



RAF Tornado GR4



Photo credit: Sgt Peter Mobbs RAF

Thank you for joining us, as we welcome the Tornado GR4 to the Aviation Heritage Museum.

After an impressive 39-year career the Tornado GR4 was retired from service in 2019 by the RAF and the Aviation Heritage Museum is the only museum outside of the UK to be gifted one to display.

Ian Craig, the Head of Clear Skies at RAAFA, who oversees the museum, said it “was a piece of aviation history we had to take a shot at getting for our museum, so we wrote a letter to the RAF. We already have a Spitfire and a Lancaster which show the close relationship between RAAF and RAF so the Tornado GR4 felt like the next important piece of the puzzle.”

“To our delight the RAF saw the value in having one in Australia and in January it left the UK via sea for our museum in Bull Creek”.

“It has been a long project to get the aircraft to our museum and it has been such a privilege to work the RAF, RAAF and RAAFA WA teams to install this new exhibit and we are so excited to show it to our community,” remarked Mr Craig.

The following document shares some key information on the Tornado GR4, for you to enjoy as you view the aircraft.



Photo credit: Sgt Peter Mobbs RAF

Role	Multirole aircraft, strike aircraft
National origin	Italy, West Germany, United Kingdom
Manufacturer	Panavia Aircraft GmbH
First Flight	14 August 1974
Introduction	1979
Retired	2019 (RAF)
Status	In Service
Primary users	Royal Air Force (historical) German Air Force Italian Air Force Royal Saudi Air Force
Produced	1979 - 1998
Number built	990 <ul style="list-style-type: none">• 745, Panavia Tornado IDS• 194, Panavia Tornado ADV• 51, Panavia Tornado ECR

Key Statistics



Photo credit: Chris England, ABPics

Source - Wikipedia

History

The Panavia Tornado is a family of twin-engine, variable-sweep wing multirole combat aircraft, jointly developed and manufactured by Italy, the United Kingdom and West Germany. There are three primary Tornado variants: the Tornado IDS (interdictor/strike) fighter-bomber, the suppression of enemy air defences Tornado ECR (electronic combat/reconnaissance) and the Tornado ADV (air defence variant) interceptor aircraft.

The Tornado was developed and built by Panavia Aircraft GmbH, a tri-national consortium consisting of British Aerospace (previously British Aircraft Corporation), MBB of West Germany, and Aeritalia of Italy. It first flew on 14 August 1974 and was introduced into service in 1979–1980. Due to its multirole design, it was able to replace several different fleets of aircraft in the adopting air forces. The Royal Saudi Air Force (RSAF) became the only export operator of the Tornado in addition to the three original partner nations. A tri-nation training and evaluation unit operating from RAF Cottesmore, the Tri-National Tornado Training Establishment, maintained a level of international co-operation beyond the production stage.

The Tornado was operated by the Royal Air Force (RAF), Italian Air Force, and RSAF during the Gulf War of 1991, in which the Tornado conducted many low-altitude penetrating strike missions. The Tornados of various services were also used in The Bosnian War, Kosovo War, Iraq War, in Libya during the 2011 Libyan civil war, as well as smaller roles in Afghanistan, Yemen, and Syria. Including all variants, 990 aircraft were built.

Source - Wikipedia

Design

The Panavia Tornado is a multirole, twin-engined aircraft designed to excel at low-level penetration of enemy defences. The mission envisaged during the Cold War was the delivery of conventional and nuclear ordnance on the invading forces of the Warsaw Pact countries of Eastern Europe; this dictated several significant features of the design. Variable wing geometry allowed for minimal drag during the low-level dash towards a well-prepared enemy. Advanced navigation and flight computers, including the then-innovative fly-by-wire system, greatly reduced the workload of the pilot during low-level flight and eased control of the aircraft. For long range missions, the Tornado has a retractable refuelling probe.

As a multirole aircraft, the Tornado is capable of undertaking more mission profiles than the anticipated strike mission; various operators replaced multiple aircraft types with the Tornado as a common type – the use of dedicated single role aircraft for specialist purposes such as battlefield reconnaissance, maritime patrol duties, or dedicated electronic countermeasures (ECM) were phased out – either by standard Tornados or modified variants, such as the Tornado ECR. The most extensive modification from the base Tornado design was the Tornado ADV, which was stretched and armed with long range anti-aircraft missiles to serve in the interceptor role.

