MiG-25 'Foxbat' MiG-31 'Foxhound'

Russia's Defensive Front Line

Yefim Gordon

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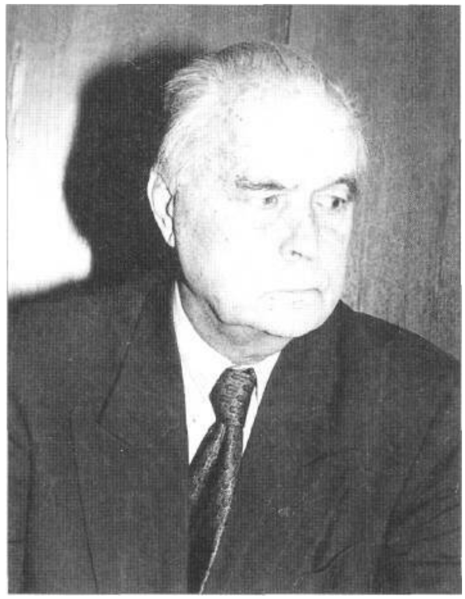
Foreword



Уважаемые читатели английского издания книга МИГ-25/МИГ-31!

Эти самолеты стали эпохой не только в Российской, но и в мировой авиации» Знакомство с историей создания этих самолетов поможет вам лучше понять жизнь конструкторского бюро и создателей знаменитых МИГов.

Желаю всего наилучшего читателям и издательству

Генеральный конструктор Ростислав Беляков

Dear Readers,

These warplanes became an epoch, not just of Russian, but of world aviation. By acquainting yourselves with the design history of these two aircraft, it will help you to appreciate the life of the Design Bureau itself and its famous aircraft and personalities.

With best wishes to the readers and to the publisher.

Rotislav Belyakov,
General Designer, MiG-MAPO

Abbreviations and Designations

ДАМ Air-to-air missile.
ABNCP Airborne Command Post.
AFCS Automatic Flight Control System.
AoA Angle of Attack.
ANS Automatic Naviation System.
APU Auxiliary Power Unit.
ARM Anti-Radiation Missile
ASCC Air Standards Co-ordinating Committee, allocated reporting names to WarPac types, eg 'Fishbed'.
ASI Air speed indicator.
CAHI Central Aerodynamic and Hydrodynamic Institute, often rendered in English phonetically as TsAGI (Tsentralny Aerogidrodynamichesky Institut).
eg Centre of gravity.
ChR Special combat regime flight rating.
CIAM Central Institute of Aviation Motors - Tsentral'nyi Institut Aviatsionnogo Motorostoeniya.
C-in-C Commander-in-Chief.
C^{3}I Command, Control, Communications and Intelligence.
CTP Chief Test Pilot.
D As a designation suffix: Modified or Upgraded - Dorabotannyy - MiG-25.
ECCM Electronic counter-countermeasures.
Elint Electronic intelligence.
ESM Electronic Support Measures.
F As a designation suffix: Tactical - Frontovoy.
FAI Federation Aeronautique Internationale - intertional organisation overseeing record flights.
g Gravitational pull, ie 1g = the gravitational force experienced on Earth, 7g is seven times this.
gal Units used are Imperial gallons, 500 Imp gal = 600 US gallons = 2,273 litres.
GosNIIAS Russian state research institute for aviation systems - Gosudarstvennyi Nauchno-Issledovatel'skii Institut Aviatsionnyikh Sistem.
HAS Hardened Aircraft Shelter.
HDU Hose Drum Unit.
HF High Frequency.
I- As a prefix: Product or item - Izdelye.
IA-PVO Interceptor Force of the Air Force of the Anti-Aircraft Defence of the Homeland - Istrebitel'naya Aviatsiya-Protivovozdusdushnaya Oborona.
IAS Indicated Air Speed.
IFF Identification friend or foe.
IFR In Flight Refuelling.
IFR Instrument Flight Rules.
ILS Instrument Landing System.
INS Inertial Naviagtion System.
IOC Initial Operating Capability.
IR Infra-red, heat radiation.
IRCM Infra-red Countermeasures.
IRST Infra-red Search and Track.
K As a designation suffix: Fitted with a weapon system (often for air defence suppression) - Kompleks.
kN KiloNewton, SI measurement of force (thrust). 1kN = 224.8lb = 101.96kg.
Kompleks Integrated electronic, or weapon, system.
LERX Leading Edge Root Extension.
LII Ministry of Aviation Industry Flight Research Insitut, at Zhukovsky - Letno-Issledovatel'skii Institut.
LL Flying laboratory - Letayushchaya Laboratoria, or in some cases just'!_'.
LLTV Low Light Television.
LORAN LOng Range Aid to Navigation.
LSK-LV East German (former German Democratic Republic) Air Force and Air Defence Command - Luftstreitkrafte und Luftverteidigung.
M Designation suffix: Modified - Modifikatsirovanny.
MAPO Moscow Aircraft Production Association, merged with the MiG OKB in the mid-1990s.
MER Multiple Ejection Rack.
Mischen Literally 'machine', used to denote unmanned (pilot-less) drones.
MLU Mid-Life Update.
MTBF Mean time between failures.
MTOW Maximum Take-off Weight.
N As a designation suffix: Night capability - Nochnoy.
NBC Nuclear, Biological and Chemical.
Nil Scientific and Research Institute (of the WS) at Akhtubinsk - Nauchno Issledovatelyskii Institut.
OKB Experimental design bureau - Opytno Konstruktorskoye Byuro .
P As a designation suffix: Interceptor, radar-directed, all-weather - Perekhvatchik.
Photint Photographic Intelligence.
PLAAF People's Liberation Army Air Force, China.
PRF Pulse repetition frequency.
PVO Air defence forces - Protivo Vozdushnaya Oborona.
R As a designation suffix: Reconnaissance - Razvedchik.
RB As a designation suffix: Razvedchik-Bombardirovschchik - reconnaissance/bomber.
RCS Radar Cross Section.
RHAWS Radar Homing and Warning System.
Rint Radio (or radiation) Intelligence.
RPV Remotely Piloted Vehicle (drone)
RR As a designation suffix: Radiation intelligence - Radiatsionnyy Razvedchick.
RWR Radar warning receiver.
S As a designation suffix: Field Modification - Stroyov, MiG-25.
S As a designation suffix: Operational - Stroyevoy, MiG-31.
SAM Surface-to-Air Missile.
SAR Synthetic-aperture radar.
SFC Specific Fuel Consumption.
Sh As a designation suffix: Fitted with 'Shompol' SLAR.
SHORAN SHOrt Range Air Navigation.
Sigint Signals Intelligence.
SLAR Sideways-looking airborne radar.
SOR Specific Operational Requirement.
SOTN As a designation suffix: Optical and televisual surveillance - Samolyot Optiko-Televizionnovo Nablyudeniyn.
STOL Short take-off and landing.
t Tonnes. 1 tonne = 2,205lb = 1,000kg.
T As designation suffix: Additional fuel capacity - fuel = Toplivo.
T As a designation suffix: Fitted with Tangazh' Sigint.
TACAN Tactical Air Navigation system.
TBO Time between overhauls.
TOW Take-off Weight.
TsAGI See CAHI.
U As a designation suffix: Trainer - Uchyebnii.
V As a designation suffix: Fitted with 'Virazh' Sigint.
VG Variable Geometry (= 'swing-wing').
VFR Visual Flight Rules.
WS Air forces of the USSR/Russia - Voenno-vozdushniye Sily.
WSO Weapon Systems Operator.
Ye- 'Single unit', or more practically one-off or prototype - Yedinitsa.
Z As a designation suffix: Refuelling - Zapravka.

Note:
Designations suffixes are frequently used in multiples, eg MiG-25PDS, MiG-25RBVDZ.

RUSSIAN LANGUAGE AND TRANSLITERATION

Russian is a version of the Slavonic family of languages, more exactly part of the so-called 'Eastern' Slavonic grouping, including Russian, White Russian and Ukrainian. As such it uses the Cyrillic alphabet, which is in turn largely based upon that of the Greeks.

The language is phonetic - pronounced as written, or 'as seen'. Translating into or from English gives rise to many problems and the vast majority of these arise because English is not a straightforward language, offering many pitfalls of pronunciation! Accordingly, Russian words must be translated through into a *phonetic* form of English and this can lead to different ways of helping the reader pronounce what he or she sees. Every effort has been made to standardize this, but inevitably variations will creep in. While reading from source to source this might seem confusing and/or inaccurate but it is the name as *pronounced* that is the constancy, if not the *spelling* of that pronunciation!

The 20th letter of the Russian (Cyrillic) alphabet looks very much like a T but in English is pronounced as a 'U' as in the word 'rule'. (See the illustration of the Ye-155U two-seater prototype on page 34.) This is a good example of the sort of problem that some Western sources have suffered from in the past (and occasionally get regurgitated even today) when they make the mental leap about what they see approximating to an English letter.

MiG-25 and MiG-31 DESIGNATIONS

WS	OKB /Ye-	Izdelye	ASCC
	Ye-155P		
	Ye-155R		
MiG-25P		84	'Foxbat-A'
MiG-25PD		84D	'Foxbat-E'
MiG-25PDS			
MiG-25PDSL			
MiG-25R		02	
MiG-25RB		02B	'Foxbat-B'
M1G-25RBK		02K or 51	
M1G-25RBS		02S or 52	
MiG-25RBV			
MiG-25RBN			
M1G-25RBT		02T	
MiG-25RBSh		02Sh	
MiG-25RBK		02F	
MiG-25RR			
MiG-25MR			
MiG-25BM		02M	'Foxbat-F'
MiG-25M	Ye-266M		
MiG-25 with PS-30F		99	
MiG-25PD test-bed		84-20	
M1G-25PU	Ye-155U	22	'Foxbat-C'
	Ye-133		
MiG-25RU		39	
MiG-25PDZ			
MiG-25RBVDZ			
MiG-25RBShDZ			
MiG-25PA	Ye-155PA		
MiG-31 MP	Ye-155MP	83	
MiG-31		01	'Foxhound'
MiG-31		01 DZ	
MiG-31 B		01 B	
MiG-si BS		01 BS	
MiG-31 M		05	
MiG-31 D		07	
MiG-31 E			
MiG-31 F			
MiG-31 FE			

Awakening

Yakovlev Yak-27 'Flashlight' all-weather interceptor, the late 1950s PVO solution to the western threat. Yefim Gordon archive

Western aerospace journalists and experts always kept a close watch on new Soviet aircraft. Until the early 1960s, however, there were practically no aircraft that could create a sensation in the West. Of course, there were the Myasischchev M-4 (ASCC reporting name 'Bison') and Tupolev Tu-95 'Bear' bombers and Yakovlev Yak-25 'Flashlight', Mikoyan Ye-2A 'Faceplate' and Ye-4/Ye-5 'Fishbed' fighters. (Ye - Yedinitsa, literally 'single unit', but more appropriately 'one off'; prefix used to designate Mikoyan prototypes all the way along to the MiG-25.) These aircraft caused a bit of a stir but did not cause the West to worry too much.

Judging by foreign authors' reports, the first signs of trouble came in the summer of 1961 when the Soviet Union unveiled the M-50 'Bounder', Tu-22 (Tu-105A) 'Blinder' bombers, Ye-152A 'Flipper' high speed interceptor and the Tu-28 'Fiddler' long range interceptor. (The prototype, which took part in the 1961 Tushino airshow, had the service designation Tu-28 and the manufacturer's designation Tu-102. Production aircraft were redesignated Tu-128.) Besides these developments, a Lockheed U-2 high altitude reconnaissance aircraft flown by Francis Gary Powers was shot down near Sverdlovsk on 1st May, 1960, in an incident which put an end to the type's almost unhindered penetrations of Soviet air defences.

Until then the West did not rate the Soviet air defence force (PVO - Protivovozdooshnaya Oborona) any too highly. The S-25 surface-to-air missile (SAM) system designed and fielded in the early 1950s had limited range and could engage targets only at modest altitudes. Designed for point defence of large cities and major military bases, the S-25 was not used on a wide scale and the backbone of the PVO was formed by obsolete day interceptors - the Mikoyan-Gurevich MiG-17PF 'Fresco-D', MiG-17PM (or 'PFU) 'Fresco-E', MiG-19PM 'Farmer-C' and Yak-25 'Flashlight-A'.

Sure enough, there were some attempts to boost the capability of these aircraft for PVO needs. A number of experimental versions of the MiG-19 were tested, including aircraft with liquid-propellant rocket boosters to increase the ceiling and give a burst of speed when chasing an intruder. One of these so-called 'Rocket Riders', the MiG-19PU (PM - Perekhvatchik Modifikatsirovanny, modified and revised; manufacturer's designation SM-51), even entered small-scale production but never achieved operational status. Yakovlev tried upgrading the Yak-25; the Yak-27K-8 interceptor weapons system derived from it was tested in the late 1950s but found unsatisfactory.

The design bureau (0KB - Opytno-Konstrooktorskoye Byuro) led by Pavel Osipovich Sukhoi had better luck with their T-3 fighter. In 1958 the aircraft entered production as the Su-9 'Fishpot' and achieved initial operational capability the following year. The Su-9-51 interceptor weapon system was capable of destroying supersonic targets at altitudes of up to 20,000m (65,600ft) but had very limited range.

Since the potential adversary had large numbers of strategic bombers capable of delivering nuclear weapons (including stand-off air-to-ground missiles), Soviet leaders urged the enforced development of long range, high altitude and high speed air defence systems to counter the bomber threat. State leader Nikita Sergeyevich Khruschchev maintained a very close interest in SAM systems. Thus, the S-75 Tunguska' (ASCC SA-2 'Guideline') missile system was developed and fielded in the late 1950s after successfully completing the trials programme. It was this missile which blasted Powers' U-2 out of the sky.

Meanwhile, the aircraft designers kept on searching for new ideas. By the early 1960s succeeded in creating a new class of fighter aircraft - the so-called heavy interceptors. These aircraft the customary gun armament and were not designed for dogfighting. Instead, they were to destroy enemy strategic bombers a long way off from state borders with medium-to-long range air-to-air missiles (AAMs).

The first major effort in this direction came from the design bureau led by Semyon Alekseyevich Lavochkin with the La-250 heavy interceptor (dubbed 'Anaconda' by its pilots), a component of the La-250-15 weapon system. The production La-250A was to carry two newly-developed K-15 medium range AAMs (which never entered production). The 'Anaconda' entered flight test but the advent of the S-75 missile system and Khruschchev's bias towards rocketry killed off the aircraft.

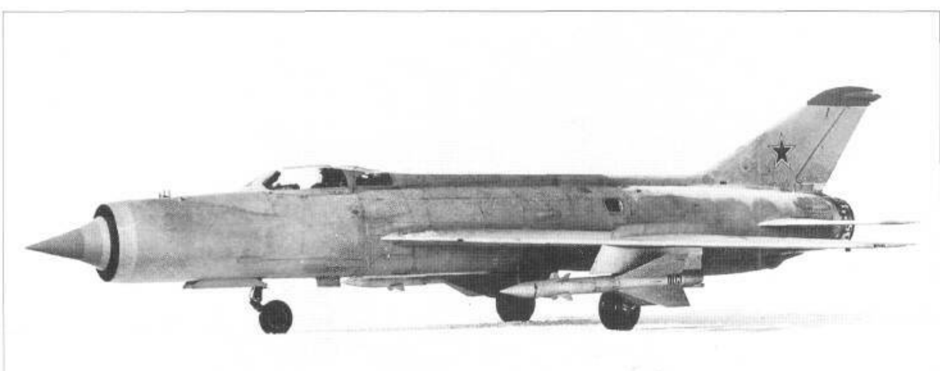
A while later, in the late 1950s, various Mikoyan designs - the I-75, Ye-150 and particularly the Ye-152, 'A and 'M - suffered the same ignominious fate. These were remarkable aircraft capable of destroying almost any target at altitudes of up to 22,000m (72,180ft) and ranges of up to 1,000km (625 miles) shortly after take-off. Like the 'Anaconda', they did not progress beyond the prototype stage. The S-75's success on 1 st May 1960 was undoubtedly a major contributing factor. The T-37 heavy interceptor developed by Sukhoi, an innovative design which made use of titanium alloys and all-welded assemblies, was even less fortunate: the prototype was scrapped without ever being flown.

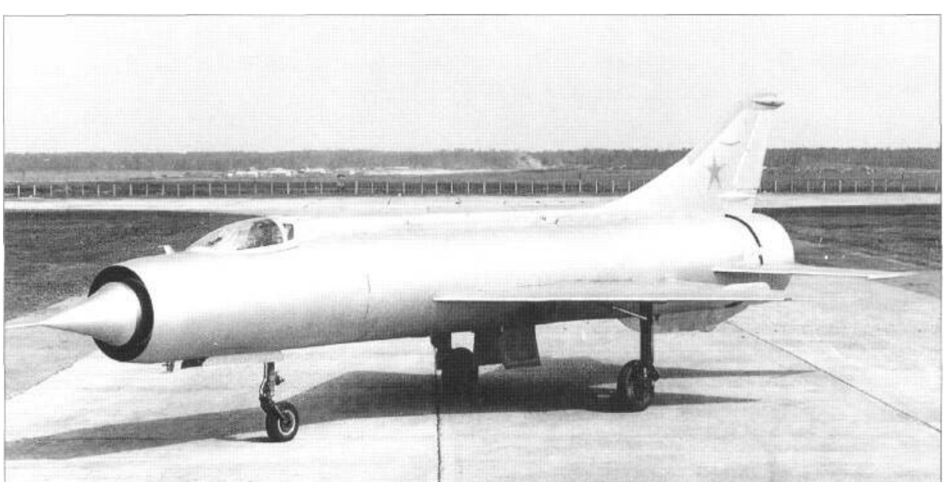
Still, the threat posed by USAF's large strategic bomber force led the Soviet leaders in 1965 to adopt the Tu-28-80 weapon system comprising the Tu-128 twin-engined heavy interceptor and the R-4 (alias K-80) long range AAM.

The Tu-128's top speed with a full complement of missiles (1,665km/h - 1,040mph) was not a very impressive figure, and the main reason why the aircraft saw front line service with the PVO was its great range (in excess of 2,500km -1,560 miles). The R-4's performance and special missile launch tactics enabled the Tu-128 to shoot down targets flying much higher than the aircraft's practical ceiling. Besides, the crew included a navigator/weapon systems officer which effectively turned the Tu-128 into a flying missile director capable of operating far away from its base.

The heavy interceptor development work in the late 1950s and early 1960s proved invaluable for the Soviet aircraft industry. The Tumansky R15B-300 single-shaft turbojet with a reheat thrust of 100.2kN (22,376lbst), which had been put through its paces on the Ye-152 series, finally entered production. This mighty powerplant had taken the Ye-152/Ye-166 to a number of world speed records. (The ill-starred T-37 was designed around the same engine.) The RP-S 'Smerch' (Tornado) fire control radar installed on the Tu-128 had an impressive target detection and missile guidance range.

Thus, many of the technological prerequisites for the birth of a high speed long range interceptor were there by 1960. What actually triggered its appearance was yet another lap in the arms race.





Top: Tupolev's huge Tu-128 'Fiddler' (27.2m/ 89ft Sin in length), early/late 1960s thinking long range, heavily armed bomber interceptor.

Above left: While the format was similar to the MiG-21 the I-75 of 1957 was an all-weather interceptor of scaled-up dimension.

Left: Also following the established 'tailed-delta' MiG-21 configuration the Ye-150 heavy interceptor of 1958 showed promise and gave rise to the developed Ye-152 'family'.
All Yefim Gordon archive

A (Red) Star is Born

As the Convair B-58 Hustler supersonic bomber became operational with the USAF and the Lockheed YF-12A/SR-71 Blackbird programme got under way, Soviet leaders felt compelled to give an adequate answer to these threats. Incidentally, Soviet intelligence got news of this highly classified programme almost two years before the A-12 prototype made its first 'official' flight on 30th April 1962.

The design bureaux led by Vladimir Mikhayiovich Myasischchev and Andrei Nikolayevich Tupolev persisted with supersonic bomber and missile carrier projects - and in so doing were influenced by US aircraft design practices to a certain extent. The Mikoyan-Gurevich Opytno-Konstruktorskoye Byuro - 0KB - design bureau) was tasked with developing a multi-role supersonic aircraft suitable for the interceptor and reconnaissance missions. (Mikhail losifovich Gurevich retired from the OKB in 1964 and it is generally accepted that the MiG-25 is the last design under the 'Mikoyan-Gurevich' heading, further designs from the OKB, eg MiG-27 using only the name 'Mikoyan'.)

Preliminary design work had started as early as 1958, when the Ye-150/Ye-152 interceptor series was under development and test. In this instance an aircraft possessing exceptional flight characteristics (particularly in speed capabilities) and a comprehensive equipment suite was required.

Rumour has it that the story of the MiG-25 began with a conversation between chief designer Artyom Ivanovich Mikoyan and lead designer Ya I Seletskiy. Mikoyan had just returned from the 1959 Paris airshow and ran into Seletskiy in a corridor and suggested that he should 'draw an interceptor along the lines of the Vigilante but powered by two R15-300 engines, designed to fly at 300km/h and without all-too-sophisticated high-lift devices'. At the time, such a phrase from the OKB chief was tantamount to an official go ahead.

Other sources state that the general arrangement of the aircraft was drawn up unofficially *before* any information on the North American A-5 Vigilante became available - the prototype first flew on 3rd August 1958. The resulting sketches were shown to the preliminary design (PD) section chief Rostislav Apollosovich Belyakov (later Mikoyan's successor), then to Nikolay Z Matyuk and finally to Mikoyan. Either way, actual work did not begin until mid-1959. Employees of other sections of the OKB were called on to help the PD section with the aircraft's unusual layout.

After a few weeks' hard work, a design was born that obviously had good potential. It was immediately apparent that the development of

The first prototype MiG Ye-152 **all-weather interceptor of 1959. The** Ye-150 **and** Ye-152 **'family', although unsuccessful, were to help in the development of the** Ye-155.
Yefim Gordon archive

Development of the Ye-152 continued with the twin-engined Ye-152A of 1959 and first seen in public in 1961. Yefim Gordon archive

this aircraft called for a new approach in design, avionics, weaponry and, most importantly, new production technologies. The project aroused the interest of the PVO (Protivovozdushnaya Oborona-Air Defence Forces) command, which needed a high speed, high altitude interceptor, and also the Soviet Air Force (VVS - Voyenno-vozdushniye Sily) which wanted a new reconnaissance platform. A strike version armed with an air-launched ballistic missile was also proposed.

Since the requirements stated by the PVO and the VVS for the interceptor and reconnaissance aircraft respectively were broadly similar (a top speed of about Mach 3 and a service ceiling in excess of 20,OOOm/65,600ft), it was decided in 1960 to design a single aircraft to fulfil both roles. In February 1961 the Central Committee of the Communist Party of the Soviet Union issued a joint directive with the Council of Ministers of the USSR, tasking the Mikoyan 0KB with the development of an aircraft designated Ye-155, the interceptor and reconnaissance versions of which were designated Ye-155P (Perekhvatchik - radar-directed, all weather interceptor) and Ye-155R (Razvedchik -reconnaissance) respectively. On 10th March 1961, Mikoyan signed an order to start design work on the Ye-155. Meanwhile, the WS and PVO each issued a general operational requirementforthe two main versions.

By the time work really got started the designers had a wealth of experience. The only suitable engine - the R15B-300 designed by Aleksandr Aleksandrovich Mikulin and his closest aide Sergei Konstnatinovich Tumanskii - was well developed. The R15B-300 was a spin-off of the earlier Model 15K axial turbojet designed for use in a remotely piloted vehicle (RPV). Within a short period, the engine designers altered the compressor, combustion chamber and afterburner, increasing the gas temperature throughout, and incorporated a new variable area nozzle. The hydromechanical fuel flow control unit of the earlier version was replaced by an electronic one.

To be frank, the R15B-300 was *not* the only suitable engine. Concurrently, the Rybinsk engine design bureau led by P A Kolesov was testing the even more powerful RD17-16 turbojet. But that was built in a handful of examples and intended chiefly for supersonic heavy bombers (eg, the Myasischchev M-52 which never flew). Lyul'ka was also working on an engine in the same thrust class but their contender was still on the drawing board.

Besides the engine, the Ye-150/Ye-152 family helped to refine other items which would go into the future Ye-155, such as analog computers, communications, identification, friend or foe (IFF) and command link equipment, ejection seats, air conditioners etc. They also provided valuable data on aerodynamics, gas dynamics, flight controls, aircraft stability and controllability at high Mach numbers and airframe thermal loads.

The design team worked enthusiastically. Before long, three possible general arrangements were devised, all three envisaging a twin-engined aircraft. One had the engines located side-by-side, as on the MiG-19 and Ye-152A. The second had a stepped arrangement similar to the Mikoyan I-320 experimental fighter (ie, with one engine amidships, exhausting under the fuselage, and another in the aft fuselage). The third project utilised an arrangement identical to the BAC (English Electric) Lightning with the engines located in the aft fuselage one above the other.

The second and third options were rejected because the powerful engines had a large diameter and increased the aircraft's height appreciably, complicating removal and replacement of engines for servicing. The idea of placing the engines in underwing nacelles was also rejected because of the dangerously large thrust asymmetry if an engine or an afterburner failed on take-off. Moreover, the designers decided to drop the single forward air intake and circular fuselage cross section so characteristic of earlier MiG jet fighters.

As the scope of work increased it became necessary to appoint a chief project engineer, as was customary in the OKB. Mikoyan offered this job to his first deputy Anatoliy G Brunov but the latter refused. While the reason behind this refusal remains uncertain to this day, it could have been poor health ... or perhaps Brunov just did not believe in the Ye-155.

At that time the branch of OKB-155 (MiG's code designation for security reasons) responsible for RPVs and drones, led by Aleksandr Ya Bereznyak, was becoming increasingly powerful and was about to become a separate design bureau. Gurevich also led a design group tasked with RPVs and faced a difficulties since the breakaway Bereznyak group was likely to take his staff away with it.

Mikoyan opted for an unusual but highly effective solution to this crisis by assigning two chief project engineers to the programme. Gurevich was responsible for the airframe (while *still* looking after the RPVs) and Matyuk for weapons and equipment integration, since he had been project chief of the 1-75 and Ye-150 interceptors and was well experienced in dealing with avionics and weaponry. Gurevich had the lead at first; however, he could do less and less design work due to his advanced age and failing health and he finally retired, leaving Matyuk with the entire project.

In addition to this, leading specialists for various design areas were appointed. These were L G Shengelaya (equipment); Yu F Polushkin (efficiency planning and reconnaissance systems design); Seletskiy (systems integration); A A Chumachenko (aerodynamics); Gleb Ye Lozino-Lozinskiy and V A Lavrov (powerplant and air-conditioning systems); Belyakov, V M lezuitov, A A Nefyodov and Aleksey V Minayev (flight controls and landing gear); D N Kurguzov and Z Ye Bersudskiy (structural engineering); L P Voynov (gas dynamics / thermal load calculations); D A Gringauz (chief engineer, interceptor version); V A Shumov (missile-armed strike project); I V Frumkin (chief engineer of the reconnaissance version); Ye V Lyubomudrov (reconnaissance equipment); and finally A A Sorokin and B L Kerber (aircraft systems).

A design group responsible for the Ye-155 project was created in the design section, reporting to project chief Matyuk. Mikoyan 0KB employee, V Stepanov, recalled that 'Mikoyan selected engineers with progressive views and the ability and aptitude to find non-standard solutions'. And so the work of defining and refining the general arrangement of the aircraft went on.

Design Aspects

The LII (Letno-Isssledovatel'skii Institut- Flight Test Institute named after M M Gromov at Zhukovsky) and the VNIIRA (Vsesoyuznyy Nauchno-Issledovatel'skii Institut Radioelektroniki i Avtomatiki - All-Union Electronics and Automatic Equipment Research Institute) initiated the development of the 'Polyot' (Flight) unified navigation suite. The ground part of the system consisted of 'Svod' (Arch) and 'Doroga' (Road) azimuth-rangefinder radio beacons and a 'Katef (Cathetus) combined localiser/glideslope beacon. The on-board equipment included a navigational computer, an autopilot, a flight parameter measurement system, a combined navigation/IFF set and an antenna/feeder set. This system enabled the aircraft to follow a planned course, then return to base and make an automatic approach. It also gave inputs to other systems, triggering reconnaissance cameras etc.

The absence of the traditional single forward air intake meant that the fuselage could be shortened and the cross section and area decreased while still leaving enough internal volume for fuel. Instead, rectangular lateral scoop intakes with movable ramps for adjusting the airflow were used and proved to be very successful.

The trapezoidal wings with an unswept trailing edge were tested in the Central Aerodynamic and Hydrodynamics Institute (CAHI, often rendered in English phonetically as TsAGI -Tscentrainy Aerogiddrodynamichesky Institut) wind tunnel and found to have an adequate lift/drag ratio at speeds between Mach 2.0 and 3.0. The wing structure was relatively light weight, providing adequate fuel tankage.

The shoulder-mounted wing arrangement was selected because it tied in conveniently with the lateral air intakes and enabled the aircraft to carry large AAMs, which would have been impossible with a low wing arrangement. A mid-wing arrangement was ruled out for structural reasons. The high wing layout also permitted the use of a one-piece wing.

Early projects envisaged a tail unit with a single fin and rudder and canard foreplanes to augment the all-moving stabilisers for pitch control. Designing the main landing gear units proved to be tricky. A complex layout had to be developed in order to give a sufficiently wide track while still enabling the oleo legs and mainwheels to fit into a rather small space in the fuselage when retracted.

The 'Smerch' radar developed for the Tu-128 interceptor by a design team under F F Volkov was selected for the interceptor version as the most suitable among available fire control radars. The radar was specially upgraded for the Ye-155P by adding a 2cm waveband channel to increase resistance to 'jamming', the resulting version being designated 'Smerch-A'. It was larger and heavier than the 'OryoГ (Eagle) radar capable of tracking targets and guiding medium range R-8 missiles but offered greater detection range (up to 100 km/62.5 miles) with a scan azimuth of 120°. The 'Smerch' radar was developed for the initial production Sukhoi Su-15 'Flagon' which was originally fitted with the 'Oryol-D' version and later with the 'Oryol-DM'. The parabolic antenna dish of the 'Smerch' radar had a horizontal emission angle twice as big as that of contemporary Soviet airborne radars. The radar set was based on electron tubes, which suffered from poor reliability.

Originally the Ye-155P's armament was to have consisted of two (later four) K-9M missiles, which were a version of the K-9 adapted to be guided by the 'Smerch' radar instead of the TsP radar. As the design work progressed, the 'Molniya' (Lightning) design bureau led by M R Bisnovat proposed fitting the aircraft with their all-new K-40 missile. The K-40 had a titanium body giving a weight saving and better heat resistance at high Mach numbers and could have either dual-range semi-active radar homing (SARH) or infra-red (IR) guidance.

The latter version was very promising, since the Ye-155P was to destroy supersonic targets with a high IR signature. Heat-seeking missiles allowed the aircraft to attack the target from any angle. Besides, carrying a mixed complement of SARH and IR-homing missiles made the weapons system more proof against enemy countermeasures. A built-in cannon was also proposed but was eventually dismissed.

The interceptor version was to operate within the 'Vozdookh-1' (Air-1) ground guidance system - the first Soviet system of the kind to enter production. This system saw service with the air defence of the USSR and other Warsaw Pact countries for a good many years.

The reconnaissance version (Ye-155R) was to differ markedly from the Yakovlev Yak-25RV, Yak-27R and Tu-16R making up the backbone of the VVS reconnaissance force. The high flying subsonic Yak-25RV provided adequate intelligence but was becoming increasingly vulnerable. Att-empts had been made to create a high, altitude high speed reconnaissance vehicle which could penetrate enemy defences with impunity, but all of them proved unsuccessful. Thus the VVS showed a great interest in the reconnaissance version of the new aircraft and proposed its first equipment fit as early as in May 1960.

Defensive equipment comprised a cannon firing shells filled with chaff, ASO-2I chaff/flare dispensers, 'Zarevo' (Glow) infra-red countermeasures (IRCM) bombs, a 'Sirena-3' rear warning receiver (RWR), a 'Rezeda' (Mignonette) electronic countermeasures (ECM) package and an SRZO-2 'Odd Rods' IFF transponder. The avionics suite included an 'Initsiativa-2' ground-mapping radar, a 'Strela' (Arrow) Doppler speed and drift meter, a KSI route navigation system coupled with an STsGV gyro, a 'Svod' short range air navigation (SHORAN) set, a navigation data link system, an autopilot and a 'Put' (Track) flight director.

The navigation equipment was to work as an integrated system built around either an analog processor or a 'Plamya-VT (Flame) computer, one of the first Soviet digital airborne computers. This was to ensure a maximum course deviation of ±5km (3 miles), a target approach accuracy of 1-2km (0.625-1.25 miles) and determine airspeed and heading with a 0.5% error margin. Aircraft-to-ground communication was by means of an RSIU-5 VHF radio set.

Initially eight interchangeable reconnaissance suites were proposed :

- Version 1 comprised five cameras and an SRS-4A general-purpose signals intelligence (Sigint) pack. The cameras included three AFA-44s, two of which were mounted obliquely and one vertically, and two AFA-42s with a limited film capacity for covering the entire route.
- Version 2 was fitted with four AFA-45 cameras, one AFA-44 and two AFA-42s for oblique and plan view photography and also carried the SRS-4A Sigint pack.
- Version 3 carried an ASchAFA-5 or ASchAFA-6 slot camera for continuous shooting, working in a way similar to a movie camera, plus one AFA-44 and two AFA-42s. A 'Bariy-1' (Barium) TV system could also be fitted.
- Version 4 was intended for topographic reconnaissance. It carried an AFA-41 camera on a TAU mounting, one AFA-44, two AFA-42s and the 'Bariy-1' TV system.
- Version 5 was configured for night reconnaissance with two NAFA-MK or NAFA-100 night

cameras. It carried 12 FotAB-100 flare bombs or 60 FotAB-MG flares for target illumination and could also be fitted with the SRS-4A Sigint pack.

- Version 6 was another night reconnaissance aircraft fitted with a NAFA-Ya-7 camera coupled with a 'Yavor-7' (Sycamore) airborne flash unit and the SRS-4A Sigint pack.
- Version 7 was to carry thermal imaging equipment.
- Version 8 was a dedicated electronic intelligence (Elint) aircraft equipped with SRS-4A, SRS-4Band 'Romb-3' (Rhombus) general-purpose Sigint packs and a 'Koob-3' (Cube) pack for more detailed Sigint.

All versions could be fitted with an FARM photo adapter, an MIZ-9 tape recorder and an optical tracker. Some avionics items were optional. For example, the 'Put' flight director could be replaced with a 'Priboy' (Surf) FD, the RSIU-5 radio with a 'Pero' (Feather) or 'Lotos' set. The reconnaissance version could be equipped with 'Looga' and 'Polyot' navigation aids. The SRS-4A and SRS-4B Sigint packs were meant to be easily interchangeable. In general, the range of reconnaissance equipment proposed for the Ye-155R was much the same as that carried by contemporary Soviet combat aircraft.

The reconnaissance suite originally proposed was promptly criticised as inefficient. In March 1961 the VVS came up with a specific operational requirement for the Ye-155R. The range of 'targets' (or objectives) included missile launch pads, ammunition depots, naval bases and harbours, ships, railway stations, airfields, C^3I (Command, Control, Communications and Intelligence) centres, bridges and vehicles, both soft-skinned and armoured. The equipment suite was specified more clearly and had now to meet more stringent requirements. Now the location of small targets such as bridges had to be pinpointed with a 100-150m (330-500ft) accuracy; for large targets (large factories etc) the error margin was 300-400m (990-1,300ft). Intelligence was to be transferred via data link within three to five minutes after passing over the target.

The navigation suite comprised: a SHORAN set based on the RSBN-4N 'Doroga' beacon; KSI route system; 'Privod' (Drive) marker beacon receiver; airspeed and altitude sensors; 'Strela-B' Doppler speed and drift meter; automatic navigation system (ANS) central navigation computer and a 'Polyot' autopilot. The system was to operate with an error margin of 0.8-1% in areas devoid of landmarks, ensuring target approach with a maximum deviation of 200-300m (660-990ft) and landmark following with a maximum deviation of 500-1,000m (1,640-3,280ft).

The VVS also asked the Mikoyan bureau to consider fitting the aircraft with the 'Puma' radar - developed for the early versions of the Su-24 'Fencer', the FARM-2 adapter for taking pictures from the radar screen, a camera programming module and an RV-25 radio altimeter. The 'Droozhba' (Friendship) radar intended for Pavel Vladimorivich Tsybin's ill-fated RS (or NM-1) supersonic reconnaissance aircraft was proposed as a possible alternative to the 'Puma'. In a nutshell, the VVS proposed three basic reconnaissance versions: a photo-intelligence (Photint) and general purpose Elint version, a detailed Elint version and a radar imaging version.

The Photint/Elint version was to carry an SRS-4A or SRS-4B Sigint pack (with quick-change capability) and seven interchangeable camera sets intended for:

- high altitude general day reconnaissance
- high altitude detailed day reconnaissance
- low level day reconnaissance
- topographic day reconnaissance
- high altitude night reconnaissance
- medium-altitude night reconnaissance
- low level night reconnaissance.

The detailed Elint version was fitted with a 'Koob-3' centimetre- and decimetre-waveband sideways looking airborne radar (SLAR) and a 'Voskhod' (Sunrise) metre-waveband SLAR. he third version had an 'Igla' (Needle) SLAR and a TV system based on the 'Bariy' set. Air-to-ground communication in each case was provided by a 'Prizma-2' HF radio and an RSIU-5 VHF set coupled to a 'Lira' (Lyre) cockpit voice recorder.

This proposal needed a lot of changes. The designers did some homework and pointed out that the chances of getting through enemy air defences at medium altitudes would be practically nil. With no clouds to hide it from view between 10 and 20km (32,800 to 65,600ft), the Ye-155R would be a sitting duck. Thus, the principal mode would be high altitude supersonic flight; this in turn necessitated an increase the focal length of the cameras.

In 1961, the creation of a 'mother ship' carrying a drone which could be fitted with a limited number of equipment suites was suggested. However, this idea was quickly discarded. (Shades of the SR-71/D-21 combination.)

In the late 1950s, the Krasnogorsk Optics and Machinery Plant developed an unparalleled design - the AFA-70 four-lens camera. It comprised two modules with asymmetrical optical axes. The design was heavily influenced by N Beshenov and Yu Ryabushkin, the two chiefs of the design group.

Another group, under 0 V Uspenskiy, produced two versions of the SAU-155 automatic control system (SAU-155R for the reconnaissance version and SAU-155P for the interceptor). An equally interesting piece of equipment, the 'Peleng' (Bearing) navigation complex, was devised by the Ramenskoye Instrument Design Bureau under S V Zelenkov. Besides taking care of navigation, it allowed automatic and semi-automatic flight along a pre-set route (working in conjunction with the SAU-155) and provided inputs for the reconnaissance suite.

The 'Peleng' system was to include an inertial navigation system (INS), corrected by a Tropic' pulse-phased hyperbolic navigation system designed by the Leningrad Electronics Institute and a digital main computer based on the 'Plamya' unit, developed by the Elektroavtomatika design bureau under P A Yefimov and VI Lanerdin. The Ye-155 was the first aircraft of its class to carry a digital computer linked to the automatic flight control system. After considering the merits and shortcomings of analog and digital processors, the designers opted for digital as more lightweight, reliable and precise.

The OKB also gave some recommendations as to the reconnaissance, ECM and communications suites. On 20th January 1962 a unique joint order was issued by the State Committees for Aircraft Technology, for Electronics and for Defence Materiel, concerning the equipment to be fitted to the Ye-155. The order was signed by the chairmen of the three committees and by the Chairman of the High Economic Council.

Layouts and Projects

Meanwhile, preliminary design work on the Ye-155P interceptor and the Ye-155R reconnaissance aircraft proceeded apace. A series of configurations was tried and discarded before the design was finalised; these included unconventional layouts with 'swing' or variable geometry (VG) wings and lift engines. Three versions of wing structural design were contemplated, two of them being rejected upon failing the stringent static tests. The reconnaissance version was originally to have a crew of two, with a navigator's station in the nose; this was discarded later, giving way to additional Elint equipment. Among the layouts considered at the early design stage were:

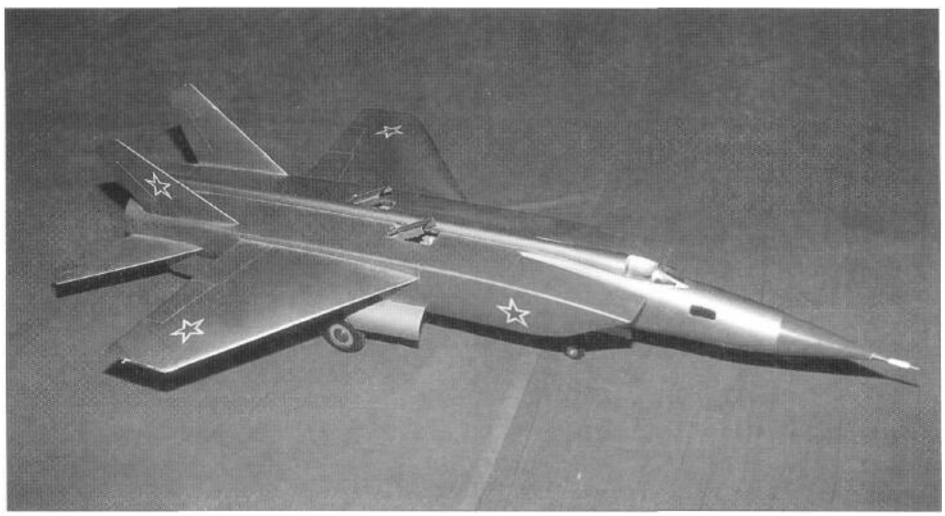
Ye-155R high altitude, high speed VG reconnaissance aircraft

In one of the preliminary design studies the Mikoyan OKB attempted to marry the MiG-25 to a VG wing. Besides having a swing-wing, the aircraft differed in having a crew of two - a navigator's station with small rectangular lateral windows was located in the nose ahead of the pilot's cockpit. The shape of the wings and horizontal tail was reminiscent of the General Dynamics FB-111A tactical bomber. At maximum sweepback the wing panels combined with the stabilators effectively formed a delta wing, improving the aircraft's speed capabilities. At minimum sweep, manoeuvrability, endurance and especially short field performance were improved considerably.

This arrangement further increased the aircraft's maximum take-off weight (MTOW). Besides, the Ye-155R was intended for high speed and high altitude photographic reconnaissance and Elint duties, and good manoeuvrability was of little use to it. Nor was short take-off and landing (STOL) performance called for, as the aircraft was to operate from standard airstrips. Finally, the navigator was deemed unnecessary and a single-seat configuration was adopted for the reconnaissance version, so the swing-wing two-seater was abandoned.

Model of the proposed Ye-155R variable geometry reconnaissance version. Yefim Gordon

Open covers reveal the position of the staggered lift-jets on the Ye-155R 'STOL Foxbat' project. Yefim Gordon



Ye-155N high altitude, high speed missile carrier

In 1961 OKB-155 considered developing a version of the basic Ye-155 capable of carrying a strategic air-to-ground missile. The project was designated Ye-155N (Noseetel - 'carrier', or mother ship). Depending on whether the aircraft was to carry a pure ballistic or an aero-ballistic missile the OKB was to co-operate with the Moscow Thermal Equipment Institute or the 'Raduga' design bureau respectively. The idea of a MiG-25 toting a ballistic missile was soon put on hold. However, two attempts to revive it were made in the late 1970s.

Ye-155RD reconnaissance drone carrier (project)

As work progressed on the Ye-155R reconnaissance version, the general belief was the main reconnaissance mission profile that would be high altitude supersonic flight since the aircraft stood little chance of avoiding air defences at medium altitude. However, the medium altitude reconnaissance mission had to be fulfilled. Therefore, the Ye-155RD reconnaissance version was evolved in 1961 in parallel with the Ye-155N missile carrier.

In lieu of a missile the Ye-155RD was to carry an expendable reconnaissance RPV for close-in work. This would be released at a safe distance and glide towards the target in adverse weather. Even before it reached the target area the 'mother ship' would complete its reconnaissance run, then make a U-turn and pick up intelligence from the RPV via a data link. A recoverable RPV was also contemplated; after making its reconnaissance run it would escape to the recovery zone at low level.

The RPV could be configured with four different equipment packages, including day cameras, night cameras, low level television (LLTV) and SLAR. The 'mother ship' could also carry three different equipment fits for day photographic reconnaissance, general and detailed photo-recce and Elint. The drone carrier was also abandoned.

Ye-155R high speed reconnaissance aircraft with auxiliary lift engines

In contemplating possible configurations of the Ye-155 project the Mikoyan designers tried making use of the small RD36-35 turbojet developed in the Rybinsk engine design bureau under Kolesov. The engine was a lift-jet intended to improve the field performance of combat aircraft.

In the early 1960s, work on the MiG-23 multi-role tactical fighter was proceeding in the Mikoyan OKB in parallel with the Ye-155 programme. One of the projected versions of the MiG-23, designated Izdelye (product) 23-01, made use of lift-jets installed in the fuselage. To test the feasibility of this combined powerplant, a production MiG-21 PFM was converted into a technology demonstrator called Izdelye 23-31. (See the companion volume *MiG-21 'Fishbed'* by Yefim Gordon and Bill Gunston, published by Aerofax). The strengths and weaknesses of the combined powerplant concept were not yet fully studied at the moment, and it was then that this concept was applied to the Ye-155R.

The RD36-35 lift-jets were located almost vertically on both sides of the fuselage spine with the port group being shifted slightly relatively to the starboard one (two locations were considered). The engines breathed through intakes with aft-hinged covers which closed flush with the fuselage topside in cruise flight.

Like the swing-wing version, the 'STOL Foxbat' had a crew of two, with the navigator sitting ahead of the pilot in a compartment with small rectangular windows. In general, the lift-jets were of little use to the reconnaissance mission. They reduced range appreciably as they decreased the internal fuel volume - hence the STOL version was dropped as impractical.

Ye-155Sh attack aircraft

A dedicated low-level ground-attack version - the Sh suffix standing for shturmovik, the classic Russian 'assaulter'. Since the Ye-155 was ill-suited for low altitude missions, the project was quickly discarded.

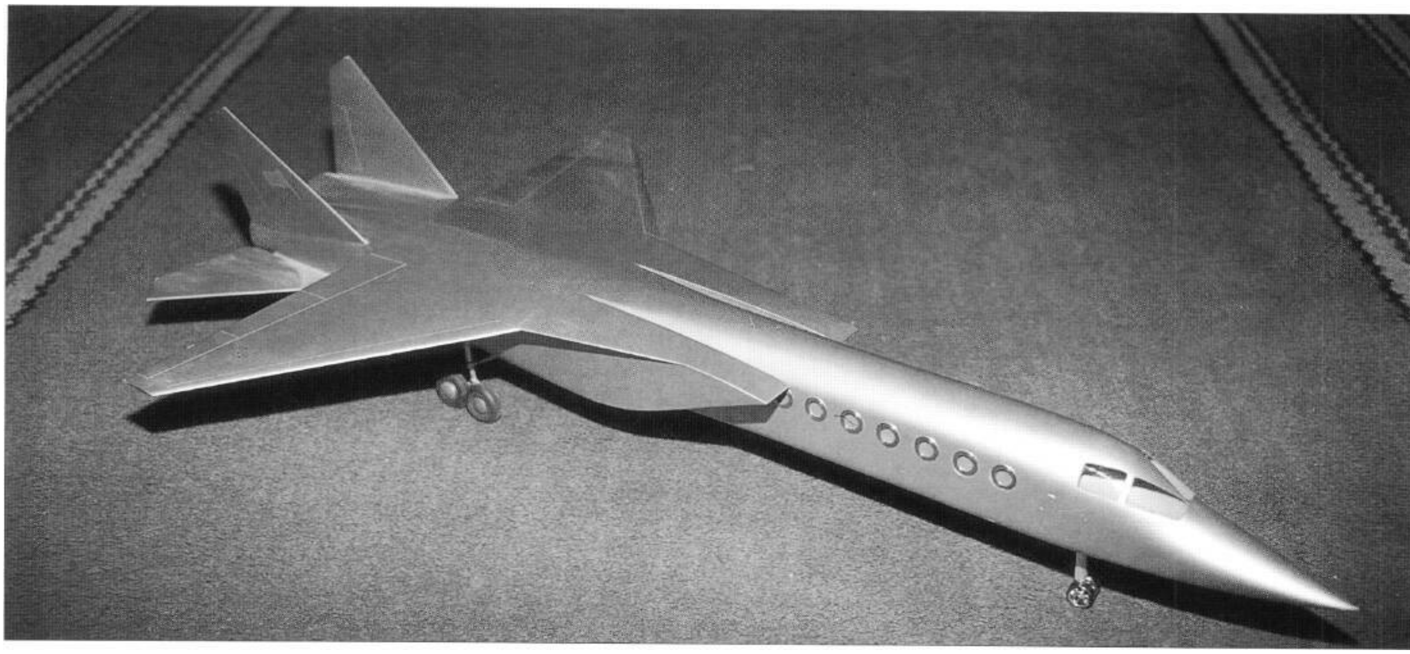
Ye-155ShR attack/reconnaissance aircraft

A proposed dual-role version optimised for ground-attack and low altitude reconnaissance duties. Like the versions described above, it never got off the drawing board.

