NORTHROP/McDONNELL DOUGLAS

YF-23

This aircraft will go down in aviation history as the big loser in the competition for a new fighter jet for the US Air Force. On April 23, 1991, the victory of the YF-22 Lightning II competitor aircraft prepared by a team of 3 companies: Lockheed, Boeing and General Dynamics was announced. However, it is worth getting acquainted with the design of the outcast YF-23, which in many respects turned out to be better than its rival YF-22. Today, it is safe to say that the YF-23, constructed jointly by engineers from Northrop Corporation and McDonnell Douglas Corporation, is an example of the possibilities offered to fighter aviation in the 21st century by the use of the latest technologies in the field of materials engineering and electronics.

In October 1986, the Air Force Systems command decided to conclude contracts with two teams of companies: one led by Lockheed (plus Boeing and General Dynamics) and the other led by Northrop (plus McDonnell Douglas) for the preparation of prototypes of the modern ATF (Advanced Tactical Fighter) tactical fighter, which was to gradually replace the F-15 Eagle and F-16 Fighting Falcon aircraft in USAF units from the mid-1990s. Initially, it was estimated that the demand for ATF fighters would amount to 750 aircraft, it was decided that two teams of airframe

companies would prepare competing designs, and then fly prototypes designated YF-22 and YF-23, respectively. Each team



First prototype with flaps down



Competitors: the second prototype of the YF-23 in flight in formation : YF-22

received a sum of 818 million for the purposes of these works USD.

As early as September 1983, 3 years before the official start of the ATF program, the engine companies General Electric and Pratt & Whitney began work on new types of turbojet engines, designated XF120 and XF119, respectively. The contract value with each of these companies was USD 200 million. Four prototypes of ATF aircraft (i.e. all possible airframe-engine combinations) were to become the basis for the selection of the final winner - the prototype for the future.

R&D and final R&D
production.
According to the assumptions of the ATF program, the new self-driving
The flight was to be
similar to the F-15 Eagle. Among the formulations
requirements set out by the USAF included, among others:
· the ability to effectively reach the region
intercepted air target in flight
supersonic,
· the ability to effectively penetrate hostile
(read Soviet) defence systems
and thus stealth properties
- aircraft difficult to detect by radar
(small effective reflection area
radar beam, appropriate reflection of the
and absorption of microwaves by the structure of the
A
· the ability to fly at supersonic speeds.
without turning on the afterburners of turbo engines.
throwing events. Maximum speed corresponding to 2.5
Has
· combat action radius without additional
1300 km of fuel tanks,
· short inrun and inrun (STOL - Short
Take-Off and Landing): less than 600 m at
using a drive unit consisting of 2 engines with a
thrust of 136 kN each,
· very good manoeuvrability in high volumes
department of possible speeds and angles of attack,
· Detectability and attack
missiles from a distance of about 40-50 km,
before the own aircraft

two YF-23 prototypes. Northrop was
responsible for the final assembly and integration of
aircraft systems, the production of rear
parts of the fuselage and tailplane, defensible
avionics systems and
control system. McDonnell Douglas produced
produced the front and middle parts of the fuselage,
wings, landing gear, fuel system,
armament systems, offensive systems
avionics and control and measurement devices
and electronic displays for the cockpit.
The cabin itself and the issue of pilot cooperation
with the equipment of the aircraft have become
the work of a team composed of specialists from the
of both companies.

Division of the production of composite
airframe was similar to that of the
mass-produced aircraft for 13 years
F/A-18 Hornet, in the case of
which, however, is responsible for the final assembly
McDonnell Douglas. Northrop in the design of the
YF-23 composite elements made of
used his experience dating back to 1969,
when he started installing composite
horizontal stabilizers and maintenance hatches
in F-5 fighters. In the seventies,
Northrop has developed numerous elements of the
composites for YF-17 (YF-16's competitor in
LWF competition, see LAI 10/91) and in the years
The eighties gained new experience
producing elements of the F/A-18 airframes in
opened in 1979 in the production of spare parts

The upper stringers and most of the frames were made of composites. Titanium frames were used to lift the engine suspension, as well as the lower stringers - mainly to ensure adequate rigidity of the entire airframe on the ground.

In the construction of YF-23 prototypes from the about 30% of the airframe elements were made. According to the assessments of Northrop and McDon-



YF-23 in flight. According to specialists, it has been more carefully refined from the point of view of stealth technology than its competitor YF-22

Douglas in serial production used in the
composites could even lead to
45-50%. It is worth noting here that the share of material
composite components in the F-15 Eagle design
is only 2.2%, and in the F/A-18 Hornet 9.9%.

