

Milestones in the history
of aviation:
The F-104 Starfighter

Starfighter



Created more than 50 years ago, the design still looks 'futuristic'. An aircraft that looks good flies well, as the old aviation adage has it, and there are few aircraft for which this saying is as true as for the F-104. Elegance and speed coupled with phenomenal performance made it the ultimate 'pilot's aircraft'. Even today for many pilots and aircraft enthusiasts it is the aeroplane of their dreams.

Fifty years ago it was already not only the first Mach 2 fighter really able to fly at twice the speed of sound for a lengthy period, but also the first aircraft to hold the world records for both speed and altitude simultaneously.

The large-scale F-104G licence manufacturing programme enabled the German aerospace industry to get back to international standard and to create thousands of jobs, eventually resulting in highly successful European programmes such as the Tornado.



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Genesis of the F-104

The Lockheed F-104 Starfighter was both the result of lessons learnt from the Korean War and an early attempt to reverse the trend of ever more complex, heavy, expensive fighter aircraft. The basic concept was a light air-superiority fighter, the first aircraft able to maintain a constant speed of more than Mach 2 over a sustained period.



Clarence Kelly Johnson, Lockheed's designing genius

Although no official request to develop such an aircraft had been made, in November 1952 Lockheed kicked off Project 242 with a team headed by Clarence L. 'Kelly' Johnson. Convincing Lockheed of the validity of the concept, Johnson was granted permission by the company to continue with his project, and in the spring of 1953 these studies led to Project L-246, the model 83.

In the meantime, the USAF, similarly persuaded of the value of a light air-superiority fighter, issued a corresponding General Operational Requirement. Several aerospace companies took part in the ensuing competition: Republic with what became the XF-91,



In its design similar to the F-104: the experimental aircraft Douglas X-3 Stiletto

North American with the NA-212 (later the ill-starred F-107), and Northrop with the N-102. The Lockheed proposal was by far the most sophisticated in terms of development and design, and on 12 March 1953 the company was given an order for two prototypes (designation XF-104).



North American F-107A

On 30 April 1953 the design model was completed and decisions concerning armament and engine could be taken. The armament component selected was a 20-mm General Electric Vulcan Gatling cannon with a 4,000 rounds/minute capability and two of the new AIM-9B Sidewinder air-to-air missiles. The engine chosen was the brand new General Electric J79. (However, as this particular engine was not available at the time, the first prototype carried a Wright J65 B-3 engine, a US-licensed product of the British Armstrong Siddeley Sapphire, which did not include an afterburner.)



Mikoyan Gurevich MiG 15, in the beginning of the fifties the standard fighter plane of the Warsaw Pact....



... and its Western counterpart: North American F-86 Sabre



Republic XF-91

The F-104 airborne

The During the summer and autumn of 1953 work started on the two XF-104s. In addition to being equipped with lower-performance provisional engines their air intakes were non-adjustable without (initially classified) half cones.

The XF-104s were discreetly transported under cover of darkness to Edwards AFB, where test pilot A.W. (Tony) LeVier started taxiing runs on 27 February 1954. The very next day, the XF-104 achieved a low-level, short-hop take-off (approx. 1.5 m) during high-speed taxiing tests.

The first official flight took place on 4 March 1954 – 20 minutes in the air during which the only problem was the fact that LeVier was unable to retract the undercarriage. After landing, technicians adjusted the undercarriage, and LeVier took off once more, but was still unable to retract the undercarriage. (The reason, it was discovered later, was insufficient pressure in the hydraulic system.)

In July 1954 the provisional engine was replaced with an afterburning Wright J65-W-7 and the USAF placed an order for a further 17 test aircraft. The second prototype took off for the first time on 5 October 1954.

On 17 December 1954 there was an explosion in the fuselage of the first XF-104 during cannon-firing trials: LeVier responded by cutting the engine and deadsticked into Edwards AFB. A round had exploded in the cannon breech and parts of the ammunition and the cannon had impacted with a fuel cell, releasing jet fuel which flooded the gun bay and the engine via a hole in the left air intake.

On 15 March 1955 the first prototype reached the highest ever flown speed attained by an XF-104: Mach 1.79 at an altitude of 18,300 m.

On 15 April 1955 the second prototype was lost during cannon-firing trials. At an altitude of 12,250 m firing cannon vibrations caused the cockpit hatch to loosen. Cabin pressure fell, causing the pressure suit that the pilot Herman 'Fish' Salmon was wearing to inflate and he lost vision. He assumed he was experiencing a repeat of what had happened to LeVier, so he ejected from the aircraft using the downward-firing C-1 ejection seat. It was subsequently recognised that he only needed to descend a bit to a lower altitude and wait for the pressure suit to deflate. A remarkable event followed, probably unique in the history of test flying – in the interests of establishing the veracity of his account, Salmon agreed to be interrogated under the influence of a 'truth drug'.

In November 1955 the surviving XF-104 was taken over by the USAF; on 11 July 1957 the aircraft finally met its end, written off in a crash.



The first XF-104

Kelly Johnson (l.) congratulates Tony LeVier (r.) to a successful first flight



The second F-104 without tiptanks



Tony LeVier in the cockpit of the XF-104



Both prototypes in flight



The record-breaking YF-104



QF-104A target drone

The YF-104A pre-series production featured various modifications compared to the XF-104. The fuselage was around 1.7 m longer, to incorporate not only the GE J79 engine (4,060 kp thrust w/o, resp. 6,713 kp with afterburner) but also two additional fuel cells. The fin was slightly enlarged, the span slightly increased, the nose wheel retracted forwards and the air intakes were equipped with adjustable half cones.

Herman 'Fish' Salmon (center) and Kelly Johnson (r.)



