

# ARCHIVED REPORT

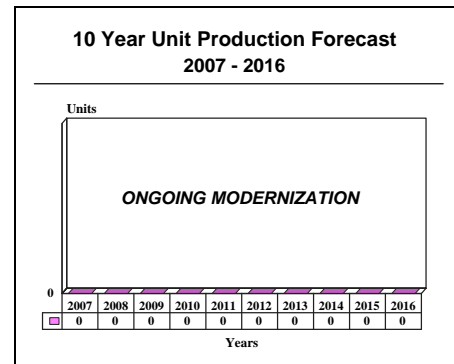
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## Panavia Tornado - Archived 3/2008

### Outlook

- The RAF F3 Sustainment Program has been completed
- Other Tornado modification programs are under way or may soon be in the works for various operators
- New production of the Tornado has ended



### Orientation

**Description.** Twin-engine, two-seat, all-weather multirole strike and air combat fighter.

**Sponsor.** The British, Italian, and German defense ministries.

**Status.** Production was completed in 1998.

**Total Produced.** A total of 992 aircraft, including 12 prototypes and six pre-series aircraft, were produced.

**Application.** Medium-range strike and interdiction, air superiority, reconnaissance, defense suppression.

**Price Range.** Unit flyaway: IDS/ADV, \$32-\$33 million; ECR, estimated at \$38 million – in 1998 U.S. dollars.



TORNADO F3

Source: U.K. Royal Air Force

## Panavia Tornado

## Contractors

## Prime

<b>Panavia Aircraft GmbH</b>	Airport Business Centre, Am Söldnermoos 17, Hallbergmoos, 85399 Germany, Tel: + 49 811 80 0, Fax: + 49 811 80 1386, Prime
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## Subcontractor

<b>Dunlop Aerospace Braking Systems</b>	<a href="http://www.dunlop-aerospace.com">http://www.dunlop-aerospace.com</a> , Holbrook Ln, Coventry, CV6 4AA United Kingdom, Tel: + 44 2476 666 655, Fax: + 44 2476 662 294 (Brakes; Wheels)
<b>Hilliard Corp</b>	<a href="http://www.hilliardcorp.com">http://www.hilliardcorp.com</a> , 100 W Fourth St, Elmira, NY 14902 United States, Tel: + 1 (607) 733-7121, Fax: + 1 (607) 733-3009 (TC Series Starter)
<b>Lital SpA</b>	<a href="http://www.lital.it">http://www.lital.it</a> , Via Pontina, Km 27800, Pomezia, I-00040 Italy, Tel: + 39 06 911 922 63, Email: <a href="mailto:info@lital.it">info@lital.it</a> (AHRs)
<b>Magneti Marelli Holding SpA</b>	<a href="http://www.magnetimarelli.com">http://www.magnetimarelli.com</a> , Viale Aldo Borletti 61/63, Corbetta, 20011 Italy, Tel: + 39 02 9722 7111, Fax: + 39 02 972 7355 (Battery Charger; Transformer Rectifier)
<b>Turbo-Union Ltd</b>	PO Box 3, Bristol, BS34 7QE United Kingdom, Tel: + 44 117 979 1234, Fax: + 44 117 979 7575 (RB199 Turbofan)
<b>Wood Group Fuel Systems Ltd</b>	<a href="http://www.woodgroup.com">http://www.woodgroup.com</a> , Wellshead Industrial Ctr, Dyce, Unit 22, Aberdeen, AB21 7GA Scotland, United Kingdom, Tel: + 44 1224 771 133, Fax: + 44 1224 725 275 (Fuel Nozzle)

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## Technical Data

**Design Features.** Cantilever shoulder-wing design with variable geometry wing; leading edge sweep of 25 degrees in fully forward position, 67 degrees when swept fully aft. The wings are equipped with full-span leading edge slats, double-slotted fixed-vane full-span trailing edge flaps, and spoilers. Control surface actuation is by double hydraulic ball screw jacks. The tail unit is composed of a single swept vertical stabilizer and twin all-moving, swept, horizontal stabilizers also known as tailerons. Landing gear is tricycle type and hydraulically actuated, with dual wheels on the nose unit and single wheels on the main gear.