Supersonic business jet

Perhaps the most unusual and unlikely of the many spin-offs of the Ye-155 design was a proposed business jet derivative. Preliminary design work on this aircraft started in 1963 and continued well into 1965. The aircraft was to carry five to seven passengers or 700-1,000kg (1,543-2,204lbs) of cargo and be capable of operating from second class (unpaved) airstrips.

The idea came first as a proposal addressed to the OKB's leaders. These approved the idea and gave the go-ahead for a more detailed project. The Soviet Air Force also showed some



interest, but generally the designers worked on the 'biz-jet' at their own risk, as what their Western counterparts would term a private venture.

The main thrust of the project was ensuring maximum commonalty with the existing fighter. In effect, only the forward fuselage was all-new, being much longer and wider. Behind the flight deck was a passenger cabin with one-abreast seating for six and an aisle, with an entry door on the port side immediately aft of the cockpit. The cabin could be converted into a cargo hold by removing the seats. The wider fuselage necessitated an increase in the fuel load in order to extend the range to 3,000-3,500km (1,875-2,178 miles) at a cruise speed of Mach 2.35 (2,500km/h, or 1,562mph). The relatively short range, limited usage of the aircraft and the large amount of design work needed all conspired against the 'Foxbat biz-jet' and the project was abandoned.

This was probably the world's first SSBJ design. Interestingly, the Sukhoi 0KB combined with Gulfstream of the USA in 1988 to produce a 10/12 passenger SSBJ using the OKB's extensive fighter technology and design capacity, but this was abandoned by 1992.

Advanced Design Stage

The PD stage was followed by the advanced design stage where various design aspects and systems could be dealt with in detail. At this stage, the interceptor's MTOW grew, approaching that of the reconnaissance version. Mikoyan pressured his design team into completing the advanced design stage in six months. In 1962 a mock-up commission convened to inspect the Ye-155R, since the prototype of the reconnaissance version was to be built first.

The aircraft was a twin-engined shoulder-wing monoplane with twin tails. An integral welded steel fuel tank holding more than 10 tons (22,000lbs) of fuel formed the centre fuselage; additional fuel was carried in wingtip tanks. This huge quantity of fuel was necessary for prolonged flight at high Mach numbers. The forward fuselage housed radar and reconnaissance equipment, the engines being located in the aft fuselage. Large rectangular air intakes with movable horizontal ramps flanked the fuselage, a feature that was later used on both Soviet and Western combat aircraft. The twin-engined configuration was selected on account of the aircraft's large weight.

Calculations showed that a single fin and rudder could not provide adequate directional stability, except by making the fin overly large. Therefore, twin tails slightly canted outwards were used, augmented by ventral strakes on the aft fuselage and small fins at the wingtips.

The selection of suitable structural materials was a singularly important issue. The immense kinetic heating at high Mach numbers ruled out aluminium alloys. The fuselage and wing centre section were designed as a huge fuel tank. In theory, they could just as well be made of aluminium alloy, since they would be cooled by fuel and would only be subject to dangerous overheating after fuel burn-off. However, in this case the structure had to be riveted and sealed with special heat-resistant sealants which were lacking in the USSR.

It seemed the only alternative was titanium. Or was it? Titanium was difficult to machine and had the annoying tendency to crack after it was welded. That left steel, which could be welded without undue problems and, incidentally, obviated the need for special sealants and the labour-intensive riveting process. The automated welding methods developed by Ye O Paton were widely used in various branches of industry, especially in weaponry production.

The engineers had their share of doubts about using steel. Many of them believed that the welded integral tanks would be incapable of absorbing the flight loads and crack after each landing. Fortunately, numerous static tests showed that this was not true.

The supersonic business jet development of the MiG-25 airframe. Design work, largely as a private venture, started in 1963 but was abandoned in 1965. Yefim Gordon

Indeed, the choice of materials was perhaps the worst problem facing the engineers. Plexiglass, for one, could not be used for the cockpit canopy because of the high temperatures. Existing hydraulic fluids would decompose and tyres and other rubber parts become hard and brittle in these conditions.

In early 1962 the Central Committee of the Communist Party of the Soviet Union and the Council of Ministers of the USSR issued another directive, ordering the construction of several prototypes, specifying general operational requirements, construction and test commencement schedules, the order of co-operation with other design bureaux and the amount of state financing. After that, specific operational requirements (SORs) for the two versions were drawn up. In September 1962, the State Commission for Defence Industry finalised the equipment suite to be fitted to the reconnaissance version. The SOR for the interceptor version was signed on 15th June 1963.

Many equipment items were put through their paces on various test-beds. Earlier, the only systems development aircraft used by OKB-155 had been engine test-beds and those for testing RPV equipment. With the advent of the Ye-155 this range was vastly increased. The Ye-150, Ye-152 and Ye-152M helped refine the R15B-300 turbojet. Two Tu-104 (ASCC reporting name 'Camel') airliners were converted into electronics test-beds for the 'Peleng' navigation suite, the 'Anis' (Aniseed) INS, the 'Strela' Doppler airspeed/drift indicator, the receiver for the Tropic' navigation system and the main digital computer (of which several versions were tested). Another Tu-104 and one of the two Tu-110 'Cooker' airliner prototypes were converted into test-beds for the 'Smerch-A' (ASCC 'Fox Fire') radar and SARH guidance system for the R-40 missile respectively. The long pointed radome replacing the Tu-104's glazed nose gave rise to the nickname 'Buratino' (Pinocchio). A MiG-21 fighter served as test-bed for the 'Polyot' navigation system.

The LII and the design bureaux developing equipment for the Ye-155 had an important part in performing these tests and analysing their results. The assorted test-beds of the Ye-155 programme served on for a considerable time, tests continuing even as the first prototypes were being flown. A V Lyapidevskiy, the one-time Polar aviation pilot and first Hero of the Soviet Union (HSU), and Minayev made themselves prominent in creating the test rigs and test-beds (Minayev was later appointed Mikoyan's deputy in this area).

Besides the Mikoyan OKB, a variety of organisations had a hand in making the Ye-155 fly. These included: Ramenskoye Instrument Design Bureau; State Aircraft Systems Research Institute (GosNIIAS - Gosudarstvennyi Nauchno-Issledovatel'skii Institut Aviatsionnyikh Sistern); Moscow Instruments Research Institute; Avionika Scientific & Production Association; Voskhod engine design bureau; Kursk industrial automation design bureau; Soyuz engine design bureau; VNIIRA; Pal'ma Scientific and Production Association; AH-Union Technology Research Institute; State Radio Communications Research Institute; Moscow Radio Communications Research Institute; the optical and mechanical equipment plants in Kazan and Krasnogorsk; the Ekran plant in Samara (then Kuybyshev); Detal design bureau in Kamensk-Ural'skiy; Mars engine design bureau; TsAGI; AH-Union Aviation Materials Institute (VIAM); Central Aero Engine Institute (TslAM) and many more.

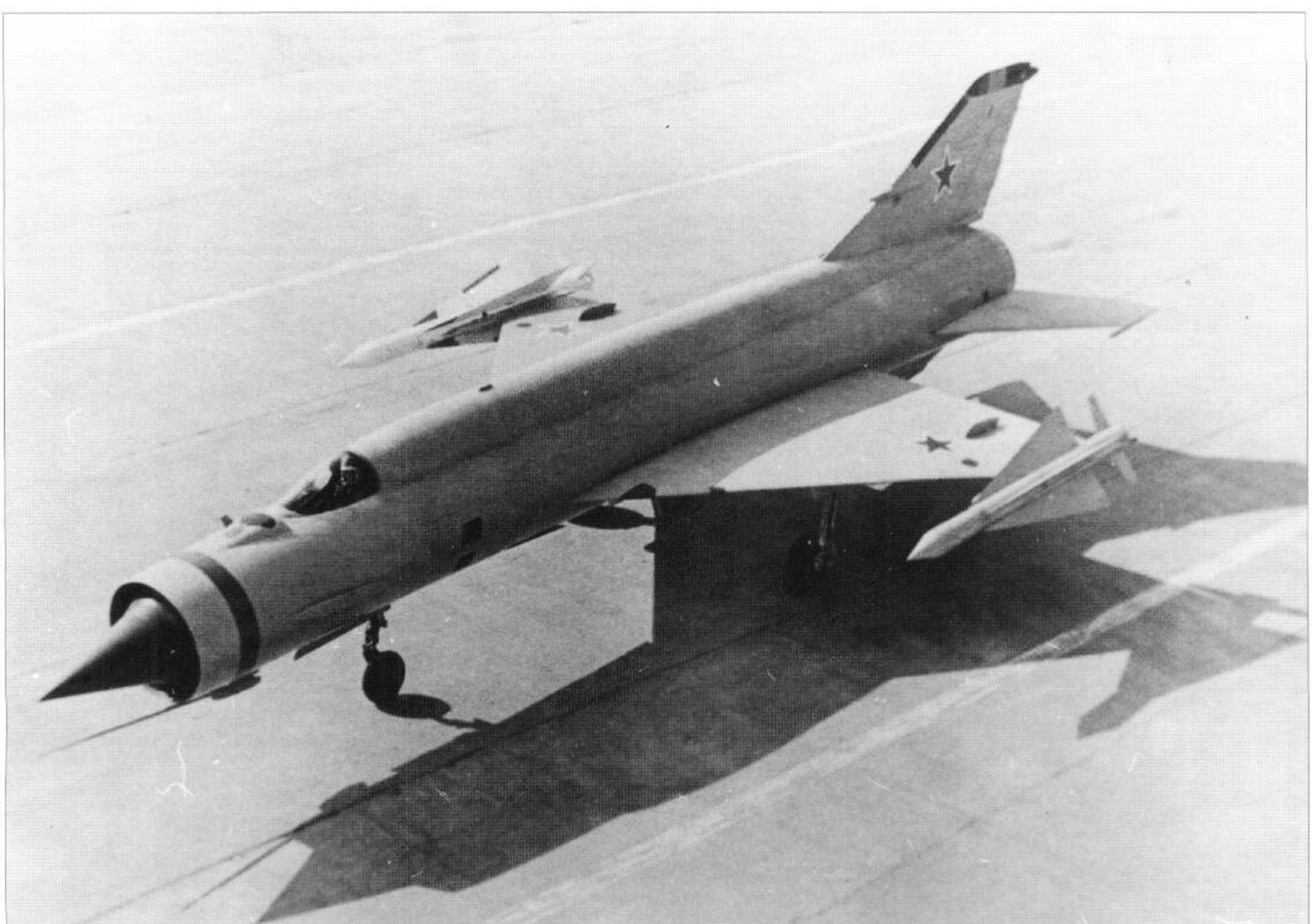
Metallurgical institutes and specialised labs produced new brands of high-strength heat-resistant stainless steel, titanium and aluminium alloys (the latter for use in relatively 'cold' areas of the airframe). Tools and jigs for casting, extruding, welding and assembling parts made of these alloys were developed. Tests were run to determine the behaviour of various alloys during welding, their propensity to cracking during heating-cooling cycles and the compatibility of primary and secondary structural materials. The crystallisation laws in welding were studied, resulting in methods of controlling crystallisation when alloys with different properties were welded. The Gorkii aircraft factory (Plant No.21), a long-standing manufacturer of MiGs which was earmarked for production of the Ye-155, began upgrading its workshops to cope with the newtechnologies.

Mikoyan and Belyakov, who succeeded Gurevich as First Deputy General Designer, handled all matters concerning the Ye-155. Besides, the design team under project chief Matyuk included his deputy P Ye Syrovoy (responsible for technical documents development) , Minayev, V A Arkhipov (lead engineer of the first prototype) and the chiefs of some other sections of the Mikoyan OKB.

A sizeable contribution was made by the State Committee for Aircraft Technologies (later renamed Ministry of Aircraft Industry) and its Chairman (later Minister) P V Dementyev, as well as by the VVS and PVO commanders.

Meanwhile, the Gorkii aircraft factory was getting ready for full scale production. New technologies of working with heat-resistant alloys and composites had to be mastered, welding and thermal treatment of major airframe assemblies had to be automated. The Soviet aircraft industry was poised to jump its own hurdle by creating the fastest third-generation combat aircraft. Work on the Ye-155 prototype and technical documents proceeded at a fast rate, and by late 1963 the first prototype was largely complete.

Final development of the MiG Ye-152 series was the 'P (also known as the Ye-152M) which further gave rise to the similar and record-breaking Ye-166. Yefim Gordon archive



All the King's Horses

Designated Ye-155R-1, the first prototype was rolled out at the Zenit Machinery Works (as the Mikoyan OKB and its experimental factory were euphemistically referred to at the time) and trucked to the flight test base at Zhukovsky in December 1963. It had taken a whole year to complete the aircraft which represented the reconnaissance version but carried a rather incomplete equipment fit, lacking reconnaissance cameras, ECM gear, 'Peleng' long range aid navigation (LORAN) and RSBN short range air navigation (SHORAN) systems, high frequency (HF) radio set and automatic route following system.

It further differed from production aircraft in having zero wing incidence, smaller vertical tails and no yaw dampers on the rudders.

Two 600 litre (132 Imp gallon) non-jettisonable fuel tanks were fitted to the wingtips, doubling as anti-flutter weights. Small trapezoidal fins were attached to the aft portions of the tanks from below and slightly canted outwards. These increased longitudinal stability while decreasing lateral stability, ie they had the effect of an inverted wing. Mathematical analysis and wind tunnel tests showed that these 'inverted winglets' made up for the zero incidence of the wings. It was also believed that they could enhance the aerodynamic efficiency of the wings (though later tests showed that this belief was wrong).

Like other MiG-25 prototypes, the Ye-155R-1 had removable panels on the sides of the air intakes. These were provisions for movable canard surfaces meant to enhance pitch control at high Mach numbers. (The idea was dropped later in the test phase and the canards were never installed.) The first prototype was intended for initial flight testing, refining the aerodynamic layout, checking the manual control system and certain other systems.

By the time the aircraft received its engines, the R15B-300 turbojets had been uprated to 11,200kg (24,691 lb st). The prototype was light grey overall, with extensive use of matt black on the nose. The unusual four-digit tactical number 'Red 1155' (ie, first prototype of the Ye-155) was carried under the cockpit canopy in large numerals.

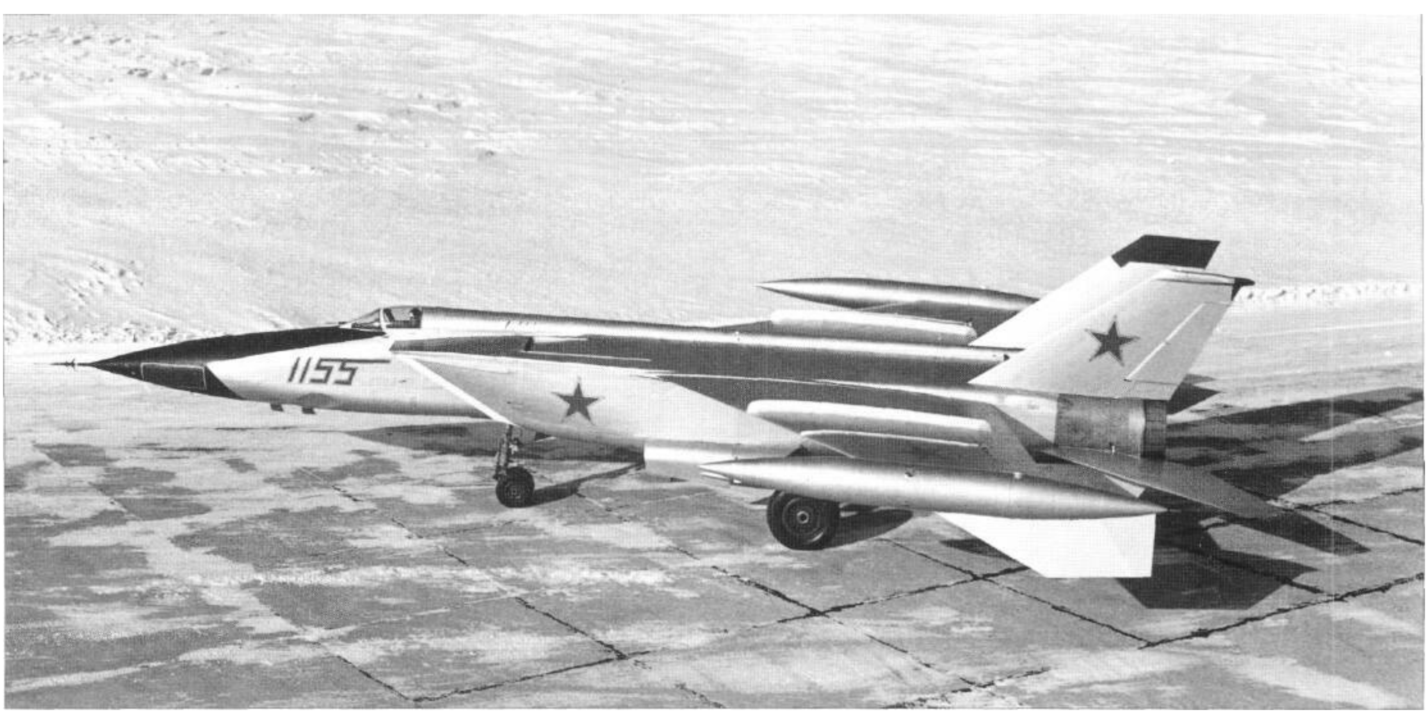
The aircraft was prepared for its first flight under the auspices of V A Arkhipov, engineer-in-charge, and his assistant L G Shengelaya. Besides the general designer (ie, OKB chief) and the chief project engineer, the test programme was monitored by G A Sedov and K K Vasil'chenko of the flight test section.

Ground checks and systems tests proceeded until the spring of 1964. Data recorders were installed and hooked up to the aircraft's systems, and the necessary paperwork was completed. Finally, on 6th March, the Ye-155R-1 took to the air for the first time - it being flown by Aleksandr V Fedotov who had superseded Georgiy K Mosolov as chief test pilot after Mosolov suffered an accident in the Ye-8. Thus commenced the 'Foxbats' factory tests. Soon afterwards, Pyotr M Ostapenko joined the test programme. Along with Fedotov he bore the brunt of the early test flying.

At subsonic speeds all went smoothly. But as transonic tests began an immediate problem arose. At transonic speeds the prototype would start banking sharply, which could not be countered even by full aileron deflection. As a temporary remedy, the pilots devised a special tactic, initiating a slow roll in the opposite direction before going transonic. As the aircraft slipped through the 'sound barrier' the bank angle decreased automatically, even though the pilot tried to prevent it.

The Mikoyan OKB was familiar with this phenomenon, having encountered it on earlier aircraft with more sharply swept wings - the MiG-15 'Fagot', the MiG-17 'Fresco' and the MiG-19 'Farmer'. However, on these types lateral control was regained as the speed grew.

'Red 1155', the Ye-155R-I poses for official photographs at Zhukovsky. On 6th March 1964 this, the prototype 'Foxbat' was flown for the first time, at the hands of Fedotov. MiG OKB



The message was clear enough - the Ye-155 needed modifications.

The next snag encountered was excessive wing vibration caused by fuel sloshing to and fro in the wingtip tanks as it was burned off. The problem was solved by the simple expedient of eliminating the tanks.

A spate of problems surfaced at near maximum speed. The aircraft's static stability deteriorated as speed grew; the afterburners tended to flame out at high altitude, increasing fuel consumption and decreasing the service life of the engines and other mechanisms located in the aft fuselage due to excessive vibration. A so-called 'mist' - plainly visible boundary layer turbulence in the air intakes - appeared at high Mach numbers and high angles of attack (or 'alpha'), increasing drag and vibration and spoiling the intake's characteristics.

Fuel consumption during climb was rather greater than anticipated. So was the maximum take-off weight (MTOW), both of which caused the first prototype's range to fall short of the target figure.

In 1965 the second prototype was completed it was also a reconnaissance aircraft and hence designated Ye-155R-2. This allowed the scope of the flight test programme to be extended appreciably. Unlike the first prototype, the Ye-155R-2 lacked wingtip tanks. Meanwhile, the Gorkii aircraft factory was preparing to commence production of the aircraft. Soon two interceptor prototypes joined the test programme (these will be described separately) to speed up the 'debugging' of the airframe, engines and avionics. Principal avionics ^nd weapons systems were tested on the Tupolev Tu-104, Tu-110 and MiG-21 mentioned in Chapter Two. Letno-Issleovatel'skii Institut (LlI - the Zhukovsky flight test institute) and Nauchno Issledovatelyskii Institut (NiI -the Air Force Scientific and Research Institute at Akhtubinsk) test pilots started flying the MiG-25 prototypes, as did pilots from the Gorkii factory.

Problems of varying complexity and urgency had to be dealt with during the early tests. Among these it was found that heat-resistant paints were required, as ordinary paint would be so blackened after a few high speed flights that the colour of the national markings became indiscernible. A high-reflectivity, heat-resistant grey paint was specially developed for the 'Foxbat'. Suitable black and white paints were also selected.

The Voenno-vozdushniye Sily (VVS - Air Forces of the USSR) was generally pleased with the Ye-155's performance during the factory tests which comprised about 200 flights. The aircraft's speed and altitude ranges had been determined and the engineers succeeded in attaining adequate stability and controllability.

Pre-production Aircraft

Since the state acceptance trials programmes developed for the reconnaissance and interceptor versions of the Ye-155 differed considerably, it was decided that the two versions would be tested in parallel by separate teams. Each version was to make several hundred flights before it could be found satisfactory and taken on strength.

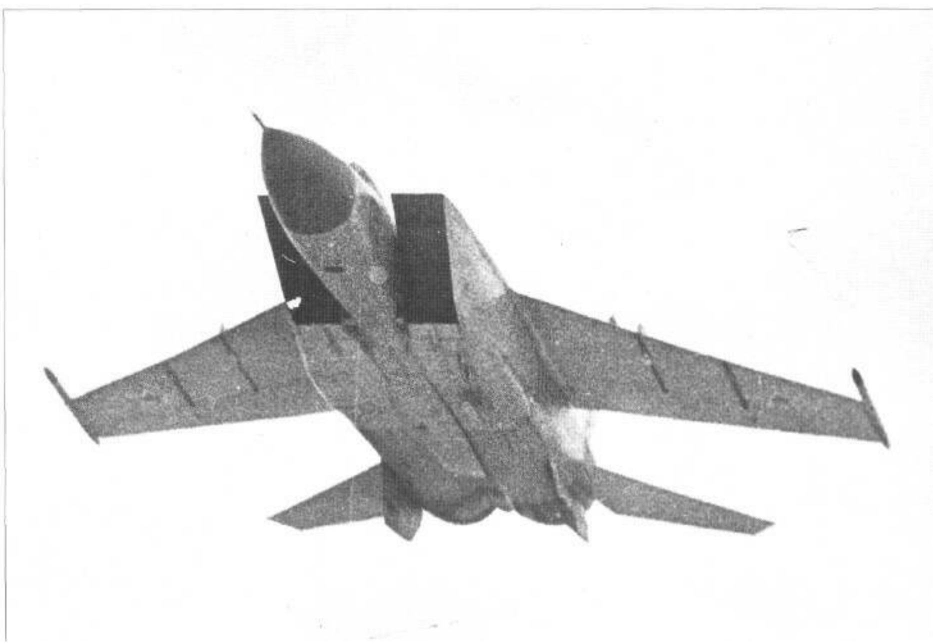
More prototypes were needed to expedite tests. However, the Mikoyan bureau's experimental plant in Moscow was not in a position to produce more Ye-155s, as it was about to start building the MiG-23-01 and MiG-23-11 'Flogger' prototypes. Therefore, it was decided to build pre-production batches of both MiG-25 versions at the Gorkii factory. This, in turn, brought about a re-equipment of the plant. This involved a lot of disruption but paid off by shortening the transition period to full scale production of the type.

Another view of the prototype amid Zhukovsky's snow. Yefim Gordon archive

Mikoyan with test pilots Mosolov and Fedotov pose, with others, in front of the Ye-166 (Ye-152M). Yefim Gordon archive

Pre-production interceptor and reconnaissance 'Foxbats' started rolling off the Gorkii line before the end of 1965. The third reconnaissance prototype, Ye-155R-3, 'Red 3155', was the first to come. It carried a complete camera and avionics fit and was intended for testing various daylight camera arrangements.

Quite a few changes based on input from the early flight tests of the Ye-155R-1 were incorporated into the third prototype. The wingtip tanks were replaced by anti-flutter weights in slender cigar-shaped fairings (sometimes referred to as 'balance booms'). The wings were set at 2° incidence. The fins were taller and had the tips cut off at an angle, not horizontally as on the first prototype; this necessitated a relocation of the aerials housed in the dielectric fintip fairings. The forward fuselage had structural changes made in order to permit the installation of reconnaissance equipment. Finally, the third prototype carried an enormous ventral drop tank holding 5,300 litres (1,166 Imp gallons), more than half as long as the aircraft itself. Never before had such huge reservoirs been carried externally by Soviet aircraft.



'Red 3155' was the first of the pre-production batch, it was destined to test daylight camera arrangements.

The Ye-155P-5 interceptor prototype.

Front view of the Ye-155R-3 showing the huge ventral tank. All Yefim Gordon archive

The joint state acceptance trials (ie, for both versions of the aircraft) were carried out chiefly by Nil VVS at the institute's test centre in Akhtubinsk. The Nil VVS test team under Colonel Roomyantsev included project chief test pilot Colonel Aleksandr S Bezhevets and military engineers B Klimov, V Tokarev and A Klyagin. The latter was responsible for evaluating the combat efficiency of the Ye-155.

The designers and engineers responsible for the aircraft's systems were to find out how the boundary layer, shock waves and vibrations affected the quality of pictures generated by the cameras, whether airframe heating and cooling cycles made the camera port glazing excessively brittle, if heat from the aircraft's skin affected the cameras, whether glass heated to 250°C would distort the pictures etc. Any one of these questions could pose a problem, significantly impairing the resolution of the long range cameras with a focal length ranging from 750 to 1,200mm ($29^1/_2$ to 47% in). The designers had every reason to be apprehensive. On the Yakovlev Yak-27R 'Mangrove' the cameras mounted in the bomb bay had a resolution of only about ten lines to a millimetre, three times lower than in static ground conditions.

To find the answers to these questions a comprehensive research programme was arranged. It included temperature and vibration measurements in the camera bay and flights over a special test range near Serpukhov in the Moscow region with accurate navigation using geodetical markers. The cameras' field of view was divided into four zones by glueing on special glass squares of varying thickness, imitating four lenses with different focal lengths; this helped to select the lens giving maximum picture sharpness. To ensure a stable thermal environment the camera was placed in a special capsule in which a pre-set temperature (between 35°C and 50°C) was automatically maintained. The cameras incorporated rods made of a special alloy called 'Invar' with a thermal expansion quotient equal to that of glass, meant to reduce dangerous tensions in the lenses.

Fortunately, the tests showed that the designers had no reason to worry about the quality of the pictures. In flight, the lenses offered a resolution of about 30 lines/millimetre. In practice, at 20km (65,616ft) the A-72 and A-70M cameras had a resolution of 30cm (11%in) and 40cm (15^3/iin.) respectively, with a contrast quotient of 0.4.

Engineer V K Khomenko suggested a flexible attachment for the optically flat camera port glass, which eliminated tensions in the glass caused by heating. This and the location of the cameras in the nose, so that they 'fired' through a relatively thin boundary layer with no appreciable turbulence to distort the picture, helped to complete the camera tests successfully. A carefully selected flight mode (at flight level 20km, airspeed in excess of Mach 2.35) and the Ye-155's relatively rigid airframe ensured an acceptable vibration level. Later, photography at subsonic speeds and lower levels was successfully tried. The A-70M and A-72 cameras gave acceptable results at altitudes of 6km (19,685ft) and 10km (32,800ft) respectively with no need for adjustments.

The A/E-10 topographic camera designed by the 'Peleng' design bureau in Minsk and the SRS-4A/SRS-4B Sigint packs were put through their paces with no major complications. The SRS-4A pack was capable of detecting centimetre and decimetre waveband radar. Its aerials were located on the forward fuselage sides. After being picked up, the enemy radar signal was amplified, classed by frequency, converted and recorded by a photographic registrator unit. The interchangeable SRS-4B pack differed only in the range of detectable frequencies.

The Ye-155R-3 was flown by Mikoyan test pilots A V Fedotov, P M Ostapenko, Boris A Orlov, O Goodkov, A Kravtsov, A Bezhevets, Igor Lesnikov and others. It was on this aircraft that the greater part of the test program for the reconnaissance version was completed.

The second pre-production machine, designated Ye-155R-4, represented the 'production standard' configuration and was also built in Gorkii. The aircraft served for performance testing and reconnaissance suite calibration. Several new items were also tested on this machine - namely the 'Peleng-S' and 'Polyot-1Г navigation systems, several interchangeable liquid-cooled electronic countermeasures (ECM) pallets and the 'Prizma' HF radio set. A Ya Ischchenko was in charge of this aircraft.

The test programme lasted several years, during which the prototypes made several hundred flights. Finally, in 1967 the State Commission signed the Act of Acceptance for Stage A (ie, preliminary) tests of the reconnaissance version and recommended the aircraft for production.

Toughest part was the testing of the 'Peleng-S' and 'Polyot-1 Г navigation systems, the latter consisting of an inertial navigation system (INS), a 'Strela' Doppler airspeed/drift meter and an 'Orbita' digital computer. (The Ramenskoye Instrument Design Bureau assigned a representative, G N Burov, to these tests.) The former system did not cause too many problems, but a good many flights were necessary to check out the various operation modes, obtain statistical data and make adjustments (eg, to the autopilot gear ratios). The latter system, however, turned into a 'can of worms', as the navigation computer proved very unreliable and needed debugging.

If the designers had chosen to go by the book, the 'Polyot-1 Г would be turned down as not meeting the Air Force's reliability criteria. Gregoriy A Sedov, Shengelaya, Vasil'chenko, A V Minayev (Mikoyan OKB), S V Zelenkov, V S Magnusov (Ramenskoye Instrument Design Bureau), VI Lanerdin and R A Shek-lovsipyants (Elektroavtomatika Design Bureau) managed to persuade the VVS that reliability could be improved in service conditions - and were later proven right. The need for a new reconnaissance aircraft was so dire that A A Pol'skiy, chief of the Avionics Test Department, made the risky but correct decision to clear the Ye-155R for production with the controversial 'Peleng-S' suite. The State Commission was not even put off by the crash of the third pre-production aircraft, Ye-155R-5, during its acceptance flight in Gorkii on 30th August 1965, in which test pilot LI Minenko was injured.

A total of four development reconnaissance aircraft participated in the factory and state acceptance trials. The fourth, Ye-155R-6, was stationed at the Mikoyan OKB's test base in Zhukovsky (at the LII). One more airframe was completed for static testing. Finally, in late 1969, the State Commission under Major General Seelin, the Soviet Air Force's reconnaissance chief, signed the Act of Acceptance and the reconnaissance version entered production as the MiG-25R.

Interceptor Prototypes

The first prototype of the Ye-155P interceptor was completed in Moscow in the summer of 1964 and made its first flight on 9th September at the hands of test pilot Ostapenko. It was basically similar to the Ye-155R-3 (all the refinements introduced on the first pre-production reconnaissance aircraft were incorporated into the interceptor prototype). However, the nose section was different. The 'camera case' nose of the Ye-155R gave way to an ogival radome which housed the 'Smerch-A' fire control radar - or, rather, was to house (the radar set and dish were replaced by test instrumentation on the first prototype). The two outboard pylons (the inboard ones did not appear until later) carried mock-ups of K-40 missiles painted bright red, and a small data link aerial, part of the test instrumentation, was mounted under the forward fuselage.

The second prototype, the Ye-155P-2, was also built in Moscow the following year and was almost identical to the Ye-155P-1, right down to the lack of radar. The only visible difference was the data link aerial repositioned to the centre fuselage underside. The Ye-155P-1 was used to complete the greater part of the factory trials and also claimed a few world records. The two prototypes took almost no part in the state acceptance trials.

Pre-production Interceptors

Even as the factory trials of the two interceptor prototypes progressed it was obvious that the aircraft had record breaking potential. A major effort was launched to develop the state acceptance trials programme jointly with VVS and Protivoozdushnaya Oborona (PVO - Air Defence Forces) 'top brass'.

The programme took rather a long time to get the official go-ahead. The complexity of the new interceptor system and the stringent demands of the military (the PVO wanted kill probability statistics, navigational accuracy data etc) meant that more test flights than usual were needed. This, in turn, called for more prototypes and an extended flight test period.

A new approach to test flight planning was needed. Problems arose with procuring the necessary test instrumentation. One major issue was safety during live missile launch trials, especially when the aircraft and the target drone closed in head-on at supersonic speed. The missile would blow the drone apart and the debris scattered in an area hundreds of miles long and dozens of miles wide, which was much larger than the affordable area of the firing ranges.

The pre-production batch intended chiefly for state acceptance trials consisted of nine aircraft, designated Ye-155P-3 through to 'P-11. These aircraft, too, carried test instrumentation - either in a ventral pod or in lieu of certain avionics items (radar etc).

The 'Smerch-A' radar developed for the Ye-155 differed slightly from the original RP-S 'Smerch' as installed on the Tu-128 (see Chapter One). (RP-S-Radiopritsel'Smerch', Tornado' radio sight.) Later on, when the MiG-25 entered production, the radar was designated RP-25 ('Radio sight for MiG-25').

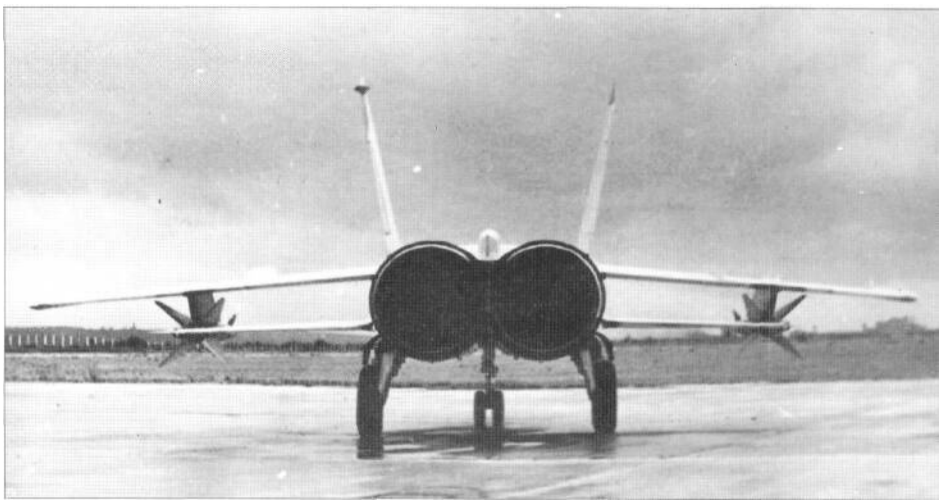
After the first few test flights, the joint state acceptance trials, by MiG, VVS and PVO, began in November 1965 as directed by the Defence Industry Commission. These included Stage A, general flight tests, and Stage B, testing and evaluating the interceptor weapons system. The State Commission was headed by twice Hero of the Soviet Union (HSU) Air Marshal Yevgeniy Yakovlevich Savitskiy, deputy Commander-in-Chief (C-in-C) of the PVO.

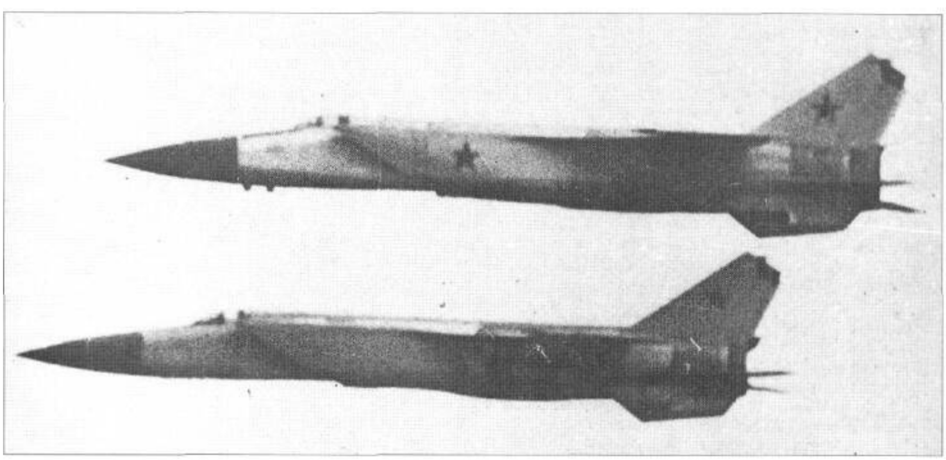
Before long the nine aircraft were completed and six of them turned over for flight testing. In the pre-production batch (Ye-155P-5 through to Ye-155P-11) most differed from the earlier ones in having triangular vertical surfaces mounted at the wingtips. These surfaces, dubbed 'webbed feet' because of their shape, incorporated anti-flutter weights and were meant to improve directional stability when the aircraft carried a full complement of missiles. Unlike the two prototypes, the pre-production aircraft could be fitted with four underwing missile pylons.

The first pre-production interceptors commenced test flights in 1966, with others joining the programme as they became available. The six aircraft participating in the state acceptance trials (the Ye-155P-3, 'P-4, 'P-5, 'P-6, 'P-10 and 'P-11) operated from the Nil VVS test centre in Akhtubinsk most of the time. The remaining three were operated by the Mikoyan bureau and based at Zhukovsky.

All development interceptors were built in the cramped old assembly building of the Mikoyan experimental plant. Each aircraft had to be tilted as it was rolled out in order for the fins to clear the low door of the workshop.

The Ye-155P-3 was the first to have the 'Smerch-A' radar; however, as on the next two aircraft, the radar installation was incomplete. Not until the sixth pre-production aircraft (the





The first interceptor prototype, the Ye-155P-1, carrying two missile mock-ups.

Rear view of the Ye-155P-1.

The Ye-155P-1 (with red stars) with the Ye-155P-*2* make a fly-by at Domodedovo, July 1967.
All Yefim Gordon archive

Ye-155P-6) was a complete equipment suite installed.

On 9th July 1967, three of the development interceptors took part in a flypast during an airshow in Moscow's Domodedovo airport together with the Ye-155R-3. All four were flown by Nil VVS pilots taking part in the state acceptance trials since the Mikoyan test pilots were otherwise engaged. Lesnikov and Gorovoy flew the first and second prototypes respectively, G B Vakhmistrov was at the controls of the Ye-155P-5 ('Red 05' without the endplate fins, a special feature for the display), while VI Petrov flew the reconnaissance machine. All three interceptors carried conformal ventral containers with test instrumentation between the engines. During rehearsals before the actual event one of the Ye-155s was replaced by a standard MiG-21 F-13 'Fishbed'.

Stage B of the Ye-155P's state acceptance trials was split into two halves. The first ended in 1968, resulting in a tentative go-ahead for full-scale production. The second half was completed in 1969; during this stage the test aircraft made 161 flights at Akhtubinsk and 51 flights at Zhukovsky. A further 116 flights were made to calibrate the aircraft's systems and simulate missile launches, with the tenth and eleventh development aircraft posing as 'targets'. The latter two aircraft were also used to train regular VVS pilots.

Besides the interceptor prototypes, several support aircraft took part in the trials programme. These included the three Tu-104 navigation systems and radar test-beds, the Tu-110 missile guidance system test-bed, a MiG-21 US 'Mongol' trainer and a Sukhoi Su-9 'Fitter' interceptor, all converted into avionics test-beds; and an Ilyushin 11-14 'Crate' command relay and guidance aircraft. Various ground equipment and simulators were also used. In addition to some of the Ye-155Ps, a number of Su-9s, MiG-17 and MiG-21 fighters, Yak-25RV reconnaissance aircraft and Tu-16 'Badger', Tu-22 'Blinder' and Il-28 'Beagle' bombers served as targets during simulated missile launches.

In all, 1,291 test flights were made in Akhtubinsk, including 693 for the state acceptance programme (including 353 'official' flights). During live missile launch tests, 105 missiles were fired at 33 assorted target drones - Il-28M (Mishen - literally 'machine', but in this context 'drone' or 'target'), M-21 (a MiG-21 conversion), Tu-16M, Yak-25RV-II, KRM (Krylataya Raketa-Mishen - [anti-shipping] cruise missile target [conversion]). Eight more target drones were destroyed during other trials. The development interceptors based at Zhukovsky made 170 flights, the mixed bag of support aircraft making some 600 flights in all.

Some design deficiencies were discovered during tests - and they were discovered the hard way after some fatal crashes. For example, when the pilot pulled 5g during a manoeuvre, the wingtips were deflected up to 70cm (2ft Sin) from normal position, which could result in aileron reversal and loss of control. Rather than change the wing design, the designers imposed a Mach 2.83 speed limit on the MiG-25.

Controllability remained inadequate, and breaking the Mach 2.83 speed limit could cause serious problems for the pilot or even prove fatal. Test pilot Lesnikov, one of the participants of the Domodedovo flypast, crashed in the first interceptor prototype on 30th October 1967, while trying to set a time-to-height world record. On 26th April 1969, PVO aviation commander General Anatoliy L Kadomtsev made his first flight in the Ye-155P-11 - it was also to be his last. Shortly after take-off one of the engines disintegrated, the resulting fire burned through hydraulic lines and the uncontrollable aircraft dived into the ground, killing the pilot.

On 28th April 1970 the interceptor version passed the state trials and was cleared for production, notwithstanding the crashes. The Act of Acceptance was signed by VVS C-in-C Marshal P S Kutakhov, PVO C-in-C P F Batitskiy, ministers P V Dementyev, V D Kalmykov, S A Zverev and Bakhirev and approved by VVS Deputy C-in-C (Armament) A N Ponomaryov. Belyakov signed the Act on behalf of Mikoyan. The Act said: The S-155 aircraft/missile interceptor system generally meets the requirements of the Central Committee of the CPSU and the Council of Ministers of the USSR. As compared with other interceptor systems in service with the PVO it has better command and control capabilities at high and medium altitude, better jam-proofness, radar detection range and missile launch range and more modern avionics enabling it to operate in adverse weather conditions'.

In 1971 the interceptor entered production as the MiG-25P. By then, quite a few changes had been introduced. The aerodynamic efficiency was improved, the fins were enlarged and recontoured, the ventral strakes likewise recontoured. Wing incidence was increased to 2°, the triangular endplate fins were deleted and differentially movable tailplanes were introduced. The service durability of the integral fuel tanks (ie, their resistance to cracking during normal heating and cooling cycles) was increased to an acceptable level and a technique developed for repairing (welding) hairline cracks in service conditions.

The rudders were modified and special dampers added to the hinges. The landing gear was modified after a case of inter-crystalline corrosion on Ye-155P-3 which caused a main gear leg to fail when the aircraft was refuelled and left overnight. The engines' electric starters were replaced by an auxiliary power unit (APU) and the automatic electric engine controls improved.

The reliability of many avionics and electronic equipment items, including the radio altimeter and the 'Romb-1K' signals intelligence (Sigint) pack, was improved. The radar set had an increased output and was less sensitive to jamming and clutter (at low level). A wave conductor link was established between the radar and the missiles' semi-active infra-red homing (SARH) warheads to keep them 'in tune' with the radar until launched. The SAU-155 automatic flight control system (AFCS) was also refined.

These modifications increased the MiG-25's indicated airspeed (IAS) to 1,300km/h (812.5 mph). Several issues concerning intercept tactics, flight safety and test data processing were resolved and steps taken to improve serviceability and ease of maintenance.

Generally the aircraft met the government's main requirements as to the types of target, practical and dynamic ceiling, maximum speed, intercept range, kill probability, g limits, radar and missile launch range, scramble time etc. It also partially met the requirement to be able to use dirt strips (the MiG-25 could not use them in spring and autumn when the surface was soft because with full fuel and ordnance the load on the main gear units was too great). The required systems mean time between failures (MTBF) and mission preparation time were yet to be reached.

Air force test pilots Petrov, Kazaryan, Gorovoy, Kuznetsov, Stogov, V A Mikoyan and OKB test pilots Fedotov and Orlov signed the pilot evaluation section of the Act.

This section said, among other things: The aircraft's performance is much higher than that of existing interceptors. The powerful engines enable it to quickly reach high speeds and altitudes. The aircraft is equipped with a modern navigation suite and automatic flight control system which enhances its capabilities as compared to existing interceptors.'

The Act of Acceptance contained the following conclusions based on the test results:

'1 The aircraft is capable of following a pre-set route and making an automatic landing approach down to 50m.

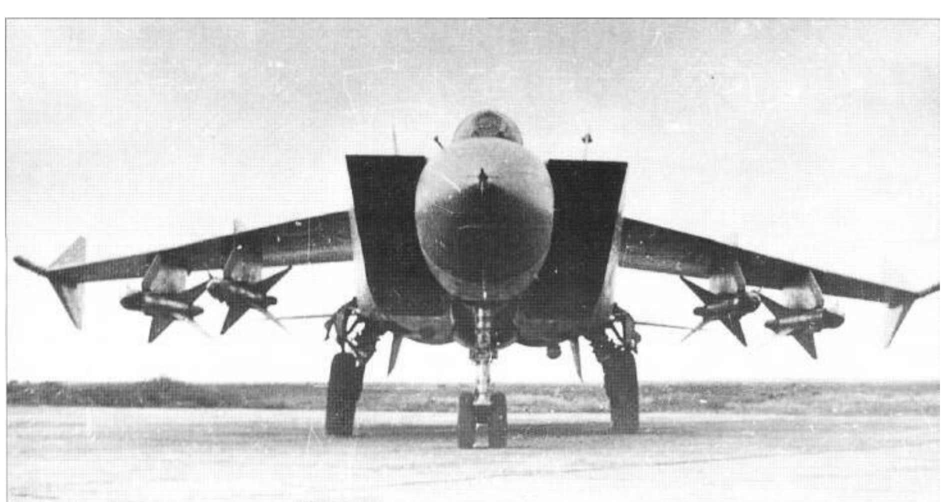
2 Piloting techniques at subsonic speeds are quite similar to existing interceptors, except for high stick forces in the pitch channel. Take-off and landing is easy.

3 The aircraft can be mastered by pilots with flying experience on contemporary interceptors after taking a transition course.'

The Acts of Acceptance for the reconnaissance and interceptor versions were the culmination of many years' hard work of the Mikoyan bureau, the factories and test personnel, especially the pilots. Leading engineers Polyakov, Novikov, Slobodskiy, O Ryazanov, Proshin, Ischchenko, Solodun, Syrovoy and Schcheblykin were highly commended in the Acts.

Upon completion of the tests some of the development aircraft were transferred to service units so that the new MiG could become operational more quickly.

An incident which occurred in late 1970 proved the MiG-25's superiority to contemporary Soviet interceptors. A group of high-ranking VVS officers arrived at an air base to take proficiency training. The final flights were to be at night and under instrument flight rules (IFR) conditions. Four MiG-25s and three Su-15



Third of the pre-production batch, the Ye-155P-5 displaying full missile load and the distinctive 'webbed feet' at the wingtips.

Front view of the Ye-155P-5.
Both Yefim Gordon archive

One of the first production MiG-25Ps, 'Blue 83'. Yefim Gordon

'Flagons' took off. Immediately afterwards the weather deteriorated sharply; as a result, only the MiG pilots were able to find the runway and land successfully. All three Su-15s lost their way and crashed, killing the pilots.

Record Breakers

The Ye-155 prototypes claimed an impressive series of world records which clearly testified to the aircraft's enormous potential and the high class of Soviet test pilots. They took the aircraft beyond the limits originally set for it, and these record-breaking flights yielded invaluable information for the designers as to what their brainchild was actually capable of (short of killing the pilot). The Ye-155's record series resulted in unique data on the aircraft's stability and controllability, engine operation in supersonic flight at low IAS, airframe heat resistance during prolonged flight at Mach 2.75 to 2.83, the functioning of life support systems at altitudes in excess of 35km (114,830ft), that is 10-12km (32,800-39,370ft) higherthan the design ceiling, etc.

