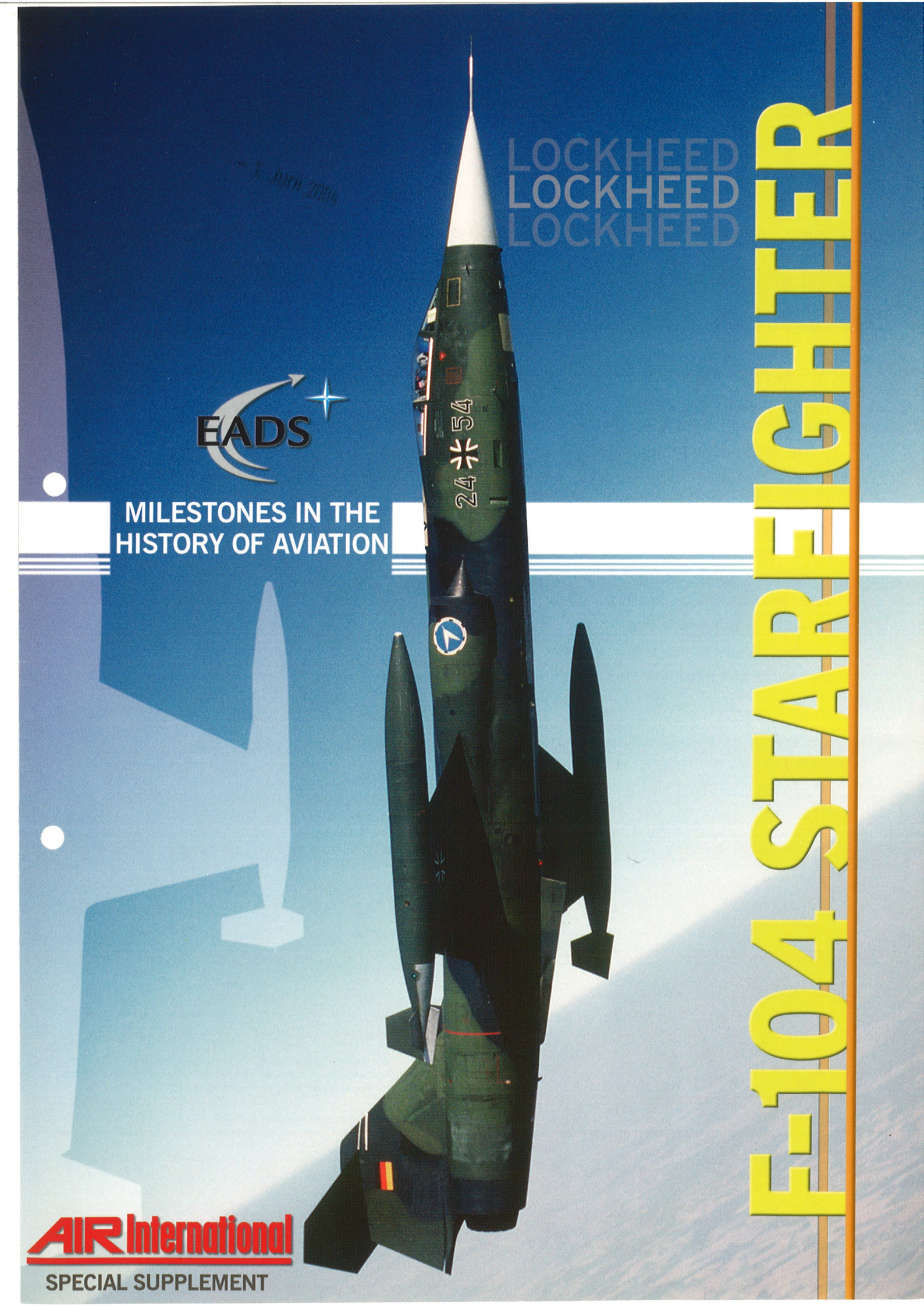
LOCKHEED
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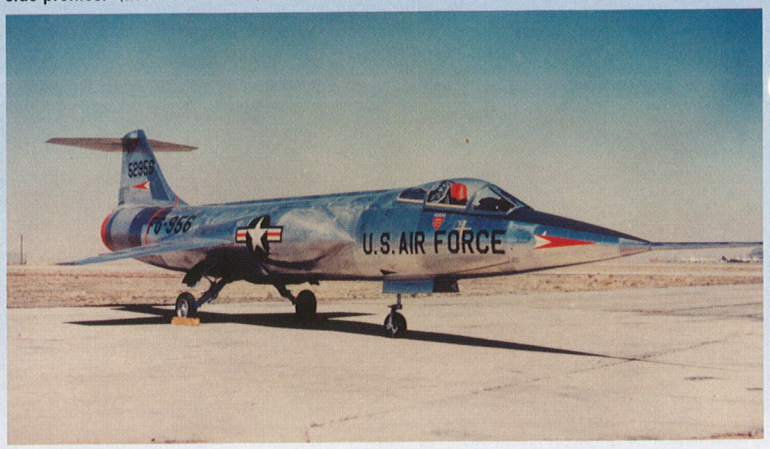
HISTORY OF AVIATION
F-104 STARFIGHTER
AIR International
SPECIAL SUPPLEMENT

F-104 STARFIGHTER

In this Special *AIR International* Supplement Malcolm English pays tribute to one of the most remarkable military aircraft to enter service – the Lockheed F-104 Starfighter – and in particular to the important role it played, both in the future of the German aerospace industry and in service with the German air arms, the *Luftwaffe* and *Marineflieger*.

Above: **This view of the first two XF-104A prototypes, 53-7786 'FG-786' (lower) and 53-7787 'FG-787' (top), with and without wing-tip fuel tanks, clearly illustrates the Starfighter's plan and side profiles.** (Lockheed Martin)



Above: **Such was the security surrounding the Starfighter programme that the air intake shock cones were hidden from view in this, the first publicly-released photograph of YF-104 55-2956 'FG-956', the second of 17 pre-production YF-104s.** (Lockheed Martin)

Background Picture: **An F-104A at altitude.** (Lockheed Martin)

CONCEIVED in response to a plea for a fast, high-altitude fighter by USAF pilots fighting in Korea, the Lockheed F-104 Starfighter became one of the most widely-built military aircraft in history. When production of the Starfighter ended in 1979, no fewer than 2,578 aircraft had been built by manufacturers in seven countries – including Germany, where the large-scale F-104G manufacturing programme restored the German aerospace industry to international standard and created thousands of jobs. This restructuring of the industry eventually resulted in Germany playing pivotal roles in a number of highly successful European programmes, such as the Panavia Tornado and the Eurofighter Typhoon.

Initially designed as a lightweight, simple interceptor, the Starfighter underwent a metamorphosis and also achieved recognition as a low-level attack and nuclear strike aircraft. It is testament to the genius of its designer, Clarence L 'Kelly' Johnson, that 50 years after making its maiden flight, the Starfighter is still in operational front-line service with the Italian Air Force.

As a result of air combat experience in Korea, fighter designers were asked for more speed and height. Even the latest fighter in service at that time with the USAF, the North American F-86 Sabre, lacked a sufficient performance margin over the North Korean's Soviet-built Mikoyan-Gurevich MiG-15 to give a worthwhile advantage.

Although no official request to develop such an aircraft had been made, in November 1952, Lockheed initiated Project 242 with a team headed by Kelly Johnson. Never one to do things by halves, Johnson proposed a Mach 2+ fighter with a combat ceiling of over 60,000ft (18,290m). Aerodynamically, the Starfighter was revolutionary, having an extremely thin, low-aspect-ratio trapezoidal wing and slender rocket-like fuselage. Not surprisingly, the new aircraft was soon dubbed 'the missile with a man in it'.

On March 12, 1953, after competing with Republic with what became the XF-91; North American, with the F-107; and Northrop, with the N-102, Lockheed was awarded a contract for two prototypes, designated XF-104.

By April 30, 1953, the design had been completed and decisions taken on the armament and engine choice. It was decided to arm the aircraft, by now named 'Starfighter' by the USAF, with an internal 20mm General Electric Vulcan cannon capable of firing 4,000 rounds per minute and two AIM-9B Sidewinder air-to-air missiles. The engine chosen was the brand-new General Electric J79, but as this was not available at the time, the prototypes were fitted with Wright J65 B-3s. This was a US-licensed variant of the Armstrong Siddeley Sapphire, which lacked an afterburner.

Following their completion at Lockheed's Skunk Works, Burbank, facility in California, the two XF-104s were discreetly transported under cover of darkness to Edwards Air Force base, California, where test pilot A W (Tony) LeVier began taxiing trials on February 27, 1954. The next day, XF-104 53-7786 made a brief maiden flight during high-speed taxiing tests; the first official flight took place on March 4. In July 1954, the provisional engine was replaced with an afterburning Wright J65-W-7 and the second prototype made its maiden flight on October 5.

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Above: **A number of F-104s are currently in the hands of private owners, a fact which would seem to belie the story that the Starfighter was a difficult and dangerous aircraft to fly. Since this photograph was taken in October 1998, CF-104D 12850/N104JT has been re-registered N104RD and is owned by RLB Aviation at Clearwater.** (Key-Alan Warnes)

DEVELOPMENT

In January 1954, the USAF ordered 17 pre-production YF-104s for extensive service trials and development. Compared with the XF-104, the YF-104A featured a number of modifications. The fuselage was around 5ft 7in (1.7m) longer, to incorporate the 8,877lb st (39.48kN) (14,807 lb st [65.87kN] reheat) GE J79 engine and additional fuel cells. Other changes were that the fin was slightly enlarged, the wingspan slightly increased, the nose wheel retracted forwards and the air intakes were equipped with adjustable shock cones.

Assembly of the first YF-104A, 55-2955, was completed in February 1956 and on February 16, the Starfighter was officially rolled out – making its public debut at Lockheed's Burbank plant, though the secrecy surrounding the aircraft was such that the air intakes were faired over. The following day, the first YF-104 made its maiden flight in the hands of test pilot Herman Salmon.

On February 28, 1956, the Starfighter established the first of a number of records it was to make when a YF-104A attained Mach 2 in level flight – the first time in level flight that a jet-powered aircraft had reached that speed.

On October 14, 1956, the USAF placed its first order for F-104A series production and in May 1958 two new world records were established: on May 7, Major Howard C Johnson set a world record for altitude at 91,250ft (27,813m) and on May 16, with an average speed of 1,214.85kts (2,253.89km/h) over a 9.32 –15.53 mile (15–25km) 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 the world records for altitude and speed at the same time.

Of the 17 YF-104As produced, many were lost in crashes, whilst others were modified to F-104A standard. After the F-104A was phased out, some YF-104s were converted to QF-104A target drones. Two YF-104s still exist today.