Prime contractor for the Tornado was Panavia Aircraft GmbH. Panavia is a consortium that consists of BAE Systems (42.5 percent), EADS (42.5 percent), and Alenia (15 percent). British production of the Tornado occurred at Preston in Lancashire, German production at Munich, and Italian production at Turin.

Major subsystem suppliers included Normalair-Garrett (cockpit ECS and pressurization system), Nordmicro/

BAE/Microtecnica (inlet control system), Dowty/Liebherr (intake actuation system), Vickers (twin hydraulic pumps), Lucas/Siemens (integrated electric drive system), Graviner (fire suppression and indication system), GEC-Marconi/Bodenseewerk (triplex command stability augmentation system), and GEC-Marconi/Alenia (autopilot and flight director). Major electronic systems were provided by Raytheon (multimode, terrain-following, ground-mapping radar), GEC-Marconi (three-axis digital INS and laser range-finder/marked target seeker), Decca (Type 72 Doppler radar), Litel (central processor), Smiths/Teldix (HUD with Davall camera), Elettronica or GEC-Marconi (radar warning receiver), and GEC-Plessey or Rohde and Schwarz (UHF/VHF transceiver). The Raytheon radar, the Decca Doppler radar, and the GEC-Marconi laser rangefinder and marked target seeker are not in the ADV version.

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	<u>Metric</u>	<u>U.S.</u>
<b>Dimensions (IDS/ADV)</b>		
Length overall	16.72/18.68 m	54.86/61.29 ft
Height overall	5.95 m	19.52 ft
Wingspan		
Fully swept	8.60 m	28.22 ft
Fully spread	13.91 m	45.64 ft
<b>Weight (IDS/ADV)(a)</b>		
Empty, equipped (IDS)	14,091 kg	31,065 lb
Operational weight empty (ADV)	14,500 kg	31,970 lb
Nominal max weapons load	9,000+/8,500 kg	19,840+/18,740 lb
Max TOW(b)	27,950/27,986 kg	61,620/61,700 lb
<b>Performance (IDS/ADV)</b>		
Max speed in level flight at altitude, clean	Mach 2.2	Mach 2.2
Max level speed, clean	1,480 kmph	800 kt
Max level speed with external stores (IDS only)	1,112 kmph	600 kt
Ferry range, approx. (IDS only)	3,890 km	2,100 nm

**Propulsion**

Tornado IDS	(2)	Turbo-Union RB199-34R Mk 101 three-spool augmented turbofans rated at 66.0 kN (14,840 lbst) each (with afterburning) for initial production aircraft. Aircraft produced from May 1983 use Mk 103 engines rated at 71.5 kN (16,075 lbst) each with afterburning.
Tornado ADV/F2/F3	(2)	Turbo-Union RB199-34R Mk 103 three-spool augmented turbofans for first 18 production aircraft. From 19th production aircraft, RB199-34R Mk 104 turbofans rated at 73.5 kN (16,520 lbst) each with afterburning.
Tornado ECR	(2)	Turbo-Union RB199-34R Mk 105 augmented turbofans rated at approximately 76.95 kN (17,300 lbst) each with afterburning are used on German Tornado ECRs.

**Armament**

Two Mauer 27mm cannon with 180 rounds each on IDS. One cannon on ADV; none on ECR. Three underfuselage attachments and four underwing hardpoints accommodate a wide variety of stores depending upon mission. Stores that can be accommodated include AIM-9 Sidewinder and (on ADV) Sky Flash air-to-air missiles; Kormoran, Sea Eagle, and Maverick air-to-surface missiles; HARM and ALARM anti-radiation missiles; BL755 cluster bombs; MW-1 munitions dispenser; 1,000-pound bombs; Paveway II laser-guided bomb; JP233 runway cratering weapon; BLU-1B fire bomb; LAU-51A and LR-25 rocket launchers; ECM pods including Sky Shadow, BOZ 101/102/107, and CERBERUS II or III; and external fuel tanks.

