale on parts.

“When I got to Raptor, if I go to a vendor and say, ‘Hey, I need 187 of



**SSgt. Anthony Ovechka inspects an AIM-9X missile on an F-22 at Hill AFB, Utah, during a Combat Archer exercise in 2016.**

these [parts], plus spares, I get a price tag that’s pretty high,” he said. “And when Jeff goes to them and says, ‘Hey, I need 2,000 plus spares, the price comes down a lot.’” Combining orders for parts on things like “auxiliary power units, ... environmental control systems,” and many other basic utilities can save big dollars, Merchant asserted.

On every new order, he asks, “Is there a way we can get a lift off each other, here?” The opportunities to do so are multiplying, he said, because of diminishing manufacturer syndrome: An increasing number of cases where the original vendor pulled out of the business to pursue something more lucrative or just because technology has moved on. In those cases, the two programs are looking for common replacements.

The benefit of adding the F-22’s parts needs to those of the F-35 approaches “10 percent,” Merchant reported.

Both programs are pursuing open mission systems with sharing of parts in mind. “At some point,” he said, the aircraft may be able to swap circuit cards and both use the software that drives them. An upgrade to the software-based radio on one, for example, could, with little or no tweaking, work on the other. Eventually, “everything’s plug-and-play, for the most part.” They will also be able to use commercial cards, which will drastically reduce the cost, again, because of the economies of scale.

“The radar’s probably the biggest win we’ve had so far,” Merchant said. The two jets using a common waveform, but he could not go into detail except to say that they now share “some software and functionality” of the radars, particularly in ground-mapping mode.

The two jets still have different electronic architectures, but “the stuff that’s pumping out of those TR (transmit/receive) modules is very much the same.” Electronic warfare capabilities are similar and eventually could use the same hardware as well.

In self-protection, the aircraft can share common flares and magazines, “common EW,” or electronic warfare systems, but mostly in the utilities, such as avionics, subsystems, hydraulics, and interfaces for weapons.

Merchant also said a new helmet will advance the F-22’s capabilities, and he’s looking to redo the cockpit as part of an F-22 “midlife update.”

The flat panels in the F-22 cockpit were cutting-edge when they were built, but compared to modern flat screens, they are thick and bulky. Merchant sees a chance to replace them with an F-35-like display thin enough that the new processors could fit right behind them, allowing easier service and freeing up space elsewhere on the airplane for growth mission hardware.

“It’s lighter, and I have a shorter wire run” to do the new displays, he said. “I have a team looking at what the pilot interface would look like” in an upgraded Raptor cockpit.

## Making the Whole Fleet Whole

The F-22s of the 325th Fighter Wing at Tyndall AFB, Fla., are used in flight and mission training for F-22 pilots, but they aren't up to the most advanced configuration of the Raptor. There's good reason to bring them up to par, Lockheed Martin F-22 Vice President Ken Merchant argued.

"It's about \$25-\$30 million an airplane" to upgrade the early version F-22s up to a common fleet configuration, Merchant said. One of the biggest costs would be to upgrade their radars "and put Gen 4 radars on those 34 jets." "There's a good bit of money that could be saved" by doing so, he asserted. If a jet comes in for depot maintenance, and all aircraft are of the same configuration, it doesn't necessarily have to go back to the unit it came from.

That's important because the Air Force is husbanding its F-22 fleet very carefully—by tail number—to balance the number of hard and easy hours each jet flies, or how long each one soldiers on in a harsh environment. Merchant said the F-22 has the potential—using careful monitoring, balancing fleet hours, and assuming a midlife upgrade in the 2020s—that the F-22 could serve another 40 years. The Air Force asked the company to do an analysis to see if it could stretch the Raptor fleet to last until 2045, and the analysis showed "we can get them all the way out to 2060," Merchant boasted.

"Now, is it a frontline, go downtown, take the fight to the bad guy kind of airplane in that time frame? Probably not. But it might be your homeland defense airplane, much like the F-15 today," he said. The F-22 design life was 6,000 hours, but tests showed it could go to 14,000-15,000.

The training Raptors at Tyndall are aging faster than those at other bases because of the salty, humid air. Without a commonality upgrade, they will have to operate only there, corroding and aging out faster than the others.

Merchant said the F-22 fleet could be managed the way the Air Force has been controlling the aging of other types. It swaps airplanes between Active, Guard, and Reserve jets because the Active Duty force uses their airplanes "a little harder" while the Guard and Reserve jets are flown "less hard, and they take really good care of their airplanes, they freshen them up." Plus, a different simulator wouldn't have to be maintained with different software.

In the F-22 fleet, jets that have been flying in Operation Inherent Resolve are also being swapped with aircraft that have been Stateside because, paradoxically, the ones "downrange" are mostly flying benign "highway miles," Merchant said.

"When they're over in the AOR, you fly out, you hit the tanker, you fly ... to your overwatch area, or fly in as an escort to the fourth gen fighters, and you're just flying pretty much straight and level," said Merchant. This doesn't put too much stress on the aircraft. Stateside, the jets "fly out to the target area and ... mix it up pretty good," putting a lot of loads on the airframe with violent maneuvering.

Keeping all the aircraft common would keep "overall average hours down on the fleet" and provide Air Combat Command the flexibility to take aircraft from depot and put them—with their up-to-the-minute configuration—wherever they most need to go.

Gen. James "Mike" Holmes, commander of ACC, told *Air Force Magazine* last spring that he'd like very much to upgrade the training F-22s, but other programs have so far had higher priority. Merchant noted, though, that besides making the fleet cheaper and easier to maintain, upgrading the training jets "gives [ACC] potentially another 20 percent operationally capable airplanes they could take to war tomorrow."

That would be a great deal less costly than reopening the F-22 line, which the Air Force has been asked to cost out but says it simply can't afford to do.

"I haven't met anybody in the Air Force who says it's a dumb idea," Merchant said.

an infrared search and track (IRST) system for the F-22 to help it better see stealthy adversaries, Merchant said, "we really don't have the real estate" in the same location on the F-22. "We're looking at other options." He was unable to elaborate due to classification.

In cooperation with the Air Combat Command, Merchant said, Lockheed is looking at trying out some new capabilities for the F-35 on the F-22 first.

"I can get things on the jet much quicker," he said, "because I don't have to do the negotiations with the foreign partners" to wedge an improvement into the already-robust F-35 Block IV program. Babione can lend Merchant some engineers "that would work on my team with the uniqueness ... maybe there's ... an extra connection, some bit of software," that would have to be finessed, but both jets could use the result.

A small number of F-35s could then be tested with the improvement, and if it works, it could be deployed on the F-22 first as the F-35 production line is adjusted. "And you save a whole lot of money," Merchant insisted. Otherwise, with two engineering and production teams—unlikely to come to a common solution—"the Air Force is spending twice to get that same capability on two jets."

Babione said the fifth gen synergy doesn't stop between the F-22 and F-35.

"There will absolutely be more technology sharing across various Air Force programs," he said, noting that fifth gen technologies are migrating to the company's T-50A candidate for the new Air Force trainer, its JSTARS recap offering, "and other Skunk Works efforts," referring to the company's advanced technology shop. Merchant said that, although Lockheed has not yet been asked, it's possible the Air Force will request it to collaborate with Northrop Grumman on the service's other fifth gen aircraft, the B-21 bomber. An antenna designed for the F-35, for example, proved a perfect "drop-in" fit for the B-2 and will soon be fitted to the F-22.

"We'll see more of that moving forward," Babione said.

"There are incentives—financial and otherwise—for everyone involved here to find more synergy across programs. Synergy between the F-35 and F-22 is a good example, but certainly not the only one," according to Babione. ❄

### NOT EVERYTHING TRANSFERS

One thing the jets could not share is the F-35's electro-optical targeting system (EOTS), the diamond-shaped

wedge under the F-35's "chin" that provides many of the visual and infrared sensors other jets must carry in pods. Though the Air Force is considering

### Of Glass Houses ...

"We need to move quickly. We need to accelerate [space] acquisition. We need to innovate and prototype new systems faster ... stop studying things to death, and get capability in orbit for the warfighter. ... The US built a glass house before the invention of stones. The shifting of space [from] being a benign environment to being a warfighting environment requires different capabilities."—**Secretary of the Air Force Heather Wilson, Reagan National Defense Forum, Dec. 2.**

### ... and Tortoises

"I'm worried about the future because, I don't know how it happened, but somehow this country just lost the ability to go fast. And we have adversaries that go fast. We take four years to study a program before we do anything. We do four years of risk reduction for technologies we built fifty years ago. Why do we take that much time?"—**USAF Gen. John E. Hyten, head of US Strategic Command, Reagan National Defense Forum, Dec. 2.**

### End Stage

"We're getting close to a military conflict [with North Korea]. ... We're running out of time. ... I'm going to urge the Pentagon not to send any more dependents to South Korea. South Korea should be an unaccompanied tour. It's crazy to send spouses and children to South Korea, given the provocation of North Korea. So I want them to stop sending dependents. And I think it's now time to start moving American dependents out of South Korea."—**Sen. Lindsey Graham (R-S.C.), Senate Armed Services Committee, on CBS's "Face the Nation," Dec. 2.**

### Reassurance You Can Hear

"Owning the ... high ground is continually going to be important as we go forward. Air superiority is not an American birth right. It's actually something we have to plan for, train for, fight for, and win. I see it as nothing short of a moral obligation that, when any soldier or airman hears a jet noise overhead, they don't look up. They know it's us."—**Gen. David L. Goldfein, USAF Chief of Staff, airforcetimes.com, Sept. 18.**

### Crystal

"I ... sent a note to Qasem Soleimani [commander of Iran's Quds Force]. I sent it because he had indicated that forces under his control might, in fact, threaten US forces in Iraq. ... What we were communicating to him in that letter is that we would hold him and Iran accountable for any attacks on American interests in Iraq by forces under his control. We wanted to make sure he and Iranian leadership understood that in a way that was crystal clear."—**CIA Director Michael Pompeo, Reagan National Defense Forum, Dec. 2.**

### Lead or Die

"Rapid advances in artificial intelligence—and the vastly improved autonomous systems and operations they will enable—are pointing toward new and more novel warfighting applications involving human-machine collaboration and combat teaming. These new applications will be the primary drivers of an emerging military-technical revolution. [The US] can either lead the coming revolution, or fall victim to it."—**Robert O. Work, former Deputy Secretary of Defense, Washington Post, Dec. 3.**

### Lost in Space

"To attack a satellite probably does not require nation-state space capability. Due to cost saving measures, the command and control channel to the satellite is unencrypted. The security is little more than a password. To hack such a system would require sophisticated and proprietary equipment, although with today's Digital Signal Processing systems, it is becoming trivial. By the time it was noticed that a bird was put into a spin of death, the fuel is shot, there is very little fuel, ... and there's a \$75 million dollar paperweight spinning in space."—**Stephen Northcutt, SANS Technology Institute, Los Angeles Times, Nov. 13.**

### Legal and Illegal

"Some people think we're stupid. We're not stupid people. We think about [use of nuclear weapons] a lot. ... If you execute an unlawful order, you will go to jail. It applies to nuclear weapons. ... I provide advice to the President. He'll tell me what to do and, if it's illegal, guess

what's going to happen? I'm going to say, 'Mr. President, it's illegal.' And guess what he's going to do? He's going to say, 'What would be legal?' And we'll come up with options and a mix of capabilities to respond to whatever the situation is. That's the way it works."—**USAF Gen. John E. Hyten, head of US Strategic Command, Halifax International Security Forum, Nov. 18.**

### Root and Branch

"It [creation of a separate Space Corps] is going to happen. It's inevitable. ... By segregating those space professionals in the Air Force into a separate organization, segregating the resources, [with] an educational system for space professionals, we can develop a culture that focuses on the No. 1 mission, which is space dominance. ... We are going to have to rip this out by the roots."—**Rep. Michael D. Rogers (R-Ala.), House Armed Services Strategic Forces subcommittee, Reagan National Defense Forum, Dec. 2.**

### Game Changer?

"[The US has] developed a sustained air interdiction campaign and, for the first time in this war, a counter-threat revenue campaign. Using airpower, we have been able to target the Taliban in their so-called safe zones, command and control nodes, illicit revenue-generating ventures, and their logistical networks .... Keep in mind that this is the first time we have persistently used our airpower in this interdiction role. The Taliban narcotics leadership was absolutely caught off-guard .... The Taliban have never had to face a sustained targeting campaign focused on disrupting their illicit revenue activities. And it's not over. In fact, it's only just begun .... With the air interdiction campaign, we are able to go after the Taliban's support structure .... We're able to go after their weapons cache sites, their revenue generation, and their C2 nodes. All the areas where they thought they were safe and they are no longer so .... That is our new strategy going forward and it's definitely been a game-changer and the Taliban is definitely feeling it."—**USAF Brig. Gen. Lance R. Bunch, chief of future operations in Afghanistan, Kabul news conference, Dec. 12.**



Then-1st Lt. Duston O'Brien, a pilot with the 71st Fighter Training Squadron, boards a T-38 at JB Langley-Eustis, Va.

# GROWING PAINS

Something's Gotta Give.

By Amy McCullough, News Editor

In congressional testimony and speeches over the last few years, senior Air Force leaders have gotten almost rote in their message: USAF is simply too small to do all the missions being asked of it.

Lately, though, the language has become more urgent. Last fall, Air Force Secretary Heather Wilson and Chief of Staff Gen. David L. Goldfein began to

compare the service to a rubber band that's been stretched too far, implying that at some point—possibly quite soon—it's going to break.

In 1991 the Air Force had 134 fighter squadrons; today, it has just 55. “Yet, we are much more active in combat than we were during the Cold War,” said Wilson during an event at the Center for Strategic and International Studies in October. In order to “win any fight at any time ... we have to restore the readiness of the force. That means,

first and foremost, people. We are too small [to do what] the nation expects us to perform.”

In recent years, budget constraints have pushed the Air Force to make a priority of capability over capacity leading to a drastic reduction in the service's personnel end strength.

In 2001, there were 357,000 Active Duty airmen, but USAF cut the Active force by 10 percent, leading to an all-time low of 311,357 in 2015, said Col. Dennis A. Haught, the Air Force's chief



MSgt. Alex (full name withheld, in the foreground), an Enlisted Pilot Initial Class student, works with Lt. Col. Aaron, a course director, during a simulator flight at JBSA-Randolph, Texas, in May.

of program development for Manpower, Organization, and Resources.

It didn't take long for senior leaders to realize they'd cut too much, too fast, and that there was nothing to suggest the demand for Air Force capabilities would ease. In Fiscal 2016 the service moved to bring end strength back up to 317,000 Active Duty personnel.

That was the largest increase in accessions since the Vietnam War, Lt. Gen. Darryl Roberson, then-commander of Air Education and Training Command, told *Air Force Magazine*. "That was a really important number for us," said Roberson, because Congress didn't believe the service was capable of growing as quickly as it wanted to and had threatened to withhold funding for future growth if USAF didn't reach the targeted 317,000 airmen in Fiscal 2016.

The goal was met, though, and end strength is still increasing. In Fiscal 2017, USAF grew to 321,000 Active Duty people and is on track to grow to 325,000 in Fiscal 2018. The plan is to have 327,000 Active Duty in Fiscal 2019, toward a goal of about 350,000 in the coming years, Roberson explained.

As more airmen move into the train-

"WE CAN'T AFFORD NOT TO COMPENSATE OUR TALENTED AVIATORS."

—Secretary of the Air Force Heather Wilson

ing pipeline, AETC will have its hands full training them and will have to grow its own ranks to accommodate the surge. For example, AETC added 95 recruiters last year toward a goal of adding between 240 and 250 new recruiters overall to sustain the growth. It will also have to increase the number of instructors at basic military training and at the various technical schools to train the new recruits.

"We're not looking to spike up and come back down. We're trying to build back up and build a more stable and sustainable succession plan for USAF in the long term," asserted Roberson. He added, "That all costs resources. All of this takes a little bit of time and preparation to make it work smoothly."

Though there are shortages across the force, the most urgent need is to boost the number of pilots and maintainers, which most immediately affect combat capability. Other populations that need to grow include intelligence, security

forces, nuclear forces, and cyber communities.

