LESSON 2

The Significance of Stealth Aircraft

Quick Write

If you had been an American military planner in 1982, what lessons do you think would you have drawn from the Israeli experience with drones in the Bekaa Valley?

Learn About

- the development of stealth aircraft
- the development of precision weapons
- the development of unmanned aerial vehicles (UAVs)

FOR MUCH OF THE FIRST HUNDRED YEARS of aviation, the US military varied in its enthusiasm for unmanned flight. During both world wars, the US sought ways to deliver bombs without putting American crews at risk. Experiments with unmanned aircraft went on. But after both wars, interest waned.

This pattern continued through the 20th century. It held even after episodes like the shooting down of Francis Gary Powers's U-2 over the Soviet Union in 1962. This had made some military planners feel manned surveillance flights were too risky. But the United States continued largely to ignore the potential for unmanned flight.

The turning point came in 1982, however. Israel launched a volley of unmanned decoy aircraft in Lebanon's Bekaa Valley. The valley was protected by Syrian air defenses. The Syrians fell for the trick. They fired their surface-to-air missiles back at the Israelis. This let the Israelis know just where each launch site was. The Israelis then moved decisively to destroy the Syrian air defenses.

It was a stunning victory. It got American attention. US defense officials suddenly saw the potential of unmanned aircraft.

The Development of Stealth Aircraft

As you read in Chapter 5, Lesson 4, *stealth technology*—also called low-observable technology—goes back to the early 1970s. That's when an important study came out from DARPA—the Defense Advanced Research Projects Agency. DARPA is a government agency whose mission is "to make pivotal investments in breakthrough technologies for national security."

What the study showed was how much US military aircraft were at risk of detection and attack. Military planners had run war games modeling a possible Soviet invasion of Western Europe through the Fulda Gap in Germany. These war games suggested that if Soviet forces ever actually did invade, US and NATO forces would have trouble fighting them off.

The vulnerability the war games uncovered was partly the result of US adversaries getting better air defenses. They effectively combined the use of radar-guided surface-to-air missiles (SAMs) and air-launched radar-guided missiles, for instance.

But was it also partly the result of aircraft themselves having distinctive signatures, or *recognizable profiles and characteristics*. Their engines gave off heat signatures that adversaries could detect. The shapes of the planes were recognizable. And to a certain extent, their sophisticated electronic systems themselves made aircraft easier to track. (It's not unlike the way you can be tracked more easily if you're carrying your cellphone with you.)

After this study, it was clear that US defense planners needed some radical new ideas. The idea they decided to pursue was high-stealth aircraft.

Vocabulary

- low-observable technology
- signatures
- classified
- fifth generation
- reverse engineering
- drone
- unmanned aerial vehicles
- loiter time
- expeditionary teams

And so DARPA set out to develop some new strategies and technologies. They wanted to make US aircraft harder for enemy radar to "see." Low observable technology does this by reducing as much as possible the signatures of aircraft, vehicles, and other military assets. Researchers considered how these assets look to adversaries, how they sound, and how they show up on radar and sensor screens. They even considered the amount of heat that aircraft generated. This mattered because new infrared imaging displays let adversaries see that heat. The result of all this research was the modern stealth aircraft.

Every part of a stealth plane is designed to hide it from detection. Manufacturers use radar-absorbent materials, infrared shielding, exhaust cooling and shaping, and better ways to disperse heat. They seek to reduce visual signatures. They use special windshield coatings. The plane's paint can absorb and deflect radar pulses. Its shape cloaks the aircraft as well. Many details about stealth materials and design are classified—*withheld from public knowledge for reasons of national security.*

The stealth ability allows aircraft to undertake dangerous missions more safely. They can run reconnaissance without being caught. A stealth aircraft can bomb an enemy with little chance of being spotted, especially at night. Imagine if the Germans had been able to escape radar as they approached the British Isles in 1941. The Battle of Britain, and perhaps World War II, might have ended differently.