In February 1956 the first YF-104A was completed and, like the XF-104, transported secretly to Edwards AFB. On 17 February Herman Salmon took it up for a maiden flight. The official roll-out and first public appearance of this much talked-about aircraft had actually taken place the day before at the Lockheed plant in Burbank, CA, together with the second YF-104. At this point the air intakes remained covered; the first photograph of the aircraft with the air intakes fully visible was not released until mid 1956.



On 28 February 1956 the first YF-104A attained Mach 2 in level flight, the first time that a jet-engine aircraft had reached that speed in level flight.

On 14 October 1956 the USAF placed its first order for F-104A series production.

In May 1958 two new world records were established: on 7 May Major Howard C. Johnson set a world record for altitude at 27,813 m and on 16 May, with an average speed of 2,253,89 km/h over a 15–25 km course, Captain Walter W. Irwin set a new speed world record. This in itself set another new world record, that of a single type of aircraft holding at the same time the world records for altitude and speed.

Major Howard C. Johnson (r.) reached an altitude of 27,811 m

Seventeen YF-104As were produced in total. Many of them were lost in crashes, others were modified to type F-104As. After the F-104A was phased out, some of the YF-104s were converted to remote-controlled QF-104A target drones. Two YF-104s still exist today.



Major Walter W. Irwin broke the speed record

Presentation of the YF-104 - still with covered air intakes - to the world's press and media



First series production: the F-104A



In the same way that the YF-104A improved upon the XF-104, the F-104A, the first real series-production version of the Starfighter, was further improved with respect to the YF-104A. The fuselage was strengthened, a

dorsal fin was added to the empennage to improve directional stability and a boundary layer system (BLC) installed. This BLC utilised bleed air from the engine, blowing it over the flaps whenever they were lowered more than 15 degrees. This aircraft version achieved impressive landing speeds of only around 5% higher than other fighter planes of the time, in spite of its small wings.

The BLC system, together with slats and flaps connected to the ailerons across the whole length of the wing's leading and trailing edge, ensured reasonable speeds for take-off, landing and manoeuvring.

The T-tail was now equipped with a flying stabiliser, which led to some fairly dangerous stall characteristics (super-stall). To counter this, an automatic pitch control system was added. As soon as the aircraft approached the critical point of the flight envelope, the stick automatically started to shake and, if the pilot took no action, was pushed forward electro-hydraulically.

The F-104A was intended to replace the F-100 Super Sabre from 1956, but by this date the USAF's requirements had changed, and the aircraft's marginal range and insufficient offensive capabilities meant that the F-104A was not get an option for the Tactical Air Command (TAC). Such drawbacks would have spelled the end for the F-104, had deliveries of the F-106 Delta Dart for the Air Defence Command (ADC) had proceeded as planned. But because of its superb climb performance the ADC accepted the F-104 as a stopgap solution despite its limited range and lack of all-weather-capability.

However, no sooner had the aircraft been put into service when in February 1958 all F-104s were grounded due to increasing problems with the new J79 engine, and it was only after further modifications and a change to new J79-GE-3B engines that they were allowed to fly again.

Further problems arose with the T-161 cannon, and the weapon was subsequently removed from newbuilt aircraft. It was only in 1964, when the much-modified and improved M61A1 became available, and the F-104 received the armament originally intended for it got.

On-going problems linked to the high T-tail continued to afflict the downward-firing Lockheed C-1 ejection seat – a rescue device completely inadequate (for obvious reasons) for emergency situations during take-off and landing as well as for low-altitude bail-outs – and the aircraft were gradually converted to the upward-firing C-2 seat.



F-104A equipped with two AIM-9



F-104A showing its deployed speed brakes

The reliable 'original' Gatling (l.) and its at first unreliable 'grandson' T-161



F-104A in formation over San Francisco, CA



The ADC's F-104A with pylon fuel tanks



The TAC aircraft: the F-104C

The F-104C was the fighter bomber version for the TAC, who hoped thereby to fill the middle ground between the F-100C and the F-105.



A three-ship-formation F-104C

Initially Lockheed was awarded a contract on 2 March 1956 for the procurement of 56 F-104 Cs. Production of 363 aircraft was planned, but only 77 were eventually delivered. On 24 July 1958 the first F-104 C took off, with a GE J79-GE-7 engine giving around 470 kp more thrust than the older F-104A engine.

The F-104C (and its trainer derivation F-104D) were also equipped with a removable air-to-air refuelling probe. The F-104C was optimally configured as a carrier system for a tactical nuclear weapon, but it also offered a conventional weapon option.

On 12 December 1959 a F-104C piloted by Captain Joe B. Jordan increased the world altitude record to 31,513 m; this was also the first time that an aircraft that took off under its own power climbed beyond the significant 100,000 ft limit – the border with space.

From April 1965 an F-104C squadron was based in DaNang, South Vietnam. Their duty was to escort fighter bombers and protect them from North Vietnamese fighters (MiG Combat Air Patrol). As the F-104C's range was still only marginal, it was hardly adequate for this role. In fact, the North Vietnamese made use of this deficiency by simply waiting until the F-104s were obliged to turn back and then scrambling their fighters. The F-104C was replaced in Vietnam by the far this type of mission more efficient F-4 Phantom II in July 1967.

Soon afterwards the TAC phased out its F-104C and handed them over to different Air National Guards (ANG). The last of these aircraft were flown by the Puerto Rico ANG until July 1975, then replaced by the LTV A-7D.



Handing-over the first F-104C to the TAC



F-104C 'wingtip-to-wingtip'



A rare event: air-to-air refuelling of a F-104C



F-104C departing for Vietnam



The first trainers: the F-104B and D



The first double-seated Starfighter: the prototype F-104B

Based on the F-104A, the first of a long series of trainers was built: the F-104B.

The trainer aircraft were originally intended to provide the same levels of performance as the single-seater. But the cannon armament was removed to make room for the second cockpit, leaving only the wingtip Sidewinder Air-to-Air missiles. Additionally the internal fuel capacity had to be reduced from 3.396 l to 2.847 l, the nosewheel was again retracted backwards and the fin enlarged for greater stability.