Tornado operators have undertaken various life extension and upgrade programmes to keep their Tornado fleets as viable frontline aircraft. With these upgrades it is projected that the Tornado shall be in service until 2025, more than 50 years after the first prototype took flight.

Source - Wikipedia

Variable Sweep Wing

In order for the Tornado to perform well as a low-level supersonic strike aircraft, it was considered necessary for it to possess good high-speed and low-speed flight characteristics. To achieve high-speed performance, a swept or delta wing is typically adopted, but these wing designs are inefficient at low speeds. To operate at both high and low speeds with great effectiveness, the Tornado uses a variable-sweep wing. This approach had been adopted by earlier aircraft, such as the American General Dynamics F-111 Aardvark strike fighter, and the Soviet Mikoyan-Gurevich MiG-23 fighter. The smaller Tornado has many similarities with the F-111, however the Tornado differs in being a multi-role aircraft with more advanced onboard systems and avionics.



Source - Wikipedia

The Tornado is cleared to carry the majority of air-launched weapons in the NATO inventory, including various unguided and laser-guided bombs, anti-ship and anti-radiation missiles, as well as specialised weapons such as anti-personnel mines and anti-runway munitions.

To improve survivability in combat, the Tornado is equipped with onboard countermeasures, ranging from flare and chaff dispensers to electronic countermeasure pods that can be mounted under the wings.

Underwing fuel tanks and a buddy store aerial refuelling system that allows one Tornado to refuel another are available to extend the aircraft's range.



Source - Wikipedia



Armament and Equipment

The Tornado features a tandem-seat cockpit, crewed by a pilot and a navigator/weapons officer; both electromechanical and electro-optical controls are used to fly the aircraft and manage its systems. An array of dials and switches are mounted on either side of a centrally placed CRT monitor, controlling the navigational, communications, and weapons-control computer. BAE Systems developed the Tornado Advanced Radar Display Information System (TARDIS), a 32.5-centimetre (12.8 in) multi-function display, to replace the rear cockpit's Combined Radar and Projected Map Display; the RAF began installing TARDIS on the GR4 fleet in 2004.

The primary flight controls of the Tornado are a fly-by-wire hybrid, consisting of an analogue quadruplex Command and Stability Augmentation System (CSAS) connected to a digital Autopilot & Flight Director System (AFDS). In addition a level of mechanical reversion capacity was retained to safeguard against potential failure. To enhance pilot awareness, artificial feel was built into the flight controls, such as the centrally located stick. Because the Tornado's variable wings enable the aircraft to drastically alter its flight envelope, the artificial responses adjust automatically to wing profile changes and other changes to flight attitude. As a large variety of munitions and stores can be outfitted, the resulting changes to the aircraft's flight dynamics are routinely compensated for by the flight stability system.

The Tornado incorporates a combined navigation/attack Doppler radar that simultaneously scans for targets and conducts fully automated terrain-following for low-level flight operations. Being able to conduct all-weather hands-off low-level flight was considered one of the core advantages of the Tornado. The Tornado ADV had a different radar system to other variants, designated AI.24 Foxhunter, as it is designed for air defence operations. It was capable of tracking up to 20 targets at ranges of up to 160 kilometres (100 mi). The Tornado was one of the earliest aircraft to be fitted with a digital data bus for data transmission. A Link 16 JTIDS integration on the F3 variant enabled the exchange of radar and other sensory information with nearby friendly aircraft.



Forward Cockpit



Aft Cockpit

Engines

Britain considered the selection of Rolls-Royce to develop the advanced engine for the MRCA to be essential, and was strongly opposed to adopting an engine from an American manufacturer, to the point where the UK might have withdrawn over the issue. In September 1969, Rolls-Royce's RB199 engine was selected to power the MRCA.

One advantage over the US competition was that a technology transfer between the partner nations had been agreed; the engine was to be developed and manufactured by a joint company, Turbo-Union. The programme was delayed by Rolls-Royce's entry into receivership in 1971, however the nature of the multinational collaboration process helped avoid major disruption of the Tornado programme. Research from the supersonic airliner Concorde contributed to the development and final design of the RB199 and of the engine control units.

