Grumman F-14 Tomcat

F-14 Tomcat

An F-14A Tomcat from the USS *Nimitz* (CVN-68) during Operation Southern Watch, with its wings fully swept

Role	Interceptor, air superiority and multirole combat aircraft
National origin	United States
Manufacturer	Grumman
First flight	21 December 1970
Introduction	September 1974
Status	In service with Iranian Air Force
Primary users	United States Navy (retired) Imperial Iranian Air Force Islamic Republic of Iran Air Force
Number built	712
Unit cost	US$38 million (1998)

The **Grumman F-14 Tomcat** is a supersonic, twin-engine, two-seat, variable-sweep wing fighter aircraft. The Tomcat was

developed for United States Navy's Naval Fighter Experimental (VFX) program following the collapse of the F-111B project. The F-14 was the first of the American teen-series fighters which were designed incorporating the experience of air combat against MiGs during the Vietnam War.
The F-14 first flew in December 1970. It first deployed in 1974 with the U.S. Navy aboard USS *Enterprise* (CVN-65), replacing the McDonnell Douglas F-4 Phantom II. The F-14 served as the U.S. Navy's primary maritime air superiority fighter, fleet defense interceptor and tactical reconnaissance platform. In the 1990s it added the Low Altitude Navigation and Targeting Infrared for Night (LANTIRN) pod system and began performing precision strike missions. The F-14 was retired from the active U.S. Navy fleet on 22 September 2006, having been replaced by the Boeing F/A-18E/F Super Hornet.

The F-14 Tomcat was designed as both an air superiority fighter and a long-range naval interceptor. The F-14 has a two-seat cockpit with a bubble canopy that affords all-round visibility. It features variable geometry wings that swing automatically during flight. For high-speed intercept, they are swept back and they swing forward for lower speed flight. It was designed to improve on the F-4 Phantom's air combat performance in most respects. The F-14's fuselage and wings allow it to climb faster than the F-4, while the twin-tail arrangement offers better stability. The F-14 is equipped with an internal 20 mm M61 Vulcan Gatling-type gun mounted on the left side, and can carry AIM-54 Phoenix, AIM-7 Sparrow, and AIM-9 Sidewinder anti-aircraft missiles.

F-14's large flat area between the engine nacelles is called the "pancake".

The fuselage consists of a large flat area called the "pancake" between the engine nacelles and, by itself, provides more than half of the F-14's aerodynamic lifting surface. Fuel, electronics, flight controls, and the wing-sweep mechanism are all housed in the fuselage "pancake". The wings pivot from two extensions on either side of the "pancake", called wing gloves. The twin engines are housed in nacelles below and slightly to the rear, with the fuselage smoothly blending into the shape of the exhaust nozzles. The nacelles are spaced apart 1 to 3 ft (0.30 to 0.91 m). This produces a wide tunnel between the nacelles which causes some drag, but adds considerable lift and pitching ability. The resultant tunnel provides space to carry Phoenix or Sparrow missiles, assorted bombs, or the TARPS (Tactical Airborne Reconnaissance Pod System) reconnaissance pod, and increases fuel capacity and room for equipment.

The F-14's wing sweep can be varied between 20° and 68° in flight, and can be automatically controlled by the Central Air Data Computer when the pilot selects "auto" wing sweep mode. This maintains the wing sweep to give the optimum lift-to-drag ratio as the Mach number varies, but the system can be manually overridden by the pilot if necessary. When the aircraft is parked, the wings can be "overswept" to 75°, where they overlap the horizontal stabilizers to save space on crowded carrier decks. In an emergency, the F-14 can land with the wings fully swept to 68°, although this is far from optimum and presents a significant safety hazard due to significantly increased airspeed. An aircraft is typically diverted from the aircraft carrier to a landing field ashore in the rare event that would occur. The F-14 has also flown and landed safely with the wings swept asymmetrically even from an aircraft carrier in emergencies.