**Crew**

Two, seated in tandem.

(a)All ADV weights are approximate.

(b)IDS maximum takeoff weight is approximate.

## Variants/Upgrades

**IDS.** The Interdictor/Strike (IDS) version is the basic multirole model in service in the U.K., Germany, Italy, and Saudi Arabia. The initial British Royal Air Force (RAF) designation was Tornado GR1. In mid-1994, the British government awarded a contract to British Aerospace (now BAE Systems) to upgrade 142 RAF Tornado GR1s to the Tornado GR4 configuration. The GR4 standard, which represents a mid-life update for the GR1, includes a new forward-looking infrared

(FLIR) system, night vision goggle compatibility, and an updated weapon control system. Redeliveries to the RAF began in October 1997 and were completed in June 2003.

**ADV.** The Air Defense Variant (ADV) is in service in the U.K. and Saudi Arabia. British RAF designations are Tornado F2 and Tornado F3. The ADV has a longer fuselage than the IDS in order to accommodate a longer

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radome as well as to permit carriage of Sky Flash missiles in two tandem pairs. The ADV also features a 1,300-pound internal fuel capacity increase and a GEC-Marconi Foxhunter air intercept radar. It is equipped with one Mauser 27mm cannon. The first 18 production ADVs were the F2 version with RB199 Mk 103 engines. A proposal to upgrade these to a Tornado F2A configuration was abandoned. The F2A configuration was similar to the F3 standard, but without the Mk 104 engines.

A total of 100 RAF Tornado F3s were modified under a GBP125 million (\$187 million) program that allows the aircraft to carry the Advanced Medium-Range Air-to-Air Missile (AMRAAM) and the Advanced Short-Range Air-to-Air Missile (ASRAAM). The program was intended to improve the U.K.'s air defense capability, pending introduction of the Eurofighter Typhoon.

**ECR.** The Electronic Countermeasures and Reconnaissance (ECR) variant is equipped with an infrared

linescanner and a passive modular infrared system. The twin Mauser cannon are eliminated. The aircraft is normally equipped with two High-Speed Anti-Radiation Missiles (HARMs), two Sidewinder air-to-air missiles, one active electronic countermeasures (ECM) pod, and two 396-U.S.-gallon fuel tanks. Power on German ECRs is provided by twin Mk 105 engines. The Mk 105 provides about 10 percent more thrust than the Mk 103 powerplant. The ECR performs tactical air reconnaissance, suppression of enemy air defenses, pathfinder operations, and electronic countermeasures.

The Italian government retrofitted 15 Tornado IDS aircraft to the ECR configuration. The Italian ECRs have an equipment fit similar to that of the Tornado ECRs used by the German Air Force, as well as additional improvements. The conversions were performed by Alenia.

## Program Review

**Background.** The Tornado fighter/attack aircraft stems from a six-nation feasibility study begun in 1968 and completed the following year. This study originally involved the governments of Belgium, Canada, the Netherlands, Italy, the U.K., and West Germany; the first three nations dropped out by 1969. The initial design was known as the MRCA-75 (Multi-Role Combat Aircraft-1975), a swing-wing fighter to be produced in several variants. Deliveries for the three partner nations eventually totaled 359 aircraft for Germany (212 IDS aircraft for the German Air Force, 35 of the ECR variant for that service, and 112 IDS aircraft for the German Navy), 402 for the British RAF (229 IDS aircraft and 173 ADV models), and 100 for the Italian Air Force (all IDS aircraft).

Airframe design leadership was vested with Germany, and the Rolls-Royce RB199 was chosen to power the aircraft. However, to ensure development of the engine on an international level, a company called Turbo-Union Ltd was established. Partners in the firm included MTU, 40 percent; Rolls-Royce, 40 percent; and Avio, 20 percent. Also, for development and procurement of the necessary avionics packages, a company was established under the name Avionics Systems Engineering GmbH.