As you read in the last chapter, the first operational stealth aircraft was the F-117 Nighthawk. A few years later the B-2 bomber followed. The F-22 Raptor stealth fighter is the first air superiority fighter completely designed from stealth technology. The F-35 Lightning II stealth fighter, which you'll read about in the next lesson, will be next to join the Air Force fleet.

An F-22 does a flyby in Dubai, United Arab Emirates, in 2009.
vaalaa/Shutterstock

Lockheed Martin F-22 Raptor

The F-22 is both stealthy and maneuverable. It can fly long distances at supersonic speeds. It is effective against both other aircraft and ground targets. The aircraft is jointly produced: Lockheed Martin builds the forward fuselage and does final assembly. Boeing builds the wings and back fuselage. Pratt & Whitney supplies the engines.

The F-22 carries a 20-millimeter cannon and several Sidewinder air-to-air missiles. Its main internal weapons bays can hold up to six air-to-air missiles or two air-to-ground missiles and two 1,000-lb. bombs. It can fly at a top speed of Mach 2, and has a range of 1,850 miles. The F-22's sophisticated sensors allow it to identify and shoot down hostile aircraft before the enemy detects it.

The Air Force took delivery of the first F-22 in 2005. By the time production ended in 2012, 187 operational aircraft had been built. For a while, the aircraft experienced some operational problems related to pilots' oxygen supply. Lockheed Martin has since installed new equipment to fix the issue. The plane first saw combat in 2014 in Syria.

Russia's Sukhoi T-50/PAK FA Stealth Fighter

The Russian Sukhoi T-50 is meant to compete directly with the F-22 Raptor. Its manufacturer is Sukhoi OKB. This is a Russian aircraft maker that dates back to World War II.

When the T-50 is deployed, the United States will no longer have a monopoly on "fifth generation" stealth fighters. There is no precise definition of this term. But generally, fifth generation refers to *fighter aircraft using the latest technology as of 2016*. This means the latest aviation technology and radar-absorbing materials, as well as cutting-edge weaponry.

American experts see the PAK-FA as a worthy competitor to the Raptor. The PAK-FA will fly high and fast. That will give its missiles an extra boost at launch. And that, in turn, will give those missiles a much bigger range than otherwise.

The first T-50 prototype had its maiden flight in 2010. News reports suggest some slippage in the original timetable for serial production of the fighter. At this writing, production is expected sometime in 2017 or 2018.

India has worked with Russia on this aircraft and hopes to have its own version of the PAK-FA eventually.

A Sukhoi T-50 Russian stealth fighter does a fly-by at a 2011 air show in Zhukovsky, Russia.

Fasttailwind/Shutterstock

China's Chengdu J-20 Stealth Fighter

Beijing's answer to the F-22 Raptor made its public debut on 1 November 2016. That's when two of China's new J-20 stealth fighters made passes over Airshow China. This show takes place every other year. It was held in Zhuhai, China, 35 miles west of Hong Kong. It's often the place where China shows off new military hardware.

The J-20 is considered a big step forward in making the Chinese air force a Pacific power. As you read in Chapter 5, Lesson 5, Serbian/Yugoslav forces shot down an F-117 in 1999. The Chinese may have used reverse engineering of the F-117 to build their new J-20 fighter. Reverse engineering means *reproducing someone else's product after taking it apart and studying it carefully.* Wreckages of enemy aircraft shot down in battle can offer opportunities for reverse engineering.

Shenyang J-31 "Gyrfalcon" Stealth Fighter

Another fifth generation fighter being developed by China is the Shenyang J-31. Although not much is known about Chinese military weapons production, this fighter looks very similar to the US Air Force's F-22.

Some experts speculate that this fighter will be deployed as a naval fighter, based on the growing Chinese aircraft carrier fleet. China has stated that this aircraft is intended for export sales to other countries and not its own military. The aircraft is expected to reach operational status by 2018. Some countries have already expressed interest in buying it.

