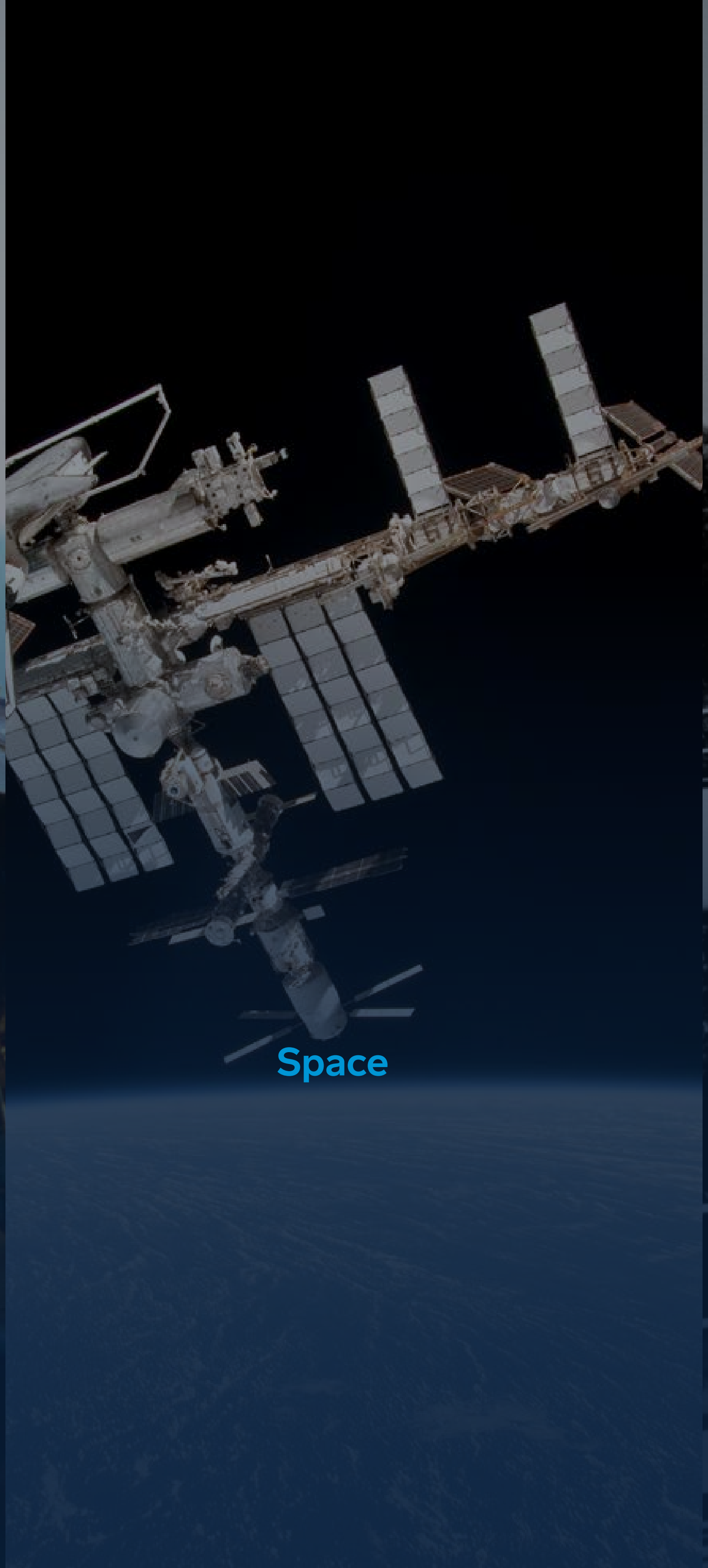
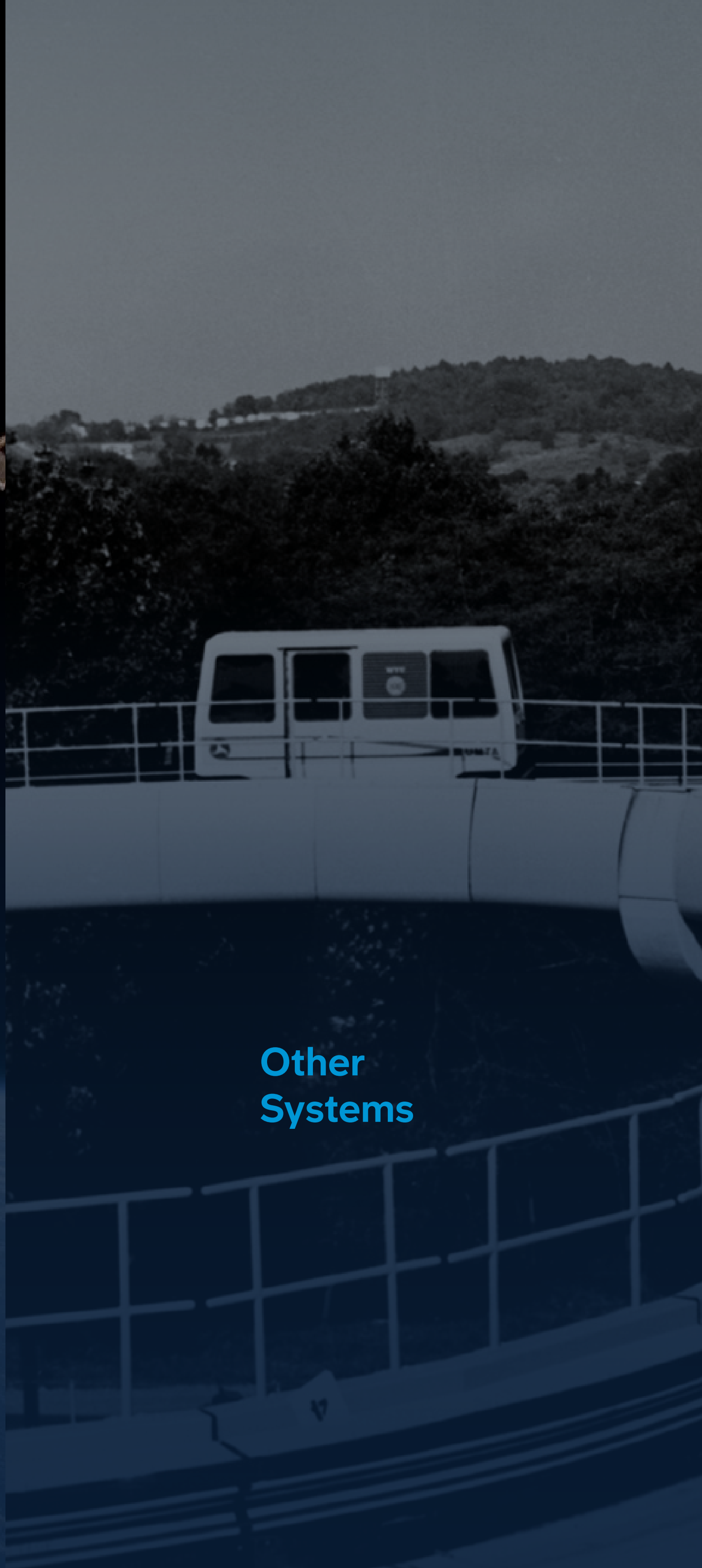
Select Products in Boeing History

Commercial Airplanes

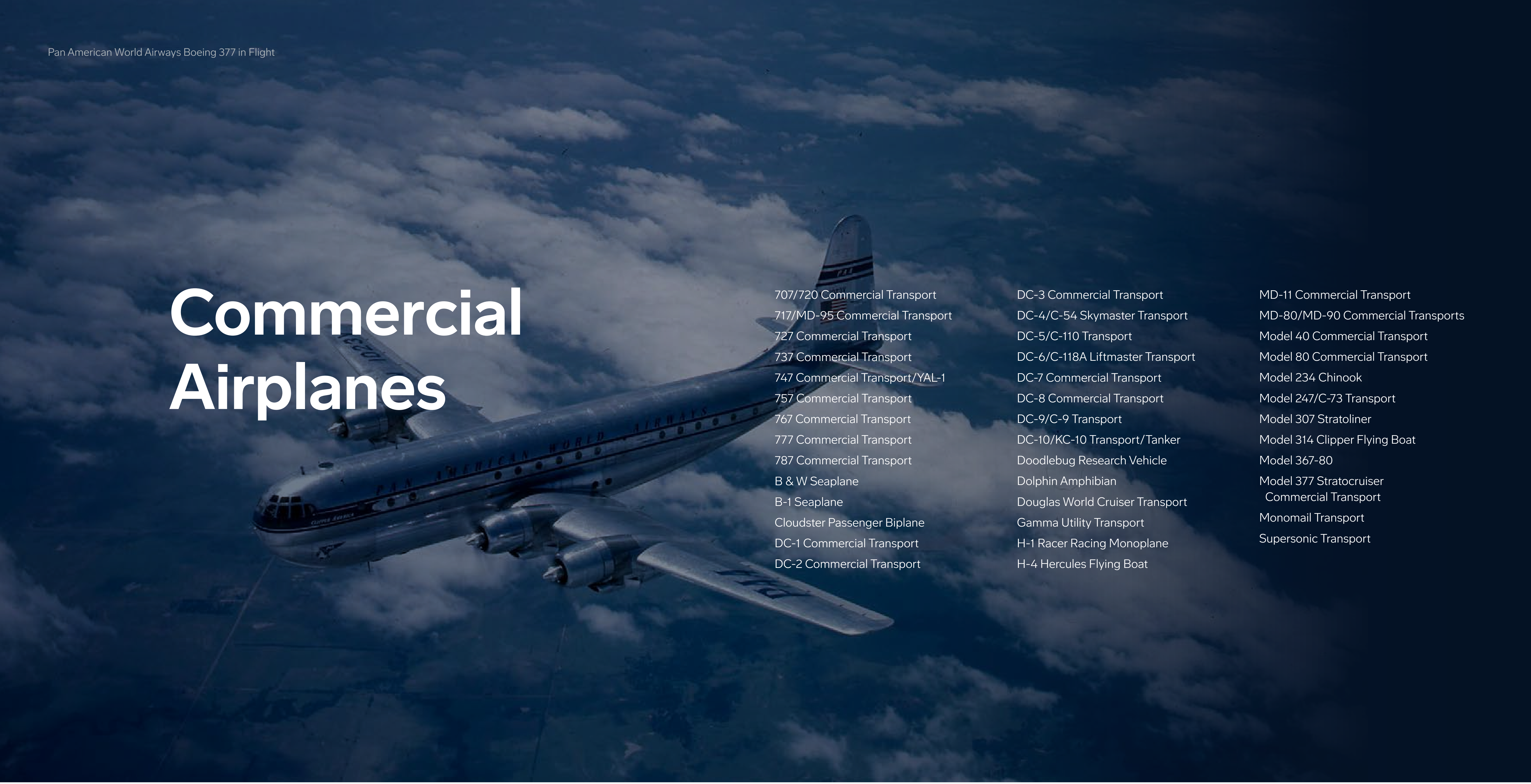
Defense



Space



Other Systems



Pan American World Airways Boeing 377 in Flight

Commercial Airplanes

- 707/720 Commercial Transport
- 717/MD-95 Commercial Transport
- 727 Commercial Transport
- 737 Commercial Transport
- 747 Commercial Transport/YAL-1
- 757 Commercial Transport
- 767 Commercial Transport
- 777 Commercial Transport
- 787 Commercial Transport
- B & W Seaplane
- B-1 Seaplane
- Cloudster Passenger Biplane
- DC-1 Commercial Transport
- DC-2 Commercial Transport
- DC-3 Commercial Transport
- DC-4/C-54 Skymaster Transport
- DC-5/C-110 Transport
- DC-6/C-118A Liftmaster Transport
- DC-7 Commercial Transport
- DC-8 Commercial Transport
- DC-9/C-9 Transport
- DC-10/KC-10 Transport/Tanker
- Doodlebug Research Vehicle
- Dolphin Amphibian
- Douglas World Cruiser Transport
- Gamma Utility Transport
- H-1 Racer Racing Monoplane
- H-4 Hercules Flying Boat
- MD-11 Commercial Transport
- MD-80/MD-90 Commercial Transports
- Model 40 Commercial Transport
- Model 80 Commercial Transport
- Model 234 Chinook
- Model 247/C-73 Transport
- Model 307 Stratoliner
- Model 314 Clipper Flying Boat
- Model 367-80
- Model 377 Stratocruiser Commercial Transport
- Monomail Transport
- Supersonic Transport

Technical Specifications

First flight	Dec. 20, 1957
Model number	707-120
Classification	Commercial transport
Span	130 feet 10 inches
Length	144 feet 6 inches
Gross weight	248,000 pounds
Cruising speed	600 mph
Range	3,000 miles
Ceiling	41,000 feet
Power	Four 13,500-pound-thrust P&W JT3C-6 turbojet engines
Accommodation	Up to 181 passengers

707/720 Commercial Transport

Historical Snapshot

After World War II, the British paved the way for commercial jets with the de Havilland Comet. Tragically, structural problems that led to catastrophic accidents grounded the Comet — and enthusiasm for the commercial jet.

Boeing Company President William Allen and his management are said to have "bet the company" on a vision that the future of commercial aviation was jets. In 1952, the Boeing board gave the go-ahead to commit $16 million of the company's own money to building the pioneering 367-80, nicknamed the "Dash 80." That then-huge amount represented nearly all the profit the company had made since the end of the World War II.

They set out to counter public nervousness. The Boeing strategy was to use the Dash 80 prototype for press and customer flights and an advertising campaign that was directed at the public, stressing the comfort and safety of jet air travel.

The campaign also included a film shown to airline customers titled "Operation Guillotine." The film of a Boeing test showed a conventional, fully pressurized airplane fuselage being pierced by two metal blades, resulting in a catastrophic failure and disintegration of the structure. Next, the 707 fuselage was put to the same test; this time, five blades pierced the pressurized fuselage, resulting in wisps of air escaping from the punctures — but no cracks and no structural failure.

The Dash 80 prototype led to the commercial 707 and the military KC-135 tanker. Both planes shared the basic design of the Dash 80 but were very different airplanes, neither one being a derivative of the other. One great difference was in the width and length of the fuselage. Airlines wanted the 707 fuselage to be 4 inches (2.5 centimeters) wider than the tanker's. Its width and the 100-foot length (30.5-meter) made it the largest passenger cabin in the air. Placement of its more than 100 windows allowed airlines to rearrange seats. Location of passenger doors on the left side, at the front and at the rear of the cabin, became standard for subsequent Boeing jets. The exteriors of the 707 and its competitor, the DC-8, were almost identical, but the 707 wing had more sweepback, so it could fly about 20 mph (32 kph) faster.

In just two years, the 707 would help change the way the world traveled. Travel by air eclipsed travel by rail and sea. The dawn of a new era in travel helped to make the terms "Boeing" and "707" fashionable. Requests poured into Boeing for rights to use "707" for naming products. Jantzen swimwear titled its 1957 collection "the 707."

To take market share away from its strong competitor the Douglas DC-8, Boeing custom-designed 707 variants for different customers. Boeing, for example, made special long-range models for Qantas Airways of Australia and installed larger engines for Braniff's high-altitude South American routes. Costs of such customizing were high, so with every version of the 707, the financial risk increased. After much effort, sales of the 707 picked up. The risk taking paid off, and the 707 outpaced the DC-8 in sales.

Although the 707s were intended as medium-range transports, they were soon flying across the Atlantic Ocean and across the continent. Boeing delivered 856 Model 707s in all versions between 1957 and 1994; of these, 725, delivered between 1957 and 1978, were for commercial use.

The 707 was designated the 720 when it was modified for short- to medium-range routes and for use on shorter runways. Engineers reduced the fuselage length by 9 feet (2.7 meters), changed the leading edge flaps and later installed turbofan engines. Boeing built 154 720s between 1959 and 1967. Its short- to medium-range role was later filled by 727s and 737s.

Technical Specifications	
First flight	Sept. 2, 1998
Model number	717-200
Classification	Commercial transport
Span	93 feet 4 inches
Length	124 feet
Gross weight	110,000 pounds
Range	1,647 miles
Power	Two 18,500- to 21,000-pound-thrust Rolls-Royce 715 high-bypass-ratio engines
Accommodation	106 passengers

717/MD-95 Commercial Transport

Historical Snapshot

The Boeing 717-200 twinjet was specifically designed for the short-haul, high-frequency 100-passenger airline market.

The program was launched by an order from AirTran Airways in 1995, and the airplane quickly became renowned by customers for its excellent economics, performance and reliability.

Final assembly of the 717 took place at the Long Beach, Calif., facility opened by Douglas Aircraft Co. in 1941 as part of President Roosevelt's Arsenal of Democracy — a request to the nation's industries to halt civilian production and assist in making wartime equipment. The facility produced almost 10,000 airplanes for World War II before transitioning to commercial airplane production after the war. Douglas merged with the McDonnell Aircraft Co. in 1967, forming the McDonnell Douglas Corp.

Based on the Douglas DC-9 and launched as the McDonnell Douglas MD-95, the 100-seater was renamed the Boeing 717 after McDonnell Douglas and Boeing merged in 1997.

It entered a rigorous flight-test program in September 1998 and received joint certification a year later. It was the first commercial airplane to receive a Concurrent and Cooperative Certification from the U.S. Federal Aviation Administration (FAA) and Europe's Joint Aviation Authorities (JAA). The FAA and JAA jointly certified the 717's first major upgrade to the airplane's flight control computer and flight management system in October 2000.

The launch customer, AirTran Airways of Orlando, Fla., took delivery of the first 717 in September 1999. Boeing built a total of 156 717s until production ended.

On May 23, 2006, Boeing delivered the final two 717s to Midwest Airlines and AirTran Airways in a ceremony before thousands of employees, retirees and dignitaries in Long Beach. The deliveries concluded commercial airplane production in Southern California that began in the 1920s with Douglas Aircraft Co. More than 15,000 airplanes had been produced in the Long Beach factory.

Technical Specifications

First flight	Feb. 9, 1963
Model number	727-100
Classification	Commercial transport
Span	108 feet
Length	133 feet 2 inches
Gross weight	170,000 pounds
Top speed	632 mph
Cruising speed	570 mph
Range	3,110 miles
Ceiling	36,100 feet
Power	Three 14,000-pound-thrust P&W engines
Accommodation	131 passengers

727 Commercial Transport

Historical Snapshot

It was the first commercial airplane to break the 1,000-sales mark, but it started out as a risky proposition. The 727 was designed to service smaller airports with shorter runways than those used by Boeing 707s. U.S. companies already working to compete in this market included Lockheed, Convair and later Douglas, with what would become the DC-9. Boeing also faced overseas competition from such airplanes as the de Havilland Trident, Sud Aviation Caravelle and British Aircraft Corp. BAC 1-11.

Adding to Boeing's challenges were conflicting demands from customers: some wanted four engines, another wanted a twin, still others were satisfied with prop planes. Boeing was also still grappling with the startup and production costs of the 707. The decision to go forward on a new commercial plane was a risk that many at Boeing advised against. On Dec. 5, 1960, Boeing announced the three-engine 727, with 40 orders each from launch customers United Airlines and Eastern Air Lines.

Of all the early Boeing jets, the 727 had the most distinctive appearance, with its rakish T-shaped tail and its trio of rear-mounted engines. It carried billions of passengers on everything from short hops to cross-country flights.

The 727 was the first Boeing jetliner to undergo rigorous fatigue testing, the first to have completely powered flight controls, the first to use triple-slotted flaps and the first to have an auxiliary power unit (APU). The APU was a small gas-turbine engine that eliminated the need for ground power or starting equipment in the more primitive airports of developing countries.

The first 727 rolled out Nov. 27, 1962, bearing a lemon-yellow and copper-brown color scheme similar to the livery of the Dash 80. However, by the time of its first flight, on Feb. 9, 1963, orders were still below the estimated break-even point of 200. To help spur sales, Boeing sent a 727 on a 76,000-mile tour of 26 countries.

Originally, Boeing planned to build 250 of the planes. However, they proved so popular (especially after the larger 727-200 model, which carried up to 189 passengers, was introduced in 1967) that a total of 1,832 were produced at the Renton, Wash., plant. Variants included a convertible passenger-cargo model with a Quick Change (QC) option — seats and galleys attached to removable pallets.

In September 1984, after a 22-year production run, the last 727 was delivered (a 727-200F to Federal Express). The once "very risky" 727 had become one of the greatest selling commercial jets in history.

Technical Specifications	
First flight	April 9, 1967
Model number	737-100/-200
Classification	Commercial transport
Span	93 feet
Length	93 feet 9 inches
Gross weight	111,000 pounds
Cruising speed	580 mph
Range	1,150 miles
Ceiling	35,000 feet
Power	Two 14,000-pound-thrust P&W JT8D-7 engines
Accommodation	2 crew, up to 107 passengers

737 Commercial Transport

Historical Snapshot

In 1965, the Boeing name was synonymous with big multiengine jet airplanes, so when the company announced its new commercial twinjet, the 737, it quickly earned the nickname "Baby Boeing."

The first 737 was the last new airplane to be built at Plant 2 on Boeing Field in Seattle, with a production run that included the legendary B-17 Flying Fortress, B-52 Stratofortress and the world's first large swept-wing jet — the XB-47 Stratojet. While the old assembly building at Plant 2 seemed cavernous, it still wasn't tall enough for the 737's tail, which was attached using a crane in the parking lot. The plane was then rolled down to a nearby plant known as the Thompson Site, where Boeing had set up the first production line for the 737.

At a ceremony inside the Thompson Site on Jan. 17, 1967, the first 737 was introduced to the world. The festivities included a christening by flight attendants representing the 17 airlines that had ordered the new plane.

In 1967, the smaller, short-range 737 twinjet was the logical airplane to complement the 707 and the 727. There was increasing demand for transports in its category, but the 737 faced heavy competition from the Douglas DC-9 and the British Aircraft Corp. BAC 1-11.

To save production time, and get the plane on the market as soon as possible, Boeing gave the 737 the same upper lobe fuselage as the 707 and 727 so that the same upper deck cargo pallets could be used for all three jets. The 737 later adopted the 727's cargo convertible features, which allowed the interior to be changed from passenger to cargo use in the 737-200 series.

The 737 had six-abreast seating — a selling point, because this way it could take more passengers per load (the DC-9 seated five abreast). The number of seats in the 737 also was increased by mounting the engines under the wing. This engine placement buffered some of the noise, decreased vibration and made it easier to maintain the airplane at ground level. Like the 727, the 737 could operate self-sufficiently at small airports and on remote, unimproved fields. The plane's performance in these conditions led to orders in Africa, Central and South America, Asia and Australia.

At first, the 737 was called the "square" airplane because it was as long as it was wide. The new technology made the position of flight engineer redundant; the 737's two-person flight deck became standard among air carriers.

On Dec. 27, 1967, Lufthansa took delivery of the first production 737-100 model, in a ceremony at Boeing Field. The following day, United Airlines, the first domestic customer to order the 737, took delivery of the first 737-200. The last 737-200 was delivered Aug. 8, 1988.

By 1987, the 737 was the most ordered plane in commercial history. In January 1991, 2,887 737s were on order, and Models 737-300, -400 and -500 were in production.

By 1993, customers had ordered 3,100 737s, and the company was developing the Next-Generation 737s — the -600, -700, -800 and -900. Boeing certified and delivered the first three Next-Generation models in less than one year.

The 126- to 149-seat 737-700 was launched in November 1993 and first delivered in December 1997. The 162- to 189-seat 737-800 was launched Sept. 5, 1994. The 110- to 132-passenger 737-600 was first delivered in 1998, and the 177- to 189-passenger 737-900 was first delivered in 2001. Customers began ordering the -900's replacement, the higher capacity, longer range 737-900ER, in 2005.

The Boeing Business Jet (BBJ), launched in 1996 as a joint venture between Boeing and General Electric and designed for corporate and VIP applications, is a high-performance derivative of the 737-700. The BBJ 2, announced in October 1999, is based on the 737-800 and has 25 percent more cabin space and twice the cargo space of the BBJ.

737 Commercial Transport (cont'd)

The 737 serves as a platform for military derivatives, including airborne early warning and control (AEW&C). Nineteen 737-200s, modified as T-43 navigator trainers, served with the U.S. Air Force. The 737 also provides a platform for the U.S. Navy P-8A Poseidon, a long-range maritime patrol and reconnaissance aircraft. The Navy C-40A Clipper is certified to operate in an all-passenger configuration, an all-cargo variant, or as a "combi" that accommodates both cargo and passengers on the main deck. The Air Force C-40B provides safe, comfortable and reliable transportation for U.S. combatant commanders and other senior government officials to locations around the world.

The 737 MAX is Boeing's newest family of single-aisle airplanes. The family includes the 737 MAX 7, 737 MAX 8 and 737 MAX 9. The program has also launched the 737 MAX 200, a new variant based on the 737 MAX 8.

The 737 MAX's more efficient structural design, lower engine thrust and less required maintenance are designed to give customers substantial cost savings. The 737 MAX will incorporate the latest quiet engine technology to reduce the operational noise footprint, and emissions will be approximately 50 percent below the International Civil Aviation Organization's (ICAO) Committee on Aviation Environmental Protection (CAEP)/ 6 limits for nitrogen oxides (NOx).

Boeing Commercial Airplanes set a new Guinness World Record for "highest production large commercial jet" when the 10,000th 737 airplane was assembled in Renton, Wash., USA. The March 2018 milestone beat the Boeing Renton site's previous World Record set in January 2006 for 5,000 737 airplanes assembled. The site is now producing 737s at a rate of 52 airplanes per month and is on track to increase production to a rate of 57 per month in 2019.

The number one 737 was a prototype used for flight test and certification and never went into revenue service. In 1974, the plane turned in its Boeing house livery of dark green and cream for the sporty white and blue colors of NASA. For the next two decades, the plane was based at the NASA Langley Research Center in Virginia and had an outstanding career as a flying laboratory. Today, the plane is on display at the Museum of Flight in Seattle surrounded by its bigger family members from the early 7 series and parked just a few hundred feet from where it first took to the air 40 years ago.

Technical Specifications	
First flight	Feb. 9, 1969
Model number	747-100/-200
Classification	Commercial transport
Span	195 feet 8 inches
Length	231 feet 4 inches
Gross weight	735,000 pounds
Cruising speed	640 mph
Range	6,000 miles
Ceiling	45,000 feet
Power	Four 43,000-pound-thrust P&W JT9D-3 engines
Accommodation	33 attendants, 374 to 490 passengers

747 Commercial Transport/YAL-1

Historical Snapshot

The 747 was the result of the work of some 50,000 Boeing people. Called “the Incredibles," these were the construction workers, mechanics, engineers, secretaries and administrators who made aviation history by building the 747 — the largest civilian airplane in the world — in roughly 16 months during the late 1960s.

The incentive for creating the giant 747 came from reductions in airfares, a surge in air-passenger traffic and increasingly crowded skies. Following the loss of the competition for a gigantic military transport, the C-5A, Boeing set out to develop a large advanced commercial airplane to take advantage of the high-bypass engine technology developed for the C-5A. The design philosophy behind the 747 was to develop a completely new plane, and other than the engines, the designers purposefully avoided using any hardware developed for the C-5.

The 747’s final design was offered in three configurations: all passenger, all cargo and a convertible passenger/freighter model. The freighter and convertible models loaded 8- by 8-foot (2.4- by 2.4-meter) cargo containers through the huge hinged nose.

The 747 was truly monumental in size. The massive airplane required construction of the 200 million-cubic-foot (5.6 million-cubic-meter) 747 assembly plant in Everett, Wash., the world’s largest building (by volume). The fuselage of the original 747 was 225 feet (68.5 meters) long; the tail as tall as a six-story building. Pressurized, it carried a ton of air. The cargo hold had room for 3,400 pieces of baggage and could be unloaded in seven minutes. The total wing area was larger than a basketball court. Yet, the entire global navigation system weighed less than a modern laptop computer.

Pilots prepared for the 747 at Boeing training school. The experience of taxiing such a large plane was acquired in a contraption called “Waddell’s Wagon," named after Jack Waddell, the company’s chief test pilot. The pilot sat in a mockup of the 747 flight deck built atop three-story-high stilts on a moving truck. The pilot learned how to maneuver from such a height by directing the truck driver below him by radio.

The National Aeronautics and Space Administration later modified two 747-100s into Shuttle Carrier Aircraft. The next version, the 747-200, holds approximately 440 passengers and has a range of about 5,600 nautical miles (10,371 kilometers). In 1990, two 747-200Bs were modified to serve as Air Force One and replaced the VC-137s (707s) that served as the presidential airplane for nearly 30 years. The 747-300 has an extended upper deck and carries even more passengers than the -200.

The 747-400 rolled out in 1988. Its wingspan is 212 feet (64 meters), and it has 6-foot-high (1.8-meter-high) “winglets" on the wingtips. The 747-400 also is produced as a freighter, as a combination freighter and passenger model, and as a special domestic version, without the winglets, for shorter range flights.

In August 1999, major assembly began on a militarized 747-400 Freighter to be used as a platform for the U.S. Air Force’s Airborne Laser (ABL) program. It rolled out on Oct. 27, 2006, and was eventually designated YAL-1. Boeing was the prime contractor for ABL, which was designed to provide a speed-of-light capability to destroy all classes of ballistic missiles in their boost phase of flight. Boeing provided the modified aircraft and the battle management system and is the overall systems integrator. ABL partners were Northrop Grumman, which supplied the chemical oxygen iodine, or COIL, high-energy laser associated lasers, and Lockheed Martin, which provided the nose-mounted turret in addition to the beam control/fire control system. On Feb. 11, 2010, the flying test bed destroyed a ballistic missile off the coast of Southern California. The program was canceled in 2011, and in 2012, YAL-1 was flown to the U.S. Air Force “bone yard” near Pima, Ariz., to be scrapped.

Another variant is the Dreamlifter — a specially modified 747-400 — that transports the large composite structures, including huge fuselage sections of the

747 Commercial Transport/YAL-1 (cont'd)

787 Dreamliner, from partners around the world to Everett, Wash., and Charleston, S.C., for final assembly. The massive cargo is loaded and unloaded from a hinged rear fuselage. The fourth and final Dreamlifter entered service Feb. 16, 2010.

The longer range 747-400 airplanes (also known as 747-400ERs) were launched in late 2000. The 747-400ER (Extended Range) family is available in both passenger and freighter versions. The airplanes are the same size as current 747-400s and have a range of 7,670 nautical miles (14,205 kilometers) as opposed to the 747-400 range of 7,260 nautical miles (13,450 kilometers). It incorporates the strengthened -400 Freighter wing, strengthened body and landing gear, and an auxiliary fuel tank in the forward cargo hold, with an option for a second tank. When the 747-400ER's full-range capability is not needed, operators can remove the tank (or tanks), freeing up additional space for cargo.

In November 2005, Boeing launched the 747-8 family — the 747-8 Intercontinental passenger airplane and the 747-8 Freighter. These airplanes incorporate innovative technologies from the 787 Dreamliner. In fact, the designation 747-8 was chosen to show the technology connection between the 787 Dreamliner and the new 747-8, including the General Electric GEnx-2B engines, raked wingtips and other improvements that allow for a 30 percent smaller noise footprint, 15 percent reduction in-service carbon emissions, better performance retention, lower weight, less fuel consumption, fewer parts and less maintenance.

The 747-8 Freighter first flew on Feb. 8, 2010. The airplane is 250 feet, 2 inches (76.3 meters) long, which is 18 feet, 4 inches (5.6 meters) longer than the 747-400 Freighter. The stretch provides customers with 16 percent more revenue cargo volume compared with its predecessor. That translates to an additional four main-deck pallets and three lower hold pallets.

The passenger version, the Boeing 747-8 Intercontinental, serves the 400- to 500-seat market and took its first flight on March 20, 2011. The cabin's sculpted ceilings, bigger overhead and side stowbins, a redesigned staircase and dynamic LED lighting all add to an overall more comfortable passenger experience. With 51 additional seats and 26 percent more revenue cargo volume than the 747-400, Boeing delivered the first 747-8 Intercontinental to an undisclosed Boeing Business Jet customer on Feb. 28, 2012. Launch customer Lufthansa took delivery of the first airline Intercontinental April 25, 2012.

On June 28, 2014, Boeing delivered the 1,500th 747 to come off the production line to Frankfurt, Germany-based Lufthansa. The 747 is the first wide-body airplane in history to reach the 1,500 milestone.

Technical Specifications	
First flight	Feb. 19, 1982
Model number	757-200
Classification	Commercial transport
Span	124 feet 10 inches
Length	155 feet 3 inches
Gross weight	255,000 pounds
Top speed	609 mph
Cruising speed	500 mph
Range	3,200 to 4,500 miles
Ceiling	42,000 feet
Power	Two 37,000- to 40,100-pound-thrust RB.211 Rolls-Royce or 37,000- to 40,100-pound-thrust 2000 series P&W engines
Accommodation	200 to 228 passengers

757 Commercial Transport

Historical Snapshot

The twin-engine, medium-range 757 was up to 80 percent more fuel efficient than the older 727 jetliners it was designed to replace but retained the 727's short-field capability. The 757-200 carried up to 228 passengers and had a range of approximately 3,900 nautical miles (7,222 kilometers).

The 757 and the 767 were developed concurrently, so both shared the same technological advances in propulsion, aerodynamics, avionics and materials. The pioneering two-crew computerized flight decks, or "glass cockpits," of the 757 and 767 are nearly identical, so pilots could easily qualify to fly both.

The first 757 rolled out of the Renton, Wash., factory in 1982. On March 29, 1991, a 757, powered by only one of its engines, took off, circled and landed at the 11,621-foot-high (3,542-meter-high) Gonggar Airport in Tibet. The airplane performed perfectly although the airfield was in a box canyon surrounded by peaks more than 16,400 feet (4,998 meters) high.

In 1996, the company launched the 757-300. It seated up to 280 passengers and had about 10 percent lower seat-mile operating costs than the -200. The first 757-300 was delivered in 1999. By then, Boeing had delivered more than 1,000 757s. Four 757s were modified as replacements for the older 707-based VC-137 executive transports for government officials and designated C-32As.

In late 2003, Boeing decided to end 757 production because the increased capabilities of the newest 737s and the new 787 fulfilled the 757 market's needs. On April 27, 2005, Boeing concluded the remarkable 23-year run of the 757 passenger airplane by delivering the final one to Shanghai Airlines. The airplane was the 1,050th Boeing 757.

Technical Specifications	
First flight	Sept. 26, 1981
Model number	767-200
Classification	Commercial and military transport
Span	156 feet 1 inches
Length	159 feet 2 inches
Gross weight	300,000 pounds
Cruising speed	550 mph
Range	3,840 to 7,800 miles
Ceiling	43,199 feet
Power	Two 48,000- or 50,000-pound-thrust P&W JT9D-R4D or 57,900-pound-thrust GE CF6-80A2 engines
Accommodation	216 to 290 passengers

767 Commercial Transport

Historical Snapshot

The Boeing 767, built in Everett, Wash., alongside the 747, can carry from 200 to 300-plus passengers. The 767 is a wide-body, double-aisle jet, but, like the smaller standard-body 757, it was designed for fuel efficiency. Both planes have nearly identical digital cockpits, allowing crews to be easily qualified on both. In 1985, as the pioneer for ETOPS (for "Extended-range Twin-engine Operational Performance Standards"), the 767 was certified for extended flights that would make it the first commercial twin jet to fly regular routes across the Atlantic. The 767-200 was first ordered in 1978, and the last was delivered in 1994. Its extended-range model, the 767-200ER, entered service in 1984. The 767-300 was first ordered in 1986 and was followed by its extended-range model, first delivered in 1988.

The 767 family includes five passenger models — the 767-200, 767-200ER, 767-300, 767-300ER and 767-400ER. The 767-400ER, which first flew in 1999, can carry 304 passengers in a two-class configuration more than 7,000 miles (11,265 kilometers). The family also includes the 767 Freighter, based on the 767-300ER fuselage, rolled out in May 1995 and first delivered in October 1995.

In December 1991, Boeing offered a modified 767 commercial jetliner as the platform for its Airborne Warning and Control System (AWACS), previously carried aboard the 707. The first of the 767 AWACS, designated E-767, made its first flight Aug. 9, 1996, and the government of Japan ordered four of them.

In 2000, Boeing launched its international 767 tanker/transport. The Italian Air Force and the Japan Air Self-Defense Force became customers.

On Feb. 2, 2011, hundreds of employees, joined by Boeing retirees who worked on the first 767, gathered to celebrate the 1,000th 767 at the Everett, Wash., factory. Just weeks later, on Feb. 24, the U.S. Air Force awarded a contract to Boeing to develop a tanker to replace its aging KC-135 fleet. Based on the 767-2C, a freighter version of the 767-200ER, the new KC-46 Pegasus is able to refuel 64 different aircraft and can detect, avoid, defeat and survive threats using multiple layers of protection. The U.S. Air Force took delivery of its first two KC-46A tankers in December 2018.

The 767 has evolved to meet changing market requirements. The 767 freighter has a high-capacity cargo arrangement on both main deck and lower hold and can carry 59 tons (53 tonnes) of revenue cargo with intercontinental range. The 767 has also incorporated advanced avionics, aerodynamics, materials and propulsion into the passenger airplanes. The 767 is the only Boeing product that serves the freighter, passenger and tanker markets.

Technical Specifications	
First flight	June 12, 1994
Model number	777-200
Classification	Commercial transport
Span	199 feet 11 inches
Length	209 feet 1 inch
Gross weight	506,000 pounds
Cruising speed	615 mph
Range	4,210 to 8,270 miles
Ceiling	37,900 feet
Power	Two 74,500-/77,200-pound-thrust P&W 4074/4077 engines; two 74,500-/76,400-pound-thrust GE90-75B/76B engines; or two 74,600-/76,900-pound-thrust RR Trent 875/877 engines
Accommodation	305 to 440 passengers

777 Commercial Transport

Historical Snapshot

The Model 777, the first entirely new Boeing airplane in more than a decade, was the first jetliner to be 100 percent digitally designed using three-dimensional computer graphics. Throughout the design process, the airplane was "preassembled" on the computer, eliminating the need for a costly, full-scale mock-up.

The 777 program was launched in October 1990 with an order from United Airlines. In June 1995, United flew its first 777 in revenue service. The Boeing board of directors authorized production of the 777-300 on June 26, 1995, and the first 777-300 was delivered to Cathay Pacific Airways in June 1998.

The 777 was larger than all other twinjet or trijet airplanes but smaller than the 747 and included improvements in airfoil technology, flight deck design, passenger comfort and interior flexibility. The airplane seats from 301 to 386 passengers in a three-class configuration with a range capability of 5,240 nautical miles (9,700 kilometers) to 9,395 nautical miles (17,395 kilometers).

By 2014, the 777 was available in six models: the 777-200, 777-200ER (Extended Range), a larger 777-300, two longer range models, the 777-300ER, which rolled out Nov. 14, 2002, and 777-200LR Worldliner (the world's longest range commercial airplane) and the Boeing 777 Freighter.

The 777X is Boeing's newest family of twin-aisle airplanes. In November 2013, Boeing Commercial Airplanes launched the airplane at the Dubai Airshow with 259 commitments from four customers. Production of the 777X was scheduled to begin in 2017, and first delivery was targeted for 2020.

The 777X was designed to be the largest and most-efficient twin-engine jet in the world, with 12 percent lower fuel consumption and 10 percent lower operating costs than the competition.

In 2012, Boeing began developing an advanced manufacturing technology for 777 fuselages known as Fuselage Automated Upright Build, or FAUB. With this technology, fuselage sections are built using automated, guided robots that fasten the panels of the fuselage together, drilling and filling the approximately 60,000 fasteners that were originally installed by hand.

On Oct. 21, 2014, Boeing broke ground for a new 1 million-square-foot (304,800-square-meter) 777X Composite Wing Center at its Everett, Wash., site.

The 777 is the first airplane to have a rose named after it. The deep purple-red rose, with a citrus-like fragrance, was developed by Olympia, Wash., Western Independent Nurseries.

Technical Specifications	
First flight	Dec. 15, 2009
Model number	787-8
Classification	Commercial transport
Span	199 feet 11 inches
Length	186 feet
Height	56 feet
Total cargo volume	4,400 cubic feet
Gross weight	484,000 pounds
Cruising speed	Mach 0.85
Accommodation	210 to 250 passengers

787 Commercial Transport

Historical Snapshot

On Jan. 29, 2003, Boeing gave a development designation to name to a new super-efficient, midsized airplane — the Boeing 7E7 — and released the first image of the airplane concept. The company said the designation signaled its commitment to develop a new airplane with major breakthroughs in a lot of areas starting with the letter "E," including "efficiency, economics, environmental performance, exceptional comfort and convenience, and e-enabled systems."

The Boeing 7E7 was developed with an international industry team as a 200- to 250-seat airplane providing nonstop, point-to-point service at speeds similar to the Boeing 777 and 747. The company expected to formally offer the new airplane to customers in early 2004, with entry into service targeted for 2008. It took longer than expected, but when it arrived, it was the fastest selling wide-body airplane in history.

On Dec. 15, 2009, the 787 Dreamliner made its first flight from Paine Field in Everett, Wash., under the control of Capt. Mike Carriker and Capt. Randy Neville. It took off at 10:27 a.m. Pacific time and concluded its flight with touchdown at 1:33 p.m. Pacific time at Boeing Field in Seattle. Boeing celebrated the delivery of the first 787 Dreamliner to launch customer ANA on Sept. 26, 2011, at the Everett plant. The 787-9 took flight on Sept. 17, 2013, launching a comprehensive flight-test program leading to certification and first delivery to launch customer Air New Zealand in June 2014.

The 787-8 Dreamliner can carry 210 to 250 passengers on routes of 7,650 to 8,200 nautical miles (14,167 to 15,186 kilometers), while the 787-9 Dreamliner carries 250 to 290 passengers on routes of 8,000 to 8,500 nautical miles (14,816 to 15,742 kilometers).

At the Paris Air Show on June 18, 2013, Boeing launched the 787-10 Dreamliner, the third member of the 787 family, with commitments for 102 airplanes from five customers. The third and longest 787, the 787-10, achieved firm configuration in April 2014 and was scheduled for delivery in 2018. The new 787-10 was designed to fly up to 7,000 nautical miles (12,964 kilometers) — covering more than 90 percent of the world's twin-aisle routes — with seating for 300 to 330 passengers, depending on an airline's configuration choices.

In addition to bringing big-jet ranges to midsized airplanes, the 787 provides airlines with unmatched fuel efficiency, using 20 percent less fuel for comparable missions than other similarly sized airplanes. It can travel at speeds similar to today's fastest wide bodies (Mach 0.85), and it provides airlines with more cargo revenue capacity.

Passengers enjoy an interior environment with higher humidity and a feeling of space and comfort, with larger windows and an open architecture with streamlined arches.

As much as 50 percent of the primary structure on the 787, including the fuselage and wing, is made of composite materials. General Electric and Rolls-Royce provide engines for the 787.

The 787 program opened its final assembly plant in Everett in May 2007. On July 30, 2008, Boeing acquired the business and operations conducted by Vought Aircraft Industries in North Charleston, S.C. On Oct. 28, 2009, Boeing announced the facility will be the location for a second final assembly site for the 787 Dreamliner, breaking ground less than a month later. In late 2011, the airplane earned records for completing the longest flight for an airplane in its weight class (440,924 to 551,155 pounds, or 200,000 to 250,000 kilograms) with a 10,336-nautical-mile (19,142-kilometer) flight to Dhaka, Bangladesh. This record had previously been held by the Airbus A330 with a 9,126-nautical-mile (16,901-kilometer) flight in 2002. Following refueling in Dhaka, the crew continued eastbound and returned to Seattle 42 hours, 26 minutes after their initial departure, completing the fastest around-the-world trip for the same weight class at 470 knots (541 mph, 871 kph). There was no previous around-the-world speed record for this weight class.

787 Commercial Transport (cont'd)

In 2012, the Dreamliner team was honored with a 2012 Aviation Week Laureate Award in Aeronautics/Propulsion; the 2011 Robert J. Collier Trophy; and the 2012 Hermes Awards for Innovation given by the European Institute for Creative Strategies and Innovation.

On Nov. 17, 2013, the airplane received its 1,000th customer order when Etihad Airways announced an order for 30 787-10 Dreamliners. The Dreamliner family had reached this sales milestone faster than any other wide-body airplane in aviation history, and eight years faster than the popular 777.

On Nov. 8, 2014, Boeing donated one of the original 787-8 Dreamliner flight test airplanes to the Museum of Flight in Seattle. The airplane Boeing donated to the museum, known as ZA003, was the third 787-8 produced. The airplane had been part of the 787 flight test and certification program, and it circumnavigated the globe several times in 2011 and 2012 during a "Dream Tour" that introduced the 787 to more than 68,000 visitors in 23 countries.

Technical Specifications	
First flight	June 15, 1916
Model number	1
Classification	Utility seaplane
Span	52 feet
Length	27 feet 6 inches
Gross weight	2,800 pounds
Top speed	75 mph
Cruising speed	67 mph
Range	320 miles
Power	125-horsepower Hall-Scott A-5 engine
Accommodation	Two crew

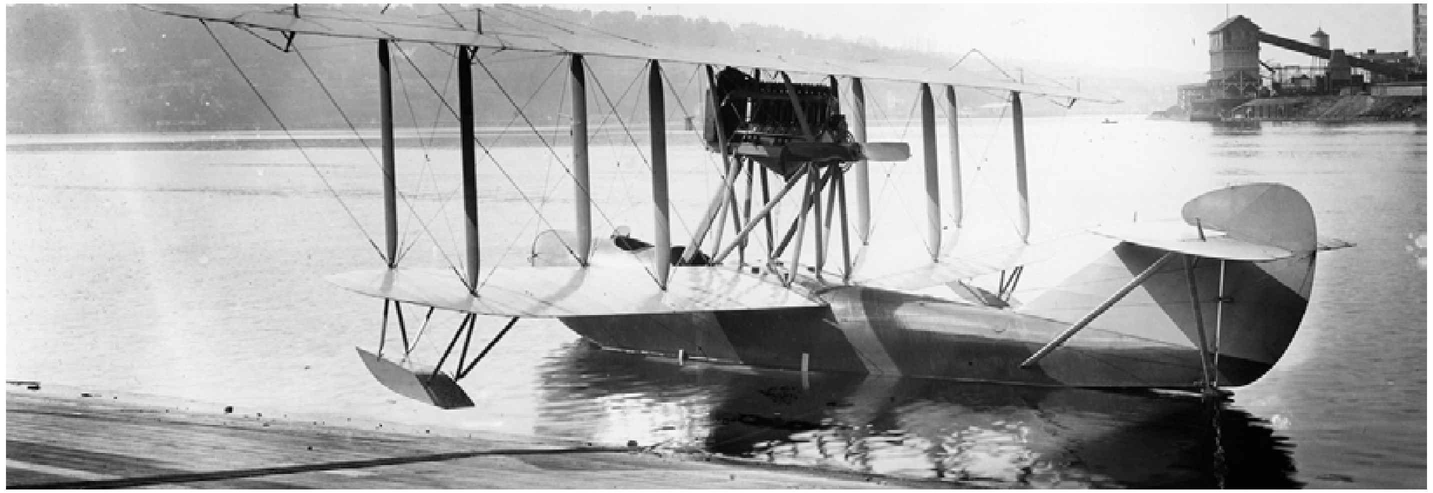
B & W Seaplane

Historical Snapshot

The B & W was the first Boeing product, named after the initials of its designers, William Boeing and U.S. Navy Lt. Conrad Westervelt.

The first B & W, completed in June 1916, was made of wood, linen and wire. Inspired by the Martin TA trainer that Boeing owned, the B & W had, among other improvements, better pontoons and a more powerful engine.

The two B & Ws were offered to the U.S. Navy. When the Navy did not buy them, they were sold to the New Zealand Flying School and became the company's first international sale. The B & Ws later were used for New Zealand express and airmail deliveries, set a New Zealand altitude record of 6,500 feet (1,981 meters) on June 25, 1919, and made that country's first official airmail flight on Dec. 16, 1919.



B-1 Seaplane

Historical Snapshot

The B-1 was the company's first offering for the civil market, and although it had a successful career, only one was built. A "pusher-style" flying boat, with its engine at the rear, it could carry a pilot and two passengers, as well as mail or cargo. The hull was laminated wood veneer, and the wing frames were spruce and plywood.

After its first flight on Dec. 27, 1919, it outlasted six engines in eight years of international airmail runs between Seattle, Wash., and Victoria, British Columbia. In an era with few airports, a boat that could land on water made sense. Flown by Eddie Hubbard, the B-1 covered 350,000 miles (563,000 kilometers) — remarkable for the time.

The B-1 mail flights took off from Lake Union in Seattle, and today, meticulously restored, it hangs from the ceiling of the Museum of History and Industry on the shore of Seattle's Lake Union that served as its base of operations.

Technical Specifications	
First flight	Dec. 27, 1919
Model number	6
Classification	Civil flying boat
Span	50 feet 3 inches
Length	31 feet 3 inches
Gross weight	3,850 pounds
Top speed	90 mph
Cruising speed	80 mph
Range	400 miles
Ceiling	13,300 feet
Power	200-horsepower Hall-Scott L-6 or 400-horsepower Liberty engine
Accommodation	1 pilot, 2 passengers

Technical Specifications	
First flight	Feb. 24, 1921
Wingspan	56 feet
Length	36 feet 9 inches
Height	12 feet
Ceiling	19,160 feet
Range	2,800 miles
Weight	9,600 pounds
Power plant	400-horsepower Liberty engine
Speed	120 mph

Cloudster Passenger Biplane

Historical Snapshot

The Cloudster was the first Douglas product. It was also the first airplane in history to airlift a useful load exceeding its own weight. The strut-braced wood, wire and doped-cloth (glue-covered) biplane was powered by a World War I surplus 400-horsepower Liberty engine. David R. Davis funded the establishment of the Davis Douglas Co. to build an airplane that would make the first nonstop flight across the country.

Components were built in the loft of a Los Angeles, Calif., planing mill rented by Donald Douglas, lowered down a shaft and trucked to Goodyear Field, where they were assembled in a hangar.

On March 19, 1921, the original Cloudster broke the Pacific Coast altitude record by climbing 19,160 feet (5,839 meters). On June 27, 1921, it started out on its flight across the country but had to make a forced landing at Fort Bliss, Texas. After the Cloudster's transcontinental flight was aborted, Davis lost interest and left the company. Two Army pilots in a Fokker monoplane ultimately beat the Cloudster in its quest to make the first nonstop flight across the country.

The Cloudster was later rebuilt as an airliner and sold to Claude Ryan of San Diego, Calif. With the ability to carry 12 passengers, the Cloudster became the flagship of Ryan's San Diego–to–Los Angeles airline, one of the first scheduled passenger lines in the country.

It ended its career making chartered flights between Los Angeles and San Diego, and it flew beer to Tijuana, Mexico, after the 1926 floods. During a chartered flight to Ensenada, Mexico, the Cloudster made a forced landing on the beach and was destroyed by the high tide.

Technical Specifications	
First flight	July 1, 1933
Wingspan	56 feet
Length	60 feet
Height	16 feet
Ceiling	23,000 feet
Range	1,000 miles
Weight	17,500 pounds
Power plant	Two 710-horsepower Wright engines
Speed	190 mph
Accommodation	2 crew, 12 passengers

DC-1 Commercial Transport

Historical Snapshot

Introduction of the DC-1 (Douglas Commercial Model One) in 1933 marked the beginning of 64 years of continuous production of passenger planes by the Douglas Aircraft Co.

The airplane was designed as a series prototype for TWA to compete against the revolutionary Boeing Model 247 ordered by Boeing subsidiary United Air Lines. The DC-1 exceeded all but one of the tough specifications set by its buyer — TWA wanted three engines; the DC-1 had only two.

The DC-1 was very advanced for its day. Its fuselage was streamlined, as were its wings and engine cowlings. It featured all-metal construction and retractable landing gear. Variable-pitch propellers gave the plane remarkable takeoff and landing characteristics. With plush seats, a kitchen and a comfortable restroom, the DC-1 set a new standard for passenger comfort.

Great efforts were made to insulate the passenger compartment from the noise of the plane's engines. The plane's passenger seats were mounted on rubber supports, while the cabin was lined with noise-absorbing fabric. Carpet covered the cabin floor, and even the engines were mounted on rubber insulators.

The DC-1 carried 12 passengers (two more than the Model 247) and could fly as fast as 180 mph (289 kph). In April 1935, it set a transcontinental speed record, covering the distance from Los Angles, Calif., to New York in 11 hours, five minutes. Pleased with its new plane, TWA placed an order for 25 larger aircraft designated the DC-2. Enlarged once more, the DC-2's basic design evolved into the world famous DC-3. For all the DC-1's historical significance, only one was built.

Technical Specifications

First flight	May 11, 1934
Wingspan	62 feet
Length	61 feet 11.75 inches
Height	16 feet 3.75 inches
Ceiling	22,450 feet
Range	1,000 miles
Weight	18,560 pounds
Power plant	Two 875-horsepower Wright Cyclone engines
Speed	200 mph
Accommodation	4,129 pounds of payload, including 2 crew, 14 passengers and 1,740 pounds of cargo/baggage

DC-2 Commercial Transport

Historical Snapshot

Inspired by the technical success of the Douglas DC-1, the DC-2 was introduced less than a year after the DC-1's first flight.

The new plane was similar in shape to the DC-1 but had more powerful engines, was faster and was capable of longer flights. More important, it was 2 feet longer and could carry two more passengers — 14 instead of 12.

The DC-2 was an instant hit. In its first six months of service, the DC-2 established 19 American speed and distance records. In 1934, Transcontinental & Western Air put DC-2s on overnight flights from New York to Los Angeles. Called "The Sky Chief," the flight left New York at 4 p.m. and, after stops in Chicago, Kansas City, Missouri, and Albuquerque, New Mexico, arrived in Los Angeles at 7 a.m. For the first time, the air traveler could fly from coast to coast without losing the business day.

The DC-2 was the first Douglas airliner to enter service with an airline outside the United States. In October 1934, KLM Royal Dutch Airlines entered one of its DC-2s in the London-to-Melbourne, Australia, air race. It made every scheduled passenger stop on KLM's regular 9,000-mile (14,484-kilometer) route (1,000 miles, or 1,609 kilometers, longer than the official race route), carried mail and even turned back once to pick up a stranded passenger. Even so, the DC-2 finished in second place behind a racing plane built especially for the competition. After that, the DC-2's reputation was ensured, and it became the airplane of choice for many of the world's largest airlines.

In 1935, the DC-2 became the first Douglas aircraft to receive the prestigious Collier Trophy for outstanding achievements in flight. Between 1934 and 1937, Douglas built 156 DC-2s at its Santa Monica, California, plant.

Technical Specifications	
First flight	Dec. 17, 1935
Model number	DC-3
Wingspan	95 feet
Length	64 feet 5.5 inches
Height	16 feet 3.6 inches
Ceiling	20,800 feet
Range	1,495 miles
Weight	30,000 pounds
Power plant	Two 1,200-horsepower Wright Cyclone radial engines
Speed	192 mph
Accommodation	3 crew and 14 sleeper passengers, or 21 to 28 day passengers, or 3,725 to 4,500 pounds freight

DC-3 Commercial Transport

Historical Snapshot

The Douglas DC-3, which made air travel popular and airline profits possible, is universally recognized as the greatest airplane of its time. Some would argue that it is the greatest of all time.

Design work began in 1934 at the insistence of C.R. Smith, president of American Airlines. Smith wanted two new planes — a longer DC-2 that would carry more day passengers and another with railroad-type sleeping berths, to carry overnight passengers.

The first DC-3 built was the Douglas Sleeper Transport — also known as Skysleepers by airline customers — and it was the height of luxury. Fourteen plush seats in four main compartments could be folded in pairs to form seven berths, while seven more folded down from the cabin ceiling. The plane could accommodate 14 overnight passengers or 28 for shorter daytime flights. The first was delivered to American Airlines in June 1936, followed two months later by the first standard 21-passenger DC-3.

In November 1936, United Airlines, which had been a subsidiary of Boeing until 1934, became the second DC-3 customer. The DC-2 had proved more economical than the Model 247, and United assumed the DC-3 would continue that lead. Initial orders from American and United were soon followed by orders from more than 30 other airlines in the next two years.

The DC-3 was not only comfortable and reliable, it also made air transportation profitable. American's C.R. Smith said the DC-3 was the first airplane that could make money just by hauling passengers, without relying on government subsidies. As a result, by 1939, more than 90 percent of the nation's airline passengers were flying on DC-2s and DC-3s.

In addition to the 455 DC-3 commercial transports built for the airlines, 10,174 were produced as C-47 military transports during World War II. For both airline and military use, the DC-3 proved to be tough, flexible, and easy to operate and maintain. Its exploits during the war became the stuff of legend. Today, more than six decades after the last one was delivered, hundreds of DC-3s are still flying and still earning their keep by carrying passengers or cargo.

Technical Specifications	
First flight	Feb. 14, 1942
Wingspan	117 feet 6 inches
Length	93 feet 5 inches
Height	27 feet 7 inches
Operating altitude	10,000 feet
Range	4,200 miles
Weight	82,500 pounds
Power plant	Four 1,450 horsepower Pratt & Whitney R-2000 “Twin-Wasp” engines
Speed	207 mph
Accommodation	44 to 80 passengers

DC-4/C-54 Skymaster Transport

Historical Snapshot

In 1938, Douglas Aircraft Co. decided to produce a four-engine transport about twice the size of the DC-3. It developed the single DC-4E to carry 42 passengers by day or 30 by night. The DC-4E had complete sleeping accommodations, including a private bridal room.

It proved too expensive to maintain, so airlines agreed to suspend development in favor of the less complex DC-4, which was not put into commercial service until 1946. Its military derivative was the C-54 “Skymaster” transport, ordered by the U.S. Army Air Forces in 1942.

Douglas built 1,241 of the DC-4s and its military counterparts, including the R5D for the Navy. During the war, C-54s flew a million miles a month over the rugged North Atlantic — more than 20 roundtrips a day. A special VC-54C, nicknamed the “Sacred Cow” by the White House press corps, became the first presidential aircraft, ordered for Franklin D. Roosevelt.

After World War II, commercial airlines placed more than 300 civilian DC-4 transports into service. These DC-4s, along with C-54s converted for civil use, carried more passengers than any other four-engine transport. Some were still flying through 2014.

Technical Specifications	
First flight	Feb. 20, 1939
Wingspan	78 feet
Length	62 feet 2 inches
Height	19 feet 10 inches
Operating altitude	23,700 feet
Range	1,600 miles
Weight	20,000 pounds
Power plant	Two 900-horsepower Wright Cyclone engines
Speed	202 mph
Accommodation	16 to 22 passengers

DC-5/C-110 Transport

Historical Snapshot

The twin-engine DC-5 was the only DC-series aircraft designed by Ed Heinemann, creator of the A-4 Skyhawk, in the El Segundo plant in California. With its high-wing, the DC-5 was more similar to the DB-7 bomber than the previous DC airliners.

The DC-5 prototype and four production DC-5s were built before World War II. The 16-seat airliner featured innovative tricycle landing gear and was intended for shorter routes, but by the time it entered service in 1940, the war was underway.

Only five civilian DC-5s were built as the Douglas Aircraft Co. turned its attention to military airplanes; William Boeing bought the prototype for his personal use. It later served with the U.S. Navy as the R3D-3. KLM bought the other four airplanes, and these were used to evacuate civilians from Java to Australia in 1942. One was captured by the Japanese, one was scrapped after a landing accident, and two later joined the U.S. Army Air Forces as C-110s.

The DC-5 entered service with the U.S. Navy and seven were built as R3Ds. Three R3D-1s became 16-seat personnel carriers, and the four R3D-2s with the U.S. Marine Corps became 22-seat paratrooper versions of the plane.

Technical Specifications	
First flight	Feb. 15, 1946
Model number	DC-6
Span	117 feet 6 inches
Length	100 feet 7 inches
Height	28 feet 5 inches
Power	Four 2,400-horsepower Pratt & Whitney R2800CB engines
Weight	107,000 pounds
Operating altitude	28,000 feet
Range	2,990 miles
Speed	308 mph
Accommodation	3 crew, 52 to 102 passengers

DC-6/C-118A Liftmaster Transport

Historical Snapshot

The Douglas DC-6 was one of the first airplanes to fly a regularly scheduled around-the-world route. With its higher performance, increased accommodation, greater payload and pressurized cabin, it was a natural evolution of the DC-4.

Although the DC-6 had the same wingspan as the DC-4, its engines helped it fly 90 mph (145 kph) faster than the DC-4, carry 3,000 pounds (1,350 kilograms) more payload and fly 850 miles (1,368 kilometers) farther. The DC-6 could maintain the cabin pressure of 5,000 feet (1,524 kilometers) while flying at 20,000 feet (6,096 meters).

American Airlines and United Airlines ordered the commercial DC-6 in 1946, and Pan American Airways used the DC-6 to start tourist-class service across the North Atlantic. The 29th DC-6 was ordered by the U.S. Air Force, adapted as the presidential aircraft and designated the VC-118. It was delivered on July 1, 1947, and named *The Independence* after President Harry Truman's hometown, Independence, Mo.

The larger, all-cargo DC-6A first flew Sept. 29, 1949; the larger capacity DC-6B, which could seat up 102 people, first flew Feb. 10, 1951. After the Korean War broke out in 1951, the military ordered DC-6As modified as either C-118A Liftmaster personnel carriers, as the Navy's R6D transports or as MC-118As for aeromedical evacuation. Between 1947 and 1959, Douglas built a total of 704 DC-6s, 167 of them military versions.

By the end of the twentieth century, DC-6 airplanes were still flying around the world.

Technical Specifications	
First flight	May 18, 1953
Model number	DC-7
Wingspan	117 feet 6 inches
Length	108 feet 11 inches
Height	28 feet 7 inches
Power plant	Four 3,250-horsepower Wright R3350 engines
Weight	144,000 pounds
Ceiling	25,000 feet
Speed	330 to 400 mph
Range	5,635 miles
Accommodation	74 to 110 passengers

DC-7 Commercial Transport

Historical Snapshot

The DC-7 was the last of the Douglas propeller-powered transports. Introduced in May 1953, it entered service with American Airlines in November 1953. It was the first commercial transport able to fly nonstop westbound across the United States against the prevailing winds.

The extended-range DC-7C, or the "Seven Seas," lived up to its name because it could fly 110 passengers anywhere in the world.

Douglas built 338 DC-7s and delivered the last in 1958. Most DC-7s were modified as freighters or scrapped. Some were kept for air racing, aerial firefighting and satellite tracking.

Technical Specifications	
First flight	May 30, 1958
Model number	DC-8
Wingspan	142 feet 5 inches
Length	150 feet 6 inches
Height	42 feet 4 inches
Weight	355,000 pounds
Speed	570 mph
Ceiling	35,000 feet
Range	4,773 miles
Power plant	Four 13,500-pound-thrust P&W JT3C turbojets
Accommodation	3 crew, 8 attendants, 117 to 259 passengers

DC-8 Commercial Transport

Historical Snapshot

The DC-8 was the first Douglas jet-powered transport. It entered service simultaneously with United Airlines and Delta Air Lines on Sept. 18, 1959. Powered by four jet turbine engines, the DC-8 was capable of speeds of more than 600 mph (966 km/h). In a test dive, it became the first commercial transport of any kind to break the sound barrier. Throughout its 14-year-long production run, the DC-8 went through seven major variants, for a total of 556 aircraft.

The basic domestic version, the DC-8 Series 10, had increased fuel capacity for intercontinental flights, and the Series 30 and 40 were the first to use the 17,500-pound-thrust (7,938-kilogram-thrust) turbojet engines.

The DC-8 Series 50 were the first DC-8s powered by new, more efficient turbofan jet engines with 18,000 pounds (8,165 kilogram) thrust and longer range. The Series 50 were also the first to be offered customers in the convertible passenger-freight version or the windowless all-freight version.

The DC-8 Series 60 extended the length of the fuselage. Nearly 37 feet (11 meters) longer than the original model, in an all-economy passenger configuration, the DC-8-61 could carry 259 people. Its convertible-freighter configuration had a cargo volume of 12,535 cubic feet (3,820 cubic meters). The DC-8-62, for extra-long routes, had a fuselage stretched 6 feet 8 inches (2 meters) longer than the original model and 3-foot (91-centimeter) wingtip extensions.