Above: **Although conceived as a lightweight fighter/interceptor, the Starfighter soon adopted other roles, including ground attack. An F-104C is seen in May 1963 with some of the stores it was called upon to carry in Vietnam.** (Ray Holt via Warren Thompson)

FIRST SERIES PRODUCTION F-104A

A number of significant changes were made to the YF-104A to bring it up to production standard as the F-104A. They included the incorporation of a fuselage-strengthening modification; installation of a production G79-GE-3B engine; addition of a long ventral fin to improve directional stability and alleviate snaking problems; and provision for an in-flight refuelling probe. Most importantly, a boundary-layer control (BLC) system was installed. Boundary-layer control utilised bleed air from the engine, blown over the flaps whenever they were lowered more than 15°, to reduce the landing speed and increase the Starfighter's manoeuvrability. Thanks to BLC and to the wing's flap and slat high lift devices, this variant had landing speeds only around 5% higher than contemporary fighters – in spite of its small wing area.

A characteristic of the 'all-flying' tailplane and T-tail was its ability to get the aircraft into a dangerous stall condition (superstall), from which it was not possible to recover.

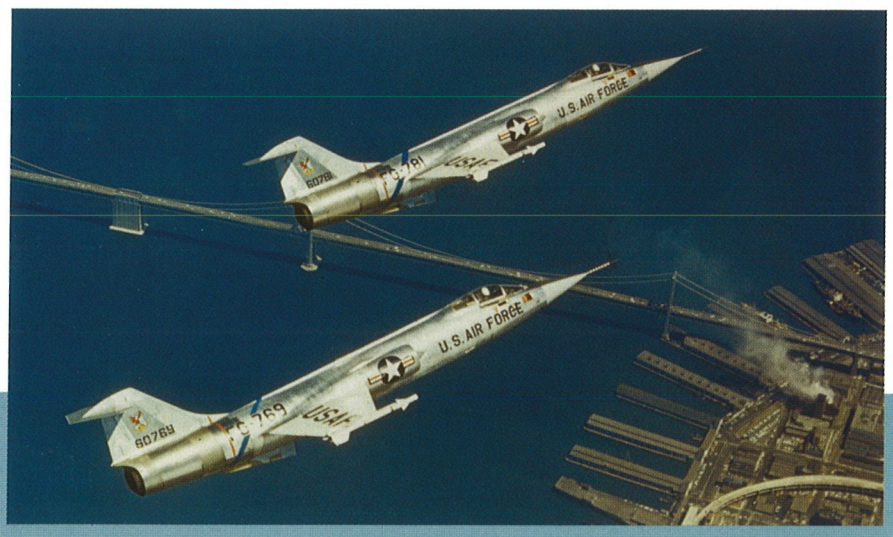
To counter this tendency, an automatic pitch control system (stick-shaker) was added. As the aircraft approached a critical point of the flight envelope, the stick automatically started to shake and, if the pilot took no action, was pushed forward electro-hydraulically, which resulted in the aircraft pitching nose down and recovering from the incipient stall condition.

The F-104A was intended to replace the F-100 Super Sabre from 1956, but by this time the USAF's requirements had changed, and the aircraft's marginal range and limited weapons load resulted in it entering service with only seven squadrons. Such drawbacks would have spelled the end for the F-104 had deliveries of the Convair F-106 Delta Dart for the Air Defence Command (ADC) proceeded as planned. However, because of its superb climb rate, the ADC accepted the F-104A as a stopgap solution, despite its limited range and lack of all-weather-capability.

No sooner had the aircraft been put into service when, in February 1958, all F-104s were temporarily grounded due to increasing problems with the new J79 engine. Further difficulties arose with the T-161 cannon and the weapon was subsequently omitted from aircraft coming off the production line. It was only in 1964, when the much-modified and improved M61A1 became available, that the F-104 received the armament originally intended for it.

Concern over the severely restricted safe ejection envelope of the downward-firing Lockheed C-1 ejection seat resulted in it being progressively replaced by the upward-firing C-2 seat.

Above: **A wide-angle lens emphasises the Starfighter's sleek lines and justifies its description as a 'missile with a man in it'. The pilot of this F-104A of the 83rd FIS is wearing a T-1 pressure suit.** (Lockheed Martin)



Left: **A pair of Sidewinder-armed F-104As of the 337th FIS over San Francisco harbour.** (Lockheed Martin)

F-104C

First flown on July 24, 1958, the F-104C was conceived as a nuclear strike aircraft and a fighter bomber for Tactical Air Command, filling a capability gap between its F-100C and the F-105.

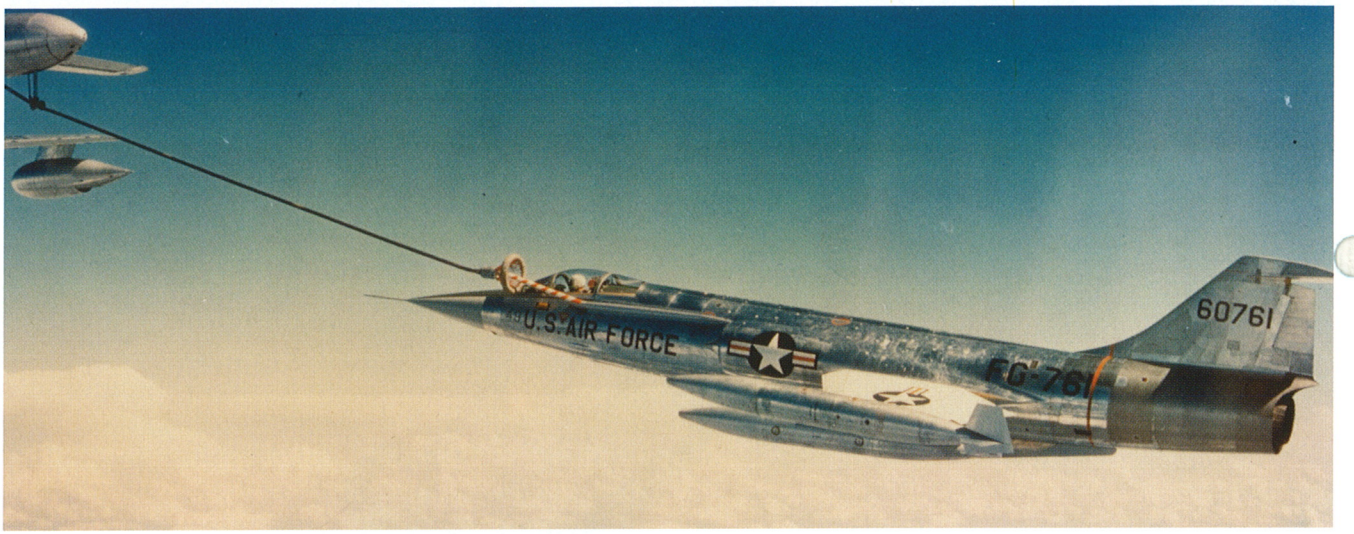
Lockheed was awarded an initial contract on March 2, 1956, for the procurement of 56 F-104Cs. Follow-on orders for production of 363 aircraft were planned, but only 77 were delivered as the USAF cancelled funding when it terminated all its Starfighter procurement plans.

The F-104C was powered by a 15,800lb st (70.29kN) J79-GE-7A engine, which had greater thrust and a lower fuel consumption than the F-104A's powerplant. Other differences between the two types were the addition of a centre-line hardpoint for the carriage of tactical nuclear weapons, the facility for a fixed in-flight refuelling probe on the port side of the cockpit and the upward-firing Lockheed C-2 ejection seat as standard.

On December 12, 1959, an F-104C piloted by Captain Joe B Jordan increased the world altitude record to 103,586ft (31,513m).

Although the F-104C had limited success in Vietnam as an escort fighter and subsequently as a multi-role aircraft, the Starfighter's marginal range and warload restricted its use. It entered service in that theatre in April 1956 and continued until it was replaced by the ubiquitous McDonnell Douglas F-4 Phantom in July 1967.

Soon afterwards, Tactical Air Command phased out its F-104Cs, handing them over to a number of Air National Guard (ANG) units. The last unit to operate F-104Cs, the Puerto Rico ANG, retired its Starfighters in July 1975, when they were replaced by Ling Temco Vought A-7D Corsair IIs.



Above: **A flight-refuelling probe-equipped F-104C is pictured refuelling from a Boeing KB-50J.** (via EADS)

Right: **CF-104D, 104663, now appropriately registered N104, was photographed at Williams AFB, Mesa, in October 2001. Note that as with all other two-seat Starfighters, the nosewheel retracts rearwards.** (Key-Steve Fletcher)

F-104B AND D: THE FIRST TRAINERS

Although originally intended to provide the same combat capability as the single-seat Starfighter models, the trainer variants lacked the cannon armament – which was removed to accommodate the second cockpit, leaving only the wingtip-mounted Sidewinder air-to-air missiles. Other changes necessitated by the extra cockpit included a reduction in the internal fuel capacity from 747 Imp gal (3,396 lit) to 626 Imp gal (2,847 lit), and an increase in the fin and rudder areas. The latter was found to be required following directional snaking caused by the destabilising effect of the longer cockpit canopy, experienced during early test flying with the F-104B. Another modification was the repositioning of the nosewheel, which was located at the front of the undercarriage bay and retracted rearward, as opposed to the F-104A on which it retracted forwards.

A total of 26 aircraft were ordered and built, the first making its maiden flight on January 16, 1957, having been hand-built at Lockheed's Burbank facility.

The F-104D was the last Starfighter variant to enter service with the USAF and combined the cockpit layout of the F-104B with the armament, engine and flight-refuelling capability of the F-04C. Following its maiden flight on October 31, 1958, 21 F-104Ds were delivered to Tactical Air Command between November 1958 and August 1959. Unlike the F-104B, which had a cockpit canopy comprising two halves, without a dividing centre section, the F-104D had a strengthened canopy, offering greater protection from bird-strikes, and a fixed centre-section.

MULTI-ROLE AIRCRAFT FOR GERMANY

Left: **Convair F-106 Delta Dart.** (Key Archive)

Paradoxically, in the light of its subsequent sales success in Europe, after the USAF's first flush of enthusiasm for the Starfighter it showed little further interest in the aircraft. Its short range, limited endurance and restricted payload capacity, together with its lack of all-weather capability, led to the F-104 being phased out of operational service in 1975, only 17 years after entering service with Air Defense Command, although the Starfighter continued to be used in a training role until 1983. Surplus aircraft were given to a number of foreign air forces, including those of Jordan, Pakistan and Taiwan.

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 might be a very short one. Then, in a seemingly miraculous reversal of fortune, the F-104 became the focus of a giant European manufacturing programme which became

Above: **Saab J35 Draken.** (Saab)

Above: **Four of the competitors for Germany's requirement for a supersonic multi-role combat aircraft in the mid-1950s are seen on this page, including the Ling–Temco-Vought F-8 Crusader.** (Key-Dave Allport)

Left: **English Electric Lightning F.1.** (Key Archive)

colloquially known as 'The Sale of the Century'.