The J-31 stealth fighter is presented for the first time publicly at Airshow China 2014.
plavevski/Shutterstock

An MQ-1 Predator armed with Hellfire missiles flies a combat mission over southern Afghanistan.

Lieutenant Colonel Leslie Pratt/Courtesy US Air Force

The Development of Precision Weapons

Among the other modern weapons the Air Force has used in recent conflicts are precision weapons. Precision weapons are also known as *precision-guided weapons*, or PGMS. They are so accurate that they can be placed within feet of their targets.

Precision weapons are the wave of the future, because they can keep US forces far from combat. This helps keep US casualties down.

The air-to-surface Hellfire missile is one of the precision weapons used in Afghanistan. The MQ-1 Predator delivers the Hellfire. The Predator is a drone—*an unmanned aircraft*—that a pilot controls remotely. After the pilot has fired the missile, sensor operators guide the missiles to their targets.

Precision weapons have also played a large role in Iraq. About 70 percent of all weapons used in *Operation Iraqi Freedom* were of the precision type. These included the GBU-38 and GBU-39. GBU stands for *guided-bomb unit*.

The GBU-38 went into action for the first time in 2004, when it was used to bomb a terrorist meeting in central Iraq. F-16 fighters delivered those GBU-38s.

An Airman aligns a GBU-38 precision bomb at Bagram Air Base, Afghanistan.

Master Sergeant Demetrius Lester/Courtesy US Air Force

Weighing 500 pounds, they are smaller than some other bombs. But the GBU-38's size and accuracy let the military target a particular building without seriously damaging surrounding buildings. This precision approach puts nearby civilians at less risk. The US military tries to avoid civilian deaths when fighting in crowded areas such as Baghdad.

German "Fritz X" Guided Bomb on display at the National Museum of the US Air Force

Ken LaRock/Courtesy US Air Force

VB-1 Azon Guided Bomb on display at the National Museum of the US Air Force

Courtesy US Air Force

The US Air Force used the GBU-39 in combat for the first time on 5 October 2006 in support of ground troops in Iraq. At 250 pounds, it is the smallest guided bomb the Air Force has. F-15Es employ this weapon, which can strike within six feet of a target from 60 miles away.

A Brief History of Precision-Guided Munitions

Precision weapons have been around since World War II. Nazi Germany became the first country to use them. Its Fritz X PGM sank the Italian battleship *Roma* in 1943. The Italian fleet was on its way to surrender to the British, and the Germans wanted to prevent this.

The US experimented with many different types of PGMs. Most did not see combat. One that did, though, was the VB-1 Azon. The US successfully used it in Europe and in China, Burma, and India—mostly against bridges.

The Air Force used two guided bombs in Korea, also primarily against bridges: the VB-3 Razon and the VB-13 Tarzon. An aircraft would drop the bombs. Then the bombardier would use radio control to guide them by sight to their target.

Bombardiers could control the Razon and Tarzon bombs in two directions, or *axes*. They could control their *range* (up or down) and *azimuth* (left or right). Each bomb also carried a flare to make it easier to see after release.

The Air Force had mixed results with these two bombs in Korea. But they were the forerunners of more-widespread use of precision weapons in the future.

Real progress in the development of precision weapons came during the Vietnam War. In fact, despite their early problems, PGMs revolutionized the air war in Southeast Asia.

Early on, the Air Force used radio-guided AGM-12 Bullpup missiles. They had just a 250-pound warhead, however—too lightweight to do real damage to a target. The Air Force also had the GBU-8 and AGM-62 Walleye bombs. They had television guidance. But they had trouble distinguishing their targets. They were also too expensive or too small for targets like large bridges.

In 1968, however, the Air Force tested the BOLT-117 in combat. It was the world's first laser-guided bomb (LGB). It marked a major leap forward in technology.