All design improvements of the DC-8-61 and -62 were incorporated in the DC-8-63. The -63 could fly more than 4,500 miles (7,242 kilometers) nonstop, carrying 259 passengers because of its extended fuselage; aerodynamic improvements to nacelles, pylons and flaps; and increased wingspan and fuel capacity.

The DC-8 Series 70 was a re-engined version of the popular Super 60 Series, substituting CFM56 engines for the latter's Pratt & Whitney engines. The result was an aircraft that retained the Super 60 operating weights but with a longer range due to the newer, more fuel-efficient turbofans. The Series 70 was also able to meet later, more stringent noise regulations that were implemented in the 1980s.

In 1995, more than 300 DC-8s remained in service, making more than 340 scheduled flights a day. In January 2013, *Aviation Week* Intelligence Network's Fleet Database reported that there were 36 DC-8s left in service worldwide.

Technical Specifications	
First flight	Feb. 25, 1965
Model number	DC-9/C-9
Wingspan	89 feet 4 inches
Length	104 feet 4 inches
Height	27 feet 6 inches
Power plant	Two 12,250-pound-thrust P&W JT8D engines
Weight	90,700 pounds
Ceiling	37,000 feet
Speed	550 mph
Accommodation	70 to 172 passengers

DC-9/C-9 Transport

Historical Snapshot

The Douglas DC-9 entered service Dec. 8, 1965, and was produced until 1982. A total of 976 DC-9s were built — including 41 C-9 aircraft for military customers.

The C-9A Nightingale was used by the U.S. Air Force to transport sick and injured military personnel. The U.S. Navy and Marine Corps flew C-9B Skytrain IIs. Three VC-9Cs configured as VIP transports were delivered to the Air Force by the end of 1976.

The 90-passenger DC-9-10 was expanded into the 15-foot (4.6-meter) longer DC-9-30, which first flew on Aug. 1, 1966, and could carry up to 115 passengers. The DC-9-20, which first flew Sept. 18, 1968, was especially useful for short landing fields.

The DC-9-40, first flown Nov. 28, 1967, was 6 feet (1.8 meters) longer than the -30 and could hold 125 passengers, and the DC-9-50, which first flew in 1974, was 12 feet (3.6 meters) longer and had the "new look" interior patterned after the wide-cabin DC-10. The DC-9-80, later redesignated MD-80, launched the family of commercial jet airliners with McDonnell Douglas "MD" designation.

In 1996, more than 880 DC-9s were still flying. However, on Jan. 6, 2014, Delta Airlines officially retired its remaining DC-9 following flight 2014 departing Minneapolis/St. Paul for Atlanta. The airline said it was the last scheduled commercial flight of the DC-9 by a major U.S. airline.

Technical Specifications	
First flight	Aug. 29, 1970
Model number	DC-10/KC-10
Wingspan	155 feet 4 inches
Length	182 feet 3 inches
Height	57 feet 6 inches
Power plant	Three 40,000-pound-thrust GE CF6 engines
Weight	444,000 pounds
Ceiling	42,000 feet
Speed	587 mph
Accommodation	250 to 380 passengers

DC-10/KC-10 Transport/Tanker

Historical Snapshot

The McDonnell Douglas DC-10 was produced in three basic models, the Series 10 for domestic routes to 3,500 miles (5,632 kilometers) and the Series 30 and 40 for extended range and intercontinental travel. DC-10s were modified as passenger/cargo convertible versions and as the KC-10 aerial tanker for the U.S. Air Force.

In addition to the luxury and spaciousness inherent in its wide cabin, the three-engine DC-10 incorporated improvements in propulsion, aerodynamics, structure, avionics, flight control systems and environmental compatibility that advanced industry standards.

The DC-10 was designed and built in Long Beach, Calif., and went into production in January 1968. First deliveries were in 1971, and the last of the giants was delivered in 1990. By 1990, 386 commercial DC-10s were delivered, plus 60 KC-10 tanker/cargo models built for the Air Force.

On June 23, 2010, Boeing announced that it had received a $216 million contract from the Air Force to upgrade the service's 59-jet KC-10 tanker fleet with a new communication, navigation, surveillance and air traffic management (CNS/ATM) system.

Technical Specifications	
First flight	Nov. 15, 1929
Wingspan	35 feet
Length	21 feet 4 inches
Weight	1,800 pounds
Speed	110 mph
Power plant	One 110-horsepower Warner Scarab 7-cylinder radial engine
Accommodation	Two crew

Doodlebug Research Vehicle

Historical Snapshot

The Doodlebug was the first airplane James McDonnell both designed and built, but it was doomed by its timing — it was produced just before the Great Depression.

The Doodlebug was a two-seat, low-wing monoplane that was pleasant to fly and fun to watch. It had spectacular takeoff and landing capabilities, and it seemed to have a good chance of winning McDonnell the stake he needed to start his aircraft-building business.

On April 20, 1927, the Daniel Guggenheim Fund for the Promotion of Aeronautics sponsored an international Safe Aircraft Competition. The prize for the winning design that demonstrated a real advance in the safety of flying was $100,000.

James McDonnell and his two engineers, Constantine Zakhartchenko and James Cowling, entered and, despite a shortage of funds, built the Doodlebug in a hangar provided by the Hamilton Aero Manufacturing Co.

Lack of funds and bad luck slowed production. The Doodlebug missed the Oct. 21, 1929, deadline, but was granted an extension. However, during a test flight on Nov. 21, 1929, the horizontal tail of the Doodlebug folded, and the plane crashed. McDonnell rode the airplane to the ground and suffered severe damage to his back. But the airplane showed so much promise that it got a second extension. However, the engine failed as the Doodlebug was being ferried to New York for the competition, and the plane was damaged again. It never had the chance to compete for the Guggenheim purse.

McDonnell did not give up. He took the Doodlebug around the country, flying for various air shows. Then the Depression eliminated the private market, and nobody could afford to buy the airplane. Finally, in 1931, McDonnell sold the Doodlebug to the National Advisory Committee for Aeronautics (NACA — now NASA), which used it as a test airplane. McDonnell would not get to produce another airplane of his own design until 1945.

Technical Specifications	
First flight	July 1930
Wingspan	60 feet
Length	43 feet 10 inches
Height	14 feet 1 inch
Ceiling	15,900 feet
Range	770 miles
Weight	9,387 pounds
Power plant	Two 300- to 450-horsepower Wright air-cooled radial engines
Speed	153 mph (sea level)

Dolphin Amphibian

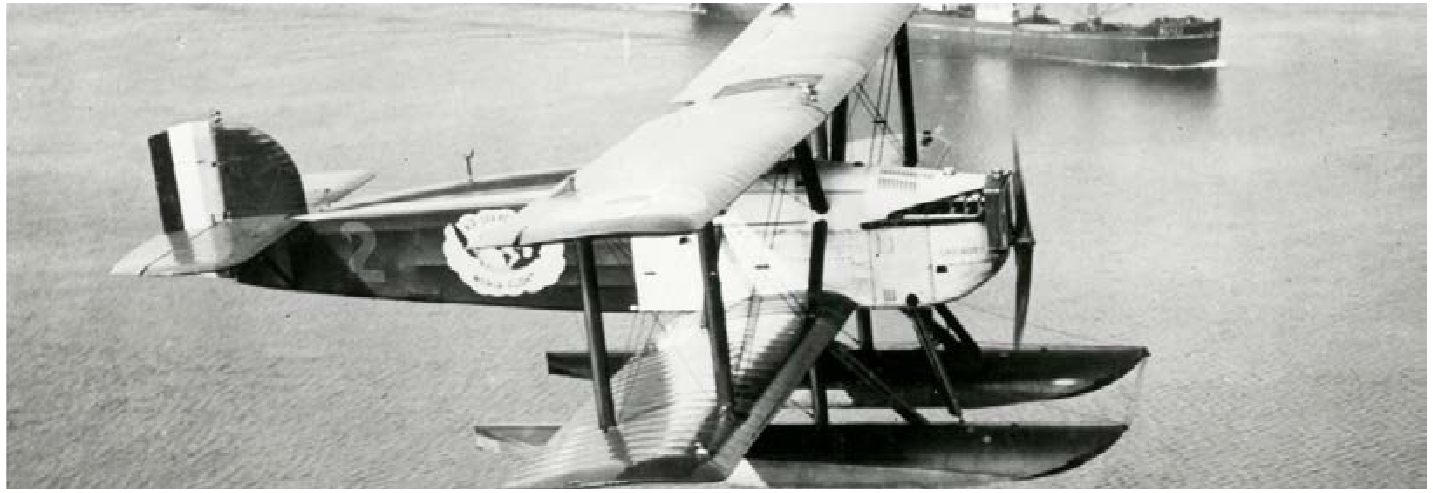
Historical Snapshot

The success of the Dolphin, a military amphibian, helped the Douglas Aircraft Co. survive the Great Depression.

It began as the twin-engine “Sinbad,” intended to be a luxury “air yacht.” It was a high-wing monoplane, with its engines mounted above the wing. Its six to eight passengers looked out picture windows, and their baggage was stored in a 30-cubic-foot (9.14-cubic-meter) area.

Sinbad had no market during the luxury-deprived era. However, 59 of the next version, the Dolphin, were built between 1931 and 1934. The Dolphin retracted its landing gear for water landings and was adapted to meet customer requirements, both military and civilian. It evolved into 17 variants. Among the first purchasers were the Wilmington-Calantina Airline and Standard Oil of New Jersey.

The U.S. Army, Navy and Coast Guard bought the Dolphin in quantities. Some military Dolphins remained in service until World War II. The wealthy Vanderbilt family bought two. One, called “Rover,” was sold to William Boeing, who took delivery of his Dolphin in 1934, just before he left the company he founded. Still flying in 1977, it was the last known survivor of the Dolphin series, and it is now part of the collection of the National Naval Aviation Museum.



Technical Specifications	
First flight	November 1923
Wingspan	50 feet
Length	35 feet 6 inches
Height	13 feet 7 inches
Ceiling	5,000 feet
Range	2,200 miles
Weight	8,180 pounds
Power plant	One 420-hp Liberty V-12 engine
Speed	103 mph
Accommodation	Two (pilot and flight mechanic)

Douglas World Cruiser Transport

Historical Snapshot

The Douglas World Cruiser (DWC) was one of the most famous of the early Douglas airplanes. Ordered by the U.S. Army Air Service in 1923, five Douglas World Cruisers were built for the sole purpose of attempting the first circumnavigation of the globe by air.

The DWC was a modified version of the DT-2 torpedo bomber the company had built for the Navy, but its fuel system was completely redesigned to increase capacity from 115 gallons in the DT-2 to 644 gallons for the DWC. Other changes included using a different vertical tail with extra bracing struts beneath the tail and bringing the pilot's and flight mechanic's cockpits closer together to improve communication between the two.

The DWC retained the DT-2's 420-horsepower Liberty V-12 engine, but two different-sized radiators were included, the larger one for use in the tropics. Finally, the DWC's undercarriage was designed to be easily changed from wheels to floats for operations from land or sea. The prototype, built in 45 days at a cost of $23,721, was delivered to the Army for evaluation in November 1923. Soon after, Douglas received a contract for four production aircraft.

On March 17, 1924, four DWCs and their eight crew members left Clover Field, Santa Monica, Calif., for Seattle, Wash., the official starting point. While in Seattle, Boeing employees exchanged the planes' wheels for pontoon floats for the long over-water portion of the flight. It was also in Seattle that the planes were formally named for four major American cities, representing north, south, east and west geographical areas of the continental United States.

On April 6, the Chicago, New Orleans, Boston and Seattle took off from Sand Point on Lake Washington on the first leg of their long flight. The Seattle, surrounded by fog, crashed on April 30 on an Alaskan mountainside. After walking 10 days through the frozen wilderness, the two-man crew safely reached Dutch Harbor. The other three DWCs continued on and were kept flying with the help of 15 extra engines, 14 extra sets of floats and duplicates of all airframe parts, stashed at various sites around the world.

On June 26, they reached Calcutta, India, where the floats were replaced with wheels. The DWCs departed the Orkney islands in Scotland on July 30, again as seaplanes. On Aug. 3, with nearly three-quarters of the flight completed, the Boston made a forced landing in the mid-Atlantic. The crew was rescued and reunited with the Chicago and New Orleans on Sept. 3 in Nova Scotia, Canada. Two days later, the prototype DWC, now named Boston II, joined the group in Newfoundland so that its original crew could complete the flight.

On Sept. 28, as landplanes, they returned to Seattle. They had logged 27,553 miles (44,342 kilometers) in six months and six days, with an actual flying time of 371 hours. They had touched down in 28 countries and had crossed the Atlantic and Pacific Oceans. The flight was the greatest feat in aviation up to that time and earned the Douglas Aircraft Co. its motto, "First Around the World."

Technical Specifications

First flight	August 1932
Wingspan	48 feet
Length	29 feet 9 inches
Height	9 feet
Weight	3,500 pounds
Power plant	One 785-horsepower Wright Whirlwind GR-1510 14-cylinder air-cooled radial engine
Max. speed	248 mph
Ceiling	23,400 feet
Range	2,500 miles
Accommodation	One crew

Gamma Utility Transport

Historical Snapshot

The Douglas/Northrop Gamma was a sleek, all-metal aircraft that led to a series of military light-attack airplanes. John K. Northrop, who had worked at Douglas from 1920 to 1927, returned to design and build six Gammas between 1932 and 1937, followed by 12 Deltas. A second batch of Gammas was built from 1934 to 1936. Of the 61 Gammas built, 49 were produced for the Chinese and others were custom built for private owners, including the Texas Company (later Texaco).

The Gamma 2B, named *Polar Star*, was delivered to polar explorer Lincoln Ellsworth Nov. 29, 1932, for a flight across the Antarctic. Skis replaced the main and tail wheels, and twin floats replaced the main undercarriage. In 1935, Polar Star was the first airplane to cross the Antarctic continent, mapping islands, fjords and mountain peaks. Piloted by Herbert Hollick-Kenyon, with Ellsworth, it flew 2,400 miles (3862 kilometers), sometimes at as high as 33,000 feet (10,058 meters). *Polar Star* now rests in the Smithsonian's National Air and Space Museum.

The Gamma flown by Capt. Frank Hawks June 2, 1933, broke several speed records, including flying 13 hours, 26 minutes and 15 seconds at 181 mph (291 kph) nonstop between Los Angeles, Calif., and New York. A Gamma owned by noted pilot Jacqueline "Jackie" Cochran, and leased to Howard Hughes, set a new transcontinental nonstop record Jan. 13 to 14, 1936, flying at an average speed of 259 mph (417 kph).

The Gamma was the second in the series of all-metal airplanes designed by Jack Northrop. The first was the Alpha that Northrop developed when his research company was bought by United Aircraft and Transportation, the holding company controlling all the Boeing enterprises in 1930. The Alpha carried passengers in an enclosed cabin, along with 465 pounds (209 kilograms) of mail — but the pilot still sat outside in an open cockpit. The Gamma and the third in the series, the Delta, had enclosed cockpits and were the first aircraft built at the El Segundo, Calif., plant.

Deltas flew for Swedish Air Lines and established a record flight between Paris and Stockholm at an average 198 mph (319 kph). However, after Oct. 1, 1934, only multiengine aircraft were allowed to carry passengers at night over rough terrain, so the Delta airplane lost some of its airline customers.

Technical Specifications	
First flight	August 1935
Model number	Hughes H-1
Classification	Racing monoplane
Length	27 feet
Wingspan	31 feet 9 inches
Gross weight	5,000 pounds
Top speed	352 mph
Range	200 miles
Altitude	8,500 feet
Power	700-hp Pratt & Whitney Twin Wasp Junior radial piston engine and controllable-pitch Hamilton Standard metal propeller

H-1 Racer Racing Monoplane

Historical Snapshot

On Sept. 13, 1935, one month after its first flight, Howard Hughes flew the H-1 Racer over a specially instrumented course near Santa Ana, Calif., and set a world landplane speed record of 352 mph (566 kph). In 1936 and 1937, Hughes flew the H-1 to set two transcontinental speed records.

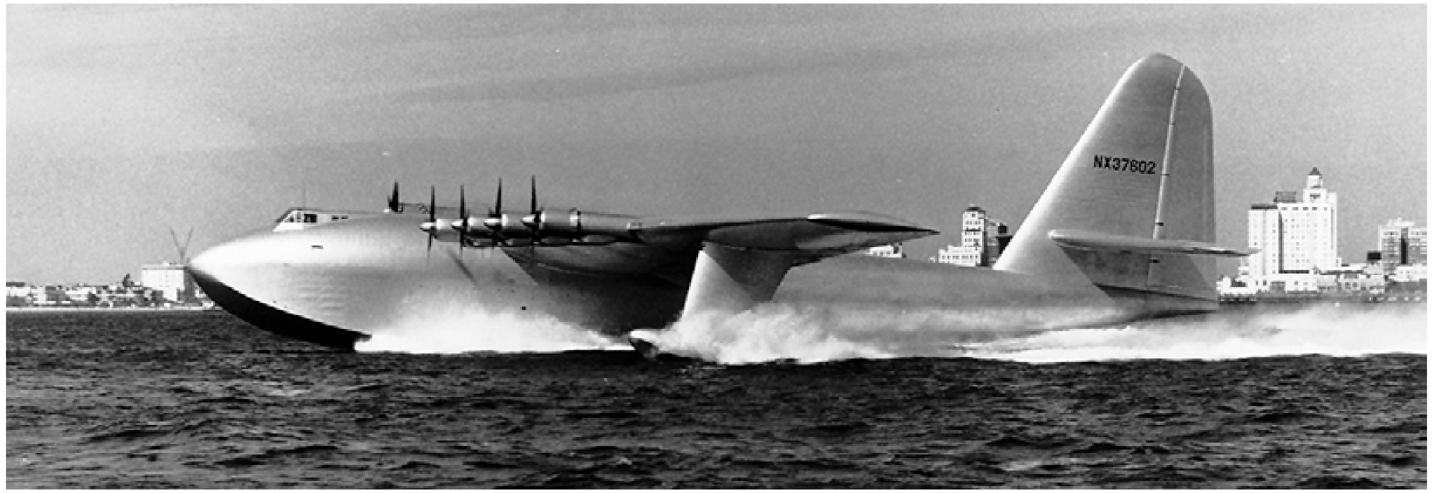
The Hughes Aircraft Co., a division of the Hughes Tool Co., was formed in 1932 by Howard Hughes to develop the H-1 Racer. He built the wood and metal single-seat monoplane in Charles Babb's hangar at Grand Central Air Terminal, Glendale, Calif. The Hughes team took 18 months to design and build the plane and to extensively test the H-1 model in the 200-mph (321 kph) wind tunnel at the California Institute of Technology's Guggenheim Aeronautical Laboratory.

The aluminum fuselage was left in its natural polished state, and because Hughes did not need a sponsor for the aircraft, the H-1 had no markings. The license number NR258Y (later NX 258Y) was painted in chrome yellow against the dark blue background of the wings and in black against the rudder.

Hughes had two sets of wings for the H-1. Those installed when the H-1 broke the landplane speed record were of a low aspect ratio and shorter than those fitted when it broke the transcontinental speed record, Jan. 19, 1937. At that time Hughes flew the H-1 from Los Angeles to Newark (N.J.) Airport, outside New York City, in 7 hours, 28 minutes, 25 seconds, flying 2,490 miles (4,007 kph) at an average of 332 mph (534 kph).

Innovative features on the H-1 included a close-fitting bell-shaped engine cowling to reduce airframe drag and improve engine cooling; gently curving wing fillets between the wing and the fuselage to help stabilize the airflow, reduce drag, and prevent potentially dangerous eddying and tail buffeting; and retractable landing gear to reduce drag and increase speed and range. The landing gear were fitted so precisely that the gear fairings and doors were almost invisible. All rivets and joints were flush with the aircraft's skin, and flathead screws were countersunk on the plywood wings. Its ailerons were designed to droop 15 degrees when flaps were fully extended to improve lift. The cockpit was smoothly faired and totally enclosed. It had an adjustable canopy windscreen for easy entry and exit from the aircraft.

These innovations led to development of radial-engine-powered World War II fighters, such as the American Grumman F6F Hellcat and Republic P-47 Thunderbolt. The H-1 remained at the Hughes factory at Culver City, Calif., until it was donated to the Smithsonian Institution in 1975. The Hughes H-1 is on exhibit in the Golden Age of Flight gallery of the National Air and Space Museum.



Technical Specifications	
First flight	Nov. 2, 1947
Model number	Hughes H-4
Classification	Flying boat
Height	79 feet 4 inches
Fuselage height	30 feet
Length	218 feet 8 inches
Wingspan	319 feet 11 inches
Gross weight	400,000 pounds
Service ceiling	20,900 feet
Cruising speed	Approximately 220 mph

H-4 Hercules Flying Boat

Historical Snapshot

The single 400,000-pound (181,436-kilogram) H-4 Hercules flying boat, built by the Hughes Aircraft Co., was the largest flying boat ever built with the widest wingspan. It was built after a U.S. government request in 1942 for a cargo and troop carrier that would not be susceptible to Axis submarines and, by substituting wood for metal in its construction, would not use critical wartime materials.

Originally conceived by Henry J. Kaiser, a steelmaker and builder of Liberty ships, the aircraft was designed and constructed by Howard Hughes and his staff; hence, the original HK-1 Hercules (NX37602) designation. Kaiser withdrew his support in 1944 because Allied aircraft needs shifted toward bombers and the type of aircraft was no longer needed.

Hughes continued to develop the aircraft under the H-4 designation. The press nicknamed it the "Spruce Goose" — a name Hughes hated because it insulted its builders and, in fact, the plane was built almost entirely of laminated birch, not spruce.

The cargo-type flying boat was designed to carry 750 fully equipped troops or two Sherman tanks over long distances. It has a single hull, eight radial engines, a single vertical tail, fixed wingtip floats, and full cantilever wing and tail surfaces. The entire airframe and surface structures are composed of laminated wood and all primary control surfaces, except the flaps, are fabric covered. The aircraft's hull includes a flight deck for the operating crew and a large cargo hold. A circular stairway connects the two compartments. Fuel bays, divided by watertight bulkheads, are below the cargo hold.

By 1947, the U.S. government had spent $22 million on the H-4 and Hughes had spent $18 million of his own money. Finally, on Nov. 2, 1947, Howard Hughes and a small engineering crew fired up the eight radial engines for taxi tests. Hughes lifted the giant aircraft 33 feet (10 meters) off the surface of Long Beach (Calif.) Harbor and flew it for 1 mile (1.6 kilometers), for less than a minute, remaining airborne 70 feet (21 meters) off the water at a speed of 80 mph (128 kph) before landing.

The H-4 Hercules never flew again. Until he died in 1976, Hughes made sure that the HK-1/H-4 was constantly maintained and kept in flight-ready condition. The "Spruce Goose" then found a home with the Aero Club of Southern California, preserved in its own circular building, next to the former ocean liner *Queen Mary*, at Long Beach, Calif. In 1988, The Walt Disney Co. acquired the location, and Disney's plans for the site did not include the "Spruce Goose." Facing loss of its lease, the Aero Club sold the giant plane to the Evergreen Aviation Museum (now the Evergreen Aviation & Space Museum) in 1993, which disassembled the aircraft and moved it by barge to its current home in McMinnville, Ore.

By the mid-1990s, the former Hughes Aircraft buildings in Los Angeles, Calif., including building 15 where the "Spruce Goose" was built, had been converted into movie sound stages. Scenes from movies such as "The Aviator", "Titanic", "Avatar", "Eagle Eye" and "Transformers" have been filmed on location in the 315,000-square-foot airplane hangar where Howard Hughes created the legendary flying boat and other famous Hughes aircraft.

Google now leases the four-building property, and officially moved into the hangar — which has since been transformed into creative office space — in late 2018.

Technical Specifications	
First flight	Jan. 10, 1990
Wingspan	169 feet 10 inches
Length	200 feet 11 inches
Height	57 feet 11 inches
Weight	602,500 pounds
Power plant	Three 60,000/62,000-pound thrust P&W PW4460/PW4462 engines or three 61,500-pound thrust GE CF6-80C2 engines
Speed	588 mph
Range	7,000 to 10,000 miles
Accommodation	293-405 passengers

MD-11 Commercial Transport

Historical Snapshot

Deliveries of the MD-11, a wide-cabin trijet, began in 1991 and ended in 2001.

The MD-11 was 18.6 feet (5.6 meters) longer than the DC-10 trijet, from which it was derived, and carried about 50 more passengers. It was produced in Long Beach, Calif. A worldwide network of subcontractors and suppliers supported the assembly line.

The MD-11 was available in four models: passenger, all freighter, convertible freighter and "combi," where passengers and freight were carried on the main deck and additional freight below the deck. An extended-range (ER) feature was available on all versions.

Seating capacities on the standard airplane varied from 285 in a three-class arrangement to 410 in an all-economy configuration. Advances in aerodynamics, propulsion, aircraft systems, cockpit avionics and interior design contributed to the performance and operating economy of all MD-11 models. Aerodynamic improvements included winglets and a redesigned wing trailing edge, a smaller horizontal tail with integral fuel tanks and an extended tailcone. These features reduced drag, saved fuel and added range.

By January 1998, 174 MD-11s had been delivered, and the aircraft was in service with more than 20 operators, serving more than 100 cities in 55 countries with more than 270 scheduled daily flights. The fleet had compiled more than 2.7 million revenue flight-hours and 1.3 billion statute miles (2 billion kilometers), carrying nearly 70 million passengers.

Boeing ended production of the MD-11 in 2000 after 200 planes were built. The last MD-11 was delivered Feb. 22, 2001.

MD-80/MD-90 Commercial Transports

Historical Snapshot

The McDonnell Douglas MD-80 and MD-90 families of jetliners were built on the same assembly line in Long Beach, Calif.

Conceived as a stretched variant of the DC-9, the MD-80 made its first flight as the DC-9 Super 80. The MD-80 Series of twinjets, featuring many advances in technology, was certified by the Federal Aviation Administration in August 1980 and entered airline service three months later.

There were 1,191 MD-80s delivered between 1980 and 1999.

The MD-90 was an advanced midsized, medium-range airliner that was first delivered in February 1995 and entered service two months later.

The MD-90's advanced flight deck included an electronic flight instrument system, a full flight management system, a state-of-the-art inertial reference system, and LED dot-matrix displays for engine and system monitoring.

Two versions of the MD-90 entered production, and 116 were delivered between 1995 and 2000.

The MD-95, designed to replace the DC-9-30, was launched in 1995 and was renamed the Boeing 717 after McDonnell Douglas and Boeing merged in 1997. Production of the 717 began in 1998, and on May 23, 2006, Boeing delivered the final two of the 156 717s produced.

Technical Specifications

	MD-80	MD-90
First flight	Oct. 18, 1979	Feb. 22, 1993
Model number	MD-81	MD-90-30
Wingspan	107 feet 8 inches	107 feet 10 inches
Length	147 feet 9 inches	152 feet 7 inches
Height	30 feet 5 inches	30 feet 11 inches
Weight	140,000 pounds	156,000 pounds
Power plant	Two 18,500-pound-thrust Pratt & Whitney JT8D-209 engines	Two 25,000-pound-thrust International Aero Engines V2500 engines
Speed	546 mph	0.76 Mach
Range	1,600 miles	2,400 miles
Accommodation	155 passengers	153 passengers

Model 40 Commercial Transport

Historical Snapshot

The first Model 40 was built for a 1925 U.S. Post Office competition as a replacement for the converted military de Havillands that had carried the airmail since 1918.

The Model 40 used steel tubing for the nose and curved wood-veneer laminate for the middle of the fuselage. The wings were wood and fabric. The plane was hampered by the antiquated water-cooled Liberty engine, required by the government in order to use up large stocks of surplus war equipment.

The Boeing Model 40A, which first flew May 20, 1927, used an air-cooled Pratt & Whitney Wasp engine that was about 200 pounds (91 kilograms) lighter than the water-cooled engines used to power its competitors. The biplane used welded-steel tubing throughout its fuselage but could still carry a heavier load and was less expensive to operate.

The Model 40A was the first Boeing airplane to carry airline passengers, with room for two people in a tiny cabin, as well as cargo space for mail. Twenty-four of the Model 40A mail planes were ready to fly July 1, 1927, for their first day of airmail service between San Francisco, Calif., and Chicago, Ill. The 25th was delivered to Pratt & Whitney as a flying testbed.

The Model 40B-4, which first flew Oct. 5, 1928, was the major production model of the mail plane series. It used the larger Hornet engine and carried four passengers and 500 pounds (226 kilograms) of mail. Including the first Model 40, 77 Model 40s were built between 1925 and 1932.

Technical Specifications	
First flight	May 20, 1927
Model number	40A
Classification	Commercial transport
Span	44 feet 2 inches
Length	33 feet 2 inches
Gross weight	6,000 pounds
Top speed	128 mph
Cruising speed	105 mph
Range	650 miles
Ceiling	14,500 feet
Power	420-horsepower P&W Wasp engine
Accommodation	Pilot, 2 passengers, 1,200 pounds of mail

Model 80 Commercial Transport

Historical Snapshot

In 1928, Boeing introduced America's first airliner designed specifically for passenger comfort and convenience. The Model 80's fuselage was made of welded-steel tubing covered with fabric, and its wooden wingtips were removable so the airplane could fit into the primitive hangars along its route.

Despite complaints by pilots accustomed to flying in an open cockpit, the size of the Model 80 required a separate, enclosed flightdeck. The Model 80 carried passengers in a spacious cabin appointed with leather upholstery, reading lamps, forced-air ventilation, and hot and cold running water. The first version carried 12 people, and it was followed by the larger, 18-passenger Model 80A, which made its first flight, Sept. 12, 1929. Ten Model 80As flew for the Boeing airlines.

Ellen Church, a registered nurse, convinced Boeing managers that women could work as stewards, so nurses serving aboard the Model 80A became aviation's first female flight attendants. They earned $125 for flying 100 hours a month.

Technical Specifications	
First flight	July 27, 1928 (Model 80)
Model number	80A
Classification	Commercial transport
Span	80 feet
Length	56 feet 6 inches
Gross weight	17,500 pounds
Top speed	138 mph
Cruising speed	125 mph
Range	460 miles
Ceiling	14,000 feet
Power	Three 525-horsepower P&W Hornet engines
Accommodation	3 crew, 18 passengers, 898 pounds of cargo

Technical Specifications	
First flight	Aug. 19, 1980
Model number	Model 234
Classification	Commercial helicopter
Length	52 feet 1 inch
Gross weight	51,000 pounds
Top speed	167 mph
Power	Two 4,335-shaft-horsepower AL5512 engines
Accommodation	44 passengers

Model 234 Chinook

Historical Snapshot

The Boeing Model 234 was the commercial derivative of the CH-47 family of Chinooks. First built for British Airways to carry passengers and cargo to offshore oil platforms in the North Sea, it incorporated many of the latest technological advances in aircraft development. These included fiberglass composite rotor blades, composite airframe structures, improved engine and drive systems, advanced avionics, and a triple cargo-hook suspension system.

The Model 234 had more windows than its military counterpart and had a longer nose to house weather radar. The utility version, the Model 234UT, had a 51,000-pound gross weight capacity and could lift extremely heavy equipment, pipelines, towers, bulk containers or even another helicopter.

The long-range passenger version, Model 234LR, could fly 644 miles and had an interior design much like Boeing commercial airplanes, including a galley and overhead bins.

In addition to its service as a commercial transport, the Model 234 proved to be useful in a variety of functions. In 1987, a Model 234 established a new record for hanging wire when it strung two power lines from 570-foot-high transmission towers 1.5 miles apart on either side of a river in China.

Model 234s also were used to harvest timber in Washington state. On fire duty in 1988, they dropped more than 2.25 million gallons of water in 13 days on forest fires near West Yellowstone, Mont.

Technical Specifications

First flight	Feb. 8, 1933
Model number	Model 247
Classification	Commercial airplane
Length	51 feet 7 inches
Gross weight	13,650 pounds
Top speed	200 mph
Power	Two 500 hp Pratt and Whitney Wasp engines
Accommodation	10 passengers, 400 lbs mail

Model 247/C-73 Transport

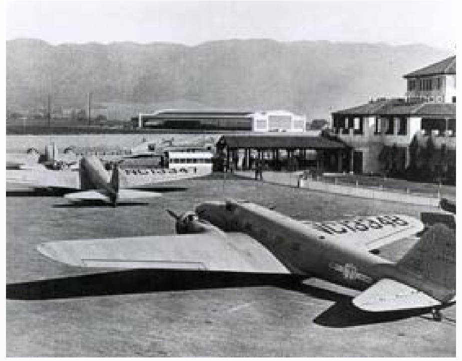
Historical Snapshot

The revolutionary Boeing Model 247, developed in 1933, was an all-metal, twin-engine airplane and the first modern passenger airliner. It had a gyro panel for instrument flying, an autopilot, pneumatically operated de-icing equipment, a variable-pitch propeller and retractable landing gear.

It took the Model 247 20 hours, with seven stops, to fly between New York and Los Angeles. However, because the 247 flew at 189 mph (304 kph), its trip was seven and a half hours shorter than that made by any previous airliners.

Seventy-five 247s were built. Boeing Air Transport flew 60 Model 247s. United Aircraft Corp. flew 10, and the rest went to Deutsche Lufthansa and a private owner in China. The 247s remained in airline service until World War II, when several were converted into C-73 transports and trainers. Some were still flying in the late 1960s.

Along with the Douglas DC-2 that supplanted it, the Model 247 ushered in the age of speed, reliability, safety and comfort in air travel.



Model 307 Stratoliner

Historical Snapshot

The Boeing Model 307 Stratoliner was the world's first high-altitude commercial transport and the first four-engine airliner in scheduled domestic service. With names such as Rainbow, Comet, Flying Cloud and Apache, the Stratoliner set new standards for speed and comfort.

Its pressurized cabin allowed the airplane to soar above rough weather at an altitude of 20,000 feet (6,096 meters) — higher than any other transport of its time. Its circular fuselage provided maximum space for the five crew members and 33 passengers. The nearly 12-foot-wide (3.6-meter-wide) cabin had space for comfortable berths for overnight travelers.

The Stratoliners attracted the attention of multimillionaire Howard Hughes, who bought one for himself and transformed it into a "flying penthouse" with a master bedroom, two bathrooms, a galley, a bar and a large living room. Hughes sold it to a Texas oil millionaire, and it eventually became a Florida houseboat.

The Stratoliner was the first airplane to have a flight engineer as a member of the crew. The engineer was responsible for maintaining power settings, pressurization and other subsystems, leaving the pilot free to concentrate on other aspects of flying the aircraft.

Boeing built 10 Stratoliners. In 1940, the 307s started flying routes to Latin America and from New York to Los Angeles. Production stopped at the onset of war, and five were drafted into the Army Transport Command as C-75 military transports.

The last remaining Stratoliner, flown by Pan American as Clipper Flying Cloud, was purchased by the Smithsonian's National Air and Space Museum in 1969. After being stored in the Arizona desert for 20 years, it was restored at Boeing in Seattle, Wash., and in August 2003, it flew to its new home on permanent display at the museum's new companion facility, the Steven F. Udvar-Hazy Center near the Washington, D.C., Dulles International Airport.

Technical Specifications	
First flight	December 31, 1938
Model number	SA-307B and C-75
Classification	Commercial and military transport
Span	107 feet 3 inches
Length	74 feet 4 inches
Gross weight	42,000 pounds
Top speed	246 mph
Cruising speed	220 mph
Range	2,390 miles
Ceiling	26,200 feet
Power	Four 1,000-horsepower Wright Cyclone engines
Accommodation	5 crew, 33 passengers

Model 314 Clipper Flying Boat

Historical Snapshot

As airplane travel became popular during the mid-1930s, passengers wanted to fly across the ocean, so Pan American Airlines asked for a long-range, four-engine flying boat. In response, Boeing developed the Model 314, nicknamed the "Clipper" after the great oceangoing sailing ships.

The Clipper used the wings and engine nacelles of the giant Boeing XB-15 bomber on the flying boat's towering, whale-shaped body. The installation of new Wright 1,500-horsepower Double Cyclone engines eliminated the lack of power that handicapped the XB-15. With a nose similar to that of the modern 747, the Clipper was the "jumbo" airplane of its time.

The Model 314 had a 3,500-mile range and made the first scheduled trans-Atlantic flight June 28, 1939. By the year's end, Clippers were routinely flying across the Pacific. Clipper passengers looked down at the sea from large windows and enjoyed the comforts of dressing rooms, a dining salon that could be turned into a lounge and a bridal suite. The Clipper's 74 seats converted into 40 bunks for overnight travelers. Four-star hotels catered gourmet meals served from its galley.

Boeing built 12 Model 314s between 1938 and 1941. At the outbreak of World War II, the Clipper was drafted into service to ferry materials and personnel. Few other aircraft of the day could meet the wartime distance and load requirements. President Franklin D. Roosevelt traveled by Boeing Clipper to meet with Winston Churchill at the Casablanca Conference in 1943. On the way home, Roosevelt celebrated his birthday in the flying boat's dining room.

Technical Specifications	
First flight	June 7, 1938
Model number	314A
Classification	Commercial transport
Span	152 feet
Length	106 feet
Gross weight	84,000 pounds
Top speed	199 mph
Cruising speed	184 mph
Range	5,200 miles
Ceiling	19,600 feet
Power	Four 1,500-horsepower Wright GR-2600 Double Cyclone engines
Accommodation	10 crew, 74 passengers

Model 367-80

Technical Specifications	
First flight	July 15, 1954
Model number	367-80
Classification	Jet transport and tanker prototype
Span	130 feet
Length	128 feet
Gross weight	160,000 pounds
Top speed	More than 600 mph
Cruising speed	550 mph
Range	2,000 miles
Ceiling	More than 42,000 feet
Power	Four 10,000-pound-thrust P&W JT3 turbojet engines
Accommodation	3 crew

Historical Snapshot

Seventy-two-year-old William Boeing came back to visit his former company for the May 14, 1954, rollout of the Model 367-80 at the Renton, Wash., plant. His wife, Bertha, christened the yellow and brown airplane with real champagne, and the Renton High School band played the Air Force theme. It was the prototype for the 707 passenger jet and the KC-135 jet tanker and would be the first member of the “700” family of commercial and military jets.

The Boeing Company had invested $16 million (two-thirds of the company’s net profits from the post-war years) to build this prototype for a long-range jet aircraft. It was developed in secrecy and designated Model 367-80 to disguise it as merely an improved version of the C-97 Stratofreighter. It was subsequently nicknamed the “Dash 80,” had jet engines and swept wings, and was very different from the straight-wing, propeller-powered Stratofreighter. When the Dash 80 was almost finished, the company gambled again — by tooling and gearing up for a production aircraft, although neither the Air Force, nor any airline, had placed a single order.

Because the prototype was constructed not just to sell to airlines, but to the military as well, it had few windows and two large cargo doors. A week after its first flight, the Air Force ordered 29 tanker versions, the KC-135. The commercial version, the 707, however, faced tough competition from the Douglas DC-8. Boeing salespeople directed their efforts to Pan American World Airways, Trans World Airlines and large European airlines. On Oct. 14, Pan Am ordered 20 707s. At the same time, Pan Am ordered 25 DC-8s. The race was on.

In 1972, the Dash 80 became part of the Smithsonian’s National Air and Space Museum collection. In August 2003, it flew to its new home on permanent display at the museum’s new companion facility, the Steven F. Udvar-Hazy Center near Washington, D.C.’s Dulles International Airport.

Model 377 Stratocruiser Commercial Transport

Historical Snapshot

After World War II, Boeing reentered the commercial market with a new long-range airliner, Stratocruiser (Model 377). It was the first Boeing commercial transport since the Stratoliner, and like its military counterpart, the C-97, was based on the B-29 bomber. It possessed all the speed and technical improvements available to bombers at the end of the war.

The Stratocruiser set a new standard for luxurious air travel with its tastefully decorated extra-wide passenger cabin and gold-appointed dressing rooms. A circular staircase led to a lower deck beverage lounge, and flight attendants prepared hot meals for 50 to 100 people in a state-of-the-art galley. As a sleeper, the Stratocruiser was equipped with 28 upper-and-lower bunk units.

Pan American placed the first order for 20 Stratocruisers, worth $24 million, and they began service between San Francisco, Calif., and Honolulu, Hawaii, in 1949. Boeing built 56 Stratocruisers between 1947 and 1950. The airplane marked the company's first significant success selling passenger planes to airlines in other countries.

During the early 1960s, Aero Spacelines ballooned the Stratocruiser's fuselage into a whale-like shape to carry spacecraft sections. Nine of the variants were assembled. The first was called the "Pregnant Guppy," followed by five larger "Super Guppies" and three smaller "Mini Guppies."

Technical Specifications	
First flight	July 8, 1947
Model number	377
Classification	Commercial transport
Span	141 feet 3 inches
Length	110 feet 4 inches
Gross weight	145,000 pounds
Top speed	375 mph
Cruising speed	300 mph
Range	4,600 miles
Ceiling	More than 33,000 feet
Power	Four 3,500-horsepower P&W R-4360 Wasp Major engines
Accommodation	55 to 100 passengers and attendants

Technical Specifications	
First flight	May 6, 1930
Model number	200, 221
Classification	Mail and cargo carrier
Span	59 feet 1 inch
Length	41 feet 10 inches
Gross weight	8,000 pounds
Top speed	158 mph
Cruising speed	135 mph
Range	575 miles
Ceiling	14,700 feet
Power	575-horsepower P&W Hornet B engine
Accommodation	Pilot, approximately 1,500 pounds of cargo

Monomail Transport

Historical Snapshot

In 1930, Boeing created the revolutionary Monomail, which made traditional biplane construction a design of the past. The Monomail wing was set lower, was smooth, was made entirely of metal and had no struts (cantilevered construction). The retractable landing gear, the streamlined fuselage and the engine covered by an antidrag cowling added up to an advanced, extremely aerodynamic design.

The Monomail Model 200 was a mail plane, and the Model 221 was a six-passenger transport. Both were later revised for transcontinental passenger service as Model 221As.

The major drawback of the Monomail was that its design was too advanced for the engines and propellers of the time. The airplane required a low-pitch propeller for takeoff and climb and a high-pitch propeller to cruise. By the time the variable-pitch propeller and more powerful engines were available, the Monomail was being replaced by newer, multiengine planes it had inspired.

Technical Specifications	
Contract award	Dec. 31, 1966
Classification	Proposed supersonic transport
Length	318 feet
Cruising speed	Mach 2.7
Altitude	More than 60,000 feet
Power	Four 60,000-pound-thrust engines

Supersonic Transport

Historical Snapshot

On New Year's Eve 1966, after more than 14 years of study, design work and competition, the U.S. federal government selected Boeing to build the prototype for the country's first supersonic transport (SST).

Twenty-six airlines ordered 122 of the transports. The final design featured a double-jointed, needle-shaped nose that would drop during takeoff and landing for improved pilot visibility.

Government funding was withdrawn in 1971 before the prototype was finished. However, the Boeing SST fostered advances in supersonic transportation, leading to the High Speed Civil Transport project that ran from 1990 to 1999, part of the NASA High-Speed Research program supported by a team of U.S. aerospace companies.

F/A-18 Hornet on Tarmac

Defense

A-17/8A Light Attack Bomber
A-26/B-26 Invader Light Bomber
A3D/A-3 Skywarrior, B66 Destroyer Bomber
A3J-1/A-5/RA-5C Vigilante
A4D/A-4 Skyhawk Light Attack Bomber
A8 Beaufighter
A9 Beaufort Torpedo Bomber
A17 Tiger Moth Trainer
A20 Wirraway Trainer, Fighter
A46 Boomerang Fighter
A52 Mosquito Light Bomber
A68 Mustang Fighter
A73 Lincoln B Mk 30 Bomber
A79 Vampire Fighter
A84 Canberra Bomber
A94 Sabre Fighter
AD/A-1 Skyraider Attack Bomber
Aermacchi MB326 Trainer
AGM-69 Short Range Attack Missile
AGM/RGM/UGM-84D Harpoon Missile
AGM-86B/C Air Launched Cruise Missile
AH-64 Apache Attack Helicopter
AJ Savage Bomber
AV-8B Harrier II/(V/STOL) Aircraft
Avenger Missile Launcher
B-1 Lancer Bomber
B-2 Spirit Bomber
B-9 Bomber
B-17 Flying Fortress
B-18 Bolo Bomber
B-25 Mitchell Bomber
B-29 Superfortress
B-45 Tornado Bomber
B-47 Stratojet
B-50 Bomber
B-52 Stratofortress
BT-9 "Yale" Trainer
C-17 Globemaster III
C-47 Skytrain Military Transport
C-74 Globemaster I
C-97/KC-97 Stratofreighter
C-124 Globemaster II Military Transport
C-133 Cargomaster
CH-21 Shawnee/Vertol 44 Helicopter
CH-46 Sea Knight
CH-47 Chinook
Condor Unmanned Aerial Vehicle
DarkStar Unmanned Aerial Vehicle
DB-7/A-20 Boston/Havoc Attack Bomber
DT Torpedo Bomber
E-3 Airborne Warning and Control System
E-4 Advanced Airborne Command Post
E-6 Mercury TACAMO Airborne Communication System
F/A-18 Hornet Fighter
F-15 Eagle Tactical Fighter
F-22 Raptor
F-100 Super Sabre
F-101 Voodoo Fighter
F2H Banshee Fighter
F3D/F-10 Skyknight Fighter
F3H/F-3 Demon
F-4 Phantom II Fighter
F4D/F-6A Skyray Fighter
F-86 Sabre
FH-1 Phantom I
FJ Fury Fighter
GAM-77/AGM-28 Hound Dog Missile
GBU-15/AGM-130 Weapon System
Gargoyle Missile
Ground-to-Air Pilotless Aircraft Missile
HiMAT Research Vehicle
HRP-1 Helicopter
HUP-1 Retriever/H-25 Army Mule Helicopter
IM-99A/B Bomarc Missile
Jindivik Target Drone
Joint Direct Attack Munition
Joint Helmet Mounted Cueing System
KC-135 Stratotanker
LGM-30 Minuteman Missile
MB-1/AIR-2 Genie Missile
Mirage III Fighter
Model 79 Big Henry
Model C Trainer
NA-16 Basic Trainer
NA-21 Bomber Dragon
Nike Missile
Nomad Transport and Utility Aircraft
O-2 Surveillance
O-31/O-35/O-43/O-46A Surveillance
O-47 Surveillance
OH-6 Cayuse/Hughes 500
OV-10 Bronco Multimission Aircraft
P-12/F4B Fighter
P-26 Peashooter Fighter
P-51 Mustang Fighter
P-82 Twin Mustang Fighter
PW-9/FB Fighter
RAH-66 Comanche Helicopter
SBD/A-24 Dauntless Dive Bomber
ScanEagle Unmanned Aerial Vehicle
Stearman Kaydet Trainer
T-2 Buckeye Trainer
T-28 Trojan Trainer
T2D-1 Torpedo Bomber
T-39 Sabreliner Trainer/Transport
T-45 Goshawk Trainer
T-6 Texan Trainer
TBD Devastator Torpedo Bomber
Thor Missile
V-22 Osprey Tiltrotor
VC-137C Air Force One
WAC Corporal Missile
Winjeel Trainer
X-3 Stiletto Test Aircraft
X-31 Test Aircraft
X-32 Joint Strike Fighter
X-45 Joint Unmanned Combat Air System
XB-15 Bomber
XB-70A Valkyrie
XF-11 Reconnaissance Aircraft
XF-85 Goblin Parasite Fighter
XF8B-1 Fighter-Bomber
XH-20 Little Henry Research Helicopter
XP-67 Fighter
XPBB-1 Sea Ranger Flying Boat Patrol Bomber
XSM-64 Navaho Missile
YC-15 Military Transport
YF-107 Fighter

A-17/8A Light Attack Bomber

Historical Snapshot

The 1935 contract for 110 A-17 attack bombers from the Northrop division of the Douglas Aircraft Co. launched the company as a producer of light, tactical bombers.

The A-17 started as an attack version of the Northrop Gamma and was designed principally for export. It had the same wings and undercarriage but had a new fuselage with an enclosed canopy for the pilot and radio operator/gunner.

A number of fixed- and retractable-undercarriage A-17 models were developed for sale to overseas customers, and because they were produced after the Northrop facility became the El Segundo Division of Douglas, they also were known as Douglas 8As.

Douglas built 352 A-17/8As. In addition to the U.S. Army Air Corps, they flew for air forces around the world.

Technical Specifications	
First flight	December 1935
Model number	A-17
Span	47 feet 8.5 inches
Length	31 feet 8.6 inches
Height	11 feet 10.5 inches
Ceiling	20,700 feet
Range	650 miles
Weight	7,337 pounds
Speed	170 mph
Accommodation	Two crew
Armament	Five .30-caliber machine guns, 1,200-pound bomb load

A-26/B-26 Invader Light Bomber

Historical Snapshot

The Douglas A-26/B-26 bomber was the only American bomber to fly missions in three wars. After World War II, it served as a first-line bomber during the Korean War and during the Vietnam War. Douglas started the A-26 in 1941 to follow the A-20/DB-7 Havoc bomber.

During production, a number of modifications were progressively introduced so that by 1948, the A-26 was one of the few wartime aircraft types still in service with the post-war U.S. Air Force. When the famous Martin B-26 Marauder retired and the Air Force deleted the designation “A” (for attack category), the Douglas Invader took on the B-26 designation.

Invader versions included the A-26D and A-26E light bombers, GA-26C ground training aircraft and the KA-26A tanker. Some A/B-26s were equipped for photo reconnaissance, and during the 1960s, some surplus B-26s were used to tow targets. The last U.S. military Invader was retired in 1972 and donated to the Smithsonian’s National Air and Space Museum.

Technical Specifications	
First flight	July 10, 1942
Wingspan	70 feet
Length	50 feet
Height	18 feet 6 inches
Ceiling	22,100 feet
Range	1,400 miles
Weight	35,000 pounds
Power plant	Two 2,000-horsepower P&W R-2800-27 engines
Speed	355 mph
Accommodation	Three crew
Armament	Eight .50-caliber machine guns, 14 5-inch rockets and 5,000-pound bomb load

A3D/A-3 Skywarrior, B-66 Destroyer Bomber

Historical Snapshot

The Douglas A3D Skywarrior was the U.S. Navy's first twinjet nuclear bomber.

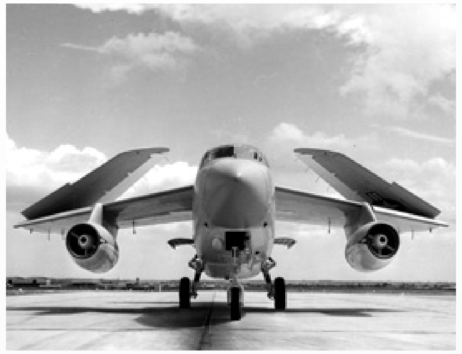
Douglas started designing the airplane in 1947, after the U.S. Navy commissioned studies to determine whether it was possible to overcome weight problems and build a carrier-based strategic bomber. The project was challenging because anything to do with nuclear armament was top secret, and designers had to guess the appearance and weight of the nuclear bombs to be carried aboard. Moreover, the internal bomb bay had to be accessible from the cockpit so that the crew could arm the nuclear device during flight.

Douglas built 282 Skywarriors. The first production version, the A-3A (A3D-1), with a radar-controlled tail turret and a crew of three, entered service with the Navy Heavy Attack Squadron One in 1956. At 70,000 pounds (31,800 kilograms), the A3D was the largest and heaviest aircraft ever to operate from an aircraft carrier.

After flying a few conventional bombing missions over North and South Vietnam, Skywarriors were used as carrier-based aerial-refueling tankers and as reconnaissance aircraft covering the Ho Chi Minh trail. As advancing technology rendered its old role obsolete, the resilient aircraft continued to evolve. It was used for electronic countermeasures, photographic reconnaissance, and crew trainers and as a VIP transport.

The revised U.S. Air Force version of the Skywarrior was named the Destroyer and designated the B-66. Douglas built 294 B-66 Destroyers. In speed, range and capacity, the B-66 twinjet met all tactical requirements for delivering the most potent weapons. The RB-66 was modified for use in night photo, electronics and weather reconnaissance.

Technical Specifications	
First flight	Oct. 28, 1952
Wingspan	72 feet 6 inches
Length	74 feet 5 inches
Height	22 feet 9.5 inches
Weight	70,000 pounds maximum
Speed	621 mph
Ceiling	40,500 feet
Range	2,300 miles
Power plant	Two 10,000-pound-thrust Pratt & Whitney J57-P-10s
Accommodation	Three crew
Armament	12,000-pound bomb load



Technical Specifications

First flight	- A-5A: Aug. 31, 1958 - A-5B: April 29, 1962 - RA-5C: June 30, 1962
Span	50 feet
Length	70 feet
Height	20 feet
Power plant	Two General Electric J79-8 turbojet engines, each producing 10,900 pounds thrust without afterburner, and 17,000 pounds thrust with afterburner
Speed	Mach 2 range
Bomb delivery	Linear bay that ran lengthwise in fuselage; bomb load was ejected rearward
Crew	Pilot and bombardier-navigator
Landing gear	- Type: Tricycle, hydraulically retracted tires and wheels: (2) 36 x 11 and (1) 26 x 6.6 - Brakes: Multiple disc - hydraulic landing gear shock - Struts: Air-oil JSE 113064

A3J-1/A-5/RA-5C Vigilante

Historical Snapshot

The Vigilante, designed and built for the U.S. Navy by North American Aircraft Division at Columbus, Ohio, was the only Mach 2 bomber to serve aboard a Navy carrier. Initially designated the A3J-1 attack bomber, it was one of the largest and heaviest aircraft ever accepted for service aboard U.S. Navy carriers. Production began in 1956, and it entered squadron service in June 1961. It was redesignated the A-5 and fully deployed by August 1962, when the USS *Enterprise*, the Navy's first nuclear aircraft carrier, made its inaugural cruise.

Changing defense strategies marked a hange of focus away from carrier-based, heavy-attack squadrons. In 1964, all the Vigilantes were reconfigured as reconnaissance aircraft and designated RA-5C. Reconnaissance gear was mounted in what had been the Vigilante's bomb bay. Other modifications allowed the RA-5C to carry four external fuel tanks. These additions increased the airplane's range on reconnaissance missions and allowed it to keep its attack capability with externally mounted bombs and rockets.

The RA-5C Vigilante first flew on June 30, 1962, and was capable of all-weather, long-range, carrier- or land-based, multisensor, reconnaissance missions involving high-altitude supersonic, or very low-altitude, high-speed penetrations. Its inertial navigation system provided the precise position location information demanded. The Vigilante pilot and the reconnaissance/attack navigator (RAN) sat in tandem under individual clamshell-type canopies.

The RAN controlled all reconnaissance functions, although the pilot could assume control of the oblique-mounted serial frame cameras. Each crewmember had a catapult/rocket-powered ejection seat, also designed and produced at the Columbus facility, capable of high-altitude, high-speed or ground-level recoveries.

The RA-5C featured a high, thin swept wing and all-movable slab-type tail surfaces with spoiler/deflectors in lieu of conventional ailerons for lateral control. The wing was equipped with flaps and droopable leading edges with boundary layer control, which, when used in conjunction with the spoiler/deflectors, improved low-speed flight characteristics.

The combination of the RA-5C Vigilante's ability to deliver conventional weapons, day or night in all kinds of weather, as well as to complete tactical reconnaissance missions made it one of the most versatile aircraft in the world. RA-5Cs served throughout the Vietnam War and were retired from service in 1979.

A4D/A-4 Skyhawk Light Attack Bomber

Historical Snapshot

Douglas built 2,960 Skyhawks between 1954 and 1979. Built small to be cost effective and so that more of them could be accommodated on a carrier, the lightweight, high-speed bombers were affectionately nicknamed “Heinemann’s Hot Rod” (after Douglas designer Ed Heinemann), the Bantam Bomber, Mighty Mite and Scooter. Skyhawks provided the U.S. Navy and Marines and friendly nations with maneuverable, yet powerful, attack bombers that had great altitude and range capabilities, plus an unusual flexibility in armament capacity.

The Skyhawk A4D was roughly half the empty weight of its contemporaries and could fly at 677 mph (1090 kph) at sea level. After 1956, it had provisions for in-flight refueling. After 1966, it included a hump-like avionics pod. Upgraded models had improved engines and a drogue parachute, new avionics displays, larger cockpit canopies and more ammunition for the two cannons. Two-seat trainer versions included the TA-4F, TA-4J and the TA-4K series.

Its combat career began with the first American carrier-launched raids on North Vietnam, Aug. 4, 1964. Later, during Israel’s Yom Kippur war in 1973, Israeli Air Force Skyhawks provided much of the short-range striking power on the Sinai and Golan Heights fronts.

The Navy’s Blue Angels flight demonstration squadron flew the A-4 Skyhawk II from 1974 to 1986. Skyhawks have also been used by the armed forces of Argentina, Australia, Brazil, Indonesia, Israel, Kuwait, Malaysia, New Zealand and Singapore. A number of A-4 variants were still in active military service in South America in 2021.

Technical Specifications	
Power plant	Two 1,725-horsepower Bristol Hercules XVIII radial engines
Span	17.63 meters (57 feet, 10 inches)
Length	12.70 meters (44 feet, 8 inches)
Height	4.82 meters (15 feet, 9 inches)
Empty weight	7,076 kilograms (15,600 pounds)
Loaded weight	11,521 kilograms (25,150 pounds)
Maximum speed	515 kph (320 mph)
Range	2,365 kilometers (1,470 miles)
Service ceiling	5,791 meters (19,000 feet)
Armament	Four 20 mm cannons in fuselage nose and four 0.5-inch guns in the wings. A single 0.3-inch gun could be mounted in the rear cupola. Eight rockets plus two 112-kilogram (250-pound) bombs, two 230-kilogram (500-pound) bombs or one Mk 13 torpedo.

A8 Beaufighter

Historical Snapshot

In 1942, the British-built Beaufighter began operating with the Royal Australian Air Force (RAAF) under the designation A19. These aircraft proved to be extremely effective in operations and are particularly well known for their role in the Battle of the Bismarck Sea. In January 1943, the Department of Aircraft Production (DAP) made the decision to end Beaufort production in favor of an Australian-built version of the Beaufighter.

The Bristol Company dispatched 55,000 drawings via Airgraph Service (similar to the United States' "Victory Mail") to DAP. The original plan was to produce an Australian equivalent of the British Beaufighter Mk VII, but it was ultimately decided to build a version similar to the British Beaufighter TF Mk X, which was designated DAP Bristol Beaufighter Mk 21. Unlike the British version, the Air-to-Surface Vessel (ASV) radar and dorsal fin were never applied to the DAP model. However, like the Mk X aircraft flown by RAAF crews in Europe, all the Hercules XVII engines had their two-speed blowers made fully operational, thus becoming Hercules XVIIIs.

The first DAP Beaufighter was flown on May 26, 1944, and five days later, the aircraft was taken over by the RAAF and given the designation A8. As production continued at Fishermans Bend and Mascot factories, the Australian A8 Beaufighter began to replace the British A19 Beaufighter. Beaufighters saw combat throughout New Guinea, the Celebes, Borneo and the Philippines. The longest mission flown by the Australian Beaufighters was a bomber escort mission to Tarakan on May 2, 1945, as part of the opening moves of Operation Oboe, the campaign to liberate Borneo. Beaufighters served with Nos. 22, 30, 31, 92 and 93 Squadrons, and when production ceased at the end of 1945, a total of 364 DAP Beaufighters had been built.

In the post-war years, Beaufighters continued to operate with No. 30 Squadron, where they were gradually reduced to a target-towing role. The last aircraft, A8-357, was flown to Edinburgh for disposal on Dec. 9, 1957.

Technical Specifications	
Power plant	Two 1,200-horsepower Pratt & Whitney Twin Wasps
Span	17.63 meters (57 feet, 10 inches)
Length	13.49 meters (44 feet, 4.5 inches)
Height	4.83 meters (12 feet, 5 inches)
Empty weight	6,382 kilograms (14,070 pounds)
Loaded weight	10,206 kilograms (22,500 pounds)
Maximum speed	431 kph (268 mph)
Range	1,706 kilometers (1,060 miles)
Service ceiling	5,500 meters (18,000 feet)
Armament	990-kilogram (2,000-pound) bomb load or torpedo; 0.303-inch (and later 0.5-inch) machine guns in turret, nose or wing

A9 Beaufort Torpedo Bomber

Historical Snapshot

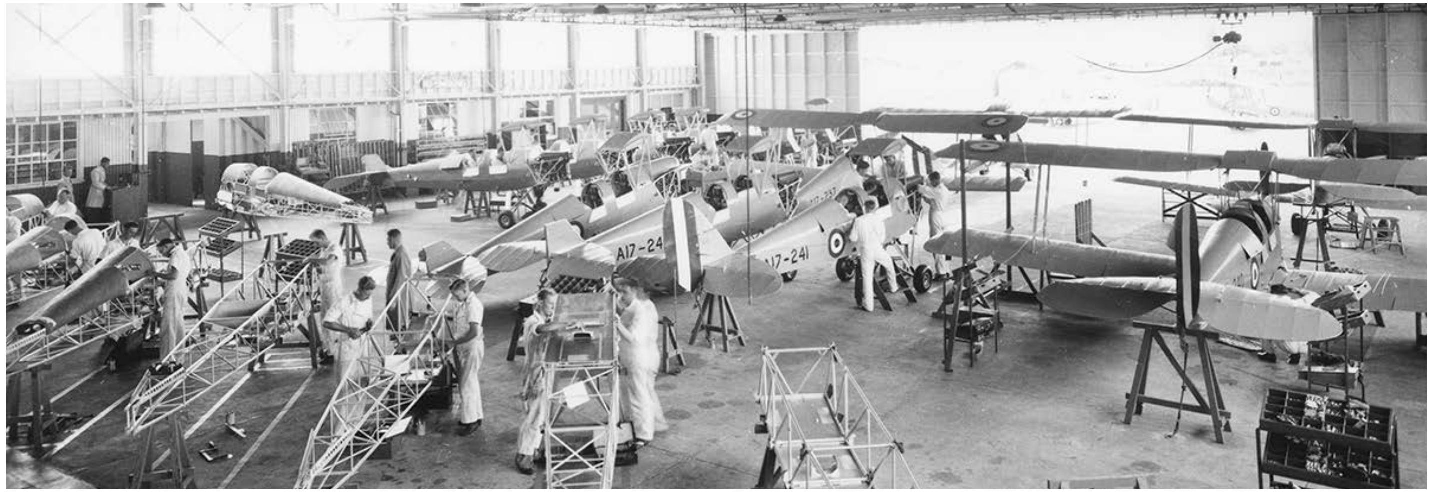
The Bristol Beaufort was derived from the Blenheim — another light bomber built by Bristol — to fulfill the requirement to carry a torpedo and to increase the crew from three to four. The first Beaufort flew on Oct. 15, 1938, and soon after the Australian Government chose the Beaufort for local manufacture. The Beaufort was the largest aircraft production effort yet attempted in Australia, and to accomplish this major challenge, the Australian Government established the Beaufort Division of the Department of Aircraft Production (DAP). Four-hundred specialized subcontractors built components for the Beaufort, which were shipped to three railway workshops for fabrication of major subassemblies that were then delivered to two final assembly plants at Fishermans Bend, Melbourne, and Mascot, Sydney.

Due to a shortage of British-built engines — a common issue in Australian aircraft production — the Beaufort was modified to use Pratt & Whitney Twin Wasp engines license-built in Australia.

On July 1, 1939, the Royal Australian Air Force awarded DAP a contract for 180 Beauforts, and the first Beaufort assembled in Australia (built from mostly British parts) was flown May 5, 1941. The first all Australian-built Beaufort (A9-7) began flight tests in August 1941. The initial batch of aircraft were designated Beaufort V, Va, VI and VII, signifying different engines and propeller manufacturers. After the first 180 planes had been built, the supply issues were solved, and in November 1942, production commenced on the next 520 aircraft designated Beaufort Mk VIII. Production of the Mk VIIIs continued at a rate of 30 per month until 1944 when production shifted to the Beaufighter.

The last 46 of the 700 Beauforts produced were converted into unarmed transports, designated Beaufort Mk IX, and soon became known as Beaufreighters.

Beauforts served with numerous units, including Nos. 1, 2, 6, 7, 8, 13, 14, 15, 32 and 100 Squadrons, and established an impressive operational record-making long-range attacks against Japanese shipping from the Solomons to Northern New Guinea and Timor. They were also used for routine convoy protection and coastal reconnaissance. Most of the Beauforts were phased out of service soon after the war; however, limited numbers were used to combat the great locust plague in 1947.