The wings have a two-spar structure with integral fuel tanks. Much of the structure, including the wing box, wing pivots and upper and lower wing skins is made of titanium, a light, rigid and strong material, but also difficult to weld, and costly. Ailerons are not fitted, with roll control being provided by wing mounted spoilers at low speed (which are disabled if the sweep angle

exceeds 57°), and by differential operation of the all-moving tailerons at high speed. Full-span slats and flaps are used to increase lift both for landing and combat, with slats being set at 17° for landing and 7° for combat, while flaps are set at 35° for landing and 10° for combat. The twin tail layout helps in maneuvers at high AoA (angle of attack) while reducing the height of the aircraft to fit within the limited roof clearance of hangars aboard aircraft carriers. Two under-engine nacelle mount points are provided for external fuel tanks carrying an additional 4,000 lb (1,800 kg) of fuel.
Two triangular shaped retractable surfaces, called glove vanes, were originally mounted in the forward part of the wing glove, and could be automatically extended by the flight control system at high Mach numbers. They were used to generate additional lift ahead of the aircraft's center of gravity, thus helping to compensate for the nose-down pitching tendencies at supersonic speeds. Automatically deployed at above Mach 1.4, they allowed the F-14 to pull 7.5 g at Mach 2 and could be manually extended with wings swept full aft. They were later disabled, however, owing to their additional weight and complexity.
The air brakes consist of top-and-bottom extendable surfaces at the rearmost portion of the fuselage, between the engine nacelles. The bottom surface is split into left and right halves, with the arrestor hook hanging between the two halves. This arrangement is sometimes called the "castor tail", or "beavertail". The Tomcat has fully mechanical flying controls, with the only exception being the spoilers, which are hydro-electrically driven.

Two rectangular air intakes located under the wings fed two Pratt & Whitney TF30 (or JT10A) engines, which were relatively powerful for the time (5.670/9.480 kg/t) and being turbofans allowed reduced fuel consumption while cruising, which was important for long patrol missions.

Both air intakes have movable ramps and bleed doors that are operated by the air data computer to enable enough air to enter the engine while keeping shockwaves away from the engine. The exhausts also feature variable nozzles with moving petals that open or close depending on engine state. The TF30 engine left much to be desired both in power and reliability. John Lehman, Secretary of the Navy, told Congress that the F-14/TF30 combination was "probably the worst engine/airframe mismatch we have had in years" and said that the TF30 was "a terrible engine", with F-14 accidents attributed to engine failures accounting for 28% of overall losses. Cracks in the turbines were dangerous to the point that the engine bay was reinforced in case of blade failure, to help reduce damage to the rest of the aircraft. The TF30 engines were also extremely prone to compressor stalls, which could easily result in loss of control due to the wide engine spacing, which causes severe yaw oscillations and can lead to an unrecoverable flat spin. At specific altitudes, the exhaust from a launched missile could cause the engine compressor to stall. This resulted in the development of a bleed system that temporarily reduced the power of the engine and blocked the frontal intake during missile launch. The overall thrust-to-weight ratio at maximum takeoff weight is around 0.56, which does not compare favorably with the F-15A's ratio of 0.85. The aircraft had an official maximum speed of Mach 2.34. Internal fuel capacity is 2,400 USgal (9,100 l): 290 USgal (1,100 l) in each wing, 690 USgal (2,600 l) in a series of tanks aft of the cockpit, and a further 457 USgal (1,730 l) in two feeder tanks. It can carry two 267 USgal (1,010 l) external drop tanks under the engine intakes. There is also an air-to-air refueling probe, which folds into the starboard nose. The F-14 with General Electric F110 engines had a thrust-to-weight ratio of 0.73 at maximum weight and 0.88 at normal takeoff weight.

The undercarriage is very robust, in order to withstand the harsh takeoffs and landings necessary for carrier operation. It comprises a double nose wheel and widely spaced single main wheels. There are no hard points on the sweeping parts of the wings, and so all the armaments are fitted on the belly between the air intakes and on pylons under the wing gloves (external fuel tanks can also be mounted directly below the intakes to increase the F-14's range, as seen in the image above).