In the mid-1950s, NATO forces in Europe (excluding the UK and France) were looking for a nuclear-capable, supersonic multi-role combat aircraft. In Germany, the German Air Force was seeking a replacement for its North American F-86 Sabre and Republic F-84 Thunderstreak aircraft (which were effectively obsolete even at the time of entering service), whilst the German Navy wanted a replacement for its Hawker Seahawks. The objective was for all these different types to be replaced by a single, multi-role aircraft. On the assumption that other NATO countries would follow Germany's lead, numerous aircraft manufacturers from France, Sweden, the UK and the USA submitted proposals: 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.

ENTER THE F-104G

Lockheed proposed a variant of the Starfighter appropriately designated F-104G ('G' for Germany). For its demanding all-weather low-level role, the F-104G was equipped with a new avionics suite, including an F15A NASARR search and range radar and fire-control computer, an inertial navigation system and an automatic flight control system. It also had a strengthened airframe structure, which together with its new avionics, increased the empty weight by 1,000lb (454kg).

A subtle, but significant, modification was made to the flaps, allowing them to be partially deflected during combat – this resulted in a reduction of up to 33% in the turn radius at altitudes of around 5,000ft (1,524m).

On November 6, 1958, the German Minister of Defence, Franz-Josef Strauss, officially declared the F-104G the winner of the competition. At that time, the F-104G existed only on the drawing board and this, together with the aircraft's high accident rate and the USAF's well-known aversion to the Starfighter, generated substantial political controversy which culminated in accusations of corruption at an international level.

In spite of this, an initial contract was announced on March 18, 1959, for the first batch of 66 (later increased to 96) Lockheed-built F-104Gs and 30 two-seat F-104F trainers. A consortium of German aerospace companies would also build 210 F-104Gs under licence and buy a further 364 from joint co-production in Europe, giving a total Federal Republic of Germany Starfighter procurement of 670 aircraft.

As predicted, Germany's choice of aircraft was followed by other countries: Canada becoming the second NATO nation to decide to procure the F-104, followed by the Netherlands, Belgium, Italy and finally Norway. Other derivatives of the Starfighter ordered by Germany were the combat-capable two-seater TF-104G and the RF-104G reconnaissance version, which entered service in 1963.

Above: **A pair of F-104Gs during *JaboG* 33's pre-camouflage period.** (Lockheed Martin)

Above: **'KF+134', the third Lockheed-built F-104G for Germany, in formation with USAF F-104A 56-0748 'FG-748'.** (Lockheed Martin)

F-104F

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

Manufactured by Lockheed, the first F-104F (59-4994/BB-360) was handed over to the German Air Force in October 1959 to serve as an instructional airframe for a crew of *Luftwaffe* technicians. In February 1960, a team of six pilots, led by Lieutenant-Colonel Günter Rall, arrived in the USA, and training began in March.

After this transition phase these aircraft were put into service as the first German Starfighters at *Waffenschule* (Weapon School) 10, in Nörvenich, near Cologne, from where, on July 23, 1960, Lieutenant-Colonel Rall became the first German pilot to fly a Starfighter in Germany.

Following a fatal accident due to asymmetric flap blowing, the F-104Fs were grounded and phased out of service by the end of 1971. It had been intended to put new engines and Martin-Baker ejection seats into the remaining F-104Fs as they reached the end of their service life, but the rapid phasing-out meant that only test aircraft were finally converted. Although only 30 F-104Fs were procured, several are preserved at a number of German Air Force bases and museums.

Without the F-104G's strengthened airframe and avionics, the F-104F's thrust-weight ratio was one of the highest of all the Starfighter models and this, from a pilot's point of view, possibly made it the most exciting to fly.

Above: **One of the first F-104Gs built for Germany at the Lockheed plant nears completion.** (via EADS)

F-104G PRODUCTION

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 March 24, 1959.

The first of these modified aircraft made its maiden flight on December 6, 1959 and the second on June 7, 1960. Flight tests were completed on July 31, 1961.

Licence production in Europe of the 1,000-plus Starfighter aircraft on order involved over 100,000 staff, 25 manufacturing plants, three engine plants and 36 electronics companies. Five working groups (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 October 5, 1960; first flight of a series-production F-104G.
- ARGE-Nord (Avio Diepen, Aviolanda, Fokker, NV't Hart, NV Breda, Focke-Wulf, HFB and Weserflug); first flight on November 11, 1961.
- ARGE-Süd (Dornier, Heinkel, Messerschmitt and SIATWMD); first flight on October 5, 1961.
- ARGE-West (Avions Fairey, Aerfer, Fiat, Heinkel, SIATWMD and SABCA); first flight on August 3, 1961.
- ARGE-Italien (Aerfer, Avions Fairey, SACA, Macchi, Piaggio, Aeronavali, SIAI and FIAT); first flight on May 21, 1964.

In order to alleviate production hold-ups, there was some supply duplication which allowed items to be provided by companies within the 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 duration. Not only were delivery dates adhered to almost to the month, but costs even remained within the 1959 estimates. In 1962, monthly production was 12–13 F-104Gs with a fly-away price of around DM 6 million (approximately £2 million).

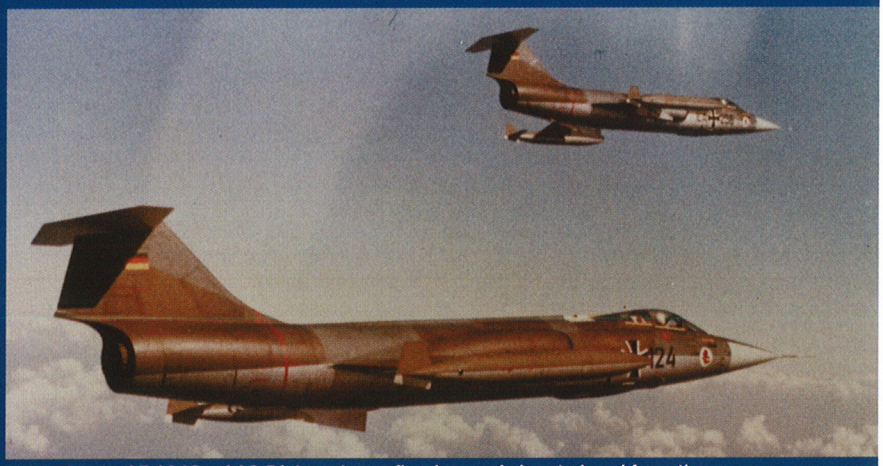
Left: **An F-104G fuselage section under construction. Compared with earlier models of the Starfighter, the F-104G had a considerably strengthened structure to meet Germany's demanding fighter-bomber role.** (via EADS)

Right: **A view of the Starfighter final assembly line at Manching, near Ingolstadt.** (via EADS)

STARFIGHTER IN GERMANY

Above: **F-104G 22+91 of LVR 1 shortly before the disbandment of *Kommando* F-104 in September 1988.** (Gottfried Schwarz)

Above: ***Marineflieger* Starfighter display team, the Vikings, formate on an F-104G of LVR 1, in the summer of 1986.** (Gottfried Schwarz)



Above: **A pair of F-104Gs of AG 51 *Immelmann* fly a loose echelon starboard formation.**

Above: **Two F-104Gs, 20+62 and 26+30, in a special colour scheme to commemorate *JaboG* 32's 25th anniversary.** (Gottfried Schwarz)

A total of 916 Starfighters were manufactured for Germany: 30 F-104F, 137 TF-104G, 749 RF/F-104G, making the German Federal Republic's armed forces by far the biggest user of the F-104. Overall, more than 2,000 German Air Force and Navy pilots received their training on the type.

Not unnaturally, introducing such a complex weapon system resulted in problems, not the least of which was a seemingly disproportionately high loss rate. However, a glance at the figures reveals that in 30 years almost 2 million flight hours were flown, during which 298 aircraft met with accidents and had to be written off, and in which, tragically, 116 pilots died. This resulted in one complete write-off for every 6,630 flight hours – a relatively modest figure compared with other combat aircraft of the time.

GERMAN AIR ARM UNITS THAT OPERATED THE STARFIGHTER

***Luftwaffe* Units**

JaboG 31 ('Boelcke'), Nörvenich
February 1962 – March 1983, 211,412hrs
JaboG32, Lechfeld
January 1965 – April 1984, 204,986hrs
JaboG 33, Büchel
August 1962 – May 1985, 231,900hrs
JaboG 34, Memmingen
July 1964–October 1987, 242.785hrs
JaboG 36, Rheine-Hopsten
February 1965 – January 1975, 82,722hrs
JG 71 ('Richthofen'), Wittmund
April 1963 – September 1974, 83,182hrs
JG 74 ('Mölders'), Neuburg/Donau
May 1964 – July 1974, 81,840hrs
AG51 ('Immelmann'), Manching/Bremgarten
November 1963 – April 1971, 61,390hrs
AG 52, Leck
November 1964 – September 1971, 56,571hrs

***Marineflieger* Units**

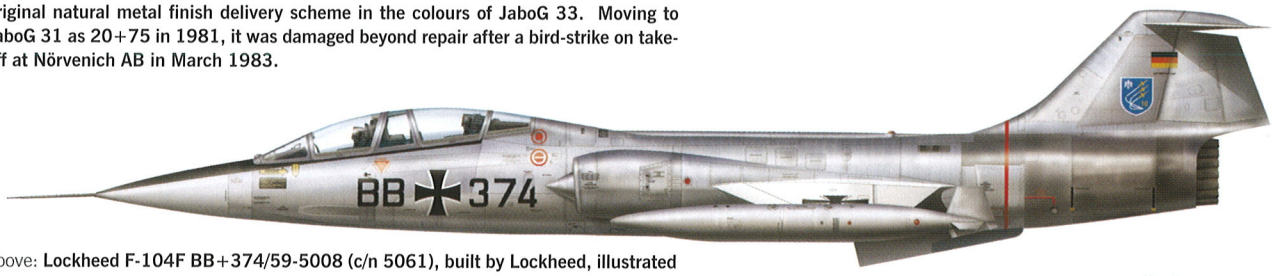
MFG 1, Schleswig-Jagel
September 1963 – October 1981, 131,915hrs
MFG2, Eggebeck
March 1965 – September 1986, 173,070hrs

Miscellaneous Units

WaSLw 10, Nörvenich/Jever
May 1960 – September 1983, 123,728hrs
ErpSt/WTD 61, Manching
February 1962 – May 1991, 10,500hrs
LVR 1, Erding
May 1984 – September 1988, 9,895hrs
2. DtLwAusbSt., Luke AFB
February 1964 – March 1983, 269,750hrs

Above: **Lockheed F-104G 63-13243 (c/n 2026) was delivered to JaboG 31 in Germany as DA+231 in 1962. Illustrated in the colours of the 58th TTW in 1982, it was eventually sold to the RoCAF and crashed in March 1990.**

Above: **Lockheed F-104G DC+111 (c/n 2088), built by Lockheed, is illustrated with the original natural metal finish delivery scheme in the colours of JaboG 33. Moving to JaboG 31 as 20+75 in 1981, it was damaged beyond repair after a bird-strike on take-off at Nörvenich AB in March 1983.**



Above: **Lockheed F-104F BB+374/59-5008 (c/n 5061), built by Lockheed, illustrated in the colours of WaSLw 10 Operational Conversion Unit. Crashed as 29+11 December 1970 during emergency landing after bird strike at Soesterberg AB, Netherlands.**