Technical Specifications

Power plant	One 130-horsepower DH Gypsy Major I
Span	8.94 meters (29 feet, 4 inches)
Length	7.29 meters (23 feet, 11 inches)
Height	2.68 meters (8 feet, 9.5 inches)
Empty weight	506 kilograms (1,115 pounds)
Loaded weight	828 kilograms (1,650 pounds)
Maximum speed	175 kph (109 mph)
Range	483 kilometers (300 miles)
Service ceiling	4,267 meters (14,000 feet)
Armament	None

A17 Tiger Moth Trainer

Historical Snapshot

Along with the Boeing Stearman Kaydet, the Tiger Moth is one of the world's most famous primary trainers.

de Havilland first flew the DH.82 Tiger Moth at Stag Lane Aerodrome on Oct. 26, 1931. Soon after, it was adopted as the primary trainer for the Royal Air Force and throughout the Commonwealth. In 1934, the design was modified with the de Havilland Gypsy Major engine, and the fabric-covered rear fuselage was replaced with plywood; this new version was designated DH.82A Tiger Moth II.

At the outbreak of World War II, the Tiger Moth II was selected as the basic trainer for the Empire Air Training Scheme — the Australian name for the wider British Commonwealth Air Training Plan. The first of 20 Royal Australian Air Force (RAAF) Tiger Moths, A17-1, was delivered from Great Britain in May 1940.

de Havilland Australia delivered the first of 732 Australia-built Tiger Moths to the RAAF in June 1940, with the last delivered in February 1945. In all, de Havilland Australia built 1,085 Tiger Moths, with the remainder being shipped overseas to other training schools in South Africa, Rhodesia, India and the Netherlands East Indies.

A small number of Tiger Moths were also transferred to the Royal Australian Navy after World War II. Tiger Moths had served the RAAF for almost 17 years when the last 10 were retired on Jan. 9, 1957.

Technical Specifications	
Power plant	One 600-horsepower CAC-manufactured Pratt & Whitney Wasp nine-cylinder air-cooled radial engine
Span	13.10 meters (43 feet)
Length	8.48 meters (27 feet, 10 inches)
Height	2.66 meters (8 feet, 9 inches)
Empty weight	1,811 kilograms (3,980 pounds)
Loaded weight	2,991 kilograms (6,595 pounds)
Maximum speed	354 kph (220 mph)
Range	1,158 kilometers (720 miles)
Service ceiling	7,010 meters (23,000 feet)
Armament	Two fixed, forward-firing 0.303-inch machine guns in the cowl, one rear-facing 0.303-inch gun on a flexible mount

A20 Wirraway Trainer, Fighter

Historical Snapshot

The story of what is arguably Australia's most famous aircraft began in February 1936 when a technical mission consisting of Cdr. Wackett and Sqd. Leaders Harrison and Murphy visited European and U.S. aircraft manufacturers to investigate aircraft production, and to determine the basic features for an aircraft to be produced in Australia. Later that year, on Oct. 17, Commonwealth Aircraft Corp. (CAC) was formed to ensure that Australia had the indigenous capability to produce aircraft for the Royal Australian Air Force (RAAF).

CAC concluded that the aircraft that best represented what the technical commission had recommended was the NA-16 monoplane trainer — known as the BT-9 and BC-1 in the U.S. Army Air Corps and as the Yale in the Royal Air Force — built by Boeing heritage company North American Aviation. North American produced two prototype airplanes, designated NA-32 and NA-33, that were then shipped to Australia for evaluation. The NA-33 design was selected and modified into a combat aircraft with the addition of machine guns and strengthened wings to carry additional bomb racks. The airplane was given the aboriginal name "Wirraway" meaning "Challenge."

In June 1938, CAC was awarded an initial order for 40 Wirraways, and on March 27, 1939, Flt. Lt. H. "Boss" Walker took the first CAC-manufactured Wirraway (A20-3) up on its first flight from Fishermans Bend. Deliveries to the RAAF began in July 1939. By September 1941, CAC was manufacturing 45 Wirraways per month and had built 620 by June 1942. Production continued until 1946 when the last of 755 was delivered.

The Wirraway served as a frontline combat aircraft in the first year of the Pacific War, notably supporting operations in Malaya and over Rabaul, where eight Wirraway pilots courageously intercepted more than 100 attacking Japanese planes on Jan. 20, 1942. Greatly outclassed by Japanese fighters, the Wirraway did serve successfully in Army co-operation missions during the New Guinea campaign and made Wirraway history over Gona, New Guinea, on Dec. 26, 1942, when Pilot Officer J. Archer shot down a Zeke fighter during the Battle of Buna-Gona. By mid-1943, the "Wirra" had been replaced in frontline service by the Boomerang, but continued serving as a trainer with both the RAAF and the Royal Australian Navy until 1959.

Technical Specifications	
Power plant	One 1,200-horsepower CAC license-built Pratt & Whitney Twin Wasp
Span	10.97 meters (36 feet)
Length	7.77 meters (26 feet 6 inches)
Height	3.20 meters (10 feet, 6 inches)
Empty weight	2,437 kilograms (5,373 pounds)
Loaded weight	3,492 kilograms (7,699 pounds)
Maximum speed	491 kph (305 mph)
Range	1,496 kilometers (930 miles)
Service ceiling	10,363 meters (34,000 feet)
Armament	Two 20 mm cannons, 4 x 0.303 Browning machine guns

A46 Boomerang Fighter

Historical Snapshot

In early 1942, Imperial Japanese forces were sweeping through the South Pacific into New Guinea, and the Solomon Islands, Australia, was faced with the imminent threat of invasion, or in the least, being isolated from the U.S. and Great Britain. And to make matters worse, the Royal Australian Air Force (RAAF) did not have fighter aircraft for home defense. To address this emergency, Commonwealth Aircraft Corp. (CAC) set out to design a n indigenous interceptor, and in just 14 weeks, CAC engineers went from inception to first flight of a new fighter airplane called the Boomerang.

Following a pattern that Boeing heritage company North American Aviation set with the NA-68 (P-64) — a heavily modified fighter version of the BC-1 trainer — the Boomerang was a single-seat fighter based on the Wirraway trainer, with which it shared a common wingbox and tail unit. Ordered into production on Feb. 2, 1942, the first Boomerang, A64-1, was flown by pilot Ken Frewin on May 29, 1942.

Pilot conversion was carried out with No. 2 Operational Training Unit at Mildura, and those pilots formed the first operational units: Nos. 83, 84 and 85 Squadrons.

The Boomerang was a stopgap design and its performance was not optimal for a frontline fighter. While Boomerangs did drive off enemy air attacks, they did not destroy any enemy aircraft and were soon replaced in the fighter role by Kittyhawks and Spitfires. The Boomerang did continue to serve very effectively in combat, performing aerial reconnaissance and ground support during the New Guinea and Solomon Islands campaigns as well as in Borneo.

The first Boomerang, A46-1, was accepted by the RAAF on July 15, 1942, and the last, A46-249, was delivered Feb. 1, 1945. A total of 249 Boomerangs were built: 105 CA-12 (Mark I), 95 CA-13 (Mark II) and 49 CA-19 tactical reconnaissance aircraft.

Technical Specifications	
Power plant	Two 1,460-horsepower Packard Merlin 31s or Merlin 33s
Span	16.51 meters (54 feet, 2 inches)
Length	12.45 meters (40 feet, 6 inches)
Height	4.65 meters (15 feet, 3 inches)
Empty weight	6,506 kilograms (14,344 pounds)
Loaded weight	10,096 kilograms (22,258 pounds)
Maximum speed	611 kph (380 mph)
Range	1,802 kilometers (1,120 miles)
Service ceiling	10,058 meters (33,000 feet)
Armament	Four 20 mm cannons, four 0.303 guns forward; two 227-kilogram (500-pound) bombs in fuselage, plus two 227-kilogram (500-pound) bombs or rocket projectiles under the wings

A52 Mosquito Light Bomber

Historical Snapshot

The de Havilland DH 98 Mosquito was one of the greatest combat aircraft of World War II. Originally conceived as a fast, unarmed, light bomber that would be able to outfly fighters, the lightweight, all-wood construction "Mossie" first flew on Nov. 25, 1940, and had a top speed of almost 400 mph. Mosquitoes were built in several different versions, including fighter-bombers (FBs), photo-reconnaissance, day and night bombers, and long-range day and night fighters.

Mosquitoes were assembled in Great Britain, Canada, and in 1942, the Australian de Havilland factory at Bankstown commenced production of an FB version of the Mosquito. A Royal Air Force Mk II (DD664) was delivered to Bankstown and used as a prototype for the Australian FB Mk 40s. It made its first flight on Dec. 17, 1942, and was later delivered to the Royal Australian Air Force (RAAF) on Jan. 28, 1943, and registered as A52-1001.

In April 1943, a new assembly building was finished at Bankstown, and the first Australian-built Mosquito FB Mk 40, A52-1, was flown July 23, 1943, by de Havilland test pilot Wing Cdr. Gibson Lee with the Merlin engines borrowed from the British sample airplane. A52-1 was accepted by the RAAF on Mar. 5, 1944.

Initial delays in production were due to the difficulties of importing engines, tools and priority equipment from de Havilland in Great Britain and Canada. Soon after production began, the manufacturer discovered an issue with wing assembly, and the first 50 sets of wings required modification. This, and the discovery of flutter issues, further delayed production, which eventually amounted to just 75 airplanes being built between March 1944 and May 1945. By the end of the war, production issues had been resolved, and 212 Mosquitoes were built at Bankstown. Of these, six FB Mk 40s were converted for photo reconnaissance as PR Mk 40s, and a further 28 were converted to PR Mk 41s, with the last delivered July 22, 1948.

In addition to the Australian-built Mosquitoes, 76 British-built Mosquitoes served with the RAAF.

The RAAF Mosquitoes saw limited, but effective, service at the end of the war in the Pacific, serving with No. 1 Squadron in Halmahera and Borneo, and No. 87 Squadron (No. 1 PRU), which performed reconnaissance missions over Java, Balikpapan, Biak, Halmahera and the Philippines. Mosquitoes were also assigned to No. 94 Squadron, No. 1 Aircraft Performance Unit, and the Aircraft Research and Development Unit.

Post war, PR Mk 41 Mosquitoes were used extensively for a large-scale air survey of Australia. The Mosquito was retired from service in 1954.

Technical Specifications	
Power plant	One 1490-horsepower Packard Merlin V1650-3, -7
Span	11.28 meters (37 feet)
Length	9.83 meters (32 feet, 3 inches)
Height	3.71 meters (12 feet, 2 inches)
Empty weight	3,567 kilograms (7,863 pounds)
Loaded weight	4,763 kilograms (10,500 pounds)
Maximum speed	636 kph (395 mph)
Range	1,529 kilometers (950 miles)
Service ceiling	12,771 meters (41,900 feet)
Armament	Six 0.50-inch caliber machine guns; two 454-kilogram (1,000-pound) bombs or up to 10 rockets

A68 Mustang Fighter

Historical Snapshot

Arguably the best fighter plane of the Second World War, the Mustang was selected by the Australian Government to fulfill an urgent need by the Royal Australian Air Force (RAAF) for a new fighter at the height of the war in the Pacific. Commonwealth Aircraft Corp. (CAC) had already built a relationship with Boeing heritage company North American Aviation during its work on the Wirraway, and was selected to manufacture the Mustang Mk IV (P-51D) under license. North American shipped 80 unassembled P-51D-1 (NA-110) Mustangs to CAC; these were designated CA-17 by CAC and Mustang Mk 20 by the RAAF. The first Australian-assembled Mustang, A68-1, flew from Fishermans Bend on Apr. 29, 1945. The first Mustang was turned over to the RAAF on June 4, 1945.

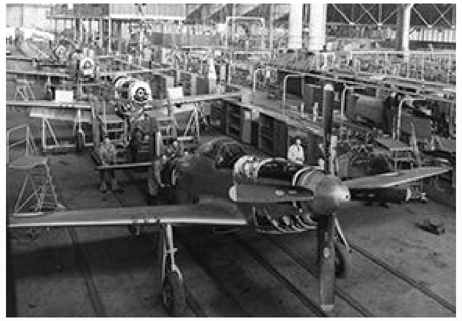
A second contract resulted in 120 additional Mustang 21 and 22s (A68-81/200) that were built entirely in Australia and designated CA-18 by CAC.

The RAAF also received 298 lend-lease P-51Ds and Ks (A68-500/583 and A68-600/813). In addition, the RAAF also accepted Mustangs for the Netherlands East Indies Air Force (N3-600/640).

Produced too late for World War II, RAAF Mustangs were assigned to Japan for occupation duties. In early 1946, Mustang Wing No. 81, comprised of Nos. 76, 77 and 82 Squadrons, flew into Iwakuni.

In 1949, the Mustangs of No. 77 Squadron remained in Japan, but when war broke out on the Korean peninsula in June 1950, U.S. Army General Douglas MacArthur requested that the squadron provide ground support for the hard-pressed UN forces holding the Pusan Perimeter. Later, on July 2, 1950, No. 77 Squadron flew its first mission over North Korea, escorting Boeing B-29 Superfortresses.

Australian Mustangs continued combat missions until April 1951, when they were replaced by Gloster Meteors, and remained in service with Citizen's Air Force Squadrons until 1959.



Technical Specifications	
Power plant	Four 1,750-horsepower Rolls Royce Merlin 85 engines
Span	36.57 meters (120 feet)
Length	23.86 meters (78 feet, 3.5 inches)
Height	5.26 meters (17 feet, 3.5 inches)
Empty weight	19,686 kilograms (43,400 pounds)
Loaded weight	34,019 kilograms (75,000 pounds)
Maximum speed	499 kph (310 mph)
Range	6,900 kilometers (4,287 miles)
Service ceiling	8,534 meters (28,000 feet)
Armament	Twin 0.50 guns in each of nose and tail turret; twin 20 mm guns in dorsal turret; maximum bomb load 6,350 kilograms (14,000 pounds)

A73 Lincoln B MK 30 Bomber

Historical Snapshot

In 1943, Avro began improving the Lancaster four-engine bomber for operations in the Pacific Theater by extending the range, and adding more powerful engines and more defensive armament. The modifications were so extensive that the design became a new airplane called the Lincoln. The first Royal Air Force (RAF) Lincoln B Mk I flew on June 9, 1944, and operational squadrons were preparing to join the war against Japan when World War II ended. The Lincoln was the last piston-engine bomber flown by the RAF.

Also in 1943, plans were underway in Australia for the Beaufort Division of the Department of Aircraft Production (DAP) to build the Lancaster Mk III, but a plane with greater range was needed for operations in the Pacific, so the Lincoln B Mk 30 was chosen instead. As the war ended, DAP became Government Aircraft Factories (GAF) and the Australian government placed an order for 85 Lincolns. The first five Lincolns were constructed from British-supplied components, and A73-1 made its first flight on Mar. 17, 1946. The first Australian-built Lincoln, A73-6, was delivered in November 1946. The Lincolns became operational with Nos. 1, 2 and 6 Squadrons of No. 82 Wing, and a fourth squadron, No. 10, was added on Mar. 17, 1949, as a general reconnaissance squadron.

The Lincoln Mk 30 originally had four Merlin 85 engines, though later models were equipped with Merlin 102s and designated Mk 30A. Eighteen Lincolns, designated MR31, were modified with a 6-foot, 6-inch extension to the forward fuselage to house radar equipment and operators. This version — nicknamed the “long-nose Lincoln” — was delivered to No. 10 Squadron for maritime reconnaissance and anti-submarine missions. GAF delivered the last of 73 Lincolns built, A73-73, on Sept. 23, 1953.

Lincoln bombers saw combat with No. 1 Squadron in Malaya. This squadron arrived in Singapore on July 17, 1950, and remained there for eight years, during which time more than 3,000 sorties were carried out against the Communists. No. 10 Squadron continued to operate Lincoln MR31s until the last flight was made by A73-65 in June 1961. The Lincoln holds the distinction of being the largest aircraft to be built in Australia.

Technical Specifications	
Power plant	One 2,268-kilogram (5,000-pound) thrust Rolls-Royce/CAC Nene 2-VH turbojet engine
Span	11.58 meters (38 feet)
Length	9.37 meters (30 feet, 9 inches)
Height	2.69 meters (8 feet, 10 inches)
Empty weight	3,447 kilograms (7,600 pounds)
Loaded weight	5,942 kilograms (13,100 pounds)
Maximum speed	882 kph (548 mph)
Range	1,266 kilometers (787 miles)
Service ceiling	13,100 meters (43,000 feet)
Armament	Four 20 mm cannons, eight 27-kilogram (60-pound) rockets or two 454-kilogram (1,000-pound) bombs

A79 Vampire Fighter

Historical Snapshot

The de Havilland Vampire followed the Gloster Meteor as one of Great Britain's first jet fighters. First flown on Sept. 20, 1943, the small fighter was very underpowered, yet it was the first Allied production fighter to exceed 804 kph (500 mph). The German ME-262 had a top speed of 900 kph (559 mph) and also set an altitude record of 18,119 meters (59,446 feet).

The Vampire was Australia's first jet fighter and served in that role for 10 years before being replaced by the Sabre. From 1949 to 1953, de Havilland Aircraft built 80 single-seat Vampire fighters and fighter-bombers for the Royal Australian Air Force (RAAF) at the plant in Bankstown, New South Wales. The Australian-built Vampires were powered by the Rolls-Royce Nene jet engine, built by Commonwealth Aircraft Corp. (CAC), differing significantly from most all other Vampires that relied on the DH Goblin engine.

The first de Havilland Australia Vampire F Mk 30 (A79-1) flew for the first time in June 1949, and it was followed by 56 more F 30 variants before the final 23 aircraft were completed as FB Mk 31s modified with strengthened wings and hardpoints for bombs and rockets. The last FB Mk 31 was delivered in August 1953, and 24 late-production Mk 30s were subsequently upgraded to FB Mk 31 standard.

Australia's Vampire were operated by Nos. 75 and 76 Squadrons of No. 78 Wing and also served with Nos. 21, 22, 23 and 25 Squadrons of the Citizen's Air Force (CAF) until the CAF ceased flying in 1954.

Vampire trainer production began with an initial order for 35 T Mk 33s for the RAAF, which were delivered in 1952. Five Mk 35s were ordered for the Royal Australian Navy (RAN) and delivered in 1954. One extra aircraft was later built to replace an RAN Vampire lost in an accident. In September 1957, the RAAF took delivery of the first of 69 Mk 35A trainers that included a modified tail and canopy, increased fuel capacity and non-skid hydraulic brakes.

The trainer variants were operated by No. 1 Advanced Flying Training School at RAAF Bases Point Cook and Pearce, the Central Flying School, and Nos. 2 and 5 Operational Training Units. Trainers were also attached to the CAF squadrons. The Vampire trainers served until they were replaced by Macchi MB-326H aircraft; the Vampires were phased out beginning in 1968, with the last flown in September 1970. RAN Vampire operations ceased the following year.

Technical Specifications

Power plant	Two CAC-built Rolls-Royce Avon turbojets
Span	19.50 meters (64 feet)
Length	19.96 meters (65 feet, 6 inches)
Height	4.75 meters (15 feet, 7 inches)
Empty weight	11,521 kilograms (25,400 pounds)
Loaded weight	22,680 kilograms (50,000 pounds)
Maximum speed	933 kph (580 mph)
Range	5,841 kilometers (3,629 miles)
Service ceiling	13,716 meters (45,000 feet)
Armament	Maximum bomb load 3,629 kilograms (8,000 pounds)

A84 Canberra Bomber

Historical Snapshot

Named after Australia's capitol Canberra, in honor of the Royal Australian Air Force (RAAF) showing early interest in the plane, the early jet bomber from English Electric first flew on May 13, 1949. In 1951, the Government Aircraft Factory (GAF) was made ready for production of the Canberra at Fishermans Bend and Commonwealth Aircraft Corp. (CAC), who began building the Canberra's Avon engines. Two English Electric-built Canberra B-2s were purchased by Australia to serve as pattern aircraft. The delivery flight of the first Canberra in August 1951 represented the first jet flight between England and Australia. The four-day flight required six stops and covered 16,480 kilometers (10,240 miles). When the Australian crew arrived at Darwin, they had spent a total of 21.5 hours in the air.

The GAF Canberras were designated B.20, and were similar to the British B.2 with the addition of internal wing tanks. The first Canberra B.20 flew at Avalon airport on May 19, 1953. RAAF Nos. 2 and 6 Squadrons at Amberly were the first to operate the Canberra, making the transition from the Lincoln in 1955. No. 1 Squadron became the third to operate the Canberra in 1958. The last of the 48 B.20s built by GAF rolled out in December 1958. Follow-on work included converting five B.20s and the two original B.2s into trainers designated T.21.

Canberras saw combat during the Malaysian Emergency and later, in 1967, eight Canberras from No. 2 Squadron deployed to Phan Rang Air Base in Vietnam, where Australian crews flew nearly 12,000 low-level bombing missions in Southern Vietnam's III and IV Corps tactical zones, which included the area around the capitol city of Saigon and the Mekong Delta.

During the war, two Canberras were lost, one (A84-228) was shot down by a surface-to-air missile; the crew safely ejected and were rescued. The other (A84-231), call sign "Magpie 91," was listed as missing in action near the Vietnam-Laotian border after a successful bomb run supporting U.S. ground troops on Nov. 3, 1970. The remains of Flying Officer Michael Herbert (Pilot) and Pilot Officer Robert Carver (Navigator) were finally discovered by a Defense Historical Unit and returned to Australia on Aug. 31, 2009. No. 2 Squadron redeployed from Vietnam after its last mission on May 31, 1971.

The Canberra was eventually replaced by the F-111C, but continued limited service until 1982.

Technical Specifications	
Power plant	One 3,402-kilogram (7,500-pound) thrust CAC Avon 26 turbojet
Span	11.30 meters (37 feet, 1 inch)
Length	11.43 meters (37 feet, 6 inch)
Height	4.37 meters (14 feet, 4 inches)
Empty weight	5,443 kilograms (12,000 pounds)
Loaded weight	8,038 kilograms (17,720 pounds)
Maximum speed	1,126 kph (700 mph)
Range	1,850 kilometers (1,150 miles)
Service ceiling	15,850 meters (52,000 feet)
Armament	Two 30 mm Aden cannons; alternative loads of Sidewinders, rockets and bombs

A94 Sabre Fighter

Historical Snapshot

As early as 1949, the Royal Australian Air Force (RAAF) began planning a replacement jet fighter for the locally built Commonwealth Aircraft Corp. (CAC) Mustang and de Havilland Vampire. The Hawker P.1081, a swept wing version of the Hawker Sea Hawk, was initially selected, but Hawker stopped work in November 1950 and RAAF interest shifted to the F-86 Sabre — built by Boeing heritage company North American Aviation — that had recently made its debut over the skies of Korea. At that time, No. 77 Squadron was in combat over Korea and had traded its Mustangs for Gloster Meteors, which were outclassed by their primary opponent: the MiG-15. This made it even more urgent for the RAAF to acquire the Sabre. In April 1951, a license was negotiated with North American for the F-86F and an initial order was placed with CAC for 72 Sabres.

Due in part to the technical investigations initiated by CAC Manager, L. J. Wackett, the RAAF decided to install the 7,500-pound thrust Rolls-Royce Avon RA.7 turbojet in place of the 6,100-pound thrust General Electric J-47 engine. To accommodate the 25 percent increase in air needed for the Avon, a 3.5-inch splice was added to the intake, similar to what would be done on the F-86H. To maintain the original center of gravity, the smaller, lighter engine was mounted farther aft in the fuselage, requiring a new position of the fuselage break needed for engine removal. Other major modifications included a revised cockpit layout and the replacement of the six .50-inch machine guns with two 30 mm Aden cannons. After all of the modifications designed into the airplane by CAC, only about 40 percent of the original airframe remained. The modified airplane was nicknamed the Avon Sabre and was the fastest model of the ubiquitous North American fighter.

The prototype CAC CA-26 Sabre Mk 30, A94-101, first flew on Aug. 3, 1953, piloted by Flight Lieutenant W. Scott. The first of 21 production CA-27 Sabre Mk 30s, A94-901, flew on July 13, 1954. Mk 30s were equipped with imported Avon 20 engines and leading-edge slats, which were later modified to Mk 31s with the North American "6-3" wing modification. Beginning in 1955, the next 21 Sabre Mk 31s, A94-922 through A94-942, were powered with the CAC Avon Mk 20 and included the 6-3 wing with additional fuel cells and hard points for drop tanks, bombs and rockets. The final version of the CAC Sabre was the Mk 32 of which 69 — A94-943 through A94-990 and A94-351 through A94-371 — were built. These were powered by the CAC-built Avon Mk 26 and included dual store wings that reduced fuel capacity but allowed for additional drop-tanks, rockets and Sidewinder air-to-air missiles. The last of 112 CAC Sabres, A94-371, completed acceptance trials on Dec. 19, 1961.

The first production Sabres were delivered to the Sabre Trials Unit, RAAF Williamtown, on Nov. 1, 1954. On April 4 of the following year, No. 75 Squadron became the first Sabre squadron. No. 3 Squadron received its first Sabres on Mar. 1, 1956, and No. 77 Squadron on Nov. 19, 1956.

RAAF Sabres went into combat when Nos. 3 and 77 Squadrons deployed to Butterworth, Malaya, in October 1958, where they flew more than 11,000 sorties against the Communist guerillas until the state of emergency ended on July 31, 1960. On June 1, 1962, eight Sabres from No. 79 Squadron deployed from Butterworth to Ubon, Thailand, to support the Thai government against communist insurgents, and later contributed to air defense and support for U.S. Air Force operations in Thailand until it withdrew and disbanded in August 1968. The Mirage III began to replace the Sabre in 1964 and the final Avon Sabre was retired on July 31, 1971.

Technical Specifications	
First flight	March 18, 1945
Wingspan	50 feet
Length	39 feet 3 inches
Height	15 feet 8 inches
Weight	18,398 pounds
Power plant	One 2,700-horsepower Wright R-3350 engine
Speed	More than 300 mph
Ceiling	23,800 feet
Accommodation	One crew
Armament	Four 20 mm cannons and a 2,000-pound bomb load, or an assortment of bombs, rockets, mines, grenades, flares and gun pods

AD/A-1 Skyraider Attack Bomber

Historical Snapshot

The Douglas Skyraider, with its straight, low-mounted, tapered wings, was the only aircraft of its time capable of delivering 8,000 pounds (3,630 kilograms) of bombs with dive-bombing precision against such difficult targets as mountain bridges and hydroelectric dams. The AD-4B could deliver nuclear bombs using the "toss-bombing" or "over-the-shoulder" bombing technique.

The first AD-1 Skyraider was delivered in 1946 and named according to the Douglas tradition of starting the names of U.S. Navy aircraft with "Sky." When the Navy, Marine Corps and Air Force numbering systems merged in 1962, the "AD" series Skyraiders were redesignated as "A" series aircraft.

Before production ceased in 1957, 12 years after the airplane was introduced, Douglas built 3,180 Skyraiders in 28 variations. These included carrier- or land-based airplanes, day or night attack bombers, and versions for photographic reconnaissance, electronic countermeasures, airborne early warning, utility and search missions.

Different configurations carried a pilot in an enclosed cockpit, a pilot and another person (either a radar operator or a co-pilot), and a pilot and two other crew. The AD/A-5 could carry a crew of four, plus four passengers or 12 troops, four stretchers, or 2,000 pounds of cargo.

During the Korean War, Skyraiders first saw action over the Korean Peninsula in July 1950, and by 1955, there were 29 Navy Skyraider squadrons on carriers.

Redesignated the A-1E/A-1H in 1962, the Skyraider was modified for service in the Vietnam War in 1964 and was used by the U.S. Navy and the U.S. and South Vietnamese air forces. Because of its ability to carry large bomb loads, absorb heavy ground fire and fly for long periods at low altitude, the Skyraider was particularly suited for close-support as well as search and rescue missions.

Technical Specifications	
Power plant	One Armstrong Siddeley Viper turbofan engine
Span	10.15 meters (33 feet, 4 inches)
Length	10.7 meters (35 feet)
Height	3.72 meters (12 feet, 2 inches)
Empty weight	2,964 kilograms (6,534 pounds)
Loaded weight	5,897 kilograms (13,000 pounds)
Maximum speed	685 kph (425 mph)
Range	1,850 kilometers (1,150 miles)
Service ceiling	14,325 meters (47,000 feet)
Armament	None

Aermacchi MB326 Trainer

Historical Snapshot

After World War II, Italy was physically and economically devastated. The Aeronautica Militare lacked substantial financial resources to develop a broad range of supersonic interceptors, fighters and bombers it needed to rebuild and defend itself during the jet-powered era of the Cold War. Thus, Italy needed to focus its research and development on a light trainer and fighter with multiple capabilities. Ermanno Bazzochi, who studied mechanical engineering at Italy's top technical university, Politecnico di Milano, went on to become an aircraft designer at Aeronautica Macchi (Aermacchi) in Varese. He presented his design for the MB-326, an aircraft featuring a single Armstrong Siddeley Viper engine. At the time, the Viper was an inexpensive, shorter life span engine designed for target drones, like the Jindivik, yet it proved itself far more reliable. Aermacchi accepted Bazzocchi's design and began production.

Aermacchi's design team put the MB-326 through a long development period, seeking to perfect the aircraft. The first prototype flight took place on Dec. 10, 1957, flown by Guido Carestiato, Aermacchi's chief test pilot. However, the first prototype later crashed during a flight demonstration in Egypt in April 1959. Aermacchi test pilot Nicola Macchia died in the accident. The second prototype flew successfully at the June 1959 Le Bourget airshow in France, attracting customer interest. Further successful test flights led to a 118-aircraft order from the Aeronautica Militare, the first of which entered service in 1962. Aermacchi delivered the first MB-326s to the No. 214 Group Lecce-Galatina aviation school at Brindisi in southeast Italy.

About the time the MB-326 became available for international sales and licensing, the Royal Australian Air Force (RAAF) began looking for a new jet-powered trainer to succeed the aging Wirraway, Vampire and Winjeel. The RAAF sought to implement an all jet-powered training course to prepare its pilots for jet-powered flight from the beginning. RAAF instructors also hoped the MB-326 would provide a baseline for the more advanced French-built Mirage III interceptor the RAAF had recently brought into service.

In August 1965, the RAAF selected the Italian trainer aircraft and test flew it for the first time in Italy in April 1967 for Commonwealth Aircraft Corp. (CAC), which served as prime contractor alongside Hawker de Havilland. Aermacchi and CAC coordinated the delivery before its acquisition by RAAF in October 1968. The CAC production line located at Fisherman's Bend, Victoria, produced the MB-326 while a Hawker de Havilland facility at Guildford, Western Australia, provided maintenance and repair services for all MB-326s. At this point, CAC conducted MB-326 production until the last delivery in September 1972. In all, CAC built 97 MB-326s. Australia was not the only country to build the MB-326 outside Italy; Brazil's Embraer and South Africa's Atlas Aircraft also built the MB-326 aircraft for their respective militaries.

The RAAF used 97 MB-326s in four different squadrons from 1967 until all came out of service in 2000. In the 1970s and 1980s, the RAAF demonstration team, "The Roulettes," flew the MB-326 at flight shows. The MB-326 was later replaced by the Pilatus PC-9 after training many Australian pilots.

Technical Specifications	
First launch	July 29, 1969
Air Force designation	AGM-69
Classification	Missile
Diameter	18 inches
Length	14 feet
Top speed	Supersonic
Armament	Nuclear warhead

AGM-69 Short-Range Attack Missile

Historical Snapshot

The Boeing short-range attack missile (SRAM) was first deployed as a strategic weapon to be carried by FB-111A and B-52 crewed bombers. The AGM-69 is also part of the B-1B armament.

The missiles are small, so many can be carried by each bomber, and can fly at subsonic or supersonic speeds. The SRAM guidance system allows for individually programmed flights, and the missiles can change direction after they have been launched.

By the time the last of 1,500 SRAMs rolled out of assembly in 1975, they were a key element in the U.S. Strategic Air Command's weapon inventory.

Technical Specifications	
irst flight	Dec. 20, 1972
Diameter	13.5 inches
Length	Ship launch: 15 feet 2 inches; air launch: 12 feet 7.5 inches
Range	In excess of 67 nautical miles
Weight	1,160 pounds, air-launched configuration
Power plant	Air-breathing turbojet engine (cruise), solid-propellant booster

AGM/RGM/UGM-84 Harpoon Missile

Historical Snapshot

The McDonnell Douglas Harpoon was originally developed for the U.S. Navy but in 1983 was adapted for use on B-52H bombers. The Harpoon, first deployed in 1977, is an all-weather, over-the-horizon, anti-ship missile system. It has a low-level, sea-skimming cruise trajectory with active radar guidance.

The Harpoon missile is the world's most successful anti-ship missile and is in service with the armed forces of more than 30 countries. It has been upgraded over the years and is now available as the Harpoon Block II. It also led to the development of the standoff land attack missile (SLAM) and subsequently the SLAM expanded response (SLAM-ER).

Harpoon Block II incorporates key guidance technologies from two other Boeing weapons programs — the low-cost, integrated global positioning system/inertial navigation system (GPS/INS) from the Joint Direct Attack Munition and the software, mission computer, GPS antenna and receiver from the SLAM-ER. Boeing has delivered more than 7,000 Harpoon missiles.

The Harpoon is capable of executing both land-strike and anti-ship missions. To strike targets on land and ships in port, the missile uses GPS-aided inertial navigation to hit a designated target aimpoint. The 500-pound blast warhead delivers lethal firepower against a wide variety of land-based targets, including coastal defense sites, surface-to-air missile sites, exposed aircraft, port/industrial facilities and ships in port. For conventional anti-ship missions, such as open ocean or near-land, the GPS/INS improves midcourse guidance to the target area. The accurate navigation solution allows users to discriminate target ships from islands or other nearby land masses or ships.

Technical Specifications	
First flight	August 1979
Air Force designation	AGM-86B/C
Classification	Missile
Span	144 inches
Length	20 feet 10 inches
Gross weight	3,200 pounds
Range	More than 1,500 miles
Power	600-pound-thrust F-107-WR-101 turbofan engine
Armament	Nuclear (AGM-86B) or conventional (AGM-86C) warhead

AGM-86B/C Air Launched Cruise Missile

Historical Snapshot

The Boeing AGM-86B/C air launched cruise missile is a long-range subsonic, 3,200-pound self-guided missile carried by a B-52 bomber at high and low altitudes. Armed with a nuclear warhead, it is designated ALCM. With a conventional warhead, it is designated CALCM. The missile electronically "sees" the terrain over which it flies and can travel more than 1,500 miles to hit the target. Boeing began modifying the ALCM inventory from nuclear to nonnuclear warheads in June 1986.

The program began in June 1974. Six short-range ALCM missiles (AGM-86A) were test-flown in 1977, but in 1980, the longer range AGM-86B was ordered into production.

The AGM-86C configuration features a 3,000-pound-class, high-explosive, blast-fragmentation warhead and a Global Positioning System, or GPS, receiver for accurate inertial navigation. The AGM-86D program modifies additional ALCM missiles with an advanced penetrating warhead to quickly provide theater commanders with a long-range weapon to precisely attack an enemy's most valuable facilities. The penetrator warhead allows the missiles to destroy buried or reinforced targets from standoff ranges of hundreds of miles.

The missile's wings and tail surface can fold around its fuselage so it can be carried inside or outside the bomber. A B-52, for example, can carry 20 AGM-86 missiles, eight in a rotary launcher in the bomber weapons bay and another 12 on pylons under the wings.

Because of its long range, the missile can be launched far from hostile territory and still reach its target. After launch, the wings and tail unfold and the turbofan engine powers the missile at subsonic speeds. The AGM-86 collects electronic data from the land below, compares the readings with maps stored on its computer and adjusts its flight to reach its destination. It has a low radar cross section and can cruise at low altitudes, making it hard to detect.

By October 1986, Boeing had built 1,715 AGM-86 missiles. They were used in combat for the first time during the 1991 Persian Gulf War. The Air Force exercised its options for an engineering services contract in 1997 for the AGM-86 program and extended its engineering services contract with Boeing in 1998.

Technical Specifications	
First flight	Sept. 30, 1975
Model number	AH-64
Rotor diameter	48 feet
Length	48 feet 2 inches
Height	15 feet 3 inches
Ceiling	21,000 feet
Range	260 miles
Power plant	Two 1,900-shaft-horsepower GE T700 turboshaft engines
Top speed	192 mph

AH-64 Apache Attack Helicopter

Historical Snapshot

The AH-64 Apache was designed to be an extremely tough survivor under combat. The prototype Apache made its first flight in 1975 as the YAH-64, and in 1976, Hughes received a full-scale development contract. In 1982, the Army approved the program, now known as AH-64A Apache, for production. Deliveries began from the McDonnell Douglas plant at Mesa, Ariz., in 1984 — the year Hughes Helicopters became part of McDonnell Douglas.

A target acquisition and designation sight/pilot night-vision sensor and other advanced technologies added to its effectiveness in the ground support role. To reduce costs and simplify logistics, the Apache used the same T700 engines as the Army's Sikorsky UH-60 Black Hawk utility helicopter and its naval cousin, the SH-60 Seahawk.

Highly maneuverable and heavily armed, the combat-proven Apache helicopter is the backbone of the U.S. Army's all-weather, ground-support capability. The AH-64D Apache Longbow, which first flew as a prototype on May 14, 1992, provided a quantum leap in capability over the AH-64A. The Apache Longbow's fire-control radar and advanced avionics suite gave combat pilots the ability to rapidly detect, classify, prioritize, and engage stationary or moving enemy targets at standoff ranges in nearly all weather conditions. There is also an international Apache export version.

Over the years, the Apache has been enhanced with advanced technology to make the helicopter more survivable, deployable and easier to maintain. The AH-64 Apache is the most advanced multirole combat helicopter for the U.S. Army and a growing number of international defense forces.

In 2003, the Army accepted the first advanced technology Boeing AH-64D Apache Longbow, referred to as Block II. The Block II version incorporated advanced avionics, digital enhancements and communications upgrades.

In 2011, Boeing delivered the first AH-64D Apache Block III multirole attack helicopter to the Army. Block III brought superior flight performance and increased networked communications capabilities. The AH-64D Apache Block III was renamed the AH-64E Apache "Guardian" in 2012.

In 2012, Boeing also received all-new fuselages for the first AH-64E helicopters, incorporating a variety of small but important modifications to accommodate AH-64E configuration changes, such as enhancements to the extended forward avionics bays and slots for new electronics. More than 100 AH-64Es had been produced as of October 2014.

Technical Specifications	
First flight	July 3, 1948
Span	75 feet 2 inches
Length	63 feet 1 inches
Gross weight	52,862 pounds
Power plant	Two 2,400-horsepower Pratt & Whitney R-2800-44W piston engines, 4,600-pound thrust Allison J33-A-10 turbojet engine
Max speed	471 mph (all engines)
Crew	Three
Range	1,630 miles

AJ Savage Bomber

Historical Snapshot

The AJ Savage was the first U.S. bomber designed especially to carry the atomic bomb. It was North American's first attack bomber specifically for the U.S. Navy and was designed shortly after the end of World War II. It was a large twin-engine heavy-attack aircraft, as big as Air Force medium bombers of the time, such as the B-45 Tornado.

In those early years of jet aircraft development, manufacturers were exploring ways to provide power using piston engines and a jet engine on the same airframe. The AJ-1 attack bomber used two 2,400-horsepower piston engines to power four-bladed propellers for long-range cruise. It then fired a 4,600-pound-thrust turbojet engine for extra speed over the target.

The AJ Savage had a crew of three and a single tail unit. Its folding wings allowed it to be stored on an aircraft carrier. After building three XAJ-1 prototypes and a static test model, North American began delivering the AJ-1.

The Savage entered service in September 1949 and carrier operations began in April 1950 on the USS Coral Sea. North American built more than 140 in the series. Later, some AJ models were converted into aerial tankers. Others, the AJ-2Ps, with a modified radome, carried 18 cameras. Their night shots were illuminated by a photo-flash unit in the fuselage. These models were standard equipment for the Navy heavy photographic squadrons until the early 1960s.

Technical Specifications	
First flight	Nov. 9, 1978
Wingspan	30 feet 4 inches
Length	46 feet 4 inches
Height	11 feet 8 inches
Weight	31,000 pounds
Speed	647 mph
Ceiling	38,000 feet
Range	2,416 miles
Power plant	One Rolls Royce 23,400-pound-thrust F402-RR-408 turbofan engine
Accommodation	One crew
Armament	Two 25 mm cannons, plus 9,200 pounds of bombs, rockets, missiles or extra fuel tanks.

AV-8B Harrier II/(V/STOL) Aircraft

Historical Snapshot

Based on the 1957 British-designed Hawker-Siddley Kestrel, the AV-8B Harrier II was developed by a team representing McDonnell Douglas, British Aerospace and Rolls-Royce. Production of the St. Louis, Mo.-built AV-8B began in 1981, and more than 340 Harrier IIs were produced. They carried more fuel than the earlier AV-8As and had higher lift and better cruise characteristics.

In 1991, Harrier IIs were the first U.S. Marine Corps tactical aircraft to arrive for Operation Desert Storm over the Persian Gulf. During the 42 days of combat, 86 Harrier IIs flew 3,380 combat sorties (4,112 combat hours) and delivered more than 6 million pounds of ordnance.

A fixed-wing vertical/short takeoff and landing (V/STOL) aircraft, its ability to take off vertically makes it one of the most maneuverable combat aircraft in service. It can zoom out of the range of enemy fire extremely quickly.

The United States, Spain and Italy coordinated efforts to develop the AV-8B Harrier II Plus, which first flew Sept. 22, 1992. Prime contractors were McDonnell Douglas Aerospace and British Aerospace. The AV-8B Harrier II Plus, with a more powerful engine and advanced radar and avionics, can operate efficiently in darkness and in adverse weather conditions.

Production of both versions ended in 2003 with the St. Louis, Mo., delivery of the last AV-8B. In 2007, Boeing signed a $258.5 million performance-based logistics contract to support AV-8B Harriers operated by the U.S. Marine Corps, Italy and Spain.

Technical Specifications	
First firing	April 1984
First delivery	Nov. 1, 1988
Classification	Air defense system
Turret size	84 by 85 inches
Weight	2,500 pounds
Armament	Eight Stinger missiles and pods, .50-caliber machine gun

Avenger Missile Launcher

Historical Snapshot

The fully automated, short-range Boeing Avenger air defense system is the Army's premier shoot-on-the-move air defense weapon. It is a lightweight, highly mobile, easily transportable surface-to-air missile fire unit with eight Stinger missiles in two missile pods. It acquires, identifies, tracks and engages targets (low-flying helicopters or fixed-wing aircraft) from a stationary or moving position.

Mounted on a high-mobility, multipurpose wheeled vehicle, the Avenger can operate in extreme weather conditions. Its infrared system, computer, communications equipment and laser rangefinder locate targets in daylight and at night.

The Avenger turret can be easily adapted to different combat vehicles, such as trucks, trailers and track vehicles, or employed as a remotely operated autonomous unit. Its system is highly automated to rapidly and efficiently assist the gunner with target location, identification, tracking and missile lock-on. Total system performance is optimized by the automatic insertion of lead angle and super elevation at missile launch. Avengers can be airlifted by helicopter and, when pallet-mounted, dropped from tactical aircraft.

The Avenger was a valuable U.S. Army asset during the Persian Gulf War and is fielded in U.S. units throughout the world. In addition, the system is produced for the Army National Guard and for Foreign Military Sales contracts.

Boeing delivered the first production unit in 1988, and by 2002 more than 1,100 Avenger units had been delivered to the Army, Marine Corps and National Guard. Upgraded with new products, Avenger production is planned beyond 2005.

Technical Specifications	
First flight	Dec. 23, 1974
Span	137 feet (extended), 79 feet (swept aft)
Length	146 feet
Height	34 feet
Gross weight	477,000 pounds
Power plant	Four 30,000-plus-pound-thrust General Electric F-101-GE-102 turbofan engines with afterburners
Speed	Mach 1.2 at sea level
Crew	Four
Operating altitude	60,000 feet
Armament	Up to 84 Mark 82 conventional 500-pounds bombs, or 30 CBU-87/89/97, or 24 JDAMS, or can be reconfigured for wide range of nuclear bombs

B-1 Lancer Bomber

Historical Snapshot

The B-1 Lancer is a swing-wing bomber intended for high-speed, low-altitude penetration missions. Its first flight was in December 1974, but by June 1977 the program was canceled. Four Rockwell International B-1As were built and used for flight testing with the final flight made in April 1981. In October, President Ronald Reagan revived the program as the B-1B. It first flew Oct. 18, 1984, could operate at 60,000 feet and had a range of more than 7,000 miles. The U.S. Air Force ordered 100 B-1Bs in 1982, and the first B-1B aircraft was delivered to the Air Force at Edwards Air Force Base, Calif., in October 1984, just 33 months after contract go-ahead. The last Rockwell B-1B rolled out of final assembly at Palmdale, Calif., on Jan. 20, 1988.

Initial delivery to the Strategic Air Command took place in June 1985, at Dyess AFB, Texas. On Oct. 1, 1986, the B-1B achieved initial operational capability, and by November 1986, B-1Bs were coming off the production line at a rate of four per month. B-1Bs were based at Dyess AFB, Texas; Ellsworth AFB, S.D.; McConnell AFB, Kan.; Robins AFB, Ga.; and Mountain Home AFB, Idaho. In 2001, the Air Force decided to retire 33 B-1Bs and remove the aircraft from Mountain Home and the Georgia and Kansas Air National Guard bases. The remaining aircraft were consolidated at Dyess AFB and Ellsworth AFB.

The B-1B holds 61 world records for speed, payload and distance. The National Aeronautic Association recognized the B-1B for completing one of the 10 most memorable record flights for 1994.

The first combat use of the B-1B was in December 1998 during operation Desert Fox, where the aircraft penetrated Iraqi air defenses to destroy Republican Guard barracks. This debut mission validated the B-1B's conventional role and its ability to operate in a force package. In 1999, six B-1Bs were deployed to Royal Air Force Base Fairford, England, to support Operation Allied Force in Kosovo. Those six aircraft dropped more than 20 percent of the total tonnage in the conflict. In operation Enduring Freedom, B-1Bs dropped 40 percent of the weapons and 70 percent of the precision-guided JDAM weapons..

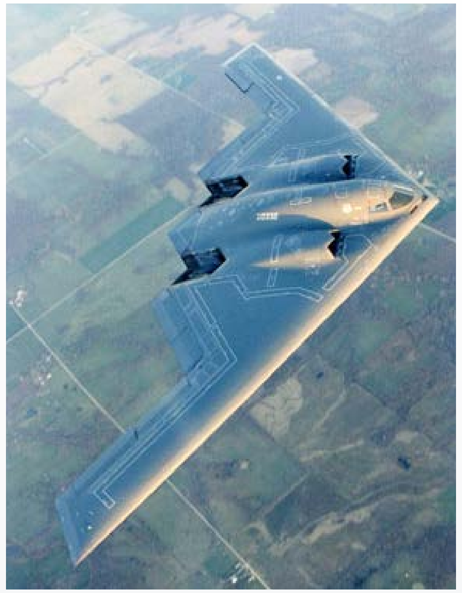
B-2 Spirit Bomber

Historical Snapshot

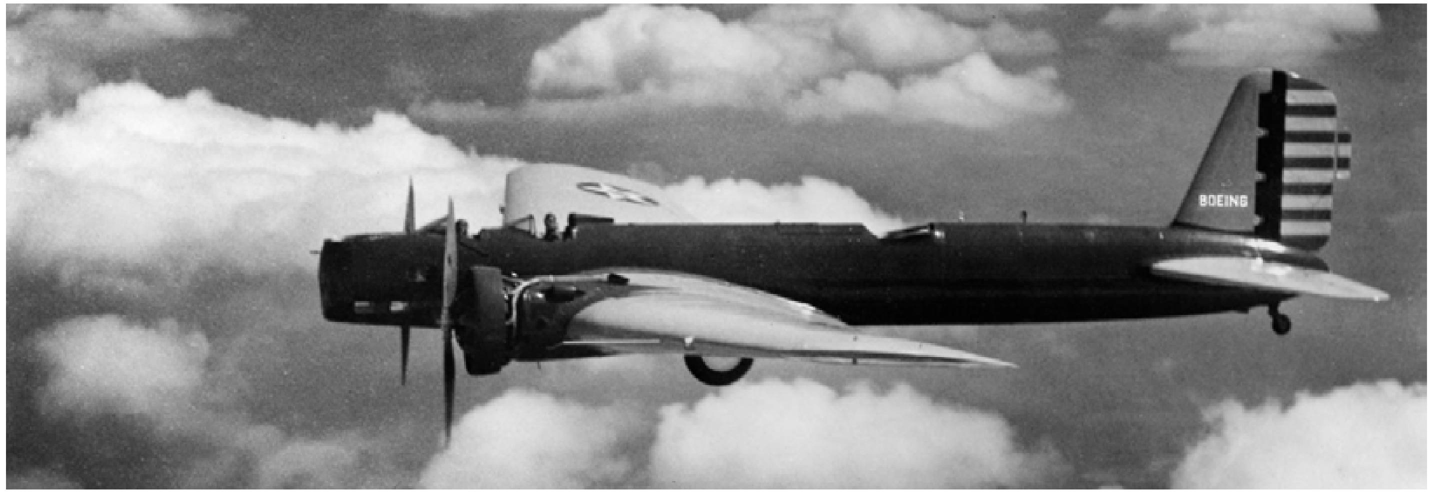
The B-2 stealth bomber, with its unique flying wing configuration and low-observable, radar-evading, or “stealth,” technology is a versatile multi-role bomber, capable of delivering both nuclear and conventional munitions. The sleek structure is reminiscent of the B-35, developed by Northrop during the 1940s, and uses advanced composites, such as resin-impregnated graphite fiber, rather than metal.

As part of an industry team led by Northrop, Boeing built the outboard portion of the B-2 stealth bomber wing, the aft center fuselage section, landing gears, fuel system and weapons delivery system. At its peak in 1991, the B-2 was the largest military program at Boeing, employing about 10,000 people. The same year, the National Aeronautic Association of the U.S.A. awarded the B-2 design team the Collier Trophy for the greatest achievement in aeronautics or astronautics in America, as demonstrated in actual use.

The first B-2 rolled out of the bomber’s final assembly facility in Palmdale, Calif., in November 1988 and it flew for the first time on July 17, 1989. The first B-2 entered the Air Force’s operational fleet at Whiteman Air Force Base, Mo., on Dec. 17, 1993. On Oct. 29, 1994, the Air Force’s fourth operational B-2 was named “Spirit of Washington” in Seattle, Wash., to honor the people of the state who helped make the B-2 a reality.



Technical Specifications	
First flight	July 17, 1989
Classification	Bomber
Span	172 feet
Length	69 feet
Gross weight	336,500 pounds
Cruising speed	High subsonic
Range	6,000 miles plus
Ceiling	50,000 feet
Power	Four 19,000-pound-thrust F118-GE engines
Accommodation	2 crew
Armament	More than 40,000-pound nuclear or conventional weapon payload



B-9 Bomber

Historical Snapshot

The Boeing B-9 bomber was the earliest plane based on the advanced, extremely aerodynamic Monomail design of 1930 that made traditional biplane construction obsolete.

It had a top speed of 186 mph (299 kph) and could outrun the fighters of the day by 5 mph (8 kph). The monoplane bomber reached this speed even though it had a five-person crew (in open cockpits) and carried a 2,400-pound (1,089 kilogram) bomb load.

Boeing built the YB-9 prototype bombers at company expense to show their design potential to the military. The B-9 is recognized as a revolution in bomber design, introducing new structures and aerodynamic concepts including the first use of a servo tab on an American airplane. Unfortunately for Boeing, this high-speed aircraft inspired the Glenn L. Martin Company to launch a new generation of bombers, resulting in the B-10, which quickly surpassed the B-9.

Technical Specifications	
First flight	April 13, 1931
Model number	214/215
Classification	Bomber
Span	76 feet
Length	51 feet 5 inches
Gross weight	13,919 pounds
Top speed	186 mph
Cruising speed	158 mph
Range	1,150 miles
Ceiling	20,150 feet
Power	Two 575-horsepower P&W Hornet engines
Accommodation	5 crew
Armament	2 machine guns, 2,400-pound bomb load

B-17 Flying Fortress

Historical Snapshot

On July 28, 1935, a four-engine plane took off from Boeing Field in south Seattle on its first flight. Rolling out of the Boeing hangar, it was simply known as the Model 299. Seattle Times reporter Richard Smith dubbed the new plane, with its many machine-gun mounts, the "Flying Fortress," a name that Boeing quickly adopted and trademarked. The U.S. Army Air Corps designated the plane as the B-17.

In response to the Army's request for a large, multiengine bomber, the prototype, financed entirely by Boeing, went from design board to flight test in less than 12 months.

The B-17 was a low-wing monoplane that combined aerodynamic features of the XB-15 giant bomber, still in the design stage, and the Model 247 transport. The B-17 was the first Boeing military aircraft with a flight deck instead of an open cockpit and was armed with bombs and five .30-caliber machine guns mounted in clear "blisters."

The first B-17s saw combat in 1941, when the British Royal Air Force took delivery of several B-17s for high-altitude missions. As World War II intensified, the bombers needed additional armament and armor.

The B-17E, the first mass-produced model of the Flying Fortress, carried nine machine guns and a 4,000-pound bomb load. It was several tons heavier than the prototypes and bristled with armament. It was the first Boeing airplane with the distinctive — and enormous — tail for improved control and stability during high-altitude bombing. Each version was more heavily armed.

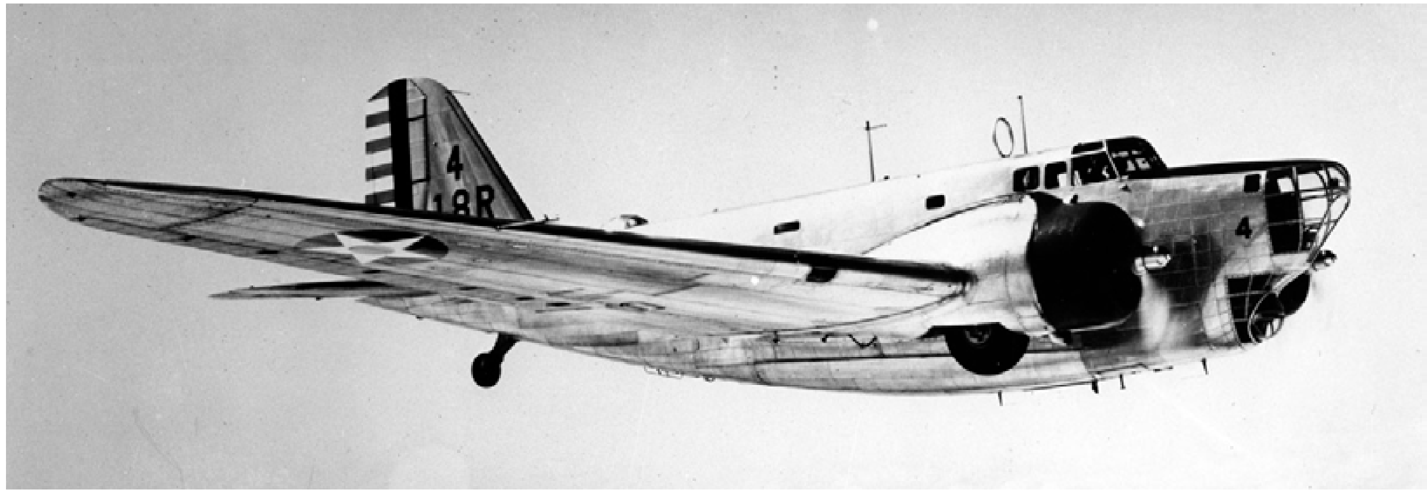
In the Pacific, the planes earned a deadly reputation with the Japanese, who dubbed them "four-engine fighters." The Fortresses were also legendary for their ability to stay in the air after taking brutal poundings.

Seventy-five years after the B-17's first flight, an 88 year-old veteran sent The Boeing Company a letter. After explaining how he returned to England after a bombing raid over Germany with 179 flak holes and only two out of the four engines, he wrote: "I'm glad to be alive. Thank you for making such a good airplane."

Gen. Carl Spaatz, the American air commander in Europe, said, "Without the B-17 we may have lost the war."

Boeing Plant 2 built a total of 6,981 B-17s in various models, and another 5,745 were built under a nationwide collaborative effort by Douglas and Lockheed (Vega). Only a few B-17s survive today, featured at museums and air shows; most were scrapped at the end of the war.

Technical Specifications	
First flight	July 28, 1935 (prototype)
Model number	299
Classification	Bomber
Span	103 feet 9 inches
Length	74 feet 9 inches
Gross weight	65,000 pounds
Top speed	287 mph
Cruising speed	150 mph
Range (max.)	3,750 miles
Ceiling	35,600 feet
Power	Four 1,200-horsepower Wright R-1820-97 engines
Accommodation	2 pilots, bombardier, navigator, radio-operator, 5 gunners
Armament	11 to 13 machine guns, 9,600-pound bomb load



B-18 Bolo Bomber

Historical Snapshot

The twin-engine B-18 Bolo was the first Douglas medium bomber. It was a combat version of the DC-2 commercial transport, absorbed punishment well and was especially useful during the early days of World War II.

The prototype (Douglas Bomber 1, or DB-1), finished in 1935, was designed around the DC-2's wings, but had a deeper and fatter fuselage with a bomb bay under its center section. The single DB-1 later was used to test the firing of large cannons from an aircraft.

Douglas produced 370 of the production model B-18 Bolos, and their availability during the late 1930s allowed the Air Corps to train bomber crews. The B-18 Bolos made up most of the bombers deployed outside the country as the United States entered World War II.

B-18 Bolos were used for antisubmarine operations in American and Caribbean waters and as trainers and transports. Twenty served as general reconnaissance bombers with the Royal Canadian Air Force as Digby Mk1s.

In November 1938, Douglas used the stronger wings of the DC-3, a new and better streamlined fuselage, and large fin and rudder for the Bolo's successor — the B-23 Dragon. The first of 38 B-23 Dragons built flew July 27, 1939. The 26,500-pound (12,000-kilogram) B-23 bomber incorporated the first tail turret installed in an Air Corps bomber and was powered by two 1,600-horsepower Wright R-2600-3 engines. Following the war, many Dragons were adapted as corporate aircraft.

Technical Specifications	
First flight	April 1935 (prototype)
Model number	B-18
Wingspan	89 feet 6 inches
Length	56 feet 8 inches
Height	15 feet 2 inches
Ceiling	25,850 feet
Range	1,200 miles
Weight	21,130 pounds
Power plant	Two 930-horsepower Wright R-1820-45 engines
Speed	217 mph
Crew	Six crew
Armament	Three .30-caliber machine guns, 2,000-pound bomb load

Technical Specifications	
First flight	Aug. 19, 1940
Span	67 feet 6.7 inches
Wing area	610 square feet
Length	53 feet
Weight	Empty, 20,305 pounds; normal gross weight, 27,051 pounds; useful load, 6,746 pounds
Power plant	Two 1,700-hp Wright Cyclone supercharged 14-cylinder radial engines, driving 12-foot-7-inch full-feathering, constant-speed Hamilton Standard three-bladed props
Speed	In excess of 300 miles per hour
Crew	Pilot, co-pilot, bombardier, radio operator, gunner
Range	In excess of 3,000 miles, using droppable tanks
Landing gear	Hydraulically operated tricycle

B-25 Mitchell Bomber

Historical Snapshot

The North American B-25 Mitchell, a twin-engine bomber that became standard equipment for the Allied air forces in World War II, was perhaps the most versatile aircraft of the war. It became the most heavily armed airplane in the world, was used for high- and low-level bombing, strafing, photoreconnaissance, submarine patrol, and even as a fighter and was distinguished as the aircraft that completed the historic raid over Tokyo in 1942.

It required 8,500 original drawings and 195,000 engineering man-hours to produce the first one, but nearly 10,000 were produced from late 1939, when the contract was awarded to North American Aviation, through 1945.

Named for famed airpower pioneerBrigadier General William “Billy” Mitchell, it was a twin-tail, mid-wing land monoplane powered by two 1,700-horsepower Wright Cyclone engines.

Normal bomb capacity was 5,000 pounds (2,268 kilograms). Some versions carried 75 mm cannon, machine guns and added firepower of 13 .50-caliber guns in the conventional bombardier’s compartment. One version carried eight .50-caliber guns in the nose in an arrangement that provided 14 forward-firing guns.

B-29 Superfortress

Historical Snapshot

Boeing submitted the proposal for the B-29 long-range heavy bomber to the Army in 1940, before the United States entered World War II.

One of the most technologically advanced airplanes of World War II, the B-29 had many new features, including guns that could be fired by remote control. Two crew areas, fore and aft, were pressurized and connected by a long tube over the bomb bays, allowing crew members to crawl between them. The tail gunner had a separate pressurized area that could only be entered or left at altitudes that did not require pressurization.

The B-29 was also the world's heaviest production plane because of increases in range, bomb load and defensive requirements.

The B-29 used the high-speed Boeing 117 airfoil, and its larger Fowler flaps added to the wing area as they increased lift. Modifications led to the B-29D, upgraded to the B-50, and the RB-29 photoreconnaissance aircraft. The Soviet-built copy of the B-29 was called the Tupolev Tu-4.

The earliest B-29s were built before testing was finished, so the Army established modification centers where last-minute changes could be made without slowing expanding assembly lines.

Boeing built a total of 2,766 B-29s at plants in Wichita, Kan., (previously the Stearman Aircraft Co., merged with Boeing in 1934) and in Renton, Wash. The Bell Aircraft Co. built 668 of the giant bombers in Georgia, and the Glenn L. Martin Co. built 536 in Nebraska. Production ended in 1946.

B-29s were primarily used in the Pacific theater during World War II. As many as 1,000 Superfortresses at a time bombed Tokyo, destroying large parts of the city. Finally, on Aug. 6, 1945, the B-29 *Enola Gay* dropped the world's first atomic bomb on Hiroshima, Japan. Three days later a second B-29, Bockscar, dropped another atomic bomb on Nagasaki. Shortly thereafter, Japan surrendered.

After the war, B-29s were adapted for several functions, including in-flight refueling, antisubmarine patrol, weather reconnaissance and rescue duty. The B-29 saw military service again in Korea between 1950 and 1953, battling new adversaries: jet fighters and electronic weapons. The last B-29 in squadron use retired from service in September 1960.

Technical Specifications

First flight	Sept. 21, 1942
Model number	345
Classification	Bomber
Span	141 feet 3 inches
Length	99 feet
Gross weight	105,000 pounds (140,000 pounds postwar)
Top speed	365 mph
Cruising speed	220 mph
Range	5,830 miles
Ceiling	31,850 feet
Power	Four 2,200-horsepower Wright Duplex Cyclone engines
Accommodation	10 crew
Armament	12 .50-caliber machine guns, 1 20 mm cannon, 20,000-pound bomb load

Technical Specifications	
First flight	March 17, 1947
Span	89 feet
Length	75 feet 11 inches
Gross weight	82,600 pounds
Power plant	Four General Electric J47A jet engines with water injection. First 22 produced with Allison J35 engines.
Speed	575 mph class
Crew	Four
Service ceiling	Over 45,000 feet
Armament	Two .50-caliber machine guns
Payload	More than 20,000 pounds
Number built	143

B-45 Tornado Bomber

Historical Snapshot

The North American Aviation B-45 was one of America's first operational bombers to employ jet propulsion. Designed during 1944 and 1945, the straight-wing Tornado was the first jet bomber in service with the U.S. Air Force and was the first four-jet aircraft to fly in the United States.

Other versions include the longer range B-45C with wingtip tanks and the photoreconnaissance version, the RB-45C.

Rated as a light bomber by modern-day standards, it was the first four-jet aircraft to drop an atom bomb and the first to be refueled in midair.

B-47 Stratojet

Historical Snapshot

The best way to tell about the performance of the Stratojet is to say that any good crew could have flown it. It took no unusual ability or education. Neither Scott Osler nor I deserve any credit for the flight. Rather, the credit should go to the men who carried out these visions on the drafting boards and the factory workers who made the visions a reality.

— Robert Robbins, test pilot for the B-47, 1949

The Boeing B-47 was the country's first swept-wing multiengine bomber. It represented a milestone in aviation history and a revolution in aircraft design. Every large jet aircraft today is a descendant of the B-47.