The cockpit has two seats, arranged in tandem. The pilot and radar intercept officer (RIO) sit in Martin-Baker GRU-7A rocket-propelled ejection seats, rated from zero altitude and zero airspeed up to 450 knots. They have a 360° view in a canopy that is also fitted with four mirrors, one for the RIO and the others for the pilot. The canopy is still fairly traditional; being in three parts, but the overall structure is large and gives good visibility. The crews have classical controls and many older instruments, with an analog-digital hybrid lay out. Only the pilot has flight controls. No dual control version was ever made for the F-14, so the pilot starts to learn how to fly the machine using other aircraft and simulators. The main control systems are a HUD made by Kaiser, a VDI and a HSD display that gives data on airspeed, navigation and other information.

The Tomcat was also notable for its Central Air Data Computer (CADC), the integrated flight control system used in the early versions of the fighter. It used a MOS-based LSI chipset, the MP944, making it a candidate for the first microprocessor design in history. The CADC was designed and built by Garrett AiResearch.

The nose of the aircraft is large because it carries not only the two person crew, but also a large number of avionics systems. The ECM and navigation suite are extremely comprehensive and complex. The main element is the Hughes AWG-9 X-band radar, which in the initial version included a lightweight 5400B digital system with 32 kilobytes of RAM. The antenna dish is a 36 in (91 cm) wide planar array, uses 10 kW of power, and has integrated IFF antennas. There are available several search and tracking modes, such as Track-While-Scan (TWS), Range-While-Search (RWS), Pulse-Doppler Single-Target Track (PDSTT), and Jam Angle Track (JAT). A maximum of 24 targets can be tracked simultaneously, and six can be engaged in TWS mode up to around 60 mi (97 km). Pulse-only STT mode has a maximum range of around 96 statute miles (150 km). The maximum search range can exceed 120 statute miles (190 km) and even a fighter can be locked onto at around 72–90 statute miles (120–140 km). Cruise missiles are also possible targets with the AWG-9, since this radar can lock onto and track even small objects at low altitude when in a Pulse-Doppler mode. The radar antenna dish is in the nose, and most of the radar avionics are located just behind the nose, near the pilot's position. Other avionics (such as IFF, communication radios, direction-finding equipment, etc.) are near the RIO's position, and are mostly integrated into the AWG-9 display system.

Tomcats also feature electronic countermeasures (ECM) and radar warning (RWR) systems, chaff/flare dispensers in the tail, fighter-to-fighter data link, and a precise inertial navigation system. The early navigation system was purely inertial. Initial coordinates were programmed into the navigation computer, and a gyroscope in the system would track the aircraft's every motion. These aircraft motions were sent to the navigation computer, allowing it to calculate the jet's distance and direction from the initial starting point. Later, GPS was integrated into this inertial system, providing not only more precise navigation, but providing redundancy in case either system failed.
The chaff/flare dispensers were located on the belly, at the very tip of the tail, just to one side of the arresting hook. The dispenser contained several cylinders, into which either flares or chaff could be loaded in any combination. The RWR system was arranged with 4 antennae around the aircraft, and could roughly calculate the direction and the distance of many different types of radar from various aircraft and missile types. The RWR set could also display the status of the tracking aircraft's radar. It could differentiate between search radar, tracking radar, and missile-homing radar. The electronic countermeasures system could analyze incoming radar signals and send confusing radar signals back to the source.

The original set of sensors also comprised an infrared sensor under the nose in a "chin pod": it was AN/ALR-23 with indium antimonide detectors, cooled by a self-contained Stirling cycle cryogenic system, but this proved ineffective, and was replaced with a new system. This was an optical system, Northrop AAX-

1, also called TCS (TV Camera Set) and was used to help pilots visually identify and track aircraft, at least on day missions, up to a range of more than 60 miles (97 km) for large aircraft (a zoom function was included to help with small fighters). The TCS could be "slaved" to the radar to follow whatever the radar is tracking, and the radar could be slaved to the TCS to track whatever the camera "sees." Both the crew have access to the images on their displays. Despite its utility, for a long time most F-14s did not have the system added. Bill Gunston reported that even in 1983, only one in eight aircraft had the system fitted.