The aircraft's unique performance, the availability of highly skilled pilots (notably Fedotov) and engineers and the LII's trajectory tracking capabilities all contributed to the impressive number of records (29 in all) set by the future MiG-25. The records were set by development aircraft with minimum modifications, such as the addition of an oxygen bottle for high altitude flights. Most flights were preceded by much calculation (optimum trajectories, heat dissipation figures etc) using computers. Engineer Yu S Vygodskiy made major contributions to selecting the correct trajectories.

According to the Federation Aeronautique Internationale (FAI) classification the Ye-155 belonged to the C1 (III) class, ie, jet-powered landplanes with unlimited MTOW.

The absolute world records, seven in all, were especially impressive. These included altitude, speed over a closed circuit and time-to-height for altitudes of 20km and higher. The Ye-155 was the first to set a time-to-height record for a 35km altitude. The aircraft's remarkable speed and ceiling, excellent stability and controllability and high thrust-to-weight ratio were all contributing factors.

The absolute speed records were set on a 3km (1.875 mile) stage at low level (not more than 100m/328ft) or on a 15-25km (9.375-15.625 mile) stage with a variance in altitude not exceeding 100m. Absolute world speed records over a closed circuit were set on circuits 100; 500; 1,000; and 2,000km long (62.5; 312.5; 625; and 1,250 miles respectively), maintaining a constant altitude over the entire circuit. The length of the triangular circuit was measured by adding up the lengths of the three sides, so in reality the distance covered by the aircraft was slightly greater, demanding a higher speed.

The closed-circuit flights entailed high g loads and sharp bank angles, the aircraft and pilot being subjected to these flight modes for considerable periods. On the 100km circuit, for instance, flight at 4g and 75° bank angle totalled about 2.5 minutes. Total time on the 500km circuit was about 10 minutes and twice as much on the 2,000km. During this time the aircraft experienced peak thermal loads.

One year after the Ye-155's first flight, the FAI received official documents from the USSR claiming that on 16th March 1965, pilot Fedotov set world speed records with payloads of 1 and 2 tons (2,204 and 4,409lbs). The aircraft in question was given as a 'Ye-266 powered by two R-266 turbojets'. These spurious designations, however, left no doubts as to the origin of the aircraft and powerplant - the engines' stated thrust (10,000kg/22,045lb st) was the giveaway. Western experts knew that several years earlier the FAI had registered a number of world records set by the Ye-166 (which was actually a specially modified Ye-152 heavy interceptor, see Chapter Two), powered by an R-166 turbojet with an identical rating.

Thus, it was clear that the aircraft was designed by Mikoyan and the engines by Tumanski. And the subject of the claim - an average speed of 2,319.12km/h (1,449.45mph) over a 1,000km (625 mile) circuit - was but a taste of things to come.

Whatever doubts the West may have had about the MiG-25's capabilities were dispelled when the type made its first public appearance at the 1967 Domodedovo flypast. No photographs or other information had been published before. The aircraft's appearance showed clearly that the new MiG was a potent piece of hardware.

The performance displayed by the development aircraft during trials made it possible to set more world records. Three months after the sensational flypast, Mikoyan test pilot Mikhail M Komarov averaged 2,982.5km/h (1,864mph) over a 500km (312.5 mile) closed circuit. The same day, Fedotov took a 1,000kg (2,204lb) payload to an altitude of 29,977m (98,349.7ft). These impressive records gave the Western world a clearer idea of the new MiG's performance.

The prototypes' test flights continued for some considerable time even after the MiG-25

became operational with the VVS. A new spate of speed, altitude and time-to-height records followed in 1973. On 8th April Fedotov attained an average of 2,605.1km/h (1,628.1 mph) on a 100km (62.5 mile) closed circuit. The difficulty of sustaining a high speed on a short course accounted for the lower result than on the 1,000km course.

On 4th June 1973, Orlov climbed to 20,000m (65,616ft) in 2 minutes 49.8 seconds. The same day, Ostapenko reached 25,000m (82,021ft) in three minutes, 12.6 seconds and 30,000m (98,425ft) in four minutes, 3.86 seconds on the same aircraft.

Moreover, the same aircraft was used to set new altitude records. Reaching the aircraft's dynamic ceiling in a zoom climb demanded considerable courage and skill from the pilots. On 25th July 1973, Fedotov made two sorties, achieving remarkable results. With a 1,000kg payload he reached 35,230m (115,584ft) - 5,253m (17,234ft) better than his own result of 1967 - and 36,240m (118,897.6ft) with no load - an absolute world record. The aircraft moved by inertia over a substantial part of the trajectory after the engines flamed out in the thin air of the stratosphere. At the highest point the IAS dropped to a mere 75km/h (46mph), which was five times lower than the minimum set in the flight manual. The mission was complicated by very limited allowable elevator inputs, the need to follow the predefined trajectory very closely, and extremely high angles of attack (AoAs or 'alpha') and vertical speeds (300-400 km/h = 187-250 mph).

Until recently, information on what aircraft were actually used to set the records was classified information. Now it is known that these were the Ye-155R-1, Ye-155R-3 and Ye-155P-1 prototypes with some equipment removed to cut empty weight. The Ye-155R-3 survived and is currently on display in the Soviet Air Force Museum in Monino near Moscow as 'Red 25'. Visitors who are familiar with the MiG-25 will immediately notice a curious discrepancy: the aircraft has *both* the camera ports characteristic of the reconnaissance version and the missile pylons of the interceptor! The pylons were added erroneously after the aircraft was put on display.

Early Production MiG-25P (Izdelye 84, ASCC 'Foxbat-A')

The pre-production batch built by the Gorkii aircraft factory and intended for state acceptance trials was followed by an initial production run. These were the first aircraft to be officially designated MiG-25P, or Izdelye 84 (Product or item 84) as the type was coded at the plant. The first production MiG-25Ps were almost identical to the development interceptors - they had the old vertical tails and ventral fins and sported endplate fins at the wingtips.

The Lockheed SR-71 Blackbird, a strategic reconnaissance aircraft with remarkable speed and altitude capabilities, was completing its flight test programme at the time. The MiG-25P was the only real means of countering the Blackbird threat; therefore, the PVO top command wanted major industrial centres and important military bases, especially in the eastern and northern regions of the USSR, to be protected by MiG-25Ps.

In 1969 the first production aircraft were delivered to the PVO Fighter Weapons School and one regular interceptor unit based near Gorkii in order to train pilots and ground crews and refine combat tactics. This initial delivery was effectively for service test purposes. The convenient location of the interceptor unit allowed spares to be delivered quickly. Factory

Early production MiG-25P '06' used for test work.

Operational 'Foxbat-A' taxies past an L 29 Delfin. Both Yefim Gordon archive

specialists could be summoned fast if the need arose, and crew training could be organised at the factory airfield. The servicing manuals were still far from perfect at the time, some structural details and equipment items needed redesigning, and the technical staff grew increasingly vocal in their complaints. The pilots were more tolerant, though they, too, had their share of trouble mastering the aircraft.

This was a singularly important point in the aircraft's career as the service tests were completed and the MiG-25P achieved initial operational capability. During the service tests, live missile launches were made at the Nil VVS test range. For the first time R-40 missiles were fired successfully at targets in the aircraft's forward and rear hemisphere flying at 20,000m and speeds of up to 2,700km/h (1,687.5mph). This proved that the MiG-25P was actually capable of intercepting and destroying the SR-71. In general, the service tests went well and the 'bugs' that came up were quickly ironed out.

Late Production MiG-25P (Izdelye 84)

In 1971 the MiG-25P entered full-scale production at the Gorkii aircraft factory. The basic production version differed from initial production aircraft in having enlarged fins with an area of 8m^2 (26ft^2) each, redesigned ventral strakes and wing anhedral increased to 5°. These changes made it possible to delete the triangular endplate fins at the wingtips.

The 'Smerch-A1' radar (otherwise know as the RP-25 or Izdelye 720) and the K-10T sight were the main elements of the weapons control system. The radar could search and track targets either autonomously or using ground inputs relayed via the 'Vozdookh-1' command line. After that, target lock-on, aircraft guidance towards the launch point and data feed to the missiles' warheads occurred automatically.

The weapons load consisted of four R-40 missiles (Izdelye 46, ASCC AA-6 'Acrid')): two with SARH guidance (R-40R, or Izdelye 46R) and two with infra-red (IR) guidance (R-40T, or Izdelye 46T). The missiles were carried on underwing pylons, one of each kind under each wing.

The MiG-25P was fitted with the 'Lazur' (Prussian Blue) command link system and the 'Polyot-1 Г flight control system which automated flying a great deal. The command link system was connected with the radar and target acquisition system, enabling the aircraft to be directed to the target area automatically or semi-automatically. The flight control system provided automatic climb and acceleration to a pre-set speed and autostabilisation around all three axes, maintained a constant speed and altitude, and limited g loads and alpha.

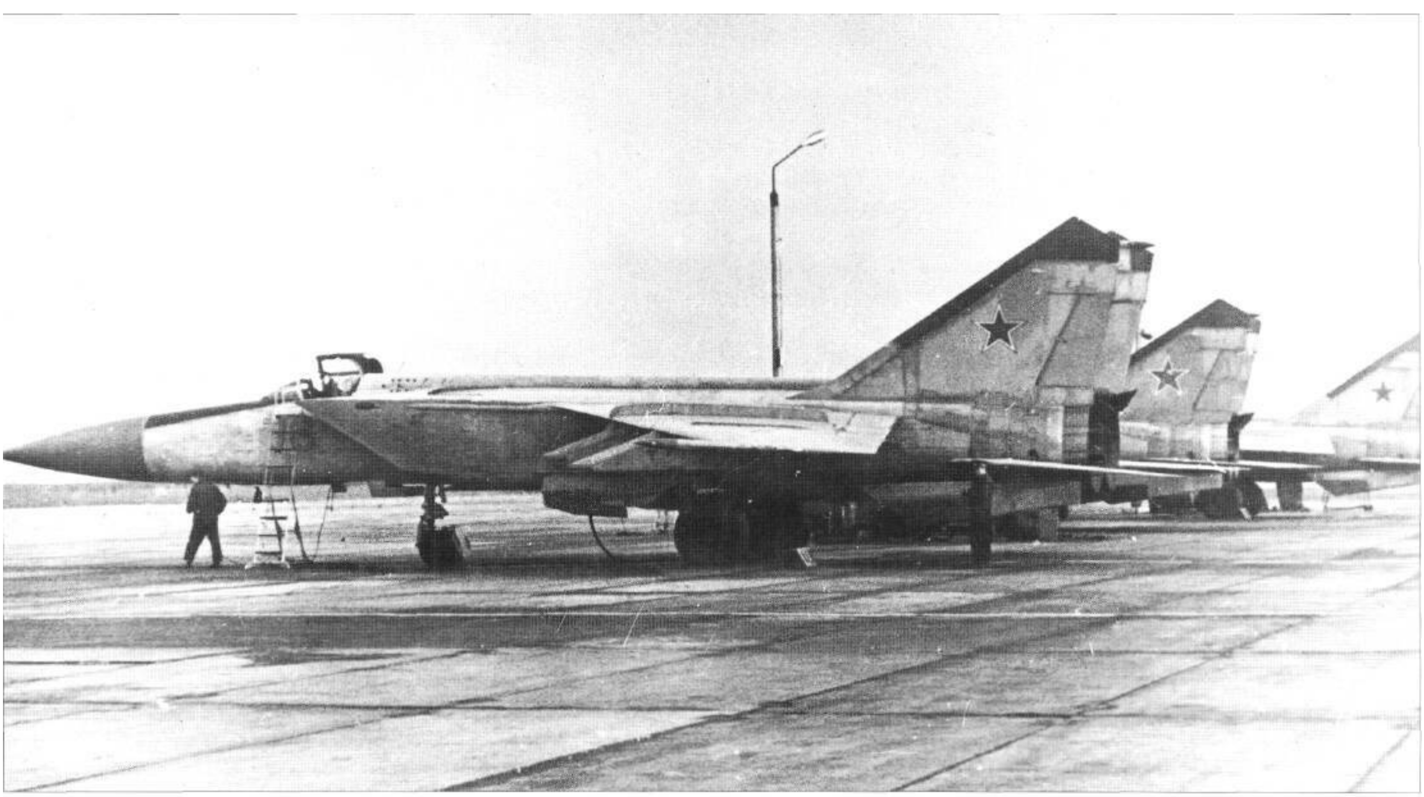
Besides the radar and sight, the avionics suite included an identification, fried orfoe (IFF) set (an SRO-2M transmitter and an SRZM-2 receiver) mounted on the starboard fin, a 'Sirena-3' radar warning receiver (RWR) with antennas located at the top of the starboard fin and in the anti-flutter weight fairings at the wingtips, an RV-UM (RV-4) low-altitude radio altimeter, and ARK-10 radio compass, an MRK-56P marker beacon, an SP-50 instrument landing system (ILS) receiver, an RSBN-6S SHORAN set, R-832M and 'Prizma' radios and SAU-155P1 automatic control system.

The MiG-25P differed from the reconnaissance version in having a large ogival dielectric nose cone (instead of the MiG-25R's conical metal nose with camera ports), marginally greater wing span and a kinked wing leading edge. Early production aircraft had a KM-1 ejection seat allowing safe ejection at up to 1,300km/h (812mph). Later this was replaced by a KM-1 M seat with an extended operational envelope. Unlike the reconnaissance version, the interceptor did not have provision for a drop tank.

The aircraft's structural strength and thrust-to-weight ratio enabled it to reach high indicated airspeeds. The main limiting factor was inadequate aileron efficiency. Lesnikov's fatal crash on the Ye-155R-1 proved it, since it was caused by exceeding the IAS limit by a considerable margin while trying to set a world record. Yet, as the Act of Acceptance pointed out, an increase in IAS could make the interceptor a more effective weapon.

A way of improving controllability at high IAS had been successfully tried on the MiG-23 fighter in the late 1960s. It involved differentially movable stabilisers and an additional control actuator. Differential stabiliser deflection was the main means of roll control at high speed.

This feature was also introduced on the 'Foxbat' and was tested successfully, showing good roll control characteristics at up to 1,300km/h (812mph), ie 200km/h (125mph) better than the original aircraft. Production MiG-25s also had differentially movable stabilisers. A series of fatal accidents then followed at speeds around 1,000km/h (625mph) which puzzled the designers and the Air Force mightily.



Headed by '76', a line-up of MiG-25Ps.
Yefim Gordon archive

PVO Fighter Weapons School pilot Maystrenko was the first to be killed, crashing at Kubinka air base on 30th June 1969 while practising for a flying display. The aircraft rolled over on its back and dived into the ground during a low level pass over the airfield. The Mikoyan 0KB immediately set to work searching for the cause of the crash but inspection of the wreckage showed no mechanical failures. Various theories were tried, from wind shear to pilot error. But then, reports of brief roll control failures started coming in from MiG-25 units. Several years later, an experienced Air Force test pilot named Kuznetsov lost his life in similar circumstances. Pilot Kolesnikov had a near-accident as well.

To find the reason a special flight test programme was initiated by LII and performed by Oleg Gudkov, one of the most experienced test pilots. A MiG-25 was fitted with test instrumentation and telemetry equipment, and special safety precautions (altitude limits) were taken.

However, the latter proved insufficient. On 4th October 1973 Gudkov managed to detect the flight mode leading to loss of control at high speed but it was too late to eject. At 500m (1,640ft) the aircraft started rolling uncontrollably and crashed into a textile factory warehouse in Ramenskoye not far from the airfield, killing the pilot. It was the purest luck that no one was killed on the ground, except for a dog sitting in the sidecar of a police motorcycle when the policeman stopped on hearing the sound of the diving jet.

This time the cause of the crash was found. It turned out that the stabilator actuators were not powerful enough to counteract the torque when stabilator deflection exceeded a certain angle since the tailplane hinges were located well aft, leading to overcompensation. To correct this, the hinges were moved forward by 140mm (55in), extending the actuator arm. Within six months all MiG-25Ps in service with PVO units were updated.

The first PVO units to receive the MiG-25P were stationed near Moscow, Kiev, Perm, Baku, Rostov and in the North and Far East. Overhaul facilities were set up at Nasosnaya air base near Baku and at the existing military aircraft overhaul plant in Dnepropetrovsk.

Generally, service introduction went well, though of course there were incidents - sometimes unique ones. On one occasion a young pilot stationed in Kotlas took off to intercept a target drone. While manoeuvring to get a lock on the target, he rolled the aircraft more than 90° and the radar got a lock-on the ground. Instead of climbing, the aircraft entered a steep dive in full afterburner, going automatically after the 'target' and exceeding the speed limit in so doing. The pilot, realising he was in deep trouble, initiated a recovery manoeuvre but pulled the stick back far too hard. At 1,600km/h (1,000mph) IAS, the aircraft was subjected to 11 or 12g when pulling out of the dive, causing the pilot to black out. After regaining consciousness, he immediately saw the *real* target on the radar screen, destroyed it with a missile and landed safely. The airframe was bent quite badly, being stressed for 5g as it was, but stayed in one piece thanks to the double structural strength reserve.

MiG-25P testing the 'ParoP IFF system - the small 'bump' at the base of the radome.
Yefim Gordon archive

In another unit stationed in Pravdinsk a 'Foxbat' coming in to land lost a dummy missile which dropped on an innocent cow. RIP cow!

In Rostov, a pilot displayed extraordinary courage, managing to land safely in adverse weather when nearly all flight instruments died because of a short circuit in a defective distribution bus. This would have been impossible if the chief project engineer had not foreseen this and insisted on installing reserve instruments (airspeed indicator, altimeter and sideslip indicator) not using electric power.

Over the years, the designers and engineers of the Mikoyan 0KB, the Gorkii factory and the WS did a colossal job, extending the service life of the MiG-25 to 800, 900 and later 1,000 hours from an initial 50 hours (!). Engine life increased from just 25 hours to 750 hours. As the pilots and ground crews grew more qualified and familiar with the aircraft the number of complaints about defects and failures dropped markedly. In due course the interceptor earned the reputation of a simple and reliable aircraft.

Officially the MiG-25P entered service after a directive of the Council of Ministers dated 13th April 1972. By the mid-1970s the type made up the backbone of the Soviet Air Force's interceptor inventory. After converting to the MiG-25P, PVO units stationed near the borders successfully intercepted SR-71 As, the weapons system indicating 'Ready for launch'. This input is only given if the SARH warhead carried on the pylon gets a lock-on and if speed, altitude, g load, triangulation errors and target range are all right. In a nutshell, the Blackbirds *could* have been shot down (despite the USAF's allegations to the contrary), and the only reason that they weren't is that the actual order to fire had not been given. Anyway, the SR-71 s and Lockheed U-2s stayed clear of the areas where MiG-25Ps were based; in contrast, these types continued their reconnaissance missions over other parts of the USSR and its allies, such as Cuba and North Korea, for quite some time.

As the aircraft entered service the designers set to work refining it. A new ground-based 'Vozdookh-1 M' command system expanded its tactical capabilities. During the mid-1970s, the MiG-25P received an upgraded 'Smerch-A2' radar (Izdelye 720M), later supplanted by the 'Smerch-A3'. A further version, the 'Smerch-A4', was designed but by then radars had to be able to pick out targets among ground clutter, which a monopulse low-pulse repetition frequency (PRF) radar was incapable of doing.

A production MiG-25P test the new 'Parol-2' ('Password') IFF system consisting of the 632-1 transmitter and 620-20P receiver.

MiG-25PD - Reacting to Belenko's 'Gift' (Izdelye 84D, ASCC 'Foxbat-E')

After Lt Viktor I Belenko's widely publicised defection to Japan the Soviet air defence force found itself in a predicament. The specially-created state commission did some homework and reported that the Americans had studied the MiG-25P in detail. It was clear that, unless the design was drastically upgraded, the type's combat efficiency would be far too low. To correct this, it was decided to develop a new weapons control system for new-build aircraft and retrofit it to existing ones.

In a joint effort with the Ministry of Aircraft Industry and military experts, the Mikoyan ОКБ developed a comprehensive upgrade programme in a remarkably short time. The 'Smerch-A' radar was to be replaced by the 'Sapfeer-25' (Sapphire for the MiG-25) quasi-continuous emission radar which had been only recently debugged for the MiG-23 as the 'Sapfeer-23'. An infra-red search and track (IRST) system coupled with the radar would be added to make the weapons system less susceptible to enemy ECM and enable the aircraft to make 'sneak attacks' without switching on the radar. An all-new ground-based command system (with a more modern and jam-proof aircraft receiver) was to take the place of the 'Vozdookh-1 M'. Likewise, a new IFF set was to be installed.

The aircraft was to carry upgraded missiles with almost doubled range thanks to more effective homing heads (both SARH and IR) and higher capacity batteries. New weapons loads were suggested (eg two of the R-40 missiles could be replaced by four R-60 or R-60M (AA-8 'Aphid') short range missiles. Unlike its predecessor, the 'Sapfeer-25' radar used three-phase alternating current, requiring modifications to the electric system and engine accessory gearboxes in order to install new generators.

An appropriate government directive appeared on 4th November 1976. Before long, technical details were worked out and specifications sent to aircraft factories, electronics plants and other defence industry factories for production.

Work on the new interceptor, designated MiG-25PD or Izdelye 84D (D - Dorabotannyy - modified or upgraded) progressed very fast. This was largely due to the carefully prepared test programme developed and supervised by project chief N Z Matyuk and L G Shengelaya.

As predicted, the new weapons system was built around a suitably modified 'Sapfeer-23' (S-23) radar and designated S-25. The new version developed by Yu Kirpichnikov's design bureau differed in having an enlarged antenna dish and was capable of detecting targets with a radar cross section (RCS) of $16m^2$ ($172.16ft^2$) at more than 100km (62.5 miles) range. The new radar was also better at discerning targets from ground clutter. The R-40 missiles were also modified to permit integration with the new radar and redesignated R-40RDand R-40TD.

Several MiG-25PD prototypes completed their test programme in 1978 and the type entered production in Gorkii same year. In the technical manuals the new radar was referred to as RP-25M and the missiles as Izdelye 46TD and Izdelye 46RD.

The MiG-25PD was also equipped with the new BAN-75 target indication and guidance system acting in concert with the ground-based 'Luch-1' (Ray) guidance system. The latter aligned the optical axis of the aircraft's radar with the target, making the radar less sensitive to jamming.

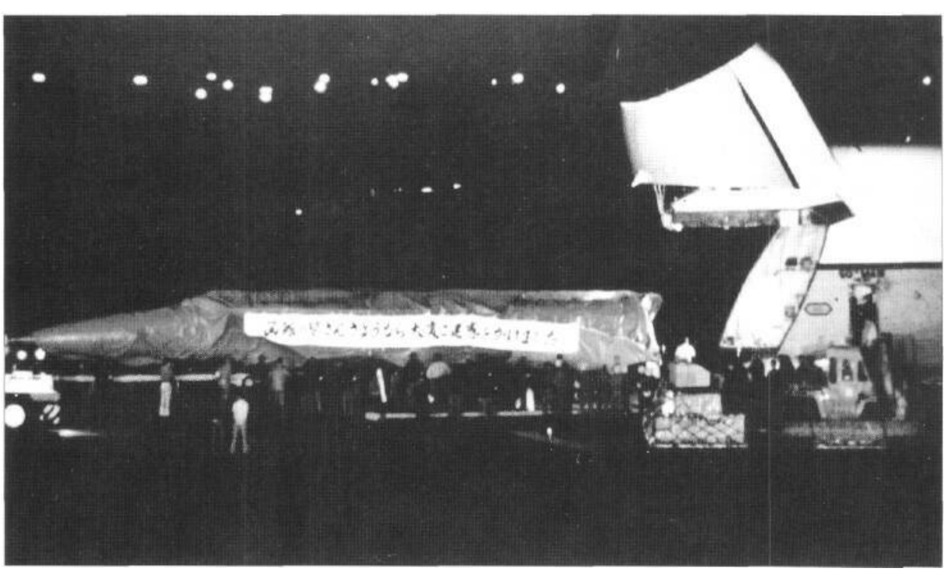
The weapon load was modified as planned with four R-60s carried on twin missile rails on the outboard pylons instead of the R-40TDs. Production aircraft were fitted with a 26Sh-1 IRST unit in an undernose fairing.

In 1979 the State Commission signed the Act of Acceptance, confirming that tests had been successfully completed. The MiG-25PD had a normal take-off weight of 34,920kg (76,984lb) and a MTOW of 36,720kg (80,952lb). Unlike the MiG-25P, it could carry a 5,300 litre (1,166 Imp gallon) drop tank. Cruising at Mach 2.35, the aircraft had a range of 1,250km (781 miles) with four R-40 missiles and no drop tank; in subsonic flight the range was 1,730km (1,081 miles). The drop tank extended the range to 2,400km (1,500 miles). With no drop tank the aircraft could climb to 19,000m (62,336ft) in 6.6 minutes and had a service ceiling of 20,700m (67,913ft).

Externally the MiG-25PD differed from its predecessor in having a modest fuselage stretch ahead of the cockpit to accommodate the new radar set, with recontoured skin panels and relocated radar set access hatches. The undernose IRST fairing was another distinguishing feature. The 'PD was powered by R15BD-300 engines with a modified accessory gearbox.

The MiG-25PD was a singularly reliable aircraft. Only one aircraft was lost due to structural failure when the radome disintegrated at high speed and the aircraft became uncontrollable. MiG-25PDs were very successful in destroying practice targets, but once a reckless missile launch ended in tragedy. A pair of MiGs was intercepting a target drone and the flight leader got in the way of the R-60 fired by his wingman. The missile locked on the new target and destroyed the MiG.

MiG-25PD production continued into 1982, though some of the aircraft planned for that year did not leave the factory until 1983. After that, the Gorkii aircraft factory switched to the MiG-31 'Foxhound' (see Chapter Six).



This page:

Lt V I Belenko's defection to Japan in MiG-25P 'Red 31' was a spectacular coup for the West. The machine was subjected to intensive, if hasty, examination. Yefim Gordon archive

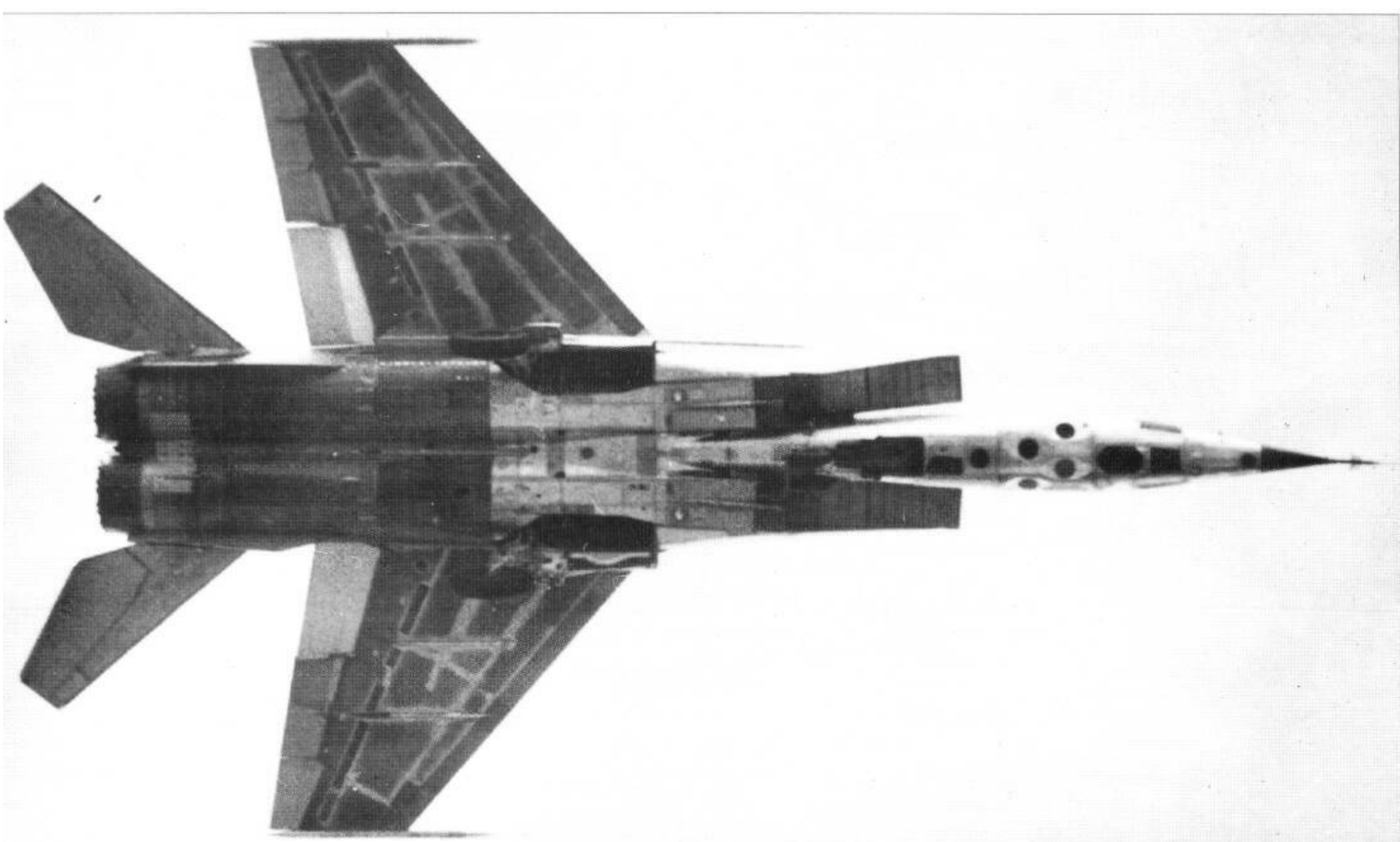
Pressure from the Soviet Union was intense to have 'Red 31' returned. A USAF Lockheed C-5A Galaxy and a JASDF Kawasaki C-1 flew the dismantled fighter from Hokodate to Hyakuri for shipment to the USSR. By then, of course, the dreaded 'Foxbat' was far less of a mystery to the West. Yefim Gordon archive

Opposite page:

Top: One of the MiG-25PD prototypes, '04', under test at Zhukovsky. Yefim Gordon archive

Centre: The first production MiG-25R fitted with the original style tail. Yefim Gordon archive

Bottom: A MiG-25RB under test at Gorkii showing to advantage the camera ports.
Victor Drushlyakov



MiG-25PDS Mid-Life Update

Due to the substantial improvement in the combat capabilities of the M1G-25PD over its predecessor, the MiG-25P, the Mikoyan OKB made the unprecedented decision to upgrade all early production aircraft to MiG-25PD standard. The modification programme began in 1979; the aircraft were returned to the Gorki! aircraft factory for conversion at the time of overhaul. This involved replacing the 'Smerch-A/A2' radar with the 'Sapfeer-25', inserting a small plug in the nose section, installing new IRST and command link equipment and R15BD-300 engines. The upgraded aircraft were redesignated MiG-25PDS (Perekhvatchik, Dorabotannyy v Stroyou - field-modified interceptor) and were almost identical to new production standard MiG-25PDs. The only difference was the lack of provision for a drop tank.

The upgrade programme was completed in 1982, just as the MiG-25PD production terminated. Thus, the capabilities of the entire interceptor fleet were not only retained but enhanced.

MiG-25PDSL One-Off

Operational experience with the MiG-25P/PD showed that these aircraft might well have to intercept low level targets (and were quite capable of doing so). Hence, ECM and IRCM gear was needed to make the aircraft less vulnerable to enemy fire. To this end, a single production MiG-25PD was fitted experimentally with an ECM pack in a ventral container and IRCM flare dispensers.

The aircraft was designated MiG-25PDSL, the '!_' probably standing for Letayuschchaya Laboratoriya - 'flying laboratory' or test-bed. It was tested successfully but remained a one-off because the ECM pack could not be produced in sufficient quantities.

Export MiG-25PS

Initially the MiG-25P was not even considered for export since in the early 1970s it had the most sophisticated weapons system in the PVO's fighter inventory. They were not even flown by VVS units stationed in the Warsaw Pact countries. However, Lt Belenko's defection and other reasons brought about a change in policy. The more capable MiG-25PD was rushed into production, and since the potential adversary had had a close look at the early version anyway, there was no point in stopping it from being exported to 'friendly' nations. Hence, an export version of the MiG-25PD was developed at the request of some Middle East states.

The aircraft had the obsolete weapons system built around the 'Smerch-A2' radar but could carry R-60M missiles. The export customers included Algeria (16?), Iraq (reportedly 20 aircraft), Libya and Syria (30).

Export MiG-25Ps are said to have seen action in various local wars. When the Gulf War broke out in the winter of 1991 the US command reported that a USAF McDonnell Douglas F-15C shot down two Iraqi MiG-25Ps with AIM-7M Sparrow AAMs after the MiGs behaved very aggressively and attacked a General Dynamics F-16 Fighting Falcon. Sometimes, however, the tables were turned. In September 1992 the *New York Times* quoted a US Navy intelligence officer as saying that on 17th January 1991 - the second day of Operation 'Desert Storm' - an Iraqi MiG-25P shot down a McDonnell Douglas F/A-18 Hornet. Besides the Gulf War, Iraqi aircraft saw action during the Iran-Iraq war. MiG-25s of the Libyan Arab Republic Air Force were reportedly very active over the Mediterranean, especially when US Navy ships were exercising close at hand.

MiG-25R High Speed Recce (Izdelye02)

The first production MiG-25R reconnaissance aircraft rolled off the Gorki! production line in 1969. Deficiencies noted during the state acceptance trials and the initial service period were quickly corrected, and more changes were introduced by the OKB. As the factory's equipment was upgraded, production became less labour-intensive and costly, and MiG-25R production volume started to grow.

The equipment suite of production MiG-25Rs comprised four oblique A-70M cameras for general-purpose Photint and one A/E-10 topographic camera with a 130cm (5.11 in) lens. These cameras were developed by the Krasnogorsk 'Zenit' Optics and Machinery Plant under A Beshenov and enabled pictures to be taken at flight levels of up to 22,000m (72,178ft). The cameras 'fired' through five optically flat windows in the underside of the nose.

The reconnaissance version differed from the interceptor in having integral fuel tanks in the fins to extend range. As with the MiG-25P, early aircraft were fitted with the KM-1 ejection seat later replaced by the KM-1 M.

In keeping with VVS plans, the first production aircraft (production batches Nos.3 and 4) were delivered to the Lipetsk training centre to be used for conversion training (since the two-seater trainer version was still in prototype form) and reconnaissance efficiency/operational evaluation. The majority, however, went to the Moscow military district - specifically, to the Guards independent aerial reconnaissance regiment operating out of Shatalovo air base near Smolensk. This unit was tasked with the service test programme.

As MiG-25Rs were delivered to the independent aerial reconnaissance regiments of the Air Armies of the VVS, each unit initially operated a mixed bag of types. One squadron was equipped with the new MiGs used for high altitude clear weather day reconnaissance, the other with long-in-the-tooth Yak-27R 'Mandrakes' used chiefly for night and low level day reconnaissance. For service test purposes the number of MiGs per regiment was temporarily increased to 17.

Pilot training proved to be a problem. Mikoyan test pilots (especially chief test pilot Fedotov), Gorkii aircraft factory pilots and WS test. pilots provided assistance to service units, speeding up conversion to the type. However, the problem of staffing the units with computer technicians qualified to work with the MiG-25R was even worse. Hasty changes had to be made to the educational programme at the Air Force Engineering Academy named after N Ye Zhukovsky, and some students reprofiled right in the middle of their courses. Despite these difficulties the service tests were completed successfully and the MiG-25R became one of the principal reconnaissance aircraft of the Soviet tactical aviation.

Meanwhile, successive improvements were incorporated into the aircraft as production grew. Aircraft up to c/n 020CT03 (Russian transcription, or 020ST03) had ordinary wingtips; later MiG-25Rs were fitted with anti-flutter 'balance booms'. All early MiG-25Rs were later retrofitted to MiG-25RB standard (see below).

M1G-25RB Reconnaissance/Strike (Izdelye 02B, 'Foxbat-B')

After defeating the Arab states in the Six Day War of 1967, Israel resorted to systematic strike missions against Egyptian military bases and industrial centres so as to maintain military superiority. When Israeli aircraft bombed a transformer station near Cairo and knocked out all the power in the city, the Egyptian leaders decided that they had enough and addressed the USSR, requesting technical and military assistance for the air defence, reconnaissance and strike missions.

Supporting Egypt and Syria was an important political issue for the Soviet Union at the time, since the Arab states were perpetually at war with Israel, which was backed by the USA. The Soviet military leaders, notably the defence minister Marshal D F Ustinov, decided to use the MiG-25 in the Middle East in the reconnaissance and tactical bomber roles (the MiG-25R could carry flare bombs for night reconnaissance missions, so in theory there was no reason why it could not carry general purpose bombs). Thus, in late 1969 the Mikoyan OKB and some related organisations were tasked with converting the pure reconnaissance MiG-25R to a dual-role aircraft within three or four weeks.

Work started immediately. To increase bombing accuracy the designers fed inputs from the RSBN-6 SHORAN set into the 'Peleng' navigation system. A programme for calculating bomb travel was installed in the navigation computer for calculating the bomb release point. A bomb release system was fitted, the bomb shackles were made heat-resistant, safe bomb temperatures were calculated, drop modes devised, and multiple ejection racks (MERs) designed and manufactured. Simultaneously an inter-department group was formed to evaluate the aircraft's survivability in the bomber role. The group included A G Zaytsev (of GosNIIAS) and Yu F Polushkin (from the Mikoyan OKB).

As early as February 1970 conversion work started at the Nil VVS test best at Akhtubinsk. The subject of the conversion was the fourth reconnaissance prototype, Ye-155R-4, 'Blue 024' (ie Izdelye 02, airframe No.4, factory number 020SA01). In March, Mikoyan test pilot Aviard G Fastovets made the first bomb drop at 20,000m (65,616ft) and 2,500km/h (1,562.5 mph) - a world first. Later, VVS test pilots A S Bezhevets and N I Stogov took over the main part of the flight testing. Aleksey V Minayev (a senior Mikoyan official and later deputy minister of aircraft industry) supervised the test programme.

Various defects and nasty surprises popped up during the test programme, ranging from primitive mistakes like wrong grade solder in the electrical connectors which melted in flight to serious problems, such as 'lapses' in the navigation system when following ground beacons. The zone where the pyrotechnic bomb racks were located under the wings proved to be hotter than anticipated. On one occasion in April 1970 Bezhevets switched to an alternate test mission when the 'Peleng' navigation system went down, rendering the primary mission impossible. The alternate mission involved prolonged supersonic flight; the pyrotechnic cartridges in the bomb racks overheated and exploded, causing an uncommanded bomb release.

To prevent similar incidents in the future the racks were moved to a colder area under the fuselage. New cartridges with a higher blast point were developed later and the designers reverted to the underwing location. The tests showed that the FAB-500M-62T specially developed heat-insulated 500kg (1,102lb) high explosive (HE) bombs and cartridges could be used throughout the aircraft's speed range. Other types of bombs, including heavier calibre weapons, could also be carried.

When the aircraft was bombed-up the ceiling decreased slightly. To make up for this the area of the air intakes' upper surface was increased. The modification was tested successfully on the Ye-155R-4. With a full bomb load, the aircraft's ceiling was increased by 500-700m (1,640-2,296ft) without affecting speed and range.

After that it was decided to urgently modify a number of production MiG-25Rs a /a Ye-155R-4 for service tests in which regular VVS pilots were to participate along with test pilots. The aircraft were modified in Gorkii; after that, new MiG-25Rs were to be built as dual-role aircraft. To increase bombing accuracy, a new navigation complex, 'Peleng-D', was developed. It included a new and more accurate INS with float gyros (the old 'Anis' INS used special ball bearings), a vertical accelerometer for registering the aircraft's vertical speed at the bomb release point and making corrections, and a correction system receiving inputs from a hyperbolic LORAN system.

A massive crew training and systems debugging effort began in Akhtubinsk. The test pilots succeeded in finding optimum climb-to-cruise transition modes causing no appreciable oscillation and an optimum turn trajectory after bomb release with minimum fuel consumption, altitude and speed loss.

Quite a few bugs had to be eliminated, as it turned out. The navigation computer and INS failed at regular intervals. There were flying accidents, too. One of the service pilots, Krasnogorskiy, undershot on landing and bent the aircraft, but managed to keep it on the runway. Pilot Uvarov had an uncommanded nose gear extension caused by an improperly set gear uplock but managed to land safely. Generally the service tests went well.

Concurrently with the tests, the Gorkii factory started producing the dual-role MiG-25RB, or Izdelye 02B, in 1970. (The RB suffix denoted Razvedchik-Bombardirovschchik - reconnaissance aircraft/bomber.) The production aircraft was intended for clear-weather day and night Photint, general purpose and detailed Sigint, day/night radar imaging in visual flight rules (VFR) and IFR conditions and day/night bomb attacks in VFR and IFR conditions. Reconnaissance was possible up to 23,000m (75,460ft) and at speeds of 2,500-3,000km/h (1,562-1,875mph) within a combat radius of 920km (575 miles). It was possible to drop bombs at 21,000m (68,897ft) and 2,500km/h within a combat radius of 650km (406 miles) while performing all kinds of reconnaissance tasks.

The camera fit was identical to that of the MiG-25R, consisting of four A-70Ms and one A/E-10. Alternate fits comprised two A-72 cameras with 150mm (5.9in) lenses for detail reconnaissance of a narrow strip of terrain or a single A-87 with a 650mm (25.6in) lens. For Sigint duties, an SRS-4A (Izdelye 30A) or SRS-4B (Izdelye 3OB) or SRS-4V (Izdelye 30V) set could be carried. It was fitted with an SPS-141 'Siren' (Lilac) ECM pack, Izdelye 141.

The MiG-25RB became operational in December 1970 and was the first of the reconnaissance/strike versions of the 'Foxbat'. Early production aircraft had a bomb load restricted to 2,000kg (4,409lbs) and carried four FAB-500 M-62 bombs under the fuselage. Later, wing pylons were added, doubling the bomb load. Four MBDZ-U2 MERs with DZU-1 shackles, two under the fuselage and one under each wing, could carry various combinations of bombs: four to eight FotAB-100-80 flare bombs or 250kg (551 lb) FAB-250 HE bombs, or eight FAB-500M-62 (regular) or FAB-500M-62T (heat-insulated) HE bombs. For mixed reconnaissance/strike missions the aircraft carried four FAB-250 bombs on the belly MERs (no drop tank could be carried in this case).

Late production MiG-25RBs, starting with constructor's number 02022077, had the bomb load increased to 5,000kg (11,022lb) and could carry 10 FAB-500M-62s (four in tandem pairs under the wings and six under the fuselage). However, it quickly became obvious that this load was excessive, impairing speed and ceiling drastically because of the added drag and all-up weight. Besides, wing loading was excessive at subsonic speeds and the air intake walls were subject to added loads at supersonic speeds, which could cause fatigue problems.

The fin tanks were deleted on late production aircraft in the mid-1970s, restricting fuel tankage to the wings and fuselage. The 5,280 litre (1,173 Imp gallon) drop tank also impaired performance a good deal, still it was rarely jettisoned when it ran dry. No bombs could be carried when the drop tank was fitted.

For pinpoint bomb aiming and automatic bomb release using pre-set target co-ordinates the MiG-25RB and later reconnaissance/strike models were equipped with a 'Peleng-D' or 'Peleng-DR' navigation/bombing system. The more accurate 'Peleng-DM' was retrofitted later. The MiG-25RB also had the 'Polyot-11' navigation/flight control system.

The aircraft's manoeuvrability and the thrust of its massive turbojets enabled it to fly horizontally, albeit decelerating, at altitudes exceeding its service ceiling. The effective maximum horizontal flight ceiling in full afterburner with 3,300kg (7,275lb) of fuel remaining at the end of the flight was 26,000-27,000m (85,301-88,582 ft). The MiG-25RB could exceed Mach 2.4 for 15 minutes but a Mach 2.65-2.83 dash was not to exceed five minutes. Cruising time at speeds below Mach 2.4 was unlimited.

MiG-25RB deliveries to units based in the Ukraine commenced in 1970. Some aircraft were delivered to the Lipetsk training centre. Five MiG-25RB regiments were stationed in Poland and East Germany. Later the aircraft served in units of the Belorussian, Trans-Caucasian, Middle-Asian, Siberian and Leningrad military districts.

The MiG-25RB stayed in production for two years until superseded by more sophisticated versions in 1972. The first reconnaissance/strike version saw some action on the Middle East theatre of operations. In 1971, a Soviet Air Force Antonov An-22 'Antei' (Antheus, ASCC 'Cock') airlifted four dismantled MiG-25RBs to Egypt. There the MiGs were reassembled and successfully flew reconnaissance missions against Israeli forces, piloted by six Soviet airmen (three regular WS pilots, two Nil VVS test pilots and one test pilot from the Ministry of Aircraft Industry).

The MiG-25RB and its versions were popular with their crews due to their exceptional performance: high speed, excellent picture quality, the ability to reconnoitre large areas in a single sortie and low vulnerability to enemyfire.

The aircraft was sometimes used for civilian and government agency purposes (for example, defining areas engulfed by forest fires, snow covered or flooded areas). Using the MiG-25 to get this kind of data seems at first odd, but was quicker and cheaper than if satellites or other space vehicles or dedicated topographic reconnaissance aircraft (such as the Antonov An-30 'Clank' and the like) were employed.