Boeing engineers had envisioned a jet-powered plane as early as 1943. However, wind tunnel tests of straight-wing jet aircraft indicated that the straight wing did not use the full potential of jet-engine power.

Near the end of World War II, Boeing aerodynamicist George Schairer was in Germany as part of a fact-finding mission. At a hidden German aeronautics laboratory, Schairer saw wind tunnel data on swept-wing jet airplanes and sent the information home. Engineers then used the recently completed Boeing High-Speed Wind Tunnel to develop and design the XB-47, with its slender 35-degree swept-back wings.

Another innovation pioneered on the B-47 was the concept of placing the engines in pods (nacelles) suspended under the wings. A pod containing two General Electric J-35 engines (GE J-47 engines for all production models) hung from each wing inboard, and a single engine hung farther out. The B-47 had tandem bicycle-type landing gear under the front and back sections of the fuselage. Small outrigger wheels on the inboard engines kept the airplane from tipping over when it was on the ground.

Because early jet engines could not provide enough thrust for takeoff, the XB-47, B-47A, and B-47B had 18 small rocket units in the fuselage for jet-assisted takeoff (JATO). Thrust reversers and antiskid brakes had not yet been developed, so a ribbon-type drag parachute reduced the B-47 landing speed.

Technical Specifications	
First flight	Dec. 17, 1947 (prototype XB-47)
Model number	450
Classification	Bomber
Span	116 feet
Length	107.1 feet
Gross weight	133,030 pounds
Top speed	607 mph
Max. range	4,990 miles
Ceiling	40,500 feet
Combat radius	2,358 miles
Power	Six 7,200-pound-thrust GE J-47-GE-25 turbojet engines
Accommodation	3 crew
Armament	Two 20 mm cannons, 25,000 pounds of bombs

Once airborne, the graceful jet broke speed and distance records; in 1949, it crossed the United States in under four hours at an average speed of 608 mph (978 km/h). The B-47 needed defensive armament only in the rear because no fighter was fast enough to attack from any other angle.

The B-47 medium bomber became the foundation of the Air Force's newly created Strategic Air Command, and many were adapted for several specialized functions. One became a missile carrier, others were reconnaissance aircraft or trainers or carried remote controls for other aircraft. Between 1947 and 1956, a total of 2,032 B-47s in all variants were built. Boeing built 1,373, Douglas Aircraft Co. built 274 and Lockheed Aircraft Corp. built 385.

B-50 Bomber

Historical Snapshot

The four-engine, propeller-powered Boeing B-50 bomber was among the last piston-powered bombers built during an era that was to be dominated by jets, particularly the B-47 and the B-52. In 1949, the B-50A, the Lucky Lady II made the first nonstop flight around the world in 94 hours, refueled in flight four times by KB-29Ms.

The B-50 evolved from the B-29D, but because it included so many improvements, it was redesignated the B-50A, with 59 percent more power than the B-29. Other improvements were more aerodynamic nacelles, larger flaps, fast-retracting ball-screw landing gear, hydraulic rudder boost, hydraulic nosewheel steering and heated-wing deicing. It also had a higher vertical tail that folded when the bomber rolled into standard-height hangars. The B-50's wing, made from the new 75ST aluminum alloy, was 16 percent stronger and 600 pounds (272 kilograms) lighter than the otherwise identical B-29 wing.

Sixty B-50As were ordered by the U.S. Army Air Forces before the end of World War II, and delivery began in 1947. In all, 79 B-50As were built. The next version, the B-50B, was heavier, with a gross weight of 170,000 pounds (77,110 kilograms). Fitted with cameras and wing tanks, it was designated of RB-50B and used for strategic reconnaissance. The B-50D was distinguished by a one-piece transparent-plastic nose molding and an optically flat bombardier's window in the lower portion. Some B-50s were later converted to hose-type KB-50 aerial tankers, their speed enhanced by the addition of two 5,200-pound-thrust (235-kilogram-thrust) jet engines, so at 400 mph (644 km/h) they could refuel jet aircraft. Thirty six B-50Ds became long-range reconnaissance aircraft (WB-50D); serving until 1967, these were the last B-50s to be retired.

The final production version of the B-50 was the TB-50H, 24 of these bomber-navigation trainers were built and were later converted to KB-50K tankers.

Boeing built 371 B-50s between 1947 and 1953. Some served until 1965 and were in action during the Vietnam War as refueling tankers.

Technical Specifications	
First launch	June 25, 1947
Model number	345-2-1
Classification	Bomber
Span	141 feet 3 inches
Length	99 feet
Gross weight	168,708 pounds
Top speed	385 mph
Cruising speed	235 mph
Range	4,650 miles
Ceiling	37,000 feet
Power	Four 3,500-horsepower P&W R-4360-35 engines
Accommodation	12 crew
Armament	12 .50-caliber machine guns, 1 20 mm cannon, 20,000-pound bomb load

B-52 Stratofortress

Technical Specifications	
First flight	April 15, 1952
Model number	464-67
Classification	Bomber
Span	185 feet
Length	157 feet 7 inches (B-52H)
Gross weight	488,000 pounds (B-52H)
Top speed	650 mph (B-52H)
Range	More than 10,000 miles (B-52H)
Ceiling	More than 50,000 feet (B-52H)
Power	Eight 17,000-pound-thrust TF-33 turbofan engines (B-52H)
Accommodation	5 crew
Armament	2 Hound Dog supersonic missiles and bombs, 20 mm cannon in radar-directed tail turret, 20 SRAMs or 20 ALCMs (B-52H)

Historical Snapshot

In August 2014, the B-52 Stratofortress celebrated 60 years in the air. The eight-engine, 390,000-pound (176,901-kilogram) jet was America's first long-range, swept-wing heavy bomber. It began as an intercontinental, high-altitude nuclear bomber, and its operational capabilities were adapted to meet changing defense needs.

B-52s have been modified for low-level flight, conventional bombing, extended-range flights and transport of improved defensive and offensive equipment — including ballistic and cruise missiles that can be launched hundreds of miles from their targets.

It had a rocky beginning. The original XB-52 design, selected by the Army Air Forces in 1946, was for a straight-wing, six-engine, propeller-powered heavy bomber. On Oct. 21, 1948, Boeing Chief Engineer Ed Wells and his design team were in Dayton, Ohio, when the Air Force's chief of bomber development told them to scrap the propellers and come up with an all-jet bomber. Over the following weekend, in a Dayton hotel room, the team designed a new eight-engine jet bomber, still called the B-52, made a scale model out of balsa wood and prepared a 33-page report.

This effort impressed the Air Force's Air Materiel Command, and the design was approved. As the war worsened in Korea, the Air Force, in 1951, designated the B-52 the country's next intercontinental bomber and approved an initial production order for 13 B-52s. The first B-52A flew Aug. 5, 1954.

After assembly of three B-52As, production converted to B-52Bs, with more weight and larger engines. Some had photoreconnaissance or electronic capsules in their bomb bays and were redesignated RB-52Bs. The turbofan powered B-52H, the final version of the B-52, made its first flight March 6, 1961, and is still in service.

With each variant, the B-52 increased in range, power and capability. In all, 744 B-52s were produced by Seattle, Wash., and Wichita, Kan., plants between 1952 and 1962.

Throughout the 1950s, the B-52 chalked up many distance and speed records. It cut the round-the-world speed record in half, and in January 1962, flew 12,500 miles (20,117 kilometers) nonstop from Japan to Spain without refueling. This flight alone broke 11 distance and speed records. The B-52 saw active duty in the Vietnam War and was used in the Persian Gulf War in 1991 and over Afghanistan in 2001.

On Oct. 26, 2012, Boeing marked 50 years since it had delivered its last B-52 Stratofortress to the U.S. Air Force. H-model bomber 61-040 had been assigned to Minot Air Force Base, N.D., where it remained in active service. Modern engineering analyses showed the B-52's expected lifespan extending beyond 2040.

In May 2014, the Air Force introduced the first B-52 aircraft upgraded with an advanced communications system developed by Boeing into its fleet. The Combat Network Communications Technology (CONECT) modification added several communication data links, full-color LCD displays with real-time intelligence feeds overlaid on moving maps, a state-of-the-art computing network, and the ability to retarget a weapon, or mission parameters, in flight. At that time, the Air Force operated 76 B-52s primarily out of Barksdale Air Force Base, La.; Minot Air Force Base, N.D., and Andersen Air Force Base, Guam, and planned to upgrade all of them.

Technical Specifications	
First flight	April 15, 1936
Span	42 feet
Length	28 feet
Height	8 feet 6 inches
Weight	3,078 pounds (empty)
Power plant	400-horsepower Wright Whirlwind engine
Speed	174 mph
Crew	Two
Service ceiling	19,250 feet
Armament	(BT-9C only) Two .30-caliber machine guns

BT-9 "Yale" Trainer

Historical Snapshot

The BT-9 "Yale" Army Air Corps basic trainer evolved from North American Aviation's NA-16, the last prototype built in the General Aviation plant at Dundalk, Md. The production model, the NA-19, was first flown at Inglewood, Calif. The Navy version of the trainer was designated NJ-1.

The BT-9, a two-seat monoplane with enclosed tandem cockpits, was of all-metal construction with removable fabric-covered side panels for easy maintenance. The engine and its accessories could be removed as a unit and changed in less than an hour. The BT-9C included a fixed forward gun that fired through the propeller arc and a flexibly mounted gun in the rear cockpit.

North American built a total of 766 BT-9s and NJ-1s, and the initial follow-up to the BT-9 series was the BC "Basic Combat" trainer which was then followed by the ubiquitous T-6/SNJ "Texan" series. During the next decade, North American produced more than 17,000 variants of the trainer at the company's Los Angeles, Calif., and Dallas, Texas, plants. In addition, four other countries built about 4,000 more under special license.

C-17 Globemaster III

Historical Snapshot

The C-17 Globemaster III is a high-wing, four-engine, T-tailed aircraft with a rear loading ramp. In 1980, the U.S. Air Force asked for a larger transport that could be refueled in flight and use rough forward fields so that it could fly anywhere in the world. On Aug. 28, 1981, McDonnell Douglas won the contract with its proposal to build the C-17. The design met or exceeded all Air Force design specifications, and the huge transport was able to use runways at 19,000 airfields.

The C-17 was built in Long Beach, California, and the first C-17 squadron was operational in January 1995. The C-17 fleet has been involved in many contingency operations, including flying troops and equipment to Operation Joint Endeavor to support peacekeeping in Bosnia and the Allied Operation in Kosovo. Eight C-17s, in 1998, completed the longest airdrop mission in history, flying more than 8,000 nautical miles (14,816 kilometers) from the United States to Central Asia, dropping troops and equipment after more than 19 hours in the air.

With its 160,000-pound (72,600-kilogram) payload, the C-17 can take off from a 7,600-foot (2,316-meter) airfield, fly 2,400 nautical miles (4,444 kilometers) and land on a small, austere airfield in 3,000 feet (914 meters) or less. The C-17 can be refueled in flight. On the ground, a fully loaded aircraft, using engine reversers, can back up a 2% slope.

During normal testing, C-17s have set 33 world records, including payload to altitude time-to-climb and the short takeoff and landing mark, in which the C-17 took off in less than 1,400 feet (427 meters), carried a payload of 44,000 pounds (20,000 kilograms) to altitude and landed in less than 1,400 feet (427 meters).

In May 1995, the C-17 received the prestigious Collier Trophy, symbolizing the top aeronautical achievement of 1994. In February 1999, President Bill Clinton presented the nation's top award for quality — the Malcolm Baldrige National Quality Award — to Boeing Airlift and Tanker programs, maker of the C-17, for business excellence.

On Dec. 20, 2010, the worldwide fleet of C-17 Globemaster III airlifters surpassed 2 million flying hours during an airdrop mission over Afghanistan. Reaching 2 million flight-hours equates to 1.13 billion nautical miles — the equivalent of a C-17 flying to the moon and back 2,360 times.

On Sept. 18, 2013, Boeing announced it would complete production of the C-17 Globemaster III and close the C-17 final assembly facility in Long Beach in 2015. Dennis Muilenburg, who was president and CEO of Boeing Defense, Space & Security at the time but today serves as chairman, president and CEO of The Boeing Company, said, "Our customers around the world face very tough budget environments."

By February 2014, Boeing had delivered 260 C-17s, including 223 to the U.S. Air Force and a total of 37 to Kuwait, Australia, Canada, India, Qatar, the United Arab Emirates, the United Kingdom and the 12-member Strategic Airlift Capability initiative of NATO and Partnership for Peace nations.

Technical Specifications

First flight	Sept. 15, 1991
Model number	C-17
Length	173 feet 11 inches
Height	55 feet 1 inch
Wingspan	169 feet 10 inches
Weight	277,000 pounds
Maximum takeoff gross weight	585,000 pounds
Power plant	Four Pratt & Whitney 40,500-pound thrust engines
Range	2,762 miles
Cruise speed	0.77 Mach
Service ceiling	45,000 feet
Accommodation	102 troops or paratroops; 48 litter and 54 ambulatory patients and attendants; or 170,900 pounds of cargo
Crew	2 flight crew, 1 loadmaster

C-47 Skytrain Military Transport

Technical Specifications	
First flight	Dec. 23, 1941
Model number	C-47/R4D
Wingspan	95 feet 6 inches
Length	63 feet 9 inches
Height	17 feet
Service ceiling	24,000 feet
Normal range	1,600 miles
Maximum range	3,800 miles
Weight	31,000 pounds
Cruise speed	160 mph
Power plant	Two 1,200 horsepower Pratt & Whitney R-1830 radial engines
Accommodation	Three crew and 6,000 pounds of cargo, or 28 airborne troops, or 14 stretcher patients and three attendants

Historical Snapshot

The military career of the Douglas DC series began in 1936, when the U.S. Army Air Corps ordered a pair of DC-2 commercial transports under the designation C-32. A contract followed for 18 DC-2s in the C-33 freighter configuration and two more as C-34 staff transports. Then, in 1937, the U.S. Army ordered a plane built to its own specifications. It was a hybrid design that combined the fuselage of the DC-2 with a DC-3 tail. This was the sole C-38 prototype, and it led to 35 production versions called the C-39. The C-39 represented the first serious effort by the Army to establish an airlift capability.

By 1941, the old Air Corps had been transformed into the Army Air Forces, and it selected a modified version of the DC-3 — the C-47 Skytrain — to become its standard transport aircraft. A reinforced fuselage floor and the addition of a large cargo door were the only major modifications. Other changes included the fitting of cargo hooks beneath the center wing section and the removal of the tail cone to mount a hook for towing gliders.

As a supply plane, the C-47 could carry up to 6,000 pounds of cargo. It could also hold a fully assembled jeep or a 37 mm cannon. As a troop transport, it carried 28 soldiers in full combat gear. As a medical airlift plane, it could accommodate 14 stretcher patients and three nurses. Seven basic versions were built, and the aircraft was given at least 22 designations, including the AC-47D gunship, the EC-47 electronic reconnaissance aircraft, the EC-47Q antiaircraft systems evaluation aircraft and the C-53 Skytrooper.

Every branch of the U.S. military and all the major allied powers flew it. The U.S. Navy version was the R4D. The British and the Australians designated it the Dakota (a clever acronym composed of the letters DACoTA for Douglas Aircraft Company Transport Aircraft). The aircraft operated from every continent in the world and participated in every major battle. By the end of World War II, more than 10,000 had been built. For all of its official and unofficial names, it came to be known universally as the “Gooney Bird;” General Dwight D. Eisenhower, Supreme Commander of Allied Forces in Europe, termed it one of the most vital pieces of military equipment used in winning the war.

C-47s remained in active military service long after the end of World War II. They played a critical role in the 1948 Berlin Airlift and saw action in the Korean and Vietnam wars.

Technical Specifications	
First flight	Sept. 5, 1945
Wingspan	173 feet 3 inches (52.81 m)
Length	124 feet 2 inches (37.85 m)
Height	43 feet 9 inches (13.34 m)
Weight (max)	172,000 pounds (39.018 kg)
Speed (max)	328 mph (528 km/h)
Ceiling	21,000 feet (6,490 m)
Range	7,250 miles (11,670 km)
Power plant	3,250 horsepower Pratt & Whitney R-4360-69
Accommodation	125 troops, 115 stretchers or 48,150 pounds (21,840 kg) of cargo

C-74 Globemaster I

Historical Snapshot

Beginning in early 1942, Douglas began development of the C-74 Globemaster I. This large four-engine transport would meet the need for an aircraft that could support the demands of a global logistics network with larger payload and transoceanic range. In July of that year, a contract was awarded to Douglas to build 50 of the giant planes. Development took longer than expected, and the first aircraft did not fly until just after the end of the war. By that time the government was canceling or reducing all aircraft production, including the production run of the C-74, which was reduced to just 14 aircraft.

Called Globemaster because of its ability to circumnavigate the world with only two stops, the C-74 was designed for self-sufficiency. A combination of features enabled it to operate anywhere in the world, independent of any transportation network or facilities. Self-contained electrical power enabled the crew to change engines if needed and to load cargo using internal cranes and freight elevators that lifted cargo to and from the ground.

The C-74 featured a laminar-flow wing and full-span Fowler flaps. One of its strangest features was the twin bubble canopies. The separate canopies made communication and cooperation between the pilot and copilot difficult; a conventional cockpit would later be retrofitted.

During its short career, the C-74 participated in the Berlin Airlift, set a record for being the first aircraft to cross the North Atlantic with more than 100 passengers, and was flown at a gross weight of 86 tons — the most weight for any powered aircraft up to that time. The fifth Globemaster had the distinction of being the prototype for the plane that would replace the C-74: the C-124 Globemaster II.

Technical Specifications	
First flight	Nov. 9, 1944
Model number	367
Classification	Military transport
Span	141 feet 3 inches
Length	117 feet 5 inches (including boom)
Gross weight	175,000 pounds
Top speed	375 mph
Cruising speed	300 mph
Range	4,300 miles
Ceiling	35,000 feet
Power	Four 3,500-horsepower P&W Wasp major engines
Accommodation	4 crew, 96 troops or 69 stretchers, tanker equipment

C-97/KC-97 Stratofreighter

Historical Snapshot

Toward the end of World War II, Boeing developed the Model 367, a military transport based on the B-29 bomber. Its civilian counterpart was the Model 377 Stratocruiser. Designated the C-97, it had a double-lobe fuselage consisting of two intersecting circular sections, so that the 74-foot-long (23-meter-long) upper deck had a larger diameter.

Cargo was loaded through large clamshell-type doors in the belly of the aircraft using a built-in ramp and a hoist. Its wings, engine gear and other parts were similar to the B-29. In January 1945, an XC-97, piloted by Maj. Curtin L. Reinhardt, set a transport speed record by flying 383 mph (617 kph) between Seattle, Wash., and Washington, D.C., with 20,000 pounds (9,072 kilograms) of cargo. The production version that flew in June 1949 had outboard wing fuel tanks to increase its range.

During the Korean War, C-97s were used to evacuate casualties. Others became flying command posts for Strategic Air Command (SAC) personnel. The C-97 was designated KC-97 when it was equipped with the Boeing-designed flying boom for aerial refueling — the boom had controls so the boom operator or “boomer” could literally “fly” the end of the boom from the KC-97 aerial tanker into the receiving airplane.

There were 888 C-97s built between 1947 and 1958. Of those, 219 were adapted as KC-97E and F tankers and 592 were KC-97G models. The KC-97Gs had additional 700-gallon (2,650-liter) external fuel tanks under each wing and could dispense 8,513 gallons (32,225 liters) of fuel while carrying 96 troops.

Sales of the KC-97s helped pull Boeing out of the postwar slump, and because they extended the range of bombers and fighters, the KC-97 tankers became crucial to SAC operations.

C-124 Globemaster II Military Transport

Historical Snapshot

The Douglas C-124 Globemaster II, also fondly called “Old Shaky,” could carry more than 200 troops. It had clamshell-type loading doors, built-in double hydraulic ramps and an elevator under the aft fuselage. It could load tanks, field guns, bulldozers and trucks.

Deliveries of the C-124A Globemaster II began in May 1950, and before production ended in 1955, the U.S. Air Force purchased 448. The Globemaster IIs provided airlift support in the Far East and Southeast Asia, went on resupply missions to Antarctica, evacuated refugees from the Congo, and made mercy flights to Morocco, Chile and elsewhere throughout the world following floods and other natural disasters.

By 1970, most C-124s were transferred to the Air Force Reserve and Air National Guard. Although in production for only five years, the C-124s had a long and useful service life. The last C-124 was phased out in 1974.

Technical Specifications	
First flight	Nov. 29, 1949
Wingspan	174 feet 1 inch
Length	130 feet 5 inches
Height	48 feet 4 inches
Weight	185,000 pounds
Speed	304 mph
Ceiling	18,400 feet
Range	1,200 miles
Power plant	Four 3,800-horsepower Pratt & Whitney R-4360 engines
Accommodation	5 crew and 200 troops, or 123 litters, or 45 patients with 15 attendants, or 74,000 pounds cargo

Technical Specifications	
First flight	April 23, 1956
Model number	C-133
Wingspan	179 feet 8 inches
Length	157 feet 6 inches
Height	48 feet 3 inches
Ceiling	19,000 feet
Range	3,975 miles
Speed	359 mph
Power plant	Four 6,500-horsepower P&W T34-P-7WA turboprop engines
Accommodation	10 crew, 200 passengers or 80,000 pounds of equipment

C-133 Cargomaster

Historical Snapshot

The Douglas C-133 Cargomaster, a four-engine turboprop transport, was larger and faster than earlier Douglas military cargo airplanes. The Cargomaster went into production without a prototype and had an unusual circular fuselage with top-mounted wings.

The C-133 could fly the equivalent of 22 loaded railroad boxcars nonstop between Los Angeles, Calif., and New York for about 5 cents per ton per mile (907 kilograms per 1.6 kilometers). It carried fully assembled tanks and transported the Douglas-built Thor intermediate-range ballistic missiles. Douglas built and delivered the last Cargomasters in 1961. NASA used Cargomasters to drop-test early space capsules and to transport a variety of space products. Douglas built 50 Cargomasters, but after the C-133, Douglas did not build transports specifically for the military for another 10 years.

CH-21 Shawnee/Vertol 44 Helicopter

Historical Snapshot

The H/CH-21 Shawnee/Vertol 44 was the first helicopter to make a nonstop transcontinental flight across the United States. Originally designed for high-altitude, cold-weather operations, the first H-21s joined the U.S. Air Force in 1953 for rescue operations in the Arctic. Proving to be rugged and reliable, the Shawnee also served in Alaska, Northern Canada and Greenland.

Initially designated Piasecki Model 44, the H-21 Shawnee was the fourth tandem-rotor helicopter designed by Frank Piasecki, founder of the P-V Engineering Forum, later the Piasecki Helicopter Corp. After Piasecki left the enterprise in 1955, it became the Vertol Aircraft Corp. Boeing bought Vertol in 1960.

Although the Shawnee usually had a crew of two (pilot and copilot), it could carry either 20 fully equipped troops or 12 litter patients. In the U.S. Air Force, it earned the nickname "Workhorse" and, along with others in the tandem-rotor series, was also called the "flying banana."

The U.S. Air Force took its first delivery of the H-21 in August 1957, and the helicopter was deployed to Myrtle Beach Air Force Base, S.C., and Havana, Cuba.

Redesignated CH-21B in 1962, the CH-21 served in Vietnam until 1964, when it was replaced by the UH-1 "Huey" and the CH-47 Chinook. The Shawnee went on to support the Utah Test and Training Range until its retirement in April 1971, to Davis-Monthan Air Force Base, Ariz. It was dropped from the Air Force inventory the following November.

The CH-21C version served in combat with the French in Algeria as well as with the armed forces of Canada, Sweden and West Germany. The commercial transport version, the Vertol 44, was operated by several airlines. A total of 707 in the CH-21 series were built.

Technical Specifications	
First flight	April 11, 1952
Model	CH-21
Type	Tandem-rotor helicopter
Fuselage length	52 feet 7 inches
Overall length	86 feet 4 inches (including rotor arcs)
Rotor diameter	44 feet
Height	15 feet 4 inches
Weight	10,223 pounds loaded
Cruising speed	90 mph
Maximum speed	132 mph
Power	1,425-hp Wright R-1820 radial engine
Range	400 miles
Service ceiling	19,200 feet
Accommodation	2 crew, 20 fully-equipped troops or 12 litter patients and 2 medical attendants
Armament	7.62 mm or 12.7 mm door guns (CH-21B/C)

Technical Specifications	
First flight	August 1962
Model number	Vertol 107
Classification	Military helicopter
Rotor diameter	50 feet
Fuselage length	44 feet 7 inches
Maximum gross weight	23,000 pounds (CH-46D), 24,300 pounds (CH-46E)
Top speed	165 mph
Cruising speed	155 mph
Range	265 miles
Ceiling	12,800 feet (with normal load)
Power	Two 1,250-horsepower T58-GE-8B engines
Accommodation	3 crew, 17 troops or 15 litters and 2 attendants

CH-46 Sea Knight

Historical Snapshot

In 1960, Boeing bought Vertol, a helicopter manufacturer in Philadelphia, Pa. The company had three tandem-rotor helicopters under production: the Chinook for the U.S. Army, the Sea Knight for the Navy and the Marines, and the commercial 107-II for the airlines.

The twin-turbine tandem-rotor CH-46A Sea Knight won a design competition for a medium assault transport helicopter for the Marine Corps in 1961 and made its first flight in August 1962.

The first U.S. Marine Corps Sea Knight was delivered in 1964 and began military service during the Vietnam War a year later, carrying troops and cargo to and from Navy ships in the China Sea.

By 1968, the Sea Knight had flown 75,000 hours on 180,000 missions, including 8,700 missions rescuing wounded Marines, and had carried 500,000 troops.

Between 1964 and 1990, Boeing Vertol delivered more than 600 Sea Knights. The passenger version of the Sea Knight, the Model 107-II, entered service with New York Airways in July 1962. During the 1980s and 1990s, Boeing developed modification kits and upgrades to modernize the Sea Knights.

The Sea Knight, affectionately known as the "Phrog," is no longer in production. It has served in such venues as Vietnam, Beirut, Desert Storm, Iraq and Afghanistan. The CH-46 was replaced by the V-22 Osprey. In October 2014, the Marines flew the last service flight of the CH-46.

Technical Specifications

Rotor diameter	18.29 m (60 ft)
Length with rotors operating	30.14 m (98 ft, 10.7 in)
Fuselage	15.46 m (50 ft, 9 in)
Height	5.68 m (18 ft, 7.8 in)
Fuselage width	3.78 m (12 ft, 5 in)
Fuel capacity	3,914 liters (1,034 gallons)
Maximum speed	302 km/h (170 KTAS)
Cruise speed	291 km/h (157 KTAS)
Mission radius	200 nm (370.4 km)
Service ceiling	6,096 m (20,000 ft)
Max gross weight	22,680 kg (50,000 lbs)
Useful load	24,000 lbs (10,886 kg)

CH-47 Chinook

Historical Snapshot

In 1960, Boeing bought Vertol Aircraft Co., a helicopter manufacturer in Philadelphia, Pa. The company had three tandem-rotor helicopters under production: the Chinook for the U.S. Army, the Sea Knight for the U.S. Navy and Marines, and the commercial 107-II for the airlines.

Vertol had started out as the P-V Engineering Forum, owned by Frank Piasecki, which established the "banana shaped" two-rotor helicopter in 1945. Shortly thereafter, the company was renamed Piasecki Helicopter Corp. Piasecki left the corporation in 1955, and it was renamed Vertol the following year.

The first in the long line of Chinooks was the YHC-1B tandem-rotor transport helicopter that rolled out in 1961. It was designed to serve the U.S. Army and Air Force as a medium-lift helicopter and evolved into several versions.

The first fully equipped Army Chinook, designated the CH-47A, entered service in August 1962 with a gross weight of 33,000 pounds (14,969 kilograms). Boeing introduced the CH-47B in 1966 with an improved airframe and power plant provided by the T55-l-7C engines. The gross weight rose to 40,000 pounds (18,144 kilograms). The CH-47C was developed in 1967 in response to the Army's request for transporting a 15,000-pound (6,804-kilogram) payload a distance of 30 nautical miles (56 kilometers) on a 95-degree Fahrenheit (35-degree Celsius) day at 4,000 feet (1,219 meters). It was powered by T55-l-11 engines and had a gross weight capability of 46,000 pounds (20,865 kilograms).

Chinooks were first used in combat in 1965 during the Vietnam conflict. During the last days of the war, one Chinook is reported to have carried 147 refugees in a single lift. CH-47A, B and C models served with until the war's end in 1975.

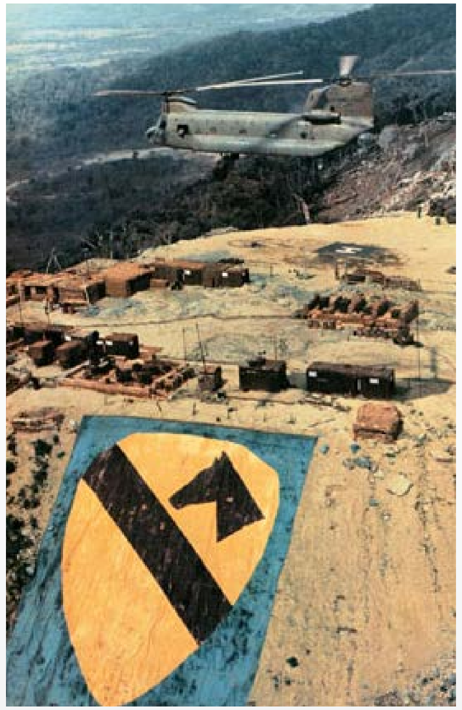
After the Vietnam War, Boeing and the Army began a major fleet upgrade that led to development of the CH-47D. Almost 500 early model Chinooks went through an extensive modernization process in Philadelphia that produced an essentially new H-47 fleet. The CH-47D Chinook was a central element in U.S. Army operations in the Persian Gulf War. Versions of the D model were also used for export including the "International Chinook" and the SD "Super D," in all 20 nations have operated various models of the H-47.

The CH-47F is an advanced multimission helicopter with a fully integrated, digital cockpit management system, Common Avionics Architecture Cockpit and advanced cargo-handling capabilities that complement the aircraft's mission performance and handling characteristics.

The Army Special Operations Command MH-47G combines many proven Chinook systems and features. Notable among these are fuel tanks providing twice the capacity of the CH-47F and an in-flight refueling system. MH-47Gs are remanufactured on the common MH-47G/CH-47F production line.

Using the Chinook airframe, Boeing Helicopters also built the Model 234, the commercial Chinook used for passengers, cargo, oil and gas exploration, and logging.

In 2014, Boeing said that ongoing CH-47F/MH-47G modernization programs, which include a mix of remanufactured and new aircraft, would ensure that this tandem rotor helicopter remains in the Army fleet through at least the 2030s. Chinooks have served the armed forces of more than 19 international customers and performed in commercial service around the world.



Technical Specifications	
First flight	Oct. 9, 1988
Classification	Liaison-observation unmanned aerial vehicle
Wingspan	200 feet
Length	66 feet
Gross weight	20,300 pounds
Cruising speed at altitude	230 mph
Ceiling	67,028 feet during testing
Power	Two 175-hp liquid-cooled, fuel-injected, 6-cylinder piston engines

Condor Unmanned Aerial Vehicle

Historical Snapshot

The Condor was a revolutionary aircraft built entirely of all-bonded composite materials, designed for remote-controlled, high-altitude, long-endurance missions. During its 141-hour flight test program in 1988 and 1989, it set several records for piston-powered aircraft by reaching a top altitude of 67,028 feet (20,430 meters) and staying aloft for nearly two and one-half days.

Boeing developed two vehicles as technology demonstrators. The airplane successfully merged the latest advances of the time in aerodynamics, propulsion, materials and remote controls.

The Condor could provide rapid response and continuous, unmanned, wide-area coverage for days. Unlike other remotely piloted air vehicles of its era, the entire flight from takeoff through landing could be preprogrammed. Once it was airborne, its flight path could also be modified via communications links with ground controllers.

According to its engineers, it did not achieve its full potential during testing. They claimed it could have flown more than 23,000 miles (37,000 kilometers), remained airborne for longer than a week and reached an altitude of 73,000 feet (22,250 meters).

Originally, the Condor was intended for both military and commercial purposes; however, it could not find a customer. Because of its large size, slow speed and lack of stealth, it was too vulnerable to be used for military operations. It had tremendous civilian potential for weather monitoring and atmospheric research, but at the time the expense of such a vehicle was beyond the budgets of most civilian agencies.

In the long run, Condor laid the groundwork for more successful follow-on unmanned aerial vehicles.

Technical Specifications	
First flight	March 29, 1996
Classification	Experimental unmanned aerial vehicle
Span	69 feet
Length	15 feet
Range	500 nautical miles
Ceiling	Greater than 45,000 feet
Power	Single turbofan engine
Accommodation	Unmanned

Darkstar Unmanned Aerial Vehicle

Historical Snapshot

In 1994, Boeing teamed with Lockheed Martin to design and build a stealthy unmanned reconnaissance plane called DarkStar for the U.S. Department of Defense Tier III Minus program. Boeing applied its expertise in unmanned aerial vehicles (UAV), gained over three decades of UAV experience, to develop the DarkStar's wings and integrated avionics.

On March 29, 1996, DarkStar made its first flight. It reached an altitude of 5,000 feet (1.5 kilometers) and successfully executed a fully automated flight from takeoff to landing using the global positioning system. It operated at ranges greater than 500 nautical miles (926 kilometers) and was able to stay on station for more than eight hours at altitudes greater than 45,000 feet (13.7 kilometers).

In late January 1999, the Defense Department announced that the DarkStar UAV program had been terminated.

DB-7/A-20 Boston/Havoc Attack Bomber

Technical Specifications	
First flight	Aug. 17, 1939
Wingspan	61 feet 4 inches
Length	47 feet 4 inches
Height	17 feet 7 inches
Weight	21,500 pounds
Power plant	Two 1,600-hp Wright R-2600-23 engines
Top Speed	342 mph
Ceiling	25,320 feet
Range	745 miles
Accommodation	Three crew
Armament	2,000-pound bomb load, seven machine guns

Historical Snapshot

The Douglas DB-7/A-20 Havoc was the most-produced attack bomber during World War II. A total of 7,478 DB-7/A-20s were built, most at Douglas, although 380 were built at the Boeing plant in Seattle, Wash. The Havoc was a mid-wing, twin-engine, three-place medium bomber that earned a reputation for getting its crews home, even when both crew and aircraft suffered crippling blows. It was called the "Boston" when in service with England's Royal Air Force.

It entered production when, despite official neutrality in 1938, there was little doubt in the United States that the country should support its allies, Britain and France. The French saw the secret bomber project at the Douglas Santa Monica, Calif., facility and ordered the first 107 DB-7s; they were to be delivered to the French Purchasing Commission at Santa Monica starting in October, with deliveries made by ship to Casablanca. The French then ordered another 270 DB-7s. Before the fall of France in June 1940, half had been accepted, but many were still en route. Sixteen had been diverted to Belgium's Aviation Militaire.

The United Kingdom took over 162 of the DB-7s intended for France as well as Belgium, which also had fallen. By the time the United States entered World War II at the end of 1941, British Havocs and Bostons had already performed well for most of the year against German targets in North Africa and Europe. The U.S. Army Air Corps designated the plane the A-20 Havoc, and it served in every theater of the war.

More than half of the DB-7/A-20s built went into service in other countries, predominantly the Soviet Union. Versions also included the F-3 photoreconnaissance aircraft and the P-70 night fighter.

Technical Specifications	
First flight	November 1921
Wingspan	50 feet
Length	34 feet 2 inches
Height	13 feet 1 inch
Empty weight	3,737 pounds
Speed	101 mph
Power plant	420-horsepower Liberty engine
Accommodation	2

DT Torpedo Bomber

Historical Snapshot

The Douglas DT Bomber was built under the company's first military contract, forging a link between Douglas and the U.S. Navy. Navy Contract No. 53305 of April 14, 1921, required only 18 pages to set out the specifications that resulted in the purchase of three DT (D for Douglas, T for torpedo) folding-wing aircraft.

The DT used a welded-steel fuselage with aluminum covering the forward and center sections and fabric covering the rear section. Douglas built 41 DT-1 and -2 torpedo bombers for the Navy. Other companies built 55. The DT could be fitted either with pontoons or wheeled landing gear and could carry a 1,800-pound (816-kilogram) torpedo.

E-3 Airborne Warning And Control System

Technical Specifications	
First flight	May 25, 1976 (E-3A with full mission avionics)
Model number	707 airframe (E-3)
Classification	Airborne Warning and Control System
Span	145 feet 9 inches
Length	152 feet 11 inches
Gross weight	325,000 pounds
Top speed	530 mph
Endurance	6 hours at 1,000 miles from base
Ceiling	More than 29,000 feet
Power	Four 21,000-pound-thrust turbofan P&W TF-33 engines
Accommodation	4 crew, 13 to 18 AWACS specialists

Historical Snapshot

The E-3 Airborne Warning and Control System (AWACS) was first carried aboard militarized 707 commercial aircraft with a rotating radome mounted above the fuselage carrying the airplane's avionics and radar. It has a 360-degree view of an area and at operating altitudes can detect, identify and display hostile aircraft and friendly aircraft in the same airspace more than 200 miles (322 kilometers) away.

The first E-3 entered U.S Air Force service in 1977, preceded by more than 10 years of competitive fly-offs, prototype design and development. Thirty-four U.S. AWACS aircraft were delivered to the Air Force, the last in 1984.

By 1994, 68 707 AWACS aircraft were in service worldwide with the United States, NATO, Saudi Arabia, France and the United Kingdom. E-3 AWACS provided airborne surveillance and command and control functions over Afghanistan during Operation Enduring Freedom in 2001.

Throughout its history, the AWACS fleet has undergone extensive enhancements, including upgrades to radar, computing, satellite communications and air traffic management. In 2014, Boeing received a contract from NATO to install digital flight decks and avionics on 13 of the alliance's AWACS aircraft based on the Boeing 707.

In December 1991, Boeing announced it would offer a modified 767 commercial jetliner as the platform for the system.

The first of the 767 AWACS, designated E-767, made its first flight Aug. 9, 1996, and the government of Japan ordered the first four 767 AWACS.

In February 1997, Boeing announced that it would offer a 737-700 as the platform for an airborne early warning and control (AEW&C) system with a variety of aircraft control and advanced radar systems for the Royal Australian Air Force (RAAF). Named "Wedgetail" in honor of Australia's native eagle, the 737 AEW&C platform would be completely interoperable with the E-3 and 767 AWACS aircraft. Joining Boeing and Boeing Australia Ltd. on the Wedgetail team were Northrop Grumman Electronic Sensors and Systems Division and British Aerospace Australia.

The AEW&C had a different look. Instead of the rotating, circular radome, its multimode electronically scanned array (MESA) radar was enclosed in a fuselage-mounted structure nicknamed "top hat" for its shape. The 737 AEW&C aircraft is designed to provide airborne battle management capability, with its advanced multirole electronically scanned radar and 10 state-of-the-art mission crew consoles that can track airborne and maritime targets.

The sixth and final Wedgetail AEW&C aircraft was delivered to the RAAF on June 4, 2012. Oct. 24, a fourth and final 737 AEW&C Peace Eye aircraft was delivered to the Republic of Korea Air Force. A third customer, the Turkish Armed Forces, received the third of four Peace Eagle AEW&C aircraft on Sept. 9, 2014.

E-4 Advanced Airborne Command Post

Historical Snapshot

The huge capacity of the Boeing 747 made it an ideal airframe for the Advanced Airborne Command Post (E-4). In 1973, the E-4 took over the mission of the EC-135 flying command post aircraft: to provide safe airborne headquarters for military and civilian leaders, including the president, secretary of Defense, and Joint Chiefs of Staff in times of emergency.

The original three E-4As were upgraded to the standard of the E-4B. The first B model was delivered Dec. 21, 1979, and entered service in January 1980. By 1985, all aircraft were converted to B models.

The four E-4s carry 13 external communications systems and are designed for missions lasting 72 hours. Their "hardness" features protect the crew from electromagnetic radiation and the effects of a nuclear blast.

Secondary missions assigned to the E-4B include VIP travel support and Federal Emergency Management Agency support, which provides communications to relief efforts following natural disasters such as hurricanes and earthquakes.

All E-4Bs are assigned to the 595th Command and Control Group at Offutt Air Force Base, Nebraska.

Technical Specifications	
First flight	June 19, 1973
Airframe	Model 747
Classification	Advanced Airborne Command Post
Span	195 feet 8 inches
Length	231 feet 4 inches
Gross weight	800,000 pounds
Top speed	More than 600 mph at 30,000 feet
Endurance	More than 12 hours
Ceiling	45,000 feet plus
Power	Four 52,000-pound-thrust F103-GE-100 turbofan engines
Accommodation	Up to 94 personnel, including flightcrew and 30 battle staff members

E-6 Mercury Tacamo Airborne Communication System

Historical Snapshot

Assembled on the same production line as the E-3 Sentry Airborne Warning and Control System (AWACS) aircraft, was the E-6 Mercury, TACAMO ("Take Charge and Move Out") aircraft, also based on the Boeing 707 airframe.

The U.S. Navy awarded Boeing a full-scale development contract for the E-6A in 1983, and the prototype E-6A rolled out from the Renton, Wash., factory in December 1986.

First flight was in February 1987. Delivery of the first production aircraft was in August 1989, with delivery of the final airplane in May 1992.

Boeing delivered a total of 16 E-6 "survivable airborne communication system" airplanes to the Navy from 1989 to 1992.

The TACAMO airplanes support the Navy's ballistic missile submarine force, providing a vital link to the force from national command authorities. The TACAMO E-6B airplanes are equipped with dual trailing wires that serve as transmitter and antenna, transmitting in the very low frequency spectrum.

Technical Specifications	
First flight	May 25, 1976 (E-3A with full mission avionics)
Model number	707 airframe (E-3)
Classification	Airborne Warning and Control System
Span	145 feet 9 inches
Length	152 feet 11 inches
Gross weight	325,000 pounds
Top speed	530 mph
Endurance	6 hours at 1,000 miles from base
Ceiling	More than 29,000 feet
Power	Four 21,000-pound-thrust turbofan P&W TF-33 engines
Accommodation	4 crew, 13 to 18 AWACS specialists

Technical Specifications

First flight	Nov. 18, 1978
Wingspan	37 feet 5 inches
Length	56 feet
Height	15 feet 3.5 inches
Takeoff weight	Fighter, 36,710 pounds; attack, 49,224 pounds
Speed	1,360 mph plus
Ceiling	50,000 feet
Power plant	Two 16,000-pound-thrust GE F404-GE-400 low-bypass turbofan engines
Accommodation	One crew (F/A-18A/C); two crew (F/A-18B/D)
Armament	One 20 mm M61A1 Vulcan six-barrel cannon with 570 rounds, plus up to 17,000 pounds ordnance, including bombs, rockets, missiles and drop tanks on nine external points

F/A-18 Hornet Fighter

Historical Snapshot

The McDonnell Douglas F/A-18 Hornet was designed for aircraft carrier duty and was the first tactical aircraft designed to carry out both air-to-air and air-to-ground missions. The U.S. Marines ordered it as an F-18 fighter and the Navy as an A-18 attack aircraft. It can switch roles easily and can also be adapted for photoreconnaissance and electronic countermeasure missions.

The F/A-18 Hornet was also the first aircraft to have carbon fiber wings and the first tactical jet fighter to use digital fly-by-wire flight controls. Variants included a two-seater, an improved fighter, a reconnaissance aircraft and a night-attack fighter.

Hornets entered active duty in January 1983. In 1986, Hornets on the USS *Coral Sea* flew their first combat missions. During the 1991 Persian Gulf War, while performing an air-to-ground mission, Hornets switched to fighter mode and destroyed two Iraqi MiG-21s in air-to-air combat, then switched back to attack mode and successfully completed their air-to-ground mission. During 2001, Hornets provided around-the-clock battlefield coverage in the Afghanistan Theater of operations.

The F/A-18E/F Super Hornet made its first flight in November 1995. The Super Hornet is a low-observable aircraft that performs multiple missions, including air superiority, day-and-night strike with precision-guided weapons, fighter escort, and close air support. It is operational in 10 U.S. Navy Carrier Air Wings (25 squadrons) and the Royal Australian Air Force.

The Super Hornet is produced in the single-seat E model and the two-seat F model. The F/A-18E/F is 25 percent larger than the original Hornet and has increased maneuverability, range, and payload, and more powerful engines. It entered operational service with the U.S. Navy in 1999, after Boeing had merged with McDonnell Douglas, won the Collier Trophy for that year and flew its first combat missions in 2002.

In April 2005, Boeing delivered the first Block II Super Hornet, an upgraded Super Hornet with the world's first tactical multimode active electronically scanned array (AESA) radar.

In 2008, the EA-18G Growler joined the Navy's aircraft fleet. A Super Hornet derivative, the EA-18G provides tactical jamming and electronic protection for U.S. and allied forces, delivering full-spectrum airborne electronic attack capability along with the targeting and self-defense capabilities of the Super Hornet.

On April 22, 2010 — Earth Day — an unmodified, Boeing-built F/A-18F Super Hornet took off from Naval Air Station Patuxent River, Md., powered by a sustainable biofuel blend of 50 percent camelina and 50 percent JP-5 aviation fuel. Boeing had worked with the Navy on laboratory testing of fuel properties and engineering evaluations of fuel system compatibility. Nicknamed Green Hornet, the F/A Super Hornet has won seven consecutive awards for environmental excellence from the U.S. Navy.

In August 2013, Boeing and Northrop Grumman began flight tests with a prototype of an Advanced Super Hornet aircraft with conformal fuel tanks, an enclosed weapons pod and signature enhancements.

Technical Specifications	
First flight	July 27, 1972
Wingspan	42 feet 10 inches
Length	63 feet 9 inches
Height	18 feet 8 inches
Ceiling	65,000 feet
Range	2,400 miles
Weight	68,000 pounds
Power plant	Two 25,000-pound-thrust P&W F100-PW-100 turbofan engines
Speed	1,875 mph
Accommodation	F-15A/C, 1 crew; F-15B/D, 2 crew
Armament	AIM-7F/M Sparrow missiles or AIM-120 advanced medium-range air-to-air missiles; AIM-9L/M Sidewinder or AIM-120 missiles; 20 mm Gatling gun

F-15 Eagle Tactical Fighter

Historical Snapshot

McDonnell Aircraft formalized the concept for the F-15 in 1967 when the company was selected to enter the second phase of the U.S Air Force's FX competition. Competing against Fairchild Hiller and North American Rockwell, McDonnell used lessons learned during the Vietnam War on the changing nature of jet age air-to-air combat, given that the F-4 Phantom II was earning its reputation as a formidable fighter. On Dec. 23, 1969, after more than two years of intensive testing and evaluation, the Air Force awarded McDonnell Douglas the F-15 Advanced Tactical Fighter contract. The McDonnell Douglas team had placed first among the three competitors in all phases of the competition and had the lowest contract price.

The F-15 is a twin-engine, high-performance, all-weather air superiority fighter known for its incredible acceleration and maneuverability. With a top speed in excess of Mach 2.5 (more than 1,600 mph or 2,575 kph), it was the first U.S. fighter with enough thrust to accelerate vertically. The F-15 carries a large complement of missiles — including AIM-9 Sidewinders and AIM-7 Sparrows; the Boeing-built Small Diameter Bomb I, Joint Direct Attack Munition (JDAM) and Laser JDAM weapons; and an internal 20 mm Gatling gun — all vital for modern engagements.

On June 26, 1972, James S. McDonnell, founder of McDonnell Aircraft, christened the F-15 "Eagle." Test pilot Irv Burrows took the first F-15 Eagle to the air on July 27, 1972, at Edwards Air Force Base in California. Six months later, the Air Force approved the Eagle for full-rate production.

In early 1975, flying out of Grand Forks Air Force Base in North Dakota, an F-15A known as Streak Eagle set many time-to-climb world records. Between Jan. 16 and Feb. 1, 1975, the Streak Eagle broke eight time-to-climb world records. It reached an altitude of 98,425 feet just 3 minutes, 27.8 seconds from brake release at takeoff and coasted to nearly 103,000 feet before descending.

Eagles flown by Israel's air force were the first to face a true adversary in the air. They downed more than 50 Syrian fighters with no losses of their own. In service with the U.S. Air Force, the F-15 Eagle downed MiG fighters during the Balkan conflict and the majority of Iraq's fixed-wing aircraft during Operation Desert Storm.

To meet the U.S. Air Force requirement for air-to-ground missions, the F-15E Strike Eagle was developed. It made its first flight from St. Louis in December 1986. The Strike Eagle can carry 23,000 pounds of air-to-ground and air-to-air weapons and is equipped with an advanced navigation and an infrared targeting system, protecting the Strike Eagle from enemy defenses. This allows the Strike Eagle to fly at a low altitude while maintaining a high-speed, even during bad weather or at night.

The F-15 has been produced in single-seat A model and two-seat B versions. The two-seat F-15E Strike Eagle version is a dual-role fighter that can engage both ground and air targets.

F-15C, -D, and -E models participated in Operation Desert Storm in 1991. F-15s downed 32 of 36 U.S. Air Force air-to-air victories and struck Iraqi ground targets. F-15s also served in Bosnia in 1994 and downed three Serbian MiG-29 fighters in Operation Allied Force in 1999. They enforced no-fly zones over Iraq in the 1990s. Eagles also hit Afghan targets in Operation Enduring Freedom, and the F-15E version performed air-to-ground missions in Operation Iraqi Freedom.

Boeing has continued to evolve the F-15 with advanced technology, and it is undefeated in air-to-air combat — 101 aerial victories and 0 defeats. Production continues today with advanced models for several international customers.

In all models, more than 1,500 F-15s have been built. F-15 will be a major player in the U.S. Air Force air superiority and dominance arsenal through the 2040 timeframe using leading-edge technology and capabilities that will keep the Advanced F-15 and its mission systems current.

Technical Specifications	
First flight	(YF-22 prototype) Sept. 29, 1990; (F-22 Raptor) Sept. 7, 1997
Classification	Fighter
Span	44 feet 6 inches
Length	62 feet 1 inches
Speed	Mach 2
Power	Two Pratt & Whitney F119-PW-100 engines
Accommodation	One crewperson
Armament	Air-to-air and air-to-ground missiles

F-22 Raptor

Historical Snapshot

In the mid-1990s, Boeing teamed with Lockheed Martin to develop and build the F-22, an extremely advanced tactical fighter that combined stealth, integrated avionics and maneuverability. The F-22 was intended as replacement for the F-15 as America's front-line dominance fighter.

The first production F-22 was unveiled April 9, 1997, at a rollout ceremony hosted by Lockheed Martin, Boeing and Pratt & Whitney. It was the first of nine flyable F-22s built for flight testing.

Lockheed Martin Aeronautical Systems, a division of Lockheed Martin Corp., based in Marietta, Ga., was responsible for program management; the integrated forebody (nose section) and forward fuselage, including the cockpit and inlets; the wing leading edge; the fins and stabilators, flaps, ailerons and landing gear; and final assembly of the aircraft. Lockheed Martin Tactical Aircraft Systems, based in Fort Worth, Texas, was responsible for the center fuselage; stores management; integrated navigation and electronic warfare systems; the communications, navigation, and identification system; and the weapon support system. Boeing in Seattle, Wash., built the wings and aft fuselage, including the structures necessary for engine and nozzle installation, and was responsible for avionics integration, 70 percent of mission software, the training system, the life support and fire protection systems, and the pilot and maintenance training systems.

In 2002, Boeing delivered the 2,000-pound (907-kilogram) titanium and composite wings for the first F-22 production aircraft. By April 2005, Boeing had delivered 61 sets of wings and 66 aft fuselages as well as a number of integrated avionics flight-test packages and updates to Lockheed Martin.

The F-22 entered service in 2005, and it won the prestigious Collier Trophy for 2006, but in the years to come it was surrounded by controversy about costs and its suitability in a post–Cold War environment. After the collapse of the Soviet Union, the next generation of Soviet fighters the aircraft had been intended to dominate in aerial combat never materialized. The U.S. Department of Defense announced the decision to end F-22 production at 187 aircraft in April 2009. The Air Force received the last F-22 in 2012.

In September 2014, the F-22 Raptor made its combat debut in coordinated strikes with other fighter jets and bombers against Islamic State (ISIS) strongholds in Syria.

Modernization, Sustainment & Training

The F-22 Raptor is one of the newest fighters in the U.S. Air Force fleet. It offers a combination of stealth, speed, maneuverability, and robust warfighting capabilities. A suite of sensors and highly-lethal weapons guarantee air dominance, supporting the mission at hand.

Boeing partners with Lockheed Martin to design and install modernization upgrades for the F-22 Raptor, allowing U.S. Air Force pilots to maintain air superiority and stay ahead of potential threats. In addition to performance-based logistics support on several F-22 components, Boeing also provides pilot and maintainer training, with onsite support, to ensure mission-readiness around the clock.

The F-22 maintenance training system includes a suite of high-fidelity training devices, labs and classrooms that provide theoretical and hands-on maintenance training to produce mission-ready maintainers.

Designed to preserve air dominance, the F-22 Raptor is known for its stealth, agility and lethality, with the ability to target air and ground-based threats.

F-100 Super Sabre

Historical Snapshot

The North American Aviation F-100 Super Sabre was a sleek, swept-back-wing fighter that gave the United States a supersonic Air Force. Although the first version was produced prior to 1950, various improved versions served as trainers and as active military craft at many U.S. and foreign bases.

Since May 1953, when the first prototype model, the YF-100, bettered the speed of sound on its first flight, the versatile fighter set numerous records for speed, endurance, range and maintenance.

Late production models of the F-100D and F-100F had the capability of being launched from remote areas in the manner of manned missiles. An F-100D Super Sabre became the first supersonic aircraft to be "boosted" airborne without use of a runway in successful Zero Length Launch (ZEL) tests at Edwards Air Force Base, Calif., in 1958.

In addition to its nuclear bomb armament and four 20 mm cannons, the Super Sabre could be equipped to fire rockets and missiles, including the heat-seeking GAR-8 Sidewinder.

While the later models of the F-100 had a speed in excess of 1,000 mph, two earlier models of the "A" and "C" established the world's first supersonic speed records. Colonel F.K. (Pete) Everest reached 755.149 mph in October 1953, and Colonel Horace Hanes topped 822 mph in August 1955.

To demonstrate the ability of its pilots and aircraft, the Air Force chose F-100 Super Sabres to perform throughout the world in aerial precision demonstration flights. The famed "Thunderbirds," a four-man aircraft team, were viewed by over 19 million people as the storied pilots performed intricate precision maneuvers at low altitude. In Europe the "Skyblazers" flew similar demonstrations.

The jet fighter was originally powered by a Pratt & Whitney J57-P-7 axial-flow engine. Later models of the F-100 were powered by a Pratt & Whitney J57-P-21A engine. Both were two-stage turbojet engines with afterburner, rated in the 10,000-pound thrust class.

The F-100 had a service ceiling above 50,000 feet and a range of more than 1,000 statute miles.

In addition to the thin, highly swept wing and tail, the F-100 design incorporated other features that reflect an answer to the problem of supersonic flight. Heat-resisting titanium was used extensively throughout the plane. A low-drag, ultra-streamlined fuselage and canopy with but one thin-lipped air intake duct helped make supersonic speed possible. The canopy line matched the rear fuselage in a smoothly curving line so that from the side, the Super Sabre appeared to be slightly arched. Other features included automatic leading-edge slats and a low-positioned one-piece horizontal stabilizer. The F-100 was the first USAF airplane to utilize the low tail.

The plane had an automatically regulated air conditioning and pressurizing system and automatic fuel system.

Particular attention was given to placement of all controls, equipment and instruments in the cockpit for ease of operation.

Technical Specifications

First flight	May 25, 1953
Wing span	38.6 feet; Sweepback (25% chord) 45 degree
Length	47.8 feet
Height	15.3 feet
Tread	12.4 feet
Weight	28,971 pounds
Power plant	Pratt & Whitney J57-P-7 or -39 engine (producing 14,800 pounds thrust with afterburner); or Pratt & Whitney J57-P-21A engine (16,000 pounds thrust with afterburner)
Speed	In excess of 1,000 mph
Service ceiling	Above 50,000 feet
Range	In excess of 1,000 statute miles
Other features	- In-flight refueling system - Extra fuel drop tanks and bombs - Radar - Autopilot - Two-place tandem cockpit

Technical Specifications	
First flight	Sept. 29, 1954
Wingspan	39 feet 8 inches
Length	67 feet 5 inches
Height	18 feet
Weight	48,120 pounds
Speed (max.)	1,009 mph
Ceiling	38,900 feet
Power plant	Two 15,000-pound-thrust Pratt & Whitney J57-P-13 axial-flow turbojets
Accommodation	One crew
Armament	Four 20 mm cannons, low-altitude bombing systems, 1,620-pound bomb or 3,721-pound nuclear bomb

F-101 Voodoo Fighter

Historical Snapshot

McDonnell Aircraft's Voodoo was a supersonic fighter, bomber escort, all-weather interceptor and photor-econnaissance aircraft. It served during the Cuban Missile Crisis and during the Vietnam War.

It began as the XF-88 all-weather interceptor (fighter) and first flew at Muroc Dry Lake Air Base, Calif., in 1948. The XF-88 Voodoo had thin wing and tail surfaces designed to literally slice through the air and reduce drag to an absolute minimum. The wings were swept back sharply at a 35-degree angle to reduce compressibility effects. Only two XF-88 Voodoos were built; the U.S. Air Force canceled the project after the start of the Korean War.

In 1952, McDonnell received a development contract for the F-101 Voodoo, based on the XF-88. F-101s were designed as long-range twinjet fighters to escort bombers, attack distant targets and provide close support for ground troops.

The new fighter jet kept some of the supersonic aerodynamic characteristics of the XF-88, such as the wing area and wing platform, tail platform, and side-by-side arrangements of the engines. However, the F-101 wings were thinner, the size and location of the tail were altered, and the engines were moved forward in a larger fuselage.

Attack fighter, interceptor and reconnaissance versions served in the U.S. Air Force Strategic Air Command, Air Defense Command, and Tactical Air Command as well as in Canada.

Voodoo versions included the F-101A fighter-bomber; the F-101B two-seat, long-range interceptor; the RF-101A photoreconnaissance version; the RF-101C single-seat reconnaissance version; the TF-101B trainer version; the F-101C (an upgraded F-101A); and the CF-101F, transferred under license from the United States to the Royal Canadian Air Force.

The F-101 set several new speed records. In Operation Sun Run on Nov. 27, 1957, RF-101As set a transcontinental speed record by racing from Los Angeles, Calif., to New York and back to Los Angeles in 6 hours, 46 minutes—flying faster than the sun.

In Operation Firewall on Dec. 12, 1957, an F-101A fighter-bomber set a new absolute world speed record of 1,207.6 mph (1,943.4 kph) over the Mojave Desert in California. Because of its speed, pilots nicknamed the aircraft "One-oh-Wonder."

During the Cuban Missile Crisis RF-101s flew 82 missions over Cuba, flying low to avoid fire from Soviet surface-to-air missiles. One RF-101 pilot claimed he flew so low that a Soviet technician almost hit his Voodoo with a volleyball.

Thanks to the Voodoo's reconnaissance flights, the United States could confirm that the Cuban nuclear sites were being dismantled. In recognizing the achievements of the 363rd Tactical Reconnaissance Wing pilots who made those flights, President John F. Kennedy said, "You gentlemen have contributed as much to the security of the United States as any group of men in our history."

McDonnell delivered 807 F-101 Voodoos to the U.S. Air Force. The last Voodoo was retired in 1986.

F2H Banshee Fighter

Historical Snapshot

The McDonnell F2H Banshee fighter, immortalized by James Michener in his novel, The Bridges of Toko-Ri, was similar in design and appearance to the FH-1 Phantom, but it had twice the power and carried bombs as well as rockets and cannons. McDonnell Aircraft Corp. built 895 Banshees, and they established the company as a new star in the U.S. aircraft manufacturing industry.

The Banshee was a multimission aircraft used as a day fighter, as a night fighter and for photoreconnaissance; a variant was specially strengthened to carry nuclear weapons. It went into combat in 1951 and served as one of the principal fighters with the Navy's Seventh Fleet for the duration of the Korean War.

The F2H-2 Banshee included 200-gallon (757-liter) fuel tanks for the wingtips. By installing the engines in the expanded wing roots next to the fuselage, engineers reduced aerodynamic drag. In 1949, an F2H-2 set a jet altitude record of 52,000 feet (15,000 meters).

The F2H-3 fuselages were 8 feet (2.4 meters) longer than the F2H-2s and accommodated radar equipment and an extra 1,102 gallons (4,171 liters) of gas. Some were fitted for aerial refueling. Banshees became the U.S. Navy's standard aircraft for all-weather fighter missions of extended range and remained in service until September 1959. In November 1955, 39 former U.S. Navy F2H-3s were transferred to the Canadian Navy, the last of which were retired from service in September 1962.

Technical Specifications	
First flight	Jan. 11, 1947
Model number	F2H-2
Wingspan	44 feet 11 inches (without tip tanks, 41 feet 8 inches)
Length	40 feet 4 inches
Height	14 feet 6 inches
Weight	14,234
Ceiling	48,500 feet
Speed	586 mph (max.)
Range	1,200 miles
Power plant	Two 3,250-pound-thrust J34-WE-34 turbojets
Accommodation	1 crew
Armament	Four 20 mm cannons, 1,000-pound bomb load

Technical Specifications

First flight	March 23, 1948
Wingspan	50 feet
Length	45 feet 5 inches
Height	16 feet 1 inches
Weight	24,485 pounds
Speed	478 mph
Range	1,068 miles
Power plant	Two 3,400-pound-thrust Westinghouse J46-WE-36 engines
Accommodation	Two crew
Armament	Four 20 mm guns

F3D/F-10 Skyknight Fighter

Historical Snapshot

The Douglas F3D Skyknight (later designated the F-10) was the world's first jet fighter designed for use as a carrier-based night fighter. Its radar equipment required a wider-than-usual fuselage, so it was nicknamed "Willie the Whale."

The U.S. Navy asked Douglas to develop a carrier-based night fighter in 1946. Specifications included twin-jet power, side-by-side seating for a radar operator, a top speed of 500 mph (805 kph), a combat radius of 500 miles (805 kilometers), an operating altitude of 40,000 feet (12,192 meters) and an escape system that allowed the crew to depart downward through the bottom of the fuselage.

The result was the straight-wing, two-seat, twin-engine F3D. The first of 28 production-model F3D-1s was delivered to the Navy in late 1950, as work began on the more powerful F3D-2. The F3D-2 flew 100 mph (161 kph) faster and had twice the range. It incorporated new electronic and radar equipment, air-to-air rockets, a thicker bulletproof canopy, wing spoilers to improve the rate of roll and an automatic pilot.

Douglas produced 268 Skyknights, including several conversions to special-duty variants. During the Korean War, in 1952, an F3D Skyknight shot down a Yak-15 in the first jet-to-jet aerial victory scored at night. One Marine Corps night-fighter squadron went on to rack up the best night-fighter record of the Korean conflict.

After 1953, Skyknights were converted as trainers for radar intercept officers and for use as electronic reconnaissance and countermeasure aircraft during the Cuban Missile Crisis and the Vietnam War. The Skyknight was the only Navy/Marine fighter to fly combat missions in both Korea and Vietnam, and the last was retired in 1978.

Technical Specifications	
First flight (XF3H-1)	Aug. 7, 1951
Wingspan	35 feet 4 inches
Length	58 feet 11 inches
Height	14 feet 7 inches
Ceiling	42,650 feet
Range	1,180 miles
Weight	39,000 pounds
Power plant	One 14,250 pound-thrust J71-2A
Speed	716 mph (Mach 0.97)
Accommodation	One pilot
Armament (F3H-2)	Four Sparrow or two Sidewinder missiles; four 20 mm cannons; up to 6,000 pounds of external stores, including fuel tanks, bombs and rocket pods

F3H/F-3 Demon

Historical Snapshot

The F3H Demon (later designated the F-3) was the first swept-wing jet fighter designed by McDonnell Aircraft and the only single-engine carrier-based fighter built by the company. Design began in 1949, with the XF3H-1 prototype making its first flight Aug. 7, 1951.

The plane's original Westinghouse J40 engine proved to be so unreliable that, after the loss of six aircraft and four pilots, the first production F3H-1N Demons were permanently grounded. Even with the troubled engine, one F3H-1N Demon, flown by McDonnell test pilot Chet Braun, set an unofficial time-to-climb record in 1955 of 10,000 feet (3,000 meters) in 71 seconds.