Above: **Lockheed F-104G 20+50 illustrated in the colours of JaboG 31 *Boelcke*. The 78th TFS, USAF, badge on the intake sides marks a previous squadron exchange.**

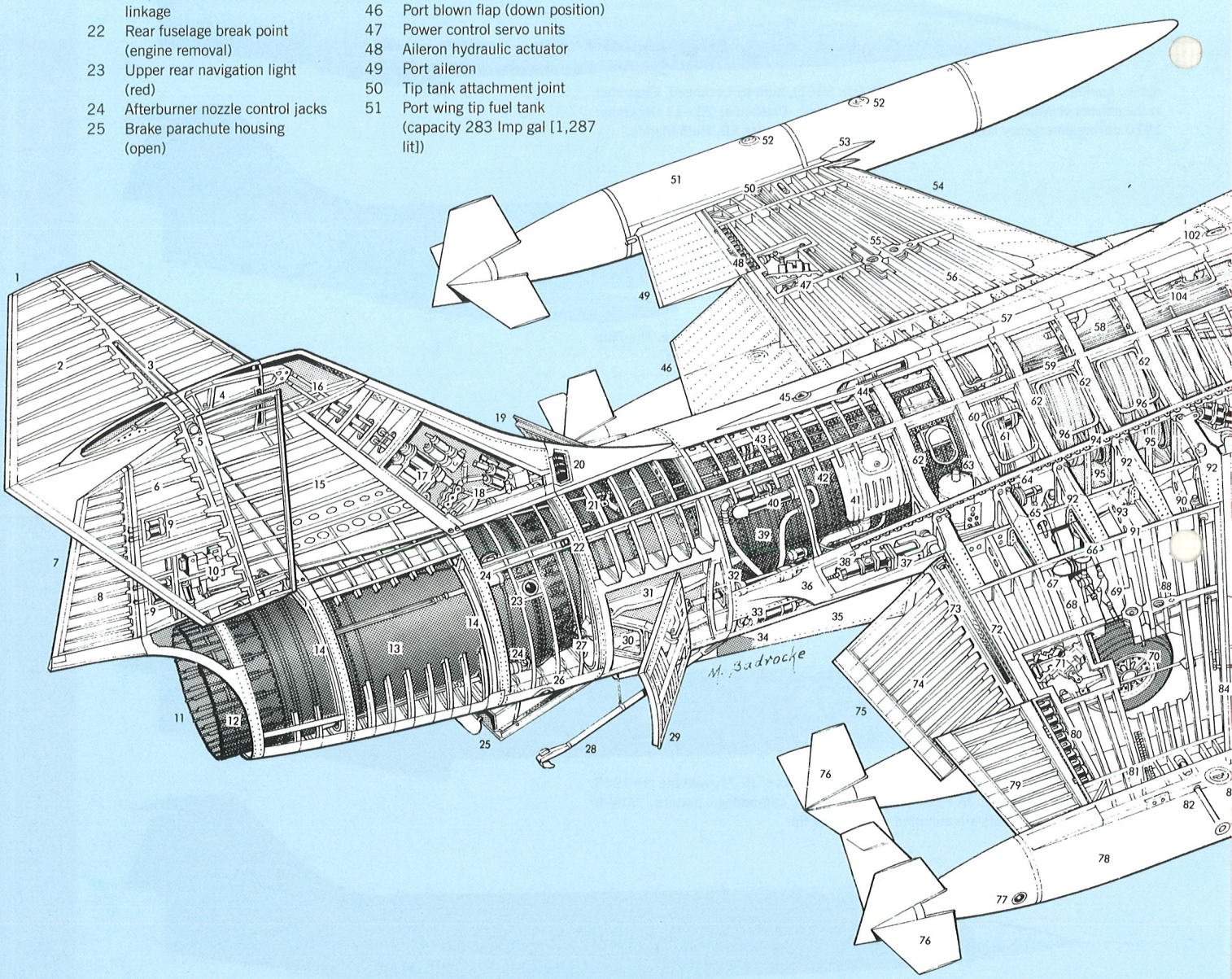
Above: **Lockheed F-104G 26+66 (c/n 7412), built by Messerschmitt, illustrated in the colours of MFG 2. To Test Unit WTD 61 in 1986, scrapped in 1987.**

Above: **Lockheed TF-104G JA+124 illustrated in the colours of JG 71, with the pre-1968 tactical number system of JA+124 and new splinter camouflage pattern. AIM-9 Sidewinder training rounds are mounted on the wing tip.**

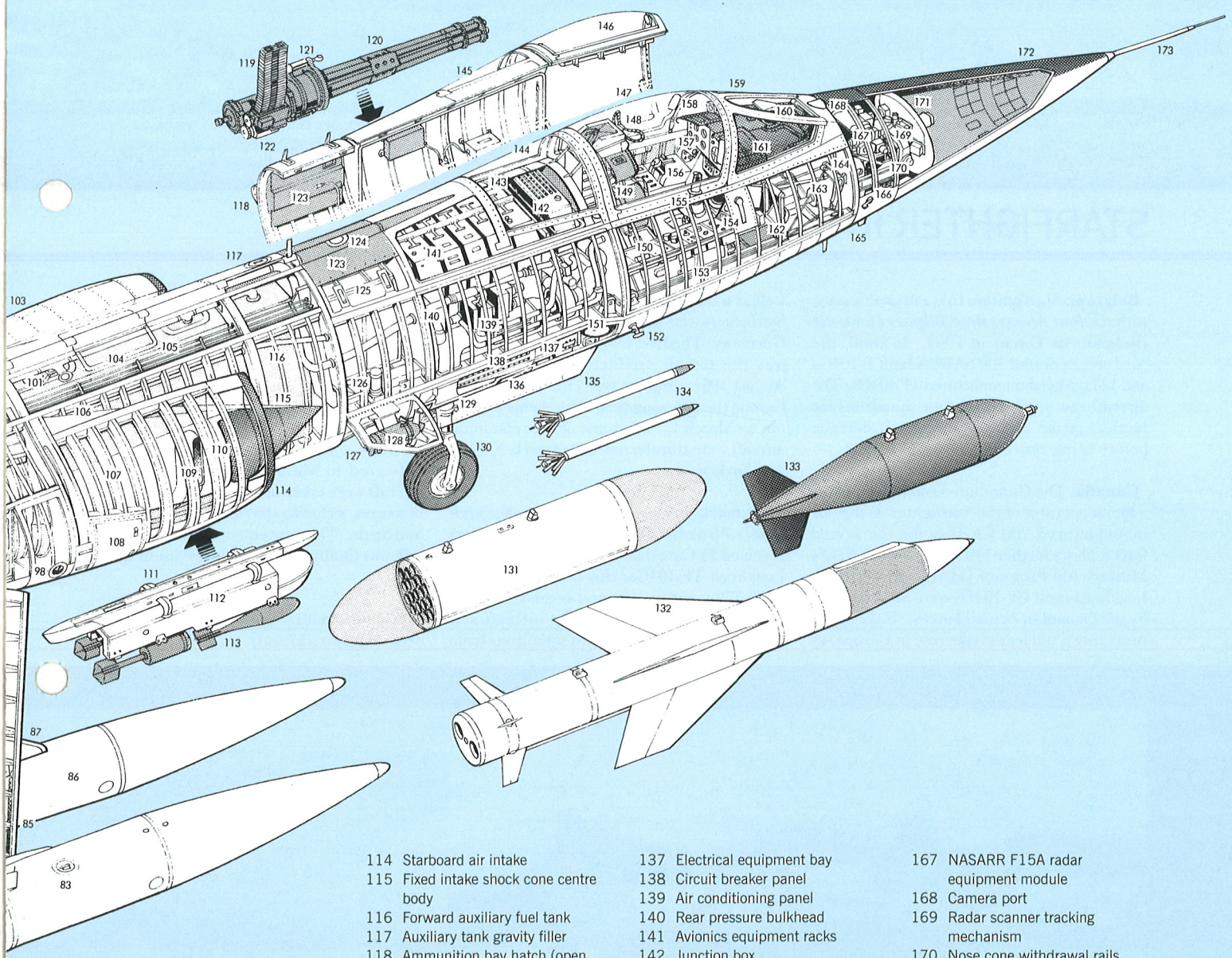
Above: **Lockheed F-104G 20+36 (c/n 2043), built by Lockheed, illustrated in the later three-tone 'lizard' camouflage scheme and colours of JaboG 34. The aircraft crashed in December 1984 at Niederpöring.**

LOCKHEED F-104G STARFIGHTER • CUTAWAY DRAWING KEY

1 One-piece all-moving tailplane
2 Tailplane rib construction
3 Tailplane spar
4 Rocking control arm
5 Tailplane pivot fixing
6 Fin trailing-edge ribs
7 Rudder
8 Rudder rib construction
9 Power control actuators
10 Power actuator servo valves
11 Variable-area afterburner nozzle
12 Nozzle control flaps
13 Afterburner duct
14 Fin attachment fuselage main frames
15 Tailfin construction
16 Tailplane control rods
17 All-moving tailplane dual hydraulic actuators
18 Power control unit servo valves
19 Port airbrake (open)
20 Hydraulic connectors (3,000psi [20.7MPa])
21 Tailplane control push rod linkage
22 Rear fuselage break point (engine removal)
23 Upper rear navigation light (red)
24 Afterburner nozzle control jacks
25 Brake parachute housing (open)
26 Lower rear navigation light (white)
27 Jet pipe thrusting mounting
28 Runway emergency arrester hook (lowered)
29 Starboard airbrake (open)
30 Airbrake hinge linkage
31 Airbrake housing
32 Airbrake hydraulic jack
33 Vertical hydraulic equipment servicing bay
34 IFF/TACAN antenna
35 Ventral fin
36 Wing root trailing-edge fillet
37 Flap actuator
38 Electric drive motor
39 General Electric J79-GF 11 afterburning turbojet
40 Oil coolers
41 Engine oil tank
42 Compressor section variable stators
43 Engine withdrawal rail
44 Bleed air supply duct
45 Anti-collision light
46 Port blown flap (down position)
47 Power control servo units
48 Aileron hydraulic actuator
49 Port aileron
50 Tip tank attachment joint
51 Port wing tip fuel tank (capacity 283 Imp gal [1,287 lit])
52 Fuel filler caps
53 Tip tank vane
54 Port leading-edge flap (lowered)
55 Wing pylon hardpoint
56 Port wing panel multi-spar construction
57 Dorsal spine air duct fairing
58 Fuselage rear main fuel tank total internal fuel capacity 746 Imp gal (3,391 lit)
59 Upper main longeron
60 Intake duct spill flaps (engine bay ventilation)
61 Engine starter
62 Wing attachment fuselage main frames
63 Hydraulic reservoir
64 Aileron control cable quadrant
65 Main undercarriage leg pivot fixing
66 Shock absorber strut
67 Undercarriage leg door-mounting landing lamp
68 Main undercarriage leg strut
69 Swivelling axle control rods
70 Starboard mainwheel
71 Aileron servo control valves
72 Rear spar
73 Flap blowing air duct
74 Flap rib construction
75 Starboard blown flap (down position)
76 Auxiliary fuel tank tail fins
77 Starboard navigation light
78 Wing tip fuel tank
79 Starboard aileron
80 Aileron ten-cylinder hydraulic actuator
81 Tip tank fuel connectors
82 Jettisonable tip tank attachment joint
83 Fuel filler caps
84 Front spar
85 Starboard leading-edge flap (lowered)
86 Underwing fuel tank capacity 283 Imp gal
87 Starboard wing pylon