MiG-25RB - Basic Performance

MTOW - with drop tank, no bombs	39,830kg	87,808lb
- without drop tank, no bombs	35,060kg	77,292lb
- with four FAB-250 bombs	37,21 Okg	82,032lb
Fuel load in main tanks	15,000kg	33,068lb
Fuel load in drop tank	4,450kg	9,810lb
Top speed - at altitudes exceeding		
-18,000m (59,055ft)	3,000km/h	1,875mph
Top speed - clean	2,500km/h	1,562.5
Maximum IAS- below 5,000m (16,404ft)	1,000km/h	625mph
-5,000 to 18,200m (16,404to59,711ft)	1,100km/h	687.5
Maximum Mach number		
-above 18,200m (59,71 1ft)	2.83 Mach	
Maximum IAS (Indicated Air Speed) - with drop tank		
-below-1 1,000m (36,089ft)	1,000km/h	625mph
-above 11, 000m (36,089ft)	1.5 Mach	
Maximum IAS - with four FAB-500 bombs		
-below 5,000m (16,404ft)	1,000km/h	625mph
-at5,000-15,800m (16,404 -51, 837ft)	1,100km/h	687.5
- above 15,800m (51,837ft) -15 min only	2.35 Mach	
Max cruising speed with FAB-500 bombs	2,500km/h	1,562.5
Time -to 10,000m (32, 808ft)	1.33 min	
-to 20,000m (65,61 6 ft)	6.7 min	
-to minimum combat altitude (20,200m/66,273ft)		
-with four FAB-250 bombs	8.2 min	
Cruising altitude - 1 9,000 to 21 ,000m	62,336 to 68,897ft	
Altitude over target - 4 FAB-250 bombs	20,700m	67,91 3ft
Service ceiling -		
- TOW 22,600kg (49,823lbs), clean	23,000m	75,459ft
- TOW 30,100kg (66,358lbs), with four FAB-500 bombs		
and Mach 2.35 cruise	20,200m	66,273ft
Practical horizontal flight ceiling	26,000m	85,301ft
Combat radius (recce mission)		
- with drop tank	920km	575mls
- without drop tank	675	422miles
Maximum base to target distance - with corrections		
for FAB-500 bomb travel	560km	350miles
Maximum range		
-with drop tank, altitude 9,000 -12,000m (29,257-39,370ft)		
speed 1,000km/h (625 mph)	2,900km	1,812mls
-with drop tank, altitude 19,000-21, 000m (62,335-68, 897ft)		
speed 2,500km/h(1,562mph)	2,610km	1,631 mis
- without drop tank, altitude 19,000-21, 000m (62,335-68,897ft)		
speed 2,500km/h (1 ,562mph)	2,1 20km	1 ,325mls
Range at Mach 2.35		
- with drop tank (TOW 35,060kg/77,292lb		
and fuel 14,900kg/32,848lb)	2,045km	1,278mls
- with drop tank (TOW 39,830kg/87,808lb		
and fuel 19,350kg/42,658lb)	2,560km	1,600mls
Range at Mach 0.92 - without drop tank	2,280km	1,425mls
- with drop tank	2,810km	1,756mls
Range at 1,000m (3,280ft) and speed 800km/h (SOOmph) IAS		
- without drop tank	1,243km	776 miles
- with drop tank	1,504km	940 miles
-with four FAB-500 bombs	1,017km	635 miles
Range with FAB-500 bombs		
- if dropped halfwayalong route,	1,090km	681 miles
Endurance at Mach 2.35		
- without drop tank (TOW 35,060kg/77,292lb		
andfue!14,900kg/32,848lbs)	67 min	
- with drop tank (TOW 39,830kg/87,808lb		
and fuel 19,350kg/42,658lbs)	81 min	
Endurance at 1,000 m (3,280 ft) and 800 km/h (500 mph) IAS		
- without/with drop tank	92/1 1 0 min	
-with four FAB-500 bombs	75 min	
Endurance at Mach 0.92 - without/with drop tank	146/180min	

Field Performance

Take-off weight - without drop tank	33,500kg	73,853lb
- with drop tank	39,000kg	85,978lb
Take-off run - without drop tank	1,050m	3,444ft
- with drop tank	1,400m	4,593ft
- with four FAB-500 bombs	1,250m	4,100ft
Unstick speed - without drop tank	350km/h	218mph
- with drop tank	375km/h	234mph
- with four FAB-500 bombs	375km/h	234mph
Take-off run time -without drop tank		n/a
- with drop tank		n/a
- with four FAB-500 bombs		24sec
Landing weight - without drop tank	22,000kg	48,500lb
- with drop tank		n/a
- with four FAB-500 bombs	23,000kg	50,705lb
Landing run with brake parachute -		
- without drop tank	830m	2,723ft
- with drop tank		n/a
- with four FAB-500 bombs	800m	2,624ft
Landing run time - with/without drop tank		n/a
-with four FAB-500 bombs		22sec

Take-off Data

Taxi weight - without drop tank	35,060kg	77,292lb
- with drop tank	39,830kg	87,808lb
- with four FAB-500 bombs	37,210kg	82,032lb
Take-off weight - without drop tank	34,560kg	76,190lb
- with drop tank	39,330kg	86,706lb
- with four FAB-500 bombs	36,710kg	80,930lb
Fuel weight -without drop tank	15,000kg	33,068lb
- with drop tank	19,450kg	42,879lb
- with four FAB-500 bombs	15,000kg	33,068lb
Rotation speed - without drop tank	285km/h	178mph
- with drop tank	300km/h	187.5mph
-with four FAB-500 bombs	300km/h	187.5mph
Unstick speed - without drop tank	350km/h	218mph
- with drop tank	380km/h	237.5mph
-with four FAB-500 bombs	360km/h	225mph
Take-off run - without drop tank	1,100m	3,608ft
- with drop tank	1,400m	4,593ft
- with four FAB-500 bombs	1,200m	3,937ft
Take-off run time - without drop tank		21sec
- with drop tank		26sec
- with four FAB-500 bombs		24sec
Take-off distance to 25m (82ft)		
- without drop tank	2,100m	6,890ft
- with drop tank	2,700m	8,858ft
- with four FAB-500 bombs	2,300m	7,545ft

Landing Data

Landing weight -clean	23,000kg	50,705lb
- with four FAB-500 bombs	24,000kg	52,910lb
Fuel weight -clean	3,000kg	6,613lb
- with four FAB-500 bombs	1,800kg	3,968lb
Touchdown speed - clean	280km/h	175mph
- with four FAB-500 bombs	290km.h	181mph
Landing run with brake parachute - clean	750m	2,460ft
- with four FAB-500 bombs	800m	2,624ft
Landing run, no brake parachute - clean	1,450m	4,757ft
- with four FAB-500 bombs	1,500m	4,921ft
Landing run time with brake parachute - clean		23sec
- with four FAB-500 bombs		24sec
Landing run time without brake parachute - clean		35sec
- with four FAB-500 bombs		37sec

MiG-25RBK Reconnaissance / Strike with Sigint (Izdelye 02K or Izdelye 51)

To meet VVS requirements, a version of the basic MiG-25RB fitted with a 'Koob-3' Sigint suite was developed, receiving the logical designation MiG-25RBK or Izdelye 02K, or '51. Work on this version started concurrently with the MiG-25R, since the Sigint equipment carried by the latter could detect pulse-Doppler radars but could not transmit data to ground command centres. In contrast, the 'Koob-3' system could pinpoint the location of enemy transmitters (both pulsed and continuous), define their class and relay intelligence immediately by data link while recording it digitally on board the aircraft for later analysis.

The 'Koob' weighed several hundred kilos and was too bulky to install on an interchangeable pallet like the SRS-4 packs. The aircraft's nose had to be redesigned; some of the cameras were deleted and the ports faired over.

The MiG-25RBK was tested successfully and entered production at Gorki! in 1971, staying in production until 1980. Production aircraft had an upgraded 'Koob-3M' unit, (Izdelye K-3M), an SPS-143 ECM fit (Izdelye 143) and similar armament to the MiG-25RB. Starting 1981, MiG-25RBKs were retrofitted with more modern reconnaissance equipment.

MiG-25RBS Reconnaissance / Strike with SLAR (Izdelye 02S or Izdelye 52)

Almost simultaneously with the development of the MiG-25RBK another dual-role version, the MiG-25RBS (Izdelye 02S or '52), entered production in 1971. The S-suffix indicated that the aircraft carried the 'Sablya-E' (Sabre-E, Izdelye 122) monobloc sideways-looking airborne radar (SLAR). The Moscow Instrument Research Institute had suggested developing a SLAR for the MiG-25 as early as 1963, but not until 1965 did the VVS complete a specific operational requirement for a SLAR-equipped version.

It took almost seven years to design the SLAR, but finally the installation was successfully tested on a MiG-25RB. The new version could be identified by two large dielectric panels on the sides of the nose and differently-shaped skin panels. The MiG-25RBS was fitted with an SPS-142 'Siren' (Lilac, Izdelye 142) ECM pack and had identical armament to the earlier strike version.

The picture generated by the radar was 'developed' on the ground in a specially equipped van. The SLAR could detect parked aircraft, trains, ships and visualise the condition of bridges and similar structures.

The MiG-25RB, 'RBK and 'RBS entered service in 1972 pursuant to the same directive of the Council of Ministers. Production continued into 1977; some aircraft were later refitted with new Elint gear.

MiG-25RBV Upgraded Recce / Strike

From 1978, series MiG-25RBs were upgraded by replacing the SRS-4A and SRS-4B Sigint packs with a more modern SRS-9 'Virazh'

(Turn, Izdelye31). Late production aircraft were further improved by substituting the SPS-141 'Siren' ECM set with an SPS-151 'Lyutik' (Buttercup) set.

Those updated became MiG-25RBVs (for 'Virazh'); however, the designation is somewhat misleading since in the mid-1970s the remaining *unupdated* aircraft with SRS-4 packs received the same designation! The factory code (Izdelye02B) remained unchanged.

MiG-25RBN Night Reconnaissance / Strike

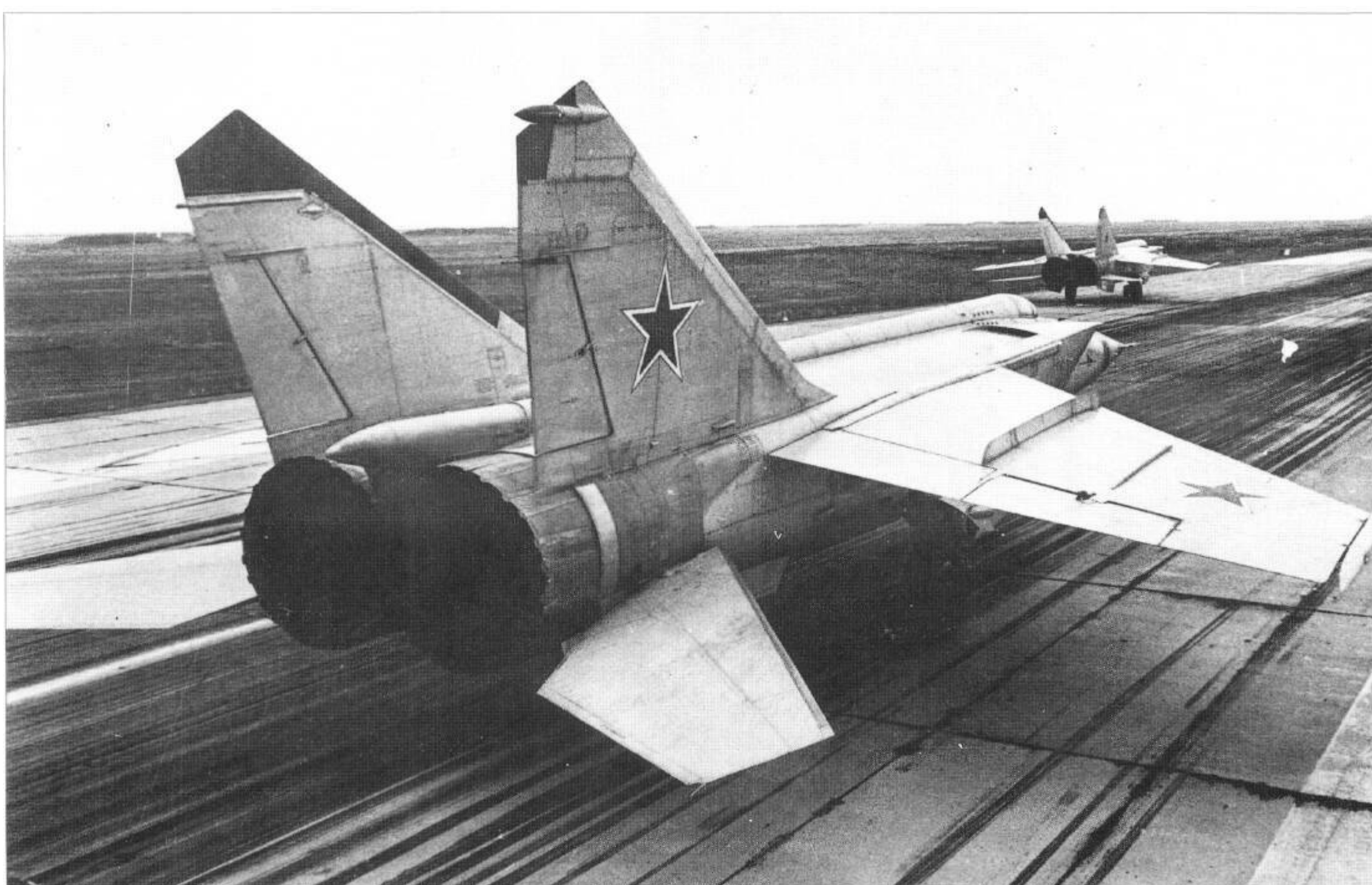
In keeping with the requirements of the VVS the Mikoyan design bureau had made provisions for high-altitude night Photint missions. Two NAFA-MK-75 night cameras designed by the Kazan Optical and Mechanical Plant could be installed in the standard camera nose with the optical axes slightly tilted aft.

Four to ten FotAB-100 or FotAB-140 flare bombs were carried on under fuselage racks. The flare bombs were released over the target area by the 'Peleng' navigation system, the initial flash triggering the camera shutters. The burn time of a single bomb was sufficient for two exposures. The NAFA-MK-75 cameras had powerful lenses (1:3.5) and shutter speeds between 1/25 and 1/80. When extra sensitive film was used it was possible to shoot in dusk without the benefit of flare bombs.

Yet it was clear from the start that the night Photint version offered no great advantage. First, the results simply were not worth the effort. The very complicated mission yielded just 16 pictures of rather poor quality, and photography was only possible in clear weather. Second, in peacetime, night photography was only possible over sparsely populated areas because the bright flashes of the exploding bombs could cause panic among civilians, to say nothing of the splinters which could cause death and destruction. Therefore, the night Photint version was excluded from the state acceptance trials programme.

In the course of the trials programme the shutter operating logic was changed. The shutters opened in advance and closed right after the flash; thus, the burn time of the flare bombs was used to greater advantage. Despite being scheduled to begin right after the state acceptance trials of the basic MiG-25R and be finished as soon as possible, the 'night eyes' testing was not completed until the MiG-25RB came into being. The night Photint version was designated MiG-25RBN (Nochnoy - night, used attributively). The aircraft could also be fitted with the 'Virazh' Sigint suite.

Front view of a MiG-25RBK in use with a Polish-based Soviet Air Regiment. Note the large ventral fuel tank.



An 'RBK and an 'RBS ready for take-off.
Both Yefim Gordon archive

'Blue 701', a MiG-25RBK used for a variety of record breaking flights. Yurii Popov

MiG-25RB and 'RBV Principal Data
(Equipped for night Photint)

MTOW- with four FotAB-1 00 bombs	35,740kg	78,791lb
-with eight FotAB-1 00 bombs	36,420kg	80,291lb
Fuel weight	15,000kg	33,068lb
Maximum cruising speed - without bombs	2,500km/h	1 ,562.5
- with FotAB-1 00 bombs	2,390km/h	1 ,493mph
Unstick speed		
- with eight FotAB-1 00 bombs,	355km/h	221 mph
Combat radius with 4 FotAB-1 00 bombs	530km	331mls
- with eight FotAB-1 00 bombs	505km	31 5mls
Cruise altitude, night Photint mission	1 9,700 to 20,700m	
	64,632 to 67,91 3ft	
Service ceiling at 29,800kg (65,696lbs) TOW		
- with (8 x bombs) and Mach 2.25	1 9,700m	64,632ft
Range with bombs if dropped halfway along route		
-with four FotAB-1 00 bombs	1,145km	715mls
- with eight FotAB-1 00 bombs	1 ,085km	678mls
Take-off run with eight FotAB-1 00 bombs	1 ,200m	3,937ft
T/0 run time with eight FotAB-1 00 bombs	23sec	
T/0 distance with 8 FotAB-1 00 bombs	2,300m	7,545ft

MiG-25RBT Reconnaissance / Strike with 'Tangazh' (Izdelye 02T)

In 1978 the Gorki! aircraft factory started producing yet another reconnaissance/strike model - the MiG-25RBT (Izdelye 02T). This differed from the MiG-25RBV only in having the 'Virazh' Sigint pack replaced by a Tangazh' (Pitch) unit, hence the T and the new 'Parol' (Password, Izdelye 62) IFF system. The Tangazh' pack had a wider range of detectable radars and their location could be pinpointed when the recorded intelligence was processed post-flight. In 1980 the 'Sirena-3M' (Siren-3M, Izdelye S-3M) RWR was replaced by the LO-06 'Beryoza' (Birch, Izdelye 006) RWR.

MiG-25RBSh Upgraded 'RBS (Izdelye 02Sh)

An upgrade programme for the MiG-25RBS was launched in 1981. The extremely troublesome 'Sablya' SLAR was replaced by a new-generation 'Shompol' (Ramrod) SLAR; hence, the updated aircraft became MiG-25RBSh or Izdelye 02Sh.

The 'Shompol' had a resolution two to three times better than the old SLAR. Besides, it enabled the aircraft to work at any altitude between 300 and 23,000m (984 and 75,459ft), whereas the 'Sablya' could not operate below 17,000m (55,774ft). Finally, the new SLAR had a moving target selection (MTS) mode and a combined mapping/MTS mode.

MiG-25RBF Upgraded 'RBK (Izdelye 02F)

In 1981 it was the MiG-25RBK's turn to get a mid-life update. The 'Koob-3M' Sigint suite was replaced by an up-to-date 'Shar-25' (Ball, or Balloon, Izdelye F-25S) detailed Sigint system. The aircraft could also carry panoramic cameras and was fitted with ECM gear and chaff/flare dispensers.

'Shar' begins with 'Sh' but this suffix was by then allocated to the MiG-25RBSh equipped with 'Shompol' and could not be used; therefore, the latest version received the 'out-of-sequence' designation MiG-25RBF, or Izdelye 02F. It could be outwardly distinguished from the MiG-25RBK by the small dielectric panels located low on both sides of the nose.

The 'Shar-25' suite was speedy and could work in a jumbled radio signal environment, picking out assorted transmitters. It could detect modern radars with a complex emission spectrum and quickly relay data to ground command centres.

The MiG-25RBK to 'RBF and MiG-25RBS to 'RBSh upgrades were done at VVS repair shops as the aircraft came in for overhaul.

MiG-25RR Radiation Intelligence

Eight MiG-25RBVs were fitted with 'Vysota' (Altitude) equipment and filter canisters under the wings for air sampling at high altitude so as to detect radioactivity. Previously, radiation intelligence (Rint) duties had been performed by Yak-25RR (Radiatsionnyy Razvedchik-Rint aircraft) and Yak-25RRV (Radiatsionnyy Razvedchik Vysotnyy - high altitude Rint aircraft), both based on the single-seat straight-wing Yak-25RV reconnaissance aircraft, and later the Yak-28RR. The MiG-25RR had a higher ceiling than either of these aircraft and, importantly, could slip through the high radiation area quicker, decreasing pilot exposure. In the decade 1970 to 1980, MiG-25RRs were flown close to the Chinese border.

The modification work was done by the Mikoyan bureau under a special 'Vysota' (Altitude) programme. The MiG-25RRs were later fitted with upgraded Rint equipment.

Export MiG-25RBs

An export version of the reconnaissance/strike model for 'friendly' nations was developed concurrently with the export version of the MiG-25PD interceptor. More than 30 MiG-25RBs were reported as delivered to Algeria, India (six), Iraq (eight), Libya (five) and Syria (eight). Three or four aircraft reportedly saw brief service with the Bulgarian Air Force but were soon exchanged for MiG-23BN 'Flogger' strike fighters. The reason was ostensibly problems with spares, but in reality Bulgaria probably just didn't need that kind of aircraft.

The Iraqi MiG-25RBs were in action during the Iran-Iraq war, making high altitude supersonic bombing raids against Iranian oil rigs. Several aircraft were reported as lost in accidents or'due to poortactical planning'.

MiG-25MR Weather Recce

A small number of MiG-25MR weather reconnaissance aircraft were created, based upon the MiG-25RB. The 'MR lacked both cameras and the SRS-4 equipment.

Ye-155B 'Pure' Bomber

Inspired by the first successful bombing tests conducted on the MiG-25RB in the early 1970s, the Mikoyan 0KB proposed a pure bomber, the Ye-155B (for Bombardirovschchik). The aircraft was to be fitted with an 'Ivolga' (Golden Oriole) electro-optical bombing sight capable of detecting small targets any time of day/night and a radar for detecting surface ships and targets with a big RCS. It had a crew of two (pilot and navigator/bomb aimer). The Ye-155B never got even as far as the drawing board.

Ye-155K Air Defence Suppression

As the MiG-25R and MiG-25RB reconnaissance aircraft were developed, penetrating enemy air defences became a major issue. This could be attained by either of three means: enhanced speed and manoeuvrability plus evasive manoeuvres to escape missiles; sophisticated active and passive ECM and IRCM; anti-radiation missiles (ARMs).

A low level target approach followed by a zoom climb to about 25,000m (82,020ft) and prolonged high altitude flight proved a very effective tactic. The reconnaissance version had a dynamic ceiling in excess of 30,000m (98,425ft) but this could only be achieved by using specially lightened aircraft; besides, the engines would flame out in a zoom climb and had to be relit at much lower altitude.

A MiG-25 flying at top speed and altitude was hard to shoot down. Yet there could be no guarantees of absolute survivability, especially deep behind enemy lines and considering the enemy's sophisticated air defence. Besides, it was hard to speak about ECM requirements without knowing what the data of enemy weapons systems. Thus, an aircraft armed with ARMs - a 'Wild Weasel' to use an unofficial US term - was clearly the best bet.

The first ARMs designed in the 1960s weighed tons and could only be carried by heavy bombers. In the 1970s, however, smaller and lighter missiles were developed, albeit designed to be launched mostly from low and medium altitude. One of these, the Kh-58 (ASCC AS-11 'Kilter'), could be carried by the MiG-25 after some minor modifications.

Contemporary Western air defence systems, such as the MIM-14B Nike-Hercules surface-to-air missile (SAM), had a single-channel guidance system, and the Soviet designers put this to good use. After considering various tactics a 'zig-zag' manoeuvre was devised which enabled the ARM to knock out the enemy guidance radar before the SAM could get the aircraft. The Kh-58 could be fitted with various homing systems and destroy all components of the enemy air defence system. Hence, the directive of the Central Committee and the Council of Ministers, whereby the MiG-25RB was accepted for service, included a clause about fitting it with Kh-58 missiles.

The first 'Wild Weasel Foxbat' project had the form of an engineering proposal and was designated Ye-155K, (Kompleks - weapons system, a designation often used for Soviet air-to-ground missile systems). The aircraft was to be fitted with two powerful 'Landysh' (Lily of the Valley) ECM sets and carry two Kh-58U ARMs. However, the project failed to attract interest.

MiG-258 High Speed Reconnaissance /Strike

In 1977 new a reconnaissance/strike version complex was proposed under the MiG-25B designation. It was fitted with the 'Espadron' (Backsword) recce/strike complex consisting of a 'Shompol' SLAR, a new Sigint set, a thermal imaging system, a data link system and ARMs. Simultaneously some thought was given to fitting ARMs to Photint aircraft.

MiG-25BM Air Defence Suppression (Izdelye 02M - 'Foxbat-F)

The Mikoyan OKB persisted with the ideas first defined in the Ye-155K project and continued working on a 'Wild Weasel' MiG-25. However, this version took its time coming. There were two reasons for that.

First, the OKB had agreed with the WS to develop separate projects for the reconnaissance and air defence suppression missions. The latter would be fulfilled by a specialised version armed with four Kh-58 missiles and fitted with sophisticated ECM sysetems (a range of powerful ECM sets with a wide frequency spectrum). Such an aircraft could not only bite a hole in enemy defences to enable MiG-25RB recce aircraft to get through but also fulfil tactical aviation missions with a wider scope - eg hunt enemy radars on a specified section of the frontline.

Second, the Kh-58 missile needed much more extensive modifications than anticipated. To ensure faultless operation after repeated no-launch flights the missile was fitted with a new motor. The empennage had to be modified so as to permit carriage by other aircraft types. The resulting one-size-fits-all missile was designated Kh-58U (for Unifitsirovannyy - standardised) or Izdelye 112U.

Special equipment had to be developed to enable a tactical 'wolf pack' to operate above a territory measuring several thousand square miles. Its functions included threat selection and threat priority allocation, destruction of targets with known co-ordinates, definition of

The MiG-25RBK update was the 'RBF. Side-on of a camouflaged example; note the scale stick positioned near the intake.

Rare photograph of one of the fleeting Bulgarian Air Force MiG-25RBs, 'Red 754'. Bulgaria operated perhaps three or four, but they were quickly superseded by MiG-23BN 'Floggers'. Both Yefim Gordon archive

Soviet 'Wild Weasel', a MiG-25BM in use with a Polish-based Soviet Air Regiment.
Yefim Gordon archive

launch zones for the Kh-58 missiles and monitoring the missile's programme all along the trajectory. This integrated equipment package was designated 'Yaguar' (Jaguar) and, like the missile, took a lot of time to define, produce and test. The 'Yaguar' equipment package included 'Sych-M' (Little Owl) radar.

Launching Kh-58 missiles safely from the AKU-58 ejector rack was a complex task. Another problem was electromagnetic compatibility of the avionics components and compensation of possible targeting errors (especially with long-wave radars) when the enemy was using 'decoy transmitters' located close at hand. To test the equipment for electromagnetic interference and accumulate statistical data a further Tu-104 was converted into an avionics test-bed by LII. Finally, the software for the 'Peleng' navigation system was also updated.

The new version had a 200mm plug inserted into the nose section to accommodate ECM and missile guidance gear. The four missiles were carried on underwing pylons in the same fashion as on the MiG-25P; 'iron' bombs could also be carried as on the MiG-25RB. The cockpit interior differed from the latter version in lacking recce equipment control panels; the electric and air conditioning systems were also modified.

A curious feature was the self-contained missile cooling system located in each of the pylons to which the AKU-58 ejector racks were fixed. The system used an alcohol/water mixture as a cooling agent.

A prototype (c/n 47) was completed in 1976, using a rebuilt MiG-25RBV, and flight tests showed virtually no deterioration in performance. In general the tests went smoothly, despite some unpleasant surprises. To check out the operation of the targeting system a certain number of radar targets had to be provided. Real radars were used for want of expendable 'simulator' transmitters; they were switched off as the missile got too close for comfort, and 'kill' confirmation was given by telemetry equipment which the missiles carried in lieu of warheads. Many missiles, however, refused to be fooled and went all the way in, scoring direct hits and knocking out the radars completely.

The tests showed that the decision to separate the recce and air defence suppression missions had been correct. Hence, the dual-role MiG-25B project of 1977 was abandoned in favour of a dedicated 'Wild Weasel' version equipped with the 'Yaguar' system and designated MiG-25BM, or Izdelye 02M.

The MiG-25BM stayed in production from 1982 to 1985. Less than a hundred aircraft were built; to simplify conversion training they were delivered to independent tactical aerial reconnaissance units operating the MiG-25RB and its versions. The 'Wild Weasel' could be identified by a nose painted dark grey or olive drab and sporting dielectric panels and radar homing antenna blisters, and also by the different types of wing pylons.

The missile's high initial energy and highly sensitive guidance system allowed for an increase in target range. In one trial launch the missile destroyed a target located at 1.5 times the usual range. In reality, however, the missile's endurance was restricted by the capacity of its batteries; besides, at maximum range the missile heated up dangerously and could blow up before reaching the target. Thus, more modifications were needed; however, the 'Raduga' design bureau was tied up with other projects, and no one really wanted an increase in the Kh-58U's range anyway.

Following successful trials the MiG-25BM entered service, but not before 1988, three years after production had terminally ended. The delay was due to a lengthy pilot and ground crew conversion training course completed at VVS testing grounds.

MiG-25M (Ye-266M) Development

The 1972 directive ordering the service entry of the MiG-25RB, 'RBK and 'RBS also elaborated on the upgrade possibilities of the basic design. The military wanted an increase in range at low and medium altitude and an increase in ceiling and maximum speed.

The Mach 2.83 speed limit imposed on the MiG-25 was purely theoretical, since the aircraft had the potential to go faster from the very start. High speeds reduced lateral stability and service life, but there were cases of pilots exceeding the speed limit without harming the aircraft. Therefore, the designers intended to reach a Mach 3.0-3.2 top speed so that the MiG-25 could outperform its arch-rival, the SR-71A - the world's fastest recce aircraft. This could be achieved by fitting the MiG-25 with more powerful and fuel-efficient engines.

As far back as the early 1960s, a group of engine designers led by Shukhov and Rotmistrov proposed a comprehensive upgrade of the R15B-300 turbojet. The idea materialised as the uprated R15BF2-300, Izdelye 65M. The improvement in performance was achieved by adding a compressor stage and increasing the combustion chamber and turbine temperatures. As compared with the R15B-300, the R15BF2-300 had a lower specific fuel consumption, a higher thrust (10,000kgp/22,045lb st dry and 13,230 to 14,500kgp/29,166 to 31,966lb st reheat) and a higher compressor pressure ratio (4.95 vs 4.75).

The two engines were perfectly interchangeable, having identical dimensions and mountings. Providing the airframe was made more heat-resistant (that is, because of the higher turbine temperature), the new engines offered a substantial increase in rate of climb, ceiling, range and speed (up to 3,500km/h, or 2,187mph).

The Mikoyan OKB started a massive research effort with a view to increasing the MiG-25's top speed, concentrating mainly on aerodynamic stability and airframe/engine thermal limits. The aircraft's principal structure was made of steel and thus was heat-resistant enough. Some parts of the airframe, however, such as the radome and forward fuselage, wingtips, flaps and ailerons, were made of Duralumin and plastics. They were not subjected to significant structural loads but experienced high temperatures and had to be replaced with steel or titanium honeycomb structures. This, in turn, called for new technologies, Therefore the Mikoyan OKB suggested to split the work into two stages, ie, test and refine the engine on a structurally standard MiG-25 first and come back to the speed issue later.

Both the WS and the Ministry of Aircraft Industry went along with this approach and gave the go-ahead for Stage 1. In September 1964 the Ministry issued a directive detailing the test programme of the re-engined MiG-25. Yet the theoretical part, manufacturing and bench testing of the R15BF2-300 took longer than predicted, and flight tests did not begin until 1973. The VVS initially allotted a single MiG-25 for test purposes, which was later joined by a second aircraft.

Aircraft No.1 was a MiG-25RB which was given a new factory number (f/n) 02-601, after being modified (hence the tactical number 'Blue 601'). Aircraft No.2 was a standard MiG-25PD built in 1973 (f/n 84019175) which made its first flight with standard engines on 12th June 1973 with Ostapenko at the controls. (Later it was flown by Fedotov, Fastovets, Orlov and others.) On 30th August 1973 the aircraft received its intended R15BF2-300 engines, a new c/n (841710) and the tactical number 'Blue 710'.

From then on, the two aircraft served as test-beds for the new turbojet with the provisional designation MiG-25M (Modifitseerovannyy - modified). The conversion work was completed very quickly but refining the engine took a considerable time. Still, it was worth the sweat: the engine *did* produce the claimed performance. The service ceiling exceeded 24,200m (79,396ft) and supersonic cruise range was 1,920km (1,200 miles) in clean condition or 2,530km (1,581 miles) with a 5,300 litre (1,177 Imp gallon) drop tank.

The modified MiG-25RB was used to set a number of world time-to-height and altitude records. On a single day (17th May 1975) Fedotov and Ostapenko set three time-to-height records, reaching 25,000m (82,020ft), 30,000m (98,425ft) and 35,000m (114,829ft) in 143.2 seconds, 189.85 seconds and 251.7 seconds respectively. For these record flights the aircraft were designated Ye-266M for FAI registration purposes and had all non-essential equipment removed to reduce weight.

Same year the interceptor, 'Blue 710', was further modified by fitting the wings of the recce aircraft ('Blue 601') and new stabilators previously tested on another development MiG-25 ('Blue 502'). More modifications followed in 1976, this time to the electrical and control systems. The aircraft was used as a test-bed until withdrawn from use in April 1977.

The modified recce aircraft continued flying for some time. In the summer of 1977 Fedotov bettered his own altitude world records. On 22nd June he took the aircraft to 37,800m (124,015ft) with a 2,000kg (4,409lb) payload, and reached 37,650m (123,523ft) on 31st August with no payload. However, soon after the record flights, a pressure valve in the fuel system failed in a regular flight, causing one of the fuselage fuel tanks to get overpressurised and burst. A good-sized portion of the upper fuselage skin came off in mid-air; test pilot A G Fastovets displayed no mean skill and bravery, managing to land safely. The aircraft was repaired but test flights did not resume.

The test flights of the re-engined MiG-25Ms confirmed the possibility of improving the aircraft's performance considerably. In lightened form for the record breaking flights the aircraft had a thrust to weight ratio better than 1:0 for the first time in Mikoyan OKB history. As a result, the brakes could not hold the aircraft in full afterburner, and a special mobile detent had to be developed (a heavy vehicle with a jet exhaust deflector to which the aircraft was connected by a strong cable and lock).

The re-engined MiG-25 never entered production - for several reasons. First was the test programmes of two new aircraft, the MiG-25 Izdelye 99 and the MiG-31, which also began in 1975. Both aircraft were powered by the Solov'yov PS-30F (D-30F) engine with a similar rating but a lower specific fuel consumption (SFC). Second, the aero engine factories were tied up with other orders and could not produce the R15BF2-300. Finally, the PVO top command was more interested in the MiG-31 than in an upgrade of the existing MiG-25. Therefore, the MiG-25 programme was terminated.

Shortly afterwards the modified MiG-25PD ('Blue 710') was transferred to a school for junior technical staff, acting as a ground instructional airframe for a while. Later it was transferred to Moscow-Khodynka and is now on display at the open air museum there (incidentally, displaying its original construction number).

MiG-25 with Solov'yov PS-30F engines (Izdelye 99)

The production MiG-25P interceptor fulfilled all design requirements except range. To increase range one MiG-25P was experimentally re-engined with Solovyov PS-30F afterburning turbofans rated at 15,500kgp (34,170lb st). Also known as the D-30F, this engine was a derivative of the 'pure' D-30, rated at 6,800kgp (14,991lb st) which powered the Tupolev Tu-134 'Crusty' airliner, not the much later and much larger D-30KU/D-30KP, which is a totally different engine. The test-bed was designated Izdelye 99 and appropriately coded 'Blue 991'. Later, a MiG-25R was similarly converted and coded'Blue992'.

Unlike the MiG-25M described above the new engines required major modifications to the airframe. Still, outwardly the aircraft was little different from standard MiG-25s and the internal fuel volume remained unchanged (19,700 litres/4,377 Imp gallons). The new turbofan was expected to improve rate of climb and especially range (particularly at subsonic speed) by virtue of a lower SFC. Besides, the same engine was selected to power the future MiG-31.

A short while earlier, two MiG-25M test-beds powered by Tumansky R15BF2-300 turbojets had been evaluated, but there was no knowing if and when this engine would enter production. The new and fairly complex MiG-31 fighter weapons system could also take a long time testing. Thus, a MiG-25 fitted with the new fuel-efficient engines could supplant the standard MiG-25PD on the Gorkii production line for a while until the MiG-31 would be ready.

The scope of the Izdelye 99 programme was much larger than with the MiG-25M. However, with assistance from the Gorkii aircraft factory and due largely to the insistence of lead engineer M Proshin the technical problems were solved quickly enough. Shortly after test flights commenced a subsonic cruise range of 3,000km (1,875 miles) without drop tanks was achieved. Supersonic flight, though, caused more problems.

Normal take-off weight during tests was 37,750kg (83,223lbs), including 15,270kg (33,664lb) of internal fuel; MTOW with drop tank was 42,520kg (93,738lb). Range was increased to 2,135km (1,334 miles) in supersonic cruise or 3,310km (2,068 miles) at transonic speed, and service ceiling was boosted to 21,900m (71,850ft).

However, the MiG-31 was designed around the D-30F engine from the outset. And when the MiG-25MP, as the first prototype MiG-31 was initially designated, entered flight test in the autumn of 1975, interest in the MiG-25/D-30F re-engining project waned. In fact, no one took the trouble to study the aircraft's performance completely. The two modified aircraft were relegated to the role of engine test-beds under the MiG-31 development programme.

MiG-25PD Supersonic Engine Test-bed (Izdelye 84-20)

In 1991-92 one of the MiG-25PD interceptors used by the Mikoyan OKB based in Zhukovsky had one of its engines replaced by an unspecified experimental turbojet. The aircraft was designated Izdelye 84-20 and used to test the new engine in various flight modes, including supersonic flight.

The test programme was a rather complex one, since the engine (designed for a new generation multi-role fighter) had a totally different control system and a much higher rating than the standard R15BD-300. Therefore, much thought was given to safety measures in case the development engine or its air intake control system should fail, especially on take-off and in supersonic flight.

Stage A of the flight test programme (including supersonic flight) was completed without major difficulties. Aircraft 84-20 was post-Soviet Russia's first supersonic engine test-bed.

MiG-25PU Interceptor Trainer (Izdelye 22)

A two-seat trainer version of the MiG-25 was developed in the late 1960s to facilitate pilot training. This was not envisaged by the initial operational requirements, nor required by government directives. However, WS test pilots and instructors pressured the Mikoyan OKB into designing such an aircraft to fit both the interceptor and reconnaissance roles.

The designers decided to use a stepped tandem arrangement with the instructor's cockpit in a redesigned nose, ahead of and slightly lower than the trainee's cockpit. This simple but effective arrangement afforded an excellent field of view both for the instructor and the trainee and had been used before by Tupolev (on the Tu-128UT) and Yakovlev (Yak-28U). The aircraft had to be fitted with a new nose section (up to fuselage frame No.1), a second set of controls and flight instruments, a failure simulation panel in the instructor's cockpit and an intercom.

The prototype, built in 1969, was converted from a standard interceptor, since the trainer was needed first and foremost by the PVO, and received the *very* non-standard code 'Blue U01' ('Y01' in Cyrillic characters), the U denoting Uchebnyy - trainer. The interceptor trainer version was designated MiG-25PU (Perekhvatchik Uchebnyy) and bore the factory code Izdelye 22. A B Slobodskiy was appointed lead engineerforthe trainer versions.

The flight test programme was quickly completed without major problems, except for some buffeting at high Mach numbers. This problem was solved by imposing a Mach 2.65 speed limit rather than by making design changes.

Upon completion of the state acceptance trials the trainer entered production in Gorkii. Except for the weapons controls, the MiG-25PU's cockpit equipment was identical to the MiG-25PD. The wings with the kinked leading edge came straight from the interceptor, including the four pylons which could carry dummy R-40 missiles. The instructor's cockpit in the nose left no room for a radar, therefore, radar operation was also emulated.

In 1977 one MiG-25PU was specially modified for setting female world records. Svetlana Savitskaya, aerobatics world champion and daughter of Marshal Yevgeniy Savitskiy (Chairman of the State Commission for the MiG-25), got the chance to train on the MiG-25PU after graduating from the Test Pilots' School in Zhukovsky. The results exceeded by far every record set to date by female pilots, so it was decided to let her have a crack at the records without transitioning to the single-seat MiG-25.

On 31 st August 1977, Savitskaya reached an altitude of 21,209.9m (69,586.2ft). On 21st October over a 500km (312.5 mile) closed circuit, she averaged 2,466.31km/h (1,541.44 mph) . Finally, on 12th April 1978, she clocked 2,333km/h (1,458.125mph) over a 1,000km (625 mile) closed circuit. Typically, the aircraft was registered in the FAI records under the false designation Ye-133.

MiG-25RU Reconnaissance Trainer (Izdelye 39)

Quite predictably, the need arose for a reconnaissance/strike trainer fitted with recce equipment emulators. The recce trainer prototype (f/n 390CA01, or the Russian transcription, 390SA01) made its first flight from Gorkii on 20th March 1971, piloted by factory test pilot El'kinbard. After completing the test pro-

'Blue 992', a MiG-25R converted to serve as the second test-bed for the PS-30F engines. It was retired to act as an instructional airframe at the Moscow Aviation Institute. Yefim Gordon

'Red UOr. the Ye-155U, a heavily retouched photograph. Yefim Gordon archive

gramme the aircraft entered production as the MiG-25RU (Razvedchik Uchebnyy - reconnaissance aircraft, trainer) or Izdelye 39. The only difference from the MiG-25 was the absence of missile pylons (unlike the 'real-life' recce version, the recce trainer had the kinked 'interceptor wings'). The MiG-25RU also lacked the 'Peleng' navigation system.

The two trainer versions had a sizeable production run and were widely used by conversion training centres for advanced training (and also by regular units for pilot checkout, proficiency training, weather reconnaissance etc.) for many years to come.

As compared with the single-seat versions, the trainers cracked the 'sound barrier' more often in the same number of flight hours and hence suffered greater airframe loads which caused fatigue cracks in the wings - a problem the Mikoyan OKB had never encountered before. To cure the problem, changes had to be made to the manufacturing technology and overhaul procedures, and the trainers' service life was suitably increased.

The trainers were supplied to major foreign operators of the MiG-25's single-seat versions. India had two MiG-25RUs and Bulgaria, Libya and Syria also took examples. Several trainers were converted to test-beds and research aircraft described separately.

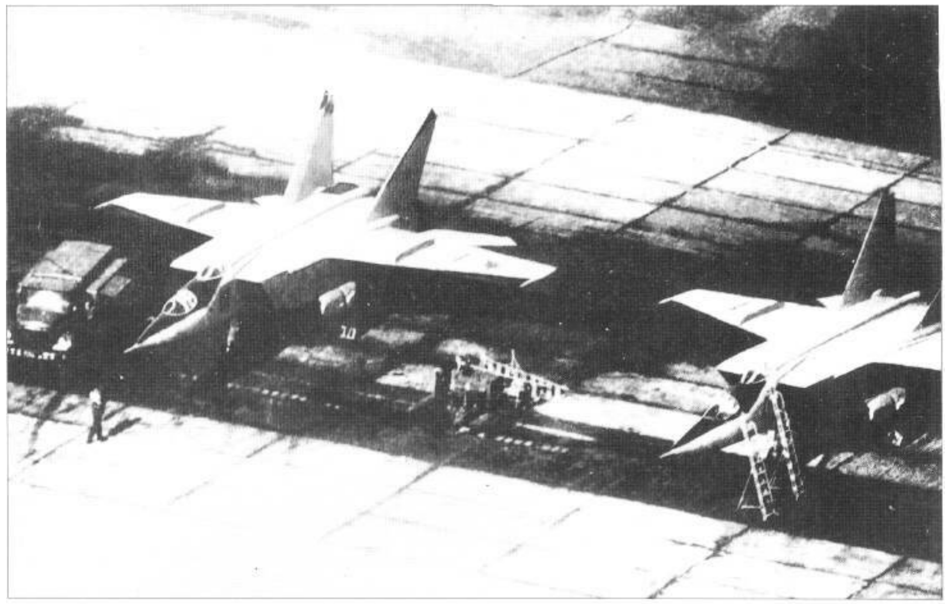
MiG-25RU - Brief Specifications

Fuselage length	19.431m	63ft 9in
Wing span	14.015m	45ft 11 in
Take off weight		
- with drop tank	39,200kg	86,419lb
- without drop tank	34,460kg	75,970lb
- with 80% fuel load (all tanks except fuselage tank No.1)	32,100kg	70,767lb
- with 50% fuel load (fuselage tanks Nos.3, 4 and wing tanks)	26,700kg	58,862lb
Top speed	Mach 2.65	

MiG-25RB Test-bed (Project Trapetsiya)

The MiG-25RB proved a very convenient aircraft for conversion into various electronic equipment and systems test-beds by virtue of the access hatches in the forward fuselage. These could be used to replace the standard Sigint gear and cameras by experimental avionics and test instrumentation.

The Lll in Zhukovsky used MiG-25RBs in various trials programmes. The first of these was Project Trapetsiya (Trapeze) under which the aircraft was used to test the navigation system of a new cruise missile.



The first photograph to be released showing a the MiG-25RU.

A long-time MiG customer, the Indian Air Force took delivery of a pair of MiG-25RUs.
Yefim Gordon archive

MiG-25 'Burarf Test-beds

Three different aircraft (MiG-25RU, MiG-25PU and MiG-25RB) were used as test-beds and support aircraft under the 'Buran' (Snowstorm) space shuttle programme. The two latter aircraft were also used as 'Buran' pilot trainers for practising the shuttle's characteristic steep landing approach.

The MiG-25RU prototype (f/n 390CA01) was turned over to Lll by the Mikoyan bureau after completing its flight test programme. The new owner converted it into a test-bed for the Zvezda K-36RB ejection seat - a version of the standard Soviet ejection seat modified for use in the space shuttle. The seat was fired from the rear cockpit suitably modified with a cutaway metal fairing in lieu of the standard canopy. A cine camera was installed in a dorsal fairing on the nose to record ejection seat separation.

Initially the aircraft was coded 'Red 46', later it was re-numbered 'Blue 01'. When the 'Buran' programme was terminated the MiG-25RU was used to test other ejection seats. On 22nd-27th August 1995, the aircraft was in the static display at the MAKS-95 airshow in Zhukovsky.

In order to calculate trajectory guidance algorithms for the space shuttle, Lll converted a MiG-25PU 'Blue 22' into the MiG-25PU-SOTN (Samolyot Optiko-Televizionnovo Nablydeniya - optical/TV surveillance aircraft). The aircraft's purposes included:

- advanced research of trajectory guidance algorithms for the space shuttle at altitudes below 20,000m (65,616ft) as part of the shuttle's total in-flight simulation complex. These tests included three Tu-154LL 'Careless' control system test-beds/approach trainers (CCCP-85024, -85083 and -85108).

- checking out monitoring techniques for the shuttle's automatic flight control system;
- training 'Buran' pilots and navigators/ system operators;
- acting as 'chase plane' for the 'Buran' during flight tests.

The aircraft was fitted with a KRL-78 radio command link integrated with the standard SAU-155 automatic control system, a B-218 data link system, test instrumentation (data recorders) and a TV tracking system for videotaping the aircraft being shadowed. This equipment suite was jointly developed for the MiG-25PU-SOTN by the 'Molniya' scientific and production association (the creator of the 'Buran') and the Institute of TV Systems.

The TV tracking system included a Sony DXM-3P video camera, a 3800PS video tape recorder, a DX-50 video monitor, a KL-108 transmitter and an MB-10 transmit antenna. The ground control room was equipped with a KL-123 receiver, short range and long range receiving antennas and control and data recording gear.

The front cockpit housed the TV camera and associated equipment. External identification features were the extra aerials under the nose and on thefuselage spine.

Lining up on the 'target aircraft', the pilot of the MiG-25PU-SOTN extended the landing gear and flaps and throttled back the engines at about 18,000m (59,055ft) in order to follow the same steep glide path, get the 'target' in his viewfinder and start 'shooting'. Until the real thing flew, the aircraft which doubled for the 'Buran' were specially modified MiG-25RB 'Red 02', MiG-31 'Red 97' and the BTS-001 CCCP-3501002 - a full-scale 'Buran' fitted with four Lyul'ka AL-31 turbofans and a lengthened nosewheel leg for taking off under its own power. Another designation for the BTS-001 (BTS - Bol'shoye Transportnoye Soodno, or 'big transport ship!) was GLI-Buran, Gorizontal'nyye Lyotnyye Ispytaniya, or horizontal flight test device.

Stage A of the programme comprised 15 flights for checking the TV tracking system's function, range and sensitivity to interference. It turned out that signals from the aircraft reached the ground control room undistorted in about 85% of the cases and the worst interference was caused by the radio altimeters of other aircraft flying nearby.

Stage B was held in September-October 1986 and served to optimise the data link transmission parameters and to determine the effect of the 'target aircraft' on picture quality. The optimum distance to the target was judged at about 10m (33ft). Therefore, an additional TV monitor was installed in the rear cockpit; the front cockpit canopy was modified and a Betacam video camera used.

Finally, Stage C was held near Yevpatoriya on the Crimea peninsula on 11 th-16th October 1986, and included ten flights with the updated and complete equipment suite. Yet the heyday of the aircraft was yet to come: it was when the real 'Buran' lifted off on its one and only unmanned space mission. Test pilot Magomed Tolboyev, flying the MiG-25PU-SOTN, intercepted the shuttle on its subsequent re-entry and flew chase during its glide and automatic approach all the way to touchdown, videotaping the entire sequence.

A MiG-25RB mentioned earlier ('Red 02') was also modified for the 'Buran' test programme. The recce and bombing system was replaced by additional communications gear, data link and other specialised equipment. The aircraft could also carry test instrumentation containers on the underwing hardpoints. 'Red 02' could be identified as a research vehicle by the additional dielectric panels on the sides of the air intakes.

MiG-25PDZ In-flight Refuelling

In the late 1980s, Soviet aircraft designers returned to the problem they had worked on intermittently for the last 40 years - the problem of aerial refuelling of tactical aircraft. The first experiments involving MiG-15, MiG-17 and Yak-15 'Feather' fighters dated back to the late 1940s and early 1950s. A second series followed in the late 1960s with an Il-28 tactical bomber and a MiG-19 (SM-10) fighter fitted with refuelling receptacles. The advent of the Il-78 'Midas' tanker derivative of the Il-76MD 'Candid' transport, the UPAZ-A unified podded hose drum unit (HDU) and retractable refuelling probes meant that tactical fighters and interceptors could finally enjoy flight refuelling capability.

Research work on aerial refuelling equipment for tactical fighters was done mainly by the Sukhoi and Mikoyan design bureaux. In the late 1980s several MiG-25s were fitted with refuelling probes and a trials programme got started. One of the aircraft, a production MiG-25PD interceptor ('Blue 45'), was used to examine the possibility of extending the intercept range and designated MiG-25PDZ (Zapravka-refuelling).

The L-shaped retractable probe was located ahead of the windscreen and slightly offset to starboard. A plug had to be inserted in the nose *a la* MiG-25BM to accommodate the probe and associated equipment. After the first few test flights the refuelling probe was shortened.

About the same time, Mikoyan and Sukhoi were working on fitting refuelling probes to fourth-generation fighters (MiG-29 'Fulcrum' and Su-27 'Flanker'). For commonalty reasons, the probes on both aircraft were offset to port; therefore, the designers considered moving the probe on the MiG-25PDZ to the port side. This called for major modifications, including more pipelines, changes to the fuel meter, additional SHORAN equipment ensuring rendezvous with the tanker and lights for illuminating the probe during night refuelling.

Ramp shot at Lipetsk of MiG-25RU 'White 36'.
Yefim Gordon

The flight tests were a complex and dangerous affair, since the hose and drogue could hit the cockpit of the fighter if the fighter pilot misjudged his position, and a broken hose could douse the fighter with fuel with an ensuing massive fire more than probable. To simplify flying the MiG-25PDZ and make refuelling easy enough for average service pilots, *a* micro-control system was proposed and tested successfully. It involved engine thrust vectoring by moving the petals of the variable nozzles.

Despite its complexity, the flight refuelling system tested on the MiG-25PDZ in its definitive form was clearly efficient, and a proposal was drafted to retrofit existing MiG-25s with it. However, the PVO was short of 11-78 tankers, since the type was primarily intended to work with the llyushin (with Beriev) A-50 'Mainstay' AWACS (another spin-off of the II-76MD). Hence, it was decided to fit the flight refuelling system to the more modern MiG-31.