The use of a power unit that allows for supersonic flight without the activation of "fuel-guzzling" afterburners allowed for a faster flight to the combat zone and a longer time of stay in this zone compared to modern fighters. The time the aircraft spends in the zone of fire of enemy anti-aircraft missiles (surface-to-air) is also shorter. Flying at supersonic cruising speed without the use of afterburners allowed the range of the YF-23 to be nearly doubled compared to the F-15. At the same time, this set strict requirements for the designers to have a high thrust-to-weight ratio of the aircraft and the lowest possible aerodynamic drag.



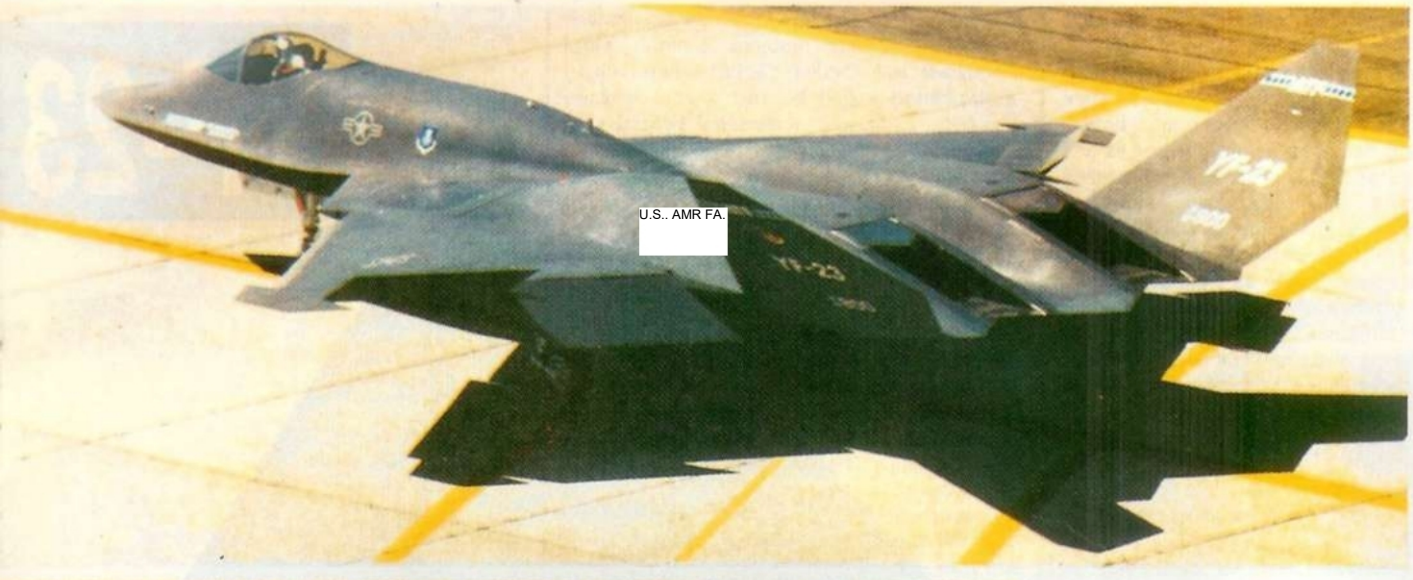
First prototype YF-23 (USAF serial no. 87-800) during an in-flight refueling test from a Boeing tanker KC-135 Stratotanker

It might seem that the heat emitted on the surface of the airframe during a long-term supersonic flight could pose a threat to the composite materials commonly found in the structure. However, according to the designers, in YF-23 the heat from the friction of air molecules caused less problems than ... internal heat sources - mainly turbojet engines, which for various reasons (mainly to comply with the rules of stealth technology) had to be hidden deeper inside the airframe structure than in aircraft built so far.