The BOLT-117 had a hand-held or pod-mounted laser designator, or indicator. This lit up a target with a laser beam. A seeker head in the bomb then guided it to where the laser pointed. The BOLT-117's success led to the more powerful GBU-10 Paveway I, a conventional bomb with a laser-guidance kit attached.

BOLT-117 laser-guided bomb on display at the National Museum of the US Air Force

Courtesy US Air Force

Almost half of all LGBs dropped in Southeast Asia directly hit their targets. Most others hit within 25 feet. By the war's end, laser guidance kits turned standard bombs into *smart bombs*, 100 times as effective as free-fall, unguided bombs.

The Air Force continued to develop precision munitions through the 1970s and 1980s. Then during *Operation Desert Storm* in 1991, the public became aware of these weapons' abilities. Suddenly everyone knew what a smart bomb was.

Since then, PGMs have only become more effective. Weapons designers have found more ways to guide munitions to their targets. New types of targeting sensors can be found even in handheld ground systems.

Improved targeting means that weapons can be smaller but just as effective. And if bombs are smaller, more will fit onto a single aircraft, allowing it to strike more targets. Some new bombs even have pop-out wings that let them fly long distances independent of the aircraft delivering them. This lets the aircraft and its crew stay outside the range of enemy air defenses.

Air-Launched Cruise Missiles

In February 1974, the Air Force started development and flight-testing of the prototype AGM-86A air-launched cruise missile. The 86A model did not go into production. Instead, in January 1977, the Air Force began full-scale development of the AGM-86B, which greatly enhanced the capabilities of B-52s and B-1s while helping the United States maintain a strategic deterrent.

Boeing AGM-86B (ALCM) being prepared for display at the National Museum of the US Air Force

Courtesy US Air Force

Although initially designed to carry only nuclear weapons, in June 1986 a limited number of AGM-86B missiles were converted to carry a high-explosive warhead and an internal global positioning system (GPS). These were redesignated as the AGM-86C. This modification also replaced the B model's terrain-following guidance system and combined a GPS capability with the existing inertial-navigation computer system.

The small, winged AGM-86B/C/D missile is powered by a turbofan jet engine that propels it at sustained subsonic speeds. After launch, the missile's folded wings, tail surfaces and engine inlet deploy, allowing the missile to fly up to 1,500 miles to reach its target. The AGM-86 flies using an onboard GPS coupled with its inertial navigation system. This allows the missile to guide itself to the target with pinpoint accuracy.

The AGM-86C/D became operational in January 1991 at the onset of *Operation Desert Storm*. Seven B-52s from Barksdale AFB, Louisiana, launched 35 missiles at designated launch points to attack high-priority targets in Iraq. These "round-robin" missions marked the beginning of the air campaign for Kuwait's liberation. They were the longest known aircraft combat sorties up to that time (more than 14,000 miles and 35 hours of flight).

In 1987, the General Dynamics AGM129A advanced cruise missile (ACM) was introduced to provide the Air Force with a long range, highly survivable, strategic standoff weapon. The ACM uses laser sensor updates to give it high navigation accuracy. Stealth technology gives it a low radar cross-section and increased chance to penetrate enemy defenses. The distinctive forward swept wing is an example of the application of stealth technology. A B52H bomber can carry up to 12 ACMs, allowing the bomber to attack multiple targets without having to enter enemy airspace.

The US Navy also has developed cruise missiles that can be launched from ships and submarines. Tomahawk sea-launched cruise missiles are designed to fly at extremely low altitudes at high subsonic speeds. Their guidance systems are similar to those the Air Force uses. The Tomahawk's first operational use was in *Operation Desert Storm*, 1991, with immense success. The missile has since been used successfully in several other conflicts.

General Dynamics AGM-129A being prepared for display at the National Museum of the US Air Force

Courtesy US Air Force

The Development of Unmanned Aerial Vehicles (UAVs)

General Henry H. "Hap" Arnold made a startling prediction at the end of World War II: "We have just won a war with a lot of heroes flying around in planes," he said. "The next war may be fought by airplanes with no men in them at all...."