The flight refuelling system as fitted to the MiG-25PDZ was also tested on reconnaissance/strike versions of the aircraft. The probe was installed as originally on the interceptor (ie offset to starboard) but located much further forward (this was dictated by the special mission equipment installed in the nose). As on the MiG-25PDZ, a slight stretch was necessary in the nose section to accommodate the probe and associated equipment.

A MiG-25RBV ('68') and a MiG-25RBSh were modified and redesignated MiG-25RBVDZ and MiG-25RBShDZ respectively (Dorabotannyy dlya Zapravki - modified for refuelling). An II-78 tanker was used during tests; however, the aircraft could also receive fuel from other tankers, including Sukhoi Su-24M 'Fencer' tactical bombers fitted with a ventral UPAZ-A HDD as a 'buddy' refuelling pack. At that time, however, the Su-24MR tactical reconnaissance aircraft entered flight test. Like the basic Su-24M, it already had a refuelling probe and was considered more advanced. The WS quickly abandoned the idea of extending the MiG-25RB's range and, as with the interceptor version, the proposed upgrade programme never materialised.

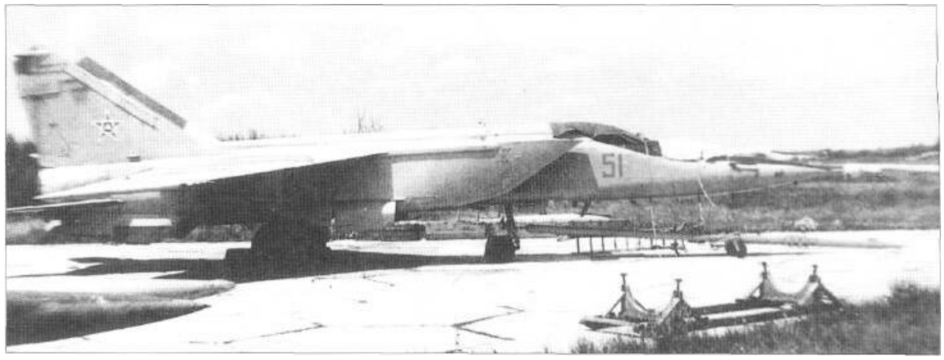
MiG-25PA(Ye-155PA) Interceptor

In the mid-1960s the Mikoyan OKB was working on an interceptor project referred to as the Ye-155PA. This aircraft was to be capable of destroying targets flying anywhere between 100 and 30,000m (328 - 98,425 ft) at speeds of 3,500 to 4,000km/h (2,187 - 2,500 mph). To this end, it was to be equipped with the brand-new 'Smerch-100' radar, later renamed 'Zaslon' (Shield), and armed with the equally new R-100 missiles. The powerplant consisted of two R15BV-300 turbojets with an improved high altitude performance (Vysotnyy - high altitude) which would take the aircraft to Mach 3.5.

Later, the requirements changed, especially regarding speed, and the project was discontinued. As for the radar, a refined version (SBI-16 'Zaslon') was later installed in the MiG-31.

MiG-25 with MiG-29 Weapons System

Experience gained in local wars gave rise to the idea of fitting the MiG-25 with the weapons package of the MiG-29 tactical fighter. The Phazotron NO-93 Topaz' radar of the MiG-29 would have to be modified by fitting a new antenna dish of 30% larger diameter. However, the R-27 missiles (ASCC AA-10 'Alamo') carried by the MiG-29 were not designed to absorb the intense heat generated at high Mach numbers. This would mean a restriction on the MiG-25's speed, and the project was abandoned.



Study of the protective sheeting over the nose reveals Bulgarian 'Red 51' to be a MiG-25RU two-seater.

MiG-25RU '46' during firing trials of the 'Buran' space shuttle ejection seats.
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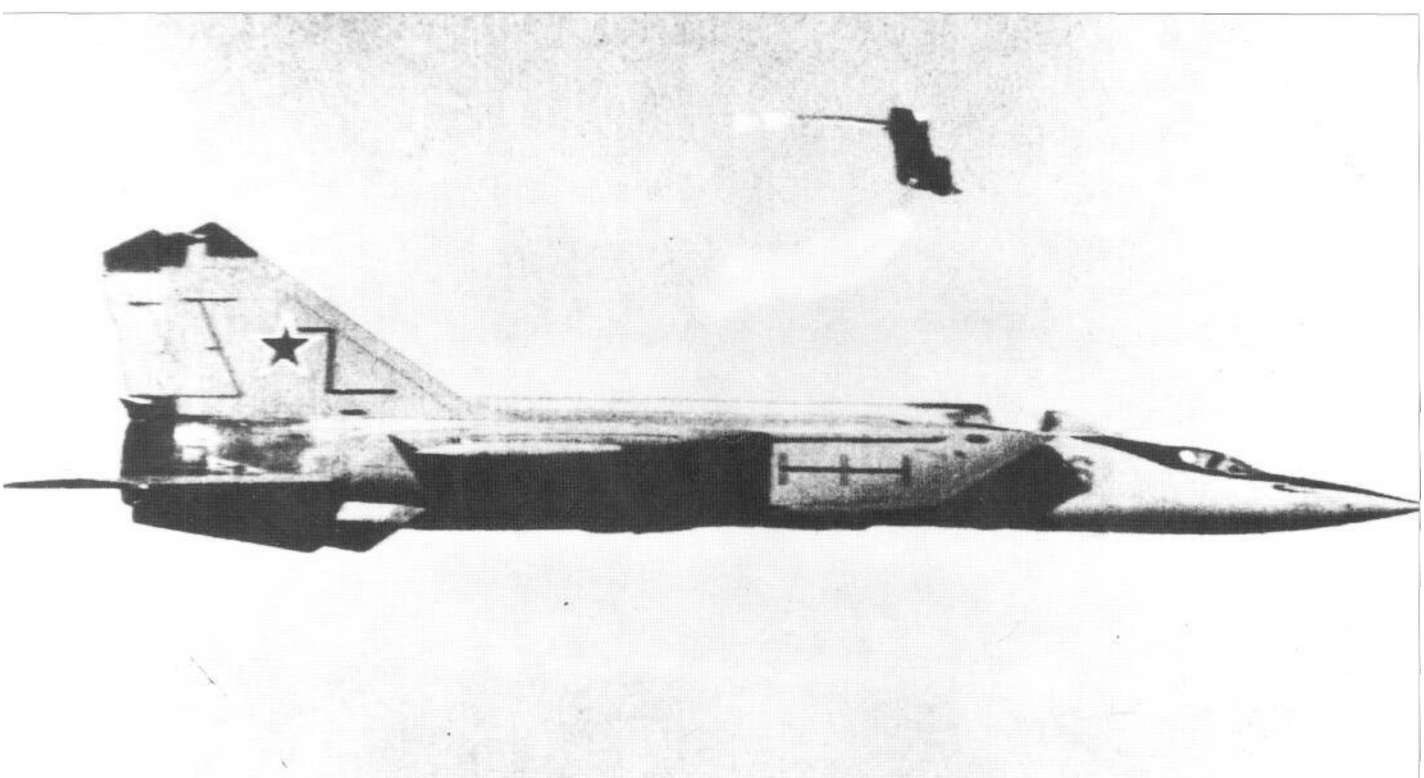


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02

Above: MiG-25RBVDZ '68' and Sukhoi Su-24M 'Fencer' '29' refuelling from an Ilyushin 11-78 'Midas'. Yefim Gordon archive

Opposite page:

Top: MiG-25PD 'Blue 45' modified with a refuelling probe(visible in stowed position in front of the cockpit) and redesignated MiG-25PDZ. Yefim Gordon archive

Centre: MiG-25RB 'Red 02' was also employed in the 'Buran' test programme. Yefim Gordon archive

Bottom: 'Blue 22' the much-modified MiG-25 PU-SOTN surveillance aircraft for the 'Buran' programme. Yefim Gordon archive

Right: Following modification test-bed MiG-25RU '46' became 'Blue 01'. Seat plus dummy are seen here being loaded into the heavily-adapted rear cockpit. Yefim Gordon archive

Below: A three-quarter front view of MiG-25RU 'Blue 01', the ejection seat test-bed for the 'Buran' programme. Yefim Gordon archive

Under the Skin

The MiG-25 is a twin-engined all-metal monoplane with shoulder-mounted trapezoidal-shaped wings, lateral air intakes, twin vertical tails and slab stabilators. The various versions of the aircraft are structurally identical, except the forward fuselage. The main structural materials used are steel (about 80%), aluminium alloys (11%) and titanium alloys (8%); other materials account for 1 % of the structure.

Fuselage

The MiG-25's fuselage is an all-metal one piece structure (ie, the aft fuselage cannot be detached for engine maintenance or change), formed mainly by a fuel tank split into several cells welded from high strength stainless steel.

The forward fuselage with the cockpit is made of aluminium alloys. Total length of the fuselage is 19.581m (64ft 2%in) for reconnaissance versions and 19.431m (63ft 9in) for the trainer versions. Fuselage cross section area is 5.54m^2 (59.6ft^2).

The fuselage is of monocoque structure with supplementary lower longerons and beams. The centre fuselage is formed by a welded steel fuel tank. The main structural materials are VNS-2, VNS-5, EI-878, SN-3, EI-703 and VL-1 high strength steel alloys, D19T aluminium alloy and OT4-1 titanium.

The structural elements were mostly assembled by automatic and semi-automatic contact and arc welding. The fuselage is composed of various panels and can be separated into the following sections:

- forward fuselage (pitot tube to frame No.2)
- bay aft of cockpit (frames No.2 and 3)
- air intakes (frames No.2 to 6)
- integral fuel cell (frames No.3 to 12)
- aft fuselage (frames No. 12 to 14)
- tailcone (frame No. Hand beyond).

The fuselage has 57 frames, 15 of which (some sources say 14) are principal load-bearing frames. Frames No.1 and 2 formed a bay, the upper half of which is the pressurised cockpit and the lower houses avionics.

The forward fuselage up to frame No. 2 is of monocoque structure and is structurally different in the interceptor, reconnaissance/strike and trainer versions. In the reconnaissance and reconnaissance/strike versions (MiG-25R, 'RB, 'RBK, 'RBS, 'RBV, 'RBF and 'RBSh) and the defence suppression MiG-25BM the forward fuselage is composed of webs and stringers to which skin panels made of D19T aluminium alloy are riveted. Cameras and electronic intelligence (Elint) equipment are mounted inside the forward fuselage on a special pallet forming part of the load-bearing structure. The pallet can be lowered on cables for servicing and raised again by means of a winch. After that the access hatch is closed by a cover held by special bolts.

In the interceptor versions (MiG-25P, 'PD and 'PDS) the forward fuselage houses the radar set and antenna dish; the latter is covered by an ogival dielectric radome. The radome can be slid forward for maintenance and is held by bolts on aflange mounting.

In the trainer versions (MiG-25PU and 'RU) the forward fuselage houses the pressurised instructor's cockpit which is structurally similar to the main (trainee) cockpit.

The pressurised cockpit located between frames No.1 and 2 has a framework of metal profiles. The canopy is attached to a supporting panel and is made of E-2 heat-resistant plexiglass. The optically flat forward panel is 20mm (%in) thick and the blown side panels and main portion are 12mm (^{1}/zin) thick. The canopy is opened and closed manually by means of an external handle and an internal folding strut. It is held in the open position by the strut forward and a retaining bar aft and secured in the closed position by four locks. Pressurisation is ensured by an inflatable ring seal. Cockpit glazing is equipped with de-icers.

Attachments for guide rails for the KM-1 ejection seat are attached to the cockpit floor at the bottom portion of frame No.2.

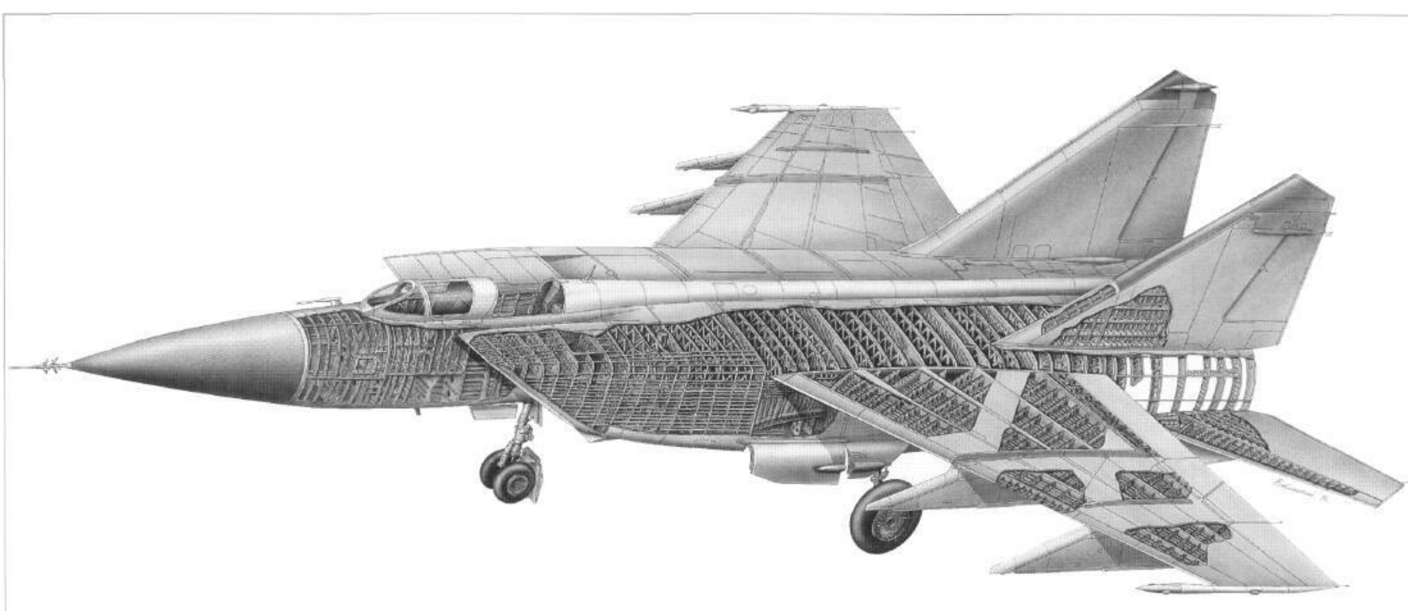
The forward fuselage skin panels and access hatch covers, canopy support frame and cockpit floor are all attached to fuselage frame No.1.

The cockpit terminates in a sloping bulkhead (frame No.2) to which the canopy support frame and cockpit floor are attached. Frame No.2 has a mortise for the nose landing gear unit and separates the cockpit from the bay aft of it. The bay aft of the cockpit connects the forward fuselage and the centre fuselage (the fuel tank bay) and is an oval-section semi-monocoque structure. The upper and side parts of the bay house avionics while the lower part is the nosewheel well. The bay is composed of panels made mainly of D19T alloy. The skin panels are spot-welded to frames No.2a and 2b, and to web-frames No.2v, 2g and 2d, longerons and stringers and incorporate a number of access panels for avionics servicing.

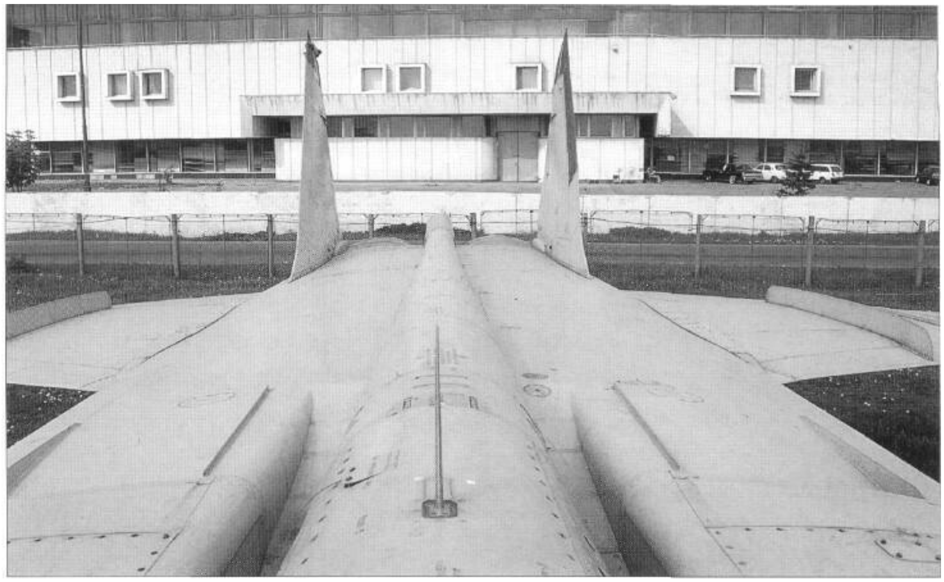
The avionics bay and wheel well are separated by a pressure bulkhead riveted to a longitudinal square-section beam assembled from metal angles. The hollow beam carries the nose gear actuator and downlock mounting and also houses control runs accessible via the removable top section of the beam. The nose gear attachments are located on frame No.3 and the actuator fitting between frames No.2v and 2g.

The bay is pressurised and heat insulated with ATAZ mats faced with ANT-7 fabric and bonded to the bay walls. The access hatches are edged with rubber seals and held by quick-release fasteners.

Detailed sectional view of the MiG-25.
Courtesy Avico-Press



Looking down the spine of a MiG-25P **towards the tail section.** Yefim Gordon



The air intakes are stressed-skin structures with frames and access panels carrying part of the load. The intake ducts run along the fuselage sides from frame No.2, connecting to the engine inlets at frame No.6. The air intakes are rectangular in cross section and have a sharp leading edge slanting steeply aft in side view. Between frames No.6 and 7 the air intake duct section changes to circular. The flat inner faces of the intakes are separated from the fuselage, acting as boundary layer splitter plates, and are attached to the fuselage by hinges and bolts. The boundary layer air is directed into the engine bays via auxiliary intakes at frame No.9 for engine cooling.

The integral fuel tank between frames No.3 and 12 is a one-piece monocoque structure welded from high strength stainless steel alloys (VNS-2, VNS-4, VNS-5and SN-3). The bottom part of the tank section and some internal webs in the tank are made of heat-resistant D19T aluminium. The structural elements of this section are mostly connected by argon arc and spot welding.

The centre fuselage tank section is the main load-bearing part of the fuselage, absorbing loads from the wings, the tail unit (via the aft fuselage), the engines and the landing gear, plus the external aerodynamic loads and the pressure loads in the air intake ducts and pressurised fuel tanks. It has eleven principal load-bearing frames and is separated into six bays by bulkheads. Technologically, the centre fuselage consists of four parts: tanks No.1 and 2 (frames No.3 to 6), tank No.3 (frames No.6 to 7), tanks No.4 and 5 (frames No.7 to 11) and tank No.6 (frames No. 11 and 12). These are made up of separate panels.

The mainwheel legs are attached to the fuselage keel beam and to frame No.8, the downlock struts being attached to frame No.9. The mainwheel wells located between frames No.6 and 9 are closed with two doors each.

The aft fuselage (frames No. 12 to 14) is a monocoque structure with two principal load-bearing frames (No. 13 and 14) madeofVL-1 steel and built-up skin panels. It incorporates the stabilator booster bays with access covers made of SN-3 steel and stabilator mounting beams made of VL-1 steel.

Frames No. 13 and 14 serve as attachment points for the vertical tails, ventral fins and stabilator mounting beams. In addition, frame No.14 is an attachment point for the upper and lower airbrake actuators and the rudder bellcranks. The upper airbrake has an area of 1.3m^2 (14ft^2) and a maximum deflection of 45°; the lower airbrake has an area of 1.0m^2 (10.76ft^7) and a maximum deflection of 43° 30'.

The tailcone consists of several panels. The internal structure is made of steel and spot welded. The external skin and webs are made of titanium and likewise spot welded, then riveted to the steel internal structure. The upper part of the tailcone begins with the upper airbrake recess, continuing into the brake parachute container with a Duralumin cover and fittings. The lower part of the tailcone incorporates the lower airbrake recess. The tailcone is attached to frame No.14 with a double row of rivets.

The lower fuselage between frames No.9 and 13 incorporates removable panels for engine maintenance and removal/installation.

Wings

Cantilever three-spar trapezoidal swept wings. Wing span is 14.015m (45ft 11^3/4in) or 14.062m (46ft 1^1/$_2$in) for the interceptor and trainer versions, depending on what type of wingtips are fitted, and 13.38m (43ft 10%in) for the reconnaissance/strike versions. Wing area for the reconnaissance/strike versions is 61.4m^2 (660.66ft^2) including centre section, or 41 .Om^2 (441.16ft^2) without centre section. Aspect ratio is 2.94, wing taper is 3.1. Recce/strike versions have a constant 41° 02' leading edge sweep. Interceptors and trainers have a kinked leading edge with 42° 30' sweep inboard and 41° 02' outboard. Trailing edge sweep is 9° 29' for all versions.

The wings use the TsAGI P-44M airfoil section at the roots with a relative thickness of 3.7% and TsAGI P-101M section at the tips with a relative thickness of 4.76%. Root chord is 6.943m (22ft 9^3/ein), tip chord is 2.237m (7ft 4in); mean aerodynamic chord (MAC) is 4.992m (16ft 4'/$_2$in.). Anhedral is 5°, incidence is 2°. The wings are cambered.

Each wing panel is attached to the fuselage by five bolts and fitted with flaps and ailerons. The wings are made largely of welded VNS-2, VNS-5 steel and OT4-1 titanium sheet. The main longitudinal elements are the front, middle and rear spars and the front and rear stringers. The leading edge and wing torsion box ribs are punched from VNS-4 sheet. Most of them are attached to the wing skin by means of 'spacer boxes'; however, ribs Nos.21, 22, 23 and 26 are attached directly to the skin. The trailing edge ribs are made of OT4-1 titanium. Each rib is thus made in two parts and spot welded during assembly. The detachable leading edge is welded from OT4-1 titanium sheet. It houses fuel lines and cable runs. The trailing edge assembly is riveted and welded. At the root it incorporates attachments for the flaps and the aileron bellcranks.

Each wing panel has four attachments for two weapons pylons, with reinforcement plates made of SOKhGSNA steel. Special deflectors are installed on the wing leading edge to keep water from getting into the pylons. The upper surface of each wing has a single airflow fence riveted and welded from D19T sheet and a shallow fairing above each hardpoint. The ailerons' middle and outer attachments are made of SOKhGSNA steel and AK4-1 aluminium alloy respectively. The rear end of rib No.22 serves as the outboard attachment point for the flap and the inboard attachment point for the aileron.

The wingtips are welded and riveted structures fitted with anti-flutter weights, radar warning receiver aerials and static discharge wicks. The MiG-25 was fitted with two types of wings featuring detachable or permanently attached wingtips. The detachable ones are connected to the wing panels by four bolts. The wing/fuselage fairing is a riveted structure with subframes and skin panels made of D19T. It is detachable and held by bolts with self-locking nuts. The internal volume of each wing forms an integral fuel tank divided by a hermetic bulkhead into a forward and an aft section. The forward tanks are limited by the forward stringer, the front spar, the root plate rib and rib No.30. The aft tanks are located along the entire span between the front and rear spars, the root rib and rib No.33. All joints are carefully welded to seal them.

The two-section ailerons are made chiefly of D19T Duralumin and have riveted skins and a honeycomb core. Anti-flutter weights are incorporated into the nose sections of the ailerons. Each aileron is 1.7m (5ft 7in) long; total aileron area is 2.72m^2 (29.26ft^2), maximum deflection is ±25° (on take-off and landing).

The flaps also have riveted skins and a honeycomb core and move on two hinges. Each flap is 1.932m (6ft 4in) long; total flap area is 4.3m^2 (46.26ft^2), maximum deflection is 25°. Early production aircraft (interceptors up to c/n 840sch09 and reconnaissance aircraft up to c/n 020SL04) had blown flaps which were deflected 47° on landing.

Tail Unit

Three-spar twin fins with spars, stringers and ribs of VNS5 steel and AK-4 Duralumin and skins of D19AT Duralumin. Leading edge and trailing edge sweepback is 54° and 4° 18' respectively; the fins are canted 8° outboard. The fins have an aspect ratio of 0.996, a taper ratio of 4.66 and an airfoil thickness ranging from 4 to 4.5%. Each fin is 3.05m (10ft Oin) tall and 4.76m (15ft 7%in) long, with a 3.22m (10ft 6%in) MAC. Total vertical area is 16.0m^2 (172.16ft^2). Port and starboard fin have different leading edges and tips. The fins are attached to four fuselage frames (Nos11 a, 12, 13 and 14). The rudders have skins riveted to ribs and stringers. They move on three hinges and have levers at the bottom for push/pull rod connection. Total rudder area is 2.12m^2 (22.8ft^2). Maximum rudder deflection is ±25°.

Cantilever differentially movable slab stabilisers with 50° 22' leading edge sweepback, an aspect ratio of 3.1 and taper ratio of 2.96. Span is 8.74m (28ft Sin), though some sources state 8.8m (28ft 10%in); area is 9.81m^2 (105.5ft^2). The stabilisers are carried on longitudinal beams in the aft fuselage. The stabiliser hinges were moved approximately 140mm (5/$_2$in) forward in 1973 to prevent elevator overcompensation The stabiliser hinges are located at 33% MAC. The trailing edges of the stabilisers are deflected 2° upwards. Deflection range is -32° to +13° on take-off and landing, diminishing to-12° 30'and +5° in cruise.

Two ventral fins with riveted skins and ribs are located symmetrically under the aft fuselage. The forward portion of each fin is dielectric and can be hinged sideways; in flight position it is attached to the aft portion by bolts. The aft portion is attached to the fuselage frames by two bolts. The port fin incorporated a brake parachute opening sensor actuated by impact on touchdown. Each ventral fin is 3.6m (11ft 9^3/4in) long; total area is 3.55m^2 (38.2ft^2).

MiG-25RB **'Red 40' camera bay.** Yefim Gordon

View of the camera bays of a MiG-25R BV. Yefim Gordon

Landing Gear

Hydraulically retractable tricycle type. All three units retract forward. The nose unit is equipped with twin KT-112/2 or KT-112A brake wheels (700-200mm) and levered suspension. The main units are equipped with single KT-111/2A or KT-111A brake wheels (1,300-360mm) and levered suspension.

All three units are fitted with automatic anti-lock brakes. The steerable nose unit has two turn limits (for low speed and high speed taxying). Retraction and extension is provided by a single hydraulic system; emergency pneumatic extension is possible in the event of a hydraulics failure.

All three units are secured in the down position by mechanical locks; the nose unit is additionally secured by a hydraulic system cock preventing the fluid from escaping from the actuator. Upon retraction the wheel wells are closed by doors which remain open when the gear is down.

Wheel track is 3.85m (12ft 7$/_{2}$in), wheelbase is 5,144m (16ft 10$/_{2}$in), though some documents quote wheelbase as 5.138m (16ft 10%in).

Powerplant

Early production MiG-25s were powered by two Tumansky R15B-300 turbojets (Izdelye 15B) rated at 7,500kgp (16,534lb st) dry or 11,200kgp (24,691 lb st) in full afterburner. Later aircraft were fitted with identically rated R15BD-300 engines with modified accessory gearboxes.

The R15B-300 (R15BD-300) is a single-shaft turbojet with axial compressor, can-annular combustion chamber, single-stage turbine, afterburner and variable (three-position) ejector nozzle. The engine's gross weight is 2,680kg (5,908lb); overall length is 4.1m (13ft 5%in) in 'clean' condition and 6.3m (20ft Sin) with inlet duct, maximum diameter is 1.74m (5ft 8$^{1}/_{2}$in). Maximum exhaust gas temperature is 800°C during start-up and 820°C in flight. Maximum engine speed at full dry thrust is 7,000rpm.

The engines are installed in fuselage bays aft of frame No.9 separated by a longitudinal firewall. To ease maintenance the engines are rotated 13° outboard so that the accessory gearboxes located at the bottom of the engines face away from each other.

The nozzles are inclined 2° 30' upwards and 1° 46' inwards for aerodynamic reasons. To reduce frontal area the nozzles were moved so close together that the distance between their centres is less than the nozzle diameter (the nozzles effectively overlap). Therefore, three inboard segments of each nozzle were removed and a fixed central boat-tail fairing installed so that the nozzle contours were slightly 'flattened' but unbroken.

The engines are installed in mountings attached to fuselage frames No.10 and 11. Each engine breathes through an individual air intake. Intake cross section and upper intake wall angle are adjusted by means of a two-segment movable ramp. The forward segment is perforated for sucking away the boundary layer; the aft segment is fitted with vortex generators to energise the airflow. In order to minimise losses in the intake duct the intakes have a movable lower lip which can be set in either of three positions.

To make the engines less susceptible to surging, inlet guide vanes attached to a thin-walled cylindrical body are located in front of the first compressor stage.

The engine bays are cooled by boundary layer bleed air to protect the airframe and engine-mounted accessories from overheating.

The engines are controlled by twin throttles located in the cockpit. Each engine has a separate electronic control system with an RRD-15B electronic mode regulator and a separate fire extinguishing system.

The main fuel grade initially was T-6 kerosene (T = Toplivo - fuel), with T-7P as a substitute; RT (Reaktivnoye Toplivo - jet fuel) grade kerosene was later found acceptable. The fuel is contained in ten integral tanks - six in the fuselage and four in the wings. Recce aircraft built before the mid-1970s had two additional integral tanks in the fins. The wing tanks were split into front and rear groups occupying almost the entire internal volume of the wings. All the fuselage tanks had a complex shape.

The total fuel capacity of the reconnaissance/strike versions is 17,780 litres (3,951 Imp gallons). Fuselage tanks No.1, 2, 3, 4, 5 and 6 house 2,810 litres (624.4 Imp gallons), 3,220 litres (715.5 Imp gallons), 3,060 litres (680 Imp gallons), 2,340 litres (520 Imp gallons), 2,370 litres (526.6 Imp gallons) and 730 litres (162.2 Imp gallons) respectively. The front wing tanks housed 550 litres (122.2 Imp gallons) each, the rear ones 1,910 litres (424.4 Imp gallons). The fin tanks on the reconnaissance aircraft held 600 litres (133.3 Imp gallons) each. The accumulator tank held a further 150 litres (33.3 Imp gallons) and the fuel lines 40 litres (8.9 Imp gallons).

The interceptors carried 14.570kg (32,120lb) of fuel and the reconnaissance aircraft 15,000kg (33,068lb). A 5,280 litre (1,173 Imp gallon) drop tank holding 4,450kg (9,810lb) of fuel can be fitted. The tank is 11.05m (36ft 3 in), with a maximum diameter of 1 m (3 ft 3^{3}/ein), and increases the total fuel load to 19,450kg (42,879lb). Early production MiG-25Ps and MiG-25PDSs had no provisions for a drop tank but the MiG-25PD can carry it on long range intercept missions in overloaded condition.

Armament

The MiG-25P was armed with four R-40 (Izdelye 46) medium-range air-to-air missiles - two R-40Rs with semi-active radar homing (SARH) and two IR-guided R-40Ts. The missiles could hit targets pulling up to 4g in an evasive manoeuvre and were carried on underwing pylons, one of a kind under each wing. The pylons were fitted with APU-84-46 launchers (APU = Avtomateecheskoye Pooskovoye Ustroystvo - automatic launcher for Aircraft 84 and Missile 46). The upgraded MiG-25PD and 'PDS carries updated R-40RD, R-40RD1 and R-40TD missiles. It can also carry two R-60 or R-60M short range air-to-air missiles on twin APU-60-11 racks on each outboard pylon instead of a single R-40. In this case only SARH missiles are carried on the inboard pylons.

The reconnaissance/strike versions (MiG-25RB, 'RBK, 'RBS, 'RBV, 'RBSh and 'RBF) can carry up to 4,000kg (8,818lbs) of bombs; starting from c/n 02022077 the bomb capacity was increased to 5,000kg (11,022lbs). The following combinations are possible:

- four FotAB-100-80 flare bombs in pairs under the wings;
- eight FotAB-100-80 flare bombs in pairs under the wings and fuselage;
- eight FAB-500M-62 HE bombs in pairs under the wings and intandem pairs underthefuselage;
- eight FAB-500M-62 HE bombs in tandem pairs under the wings and intandem underthefuselage;
- ten FAB-500M-62 HE bombs in tandem pairs under wings and in tandem pairs under the fuselage;
- ten FAB-500M-62 HE bombs in tandem pairs under the wings and in triplets underthefuselage.

Heat-insulated FAB-500M-62T bombs could be used instead of regular ones. Small calibre nuclear charges could also be carried.

The bomb armament of the air defence suppression MiG-25BM is similar to the reconnaissance/strike versions. For combating enemy radars the aircraft can carry four Kh-58U anti-radiation missiles with a range in excess of 40km (25 miles).

Avionics and Equipment

Except for the special mission equipment (including navaids), the interceptor and reconnaissance versions have identical avionics. These include an SRVMU-2A air intake auto/manual control system, an R-832M 'Evkalipt' (Eucalyptus) UHF radio, an R-802 HF radio, an ARK-10 radio compass, an RV-19 (later RV-18) high altitude altimeter, an RV-4 (RV-4A) low altitude altimeter, a 'Sirena-3M' (later LO-06 'Beryoza' [Birch]) RWR, an MRP-56P beacon, an SO-63B (later SO-69) ATC transponder, an SRO-2P IFF transponder, an R-847RM (later R-864) HF radio, an RSBN-6S 'Korall' SHORAN set, a 'Pion-3P' (Peonia) antenna feeder system, an SPU-7 intercom, a PVD-7 pitot probe, a KKO-5 oxygen mask and bottle, a Tester-UZL' flight data recorder, a P-591 cockpit voice recording system with an RI-65 tape recorder (capable of transmitting failure messages and distress signals automatically to ground control centres), an MS-6 'Lira' tape recorder etc.

All reconnaissance versions were fitted with the 'Polyot-1 Г automatic navigation and flight control system including a 'Romb-1K' SHORAN/ALS, a SAU-155P1 (interceptors) or SAU-155R1 (reconnaissance) automatic flight control system, an SKV-2N-1 (reconnaissance) or SKV-2N-2 (later SKV-2NL-2, interceptors) course system and an SVS-PN-5 navigation data link system.

Operating in concert with ground DME/DF and localiser/glideslope beacons, the 'Polyot-1 Г ensures automatic climb with subsequent transition to cruise at pre-set altitude and speed, auto route following (using reference points, including four airfields which could also be used as staging points), auto return to home base or one of three reserve bases, manual diversion to an airfield not programmed for the flight, auto landing approach down to 50m (164ft), go-around and homing in on a marker beacon.

Throughout the sortie the pilot sees his position relative to the airfield or waypoints (given in co-ordinates). The 'Polyot-1 Г is connected with the radar and the weapons aiming system and thus can direct the aircraft to the area where the target is. The system enables the MiG-25 to operate day and night in VFR and IFR conditions in automatic, semi-automatic and manual modes.

The interceptors' avionics suite is built around the weapons control system (WCS), ensuring it can intercept and destroy targets with missiles day and night in VFR and IFR conditions. The MiG-25P's WCS is based on the 'Smerch-A' radar (RP-25, or Izdelye 720) superseded in the mid-1970s by the improved 'Smerch-A2'(Izdelye 720M). The MiG-25PD/PDS is fitted with a 'Sapfeer-25' (S-25, or RP-25M or RP-25MN) radar. The radar can detect a medium sized target at more than 100km (62.5 miles) range.

Besides radar, the WCS of the MiG-25PD and 'PDS includes the TP-62Sh IRST system, the AVM-25 analogue computer and the PAU-473 pilot actions monitoring system (the modern equivalent of a gun camera). The WCS enables the aircraft to detect targets by means of radar, regardless of enemy ECM or ground clutter and to covertly attack targets in the rear hemisphere (ie without switching on the radar or switching it on very briefly), using the IRST set. The WCS is connected with the IFF system.

The interceptors are fitted with a command link system receiving, decoding and indicating instructions coming in from ground control centres. The system could also work the other way around, relaying messages to ground control. The MiG-25P had the old 'Lazoor' system, whereas the MiG-25PD and 'PDS was fitted with the BAN-75 system integrated with the ground-based 'Looch-1' guidance system.

Recce/strike versions were equipped with the 'Peleng-D' navigation/bombing system (later replaced by 'Peleng-DR' and still later by 'Peleng-DM'), comprising the 'Anis-8' INS, the DISS-3S Doppler slip/drift meter, theTsVM-10-155 'Orbita-155' digital computer etc. Other mission equipment included A-70M, A/E-10, A-72, S45-ARE day cameras and the NA-75 night camera (chiefly on the MiG-25R, 'RB,'RBNand'RBT), the 'Romb-1K' Sigint pack, DISS-7 Doppler slip/drift meter, the SRS-4A or SRS-4B Sigint pack (Izdelye 30A or 3OB) on the 'RB, the SRS-9 Virazh' Sigint pack (Izdelye 31) on the MiG-25RBV, the 'Koob-3M' Sigint pack on the MiG-25RBK, the 'Sablya' SLAR (Izdelye 122) on the MiG-25RBS, the 'Shompol' SLAR on the MiG-25RBSh, the 'Shar-25' Sigint pack on the MiG-25RBF, the 'Yaguar' targeting system on the MiG-25BM and SPS-141, SPS-142, SPS-143 or SPS-151 ECM sets (depending on the aircraft model).

Electrical System

AC and DC systems. Main power (28 volts DC) is produced by two GSR-12KIS generators feeding separate circuits. Each includes a 15SCS-45B silver-zinc battery. Each engine drives an SGK-11/1.SKIS (or SGK-11/1.5KIS-M) generator producing 200/215 V (400Hz) three-phase AC via a PPO-20 constant-speed drive (CSD), also feeding two circuits. Early MiG-25Ps and reconnaissance versions had a single-phase AC system. Some equipment uses 36 volts/400Hz AC; therefore, each circuit includes a T-1.5/02 transformer. If the port circuit fails all equipment can be run by the starboard transformer; if the starboard circuit fails, 120 volt AC is supplied by the PTO-100/1900 AC emergency converter. A failure indication system is fitted and large power consumers are shut down automatically if a circuit fails (to ensure that enough power is available for vital equipment for at least 15 minutes during landing).

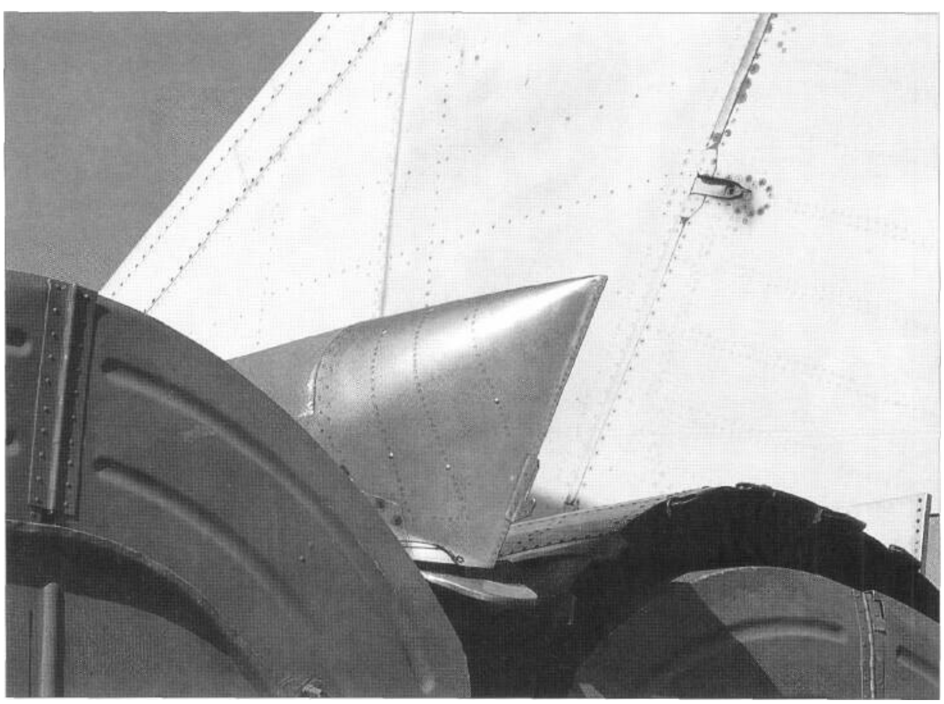
Hydraulic System

The MiG-25 has two independent hydraulic systems (general and flight control booster systems). The booster system powers one cylinder of each twin-cylinder booster controlling the stabilisers (BU-170), ailerons (BU-170E) and rudders (BU-190) and operates the emergency wheel brakes along with the general system.

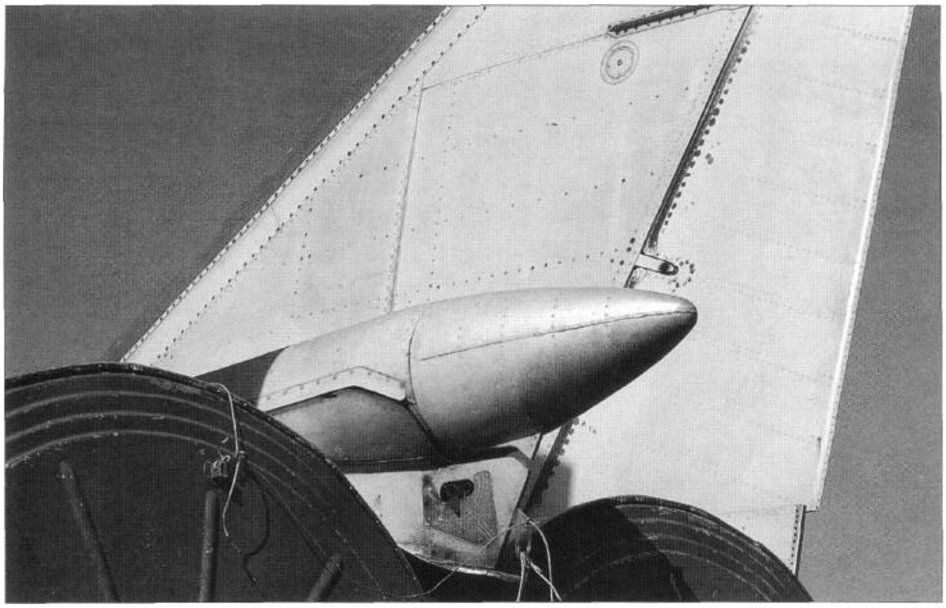
The general hydraulic system powers the other cylinder of the stabiliser, aileron and rudder boosters. It is also responsible for landing gear, flap and airbrake operation, normal wheel braking, wheel braking when the aircraft is towed, mainwheel auto braking during gear retraction, air intake ramp operation and emergency retraction, lower intake lip operation, nosewheel steering and APU air intake closure after engine start-up.

The systems use Grade 7-50S-3 silicon-based hydraulic fluid. The general and booster systems system use 53 litres (11.7 Imp gallons) and 30 litres (6.6 Imp gallons) of fluid respectively.

The systems are powered by NP-70A engine-driven variable-discharge rotary-piston hydraulic pumps coupled with fluid reservoirs. System pressure is 180-210 kg/cm^2 (2,570-3,000psi). The pumps are driven via fixed ratio drives and the output is in direct proportion to engine rpm. For added reliability, each system is served by two pumps driven by different engines; this makes sure that both systems stay operational in the event of an engine failure. Thus, the intake ramp of the failed engine remains operational, enabling a relight (unless, of course, there is a catastrophic engine failure and restarting is out of the question).



Early production MiG-25 braking parachute container. Yefim Gordon archive



Left: **Late production MiG-25 braking parachute container.** Yefim Gordon

Pneumatic System

The pneumatic system includes three independent subsystems:

- a main system,
- an emergency system and
- an avionics pressurisation system.

The main system pressurises the cockpit, controls the wheel brakes, canopy de-icing, fuel dump lines, generator cooling vents, automatic and manual brake parachute opening and manual parachute release, APU air intake opening. It also operates the winch for lowering and lifting special mission equipment pallets and controls nitrogen pressurisation of the fuel tanks.

The emergency system is responsible for emergency landing gear extension and adjusting the intake ramps for landing. The third system pressurises the avionics bays and radar/Sigint set (on interceptors and reconnaissance/strike versions respectively) cooling water tank.

Compressed air for all three systems is stored in bottles -14 litres (3.1 Imp gallons) in the main system, 10 litres (2.2 Imp gallons) in the emergency system and 2 litres (0.4 Imp gallons) in the avionics pressurisation system.

Air Conditioning System

The air conditioning system maintains the required air pressure and temperature in the cockpit and avionics bays. The system uses air bled from the engine compressors at about 400°C and 1.1 kg/cm^2 (15.7psi), supplied at a rate of about 800kg/hr (1,763lb/hr). The air is cooled in primary air-to-air heat exchangers and a water radiator and then fed to two subsystems, one for the cockpit and one for the avionics bays, at a rate of about 240kg/hr (529lb/hr) and 560kg/hr (1,234 lb/hr) respectively.

In each subsystem the air is further cooled. The cockpit subsystem uses another air-to-air heat exchanger and a turbo cooler; the avionics subsystem has a turbo cooler installed on the starboard engine. Cockpit air conditioning air is supplied at -7°C and 0.45 kg/cm^2 (6.4psi), while avionics cooling air comes at -20°C and about 0.075 kg/cm^2 (1.07psi). The capacity of the air conditioning system is enough to keep cockpit temperature at a comfortable 20°C.

Oxygen and Life Support Equipment

The MiG-25 is equipped with a KKO-5LP oxygen system which supports the pilot throughout the altitude range if the cockpit remains pressurised or up to 11,000m (36,089ft) in the event of decompression. During ejection the system automatically switches to the KP-27M portable oxygen bottle with a sufficient oxygen supply to last the pilot all the way down.

The pilot's clothing includes a Gsh-6 pressure helmet for high altitude operations (or ZSh-5 or ZSh-7 light helmet for lower altitudes), a VKK-6M pressure suit or VK-3 ventilated flying suit. For over-water operations a VMSK-4 or VMSK-2M marine high altitude rescue suit, an ASP-74 lifebelt or ASZh-58 lifejacket and a pair of gloves is provided. If the aircraft was to operate in an nuclear, biological or chemical (NBC)-contaminated environment the pilot was supplied with a 'Komplekt-L' NBC protection suit. The KM-1M ejection seat contained a survival kit, including an inflatable dinghy, a 'Komar' (Mosquito) emergency radio beacon and the usual signal flares, food ration, hunting knife, fishing gear etc.

De-icing System

The cockpit canopy has ethyl alcohol de-icing. The de-icing system is actuated by a button. Two or three seconds of operation are usually enough to clear away the ice; if not, longer operation is possible.

Flight Controls

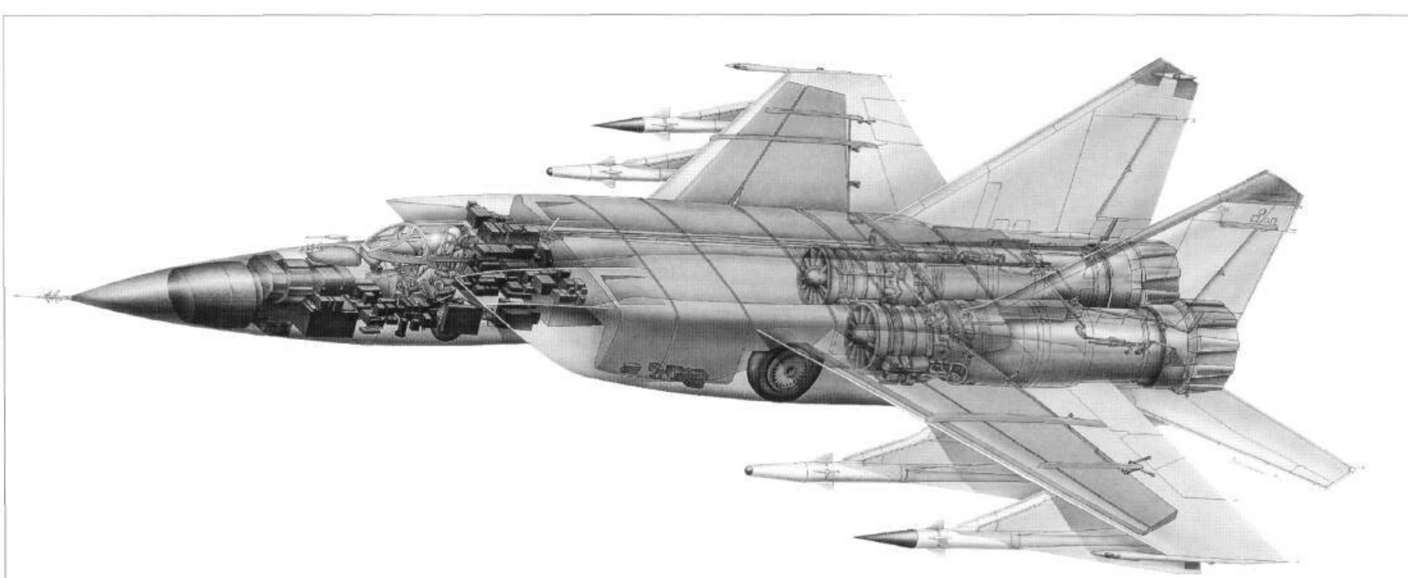
The slab stabilisers and ailerons are controlled by means of the stick and the rudders by means of the rudder pedals located on the central console. Lateral stability is enhanced by differential stabiliser deflection, with a special system countering yaw during asymmetrical missile launch.