88 Pylon attachment hard point
89 Starboard wing panel multi-spar construction
90 Leading edge flap lock actuator and linkage
91 Wing root rib
92 Forged wing root attachment fittings
93 Main undercarriage hydraulic retraction jack
94 Wing root attachment longeron
95 Intake flank fuel tanks
96 Access panels
97 Leading-edge flap electric actuator
98 Starboard position light
99 Intake ducting
100 Control cable runs
101 Fuel system piping
102 Gravity fuel filler cap
103 Port air intake duct
104 Fuselage access panels
105 Forward main fuel tank
106 Boundary layer spill duct
107 Starboard air intake duct framing
108 Intake duct access door
109 Shock cone boundary layer air ventral spill duct
110 Boundary layer air bleed slot
111 Fuselage centreline pylon
112 Practice bomb carrier
113 20lb (9.8kg) practice bombs (four)
126 Ram air turbine spring actuator
127 Ram air turbine door (open)
128 Emergency ram air turbine (hydraulic and electrical power)
129 Nose undercarriage shock absorber leg strut
130 Nosewheel (forward retracting)
131 LAU-3A rocket pack 19 x 2 3/4in (70mm) folding-fin aircraft rocket (FFAR)
132 Kormoran air-to-surface anti-shipping missile
133 1,000lb (454kg) HE bomb
134 2 3/4in (70mm) FFAR
135 Nosewheel doors
136 Refrigeration unit ram air intake
150 Side console panel
151 Liquid oxygen converter
152 Total temperature probe
153 Cockpit floor level
154 Canopy external latch
155 Control column
156 Engine throttle lever
157 Rear view mirrors
158 Instrument panel
159 Armoured windscreen panels
160 Optical sighting unit
161 Instrument panel shroud
162 Rudder pedals
163 Control cable quadrants
164 Front pressure bulkhead
165 TACAN aerial
166 Angle of attack transmitter



114 Starboard air intake
115 Fixed intake shock cone centre body
116 Forward auxiliary fuel tank
117 Auxiliary tank gravity filler
118 Ammunition bay hatch (open position)
119 Ammunition feed chute
120 M61 Vulcan 20mm six-barrel rotary cannon
121 Cannon recoil mounting
122 Gun drive motor
123 Integrated IFF/UHF/TACAN aerial
124 Upper formation light (white)
125 Ammunition magazine (725 rounds)
137 Electrical equipment bay
138 Circuit breaker panel
139 Air conditioning panel
140 Rear pressure bulkhead
141 Avionics equipment racks
142 Junction box
143 Pressurised avionics equipment compartment
144 Cockpit rear glazing
145 Avionics bay access hatch (open position)
146 Canopy (open position)
147 Cockpit canopy cover
148 Ejection seat face blind firing handle
149 Martin-Baker Mk GQ-7A ejection seat
167 NASARR F15A radar equipment module
168 Camera port
169 Radar scanner tracking mechanism
170 Nose cone withdrawal rails (radar access)
171 Radar scanner dish
172 Glass fibre radome
173 Pitot head

Above: **Royal Danish Air Force Starfighter F-104G 12341 'R-341', resplendent in its glossy dark green camouflage.** (Royal Danish Air Force via Malcolm English)

Above: **These two Norwegian Air Force Starfighters, F-104G 629 and TF-104G 469, almost blend into the background of the snow-covered terrain.** (via EADS)

STARFIGHTER IN NATO

Belgium: Starfighters first entered service with the *Force Aérienne Belge/Belgische Luchmacht* (Belgian Air Force) in 1963. In total, the Air Force operated 100 SABCA-built F-104Gs and 12 Lockheed-manufactured TF-104Gs. The aircraft saw service with four squadrons for tactical strike and all-weather air-defence before being retired in September 1983.

Canada: The Canadian Armed Forces was a major operator of the Starfighter. Canadair manufactured 200 CF-104s for the armed forces, plus a further 140 F-104Gs for NATO's Military Aid Program (MAP). Thirty-eight Lockheed-built CF-104Ds were also operated by the Canadian Armed Forces. Tasked with providing a nuclear strike role in Europe, as well as a training squadron, all the Canadian Starfighters were based either in France or West Germany. The first CF-104 to fly in Canada was the fourth production example – in August 1961 – and the type entered service in Europe the following year. After being phased out on March 1, 1986, some of the remaining aircraft were transferred to Denmark, Norway and Turkey.

Denmark: In November 1964, the *Kongelide Danske Flyveväbnet* (Royal Danish Air Force) received 25 Canadair-built F-104Gs and four Lockheed TF-104Gs; this being followed in 1972-73 by 15 CF-104s and seven CF-104Ds from Canadian sources. The aircraft saw operational service with two squadrons from December 1964 to April 1986, although four aircraft were retained for target-towing duties for a while after this.

Greece: In total the *Elliniki Vassiliki Aeroporia* (Royal Hellenic Air Force) operated 159 Starfighters. The first of 45 Canadair-built F-104Gs and six Lockheed TF-104Gs were delivered in March – April 1964. Other aircraft were taken on strength from a variety of sources, including the Netherlands, Germany and Spain. The type equipped two squadrons and was finally retired from service in spring 1993.

Italy: (for details of Italian Air Force examples, see *Starfighter Twilight*)

Above: **Belgium operated its Starfighters in the all-weather air defence and tactical strike/fighter bomber roles. F-104G FX 31 (c/n 9068) was on the strength of the Kleine Brogel-based 10 Wing assigned to the strike role.** (Jelle Sjoerdsma)

Above: **Royal Netherlands Air Force F-104G D-8300 about to depart for a towed-target gunnery flight. The '8' in the serial denotes that it was built by Fokker.** (Jelle Sjoerdsma)

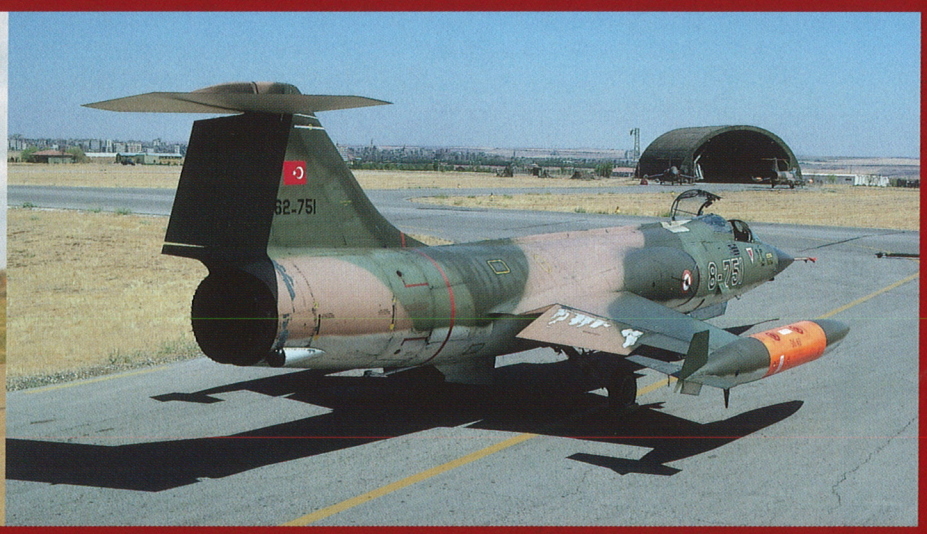
Above: **CF-104 12701 with a Vinten Vicon photo-reconnaissance pod on the fuselage centre-line.** (RCAF via Malcolm English)

The Netherlands: The Royal Netherlands Air Force (*Koninklijke Luchmacht*) took possession of a total of 120 RF/F-104Gs plus18 TF-104G trainers. Manufactured by Lockheed, Fiat and Fokker, the Starfighters were operated by five squadrons in reconnaissance and fighter-bomber roles. The Starfighter Operational Conversion Unit was established in April 1963 and the last KLu flight was made on November 26, 1984.

Norway: As part of the American Military Aid Program, the *Kongelige Norske Luftforsvaret* (Royal Norwegian Air Force) received 16 Canadair-built F-104Gs and two TF-104Gs. Subsequently, in 1973, the Air Force obtained 18 former Canadian Armed Forces CF-104s and four CF-104Ds. The aircraft equipped two squadrons and were used initially as all-weather fighter/interceptors and then in the anti-shipping role. They entered operational service in 1967 and were phased out during the winter of 1982-83.

Spain: This country operated the Starfighter for the shortest period of time and is unique in not suffering a single F-104 loss. Spain received 18 F-104Gs and three TF-104Gs in 1965. The Starfighters entered service in February of that year and were retired in May 1972. They were then returned to the USA, after which they were forwarded on to Greece and Turkey. Spain joined NATO in 1982.

Turkey: As a partner in the MAP, Turkey received the first of 32 F-104Gs and four TF-104Gs in May 1963, and in 1974 procured 40 new F-104S from Italy. From 1980-81 a substantial number of F-104G, TF-104G and CF-104 models were handed over to the *Türk Hava Kuvvetleri* (Turkish Air Force) as they were phased out of service by other NATO states. In total, Turkey operated over 400 Starfighters, making it the second largest user of the aircraft. Starfighters entered service in 1976, and shortly afterwards took part in the invasion of Cyprus. The aircraft was originally employed in the fighter/interceptor role and went on to operate in the close-air support, air-defence and interdiction roles before being phased out in 1996.



Above: **Turkey's Starfighters carried a wide variety of colour schemes, as aircraft received from other air arms were seldom re-sprayed. That said, the three-tone camouflage of CF-104 62-751, '8-751', was applied to several of its aircraft in the early 1970s.** (Gerard Boymans)

STARFIGHTERS WORLDWIDE

Right: **Six late-model F-104Bs, with increased area rudder, were supplied to the Royal Jordanian Air Force. This aircraft was restored for use as a decoy at Prince Hassan Air Base.** (KLM)

Above: **Armed with indigenous Sky Sword short-range air-to-air missiles, this Republic of China Air Force F-104G, 67-14885/'4395', was in service with the 3rd Tactical Fighter Wing.** (Malcolm English)

Japan: Japan selected the Starfighter in November 1959 to replace its F-86F Sabres, and a working group consisting of Mitsubishi and Kawasaki undertook licence production of the aircraft, dubbed the F-104J. Ishikawajima-Harima built the slightly-modified J79-IHI-11A turbojet. Structurally similar to the F-104G, but equipped as a dedicated all-weather interceptor, the first F-104J, manufactured by Lockheed, made its maiden flight on June 30, 1961. Lockheed produced a further three aircraft and delivered parts for another 29 aircraft to Japan, following which Japanese industry produced another 178 F-104Js. Of 20 F-104DJ trainers ordered by the *Nihon Koku Jieitai* (Japanese Air Self Defence Force), one was delivered by Lockheed and the rest were delivered in kit form, final assembly being carried out in Japan. Starfighters entered operational service in October 1962 and equipped seven all-weather interceptor squadrons prior to being phased out in 1986. The greater part of the Japanese Starfighter fleet was moth-balled, although some of the aircraft have been converted to drones.