#### NOT JUST THE AIR FORCE

Goldfein and other leaders have called the pilot shortage a "national crisis," and the service is working with commercial airlines, academia, and the rest of the Defense Department to find creative solutions that will help close the gap.

The Air Force closed out Fiscal 2017 about 2,000 Total Force pilots short, including remotely piloted aircraft pilots. About 1,300 are fighter pilots, service leaders said.

"The shortage in our manned platforms continued to grow by about 250 pilots" in FY17, although that loss "was offset by improvements in the health of our RPA force," according to a service spokeswoman.

The biggest shortfall is with fighter pilots, Brig. Gen. Michael G. Koscheski, director of the recently stood up Aircrew



SSgt. Jeffrey Kohler inspects an AIM-120 missile at Shaw AFB, S.C. The pilot shortage gets the headlines, but keeping enough weapons, fuel, and maintenance airmen is an issue for USAF as well.



Capt. Timothy Six, in the cockpit of an F-35, prepares for a weapons system evaluation flight at Hill AFB, Utah.

Crisis Task Force, said. He is concerned that future growth in the airline industry will cause the fighter pilot shortage to infect mobility forces, as well. In fact, the spokeswoman said the “greatest negative trend” between Fiscal 2016 and Fiscal 2017 was “in our bomber and mobility pilots.”

The task force has put together several “tiger teams” looking at all aspects of the problem. It was expected to brief senior Air Force leaders at their top-level Corona meeting in November on its

initial recommendations, but USAF has already started rolling out some solutions.

Though the service can’t compete with commercial airline salaries, it’s trying to ease the financial burden on pilots and their families by raising flight bonuses. USAF is also taking steps to keep pilots doing what they joined to do—fly—instead of sending them to nonflying jobs as they move up in rank.

In June of 2017, the Air Force announced it was increasing the Aviation

Bonus Program, under which aircrew can receive a signing bonus for up to 13 years of service, earning up to \$455,000. That’s a significant bump from the previous maximum total payout of \$225,000.

The service also has increased the monthly aviation incentive pay, commonly referred to as flight pay, for both officer and enlisted aviators for the first time since 1999. Beginning Oct. 1, flight pay increased to a maximum of \$1,000 per month for officers. Enlisted aircrew members also saw an increase, to a maximum of \$600 per month.

“We need to retain our experienced pilots and these are some examples of how we’re working to do that,” said Wilson. “We can’t afford not to compensate our talented aviators at a time when airlines are hiring unprecedented numbers.”

The Air Force is also trying to tap another resource: ex-pilots. In August 2017, the service announced the Voluntary Rated Return to Active Duty (VRRAD) program, which initially allowed up to 25 separated pilots to return to Active Duty for up to 12 months. The goal was to voluntarily bring back retired pilots to fill “critical-rated staff positions,” which would allow current pilots to remain in operational units.

“As you can imagine,” Koscheski observed in October, that program “wasn’t super appealing, being only one year.” The Air Force wanted to expand the authorities, enabling more retired pilots

Photos: A1C Tristin Biese; Joel Martinez/USAF; A1C Sean Sweeney; R. Nial Bradshaw/USAF



Maj. Trevor Cooks mentors cadets at the Utah Military Academy in Riverdale, Utah, for CyberPatriot IX, AFA's annual STEM competition for middle and high school students. The Air Force is looking to expand its cyber and intelligence workforces.

to come back to Active Duty and for a longer period of time. President Donald Trump signed an executive order in October that did just that. Specifically, Trump eliminated the cap on the number of retirees who are able to return to duty and extended the time of service to three years instead of one.

Koscheski said the move “changes the decision calculus,” enabling some recently retired pilots to return to flight status and serve as instructor pilots. However, he acknowledged that if history is any indicator, the service isn’t likely to bring in more than a few hundred retirees. Just before the executive order was announced, between 10-15 pilots had expressed interest in the program and just three were on contract, said Koscheski.

“Each pilot that comes back is one staff position we won’t have to fill for three years, so that helps with requirements,” he added. However, “our long-term fix for the pilot crisis is to grow our way out of this, so it’s going to take awhile to get in place what we need to start producing more pilots.”

On Sept. 7, 2017, the service also

announced the Second Assignment In-Place Pilot Program, which allows a limited number of Active Duty, late-career fighter pilots and weapon system officers to remain at the same base for a second tour. The goal is to improve the quality of life and potentially retain aviators with more than 20 years experience, according to an Air Force release.

“We’re going to break paradigms, go outside of traditional methods of producing Air Force pilots, and look at all options out there on how to solve some of these problems that we’re facing,” said Roberson.

#### MAXING OUT THE PIPELINE

AETC produced 1,100 pilots in 2016 and 1,200 in 2017, Roberson said. He anticipated that number will grow to 1,400 pilots per year in the “next couple of years,” and then top out at 1,600 per year in the future. At that point, Roberson said, “we’re going to have to figure out a way to get at producing pilots that is outside of the resourcing capacity of the United States Air Force.”

For example, the command is looking at universities such as Embry-Riddle

Aeronautical University in Daytona Beach, Fla., where “pilot training is a part of their culture.” Roberson said he’d like to see the Air Force take advantage of such programs, as well as similar programs at companies that train pilots, “to help us train to a certain level.” After earning a few hundred hours in the cockpit at the university, students could enter the Air Force training pipeline.

Because this problem affects the whole country and not just USAF, Roberson said the service is also looking to develop a “national academy for pilot production.” This would involve partnering with the airlines “in a way we have haven’t done before.” Under one concept, students who graduated from the national academy would serve a certain number of years in the military, but then be guaranteed a civilian flying position after that.

There isn’t a silver bullet, single-point solution to the problem, though.

“It’s going to be 100 little things. It’s going to be a journey we’re going to be on for the next 10 years,” said Goldfein at a Heritage Foundation event in Washington, D.C., last April.



Family and friends greet airmen returning from a deployment to Southwest Asia last November at McLaughlin ANGB, W. Va.

## MIND THE MAINTAINER GAP

Before the fighter pilot shortage stole the national spotlight, USAF's focus was on a critical shortfall of maintainers. At one point, the Air Force was short some 4,000 maintainers as it worked to bring the fifth generation F-35 strike fighter online while still maintaining legacy aircraft it once hoped to divest, such as the A-10 and U-2.

Because of the increase in end strength over the last couple of years, Roberson said USAF has "come a long way" and is "definitely closing the gap" in maintenance manpower. The biggest challenge now is experience. It takes time to train all the new maintainers coming into the service, which is placing a heavier burden on the more experienced maintainers.

"They are now having to take more on their backs to make sure these young, larger numbers of maintainers are getting the [on the job training] they need to become the maintainers we need them to be down the road,"

said Roberson. "It stresses the whole system, but we're closing the gap."

The Air Force is scrambling to fill the ranks of its cyber specialists, whose expertise is urgently needed as cyber attacks and cyber crimes skyrocket.

Haught said, "There is a lot of movement in the cyber realm" and the service has grown in response, but the "end-game target" is still not quite clear.

One thing that's certain is the service will have to change how it trains in order to recruit the right kind of talent. Roberson tells a story about a Microsoft executive who wanted to join the Air Force and serve his country. Because the Air Force doesn't have any type of "gifted and talented" program, the service was going to start his training on Day One as if he knew nothing about cyber.

"That was one of those cases where we had to take a step back and say, 'What are we doing?'" said Roberson. "We need more flexibility. ... We have to be more agile."

Roberson did not name the Microsoft executive, though he did say he is now

an "Air Force cyber warrior," and that the service was "able to accommodate [him] based on his talents." He said such flexibility could filter down to other career fields, though that hasn't happened yet. That's a huge part of what AETC's new "Continuum of Learning" initiative is all about.

"The Continuum of Learning is a way of describing our deliberate effort of taking training and education and combining them with experiences," Roberson said at AFA's Air, Space & Cyber Conference last September, where he unveiled the overhauled training concept. "We have to do a better job to transform what we've been doing for the last 70 years—from a pipeline, industrial-age kind of production system—into a much more modern learning system."

There's little time to figure it out, though. Those new recruits are already showing up for duty, and the Air Force will have to show Congress it can use every person to maximum benefits or the long hoped-for growth may stop abruptly. 

Photos: Paul Holcomb/USAF; Capt. Hollie Nelson/ANG



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# Replacing Minuteman

The Air Force is finally moving forward with a program to develop a next generation ICBM.

By Wilson Brissett, Senior Editor

**T**he Air Force's effort to field a next generation intercontinental ballistic missile (ICBM) system has renewed energy, as the service announced in August the award of two contracts for technology maturation and risk reduction (TMRR) work.

The contracts, to Boeing and Northrop Grumman, pave the way for replacing the Minuteman III with what is being called the Ground-Based Strategic Deterrent (GBSD). One of the two will be chosen in 2020 to build the system, and the service's Nuclear Weapons Center at Kirtland AFB, N.M.,

is working hard to keep the program on time and within budget.

It's a tough challenge, since the next ICBM needs to last until 2075 and must be able to adapt to decades' worth of evolving threats. Success will require a smart acquisition strategy and intelligent system design.

The Minuteman III replacement program hasn't always enjoyed this kind of momentum. Within the bow wave of modernization programs the Air Force is funding—a large slate of new fight-



An artist's illustration depicting a USAF crew working in a modern control room for the GBSD program.



An artist's illustration of Boeing's proposed Ground Based Strategic Deterrent missile, intended to replace USAF's Minuteman III ICBMs.



Two Minuteman III missiles are launched from Vandenberg AFB, Calif., seconds apart during a SAC readiness exercise in 1979.

ers, bombers, space systems, and surveillance platforms—recapitalizing nuclear ICBM and bomber weapon systems has repeatedly been delayed or deferred.

The new ICBM system will be very expensive. Replacing Minuteman alone could cost as much as \$85 billion for research and development, procurement, and military construction. With budget shortfalls pressing the Department of Defense from every direction, upgrading the nation's nuclear weapons is "the one place where we can save money the most clearly," said Rep. Adam Smith (D-Wash.), the ranking member of the House Armed Services Committee, in July.

In a post-Cold War world, policymakers have also questioned the need to maintain a triad of air-, sea- and ground-launched nuclear weapons. To some it seems like overkill. "A more focused strategy" could create a credible deterrent while reducing the nuclear arsenal, said Smith. "Personally, I think we need to look at whether or not the triad still makes sense. Do we need the ICBMs?"

"I THINK WE NEED TO LOOK AT WHETHER OR NOT THE TRIAD STILL MAKES SENSE. DO WE NEED THE ICBMS?"

Rep. Adam Smith (D-Wash.)

The Pentagon and Air Force leadership answer yes emphatically. In March, Vice Chairman of the Joint Chiefs of Staff, Gen. Paul J. Selva, told Congress that "there is no higher priority for the joint force" than the effort to "modernize all three legs of the triad."

All of those systems have been stretched "well beyond their designed service life," US Strategic Command boss Gen. John E. Hyten said at the same hearing, noting that the average age of a US nuclear warhead is 26 years. After a decade of uncertainty, and despite the continuing questions, the GBSD and B-21 Raider next generation programs now appear to be on their strongest footing yet.

Congress must act to modernize this capability "with urgency," Selva

warned, because "nuclear weapons pose the only existential threat to the United States."

Hyten agreed. "When I look at each element" of the triad, "we cannot slow them down," he told the audience at an AFA Mitchell Institute for Aerospace Studies event in June, insisting, "We actually need to accelerate them, not decelerate them."

In the 1960s, he pointed out, USAF built the Minuteman I in five years, and at a cost of \$17 billion in today's dollars. At AFA's Air, Space & Cyber Conference in September, Hyten said there's no reason why the service couldn't achieve similar results with GBSD. The key, he said, would be developing "simple requirements" that don't change over the life of the pro-

Photos: illustration/Northrop Grumman; illustration/Boeing; SSgt. John Marine

gram and making sure the program director is “given the authority and responsibility to execute that program” without excessive bureaucratic oversight. Finally, GBSB will require a stable annual budget to keep the program on track, Hyten said. Given that the federal government has run on 31 continuing resolutions over nine of the last 10 years, the lack of a stable, predictable budget may be the most difficult aspect of the program.

### KEEP IT SIMPLE, STUPID

Building a new ICBM system is a highly complex and technical endeavor, and the Air Force rarely misses an opportunity to remind the public that it’s more than rocket science. Besides the missiles themselves, there are launch facilities, command and control networks, nuclear warheads, and thousands of miles of copper wiring to keep the weapons connected over the vast distances of Wyoming, Montana, and North Dakota. Replacing or refreshing all of these components presents the mother of all systems engineering challenges.

Air Force GBSB program manager Col. Heath Collins insists on keeping simplicity as the No. 1 goal for his team. “We’re a program that is not looking to push the technology bounds,” he told *Air Force Magazine*. “There’s no technology miracles that have to happen for GBSB. It really is an integration program.”

From guidance systems to propulsion and software, “today’s technology, integrated and implemented in GBSB, can meet our requirements,” Collins said.

Collins believes that acquisition efforts run into schedule and cost problems primarily when managers depend too heavily on “technical miracles ... that need to happen for the program to be successful.” He learned this lesson working in space acquisition. Before taking the GBSB lead in February of 2016, Collins was a troubleshooter on programs like the Space Based Infrared System (SBIRS), which saw cost overruns of nearly 300 percent and arrived almost nine years late. To avoid a similar fate for GBSB, Collins said, “Our foundation is a low-risk, mature technology program.”

Another key to keeping costs low over the lifespan of the program is for the service to “own the tech baseline,” he said. With recent satellite programs, as with the Minuteman service life ex-



**SSgt. Stephen Kravitsky inspects a Minuteman III missile inside a silo near Grand Forks AFB, N.D., in 1989.**

tension programs (SLEP) in the 1990s, “a lot of authority and control was given” to the prime contractor, Collins said. When the government yields data rights and the technology baseline to contractors, it becomes much more difficult to maintain competition “throughout the life cycle of the program,” according to Collins.

The GBSB must not only have “a very firm requirements baseline, that we’ve spent a lot of time to mature,” stated Collins, but he and his team

have worked hard to develop “a very detailed own-the-tech baseline strategy and data rights strategy ... to make sure we ... get the best value for the government.”

No matter how simple and firm the system requirements for GBSB remain, the Air Force’s expectation that the weapon will need to be operational for nearly five decades means the new ICBM must be able to evolve to meet unknown future threats. The service’s fundamental approach to this problem



A1C William Ray removes the screws holding the Minuteman III nose point to the rest of the re-entry system while aboard a payload transporter in the F.E. Warren AFB, Wyo., missile complex in 2016.

is to build a modular system that can accommodate maximum change with minimum cost and effort.

Modularity starts with digital modeling design. For all its reliability, Minuteman III is not particularly agile, and that truth is reflected at the design level, which required “thousands of pages of blueprints,” Collins said. Both Boeing and Northrop Grumman are using computer-based 3D modeling to explore potential designs well in advance of prototyping. This process makes early design changes more efficient and less costly.

At the heart of modularity, however, is the creation of an open-systems architecture. Implementing “open standards and open designs” means that program officials can “make modifications or changes as you go forward on the program,” Collins said. Again, the contrast with Minuteman is instructive.

Minuteman III is “a very tightly coupled, integrated system,” Collins said, which means that “if you wanted to change something in the guidance system, you would actually have to change pieces and parts on the missile” and

then make changes to the “hardware and software on the ground too.” Some of these upgrades could become very labor-intensive (and therefore expensive) as well, because of the need to open launch facility doors or partially remove the missile from its silo in order to make the changes.

GBSD will have “very set, modular components that are built around a standard,” Collins said, so that a guidance system upgrade will be as easy as switching “a component we can change in and out very quickly.” The same could be true of a new re-entry vehicle or updated cyber capability or almost any part of the system. Modularity means “we can much more effectively and cost-efficiently make changes ... based on evolving threats, based on evolving capability needs, based on evolving technology,” Collins explained.

### **GETTING AHEAD OF THE COST CURVE**

Over the coming year, the Air Force will have initial opportunities to control GBSD costs. Cost has been a controversial subject already with this program, in

part because the US has not built a new ICBM system since Peacekeeper was developed in the early 1980s. In 2016, the Air Force estimated the program would cost \$62.3 billion for GBSD missiles—400 for deployment and the rest to make up a test-launch stockpile. But the DOD’s Cost-Assessment and Program Evaluation (CAPE) office later said GBSD would cost closer to \$85 billion.