In 1953, the Demon was redesigned around the more powerful Allison J71 engine. The new engine greatly improved the plane's performance, and in 1956 the F3H-2N Demon was fully qualified as a front-line fighter for the U.S. Navy.

The F3H-2M Demon, first flown in 1955, was the first U.S. combat aircraft designed to be armed primarily with missiles rather than guns. The F3H-2 Demon, first ordered in 1956, was designed as a strike fighter. It was armed with four Sparrow radar-guided missiles or two Sidewinder heat-seeking missiles and four 20 mm cannons. The F3H-2 could also carry up to 6,000 pounds (2,722 kilograms) of conventional bombs.

In service, the Demon performed dependably and gained praise from pilots for its stable flying characteristics at high altitude as well as during carrier operations. In 1958, flying day and night, Demons provided all-weather fleet defense during crises over Quemoy Island near China in the Far East and Lebanon in the Mediterranean.

McDonnell Aircraft delivered the last of 522 Demons in 1959. The Demon remained in squadron service until 1964.

Technical Specifications	
First flight	May 27, 1958 (prototype YF4H-1)
Wingspan	38 feet 5 inches
Length	58 feet 3 inches
Height	16 feet 6 inches
Ceiling	56,100 feet
Range	1,750 miles
Weight	55,597 pounds
Power plant	Two 17,900-pound-thrust General Electric J79-GE-17 jet engines
Speed	1,485 mph (max.)
Accommodation	Two crew
Armament	15,983 pounds of weapons, including 20 mm nose-mounted M-61 "Vulcan" cannon

F-4 Phantom II Fighter

Historical Snapshot

The McDonnell two-place, twinjet, all-weather F-4 Phantom II, with top speeds more than twice that of sound, was one of the most versatile fighters ever built. It served in the first line of more Western air forces than any other jet. Just 31 months after its first flight, the F-4 was the U.S. Navy's fastest, highest flying and longest range fighter. It first flew May 27, 1958, and entered service in 1961.

The aircraft was named Phantom II on July 3, 1959, during a ceremony held at the McDonnell plant in St. Louis, Mo., to celebrate the company's 20th anniversary. It remained in production until the company's 40th anniversary. By then, the numeral "II" had been discontinued; it had become the only Phantom.

The F-4 established 16 speed, altitude and time-to-climb records. In 1959, its prototype set the world altitude record at 98,556 feet (30,000 meters). In 1961, an F-4 set the world speed record at 1,604 mph (2,581 kph) on a 15-mile circuit. By the end of production in 1985, McDonnell had built 5,068 Phantom IIs, and Mitsubishi, in Japan, had built 127.

Modifications incorporated improvements to weapons, avionics, radar and engines. The RF versions were equipped with cameras and surveillance gear for aerial reconnaissance. Armament ranged from cannons to missiles.

F-4s saw combat in both the Vietnam War and Operation Desert Storm and served with the air forces of 11 countries in addition to the United States. Both U.S. military flight demonstration teams, the Navy Blue Angels and the Air Force Thunderbirds, flew the Phantom II from 1969 to 1973.

The 5,000th Phantom was delivered on May 24, 1978, in ceremonies that also marked the 20th anniversary of the fighter's first flight, and McDonnell Douglas delivered the last St. Louis–built Phantom II in October 1979. By 1998, approximately 800 were still in service around the world.

In 2014, modified Phantoms designated QF-4 were being used as remotely controlled aerial targets over the Gulf of Mexico to test pilots, aircraft such as drones and weapons at Tyndall Air Force Base near Panama City, Fla. In September 2014, the first unmanned QF-16 Viper was successfully tested there as a proposed replacement for the aging QF-4s.

F4D/F-6A Skyray Fighter

Technical Specifications	
First flight	Jan. 23, 1951
Wingspan	33 feet 6 inches
Length	45 feet 3 inches
Height	13 feet
Loaded weight	25,008 pounds
Max. speed	722 mph
Ceiling	55,000 feet
Power plant	9,700-pound thrust Pratt & Whitney J57-P-2 turbojet (later, 16,000-pound thrust with afterburner J57-P-8)
Range	593 miles
Accommodation	One crew
Armament	Four 20 mm cannons, 4,000 pounds of stores

Historical Snapshot

The single-place Douglas Skyray was named after the undersea manta ray it resembled. It was on the leading edge of aircraft design, could climb to 40,000 feet (12,000 meters) in two minutes and reach Mach 1 during a dive.

Analysis of data captured in Germany after World War II indicated that the delta-shaped wing would take the most advantage of jet propulsion for fast-climbing interceptor fighters. In 1948, Douglas signed a contract to build the F4D-1. Nicknamed “the 10-minute killer,” the Skyray broke five world time-to-height records. In 1953, the Skyray was co-winner with North American’s Super Sabre of the prestigious Collier Trophy.

In 1957 and 1958, a Skyray-equipped squadron was named the top interceptor squadron in the North American Air Defense Command, although it was the only Navy unit assigned to the Air Force-dominated command.

Douglas built 421 Skyrays, including two prototypes, and they continued to roll out of the El Segundo, Calif., plant until December 1958. After 1962, it was designated the F-6A and served Marine and Navy carrier squadrons until February 1964. An improved version, the “Super-Skyray,” was named the F5D Skylancer but never went into production. The four prototype Skylancers were delivered to NASA, where they contributed to the development of a variety of products, including the Gemini escape system and the space shuttle.

F-86 Sabre

Historical Snapshot

More than 6,000 F-86s were manufactured by North American Aviation's Los Angeles, Calif., and Columbus, Ohio, divisions.

The first swept-wing airplane in the U.S. fighter inventory, the F-86 scored consistent victories over Russian-built MiG fighters during the Korean War, accounting for a final ratio of 10-to-1. All 39 United Nations jet aces won their laurels in Sabres.

Four models of the craft (F-86A, E, F and H) were day fighters or fighter bombers, while the F-86D, K and L versions were all-weather interceptors.

Successive models of the daylight versions — all designed to destroy hostile aircraft in flight or on the ground — were equipped with more powerful engines and armament systems that ranged from bombs and rockets to machine guns and cannon. All were rated in the 650-mph (1,046-kph) class with a 600-mile (966-kilometer) combat radius and a service ceiling of more than 45,000 feet (13,716 meters).

The three interceptor versions sported black radome noses, replacing the yawning jet intakes of the other models. The K model, manufactured in Turin, Italy, by Fiat, was flown by NATO forces. The F-86L had added equipment for use in conjunction with the U.S. Semi-Automatic Ground Environment (SAGE) defense system.

Forerunner of the operational Sabre was the XF-86, first flown Oct. 1, 1947, by North American Aviation test pilot George Welch. A few months later, Welch became the first pilot to fly the plane at Mach 1 in routine flight. Although technically rated as subsonic, the Sabre was no stranger to supersonic speeds.

Various models of the Sabre held world speed records for six consecutive years, setting five official records and winning several National Aircraft Show Bendix Trophies.

In September 1948, an F-86A set the Sabre's first official world speed record of 671 mph (1,080 kph). This mark was bettered in 1952 by an F-86D that flew at 698 mph (1,123 kph). The D became the first model of a fighter to better its own record, in 1953, with a run of 715 mph (1,151 kph).

The F-86E and subsequent models incorporated a unique control system, developed by North American, called the "all-flying tail." The F-86A contained a booster control system that called for the pilot to do part of the work of controlling the aircraft, whereas the newer system added full power-operated control for better maneuverability at high speeds. An "artificial feel" was built into the aircraft's controls to give the pilot forces on the stick that were still conventional but light enough for superior combat control.

U.S. production of the F-86 ended in December 1956.

Technical Specifications	
First flight	Oct. 1, 1947 (prototype XF-86)
First delivery	Feb. 9, 1951
Span	37 feet
Length	37 feet
Height	14 feet
Wings	Spar, ribs and covering: aluminum
Speed	565 knots (650 mph) Class
Range	Approx. 870 nautical miles (1,000 statute miles)
Service ceiling	Over 45,000 feet
Power plant	General Electric 5,200-pound thrust J-47-13 turbojet
Combat weight	14,000 pounds
Armament	Six .50-caliber machine guns, 16 five-inch HVAR rockets or 2,000 pound max. bomb load
Special features	- Swept-back wing and tail - Electrically operated flaps - Hydraulically operated speed brakes - Automatic wing leading-edge slats - Hydraulic-power-operated irreversible controls with artificial feel for the all-movable horizontal tail and ailerons

Technical Specifications	
First flight	Jan. 26, 1945
Wingspan	40 feet 9 inches (wings folded, 16 feet 3 inches)
Length	38 feet 9 inches
Height	14 feet 2 inches
Weight	10,035 pounds
Speed	500 mph (max.)
Ceiling	41,100 feet
Range	695 miles
Accommodation	One crew
Armament	Four 22 mm cannons
Power plant	Two 1,600-pound thrust Westinghouse J30-WE-20 turbojets

FH-1 Phantom I

Historical Snapshot

On New Year's Eve, 1942, the U.S. Navy Bureau of Aeronautics called James S. McDonnell, founder of McDonnell Aircraft Corp., offering the company a contract to design and build the first American jet fighter capable of taking off from and landing on an aircraft carrier. McDonnell signed a letter of intent to develop the experimental, or "X," jet aircraft on Jan. 7, 1943.

The Navy wanted a single-seat, jet-propelled, low-wing monoplane. Two years later, in January 1945, Woodward "Woody" Burke piloted the XFD-1 prototype on its first flight at Lambert Field in St. Louis, Mo. The XFD-1 was still in development when World War II ended, but the Navy decided that development could go forward.

McDonnell named his new jet fighter "Phantom." McDonnell chose the name from a list of 19 entities from the spirit world — including future products Banshee and Goblin.

The XFD-1, McDonnell wrote, with a speed of 500 mph (800 kph), would "appear and disappear like an apparition."

On the morning of July 21, 1946, the XFD-1 Phantom roared 400 feet (120 meters) down the deck of the USS Franklin D. Roosevelt, a then–recently commissioned U.S. Navy aircraft carrier. The Phantom's pilot, Lt. Cdr. James T. Davidson, climbed quickly portside, circled the carrier and then landed. It marked the first takeoff and landing of a jet-powered aircraft from the deck of a U.S. aircraft carrier.

Davidson made five takeoff and landings and completed a successfl wave-off at 95 mph (150 kph). Later that day, he flew the Phantom to the Naval Air Test Center at Patuxent River, Md.

The XFD-1, later redesignated the FH-1 Phantom, ushered in a new era of naval aviation. McDonnell Aircraft produced 62 FH-1s. It was the first U.S. Navy airplane to fly 500 mph (804 kph), the first all jet airplane to operate from the deck of a U.S. aircraft carrier, and the first jet fighter to serve with both to serve with both the Navy and Marines.

Technical Specifications

First flight	Sept. 11, 1946
FJ-3 span	37 feet 1 inch
FJ-3 length	37 feet 7 inches
FJ-3 height	13 feet 8 inches
FJ-3 gross weight	Approx. 18,000 pounds
FJ-3 power plant	Wright J-65 Sapphire
FJ-3 speed	Over 650 mph
FJ-3 armament	Four 20 mm cannons

FJ Fury Fighter

Historical Snapshot

The North American Aviation FJ Fury series of U.S. Navy carrier-based fighter jets, an almost unknown twin of the famous F-86 Sabre, helped lead the Navy through the transition from piston-powered fighter planes to high-performance jets.

In 1944, to counter the growing threat of German jets, the U.S. military enlisted North American Aviation to develop a common jet-powered fighter plane to be used by both the Navy and the Army Air Force. The planes were designated XFJ-1 Fury for the Navy and XP-86 Sabre for the Air Force. At that time, the Navy used a different designation system that not only identified the mission of the airplane (F for "fighter") but also identified the manufacturer—"J" being the Navy code for North American, which was a holdover from one of NAA's predecessor companies Berliner-Joyce. In 1962, when a common designation system was adopted for all U.S. military airplanes, the FJ series became the F-1.

The XFJ-1 was first to fly. The plane borrowed the wings and tail from the successful design of the P-51 Mustang but featured a fuselage where the pilot sat above the air intake, giving the airplane a rotund appearance.

While the XFJ-1 was being evaluated, captured German data on the swept wing arrived at North American and was applied to the XP-86, sending it on a divergent develop path and creating an airplane that would become a legend in the skies over Korea.

The Navy chose to stay with the straight-winged FJ-1 because of the low-speed handling necessary to land on its carriers that were built to operate World War II piston aircraft. Thirty FJ-1s were built, and in 1948 they became the first jets to operate in squadron strength from an aircraft carrier.

The FJ-1 was soon eclipsed by the McDonnell F2H Banshee and Grumman F9F Panther, and by 1949 they were transferred to the Navy reserve. When war broke out on the Korean peninsula in June 1950, it was not long before naval aviators flying Banshees and Panthers found themselves outclassed when they encountered the Soviet-built MiG-15 swept-wing fighter. The Navy once again turned to North American.

North American's F-86 was able to match and defeat the MiG-15, and the company developed a version of the F-86E modified for carrier operations. It included a lengthened nose gear, folding wings, and an arrestor hook, plus the six .50 caliber machine guns were replaced with four 20 mm cannons. The Navy ordered 200 of the planes, designated FJ-2.

North American further modified the FJ-2 with a 7,700-pound-thrust (3492-kilogram-thrust) British Sapphire engine built under license by Curtiss-Wright. In March 1952, the Navy order 389 of these more powerful jets, designating them the FJ-3, and later, in March 1954, added an order for 149 more. The first production FJ-3 flew from North American Aviation's Columbus, Ohio, plant on Dec. 11, 1953.

At that time, North American Aviation's engineers in Columbus were working on an all new Fury, known as the FJ-4, with the first one flying Oct. 28, 1954.

The FJ-4 "Fury Four" was a major redesign with a new fuselage, thinner wider area wings, thinner tail surfaces and a 50 percent increase in internal fuel capacity.

The Navy ordered 152 FJ-4s and then placed an order for 222 of the follow-on FJ-4B. The FJ-4B, the last of the Furies, featured a strengthened wing with six hard points, which added a low-level ground attack capability to the fighter.

The FJ-4 went on its last operational in 1962 and continued in reserve squadrons well into the 1960s. In all, Columbus delivered 1,112 Furies to the U.S. Navy and Marine Corps, making the Fury a very successful program—especially in a market with tremendous competition, going up against companies that were synonymous with carrier aviation such as Douglas, Chance Vought, Grumman and McDonnell. The Fury had done its job of introducing high-performance swept-wing jets to carrier aviation and paved the way for supersonic jets such as the F-4 Phantom.

Technical Specifications

First launch	April 23, 1959
Span	12 feet 2 inches
Length	42 feet 6 inches
Height	9 feet 4 inches
Gross weight	10,000 pounds
Range	700 miles
Speed	1,200 mph
Engine	One 7,500-pound-thrust Pratt & Whitney J52 turbojet
Operating altitude	200 to 56,200 feet
Armament	Thermonuclear warhead

GAM-77/AGM-28 Hound Dog Missile

Historical Snapshot

The Hound Dog, originally designated B-77, was redesignated GAM-77 and then became the AGM-28. North American Aviation designed the missile so that two could be carried on specially modified B-52s, one beneath each wing. The navigation systems of the B-52 and the GAM-77 were integrated so that the B-52 navigator could cross-check data with the automated system in the Hound Dogs.

Named after a hit song by Elvis Presley, the AGM-28 Hound Dogs were air-launched supersonic missiles designed to destroy heavily defended ground targets. The Hound Dog missile program began on March 15, 1956, when the U.S. Air Force issued a requirement for an air-to-surface missile to be carried on the B-52 bomber. North American won the contract on Oct. 16, 1958, and delivered the first production model to Gen. Thomas S. Power, commander in chief of the Strategic Air Command (SAC), on Dec. 21, 1959, in a ceremony at North American's Downey, Calif., plant.

The first launch of the missile from a B-52 took place in April 1959. By the end of 1959, the Air Force had approved 29 B-52 squadrons to be equipped with Hound Dog missiles.

No AGM-28s were ever used in combat, but on a typical mission, an AGM-28 would be launched at an altitude of 45,000 feet (13,700 meters), climb to more than 56,000 feet (17,068 meters), cruise to the target area and then dive to the target. The missile allowed standoff launches hundreds of miles from the target, reducing risk to the launch aircraft.

In 1960, the SAC developed a method for using the missiles' jet engines to provide extra power for the B-52 carrier in flight or during takeoff. The missiles could then be refueled in flight from the bomber's fuel tanks.

The AGM-28B, incorporating an improved guidance system and with greater range, first flew in May 1961. Before production ended in 1963, almost 700 AGM-28s were built. The last AGM-28s were removed from service in 1975 and scrapped three years later.

GBU-15/AGM-130 Weapon System

Historical Snapshot

The Guided Bomb Unit-15 (GBU-15) modular weapon system is combat-proven, precision-guided and capable of destroying a variety of heavily defended targets. The GBU-15 can deliver either an MK-84 2,000-pound (907-kilogram) general-purpose bomb or a BLU-109B 2,000-pound (907-kilogram) penetrating bomb with pinpoint accuracy by data link control, from low to high altitude, at a significant standoff distance. The GBU-15 is equipped with either a television or an imaging infrared seeker. It was developed by North American Rockwell's Autonetics division and first flown in 1975.

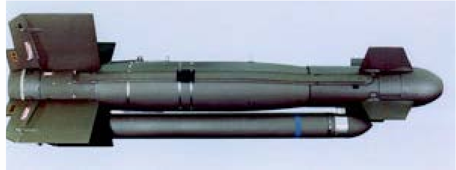
The seeker provides the launch aircraft with visual presentation of the target and surroundings as seen from the weapon. During free flight, this presentation is transmitted by a two-way data link system to the aircraft cockpit television monitor.

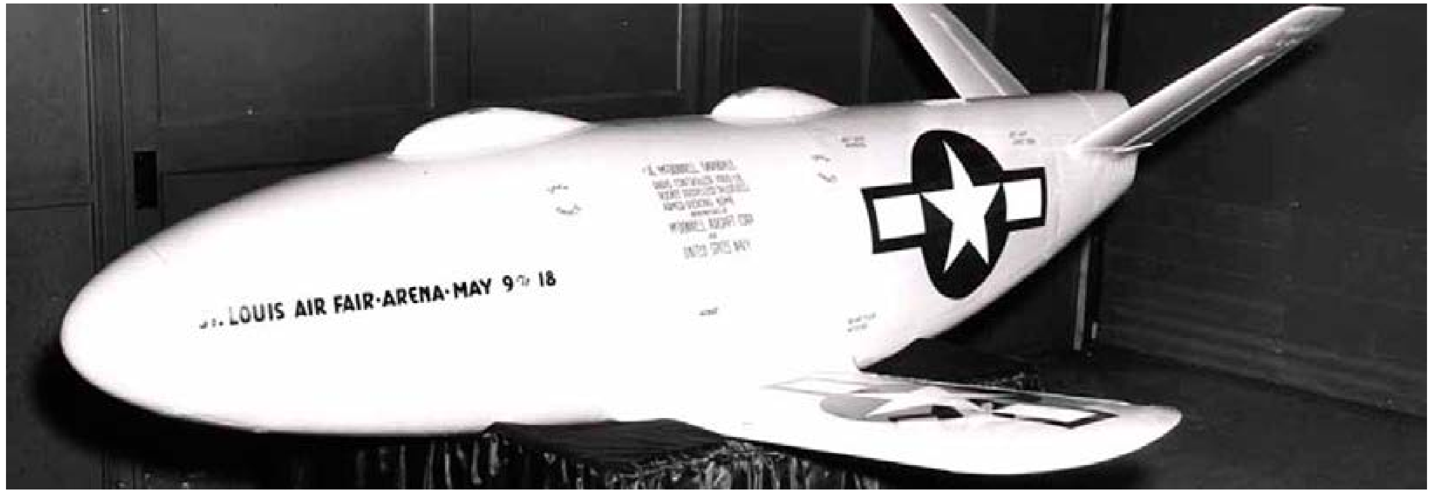
The seeker can be either locked onto the target before or after launch for automatic weapon guidance or manually steered by the weapon systems operator.

Carrying forward the modular concept of the GBU-15 guided weapon system, the AGM-130A employs a rocket motor for extended range and an altimeter for altitude control. This powered version of the GBU-15 provides a significantly increased standoff range.

The AGM-130 has two variants: the AGM-130A with a MK-84 blast/fragmentation warhead and the AGM-130C with a BLU-109 penetrator. In June 1997, an AGM-130 standoff missile successfully demonstrated increased capability during a U.S. Air Force mission at Eglin Air Force Base in northwest Florida. The updated AGM-130 was configured to allow it to be used against targets such as buried bunkers and roofs of buildings.

On Sept. 21, 1998, The Boeing Company tested a turbojet engine to extend the range of the AGM-130 standoff weapon system. The turbojet motor reached 100 percent thrust starting at the six-seconds-after-release point and traveled approximately 102 nautical miles (189 kilometers) from release, with a flight time of more than 11 minutes.





Technical Specifications

First flight	March 1945
Model number	KSD-1 (RTV-N-2)
Length	10 feet 2 inches
Wingspan	8 feet 6 inches
Weight	1,500 pounds
Speed	600 mph
Range	5 miles
Propulsion	Aerojet 8AS100 solid-fueled rocket
Warhead	1,000-pound armor-piercing

Gargoyle Missile

Historical Snapshot

In 1944, McDonnell won the contract to build the radio-controlled, rocket-propelled, air-to-surface Gargoyle missile for the U.S. Navy. The missile was intended to counter German-guided anti-ship glide bombs from carrier-based aircraft. The LBD-1 Gargoyle glide bomb was to be equipped with a 1,000-pound (454-kilogram) armor-piercing warhead.

The Gargoyle's Aerojet solid-propellant rocket booster allowed it to reach a high diving speed. A bright flare in its tail allowed operators to monitor its progress and correct its trajectory by radio. It was 10 feet, 2 inches (3.1 meters) long by 1 foot, 8 inches (0.5 meters) in diameter, with an 8-foot, 6-inch (2.6-meter) wingspan.

Glide tests of the LBD-1 began in March 1945, followed by the first-powered flights in July. The Gargoyle was redesignated as a KSD-1 anti-shipping missile in 1945, but World War II ended before it was deployed. It then became a research vehicle and designated KUD-1, which first flew in July 1946.

McDonnell produced 250 Gargoyles before production ended in mid-1947. The remaining missiles, redesignated as RTV-2 in September 1947 and RTV-N-2 in early 1948, were used to test components for other guided-missile programs. In December 1950, the program was officially terminated and surviving missiles were scrapped.

Technical Specifications	
First flight	Jan. 13, 1946 (first stable flight: July 18, 1946)
Model number	600 to 602
Classification	Missile
Length	16 feet
Diameter	10 inches
Booster weight	Up to 6,000 pounds
Top speed	1,500 mph
Ceiling	59,000 feet
Power	Rockets, ramjet engine

Ground-to-Air Pilotless Aircraft Missile

Historical Snapshot

Immediately after World War II, GAPA (for "Ground-to-Air Pilotless Aircraft") was the first Boeing missile and pioneered the company's efforts in rocket-propulsion technology. GAPA was a slim, two-stage missile that traveled at supersonic speeds.

Its mission was to intercept aircraft flying up to 700 mph (1,126 kph) at altitudes of 8,000 feet (2,438 meters) to 60,000 feet (18,288 meters). GAPA was tested using both solid- and liquid-fuel rockets as well as ramjet propulsion systems. The first flights used early radar guidance systems. Later versions had a target seeker and used solid-fuel rockets in combination with ramjet power.

Nov. 15, 1949, a GAPA reached 59,000 feet (17,983 meters), the highest altitude for a supersonic ramjet of the time. Although it was never used as a defensive weapon, GAPA provided the basis for Bomarc missiles.

Technical Specifications	
First flight	July 1979
Span	15.6 feet
Length	22.5 feet
Height	4.3 feet
Speed	Supersonic
Maneuvering	8g performance
Launch weight	3,400 pounds
Engine	General Electric J85-21

HiMAT Research Vehicle

Historical Snapshot

The HiMAT program was designed to enhance transonic maneuverability of the future U.S. fighter aircraft of the 20th century. The subscale aircraft bridged the gap between wind tunnel testing, simulators, ground tests and full-scale manned flight testing.

Rockwell, the prime contractor, developed and built two HiMAT aircraft and delivered them to NASA, who performed the first flight in July 1979. The HiMAT program represented a $17 million investment in application of advanced technology by NASA and the Air Force Flight Dynamics Laboratory. The flight test program was carried out at NASA's Hugh L. Dryden Flight Research Center, in Edwards, Calif.

HiMAT was launched from a B-52 at about 45,000 feet (13,716 meters). Unmanned, HiMAT was controlled by a NASA test pilot from the ground facility. The ground cockpit contained the normal flight controls — throttle, stick, rudder pedals and sensor displays. A computer converted the pilot's actions into electronic signals telemetered to the craft, where an onboard computer sent signals through the digital fly-by-wire system to the flight control surfaces. Telemetry equipment aboard HiMAT relayed thousands of bits per second of real-time flight data back to ground computers. The flight duration allowed multitask research missions to be performed. Landings on the dry desert lakebed were made on skid-type landing gear similar to that used by the record-setting Rockwell X-15 rocket-powered research airplane.

The craft was capable of speeds of more than 1-1/2 times that of sound. HiMAT was designed to demonstrate maneuvering performance 60 percent better than advanced fighters. The main emphasis during flight testing was on high-G maneuvers in the transonic flight regime (600 to 800 mph, or 965 to 1,287 kph), where superior performance is the most difficult and significant.

HRP-1 Helicopter

Historical Snapshot

The HRP-1 was the world's first successful tandem-rotor helicopter. It led to the development of the Boeing Chinook family of aircraft that would serve in many nations into the 21st century.

Frank Piasecki's P-V Engineering Forum produced the HRP during World War II. The company then became the Piasecki Helicopter Corp., and after Piasecki left the company in 1955, it became the Vertol Aircraft Corp., purchased by Boeing in March 1960.

During World War II, single-rotor helicopters were limited by their small payload and cramped passenger compartments, so the U.S. government asked for development of a twin-rotor helicopter that could carry troops and equipment into the battlefield. On Jan. 1, 1944, the contract went to Frank Piasecki on the basis of a demonstration of his experimental single-seat PV-2 helicopter at National Airport in Washington, D.C. Also designated internally as the PV-3, it was the world's largest helicopter at the time, with enough room for eight passengers and a two-person crew.

Originally nicknamed the "dogship" because it was a test vehicle, the U.S. Navy designated the PV-3 the XHRP-X (experimental helicopter transport, Piasecki model one), and the official Navy prototypes were designated XHRP-1. Then, the aircraft was nicknamed the "flying banana," a name that stuck with the HRPs as well as the later H-21 series.

The XHRP-X had a lightweight, steel-tube truss frame and a fixed tricycle landing gear. The pilot occupied the front seat of the two tandem seats for the crew. At first, the pilots were protected by a Plexiglas windscreen. Later, a fabric covering increased the forward speed and enclosed the crew. A single Continental R-975 engine, located in an aft compartment, powered the two three-bladed rotors of the helicopter.

The XHRP-X made its first flight on March 7, 1945. In 1946, Piasecki renamed his company Piasecki Helicopter Corp. and completed two refined versions for the Navy: the XHRP-1 as a flying prototype and a pre-production sample of the HRP-1 Rescuer. By mid-1947, production had begun on 20 HRP-1s. Three went to the U.S. Coast Guard in 1948 and the rest to the Navy and Marine Corps. The HRP-1s served with Marine helicopter squadron HMX-1 to develop vertical assault tactics.

Technical Specifications	
First flight	March 7, 1945
Manufacturer	Piasecki
Designation	HRP-1
Classification	Rescue helicopter
Rotor diameter	41 feet
Height	14 feet 11 inches
Fuselage length	47 feet 1 inch
Fuel capacity	100 gallons
Top speed	98 mph
Cruising speed	74 mph
Sea-level climb	650 fpm
Range	140 miles
Empty weight	5,200 pounds
Gross weight	6,900 pounds
Hover ceiling	8,500 feet
Power	One 600-hp Pratt & Whitney R-1340-AN-1 engine
Accommodation	2 crew, 8 passengers

The first recorded search-and-rescue mission carried out by a Coast Guard HRP-1 occurred on Dec. 31, 1948. The Search and Rescue office at Elizabeth City, N.C., received a request to transport a 14-month-old baby girl, who was suffering from pneumonia, from a remote location at Cape Hatteras, N.C., to the hospital at Elizabeth City. A local newspaper report noted, "Thanks to the Coast Guard, the girl is alive today."

The next variant was the HRP-2, with a metal fuselage and an improved fuselage layout. Five of these went to the Coast Guard. In 1953, the HRP-2's new fuselage was adapted to the highly successful H-21 airframe. The HRP also inspired the compact HUP series of fleet utility helicopters used throughout the 1950s, the massive YH-16 flying crane, the Boeing CH-46 Sea Knight and the CH-47 Chinook.

HUP-1 Retriever/H-25 Army Mule Helicopter

Historical Snapshot

The HUP-1 Retriever was a tandem-rotor, single-engine rescue and utility helicopter built by Piasecki Helicopter Corp., predecessor to Vertol Aircraft Corp., which was purchased by Boeing in March 1960.

The rugged HUP was built to higher load factors than previous helicopters in the United States and was the first helicopter to perform a loop, although unintentionally, when demonstrating its “g” capabilities. The HUP-2 was the first production helicopter to be equipped with an autopilot, which enabled hands-off flying, including hovering.

Frank Piasecki designed the HUP-1 to meet a 1945 Bureau of Aeronautics requirement for a utility helicopter based on U.S. Navy aircraft carriers for search and rescue, plane guard and general transportation duties. The proposed aircraft was given the working designation PV-14, and two XHJP-1 prototypes were completed for Navy evaluation.

The overlapped tandem design provided a compact fuselage and rotor system so that the HUP-1 could go down any aircraft carrier elevator without folding its blades. Its fuselage was an all-metal, semi-monocoque construction with conventional fixed landing gear. The cockpit had side-by-side seating with dual controls. The cabin contained about 160 cubic feet (48 cubic meters) of space for passengers or cargo.

The copilot’s seat folded forward and an electrically operated hatch door lowered to drop a rescue sling from an overhead hoist for a live rescue without crew assistance; the hydraulic hoist could lift up to 400 pounds (181 kilograms). A litter could be lifted directly into the cabin. For easier maintenance, the engine, its mount, fan cowling, oil system and accessories could be removed as one unit through an overhead hatch in the rear fuselage.

The two three-bladed rotors, which overlapped for maximum compactness and maximum lifting efficiency, were driven through two transmissions and were counter-rotated to eliminate torque.

In 1948, work began on 32 PV-18s, or HUP-1 Retrievers. The major change was the addition of inward sloping endplate fins to the horizontal stabilizers below the rear rotor head. Successful tests with a Sperry autopilot in the XHJP-1 allowed the next model, the HUP-2, which first flew in 1948, to be built without tail surfaces. The HUP-2, used the more powerful Continental R-975-42 engine.

Technical Specifications	
First flight	October 1948
Manufacturer	Piasecki
Designation	HUP-1/2/3/4/H-25
Classification	Military helicopter
Mission	Rescue, utility
Rotor diameter	35 feet
Fuselage length	32 feet
Max. speed	108 mph
Cruising speed	84 mph
Range	360 miles
Empty weight	4,100 pounds
Useful load	1,650 pounds
Ceiling with normal load	10,200 feet
Power	550-hp Continental R975-42 radial engine
Accommodation	2 crew, 4 to 7 passengers

The HUP-2 entered service with the U.S. Navy and Marine Corps in 1949. Variants with the Navy included 12 HUP-2S submarine-hunting aircraft with dunking sonar equipment and an HUP-2 with a sealed, watertight hull and outrigger twin floats for waterborne tests.

In 1951, the U.S. Air Force, on behalf of the U.S. Army, ordered a version of the HUP-2 for general support and evacuation work that had a reinforced cabin floor and hydraulically boosted controls. Seventy of these were delivered as H-25A Army Mules as were 50 similar Navy HUP-3s, including three for the Royal Canadian Navy, for ambulance and light cargo duties.

A total of 339 HUP-1/2/3/4/H-25 helicopters went to the U.S. Army and Navy, the Royal Canadian Navy and the French Navy. Over their 20 years of service life, these helicopters were responsible for saving countless lives. The last HUP left the production line in July 1954. It continued to serve with the French Navy until 1965.

IM-99A/B Bomarc Missile

Technical Specifications	
First flight	Feb. 24, 1955
Military designation	IM-99A/IM-99B
Classification	Missile
Wingspan	18 feet 2 inches
Diameter	35 inches
Length	45 feet
Approx. takeoff weight	16,000 pounds
Top speed	More than Mach 2.5
Range	More than 400 miles (IM-99B)
Ceiling	More than 80,000 feet
Power	50,000-pound-thrust solid-fuel rocket (takeoff); two 12,000-pound-thrust Marquardt ramjet engines (cruise)
Armament	Nuclear warhead

Historical Snapshot

The supersonic Bomarc missiles (IM-99A and IM-99B) were the world's first long-range anti-aircraft missiles and the first missiles that Boeing mass-produced. Boeing also designed and built the launch facilities. This ambitious program established Boeing as a leader in large-scale systems integration.

In 1949, because of the Soviet Union's nuclear weapons program and its long-range bombers that could reach the United States, the U.S. Air Force authorized Boeing to proceed with research into a new supersonic anti-aircraft missile. Two months after the go-ahead, the Michigan Aeronautical Research Center (MARC) was added to the research project — which was then labeled "Bomarc," combining the names Boeing and MARC.

In January 1951, Boeing was awarded a contract to develop the missile, which was given the designation XF-99. At that time, these missiles were considered pilotless aircraft, since their mission was to intercept enemy bombers, and they were given an "F," for "fighter," designation. Later, the Air Force refined its designation system, and the Bomarc became the IM-99 (interception missile). The first of the XF-99 research missiles flew on Sept. 10, 1952.

The first production model of the Bomarc was the IM-99A, which first flew on Feb. 24, 1955. The IM-99A was powered by an Aerojet General liquid-fueled rocket motor that boosted the missile to near supersonic speed. At that speed, twin Marquardt ramjet engines, attached by pylons to the underside of the missile, propelled the missile to its target at Mach 2.5 to a range of 250 miles (400 kilometers).

One major issue with the early Bomarc was the main booster's highly corrosive liquid rocket fuel. This fuel could not be stored on board the missile and had to be loaded before launch, a process that added nearly two minutes to the missile's launch time.

The solution was to replace the liquid-fueled motor with a large solid-fuel booster. The result was the much safer and better-performing IM-99B Super Bomarc, which had a response time of less than 30 seconds. The B model had increased range of 440 miles (710 kilometers). While its stated cruise speed was Mach 2.5, the B model had been tested to speeds of Mach 4 and was effective from sea level to 100,000 feet (30,480 meters).

Between 1957 and 1964, Boeing built 570 production missiles (269 production IM-99As and 301 production IM-99B missiles) and another 130 for various tests. The missiles were housed on a constant combat-ready basis in individual launch shelters in remote areas. They used analog computers, some of which were built by Boeing and had been developed for ground-to-air pilotless aircraft (GAPA) experiments during World War II.

Bomarc was integrated into the centralized command-and-control air-defense system for Canada and the United States, known as SAGE (semi-automatic ground environment). The system would guide the Bomarc to incoming targets until the missile's own seeker could lock on to a target and detonate the missile's warhead at the closest point of pass or on impact.

Bomarc was a successful program that met all of its original objectives, but the nature of the nuclear threat changed from primarily bombers to ballistic missiles. In 1970, Congress declared that a continental U.S. air defense missile system was no longer necessary, and on Oct. 1, 1972, the last Bomarc was retired from service.

Technical Specifications	
Power plant	One Armstrong Siddeley Adder (ASA.1) turbojet powered by a Armstrong Siddeley Viper
Span	5.8 meters (19 feet)
Length	7 meters (22 feet, 11 inches)
Height	2.08 meters (6 feet, 10 inches)
Empty weight	1,315 kilograms (2,900 pounds)
Loaded weight	1,656 kilograms (3,650 pounds)
Maximum speed	908 kph (564 mph)
Range	1,000 kilometers (621 miles)
Service ceiling	17,375 meters (57,000 feet)
Armament	No offensive armament; reconnaissance hardware and defensive flares

Jindivik Target Drone

Historical Snapshot

In March 1948, Australia and the U.K. entered an agreement to develop a remotely controlled target drone as part of a larger guided-missile testing program to benefit the Royal Australian Air Force (RAAF) and the British Ministry of Supply. The drone was named Jindivik, an Aboriginal name meaning "the hunted one." The design called for a pilotless target aircraft to fly a 15-minute attack over a maximum range of 1,000 kilometers (621 miles).

The Government Aircraft Factories (GAF) at Fishermans Bend, with support from the Aeronautical Research Laboratory, led the design, and research and development towards the Jindivik. Ian Fleming, who had studied at the University of Sydney and Cambridge, was the chief designer and later became General Manager of the GAF after his success designing the Jindivik.

The design included a turbojet engine aboard an aircraft guided by radar. In the nose cone was a large transmitter that received commands from a grounded pilot at a nearby radar station or a shepherding aircraft. The Department of Supply conducted the research and development towards the indigenously designed and manufactured Jindivik. GAF delivered the first Jindivik, the Mk 1, in October 1951. GAF built 12 Mk 1s before modifying the Jindivik to include an Armstrong Siddeley Viper ASV.3 turbojet, renaming the aircraft the Mk 2. During this time, Rolls-Royce acquired Armstrong Siddeley. The Viper flew on all subsequent Jindiviks, ending with the Mk 201.

On Aug. 28, 1952, GAF flew the Jindivik for the first time at Evetts Fields near Woomera Test Range. Flown by the RAAF Air Trials Unit, the first flight was a success. The Jindivik took off from a recoverable trolley propelled by a disposable Armstrong Siddeley Adder ASA.1 turbojet engine. The Jindivik's maximum flight of 1,000 kilometers (621 miles) concluded by landing on a skid. The first deliveries to the RAAF and to Britain followed shortly after with later orders received from the U.S. and Sweden, earning GAF $34 million in sales between 1952 and 1977, with the last delivery in 1986.

In total, 502 Jindiviks were produced between 1952 and 1986, and again in 1997 when the U.K. placed another order for 15 Jindiviks. The Jindivik provided a variety of military applications, given its ability to fly low and high altitudes. The Jindivik was capable of carrying camera systems for reconnaissance and serving as a physical decoy while also projecting decoy radio frequencies to counter enemy tracking systems. The Jindivik could also trail smoke and carried countermeasure flares for live fire tests. These capaabilities made the Jindivik a formidable test target against aircraft such as the A-4 Skyhawk armed with Sidewinder missiles. The Jindivik was an effective enemy simulator vehicle, often evading Sidewinders flying as high as 17,375 meters (57,000 feet) and as low as just meters above the sea or land.

The Jindivik ended service in 1998 with a highly successful service record. Designed to be expendable, many Jindiviks actually flew multiple times. The Jindivik served with four different militaries for several decades.

Technical Specifications

First contract	1988
Model number	JDAM
Function	Common, low-cost guidance control unit for MK-83/BLU-110, MK-84 and BLU-109
Airframe	Maneuverable with full jettison and release envelope

Joint Direct Attack Munition

Historical Snapshot

The Joint Direct Attack Munition (JDAM) is a low-cost guidance kit that converts existing unguided free-fall bombs into accurately guided "smart" weapons. The JDAM kit consists of a new tail section that contains an inertial navigation system/ global positioning system (INS/GPS) and body strakes for additional stability and lift. Bombs can be accurately delivered in any weather conditions and be launched at a great distance from the target, and the navigation system can be relied on to update the weapon all the way to impact.

Boeing heritage company McDonnell Douglas Corp. developed the JDAM kits under a contract first awarded in 1988. The Boeing facility in St. Charles produces more than 40 JDAM kits every day. On Aug. 20, 2013, Boeing marked its production of the 250,000th kit.

The U.S. Air Force, U.S. Navy and the militaries of more than 26 additional countries employ JDAM. Its first operational use was during Operation Allied Force in the Balkans in 1999. JDAM has been used extensively in Operation Enduring Freedom (OEF) and Operation Iraqi Freedom (OIF) and most recently in NATO's Operation Unified Protector in Libya.

The Laser Joint Attack Direct Munition (Laser JDAM) expanded the capabilities of the JDAM. Because of its modular design, an affordable laser sensor kit can be installed on an existing JDAM in the field within minutes. In addition to the all-weather GPS/INS capability that conventional JDAMs offer, Laser JDAM adds the ability to prosecute targets of opportunity, including mobile and maritime targets.

Laser JDAM is operational on U.S. Air Force F-15E and F-16 and U.S. Navy F/A-18 and A/V-8B platforms, and it is also used by six other countries. Boeing completed the Laser JDAM development and testing cycle in less than 17 months and delivered the first production Laser JDAMs to the U.S. Air Force in May 2008.

In August 2012, Boeing announced that a winged version of the JDAM will triple the weapon's glide range to more than 40 miles (64 kilometers) had been developed in partnership with the Commonwealth of Australia. The 500-pound (226-kilogram) JDAM Extended Range (JDAM-ER) features a modular add-on wing kit that will unfold in flight. The kit can also be coupled with other modular enhancements, such as laser sensors. Boeing said it would produce and integrate wing kits in-country for the Royal Australian Air Force.

Technical Specifications

First contract	August 2000

Joint Helmet Mounted Cueing System

Historical Snapshot

The Boeing Joint Helmet Mounted Cueing System (JHMCS) combines a magnetic head tracker with a display projected onto a pilot's visor, giving the pilot a targeting device that can be used to aim sensors and weapons wherever the pilot is looking. It does so by synchronizing aircraft sensors with the user's head movements so they automatically point where the pilot looks and displaying flight information on the inside of the helmet visor so data is always in view.

To aim and fire a missile, pilots point their heads at the targets and press a switch on the flight controls to direct and fire a weapon. To attack a ground target, pilots can acquire the target with a sensor and note its location on the helmet display. Alternatively, pilots can use the helmet display to cue sensors and weapons to a visually detected ground target.

In a dual-seat aircraft, each crewmember can wear a JHMCS helmet and perform independent operations with continuous awareness of where the other crewmember is looking.

The high off-boresight seeker (HOBS) system consists of the JHMCS and the AIM-9X high off-boresight air-to-air missile. The AIM-9X is an advanced short-range dogfight weapon that can intercept airborne targets located at high off-boresight lines of sight relative to the shooter. The combination of JHMCS and AIM-9X results in a weapon that can attack and destroy an airborne enemy seen by the pilot. This weapon can be employed without maneuvering the aircraft, minimizing the time spent in the threat environment.

In July 2000, Boeing received U.S. Navy approval for JHMCS to proceed into low-rate initial production and deliver 36 systems as part of the F/A-18E/F Super Hornet aircraft that would be delivered in fiscal year 2002.

The Navy began F/A-18E/F Super Hornet flight testing of the JHMCS in April 2001.

On Aug. 29, 2003, the U.S. Department of Defense (DOD) awarded Boeing a $24 million contract to produce 100 JHMCS destined for the U.S. Air Force F-15 and F-16 aircraft and the Navy's F/A-18E/F aircraft.

DOD contracts for full production followed in February and June 2004 for U.S. Air Force and Air National Guard F-15 Eagles and Air Force F-16 Fighting Falcons, along with U.S. Navy F/A-18E/F Super Hornets.

The system's first operational use was during Operation Iraqi Freedom. Customers for the system include Australia, Belgium, Canada, Chile, Denmark, Finland, Greece, Korea, the Netherlands, Norway, Oman, Poland, Turkey and Switzerland.

In 2012, Boeing validated the integration of the next-generation Joint Helmet Mounted Cueing System II/h (JHMCS II/h) on the company's F-15 Silent Eagle demonstrator aircraft.

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KC-135 Stratotanker

Historical Snapshot

The KC-135 was the first offspring of the Dash 80. It was designed specifically for aerial refueling and for 15 years was the only tanker used by the Strategic Air Command. More than 600 of the 732 tankers built were still in service in the mid-1990s.

The KC-135 replaced the propeller-powered KC-97 tankers, which could no longer keep up with the jet fighters and bombers. In 1956, when the first KC-135 — nicknamed "The City of Renton" — rolled out of the plant, it shared the Renton tarmac with the last KC-97, providing a vivid picture of The Boeing Company's complete conversion to jet power.

During nine years of the Vietnam conflict, KC-135s made 813,000 aerial refuelings of combat aircraft. During the Persian Gulf War, the tankers made 18,700 hookups and transferred 278 million pounds (126 million kilograms) of fuel.

A total of 820 C/KC-135s were built in Renton, Wash., through 1966: 732 as aerial tankers and 88 modified for special purposes, including cargo carriers, reconnaissance airplanes, Strategic Air Command airborne command posts and transports for high-ranking government officials.

Boeing modifications that extended service capabilities of the KC-135s included re-skinning the wings with an improved aluminum alloy and installing new, more powerful and fuel-efficient engines. Two re-engined KC-135Rs could do the work of three KC-135As.

On Feb. 24, 2011, Boeing announced that it had received a contract from the U.S. Air Force to build the next-generation aerial refueling tanker aircraft, the KC-46, based on the Boeing 767 commercial airplane, to replace 179 of the service's 400 KC-135 tankers.

Technical Specifications	
First flight	Aug. 31, 1956
Model number	KC-135 (military designation)
Classification	Military tanker-transport
Span	130 feet 10 inches
Length	136 feet 3 inches
Gross weight	297,000 pounds
Top speed	600 mph
Cruising speed	552 mph
Range	5,000 miles
Ceiling	41,000 feet
Power	Four 13,750-pound-thrust P&W J57 turbojet engines
Accommodation	4 crew, 80 troops

LGM-30 Minuteman Missile

Historical Snapshot

In 1955, the Soviet Union successfully tested a hydrogen bomb, and in 1957 it launched the Sputnik satellite, surpassing the United States in rocket technology. Fearing that the Soviet Union had the ability to attack the United States with intercontinental ballistic missiles (ICBM), the United States made development of a reliable, rapid-response ballistic missile the highest priority.

On Feb. 27, 1958, the U.S. Air Force received approval from the Department of Defense to begin research and development on the new missile designated Weapon System 133-A, called the "Minuteman." The design called for a three-stage, solid-fueled missile that was to be extremely reliable, quick to launch, have maximum simplicity and a high capability for survival, and be able to remain on alert in its silo 24 hours a day, 7 days a week for many years.

On Oct. 9, 1958, the Air Force announced its selection of Boeing as assembly and test contractor for the Minuteman missile, beginning one of the most complex, largest and longest running programs in Boeing history. At its peak, it would employ 39,700 people located at Boeing sites in Seattle and at the missile final assembly site at Plant 77 in Ogden, Utah.

Boeing teamed with nine other industry contractors — including North American Aviation's Autonetics Division, based in Anaheim, Calif. — to build, test and deploy the missiles. In 1996, Autonetics joined The Boeing Company as part of the Boeing acquisition of Rockwell International's aerospace and defense businesses.

The first launch of a Minuteman was conducted at Cape Canaveral, Fla., on Feb. 1, 1961. Within a month, construction began on the first base for the missile. On Nov. 17, 1961, the first successful launch from a silo occurred.

The first operational Minuteman site was Malmstrom Air Force Base, Mont., where the first 10-missile "flight" was rushed into activation on Oct. 27, 1962, at the height of the Cuban Missile Crisis. President Kennedy referred to the missiles as his "ace in hole" during the historic standoff with the Soviet Union.

Technical Specifications	
First flight	Feb. 1, 1961
Military designation	LGM-30A/B/F/G
Classification	Intercontinental ballistic missile
Diameter	6 feet
Length	- LGM-30A: 50 feet - LGM-30B: 55 feet 9 inches - LGM-30F: 59 feet
Weight at first-stage interstage	- LGM-30A/B: 65,000 pounds - LGM-30F: 70,000 pounds - LGM-30G: 76,000 pounds
Top speed	More than 15,000 mph
Range	More than 6,000 miles
Payload	Nuclear warhead
Power	Three solid-fuel rocket engines
Launcher dimensions	80 feet deep, 12 feet in diameter; each site surface area 2 to 3 acres

Within five years, 1,000 missiles were operational in Montana, Missouri, North Dakota, South Dakota and Wyoming. Each Minuteman was housed in its own hardened underground launch silo, which was approximately 80 feet (24 meters) deep and 12 feet (4 meters) in diameter. The company built, installed and maintained the missiles in their silos and trained Air Force personnel involved in the program.

Minuteman II, first launched in 1964, was capable of striking targets with far greater accuracy than its predecessor. The next version, Minuteman III, was first launched in 1968, with greater accuracy, range and target capability.

The last Minuteman III was delivered from Plant 77 on Nov. 30, 1978. In all, Boeing had deployed 150 Minuteman IA, 650 Minuteman IB, 500 Minuteman II, and 550 Minuteman III missiles. Minuteman III missiles are part of the United States Strategic Command that also includes the Navy's Ohio class fleet of ballistic missile submarines and Air Force's B-2 and B-52 bombers.

The Minuteman program established Boeing as a leader in large-scale system integration. Today, the combined heritage of the Minuteman programs of Boeing and Autonetics continues as Boeing Strategic Deterrence Systems (SDS), supporting the Air Force with system evaluation, testing, training and modernization.

Technical Specifications	
First flight	July 19, 1957
Model number	MB-1, AIR-2A
Classification	Air-to-air missile
Length	9 feet 8 inches
Diameter (body)	17.5 inches
Finspan	3 feet 4 inches (fins extended)
Weight	822 pounds
Speed	Mach 3
Range	6 miles
Propulsion	Thiokol SR49-TC-1 (model TU-289) solid-fueled rocket; 162 kN (36,500 lb)
Warhead	W-25 nuclear fission (1.5 kT)

MB-1/AIR-2 Genie Missile

Historical Snapshot

The Genie was the world's first nuclear-armed air-to-air weapon and was the most powerful interceptor missile ever deployed by the U.S. Air Force.

In 1954, Douglas Aircraft Co. began work on a small unguided nuclear-armed air-to-air missile and started full-scale development a year later. In 1955 and early 1956, F-89D Scorpion aircraft made the first test firings. The top-secret project had several code names, including "Bird Dog," "Ding Dong" and "High Card." Finally, it was designated MB-1 and called the "Genie." The MB-1 became operational in 1957, and the first and only live firing of a nuclear Genie was July 19, 1957.

Powered by a Thiokol SR49 solid-fueled rocket motor, it was armed with a 1.5-kiloton nuclear warhead and had flip-out fins for flight stability. F-89J, F-101B and F-106A interceptors carried the Genie. The firing aircraft had to pull away in a sharp turn to escape the blast after launching the weapon, a challenging feat.

In June 1963, the Genie rockets were designated in the AIR-2 series. The MB-1 became the AIR-2A, the MB-1-T was the ATR-2A, and the MMB-1 was the AIR-2B. The training rocket was officially designated ATR-2A and also known as ATR-2N.

Douglas built more than 1,000 Genie rockets before terminating production in 1962. However, in 1965, Thiokol began producing a motor for the AIR-2 with a longer lifespan and wider firing temperature limits. After the mid-1970s, upgraded Genie rockets were designated AIR-2B. The Air Force removed the last AIR-2 rockets from the inventory during the early 1980s.

Technical Specifications	
Power plant	One turbojet SNECMA Atar gC engine
Span	8.22 meters (27 feet)
Length	15.03 meters (46 feet, 4 inches)
Height	4.5 meters (14 feet, 9 inches)
Empty weight	7,050 kilograms (15,542 pounds)
Loaded weight	13,700 kilograms (30,203 pounds)
Maximum speed	2,716.56 kph (1,688 mph)
Range	2,408 kilometers (1,496 miles)
Service ceiling	17,000 meters (55,776 feet)
Armament	Two 30-millimeter cannons and up to 3,992 kilograms (8,800 pounds) of various external ordnance

Mirage III Fighter

Historical Snapshot

In 1952, the French government issued a call to the French aviation industry for a jet-powered interceptor fighter aircraft. Paris-based Avions Marcel Dassault (now Dassault Aviation) answered with a proposal for the Mystère-Delta MD550 and began flight testing the aircraft in 1953. Yet, this Mirage predecessor fell short of required weight and speed specifications. Dassault kept the delta-wing design, but altered the engine configuration, which led to the Mirage III 001. The Mirage III design included a Snecma Atar 101 turbojet engine, and was later accepted by the Armée de l'Aire (French Air Force). The French Air Force was particularly concerned about cost and weight of aircraft, as the Cold War battlefield featured more sophisticated, faster competition.

The Mirage III flew for the first time at Melun-Villaroche on Nov. 17, 1956, with Roland Glavany in the cockpit. Glavany was among Dassault's most experienced test pilots having World War II flight experience, flying missions to Corsica, Elba, and Provence. After the war, he earned his engineering degree from France's prestigious Institut Supérior de L'aéronautique. His first assignment as a test pilot was the Mirage I and Mirage III. A year after Glavany's flights, the French government purchased its first Mirage IIIs from Dassault following an impressive showing at the Paris Air Show.

Dassault produced the first Mirage IIIA in May 1957; this Mirage was essentially designed as an all-purpose aircraft, given the French Air Force's limited financial resources. In May 1958, again with Glavany at the controls, the Mirage IIIA achieved the first Mach 2 flight in France. By 1960, Dassault produced several variants of the Mirage III and opened the aircraft to international licensing. The Royal Australian Air Force (RAAF) began its search for a single-seat interceptor aircraft for its arsenal to replace the North American Aviation Sabre. In 1964, Australia set about building the first Mirage IIIs. Government Aircraft Factories (GAF) assembled the aircraft while Commonwealth Aircraft Corp. (CAC) subcontracted to build the wings and other components. Ian Fleming, who designed the Jindivik and became general manager of GAF, facilitated and oversaw the licensing process.

The RAAF received its first delivery from CAC in 1964, and eventually operated three different variants of the Mirage III, including the IIIO(F), IIO(A) and the IIID. The RAAF received 197 Mirage IIIs in total, all built by CAC. The Mirage III served the longest on the frontline than any other fighter in the RAAF (until the F/A-18 entered service) though it never saw combat, despite a deployment to Malaysia in 1967. The Mirage III served in four different squadrons at Base Williamtown.

This long service record was partially due to the fact that it long outlived its estimated design life of 1,500 flight hours. Several Australian Mirages flew well beyond 4,000 flight hours. The RAAF actually planned to phase the Mirage III fleet out by 1979, especially after it was used more than expected. However, the Aeronautical Research Laboratories in Fisherman's Bend extended the aircraft's lifecycle by designing fiber repair patches, which prevented wing cracks from spreading. Thus, the Mirage III served the RAAF nearly a decade longer than planned.

The final Mirage III delivery came in 1979, fulfilling the RAAF plan to begin its phase out. The Mirage III's service to the RAAF ended on Sept. 30, 1988, when many went into storage in Point Cook and Woomera. Pakistan purchased 50 of the 197 Australian Mirages in 1990.

Technical Specifications	
First flight	March 26, 1952
Model number	79
Rotor diameter	27 feet
Length	15 feet 6 inches
Height	8 feet 4 inches
Empty weight	647 pounds
Loaded weight	1,800 pounds
Power plant	Two 8RJ4 ramjet engines
Speed	86 mph

Model 79 Big Henry

Historical Snapshot

In 1950, McDonnell Aircraft Corp. began building its second ramjet-powered utility helicopter, called the Model 79. Nicknamed Big Henry, it was based on the McDonnell XH-20 Little Henry of the late 1940s.

The single test model showed satisfactory flight characteristics during testing, but like its smaller predecessor, Big Henry's ramjet engines were too noisy and used too much fuel. It did not attract a buyer, so the project was abandoned.

Model C Trainer

Historical Snapshot

The Model C two-place training seaplane was the first “all Boeing” design and the company’s first financial success.

A total of 56 C-type trainers were built. Fifty-five used twin pontoons. The Model C-1F had a single main pontoon and small auxiliary floats under each wing and was powered by a Curtiss OX-5 engine.

The U.S. Navy bought 51 of the Model C trainers, including the C-1F, and the Army bought two landplane versions with side-by-side seating, designated the EA.

The final Model C was built for William Boeing and called the C-700 (the last Navy plane had been Navy serial number 699). Boeing and Eddie Hubbard flew the C-700 on the first international mail delivery from Vancouver, B.C., to Seattle, Wash., on March 3, 1919.

Technical Specifications	
First flight	Nov. 15, 1916
Model numbers	2, 3, 5
Classification	Trainer
Span	43 feet 10 inches
Length	27 feet
Gross weight	2,395 pounds
Top speed	72.7 mph
Cruising speed	65 mph
Range	200 miles
Ceiling	6,500 feet
Power	100-horsepower Hall-Scott A-7A engine
Accommodation	2 crew

Technical Specifications	
First flight	April 1, 1935
Span	42 feet
Length	27 feet 7 inches
Weight	3,078 pounds
Power plant	400-horsepower Wright Whirlwind engine
Range	700 miles
Speed	170 mph
Crew	Two

NA-16 Basic Trainer

Historical Snapshot

The last prototype airplane from North American Aviation was the NA-16 trainer. It was initially built at North American's General Aviation Manufacturing Corp., located at the Curtiss-Caproni plant at Dundalk, Md. Later, it was produced in California. The low-wing monoplane had open cockpits in tandem and a fixed, unfaired undercarriage. Made mostly of metal, but with some fabric on the rear fuselage, it was submitted to the U.S. Army Air Corps for evaluation within a month of its first flight.

The design was selected for production as a basic trainer, although the Air Corps requested that the cockpits be enclosed, fairing be installed on the undercarriage and the engine changed to a 600-horsepower Pratt & Whitney R1340 engine. With these modifications, and a new designation of NA-18, the prototype was eventually sold to Argentina.

The production versions launched North American as a manufacturer of training aircraft, starting with 267 BT-9s and 340 BC-1 "basic combat" trainers. In all, more than 17,000 derivatives of the NA-16 were built including 13,685 of the famous T-6/SNJ series built at North American's Los Angeles, Calif., and Dallas, Texas, plants during the 1940s.

Technical Specifications	
First flight	Dec. 22, 1936
Span	95 feet
Length	61 feet 9 inches
Height	14 feet 9 inches
Gross weight	27,253 pounds
Power plant	Two 1,200-hp Pratt & Whitney R-2180-1 Hornet engines with F-10 turbo-superchargers
Speed	220 mph
Range	1,960 miles
Crew	Six
Armament	Five .30-caliber machine guns, up to 10,000 pounds of bombs

NA-21 Bomber Dragon

Historical Snapshot

The experimental NA-21 Dragon was North American Aviation's first venture into multiengine design. It was a high-altitude bomber armed with single 0.30-inch (0.76-centimeter) machine guns in each of five positions, including in a ball-type turret in the nose. The NA-21 could carry 10,000 pounds (4,535 kilograms) of bombs short distances or carry 2,200 pounds (998 kilograms) of bombs for 1,900 miles (3,057 kilometers).

After a few small changes, the NA-21 was accepted for testing at Wright Field — now part of Wright-Patterson Air Force Base — but orders did not follow. The Air Force bought the single NA-21 in 1939 and redesignated it the XB-21.

Technical Specifications	
First launch	November 1951
Length	41 feet
Diameter	31.5 inches
Weight	10,710 pounds
Power	Solid fuel
Speed	2,200 mph
Range	75 miles

Nike Missile

Historical Snapshot

The first Douglas Aircraft Co. Nike Ajax knocked out a target drone in November 1951. It was the first operational ground-based supersonic anti-aircraft missile in the United States and was deployed at sites in a circular pattern around key American industrial and military locations. The first Nike Ajax missile site became operational at Fort Meade, Maryland, in 1954.

The Nike Hercules became operational in 1958, and more than 80 Nike Hercules missiles were deployed in the United States, with 10 more in Europe and Taiwan. It was followed by the Nike Zeus missile, which had a preliminary test firing Aug. 26, 1959, and could fly more than 8,000 mph (12,874 kph).

Nike missiles were launched from a self-contained launch area, and each site had two or three launching platforms. The missiles, stored underground on rails, were brought to the surface by elevators. Once on the surface, they were pushed on rails to an erector and raised to an angle of about 85 degrees for firing.

The Nike missiles used the "command guidance" system, in which the major control equipment was ground based and not part of the expendable missile. A control area, at least 1,000 yards (914 meters) from the launch area, contained separate radars that simultaneously located and tracked both the target and the Nike missile and guided the missile to the target.

All existing U.S. Nike batteries were inactivated Feb. 4, 1974.

Technical Specifications	
Power plant	Two Allison 250-B17B turboprops
Span	16.51 meters (54 feet, 2 inches)
Length	12.57 meters (41 feet, 3 inches)
Height	5.52 meters (18 feet, 2 inches)
Empty weight	2,150 kilograms (4,730 pounds)
Loaded weight	3,855 kilograms (8,500 pounds)
Maximum speed	318 kph (198 mph)
Range	1,463 kilometers (900 miles)
Service ceiling	7,600 meters (25,000 feet)
Armament	None

Nomad Transport and Utility Aircraft

Historical Snapshot

In 1965, the Government Aircraft Factories (GAF) began Project N, which was intended to be a two-engine multipurpose transport plane. The federal government sought a new transport plane for the Army that could also be aimed at the civilian market and would sustain aircraft manufacturing at GAF with the end of Mirage III production. With government funding, GAF developed two prototypes: the N22B became the military transport and the N24 was a longer civilian version.

The Australian Army required a transport aircraft with greater range, two engines, and short take-off and landing (STOL) capabilities. The GAF settled on the Nomad twin-turboprop transport. Early designs, which were later adopted, included a rear-loading access swing door.

GAF aeronautical engineer Alan Wrigley designed the Nomad for several purposes, including surveillance, medical evacuation, personnel and supply transport, and search and rescue. The military variant could carry two crew and 11 passengers, ideally in all weather conditions over particularly rugged terrain, such as that of Papua New Guinea to the north of Australia.

The first Nomad, the military variant N22 (VH-SUP), flew on July 23, 1971, at Avalon airfield in Victoria, with Stuart Pearce at the controls. Pearce was among GAF's most experienced test pilots, having served in the British Royal Air Force, and rose to become the chief test pilot at GAF based at Avalon. Unfortunately, five years later, unresolved issues with the Nomad would cost Pearce his life, and the airworthiness of the Nomad became increasingly apparent.

Early in the Nomad's history, the aircraft experienced several incidents, which quickly gave it a negative reputation regarding safety. During a July 1973 flight from Canberra to Melbourne, both of a Nomad's engines failed due to icing. The GAF pilots glided the aircraft to a landing near Mansfield, Victoria, though the aircraft had sustained major damage. On Aug. 6, 1976, a Nomad prototype crashed while Stuart Pearce and a GAF chief designer studied the aircraft's tailplane flutter, killing both men. Over the course of the aircraft's lifecycle, Nomad-related accidents caused 76 fatalities. The Nomad's aerodynamic instability due to the tailplane structure remained the primary airworthiness concern, which was left largely unrevised by the designers.

Ultimately, the safety concerns led to the end of Nomad production in 1984 at 172, 28 shy of the 200 aircraft economic breakpoint. While the aircraft met many military needs for flight capability and transport, its airworthiness concerns kept it from many potential buyers.

Former Nomad developer and cofounder of Gippsland Aeronautics, George Morgan, considered buying the aircraft certificate and eventually restarting production of the N24A variant. GAF, which later became Aerospace Technologies of Australia, now part of Boeing, sold the certificate to Gippsland. Yet, as of 2017, only one Nomad remained in operation.

Technical Specifications	
First flight	Autumn 1924
Wingspan	39 feet
Length	29 feet 7 inches
Height	10 feet 6 inches
Ceiling	12,275 feet
Range	400 miles
Weight	4,985 pounds
Power plant	433-horsepower Liberty engine
Speed	103 mph
Accommodation	Two
Armament	Two .30-caliber machine guns, 100 pounds of bombs

O-2 Surveillance

Historical Snapshot

The Douglas O-2 observation biplane had longer wings, had lower landing speeds, flew higher and was 22 mph (35 kph) faster than its competitors. The O-2, produced for the U.S. Army Air Service, was the first of a series that remained in production for nine years.