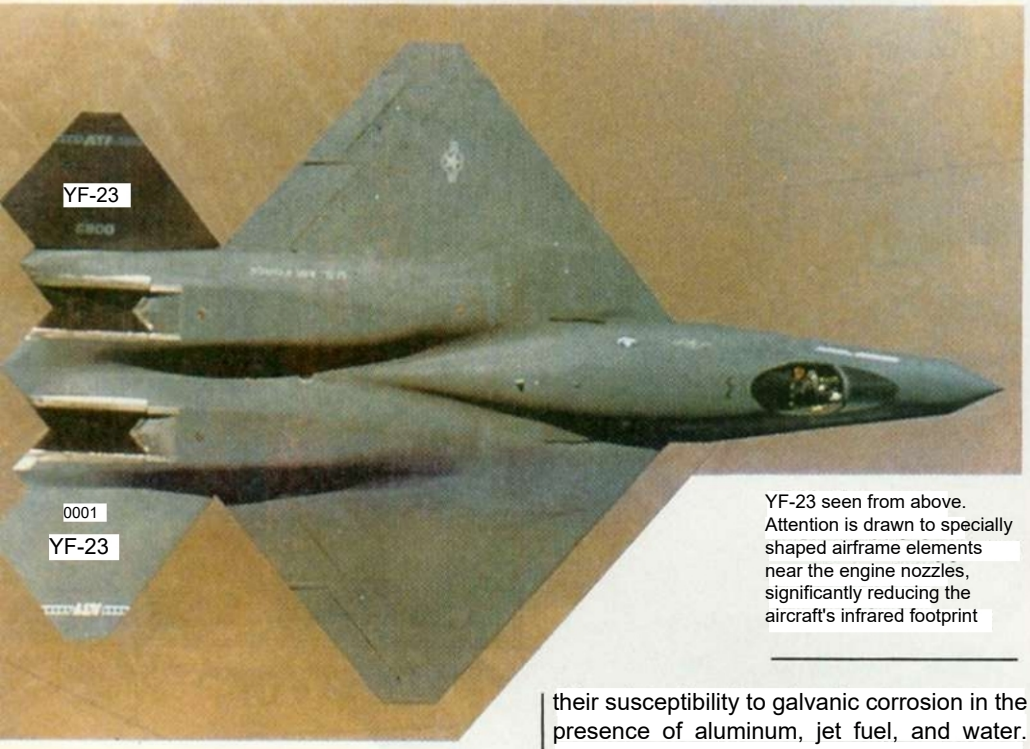
will be noticed by the enemy -
the so-called "first-look, first-kill capability". Involves
including the high technological level of its own
detection equipment (on-board radio-
kator, electronic warfare devices,
infrared observation equipment)
with simultaneous properties
the detection of the aircraft (mentioned above
stealth properties, reduced emissions
infrared radiation, etc.),
· easy ground handling and quick retrieval
combat readiness (half as long as the
in the F-15)
· Max. take-off weight (with armament and fire)
22 700 kg, later increased to 27 000 kg.
kq.
In this way, a 54-month period of
during the demonstration and validation phase,
(Dem/Val-Demonstration/Validation)
ATF gram.
Northrop and McDonnell Douglas
share the production of individual components

composite plants in Los Angeles, as well as
production of B-2 bombers (since 1985) at the plant
roof in Pico Rivera, California.
In the production of YF-23 components, the
both the classic electrophoretic method and the
and the one developed by North-Macedonia
method of computer-aided travel
allowing for the design of elements
in 3 dimensions - NCAL (Northrop Com-
puter Aided Lofting). The NCAL system allows you to
designer to develop numerical
control programs for machining in the field of
5 axes on machining machines
elements made of aluminium, steel or monolithic
graphite. The YF-23 was the second sa-
molot, the production of which was made from
NCAL technology.
The share of composite elements in the
The construction of the YF-23 airframe is huge. Sheathing

The requirements related to high temperatures drew the attention of YF-23 designers to bismaleimide resins, which are cured at 177°C. Operating temperatures for composites made with the use of these resins reach 190°C, which is completely sufficient even in such places heated by air friction as the sharp edges on the nose of the fuselage passing further into the leading edges of the wings. The disadvantage of bismaleimide resins is



U.S.. AMR FA.



YF-23 seen from above. Attention is drawn to specially shaped airframe elements near the engine nozzles, significantly reducing the aircraft's infrared footprint