CAPE said the more than \$20 billion difference was “driven by the selection of data sources.” The Air Force estimate relies on the Minuteman and Peacekeeper programs, whereas CAPE incorporated more recent evidence from the Navy’s Trident II and the Missile Defense Agency’s Ground Based Interceptor programs. With either method, CAPE concluded, “it was unusually difficult to estimate the cost of a new ICBM program because there was no recent data to draw upon.” As a result, any attempt to anticipate the cost of GBSD brings “considerable uncertainty and risk” along with it.

Collins said that more clarity on the cost of the program is not far away. Within nine months from the TMRR



2nd Lt. Nikolas Ramos (l) and 1st Lt. Terrence Dale Duarte work at a control console inside a launch control facility at F.E. Warren AFB, Wyo., in 2016.

awards, the program office will hold “cost capability technical interchange meetings” with Boeing and Northrop Grumman. The purpose of these meetings is to identify cost-capability tradeoffs in order to highlight key efficiencies for the GBSB system.

The Air Force team will be working with the contractors to find “the big cost drivers in the program from a requirements perspective,” and to outline “potential savings that could be had,” Collins noted. For example, a five percent reduction in some requirements might translate to “really huge cost savings.” These tradeoffs could include “range or ability to penetrate any of those major requirements,” Collins said.

The data from that review should be available by May of 2018. Collins’ task will then be to work with Air Force Global Strike Command, in coordination with US Strategic Command, to work out adjustments to the program that will preserve core capability while shaving cost where possible. Beyond these core capabilities, which are approved by the Joint Requirements Oversight Council, there is room to find “the knees in the curve where you start paying too much

for the incremental increase in capability,” he said.

One decision that’s already been made is to reuse the existing Minuteman launch facilities for the new missiles. An Air Force analysis of alternatives determined that “to generate and build 450 new silos was very cost prohibitive,” Collins said. His team is analyzing the concrete in the existing silos and has concluded so far that “those are still solid launch facilities.” Collins said this decision doesn’t bring with it any technical limitations. “They were big enough for whatever GBSB needed to be and to refurbish them was much more cost-effective.”

The contractors are pleased with the Air Force’s handling of the program thus far. The service “drove through evaluations and [TMRR] awards ahead of schedule,” Frank McCall, head of strategic deterrence at Boeing, told *Air Force Magazine*. He also said he expects clarity and consistency as the service drills down to the next level of detail at the systems requirements review.

As to whether the impressive speed and affordability of Minuteman can be repeated on GBSB, McCall said, “our

current acquisition plan doesn’t have that same kind of time line.” He allowed that “it could be accelerated perhaps from where it is, but that’s a decision that we as a nation need to make.” Crossing that Rubicon would mean, at least, committing to “continuity of purpose”—having the sustained national will to modernize the strategic deterrent, so it can continue to credibly hold diverse and evolving threats at risk.

Presumably, continuity of purpose includes having lawmakers consistently pass federal budgets and for them to include sufficient funding for GBSB and related defense programs. The Minuteman replacement can succeed under a shadow of inconsistent and uncertain budgets, but it will take longer to deliver that way, and will ultimately cost the nation more for the same capability.

“We hear General Hyten,” when he talks about going faster and doing it more cheaply, Collins said. “We absolutely want to deliver GBSB as quickly and efficiently and affordably as we can, and our industry partners agree.”

Perhaps the most important question, then, is what Congress thinks, and what it is willing to do. ❖

Photos: SrA. Bradon Valle; SSgt. Christopher Ruano

★ SCREENSHOT





12.13.2017

A California ANG C-130J equipped with the Modular Airborne Fire-Fighting System (MAFFS) drops Phos-Chek flame suppressant on the massive Thomas Fire in the hills above Santa Barbara, Calif.

# COMPASS CALL AND RESPONSE



**Electronic warfare isn't going away—but EC-130Hs will.**

Brian W. Everstine, Senior Editor

**T**ransplanting the innards of the Air Force's Compass Call electronic warfare aircraft to a new host platform is finally underway, after an exhausting prelude of protests, congressional interference, and public criticism of USAF's acquisition strategy on the project.

On Sept. 7, 2017, USAF awarded the first contract action to L3 Technologies to begin removing critical equipment from the aged EC-130H fleet for installation on fresh Gulfstream G550 business jets. The small, 14-aircraft EC-130H fleet has been flying since 1981—and near-constantly in the Afghanistan, Iraq, and Syrian conflicts, because of the unique capability it offers in communications jamming and electronic attack. It has been a key element in the fight against ISIS, an adversary that has adapted high technology to its tactics and strategy.

While USAF has struggled to rehost the Compass Call mission, the EC-130Hs have soldiered on. They deny "time-critical" enemy coordination in ongoing combat, according to Air Forces Central Command.

The EC-130Hs deployed for Operation Inherent Resolve have an autonomous electronic attack capability

An EC-130H Compass Call taxis at an undisclosed location in Southwest Asia. The aircraft type has been flying nonstop in the region for more than 15 years.



An artist's concept of a Gulfstream G550 in Compass Call configuration. Critical equipment from the aging EC-130H fleet will be installed on the business jets.

that can't be matched by any other aircraft. The airplane carries a team of linguists who monitor ISIS communications, while electronic warfare officers use the aircraft's electronic attack weapons system to target and block communications when needed.

The aircraft help prevent "the information from getting to the boss" and "prevents the boss from ever being able to direct his forces," Capt. Tim West, director of operations for the 43rd Expeditionary Electronic

Combat Squadron, recently told *Air Force Magazine*.

"We are inducing massive confusion and friction into their operations that make them ineffective as a fighting force," Lt. Col. Josh Koslov, 43rd Expeditionary Attack Squadron commander, said in an Air Force news release.

Because the mission has been both crucial and ever-changing, the electronic gear on the Compass Call has been constantly refreshed in recent years.



An Israeli Air Force tanker refuels a G550 airborne early warning aircraft during an Independence Day flight over Israel.

So while the EC-130Hs are largely worn out, their equipment does not need to be replaced. That's why the Air Force came up with the idea of "cross-decking," taking the equipment from the old airplane and putting it on a new one.

The final decision to cross-deck equipment from the EC-130Hs to the new bizjets was made because it could be done "quicker than we could any other way, getting a critical need to address something out in the future—a threat that is evolving," said Lt. Gen. Arnold W. Bunch Jr., USAF's top uniformed acquisition official, speaking with lawmakers last May.

In awarding the project to L3, the Air Force let the company pick the aircraft it deemed best-suited to carry the electronic warfare gear.

USAF's acquisition strategy ignited multiple protests, spurring a Government Accountability Office review that dragged throughout 2017.

### PREMATURE RETIREMENT

The Air Force took its first major step to shed the old EC-130H airframes in 2014. It was then that the service proposed a plan to Congress to retire the existing Compass Call fleet outright. This was in response to what USAF described as budget constraints and evolving worldwide threats that would

## THE FLEET REQUIRES "UNIQUE SPECIALIZED" MAINTENANCE SUPPORT DOWNRANGE.

—Lt. Col. Matthew Cunningham, EC-130H aircraft commander

reduce future effectiveness of the fleet.

This step faced immediate and strident congressional opposition, especially from Arizona lawmakers with constituencies near Davis-Monthan AFB, Ariz., where the Compass Call fleet is based. The move was stymied.

In the Fiscal 2016 National Defense Authorization Act, lawmakers called on the Air Force to submit an explanation for retiring the Compass Call, specifically calling on the service to outline how it might transfer the perfectly good mission equipment to another platform.

While it pondered this direction from Capitol Hill, USAF took a formal step in October 2015, releasing a request for information to industry. It wanted to know if aircraft manufacturers could provide a commercial derivative aircraft that could carry the the Compass Call system and meet all mission requirements.

Industrial competitors replied that the switchover could be done. The responders included Boeing, offering its

737 aircraft, Bombardier pitched its Global 6000, and Gulfstream proposed its G550 jet.

These aircraft became the candidates for cross-decking, which involves removing the antenna array components from the prop-driven EC-130Hs and installing them on each side of a new jet in "cheek" blisters. The Compass Call avionics, wiring, operator consoles, power supplies, and other equipment would then be removed from the EC-130H, installed on the new platform, and flight tested.

The Air Force notified Congress in April 2016 that Gulfstream's offering was "the only one on the market that meets size, weight, power, cooling, aperture, and performance requirements and does not require development and/or certification work that would prevent meeting schedule needs."

About four months later, USAF issued a classified "justification and approval" authorizing a sole-source award to L3

Photos: TSgt. Jonathan Hehnl; Gulfstream illustration Zigi



A1C Chase Krol completes a postflight inspection on an EC-130H Compass Call at Bagram Airfield, Afghanistan.

Communications for the cross-deck process.

L3 has been the sole company providing maintenance and integration on the current EC-130 fleet for the past 15 years, and the Air Force claimed because of national security interests and the classification of the equipment, L3 needed to be the company doing the work.

“L3 has played the role of systems integrator as we’ve modernized these aircraft over the last 15 years,” Bunch said. “They are the ones that are very familiar with the mission equipment that’s on there. That mission equipment is highly classified to be able to execute the electronic warfare mission we ask that platform to do. They have all the tooling, they have all the existing knowledge, and they have all the modeling and all the information they need to do that work.”

L3 was the only company capable of performing the “critical function” of selecting, “based on market research, the aircraft subsystem and perform the mission equipment integration effort,” an Air Force spokeswoman told *Air Force Magazine*.

Congress blessed the program in the Fiscal 2017 National Defense Authorization Act, giving the Air Force permission to “carry out a program” transferring primary mission equipment from an EC-130 to an “aircraft platform” that the service deemed “more operationally effective and survivable” than the current C-130 platform.

The Air Force had already told Congress that the G550 was the only airplane meeting its requirements, even before a contract was awarded.

After Congress green-lighted the plan for Fiscal 2017, Bombardier filed a protest with the Government Accountability Office last February, claiming the sole-source award, the classified justification, and the approval process were improper and claimed L3’s choice of the Gulfstream jet at USAF’s urging was inappropriate. The Bombardier protest was dismissed as premature by the GAO because there hadn’t been a formal solicitation.

## MOUNTING PROTESTS

The formal solicitation came in May, as the Air Force called on L3 for a proposal backing the definitization of a sole-source contract. The statement of work for the contract called on L3 to deliver one rehosted aircraft and provide a “comprehensive analysis” supporting its choice of aircraft and subcontractor.

Eleven days later, Boeing filed its own



SrA. Whitney Orgass, a cryptological language analyst, works aboard a Compass Call out of Bagram Airfield, Afghanistan.

protest with the GAO, claiming it could both do the cross-decking work and provide a 737 to meet the requirements.

“We believe that the US Air Force and taxpayer would be best served by a fair and open competition, and that the Air Force can still meet its stated time line of replacing the aging fleet of EC-130Hs within 10 years,” Boeing spokeswoman Caroline Hucheson said at the time.

Bombardier filed a protest too, on May 26, claiming its Global 6000 could meet the requirements, but it did not claim it could do the integration work.

The main claim in the protests was that the Air Force was telling L3 to pick Gulfstream for the subcontract award without a valid basis. The companies also claimed that the award violated the law, violated a prohibition on the award of contracts for governmental functions, and that the proposed award was a prohibited lead systems integrator contract.

Lastly, Boeing, in its protest, also claimed it could perform the rehost work and that a sole-source award is improper because of an unmitigable conflict of interest arising from the relationship between L3 and Gulfstream. The two companies are already working together,

along with Northrop Grumman, on the Air Force’s Joint Surveillance Target Attack Radar System (JSTARS) recapitalization, and the two companies work together on G550-based systems for foreign militaries.

In April, L3 CEO Michael Strianese shrugged off Boeing’s claim. In a first quarter conference call with investors, he said no decision had been made on the aircraft saying, “it could be a 737. It could be one of multiple business jets.”

After three months, the GAO made its decision—rendered secretly at first. In a 22-page justification, the agency rejected all the claims from both Boeing and Bombardier.

The claim that the Air Force directed L3 to choose Gulfstream was rejected because, although the service said the G550 was the only aircraft that could meet its requirements, the GAO stated that the award didn’t specify any specific aircraft for the award. The sole-source award didn’t violate the 2017 authorization act because the law didn’t require USAF to conduct its procurement in the way alleged by the companies.

The GAO stated the sole-source award didn’t meet the definition of a prohibited

contract for services or the definition of a prohibited contract for lead systems integration. The GAO also denied Boeing’s claims because the company didn’t demonstrate that the justification and approval was unreasonable, and the company failed to demonstrate a conflict of interest regarding L3 and Gulfstream.

## STEP ON IT

The Air Force moved quickly after the GAO auditors rendered their findings, awarding on Sept. 7, 2017, the undefinitized contract action to L3 to move equipment from the EC-130H Compass Call. The program also got a name: EC-X.

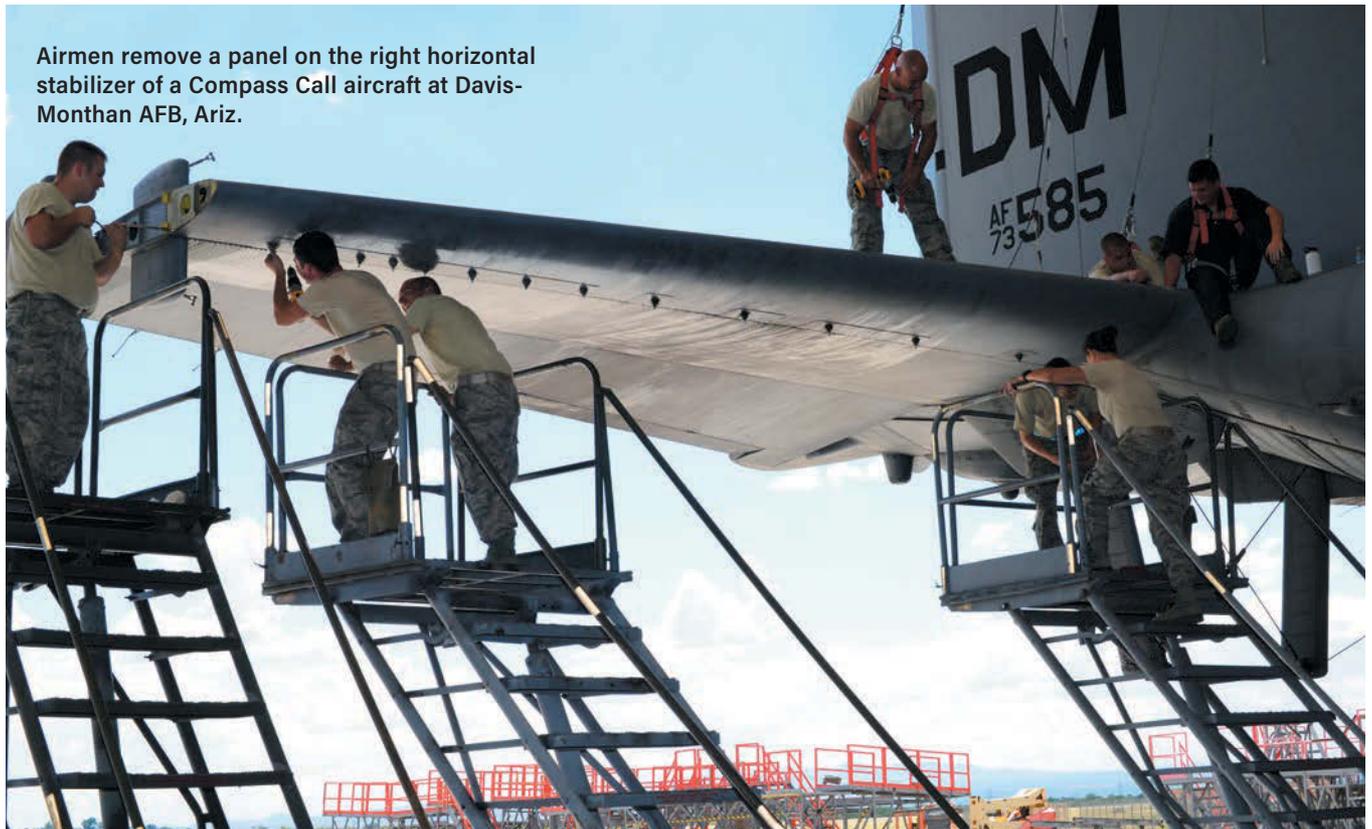
Then, in a long-expected move, L3 decided on the Gulfstream platform.