Douglas designed its first experimental observation aircraft, the XO-2, in 1923 and delivered 45 of the first production version, the O-2. On Feb. 16, 1925, a contract was signed for 75 of the O-2 type, the largest single contract in terms of production units the company had yet received.

An O-2BS, made for pilot James Dalzell McKee, after whom the Canadian aviation McKee Trophy is named, made the first single-aircraft, single-pilot flight across Canada. Because of the many Canadian rivers and lakes, twin floats were installed on the landplane. Between Sept. 11 and 19, 1926, McKee flew the 3,000 miles (4,828 kilometers) between Montreal and Vancouver, British Columbia, in 35 hours, 8 minutes, at an average speed of 85 mph (136 kph). The plane later was modified as a three-seater and used by the Canadian government until January 1930 as a high-altitude photographic survey aircraft.

Later O-2 variants had a more streamlined fuselage and a two-blade metal propeller instead of the previous wooden propeller.

Some were modified as basic trainers by adding flight controls and instruments to the rear cockpit.

During the 1920s and early 1930s, the Douglas observation biplanes were among the most important American military aircraft. During the 1934 airmail emergency, when President Franklin Roosevelt directed the Army Air Corps to take over from private contractors because of suspected improprieties in awarding contracts, Douglas biplanes flew the U.S. airmail routes for 78 days. Between 1923 and 1936, the company sold 879 in the series, one as a civil aircraft, 108 to foreign air forces and 770 to the U.S. military services.

Technical Specifications	
First flight	October 1935
Wingspan	45 feet 9 inches
Length	34 feet 6 inches
Height	10 feet 8 inches
Ceiling	24,150 feet
Range	435 miles
Weight	4,776 pounds
Power plant	One 725-horsepower Pratt & Whitney R1535 air-cooled radial engine
Speed	200 mph

O-31/O-35/O-43/O-46A Surveillance

Historical Snapshot

The Douglas Aircraft Corp.'s first observation monoplane was the XO-31, an all-metal, single-engine, straight-wing aircraft that won a contract from the U.S. Army Air Corps on Jan. 7, 1930.

The straight-wing, single-engine O-43 followed the XO-31. It had a deeper fuselage and taller vertical surfaces with an inset rudder. Twenty-four O-43s were built.

Douglas then produced 90 further-improved, single-engine, straight-wing O-46s, built for the U.S. Army Air Corps. The enclosed cockpit O-46 series was the last observation aircraft built by Douglas and was the company's most successful Air Corps program since the O-38 biplane series.

During the same period, Douglas designed the gull-winged, twin-engine XO-35. Similar to its XB-7 bomber counterpart, the XO-35 had two Curtiss Conqueror liquid-cooled engines enclosed in nacelles attached under the wing. The O-35 was never produced in quantity, but six Y1B-7s, serving with the Army Air Corps, delivered airmail to the western zone during the 1934 airmail emergency, when President Franklin Roosevelt directed the Army Air Corps to take over from private contractors because of suspected improprieties in awarding contracts.

O-47 Surveillance

Historical Snapshot

The O-47 observation monoplane began as Model GA-15 because it was on the drawing board in 1934 when General Aviation Manufacturing Corp. evolved into North American Aviation. The single-engine, mid-wing observation monoplane was developed to meet U.S. Army Air Corps requirements and made its first flight designated XO-47. It was of all-metal construction and had retractable landing gear.

The subsequent production model O-47s were built with the North American Aviation designation of NA-25 at the Inglewood, Calif., plant. The O-47As were powered by a 975-horsepower engine, while the subsequent O-47Bs carried more fuel and were powered by a 1,060-horsepower engine. In the O-47, the observer was stationed in a special compartment in the lower fuselage, giving the airplane a swollen appearance.

North American produced 238 O-47s between 1936 and 1939. They saw little operational service, however, after America entered World War II, although a few were used from overseas bases and as submarine patrols off the U.S. coasts. During the war, O-47s were used mainly as trainers and target tugs. After the war, a few O-47Bs were modified as single-seat commercial airplanes with the center and rear seats removed so they could carry cargo.

Technical Specifications	
First flight	November 1935
Span	46 feet 3.6 inches
Length	33 feet 3 inches
Height	12 feet 0.5 inches
Wing area	348.6 square feet
Weight	7,593 pounds loaded
Power plant	975-horsepower R-1820-49 engine
Speed	221 mph maximum; 200 mph cruising
Range	900 miles
Service ceiling	23,200 feet
Crew	Three
Armament	One .30-caliber machine gun in right wing, one flexible .30-caliber machine gun in dorsal mount

OH-6 Cayuse/Hughes 500

Historical Snapshot

The Hughes Tool Company Aircraft Division's entry into the U.S. Army's 1963 light-observation helicopter (LOH) competition was the two-seat Model 369.

Initially called "Loach," an adaptation of its acronym, it was officially called the "Cayuse." It was also known as the "Flying Egg," and when equipped for combat, the helicopters were known as "Killer Eggs."

The modern-day OH-6 variants flown by the U.S. Army's Special Operations Forces are known as "Little Birds," and because of their ability to strike undetected during darkness, gave Task Force 160, later the 160th Special Operations Aviation Regiment (Airborne), the name "Night Stalkers."

The Army initially ordered 1,438 OH-6As for use during the Vietnam War. First flown in February 1963, the OH-6A Cayuse entered service in September 1966, establishing 23 world records for speed, distance and altitude. The Cayuse was Hughes' longest-running helicopter program and, during the Vietnam War, as many as 100 OH-6As were built a month. The OH-6D was an improved version with more advanced electronics and heavier armament.

The OH-6 was also exported as the Model 500 Defender. It served in Granada and Panama during the 1980s, as well as in the Persian Gulf wars, Somalia and the Balkans. The commercial version was the Hughes 500, which became the MD 500 series after McDonnell Douglas acquired Hughes Helicopters in January 1984.

The MD 520N® pioneered the NOTAR® anti-torque system concept that replaces the traditional tail rotor, using compressed air to offset torque instead of a conventional tail rotor. Versions also included the Model 530 Defender, a variant with refined aerodynamics and more power, and the AH-6 Model 530 version for U.S. Special Forces. A NOTAR version of the heavy-lift Model 530 became the MD 530N. Variants included the AH-6J attack helicopter and MH-6J insertion and extraction transport, based on the MD 530F. These featured a more powerful engine and improved avionics, including an embedded global positioning system/inertial navigation system and forward-looking infrared.

Technical Specifications	
First flight	Feb. 27, 1963
Model number	OH-6A/Hughes 500
Classification	Military scout/commercial helicopter
Production	1,434
Power plant	One 317-shaft-horsepower (236-kW) Allison T63-A-5A
Top speed	147 mph
Maximum speed	150 mph at sea level
Initial climb rate	1,840 feet per minute
Service ceiling	15,800 feet
Range	413 miles
Empty weight	1,156 pounds
Max. takeoff weight	2,700 pounds
Rotor diameter	26 feet 4 inches
Length	23 feet
Length overall, rotors turning	30 feet 9.5 inches
Height	8 feet 1.5 inches
Main rotor disc area	544.63 square feet
Accommodation	2 crew, 2 to 4 passengers or 4 armed troops; (500MG) 7 armed troops or 2 stretchers; (600N) 7 to 8 passengers

On Jan. 19, 1999, after the 1997 Boeing merger with McDonnell Douglas, MD Helicopters Holding Inc., an indirect subsidiary of the Dutch company RDM Holding Inc., purchased Boeing's MD 500, MD 600N® and MD Explorer® series of light helicopter product lines, including the MD 500E and MD 530F® single-engine helicopters with conventional tail rotors, the MD 520N and MD 600N single-engine helicopters with the NOTAR system, and the MD Explorer series of twin-engine, eight-place helicopters. Boeing retained rights to the NOTAR system. MD Helicopters Holdings Inc. was recapitalized as an independent company, MD Helicopters, Inc., based in Mesa, Ariz.

By that time, more than 4,700 Model 500-series helicopters had been produced.

OV-10 Bronco Multimission Aircraft

Historical Snapshot

The OV-10 Bronco, a rugged, maneuverable, twin-turboprop, multimission aircraft, served with the U.S. Air Force and Marine Corps (OV-10A). The U.S. Navy also used the OV-10. The Navy squadron VAL-4 Black Ponies flew them with much success in the Vietnam War. Internationally, the OV-10 served with the military services of West Germany (OV-10B), Thailand (OV-10C), Venezuela (OV-10E) and Indonesia (OV-10F).

Designed and built by North American Aviation at Columbus, Ohio, the Bronco was faster and more tactically versatile than helicopters, yet slower and more maneuverable than jets, and could use tactics not possible with either.

The OV-10D night observation system (NOS) featured a unique night observation and target marking system that included forward-looking infrared (FLIR) and laser designator/ranger. With uprated 1040 SHP turboprop engines and fiberglass propellers, NOS provided greater range, improved performance and greater survivability.

In military operations, the Bronco's ability to find and hit battlefield targets close to friendly troops made it effective against conventional and guerrilla forces.

Military applications for which the Bronco was particularly suited include anti-guerrilla operations, helicopter escort, close air support, armed reconnaissance and forward air control. In addition, it could be used for utility missions such as cargo paradrop — delivery of up to six paratroops, medical evacuation, smoke screening and psychological warfare with leaflets and loudspeakers.

For peacetime operations, the guns, bomb racks and armor could be removed quickly, and the aircraft became a high-performance short takeoff and landing utility vehicle. Potential applications included aerial mapping, geological survey, spraying, disaster relief and patrol work.

Technical Specifications	
First flight	July 16, 1965
Span	40 feet (12.2 meters)
Length	41 feet 7 inches (12.7 meters)
Height	15 feet 1 inch (4.6 meters)
Weight	Empty: 7,190 pounds (3,261 kilograms); maximum take-off gross weight: 14,444 pounds (6,552 kilograms)
Power plant	Two Garrett-AiResearch turboprop engines, T76-G-412 and T76-G-413, 715 shaft horsepower each
Maximum speed at sea level	244 knots (452 kilometers/hour)
Range	700 nautical miles (1,297 kilometers) with internal fuel; 1,200 nautical miles (2,224 kilometers) with 150-gallon (568-liter) drop tank
Service ceiling	28,800 feet (8,778 meters)
Fuel	Five self-sealing fuel tanks in wing: 252-gallon capacity (954 liters); 150-, 230- or 300-gallon (568-, 871-, or 1,136-liter) external tank
Crew	One pilot and one observer (removable rear seat for greater fuselage cargo capacity)
Armament	Centerline station for 20 mm gun pod, or stores; four 7.62 mm M60C machine guns in sponsons; four sponson stations for rockets, miniguns or stores; two wing stations for rockets or missiles
Mission performance	5.5 hours loiter time with 150-gallon (568-liter) drop tank; 50 nautical miles (93 kilometers) and 2 hours loiter time with full ordnance load
Equipment	Zero-speed, zero-altitude escape seats; air-to-air and air-to-ground communication systems
Landing gear	Trailing arm articulating with two-stage air-oil telescoping shock absorbing struts
Cargo bay	75 cubic feet (2.1 cubic meters) with rear seat; 110 cubic feet (3.1 cubic meters) with rear seat removed

Civil action applications added significantly to the Bronco's cost-effectiveness.

The Bronco's fuselage was mounted under the wing and provided tandem seating for pilot and observer. Its canopy design afforded better visibility than that of most helicopters. Each crewman was equipped with an LW-3B ejection-seat system, also designed and built at Columbus, which was capable of zero-speed, zero-altitude ejections.

Armor protection, a bullet-resistant windshield and self-sealing fuel cells were provided for operations in a hostile

OV-10 Bronco Multimission Aircraft (cont'd)

environment. Twin engines, dual manual flight controls, and rugged and simple construction also contributed to survivability and safety.

The OV-10 was equipped with seven external store stations and four 7.62 mm guns installed in the sponsons. A variety of conventional ordnance could be delivered in addition to 2,000 rounds of ammunition.

The seven external store stations consisted of four sponson store stations, one centerline station and two external wing stations. Sponson accessibility provided rapid loading of stores and ammunition. The wing stations could carry the LAU-7/A launcher for mounting either rocket packages or missiles. The centerline store station could also carry either a 20 mm gun pod or a 150-, 230- or 300-gallon (568-, 871- or 1,136-liter) external fuel tank.

Removal of the armament sponsons and the backseat with its associated armor enabled a quick and simple conversion to a civil action configuration, which permitted the carrying of 3,200 pounds (1,452 kilograms) of cargo in the aft fuselage.

For operation in remote areas, the Bronco had a specially designed rough field landing gear, required no ground equipment for starting and could be maintained with simple hand tools. In the event of an emergency, the Bronco could use high-octane or automotive fuel in place of jet fuel with only a slight degradation of power.

P-12/F4B Fighter

Historical Snapshot

Early in 1928, Boeing built two new fighter biplanes using bolted aluminum tubing for the fuselage's inside structure, rather than welded steel tubing, typical of earlier models. Later versions had aluminum covering the fuselage rather than fabric or wood.

Model 83, designed for the Navy, had a hook-type arrester so that it could land on aircraft carriers. Its production version was designated F4B. The Model 89, built for the Army as the P-12, could hold a 500-pound (226-kilogram) bomb.

The military bought 586 of these fighters in different versions. The first was delivered to Army Air Corps Captain Ira C. Eaker on Feb. 26, 1929, for a special goodwill flight to Central America. Later, Brazil became an international customer for the fighters.

Boeing built four commercial versions of the model; the U.S. Bureau of Air Commerce, precursor to the Federal Aviation Agency, bought one, and Howard Hughes bought a two-seat version.

Technical Specifications	
First flight	June 25, 1928
Model number	83/89
Classification	Fighter
Span	30 feet
Length	20 feet 1 inches
Gross weight	2,629 pounds
Top speed	178 mph
Cruising speed	150 mph
Range	675 miles
Ceiling	26,200 feet
Power	450-horsepower P&W R-1340B Wasp engine
Accommodation	1 pilot
Armament	2 machine guns

P-26 Peashooter Fighter

Historical Snapshot

The all-metal, single-wing P-26, popularly known as the "Peashooter," was an entirely new design for Boeing, and its structure drew heavily on the Monomail. The Peashooter's wings were braced with wire, rather than with the rigid struts used on other airplanes, so the airplane was lighter and had less drag. Its initial high landing speeds were reduced by the addition of wing flaps in the production models.

Because the P-26 flew 27 mph (43 kph) faster and outclimbed biplane fighters, the U.S. Army ordered 136 production-model Peashooters. Acclaimed by pilots for its speed and maneuverability, the small but feisty P-26 formed the core of pursuit squadrons throughout the United States.

Twelve export versions, 11 for China and one for Spain, were also built. One of a group of P-26s, turned over to the Philippine Army late in 1941, was among the first Allied fighters to down a Japanese airplane in World War II.

Funds to buy the export version of the Peashooter were partly raised by Chinese Americans. Contribution boxes were placed on the counters of Chinese restaurants.

Technical Specifications	
First flight	March 20, 1932
Model number	248/266
Classification	Fighter
Span	28 feet
Length	23 feet 7 inches
Gross weight	2,995 pounds
Top speed	234 mph
Cruising speed	200 mph
Range	635 miles
Ceiling	27,400 feet
Power	600-horsepower P&W Wasp engine
Accommodation	1 pilot
Armament	2 machine guns, 200-pound bomb load

P-51 Mustang Fighter

Historical Snapshot

A veteran of World War II and the Korean War, North American Aviation's P-51 Mustang was the first U.S. built fighter airplane to push its nose over Europe after the fall of France. Mustangs met and conquered every German plane from the early Junkers to the sleek, twin-jet Messerschmitt 262s.

Although first designed for the British as a medium-altitude fighter, the Mustang excelled in hedge-hopping strafing runs and long-range escort duty. It made a name for itself by blasting trains, ships and enemy installations in Western Europe and by devastating Axis defenses before the Allied invasion of Italy.

The Mustang was the first single-engine plane based in Britain to penetrate Germany, first to reach Berlin, first to go with the heavy bombers over the Ploiesti oil fields in Romania, and first to make a major-scale, all-fighter sweep specifically to hunt down the dwindling Luftwaffe.

One of the highest honors accorded to the Mustang was its rating in 1944 by the Truman Senate War Investigating Committee as "the most aerodynamically perfect pursuit plane in existence."

The North American prototype, NA-73X, was first flown on Oct. 26, 1940. At least eight versions of the Mustang were produced.

Technical Specifications	
First flight (XP-51)	May 20, 1941
Wingspan	37 feet
Wing area	233 square feet
Length	32 feet
Horizontal stabilizer span	13 feet
Height	8 feet 8 inches
Power plant	Packard V-1650 "Merlin" 1,695-hp V-12
Speed	425 mph indicated (490 mph in P-51H)
Landing gear	Hydraulically operated retractable main gear and tail wheel
Propeller	Hamilton Standard, four-blade, hydraulic, constant speed, 11 feet 2 inches, non-feathering
Radar	Warning radar in tail to signal approach of other craft from rear (later models)
Armament	(Various models) 10 "zero rail" rockets under wings; six .50-caliber machine guns; bomb racks for up to 1,000 pounds of stores or extra fuel tanks under the wings

Technical Specifications	
First flight	June 15, 1945
Span	51 feet 3 inches
Length	39 feet
Power plant	Two Allison 12-cylinder V-1710-G6 engines
Speed	475 miles per hour
Range	1,600 miles
Service ceiling	42,200 feet
Armament	- Six .50-caliber machine guns standard - Eight additional .50-caliber machine guns in special center section nacelle - Five rocket-launching racks, carrying five rockets each - Other alternate payload: 7,200 pounds of bombs, photographic nacelle or 2,000-pound torpedo
Number built	272

P-82 Twin Mustang Fighter

Historical Snapshot

Once the standard long-range, high-altitude escort fighter for the U.S. Air Force, the North American Aviation P-82 Twin Mustang was the climax of the famous World War II P-51 Mustang series.

North American produced 250 of the double-fuselage airplanes for the Air Force, embracing three versions of the Twin Mustang then in service, the P-82E, P-82F and P-82G. They were ordered too late for World War II, however.

The versatile P-82 made it potentially adaptable to a wide variety of roles—fighter, long-range escort, long-range reconnaissance aircraft, night fighter, attack bomber, rocket fighter and interceptor.

With a speed of more than 475 mph (764 kph), the Twin Mustang had a combat range of more than 1,600 miles (2,574 kilometers) with full armament. Range could be extended by use of external drop tanks on the wings.

A radical departure from the conventional single-fuselage airplane, the Twin Mustang was formed by two fuselages joined by the wing and the horizontal stabilizer. With a pilot in each fuselage, it reduced the problem of pilot fatigue on ultra-long-range missions. The P-82F and G models carried a radar operator in the right cockpit instead of a co-pilot.

Both engine throttles and both propellers were controllable from either cockpit by manually operated levers. The pilot's cockpit on the left contained the normal flight and engine instruments, while the co-pilot on the right had sufficient instruments for relief and emergency operation. A simplified cockpit arrangement improved pilot comfort, including a tilting, adjustable seat to reduce fatigue during long flights.

PW-9/FB Fighter

Historical Snapshot

The Model 15 (PW-9) was the first successful Boeing-designed fighter and established the company as a major American builder of military aircraft.

Its internal bracing was arc-welded tubing rather than the spruce and wire used in older biplanes. However, it still had wooden spars and ribs. It was designated PW-9 (for "pursuit water-cooled design 9") by the U.S. Army and designated FB-1 by the Navy.

Between 1923 and 1928, Boeing built 157 PW-9/FBs in different versions, as well as 77 derivatives as NBs (Navy training planes). The NBs were 4 feet (1.21 meters) longer than the PW-9/FBs and powered by either 180- or 200-horsepower engines. Included in the 77 were five NBs that Boeing sold to Peru.

Technical Specifications	
First flight	June 2, 1923
Model number	15
Classification	Fighter
Span	32 feet
Length	23 feet 5 inches
Gross weight	3,120 pounds
Top speed	159.1 mph
Cruising speed	142 mph
Range	390 miles
Ceiling	18,925 feet
Power	435-horsepower Curtiss D-12 engine
Accommodation	1 pilot
Armament	One .30-caliber machine gun and one .55-caliber machine gun or two .30-caliber machine guns, two 122-pound bombs

Technical Specifications	
First flight	Jan. 4, 1996
Classification	Armed reconnaissance helicopter
Length	42 feet 10 inches
Weight	10,597 pounds
Dash speed	201 mph
Cruising speed	190 mph
Maximum range	1,449 miles
Power	Two 1,432-shaft-horsepower T800-LHTEC-801 turboshaft engines
Rotor system	Five-bladed bearingless main rotor and FANTAIL anti-torque system
Armament	Stowable three-barrel 20 mm Gatling gun
Accommodation	2 crew

RAH-66 Comanche Helicopter

Historical Snapshot

The Comanche was a twin-turbine, two-seat (tandem) armed reconnaissance helicopter with projected missions of armed reconnaissance, light attack and air combat.

Boeing and the Sikorsky Aircraft Corp. teamed to develop and build the RAH-66 Comanche armed reconnaissance helicopter in 1991. Other team members included Hamilton Standard, Harris Corp., Hughes Link Training Division, Kaiser Electronics, Lear Astronics, Litton, Lockheed Martin, Moog, Sundstrand Corp., TRW Military Electronics and Avionics Systems Group, and Williams International. Allison Engine Co. and AlliedSignal Engine Co. co-developed the engines for the Comanche.

Designed to replace the Army's then current Vietnam War-vintage scout and light attack helicopter fleet, the Comanche featured an all-composite fuselage, fully integrated digital flight controls, and advanced navigation and weapons systems. It was designed to provide U.S. forces with accurate, timely tactical intelligence.

The Comanche program validated a number of aircraft systems and components and built and flew two flight-test prototype aircraft in its demonstration, validation and prototype phase from contract award in 1991 through 2000. The engineering and manufacturing development phase began in mid-2000. During that time, the program was slated to build and deliver 13 new Comanches for additional flight tests and U.S. Army operational test, evaluation and training.

First deliveries were scheduled for 2006, with the Comanche program reaching full production by about 2010. Plans were to manufacture 1,213 RAH-66s for U.S. Army service. The Army canceled the program in February 2004 as a part of a reorganization of Army Aviation.

The two protoypes are now in the collection of the U.S. Army Aviation Museum at Fort Rucker, Ala.

SBD/A-24 Dauntless Dive Bomber

Historical Snapshot

The Douglas Aircraft Co. SBD Dauntless dive bomber became a mainstay of the U.S. Navy's World War II air fleet in the Pacific, with the lowest loss ratio of any U.S. carrier-based aircraft. Douglas delivered a total of 5,936 SBDs and U.S. Army Air Forces A-24s between 1940 and the end of production in July 1944.

The Dauntless was developed at the Douglas Northrop facility at El Segundo, Calif., and was based on the Northrop Model 8 attack bomber developed for both the Army and the export market.

The SBD Dauntless featured "Swiss cheese" flaps—dive brakes punched with 3-inch holes—so that it could achieve pinpoint accuracy by diving to the target, dropping the bomb and then pulling out of the near-vertical dive.

In addition to the U.S. Navy, Marine Corps and Army Air Forces, the Dauntless served air forces in New Zealand and Mexico.

The first enemy ship sunk by the U.S. Navy in World II is credited to a Dauntless from the USS *Enterprise*. The diving Dauntless went on to destroy 18 enemy warships, including a battleship and six carriers.

Technical Specifications	
First flight	May 1, 1940
Wingspan	41 feet 6 inches
Length	33 feet
Height	12 feet 11 inches
Ceiling	27,100 feet
Range	1,205 miles
Weight	9,353 pounds
Power plant	1,200-horsepower Wright R-1820-60 engine
Speed	252 mph
Accommodation	Two crew
Armament	2,250-lb bomb load; two fixed, forward-firing .50-caliber machine guns and one or two flexible, belt-fed .30-caliber machine guns mounted in rear cockpit

Technical Specifications	
First flight	April 2002
Type	Autonomous unmanned reconnaissance vehicle
Length	5 feet
Wingspan	10 feet
Altitude	15,000 feet and low altitudes
Endurance	24+ hours
Payload	Electro-optic or infrared camera

ScanEagle Unmanned Aerial Vehicle

Historical Snapshot

ScanEagle is an autonomous unmanned aerial vehicle (UAV), part of ScanEagle® Unmanned Aircraft Systems, developed and built by Insitu Inc., a wholly owned subsidiary of The Boeing Company. The UAV is based on Insitu's SeaScan miniature robotic aircraft developed for the commercial fishing industry.

ScanEagle carries an electro-optic or a dual imager in a gyro-stabilized turret. The camera has full pan, tilt and zoom capabilities and allows the operator to track both stationary and moving targets. ScanEagle vehicles can operate above 15,000 feet (4,572 meters) and loiter over a battlefield for extended missions of up to 20 hours, depending on system configuration. The five-foot-long (1.5-meter-long) ScanEagle UAV has a 10-foot (3-meter) wingspan and can operate in land and maritime environments. Its modular design allows integration of new payloads and sensors and ensures the vehicle will be able to incorporate new technology as it becomes available.

ScanEagle's modular design further supports system upgrades, including expanded payload options; an improved, purpose-built propulsion system; a fully digital video system for improved image quality; an environment of reduced electro-magnetic interference; and an improved navigation system.

ScanEagle is launched autonomously by a catapult launcher and flies preprogrammed and operator-initiated missions. The patented SkyHook® recovery system is used for retrieval. SkyHook catches the aircraft's wingtip with a rope that hangs from a 50-foot-high (15-meter-high) boom.

The prototype ScanEagle made its first flight in 2002. In August 2003, ScanEagle A demonstrated its long-endurance capability with a 15-hour flight at the Boeing Boardman test range in Oregon. The flight was also the first time the test team put two UAVs in the air simultaneously. The first ScanEagle monitored the second, sending real-time video to the ground station.

In 2004, ScanEagle was deployed to Iraq with the First Marine Expeditionary Force, operating as a forward observer to monitor enemy concentrations, vehicle and personnel movement, buildings and terrain. In April 2005, the U.S. Navy signed a $14.5 million contract with Boeing and Insitu and in September of the same year, the Navy awarded a $13 million contract modification to provide ScanEagle system support for Navy high-speed vessels and an afloat forward staging base (AFSB).

ScanEagle sets the global standard for both turn-key ISR services and system sales for land and maritime operations. ScanEagle has completed and continues to support worldwide operations with more than 50 land deployments in more than a dozen countries. As the industry leader in maritime ISR operations, Insitu ScanEagle systems have completed and continue to support more than 40 ship-based deployments on 19 separate ship classes ranging in size from fast boats to AFSB ships. This deployed work has culminated in more than 870,000 hours of operational time and experience.

A total of 19 international customers include the military forces of Australia, Canada, Italy, Japan, the Netherlands, Singapore, Spain and the United Kingdom. Civilian and commercial uses have included forest fire monitoring in Olympic National Park, a railway monitoring demonstration for BNSF Railway as part of the FAA's Pathfinder Program, a search and rescue demonstration for the U.S. Coast Guard over the Arctic Ocean, and ice floe monitoring for oil rigs off of Alaska's North Slope.

ScanEagle Unmanned Aerial Vehicle (cont'd)

In 2011, Insitu donated a ScanEagle unmanned aircraft that had supported Canadian Forces for more than 2,000 hours in Iraq and Afghanistan to the Canada Aviation and Space Museum in Toronto. In 2012, Insitu donated the historic ScanEagle aircraft that was part of a rescue mission to free Capt. Richard Phillips from Somali pirates to the Museum of Flight in Seattle.

In April of 2015, Boeing acquired 2d3 Sensing, officially making it part of Insitu. Specializing in motion imagery processing of critical intelligence, surveillance and reconnaissance data generated from aerial platforms, 2d3's products are used in Insitu unmanned systems, including ScanEagle. Now known as Mission Systems Programs, these information processing technologies and capabilities can now be further integrated into Insitu and Boeing platforms.

Stearman Kaydet Trainer

Technical Specifications

First flight	Nov. 26, 1934 (Model 73)
Model number	Wichita 75
Classification	Trainer
Span	32 feet 2 inches
Length	24 feet 3 inches
Gross weight	2,717 pounds
Top speed	124 mph
Cruising speed	106 mph
Range	505 miles
Ceiling	11,200 feet
Power	220-horsepower Continental R-670-5 piston radial engine (PT-17)
Accommodation	Two crew

Historical Snapshot

The Kaydet, the two-seater biplane introduced by the Stearman Aircraft Division of Boeing in Wichita, Kan., in 1934, became an unexpected success during World War II. Despite its almost obsolete design, its simple, rugged construction made it ideal as a trainer for novice pilots for the U.S. Army Air Corps (PT-13/-17) and Navy (NS/N2S).

The Kaydets had fabric-covered wooden wings, single-leg landing gear and an over-built welded-steel fuselage. Only radial engines were used. Between 1936 and 1944, Boeing built 8,584 Kaydets, in all versions, plus the equivalent of 2,000 more in spares.

Kaydets were widely used airplanes. In addition to sales to the U.S. Navy and the Army Air Corps, the trainers were sold to Canada, China, the Philippines, Venezuela, Argentina and Brazil for both military and civilian uses. Many were still in service in the early 1990s. Their slow, low-level flying capabilities made them particularly suitable for crop dusting and spraying.

T-2 Buckeye Trainer

Historical Snapshot

First flown in 1958, T-2 Buckeye (its original designation was T2J-1) jet trainer aircraft were produced for the U.S. Navy by North American Aviation at Columbus, Ohio. T-2 trainers were used by the Naval Air Training Command to conduct basic jet flight training for future Navy and Marine Corps aviators. The trainer established an outstanding record of safety and reliability while providing training for more than 11,000 students to pilot 18 different models of Navy jet aircraft. Buckeyes also were purchased by Venezuela (T-2D) and Greece (T-2E).

The two-place, high-performance T-2 Buckeye was used for a wide variety of pilot training, from the student's first jet flight to fully qualified flight. The aircraft was used for teaching a wide range of skills, including high-altitude, high-speed formation and aerobatic flights; basic and radio instruments; night and day navigation; and gunnery, bombing and carrier operations.

The Buckeye had a tandem seating arrangement with the rear seat elevated to provide student and instructor pilot with excellent visibility. The front and rear cockpits had duplicate controls, allowing control of the aircraft from either cockpit. The rocket-catapult ejection seats provided emergency escape capabilities from ground level to 50,000 feet (15,240 meters) at speeds from 63 mph (101 kph) to 604 mph (972 kph).

The flying characteristics, control response, low stall speed and good stability of the T-2 combined to provide the qualities required of a good training aircraft. In addition, the T-2 was a rugged, versatile and forgiving aircraft. The wide-tread tricycle landing gear provided excellent control during takeoff and landing. The thrust-to-weight ratio and high limit load factor provided performance capabilities equal to many jet tactical aircraft. The airframe was constructed to withstand carrier landings, inadvertent high g-loads and rough landings encountered during student training.

Ground-level maintenance was emphasized throughout the design of the Buckeye. Convenient access to installed components, grouped at waist level or lower, eliminated the need for workstands and ladders for most maintenance. Large quick-opening doors provided ready access to equipment.

Engine access was direct and simple. Two forward clamshell doors could be quickly opened to expose engine accessories. Opening three doors on one side permitted complete removal and installation of an engine. The engines were suspended from the primary fuselage structure, thereby eliminating the need for a fuselage field break. All primary servicing procedures, including single-point refueling, could be performed from ground level.

The versatility of the T-2 as a weapons trainer was demonstrated by the capability to install many types of practice stores and packages on the wing store stations. These stores and packages included bombs, air-to-air and air-to-ground rockets, gun pods, and aerial tow targets. An armament accessory kit was available that provided six store stations instead of two, thus making the Buckeye an excellent light-attack aircraft in addition to its training role.

Technical Specifications	
First flight	Jan. 31, 1958
Span	38.13 feet (11.6 meters)
Length	38.70 feet (11.8 meters)
Height	14.80 feet (4.5 meters)
Weight	Empty: 8,115 pounds (3,681 kilograms); take-off gross weight: 13,179 pounds (5,978 kilograms)
Power plant	Two J85-GE-4 engines, each rated at 2,950 pounds (1,338 kilograms) maximum thrust (standard day at sea level)
Max. speed at sea level	465 knots (862 kilometers/hour)
Range	930 nmi (1,723 kilometers) (10% reserve)
Service ceiling	45,200 feet (13,777 meters)
Crew	Instructor pilot, student pilot
Fuel	- Fuselage tank: 387 gallons (1,465 liters) - Wing tip tanks: 102 gallons (386 liters) each tank - Wing leading edge: 50 gallons (189 liters) each wing
Armament	- Two 320-pound (145 kilograms) capacity underwing store stations - 50-caliber gun package - Bomb racks - Rocket packs - Tow target containers - Fire control package (baggage compartment) - An armament accessory kit was available that provided six store stations
Landing gear	Tricycle; hydraulic retracted; conventional air/oil shock strut

Technical Specifications	
First flight	Sept. 24, 1949
Span	40.6 feet
Length	34.3 feet
Height	12.6 feet
Weight	8,247 pounds
Power plant	Wright R-1820, 1,425 horsepower
Speed	346 mph
Altitude	35,000 feet
Landing gear	Tricycle

T-28 Trojan Trainer

Historical Snapshot

The North American Aviation T-28 was a basic trainer that was ordered in three advanced versions, the T-28A for the U.S Air Force and T-28B and T-28C, by the U.S. Navy, with the latter version designed for carrier operation. It was the first trainer designed to transition pilots to using jet aircraft.

Originally, it was powered by a Wright R-1300 engine with a rating of 800 horsepower, a top speed of 285 mph (459 kph) and a service ceiling of 29,000 feet (8,839 meters). New versions carried a Wright R-1820 engine with a rating of 1,425 horsepower, a top speed of more than 345 mph (555 kph) and a 37,000-foot (11,278-meter) ceiling.

The T-28B and T-28C could handle accessory kits providing for bombs, rockets and machine guns.

1,194 T-28As were delivered to the U.S. Air Force and the Navy ordered 792 T-28s, 299 of which were T-28Cs that included an arrester hook for carrier landings. Some versions of the T-28 were adapted to more extensive military operations by other countries.

T2D-1 Torpedo Bomber

Historical Snapshot

The Douglas T2D-1 (the name indicated it was the second Douglas Torpedo, first version) was the first twin-engine Douglas airplane and the first twin-engine aircraft designed to operate from the decks of aircraft carriers. When fitted with floats, it also could take off from water. Twelve of these torpedo bombers were built, and they served the U.S. Navy until 1933. With their 57-foot (17-meter) wingspan, they could fly an average 124 mph (199 kph); as a landplane, they could fly 15 percent faster than similar aircraft.

The T2D-1 had open cockpits for two pilots and a gunner/wireless operator. A fourth open cockpit in the nose had a single ring-mounted machine gun and a transparent bomb-aiming panel.

In 1928, the T2D-1s were assigned to Commander Aircraft Squadrons at Pearl Harbor, Hawaii. The T2D-1s had excellent visibility and proved particularly useful for maritime reconnaissance. They were a favorite among Navy pilots because they were easy to fly and could climb quickly with heavy loads. The Navy ordered 18 more with two rudders, rather than one, and redesignated them P2D-1s because the Navy classified shore-based bombers as patrol planes.

Technical Specifications	
First flight	Jan. 27, 1927
Wingspan	57 feet
Length	42 feet
Height	15 feet 11 inches
Ceiling	13,830 feet
Range	454 miles
Weight	9,986 pounds
Power plant	Two 525-horsepower Wright radial engines
Speed	124 mph
Accommodation	Three crew
Armament	Machine guns, bombs

T-39 Sabreliner Trainer/Transport

Historical Snapshot

A twin-jet, multipurpose aircraft, the military version of the North American Aviation Sabreliner was designated the T-39 by the U.S. Air Force and Navy.

It was designed to cruise at speeds of 500 mph (804 kph) at 40,000 feet (12,192 meters), above most weather. Its leading edge slats, swept-back wing and tail gave it a strong resemblance to the F-86 Sabre Jet and the F-100 Super Sabre. It is between the two in size, with a wingspan and length of approximately 44 feet (13 meters).

Basic configuration of the military versions provided for a crew of two and four passengers. The interior could be modified from a radar or navigational trainer configuration to that of a cargo or passenger carrier in a matter of minutes. As a cargo carrier, the aircraft could transport items weighing up to 2,300 pounds (589 kilograms) with a length of 16 feet (5 meters). Seat tie-down fittings were suitable for use as cargo rings in lashing down equipment.

The civilian version of the T-39 Sabreliner, developed in 1962, was North American's only successful commercial aircraft, and the Sabreliner Division was established to build the new jet. The civilian version of the Sabreliner was essentially the same as the military version, but provided for installation of deicing boots, autopilot and other communications and navigation equipment not required by the armed services. It could accommodate a crew of two and up to seven passengers.

Sabreliners, 204 of which were for the military. The company changed its name to Rockwell International in 1973 and sold its Sabreliner Division to private investors in 1983. In January 2014, Innovative Capital Holdings acquired the assets of the resulting Sabreliner Corp. and reorganized as Sabreliner Aviation.

Technical Specifications	
First flight	Sept. 16, 1958
Wingspan	44.5 feet
Tailspan	17.55 feet
Wing area	342.1 square feet
Length	44 feet
Height	16 feet
Empty weight	9,257 pounds; military: 9,265 pounds
Max. gross takeoff weight	18,340 pounds; military: 17,760 pounds
Engines	Two P&W J60-P-3A; 3,000 pounds of thrust
Cruise speed	500 mph
Cruise range (with reserve)	1,950 statute miles
Cruise altitude	Above 40,000 feet
Single-engine cruise altitude	20,000 feet
Fuel capacity	7,284 pounds (1,087 gallons); military: 6,864 pounds (1,056 gallons)
Takeoff ground roll, sea level	2,500 feet
Landing ground roll, sea level	1,850 feet
Landing approach speed	113 mph; military: 123 mph
Touchdown speed	107 mph; military: 113 mph

Technical Specifications	
First flight	April 16, 1988
Wingspan	30 feet 10 inches
Length	38 feet 11 inches
Height	13 feet 1 inches
Speed	620 mph
Ceiling	50,000 feet
Range	1,550 miles
Power plant	One 5,450-pound-thrust Rolls-Royce Adour Mk 851 turbofan engine
Crew	1 instructor, 1 student

T-45 Goshawk Trainer

Historical Snapshot

In 1978, McDonnell Douglas and British Aerospace developed the T-45A Goshawk, a carrier-suitable version of the British Aerospace Hawk. The first Hawk, which flew Aug. 21, 1974, was established as the Royal Air Force principal jet trainer and served the U.S. and European air forces.

The Navy awarded the T-45 Training Systems contract to the McDonnell Douglas and British Aerospace team in November 1981, with McDonnell as the prime contractor. McDonnell and British Aerospace collaborated on significant modifications to make the basic Hawk design aircraft carrier suitable as the T-45A, a two-seat, single-engine jet trainer that is approximately 39 feet (12 meters) long, 14 feet (4 meters) high with a wingspan of 30 feet, 10 inches (9.4 meters).

The U.S. Navy ordered more than 125 T-45A Goshawks, intending to use them to replace the TA-4J Skyhawk in the Advanced Jet Training program and the T-2 Buckeye in the Intermediate Jet Pilot Training program. The Navy chose “Goshawk” as the name for the T-45A in 1985. The name originally was assigned to the Curtiss F11C, a U.S. Navy fighter aircraft in 1932.

The aft fuselage and wings of the Goshawk were built by British Aerospace in the United Kingdom; McDonnell Douglas assembled the forward fuselage at its Long Beach, Calif., plant and performed final assembly and production testing in Palmdale, Calif. Final assembly of the first production model of the Goshawk began in December 1988 in Air Force Plant 42 at Palmdale. In 1989, McDonnell Douglas moved production of the T-45 program to its St. Louis, Mo., facility.

The T-45C, with a digital cockpit to train pilots destined for the F/A-18 Hornet, the AV-8B Harrier II and other carrier-based aircraft, made its first flight in October 1997. It had two multifunction displays in each cockpit; the displays provided navigation, weapon delivery, aircraft performance and communication data.

Boeing delivered the 221st and final T-45 training jet to the Navy in November 2009. The company continued to support the T-45 fleet by providing engineering, logistics and support equipment in partnership with BAE Systems, the successor company to British Aerospace, which had supplied the aircraft’s rear and center fuselage sections, wing assembly and vertical tail.

On Aug. 26, 2010, Boeing joined the U.S. Navy at Cecil Field in Jacksonville, Fla., to celebrate the Naval Air Training Command’s one millionth flight-hour with the T-45 Goshawk. The Goshawk had become a component of the fully integrated T-45 training system, which also included high-fidelity instrument and flight simulators, computer-assisted classroom learning, an automated raining-management asset and contractor logistics support.

Technical Specifications	
First flight (NA-49)	Sept. 28, 1938
Span	42 feet 1/4 inch
Length	28 feet 11-7/8 inches
Seating	Tandem
Power plant	Pratt & Whitney Wasp R-1340-AN-1 550 horsepower, air-cooled
Speed	205 mph at 5,000 feet
Crew	Pilot, co-pilot
Landing gear	Retractable
Propeller	Controllable pitch

T-6 Texan Trainer

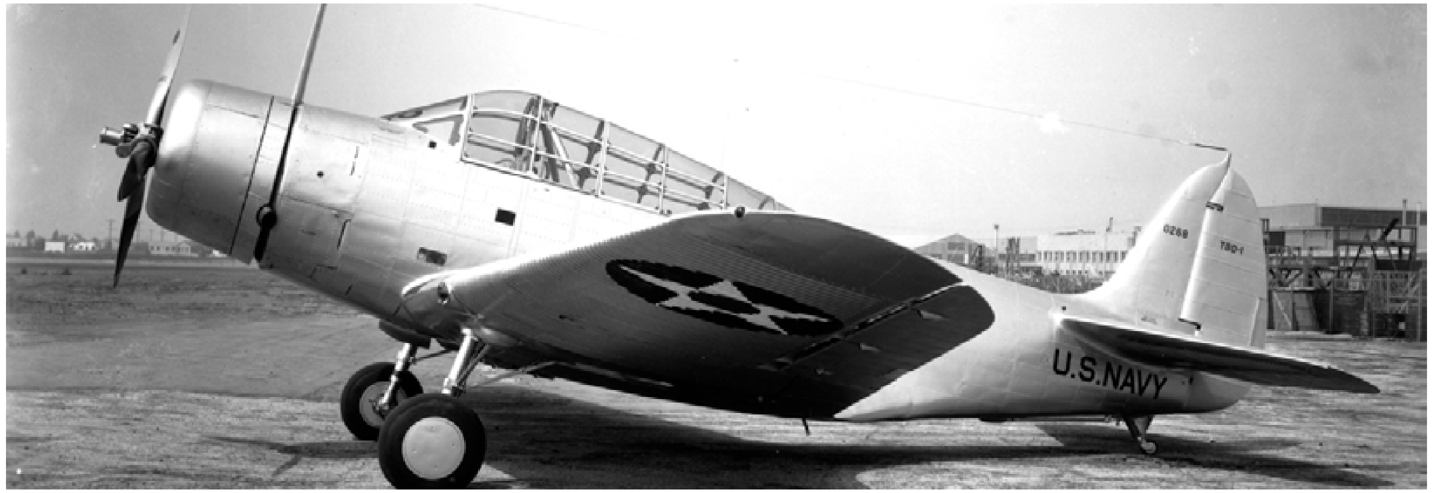
Historical Snapshot

The North American Aviation T-6 Texan two-place advanced trainer was the classroom for most of the Allied pilots who flew in World War II. Called the SNJ by the Navy and the Harvard by the British Royal Air Force, the advanced trainer AT-6 was designed as a transition trainer between basic trainers and first-line tactical aircraft. It was redesignated T-6 in 1948.

In all, the T-6 trained several hundred thousand pilots in 34 different countries over a period of 25 years. A total of 15,495 of the planes were made. Though most famous as a trainer, the T-6 Texan also won honors in World War II and in the early days of the Korean War.

The Texan evolved from the company's BC-1 basic combat trainer, which was first produced for the U.S. Army Air Corps with fixed landing gear in 1937 under a contract that called for 177 planes. North American designed the NA-49 prototype as a low-cost trainer with many of the characteristics of a high-speed fighter.

Although not as fast as a fighter, it was easy to maintain and repair, had more maneuverability and was easier to handle. A pilot's airplane, it could roll, Immelmann, loop, spin, snap and vertical roll. It was designed to give the best possible training in all types of tactics, from ground strafing to bombardment and aerial dogfighting. It contained such versatile equipment as bomb racks, blind flying instrumentation, gun and standard cameras, fixed and flexible guns, and just about every other device that military pilots had to operate.



Technical Specifications	
First flight	April 15, 1935
Wingspan	50 feet
Length	35 feet
Height	15 feet 1 inch
Ceiling	20,800 feet
Range	435 miles
Gross weight	9,862 pounds
Power plant	One 900-horsepower Pratt & Whitney R-1830-64 engine
Speed	296 mph
Accommodation	Three crew
Armament	.50-caliber machine gun, .30-caliber machine gun, 1,200-pound bomb load

TBD Devastator Torpedo Bomber

Historical Snapshot

When the U.S. Navy placed a contract with Douglas Aircraft Co. for the development of the TBD torpedo bomber in 1934, a new era in naval aviation began. Biplanes on carrier decks would soon be consigned to history.

The TBD Devastator was the Navy's first all-metal, monoplane torpedo bomber. It was also the Navy's first production carrier-based plane to come with an enclosed cockpit, and the first to use main landing gear wheel brakes. While most carrier-based aircraft of the day had manually folded wings for storage aboard ship, the TBD featured hydraulic folding wings. The plane had a crew of three (pilot, bombardier and gunner) and carried a half-ton (0.45-tonne) torpedo. It entered service with the fleet in 1937. One sailor, after looking it over, said, "It's got everything but the kitchen sink."

In December 1941, 100 TBD Devastators formed the backbone of the Navy's carrier torpedo force in the Pacific. During hit-and-run raids against Japanese bases in the Central Pacific in early 1942, TBDs sank two transports and destroyed or damaged 10 other vessels. In May 1942, during the Battle of the Coral Sea, TBDs helped sink one enemy carrier and heavily damage another. These early actions, however, revealed the Devastator's shortcomings in speed and range a nd exposed problems with its main offensive weapon: its torpedoes often failed to explode.

The TBD next saw action in the Battle of Midway in June. This was a complete victory for the Navy, but of the 41 Devastators that took part in the battle's first day, only six made it back to their carriers. The TBD's slow speed, light defensive armament and poor maneuverability made it easy prey for the famous Japanese Zero fighter. On the last day of the battle, however, three TBDs did help sink one heavy cruiser and seriously damage another.

An aircraft of advanced design in 1934, the Devastator was obsolete by 1942. Its first six months of combat would be its last. The TBD was withdrawn from front-line service in summer 1942 but continued in service as an advanced trainer until the end of the war. A total of 130 TBDs were built.

Technical Specifications

First successful launch	Sept. 20, 1957
Model number	SM-75/PGM-17
Length	64.8 feet
Diameter	96 inches
Weight	110,000 pounds
Power plant	Rocketdyne LOX-kerosene-fueled 135,000-pound-thrust engine
Range	1,500 miles

Thor Missile

Historical Snapshot

In November 1955, three companies — Douglas, Lockheed and North American Aviation — were given one week to bid on a U.S. Air Force contract to build a missile that could hit the Soviet Union from the Force chose Douglas as the prime contractor for the missile's airframe and integration, and North American's Rocketdyne division for the engine, which would produce 135,000 pounds (600 kilonewtons) of thrust.

Thor, named after the Norse god of thunder, provided nuclear deterrence before intercontinental ballistic missiles (ICBM) were ready. It was designed to deliver a payload 1,500 miles (2,400 kilometers), a range that allowed a U.K.-based missile to hit Moscow.

After several failures, Thor made its first successful flight on Sept. 20, 1957. It reached a speed of about 10,000 mph (16,093 kph) and attained an attitude of 1,100 miles (1,800 kilometers) before the inert warhead splashed into the south Atlantic. Further testing ensued, and after 18 research-and-development launches, Thor was cleared for operational use.

Under the code name Operation Go Away, the first Thor missiles were deployed in the United Kingdom in September 1958, and by April 1960, four Royal Air Force squadrons had 60 missiles, all at above-ground launch sites.

More than 200 Thor missiles were built, but once the generation of ICBMs based in the United States became operational, Thor was no longer needed. It was deactivated in 1966.

Thor missiles lived on. Later, they were reconfigured as launch vehicles for the Air Force and NASA. They provided first the hardware, then the technology, for current Air Force and NASA launch systems, including the Delta family of launch vehicles that continues to send military and commercial satellites in to orbit.

Technical Specifications	
First flight	March 19, 1989
Model number	907
Classification	Tiltrotor transport helicopter
Rotor diameter	38 feet
Span	83 feet 10 inches (rotor included)
Fuselage length	57 feet 4 inches
Gross weight	Short takeoff, 55,000 pounds; vertical takeoff, 47,500 pounds
Top speed	363 mph
Cruising speed	317 mph
Power	Two 6,150-shaft-horsepower Allison gas turbine T406-AD-400 engines
Accommodation	3 crew, 24 passengers

V-22 Osprey Tiltrotor

Historical Snapshot

The V-22 Osprey was the first aircraft designed from the ground up to meet the needs of all four U.S. armed services. In partnership with Boeing, Bell Helicopter Textron built the tiltrotor aircraft that takes off and lands vertically like a helicopter, and once airborne, can convert to a turboprop airplane capable of high-speed and high-altitude flight. Boeing was assigned responsibility for the fuselage, all subsystems, digital avionics and fly-by-wire flight-control systems.

The 30-ton (27-tonne) multirole aircraft can transport assault troops and cargo, undertake combat search-and-rescue and fleet logistic support and provide long-range transportation for special operations. On Sept. 5, 2013, the Bell Boeing V-22 program also completed an initial test of the V-22 Osprey performing as an aerial refueling tanker.

By 1997, requirements called for production of 523 Ospreys, with the first to enter service during 1999. The first V-22 built to production standards made its first flight in February 1997 and was delivered March 15, 1997, to the V-22 integrated test team at the Patuxent River Naval Air Warfare Center in Maryland. Eleven were produced by the end of 2000.

After the crash of a V-22 on Dec. 11, 2000, the aircraft did not return to flight until May 29, 2002. Five were flying by the end of 2002. The first passenger to fly aboard a V-22 after it returned to flight was Lt. Gen. Michael W. Hagee, incoming commandant of the U.S. Marine Corps.

On June 13, 2013, the Bell Boeing V-22 program was awarded a five-year U.S. Naval Air Systems Command (NAVAIR) contract for the production and delivery of 99 V-22 Osprey tiltrotor aircraft, including 92 MV-22 models for the Marine Corps and seven CV-22 models for the Air Force Special Operations Command. The contract also included a provision permitting NAVAIR to order up to 23 additional aircraft. At that time, more than 200 V-22 Ospreys were in operation and the worldwide fleet had amassed more than 185,000 flight-hours, with half of those hours logged in the previous three years.

Technical Specifications	
First flight	Jan. 11, 1959
Model number	707-320
Classification	Commercial transport
Span	142 feet 5 inches
Length	152 feet 11 inches
Gross weight	316,000 pounds
Cruising speed	600 mph
Range	6,000 miles
Ceiling	41,000 feet
Power	Four 18,000-pound-thrust P&W JT3D turbofan engines
Accommodation	Up to 189 passengers

VC-137C Air Force One

Historical Snapshot

The airplane used to transport the president of the United States is known by the radio call sign used when the president is aboard: Air Force One.

The first purpose-built Air Force One was based on the long-range Boeing 707-320 Intercontinental, which was the most commonly ordered version of the 707 airliner. Its fuselage was 8 feet (2.4 meters) longer than the 707-120, and its wingspan was 12 feet (3.7 meters) longer.

With new turbofan jet engines, the B versions had a range of 6,000 miles (1.8 kilometers), and in 1962, a 707-320B took over the role of U.S. government VIP and presidential transport, designated VC-137C. A second VC-137C was delivered in 1972.

President John F. Kennedy's wife, Jacqueline Kennedy, selected the colors of the first Air Force One, VC-137C. The 707s served as presidential aircraft until they were replaced by 747-200s, designated VC-25A, in 1990. Principal differences between Air Force One and the standard Boeing 747 include state-of-the-art navigation, electronic and communications equipment; its interior configuration and furnishings; self-contained baggage loader; and front and aft airstairs. The "flying Oval Office" has 4,000 square feet (371 square meters) of interior floor space with presidential living quarters, office areas, work and rest areas for staff, press and crews, and two galleys that can serve 100 at one sitting. Air Force One is crewed by U.S. Air Force personnel.

Technical Specifications	
First flight	Oct. 11, 1945
Model number	RTV-G-1
Length	16 feet 2 inches; booster: 7 feet 11 inches
Diameter	12 inches
Weight	690 pounds; booster: 760 pounds
Speed	3,000 feet per second
Range	50 miles
Propulsion	Sustainer: Aerojet liquid-fueled rocket, 1,500 pounds for 47 seconds; booster: Tiny Tim solid-fueled rocket, 50,000 pounds for 0.6 seconds

WAC Corporal Missile

Historical Snapshot

The Douglas Aircraft Co. WAC Corporal started as the “Baby WAC,” only one-fifth the size of the final 21-foot (6.4-meter) WAC Corporal. Some sources indicate that the initials WAC stand for “Without Attitude Control,” because the rocket had no stabilization and guidance system.

Designed and built in a cooperative effort between Douglas Aircraft and the Guggenheim Aeronautical Laboratory, in association with the Jet Propulsion Laboratory at California Institute of Technology, its technology would lead to the Viking rockets and the Titan intercontinental ballistic missile.

Initial tests of the Baby WAC started in July 1945. Further basic airframe and control tests began Sept. 26, 1945, using the first 5-foot-long (1.5-meter-long) solid-fueled booster called “Tiny Tim,” which could produce 50,000 pounds (22,679 kilograms) of thrust. After it left the launch tower, its three tail fins stabilized the missile in flight. The nose cone separated near the end of the flight and floated to the ground for instrument recovery, using a built-in parachute.

The improved 1946 WAC B had a lighter engine, a modified structure and a new telemetry system. Between December 1946 and mid-1947, eight WAC B rockets were launched, after which the WAC Corporal program was terminated.

In February 1948, the formal designation RTV-G-1 was assigned to the WAC Corporal, even though the program had already been completed. In mid-1951, this designation was changed to RV-A-1.

In June 1947, the Bumper program was formed, in which the WAC Corporal was combined with a German V-2 rocket to form the two-stage “Bumper WAC.” Douglas built the second stage and designed and built some required special V-2 parts. On Feb. 24, 1949, the Bumper WAC reached a record altitude of approximately 250 miles (402 kilometers), flying at a speed of 5,000 mph (8,046 kph). The following year, a Bumper WAC became the first rocket to be launched from Cape Canaveral, Florida.

Technical Specifications	
Power plant	One Pratt & Whitney R-985 Wasp Junior radial piston engine
Span	11.78 meters (38 feet, 8 inches)
Length	8.56 meters (28 feet, 1 inch)
Height	2.5 meters (8 feet, 3 inches)
Empty weight	1,492 kilograms (3,289 pounds)
Loaded weight	1,968 kilograms (4,340 pounds)
Maximum speed	291 kph (181 mph)
Range	1,400 kilometers (870 miles)
Service ceiling	4,816 meters (15,800 feet)
Armament	None

Winjeel Trainer

Historical Snapshot

After World War II, the Royal Australian Air Force (RAAF) required a new basic two-seat trainer aircraft to replace the quickly aging and increasingly obsolete Tiger Moth, as well as the highly successful Wirraway. The Commonwealth Aircraft Corp. (CAC), just over a decade into operation, first designed what became the CA-22 Winjeel A85-401 in 1948. The Winjeel, an Aboriginal word translating to "young eagle," went through a lengthy design process, which took the project through several versions before the final CA-25 model.

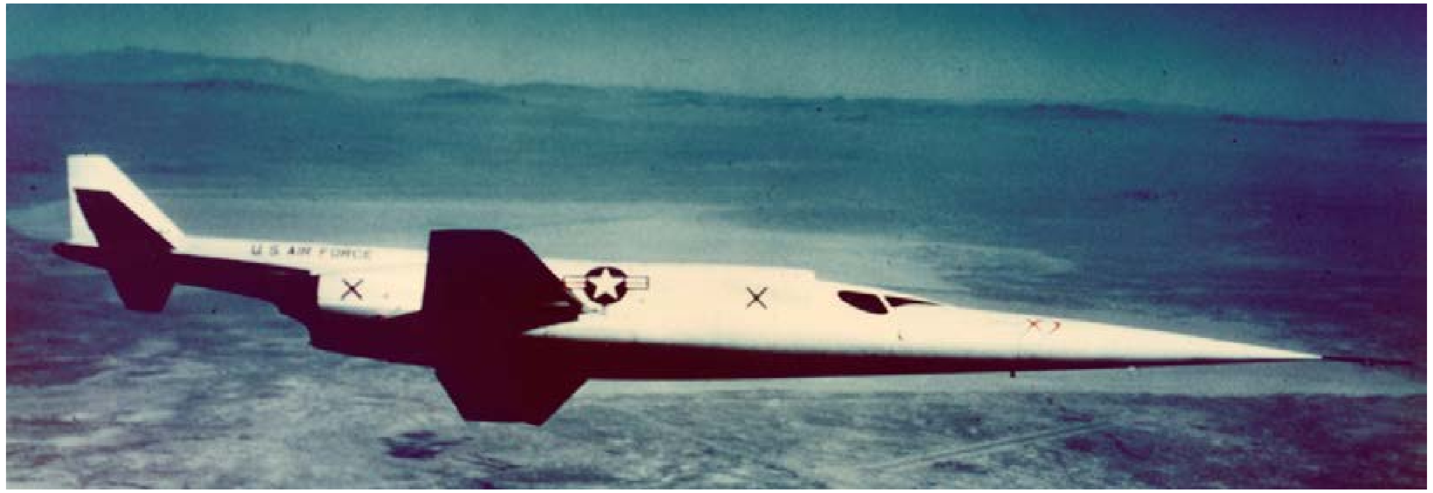
CAC began manufacturing the first Winjeels in July 1949, with the first prototype flying Feb. 3, 1951. CAC test pilot John Miles, a World War II veteran pilot trained in England who had flying experience in Europe and Africa, flew the first Winjeel. However, CAC sought revisions to the Winjeel as the RAAF added requirements, actually requesting a less stable aircraft for training purposes. RAAF flight training needed its training pilots to be able to experience spinning and perform spinning recovery. Yet it took another four years of research, development and testing to prepare the first Winjeels for delivery in February 1955. The CA-22 Winjeel that Miles flew evolved into the CA-25, and CAC delivered the first 62 to the No. 1 Basic Flight Training School of New South Wales in Uranquinty in September 1955, and the last group in January 1958.

From the CA-22 to the CA-25, CAC made major modifications to the rudders, fins and engines. Originally, the Winjeel was designed to have indigenously built CAC engines built in-house, yet CAC would later turn to Pratt & Whitney for the power plants. The rudders and fins were moved forward from the original design and CAC made revisions to the engine cowling design. These design modifications continued until 1953 when the RAAF made the decision to order 62 of the aircraft.

The first production flight by the training school came Feb. 23, 1955. The unit was later transferred to the RAAF base at Point Cook in December 1958. In addition to training, the Winjeel served in the Forward Air Control training role with No. 4 Flight, which later joined No. 76 Squadron. The Winjeel was not designed to carry armament as a trainer aircraft, yet several training missions called for the aircraft to carry smoke bombs to make training targets for pilots.

Despite the success of the Winjeel and its uses in training many Australian pilots, the RAAF considered replacing the trainer in 1968 with the Italian-designed Macchi MB-326. Yet, the military ultimately retained the Winjeel. By 1975, the RAAF again sought to phase out the Winjeel by replacing the trainer with the CT-4 Airtrainer manufactured by Pacific Aerospace Corp. in New Zealand. In the 1970s, the RAAF sought to make all trainers jet-powered aircraft to best prepare pilots for the jet aircraft in the broader fleet.

The RAAF decided to continue use of the Winjeel another two decades into the 1990s, even though the Swiss-built Pilatus PC-9/A became the chief trainer for the military. The Macchi and the CT-4 did not fully replace the Winjeel, however, as the CAC aircraft remained in service until 1994 before many were transferred into private ownership, owing to the capabilities of the Winjeel.



Technical Specifications	
First flight	Oct. 20, 1952
Wingspan	22 feet 8 inches
Length	66 feet 9 inches
Height	12 feet 6 inches
Weight	22,400 pounds (max.)
Armament	None
Power plant	Two 3,370-pound-thrust (4,900-pound-thrust with afterburner) Westinghouse J34s
Speed	706 mph
Ceiling	38,000 feet

X-3 Stiletto Test Aircraft

Historical Snapshot

The single experimental Douglas X-3, called the Stiletto because of its knife-like shape, was built to test the effects of high temperatures induced by high speeds on an aircraft, to investigate the use of new materials such as titanium, and to explore new construction techniques.

Maj. Charles E. Yeager, who was the first pilot to exceed the speed of sound, was part of the inspection team for the Stiletto mockup. The unusual aircraft had a long, tapered nose, which contained most of its 1,200 pounds (544 kilograms) of instrumentation, and tiny wings. The two engines were side by side in the fuselage, and the pilot's downward ejector seat in the pressurized cockpit also operated as an electronically controlled lift.

Although the aircraft never reached the speeds it was designed for, it contributed greatly to the development of high-speed aircraft. Data obtained with the X-3 was distributed throughout the U.S. aviation industry.

In 1956, the X-3 found its resting place at the U.S. Air Force Museum.

Technical Specifications	
First flight	Oct. 11, 1990
Wingspan	23.83 feet
Length	43.33 feet
Takeoff weight	16,100 pounds, including 4,100 pounds of fuel
Power plant	General Electric F404-GE-400 turbofan engine, producing 16,000 pounds of thrust in afterburner
Design speed	Mach 0.9
Design altitude	40,000 feet
Thrust-vectoring test speed	Mach 1.28

X-31 Test Aircraft

Historical Snapshot

Designed with a thrust vectoring control system to make the aircraft highly maneuverable, the single-seat X-31 — designed and built by Boeing heritage company Rockwell International and German manufacturer Messerschmitt-Bölkow-Blohm — was used in two major multinational flight test programs.

The thrust vectoring system of the X-31 consisted of three paddles at the rear of the fuselage that could direct the jet engine's thrust. The system provided precise control at high angles of attack (AOA) where conventional aircraft would lose aerodynamic control.

The Enhanced Fighter Maneuverability (EFM) program began in 1990. It comprised Boeing, Defense Advanced Research Projects Agency (DARPA), the U.S. Navy, NASA, Germany's defense procurement agency (BWB) and the European Aeronautic Defence and Space Co. (EADS).

During the 581 flights of the EFM program, the X-31 flew well beyond the aerodynamic limits of any conventional aircraft by demonstrating controlled flight at 70 degrees AOA, a controlled roll at around 70 degrees AOA, and a rapid minimum radius, 180-degree turn using a post-stall maneuver, dubbed the "Herbst Maneuver" after Wolfgang Herbst, a German proponent of using post-stall flight in air-to-air combat.

On January 19, 1995, near the end of a 43-minute mission, ice formed in one of the X-31's pitot tubes, incorrect data was sent to the flight control's computers and the aircraft oscillated uncontrollably and pitched. The pilot ejected safely and the plane crashed near the northern edge of Edwards Air Force Base, Edwards, Calif.

The remaining X-31 went on to fly 21 demonstration flights at the 1995 Paris Air Show, where its performance wowed the crowds. Following the EFM program's conclusion in June 1995, this aircraft was transferred to the U.S. Navy Test Pilot School at the Patuxent River Naval Air Station in Maryland.

In January 2000, the Vectoring ESTOL (extremely short takeoff and landing) Control and Tailless Operational Research (VECTOR) program began. Partners were the Boeing research and development organization, Phantom Works, the U.S. Navy, BWB and EADS.

In May, the X-31 demonstrated landing speeds of only 124 knots (142 mph, 229 kph) at 24 degrees AOA — compared to the normal landing speeds of 175 knots (201 mph, 324 kph) at 12 degrees AOA — and landed in about 1,700 feet (518. meters) rather than the more typical 8,000 feet (2,438 meters).