His prediction didn't come true exactly as he stated it. Since World War II, the United States has fought in Korea, Vietnam, Iraq, and Afghanistan, among other places. And it has done so with plenty of heroes flying around in planes.

But events are certainly moving in the direction of Arnold's prophecy. The way wars are fought is changing. The conflicts in Iraq and Afghanistan sparked a revolution in unmanned aviation. But that revolution was made possible by a group of critical technical advancements. These include systems that automatically stabilize an aircraft, remote control, and the ability to connect to satellites. All this has led to a great demand for unmanned aircraft systems (UAS).

Unmanned aircraft, or unmanned aerial vehicles (UAVs), may be the wave of the future. But they go back to very early days of aviation. In fact, the revolution in unmanned aviation noted above was made possible by pioneering work done over the century before.

Charles Kettering, along with Orville Wright, built one of the first unmanned aerial vehicles in 1918. Nicknamed the Kettering Bug, it's generally regarded as the first practical example of an unmanned aircraft. It was a small biplane powered by a four-cylinder engine and guided by gyroscopes. It also had a barometer and a mechanical "computer."

Kettering Aerial Torpedo "Bug" on display at the National Museum of the US Air Force

Courtesy US Air Force

This computer would count engine revolutions as a way to gauge distance. Then it would power down the engine and jettison the wings of the "bug" at a preset point. This was calculated before launch on the basis of wind speed and direction. Its wings gone, the fuselage would then crash into its intended target to deliver its payload. Built during the final months of World War I, the Kettering Bug was never used in actual combat, however.

After the war ended, US military interest in drones fell off sharply. Civilian hobbyists picked up the slack, though. Among these was British-born movie actor Reginald Denny. His career also included service as a World War I Royal Flying Corps observer and gunner, and later a stunt pilot. During the early 1930s, he grew interested in radio control. He built his own radio-controlled model airplane. He even opened up a shop on Hollywood Boulevard. On the eve of World War II, his Radioplane company won a sizable contract from the Army to produce drone aircraft.

During World War II, the United States tried to deliver bombs by means of unpiloted bombers. One such effort was *Operation Aphrodite*. It used specially modified B-17 Flying Fortresses and other planes. Pilots would fly the bombers partway to the target, arm the explosives, pass radio control to a "mother ship," and then bail out in parachutes. The personnel on the mother ship were supposed to guide the drone the rest of the way to the target. It never worked according to plan, however, and many crew died. Among those killed was Joseph Kennedy Jr., President John F. Kennedy's older brother.

Today's unmanned aerial vehicles and unmanned aerial systems were built on the foundation of these 20th-century pioneers. The following are some of the most important unmanned aircraft currently in use.

MQ-1B Predator

The MQ-1B Predator can be traced to that Israeli victory you read about at the beginning of this lesson. That episode reawakened US interest in acquiring unmanned aircraft systems. The Predator is an armed, multi-mission, medium-altitude, long-endurance, remotely piloted aircraft (RPA). It collects intelligence, and it also launches precision weapons.

The Predator has a long loiter time. Loiter time refers to a *combat aircraft's ability to stay aloft near its target while waiting to strike*. The Predator's missions include intelligence, surveillance, reconnaissance, close air support, combat search and rescue, and precision strike. The Predator is uniquely qualified for irregular warfare operations.

A Predator system consists of four sensor- and weapon-equipped aircraft, a ground control station, a Predator Primary Satellite Link, and spare equipment, along with operations and maintenance crews. The Predator can be taken apart and put into a freight container and shipped via C-130 Hercules transport aircraft.

An MQ-1 Predator armed with a Hellfire missile flies a training mission.

Courtesy US Air Force

MQ-9 Reaper

Like the Predator, the MQ-9 Reaper is an armed, multi-mission, medium-altitude long-endurance, remotely piloted aircraft. But the Reaper is larger and more heavily armed. And its priorities are different. The Reaper's primary mission is attacking targets. Intelligence collection comes second.