First prototype in distinctive dark grey camouflage with low-visibility markings

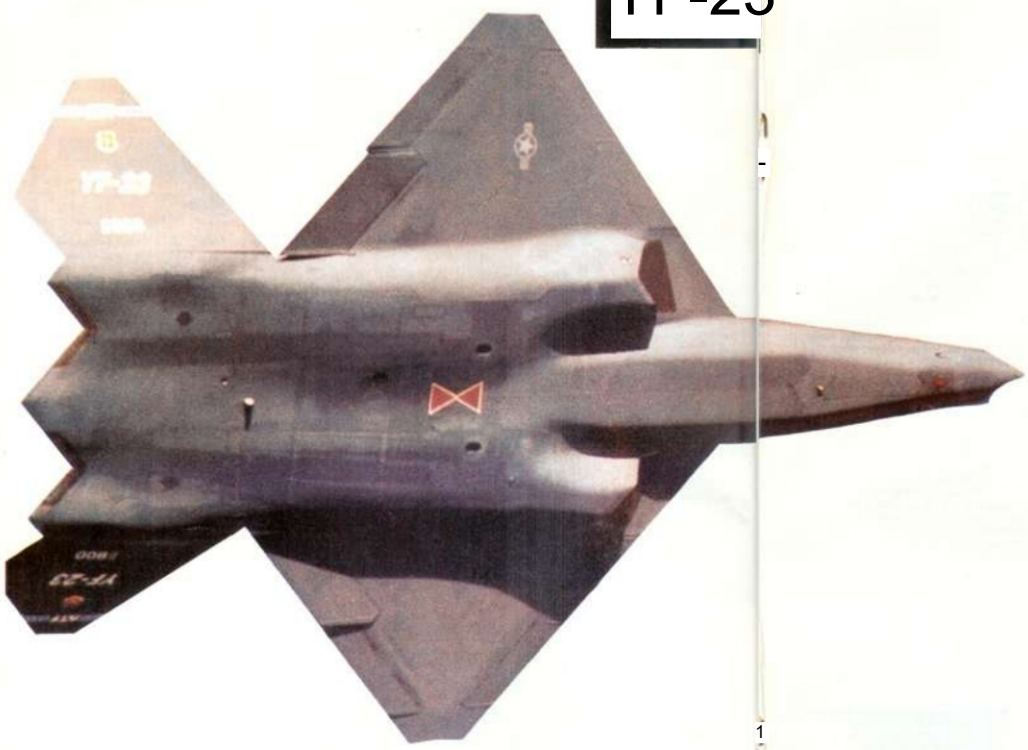
their susceptibility to galvanic corrosion in the presence of aluminum, jet fuel, and water. Fortunately, the fuel tanks were located in less heated areas of the airframe, where epoxy resins could be successfully used. The composite parts adjacent to the hotter areas near the engines are made of polyamide.

Initially, the creators of YF-23 had high hopes for the possibility of using thermoplastics on a large scale. However, it turned out that they did not meet the requirements of resistance to high temperatures and were limited to making only a few elements from them - mainly manhole covers of service openings. Fibre-reinforced composite materials were used in a similar way to other airframes built today. Hercules AS4 and IM7 carbon fiber composites were used in areas where structural rigidity was improved. The nose skin of the aircraft is made of a composite with glass fibers - mainly to ensure the appropriate dielectric properties of the on-board radar antenna cover, but also because the glass composite is softer than the sharp edges running from the nose towards the wings made of the aforementioned bismaleimide composite reinforced with graphite fibers. Glass composite elements deform more easily and relieve the stresses arising in the structure of the graphite composite. The composite skin segments are equipped with integral copper screens to protect the interior of the aircraft from the effects of lightning strikes.

The YF-23's transparent canopy was made by PPG Industries of Huntsville, Alabama. The cover has a sandwich structure. The outer layer is made of chemically toughened Herculite II glass, which is



YF-23



Silicone layer on the inside, under which the polycarbonate core of the cover is located. The whole is covered with a layer of indium and tin

oxides reflecting radar radiation (microwaves). A small part of the plane's covering is made of metal. In the rear part of the fuselage, titanium sheet was used in the vicinity of the engines. The area around the gas outlet from the engine nozzles is protected by a coating made of Allison Lamiloy plates using the phenomenon of the so-called transpiration cooling. Their total area is 6.7 m3. The tiles have a sandwich structure. They are made of a special type of steel, and their surface is covered with holes etched by electrochemical method, which are used to ensure heat transfer between individual layers. Atmospheric air flows between the layers of the tiles, allowing their structure to withstand the huge temperature difference without excessive stress. Active solutions in this way

wishes for the technology of concave forms used so far in the production of boat hulls. Such shapes have been imposed by stealth technology.

The production of large roofing elements means that there are fewer of them, as well as fewer connecting elements and discontinuities in the structure. During the production of the YF-23, 7 large segments of the tail part of the fuselage were combined into one with dimensions of 3×4.5 m, the weight of which turned out to be as much as 20% lower than the analogous element made using classic aluminum alloy technology. With this technology, the assembly of up to 8000 individual stiffeners is avoided. All elements on the inside of the roofing, i.e. stringers, fragments of frames, etc. are formed together with the coating in the same composite forming process. An example of extraordinary accuracy of workmanship were the elements of the YF-23' tail Powerful plate stabilizers (rotated in full)



Cooling the engine nozzle housings has dramatically reduced the aircraft's thermal footprint, which has a major impact on avoiding being hit by infrared-guided missiles.