To operate efficiently across a wide range of conditions and speeds up to Mach 2, the RB199 and several other engines make use of variable intake ramps to control the air flow. The hydraulic system is pressurised by syphoning power from both or either operational engine; the hydraulics are completely contained within the airframe rather than integrating with the engine to improve safety and maintainability.

Source - Wikipedia

In case of double-engine, or double-generator, failure, the Tornado has a single-use battery capable of operating the fuel pump and hydraulics for up to 13 minutes.

Relatively rarely among fighter aircraft, the RB199 is fitted with thrust reversers to decrease the distance required to safely land. To fully deploy the thrust reverser during landings, the yaw damper is connected to the steering of the nosewheel to provide greater stability.



Source - Wikipedia

Engines

Our Tornado GR4

Squadron Leader Martin Keer RAAF shares this story from his time flying ZG791:



"It is indeed a bizarre coincidence given my 5 years as an instructor on 79SQN at RAAF Base Pearce, my flights in RAAF F-111C/Gs, and as a Roulette pilot that of all the Tornado GR4 aircraft to be gifted to the Bull Creek museum this is the aircraft in which I came the closest to hostile fire.

Tail Number: 137

Serial Number: ZG791

In another coincidence I first flew ZG791 on June 13th 2001, exactly 21 years prior to the start of her rebuild in WA. My navigator for this first sortie was FLTLT Sally Willers, one of the few female RAF navigators serving at the time. The sortie involved flying cover for our element lead during a 4 ship sortie over Iraq from Ali Al Salem Air Base in Kuwait.

The hostile fire sortie occurred on July 3rd 2001 during an operational mission with my navigator FLTLT Crispin Hilton. Roughly half way through our patrol we were engaged by multiple Iraqi Anti-Aircraft Artillery (AAA) batteries. Numerous rounds from KS-19 and S-60 artillery pieces exploded around us. I had been looking over the right wing when Cris shouted "AAA out left!" I engaged the afterburner and took immediate evasive action aggressively raising the nose to take ZG791 away from the targeted height block.

My 5th and final sortie in ZG791, my first operational 4 ship lead mission, was flown with navigator FLTLT Jonny Meadows on July 21st 2001. A nerve-wracking but enormously rewarding mission.

Throughout our operational deployment ZG791 kept us safe....."

14 July 1992

It was delivered as a GR1 and began its service in 31 Squadron (Goldstar), Arthur (Bomber) Harris former CO in India.

1999

Conversion to GR4.

2000

Moved to 9 Squadron.

2001

Moved to 14 Squadron.

2004

It was part of 617 Squadron, with tail code AJ-T, commemorating Dam Buster Lancaster of Joe McCarthy.

2012 - 2019

It was part of 31 Squadron.

2019

It was part of 9 Squadron.

2 July 2019

Retired from service.

Then allocated for display at Aviation Heritage Museum WA, where you can view it today.

Arrival at the Museum

On Thursday 19 May the Tornado's fuselage, wings and fuel tanks were transported to the Museum, following seven weeks in quarantine at Fremantle Port. The transport of these components relied upon two semi-trailers, a 100-tonne crane and forklift.

On Monday 23 May, the final items of the Tornado were transferred from RAAF Base Pearce to the Museum in Bull Creek, including the fin (tail) and engine. A semi-trailer and forklift were again involved in this operation.



On Monday 13 June Wing Commander Erica J Ferguson RAF and the JARTS team landed in Perth to reconstruct and officially hand over the Tornado GR4. The specialist JARTS (Joint Aircraft Recovery and Transportation Squadron) team, led by Warrant Officer Keith Davies worked at the museum to reconstruct the aircraft and provide valuable information to our volunteers on its construction, including a detailed information session on the engine of the aircraft.

JARTS is a specialist organisation of Royal Air Force and Royal Navy personnel devoted to Aircraft Post Crash Management (APCM), Rapid Runway Clearance (RRC), Air System recovery and the transportation of aircraft or their large uncrated components. JARTS are a deployable Air Command capability which is established to provide specialist technical teams to support UK Fixed and Rotary Wing aircraft operations during peacetime and conflict. JARTS utilises RAF Heritage tasks to transport RAF Gate Guardians to train and maintain the niche skillsets required for aircraft transportation.

Construction



RAAFA

Aviation Heritage Museum

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