Jordan: Jordan acquired its first Starfighters in spring 1967, but shortly before the six-day Middle East war they were removed to Turkey and impounded. It was not until mid-1969 that the USA agreed to re-supply the *Al Quwwat Aljawwiya Almalakiya Alurduniya* (Royal Jordanian Air Force) with a number of ex-USAF F-104s and four F-104Bs. These were followed by deliveries of former RoCAF F-104As and F-104Bs, giving a total number of aircraft delivered to the RJAF of 29 F-104As and four F-104Bs. Operated by two squadrons, they saw combat in the 1971 Indo-Pakistan War and were withdrawn from service in 1983.

Pakistan: (see *Starfighters In Action* for details of Pakistan A ir Force aircraft)

Taiwan: After Japan, the Republic of China was the biggest user of the F-104 in the Far East. In 1960, under the US Military Aid Program, Taiwan received 25 F-104As and two F-104Bs. Over the years this fleet was enhanced by the delivery of aircraft from former operators including the USA, Canada, Germany, Japan, Denmark and Belgium. The versions included the F-104A, B, D, G, J, DJ, RF-105G and TF-104G; some of which were not airworthy but were cannibalised for spares. The precise number of aircraft which saw service with the Republic of China Air Force is unclear, but it is believed to be 244, the last ones being phased out on May 22, 1998.

Right: **F-104J 46-8624 sports the colourful tail markings of 207 *Hikotai*, the last Japanese front-line user of the Starfighter, which disbanded in 1986.** (via René Francillon)

STARFIGHTER TWILIGHT

Fifty years after the Starfighter made its first flight, the type is still in front-line service with its sole remaining operator, the *Aeronautica Militare Italiana* (Italian Air Force, or AMI). Over its half-century of operation, it has undergone a multitude of airframe and system modifications, which have resulted in the AMI operating what is probably the definitive Starfighter variant, the F-104S/ASA-M.

Italy received its first Starfighters (125 RF/F-104Gs and 28 TF-104Gs) in early 1963 and they became operational in March that year. These were supplemented from 1969 with 165 of the much-improved Fiat-built F-104S all-weather interceptor variant. The F-104S was equipped with a Martin-Baker ejection seat, new multi-mode radar and fire-control system, upgraded inertial navigation system, J79-GE-19 turbojet, and more underwing and fuselage stores hardpoints. Externally, it could be identified by its two ventral fins. Most significantly, the F-104S had a beyond-visual-range interception capability using AIM-7E Sparrow semi-active radar-guided air-to-air missiles.

Most of the Italian aerospace industry participated in the F-104S programme and were responsible for 65% by value of production. Approval was granted in 1981 for a major weapons system upgrade for the AMI's remaining 153 F-104S. Undertaken by Aeritalia, this gave the aircraft, designated F-104S/ASA, a look-down shoot-down capability, and provision for the all-aspect AIM-9L Sidewinder and longer-range radar-guided Aspide air-to-air missiles.

With the AMI, the Starfighter has been tasked with fighter/interceptor and reconnaissance duties and saw service with 11 wings comprising 13 squadrons.

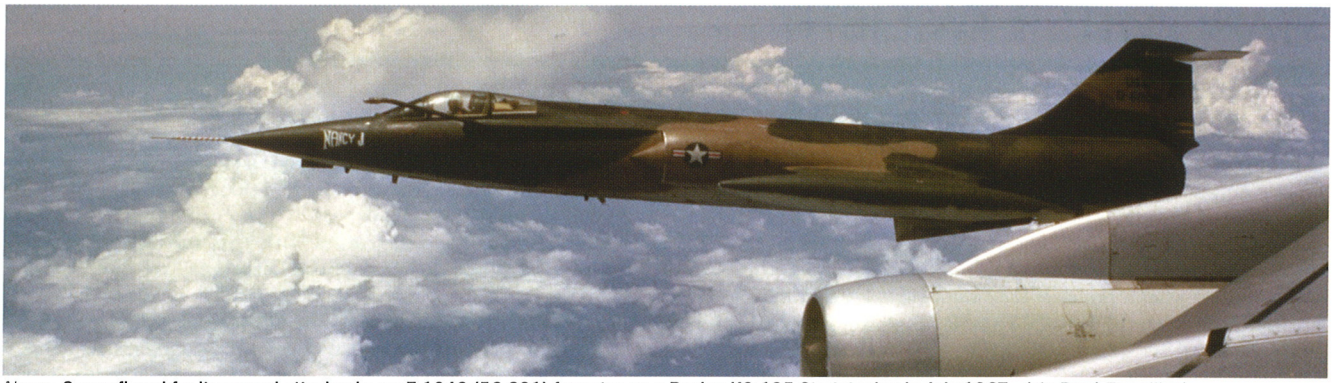
In the late 1990s the AMI's remaining fleet of 55 F-104S/ASAs and 15 TF-104Gs underwent what is likely to be the Starfighter's last modification. This programme, which redesignates the aircraft F-104S/ASA-M and TF-104G/M, has extended its life, increased its reliability and maintainability, and improved the cockpit ergonomics. To extend the life of the aircraft, the main undercarriage legs, tailplane, wing structural box skins and wing/fuselage attachments have been replaced, as have hundreds of electrical and avionic components and all of the electrical wiring. As the aircraft are no longer tasked with ground-attack, all of the equipment and wiring associated with this role were removed. Among the changes to the cockpit instrumentation which will ease the pilot's workload are a new inertial navigation platform, horizontal situation indicator and new TACAN. The last F-104S/ASA-M re-entered service in January 2002.

At present the AMI has approximately 25 Starfighters remaining in service among four *Gruppi* (squadrons), including some 20 F-104S/ASA-Ms. The last pilots to complete the Starfighter training course passed out in September 2003. The official Starfighter 'farewell ceremony' is scheduled for May 30, 2004, but the aircraft is unlikely to be retired then. The delay in the Typhoon's entry into service, combined with the global terrorist threats, may require the Starfighter to soldier on to the end of this year in order to provide a quick-reaction alert force.

Right: **A pair of 9° *Stormo* F-104S-ASA-Ms, one in a special colour scheme, break for the photographer.** (Katsuhiko Tokunaga)

Below: **For the reconnaissance role, 3° *Stormo* RF-104Gs were equipped with the Orpheus reconnaissance pod.** (AMI via Malcolm English)

Below: **For their air-superiority role, Italian Starfighters were given an overall grey camouflage scheme and low-visibility unit markings. F-104S-ASA-M '5-44' displays the badge of 5° *Stormo* on the fin and that of 23° *Stormo* on the air intake.** (Key-Duncan Cubitt)



Above: **Camouflaged for its ground attack role, an F-104C (56-891) formates on a Boeing KC-135 Stratotanker in July 1967.** (via René Francillon)

STARFIGHTERS IN ACTION

Although the Starfighter was in service with NATO air arms throughout the Cold War period, it only saw active combat in the Vietnam and Indo-Pakistan wars and the Chinese Communist Republic of China Conflict.

Vietnam

As the war in Southeast Asia escalated in 1965 with the *Rolling Thunder* bombing campaign against North Vietnam, the MiG threat increased. This was countered by three squadrons of F-104Cs from the 479th Tactical Fighter Wing, which were deployed to provide escorts for tactical operations. Although the Starfighters were somewhat lacking in range and endurance, their very presence was sufficient to deter air opposition and establish air superiority. Having reduced the air threat, the F-104Cs were given a variety of new missions, including close-air support, interdiction, reconnaissance and rescue combat air patrol. For their ground-attack missions, the F-104Cs were armed with a variety of ordnance, including 500lb (227kg) and 750lb (340kg) general purpose iron bombs, rocket pods, napalm and a 20mm Vulcan cannon .

Using Kung Kuan Air Base on Taiwan as their main base, the three squadrons rotated aircraft in and out of Danang AB, starting with the 476th TFS in early 1965. This squadron was relieved by the 436th TFS, followed by the 435th TFS. The latter squadron, operating from Royal Thai Air Force Base (RTAB), Udorn, completed the final deployment of the Starfighter in the war.

One of the last major missions the Starfighter performed in Vietnam was its involvement in Operation *Bolo* on January 2, 1967. This was a plot to lure enemy fighters into the air by 'electronically disguising' McDonnell Douglas F-4 Phantoms as Republic F-105 Thunderchiefs on a bombing mission. Although the mission was a success, and the Phantoms achieved a number of 'kills', the Starfighters failed to engage. Six months later, due largely to lack of satisfaction with the F-104Cs as a ground attack aircraft – a role far removed from the one for which it had been originally designed – the type was withdrawn from Vietnam.

In the 13 months they had been in theatre, the F-104Cs flew a total of 2,269 combat sorties, amassing 8,820 flying hours. Eight Starfighters were lost in action to surface-to-air missiles and anti-aircraft artillery, and six were destroyed in accidents.

Indo-Pakistan

Pakistan was the first non-NATO country to operate the Starfighter and on September 1, 1965, when hostilities broke out with India, the 150 aircraft in the Pakistan Air Force (PAF) inventory included 12 F-104s – ten refurbished F-104As and two F-104Bs. The PAF Starfighters were all supplied under the US Military Defense Assistance Program in response to Indian procurement of MiG-21s. The Starfighters were unique in being armed with the M-61 Vulcan cannon (the gun having been removed from USAF aircraft), equipped with an upward-firing Lockheed C-2 rocket ejection seat and powered by a 15,800lb st (70.3kN) J79-GE-11A turbojet.

Despite the aircraft having replaced piston-engined Hawker Furies, its pilots had little difficulty converting to the type and the F-104 soon acquired a healthy respect from the Indian Air Force (IAF), which referred to it as the Badmash (Scoundrel). Indeed, such was the Starfighter's reputation that an Indian Gnat, intercepted at the onset of the war, promptly surrendered without a shot being fired and landed at the nearest Pakistani airfield. Other engagements with the Starfighter included a successful night interception of an IAF Canberra B(I)58 and what may have been the first encounter in history between opposing Mach 2 fighters. On September 11, 1965, a single F-104A encountered four IAF MiG-21, and managed to outrun them – supersonically at tree-top level.

The Starfighter flew a total of 246 sorties and claimed four IAF aircraft destroyed for the loss of two F-104s.