Northrop engineers came to the conclusion that automatic equipment for the production of large composite components of B-2 bombers and civil aircraft would be of little use in the production of the YF-23 airframe, mainly due to insufficient accuracy of weight distribution. At Northrop's Los Angeles Facility with the Help of McDonnell Douglas Aircraft | Hercules, an experimental machine for the production of super-accurate fighter components was launched. Similar devices were launched for the production of YF-23 components by Cincinnati, Milacom and Morton Thiokol.

The production of components with gentle curves and excellent smoothness required a

A rare VF-21 ed dale

Y7-23. The highly visible front landing gear assembly is adapted : F-13

forming the butterfly tail of the aircraft have an area larger than the entire wings of an F-5 fighter. The fin cover consists of a single upper segment and two lower segments. 60% of the surface of the ballasts was glued with American Cyanamid FM300 glue, according to Northrop specialists, it is the most aggressive adhesive ever used in these plants. After testing, not the slightest tear was found in the glued parts, and the mounting tolerance was only +0.003 inches (0.0762 mm). Starting from July 17, 1989, tests of individual elements of the YF-23 avionics began, conducted using the flying laboratory in the British Aerospace One-Eleven (N162W) aircraft. One of the most important avionics devices of the new fighter is the FMS management control system



Prototype after landing on the runway at Edwards Air Force Base

and 87-801 light grey. The YF-23 aircraft were not given the official name USAF, but numerous sources give two proposed names: Viper and Gray Ghost.

The first prototype of the YF-23 (87-800) was first rolled out of the hangar at the U.S. Air Force's Edwards Air Force Base in the Mojave Desert on June 22, 1990.

The first flight of this aircraft took place on August 27, 1990. At the controls of the plane sat a factory pilot from the Northrop factory, Paul Metz. During the 50 min. The pilot found that the YF-23 had excellent climb performance:



First prototype equipped with Pratt & Whitney YF119 engines in front of the hangar at Edwards Air Force Base



YF-23 at the front. Under the wings, characteristic, trapezoidal air intakes are visible

YF-23 jet aircraft could not keep up with the prototype even when it flew with the landing gear extended and the escort turned on the engine boosters.

In the fourth test flight of the first prototype on September 14, 1990, the first flight refueling test from a Boeing KC-135 Stratotanker tanker aircraft was performed.

On September 18, 1990, on its fifth flight, the first prototype YF-23 (with P&W YF119 engines) achieved a supersonic cruise speed equivalent to Mach 1.43. The flight test program of the first prototype lasted a total of 43 hours. The last 34th flight was made on November 30, 1990.

On October 26, 1990, the second prototype YF-23 equipped with General Electric YF120 engines took off for its first flight. 29 November

it reached a supersonic cruise speed equivalent to Mach 1.6. In total, the second prototype flew 16 flights (the last of which took place on December 18, 1990) with a total duration of 22 h.

The two YF-23 prototypes performed a total of 50 flights lasting a total of 65 hours m.in. The ground crew demonstrated an 18-minute process of restoring combat readiness, including refueling, attaching missiles and loading ammunition to the cannon. The prototypes demonstrated the ability to fly with an angle of attack of 25º. Tunnel tests showed the possibility of achieving an angle of attack of up to 60º without the use of engine nozzles with an adjustable direction of the thrust vector. Both YF-23s performed a total of 7.2 hours of flights at supersonic speeds, demonstrating a speed equivalent to Mach 1.8 at an altitude of 15,240 m in one of the tests.

The flight test program lasted 104 days. All flights departed from Edwards Air Force Base. At the same time, flight tests of the competing YF-22 aircraft were carried out here.

As stated by YF-23 test pilot Paul Metz, this aircraft "has impressive performance in the field of supersonic turns, and the low wing load gives very good capabilities in low-speed flights". Metz claims that the YF-23s performed excellently in formation flights, as well as in refueling in flight from the KC-135 supplementary aircraft. The factory pilot believes that the YF-23 is the best-performing fighter aircraft in terms of the use of on-board small arms at G-forces of up to 4g.