The control surfaces are actuated by irreversible twin-cylinder boosters. Each stabiliser is actuated by a BU-170 booster, the ailerons by a single BU-170E (E - eleron) and both rudders by a single BU-190. Each booster is powered by both hydraulic systems at once, one system per cylinder. The stick and pedals are spring-loaded for 'artificial feel'. Tailplane deflection is limited by an ARU-90A regulator changing the tailplane actuator ratio to prevent excessive elevator inputs at low altitude and high IAS. The same regulator also altered the stick forces proportionately with speed.

Trimming to reduce stick and pedal loads is made by means of an MP-100M mechanism substituting for trim tabs.

The control runs are of mixed type, with double cables in the fuselage spine and push-pull rods elsewhere.

The aircraft is equipped with an SAU-155 automatic flight control system (SAU-155R1 on the reconnaissance/strike models and SAU-155P1 on the interceptors) with a view to enhancing combat efficiency, reducing pilot fatigue, increasing flight safety and allowing operation in adverse weather. The system operates the control surfaces by means of RAU-107A telescopic push-pull rod actuators.



Ejection System

The ejection system includes the canopy jettisoning mechanism and the ejection seat proper. Early MiG-25s had the KM-1 seat, replaced by the KM-1M on late production aircraft. The KM-1M seat permitted ejection at up to 20,000m (65,616ft) and 1,200km/h (750mph). It could be operated on take-off and landing at speeds not less than 130km/h (81 mph).

Braking System

A brake parachute container is located at the aft extremity of the fuselage spine above and between the engine nozzles. The parachute is opened automatically on touchdown, triggered by a sensor in the port ventral fin. The parachute container is made of Tekstolit' (a cheap composite material); its size was changed in 1977 when new parachutes were introduced. The total area of the two brake parachutes is $50m^2$ ($538ft^2$).

Braking in flight is done by means of two airbrakes located above and below the aft fuselage, with a deflection of 45°.

Fire Extinguishing System

The port and starboard engine have separate fire indication systems with ionisation sensors and separate fire extinguishers. Each fire extinguisher bottle holds 6.75kg (14.88lb) of $114V^2$ chlorofluorocarbon (CFC).

Opposite page: **Diagram showing engine, fuel and systems installations in the MiG-25.** Courtesy Avico-Press

Below: **Exploded view showing MiG-25 major components.** MiG OKB

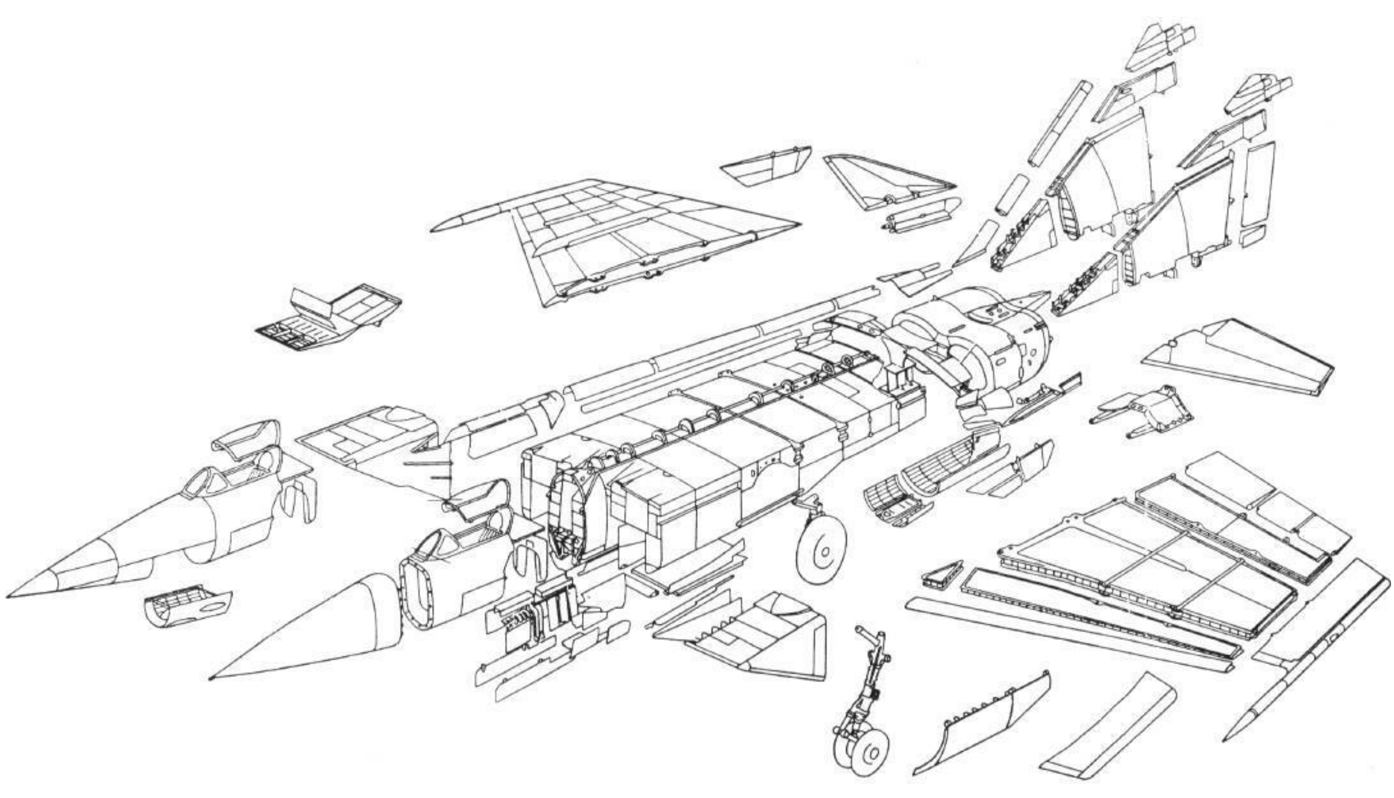
MiG-25 - Main Dimensions and Data

	MiG-25PD	M1G-25RB	MiG-25RBN	MiG-25RU
Length excluding nose probe	19.75m (64ft9/$_2$in)	21 ,55m (70ft 8%in)	21.55m(70ft8%in)	n/a
Fuselage length	n/a	19.581m (64ft 27$_8$in)	19.581m (64ft 27.in)	19.431m (63ft 9in)
Height	6.5m (21ft 4in)	6.5m (21ft 4in)	6.5m (21ft 4in)	6.5m (21ft 4in)
Wing span	14.01 5m (45ft 11^3/$_4$in)	13.38m (43ft 10^3/<in)	13.38m (43ft 1 0Wn)	14.01 5 (45ft min)
Wing area, with centre section	61 .40m^2 (660.66ft^2)	58.90m^2 (633.76ft^2)	58.90ПТ (633.76ft^2)	61 .40 (660.66ft^2)
Take-off weight - normal	34,920kg (76,984lb)	37,1 00kg (81 ,790lb)	35,740kg (78,791 lb)	32,100kg (70,767lb)
Maximum Take-off weight	36,720kg (79,960lb)'	41, 200kg (90,828lb)[s]	36,420kg (80,291 lb)	39,200kg (86,41 9lb)
Top speed - at zero level	1 ,200km/h (750mph)	1,200km/h (750mph)	1,200km/h(750mph)	1,200km/h (750mph)
-at 13, 000m (42,650ft)	3,000km/h(1,875mph)	3,000km/h(1,875mph)	3,000km/h(1,875mph)	Mach 2.65
Landing speed	290km/h(181mph)	290km/h (181 mph)	290km/h (181 mph)	290km/h (181 mph)
Unstick speed	360km/h (225mph)	360km/h (225mph)	355km/h (222mph)	350km/h(218mph)
Climb to 20,000m (65,61 6ft)	8.9min	8,2min	n/a	n/a
Service ceiling	20,700m (67,913ft)-	23,000m (75,459ft)	19,700m (64,632ft)	n/a
Range at >Mach 1.0	1,250km' (781 mis)	1,635 to 2,1 30km* (1,021 to 1,331 mis)	1,085km (678mls)	n/a
Range at <Mach 1.0	1,730km' (1,081 mis)	1,865 to 2,400km* (1,165to1.500mls)	n/a	n/a
Take-off run	1,200m (3,937ft)	1,200m (3,937ft)	1,200m (3,937ft)	n/a
Landing run	800m (2,624ft)	800m (2,624ft)	800m (2,624ft)	n/a
'g' limit	+4.5	+4.5	n/a	n/a
Armament: bombs	none	4-8 FAB-500	4-8FotAB-100	none
- missiles	2xR-40RD or 1 x R-40RD 1 x R-40TD 2-4xR-60M	none	none	inerts

Notes:

* With four R-40 missiles §With 5 tonnes (11,022lb) of bombs * MiG-25R with drop tank

Data for MiG-25RBN as carrying 8 FotAB-100 flare bombs



'Foxbats' in Action

After the Ye-155 made its public debut at the 1967 Domodedovo air parade the aircraft was allocated the NATO reporting name 'Foxbat' by the Air Standards Co-ordinating Committee (ASCC) and promptly dubbed 'MiG-23' in the belief that it was next in line to the MiG-21. This 'educated guesswork' proved to be wrong when the *real* MiG-23 was unveiled, and another year passed before the Ye-155's actual service designation become known in the West.

Many Soviet aircraft remained highly classified for a long time - perhaps none more so than the MiG-25. A turning point in the aircraft's career came when it actually saw combat on the Middle East theatre. Being on friendly terms with the Arab states, the Soviet Union could not remain unperturbed when the Israelis defeated Egypt in the Six Day War of June 1967.

'X-500S' for Egypt

In late January 1970, Gamal Abdul Nasser, President of the Arab Republic of Egypt, paid a secret visit to Moscow, asking for assistance in re-equipping the Egyptian armed forces. Specifically this included training military specialists, particularly surface-to-air missile (SAM) operators, and building up an effective air defence system.

Nasser's request was granted immediately. In February 1970 Egyptian troops began arriving in the USSR *en masse* to train, and deliveries of the latest Soviet military equipment got under way. The headquarters of all Egyptian army units, right down to battalion level, had Soviet military advisors attached.

In March-April 1970 Soviet SAM battalions and fighter units moved into Egypt to provide protection for important targets, such as the Aswan dam, the seaport of Alexandria, air bases, army depots and factories. However, the USSR did not stop at that. Soviet military experts took part in planning operations aimed at liberating Arab territories annexed by Israel. The Egyptian army was to break through Israeli defences, cross the Suez canal and move on into the Sinai Desert. However, a thorough reconnaissance of enemy forces was necessary, because the Israelis had established a mighty defence system along the Suez - the supposedly impenetrable Bar-Lev line.

A new Arab-Israeli war was brewing. Soviet leaders were well aware that the Egyptian Air Force was in no shape to take on the Israelis alone, even though it had been rebuilt by 1971 with massive aid from the USSR. Direct Soviet involvement in a Middle Eastern conflict (the way many Arab leaders would have liked it!) was out of the question, as it would be a sure route to the Third World War.

Therefore, another non-standard decision was taken: a special reconnaissance task force flying MiG-25s would be dispatched to Egypt. The Ministry of Aircraft Industry was instrumental in this decision.

While it might well have been expected that Libyan 'Foxbats' have been tempted into action, to date Iraqi and Syrian examples are the only ones to have been used in anger. Libyan 'PD 7029 illustrated. Courtesy Jane's

By then, the MiG-25 was veritably in a predicament. The test programme was dragging out with many problems requiring urgent solution, and General Kadomtsev's fatal crash in April 1969 certainly did not help (see Chapter Three). The Protivovozdushnaya Oborona (PVO - air defence forces) and Voenno-vozdushniye Sily (VVS - air forces of the USSR) were getting pessimistic about the MiG-25, and the decision whether it was going to be accepted was nowhere in sight. It was then that Deputy Aviation Industry Minister A V Minayev (who, as a former Mikoyan man, cared about the new aircraft) suggested trying it out in the Middle East. The military were also interested in finding out what the MiG-25 could do ('seeing is believing', they say!) and jumped at the opportunity to test it in actual combat instead of the customary test ranges.

In the summer of 1970 a task force led by Minayev was formed at the Nauchno Issledovatelyskii Institut (Nil - Scientific and Research Institute) VVS base in Akhtubinsk.

This included the cream of the specialists from Nil, the Lipetsk conversion training centre and a handful of regular VVS units which were by then operating the type. Mikoyan OKB and aircraft industry employees who had participated in refining the aircraft and knew it well were also included. The task force also included six experienced pilots (mostly VVS pilots) and MiG-25 deputy project chief L G Shengelaya; the Mikoyan OKB was also represented by Ischchenko and Polushkin.

The test engineers group included highly experienced men like Tokarev and Mischchuk, some engineers from the Gorki! plant (notably Goryunov) and engine experts from the Tumanskii design bureau and the plant producing the R15B-300. The Ramenskoye Instrument Design Bureau responsible for the 'Peleng' navigation system sent Burov, and Vsesoyuznyy Nauchno-Issledovatel'skii Institut Radioelektroniki i Avtomatiki (VNIIRA - AH-Union Electronics and Automatic Equipment Research Institute) was represented by Andjian, a radio navigation systems expert. All in all, the group dispatched to Egypt consisted of 50 men. The real rank and status of each man was kept secret, and the group was closely guarded by Egyptian commandos all the time after arriving in Egypt.

Test pilot Vladimir Gordiyenko (the Gorkii factory's chief test pilot) test flew nearly all the MiG-25s allocated for the effort and taught service pilots to handle the aircraft. Colonel N Stogov (Lipetsk centre) and service pilots N Borschchov, Yu Marchenko, Chudin and Krasnogorskiy were all experienced airmen. Test pilot (1st Class) Colonel Aleksandr S Bezhevets, a man renowned for his resolve and command skills, was put in charge of the flying group. Also, he was second to none in knowing the MiG-25, having flown the first Ye-155 prototypes back in 1965.

Bezhevets was faced with the daunting task of keeping the large and motley team organised. In the first days of the task force's stay in Egypt it was directed by Air Marshal Yefimov (First Deputy Commander-in-Chief of the VVS who later went on to become C-in-C) and Lt General Dol'nikov, deputy chief Air Force advisor in Egypt.

There was no point in sending the MiG-25P heavy interceptor to the Middle East. One or two aircraft could not save the Egyptian air defence force, and the USSR could not afford to send more since it was guaranteed to attract attention in the West and be regarded as direct intervention. Additionally, the M1G-25P was most effective at long range and high altitude because of its remarkable performance, and the Middle East theatre was just too cramped for it.

Besides, there was the question of enemy tactics; the situation called for many highly manoeuvrable light fighters (rather than a handful of heavy interceptors) to counter the Israeli aircraft. Thus, the Soviet leaders decided that sending four reconnaissance aircraft would do a lot more good, since they could speedily bring back tactical information and, importantly, boost the morale of Egyptian forces.

Two 'pure reconnaissance' MiG-25Rs (f/ns 020501 and 020504) and two reconnaissance/strike 'RB conversions (f/ns 020402 and 020601) were selected among the early production aircraft undergoing tests at Nil VVS. The technical staff were familiar with these aircraft, which simplified servicing. For photint duties they could carry two different camera sets composed of A-72s, A-87s and A/E-1 Os, as well as the interchangeable SRS-4A/SRS-4B Sigint packs. The MiG-25RBs differed in having provisions for bomb racks and being fitted with the 'Peleng' bombing computer.

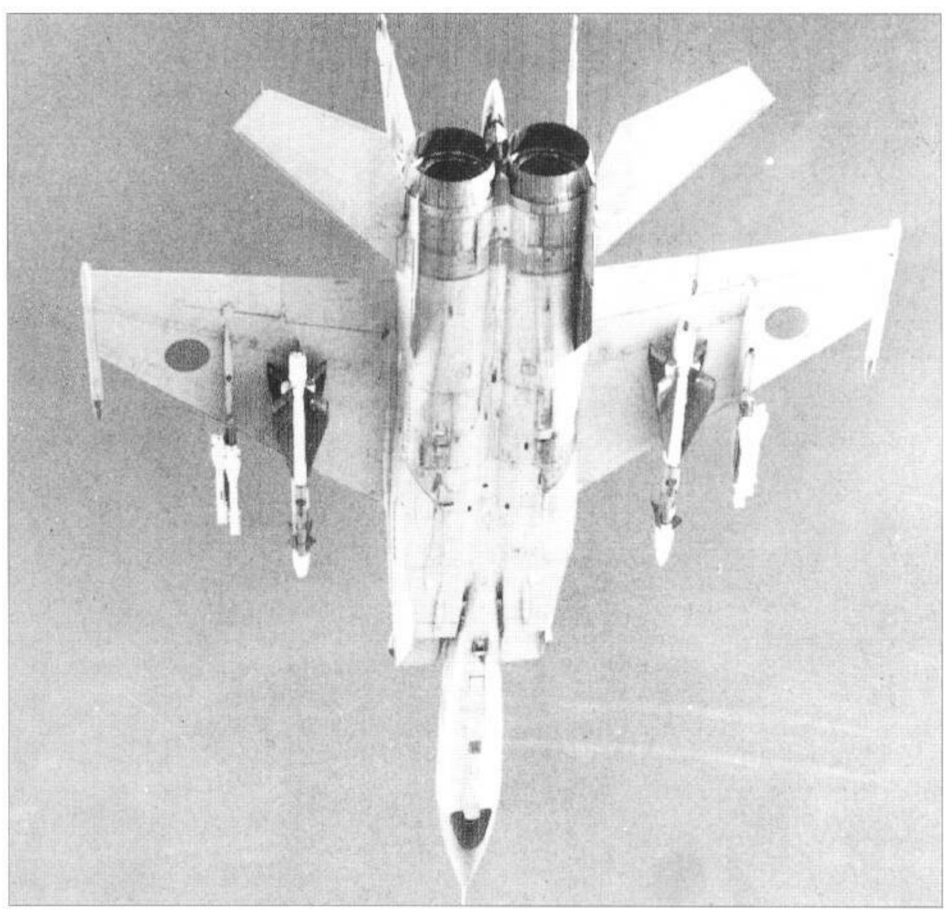
The location where the group was to operate was kept secret until the last moment. The first clue was the medical commission which all pilots had to pass to make sure they were fit for service in hot and dry climatic zones. The 'hot and dry' suggested Africa; this was confirmed soon afterwards when the top brass informed that the group was to 'extend international help' to the United Arab Republic.

Training was completed and everything set to go by late September 1970. But then Nasser died on 28th September; Anwar Sadat, his successor, seemed more intent on negotiating than waging a war. A change in Egypt's political course seemed probable, and the trip was postponed. However, Sadat confirmed that Egypt was firm in its resolve to win back the land seized by Israel, and the programme went ahead as planned.

In March 1971 the group was ordered to pack up and move to Egypt on the double. To save precious time the personnel and the four aircraft were to be airlifted by Antonov An-12 'Cub' and An-22 'Antei' (or Antheus, ASCC 'Cock') transports. But even with the wings, tail units and engines removed the MiGs would not fit into the An-22's cargo cabin - they were a couple of inches too wide and too high. The fuselage width fitted but the mainwheels got stuck in the 'Antei's' cargo door.

Thinking fast, someone suggested reversing the main gear units so that the mainwheels faced inboard instead of outboard; that took care of the problem. Someone else suggested temporarily fitting MiG-21 mainwheels. They were strong enough to hold the stripped-down aircraft but much smaller than the MiG-25's own mainwheels, enabling the aircraft to go through the cargo door, though it was a very tight squeeze.

The group, designated the 63rd Independent Air Detachment (Det 63), was based at Cairo-West airport. For security reasons all members of the group wore Egyptian uniforms with no markings of rank. Det 63 reported directly to Colonel General Okunev, the top Soviet military advisor in Egypt; Major General



Underside view of a Libyan MiG-25PD.
Courtesy Jane's

Libya also took delivery of the reconnaissance /strike MiG-25RB; 499 illustrated. Courtesy Jane's

Kharlamov, HSU, was responsible for tactical planning and objective setting. Minayev and Shengelaya monitored the group's operations from the manufacturer's side.

The Egyptians had already built huge hardened aircraft shelters for the MiGs. Using these shelters, the highly skilled Soviet technicians managed to reassemble the aircraft in a few days. In the meantime Israeli aircraft attacked the airfield several times which resulted in the air defence at Cairo-West being beefed up with S-75 and S-125 SAM batteries. The shelters containing the MiGs were further protected by five ZSU-23-4 'Shilka' quadruple 23mm self-propelled flak manned with Soviet crews. The airfield was guarded by Soviet soldiers who dug foxholes and put up barbed wire. The Egyptians were only responsible for guarding the outskirts of the field. Finally, the assembled and checked aircraft were wheeled over to the open air revetments previously occupied by Egyptian Air Force Tu-16KS 'Badger-B' anti-shipping cruise missile carriers.

It was just as well that the task force was so painstaking about security measures. It turned out that the locals, for all their friendly attitude, could not be trusted to keep quiet. Egyptian officers never seemed to give security a second thought, and having them participate in mission planning and support meant that the Israelis were aware of the group's plans almost before the meeting adjourned. A few days after the group moved to Cairo the local paper *Al-Akhram* raised a ballyhoo, carrying a banner headline 'New aircraft at Cairo-West air base!' For sheer effect the paper labelled the aircraft 'X-500', but the accompanying pictures left no doubts as to their identity (and origin).

The Soviet task force was very worried indeed by how fast the Israelis got news of its planned sorties. This forced a change in the co-operation procedures with the Egyptians to stop possible breaches of security. A meeting chaired by General Okunev resolved that from then on all work of Det 63 would be done only by the Soviet personnel.

Ensuring flight safety turned out to be a major difficulty. To avoid encounters with Israeli aircraft special air routes had to be developed, ensuring that the MiG-25s were protected by SAMs at all times during climb and descent. The pilots also perfected a steep landing approach (not unlike the 'Khe Sanh tactical approach' used by the USAF in Vietnam) and devised evasive manoeuvres for escaping missiles. During descent the MiG-25 boasted a thrust-to-weight ratio better than 1; in contrast, Israeli McDonnell F-4E Phantom Us and Dassault Mirage IIICJs had a ratio of 0.6 to 0.7.

The first trial flights over Egyptian territory began in late April. During this period, mission profiles were drawn up, cameras tested and navigation computers adjusted and programmed. Test pilot Gordiyenko was the first to go up. During that sortie the Sigint pack recorded that, in addition to Israeli radars, the aircraft had been 'painted' by a US Navy destroyer's radar and a British surveillance radar on Crete. Later, Marchenko and Bezhevets also started flying sorties. These sorties had one curious feature. To get optimum picture quality the automatic flight control system had to follow a predetermined route very closely, using landmarks which were unavailable in the desert. Hence, the famous pyramids of the Valley of the Pharaohs were used as landmarks, causing pilots to refer to these missions as 'guided tours'!

For security reasons the 'Foxbats' took off without warning before some Egyptian could shoot his mouth off that a sortie was planned. Cairo-West air traffic control (ATC) would be 'officially' advised that nothing more serious than a routine engine check or taxi trials was cooking. As a result, the first unexpected (and unauthorised) take-off caused real panic among the Egyptians.

Sorties over Israeli-held territory involved cruising in full afterburner for about 40 minutes. Air temperature in the intake ducts reached 320°C; the aircraft skin was not much colder either (303°C). By then, the Tumanskii design bureau had extended engine running time in full afterburner from three to eight minutes and then to 40 minutes. Thus, virtually all sorties could be flown at maximum thrust; the R15B-300 turbojets proved reliable enough and gave no problems in the hot Egyptian climate.

The MiG-25 used special T-6 grade jet fuel with a high boiling point which was unavailable in Egypt. To supply Det 63 with this exotic fuel, Soviet tankers sailed from Soviet seaports to Alexandria, whence the fuel was delivered to Cairo by KrAZ-214 tanker trucks.

The preparations were finally completed in May 1971 and the group was all set to start combat sorties. Missions were planned painstakingly. The pilot would start the engines while the aircraft was still in the hardened aircraft shelter (HAS), then run a systems check and taxi out for take-off. Then he carefully positioned the aircraft on the runway because the holding position ('X marks the spot') was clearly defined and entered into the SAU-155R1 automatic flight control system. This was the starting point of the mission; from there the pilot proceeded, strictly observing radio silence - pilots were allowed to get on the air only in an emergency.

The reconnaissance aircraft always operated in pairs. This increased mission success probability while giving the pilots that extra bit of confidence - 'in case I don't make it back'. If one aircraft went down because of a critical systems failure (or was shot down - war is war, after all) the other pilot could report the crash and indicate the whereabouts, helping the rescue group.

The Israelis were really taunted by the 'Foxbat' overflights and started a veritable hunt for them, but the prey invariably got away. Yet the Israelis had an excellent Sigint operation running, and calling in Egyptian fighters by radio to provide air cover would be an open invitation for the enemy to come in and try to shoot the MiG down. Since the Soviet pilots maintained radio silence the Israelis had no alternative but to circle over Cairo-West, waiting for the 'Foxbats' to line up for take-off.

Even then, they were out of luck. As the Israeli fighters moved in to attack they were immediately counter-attacked by a flight of Egyptian MiG-21MF 'Fishbed-Js' flying top cover (these were summoned in advance from another air base). After receiving word that the Soviet pilots were ready, two of the MiG-21s streaked over the runway, followed immediately by the MiG-25s, a second pair of MiG-21s protecting the rear. In a few minutes the 'Foxbats' would accelerate to Mach 2.5 and go 'up, up and away'.

Missions were flown at maximum speed and 17,000-23,000m (55,774-75,459ft). At this rate, no one could keep up with the MiG-25, which was just as well because the aircraft was unarmed. The engines burned off 500kg (1,102lb) of fuel, reducing all-up weight, and the aircraft would accelerate to Mach 2.8. Pilots recall that the canopy got so hot it burned fingers if touched. As the aircraft approached the target area the vertical and oblique cameras were operated automatically, photographing a strip of land 90km (56 miles) wide to either side. To prevent malfunctioning of the delicate equipment the camera bay was air conditioned with a temperature variance of no more than 7°C.

Besides high temperatures, photography at high Mach numbers involved another difficulty - rapid camera movement relative to the object. In a single second the MiG-25 travelled almost 1,000m (3,280ft); thus, very high shutter speeds were needed to get clear pictures. To compensate for camera movement special adapters with movable prisms were developed, allowing the object to be kept in focus.

Certain photo and cine shooting modes require that the camera ship keep a constant speed - another complication. The MiG-25 was constantly climbing as fuel burn-off reduced weight, reaching 22,000m (72,178ft) at the end of its target run. Besides taking pictures, the MiG-25Rs and MiG-25RBs pinpointed Israeli radars, communications centres and ECM facilities.

The entire flight from Suez to Port Said took just $1^1/2$ or 2 minutes. On the approach to Cairo-West the reconnaissance aircraft were met by the MiG-21MFs which escorted them all the way down, patrolling over the airfield until the Soviet aircraft were safely in their shelters.

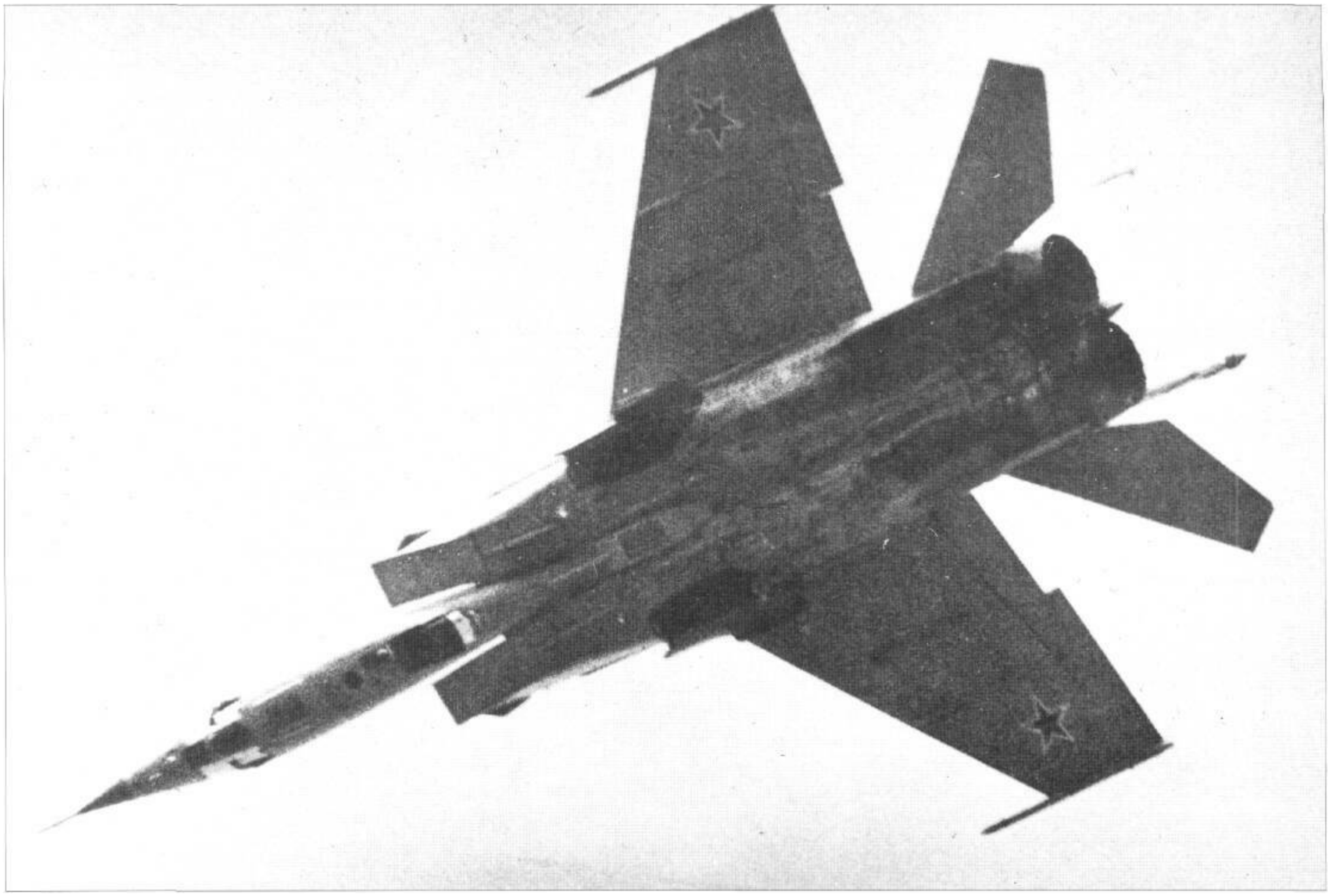
After losing several aircraft to SAMs the Israelis gave up trying to bomb the base, but the confrontation continued. In September 1971 an Israeli aircraft flying combat patrol near Cairo-West was shot down by an Egyptian SAM. The Israelis retaliated by raiding the SAM sites, knocking out two of them with AGM-45 Shrike anti-radiation missiles (ARMs); the Soviet men and officers manning the sites were killed. This led the Soviet command to take additional protective measures for Det 63. In October 1971 special underground hangars were built for the MiG-25s at Cairo-West. These shelters could take a direct hit from a 500kg (1,102lb) bomb and were fitted with all necessary communications and support equipment. Pre-flight checks and routine maintenance, including engine run-up, were done underground and the aircraft only left the shelter immediately before take-off.

The MiG-25s made two sorties per month. As they covered all of the Suez canal and went on to explore the Suez peninsula, the sorties grew longer, requiring a drop tank to be carried occasionally - with the drop tank the aircraft's range exceeded 2,000km (1,250 miles). The MiGs brought back hundreds of metres of film with valuable information, which was developed and sent to the intelligence section of the chief military advisor's HQ for analysis. The excellent images from 20,000m (65,616ft) showed not only buildings and structures but also vehicles and even groups of people. Camouflaged materiel dumps and shelters were also visible. The Sigint equipment helped to discover a camouflaged ECM facility near Jebel Umm-Mahas and pinpoint Israeli air defence radars and SAM sites.

Det 63 continued to operate successfully. The MiG-25s ventured still farther afield - that is, farther east, and by winter their routes took them over Israel. The Soviet pilots were not afraid of Israeli jets scrambling to intercept them, having encountered them before over the Sinai desert - the F-4E and Mirage IIICJ were just no match for the MiG-25. The Phantom was inferior in speed and ceiling; trying to line up for an attack it would stall and flick into a spin. The Mirage did even worse, and at best the Israeli pilots managed only to get a glimpse of the intruder.

The MIM-23 Hawk missiles used by Israel were no great threat to the MiG-25 either, since

Work underway on a PVO MiG-25P.
Yefim Gordon archive



the aircraft was out of their altitude range (12,200m/40,026ft). The MiGs' radar warning receiver often sensed that the aircraft was being 'painted' by enemy radars but no missile warning ensued. On discovering a Hawk launcher the pilot would simply switch on the 'Siren' ECM set and carry on with his business.

Deep penetration flights continued into October 1972. The Israeli ambassador to the United Nations lodged a formal complaint after each occurrence but no action on this issue was ever taken by the UN.

The Israelis *did* have a reason to be nervous. Among the support equipment and other paraphernalia Det 63 had brought with them were bomb racks for the two strike capable 'RBs and FAB-500M-62T low drag bombs, specially developed for supersonic bombing. Each aircraft could carry up to eight such weapons; after being released at high altitude they could sail through the air for miles and miles. However, the Soviet pilots' missions did not include bombing.

As an excuse for their inability to intercept the elusive MiGs the Israeli air defences stated that 'the object was clocked at Mach 3.2'! However, the flight recorders of the MiGs showed there were no major deviations from the prescribed flight profile. The aircraft were not *always* flown by the book. On one occasion Bezhevets exceeded the 'red line' to get away from pursuing Phantoms; the flight recorder showed that the Mach limit had been more than tripled(l). Other sources state that it was WS pilot Krasnogorskiy who should walk away with the record (and get the 'speeding ticket'), as he reached 3,400km/h (2,125mph) in one of the sorties. This was dangerous because the airframe could be damaged by overheating, but careful inspection of the aircraft showed no apparent damage. Still, the pilots received an unambiguous 'debriefing' afterthis incident.

The new MiGs had a good reliability record, with very few failures despite the fact that the aircraft still had its share of bugs. Each aircraft came complete with a double set of spares - just in case. Nasty surprises did happen. On one occasion Stogov's aircraft suffered an engine flame-out and began decelerating rapidly, forcing the pilot to radio for help. He was ordered to return to base immediately or land at the reserve airfield from which escort fighters scrambled. In a few seconds, the engine revived spontaneously and Stogov proceeded with the mission as planned. The trouble was traced to a faulty fuel flow control unit which the electronic engine control system somehow managed to correct.

A more serious incident happened to Bezhevets. A main gear locking arm failed on the first aircraft reassembled in Egypt and the strut would not lock in the 'down' position. Bezhevets decided to land on the nosewheel and the locked mainwheel. Touching down at 290km/h (181 mph), he kept the aircraft's weight off the damaged strut as long as possible. Finally the strut collapsed and the aircraft slewed, coming to rest on two struts and a wingtip. The landing was made so skilfully that the aircraft suffered only superficial damage to the wingtip and was soon flying again after repairs on site. (Other sources claim that the aircraft was returned to the USSR for repairs and a substitute MiG-25R sent in.)

MiG-25BM 'Wild Weasel' air defence suppression aircraft, a product of lessons learned in the Middle East and from Vietnam. Yefim Gordon archive

The original staff of Det 63 returned to the USSR in April 1972; the aircraft stayed and were operated successfully by new pilots dispatched from VVS units. The accident rate remained very low. On one occasion the cockpit glazing failed on the aircraft flown by WS pilot Yashin; the oxygen system performed flawlessly, enabling Yashin to land safely.

A total of about 20 flights over Israeli-held territory were made while the MiG-25s were stationed in Egypt; all but one were made by pairs of aircraft. The pictures brought back by the MiGs showed clearly the positions of Israeli troops. The Egyptian high command was very impressed by the detail level of the photos because their own MiG-21RFs had cameras with a narrow field of view and much valuable detail was lost.

The only sortie flown by a single aircraft was flown by Bezhevets over the Mediterranean along the boundary of Israeli territorial waters. Bezhevets fired his cameras in a turn, a reconnaissance practice hitherto unknown. The good lighting conditions, very clear air and highly sensitive film made for excellent results.

According to the mission profile the aircraft was not to get within 10-20km (6.25-12.5 miles) of the Israeli border. Navigation specialists had forgotten about the high salinity of the Mediterranean and failed to make corrections to Doppler speed/drift meter inputs when programming the navigation computer. As a result the navigation error amounted to several kilometres (usually it does not exceed 1 km/0.6 miles) and the aircraft flew directly over the border for two nautical miles (5.5km). According to Soviet military advisors, this flight alarmed the Israeli leaders greatly, showing all too clearly that the air defence was too weak.

The MiG-25's combat success in the Middle East was an excellent display of the aircraft's unique capabilities. The designers and the military got all the proof they needed, and in December 1972 the aircraft was officially taken on strength by the VVS and PVO.

As time passed, however, the Egyptian leaders grew at odds with the Soviet Union. The MiGs' excellent performance made Egypt want to buy the type, and that request was turned down. As a result the tension escalated, with Egyptian troops exercising uncomfortably close to the hangars where the MiG-25s were parked. It was decided to move the aircraft back to the USSR (the Crimea peninsula or the Caucasus region). President Sadat banished all Soviet military staff from the country in July 1972 , thus putting an end to Det 63's operations. After some negotiating it was decided to airlift the MiGs out of the country by An-22s, the way they had come. The Israelis never managed to shoot down a MiG-25 and thus prove that the USSR was involved.

In October 1973 Sadat unleashed the Yom Kippur war. At first the Egyptians did very well, penetrating the Bar-Lev line and advancing into Israeli territory. But then the tables were turned as Israel launched a counter-offensive, securing a beachhead on the Egyptian side of the Suez canal. Having no reliable information about the enemy, Egypt had no choice but to turn to the USSR for help again.

On October 19 and October 20, the first An-12s and An-22s brought new MiG-25RBs, personnel, spares, support equipment and even fuel to Cairo-West air base again. This time the ministry group headed by Ryabenko included Ryazanov and Polushkin (Mikoyan OKB), Lenivtsev (Ramenskoye Instrument Design Bureau), Andjian and Nalivayko (VNIIRA), reps from Tumanskii KB and the Gorkii factory. Lt Colonel V Uvarov of the Lipetsk training centre was commander of the flying group.

The situation was very different from last year's, with Israeli tanks advancing on Cairo at an average 10km (6.25 miles) per day. Shell fire could be heard in Heliopolis, a suburb of Cairo, in the morning hours. Thus, as the 'Foxbats' were reassembled, flying them back to the USSR was considered as an emergency option in case the Israelis got too close for comfort. (As a last ditch possibility they could be blown up to prevent them from falling into enemy hands if Cairo-West was overrun. The personnel would be trucked to the Libyan border.)

This time the Soviet contingent, apart from the MiG-25 pilots and support staff, included only a handful of SAM crews, military advisors working under contract with the Egyptians and small logistics groups responsible for organising airlifts and restoring the ties with the Egyptian top command.

A few days later truce talks began. By the time hostilities ended one MiG-25 was flying and another had been assembled. Considering the possible threat from Soviet-built S-75 SAMs captured by Israel, it was decided to send a pair of MiG-25s on a reconnaissance sortie one hour before the truce became effective; one aircraft was to reconnoitre the Suez canal, the otherflying in a more easterly direction.

The mission was successful, and developing the film and printing the pictures took the rest of the day and all of the night. By dawn the Egyptian command was aware that in some places their brigades were having trouble fighting back a *single* Israeli platoon which made like it was attacking in battalion strength! In a nutshell, the Egyptians had lost the opportunity to win a solid combat victory. After that, the Soviet SAM crews pulled out speedily but the MiGs stayed for another year, leaving for home in late 1974. This was the last Soviet involvement in a Middle Eastern conflict.

The successful combat tests of the MiG-25R and 'RB boosted the morale of the aircraft industry as well, giving rise to the spate of reconnaissance/strike versions with new Elint gear which enhanced the aircraft's capabilities considerably. The engines' service life was extended and their specific fuel consumption (SFC) reduced. The modified R15BD-300 engines were also retrofitted by overhaul workshops in some cases to replace R15B-300s that had reached the limit of their useful life. Improved 'Smerch-A2' and '-A3' radars were fitted to the interceptors, replacing the older '-A1'.

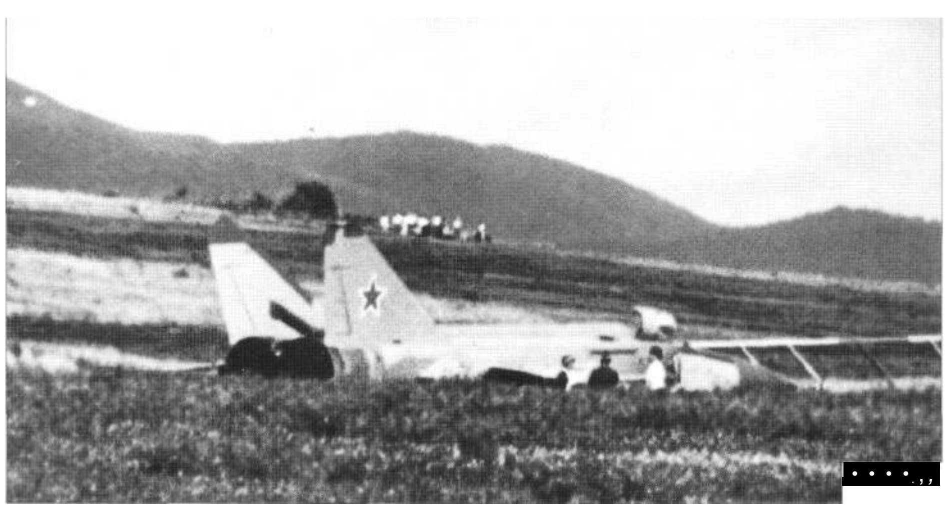
Defection to Japan

On 6th September 1976, Lt Victor Belenko, a pilot of a PVO unit based at Chuguyevka air base north of Vladivostok (some sources state Sakharovka air base) failed to return from a sortie. His superiors would hardly have been too upset if he had crashed into the Sea of Japan; as it were, the news that Belenko had landed at Hakodate International airport came as a severe shock.

It will probably never be known if Belenko contacted the US military intelligence on his own or was hired by them (there is even a theory that 'V Belenko' was just a cover name for a trained agent tasked with stealing the latest Soviet military hardware, shades of Clint Eastwood in *Firefox).* Investigators found out that the defection was not an impulsive action of a dissatisfied officer - Belenko was expected in Japan and made preparations for the flight. He high-tailed it to Japan the very first time he had a full fuel load, taking the classified technical manuals with him. (Taking the manuals on a sortie was expressly forbidden.)

Nobody at the base suspected that a defection was afoot. The mission profile included low level flight during which the aircraft would be undetectable by ground radar. Only when Belenko failed to return at the planned time did the ATC start calling him on the radio and fighters were sent up to try and locate the crash site. The message from the border guards that an aircraft had crossed the state border and was making for Japan came too late: Belenko was already approaching Japanese airspace, with Air Self-Defence Force fighters waiting to escort him.

The MiG-25P's navigation equipment could



Lt Victor Belenko's MiG-25P following its over-run at Hakodate, Japan. Speculation continues about his motives, was it a pre-planned 'plant' or swiftly executed defection?
Yefim Gordon archive

not guide the aircraft accurately during prolonged low level flight unless RSBN SHORAN beacons were available (and of course they were not). The radio compass could be helpful but again the pilot had to know the marker beacon frequency at Hakodate, which the personnel at Chuguyevka did not know. As it was, Belenko was so nervous that he misjudged his landing and over-ran, damaging the landing gear and making the aircraft unairworthy. Belenko made a statement for the press and requested political asylum in the USA. A large group of experts arrived from the US to examine the aircraft but Japanese engineers also took part in some stages of the work.

The Soviet government put pressure on Japan, demanding the delivery of the purloined 'Foxbat' pronto. Since there were no legal reasons not to, the MiG-25 was returned, in dismantled and crated condition. The Japanese did it on purpose to cover up the 'surgery' they and the US intelligence experts had undertaken on the MiG.

When the Soviet delegation led by General Dvornikov arrived in Japan the Japanese officials resorted to procrastination and bureaucratic snags. When the crates with the aircraft parts were trucked to the pier to be loaded aboard a Soviet freighter the Soviet representatives demanded that the crates be opened for inspection to make sure nothing was missing. The Japanese deliberately gave them only a few hours, hoping that the 'Russians' would not manage to check everything and repack the crates in time - but they were in for a disappointment.

The Soviet experts were quick to find out just how much the West actually knew. When the MiG-25 was returned to the USSR it was determined that the Americans had run the engines and measured the aircraft's infra-red signature and also made a detailed analysis of the systems and avionics, including the radar, and the structural materials. Not knowing how to operate the equipment, the Americans had damaged some of it and had to make hasty repairs (foreign fuses and resistors were discovered in the radar set).

The incident got the world press going wild with stories about the MiG-25. Aviation journalists derided the design as 'crude' and 'engineering archaeology' but conceded that the steel airframe worked well at high temperatures and could be built and repaired easily without requiring any great skill from the repair personnel. The radar's elements were deemed outdated; yet the radar impressed the West by having two wavebands which made it virtually jamproof - something no US radar featured at the time. In fact, USAF C-in-C Robert Siemens said that 'the MiG-25 is the only aircraft scaring all the world'. US Defence Secretary Schlesinger stated that the new Soviet interceptor was a sufficiently potent weapon to bring about drastic changes to the Western weapons systems and strategies.

The shock which the Soviet leaders, the Ministry of Defence and some other ministries experienced defies description. The West had got hold of the USSR's most secret aircraft! Worse, Belenko's statements published by the world press made it clear that Western intelligence agencies had preliminary information on the latest two-seater, the MiG-25MP (Izdelye 83). The potential adversary now had the potential to develop counter weapons and largely neutralise the MiG-25 in a short while.

This forced the Soviet government, the Ministry of Defence and the Ministry of Aircraft Industry to take resolute action which was later proven correct. The rigid and clear lines of command under the Soviet system got the design bureaux and defence industry working hard, and a much-improved MiG-25PD entered production in just two and a half years after the scandalous defection - see Chapter Three.

The MiG-25 was of special importance to the Soviet air defence, since (until the MiG-31 entered service) it was the only aircraft capable of intercepting the Lockheed SR-71A strategic reconnaissance aircraft prowling over the Barents Sea and especially the Baltic. When Poland experienced unrest in the early 1980s the West feared a possible Soviet invasion. The data provided by surveillance satellites on Soviet forces stationed at the western borders apparently proved insufficient for the Americans, and the SR-71 As began their sorties over the Baltic Sea. MiG-25PDs and 'PDSs stationed

Opposite: **A pilot poses in suitably inspiring manner for Soviet cameras.**

Below: MiG-25PDSs **taxi out for a night sortie from a snow-clad Soviet base.**
Yefim Gordon archive

in the area bore the brunt of dealing with these snoopers.

Belenko's elopement had a positive effect (besides the long term one already mentioned) - it allowed new weapons exports. The first export MiG-25s were delivered in 1979. The slightly downgraded export versions of the interceptor and reconnaissance/strike aircraft were acquired by Algeria, Bulgaria, India, Iraq, Libya, and Syria. It was an unconventional way of getting into the foreign market - the aircraft had to be *stolen* to get exports going!

Return to the Middle East

Israel had apparently sworn vengeance on the elusive MiG-25 and actually succeeded in destroying one. On 13th February 1981, two Israeli Defence Force/Air Force (IDF/AF) McDonnell RF-4E Phantoms acted as bait, intruding into Syrian airspace and luring a Syrian Air Force MiG-25P into pursuit. The MiG-25 was then ambushed by two F-15A Eagles hiding from Syrian radar behind a mountain range. Popping up from behind a cloud of chaff one F-15 approached the MiG from below so its pilot could not see the Israeli jet and fired an AIM-7 Sparrow which hit the MiG's port wing. Syrian controllers were unable to warn the pilot because the Israelis were heavily using ECM.