A dual IR/TCS system was adopted for the later F-14D variant, with an ECM antenna fitted as well in the same mast. This meant Tomcats could be configured with only an ECM antenna, or the IR sensor, or TCS, or many combinations thereof. The Tomcat's ESM system consists of many subsystems: RWR, ECM, and chaff/flare dispensers in various parts of the fuselage, nose, tail and wings. This was a marked difference with many previous fighter aircraft in that some did not even include a simple RWR.

The Tomcat was originally designed to combat both highly maneuverable aircraft and the Soviet cruise missile/bomber threat. As a result, the aircraft was designed to act effectively in every aspect of air combat. For weaponry, the Tomcat was designed as a platform for the formidable AIM-54 Phoenix, but unlike the stillborn F-111B it could also engage medium and short range threats. As such, the F-14 was a full air superiority fighter and not only a long range interceptor. It had the standard US gun, the M61 Vulcan, with 676 rounds and 4,000 or 6,000 RPM selectable (although the latter is rarely used due to jamming and overheating issues). Over 6,700 kg (15,000 lb) of stores could be carried for combat missions in several hard points under the belly and on wing-mounted hard points. Commonly, this meant a maximum of two – four Phoenixes or Sparrows on the belly stations, two Phoenixes/Sparrows on the wing hard points, and two Sidewinders on the wing hard points. On occasion, four AIM-7 Sparrows (on the belly) and four AIM-

9 Sidewinders (on the wing mounts) were carried, similar to the F-4 and F-15.

The maximum load of six Phoenix missiles was never used operationally. Although early testing proved it was possible, there was never a threat requirement to engage six hostile targets simultaneously and the load was too heavy to recover aboard an aircraft carrier. The Phoenix missile has been used twice in combat situations with the US Navy, both over Iraq in 1999, but the missiles didn't score any kills.

During the height of Cold War operations in the late 1970s and 1980s, the typical weapon load out on carrier-deployed F-14s was rarely more than one AIM-54 Phoenix, normally augmented by two AIM-9 Sidewinders, two AIM-7 Sparrow IIIs, a full load out of 20 mm ammunition for the M61 cannon and two drop tanks.

MAPS F-14B – Bureau Number 162694

The F-14 B Tomcat on display at the MAPS Air Museum was manufactured by Grumman Aviation Corporation, Bethpage, New York in January of 1986. It was delivered to the United States Navy on 1 July 1986. The aircraft was initially assigned to Fighter Squadron (VF) – 32 located at Naval Air Station (NAS), Oceana, Virginia. During assignment to this squadron, 162694 was deployed to the Mediterranean Sea aboard the U.S.S. John F. KENNEDY (from August 1986 to February 1989); to the Arabian Gulf aboard KENNEDY (from August 1990 to March 1991) in support of Operation DESERT SHIELD/DESERT STORM; once again to the to the Mediterranean aboard KENNEDY (from October 1992 to April 1993); and finally to the Caribbean Sea aboard U.S.S. Dwight D. EISENHOWER (from May 1994 to September 1994) in support of Operation RESTORE DEMOCRACY (Haiti).

The F-14 was returned to the Grumman facility in St. Augustine, Florida on 11 January 1995 for upgrades and conversion to an F-14B.

After conversion it returned to active service on 21 December 1995 and was assigned to VF-103, at NAS, Oceana, VA. While assigned to VF-103, 162694 was deployed to the Mediterranean aboard the U.S.S. ENTERPRISE (from June of 1996 to December of 1996) in support of Operations JOINT ENDEAVOR (Bosnia-Herzegovina) and SOUTHERN WATCH (Iraq).

In December of 1996 the F-14B was reassigned to VF-102, at NAS Oceana, Virginia and deployed to the Mediterranean/Arabian Gulf aboard U.S.S. George WASHINGTON (from October 1997 to April 1998) in support of Operation SOUTHERN WATCH.

In March of 2001, the aircraft was reassigned to VF-101, at NAS, Oceana, VA. In March of 2002, it was assigned to VF-32, also located at NAS, Oceana, VA. During this assignment, it was deployed to the Mediterranean aboard U.S.S. Harry S. TRUMAN (from December 2002 to May 2003) in support of Operations NOBLE EAGLE, NORTHERN WATCH and IRAQI FREEDOM and to the Arabian Gulf aboard the TRUMAN (from December 2004 to April 2005) in support of Operation IRAQI FREEDOM.