MQ-9 Reaper

Master Sergeant Dennis Henry/Courtesy US Air Force

A sensor operator and pilot fly an unmanned aerial vehicle from Creech AFB, Nevada.

Staff Sergeant N.B./Courtesy US Air Force

The Reaper has a particularly strong set of visual sensors. These help it with targeting. They include an infrared sensor, color/monochrome daylight TV camera, image-intensified TV camera, laser range finder/designator, and laser illuminator. Each of these sensors produces full-motion video that can be viewed as a separate stream or combined with the others.

The Reaper's laser range finder and designator precisely designates targets for laser-guided munitions. The Reaper can fire four laser-guided AGM-114 Hellfire missiles.

In its secondary mission of intelligence gathering, the MQ-9 helps support a range of operations. These include coastal and border surveillance, weapons tracking, enforcing embargoes, disaster assistance, and anti-drug operations.

Like the Predator, the Reaper can be taken apart and packed into a single shipping container for deployment anywhere worldwide on a C-130 Hercules.

The Reaper uses what is called a *remote split operations concept*. That is, some of its functions are controlled in the forward operating location—in Iraq, for instance. Take-off and landing of the unmanned system are typically handled from the forward location. Personnel based in the continental United States—at Creech AFB, Nevada—control the rest of the mission.

An RQ-4 Global Hawk lands at Misawa AFB, Japan.
Staff Sergeant Nathan Lipscomb/Courtesy US Air Force

RQ-4 Global Hawk

The RQ-4 Global Hawk is a high-altitude, long-endurance aircraft. A remote crew of three flies it. It provides global all-weather, day or night intelligence, surveillance, and reconnaissance (ISR). Global Hawk's mission is to support all US military forces anywhere around the world, in peace or war. Global Hawk offers imagery intelligence, signals intelligence, and moving target indicator (MTI) sensors.

The Global Hawk can fly at more than 60,000 feet, and for longer than 30 hours at a stretch. In 2014, a Global Hawk flew a 34.3-hour flight. This set the endurance record for the longest unrefueled flight by a US Air Force aircraft.

In 2016 the Air Force brought back "flying sergeants" for the first time since sergeants were trained to fly in World War II. These pilot-qualified noncommissioned officers (NCOs) were needed to help meet the shortage of trained officers to fly the Global Hawk.

An Airman prepares to launch an RQ-11 Raven at Kirkuk Air Base, Iraq.

Senior Master Sergeant Don Senger/Courtesy US Air Force

RQ-11B Raven

The RQ-11B Raven is a "back-packable" system. It's of a type known as *man-portable UAVs*, meaning a person can carry it. The Raven provides target information for troops in the field and helps them know what is going on around them. This is called *situational awareness*. The Raven system includes two aircraft, each weighing less than five pounds and with a wingspan of 4.5 feet, plus a ground control unit with a remote video terminal and support equipment. The system includes an electro-optical camera and an infrared camera. It takes two specially trained Airmen to operate each Raven system. They can control it manually, or it can travel on its own along a preplanned route. The Raven is launched by hand. It flies 150 to 500 feet above the ground and can stay up for 80 minutes.

The Raven has been in use since 2004 and is now used by all the service branches. The system has proven itself in combat in Iraq and Afghanistan, as well as other areas of conflict.

A Scan Eagle launches from a catapult.

Courtesy US Air Force

Scan Eagle

The Scan Eagle provides reconnaissance, surveillance, and target acquisition for Air Force security forces expeditionary teams—*teams sent for operations overseas*. It's classed as a small unmanned aircraft system: a Group 2 Small UAS. It includes four air vehicles plus a ground control station, remote video terminal, and a launch and recovery system. Two specially trained Airmen plus two maintenance personnel operate the Scan Eagle.