Shortly afterwards the roles in the cat-and-mouse game were reversed. Two Syrian Air Force MiG-21s provoked a couple of Israeli AF/DF F-15s which gave chase. Two MiG-25Ps took off to intercept the Eagles; one attacked the F-15 head on, the other tried for a flank attack. The first MiG-25 failed to fire its missiles after losing the target lock-on and was shot down by the F-15 flight leader. The other MiG got a good lock-on and destroyed the wingman with two R-40 missiles at about 40km (25 miles) range. That was the last time Syrian MiG-25Ps engaged in combat.

The Iraqi Air Force used its eight MiG-25RBs with some success for bombing raids on Iranian oil rigs and Tehran during the Iran-Iraq war. One aircraft was shot down by a Hawk missile, another was lost when an engine tossed a turbine blade, forcing the pilot to eject. A newly refurbished aircraft crashed on landing after a check flight in December 1987. No Iraqi MiG-25Ps were lost in the Iran-Iraq war. Soviet military experts visiting Iraq noted that Iraqi pilots were well pleased with the aircraft.

Operation 'Desert Storm' began on 19th January 1991. On the following day, an Iraqi Air Force MiG-25P destroyed a US Navy McDonnell Douglas F/A-18 Hornet. That was all the good luck the Iraqi pilots had. On the 19th two USAF F-15Cs destroyed two MiG-25Ps with AIM-7M Sparrow missiles. On 25th December 1992, two USAF F-16 Fighting Falcons used AIM-120 AMRAAMs for the first time ever, shooting down an Iraqi MiG-25. Two hours later an F-15E had a brush with a MiG-25, neither side scoring a kill. A MiG-25 trying to intercept a Lockheed U-2R high altitude reconnaissance aircraft on 2nd January 1993, was attacked by an F-150, again with no losses on either side.

Several MiG-25sfell into Azeri hands after the collapse of the Soviet Union, since the type was overhauled in Baku. Some reports state that Azeri MiG-25s destroyed a number of Armenian tanks with highly manoeuvrable R-60M missiles. The Azeris also used MiG-25RBs, but largely without success as the bombing computers were out of order on most aircraft.

Assessing the 'Foxbat'

MiG-25 production peaked at 100 aircraft per month. Initially a MiG-25 required a little more than three times the number of man-hours to build than a MiG-21, though this number was reduced ten times over the years. Interceptor production for the VVS was stopped in 1979 as the more capable MiG-31 entered production, the MiG-25PD being produced on a small scale for export only.

Production finally stopped in 1984, totalling 1,190 aircraft of all models, including the prototypes; 1,186 aircraft were built in Gorkii. All models, especially the MiG-25PD, enjoyed a good reliability record and a long service life, with no serious defects and bad accidents being recorded. More than 90% of the aircraft in service were kept flyable, with a mean time between overhauls (MTBF) of 66 hours (with a prescribed minimum of eight hours!). Average flying time per failure in the first half of 1992 was 450 hours.

New combat tactics were developed perpetually. For example, MiG-25PDs and 'PDSs could be guided to the target by an A-50 'Mainstay' AWACs or a MiG-31 (which can act as a 'mini-AWAGS' - see Chapter Eight). Work continued on service life extension, improving serviceability and reparability.

Many aviation experts believe that the 'Foxbat' influenced Western design practices to a certain extent. Similar aerodynamic solutions and layouts are to be found on some West European and American fighters. Western experts gave the MiG-25 credit (despite that 'engineering archaeology' label). Regrettably, the aircraft was often used at medium altitude or against fighters when it could not use its capabilities to advantage.

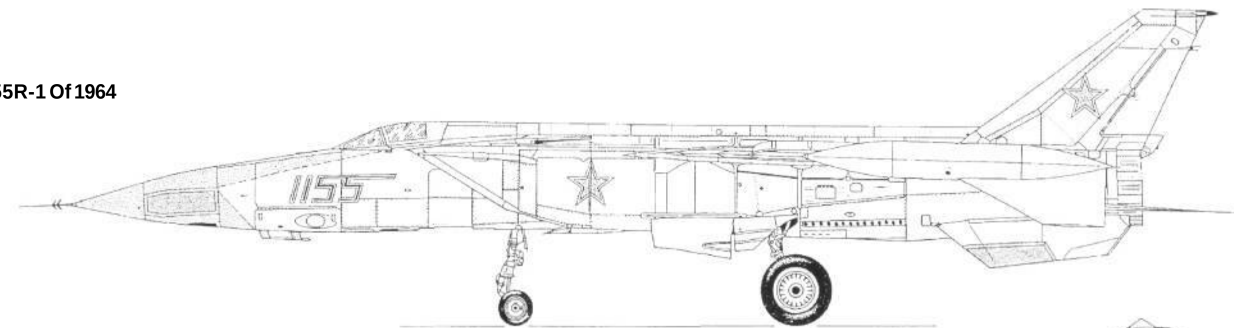
The MiG-25 was a landmark in boosting Soviet defensive capability. *Very* few incursions were reported in areas where MiG-25Ps and MiG-25PDs and 'PDSs were stationed. The aircraft proved an effective means of deterring potential aggressors.

It went on to serve as the basis for the even more effective MiG-31 'Foxhound' interceptor. And even though it was not a mass produced aircraft (certainly in MiG-21 terms), it did the job it was meant to do well.

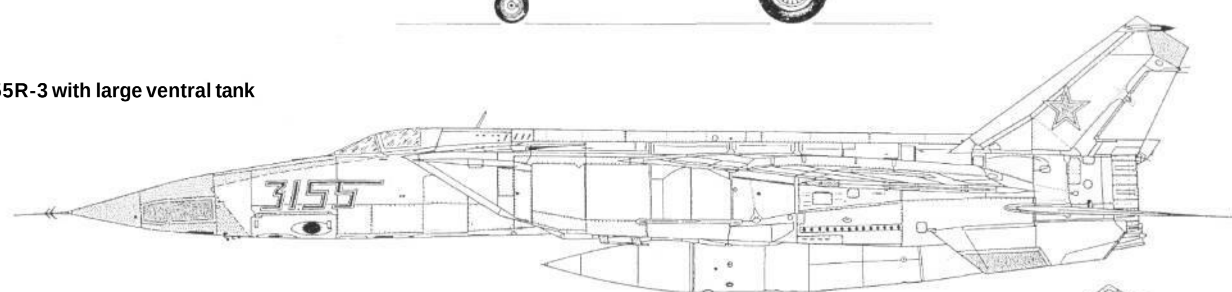
The design group behind this aircraft was decorated with state awards. Six people were awarded the Lenin Prize - no small reward in Soviet terms. They were General designer R A Belyakov, chief project engineer N Z Matyuk, Gorkii aircraft factory director I S Silayev (later Minister of Aircraft Industry), engine project chief F Shukhov, radar project chief F Volkov and Deputy Minister of Aircraft Industry A V Minayev who headed the Egyptian task force.

'Foxbats' in Detail

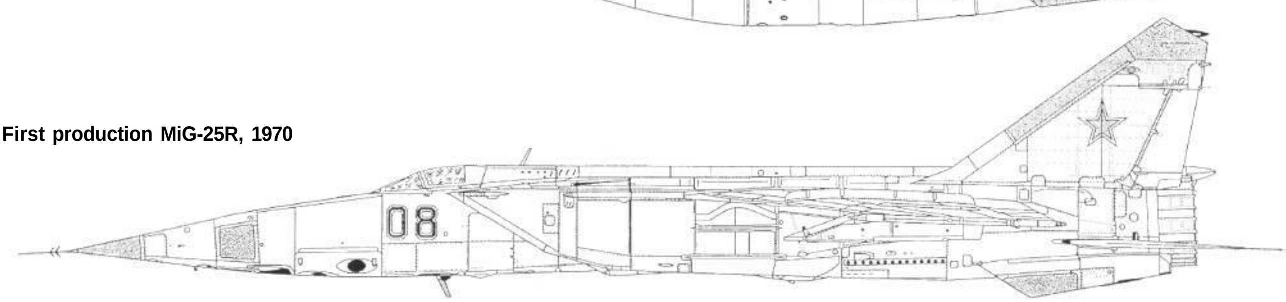
Ye-155R-1 Of 1964



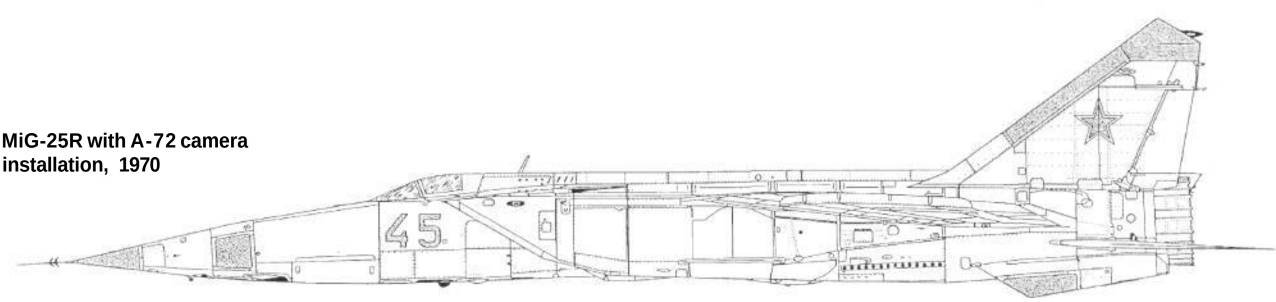
Ye-155R-3 with large ventral tank



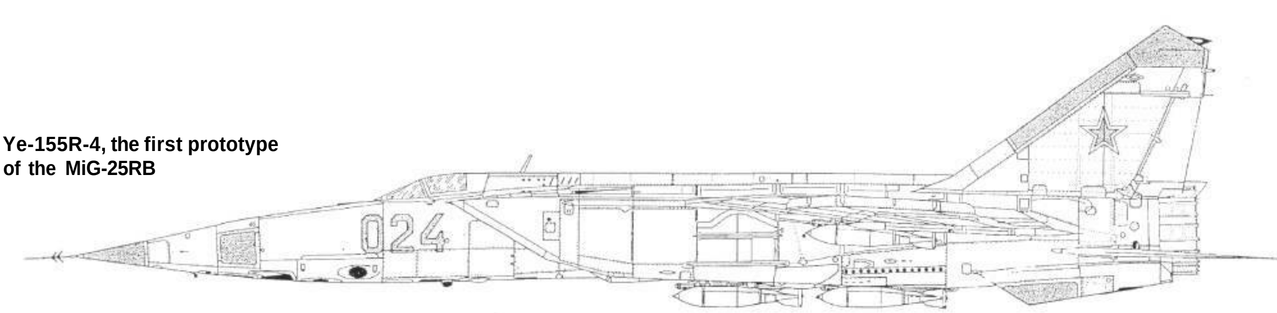
First production MiG-25R, 1970



MiG-25R with A-72 camera installation, 1970

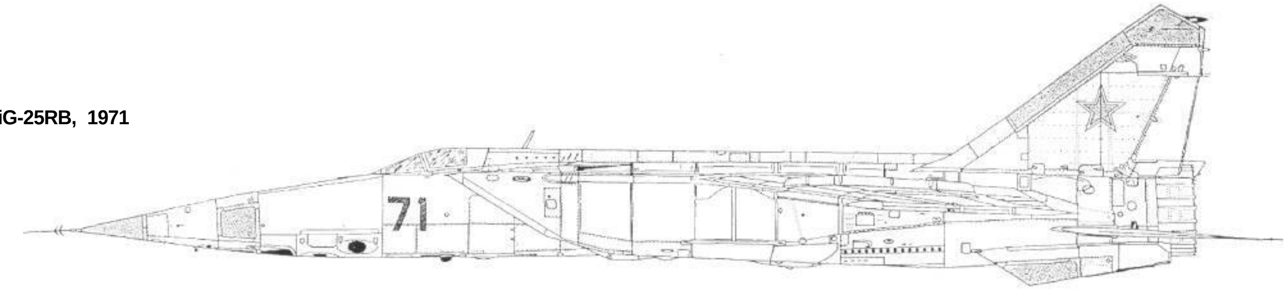


Ye-155R-4, the first prototype of the MiG-25RB

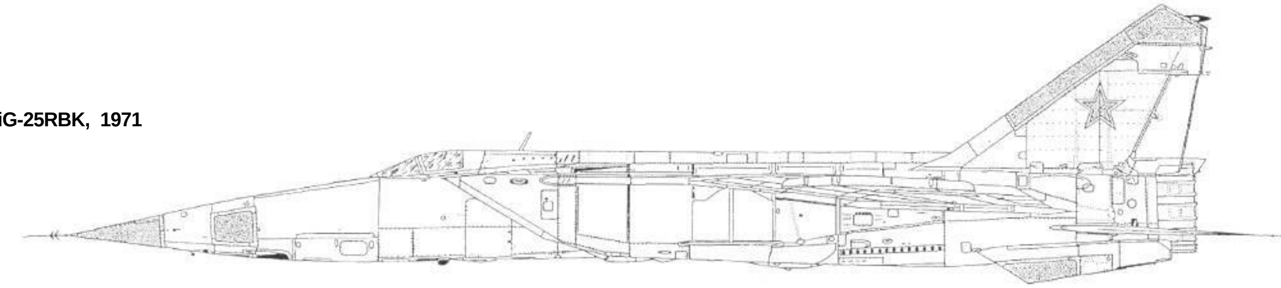


Drawings by Oleg Put'makov

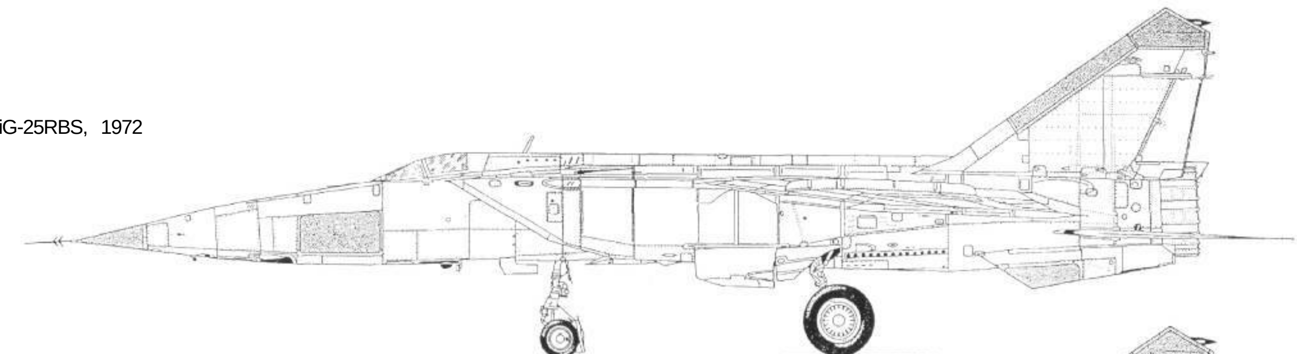
MiG-25RB, 1971



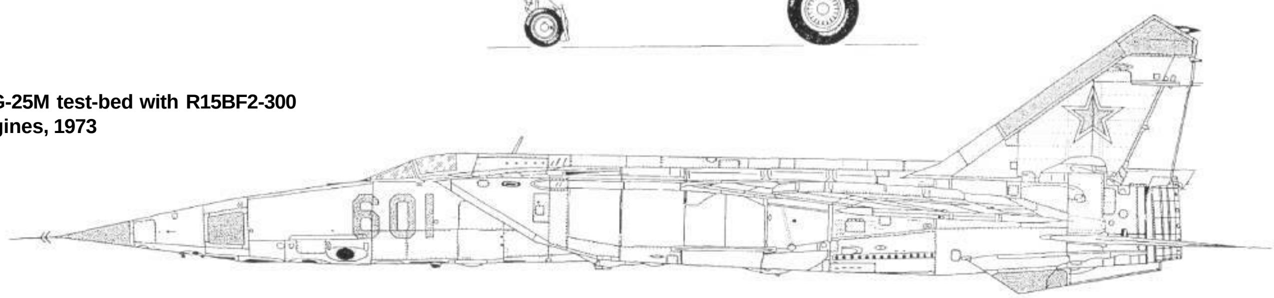
MiG-25RBK, 1971



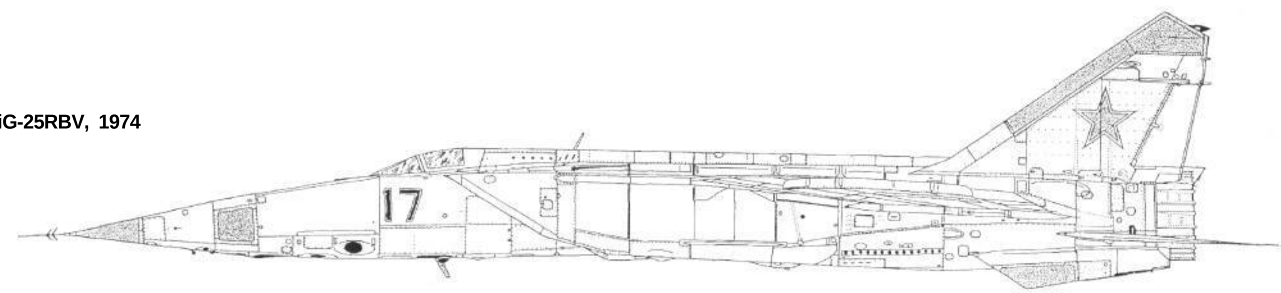
MiG-25RBS, 1972



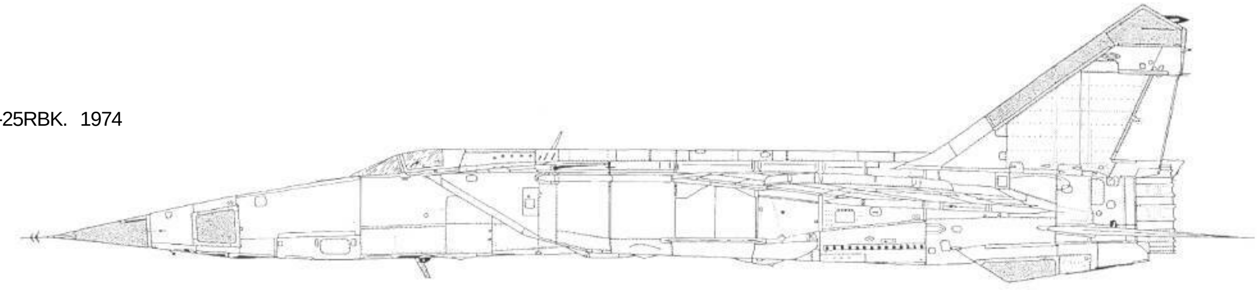
MiG-25M test-bed with R15BF2-300 engines, 1973



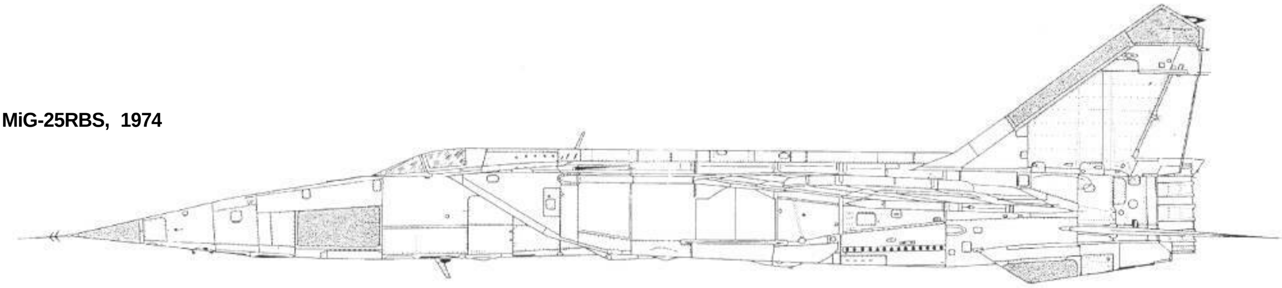
MiG-25RBV, 1974



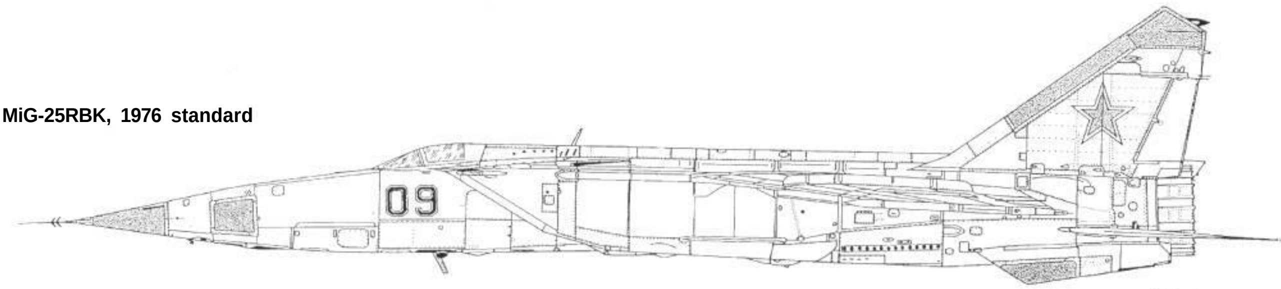
MiG-25RBK. 1974



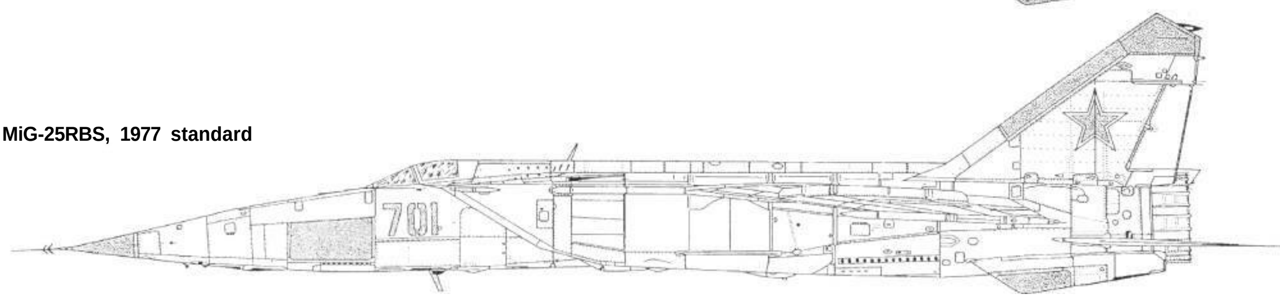
MiG-25RBS, 1974



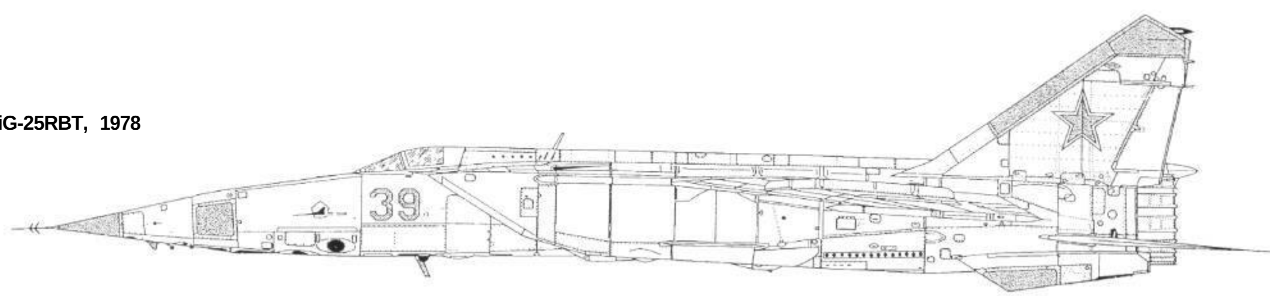
MiG-25RBK, 1976 standard



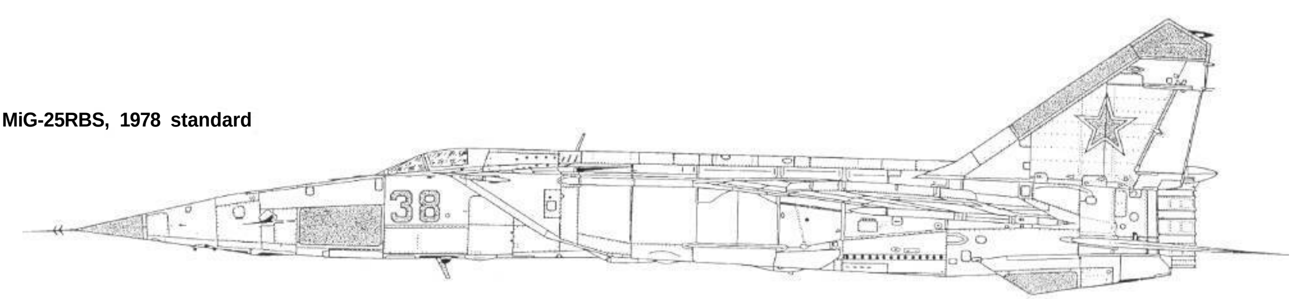
MiG-25RBS, 1977 standard



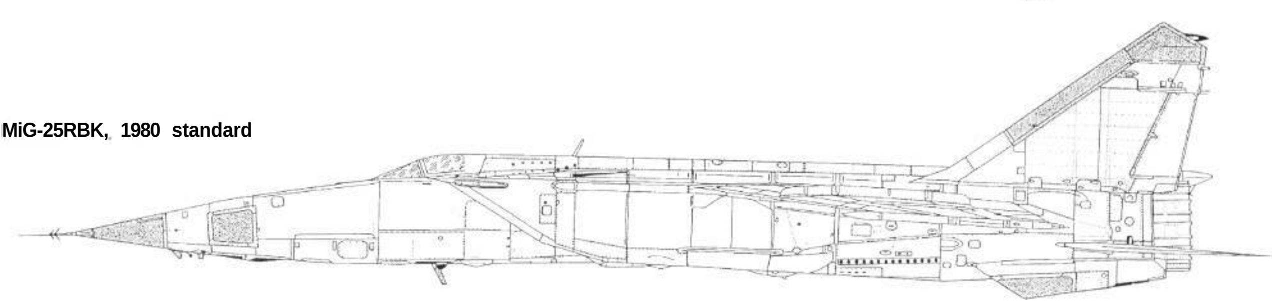
MiG-25RBT, 1978



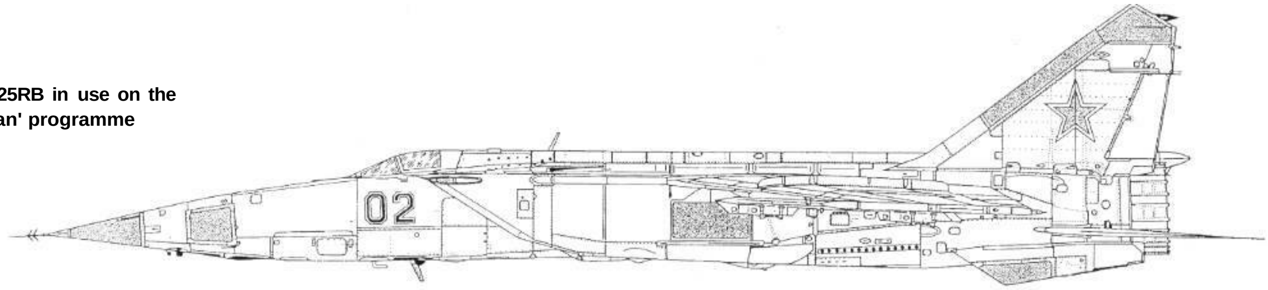
MiG-25RBS, 1978 standard



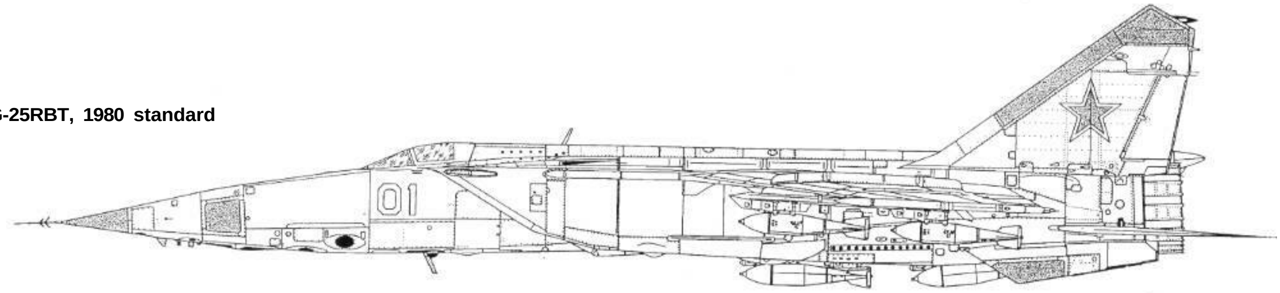
MiG-25RBK, 1980 standard



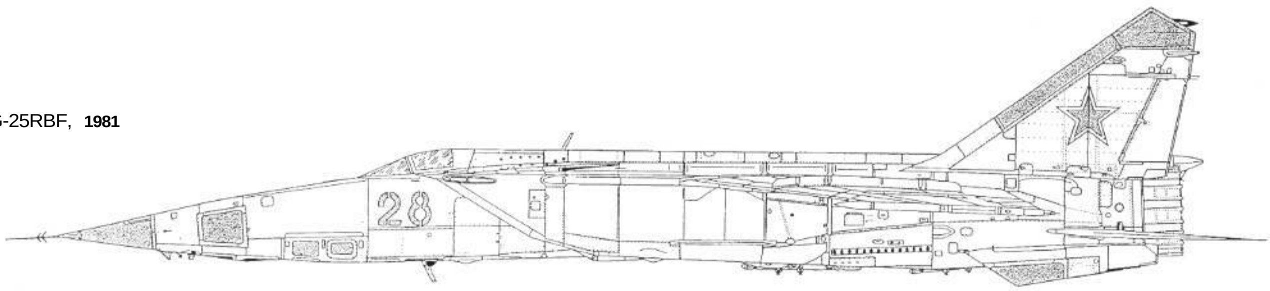
MiG-25RB in use on the 'Buran' programme



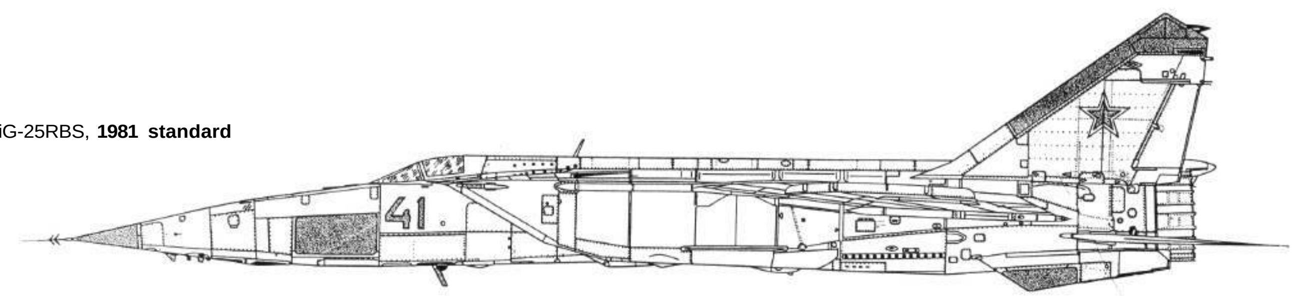
MiG-25RBT, 1980 standard



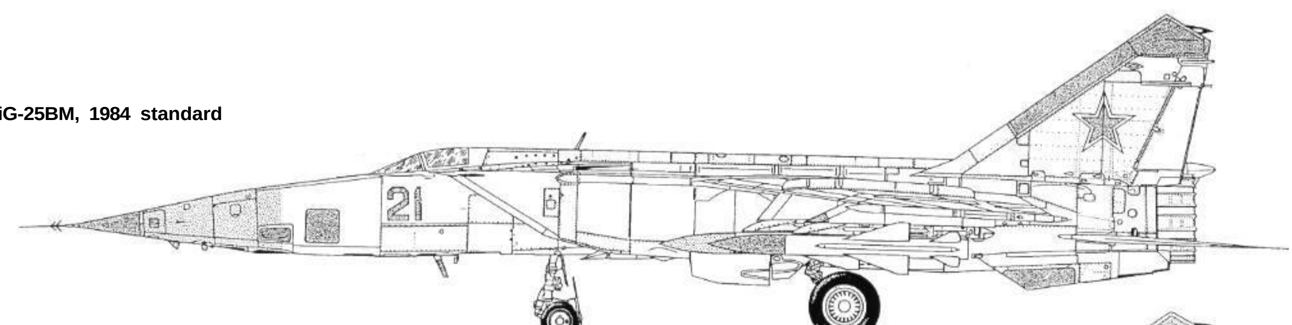
MiG-25RBF, **1981**



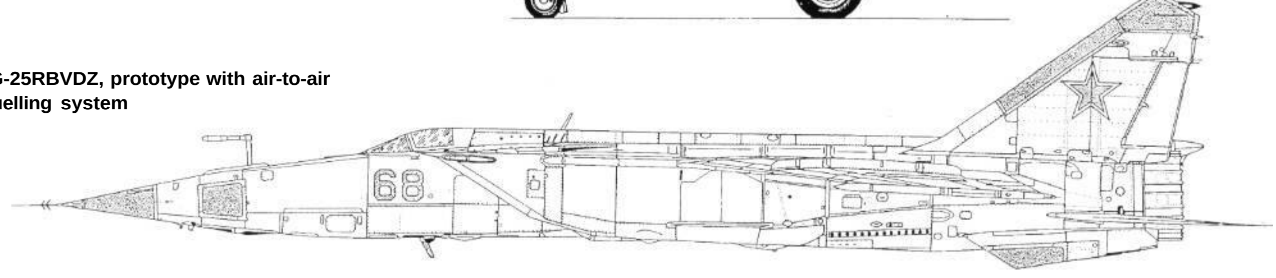
MiG-25RBS, **1981 standard**



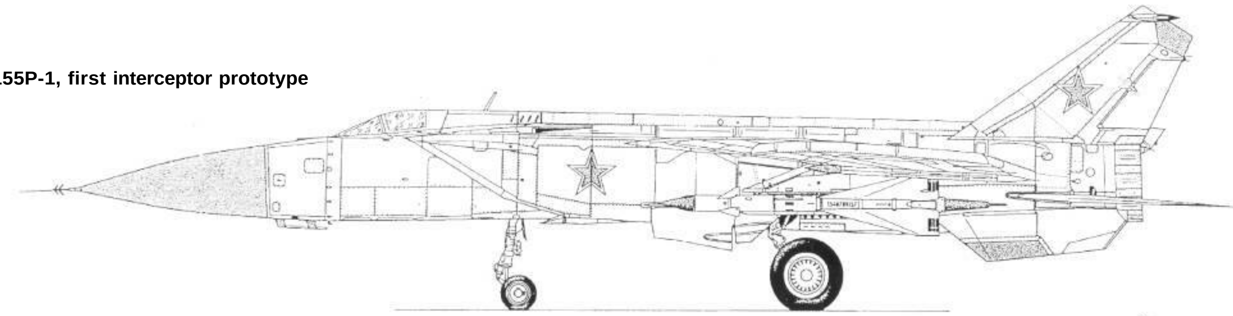
MiG-25BM, 1984 standard



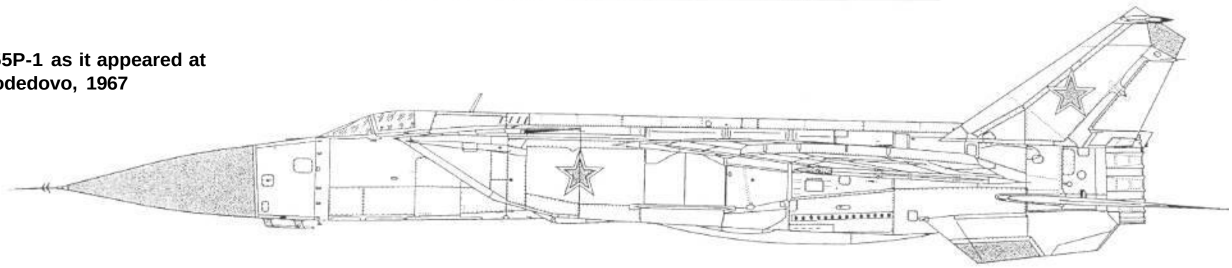
MiG-25RBVDZ, prototype with air-to-air refuelling system



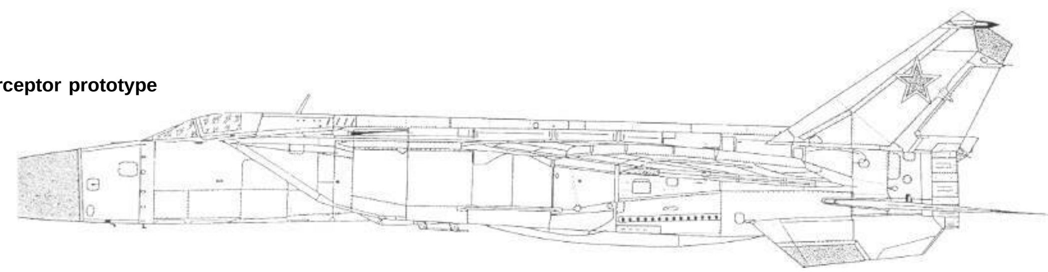
Ye-155P-1, first interceptor prototype



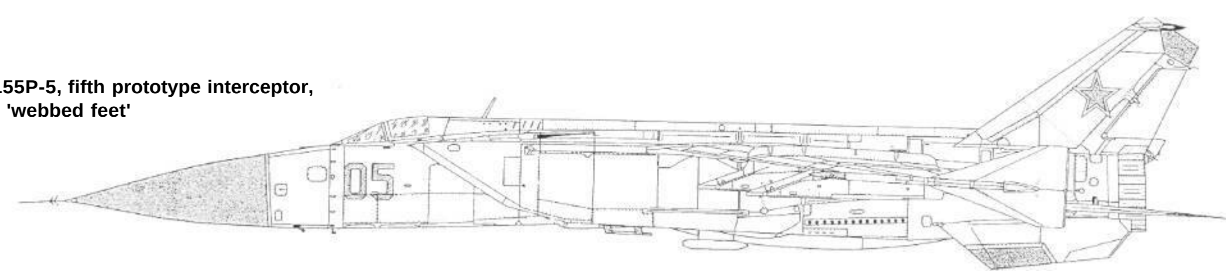
Ye-155P-1 as it appeared at Domodedovo, 1967



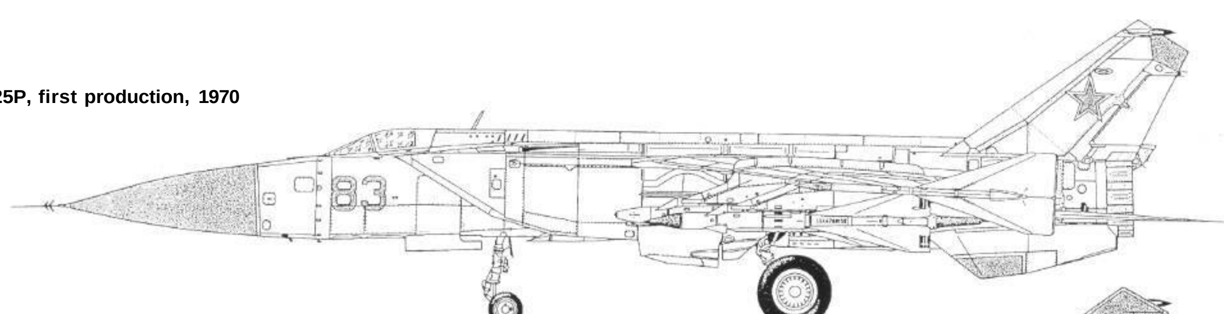
Ye-155P-2, second interceptor prototype



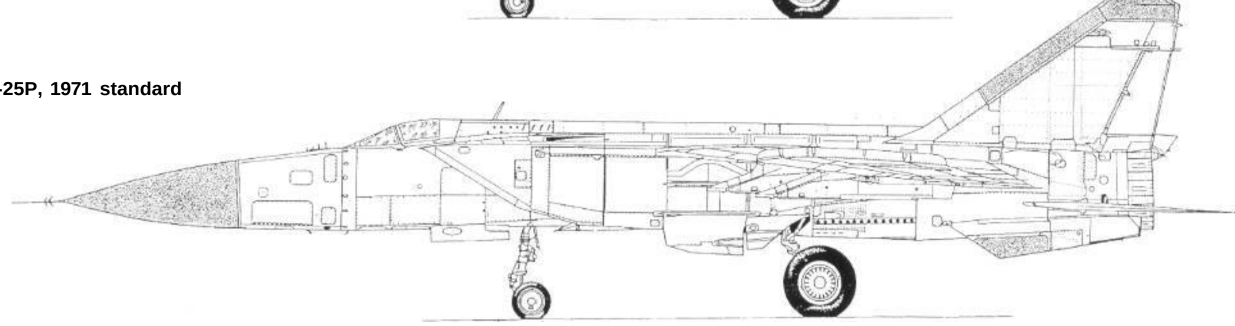
Ye-155P-5, fifth prototype interceptor, with 'webbed feet'



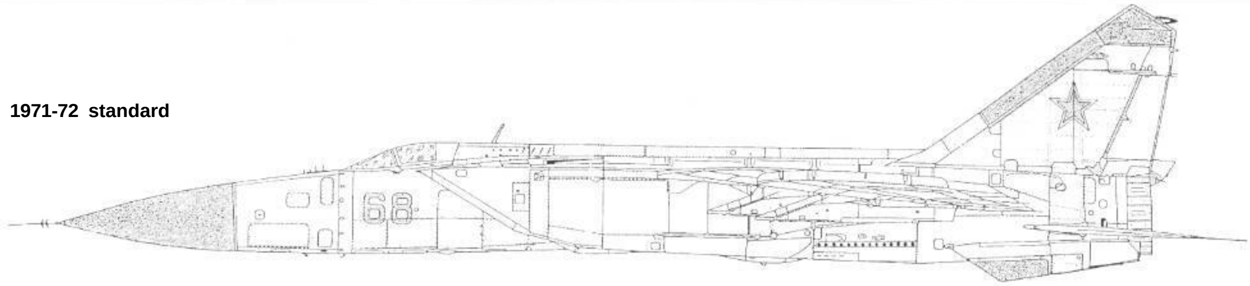
MiG-25P, first production, 1970



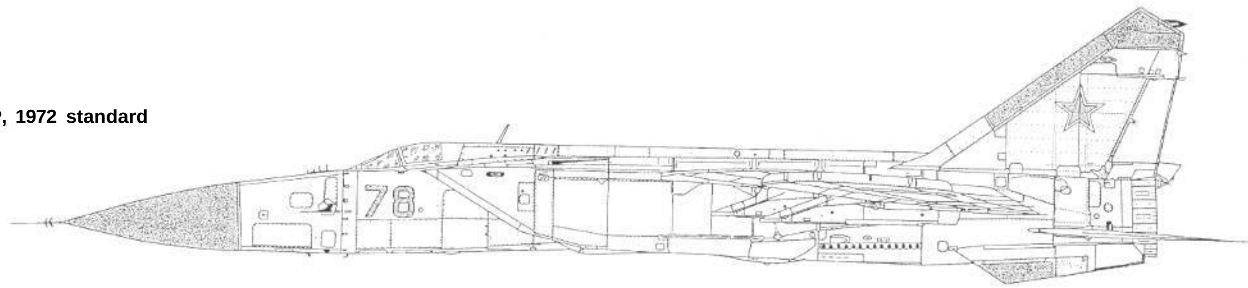
MiG-25P, 1971 standard



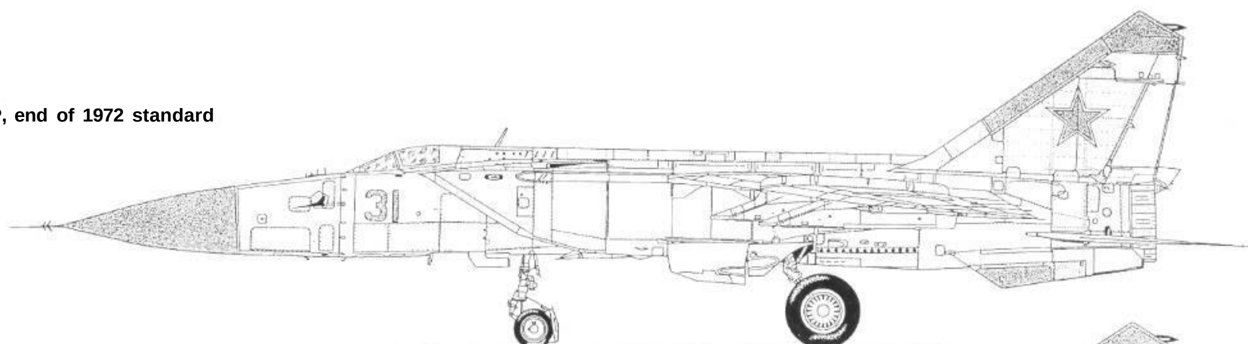
MiG-25P, 1971-72 standard



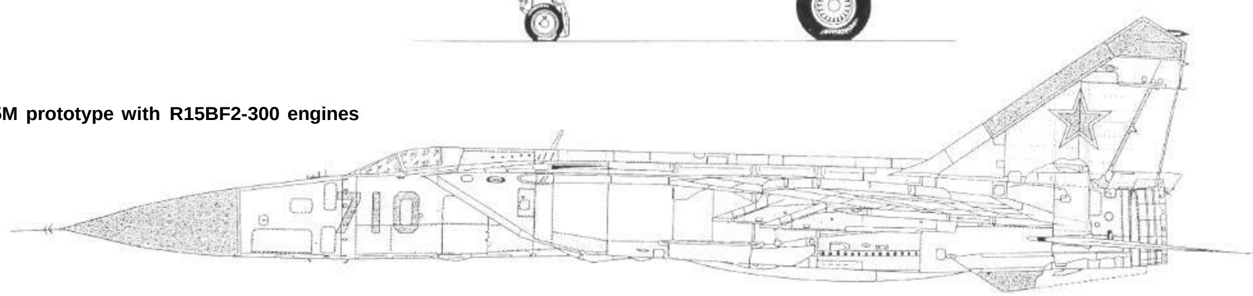
MiG-25P, 1972 standard



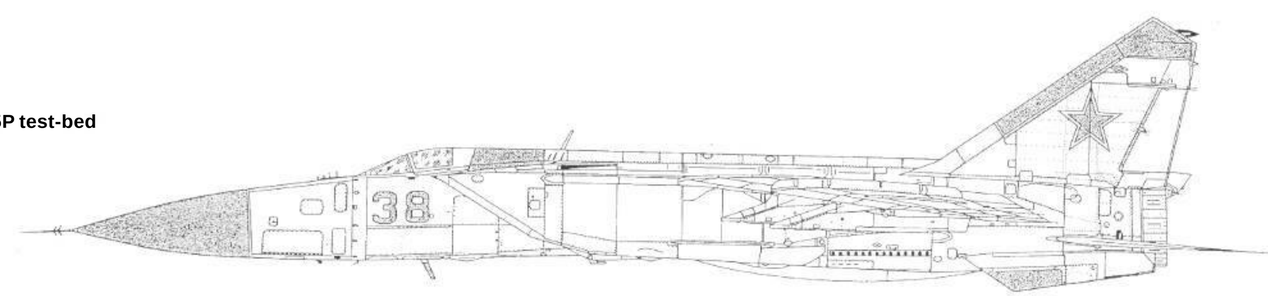
MiG-25P, end of 1972 standard



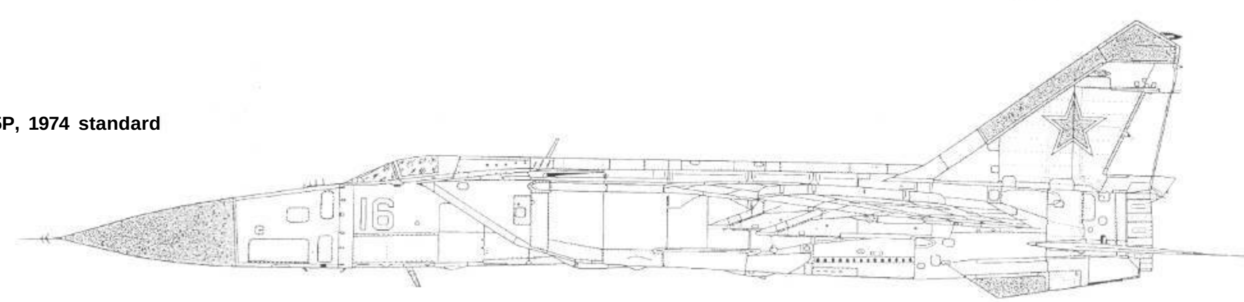
MiG-25M prototype with R15BF2-300 engines