“After their analysis and sharing that with the program office, L3 has decided to use the Gulfstream G550 Airborne Early Warning aircraft as the new platform,” the Air Force said in a statement announcing the contract.

Things moved rapidly after that. A preliminary design review was completed in late September, only a few weeks after the GAO decision.

The EC-X is not the first use of the

Airmen remove a panel on the right horizontal stabilizer of a Compass Call aircraft at Davis-Monthan AFB, Ariz.



Gulfstream G550 by the Air Force. The type is currently flown by USAF as the basis of the C-37B used for VIP transport.

Northrop Grumman also chose the G550 as the mount for its version of the proposed JSTARS recap, which would adapt the jet to provide ground moving target indication. While a speedy replacement of the existing E-8C JSTARS fleet is USAF's preferred outcome, the service does not plan to simply cross-deck equipment from those aircraft to whatever airplane is chosen for the new JSTARS. In that contest, Boeing is also offering an adaptation of its 737, and Lockheed Martin's version would ride on the Global Express business jet.

While the Compass Call replacement acquisition program moves forward, the Air Force is pressing to keep its current fleet modern and capable. In 2016, the service kicked off a \$45 million upgrade called the "avionic viability program" that keeps the fleet in line with Federal Aviation Administration and international regulations on flight information and provides a "glass" liquid crystal display information suite in the cockpit.

The upgrade, which is ongoing, helps "increase the pilot's situational awareness tenfold," said Maj. Gerardo Sanchez, the assistant director of operations for the 42nd Electronic Combat Squadron, when the program began installation in August 2016.

## Crunching the Hours

The Air Force is pressing forward on a time line to recapitalize its Compass Call fleet while reducing the impact on current operations as much as possible.

The service has 14 EC-130Hs and plans to buy a fleet of just 10 G550 replacements, known as EC-X for now. To mitigate impact on operations, the service plans to buy one new aircraft per year until 2029 when recapitalization is planned to be complete. The cross-decking process will happen one at a time, when a Compass Call EC-130H is scheduled to enter depot maintenance.

The Air Force has not announced a concrete plan for basing and operations for the new aircraft. The current Compass Call fleet calls Davis-Monthan AFB, Ariz., home. The solicitation for the next-generation aircraft calls for one operating base in the continental United States, with a "set of user-verified and published" operations and maintenance procedures.

The current fleet has a 13-member team, which includes front-end aircrew, linguists, and electronic warfare officers operating the aircraft's electronic attack weapons system. The solicitation for the new aircraft calls for two flight aircrew along with a minimum of five mission crew members.

The fleet is still showing its age, which is reflected in its availability. In 2015, as Operation Inherent Resolve hit a high operations tempo, the EC-130H fleet had just a 72 percent mission capable rate—more than a quarter of the aircraft were not available for operations. The fleet requires "unique and specialized" maintenance support downrange, with specialized maintainers from Davis-Monthan deploying alongside the aircrews to try to keep the aircraft flying.

"We do not fly our mission without our maintainers dedication and effort,"

said Lt. Col. Matthew Cunningham, an EC-130 aircraft commander, in an August 2017 release about the Compass Call's current operations.

In Afghanistan, the deployed EC-130 crews hit a 27-month record high for mission capability of 96.5 percent in November 2016. That crew, from the 455th Expeditionary Aircraft Maintenance Squadron, had 146 deployments among them. EC-130Hs there have been deployed nonstop since 2002, the longest continuously deployed Air Force unit in the Afghanistan war. ✪

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# LIFE ON THE LINE

**USAF is probably buying fewer aircraft than you think. Here's a look at what's actually in a hot production line.**



Photo: Randy Crites/Lockheed Martin

Lockheed Martin's F-35 line in Fort Worth, Texas, is the largest military aircraft production facility in the world. It is frequently updated to incorporate more efficient materials and processes.

By Brian W. Everstine, Pentagon Editor

America's military technology depends not just on the science of new technologies, but the ability to turn those breakthroughs into practical hardware.

The story of the "Arsenal of Democracy" runs from Rosie the Riveter and the gargantuan production plants of World War II to the heavily guarded desert factories where the Air Force's most secret systems are sometimes hand-built to fulfill exacting missions. From massive, robot-assisted assembly operations to small companies with a few dozen workers, production lines are the Air Force's lifeblood.

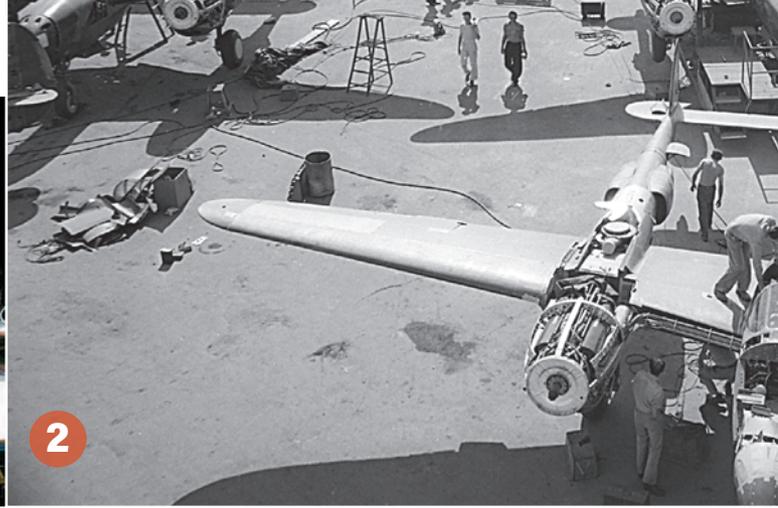
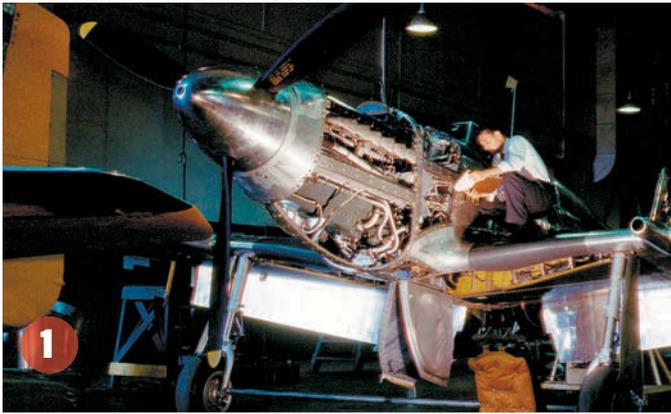
The service is ramping up production of munitions after half a decade of using them up faster than it builds them and

embarking on a modernization binge after decades of having key programs canceled or postponed.

If all goes as planned, a bevy of new fighters, tankers, bombers, trainers, and surveillance aircraft will start entering service in the next few years, although the production surge won't come close to the levels seen during the so-called "Reagan buildup" of the 1980s, when F-16 fighters were built at rates exceeding 200 a year.

### THE GREEN MILE

Lockheed Martin's mile-long production line in Fort Worth, Texas, employs about 8,800 people who work on the F-35 Joint



Strike Fighter. The famous plant—operated by predecessor entities such as Consolidated, Convair, and General Dynamics—has produced B-24 and B-58 bombers, F-106s and F-111s, among others. The last factory-fresh F-16 left the plant in December 2017, after more than 40 years of Viper production. The F-16 line will be moved to Greenville, S.C., and foreign locations to make more room for the burgeoning F-35 line.

It takes about 22 months to build an F-35, and production is slated to increase rapidly, as the plant builds jets for USAF, the Navy, Marine Corps, eight partner nations, and at least four foreign customer nations.

Last July, the Pentagon announced its 11th contract for low-rate initial production of the fifth generation fighter. The \$5.6 billion contract modification covered 48 F-35A variants for the Air Force, along with 18 F-35Bs for the US Marine Corps, and eight F-35Cs for the US Navy. In Fiscal 2018, the Air Force is requesting 46 more F-35As, aiming to get to 60 per year early in the next decade. USAF wants 1,763 F-35As in all.

The program has two more production lines globally. Europe's F-35 final assembly and checkout (FACO) facility is in Cameri, Italy, where Lockheed expects more than 6,300 people to work at peak production. The first jet rolled off the Italian line last March.

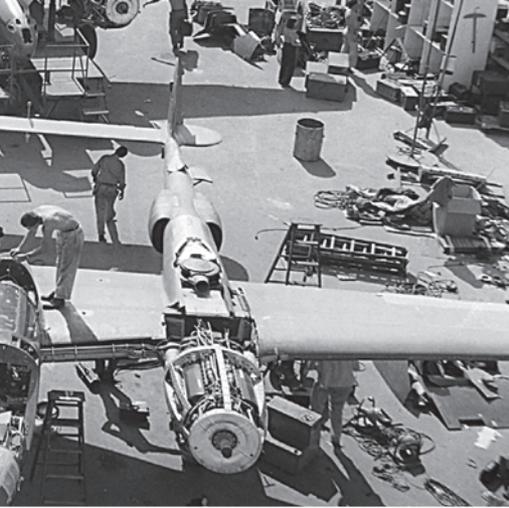
Another FACO is located in Nagoya, Japan, operated by Lockheed partner Mitsubishi Heavy Industries. At least 38 F-35s will be built there; the first Japan Air Self Defense Force F-35 rolled out last July.

## BUILD 'EM BIG

The world's largest building, by volume, sits on Boeing property in Everett, Wash. The 98.7-acre facility houses production



1/ An early P-51 Mustang is assembled at the North American Aviation plant in Los Angeles in 1942. 2/ Due to the limited space indoors, P-38 Lightnings were finished on the flight line in World War II. 3/ Workers build an SR-71 Blackbird reconnaissance aircraft at Lockheed Martin's Skunk Works facility in Burbank, Calif., in 1965. 4/ Pratt & Whitney F135 engines for the F-35 strike fighter roll down the production line in West Palm Beach, Fla. 5/ The Lockheed Martin facility in Fort Worth, Texas, is over a mile long. 6/ F-35s on the assembly line in Fort Worth. 7/ A completed KC-46 Pegasus tanker receives a coat of paint at Boeing's Everett, Wash., factory. 8/ Workers install a refueling boom on a USAF KC-46 at the Boeing factory.



Photos: Alfred Palmer/Library of Congress; Lockheed Martin; CIA; Rick Koehler/Pratt & Whitney; Neal Chapman/Lockheed Martin; Alexander Groves/Lockheed Martin; Boeing (7, 8)



for the company's civilian airliners and the Air Force's new tanker, the KC-46A Pegasus.

The tanker has suffered development delays but production is beginning to ramp up. The jet is adapted from the company's 767-200ER airliner-cargo jet.

Boeing was cleared for Pegasus production in August 2016. As of October 2017, six of 24 aircraft on contract were flying and undergoing tests. The service plans to field at least 179 KC-46s, with the first operational model coming early in 2018. Boeing had previously committed to 18 tankers being delivered by that time.

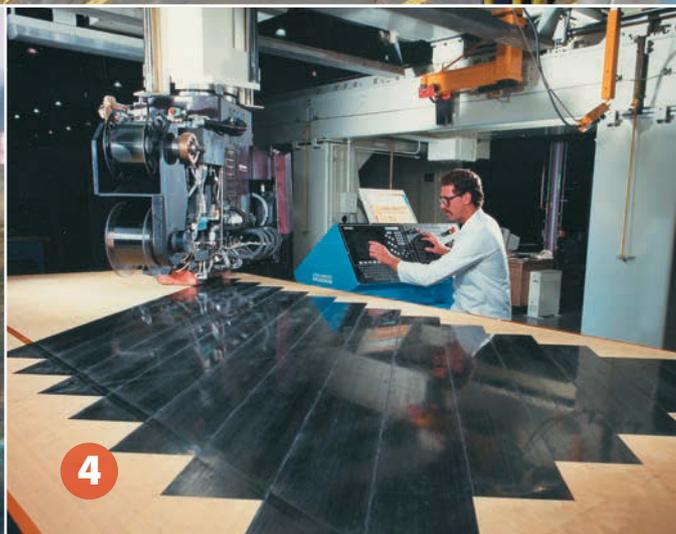
### BLACK JETS

Air Force Plant 42, north of Los Angeles in Palmdale, Calif., hosts several big contractors, all doing "special access" work. Lockheed Martin refurbishes U-2 intelligence, surveillance, and reconnaissance aircraft at its facility there, and Northrop Grumman seems to be organizing space at its portion of the sprawling plant for manufacture of the still-secret B-21 Raider stealth bomber. The B-2 Spirit stealth bomber was built in Palmdale and receives its depot maintenance there, as well.

Northrop was up to 3,000 workers at the Palmdale facility last fall, adding more at a steady clip, the *Los Angeles Times* reported. By 2019, the company expects to have 5,200 employees working on the Raider and other aircraft in Palmdale, wrote the *Times*.

Production is just beginning on the bomber. Much of its funding remains secret and the Air Force has said only that it will build "at least" 100 of the jets. The program has passed its preliminary design review, and drawings are now going





1/ A C-130J Super Hercules aircraft at Lockheed's production facility in Marietta, Ga. 2/ Two USAF KC-46 Pegasus tankers on the assembly line at Boeing's factory in Washington. The new aerial tanker can refuel all compatible US, allied, and coalition aircraft. It can also carry cargo and passengers. 3/ First flight for the last Raptor. The last production F-22 takes off on its first test flight at the Marietta facility on March 14, 2012. 4/ A Lockheed Martin technician cuts strips of thermoplastic-resin composites for an F-22 aircraft panel. The material allows airframes to be lighter than those built from metal.

Photos: Lockheed Martin; Boeing; Thinh Nguyen/Lockheed Martin; Eric Schulzinger/Lockheed Martin



to vendors to begin fabrication, according to the Air Force's Rapid Capabilities Office, which oversees the project.

### BOMBED UP

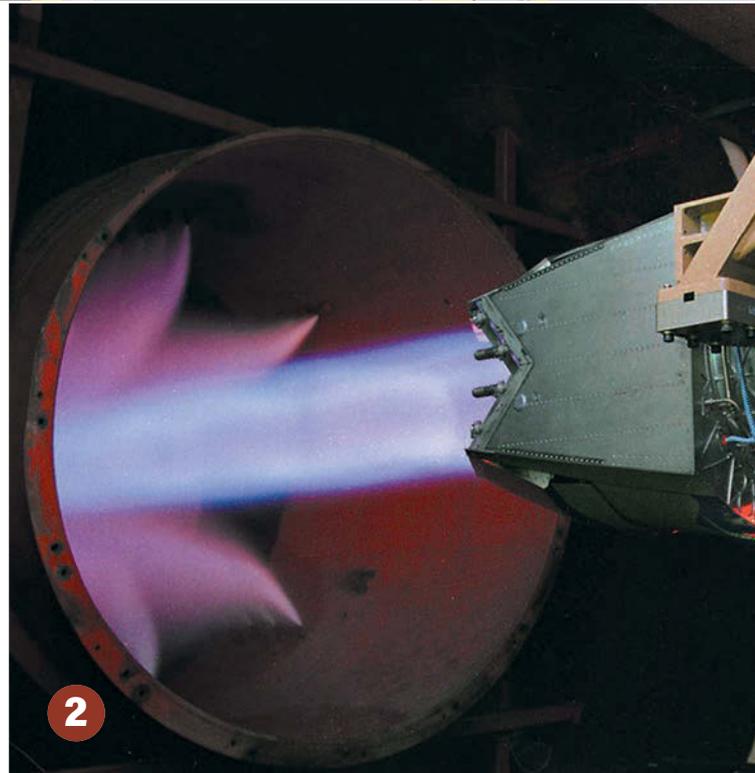
The Air Force has released 54,000 precision guided weapons against ISIS since 2014, a figure that doesn't count weapons used by the Navy, Marine Corps, and coalition partners. Wilson acknowledged in September that stockpiles haven't been replenished fast enough.