In its final flight on April 29, 2003, the X-31 performed the last in a series of fully automated ESTOL landings on an actual runway, approaching at a high 24-degree AOA (twice the normal 12-degree AOA) at only 121 knots (34 mph, 55 kph), more than 30 percent slower than the normal 175-knot (201-mph, 324-kph) landing speed. The program ended in May 2003, and later that year, Boeing and the X-31 team — past and present — received the von Karman award from the International Council of the Aeronautical Sciences.

The remaining X-31 aircraft is on display in Munich's Deutsches Museum.

Technical Specifications	
First flight	X-32A, Sept. 18, 2000; X-32B, March 29, 2001
Military model numbers	X-32A and X-32B
Classification	Concept demonstration aircraft
Span	X-32A, 36 feet; X-32B, 30 feet
Length	X-32A, 45 feet; X-32B, 43 feet 8.6 inches
Takeoff weight	50,000 pounds
Speed	Supersonic
Service ceiling	50,000 feet
Range	600 to 850 nautical-mile-radius (internal fuel only)
Power	One Pratt & Whitney JSF-119-PW-614 turbofan producing thrust in excess of 42,000 pounds
Accommodation	One pilot

X-32 Joint Strike Fighter

Historical Snapshot

In 1996, the U.S. Department of Defense awarded Boeing a four-year contract for the concept demonstration phase of the Joint Strike Fighter (JSF) program competition. The goal was to develop a low-cost, multirole tactical aircraft for the U.S. Air Force, Navy and Marine Corps and the United Kingdom's Royal Navy and Royal Air Force.

Boeing was required to build concept demonstration aircraft that would provide commonality across variants in operation, design and manufacture; direct-lift propulsion for short takeoff and vertical landing (STOVL), hover and transition between vertical and conventional flight; and capability to approach a carrier at low speeds. Boeing assembled two concept demonstration aircraft, X-32A and X-32B, at its plant in Palmdale, Calif.

On Sept. 18, 2000, the X-32A made its first flight from Palmdale to Edwards Air Force Base, Calif. The X-32A demonstrated conventional takeoff and landing characteristics for the Air Force as well as carrier approach flying qualities for the Navy. The aircraft made 66 flights during four months of testing. The flights validated the aircraft's handling qualities for inflight refueling, weapons bay operations and supersonic flight.

The X-32B aircraft made its first flight on March 29, 2001. It made 78 test flights in four months, including a transcontinental ferry flight from Edwards Air Force Base to Naval Air Station Patuxent River, Md. The aircraft successfully transitioned to and from STOVL flight mode by using its direct-lift system to redirect thrust from the aircraft's cruise nozzle to the lift nozzles. The X-32B also demonstrated its ability to hover and make vertical landings.

The flight tests, which ended in July 2001, demonstrated matching of actual flight performance with computer predictions based on years of simulation, an accomplishment that had never before been achieved.

Although not selected for full-scale development of the JSF, Boeing viewed its involvement in the competition as a strategic investment. The program yielded many advances in stealth technology and design and manufacturing methods. These achievements have been applied to other Boeing programs including the F/A-18E/F Super Hornet and the X-45A Unmanned Combat Air Vehicle, or UCAV.

X-45 Joint Unmanned Combat Air System

Technical Specifications	
First flight (X-45A)	May 22, 2002
Model number	X-45C
Classification	Unmanned combat aircraft
Wingspan	49 feet
Length	39 feet
Max. payload	4,500 pounds
Cruising speed	0.80 Mach
Combat radius	More than 1,300 nautical miles
Ceiling	40,000 feet
Armament	Two internal weapons bays, eight Small Diameter Bombs

Historical Snapshot

The Boeing Joint Unmanned Combat Air System (J-UCAS) X-45 was the first highly autonomous, unmanned system specifically designed for combat operations in the network-centric environment of the 21st century. The swept wing, stealthy jet had had fully retractable landing gear and a composite, fiber-reinforced epoxy skin. There were two internal weapons bays in its fuselage.

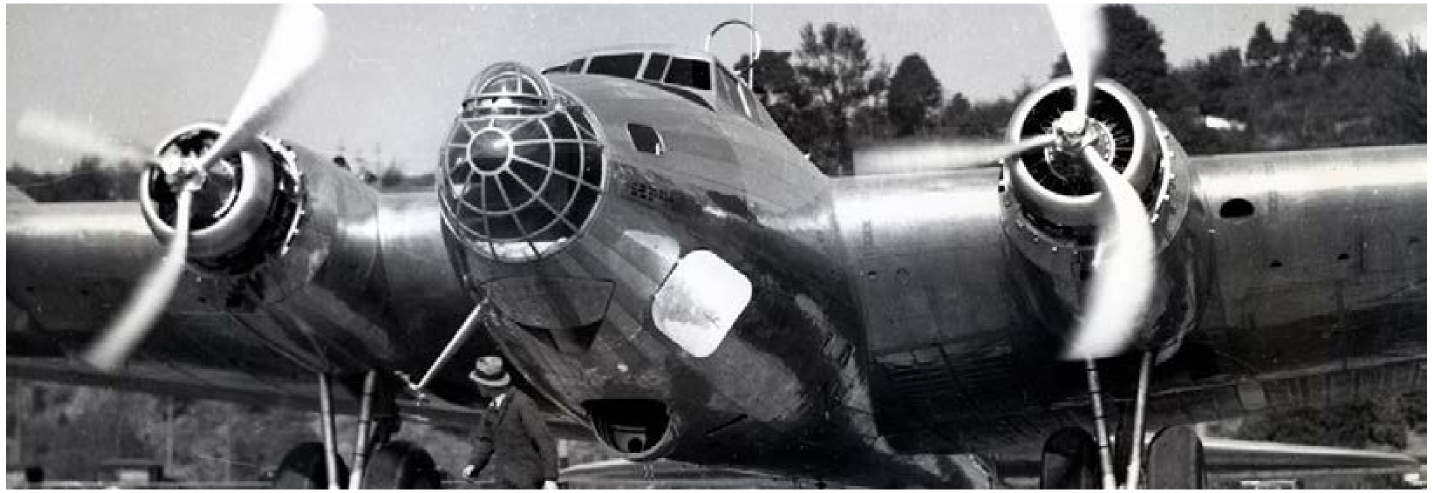
Boeing began its unmanned combat aircraft program in 1998, and the following year, Defense Advanced Research Project Agency (DARPA) and the U.S. Air Force chose Boeing to build two X-45A air vehicles and a mission control station under the J-UCAS Advanced Technology Demonstration program. During its first flight, May 22, 2002, the X-45A, nicknamed the “Elsie May,” flew for 14 minutes at NASA’s Dryden Flight Research Center at Edwards Air Force Base, Calif., reaching airspeed of 195 knots (224 mph, 361 kph) and altitude of 7,500 feet (2,286 meters). Flight characteristics and basic aspects of aircraft operations, particularly the command and control link between the aircraft and the mission-control station, were demonstrated successfully.

On April 29, 2003, Boeing announced that DARPA had asked it to modify its X-45B design then in development—a larger, more capable version of the X-45A. DARPA wanted the design to evolve into a version that could meet the objectives of both the U.S. Air Force and the U.S. Navy. Boeing asked that the modified concept be called the X-45C.

In 2004, significant X-45A test flights included a precision weapon drop in April, when the X-45A demonstrator hit a ground target with a 250-pound (113-kilogram) inert near-precision-guided weapon released from its internal weapons bay, and the first unmanned, autonomous multi-vehicle flight in August under the control of a single pilot. Flight tests were successfully concluded in 2005.

In October 2006, after 64 unprecedented flights and many firsts in autonomous combat aviation, the two X-45A unmanned combat air vehicles were sent to two prominent aviation museums to be permanently displayed. One aircraft went to the National Museum of the U.S. Air Force at Wright-Patterson Air Force Base in Dayton, Ohio, and the other to the Smithsonian National Air and Space Museum in Washington, D.C.

The Boeing design for the larger X-45C went on to serve as the basis for the internally funded Phantom Ray Demonstrator.



XB-15 Bomber

Historical Snapshot

The mammoth Boeing XB-15 began in 1934 as a design study for the U.S. Army to see if it was possible to build a heavy bomber with a 5,000-mile range. When it made its first flight, it was the largest and heaviest plane ever built in the United States. It was so large that the crew could go through passages in the wing to make minor repairs while the airplane was flying.

Because a long-range flight, powered by the engines of the time, took several days, the crew had bunks to sleep on between shifts. The XB-15 had been designed for four 1,000-horsepower liquid-cooled engines, but because those engines were not available in time, it was powered by 850-horsepower engines. Nonetheless, it set several load-to-altitude records, including taking a 31,205-pound payload to 8,200 feet on July 30, 1939.

Because the lone XB-15 was an experimental airplane, it did not serve as a bomber during World War II. The military converted it into a cargo carrier, designated the XC-105.

Technical Specifications	
First flight	Oct. 15, 1937
Model number	294
Classification	Bomber
Span	149 feet
Length	87 feet 7 inches
Gross weight	70,706 pounds
Top speed	200 mph
Cruising speed	152 mph
Range	5,130 miles
Ceiling	18,900 feet
Power	Four 850-horsepower P&W R-1830-11 Twin Wasp engines
Accommodation	10 crew
Armament	6 machine guns, 8,000-pound bomb load

Technical Specifications	
First flight	Sept. 21, 1964
Span	105 feet
Length	185 feet
Height	30 feet
Weight	Over 450,000 pounds
Engines	Six General Electric J-93 turbojets; 30,000-pound thrust class
Speed	2,000 mph
Range	Intercontinental
Altitude	70,000 feet, plus
Crew	Pilot, co-pilot
Fuel	JP-6

XB-70A Valkyrie

Historical Snapshot

The XB-70A, built by the North American Aviation (NAA) Los Angeles Division for the U.S. Air Force, was an experimental high-speed, delta-wing aircraft designed to fly at three times the speed of sound and higher than 70,000 feet (21,000 kilometers).

On Sept. 21, 1964, 5,000 employees and guests at Air Force Plant 42 in Palmdale, Calif., watched as NAA Chief Pilot Alvin White and U.S. Air Force copilot Joseph Cotton took the graceful six-engine giant up for its first flight. It was the culmination of an effort that began in 1954, when both Boeing and NAA submitted designs for the Air Force Weapon System 110A competition, and on Dec. 23, 1957, NAA won the competition.

However, federal budget cutbacks and advances in Soviet air defenses resulted in an emphasis on less expensive and theoretically more survivable intercontinental ballistic missiles as the mainstay of U.S. nuclear forces. On April 10, 1961, the Air Force cut back the B-70 to a research program, and only two of the aircraft would be built. A second Valkyrie, the XB-70A-2, flew on July 17, 1965.

The B-70 introduced an array of new technologies including a design that relied on an aerodynamic theory called “compression lift.” At supersonic speeds, the fuselage of the B-70 would create a shock wave. The inlet wedge at the front of the delta wings would create a disturbance in that shock wave, causing it to slow and build pressure under the wings, generating up to 40 pounds per square foot (1.9 kilopascals) of additional lift at Mach 3. To increase directional stability and cruise efficiency, and to hold the shock wave, a third of the wing could fold down as much as 65 degrees.

To survive an environment where sustained aerodynamic heating created aircraft skin temperatures ranging from 475 to 630 degrees Fahrenheit (246 to 332 degrees Celsius), NAA used titanium for 9 percent of the airplanes’ construction. To avoid using rare and expensive titanium, NAA came up with a high strength skin that could beat the heat by developing a steel honeycomb sandwich skin that was manufactured using brazing to join metal to metal, rather than welding. This technique later became widely used throughout the aerospace industry.

With a maximum takeoff weight of 542,000 pounds (245,847 kilograms), the XB-70 remains the largest and heaviest airplane ever to fly at Mach 3. A rugged landing gear, weighing more than 6 tons (5.4 tonnes) and consisting of 2 tons (1.8 tonnes) of wheels, tires and brakes supported the XB-70 on the ground. Each main gear had four wheels and the nose gear two. In a single stop, the XB-70 absorbed kinetic energy equivalent to that used to stop 800 medium-sized automobiles from a speed of about 100 mph (61 kph).

On June 8, 1966, an accident during a photo flight took the lives of two pilots and destroyed two airplanes—the XB-70A-2 and an F-104 that had been captured by the Valkyrie’s vortex wake.

The surviving Valkyrie, XB-70A-1, continued to fly for NASA testing the flight regime of a supersonic transport and was later added to the collection at the National Museum of the U.S. Air Force in Dayton, Ohio, on Feb 4, 1969.

XF-11 Reconnaissance Aircraft

Historical Snapshot

The Hughes XF-11 was designed to be a fast, long-range reconnaissance aircraft for the U.S. Army Air Forces. The XF-11 was a twin-engine, twin-boom, all-metal monoplane with a pressurized cockpit and tricycle landing gear. The first prototype featured a pair of four-bladed contra-rotating propellers. This unusual design increased performance and stability but added a great deal of mechanical complexity.

The Air Force originally ordered 100 XF-11s, but the order was canceled at the end of World War II, leaving Hughes with two prototypes.

Howard Hughes was flying the first prototype when it crashed on July 7, 1946, on its maiden flight. An oil leak caused the right engine propeller controls to malfunction, so the rear propeller reversed its pitch, making the aircraft difficult to control. Hughes tried to make an emergency landing on the Los Angeles Country Club's golf course, but about 300 yards short of the course, the aircraft suddenly lost altitude and clipped three houses. The third house was completely destroyed by the fire resulting from the crash, and Hughes was badly hurt.

The second prototype was fitted with conventional propellers. After Hughes had recovered from his injuries, he flew it successfully on April 5, 1947. However, it was not stable at low speeds, so the Air Force ordered the Boeing RB-50 (a reconnaissance version of the B-50 bomber), which had similar long-range photoreconnaissance capability and was less expensive.

Technical Specifications	
First flight	July 7, 1946
Model number	XF-11
Classification	Reconnaissance aircraft
Length	65 feet 5 inches
Wingspan	101 feet 4 inches
Height	23 feet 2 inches
Wing area	983 square feet
Empty weight	37,100 pounds
Max. takeoff weight	58,300 pounds
Max. speed	450 mph
Range	5,000 miles
Service ceiling	44,000 feet
Power	Two Pratt & Whitney 3,000-hp R-4360-31 radial air-cooled, 28-cylinder engines with a Hamilton-Standard eight-blade, counter-rotation, superhydromatic propeller on each engine
Accommodation	Pilot and navigator/photographer

Technical Specifications	
First flight	Aug. 23, 1948
Wingspan	21 feet
Length	14 feet 10 inches
Height	8 feet 4 inches
Weight	5,600 pounds
Ceiling	48,000 feet
Power plant	One J34 turbojet
Accommodation	1 crew
Armament	Four .50-caliber machine guns

XF-85 Goblin Parasite Fighter

Historical Snapshot

The McDonnell Aircraft Corp. XF-85 Goblin, the smallest jet-propelled fighter ever built, was a "parasite" designed to be carried by a B-36 bomber. If the host ship was attacked, the Goblin would be launched from the bomb bay to protect it. The Goblin was egg shaped and its wings — swept back 37 degrees — could fold upward. It had no landing gear and was launched from the bomber. It was then recovered using a hook and a retractable trapeze under the parent airplane. For emergencies, the Goblin had a steel skid under the fuselage and small runners on its wingtips.

It was named the Goblin because company founder James McDonnell had previously decided to name the company's jet fighters after supernatural creatures. The Goblin followed the Phantom and the Banshee.

The tiny fighter was stable, easy to fly and recovered well from spins. However, hooking the Goblin in flight to its bomber's trapeze was difficult. Its first fully released flight was on Aug. 23, 1948 at Muroc (now Edwards Air Force Base, Calif.). Lowered by the trapeze from the mother ship — a Boeing EB-29 nicknamed "Monstro" — McDonnell test pilot Ed Schoch released the Goblin and made three unsuccessful attempts to reconnect the X-85 to the trapeze, but the small jet was buffeted wildly by the larger jet's turbulence. On the last attempt, the Goblin hit the trapeze with such force that the canopy was smashed. The pilot managed to make a belly landing using the Goblin's skid on a dry lakebed.

Ultimately, only three of the seven flights of the Goblin resulted in successful connections with the arresting trapeze. The test program was canceled in 1949, and the Goblin never flew from a B-36. Docking had proved too difficult. But by that time, the Goblin was no longer needed. In 1949, the Boeing KB-29P, with its flying boom aerial refueling system, had solved the problem of long-range fighter escort for bombers.

McDonnell built two prototype Goblins, and one joined the collection at the U.S. Air Force Museum at Wright-Patterson Air Force Base, Ohio.

XF8B-1 Fighter-Bomber

Historical Snapshot

The XF8B-1 fighter-bomber was the heaviest carrier-based airplane built before the end of World War II. It was the first fighter Boeing built after the P-26 "Peashooter" of 1936 and the last before the FA-22 in 1990.

The XF8B-1 could be flown as a torpedo bomber and, because of its single-seat configuration, could also be used as a fighter. Because of its size and great horsepower, the XF8B-1 used an unusual dual six-blade contra-rotating propeller. It carried bombs internally and extra fuel externally, and its six machine guns were mounted inside the folding wings.

Only three XF8B-1s were built during 1944 and 1945. The aircraft never went into major production because changing wartime strategy required that Boeing concentrate on building land-based large bombers and transports.

Technical Specifications	
First flight	Nov. 27, 1944
Model number	400
Classification	Fighter-bomber
Span	54 feet
Length	43 feet 3 inches
Gross weight	20,508 pounds
Top speed	432 mph
Cruising speed	190 mph
Range	3,500 miles
Ceiling	37,500 feet
Power	One 2,500-horsepower P&W Wasp Major engine
Accommodation	1 crew
Armament	Six .50-caliber machine guns or 20 mm cannons, 3,200-pound bomb load

Technical Specifications	
First flight	Aug. 29, 1947
Rotor diameter	20 feet
Length	12 feet 6 inches
Height	6 feet 8 inches
Empty weight	290 pounds
Power plant	Two small ramjet engines mounted at the rotor tips
Speed	50 mph

XH-20 Little Henry Research Helicopter

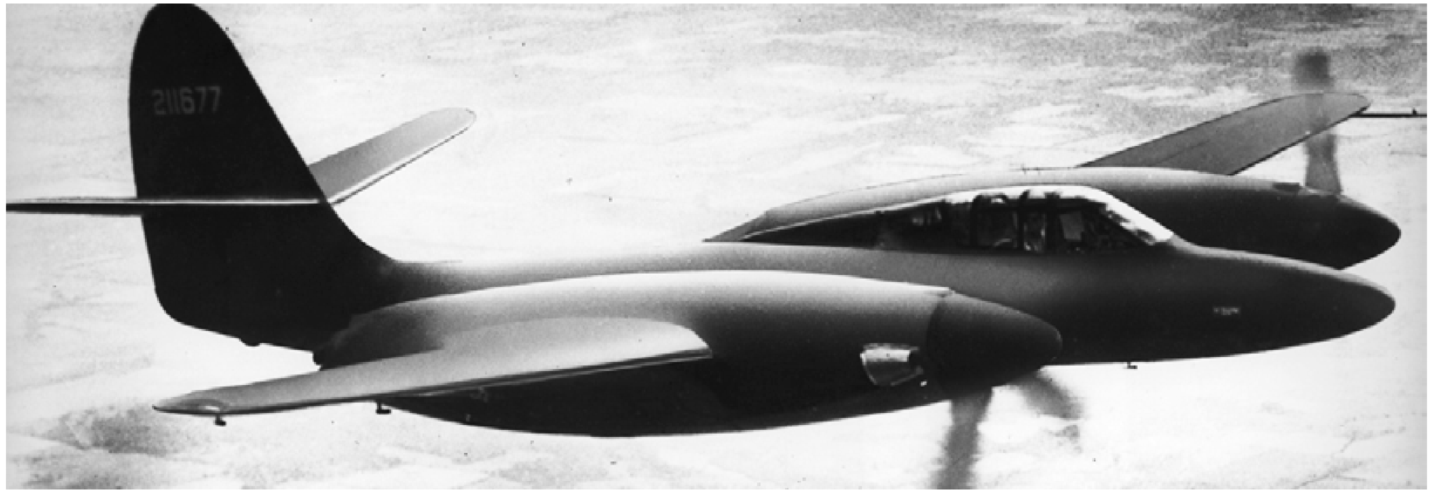
Historical Snapshot

Sponsored by the U.S. Army Air Forces and U.S. Air Force, the McDonnell XH-20 “Little Henry” proved that helicopters could fly using ramjets located in the tips of their rotor blades. The tip-driven rotor eliminated the need for a torque-compensating tail rotor. It did not need a transmission and was controlled with a rudder.

The XH-20 was a low-cost research prototype employing open-frame, steel-tube construction.

Little Henry was not a success because ramjets were too noisy and used too much fuel, so only two test models were built. One of the XH-20s is in the collection of the National Museum of the U.S. Air Force at Wright-Patterson Air Force Base, Ohio.

In 1950, McDonnell Aircraft Corp. began building its second ramjet-powered utility helicopter, called the Model 79. Nicknamed “Big Henry,” it too never went into production.



Technical Specifications	
First flight	Jan. 6, 1944
Wingspan	55 feet
Length	44 feet 9 inches
Height	15 feet 9 inches
Weight	20,000 pounds
Speed	405 mph
Ceiling	37,400 feet
Range	2,384 miles
Power plant	Two 1,060-horsepower thrust Continental XI-1430 engines
Accommodation	One crew
Armament	Six .50-caliber machine guns, four 20 mm cannons

XP-67 Fighter

Historical Snapshot

On Aug. 14, 1941, the U.S. Army Air Forces placed its first order with the tiny, 2-year-old McDonnell Aircraft Corp. for two prototypes of a novel, twin-engine, long-range fighter with a pressurized cabin. The turbo-supercharged 12-cylinder, inverted-V, liquid-cooled engines would be housed in long nacelles and would drive four-blade propellers in opposite directions. They were to maximize the use of exhaust to increase engine thrust.

McDonnell promised a top speed of 472 mph (760 kph) for the 20,000-pound (9,070-kilogram) airplane. The XP-67 was completed in St. Louis, Mo., in December 1943. The XP-67 had a unique design: the airplane's fuselage and shaped engine nacelles were blended into a laminar flow wing. This resulted in the XP-67's nicknames, "Bat" and "Moonbat."

Its first flight took place on Jan. 6, 1944, with chief test pilot E. E. "Ed" Elliot at the controls. Temperamental engines caused the airplane's first flight to last only six minutes. Further test-flight delays were caused by several bouts of engine overheating and fires. With only 40 hours on the airframe, the final blow came on Sept. 6, 1944, during a mission out of Lambert Field in St. Louis, Mo.

Shortly after takeoff, the right engine caught fire. Elliot quickly returned to base and approached for a crosswind landing, keeping the flames away from the fuselage. However, as the aircraft was coming to a full stop, a brake failure caused the aircraft to turn the burning engine upwind. Elliot escaped uninjured as the No. 1 prototype was fully engulfed in flames. The program was halted, and the No. 2 prototype, only 15 percent complete, was never finished.

XPBB-1 Sea Ranger
Flying Boat Patrol Bomber

Historical Snapshot

The Boeing XPBB-1 Sea Ranger, or the Model 344, built for the U.S. Navy, was an extremely long-range flying boat patrol bomber. It was the largest twin-engine airplane built up until the time of its first flight in 1942. It used a wing very similar to the four-engine B-29 bomber and incorporated aerodynamic features of the Boeing Model 314 Clipper.

The Navy ordered 57 Sea Rangers to be manufactured at a new plant it owned on 95 acres (38 hectares) on the south shore of Lake Washington in Renton, Wash. The waterfront site provided natural protection from prevailing winds, so it was easier to launch seaplanes directly from the plant.

The Sea Rangers were designed for a "boosted takeoff" by being catapulted from huge barges. Although the normal range of the aircraft was 4,245 miles (6,831 kilometers), designers believed this distance could be doubled by the fuel-saving catapulted takeoff.

Before the first Sea Ranger was finished, American dive bombers had destroyed four Japanese aircraft carriers at the Battle of Midway, June 4, 1942. The U.S. military changed its strategy in favor of land-based bombers.

Only one Sea Ranger was built, nicknamed the "Lone Ranger." The Boeing 25-year tradition of building seaplanes came to an end when the Lone Ranger flew out of Renton for the last time on Oct. 25, 1943, heading for the Navy base in San Diego, Calif. The one-of-a-kind seaplane served the Navy in a variety of ways for several years before it was placed in storage at the Norfolk Naval Air Station in Virginia.

The Navy traded the Renton site with the U.S. Army for a plant in Kansas City, Mo., and the Army took over the Renton plant, where Boeing workers subsequently produced 1,119 B-29 bombers. After the war, the Renton plant eventually became a manufacturing facility for Boeing commercial jet transports.

Technical Specifications	
First flight	July 9, 1942
Model number	344
Classification	Long-range patrol bomber
Span	139 feet 8 inches
Length	94 feet 9 inches
Gross weight	62,006 pounds
Top speed	219 mph
Cruising speed	158 mph
Range	4,245 miles
Ceiling	18,900 feet
Power	Two 2,000-horsepower Wright Double Cyclone engines
Accommodation	10 crew
Armament	Four machine guns, 20,000-pound bomb load

Technical Specifications

First flight (X-10)	Oct. 14, 1953
Span	40 feet 2 inches
Length	87 feet 4 inches
Diameter	6 feet 5 inches
Weight	120,500 pounds
Power plant	Three Rocketdyne liquid-fueled 135,000-pound-thrust engines
Speed	Mach 2.5 plus
Service ceiling	71,000 feet
Armament	Nuclear warhead

XSM-64 Navaho Missile

Historical Snapshot

In October 1945, the Army Technical Services Command asked aeronautical corporations in the United States to design a guided missile. Consolidated Vultee proposed the MX-774, which would become the Atlas Intercontinental Ballistic Missile. North American Aviation proposed the MX-770, the Navaho — a 500-mile-range missile with greater accuracy than the German-built V-2.

Although the Air Force canceled the Navaho program in 1957, in its 10 years of existence, the Navaho made many key technological breakthroughs. The X-10 Navaho test drone was the first turbojet-powered vehicle to reach Mach 2 and the first aircraft to fly a complete mission under inertial (computerized) guidance. Its booster engine set a record by producing 405,000 pounds of thrust. The X-10 was the only missile to be classified as an “X” plane and completed more than 20 flights. Data from these flights led to the development of the SM-64 Navaho ground-to-ground missile system.

Phase two of the nuclear Navaho development program was the G-26 drone missile, which would prove the vertical launch system. The G-26 required the development of the largest ramjet engines built, an auxiliary power unit to power the missile's electronics and hydraulics, and a more effective autonavigator unit, the N-6 or NAVAN (North American Vehicle Auto Navigation), built by North American's Autonetics Division.

The Navaho program was canceled in July 1957 when, after extensive testing at Cape Canaveral, Fla., the Atlas ICBM was chosen over winged missile designs. On July 13, 1998, exactly 41 years from the day when the Navaho was canceled, and after two years restoring the X-10, the Air Force Space and Missile Museum rolled out the only Navaho missile in existence and placed it on display.

Technical Specifications	
First flight	Aug. 26, 1975
Model number	YC-15
Wingspan	110 feet and 132 feet
Length	124 feet
Height	43 feet 4 inches
Gross weight	219,180 pounds
Cruising speed	535 mph
Range	460 miles STOL with 27,000-pound payload; 2,292 miles conventional with 38,000-pound payload
Power plant	Four 15,500-pound-thrust Pratt & Whitney JT8D-209 Turbofan engines
Accommodation	Three crew, 150 troops or 27,000 pounds of cargo (STOL) or 69,000 pounds of cargo (conventional)

YC-15 Military Transport

Historical Snapshot

Built in response to an U.S. Air Force request for an advanced medium short-takeoff-and-landing (STOL) transport (AMST), McDonnell Douglas built two YC-15 prototypes to replace the Lockheed C-130 Hercules tactical transport. They were to be used on short, undeveloped fields, and Bell, Boeing, Fairchild, Lockheed and McDonnell Douglas submitted proposals in March 1972. Boeing and McDonnell Douglas won contracts to design and build the transport; the Boeing version was designated the YC-14 and the McDonnell Douglas, the YC-15.

The YC-15 had four engines, while the Boeing version had two. The YC-15 used large, double-slotted flaps that extended over 75 percent of the wingspan to enhance STOL capabilities. To save costs, it used a modified DC-8 nosewheel unit and the DC-10 cockpit, adapted for a two-person crew, with two lower windows for visibility during short-field landings.

The YC-15 could hold 90 percent of all Army combat vehicles, including a 62,000-pound (28,122-kilogram) extended-barrel, 8-inch (203 mm) self-propelled howitzer. Vehicles were loaded through rear fuselage doors with built-in ramps. The YC-15 introduced a number of innovative features, such as externally blown flaps, which used double-slotted flaps to direct part of the jet exhaust downwards, while the rest of the exhaust passed through and downward over the flaps, introducing the Coanda effect. It was also the first military aircraft with a supercritical airfoil.

The YC-15 first flew on Aug. 26, 1975, and a competitive fly-off against its Boeing competitor was completed in 1977. However, the Air Force decided against the AMST aircraft and terminated the program. On Dec. 10, 1979, it formally cancelled the AMST program for both the YC-14 and the YC-15. This resulted in the development of the C-X (Cargo Transport Aircraft-Experimental) — the future C-17.

One YC-15 (Serial No. 72-1876) was stored at Davis-Monthan Air Force Base, Ariz., and scrapped in March 2012. The last remaining YC-15 (Serial No. 72-1875) is on display near the west Gate of Edwards Air Force Base, Calif.

Technical Specifications

First flight	Sept. 10, 1956
Span	36 feet 7 inches
Length	61 feet 8 inches
Gross weight	39,755 pounds (empty)
Power plant	24,000-pound thrust (with afterburner) Pratt & Whitney J75-P-9 turbojet
Speed	Mach 2
Crew	One
Operating altitude	53,200 feet
Armament	Four 20 mm M-39E cannon, up to 10,000 pounds of bombs

YF-107 Fighter

Historical Snapshot

After the North American F-100 Super Sabre was in production, the design was reconfigured to meet U.S. Air Force requirements for a fighter-bomber capable of delivering a nuclear payload at Mach 2 speeds. The first versions were designated F-100B, but when the Air Force ordered prototypes, the designation changed to YF-107A (NA-212).

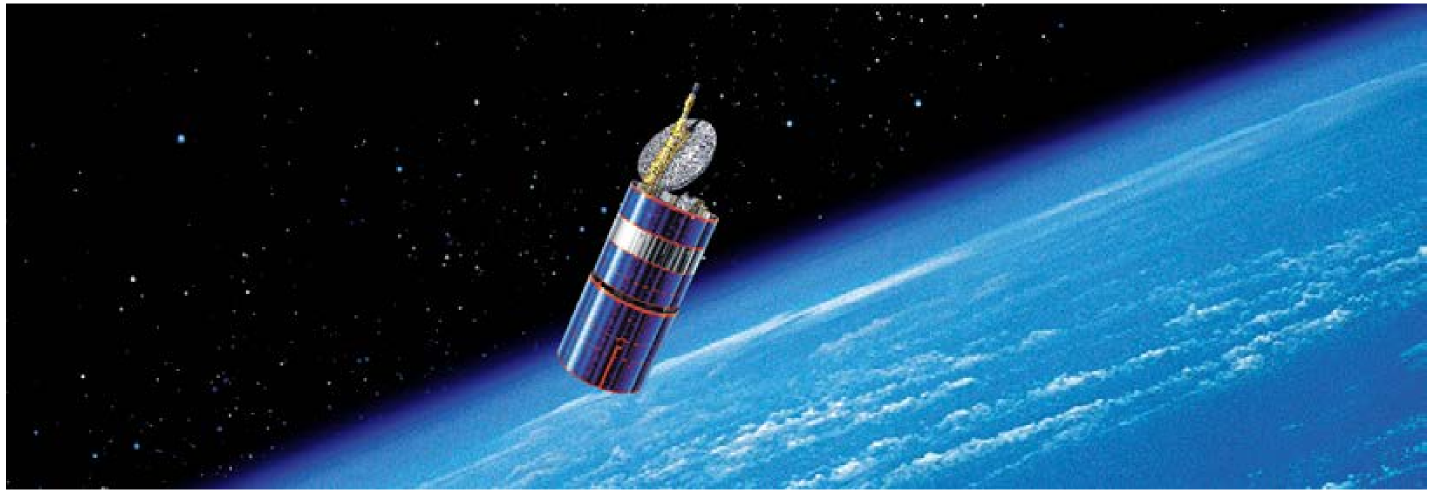
To permit installation of a fire control radar, the air intake was located behind the cockpit. The YF-107A flew Mach 2 in its first all-out test flights during 1957. It was the last fighter North American Aviation built for the Air Force.

The three YF-107As provided valuable data for advanced flight research. They were followed by the F-108 (NA-257) Rapier, which entered the design stage as a Mach 3 interceptor but was never produced.

International Space Station

Space

- 376 Satellite
- 601 Satellite
- 702 Satellite
- Apollo Lunar Spacecraft
- Delta Rocket
- Gemini Spacecraft
- Inertial Upper Stage Rocket
- International Space Station
- Little Joe Launch Vehicle
- Lunar Orbiter Spacecraft
- Lunar Roving Vehicle
- Mariner 10 Spacecraft
- Mercury Spacecraft
- Saturn V Moon Rocket
- Solar Power Satellite
- Space Shuttle Orbiter
- Surveyor Lunar Spacecraft
- X-15 Research Aircraft
- X-20 Dyna-Soar Space Vehicle



376 Satellite

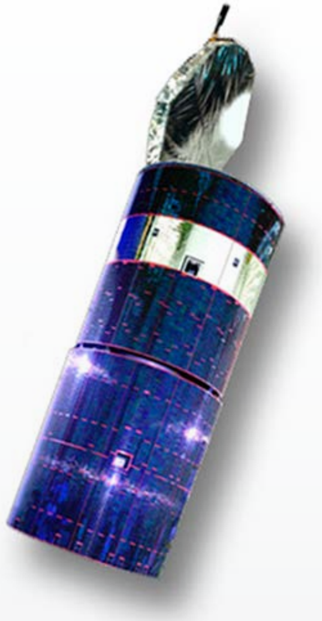
Historical Snapshot

The popular and versatile Boeing 376 spin-stabilized spacecraft was the first satellite to be launched by a Space Shuttle. First built by Hughes Space and Communications Company, all Boeing 376 models have two telescoping solar panels and antennas that fold for compactness during launch. They were available in several configurations and were boosted by many of the world's major launch vehicles.

The first Boeing 376 satellite model was launched in 1980, and in 2002, the Boeing 376 was the world's second most purchased satellite after the Boeing 601. Boeing could produce a Boeing 376 satellite in less than 14 months. Because of its shorter manufacturing time compared with larger models, the Boeing 376 filled a unique niche for customers who were entering the business and needed a smaller spacecraft, or for established operators who had a specific business opportunity for a specific region and needed a satellite on a short schedule.

e-BIRD, launched in September 2003, was the last Boeing 376 launched and remains in service today, along with several other Boeing 376 satellites. Following e-BIRD, Boeing shifted its focus to the body-stabilized satellites, such as the Boeing 601 and the Boeing 702.

Throughout the 23 years that Boeing delivered the Boeing 376 satellite, the design continuously evolved to incorporate new technologies, such as more efficient solar cells produced by Boeing subsidiary Spectrolab. The Boeing 376W model is an extension of the Boeing 376 family. The Boeing 376W is larger, wider and more powerful than the Boeing 376.



601 Satellite

Historical Snapshot

The Boeing 601 satellite was introduced in 1987 to meet anticipated requirements for high-power, multiple-payload satellites. It was designed for such applications as direct television broadcasting to small receiving antennas, very small aperture terminals for private business networks and mobile communications.

The 601 was originally developed by Hughes Space and Communications Company, which Boeing acquired in 2000.

A more powerful version, the Boeing 601HP, made its debut in 1995. The HP versions can accommodate payloads twice as powerful as the classic Boeing 601 models. They feature such innovations as gallium arsenide solar cells, advanced battery technology and an optional xenon-ion propulsion system.

The Boeing 601 body is composed of two modules: (1) the primary structure, which carries all launch vehicle loads and contains the propulsion subsystem, bus electronics and battery packs, and (2) a structure of honeycomb shelves that hold the communications equipment, electronics and isothermal heat pipes.

In the early 1990s, Hughes was contracted to participate in the development of two satellites for mobile communications services throughout North America. Hughes provided 601 spacecraft buses for the satellites.

AMSC-1 was launched on an Atlas rocket in April 1995. At the time it was state-of-the-art for commercial mobile communications. Each satellite has the capability to support 2,000 radio channels in L-band. The footprint covers the entire continental United States and Canada as well as Alaska, Hawaii, Puerto Rico, the Virgin Islands, and 200 miles of U.S. and Canadian coastal waters.

The operators provide complementary mobile telephone, radio, data and positioning service to land, aviation and maritime users. Each operator also provides the other with backup and restoration capacity.

The Boeing 601 satellite has been one of the best selling spacecraft models. More than 80 have been delivered to customers around the world.

702 Satellite

Historical Snapshot

The body-stabilized Boeing 702 was announced in October 1995 by Hughes Space and Communications Co. Evolved from the popular, proven 601 and 601HP (high-power) spacecraft, the Boeing 702 is the world leader in capacity, performance and cost efficiency.

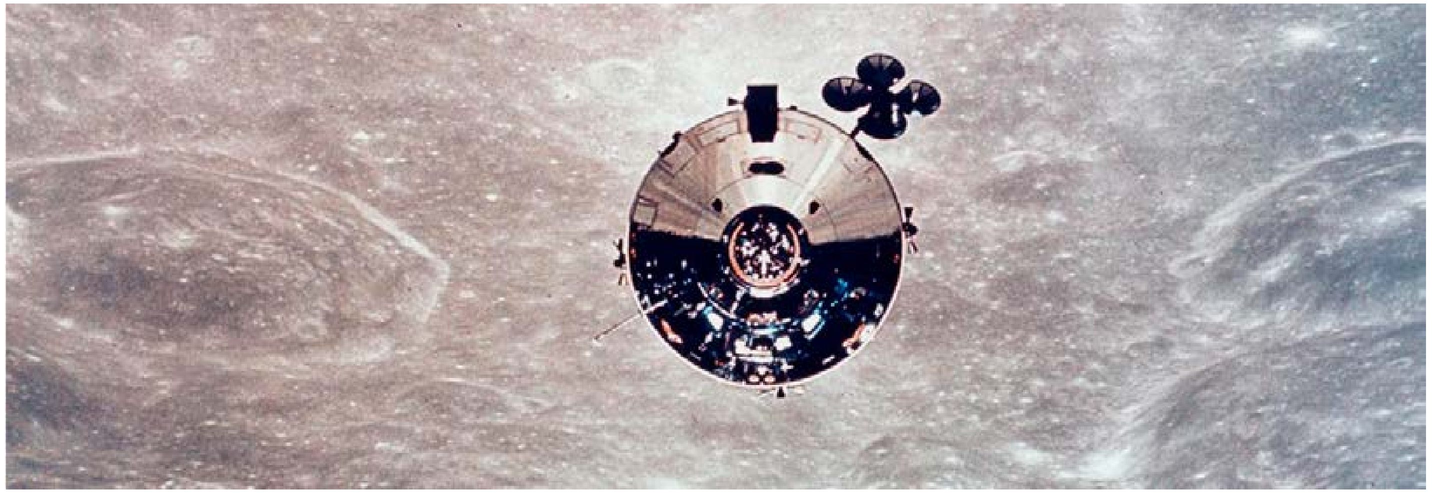
The first 702 satellite was launched in 1999. The satellite could carry more than 100 high-power transponders and deliver any communications frequencies that customers requested.

In March 2010, Boeing Space & Intelligence Systems announced it would begin marketing its 702 satellite under two names: the Boeing 702HP for the high-power version and the Boeing 702MP for the medium-power version.

The 702HP configuration carries a modern lithium-ion power system and other features designed to operate at power levels greater than 12 kilowatts. This higher-power capability is required for satellite telephone systems and fixed satellite services. The 12-kilowatt-range 702MP is powered by a bipropellant system and can accommodate a wide range of payloads and hosted payloads for commercial, civil and government customers with lower power requirements.

By March 2010, Boeing had sold 28 702 satellites. Those in service had accumulated 867,000 hours of service life for both commercial and military customers. In 2012, Boeing introduced the Boeing 702SP (small platform), an evolution of the Boeing 702 satellite. It coupled proven technology from Boeing's previous designs with next-generation technology and processes, resulting in an affordable, lightweight alternative design. 702SP passed its critical design review in May 2013.

Because of its lower mass and weight, two 702SP satellites can be launched on a single launch vehicle, resulting in a cost savings of up to 20% when compared with existing launch options.



Technical Specifications	
First moon landing	July 20, 1969
Height	12 feet
Type	Spacecraft
Crew	Three

Apollo Lunar Spacecraft

Historical Snapshot

The Apollo program sent nine expeditions to the moon between 1969 and 1972. Six succeeded in landing a total of 12 astronauts. Two early flights were for reconnaissance in lunar orbit, and one landing mission, Apollo 13, was aborted after an oxygen tank exploded. The crippled vessel flew around the moon and returned safely with its photographs.

Apollo 7 made the first flight to Earth orbit; Apollo 8 made the first orbit of the moon. Apollos 8 and 10 tested various components while orbiting the moon and returned photography of the lunar surface. Apollos 9 and 10 tested the lunar module. Apollo 11 landed men on the moon July 20, 1969. The last mission was Apollo 17, Dec. 7-19, 1972.

The six missions that landed on the moon returned a wealth of scientific data and 842 pounds (382 kilograms) of lunar samples. Experiment types included soil mechanics, meteoroids, seismic, heat flow, lunar ranging, magnetic fields and solar wind.

The program began after Russia successfully sent Sputnik, the Earth's first artificial satellite, into orbit on Oct. 4, 1957, and the Western world scurried into a competitive frenzy.

By April 1958, Congress was studying 29 different bills and resolutions dealing with space, spread between all three branches of the services, all with different plans. President Dwight Eisenhower finally harnessed the chaos by establishing a single space agency, the National Aeronautics and Space Administration, formerly the National Advisory Committee on Aeronautics. NASA then outlined specifications for the Apollo program — the U.S. entry in the race to the moon.

Robert Rowe Gilruth, NASA director, Manned Spacecraft Center, said one fundamental requirement for mission success was employing “the kind of people who will not permit it to fail.” The basic reliability philosophy, he said, was “that every manned spacecraft that leaves the earth ... shall represent the best that dedicated and inspired men can create. We cannot ask for more; we dare not settle for less.”

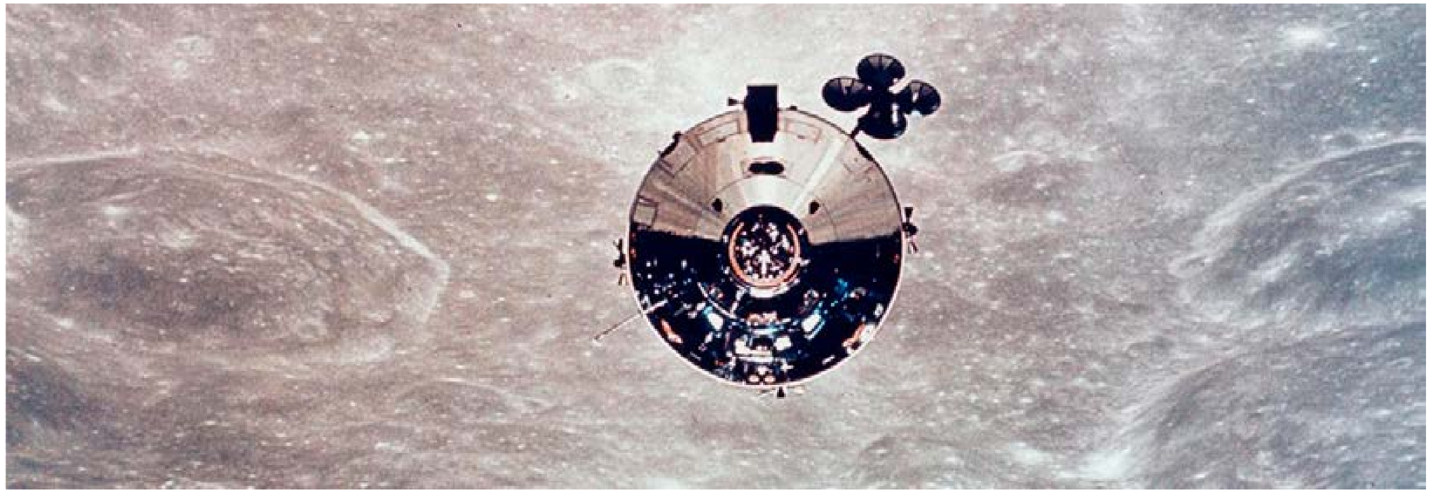
In 1961, North American Aviation's Autonetics division began developing entry monitor systems and ground support equipment for the Apollo spacecraft.

The launch vehicle from Earth was the three-stage 7.5 million-pound (3.4 million-kilogram) Saturn V, first launched Nov. 9, 1967. Its first-stage thrust was 7.5 million pounds (3.4 million kilograms), the second stage had 1 million pounds (454,000 kilograms) of thrust, and the third stage had 225,000 pounds (102,000 kilograms) of thrust.

The Apollo command and service modules were built at North American Aviation's plant at Downey, California. The many things that could doom the crew made ground testing all the more important, so the company built a 150-foot-high Impact Test Facility. It looked like a gigantic playground swing and checked the module's structural integrity and impact loads by drop-testing it on water, sand, gravel and boulders.

Boeing sent the Lunar Orbiter to take pictures of the moon's surface before the first landing mission, built the first stage of the Saturn V launch vehicle, integrated the assembly of all three stages of Saturn V and provided astronauts with the Lunar Roving Vehicle. McDonnell Douglas built the Saturn V's third stage. North American Rockwell designed and built the Saturn V second stage and the command and service modules.

North American Rockwell's Rocketdyne division built five F-1 engines for the first stage of the Saturn V, five J-2 engines for the second stage, one J-2 engine for the third stage, one engine used in the Lunar Module for ascent, 12 reaction control engines, and six small “ullage” motors that were used in the second and third stages to settle propellants before ignition of the J-2 engines.



Apollo Lunar Spacecraft (cont'd)

On Jan. 27, 1967, astronauts Gus Grissom, Ed White and Roger Chaffee died in a fire in the command module while preparing for the first crewed Apollo flight. The tragedy triggered an exhaustive investigation of NASA's Project Apollo procedures. The government approached the aerospace industry to solve the problem.

"We'll help the nation in any way NASA wants," said Boeing President William Allen, although it meant stretching company resources. NASA asked Boeing to provide Apollo technical integration and evaluation (TIE) because of its experience coordinating far-flung complex programs like Minuteman. Allen assigned 2,000 Boeing managers to the project under George Stoner, vice president and general manager of the Space division.

Because good communications were crucial to the space project, Boeing worked with Xerox, the Bell System, American Telephone and Telegraph, and Western Union to establish the Blue Teleservice Network, a dedicated system linking key managers at NASA facilities with Boeing in Seattle by telephone, telegraph, radio and high-speed data fax. Central communications rooms were set up at each NASA facility for teleconferences.

George Stoner is still remembered as a visionary. Robert Brock, 1984 vice president of the Boeing Space division, told an interviewer that during the early 1960s, Stoner talked about IBM computers, how people would fly to other planets, and how computers would become much, much smaller and would "operate with much more high speed." Stoner also encouraged research into advanced global communications, global navigation systems and environmental data gathering by way of satellites — long before these became commonplace.

The TIE personnel, under his guidance, ensured that everything worked with everything else and daily monitored millions of pieces of hardware so that the myriad components of the spacecraft were in perfect working order. They saw that contracts were met and were on schedule. Apollo TIE lasted until 1970, when NASA took it over.

Delta Rocket

Historical Snapshot

Delta's history stretches back to the late 1950s when the U.S. government, responding to the Soviet Union's launch of Sputnik in 1957, contracted for development of the rocket. These early Delta rockets derived their design from Thor, the U.S. Air Force's intermediate-range ballistic missile. The first successful Delta launch was of NASA's Echo 1A satellite on Aug. 12, 1960.

The Delta legacy grew with launches of the Tiros and GOES satellites, beginning in 1960, which revolutionized weather forecasting, and the first Telstar and Intelsat launches, which enabled the now-famous TV phrase, "Live, via satellite!" The Explorer research satellites provided data about energy fields and particles that could affect communications satellites, while NASA's Pioneer probes undertook a long series of space exploration missions.

Through the years, Delta became larger, more advanced and capable of carrying heavier satellites into orbit. Design changes included larger first-stage tanks, addition of strap-on solid rocket boosters, increased propellant capacity, an improved main engine, adoption of advanced electronics and guidance systems, and development of upper stage and satellite payload systems. In a series of incremental steps, Delta payload capacity grew from 45 kilograms (100 pounds) to a 115-mile (185-kilometer) circular low Earth orbit (LEO) up to 21,892 kilograms (48,264 pounds) to a 253-mile (407-kilometer) circular LEO and 12,980 kilograms (28,620 pounds) to geosynchronous transfer orbit (GTO) using Delta IV.

Until the early 1980s, Delta served as NASA's primary launch vehicle for boosting communications, weather, science and planetary exploration satellites into orbit.

In 1981, the U.S. space shuttle changed U.S. space policy, and after 24 years Delta production halted, as NASA planned to use the shuttle for satellite launches.

However, in January 1986, President Reagan announced that shuttles would no longer carry commercial payloads, opening the way for the return of Delta. Following a contract from the Air Force for 20 launch vehicles, the newer, more powerful Delta II version emerged in 1989.

In response to market needs for a larger rocket to launch commercial satellites, Delta III began development in 1995. Its first launch was in 1998 and its final launch in 2000, paving the way to the next configuration of the Delta rocket, the Delta IV.

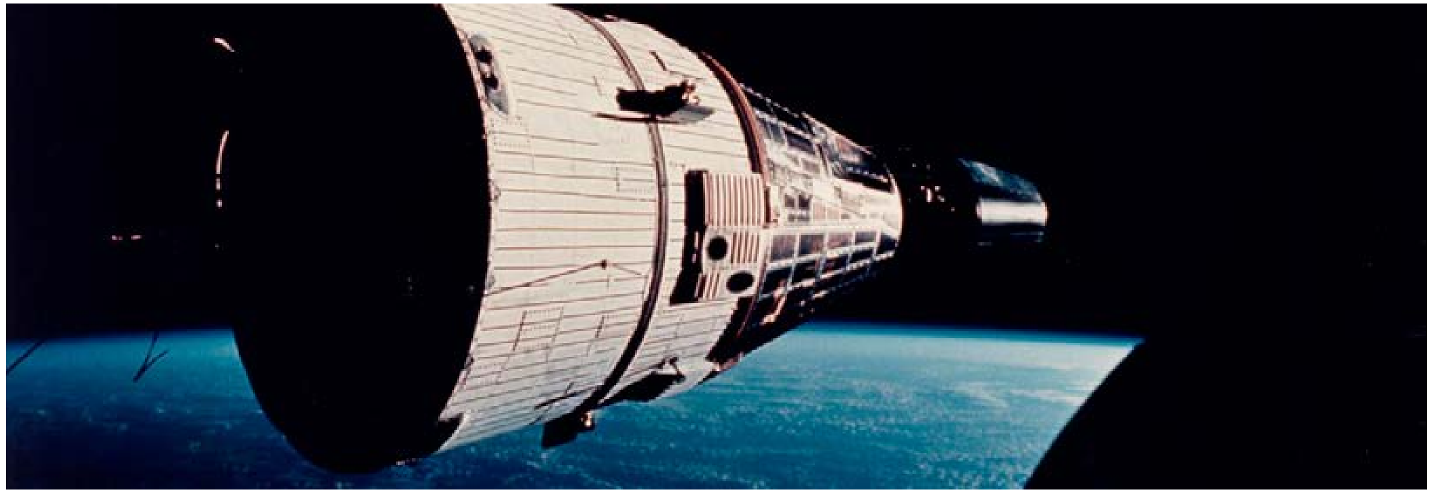
The Delta IV family of medium-to-heavy launch vehicles became operational in 2002. The first Delta IV launch, of Eutelsat's W5 commercial satellite, took place on Nov. 20, 2002. The first payload delivered for the U.S. government's Evolved Expendable Launch Vehicle program was the Defense Satellite Communications System (DSCS) A3 satellite on March 10, 2003.

Delta IV launch vehicles can accommodate single or multiple payloads on the same mission. The rockets can launch payloads to polar orbits, sun-synchronous orbits, geosynchronous orbits and GTOs, and LEO.

Each Delta IV rocket is assembled horizontally, erected vertically on the launch pad, integrated with its satellite payload, fueled and launched. This process reduces on-pad time to less than 10 days and the amount of time a vehicle is at the launch site to less than 30 days after arrival from the factory, reducing cost and increasing schedule flexibility.

In December 2006, Boeing and Lockheed Martin Corporation combined their Delta and Atlas expendable launch vehicle businesses, forming the United Launch Alliance (ULA) joint venture. ULA provides launch services to U.S. government customers. Its first Delta launch, of a National Reconnaissance Office satellite aboard a Delta II, took place on Dec. 14, 2006.

Delta launches for commercial customers are provided by Boeing. Boeing Launch Services procures the launch vehicles and related services for its commercial customers from ULA.



Technical Specifications	
First crewed launch	March 23, 1965
Length	19 feet
Diameter	10 feet
Launch weight	8,400 pounds
Crew	Two

Gemini Spacecraft

Historical Snapshot

NASA selected McDonnell to build the Gemini capsule in 1961, and it was delivered less than two years later. McDonnell also delivered the Agena target vehicle docking adapters and mission and docking simulators. Final splashdown of *Gemini XII* was Nov. 15, 1966.

The two-person Gemini spacecraft had nearly twice the room of the Mercury and included many technological improvements. Experience showed that much equipment could be placed outside the pressurized cabin and left behind at re-entry. Gemini propulsion systems allowed changes in orbit as well as re-entry maneuvers for pinpoint landings.

Gemini showed how astronauts could endure long-duration weightlessness and how they could maneuver in orbit, rendezvous and dock with another vehicle. Gemini established many records, including the longest duration flight of 330 hours, 35 minutes, 17 seconds set by *Gemini VII*; the first rendezvous of two maneuverable spacecraft, *Gemini VI* and *Gemini VII*; and the first docking of two orbiting spacecraft with *Gemini VIII* and *Agena VIII*.

Mercury and Gemini programs compiled 1,993 hours of crewed space flight.

Inertial Upper Stage Rocket

Historical Snapshot

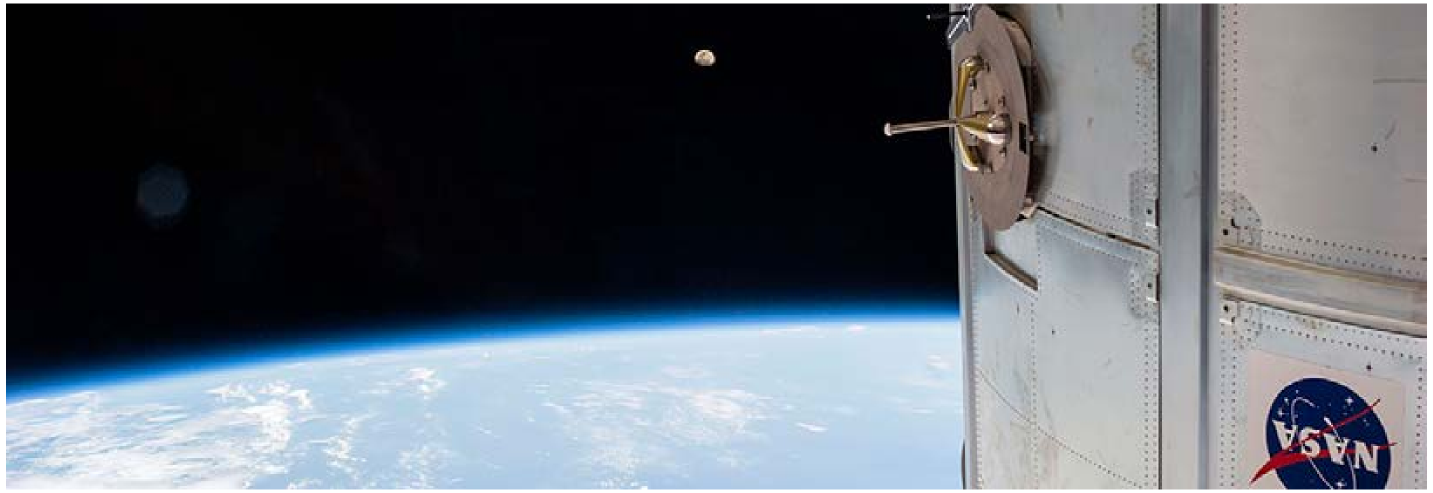
The Boeing-developed Inertial Upper Stage (IUS), an unpiloted, upper-stage booster rocket, could be launched from the Titan 34D or Titan IV expendable launch vehicles or from the Space Shuttle.

In 1989, the IUS sent the *Magellan* and *Galileo* spacecraft to Venus and Jupiter, respectively. In 1990, it sent the *Ulysses* spacecraft to the sun. On Aug. 6, 2001, an IUS successfully deployed a Defense Support Program satellite for the U.S. Air Force from Cape Canaveral Air Force Station, Fla.

A typical Boeing IUS mission launched from a Titan IVB involved IUS separation from the rocket's second-stage booster approximately nine minutes into flight. The IUS took over responsibility for the remainder of the powered portion of the flight. For the next six hours and 54 minutes, the IUS autonomously performed all functions to place the spacecraft into its proper orbit, some 22,000 miles (35,405 kilometers) above the Earth. The first IUS rocket burn occurred a little over one hour into the IUS booster flight. The IUS second solid rocket motor ignited about six-and-a-half hours into the flight, followed by a coast phase, and then, separation of the spacecraft.

The Boeing IUS was launched on its final mission, Feb. 14, 2004, when it successfully deployed a U.S. Air Force Defense Support Program (DSP) satellite. The IUS-10 and its integrated payload, DSP-22, were launched aboard a Titan IVB rocket, which also flew with a Boeing-made fairing. Liftoff occurred from Space Launch Complex 40 at Cape Canaveral Air Force Station.

On separation from the rocket, IUS-10 fired its two stages to propel the spacecraft toward its geosynchronous orbit. Following roll maneuvers, the IUS successfully deployed the spacecraft. "This last IUS mission added a critical asset to our nation's military space program with the successful launch of DSP-22," said Bill Benshoof, Boeing IUS program manager. "The flight of IUS-10 concludes a 22-year journey for one of the most successful upper stages ever built and flown."



Technical Specifications	
First launch	Nov. 20, 1998 (Zarya)
Classification	Orbiting space laboratory
Height	143 feet
Length	290 feet
Width	356 feet
Weight	One million pounds
Living and working space	More than 46,000 cubic feet
Average orbit altitude	220 miles, at an inclination of 51.6 degrees to the Equator
Accommodation	7 crew

International Space Station

Historical Snapshot

In August 1993, NASA selected Boeing as prime contractor for the International Space Station (ISS), a permanent orbiting laboratory in space and the largest international space venture ever undertaken. With a "space footprint" the size of two football fields, the space station averages an altitude of 220 statute miles (354 kilometers).

As the prime contractor, Boeing was responsible for design, development, construction and integration of the ISS and for assisting NASA in operating the orbital outpost. Boeing built all of the major U.S. elements. The company also prepared every ISS U.S. component for space flight at the Space Station Processing Facility at Kennedy Space Center, Fla.

In addition, Boeing oversaw thousands of subcontractors around the globe and worked with 16 international partners on the project. Between 1998 and 2005, 12 major ISS components were assembled in space. Scientific research was being conducted aboard the ISS in the U.S. laboratory dubbed "Destiny," which holds 24 of the telephone booth-sized International Standard Payload Racks used for science experiments and ISS equipment.

In addition to the laboratory, the ISS had living quarters aboard the Russian-built Zvezda service module. The crew could also make spacewalks from the U.S.-built Quest joint airlock. The Zvezda module also included an airlock. The 300-foot-long (91-meter-long) integrated truss structure and solar arrays, which comprised 9,601 square feet (892 square meters), generated electrical power for the space station.

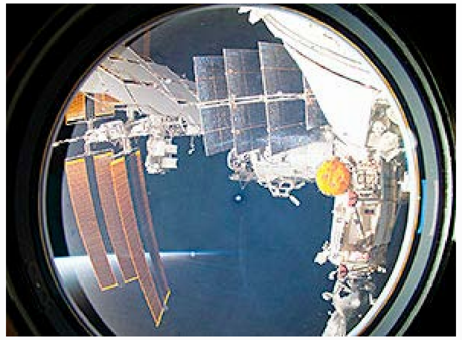
By November 2005, when ISS clocked its fifth year of providing a continuous human presence in space, it had grown and evolved into a 404,069-pound (183,283-kilogram) laboratory complex with 15,000 cubic feet (425 cubic meters) of habitable volume. Eighty-nine scientific investigations had been conducted on the ISS, which has a microgravity environment that cannot be duplicated on Earth.

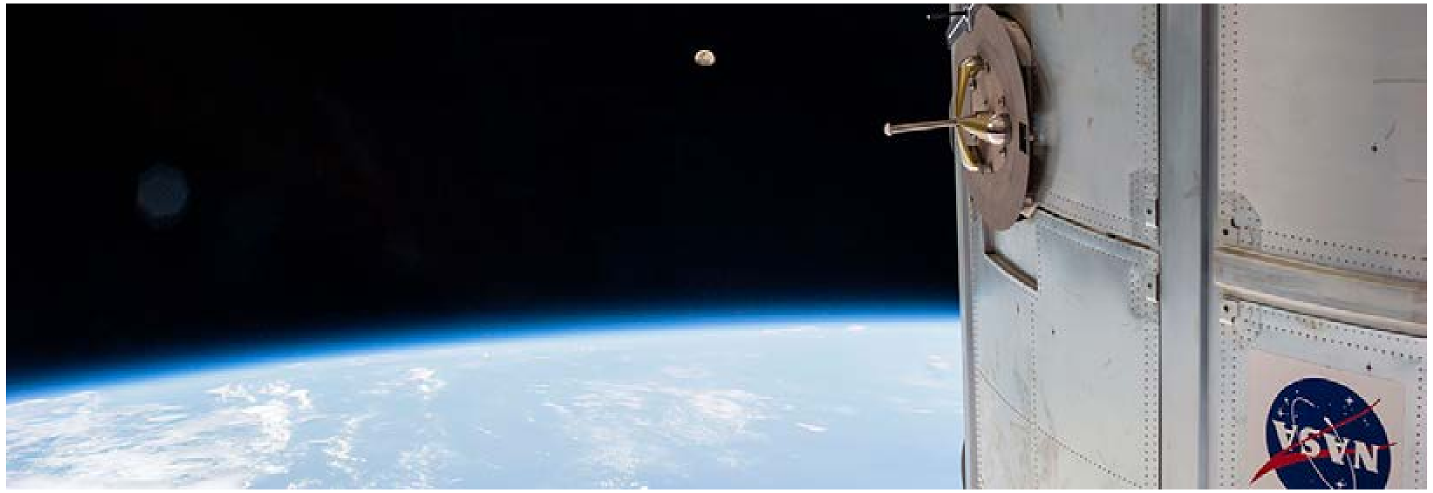
On Oct. 1, 2008, Boeing was awarded a $650 million sole-source contract from NASA to continue to deliver and integrate the remaining components and software for the ISS. The contract included the management of a majority of ISS subsystems and specialized ground-based engineering work in disciplines such as materials, electrical parts, environments and electromagnetic effects.

Boeing prepared the last major piece of ISS hardware for delivery In February 2010. Tranquility — formerly referred to as Node 3 — provided additional space for existing life support and environmental control systems. Thales Alenia Space Italy (TASI) had built the utility module and delivered it to NASA. Boeing performed final processing tasks to prepare the module for shuttle integration. Boeing had also produced many of the module's components, including windowpanes, hatches, berthing mechanisms, ammonia hoses, and ventilation and thermal-coolant valves, at the company's Huntsville, Ala., facility, and provided TASI with engineering and testing support.

On March 5, 2010, Boeing officially turned over the U.S. on-orbit segment of the ISS to NASA with the signing of government Form DD-250 at the conclusion of an acceptance review board meeting in Houston. Often referred to as "handing over the keys," the DD-250 is equivalent to a final bill of sale that formally transfers ownership.