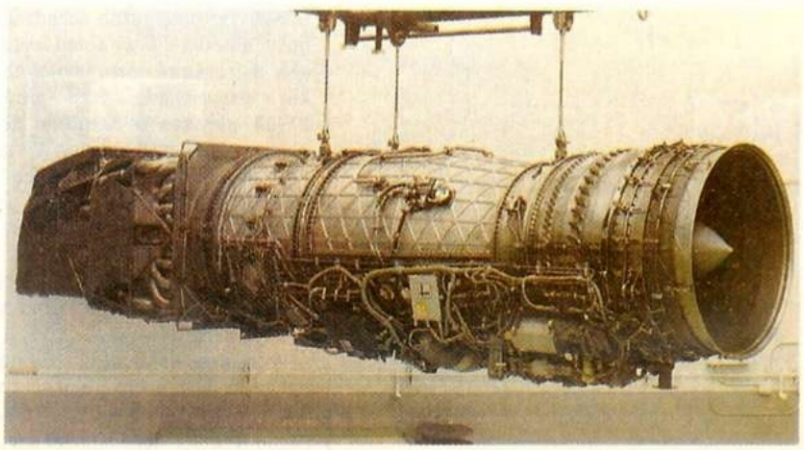
As with any new aircraft, the flight test program was not without dramatic moments.

During the third test flight of the second prototype YF-23 (87-801), a crash almost occurred. The plane climbed to an altitude of 7925 m when suddenly streams of fuel gushed out of the relief valves of the tanks. As it turned out, an overpressure of up to 80% was created in the tanks as a result of the blocking of the measuring tube with a diameter of only 3 mm with accidental contaminants. The measuring tube connected to the regulator still showed the wrong pressure. Fortunately, the fuel did not ignite. Other dangerous incidents include

| is to be counted the cracking of transparent covers of the

(Flight Management System). Its main task is to optimize the deflection of the aerodynamic rudders. Ailerons, wing flaps (on the trailing edge and on the leading edge) and the plate tail are swiveled in such a way as to obtain the most favorable parameters in terms of stability and maneuverability. The FMS system is also connected to the aircraft's electrical, hydraulic, fuel, as well as backup power systems, avionics and armament. For example, the system is able to isolate defective components of the hydraulic system and manage the remaining fluid in the circuit in a cost-effective way.

The first prototype of the YF-23 received the USAF serial number 87-800. It is an aircraft with Pratt & Whitney YF119 engines. The second YF-23 (87-801) received General Electric YF120 engines. In addition, the prototypes received the designations PAV1 and PAV2 (PAV - Prototype Air Vehicle). The 87-800 prototype received camouflage paint in the



bins: at a speed of 1.6 Mach in the first and 1.8 Mach in the second prototype. Problems were also caused by the front landing gear assembly, which vibrated during taxiing tests, which was eliminated by introducing a slight modification of its design.

As mentioned at the beginning, the US Air Force rejected the YF-23 and accepted the competing YF-22 aircraft for implementation in the 48-month EMD-Engineering and Manufacturing Development phase. Air Force officials said the YF-22 poses less risk in the use of advanced technologies to meet requirements in the field of stealth, supersonic cruising speed flight without the use of afterburners and other modern solutions. As it turned out, both planes, although designed to meet the same requirements, were created on the basis of different philosophies of the designers' thinking.

The YF-22 combined the requirements of maneuverability, speed, and low detectability in a fairly balanced way, while the YF-23 was mainly aimed at low detectability and high cruise speed. It seems indisputable to say that the Northrop/McDonnell Douglas team has challenged modern technologies more by creating a real fighter of the 21st century. The same was true when choosing the engine manufacturer for ATF aircraft: the avant-garde solutions proposed by General Electric were rejected, opting for the Pratt & Whitney engine based on slightly more conventional solutions. The decisions of the US Air Force have sparked numerous discussions and polemics in the American professional press. We will return to the details of the selection of the final finalists of the ATF competition on the pages of LAI on the occasion of the publication of the monograph on the YF-22/F-22A Lightning II aircraft.

The further fate of the two YF-23 prototypes is not yet decided. The U.S. Armed Forces have expressed no interest in this aircraft. After being rejected by the US Air Force, the YF-23 has little chance of competing for the new Navy Advanced Tactical Fighter (NATF), which is to become a successor to the F-14 Tomcat. Therefore, work in this direction was stopped at the beginning of 1991.

Meanwhile, Northrop has proposed to the National Aeronautics and Space Administration (NASA) to use the YF-23 as a research aircraft. Northrop specialists claim that thanks to their properties, they can



Northrop and McDonnell Douglas engineers on the second prototype YF-23 (87-801)

They can be used for advanced aerodynamic research on flights with a high angle of attack and manoeuvres below stall speed.