Scan Eagle aircraft are launched from a catapult and retrieved by the Skyhook system. This uses a hook on the edge of the wingtip to catch a rope hanging from a 30- to 50-foot pole. The Scan Eagle needs no runway for either launch or recovery.

Scan Eagle air vehicles have a wingspan of a little more than 10 feet. They weigh a bit less than 40 lbs. And their two-stroke engines have less horsepower than a typical walk-behind lawn mower. But they fly at an altitude of 16,000 feet and can remain aloft for more than 20 hours. Their day-night cameras and thermal imagers make them suited to operations around the clock.

Boeing originally developed the system at the request of the Marine Corps, as it sought ways to protect Marines deployed in Iraq.

Boeing X-45A J-UCAS

The Boeing X-45, had it gone into production, would have taken unmanned military aircraft even further than any of the aircraft you've just read about. The X-45 was part of the Boeing Joint Unmanned Combat Air System (J-UCAS). As that name suggests, it was meant to go into actual combat without a pilot or crew aboard.

The J-UCAS program began in 1998. It was a joint effort of DARPA, the Air Force, and the Navy. The program was meant to demonstrate that unmanned aircraft could knock out enemy air defenses, conduct surveillance, and execute precision strikes. The J-UCAS needed to be technically feasible, of course. But it also needed to prove its utility and value.

The X-45 was the first aircraft of its type. It was specifically designed for 21st-century combat operations within a networked system. The X-45 was a swept-wing stealthy jet. It landing gear retracted fully. Its skin was made of a fiber-reinforced epoxy composite. It had two internal weapons bays in its fuselage.

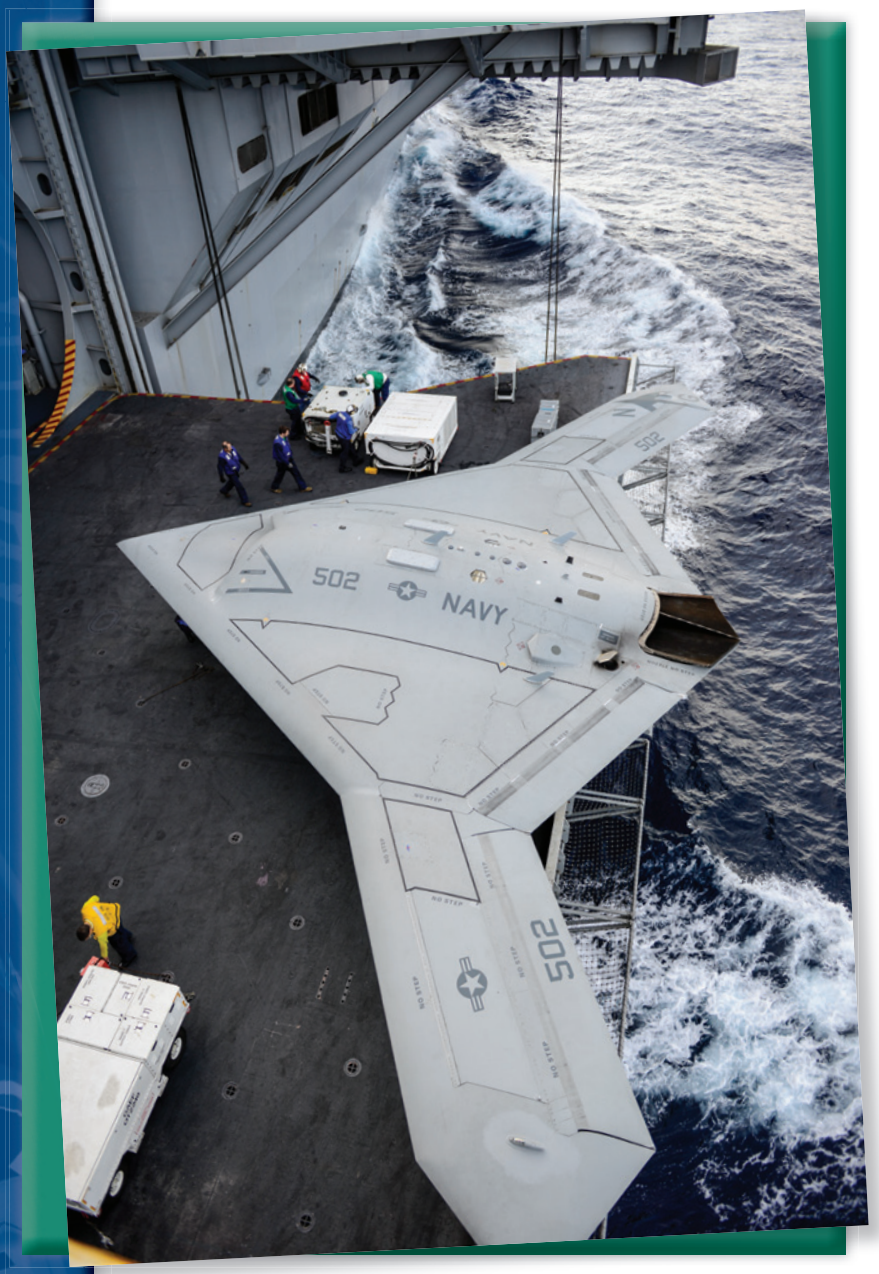
By 2005, the two X-45 demonstration vehicles (prototypes) had successfully concluded a series of flight tests. The next year 2006, they were packed up and shipped off to museums.