On October 5, 2005, F-14B Serial Number 162694 was removed from the Navy Aircraft Inventory, flown to MAPS and decommissioned. The aircraft is on loan from the National Museum of Naval Aviation

Variants

A total of 712 F-14s were built from 1969 to 1991. F-14 assembly and test flights were performed at Grumman's plant in Calverton on Long Island, NY. Grumman facility at nearby

Bethpage, NY was directly involved in F-14 manufacturing and was home to its engineers. The airframes were partially assembled in Bethpage and then shipped to Calverton for final assembly. Various tests were also performed at the Bethpage Plant. Over 160 of the US aircraft were destroyed in accidents.

F-14A

The F-14A was the initial two-seat all-weather interceptor fighter variant for the US Navy. It first flew on 21 December 1970. The first 12 F-14As were prototype versions (sometimes called YF-14As). Modifications late in its service life added precision strike munitions to its armament. The US Navy received 478 F-14A aircraft and 79 were received by Iran. The final 102 F-14As were delivered with improved TF30-P-414A engines. Additionally, an 80th F-14A was manufactured for Iran, but was delivered to the US Navy.

An F-14A Tomcat from VF-114 intercepting a Soviet Tu-95RT "Bear-D" maritime reconnaissance aircraft.

.

F-14B

The F-14 received its first of many major upgrades in March 1987 with the F-14A Plus (or F-14A+). The F-14A's P&W TF30 engine was upgraded with the GE F110-400. The F-14A+ also received the state-of-the-art ALR-67 Radar Homing and Warning (RHAW) system. Much of the avionics as well as the

AWG-9 radar were retained. The F-14A+ was later redesignated F-14B on 1 May 1991. A total of 38 new aircraft were manufactured and 48 F-14A were upgraded into B variants.

The TF30 had been plagued from the start with susceptibility to compressor stalls at high AoA and during rapid throttle transients or above 30,000 ft (9,100 m). The F110 engine provided a significant increase in thrust, producing 27,600 lbf (123 kN) with afterburner. The increased thrust gave the Tomcat a better than 1:1 thrust-to-weight ratio at low fuel quantities. The basic engine thrust without afterburner was powerful enough for carrier launches, further increasing safety. Another benefit was allowing the Tomcat to cruise comfortably above 30,000 ft (9,100 m), which increased its range and survivability. The F-14B arrived in time to participate in Desert Storm.

In the late 1990s, 67 F-14Bs were upgraded to extend airframe life and improve offensive and defensive avionics systems. The modified aircraft became known as *F-14B Upgrade* aircraft.

F-14D

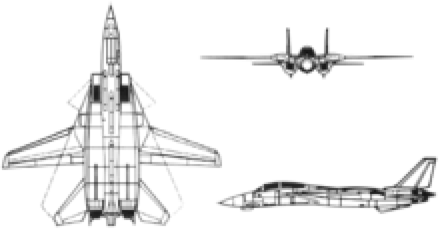
The final variant of the F-14 was the F-14D Super Tomcat. The F-14D variant was first delivered in 1991. The original TF-30 engines were replaced with GE F110-400 engines, similar to the F-14B. The F-14D also included newer digital avionics systems including a glass cockpit and replaced the AWG-9 with the newer AN/APG-71 radar. Other systems included the Airborne Self Protection Jammer (ASPJ), Joint Tactical Information Distribution System (JTIDS), SJU-17(V) Naval Aircrew Common Ejection Seats (NACES) and Infra-red search and track (IRST).

An upgraded F-14D(R) Tomcat with the ROVER transmit antenna circled. USS *Theodore Roosevelt* (CVN-71) is in the background.