When fresh fighting broke out in 1971, the Pakistan Air Force had seven F-104As left in squadron service, but these were supplemented by a number (reported as ten) of Royal Jordanian Air Force F-104As. At the onset of the 13-day war the Pakistan Air Force was considerably outnumbered, having 13 combat squadrons compared with the Indian Air Force's 37 squadrons, plus more than a dozen squadrons of support aircraft and helicopters. Claims of loss rates differ: Pakistan admitted to losing three Starfighters, while India claimed five Pakistan F-104As and four Jordanian aircraft.

The Pakistan Air Force continued to fly the Starfighter until it re-equipped with Dassault Mirage 5PAs in 1975.

Republic of China

On January 13, 1967, during a period of tension between mainland Communist China and Taiwan, 12 MiG-19s of the Chinese Air Force of the People's Liberation Army fought with four F-104Gs of the Republic of China Air Force (RoCAF) over the disputed island of Quemoy. During the skirmish, two of the Starfighters shot down two of the MiGs without loss to the RoCAF.

Above: **A Sidewinder-armed F-104C, 60886, of the 476th TFW in its Da Nang rivetment.** (via René Francillon)

In 1952, Gerhard Neumann, a German-born naturalised US-citizen, began development of what became one of the most successful military jet engines to enter production. The General Electric J79 was the first US single-shaft high-pressure axial flow turbo jet, with adjustable guide vanes, a 17-stage compressor, three-stage turbine and ten can-type burners. A particular feature of the engine was that its variable nozzle gave a rapid thrust response to throttle movement. For example, in initiating a go-around from idle thrust, the engine took only four seconds to spool up to maximum power.

In excess of 17,000 J79 engines were produced over a period of more than 30 years. After the Starfighter, the first aircraft to be powered with this engine, it became the powerplant for many more military aircraft, including models of the McDonnell Douglas F-4 Phantom, North American Rockwell A-5 Vigilante and Convair B-58 Hustler. A CJ805 civil version, without afterburner, was produced and was used to power the Convair 880 and Convair 990 airliners.

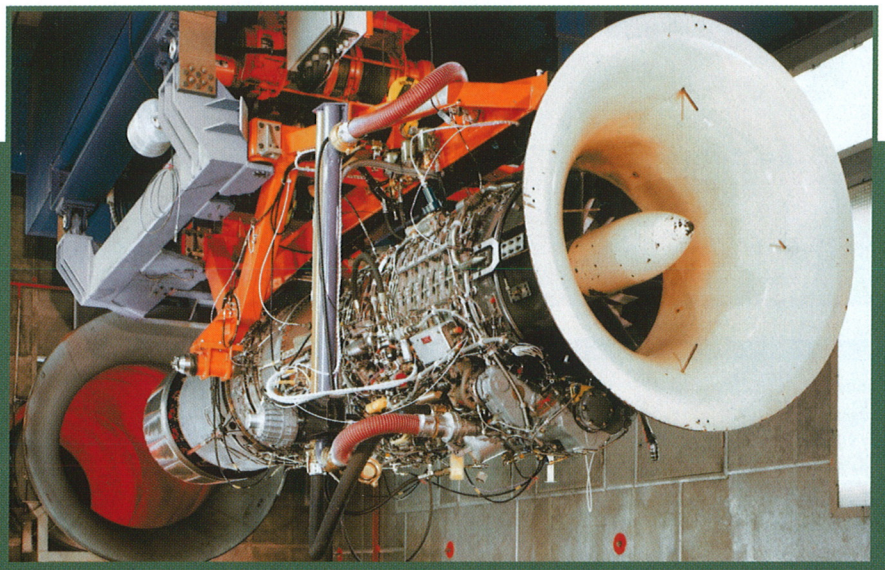
Three European companies were involved in licence production and delivery of the GE J79-11A for the European F-104 aircraft:

- 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

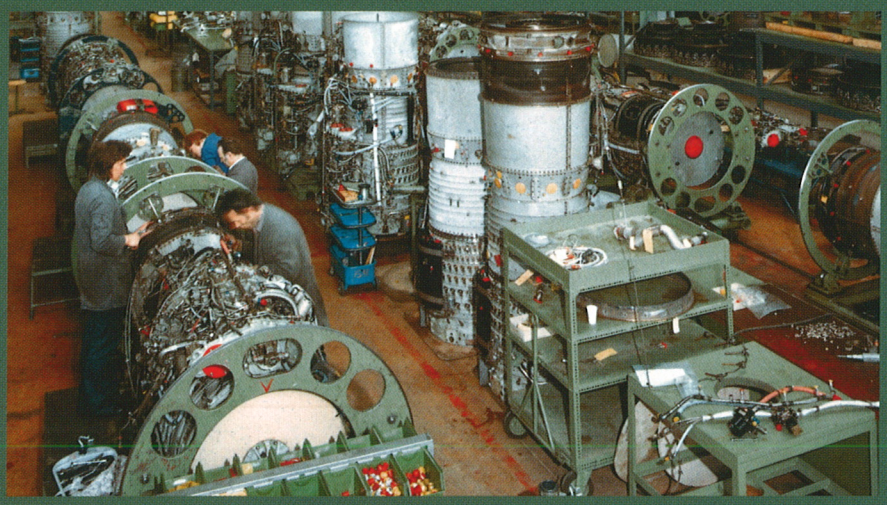
Each company was responsible for manufacturing around a third of each engine and they all had their own final assembly line and engine test facilities.

The first 144 engines were sent in kit form from the USA, and BMW delivered the first engine assembled with its own components on January 30, 1962. In total around 1,228 engines were produced, BMW producing 632, FN 334, and FIAT 262.

In addition to the above production runs, MTU Munich (now MTU Aeroengines, the result of a merger between BMW-Triebwerksbau and MAN-Turbomotoren), supplied a further 50 improved J79-MTU-1Ks and approximately 1,000 conversion kits for the J79-11A.

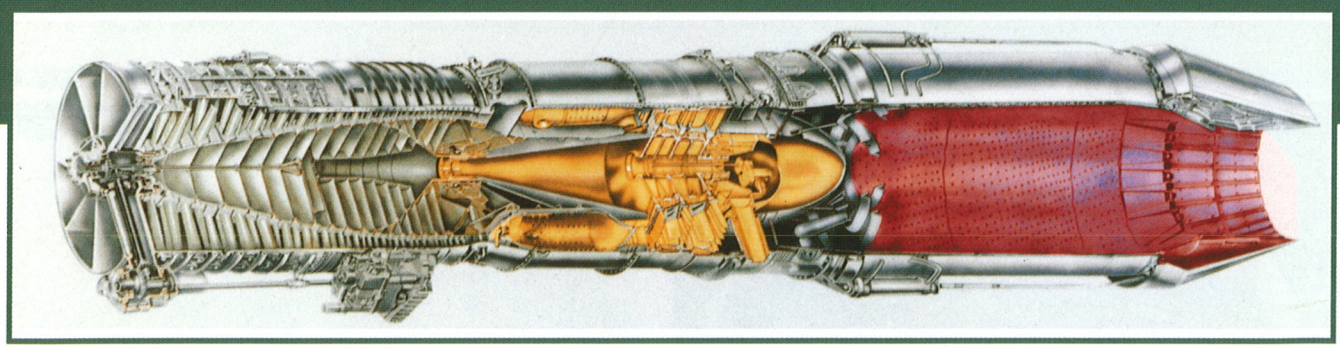


Left: **All three J79 engine manufacturers had an engine test run facility.** (via EADS)



Left: **J79 production line at MTU, in Munich.** (via EADS)

Below: **Cutaway drawing of the J79.** (via EADS)



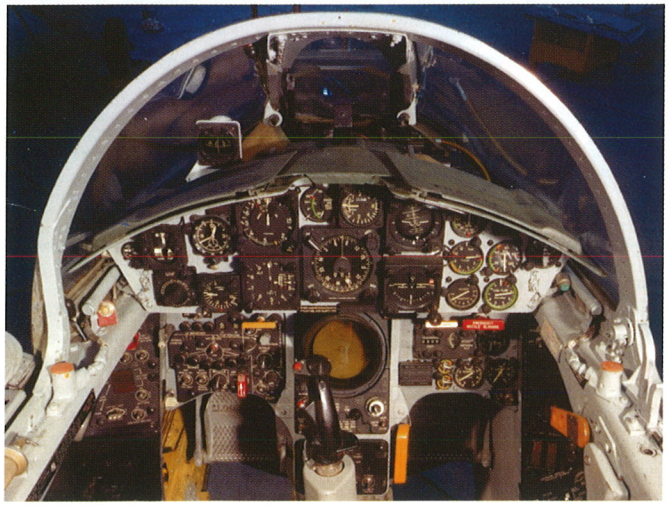
SPECIFICATIONS

Right: **NASA 826, ex-*Luftwaffe* F-104G, was flown by NASA at the Dryden Flight Research Center as an aeronautical experiments test-bed. Among its many research programmes, NASA 826 was involved in testing the Space Shuttle tiles.** (NASA Dryden)

Below: **Three F-104As were modified for astronaut training by the Edwards AFB-based Aerospace Research Pilot School. NF-104A-LO 56-0756 is zoom-climbing under the additional thrust of its 6,000lb-thrust Rocketdyne booster rocket.** (Lockheed Martin)

Versions	**XF-104**	**F-104A**
Powerplant:	J65-B-3	J79-GE-3B
Maximum thrust (reheat):	10,206lb (45.4kN)	14,792lb (65.8kN)
Performance:		
Maximum speed:	1.64M	2.0M
Service ceiling:	50,525ft (15,400m)	57,743ft (17,600m)
Maximum range with external tanks:	798nm (1,480km)	1,442nm (2,676km)
Weights:		
Empty:	11,508lb (5,220kg)	12,562lb (5,698kg)
Maximum take-off:	15,697lb (7,120kg)	24,583lb (11,151kg)
Dimensions:		
Wingspan:	21ft 5 3/4in (6.55m)	21ft 11 1/2in (6.69m)
Length overall:	49ft 2in (14.99m)	54ft 9in (16.69m)
Height:	12ft 8 1/2in (3.87m)	13ft 6in (4.11m)