First orders were for 106 aircraft and the maiden flight took place on 16 January 1957. Only 26 aircraft, however, were delivered, the last in November 1958.

The combat-capable F-104D trainer was similarly developed from the F-104C.

This aircraft differed from the F-104B principally in the external cockpit design of two left-hinged canopies with a central solid frame. The F-104D's performance was almost identical with that of the F-104C, but with a reduced fuel capacity again due to the need to make space for the second cockpit.

The F-104D was the last Starfighter model for the USAF. Only 21 F-104Ds were delivered, between November 1958 and August 1959; orders for a further 83 aircraft were cancelled when the USAF halted the procurement of all F-104-type aircraft.

In 1969 Jordan was given 32 overhauled F-104A and B aircraft from USAF stock, 10 of which were then lent to Pakistan in 1971-72 and replaced by more modern versions in 1979.

USAF sources also supplied Pakistan with 12 F-104A and B aircraft, which saw action in the 1965 and 1971 wars between India and Pakistan. Pakistan's F-104s were phased out in 1972; some are still on show in museums.



The second F-104B series aircraft



F-104D in a museum



Royal Jordanian Air Force's F-104A



Pakistan Air Force's F-104A

A multi-role combat aircraft for the German Federal Republic



Convair F-102 Delta Dagger

The Starfighter had never been the USAF's first choice: its limited range, endurance capability and payload capacity, together with its lack of all-weather capability, led to the aircraft being phased out fairly quickly and a replacement for the F-104 promptly

sought. Surplus aircraft were given to the ANGs or to the Taiwanese, Jordanian and Pakistani forces. Of an original order for 722 F-104s, all but 296 were cancelled. At the end of the 1950s the military career of the Starfighter looked as though it would be a very short one. In a seemingly miraculous reversal of fortune, however, the F-104 became the focus of a giant European manufacturing programme.

In the mid-1950s NATO forces in Europe (excluding the UK and France) were looking for a multi-role combat aircraft with supersonic capability as a carrier system for an American tactical nuclear weapon. The Bundesluftwaffe had from its outset been seeking a replacement for its F-86 Sabre and F-84 Thunderstreak aircraft (effectively obsolete even at the time they entered service), and the German Navy a replacement for its Hawker Seahawk Mk 100. The objective was for all these different types to be replaced by a single, multi-role type.

On the assumption that other NATO countries would follow Germany's choice, numerous aircraft manufacturers from the UK, France, Sweden and the USA were interested in the order, and a range of offers made: English Electric's Lightning, Saunders-Roe's SR 177, Dassault's Mirage III, Sud-Aviation's SO.9050 Trident III, SAAB's J-35 Draken, Convair's F-102 Delta Dagger and F-106 Delta Dart, Republic's F-105 Thunderchief, Vought's F-8U Crusader, Grumman's F-11F-1F Super Tiger and Lockheed's F-104 Starfighter.



Convair F-106 Delta Dart



LTV F-8 Crusader



English Electric Lightning



SAAB J35 Draken



Dassault Mirage III

The F-104G makes its debut



F-104G over Bavaria



Early cockpit layout of the F-104G

The Lockheed proposal was dubbed F-104G (G for Germany). It had all-weather capability, strengthened fuselage, empennage and wings, and an increased payload capacity of 4,000 lbs. The aircraft was adapted to the requirements of low-level missions, with a new multi-role radar and a greater internal fuel capacity. The original daylight-only air-superiority fighter had been transformed into an all-weather multi-role combat aircraft.

On 24 October 1958 the German Federal Republic decided on the F-104G, and on 6 November the Minister of Defence at the time, Franz-Josef Strauß, officially declared the F-104G the winner of the competition.

At that time the completely new version of the F-104 existed only on the drawing board. This, together with the aircraft's poor track record in terms of accidents and the USAF's well-known aversion to the Starfighter, generated substantial political controversy and long-drawn-out wranglings which finally culminated in accusations of corruption at an international level.

On 18 March 1959 a consortium of German aviation companies came to a licensing agreement to produce 210 F-104Gs; technology transfer was one of the key points of the programme.

Canada was the second NATO nation to decide to procure the F-104, followed by, the Netherlands, Belgium, Italy and finally Norway.

For training purposes the combat-capable two-seater TF-104G was developed in 1962. As well as its predecessor trainers, this aircraft did not have the cannon armament either. Simultaneously with the F-104G the Luftwaffe decided on the procurement of the reconnaissance version RF-104G, which was put into service from 1963.



Messerschmitt test pilot Jim Jester 'introduces' Franz-Josef Strauß to the F-104G



The famous record-breaking 'aviator' Jacqueline Cochran and Lockheed's TF-104G company demonstrator Free World Defender



From l. to r. Professor Willy Messerschmitt, Director Hubert Bauer and Mr Lux, Lockheed representative for Germany, in the USA inspecting an RF-104G-1 in 1967

TF-104G of WTD 61 during trials with an aerial target system



An intermediate solution: the F-104F

As an interim solution pending the availability of the F-104G, the German Federal Republic procured 30 F-104F trainers for instruction purposes. Basically, this version was a slightly modified F-104D without the strengthened airframe of the G version, and without the cannon armament or fire-control system.

In October 1959 the first F-104F was handed over to the German Air Force in Palmdale to serve as an instructional airframe for a crew of Luftwaffe technicians for about 10 weeks. In February 1960 a team of six pilots, known as the 'Arbeitsstab F-104', led by Lieutenant-Colonel Günter Rall, arrived in the USA, and the training commenced in March of that year.