Although the F-14D was to be the definitive version of the Tomcat, not all fleet units received the D variant. In 1989, Secretary of Defense Dick Cheney refused to approve the purchase of any more F-14D model aircraft for $50 million each and pushed for a $25 million modernization of the F-14 fleet instead. Congress decided not to shut production down and funded 55 aircraft as part of a compromise. A total of 37 new aircraft were constructed and 18 F-14A were upgraded to D variants, designated F-14D(R) for rebuild. An upgrade to the F-14D's computer software to allow AIM-120 AMRAAM (Advance Medium Range Air-to-Air Missile) missile capability was planned but was later terminated.

While upgrades had kept the F-14 competitive with modern fighter aircraft technology, Cheney called the F-14 1960s technology. Despite some aggressive proposals from Grumman for a replacement, Cheney planned to replace the F-14 with a fighter that was not manufactured by Grumman. Cheney called the F-14 a "jobs program", and when the F-14 was canceled, an estimated 80,000 jobs of Grumman employees, subcontractors, or support personnel were affected. Starting in 2005, some F-14Ds received the ROVER III upgrade.

General characteristics (F-14)



- **Crew:** 2 (Pilot and Radar Intercept Officer)
- **Length:** 62 ft 9 in (19.1 m)
- **Wingspan:**
  - Spread: 64 ft (19.55 m)
  - Swept: 38 ft (11.58 m)
- **Height:** 16 ft (4.88 m)
- **Wing area:** 565 ft² (54.5 m²)
- **Airfoil:** NACA 64A209.65 mod root, 64A208.91 mod tip
- **Empty weight:** 43,735 lb (19,838 kg)
- **Loaded weight:** 61,000 lb (27,700 kg)
- **Max takeoff weight:** 74,350 lb (33,720 kg)
- **Power plant:** 2 × General Electric F110-GE-400 afterburning turbofans
  - **Dry thrust:** 13,810 lbf (61.4 kN) each
  - **Thrust with afterburner:** 27,800 lbf (123.7 kN) each
- **Maximum fuel capacity:** 16,200 lb internal; 20,000 lb with 2x 267 gallon external tanks

Performance

- **Maximum speed:** Mach 2.34 (1,544 mph, 2,485 km/h) at high altitude
- **Combat radius:** 500 nmi (575 mi, 926 km)
- **Ferry range:** 1,600 nmi (1,840 mi, 2,960 km)
- **Service ceiling:** 50,000 ft (15,200 m)
- **Rate of climb:** >45,000 ft/min (229 m/s)
- **Wing loading:** 113.4 lb/ft² (553.9 kg/m²)

- **Thrust/weight:** 0.91

Armament

- **Guns:**
  - 1× 20 mm (0.787 in) M61 Vulcan 6-barreled Gatling cannon, with 675 rounds
- **Hard points:**
  - 10 total: 6× under-fuselage, 2× under nacelles and 2× on wing gloves with a capacity of 14,500 lb (6,600 kg) of ordnance and fuel tanks
- **Missiles:**
  - ** Air-to-air missiles:
    - AIM-54 Phoenix,
    - AIM-7 Sparrow,
    - AIM-9 Sidewinder
- **Loading configurations:**
  - 2× AIM-9 + 6× AIM-54 (Rarely used due to weight stress on airframe)
  - 2× AIM-9 + 2× AIM-54 + 3× AIM-7 (Most common load during Cold War era)
  - 2× AIM-9 + 4× AIM-54 + 2× AIM-7
  - 2× AIM-9 + 6× AIM-7
  - 4× AIM-9 + 4× AIM-54
  - 4× AIM-9 + 4× AIM-7
- **Bombs:**
  - ** JDAM (Joint Direct Attack Munition) Precision-guided munition (PGMs)
  - Paveway series of Laser guided bombs
  - Mk 80 series of unguided iron bombs
  - Mk 20 Rockeye II
- **Others:**
  - Tactical Airborne Reconnaissance Pod System (TARPS)
  - LANTIRN (Low Altitude Navigation and Targeting Infrared for Night) targeting pod
  - 2× 267 US gal (1,010 l; 222 imp gal) drop tanks for extended range/loitering time
- **Avionics**
  - Hughes AN/APG-71 radar

- AN/ASN-130 INS, IRST, TCS
- Remotely Operated Video Enhanced Receiver (ROVER) upgrade