But Boeing support to ISS continued. On Sept. 14, 2010, Boeing announced that NASA had awarded the company an extension to the ISS contract for sustaining engineering for hardware and software on the U.S. segment of the ISS and for common hardware and software available to the international partners. The work also included management of ISS subsystems;





International Space Station (cont'd)

analytical integration and flight support; on-orbit engineering support; monitoring and trending system performance; anomaly resolution, specialty engineering and oversight of ongoing maintenance.

At a 15-year celebration, on Nov. 20, 2013, John Elbon, vice president and general manager of Boeing's Space Exploration division, said, "Boeing congratulates NASA and its international partners on 15 years of successful ISS operations. We've seen the station grow from a single module in low Earth orbit to the world's greatest engineering feat. As NASA's prime contractor for the ISS, Boeing helped build the station, and we are proud of our continuing support for its astronauts as they live and work away from the Earth's surface."

International Space Station home page

Little Joe Launch Vehicle

Historical Snapshot

The Little Joe booster was a low-cost launcher designed to test the escape system and heat shield for the manned Mercury spacecraft. NASA awarded the contract on Dec. 29, 1958, to the Missile Division of North American Aviation. Each launcher cost only about $200,000. With its four large stabilizing fins protruding from its clustered solid rocket motor airframe, Little Joe was the only booster system designed specifically for manned capsule qualifications and was also one of the pioneer operational launch vehicles using the rocket-cluster principle.

Because initial solid-section drawings showed four holes up, the project was named "Little Joe" after a crap-game throw of a double deuce on the dice. The project saved money by allowing numerous test flights to identify solutions to problems associated with the development of manned space flight, especially the problem of escaping from an explosion midway through takeoff.

The unguided vehicle was propelled by eight solid-fuel rocket engines. Various combinations of Pollux, Castor and small Recruit engines were selected according to the trajectory desired for each flight. Typically, all four Recruits would ignite simultaneously with two larger motors, while two more large motors would ignite later in the flight. The first five launch attempts used preliminary boilerplate capsules, while the final three attempts carried full production Mercury spacecraft atop an extended spacecraft adapter.

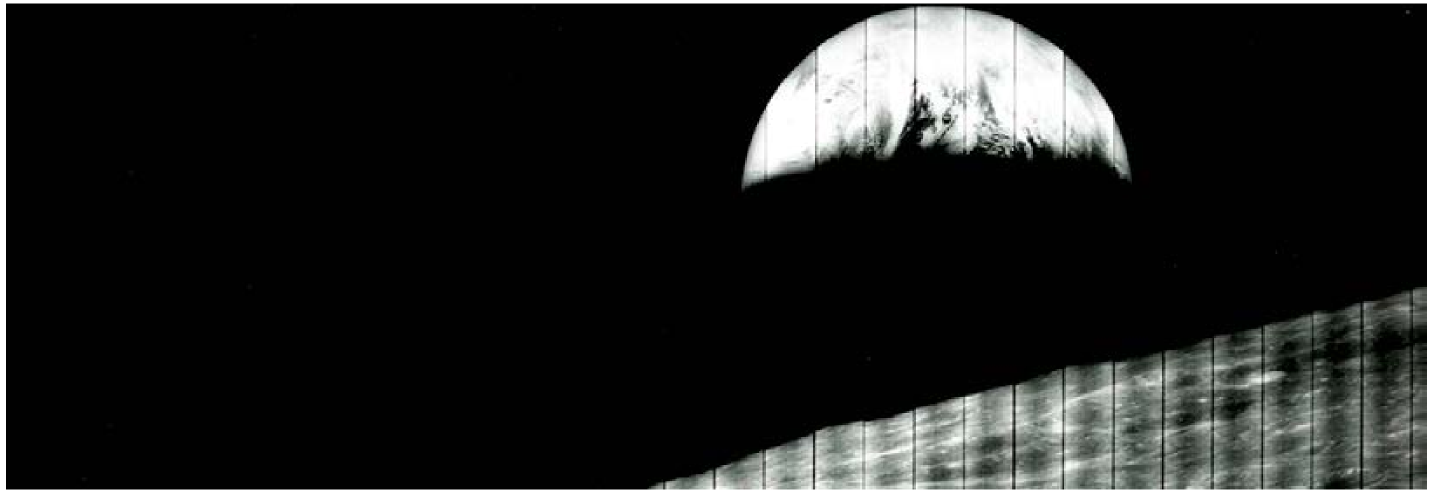
On Oct. 4, 1959, the first Little Joe I took off from Wallops Island, Va. Designated LJ-6 (Little Joe flights were numbered according to their mission goals rather than chronologically), it launched a boilerplate Mercury capsule. The five-minute flight proved the rocket for the following tests of launch escape system.

On Jan. 21, 1960, LJ-1B lifted off from Wallops Island, carrying the rhesus monkey named "Miss Sam." At an altitude of 9 miles (14.5 kilometers), the Mercury escape rocket fired, pulling the boilerplate spacecraft and its primate payload from the booster. Both the escape system and the monkey came through with flying colors, proving that even a failed Mercury flight would be survivable. The success of LJ-1B meant that the next flight, the sixth, to be known as LJ-5, would be the first to fly a real Mercury capsule from the McDonnell production line.

The final series of flights was to test an actual production spacecraft in a max-q abort. Two attempts, L3-5 and LJ-5A, failed, as escape rocket firings were mistimed. The capsule was recovered and renovated to fly aboard the last Little Joe I.

LJ-5B lifted off from Wallops Island on April 28, 1961. Because one rocket motor failed to ignite, the resulting trajectory was abnormally low. In spite of the unexpectedly harsh conditions, the escape rockets performed well, and the Mercury capsule survived in good shape. In eight launch attempts, the Little Joe I had fulfilled its mission, proving that the Mercury escape system could perform its job under the harshest conditions expected in a manned Mercury flight.

The first 13-foot-diameter (3.9-meter-diameter) Little Joe II launcher was fired for the first time from White Sands Missile Range, N.M., Aug. 23, 1963, carrying the 52-foot-tall dummy Apollo command and service module. It proved Little Joe's capability as an Apollo spacecraft test vehicle and determined base pressures and heating on the missile. North American built seven Little Joe airframes, retaining one at its Downey, Calif., plant for static loading tests.



Technical Specifications	
First launch	Aug. 10, 1966
Classification	Space probe
Width	18 feet 6 inches (with solar panels and antennas deployed)
Height	12 feet 6 inches (with solar panels)
Gross weight	850 pounds
Launch vehicle	Atlas-Agena D missile
Orbit injection	Retrorockets

Lunar Orbiter Spacecraft

Historical Snapshot

On Aug. 14, 1966, Lunar Orbiter 1 was the first U.S. spacecraft to orbit the moon. Its mission was to obtain photographs of the moon's surface. The photos sent by each of the five Lunar Orbiters helped NASA select safe landing sites for the Apollo astronauts. Other program objectives were to collect data on the moon's gravitational field, and study radiation and micrometeoroid flux in the vicinity of the moon.

Although Boeing came in with the highest bid, it had many factors in its favor. NASA's Lunar Orbiter Project Office recommended that the company, along with its subcontractors Eastman Kodak and RCA, build the Lunar Orbiters. A final contract for five orbiters was signed on May 7, 1964.

The Lunar Orbiter was an 850-pound (385-kilogram) structure that measured 5 feet (1.5 meters) wide and 5 feet, 6 inches (1.6 meters) tall in its launch configuration. With its four solar panels and two antenna booms deployed, it measured 18 feet, 6 inches (5.6 meters) wide.

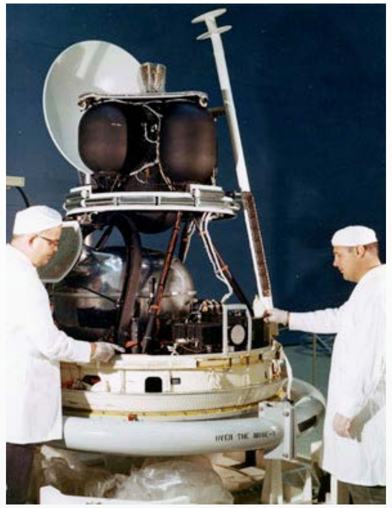
Using film laminated with darkroom chemicals, the orbiter took pictures of the moon's surface. Heat processed the film in space. Light, flashed through the resulting negative, created beams that were converted into electrical signals for transmission to Earth, where the image was pieced together.

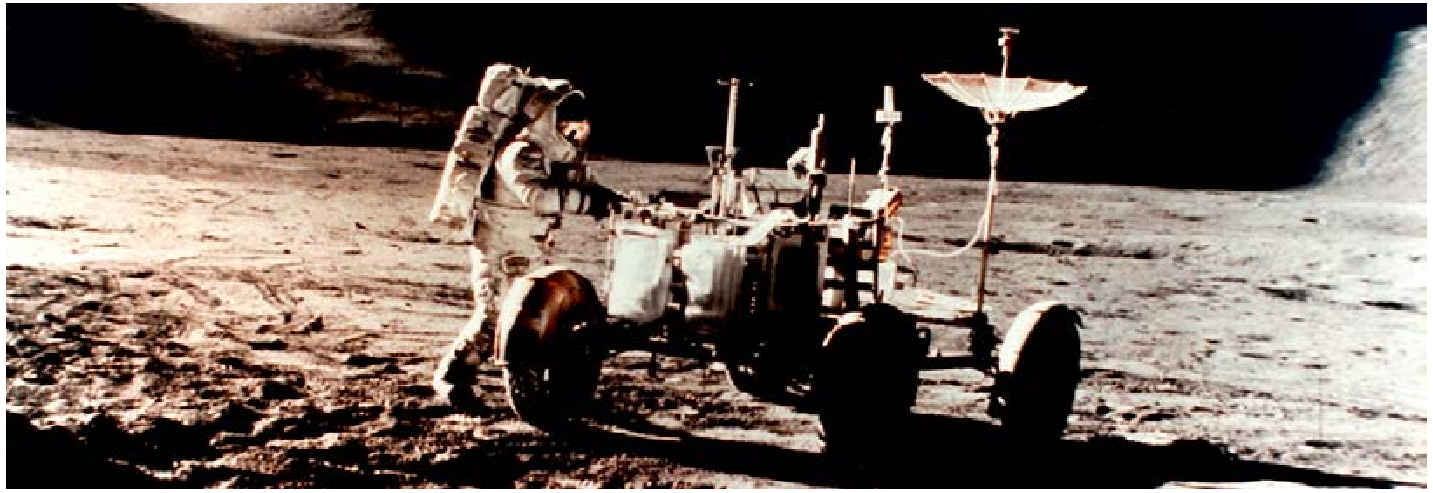
More than 90 percent of the pictures taken were transmitted successfully, including the historic Earth-rise taken from the moon Aug. 23, 1966. It was hailed at that time as the greatest photograph of the 20th century. The five orbiters took pictures of approximately 99 percent of the moon's surfaces — more than 14 million square miles (22.5 million kilometers). Lunar Orbiter photographs have provided the basis for all accurate maps of the moon.

The Lunar Orbiters were built at the Boeing Missile Production Center in Seattle, Wash., and were tested there and at the space environment test chamber at the then-new Boeing Space Center in Kent, Wash.

Orbiters 1, 2 and 3 fulfilled the program's original mission objectives, which allowed the last two orbiters to perform broader scientific studies. Both Orbiter 4 and 5 were placed into near-polar orbits and made broad photographic surveys of the lunar surface.

The Lunar Orbiters gave the Apollo project valuable data about the moon and its environment as well as flight operations experience in tracking spacecraft in lunar orbit. The alternative to sending the orbiters was a single manned Apollo mission that would have been considerably more expensive than the entire Lunar Orbiter program — and could have forced the United States to miss the goal proposed by President Kennedy for a manned landing on the moon before the end of the decade.





Technical Specifications	
First launch	July 26, 1971
Classification	Moon-exploration vehicle
Weight	462 pounds
Payload	1,600 pounds
Length	10 feet 2 inches
Width (to center of wheels)	6 feet
Wheelbase	90 inches
Range	57 miles
Power	Two 36-volt batteries powering four 1/4-horsepower electric motors (one at each wheel)
Accommodation	2 astronauts

Lunar Roving Vehicle

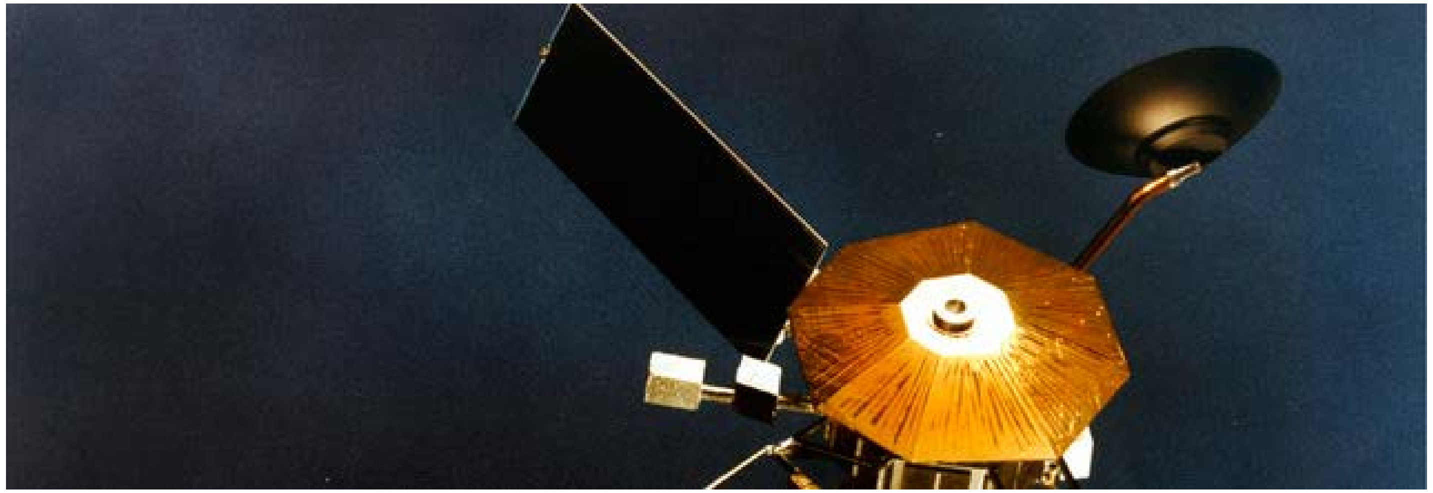
Historical Snapshot

Boeing began building the Lunar Roving Vehicle (LRV) at the Kent, Wash., facility in 1969, and the first vehicle was delivered just 17 months after the contract was signed.

It looked like a golf cart, or a stripped-down dune buggy, but was an engineering marvel. Equipped with a color television camera able to send images back to Earth via satellite, it traveled about 10 mph (16 kph), carried four times its own weight and had woven piano-wire mesh-like wheels to negotiate the strange lunar surface. An LRV traveled to the moon folded up and stuffed into a small storage space on the side of the Lunar Module on Apollo missions 15, 16 and 17.

The Lunar Roving Vehicles gave the astronauts the ability to do three times the amount of work done on the earlier voyages. The battery-powered vehicles operated faultlessly in temperatures ranging from minus 200 degrees Fahrenheit (minus 128 degrees Celsius) to more than 200 degrees Fahrenheit (93 degrees Celsius). After the Apollo program ended, the moon cars were left parked on the surface, awaiting the next generation of astronauts.

The legacy of the LRV, however, extended back to Earth, where its technology helped evolve the motorized wheelchairs that today provide many people with a way of negotiating around this world.



Technical Specifications	
First launch	Nov. 3, 1973
Classification	Interplanetary space probe
Basic diameter	54.4 inches
Solar panels	106 inches long, 38 inches wide
Gross weight	1,160 pounds
Science package	170 pounds

Mariner 10 Spacecraft

Historical Snapshot

The Boeing Aerospace Mariner 10 probe, begun in 1971, was launched from the Kennedy Space Center, Fla., in 1973.

It made the first dual-planet spaceflight by launching to Mercury using the gravitational pull of Venus. The probe's two television cameras, a radio transmitter and data collection equipment were protected from the sun's heat by solar panels.

By March 1974, Mariner 10 had transmitted hundreds of television images and large quantities of data about the two planets back to Earth. It revealed cloud circulation patterns on Venus and the lack of a magnetic field and took the first high-resolution photographs of Mercury's cratered surface.

The National Society of Professional Engineers named Mariner 10 as one of the top 10 engineering achievements of 1974.

Technical Specifications	
First crewed launch	May 5, 1961
Height (including escape tower)	28 feet
Diameter	6.5 feet
Launch weight	3,649 pounds
Crew	One
Crewed vehicles launched	Six

Mercury Spacecraft

Historical Snapshot

The Soviet Union's launching of the satellite Sputnik on Oct. 4, 1957, set off the Space Race. The United States would answer the challenge with its own manned space program — Project Mercury.

The selection of McDonnell Aircraft Corp. to design, test and build Project Mercury, NASA's new spacecraft, was at first a carefully guarded secret. The detailed contract was signed on Feb. 6, 1959.

Over the next 2-1/2 years, McDonnell worked closely with NASA and some 4,000 suppliers and contractors throughout the country to make Project Mercury a reality.

Ultimately, McDonnell would design, develop and build 20 Mercury spacecraft, two procedural trainers, and ground support and checkout equipment.

The Mercury spacecraft was a 9-foot-tall (2.7-meter-tall), 74-inch-wide (1.8-meter-wide) cone-shaped craft that weighed approximately 1 ton (0.45 tonnes) fully loaded. It was made of strong, lightweight materials such as titanium and beryllium. The spacecraft was designed so that it could be operated automatically, manually or by ground control. The spacecraft cabins were equipped with molded, contoured couches made of a crushable honeycomb aluminum bonded to a fiberglass shell and lined with protective rubber padding that would transmit bodily loads evenly during peak acceleration and deceleration periods of the missions. Mercury spacecraft were equipped with a 100 percent oxygen environment within the cabin, and the astronauts had spacesuits with a separate oxygen supply.

On May 5, 1961, in the Mercury spacecraft Freedom 7, Alan Shepard became the first American to make a suborbital space flight. On May 25, 1961, President John F. Kennedy gave a speech before a joint session of Congress noting his decision for the United States to send an American to the moon and back by the end of the decade. President Kennedy stated, "Space is open to us now; and our eagerness to share its meaning is not governed by the efforts of others. We go into space because whatever mankind must undertake, free men must fully share." President Kennedy's speech, with the support of Congress, eventually led to the Gemini and Apollo programs.

By the time the final Mercury spacecraft splashed down on May 16, 1963, McDonnell had delivered 20 vehicles, and the spacecraft had compiled 53 hours, 55 minutes, 25 seconds of crewed space flight time.

Technical Specifications	
First launch	Nov. 9, 1967
Classification	Three-stage rocket
Diameter	33 feet
Height	363 feet
Weight	More than 6 million pounds
Propulsion	7.6 million pounds thrust

Saturn V Moon Rocket

Historical Snapshot

The Saturn V was a multistage liquid-fuel expendable rocket used by NASA's Apollo and Skylab programs and a massive representation of the power generated when Boeing, McDonnell Douglas and North American Aviation coordinated their efforts.

Boeing built the Saturn V's first stage; North American, the second stage; and McDonnell Douglas, the third. Each first and second stage was test-fired at the Stennis Space Center located near Bay St. Louis, Mississippi.

The largest production model of the Saturn family of rockets, the Saturn V was designed under the direction of Wernher von Braun at the Marshall Space Flight Center in Huntsville, Alabama, with Boeing, North American, McDonnell Douglas and IBM as the lead contractors. By 2007, it was still the most powerful launch vehicle ever flown. The Saturn V had 13 missions: the first 12 for the Apollo program and the 13th to place the McDonnell Douglas Skylab into orbit.

The Saturn V could put a 120-ton (108-tonne) payload into Earth orbit or a 45-ton (40-tonne) payload near the moon. It contained 5.6 million pounds (2.5 million kilograms) of propellant, or 960,000 gallons (3.6 million liters). The assembled vehicle was so heavy that when it was rolled out of the Vehicle Assembly Building at Cape Canaveral, Florida, it pulverized the special gravel roadbed designed to accept its weight.

The first stage (S-IC) came by barge from the Boeing plant at Michoud, Louisiana, and then was placed on a block-long dolly and taken by barge to Cape Kennedy (Cape Canaveral). There, it was raised and made ready for the second stage, which was shipped from California aboard Point Barrow, a converted Navy landing ship. The third stage came from Sacramento, California, aboard the Super Guppy, a swollen version of the Boeing Stratocruiser.

In addition, North American's Rocketdyne built the five F-1 engines for the first stage, the J-2 engine for the second and third stage, the backup injector for the ascent engine of the Lunar Excursion Module, and the command module's reaction control system used for capsule repositioning during reentry. North American's Space and Information Systems division built the command and service modules and the launch escape subsystem.

The S-IC was built by Boeing at NASA's Michoud Assembly Facility in New Orleans. It was 138 feet (42 meters) tall and 33 feet (10 meters) in diameter and had five engines. It was the largest rocket produced in the United States, with a dry weight of 300,000 pounds (136,077 kilograms). When fueled, it weighed 5 million pounds (15.8 million kilograms).

Boeing's responsibility to NASA included detailed design, fabrication and assembly of the S-IC in New Orleans and testing of the first stage at the former Mississippi Test Facility (renamed the National Space Technology Laboratories) at nearby Bay St. Louis. Subsequent assignments included systems engineering, vehicle integration and mission support for the entire Saturn V vehicle at Huntsville, spacecraft engineering and assessment at the Kennedy Space Center, and technical staff support to the Apollo program office at NASA headquarters, Washington, D.C.

The second stage (S-II), built by North American Aviation at Seal Beach, California, used liquid hydrogen and liquid oxygen. It had five J-2 engines in a similar arrangement to the S-IC and accelerated the Saturn V through the upper atmosphere. When loaded, 97% of the weight of the stage was propellant. Instead of having an intertank structure to separate the two fuel tanks as was done in the S-IC, the S-II used a common bulkhead consisting of two aluminum sheets separated by a honeycomb structure made of phenol, which insulated against the 125 degrees Fahrenheit (70 degrees Celsius) temperature difference between the two tanks and saved 3.9 tons (3.6 tonnes) in weight.

The third stage (S-IVB), built by McDonnell Douglas in Huntington Beach, California, had one J-2 engine and used the same

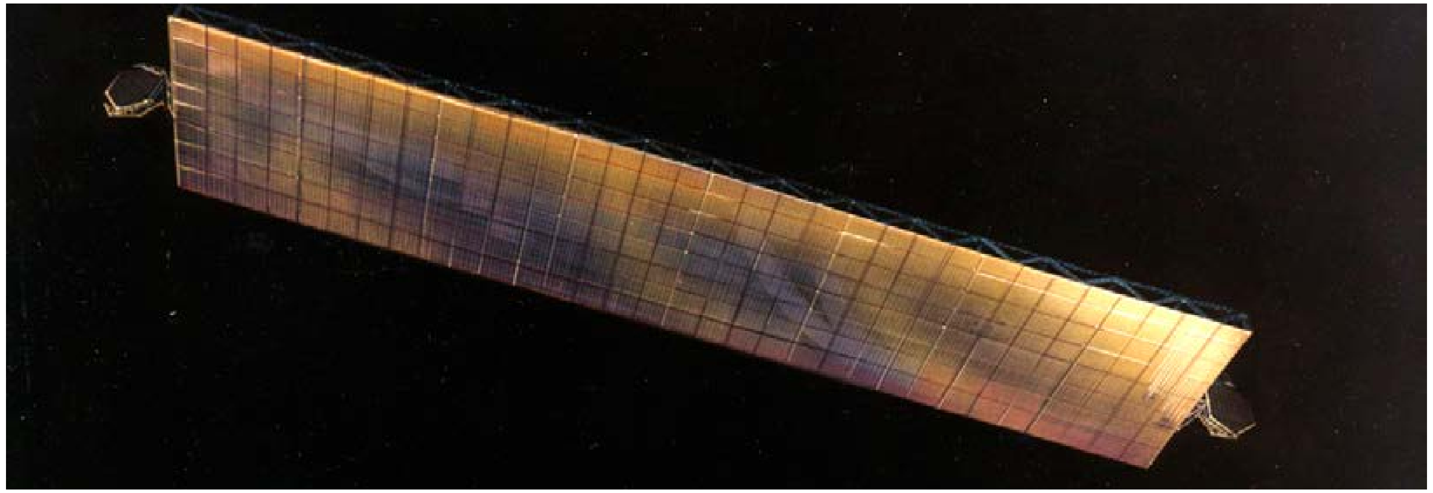
Saturn V Moon Rocket (cont'd)

fuel as the S-II. It also used a common bulkhead to insulate the two tanks. The S-IVB was used first for the orbit insertion after second stage cutoff and then for the translunar injection burn.

Two liquid-fueled auxiliary propulsion system (APS) units, at the aft end of the stage, controlled attitude control during the parking orbit and the translunar phases of the mission. The two APS units were also used as ullage engines to help settle the fuel before the translunar injection burn.

McDonnell Douglas converted one of its S-IVB sections into Skylab, America's first space station, which was placed into orbit May 14, 1973, by the 13th Saturn V. The section's internal fuel tanks were converted into an orbital workshop for a three-person crew, with sleeping quarters and storage areas for food, water and other supplies.

Three different three-person crews staffed Skylab and performed hundreds of solar and microgravity experiments. The last astronauts departed Skylab in February 1974. The abandoned space station reentered Earth's atmosphere and burned up on July 11, 1979. Weighing nearly 100 tons, Skylab orbited Earth for more than 171 days and provided invaluable information about how people are affected by long periods in space as well as data about comets, the cosmos and solar flares.



Solar Power Satellite

Historical Snapshot

During 1982, Boeing designed a solar power satellite system that could supply most of the United States at the time with electricity. Satellites would be space platforms the size of a small city deployed some 22,000 miles (35,405 kilometers) above the equator in geosynchronous Earth orbit (GEO). Platforms would carry billions of silicon solar cells that would transform sunlight directly into electrical energy transmitted to Earth as microwaves through antennas. Rectifying antennas on the ground would convert the microwaves to direct-current electricity, which would be fed into the nation's power lines. A three-year evaluation study conducted by the Department of Energy (DOE) and NASA concluded that there were no known insurmountable technical, environmental or economic issues that should stop the development of the solar power satellite.

The Boeing solar power satellites could be constructed either in low Earth orbit (LEO) for later shipment to the higher geosynchronous orbit or constructed directly at the higher orbit. Heavy-lift launch vehicles would carry cargo pallets into LEO, where they would be directed to docking stations at a space construction base. A modified space shuttle orbiter could carry the personnel needed on the orbiting construction site much as the International Space Station was subsequently constructed.

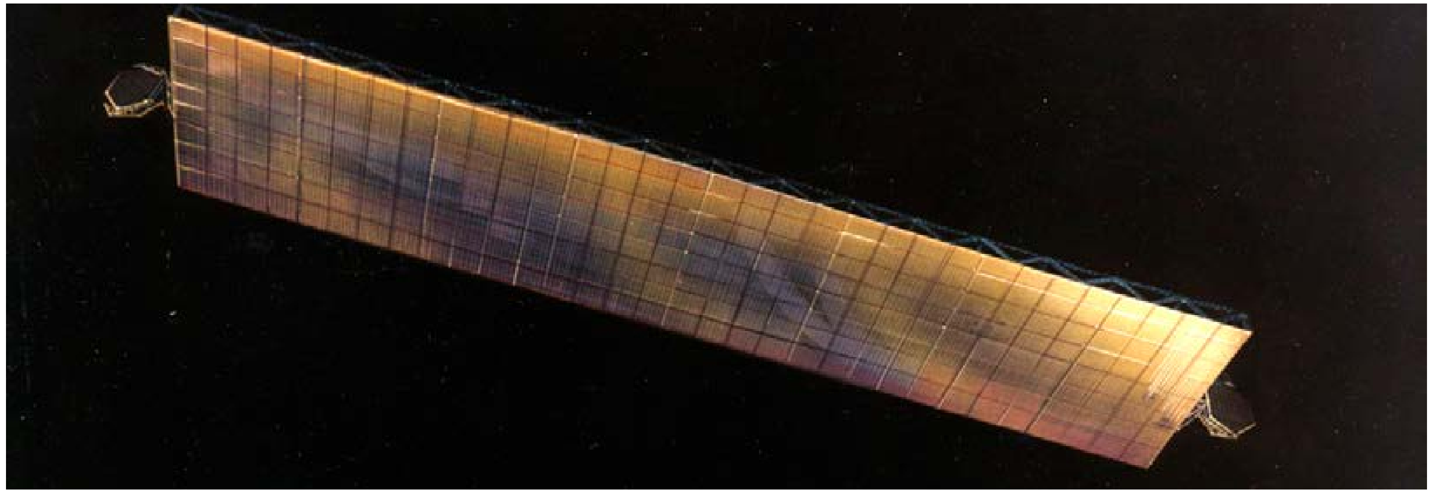
Boeing asked Congress to embark on a phased plan that would progress from concept definition to technology verification to subscale demonstration. The greatest apparent stumbling block seemed to be political rather than technological. At the time, NASA's first priority was space rather than energy, and the DOE was not involved with research involving space. In 1998, Congress authorized modest funding for further concept development.

During the energy crisis of 2007, the National Security Space Office of the U.S. Department of Defense received a recommendation from a study group of 13 leading research organizations and space advocacy groups that space-based solar power receive substantial national investment. By the 21st century, the Boeing team working on solar power satellites had decades of experience.

In the 1970s, Rockwell studies had concluded that that solar concentrator arrays can survive the tough environments of outer space. Rockwell developed a preliminary design for a hardened solar concentrator. Rockwell also studied a way to use mirrors that concentrated the sunlight in a solar furnace to heat fluid, powering electricity-generating turbine engines.

Over the years, Boeing scientists proposed and managed a half-dozen related contracts for NASA and produced about a dozen related publications. These activities included a conceptual design of a robotically constructed GEO satellite and work on smaller scale, laser-photovoltaic satellites and transmission systems, which used receivers on Earth to produce solar-photovoltaic power. Other Boeing research and development projects explored a range of applications for beamed power technology, including microwave technology for space solar power.

Boeing scientists reworked the Lunar Rover still on Earth to see if a laser-powered Lunar Rover, using wireless power transmission, could reach permanently shadowed lunar polar areas that may contain ice, and they studied the construction of a large solar power satellite to produce cryogenic propellants from water. They also looked at how a space colony on the moon could find, shape and transport the materials to build the huge satellites more economically than by building them in space, which required launching space solar power satellite components from Earth. Boeing scientists also led a study on solar power satellites presented to the National Security Space Office and participated in a NASA/DOD study of options for a near-term demonstration of space solar power technology in LEO.



Solar Power Satellite (cont'd)

In 2000, Boeing acquired Spectrolab Inc., now a wholly owned Boeing subsidiary. It is the world's leading manufacturer of high-efficiency multijunction space solar cells and panels, currently providing power to hundreds of satellite and interplanetary spacecraft and terrestrial concentrator solar cells for the emerging alternative energy market.

Spectrolab set a world record for the first solar cell to convert 41.6 percent of concentrated sunlight into electricity and won many awards. In November 2008, Spectrolab received the SpotBeam Award for Space Innovation from the California Space Authority in recognition of its 50 years of advancements in photovoltaic solar cell technology, solar panels and related products, noting that Spectrolab cells powered 60 percent of all satellites orbiting the Earth as well as the International Space Station.

Technical Specifications

First free flight	Aug. 12, 1977
Span	78.06 feet
Length	122.2 feet
Height	56.67 feet
Gross weight	4.5 million pounds
Power plant	Two 3.3 million-pound-thrust (at sea level) solid rocket boosters; three 394,000-pound-thrust orbiter main engines
Payload	55,000 pounds
Capability	Up to 12 flights a year

Space Shuttle Orbiter

Historical Snapshot

The Space Shuttle Orbiter became a Boeing program in 1996, when the company purchased Rockwell International's aerospace and defense assets. The Orbiter—the world's first reusable spacecraft—supported humanity's most challenging engineering project, the International Space Station (ISS). It launched, recovered and repaired satellites and hosted more than 2,000 scientific experiments. During its 30 years of service, 355 people from 16 countries flew 852 times aboard the shuttles.

On July 26, 1972, North American Rockwell (which became Rockwell International in 1973) won a $2.6 billion contract to build the Space Shuttle Orbiter, designated OV-101 (orbiter vehicle 101). The first test shuttle, the *Enterprise*, rolled out Sept. 17, 1976. From Jan. 31 to Oct. 26, 1977, it used a Boeing 747, modified as a shuttle carrier aircraft, to take it to the upper atmosphere for the approach and landing test program. The tests showed that the Orbiter could fly in the atmosphere and land like an airplane.

The *Enterprise* remained a test article. Its legacy of information was incorporated into the next shuttle, the *Columbia* (OV-102). On April 12, 1981, the *Columbia* was the first Space Shuttle to fly into orbit. During its 27 flights between 1981 and 2002, the *Columbia's* achievements included the first launch of satellites from a Space Shuttle, the first flight of the European-built scientific workshop called Spacelab and servicing the Hubble Space Telescope. The *Columbia* and its seven astronauts were lost Feb. 1, 2003, when the vehicle broke up over Texas during reentry from orbit. The program was then suspended until Space Shuttle *Discovery* returned to flight on July 28, 2005.

The *Challenger* (OV-99) was the second Orbiter to become operational at Kennedy Space Center in Florida. It joined the NASA fleet in July 1982, flew nine successful missions, made 987 orbits and spent 69 days in space. Then on Jan. 28, 1986, the *Challenger* and its seven-member crew were lost 73 seconds after launch.

The third shuttle, the *Discovery* (OV 103), had arrived at Kennedy Space Center in November 1983. On its first mission, on Aug. 30, 1984, it deployed three communications satellites. After modifications, it flew the first Space Shuttle mission of the post-*Challenger* era on Sept. 29, 1988. On March 9, 2011, it touched down after its final flight.

The *Atlantis* (OV-104) made its first orbital flight Oct. 3, 1985. During its second flight, Nov. 26, 1985, its astronaut crew conducted the first experiments for assembling structures in space. It was modified and returned into orbit Dec. 2, 1988. The May 19, 2000, launch of the Space Shuttle *Atlantis* introduced a host of enhancements, including an adaptation of the glass cockpit system used in the Boeing 777. The Space Shuttle used Ku-band radar, built by Boeing Satellite Systems, to communicate with the ground. The radar function can pinpoint objects in space as far away as 345 miles (555 kilometers) for shuttle rendezvous. By linking with a NASA satellite, the communications function allowed crews to transmit television-like pictures, voice messages and high-speed data streams.

The next shuttle, the *Endeavour* (OV-105), made its first flight, May 7, 1992. Its final mission lasted from May 16, to June 1, 2011. The final Space Shuttle mission ended soon after, on July 21, 2011, when the *Atlantis* rolled to a stop at Kennedy Space Center, Fla.

In 1996, Boeing and Lockheed Martin created the standalone company United Space Alliance (USA). USA served as NASA's primary industry partner in human space operations for the day-to-day management of the Space Shuttle fleet and the planning, training and operations for 55 Space Shuttle missions.

As the major subcontractor to USA, Boeing integrated shuttle system elements and payloads; it also provided operations support services and ongoing engineering support. Since 1987, Boeing had already been the prime contractor to SPACEHAB Inc. for design, maintenance, integration and operation of pressurized, habitable modules that were carried in the payload bay of the Space Shuttle to facilitate logistics delivery and science research.

The *Atlantis* is on display at the Kennedy Space Center Visitor Complex, Cape Canaveral, Fla.; the *Endeavour* can be seen at the California Science Center in Los Angeles.

Technical Specifications	
First launch	May 30, 1966
Classification	Robotic spacecraft
Height	10 feet
Width	14 feet 1 inches
Weight	2,283 pounds on Earth, 625 pounds on moon

Surveyor Lunar Spacecraft

Historical Snapshot

Built for NASA by Hughes Aircraft Co., the Surveyors were robotic spacecraft used as pathfinders for subsequent landings of humans on the moon. During 1966 and 1967, five made successful landings in support of the Apollo program.

Surveyor 1 was launched to the moon four months after Luna 9 on a direct-ascent trajectory. It was powered by three liquid-propellant variable-thrust engines and one solid propellant main engine. It proceeded to a near-hover at 13 feet (4 meters) and then made a freefall to a landing. Shock-absorber legs and crushable pads on the frame softened the blow of the impact. For the next six weeks, including a two-week-long shutdown for the lunar night, Surveyor 1 transmitted 11,237 pictures back to Earth, all in high resolution and color.

Surveyor 2 was lost because an engine failed to fire; however, Surveyor 3 bounced twice yet still managed to send back 6,300 pictures. Many of these were of its mechanical scoop used to dig 7 inches into the lunar soil. Observations and readings indicated that the soil was similar to wet beach sand and could support a human and a lander vehicle. Apollo 12 later landed within a quarter mile (402 meters) of Surveyor 3, and astronauts retrieved parts of it to determine the effects of long exposure to the lunar environment.

Surveyor 4 was lost after transmissions ceased. Surveyor 5 carried a material that irradiated the soil so that its composition could be analyzed, and Surveyor 6 hopped 8 feet (2.4 meters) away from its landing site for more pictures.

Surveyor 7 was sent to the rim of the lunar crater Tycho. The spacecraft transmitted more that 21,000 pictures, including images of two laser beams from stations on Earth.

Technical Specifications	
First flight	June 8, 1959
Span	22 feet
Length	50 feet
Height	13 feet 8 inches
Power plant	Thiokol 57,000-pound thrust liquid propellant rocket engine
Wings	Sweptback 25 degrees; area: 200 square feet
Weight	13,000 pounds empty; 15 tons loaded with fuel
Landing gear	Steel skids, nose wheel
Skin	Inconel X nickel alloy

X-15 Research Aircraft

Historical Snapshot

On June 8, 1959, a sleek black aircraft was released from a NASA NB-52B flying at 37,550 feet (11,445 meters), marking the first flight of the X-15 rocket plane. With North American Aviation test pilot and engineer Scott Crossfield in the cockpit, the unpowered test flight initiated a 10-year effort that achieved hypersonic speeds and explored the upper edge of the Earth's atmosphere.

The X-15 rocket research airplane was built by the Los Angeles Division of North American Aviation for the U.S. Air Force, the U.S. Navy, and the National Aeronautics and Space Administration. The airplane was designed to conduct research experiments during actual flight conditions beyond the Earth's atmosphere.

With the concurrent Mercury manned spaceflight program, the United States was on a fast track into space but lacked critical data needed to achieve that goal. The X-15 program would be called on to obtain knowledge of aerodynamic heating, reentry conditions, acceleration and deceleration forces, and reactions of man to weightlessness.

On Sept. 17, 1959, the first powered flight took place. Despite a small hydrogen peroxide fire in the engine section, Crossfield easily reached Mach 2.1 and an altitude of 52,341 feet (15,954 meters).

Capable of burning 18,000 pounds (8,165 kilograms) of liquid oxygen and anhydrous ammonia in a mere 85 seconds, the single XLR99 engine was installed for flight No. 34, which on Nov. 15, 1960, took U.S. Air Force test pilot Robert White to Mach 4.4 and 77,450 feet (23,607 meters).

NASA pilot Joe Walker reached a record altitude of 354,200 feet (67 miles, or 108 kilometers) on Aug. 22, 1963 — a mission in which the X-15 exceeded design specifications and earned Walker astronaut wings.

A new version, known as the X-15A-2, designed for flight at eight times faster than sound, at an altitude of 100,000 feet (30,480 meters) and creating potential temperatures of more than 2,400 degrees Fahrenheit (1,316 degrees Celsius), was turned over to the U.S. Air Force by the Los Angeles plant in February 1964.

Design changes for the X-15A-2 included two external jettisonable fuel tanks, longer main gear, lengthened and lowered nose gear, fuselage extended 29 inches, improved windshield design, ablative material on the outer skin, a removable right-hand wingtip to accept test materials, removable lower vertical fin to permit installation of ramjet engines and accommodations for photographic experiments.

Air Force Capt. William "Pete" Knight took the X-15A-2 to the fastest speed recorded during the program, Mach 6.7, during an Oct. 3, 1967, flight that reached an altitude of 102,100 feet (31,120 meters). Knight had traveled twice as fast as a bullet fired from an M-16 automatic rifle, and the unofficial speed record stood until the Space Shuttle first reentered the atmosphere at Mach 22 in April 1981.

The X-15 provided the Space Shuttle design team with invaluable information on hypersonic flight, in particular, how to reenter the earth's atmosphere with a winged vehicle and how to precisely land a low L/D (lift-to-drag) unpowered vehicle.

Later, two X-15 pilots became NASA astronauts — Neil Armstrong, on the Gemini and Apollo programs, and Joe Engle, who commanded the space shuttle *Columbia* on its second flight (STS-2) in November 1981 and *Discovery* in September 1985 (STS-51I).

Technical Specifications	
First flight	Projected, 1965
Model number	X-20
Classification	Space vehicle
Span	20 feet
Length	35 feet
Max. payload	10,500 pounds
Cruising speed	0.80 Mach

X-20 Dyna-Soar Space Vehicle

Historical Snapshot

The Dyna-Soar design contract was awarded to Boeing on Nov. 9, 1959, and on June 19, 1962, the Dyna-Soar was designated the X-20.

The Dyna-Soar, designed to be a 35.5-foot (10.8-meter) piloted reusable space vehicle, had a sharply swept delta 20.4-foot-span (62-meter-span) wing and a graphite and zirconia composite nose cap and used three retractable struts for landing. Eleven manned flights were to be launched from Cape Canaveral, Fla., starting in November 1964. Dyna-Soar's first orbital flight was tentatively scheduled for early 1965.

The X-20 reached the mockup stage. $410 million had been spent on its development, and a cadre of astronauts was training to fly it. However, the U.S. government canceled the program on Dec. 10, 1963, because Dyna-Soar had no viable military mission and was too expensive for a research vehicle. Congress diverted the X-20 funding to the Manned Orbiting Laboratory, which used McDonnell-built Gemini capsules. The partially completed X-20 prototype and the mockup were scrapped as well as initial tooling set up for a production line for 10 space planes.

In 1961, the U.S. Air Force had contracted with McDonnell Aircraft to build six experimental aerodynamic/elastic structures environment test vehicles that roughly resembled the Dyna-Soar. The scaled-down test vehicles were 5.7 feet (1.7 meters) long and used Douglas-built Thor or Thor-Delta boosters, which in turn used engines built by North American's Rocketdyne division. The program was very successful and demonstrated that winged reentry vehicles could traverse the upper atmosphere.

Boeing Personal Rapid Transit in Morgantown, West Virginia

Other Systems

Technical Specifications	
Business founded	Nov. 1, 2000
Service	Airborne mobile satellite system (AMSS) for high-speed communications
Frequency	14 GHz-14.5 GHz
Customers	- Airlines and their passengers - Executive jets - Commercial shipping companies

Connexion By Boeing® Mobile Communications Service

Historical Snapshot

Boeing began research into broadband communications in the 1980s as part of its work for the U.S. government. As the Cold War ended, the company entered discussions with commercial airlines, most notably American and Delta, about how to adapt the technology to civilian use. During the late 1990s, these initiatives became known as Aviation Information Services, and then Global Mobile Services.

As the 1990s progressed, airplane passengers became increasingly interested in using the satellite-enabled system to access the Internet. On April 27, 2000, Boeing announced it would offer high-speed connectivity to commercial aviation under a new brand, Connexion by Boeing® Mobile Communications Service. At the 2001 Paris Air Show, Lufthansa German Airlines agreed to become the international launch customer.

The events of Sept. 11, 2001, caused the business unit to change its plans and delay its commercial introduction. Arrangements with U.S. carriers who had expressed interest in the service were terminated, and Connexion by Boeing focused on launching its commercial business internationally.

The Connexion by Boeing service made its debut aboard Lufthansa Flight 452 between Munich and Los Angeles on May 17, 2004. By 2006, the Connexion by Boeing system was installed on several commercial airplanes and some large private and government-owned business jets, and Boeing was planning to enter the commercial maritime market.

On Aug. 17, 2006, however, Boeing announced that the company had decided to exit the high-speed broadband communications connectivity markets and would work with its customers to facilitate an orderly phase out of the Connexion by Boeing service.

"Over the last six years, we have invested substantial time, resources and technology in Connexion by Boeing," said Boeing Chairman, President and CEO Jim McNerney. "Regrettably, the market for this service has not materialized as had been expected."

Technical Specifications	Jetfoil	PHM
First launch	March 29, 1974	Nov. 9, 1974
Model number	929-100	928
Classification	Passenger hydrofoil	Warship
Length	90 feet	131 feet 2.5 inches
Width	18 feet	28 feet 2.5 inches
Cruising speed	46 to 51.8 mph	More than 46 mph
Draft (foilborne)	4 feet 6 inches to 6 feet 6 inches	8 feet 4 inches
Propulsion	Two Allison 501-KF turbine engines with two Rocketdyne PJ-20 waterjet pumps	Two waterjets powered by two 800-horsepower Mercedes-Benz diesel engines (hullborne), one waterjet powered by 17,000-horsepower GE marine gas turbine engine (foilborne)
Accommodation	4 to 8 crew, 250 to 350 passengers	21 to 24 crew

Jetfoil/Hydrofoil

Historical Snapshot

In 1959, Boeing began research and development of hydrofoils. The hydrodynamic test system (HTS), called the Boeing "Aqua-Jet," was launched in 1961. It was a dual-cockpit jet-powered hydroplane that served as an aquatic version of a wind tunnel. Powered by an Allison J-33 jet engine, the HTS was designed to provide a level and stable platform for straightaway runs of up to 132 knots (115 mph/185 kph). A controllable fixture mounted between two prows held models of hydrofoils in the water during the test runs.

In 1962, Boeing built *Little Squirt* as a company-sponsored research craft, powered by a Boeing Model 520 turbine engine. Water was pumped from a scoop built into the rear foil and out through a nozzle into the air behind the boat. The 20-foot-long (6-meter-long) *Little Squirt* provided information on foil depth, speeds, operation in rough water and operation amid debris. It had fully submerged foils with movable surfaces for stability and control. These surfaces were connected to a pioneering automatic control systems that sensed and controlled the boat's height above water as well its pitch, roll and heave.

Boeing Model 883, or *FRESH-1* (for "foil research experimental supercavitating hydrofoil"), was part of the U.S Navy's research into hydrofoils. Boeing designed *FRESH-1* to investigate a phenomenon known as cavitation. At high speeds, a void or bubble called a "vapor cavity" can be formed, resulting in reduced efficiency and erratic operation. The foil system was designed to allow the boat to travel beyond speeds that produce cavitation.

In 1963, *FRESH-1* achieved 84 knots (96 mph/155 kph), breaking a long-standing record set by Alexander Graham Bell in 1919. Because of a crash during one of the tests, the Navy decided not to pursue testing of a 100-knot (115-mph/185-kph) foil system.

PCH-1 ("patrol craft hydrofoil") *High Point* was the U.S. Navy's first operational hydrofoil and the first vessel of the Boeing hydrofoil family. The 117-foot-long (35-meter-long) *High Point* was primarily used for research and the development of antisubmarine warfare concepts. *High Point* was launched on Aug. 17, 1962, and tested on Puget Sound from 1963 to 1967. Powered by twin gas-turbine engines that drove four propellers, *High Point* was able to attain speeds of 50 knots (57 mph/92 kph). In 1975, High Point was transferred to the U.S. Coast Guard for evaluation, but without funds to replace a blown engine, it was returned to the Navy and retired.

Boeing Model 923, PGH-2 ("patrol gunboat hydrofoil") *Tucumcari* was launched in 1967. The 57.5-ton (58.4-tonne), 74.6-foot-long (22.7-meter-long) vessel was made of aluminum with foils and struts of corrosion-resistant steel. It used a waterjet propulsion system and was powered by a 3,200-horsepower Rolls-Royce turbine engine.

Tucumcari served with the U.S. Navy in Vietnam. Later, in August 1970, it was assigned to the Atlantic, where *Tucumcari* demonstrated its capabilities to eight NATO countries. In November 1972, while operating foil borne at night in the Caribbean, *Tucumcari* ran aground. No crew were seriously injured, but *Tucumcari* sustained enough damage while being removed from the reef to keep it from sailing again and was stricken from the record of active Navy vessels.

Italy built six Boeing-designed, Sparviero-class ships based on *Tucumcari*, and the Patrol Hydrofoil Missileship (PHM) program was formed. The armed hydrofoil was developed under a joint NATO program with the United States,

Jetfoil/Hydrofoil (cont'd)

Germany and Italy. The first PHM (Boeing Model 928) was the USS Pegasus (PHM-1) launched in November 1974. It was the first Boeing built craft, and first hydrofoil, to be a listed as a United States Ship (USS).

In 1975, Pegasus made the 1,225-mile (1,971-kilometer) trip from Seattle to San Diego in a record-breaking 34 hours, which included one stop for refueling. It was commissioned on July 9, 1977. Five more Pegasus class ships—Hercules, Taurus, Aquila, Aries and Gemini—were built at the Boeing plant in Renton, Wash., between 1981 and 1982.

Armed with a 76 mm rapid-fire cannon and eight AGM-84 Harpoon antiship missiles, the PHM could challenge much larger warships. Because it could be self-sufficient for more than five days at a time and be refueled while under way, the PHM could serve as an escort for convoys or travel as part of an aircraft carrier's battle group, but its main mission was interdicting smugglers and drug traffickers while based in Key West, Fla. In 1993, the PHMs were decommissioned due to government cutbacks.

Boeing also built commercial hydrofoils. The board gave the go ahead in 1972 for the Jetfoil program. The Boeing Jetfoil (Boeing Model 929) was designed for passenger comfort at high speeds. It gave passengers a smooth and fast ride, and its three narrow struts created a fraction of the wake that a ship of its size would normally make. It was also as quiet as a conventional auto ferry. With a stopping distance of 500 feet (152 meters) and a turning radius of just 645 feet (196 meters), it was easy to maneuver the 90-foot-long (27-meter-long) ship through congested waterways.

The standard configuration of the Jetfoil accommodated 250 passengers, but design flexibility allowed variations for up to 350 seats. The Jetfoils were powered by a pair of Allison gas-turbine engines that each drove a Rocketdyne waterjet pump, which propelled the 115-ton (104.32-tonne) vessel at speeds in excess of 45 knots (51.8 mph/83.3 kph). Boeing built 24 of the Jetfoils, all at the Boeing Renton, Wash., plant, for service in Hong Kong, Japan, the English Channel, the Canary Islands, Saudi Arabia and Indonesia.

Technical Specifications	
First use	1981
Rotor	Two-blade steel
Blade length	300 feet, tip to tip
Rotating nacelle	37-foot boxcar, containing drive train, generator and other equipment
Power potential	10 million kilowatt-hours of electricity/year

MOD-2/MOD-5B Wind Turbines

Historical Snapshot

During the early 1970s, Boeing Engineering and Construction Co. took a world leadership role in the design and development of large wind energy systems.

The federal wind energy system was initiated in 1973 by the National Science Foundation and absorbed in 1977 into the Department of Energy (DOE). Its goal was to demonstrate the commercial feasibility of wind power.

That same year, Boeing won the NASA and DOE contract for design, fabrication, construction, installation and testing of 2,500-kilowatt wind turbine systems. Five turbines, designated MOD-2, went into action during the early 1980s. Three were started up during a dedication ceremony May 29, 1981, at Goodnoe Hills, about 13 miles east of Goldendale, Wash.

The Bonneville Power Administration bought output of the Goodnoe Hills machines and integrated it into the regional power grid through lines owned by Klickitat County Public Utility District, and the three machines working together became the first "wind farm" in the world. In April 1982, Boeing completed its first wind turbine for a commercial customer, Pacific Gas and Electric Co. of San Francisco, and erected it in Solano County, northern California. On Sept. 2, 1982, the fifth and final MOD-2 began operating at Medicine Bow, Wyo.

The Goodnoe Hills site was primarily a research project for Boeing, Bonneville Power Administration, NASA and Battelle Northwest Laboratories. The Solar Energy Research Institute also evaluated the suitability of megawatt-size wind turbines as a source of electricity.

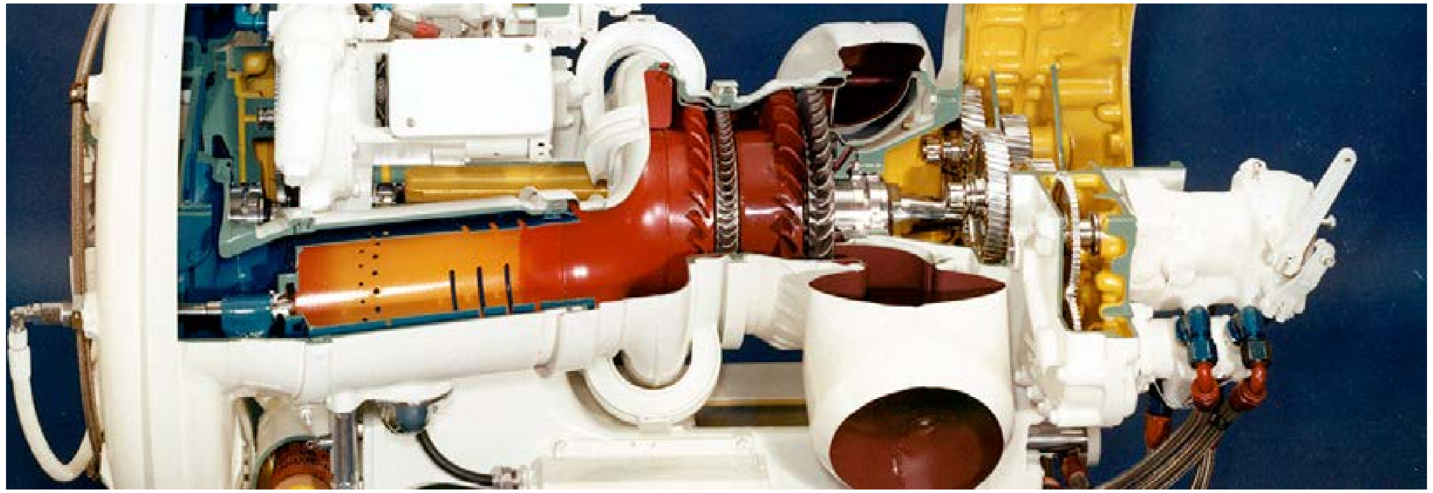
The MOD-2 wind turbines of Goodnoe Hills were running through 1986 and then dismantled. In 1985, the last full year of operation, the combined electrical output of the three turbines was 8,251 megawatt-hours—enough to power about 1,000 average Northwest homes for a year. Project manager Peter Goldman called the five-year, $55 million research project "an absolute success." The Medicine Bow MOD-2 wind turbine was sold for scrap metal in 1987 and dynamited over.

The next-generation Boeing-built wind turbine, the MOD-5B, was barged to Kahuku on the island of Oahu in Hawaii in 1986 and was running by July 1987. It weighed 939,000 pounds (425,923 kilograms) and had a 320-foot-diameter (97-meter-diameter) two-blade rotor on a 200-foot (61-meter) steel tower. It was entirely automatic, with software changes made using the public telephone system. It operated in winds from 9 to 60 miles (14 to 96 kilometers) per hour and could reach rated power at 7.2 megawatts at wind speeds of 30.6 miles (49 kilometers) per hour. At a rotational speed of 17.2 rpm, the blade tip velocity was 206 miles (331 kilometers) per hour. By Nov. 20, 1987, it completed its first 1,000 hours of operation and had produced enough electrical energy for 1,500 homes.

Early in 1988, operation of the turbine was transferred to Hawaiian Electric Inc., then to the Makani Uwila Power Corp. (MUPC) and kept in service intermittently until late in 1996. At that time, due to financial difficulties, the wind turbine was shut down, along with the rest of MUPC, and passed to the property owner, Campbell Estates. With no prospects for continued operation, Campbell Estates decided to disassemble and scrap the MOD-5B. Before this decommissioning, the DOE salvaged the drive train gearbox and generator in July 1998.

Although Boeing got out of the wind turbine business during the late 1980s and returned to its more traditional products of aircraft and spacecraft, the Boeing-built wind turbines set several world records for diameter and power output. In 1987, the MOD-5B was the largest single wind turbine operating in the world. It featured the first large-scale variable speed drive train and a sectioned, two-blade rotor that enabled easy transport of the blades.

The Boeing wind turbine research and development program pioneered many of the multi-megawatt turbine technologies in use today, including: steel tube towers, variable-speed generators, composite blade materials and partial-span pitch control, as well as aerodynamic, structural and acoustic engineering design capabilities.



Technical Specifications

Operational	1947
Model number	502
Classification	Gas turbine engine
Length	67 inches
Weight	625 pounds
Fuel consumption	32 gallons/hour at maximum horsepower
Power	300 horsepower

Model 502 Gas Turbine Engine

Historical Snapshot

Boeing was a major producer of small turbine engines during the 1950s and 1960s. The engines represented one of the company's major efforts to expand its product base beyond military aircraft after World War II.

Development on the gasoline turbine engine started in 1943, with the early engines providing about 160 horsepower. Boeing then focused most of its efforts on a two-shaft turbine engine that the company produced in 1947. In this type, the output shaft and transmission were separated from the engine itself.

A Boeing-developed gas engine with 175 horsepower was tested on a Kenworth truck in 1950. The engine then was tested on U.S. Navy boats in Lake Washington, near Seattle. By the 1960s, the engine provided about 500 horsepower.

Boeing engines offered advantages in the areas of weight, torque, reliability, simplicity and ease of starting. Major uses were for minesweeper power generation and propulsion, aircraft compressed-air starters, boost power for military tanks and power for antisubmarine drone helicopters. Later models were designated 520, 540, 551 and 553.

Boeing built 2,461 engines before production ceased in April 1968. Many applications of the Boeing gas turbine engines were considered to be firsts, including the first turbine-powered helicopter and boat. More than 746 QH-50C/D radio-controlled drones with Boeing T-50 turbines were built for the Navy antisubmarine helicopter program during the 1960s. More than 300 Boeing 551 and 553 turbines powered Swedish armored fighting vehicles.

In 1966, a number of major programs were competing for the company's limited resources, and the decision was made not to continue pursuing the turbine engine business. While limited production to fulfill contract obligations would continue until 1968, most of the division's resources and engineers were reassigned to other programs, in particular the development of the giant 747 jetliner. The small annual profit of the Turbine Division was dwarfed by the promise of an equal amount from the sale of each 747.

Technical Specifications	
Entered service	July 20, 1975
Description	Computer-controlled individual rectangular cars with rubber wheels on a concrete guideway
Length	15 feet 6 inches
Width	6 feet 8 inches
Empty weight	8,750 pounds
Body	Fiberglass
Top speed	30 mph
Capacity	8 people seated, 13 standing
Guideway	Elevated and at grade reinforced concrete and steel
Power rail	575 volts, three-phase electric
Interface	Wayside communications using embedded inductive loops

Personal Rapid Transit System

Historical Snapshot

During the 1970s, Boeing designed personal rapid transit (PRT) system rubber-tired, electrically powered vehicles that were silent and emission free. The cars traveled on computerized concrete guideways. During busy times, they had a scheduled route, but otherwise they arrived according to passenger request. Essentially, the system allowed vehicles to wait for people rather than forcing people to wait for vehicles.

A Boeing PRT is still in service at West Virginia University, Morgantown, W.Va.; by November 2014, the cars were transporting about 15,000 riders per day during the school year.

The concept started in 1962, when President John F. Kennedy asked the U.S. Congress to provide federal capital assistance for mass transportation "to conserve and enhance values in existing urban areas." Two years later, President Lyndon Johnson signed the Urban Mass Transportation Act of 1964 into law and created the Urban Mass Transportation Administration (UMTA), later the Federal Transit Administration.

In 1970, UMTA decided to implement the idea at West Virginia University in Morgantown; Boeing won the contract and proceeded to develop and test the cars at the Kent Space Center, Wash.

By the end of 1975, 45 vehicles, a central control and maintenance facility, guideways and passenger stations were serving the university's campus community. The same year, the International Oceanic Exposition opened in Kobe, Japan, with a similar Boeing-designed personal rapid transit system. It would carry 3 million people by the year's end but was no longer running by the end of the 1970s.

In 1979, Boeing began work on a fleet of 12-passenger vehicles, called the Advanced Group Rapid Transit (AGRT) project, and set aside 45 acres at its Kent, Wash., facility for a one-mile guideway and control center for the AGRT test program center. Although this effort did not lead to further contracts, it did lead to improvements to the still-rolling Morgantown system.

Morgantown cars serve five stations on an 8.65-mile (13.92-kilometer) track. Powered by electric motors, the computer-driven cars arrive at a station within five minutes of a passenger swiping a West Virginia University student, faculty or staff ID card. Others can ride for 50 cents.

Boeing provided a software upgrade in 2002, but because of its age, the Morgantown system has become increasingly difficult to maintain. A shrinking market for replacement parts has significantly increased replacement costs. In 2012, a system modernization master plan was established to make PRT system upgrades by refurbishing some systems and replacing others.

Interest is growing in sustainable PRT systems, now sometimes know as personal automated transit (PAT). In 2011, London's Heathrow International Airport began an on-demand system of small, driverless individual vehicles.

Technical Specifications

	Light Rail Vehicle	Rapid Transit Car
Entered service	Dec. 30, 1976	1976
Description	Articulated light rail vehicle	Rapid transit (rail) car
Length	71 feet	48 feet
Capacity	Boston: 52 seats and 210 passengers; San Francisco: 69 seats and 190 passengers	49 seats
Power plant	Two 210-horsepower D.C. motors, using 600-volt D.C. power line	Four 110-hp GE1262A1 motors
Speed	Multiple unit operation at 50 mph	55 mph

Light Rail Vehicle/Rapid Transit Car

Historical Snapshot

As the Vietnam War came to an end, the U.S. government looked for ways to keep its defense contractors working. Part of this effort included the Urban Mass Transportation Administration (UMTA) request for designs of a light rail vehicle to replace aging rolling stock around the country. In June 1971, UMTA selected Boeing Vertol as systems managers for the urban rapid rail vehicle and systems program.

On May 1, 1973, Boeing Vertol received the go-ahead from officials at the Massachusetts Bay Transportation Authority (MBTA) in Boston and the San Francisco Municipal Railway (Muni) to begin building 230 light rail vehicles – of these, 150 were for MBTA and 80 were for Muni. Both the MBTA and Muni would later expand their orders to 175 and 100 cars, respectively, increasing the overall cost of the contract to $72 million.

Known as the Boeing LRV (not to be confused with the Lunar Roving Vehicle), the articulated light rail vehicles entered revenue service on Dec. 30, 1976, on Boston's MBTA Green Line "D" Branch. The first regular runs on the San Francisco Muni system began in 1979.

In 1976, Boeing Vertol also began to build Model 2400 Rapid Transit Cars for the Chicago Transit Authority (CTA). A special ceremony Jan. 11, 1978, honored the delivery of the 100th RTC to the "Windy City," and the remaining 100 were delivered the same year. These stainless steel cars feature smooth curved, stainless steel exteriors and contoured fiberglass frontends. They had fiberglass seats with padded inserts, walnut grain wainscot panels and brown floors. They were the first cars built for the Chicago "L" in more than 50 years to have sliding doors, providing easier access for wheelchairs.

Some of the RTCs delivered in 1976 were painted red, white and blue to celebrate the U.S. Bicentennial. In 2014, 2400-series rail cars were in service on the Orange Line—but the CTA intended to remove the last of the 2400 series from service in October of that year, leaving about 24 cars of the series that would be retained and used out-of-service for track work.

By March 1, 1982, 114 LRVs were in Boston's MBTA active service fleet and Boeing Vertol delivered the last LRV in 1983. As Vertol moved out of the rolling stock business and back to its traditional rotorcraft production, Boston's MBTA replaced the Boeing LRV with rail cars built elsewhere and started to scrap the Boeing LRVs in 1987. The MBTA's last revenue run of a Boeing LRV was March 16, 2007. However, the MBTA continued to operate three LRV work cars. A Boeing LRV from Boston's MBTA is on display at the Seashore Trolley Museum in Kennebunkport, Maine.

San Francisco's Muni began retiring its LRV in 1995, after the first of their replacements arrived, and its last Boeing LRVs left service at the end of 2001. Two of the Muni cars were sent to museums: the Oregon Electric Railway Historical Museum near Salem, Ore., and the Western Railway Museum near Fairfield, Calif. Two others were stored in Muni railway yards.