After this transition phase these aircraft were put into service as the first German Starfighters at the Waffenschule (weapon school) 10 in Nörvenich near Cologne. After arrival in containers, the final assembly was undertaken under the supervision of Lockheed personnel, and on 23 July 1960 Lieutenant-Colonel Rall became the first German pilot to fly a Starfighter in Germany.

The F-104Fs were phased out by 1971, as sufficient numbers of trainers such as the TF-104G or T-38 Talon became available. It had been the intention to put new engines and Martin-Baker ejection seats into the remaining F-104Fs, as they reached the end of their service life, but due to the relatively rapid phasing out only test aircraft were finally converted. Although only very few aircraft of this type were procured, several F-104Fs are today preserved in various German Air Force bases and museums .

As the F-104F never carried mission equipment, the aircraft was very light and, from a pilot's point of view, possibly the most impressive of the Starfighter production series.



Three-ship-formation F-104F



Lockheed test pilot Bill Weaver (l.) and OLT Bernd Kuebart during conversion training with the F-104F



The 'Arbeitsstab F-104' in Palmdale (1960), from left to right: OLT von Stürmer, OLT Schultz, OLT Kuebart, OLT Rall, OLT Klemm, Hptm. Flade



Engine change

F-104F in Nörvenich



Production of the F-104G in Europe

After the official announcement, on 6 February 1959, of the German decision to procure the F-104G the pressure mounted for Lockheed.

To speed up development of the G model, Lockheed borrowed two F-104As from the USAF for conversion to F-104Gs, and started work on them on 24 March 1959. The first of these modified aircraft took off for the first time on 6 December 1959 and the second on 7 June 1960. Tests were completed on 31 July 1961.

After the beginning of production in the USA, Europe undertook a huge licence programme for the manufacture of more than 1,000 aircraft on order, involving over 100,000 people, 25 manufacturing plants, three engine plants and 36 electronics companies.

Five working groups (known as ARGEs, from ARbeitsGEmeinschaften) were established to produce the complete system. (Over the course of the programme various mergers took place, and company names frequently changed.)

ARGE-USA (Lockheed, Temco, Beech Aircraft, Rheem and Monrovia), with first flight on 5 October 1960 (equivalent to the first flight of a series-production F-104G)
ARGE-Nord (Avio Diepen, Aviolanda, Fokker, N.V. 't Hart, N.V. Breda, Focke-Wulf, HFB and Weserflug), with first flight on 11 November 1961
ARGE-Süd (Dornier, Heinkel, Messerschmitt and SIAT-WMD), with first flight on 5 October 1961
ARGE-West (Avions Fairey, Aerfer, Fiat, Heinkel, SIAT-WMD and SABCA), with first flight on 3 August 1961
ARGE-Italien (Aerfer, Avions Fairey, SACA, Macchi, Piaggio, Aeronavali, SIAI and FIAT), with first flight on 21 May 1964

The complete aircraft was divided into several interchangeable segments, so as to pre-empt any possible production failure by being able to provide segments from other working groups.

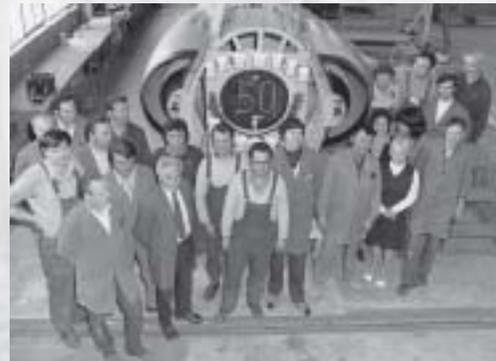
This highly complicated procedure was co-ordinated by the NATO Starfighter Management Office (NASMO), and was the first application in Europe of the US-developed complete system approach to aircraft production.

Between 1961 and 1972 the five working groups produced a total of 1,127 F-104Gs, 220 TF-104Gs and 189 RF-104Gs.

The production programme proved highly successful throughout its entire duration. Not only were delivery dates adhered to almost to the month, but costs even remained within the 1959 estimations. In 1962, monthly production was 12–13 F-104Gs with a fly-away price of around DM 6 million.



One of the very first, Lockheed manufactured F-104G



The 50th centre fuselage section at Dornier in Neuaußing near Munich



Fuselage assembly at Messerschmitt in Augsburg



Final assembly in Manching near Ingolstadt



Test flying in Manching

The Starfighter in Germany

The German Federal Republic's armed forces were by far the biggest user of the F-104 with 916 delivered aircraft. Overall more than 2,000 German Air Force and Navy pilots received their training on this type.

A total of 917 aircraft were manufactured for Germany:

- 30 F-104F
- 137 TF-104G
- 749 RF/F-104G

Introducing such a complex weapon system not unnaturally resulted in problems, last not least in a seemingly disproportionately high loss rate. However, a glance at the figures reveals that in 30 years almost 2 million flight hours were flown (1,975,646 hours to be exact): 298 aircraft met with accidents and had to be written off tragically 116 pilots died. This resulted in one complete write-off for every 6,630 flight hours – a relatively modest figure compared in international terms with other jet-propelled combat aircraft of the time.