If NASA rejects the offer, the YF-23 aircraft may be stored at Edwards Air Force Base for a long time. The possibility of dismantling or even destroying them is not excluded. They cannot yet be placed in the museum due to the technical solutions used in them, which are undoubtedly of interest to foreign military and industrial intelligence services.

The design of

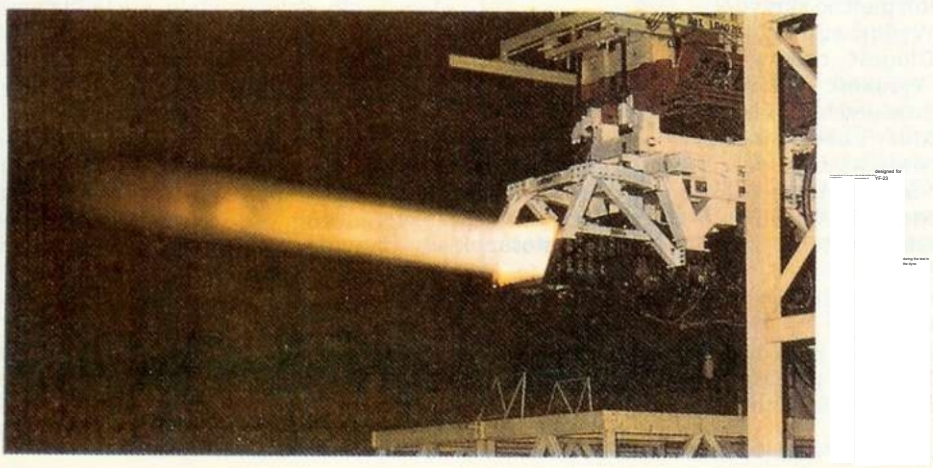
the Northrop/McDonnell Douglas YF-23 is

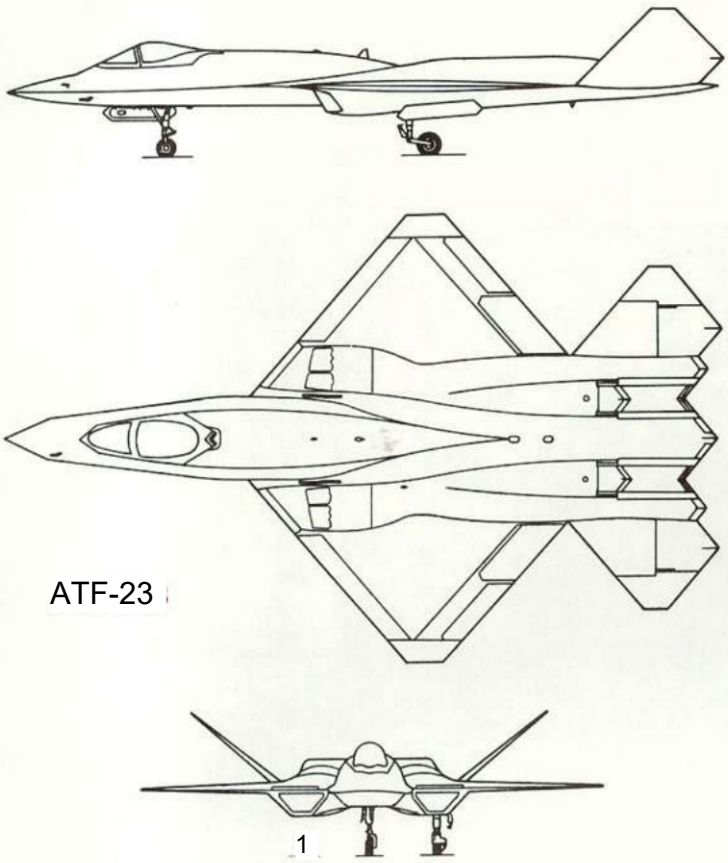
twin-engine, single-seat prototype

a multi-role medium-wing fighter aircraft with a turbofan drive, with a metal-composite structure.

The wings have a rhombic outline with beveled tips. The leading edge slant equal to the trailing edge slant is approx. 40º. The wings smoothly transition into the fuselage and engine nacelles. 90% of the trailing edge length is occupied by flaps and ailerons. Nose flaps were placed on the leading edge.