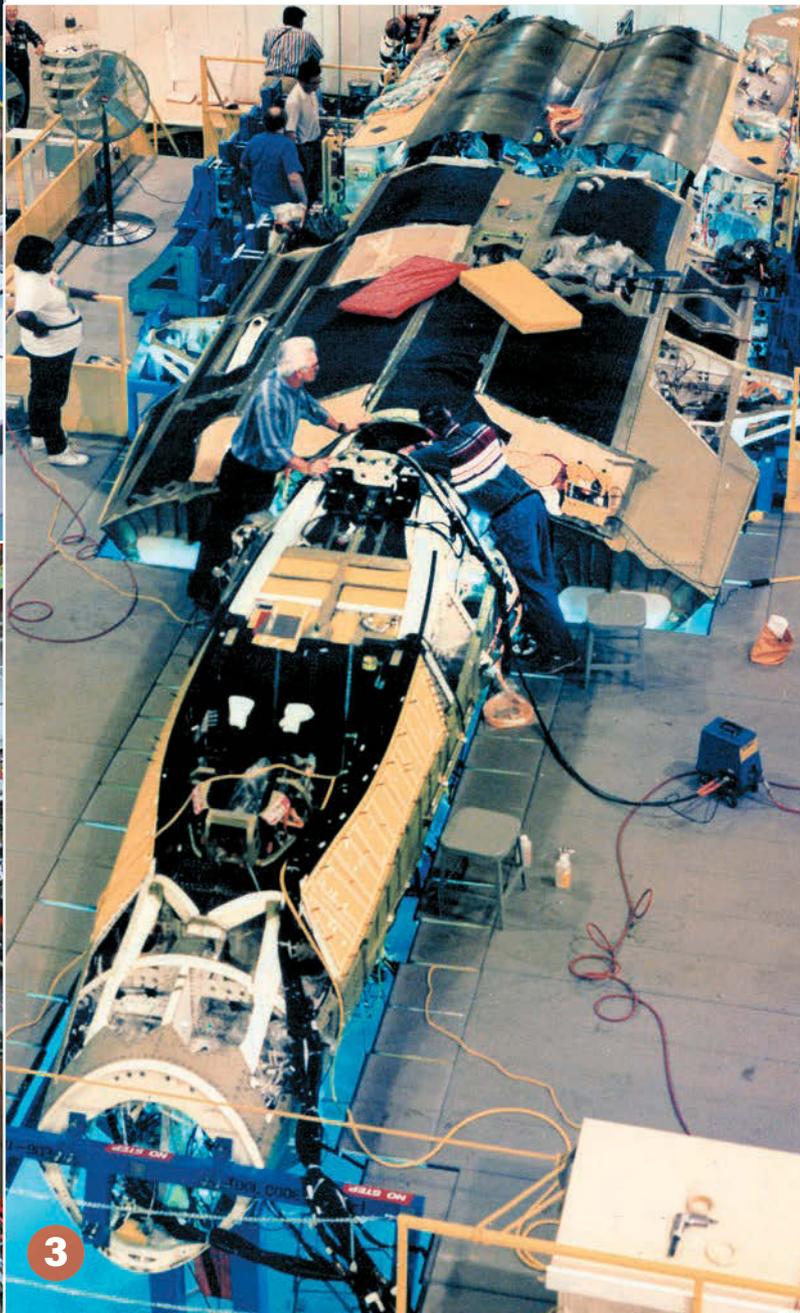
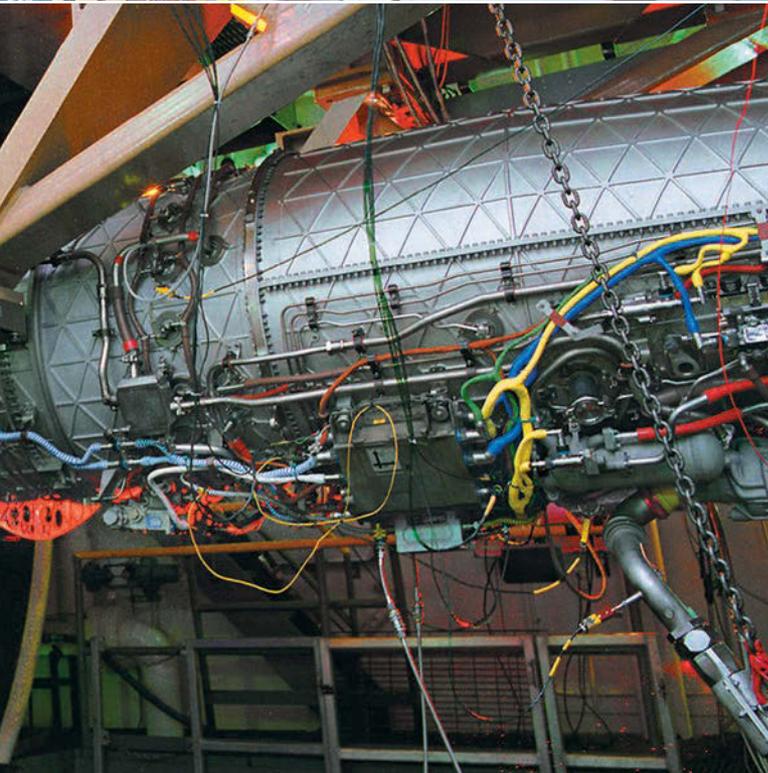
USAF is moving to get inventories back into the black. Production of the Small Diameter Bomb 1 is accelerating from 5,000 to 8,000 units per year. The Joint Direct Attack Munition production rate is ramping up to 45,000 per year—and could go higher—though production depends on several component suppliers keeping up that pace.

In concert with the Army, USAF is stepping up production of AGM-114 Hellfire missiles, and the Air Force is working with the Navy on the Advanced Precision Kill Weapon System.

These new weapons have "changed the way we fight," Wilson said in September, and many senior USAF leaders have suggested the service will never go back to imprecise weapons that may not hit exactly what they're aimed at.

"We will continue to work closely with our industry partners to manage production, she said, but keeping old equipment ready "isn't enough." Production will have to increase.





1/ The first international F-35 for the United Kingdom rolls out of the factory in 2011. The Ministry of Defense will use this short take off/vertical landing jet, known as BK-1, for training and tests. 2/ A Pratt & Whitney F119-PW-100 turbofan engine for the F-22 Raptor undergoes a test. The engine combines stealth technologies and vectored thrust to provide unprecedented maneuverability and survivability. 3/ The aft fuselage section of the first F-22 is lowered into the mate tool. This completed the primary assembly of the jet. The F-22 took advantage of new technologies such as composite materials, computerized flight control systems, thrust-vectoring engines, and radar-reducing design. Modern production lines are far quieter and more streamlined than plants of 30 years ago. Cabling, compressed-air devices, and other clutter or clutter are underground, allowing easier and safer access to the object being built.

Photos: Randy Crites/Lockheed Martin; Pratt & Whitney; John Rossino/Lockheed Martin



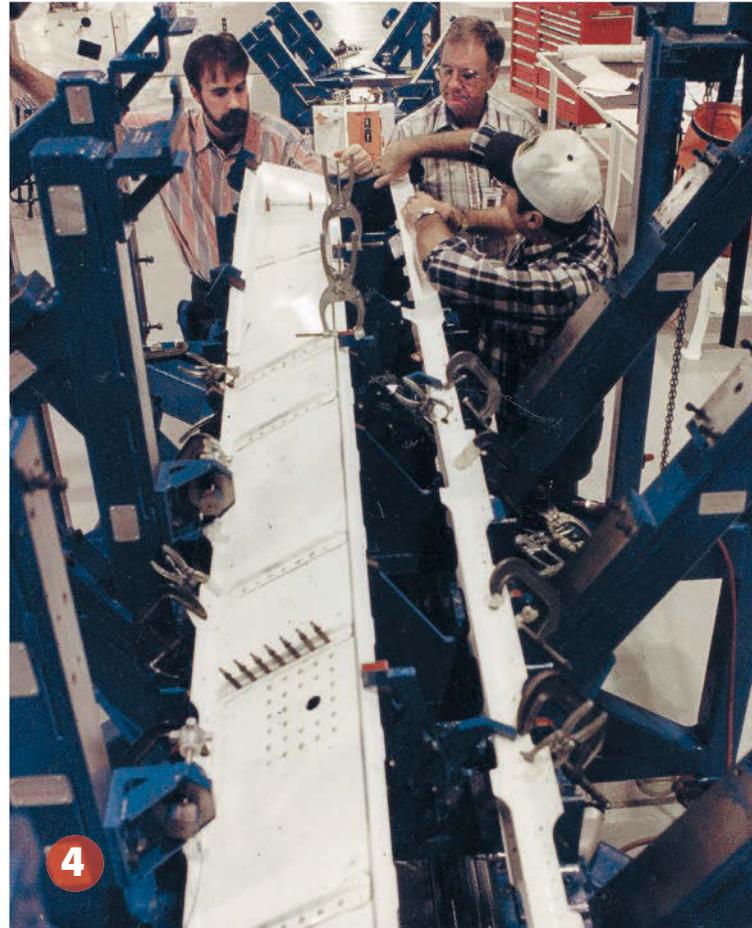
## RESTARTING THE RAPTOR

The Air Force is struggling today to meet regional commander demand for the world-beating F-22 Raptor fighter. Then-Defense Secretary Robert M. Gates halted its production in 2009, and there aren't enough to meet all of USAF's commitments; only 187 of a required 381 were built.

Since the last F-22 rolled out of Lockheed Martin's Marietta, Ga., facility in 2012, members of Congress have asked what it would take to restart the line and bring fleet strength up to par. In the Fiscal 2017 Defense Authorization Act, USAF was directed to study the costs, time lines, and effort required to produce up to another 194 F-22s.

In July 2017, the Air Force submitted its report, saying that another 194 F-22s would cost \$50 billion. That cost includes \$9.9 billion to restart the production line—a process that involves taking tooling out of storage, hiring a workforce with proper security clearance, training it, and certifying thousands of component vendors. The service has “no plans” for doing this, Air Force Secretary Heather Wilson said at the time.

Although it's unlikely the American defense industrial base will see a return to the massive output last seen in the 1980s, the production pendulum is swinging back up. After a prolonged drought, the Air Force in the 2020s will also see warm production lines for fighters, bombers, tankers, surveillance aircraft, and trainers, and a steeply accelerating output of smart munitions. Whether production reaches a sustained plateau or continues an up-and-down cycle, assembly lines will continue to be the backbone of the fighting force. ✪





1/ Technicians install the wings onto the fuselage of a Northrop Grumman RQ-4B Global Hawk at a factory in Palmdale, Calif. 2/ Joint Direct Attack Munition (JDAM) guidance tailkits on the production line at Boeing's St. Charles, Mo., factory. 3/ A robotic arm places a Small Diameter Bomb II guidance section into a test cell at Raytheon Missile Systems in Tucson, Ariz. 4/ Richard Barr, left, checks the fit as Harold Morris and Dennis Watts install a fuselage keel beam on the first F-22. 5/ Brig. Gen. Kristin K. French, left, then-commander, Joint Munitions and Lethality Life Cycle Management Command and Joint Munitions Command, listens as Steve Saunier explains the arming well of a 2,000-pound bomb at the McAlester Army Ammunition Plant in 2013.

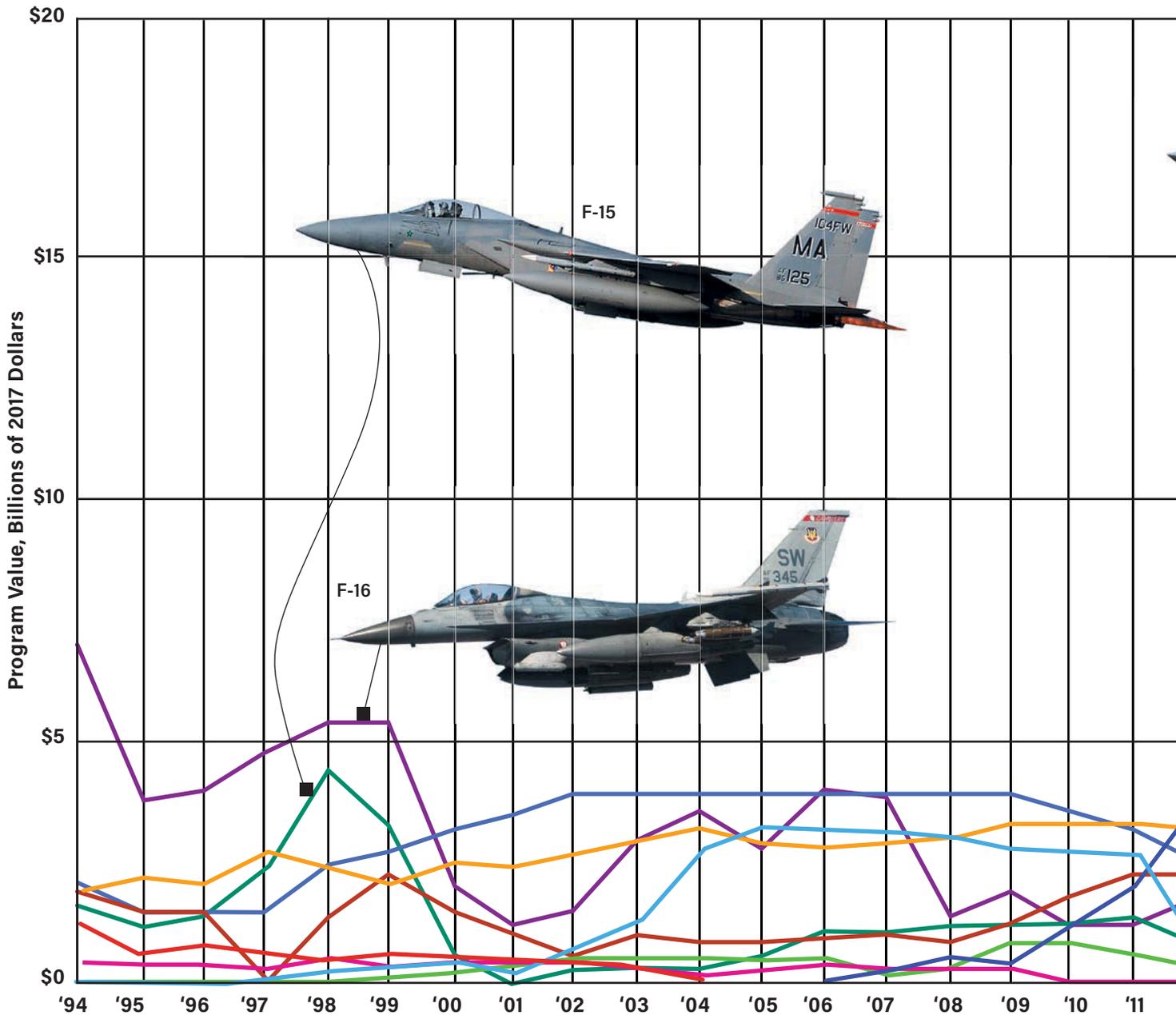


Photos: Northrop Grumman; Boeing; Raytheon; Lockheed Martin; Lea Gaudrone/US Army

# SHOW ME THE MONEY

## Aircraft Program Value

Worth of major military aircraft programs, 1994-2026



By Gideon Grudo, Digital Platforms Editor

**M**ajor governments around the planet want a slice of the swelling F-35 pie, and they're putting their money where their mouths are.

The stealth fighter's global market reached an all-time high in 2017: Militaries around the world paid a combined \$5.73 billion for F-35 deliveries. In the last 20 years, few aircraft programs could boast an annual market even close to \$5 billion. The F-16 pushed ahead of that mark in the late nineties, its worth hitting \$5.4 billion in 1999.