JaboG 31 Boelcke



JaboG 32



JaboG 33



JaboG 34



JaboG 36



JG 71 Richtbofen



JG 74



AG 51 Immelmann



AG 52



ErpSt/WTD 61



MFG 2 (26+63), LVR 1 (20+37), Lw-Schleuse (20+49)



MFG 1



MFG 2



WaSLw 10

The Bundeswehr F-104 squadrons



The following units operated the 104:

JaboG 31 ('Boelcke'), Nörvenich
February 1962–March 1983, 211,412 h



JaboG 32, Lechfeld
January 1965–April 1984, 204,986 h

JaboG 33, Büchel
August 1962–May 1985, 231,900 h

JaboG 34, Memmingen
July 1964–October 1987, 242.785 h



JaboG 36, Rheine-Hopsten
February 1965–January 1975, 82,722 h

JG 71 ('Richthofen'), Wittmund
April 1963–September 1974, 83,182 h



JG 74 ('Mölders'), Neuburg/Donau
May 1964–July 1974, 81,840 h



AG 51 ('Immelmann'), Manching/Bremgarten
November 1963–April 1971, 61,390 h



AG 52, Leck
November 1964–September 1971, 56,571 h

MFG 1, Schleswig-Jagel
September 1963–October 1981, 131,915 h



MFG 2, Eggebek
March 1965–September 1986, 173,070 h

WaSLw 10, Nörvenich/Jever
May 1960–September 1983, 123,728 h

ErpSt/WTD 61, Manching
February 1962–May 1991, 10,500 h

LVR 1, Erding
May 1984–September 1988, 9,895 h



2. DTLwAusbSt., Luke AFB
February 1964–March 1983, 269,750 h

F-104 special liveries

1



12



11

2



10



9

3



8



4

- 1 *JaboG 34, 1987*
- 2 *4° Stormo, Grosseto, 1989*
- 3 *JaboG 34, 1984*
- 4 *WTD 61, 1991, Last Flight F-104G*
- 5 *JaboG 32, 1984*
- 6 *MFG 2, 1986, Vikings*
- 7 *JaboG 31 Boelcke, 1983*
- 8 *2. DiLuAusbSt., Luke AFB, Arizona*
- 9 *LVR 1, 1986*
- 10 *3° Stormo, Verona/Villafranca, 1991*
- 11 *LVR 1, 1988*
- 12 *JaboG 33, 1985*

5



6



7



The Starfighter in NATO (I)



A Royal Canadian Air Force Tiger (CF-104)



A Belgische Luchtmacht (Blu) F-104G

After Germany, Canada was one of the countries to most use the Starfighter. Canadair manufactured a total of 200 CF-104 for the Canadian Armed Forces as well as a further 140 F-104Gs for NATO's Military Aid Program (MAP). In addition components for another 66 F-104Gs were delivered, to Lockheed and final-assembled there for the German Air Force. 38 CF-104D-type trainers were bought directly from Lockheed. Powered by a J79-OE-7 built by Orenda Engines Ltd, most of the Canadian-operated F-104s were utilised in Europe from 1962. In 1983 they began to be replaced by the CF-18, with the last CF-104 phased out on 1 March 1986. Some of the remaining aircraft were transferred to Denmark, Norway and Turkey.



A Danish twin-seater (Kongelige Danske Flyvevåbnet)

Belgium started to use the F-104G in 1963. SABCA built 100 single-seaters for the Belgian Air Force and Lockheed supplied a further 12 TF-104G trainers. In the early 1980s the Belgian F-104 was replaced by the General Dynamics (today Lockheed Martin) F-16A/B.



A Royal Hellenic Air Force (Elliniki Vassiliki Aeroporia) TF-104G

From 1962, the Dutch Air Force took possession of a total of 120 RF/F-104G plus 18 TF-104G trainers. At the end of 1984 the remaining Dutch F-104s were phased out; these, too, were replaced by the F-16A/B.



A Royal Norwegian Air Force (Kongelige Norske Luftforsvaret) F-104G

In 1963 the Norwegian Air Force received their first 19 F-104Gs together with two TF-104Gs (two more TF-104Gs were added later), and in 1973 18 CF-104s and four CF-104Ds. In 1982-83 the last F-104s in Norway were phased out and handed over to Turkey. Norway, like Belgium and the Netherlands, also procured the F-16 A/B as a replacement.

In November 1964 Denmark received 25 F-104Gs and four TF-104Gs; this was followed in 1972-73 by 15 CF-104s and seven CF-104Ds from Canadian sources. Active service for the F-104 in Denmark ended on 30 April 1986 when again, it was replaced by the F-16A/B.



A Flying Dutchman: a Royal Netherlands Air Force (Koninklijke Luchtmacht) F-104G

Greece received 45 F-104Gs and six TF-104Gs from 1964 onwards. As the F-104 was gradually phased out from German Air Force utilisation during the 1980s the Greek Air Force received increasing numbers of F/RF-104Gs and TF-104Gs. The F-104 continued to be deployed on active service in Greece until the 1990s.

The Starfighter in NATO (II)



In May 1963, Turkey, as a partner in the MAP, received the first of 32 F-104Gs and

four TF-104G aircraft, and in 1974 procured 40 new F-104Ss from Italy. From 1980–81 a substantial number of F-104G, TF-104G and CF-104 aircraft were handed over to the Turkish Air Force as they were phased out by other NATO states: a total of more than 400 F-104s delivered made Turkey the biggest user of this type of aircraft after the German Federal Republic. Active service of the F-104 in Turkey ended (Germany) in 1996 when the last aircraft were replaced by F-16C/Ds.

Spain received 18 F-104Gs and three TF-104G trainers in 1965. (In 1972 the Spanish F-104 were replaced by the F-4C Phantom II.) All 21 aircraft were given back to the USA and later forwarded to Greece and Turkey. Spain was the only F-104 operator to experience no loss of aircraft.

In 1963 Italy received 125 RF/F-104Gs and 28 TF-104Gs, and from 1969 the Italian Air Force introduced 165 FIAT-built F-104S (S for Sparrow), by far the most efficient of all the F-104 versions. This type was based on the F-104G, with the addition of enhanced versions of the J79-GE19 engine and avionics modules. There was no on-board cannon (owing to the need to make space for the electronics suite of the radar-guided AIM-7 Sparrow), but this version had two additional keel fins for greater longitudinal stability, and the number of its external store stations was increased to nine. This aircraft with its numerous combat readiness enhancements will continue in service in Italy, along with the few remaining TF-104GM trainers, and may even be around to join in the celebrations for the half centenary of the F-104 in 2004.