Boeing X-45A J-UCAS on display in the Research and Development Gallery at the National Museum of the US Air Force

Courtesy US Air Force

Northrop Grumman X-47 Pegasus

The X-47 was a Navy aircraft similar to the X-45. Northrop Grumman created the X-47 to help the Navy find out which fighter-sized tailless unmanned aircraft it could use on aircraft carriers. The idea was to launch unmanned fighters from carriers and send them off on attack missions.



Northrop Grumman X-47B aboard the aircraft carrier USS *Harry S. Truman*.
Courtesy US Navy

In August 2014 the X-47B made aviation history. It became the first-ever autonomous unmanned aircraft to be launched from and recovered on a carrier deck. Then in April 2015, the aircraft made history again. It successfully completed the first-ever autonomous aerial refueling of an unmanned aircraft.

By February 2016, though, the Navy seemed to have changed course. It canceled X-47 program.

Instead, the Navy will commit a relatively small sum to developing an unmanned aerial tanker. This new carrier-based aerial-refueling system will borrow from the technologies that made the X-47 successful in its test flights. CBARS is seen as a "combat multiplier." It would help extend the range of Navy fighters.

The X-47 still has advocates, though. They think the United States needs an unmanned fighter that can take off from an aircraft carrier. When Navy officials were ready to send their two prototypes off to a museum, as was done to the X-45s, congressional backlash forced them to reverse course.

Although both the X-45 and X-47 programs have ended for now, Air Force and Navy planners learned a great deal from both programs.

CHECKPOINTS

Lesson 2 Review

Using complete sentences, answer the following questions on a sheet of paper.

1. What did a DARPA study in the early 1970s show about military aircraft?
2. Which aircraft became the first air superiority fighter completely designed from stealth technology?
3. What issue with the F-22 did Lockheed Martin have to fix by installing new equipment?
4. Which country was the first to use precision weapons, and in what year?
5. What was the BOLT-117?
6. By the end of the war in Southeast Asia, how much more effective were smart bombs than unguided bombs?
7. In which two countries have conflicts sparked a revolution in unmanned aviation?
8. What was the Kettering Bug?
9. Where are the personnel based who largely control MQ-9 Reaper missions?

APPLYING YOUR LEARNING

10. Do you agree with General Arnold that the United States will eventually win wars using planes without pilots? In a short paragraph explain why you would agree or disagree.