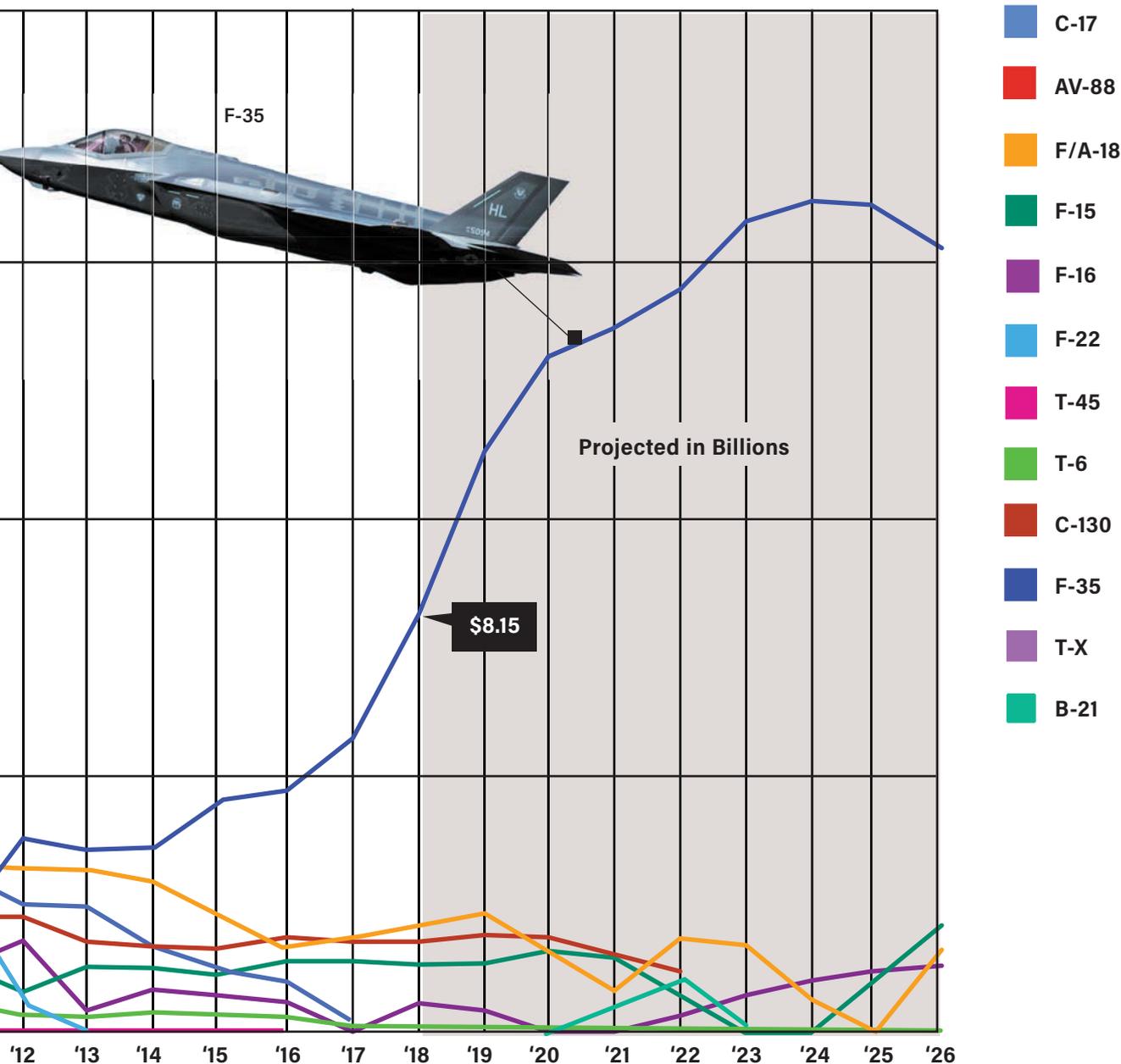
That's according to data from the DC-based Teal Group, a think tank with expertise in the market impact of military

programs. The data breaks down total market values of major fixed-wing aircraft programs, ranging from the F-15 to the B-21—from 1994 through today—and projects those values into the future through 2026. All amounts are adjusted to 2017 dollars.

The 2018 market for F-35s is projected to reach \$8.15 billion worth of deliveries. No single aircraft has surpassed the \$6 billion mark since 1994, when the F-16's market hit \$7.03 billion in today's dollars.

Looking to the future, the F-35's production value will peak in 2024, when its worldwide market reaches \$16.3 billion.

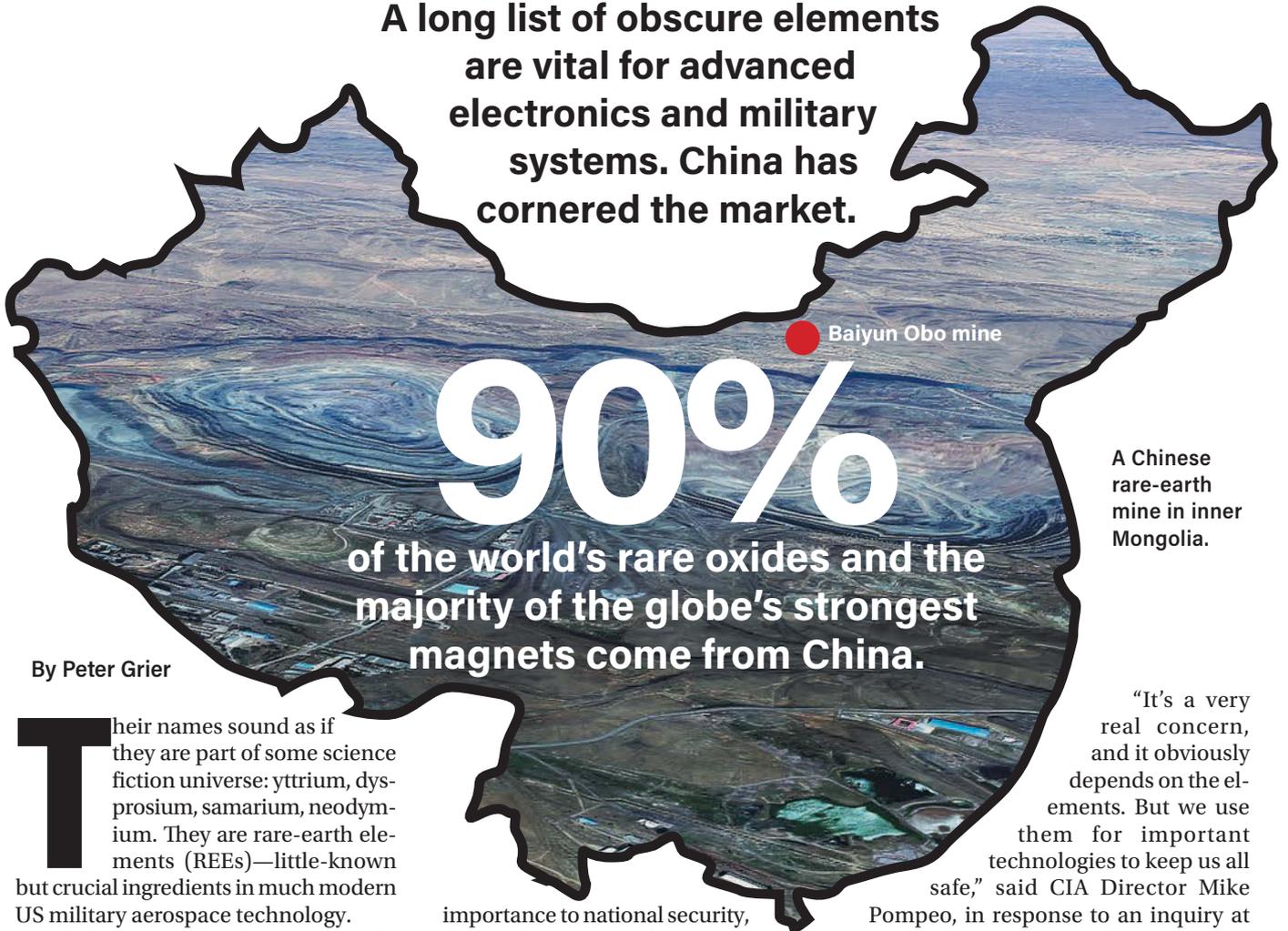
Below is a visualization of Teal's data and projections.



Photos: SSgt. Sean Martin; TSgt. Lindsey Sarah Watson-Kirwin; SrA. Malcolm Mayfield

# RARE-EARTH UNCERTAINTY

A long list of obscure elements are vital for advanced electronics and military systems. China has cornered the market.



Baiyun Obo mine

# 90%

of the world's rare oxides and the majority of the globe's strongest magnets come from China.

A Chinese rare-earth mine in inner Mongolia.

By Peter Grier

**T**heir names sound as if they are part of some science fiction universe: yttrium, dysprosium, samarium, neodymium. They are rare-earth elements (REEs)—little-known but crucial ingredients in much modern US military aerospace technology.

Take lasers. Lockheed Martin is working on a small, high-power laser weapon that the Air Force Research Laboratory wants to test in a tactical fighter aircraft by 2021. Its active gain medium is a flexible optical fiber infused with a rare-earth element such as erbium or neodymium.

Rare-earth elements are widely used in strong, permanent magnets impervious to temperature extremes. They are used in fin actuators, in missile guidance, and control systems; disk drive motors installed in aircraft and tanks; satellite communications; and radar and sonar systems.

As might be expected given their

importance to national security, these elements used to come from the United States. From the 1960s to the 1980s, the US was the global leader in rare-earth mining and production. That is no longer the case.

In recent decades China has become the source of 90 to 95 percent of world rare-earth oxides and the producer of a majority of the globe's strongest rare-earth magnets.

Many US officials and lawmakers view this situation with apprehension. They are pushing for solutions that range from stockpiling critical minerals to the development of substitutes and the reopening of key domestic mines.

“It’s a very real concern, and it obviously depends on the elements. But we use them for important technologies to keep us all safe,” said CIA Director Mike

Pompeo, in response to an inquiry at a May 2017 Senate Intelligence Committee hearing on worldwide threats to the US.

The rare-earth element group consists of 17 minerals. Fifteen are from a chemical group known as the lanthanides; scandium and yttrium are the other two. All share similar geochemical characteristics, generally resembling the chemical makeup of aluminum. Their slight differences in atomic structure give them different optical, electrical, metallurgic, and magnetic qualities. That makes them useful for a wide array of industrial applications.

Despite their name, rare-earth el-

ements are relatively widespread in the earth's crust. They are about as abundant as some major metals, such as copper and chrome. Even rare REEs are more common than gold.

Their "rarity" stems from that fact that they are found in low concentrations, up to a few hundred parts per million by weight, at most. That makes it difficult and thus expensive to separate them from surrounding substances into useful products. Development and construction of large-scale rare-earth element recovery infrastructure can take a decade or longer.

While unfamiliar to most Americans, REEs are vital components for a wide array of industries. Their unusual physical and chemical properties produce valuable effects when small amounts are combined with other minerals.

According to a US Geological Survey, yttrium, europium, and terbium are used to make phosphors—substances that emit luminescence—for the flat panel display screens that are ubiquitous in modern electronics. The glass industry is a large user of rare earths for polishing and to provide color and special optical qualities to finished products. Digital camera lenses can be up to 50 percent lanthanum.

REEs are used as catalysts in the production of petroleum and in automotive catalytic converters. They help make lighter flints and fluorescent light bulbs.

But their fastest-growing use, and the one arguably most important for US national security, is in lightweight, strong, durable magnets.

"Exceptionally notable is how REE alloys revolutionized the magnet trade and subsequently enhanced the products of all other businesses relying on that industry," wrote USAF Lt. Col. Justin C. Davey in a 2011 Air War College report. The magnets, and by extension the elements, are now common in consumer electronics and indispensable for many defense applications.

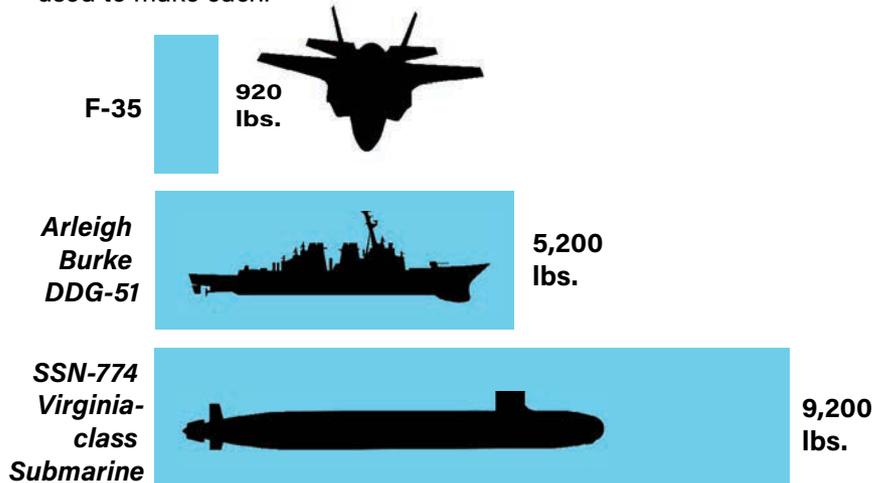
Samarium-cobalt magnets are more resistant to demagnetization than those made from any other material. This quality—called high coercivity—means high temperatures do not make them lose magnetic strength. That makes them the best choice for many military applications, according to Davey.

In contrast, neodymium-iron-boron magnets are incredibly strong and light. By weight they are almost 10 times



## Rare Ingredients

Here is the breakdown of rare-earth materials used to make each.



Source: Congressional Research Service

more powerful than traditional ferrite magnets. That makes them ideal for use in the tiny electronic components such as disk drives that have helped make possible decades of computer-driven innovation.

The world's push for renewable energy sources may only increase the demand for non-renewable REE magnets. A Toyota Prius, for example, uses about two pounds of neodymium in its hybrid power system. Wind turbines need lots of neodymium—new models use up to two tons of neodymium magnets.

The Department of Defense is not a major user of rare-earth elements, relatively speaking. Defense accounts for about five percent of US consumption, according to a Congressional Research Service background report on the subject. But REEs are integral to a vast array of Pentagon weapons and general equipment.

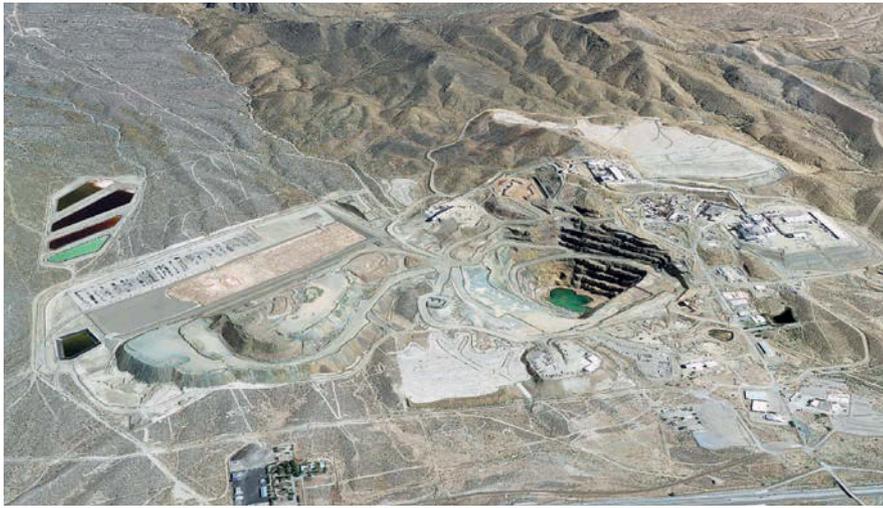
Flat screens and hard drives are per-

vasive in the military, from office computers to combat aircraft, ships, and vehicles. Missile guidance and control motors and actuators depend on small, powerful rare-earth magnets. If it were not for them, precision-guided weapons such as the satellite-guided Joint Direct Attack Munition would require much bulkier and more expensive hydraulic systems.

The generators that produce electrical power for aircraft all contain samarium-cobalt magnets. The stealth technology that produces white noise to help conceal the sound of helicopter rotor blades uses such magnets as well. F-22 tail fins and rudders move due to motors with powerful, miniature REE magnets. Electronic warfare jamming devices use rare-earth materials, as do laser targeting systems and nascent laser weapons.

Each stealthy F-35 strike fighter requires 920 pounds of rare-earth mate-

Photos: Google Maps; Scott Wolf



Mountain Pass open-pit rare-earth mine in southeastern California was the nation's most important resource for rare-earth materials.

rial, according to DOD. Each Arleigh Burke DDG-51 destroyer requires 5,200 pounds. An SSN-774 *Virginia*-class submarine needs 9,200 pounds.