An Aeronautica Militare Italiana (Italian Air Force) F-104G, with F-86 Sabre parked behind the background



A Turkish F-104 undergoing its pre-take-off checks



A Türk Hava Kuvvetleri (Turkish Air Force) TF-104G



A Spanish four-ship formation



F-104S with its nine external store stations



F-104 series production at Fiat

The F-104 in the Far East



A target drone QF-104J

Like the Germany, Japan was looking for a new interceptor aircraft in the late 1950s, and in November 1959 the F-104 was selected as the new fighter.

A working group consisting of Mitsubishi and Kawasaki was responsible for the licence production of the aircraft, now dubbed the F-104J. Ishikawajima-Harima built the slightly modified J79-IHI-11A.

The first F-104J, still built by Lockheed, made its maiden flight on 30 June 1961. This version was already equipped with the strengthened structure of the F-104G, but was only used in the fighter role. Lockheed entirely produced a further three aircraft and delivered parts for another 29 aircraft to Japan. Japanese industry delivered another 178 F-104Js. Of 20 F-104DJ trainers ordered, one was delivered by Lockheed, the rest delivered in kit form with final assembly effected in Japan.

Phasing out went on until 1986 when the Starfighter was replaced by the F-15 Eagle. The greater part of the Japanese F-104 fleet was moth-balled, although some of the aircraft have been converted to drones.

After Japan, the Republic of China was the biggest user of the F-104 in the Far East. As early as 1960 under the US Military Aid Program ruling Taiwan received 25 F-104As and two F-104Bs.

Over the years this fleet was enhanced by the delivery of eight RF-104Gs and a number TF-104Gs and 42 F-104Gs, mainly from the Deutschen Luftwaffenausbildungs-Kommando stock in Luke AFB, Phoenix (AZ), after the closure of the OCU on 16 March 1983.

Altogether Taiwan put 244 aircraft of this type into service, with the last ones phased out in 1998.



F-104J at touch-down. The braking chute is just being extracted



Two Japanese Air Self-Defence Force (Nihon Koku Jieitai) F-104J at take-off



A Japanese Air Self-Defence Force (Nihon Koku Jieitai) F-104J



A Republic of China Air Force of Taiwan TF-104G



TF-104G in Taiwan

Extraordinary ideas: SATS and ZELL



In an attempt to reduce reliance on long runways, two projects were undertaken from 1959 on.

SATS (Short Airfield for Tactical Support) was developed in close co-operation with the US Marine Corps. SATS was a test

programme for catapult and hook assisted take-off and landing on short runways, along the lines of aircraft carrier operations. In 1964–65 three German F-104Gs were modified – the undercarriage strengthened and two catapult hooks installed. Testing took place at the Naval Air Test Facility in Lakehurst (USA). The test programme included several hundred successful take-offs and landings, and although the program was cancelled, it resulted in the installation of jet-arresting gear on German jet air bases.



The other development programme, a co-operative effort with Lockheed, was called ZELL (Zero Length Launch), and was aimed at enabling the F-104G to take off without the need for any runway. Lockheed developed this programme to series production standard from 1963, and several manned take-offs were effected at

Edwards AFB and Lechfeld from 1966.

The F-104G was mounted AFB in the launch cradle at an angle of about 20 degrees. A jettisonable rocket motor was installed under the aircraft. At take-off the jet engine operated at full power in afterburner mode, then the rocket motor was fired which added a further 30,000 kp thrust. This enormous power was more than sufficient for a rocket-like take-off. In under eight seconds, the aircraft accelerated ballistically to 270 knots (ca. 500 km/h). After burn-out, the rocket motor was jettisoned and the aircraft continued its normal flight.

Five successful ZELL take-offs were made by Lockheed test pilot Ed Brown, two by the German test pilot Horst Philipp. Philipp's aircraft was already equipped with the new rocket-assisted Martin Baker GQ7 ejection seat, whereas the Lockheed-built C-2 seat was not acceptable as a rescue system, especially during take-off and landing as it had no O/O capability; the ZELL programme was instrumental in pushing through the conversion of all German F-104Gs from the C-2 seat to the much more appropriate Martin Baker seat.

Both the SATS and ZELL programmes were cancelled due to the change in the Flexible Response NATO strategy.



Ready for a catapult-assisted take-off



SATS-take-off



Preparation of a ZELL launch



Ed Brown (l.) and Horst Philipp (r.), the ZELL test pilots



From 0 to 500 km/h in 8 seconds!



Congratulations! First ZELL launch of Horst Philipp on 5 July, 1966

The sky's the limit: the NF-104A



The fascination with space that prevailed in the 1960s extended to the Starfighter, which seemed to be an ideal instrument for astronaut training.

In 1963, three F-104As which had been put into cold storage were converted to 'astronaut trainers'. military equipment was removed, the span extended and the D-version enlarged fin installed. Additionally

a couple of small hydrogen superoxide-powered rocket engines were put in at the nose, the empennage and the wingtips to facilitate aircraft handling when the aerodynamic control surfaces ceased to function at high altitude. A Rocketdyne AR-2 liquid fuel (a mixture of hydrogen peroxide and kerosene) rocket engine was also installed above the normal jet engine. This modified aircraft was named NF-104A.

After take-off and ascent to 18,000 m, the pilot fired the rocket engine. It only operated for ten seconds, but the thrust produced was enough to catapult the aircraft to 25,000m. The J79 engine then shut down and the aircraft was projected ballistically to an altitude of around 36,000 m. For a short period the pilot experienced near zero-gravity conditions.

The aircraft were used by the Aerospace Research Pilot School at Edwards AFB, at that time under the command of the already legendary Charles 'Chuck' Yeager.

On 6 December 1963 the NF-104A gave the USA an unofficial world altitude record of 36,229 m – at that time the record was held by a Soviet MiG Ye-66A, an experimental version of the Mig-21. Shortly afterwards, Major R.W. Smith took the same NF-104A to 36,901 m.