Development of the Tornado began in 1970, structural design work was completed in August 1972, and the first flight of a prototype was made in August 1974.

## Funding

Eight production batches were completed. A planned additional batch was to include 26 IDS aircraft and seven ADVs for the RAF, but procurement of these was canceled in 1990.

## Timetable

<u>Month</u>	<u>Year</u>	<u>Major Development</u>
Mar	1969	Panavia consortium formed
Jul	1970	Development begun
	1970	Design definition completed
Aug	1974	Prototype first flight
Feb	1976	Preproduction aircraft first flight
Jul	1979	First production-standard aircraft flown
Oct	1979	First flight of initial ADV prototype

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<u>Month</u>	<u>Year</u>	<u>Major Development</u>
Jul	1980	Initial IDS production deliveries
	1985	Initial ADV production deliveries
	1998	Production completed

## Worldwide Distribution/Inventories

<b>Germany</b>	266	<b>Saudi Arabia</b>	106
<b>Italy</b>	74	<b>United Kingdom</b>	187

## Forecast Rationale

The British Royal Air Force’s F3 Sustainment Program (FSP), an upgrade effort for the service’s Tornado F3s, was completed in July 2006. BAE Systems was the prime contractor on the program, with QinetiQ acting as a key subcontractor.

The FSP involved integration of the latest versions of the AMRAAM and ASRAAM, as well as upgrades to the aircraft’s main computer, radar, and datalink capabilities.

The RAF’s Tornado GR4s may undergo several upgrades in the future, including new electronic countermeasures and self-protection capabilities.

An upgrade program for Royal Saudi Air Force Tornado IDS aircraft has been the subject of discussions between the service and BAE Systems. The upgrade would improve the capabilities of the aircraft as well as extend airframe life. No firm plans, however, have been announced regarding whether this program will proceed.

Eighteen Italian Air Force Tornados are being upgraded by Alenia Aeronautica to a configuration called the Italian Mid-Life Update (MLU) 1st Upgrade standard. The initial Tornado upgraded to this standard was redelivered to the service in July 2004. The 1st Upgrade configuration includes navigation, communications, and flight safety-related equipment improvements; night vision goggle-compatible lighting modifications; and new weaponry.

A second upgrade for Italian Air Force Tornados, called the Full MLU, is in development. It will include the Defensive Aids Subsystem (DASS) that is utilized on the Eurofighter Typhoon, new cockpit displays, a Link 16 tactical datalink, and other modifications. A total of 75 of the service’s Tornados are to receive the Full MLU improvements, including the 18 aircraft modified under the 1st Upgrade program.

## Ten-Year Outlook

### ESTIMATED CALENDAR YEAR PRODUCTION

Aircraft	(Engine)	<u>High Confidence Level</u>				<u>Good Confidence Level</u>				<u>Speculative</u>				Total 07-16
		thru 06	07	08	09	10	11	12	13	14	15	16		
PANAVIA (Consortium)														
TORNADO ADV (S. ARABIA)	RB199 MK 104	24	0	0	0	0	0	0	0	0	0	0	0	0
TORNADO F2/F3(a)	RB199 MK 103/104	173	0	0	0	0	0	0	0	0	0	0	0	0
TORNADO GR1(b)	RB199 MK 101/103	234	0	0	0	0	0	0	0	0	0	0	0	0
TORNADO IDS (ITALY)(c)	RB199 MK 101/103	102	0	0	0	0	0	0	0	0	0	0	0	0
TORNADO IDS (S. ARABIA)	RB199 MK 103	96	0	0	0	0	0	0	0	0	0	0	0	0
TORNADO IDS/ECR (FRG)(d)	RB199 MK 101/103/105	363	0	0	0	0	0	0	0	0	0	0	0	0
Total Production		992	0	0	0	0	0	0	0	0	0	0	0	0

(a)Includes three prototypes.

(b)Includes four prototypes and two pre-series aircraft.

(c)Includes two prototypes and one pre-series aircraft.

(d)Includes three prototypes and three pre-series aircraft.