The ability of US contractors to quickly make use of technological innovations and translate them into high-quality military systems is a pillar of the nation's defense. Given that, the Pentagon is likely to become even more dependent in the coming years on high-tech magnets, motors, lasers, computers, and electric-drive systems that use rare-earth materials.

But as noted above, the US itself no longer produces rare-earth ore or processes the substance at early points along the supply chain. Virtually all comes from China.

### COMMUNIST CHOKE POINT

Chinese leaders, citing domestic needs and environmental effects, have in the past restricted the export of rare-earth supplies through such means as licenses, taxes, and out-and-out quotas.

For instance, in July 2010 China announced it would reduce its exports of rare earths for the second half of the year by 70 percent over the previous year's levels.

Then on September 7, 2010, a Chinese fishing boat and two Japanese Coast Guard vessels collided in waters claimed by both nations. A few days later *The New York Times* reported that, in retaliation for the accident, China had begun restricting rare-earth exports to Japan, the world's biggest user.

Beijing resumed its Japanese exports that November. But among US policymakers, worries about the incident have lingered.

It appears that China may view rare-

earth elements as akin to the oil in the 21st century—a high-demand product that can be used for many purposes.

In Washington these developments have “given rise to concerns that China may attempt to use its control of rare earth as leverage to obtain its political and economic goals,” according to the CRS report.

### ALLIES AND ADVERSARIES

Deposits of rare-earth elements are found all around the globe. But according to the US Department of Energy, only a limited number of nations have proven and significant rare-earth reserves. These include Australia, India, China, Russia, Kazakhstan, and the United States.

The US dominated the rare-earth market from the time the substances became important industrial ingredients up to the mid-1980s. The most important US source by far was one mine, Mountain Pass, Calif.

Mountain Pass is located in remote southeastern California, not too far from Arizona and only about 15 miles from the southern tip of Nevada.

Retrieving usable rare-earth elements from open-pit mines such as Mountain Pass is not easy work. The metals are generally found mixed together in deposits that also contain radioactive elements such as thorium. Rock is mined, then crushed into a fine powder, and passed through a series of tanks where the rare earths come to the top and waste material sinks to the bottom.

The waste, which contains hazardous materials, is pumped off to storage ponds. The rare-earth mixture is dried in a kiln and then dissolved in acid.

The end result is a sludge that contains a fraction of purer rare earths in the form of mixed metal oxides, which are removed.

The process is messy. When Mountain Pass was running at full capacity it was producing 850 gallons of salty wastewater per minute, which was piped to evaporation ponds 11 miles away. Over the years, thorium and uranium collected as scale inside the pipe. In the 1990s several efforts to scrub the built-up scale broke the pipes instead, spilling large amounts of hazardous material into the environment.

The state of California ordered Unocal, the oil corporation that owned the mining firm Molycorp, to clean up the spills. Then in 2002 the company ran out of space to store waste, as its ponds had filled and it was unable to get permits to build new storage. Weakened by poor financial results, the mine closed.

### EMBRACING THE DIRTY WORK

By that time, China had already emerged as the world's leading REE producer. The largest rare-earth mine, by far, is at Baiyun Obo in the Chinese region of Inner Mongolia. Valuable heavy rare earths are concentrated in areas in southern China such as Hunan and Fujian provinces. The communist nation has almost half the world's total known rare-earth reserves, according to a CRS report on China's rare-earth industry and export regime.

Actual Chinese production of rare earths was insignificant until the 1980s. Then it exploded due to improved mining and production techniques and the nation's lurch away from communism toward a more market-oriented economy. In 1986, China passed the US to become the top rare-earth producer in the world. It has sat at No. 1 in those rankings ever since.

Strong government support, low labor costs, and lax environmental standards are among the reasons for China's quick and continued domination of the industry, according to some US mining executives and members of Congress. For instance, China has the largest rare-earth tailings pond in the world in Inner Mongolia.

Built in the 1950s, the four-square-mile pond does not have a protective liner. Radioactive waste from the site is gradually working its way toward the nearby Yellow River, a crucial water source for millions.

In the 1990s high profit margins lured many Chinese start-up industries into

the rare-earth business. Exports peaked in the mid-2000s, before prices abruptly crashed, pushing some non-Chinese mines—such as California’s Mountain Pass—into bankruptcy.

Since then, Beijing has moved to exert more central control, rationalizing production and taxing and restricting exports. Compared to the low point of 2005, rare-earth prices have risen as supplies tightened. At the same time China has expanded its ability to process raw rare-earth materials into alloys and then into finished products.

According to CRS, China now produces about 90 percent of all rare-earth metal alloys. It manufactures about 75 percent of all neodymium-iron-boron magnets and 60 percent of all samarium-cobalt magnets.

In the context of China’s 2010 restriction of rare-earth exports to Japan, the message here is clear, claim US executives: If rare-earth materials are the oil of the 21st century, China wants to pump the oil, refine the gasoline—and maybe make the car too.

“Critics of China’s rare-earth policies contend that they are largely aimed at inducing foreign, high-technology and green technology firms to move their production facilities to China in order to ensure their access to rare-earth elements and to provide preferential treatment to Chinese high-tech and green energy companies in order to boost their global competitiveness,” concludes the CRS report on national defense and rare earth.

## NATIONAL SECURITY INTERESTS

Given this situation, what is the Pentagon doing to ensure a continued supply of crucial rare earth-derived products? Not enough, say some members of Congress.

On March 28, 2017, the full Senate Committee on Energy and Natural Resources held a hearing on US dependence on foreign minerals, with a focus on rare earths. Chairman Lisa Murkowski (R-Alaska)—a state with rare-earth resources of its own—said she was frustrated by what she heard.

“Instead of lessening our dependence, we are actually increasing our dependence. We have increased it from just last year. We’re not making headway on this issue,” she said.

Congressional interest in this subject is not new. Lawmakers have long urged the Pentagon to take a more organized approach to ensuring security of rare-earth supplies, in part as a reaction to

the 2010 shutoff of rare earths to Japan. Since at least 2011, defense authorization bills have generally included language directing the Pentagon to identify which rare-earth elements are strategically valuable and ways to plug holes in the rare-earth supply chain.

The Fiscal Year 2012 defense bill also included a provision requiring the Secretary of Defense to report back to Congress on the feasibility of recovering, reprocessing, and recycling rare-earth elements, including those used in the fluorescent lighting of DOD facilities.

Opinions are mixed as to whether the Pentagon has fulfilled these requirements. A February 2016 report from the Government Accountability Office assesses that it has not.

“DOD has no comprehensive, department-wide approach to determine which rare earths are critical to national security and how to deal with potential supply disruptions to ensure continued reliable access,” concluded the GAO study.

The key word there may be “comprehensive.” As the GAO documents, a number of Pentagon organizations work on identifying critical rare-earth needs and possible ways to handle a shortfall. But their work is “fragmented,” according to the study. The Defense Logistics Agency methodically analyzes risks for rare earths, but only over a four-year time frame. The Manufacturing and Industrial Base Policy office relies on others to evaluate risks, and the open market to resolve supply disruptions. The Strategic Materials Protection Board has not developed an overarching framework to mitigate the problem.

The DLA does maintain a strategic materials stockpile, which includes some rare-earth elements. In 2016 the agency awarded new contracts for multiyear purchases of yttrium oxide and dysprosium metal.

But pressure to stockpile rare earths may have been eased in recent years by the fact that, on the open market, supplies have loosened.

Since that time “There has been a significant change in the global marketplace concerning rare earths. Increased market supply from a more diversified producer base coupled with decreased demand has led to global surpluses for several rare-earth materials,” according to a September 2016 Annual Industrial Capabilities report from the Under Secretary of Defense for Acquisition, Technology, and Logistics. For much of the

decade the cost of REEs has remained relatively stable.

## CHINA RISES

But that has changed recently, with prices gaining around 65 percent from early 2016 to fall 2017. And investors may see more price in the future as demand increases due to the rise of green energy and the spread of electric vehicles. Demand for dysprosium, for instance, could increase by 2,600 percent over the next 25 years as wind turbines and electric motors proliferate, according to an MIT study.

In this context, government ownership of the Mountain Pass mine in California might be a good idea, say some industry officials.

In July 2017, Michael N. Silver, head of American Elements Corp., met with White House officials in an effort to get them interested in such a takeover. (An effort to restart Mountain Pass flopped in 2015, due to another bankruptcy. The mine has since been bought by a group of firms, one of which allegedly has ties to the Chinese government.)

For the longer term, US national labs are studying the possibility of extracting rare-earth elements from coal and coal by-products. Current US coal reserves contain about a 1,000-year US rare-earth elements supply, at current consumption levels, according to the US National Energy Technology Laboratory.

“I think we are at a point in this country—and this is something we’ve talked about on this committee—[where we need] to develop a rare-earth national security policy for the United States.

... We would be foolish if the American government didn’t come together and say, we are going to procure and secure the rare-earth metals needed from us instead of having to depend on any other country,” said Rep. Ted Yoho (R-Fla.), chairman of the House Foreign Affairs Subcommittee on Asia and the Pacific, at an April 26, 2017, hearing.

For the time being, however, defense lasers, batteries, displays, magnets, and other components—thousands of pounds of rare-earth elements in some advanced weapons systems—will continue to be purchased in a volatile marketplace dominated by one nation, China. 🌟

**Peter Grier**, a Washington, D.C., editor for *The Christian Science Monitor*, is a long-time contributor to *Air Force Magazine*. His most recent article, “Misplaced Nukes,” appeared in the August 2017 issue.

# IN PURSUIT OF THE *BISMARCK*



*Bismarck*, pictured, slams HMS *Prince of Wales* with fearsome artillery during Operation Rheinübung, an attempt to block allied shipping to Europe.

## Swordfish torpedo bombers crippled the German battleship. British battleships cruised in to finish the job.

By John T. Correll

**T**he German battleship *Bismarck* was the most powerful warship in the world. She was launched to great acclaim in 1939 and finished her sea trials in April 1941. The British knew the *Bismarck* would soon make its first sortie into the Atlantic and prepared for it as best they could.

The *Bismarck* mounted eight 16-inch guns and 81 smaller ones. She had a top speed of 31 knots and was more heavily armored than anything else afloat. No ship in the Royal Navy was a match for it in single combat, so the British planned to fight the fearsome newcomer with team tactics.

*Bismarck* and the heavy cruiser *Prinz Eugen* lifted anchor at Gotenhafen Roads near Danzig in Poland on May 18, 1941. They slipped through the channel between Denmark and

Sweden and out of the Baltic, heading for Nazi-controlled Norway on the first leg of their breakout into the North Atlantic.

Their mission was not to directly challenge the Royal Navy, which had numerical if not qualitative superiority. The objective was to sever the British lifeline, the merchant convoys that were bringing supplies from North America. German U-boats had been operating against the convoys with deadly effect, but there were not enough of them to do the job alone.

British reconnaissance confirmed the arrival May 21 of *Bismarck* and *Prinz Eugen* at Grimstad Fjord in Norway. For the next six days, *Bismarck* would command the full attention of British Home Fleet. The international press followed the action with front page reports. Before it was over, *Bismarck* would sink the pride of the Royal Navy,

the renowned battle cruiser HMS *Hood*.

The British put everything they could into the pursuit, eventually leaving convoys and troop ships unguarded and shifting all of the resources they could to find and sink *Bismarck*. Both sides were chronically hampered by bad luck, misjudgments, and mistakes. Fortunately for the British, the Germans got the worst of it.

The chase came down to a very close finish. *Bismarck*, leaking oil from a lucky British shot, was hours away from escaping toward the coast of occupied France for repair and refit. The Home Fleet battleships and cruisers were in no position to prevent it.

The only chance was by the British carrier *Ark Royal*, arriving from Gibraltar with a complement of obsolete Swordfish biplanes, but nobody expected much from the Swordfish. *Bismarck*'s armor was built to withstand attack



British pilot Dennis Briggs spotted the German battleship *Bismarck* west of Brest, France, and alerted the Royal Navy.

from weapons much bigger than their light aerial torpedoes.

However, one last turn of fate remained, and it would go against *Bismarck*.

## CONVOYS

Germany had failed in its attempt to conquer the British Isles in the Battle of Britain in 1940, but the rest of Europe, from Norway to the Pyrenees, was under German control. Britain's ability to defy the Germans and continue the war depended on the vulnerable supply lines from overseas.

When *Bismarck* began its run, the British had 11 convoys in progress. Battleships and other naval combatants had been pressed into duty as escorts. Despite the protection, German U-boats were sinking between 30 and 50 merchant ships a month.

The scheme of the *Kriegsmarine*, the German navy, was to add capital ships to the attack and cut the British lifeline once and for all. By the middle of summer, more ships would be available, including *Bismarck's* sister battleship, *Tirpitz*, then in workup trials, and the battle cruisers *Scharnhorst* and *Gneisenau*, which were in repair for battle damage.

However, Grand Adm. Erich Raeder,

commander of the the German navy, did not want to wait. Operation Rheinübung ("Rhine Exercise") would be launched in May with *Bismarck*, *Prinz Eugen*, and accompanying destroyers. Adm. Günther Lütjens would command the task force with Capt. Ernest Lindemann as captain of the flagship *Bismarck*.

Raeder was explicit in his orders to Lütjens: "First and foremost battle against supplies. Goal is always the convoys, not the escorts, which are to be evaded if they are not significantly weaker." He understood that the overall advantage in numbers of the Royal Navy was insurmountable. "We must strive for local and temporary command of the sea in this area and gradually, methodically, and systematically extend it," he said.

The British Home Fleet was based at Scapa Flow in the Scottish Orkney Islands and commanded by Vice Adm. John C. Tovey, who did not know what route the Germans would take. He led part of the responding force himself, including the battleship *King George V*, to cover the southern approaches. Vice Adm. Lancelot Holland led the northern squadron, consisting of the new battleship *Prince of Wales*, the battle cruiser *Hood*, and six destroyers.

Holland's flagship was the aging *Hood*, the largest vessel in the Navy. She had eight 15-inch guns but was rated a battle cruiser rather than a battleship because of the light armor installed when she entered service in 1920. She was called "The Mighty *Hood*" by the newspapers but the thin decking was vulnerable to enemy fire that struck on a plunging trajectory.

*Prince of Wales*, sister battleship to *King George V*, was so new that civilian contractors remained aboard trying to fix a recurring problem with the main guns.

When British bombers arrived at Grimstad Fjord in response to the reconnaissance sighting, *Bismarck* and *Prinz Eugen* were gone, leaving their destroyer escorts behind. *Prinz Eugen* had refueled in Norway, but for reasons not clear, Lütjens and Lindemann did not top off the *Bismarck* tanks.

## BREAKOUT

The Germans had several possibilities for passage to the North Atlantic. The most direct routes were to the south of Iceland, but they carried the risk of discovery by spotters from the Faroe, Shetland, and Orkney Islands or by the British Home Fleet at Scapa Flow.



British deck crew members on HMS *Ark Royal* load a torpedo onto a Swordfish aircraft in 1941.

Lütjens chose to swing wide to the north and come down the Denmark Strait between Greenland and Iceland. In May, the navigable channel of open water was only about 30 miles wide, narrowed by pack ice extending eastward from Greenland and by British mine fields.

Lütjens, told by German intelligence that the British were still at Scapa Flow, was surprised to find the British heavy cruisers *Suffolk* and *Norfolk* patrolling the strait. In an otherwise inconsequential exchange with *Norfolk*, the *Bismarck's* forward-looking radar was damaged by the firing of its own guns. *Prinz Eugen*, with its intact radar, moved into the leading position.

The German ships emerged from the strait just after midnight May 24 and encountered Holland's squadron at about 5:30 a.m.

Holland planned to double-team *Bismarck* with *Hood* and *Prince of Wales* while the two cruisers kept *Prinz Eugen* occupied, but he made several mistakes.

He could have waited across the path of the approaching Germans, presenting *Hood's* eight big guns and the 10 from *Prince of Wales* broadside to the enemy's bow. Instead, he charged

ahead on an intercept course. Thus, only the guns in his forward turrets could be brought to bear, reducing his firepower by half. It was further diminished when one of the problem guns on *Prince of Wales* stopped working altogether.

Holland initially targeted his biggest guns on the leading German ship, which he mistakenly believed to be *Bismarck*. Meanwhile, Lütjens ordered a hard turn to port and brought his ships around to fire broadside on the British.