On 10 December 1963 Chuck Yeager, flying the second NF-104A, lost control of the aircraft at an altitude of around 31,800 m, when the aircraft pitched up at an AOA of 28 degrees. The small control thrusters were insufficient and the aircraft went into a flat spin. After 13 rotations at an altitude of only 3,400 m, Yeager bailed out using the ejection seat – and after the fourteenth spin the aircraft hit the ground and exploded.



Charles 'Chuck' Yeager (r.) and Herman 'Fish' Salmon (l.)



Charles 'Chuck' Yeager in his space suit



The NF-104A rocket booster

NF-104A



The General Electric J79 engine



Test run of a J79

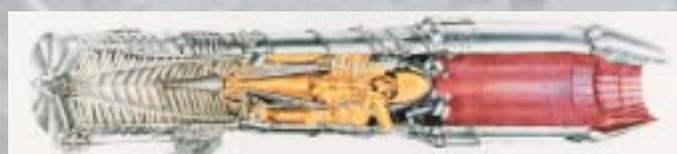
The improved J79-MTU-1K



A J79 ready to install



Manufacturing of the J79 at MTU in Munich



A cutaway-drawing of the J79

In 1952 at General Electric, Gerhard Neumann, a German-born naturalised US-citizen, began development of the J79, which became one of the most successful military jet engines. The J79 was the first US single-shaft high-pressure axial flow turbo jet, with adjustable guide vanes, a 17-stage compressor, a three-stage turbine and 10 can-type burners.

A particular feature of the engine was the quick reaction to power input from the pilot. The variable nozzle allowed a maximum thrust increase rate within the engine's temperature limits: f. e. around four seconds after initiating a go-around the engine could again provide maximum power.

In excess of 17,000 J79 engines were produced over a period of more than 30 years.

Following the F-104, the first aircraft to fly a J79, many other military aircraft were equipped with the engine. Examples include:

- F-4 Phantom II
- A-5 Vigilante
- B-58 Hustler

A civil version without afterburner, the CJ805, was produced, and used in the four-engined Convair 880 and Convair 990 air lines.

Three European companies were involved in licence production and delivery of the GE J79-11A engine for the European F-104 production:

- BMW-Triebwerksbau GmbH in München-Allach, Germany (now MTU Aeroengines)
- Fabrique Nationale d'Armes de Guerre (FN) in Herstal, Belgium
- FIAT Societa per Azioni in Turin, Italy

Each company was responsible for around a third of the engine's make-up, following the single-source principle, and each had their own final assembly line together with engine test stands. The first 144 engines were delivered in kit form from the USA.

BMW delivered the first engine with its own segments on 30 January 1962. In total around 1,228 engines were produced, with the breakdown between three companies as follows:

BMW:	632 engines (22 engines per month)
FN:	334 engines
FIAT:	262 engines

MTU Munich (today MTU Aeroengines), the result of a merger between BMW-Triebwerksbau and MAN-Turbomotoren, additionally supplied 50 improved J79-MTU-1K as well as around 1,000 conversion kits for the J79-11A.

Projects and technology testbeds based on the F-104

From 1960, the F-104G was used in Germany as a platform for various development studies, many of which were considered, even then, as highly daring and 'futuristic'. None of the resulting proposals was ever actually built.

Among the projects under discussion was a V/STOL F-104G with additional lift engines in the fuselage or in wingtip gondolas. A STOL-F-104G with swivelling lift/cruise-engines was also considered.

From 1963 ideas such as lengthening the fuselage and enlarging the tip-tanks to increase the range were bandied about. More bizarre was a proposition to tow external fuel tanks or even to procure additional direct-from-the-ground fuel tanks during the flight. But possibly the strangest concept was a proposed two-fuselage F-104G as an escort fighter for long-range maritime patrol missions.

1964 saw the beginning of conversion studies for double-seaters, and 1965 a high-altitude reconnaissance F-104G with ramjets.

Lockheed itself looked at a great many projects. The result was the development of a completely new 'European' fighter aircraft, the CL-2000 Lancer, two prototypes of which were built. The aircraft had the same basic structure as the F-104 but with a conventional tail assembly and a high wing monoplane. Its new Pratt & Whitney turbofan powered the aircraft with around 60% more maximum thrust than the J79. Payload capacity was more than double that of the F-104G and take-off distance was halved. The aircraft did not enter series production, however.

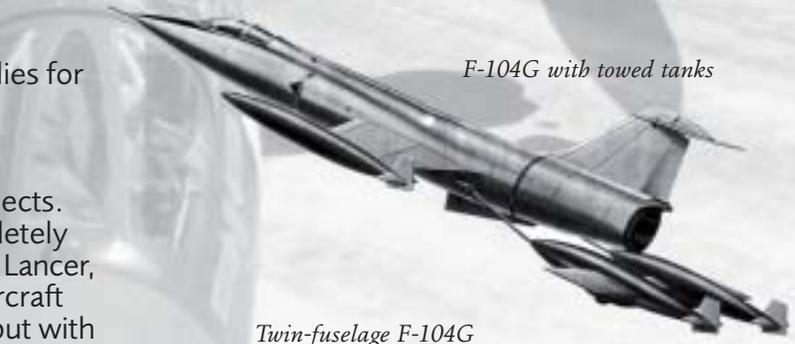
Between 1976 and 1984 the German government asked MBB to undertake trials and flight tests for CCV (Controlled Configured Vehicle) technology evaluation with a much-modified F-104 G. As well as incorporation of a fly-by-wire system, the most obvious changes consisted of several jettisonable weights and a second stabiliser behind the cockpit. An aerodynamically stable aircraft was transformed into an aerodynamically unstable computer-controlled aircraft. The programme was very successful and contributed a huge amount of data towards the development of totally new flight control systems for military and civil aviation.