The fuselage smoothly transitions into the engine nacelles and wings. The front part of the fuselage with a cross-section similar to hexagon is equipped with sharp edges passing into the noses of the wings, in the front part there is a radar cowling, then the pilot's cabin, and below it the compartment of the front landing gear assembly. On the back of the fuselage, behind the cockpit, there is a socket for the rigid fuel line of the aircraft - tanker. Adjustable air inlets with trapezoidal cross-section (shorter trapezoidal base at the bottom). S-shaped air intake ducts to hide compressor rotor discs and engine turbines from incoming radar radiation (stealth technology), additionally coated with microwave absorbing material. Engine nozzles above the fuselage to reduce detectability by infrared devices, which however severely limits the use of engines with adjustable thrust vector direction. Auxiliary air intakes on the upper surface of the wings, covered with four covers. Under the fuselage, the weapon bay: the front one for the Sidewinder missiles, the rear one for the AMRAAM. An aircraft adapted to carry armament only





chambers - due to the strict requirements for stealth technology and the lowest possible aerodynamic drag.
The
butterfly tail is set in its entirety. Stabilizers acting as both rudders and altitudes splayed at an angle of approx. 100º. The stabilizers are almost entirely composite, with the exception of only some fins made of titanium and a steel pivot pin.

Three-unit landing gear retracted in flight. All one-wheel assemblies. The front assembly is controlled, adapted entirely from the F-15 fighter (Goodyear 22 × 6.6 - 10 tire). Main assemblies with the wheels moved back on the levers in relation to the legs, equipped with oil-gas shock absorbers. The front assembly is pulled into the fuselage chamber in the forward direction with the cover opening to the right side. The main assemblies are retracted into the chambers under the air inlet ducts. Specially reinforced landing gear, adapted to operate from airports with short runways, calculated for landing with a vertical speed component of up to 3.05 m/s. Power unit - two turbofan engines .. In the first prototype Pratt & Whitney YF119-PW-100, in the second General Electric YF120-GE-100. Both types of engines with a thrust of 155.7 kN, equipped with afterburners. A detailed description of the engines for ATF aircraft will be included in the monograph of the YF-22/F-22A Lightning II aircraft in one of the next issues of LAI.

Cabin equipment. McDonnell Douglas NACES II ejection seat, zero-zero class (safe ejection with the seat possible even when stationary). Pressurized cabin, air conditioning



The first prototype of the YF-23 (87-800) in a characteristic dark gray camouflage

All illustrations by Northrop/McDonnell Douglas

matized. Cab cover from PPG Industries.

Control system - digital with fiber optic signal transmission (fly-to-light) to actuators

(hydraulic actuators, aerodynamic
rudders), avionics. Wide-angle reflective display between the pilot and the front part of the cabin glazing (HUD - Head - Up Display). ITT/Westinghouse ESM (Electronic Surveillance Measures) reconnaissance device set. Modular Unisys on-board computer. Westinghouse and Texas Instruments took part in the competition for the production of a scanning on-board radar for the YF-23 (with a phased antenna system). The radar in one of the modes of operation was to be adapted to carry out a fully automatic landing. Integrated Communications/Navigation/Identification Avionics (ICNIA) and Integrated Communications/Navigation/Identification Avionics (ICNIA). The fixed armament is a long-barreled version of the General Electric M-61A1 6-barrel 20 mm cannon.

Interchangeable armament installed in two under-fuselage compartments located one behind the other. Air-to-air missiles placed in special launchers with, as the aircraft manufacturers called it, a "revolutionary" design. It can be assumed that the ejectors have a revolver design, i.e. the rockets are placed in a rotating ejector similar to the cartridges in the barrel of a revolver. The ejector slides out of the fuselage by means of hydraulic cylinders only when the missile is fired. The aircraft is adapted to carry 8 missiles of the following types: AIM-9L/M Sidewinder, AIM-120A AMRAAM, AIM-136. According to some sources, the front armament bay is designed for Sidewinder missiles, and the rear one for AMRAAM. It was also planned to introduce the Have Dash 2 air-to-air missiles and the Have Slick air-to-ground missiles, which are currently under development, in the future.

Jacek Nowicki

NORTHROP/McDONNELL DOUGLAS YF-23
APPROXIMATE SPECIFICATIONS

Dimensions:

Wingspan Wing aspect ratio	13.29 m
Overall length Total height Wing	2.01 20.54
area Weights and loads	m 4.24 m
Operational curb weight Combat	87.8 m2
take-off weight Max. Fuel weight	
in internal tanks Powerplant load	
(thrust-to-weight ratio of aircraft	
Wing load (at combat take-off	16,782 kg
weight) Performance: Cruise	29,030 kg
speed (Pratt & Whitney YF119 engines) Cruise speed (General	10,886 kg
Electric YF120 engines) Combat radius	
)	1.1-1.4 331
	kg/m2
	1.43 Ma
	1.6 Ma
	1300 km