#### LOSS OF HOOD

The engagement began at 5:52 a.m. and rapidly closed to a range of 10 miles. The lofted ballistic trajectory of the shells from *Bismarck* brought them crashing almost straight down on *Hood*. Four minutes into the battle, a shot from *Bismarck* struck at the most vulnerable point, between the funnels where the armor plating was only three inches thick. It punched through several decks and into a magazine, setting off hundreds of tons of high-explosive shells.

The flames rose upward for a thousand feet and when they subsided, *Hood* broke into two parts and sank.

Of the crew of 1,421, only three were picked up alive. Admiral Holland was not among them.

Loss of *Hood* was a devastating blow to the British. The news enraged the nation, and especially the Royal Navy, which called in all of the assets it could—battleships, battle cruisers, aircraft carriers, cruisers, and destroyers—to find and destroy *Bismarck*. Ocean liners, merchant ships, and one convoy carrying troops to the Middle East were abandoned as their escorts rushed to the North Atlantic.

Unknown to the British, three shells from *Prince of Wales* had hit and damaged *Bismarck*, finding gaps in the defensive armor, exploding among the oil tanks, and blowing a hole in the side of the ship. Some of the oil was contaminated with water, making it useless for fuel, and some was leaking out into the sea.

There was no real danger *Bismarck* would run out of fuel, but its flexibility was limited by a reduction in speed and other measures taken to conserve oil. The declination to refuel in Norway had come back to haunt Lütjens.

Lütjens decided to head for the nearest dry dock at Saint-Nazaire on the French coast to make repairs. He



HMS *Hood* is sunk by the German battleship *Bismarck* in a painting by J. C. Schmitz-Westerholt. HMS *Prince of Wales* is in the foreground.

sent *Prinz Eugen* southward alone under covering fire from *Bismarck* to carry on the mission against the convoys. *Bismarck* headed south as well, then circled around and took up a course toward France.

### LOST AND FOUND

At 3 a.m. on May 25, the British lost contact with *Bismarck*. The cruisers were shadowing the battleship but when *Suffolk* began a zig-zag movement, *Bismarck* suddenly increased speed, looped astern of them, and was gone.

Lütjens, unaware that the British had lost track of him, broke radio silence at 9:30 a.m. with a series of coded reports to Germany. Radio direction-finding stations in Britain and Ireland intercepted his signals, determined his position, and sent the bearings to Tovey's navigation officer on *King George V*.

Unfortunately, the navigation officer made an error in plotting. Tovey changed course and headed at full speed in the wrong direction.

Lütjens was almost out of reach. By nightfall on May 26 he would be within protective range of the Luftwaffe. By the next morning, he would be in safe waters. At 10:25 a.m. on May 26, a Catalina flying boat spotted *Bismarck* from the air, 31 hours after the British



had lost contact.

The big battleship was some 700 miles from France. The only force with any hope of stopping her were the open-cockpit Swordfish torpedo bombers on *Ark Royal*. The Swordfish was an old-fashioned biplane that seldom flew faster than 100 mph when carrying ordnance. It has been described as an “ungainly array of struts, wires, and fabric-covered tubing,” but it was what the Royal Navy had.

The first Swordfish attempt,

launched at 3 p.m. on May 26, nearly led to disaster. The aviators mistook the light cruiser *Sheffield* for the enemy. Their confused attack luckily failed, mainly because faulty magnetic detonators on the torpedoes did not work properly. The Swordfish refueled and rearmed, this time with more reliable contact detonators.

At 7:10 p.m., they launched again, 15 aircraft in three flights. Winds were blowing at near gale force, and the waves were surging 25 to 40 feet high.

All the British had available for their last-ditch attack were obsolete Swordfish biplanes. Here, a Swordfish returns to HMS *Ark Royal* after making a torpedo attack on *Bismarck*.



The deck was pitching violently as the Swordfish took off and the clouds were too thick for them to hold formation. The first two flights struck *Bismarck* without inflicting any serious damage.

### SINKING BISMARCK

The last flight of five Swordfish attacked at 9:05 p.m., dropping their torpedoes from an altitude of about 50 feet and leading *Bismarck* by a standard two ship-lengths with their aim. If Lindemann had simply held his course, the torpedoes would have hit the 12½-inch armor belt amidships and done no harm.

Instead, he took an evasive maneuver—turning hard to port. The critical torpedo hit the ship in the stern, jamming the rudder at 12 degrees and putting the ship into a continuous counterclockwise turn. The rudder would not budge, and the crew was unable to cut it free with underwater saws.

No Swordfish were lost in the attack, though the German gunners hit them well enough. One aircraft had 175 holes in it from the flak, but most of the antiaircraft rounds passed through the flimsy canvas structure without detonating. There is no certainty about which Swordfish made the crippling shot, but Sub-Lieutenant J. W. C. Moffatt is usually credited.

As *Bismarck* steamed helplessly

around in a circle, the British fleet, including the battleships *King George V* and *Rodney* and the battle cruiser *Renown*, arrived on the morning of May 27. They opened fire at 8:47 a.m. from 12 miles away, quickly closed to two miles and finally to 3,000 meters, at which range the big guns readily penetrated *Bismarck*'s vertical armor.

Lütjens and Lindemann were killed, most likely by fire from *Rodney* around 9 a.m. *Bismarck*'s guns were silenced by 9:30 a.m., and by 10 o'clock the ship was blazing fiercely. The Germans, fearing that the wreckage would be towed to Britain and displayed as a trophy, opened the sea valves and exploded scuttling charges. *Bismarck* sank at 10:40 a.m. Of the initial crew of 2,400, only 118 survived.

In his memoirs, British Prime Minister Winston Churchill emphasized the battleships and the cruisers in his account of the *Bismarck* but acknowledged that it was the "seaborne aircraft who struck the decisive blows."

### THE DANGER DIMINISHES

*Prinz Eugen* arrived in France June 1, having encountered no British warships on its patrol to the south—but having found no convoys either—as all of them had been diverted away from that area. The Germans, shaken by the loss of *Bismarck*, did not again use their bat-

tlehips and cruisers in the campaign against the British supply lifeline.

Shipping losses to U-boats peaked in 1942, then declined sharply as Allied anti-submarine capabilities improved. U-boat activity in the North Atlantic was effectively over by 1943.

During the buildup between June 1943 and June 1944 for the D-Day invasion of Europe, thousands of supply ships crossed the ocean. The Germans managed to sink only 92 of them.

When *Bismarck*'s run ended, it had been in service for 277 days. Counting from the time of its departure from the mooring at Gotenhafen Roads on May 18, its single combat operation had lasted for 215 hours. That was enough to establish it as the greatest chase in naval history.

The story is best known in the United States from the 1960 movie "Sink the *Bismarck!*" and the song by Johnny Horton—which became something of a minor popular classic—that was associated with the movie, although not part of the actual soundtrack.

In 1989, an exploration found the remains of *Bismarck* at rest on the ocean floor, three miles below the surface and 400 miles from the coast of France. 📍

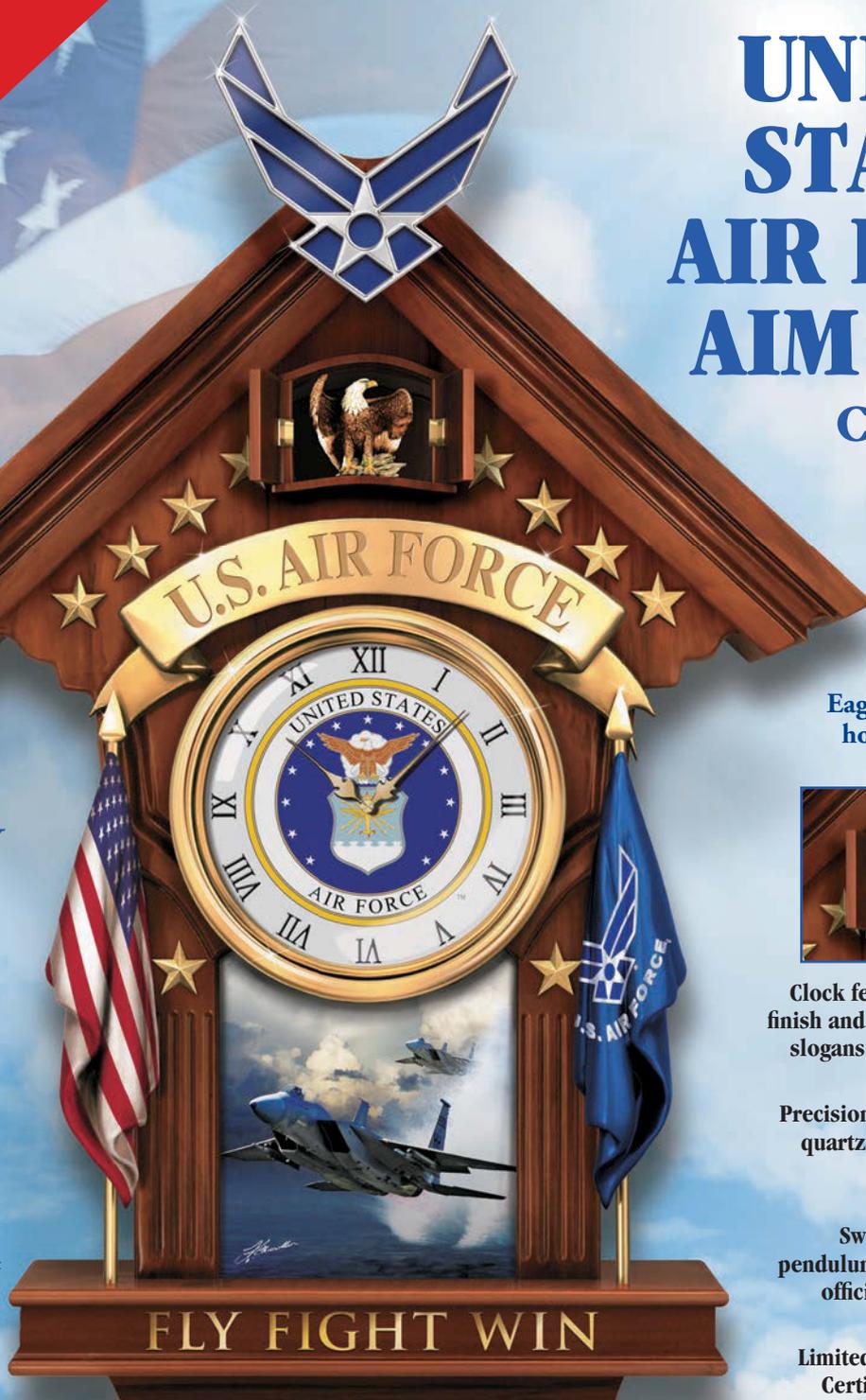
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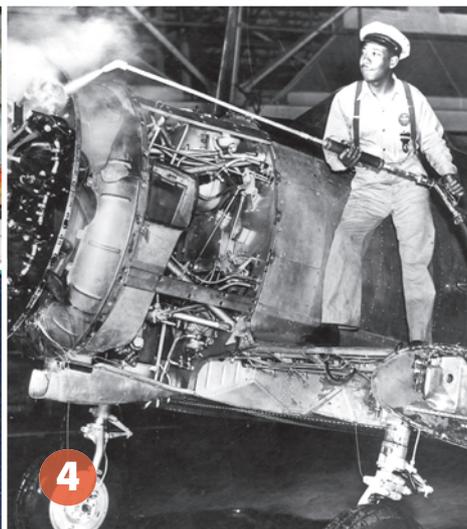
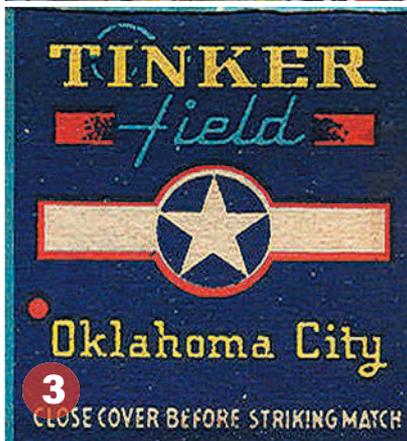
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# TINKER

## Osage Air Warrior

For a military airman, Clarence L. Tinker's life was unusual. He was born not in a US state but in the Osage Nation, closer—in time—to Custer's last stand than to Kitty Hawk. He didn't receive his wings until age 33.

Even so, he became an illustrious American general, played a key role in World War II, and died a heroic airman's death.

Tinker's birthplace—Pawhuska—is in modern Oklahoma. In 1887, it was part of Indian Territory. Young Clarence, one-eighth Osage, was raised Osage and spoke the Osage language.

An admirer of Osage scouts in the US Cavalry, Tinker entered Wentworth Military Academy. He graduated in 1908 and joined the Philippine Constabulary. In 1912, he was commissioned into the US Army, serving in infantry units in the Southwest.

For Tinker, World War I showed the future lay in aviation. In 1919, he began flying lessons. In 1920, he transferred into the Air Service. He was awarded his wings and entered flight duty in 1922.

The newly minted air officer steadily advanced. He became assistant military attaché in London (where he saved a pilot from a burning aircraft), a member of the Air Corps Chief's staff, commandant of Air Corps Advanced Flying School in Texas, and Chief of Aviation, National Guard Bureau, in Washington, D.C.

In the 1930s he commanded pursuit and bombardment units in California, Louisi-

ana, and Florida. His style was described as "tough, taciturn, quietly humorous, and deeply earnest."

Tinker, promoted to brigadier general on Oct. 1, 1940, anticipated war in the Pacific and devised plans for the defense of the Panama Canal. After the Dec. 7, 1941, attack, the Army sacked the head of Hawaiian Air Force (HAF) and installed Tinker.

The new man immediately forced a rapid reorganization of HAF for defense of the islands and offensive operations against Japan. In early 1942, Tinker pinned on his second star, thus becoming the first Native American ever to attain that rank.

Tinker always contemplated using HAF bombers offensively against Japanese naval forces. For six months—from Pearl Harbor to the Battle of Midway—he worked to acquire aircraft and personnel for the task. This preparation played a key role in the decisive US victory at Midway, June 3-7, 1942.

The last day of that battle saw Tinker take command of a bomber mission to Japan-occupied Wake Island. Shortly after takeoff from Midway, Tinker's LB-30 Liberator spun out of control and plunged into the ocean, killing all 11 crew members. No bodies were recovered.

In an unprecedented move, the Army almost immediately renamed Oklahoma City Air Depot "Tinker Field." This was at the personal request of Gen. Henry H. "Hap" Arnold, commander of US Army Air Forces.

1/ Clarence Tinker in 1942. 2/ AWACS maintenance today. 3/ Souvenir, 1940s. 4/ Engine cleaning at Tinker Field, 1940s.

### CLARENCE LEONARD TINKER

**Born:** Nov. 21, 1887, Pawhuska, Osage Nation, Indian Territory

**Died:** June 7, 1942 (MIA), near Midway Island

**College:** Wentworth Military Academy, Missouri  
**Services:** Philippine Constabulary (1908-12); US Army Infantry (1912-22); Army Air Service (1922-26); Army Air Corps (1926-41); Army Air Forces (1941-42)

**Occupation:** US Military Officer

**Main Era:** World War II

**Years Active:** 1908-1942

**Combat:** Pacific Theater

**Final Grade:** Major General

**Honors:** Distinguished Service Medal (posthumously); Distinguished Flying Cross (post.); Purple Heart (post.); Soldier's Medal

### TINKER AIR FORCE BASE

**State:** Oklahoma

**Nearest City:** Oklahoma City

**Area of Main Base:** 8.6 sq mi/5,500 acres

**Status:** Open, operational

**Designated Midwest Air Depot:** March 21, 1941

**Opened/Renamed Oklahoma City Air Depot:** March 1, 1942

**Renamed Tinker Field:** Oct. 14, 1942

**Renamed Tinker Air Force Base:** Jan. 13, 1948

**Current Owner:** Air Force Materiel Command

**Former Owners:** Air Force Logistics Command (and predecessor organizations)

Today, Tinker is home to USAF's Oklahoma City Air Logistics Complex, the largest of three depots in Air Force Materiel Command. It provides the depot-level maintenance for B-1B and B-52 bombers, KC-135 tankers, and E-3 AWACS aircraft, among other types.



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