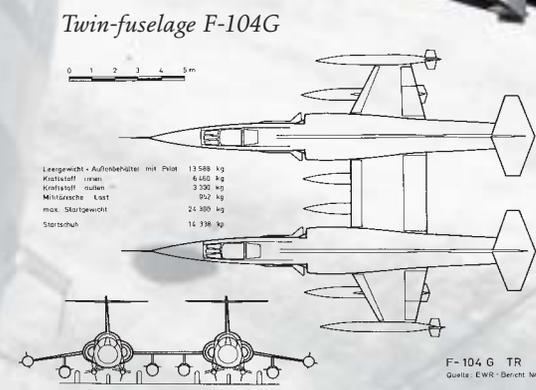
F-104G STOL



High-Altitude Reconnaissance Aircraft with ramjets



F-104G with towed tanks



Lockheed CL-1200 Lancer



F-104 CCV

Technical data

Versions	XF-104	F-104A	F-104B	F-104C	F-104D	F-104F	F-104G
Wingspan in m:	6,55	6,69	6,69	6,69	6,69	6,69	6,69
Length overall in m:	14,99	16,69	16,69	16,69	16,69	16,69	16,69
Height in m:	3,87	4,11	4,11	4,11	4,11	4,11	4,11
Basic mass empty in t:	5,220	5,698	5,836	5,682	5,930	5,927	6,166
Maximum take-off in t:	7,120	11,151	10,675	12,491	11,062	11,057	12,964
Service ceiling in m:	15.400	17.600	17.150	18.000	17.500	17.500	18.300
Maximum speed in Mach:	1,64	2,0	2,0	2,2	2,0	2,0	2,2
Maximum range with external tanks in km:	1.480	2.676	2.021	3.043	2.572	2.572	3.017
Power plant:	J65-B-3	J79-GE-3B	J79-GE-3B	J79-GE-7	J79-GE-7	J79-GE-7	J79-MTU-1K
Maximum reheat thrust in kN:	45,4	65,8	65,8	70,3	70,3	70,3	70,9
in kp:	4.627	6.713	6.713	7.167	7.167	7.167	7.235

Versions	TF-104G	CF-104	CF-104D	F-104J	F-104DJ	F-104S	NF-104A
Wingspan in m:	6,69	6,69	6,69	6,69	6,69	6,69	7,87
Length overall in m:	16,69	16,69	16,69	16,69	16,69	16,69	19,01
Height in m:	4,11	4,11	4,11	4,11	4,11	4,11	4,11
Basic mass empty in t:	6,445	6,334	6,350	6,079	5,987	6,610	6,340
Maximum take-off in t:	11,480	13,092	12,345	12,415	11,168	14,060	10,025
Service ceiling in m:	18.150	18.300	18.150	18.000	17.400	> 18.300	36.320
Maximum speed in Mach:	2,0	2,0	2,0	2,2	2,0	2,2	2,2
Maximum range with external tanks in km:	2.411	3.017	2.411	3.043	2.430	2.943	-
Power plant:	J79-MTU-1K	J79-OEL-7	J79-OEL-7	J79-IHI-11A	J79-IHI-11A	J79-GE-19	J79-GE-3B
Maximum reheat thrust in kN:	70,9	70,3	70,3	70,3	70,3	79,3	65,8
in kp:	7.235	7.167	7.167	7.167	7.167	8.119	6.713



Production figures for the different F-104-versions:

XF-104	2
YF-104A	17
F-104A	153
F-104B	26
F-104C	77
F-104D	21
F-104F	30
F-104G	1.127*



RF-104G	189
TF-104G	220
CF-104	200
CF-104D	38
F-104J	210
F-104DJ	20
F-104S	246
F-104N	3
Gesamt	2.579

F-104 production and deliveries:

Total	Deliveries to	Lockheed/ ARGE/ USA	Canada	ARGE Süd	ARGE Nord	ARGE West	ARGE Italien/ Italien	Japan
299	USAF	299						
250	USAF/ MAP	110	140					
238	Canada	38	200					
230	Japan	23						207
917*	Germany	263		260	255	89*	50	
138	Neder-land	14			99		25	
112	Belgium	3				109		
395**	Italy	25					370**	
2.579		765	340	260	354	198	445	207

* One F-104G crashed at SABCA (Belgium) prior to its delivery to the German Air Force

** including 40 F-104S for Turkey



The Starfighter myth: A fine line between rejection and acclaim

Even today, almost 50 years after its maiden flight, most people in Germany have heard of the F-104. Elegance and breath-taking speed coupled with phenomenal performance made it the 'pilot's aircraft' of all time.

Other models, albeit more powerful or more modern, have fallen into oblivion, but the F-104 has not – and this in spite of, or perhaps even because of, the many negative press reports about it, generated by its interestingly dramatic context of a presumed above-average crash-rate and the political background surrounding it in Germany at that time.

It is a fact that, in terms of number of crashes per flight hour, the F-104 was not less safe than other NATO jet fighters of its generation and its loss rate was not disproportionately high with other operators. But it goes without saying that any crash is one too many and we remember and salute the pilots and their families.

It is also true that the individual air forces of that period were not fully prepared from the outset for the operation and maintenance of such a complex weapon system. All the partners in the process went through a painful but necessary and ultimately fruitful learning curve.

In the F-104 the German Air Force and Navy had a multi-role combat aircraft which saw service for almost 30 years. Important, too, was the impact of the licence manufacturing programme for the German aerospace industry in particular and for the German economy as a whole as the country made its way back to internationally acceptable standards in technology.

The three German V/STOL-projects, the VJ 101C, Do 31E and VAK191B, are at least partially based on the project and systems management capabilities learned during the F-104 programme.

It can indeed be said that the F-104 paved the way for extremely successful programmes such as the Tornado in the military arena or the Airbus for civil aviation.



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