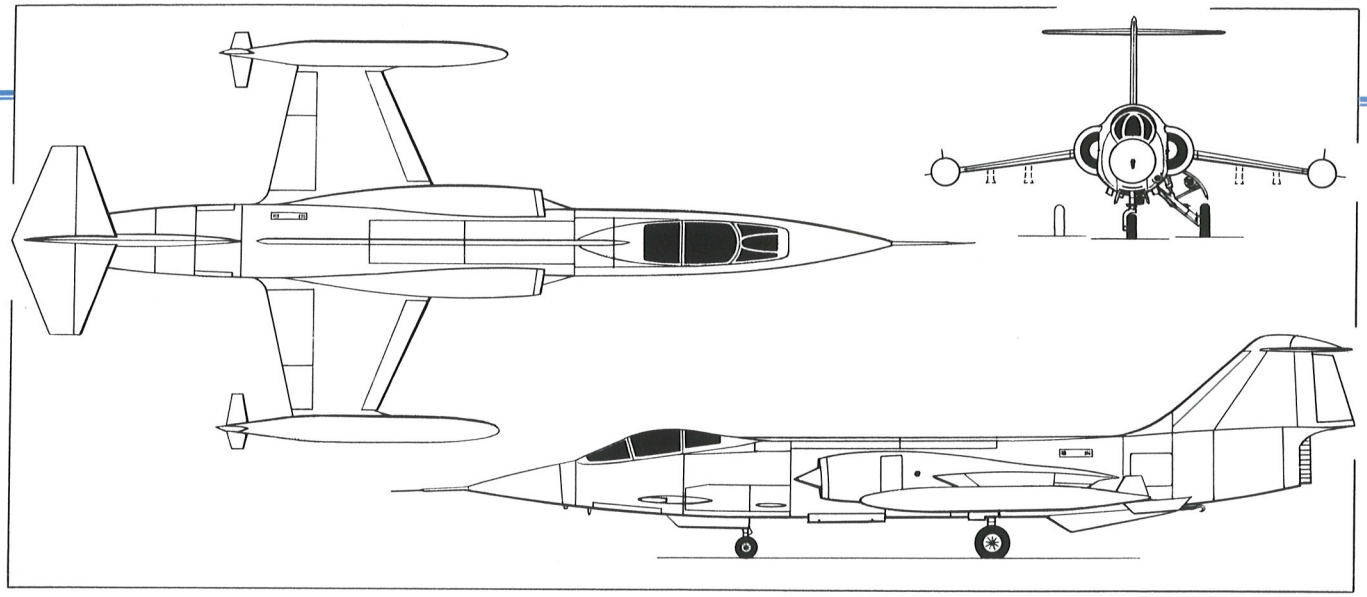
Versions:	**TF-104G**	**CF-104**
Powerplant:	J79-MTU-1K	J79-OEL-7
Maximum thrust (reheat):	15,939lb (70.9kN)	15,804lb (70.3kN)
Performance:		
Maximum speed:	2.0M	2.0M
Service ceiling:	59,547ft (18,150m)	60,039ft (18,300m)
Maximum range with external tanks:	1,300nm (2,411km)	1,626nm (3,017km)
Weights:		
Empty:	14,208lb (6,445kg)	13,964lb (6,334kg)
Maximum take-off:	25,309lb (11,480kg)	28,962lb (13,092kg)
Dimensions:		
Wingspan:	21ft 11 1/2in (6.69m)	21ft 11 1/2in (6.69m)
Length overall:	54ft 9in (16.69m)	54ft 9in (16.69m)
Height:	13ft 6in (4.11m)	13ft 6in (4.11m)



NUMBERS OF VARIANTS PRODUCED

XF-104	2	TF-104G	220
YF-104A	17	CF-104	200
F-104A	153	CF-104D	38
F-104B	26	F-104J	210
F-104C	77	F-104D	20
F-104D	21	F-104S	246
F-104F	30	F-104N	3
F-104G	1,127 *	**Total**	**2,579**
RF-104G	189		

Left: **Early cockpit layout of the F-104G** (via EADS)



Above: **Three-view drawing of the Lockheed F-104G Starfighter.** (Key)

F-104B	**F-104C**	**F-104D**	**F-104F**	**F-104G**
J79-GE-3B	J79-GE-7	J79-GE-7	J79-GE-11A	J79-MTU-1K
14,792lb (65.8kN)	15,804lb (70.3kN)	15,804lb (70.3kN)	15,804lb (70.3kN)	15,939lb (70.9kN)
2.0M	2.2M	2.0M	2.0M	2.2M
56,266ft (17,150m)	59,055ft (18,000m)	57,415ft (17,500m)	57,415ft (17,500m)	60,039ft (18,300m)
1,089nm (2,021km)	1,640nm (3,043km)	1,386nm (2,572km)	1,386nm (2,572km)	1,626nm (3,017km)
12,866lb (5,836kg)	12,526lb (5,682kg)	13,073lb (5,930kg)	13,066lb (5,927kg)	13,593lb (6,166kg)
23,534lb (10,675kg)	27,537lb (12,491kg)	24,387lb (11,062kg)	24,376lb (11,057kg)	28,580lb (12,964kg)
21ft 11½in (6.69m)	21ft 11½in (6.69m)	21ft 11½in	21ft 11½in (6.69m)	21ft 11½in (6.69m)
54ft 9in (16.69m)	54ft 9in (16.69m)	54ft 9in (16.69m)	54ft 9in (16.69m)	54ft 9in (16.69m)
13ft 6in (4.11m)	13ft 6in (4.11m)	13ft 6in (4.11m)	13ft 6in (4.11m)	13ft 6in (4.11m)
CF-104D	**F-104J**	**F-104DJ**	**F-104S**	**NF-104A**
J79-OEL-7	J79-IHI-11A	J79-IHI-11A	J79-GE-19	J79-GE-3B
15,804lb (70.3kN)	15,804lb (70.3kN)	15,804lb (70.3kN)	17,827lb (79.3kN)	14,792lb (65.8kN)
2.0M	2.2M	2.0M	2.2M	2.2M
59,547ft (18,150m)	59,055ft (18,000m)	57,087ft (17,400m)	60,039ft (18,300m)	119,160ft (36,320m)
1,300nm (2,411km)	1,640nm (3,043km)	1,310nm (2,430km)	1,586nm (2,943km)	
14,000lb (6,350kg)	13,402lb (6,079kg)	13,200lb (5,987kg)	14,572lb (6,610kg)	13,977lb (6,340kg)
27,216lb (12,345kg)	27,370lb (12,415kg)	24,621lb (11,168kg)	30,996lb (14,060kg)	22,100lb (10,025kg)
21ft 11½in (6.69m)	21ft 11½in (6.69m)	21ft 11½in (6.69m)	21ft 11½in (6.69m)	25ft 9¾in (7.87m)
54ft 9in (16.69m)	54ft 9in (16.69m)	54ft 9in (16.69m)	54ft 9in (16.69m)	62ft 41/2in (19.01m)
13ft 6in (4.11m)	13ft 6in (4.11m)	13ft 6in (4.11m)	13ft 6in (4.11m)	13ft 6in (4.11m)

STARFIGHTER PRODUCTION AND DELIVERIES

		Manufacturer						
Delivered To	**Total**	**Lockheed ARGE/USA**	**Canada**	**ARGE Süd**	**ARGE Nord**	**ARGE West**	**ARGE Italien**	**Japan**
USAF	299	299						
USAF/MAP	250	110	140					
Canada	238	38	200					
Japan	230	23						207
Germany	917*	263		260	255	89*	50	
Netherlands	138	14		99		25		
Belgium	112	3				109		
Italy	395**	25					370**	
Total	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

Above: **To reduce the dependency on long runways, Lockheed proposed a STOL variant of the Starfighter with swivelling lift/cruise engines.** (Key-Rolando Ugolini)

PROJECTS

'Futuristic' as the Starfighter undoubtedly was, a number of far-sighted, albeit still-born, studies were carried out in the 1960s to develop it even further.

In an attempt to reduce reliance on long runways, studies were undertaken into the feasibility of a V/STOL (vertical/short take-off and landing) F-104G with additional lift engines in the fuselage or in wingtip pods. A STOL-F-104G with swivelling lift/cruise-engines was also considered.

Other studies aimed at increasing the Starfighter's range and endurance. In 1963, schemes to lengthen the fuselage and enlarge the tip-tanks were suggested. More bizarre was a proposal to tow external fuel tanks or even to snatch fuel tanks from the ground during flight. An even stranger concept was a proposed twin-fuselage F-104G escort fighter for long-range maritime patrol missions.

In 1965, another role-conversion study was carried out to investigate a ramjet-powered F-104G variant for high-altitude reconnaissance.

Lockheed itself carried out a number of company-funded studies, including 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 low-set tailplane and a high wing. It was powered by a Pratt & Whitney TF80-PW-100 turbofan, which generated around 60% more thrust than the J79. This gave it a payload capacity more than double that of the F-104G and the take-off distance was halved.

Having lost to the Northrop F-5E Tiger II in the 1970 International Fighter Aircraft competition, further development of the Lancer was cancelled.

Between 1976 and 1984, the German government requested MBB to undertake trials and flight tests for CCV (Controlled Configured Vehicle) technology evaluation with a much-modified F-104G. As well as incorporating a fly-by-wire system, the most obvious changes consisted of several jettisonable ballast weights and an additional horizontal stabiliser, mounted immediately aft of the cockpit.

By suitable ballasting and with the new lifting surface, the aerodynamically-stable Starfighter was transformed into an unstable, computer-controlled aircraft. The CCV programme was very successful and contributed a huge amount of data towards the development of totally new flight control systems for military and civil aircraft.

Above: **Artist's impression of the ramjet-powered high-altitude reconnaissance Starfighter proposal.** (Key-Rolando Ugolini)

A PILOT'S VIEW

Above: **Starfighter sunset. Even in silhouette, the Starfighter is a graceful aircraft. These two F-104Gs of LVR 1 were photographed in 1986 during a night sortie.** (Gottfried Schwarz)

Generalleutnant Peter Vogler (*Luftwaffe*, retired) flew some 1,800 hours in the Starfighter, including flying training at Luke Air Force Base, operational flying with Fighter Wing (JG) 71 and as an instructor pilot with the Starfighter Operational Conversion Unit (WaSLw) 10. Whilst with WaSLw 10, he had the dubious distinction of ejecting (safely) from a TF-104G after suffering an engine failure.

With its long, slender body and razor-sharp anhedral wings, the Starfighter was ahead of its time. The wings were set so far back along the fuselage that only the wing tanks could be seen from the cockpit and these only by painful contortion on the part of the pilot. With few visual cues, aerobatics are flown largely by reference to instruments – in a loop, for example, the pilot will use the artificial horizon, g-meter, airspeed indicator and compass. The cockpit was rather small, and was even more so when the Martin Baker ejection seat was fitted. Although most of the important instruments and controls were easily accessible, in early models the radio, perversely, was tucked behind the seat.

Acceleration was impressive, with rotation at around 160kts (300km/h) and take-off at 178kts (330km/h). Even today, its performance is impressive, capable of reaching Mach 2.0 in little more than five minutes from take-off. Maximum speed at sea level was Mach 1.3 and the Starfighter could climb to 42,650ft (13km) in a little over two minutes. Handling was a 'dream': the aircraft was stable once trimmed, but capable of two rolls per second.

In order to carry out the demanding tactical roles for the *Luftwaffe*, the F-104G was heavier and more complicated than some other Starfighter variants . It called for a high degree of mental agility and independence on the part of its pilots, and forgave only a limited amount of recklessness.

The Starfighter was given a number of harsh nicknames, including 'widow-maker' but only by those who did not know the aircraft. I have never met an F-104 pilot who spoke unkindly of it.

Without exception, we were – and are – convinced of the Starfighter's abilities.

(Acknowledgement: The above was paraphrased from *German Starfighters – The F-104 in German Air Force and Naval Air Service*, by Klaus Kropf, published by Midland Counties)

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