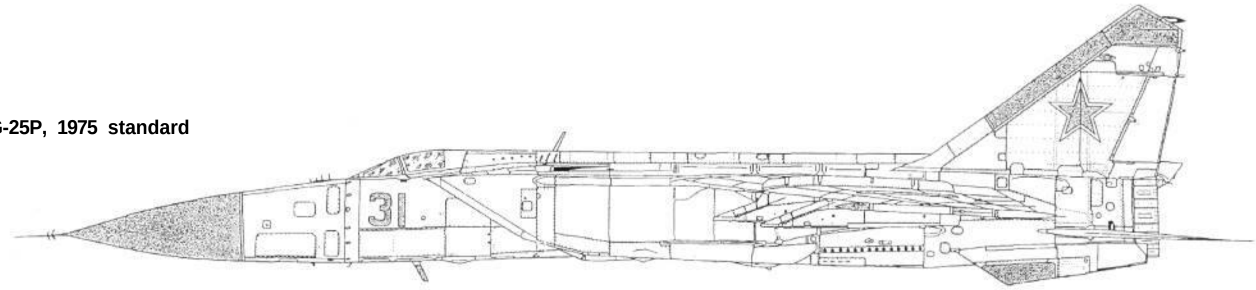
MiG-25P test-bed



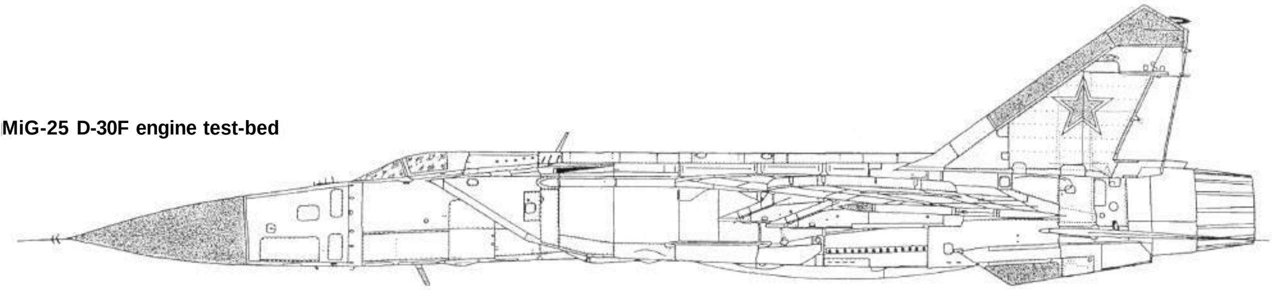
MiG-25P, 1974 standard



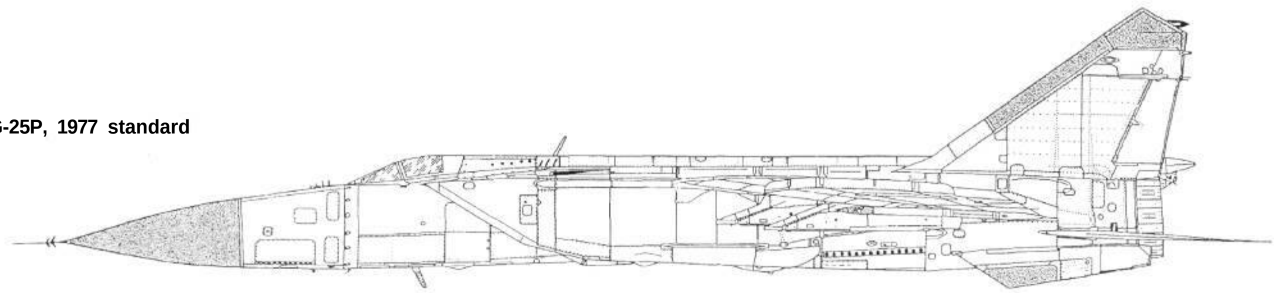
MiG-25P, 1975 standard



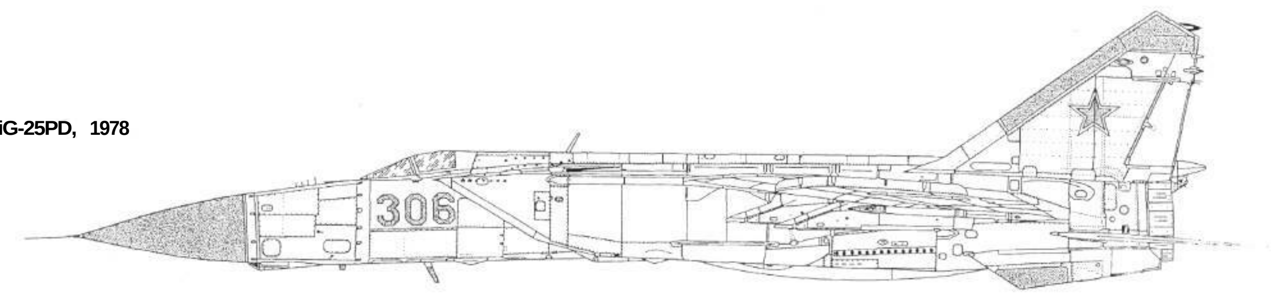
MiG-25 D-30F engine test-bed



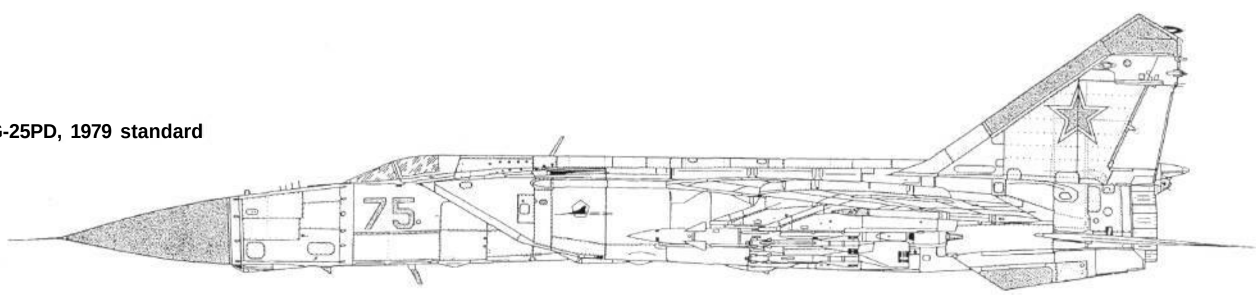
MiG-25P, 1977 standard



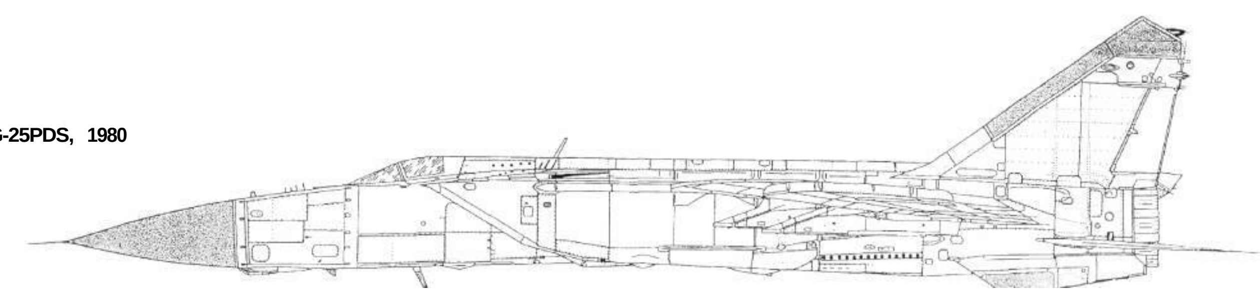
MiG-25PD, 1978



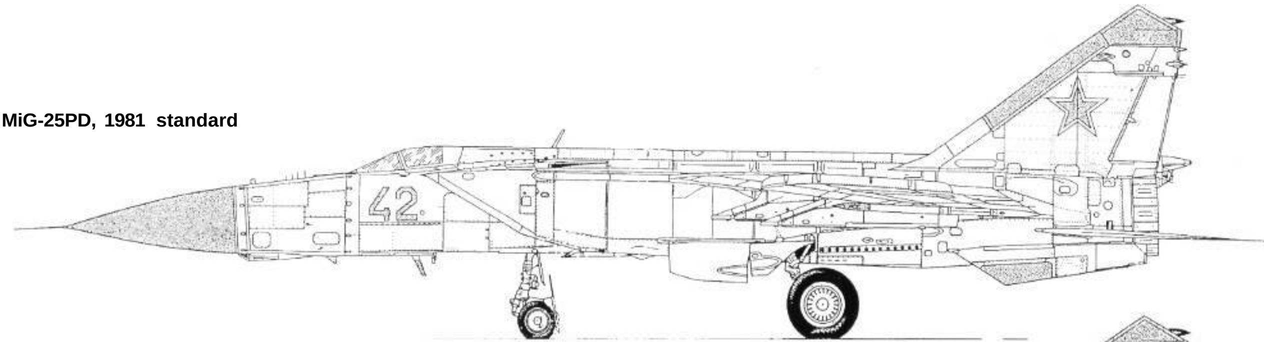
MiG-25PD, 1979 standard



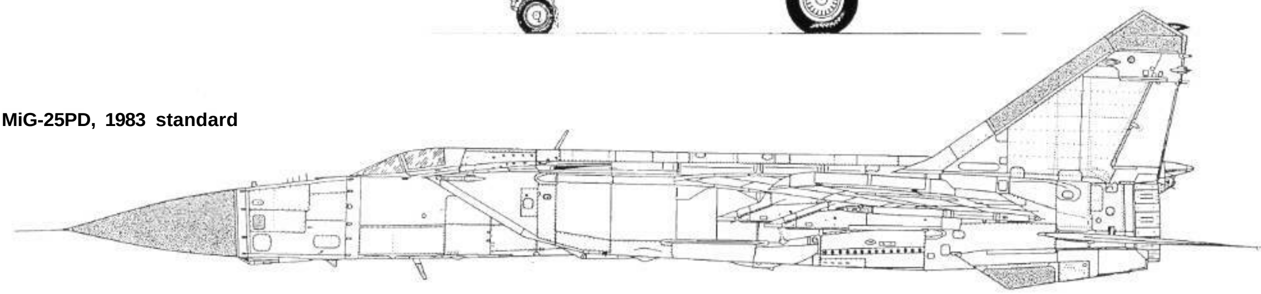
MiG-25PDS, 1980



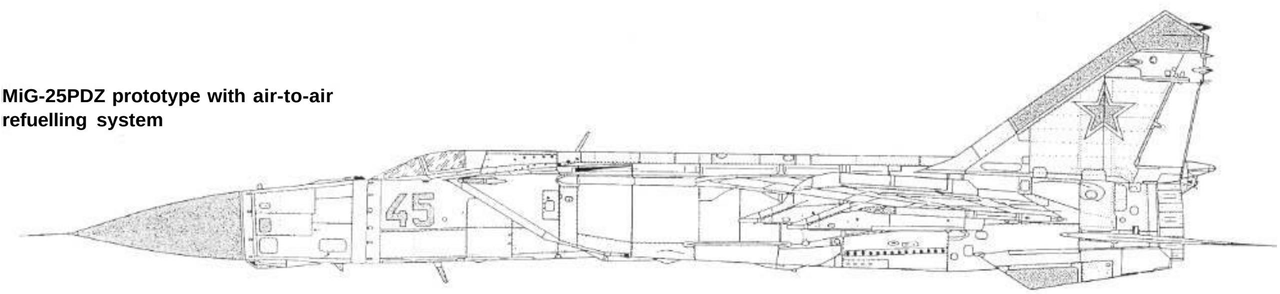
MiG-25PD, 1981 standard



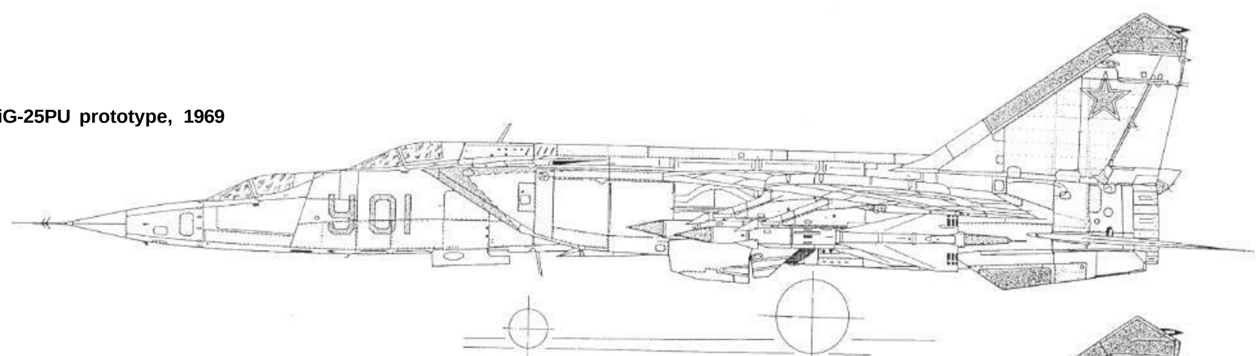
MiG-25PD, 1983 standard



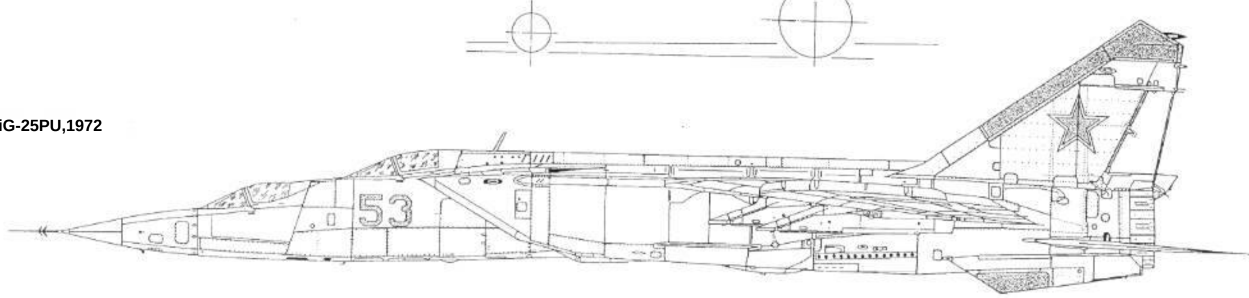
MiG-25PDZ prototype with air-to-air refuelling system



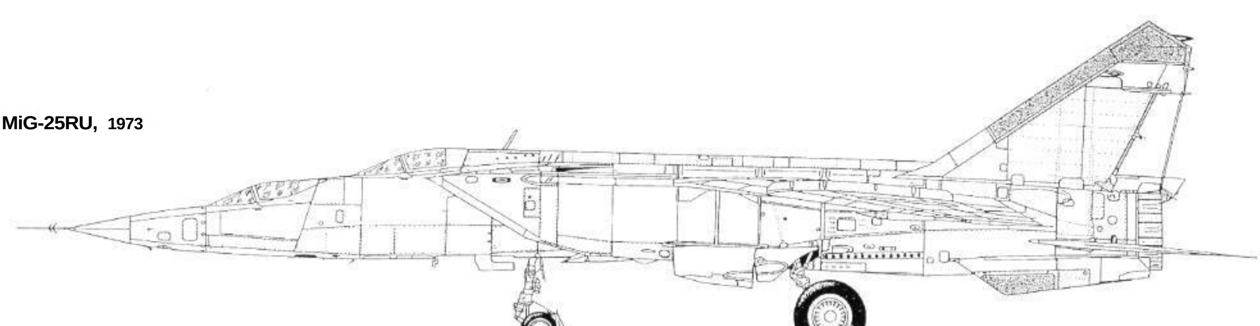
MiG-25PU prototype, 1969



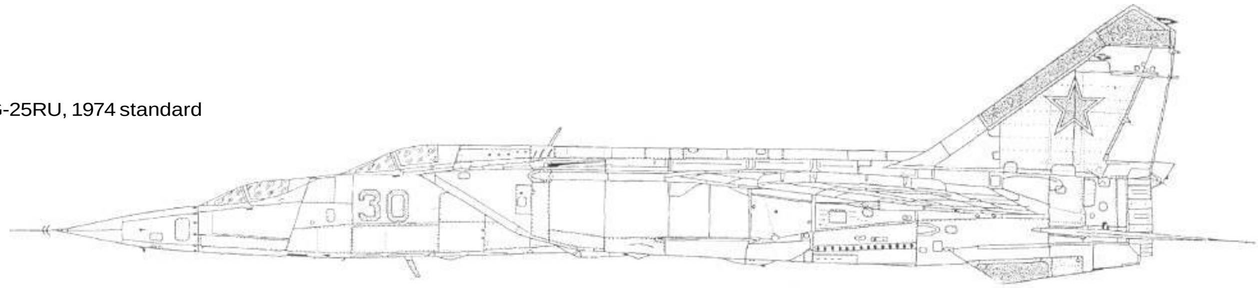
MiG-25PU,1972



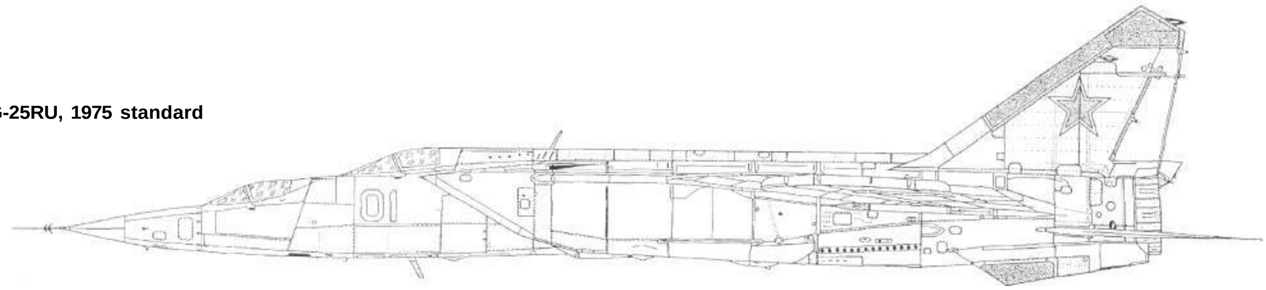
MiG-25RU, 1973



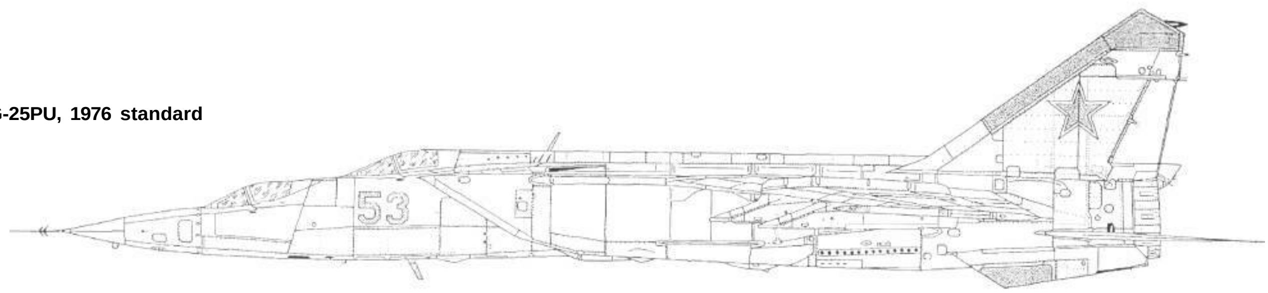
MiG-25RU, 1974 standard



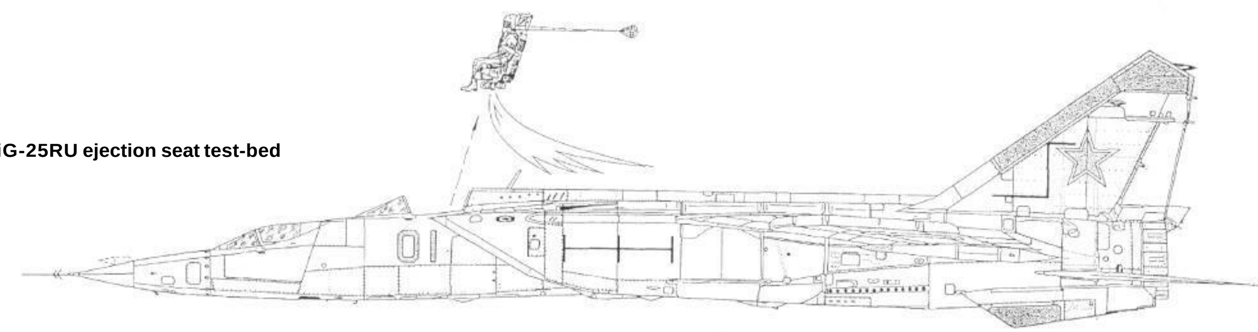
MiG-25RU, 1975 standard



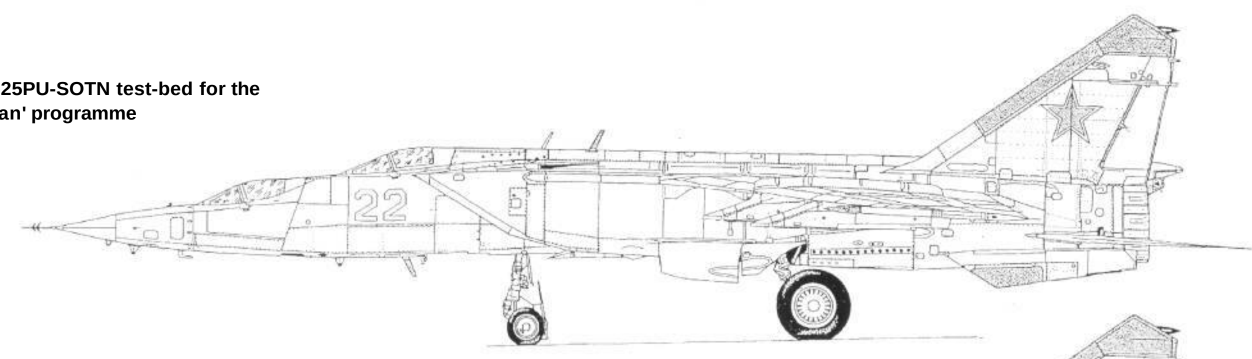
MiG-25PU, 1976 standard



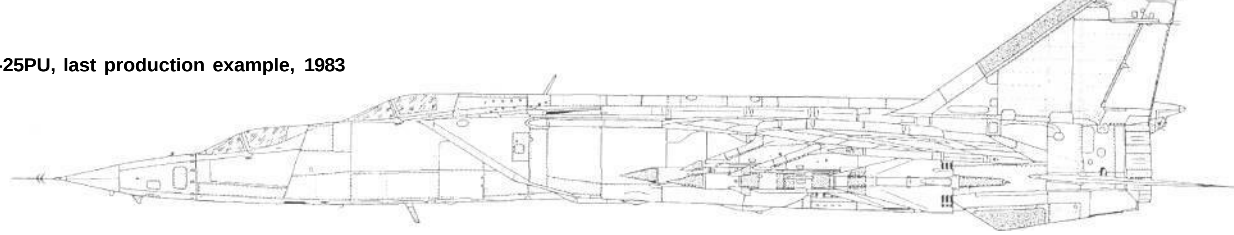
MiG-25RU ejection seat test-bed



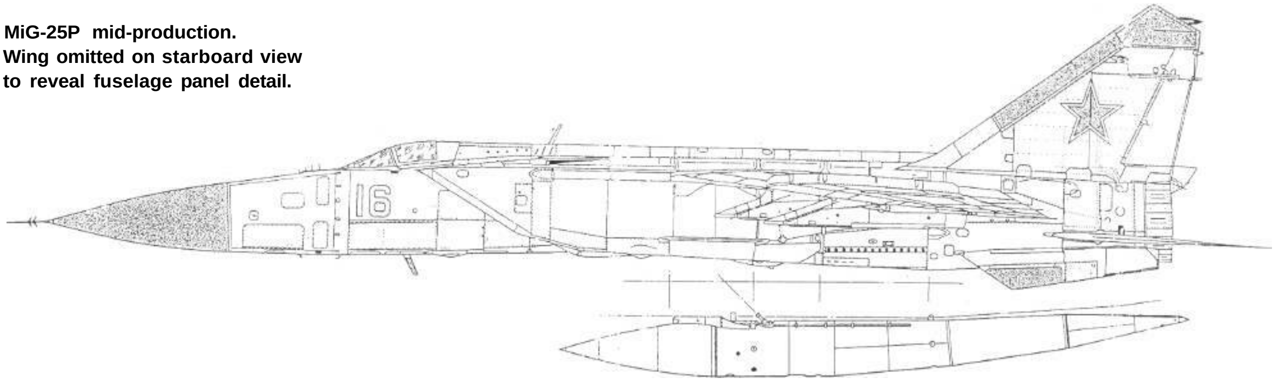
MiG-25PU-SOTN test-bed for the 'Buran' programme

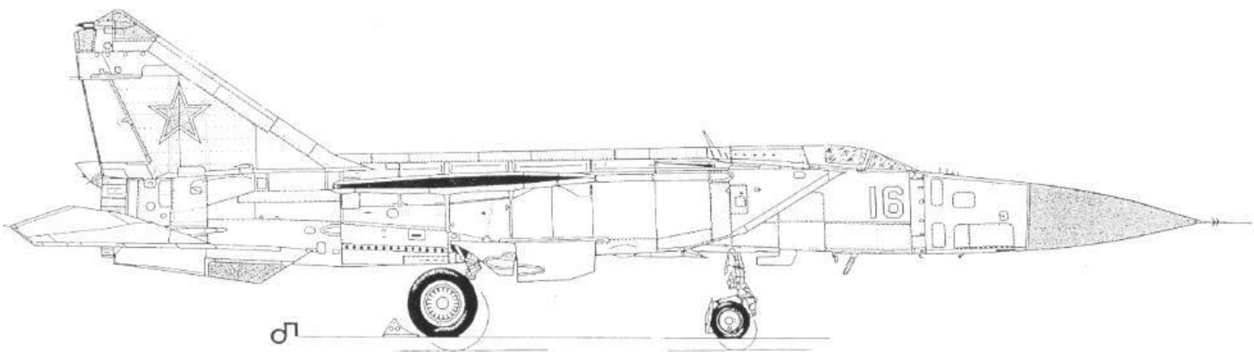


MiG-25PU, last production example, 1983

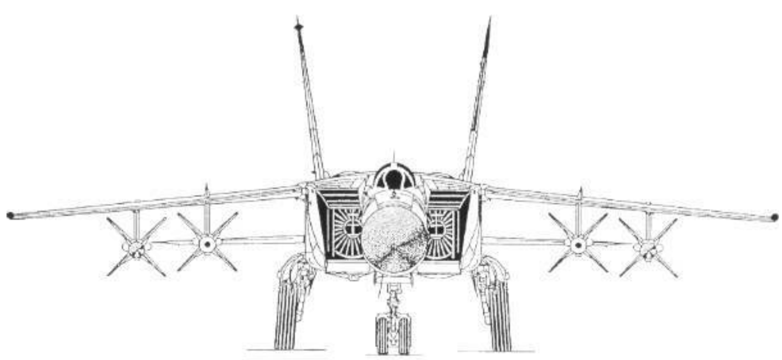


MiG-25P mid-production.
Wing omitted on starboard view
to reveal fuselage panel detail.

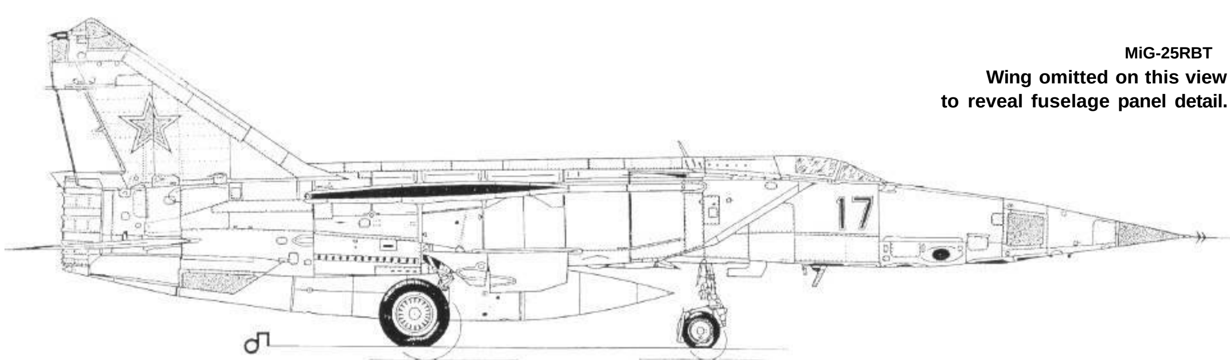




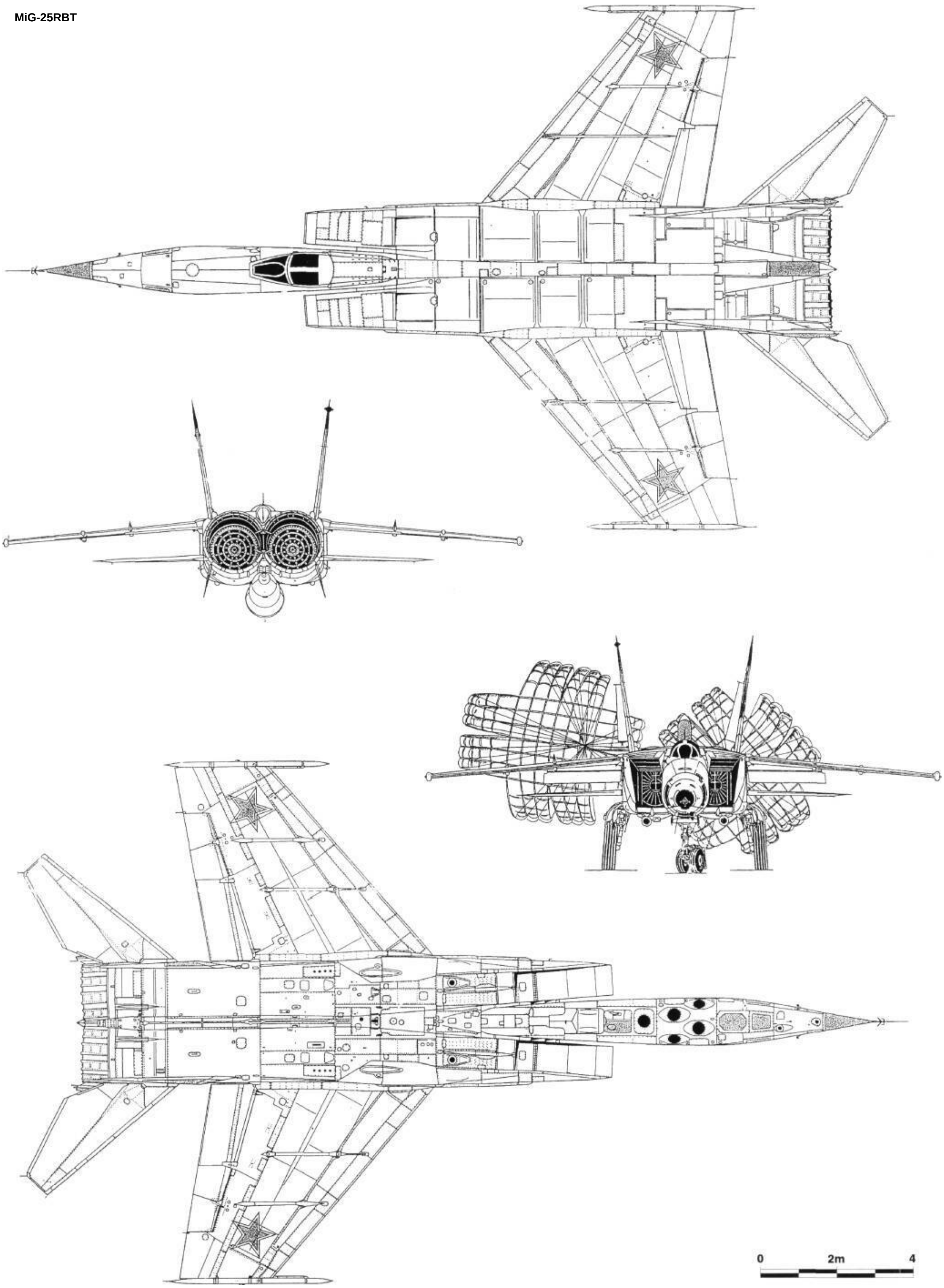
MiG-25P



MiG-25RBT
Wing omitted on this view
to reveal fuselage panel detail.



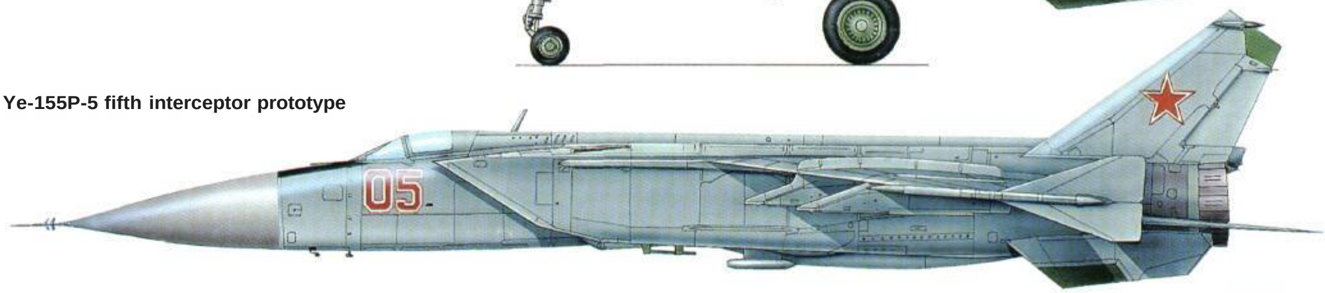
MiG-25RBT



Scale to drawings on this page

'Foxbats' in Colour

Ye-155P-1 interceptor prototype, 1964



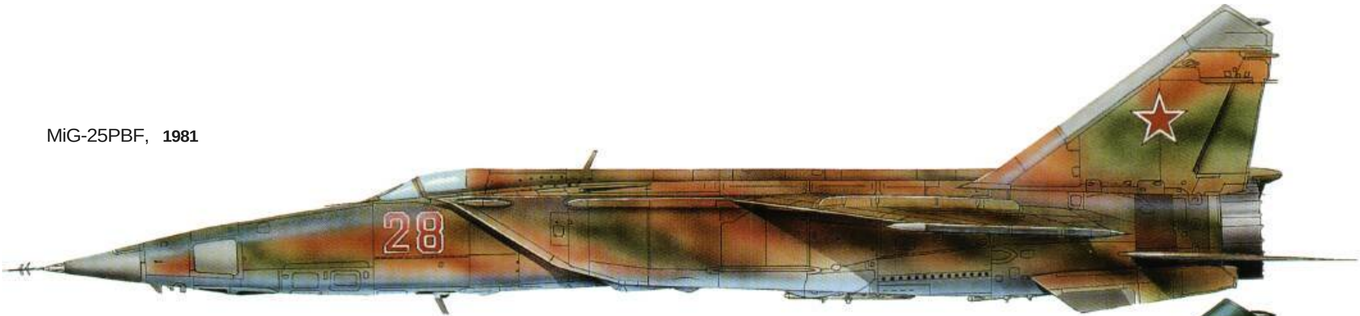
Ye-155P-5 fifth interceptor prototype

Ye 155R-1 reconnaissance prototype and first 'Foxbat' to fly

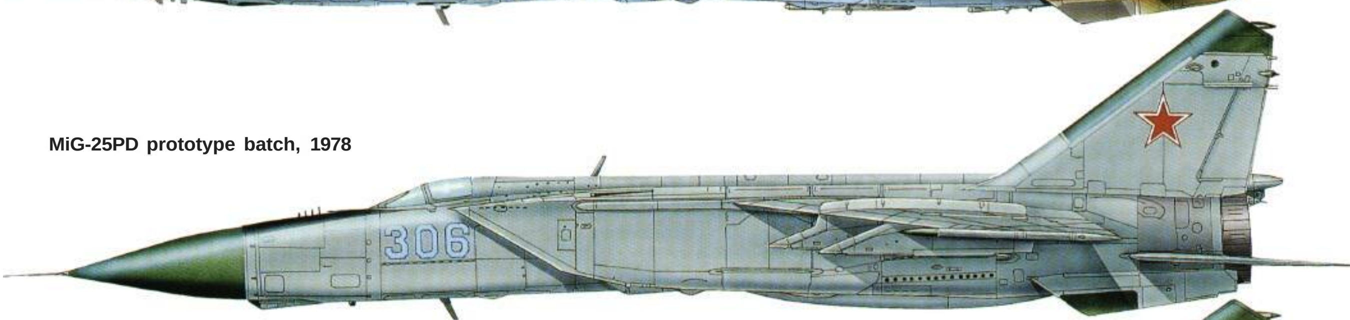
Ye-155R-3 first 'full' reconnaissance prototype

Ye-155R-3 with modifications for production

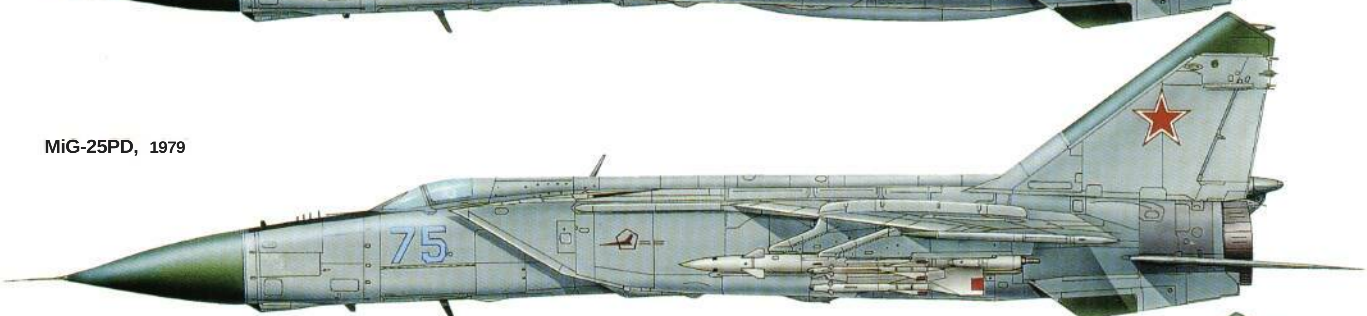
MiG-25PBF, **1981**



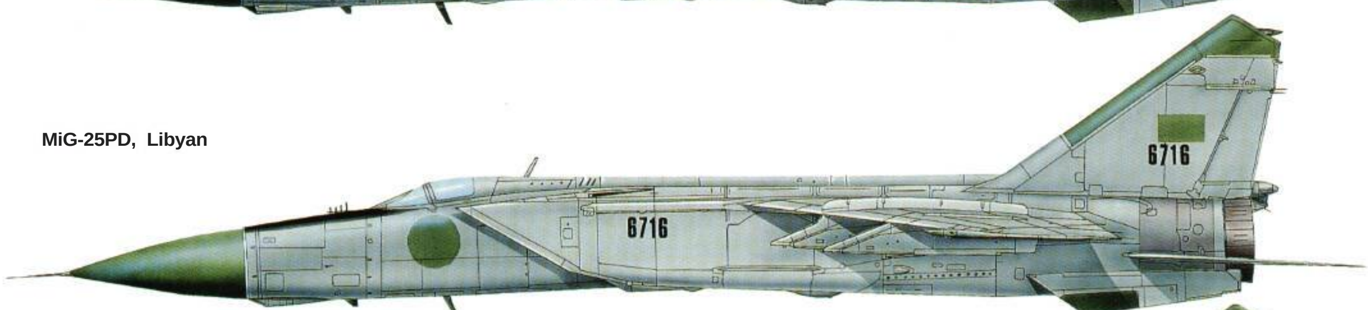
MiG-25PD prototype batch, 1978



MiG-25PD, 1979

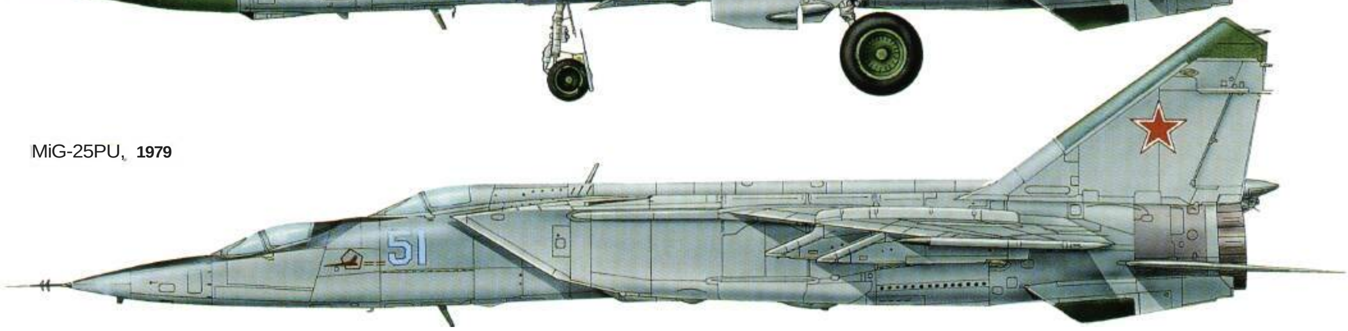


MiG-25PD, Libyan



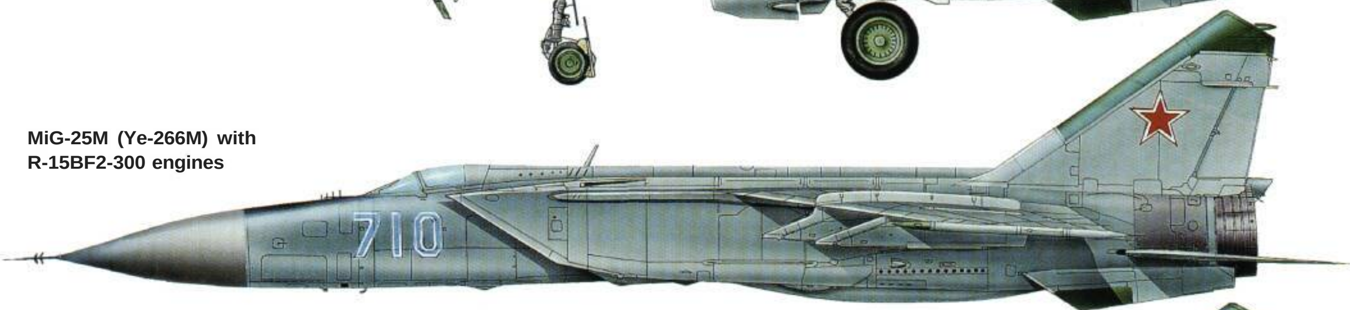
MiG-25PD, Ukrainian

MiG-25PU, **1979**

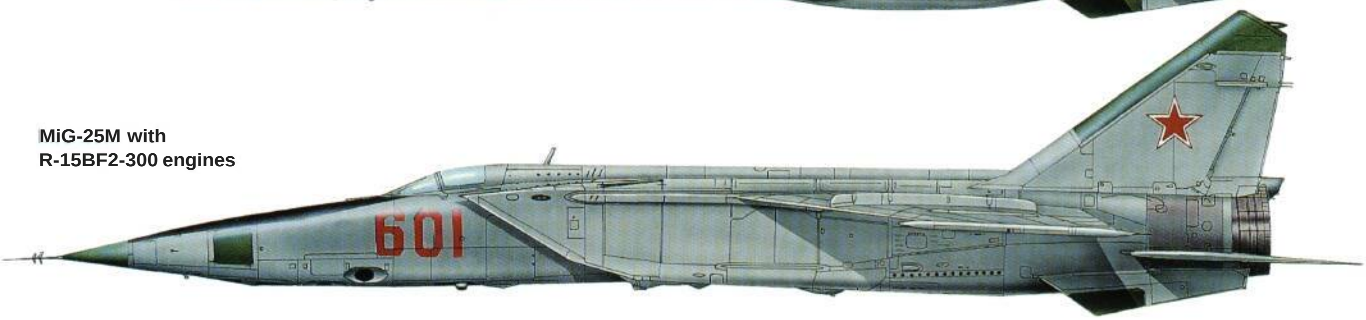


MiG-25BM, **1984**

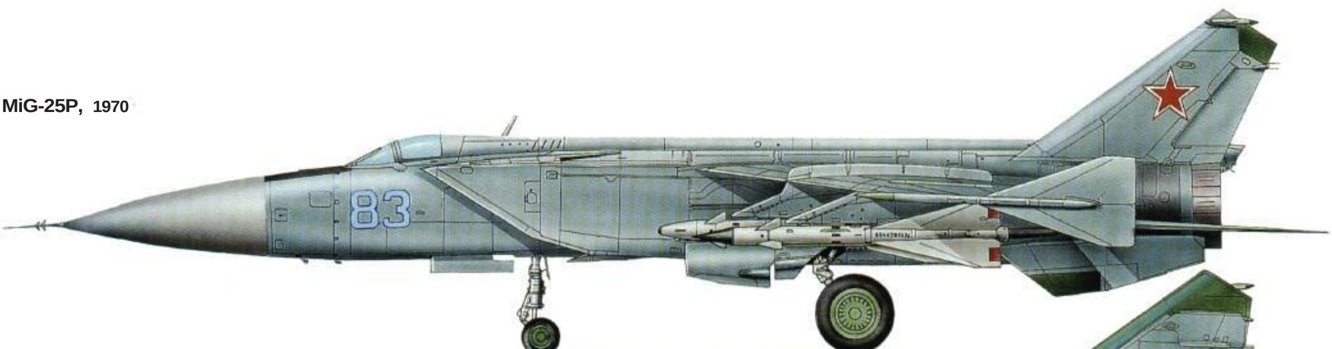
MiG-25M (Ye-266M) with
R-15BF2-300 engines



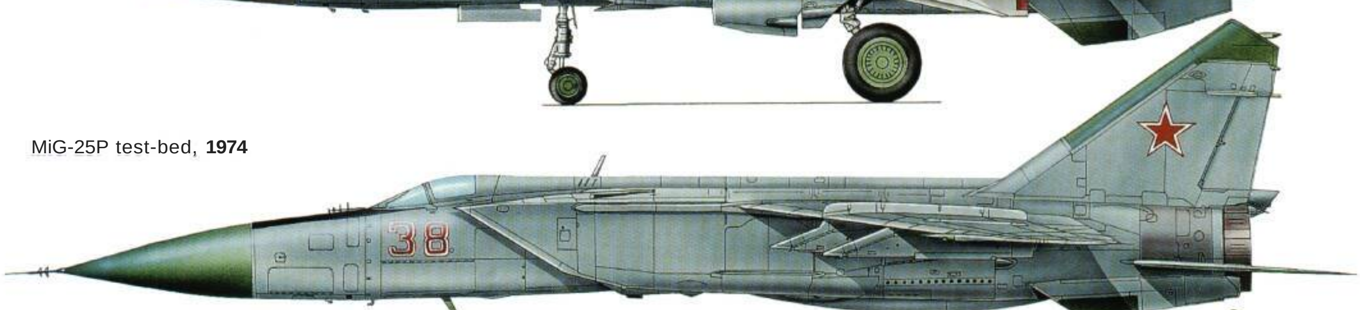
MiG-25M with
R-15BF2-300 engines



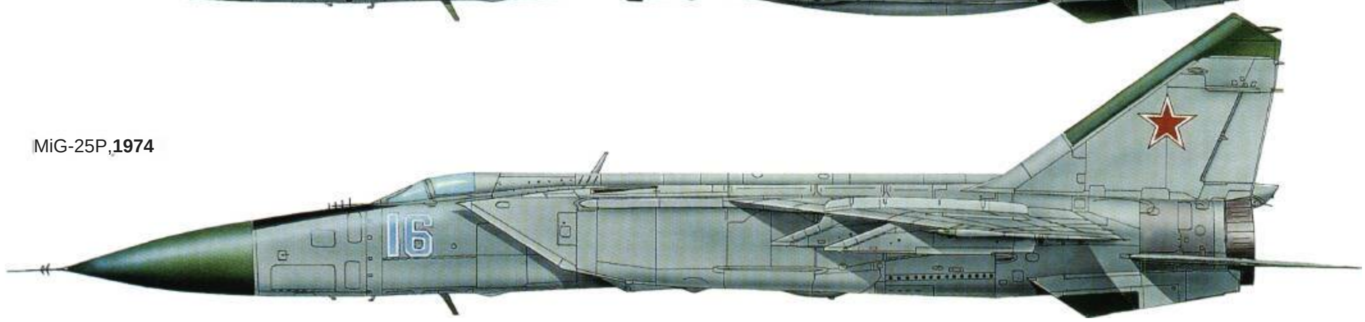
MiG-25P, 1970



MiG-25P test-bed, **1974**



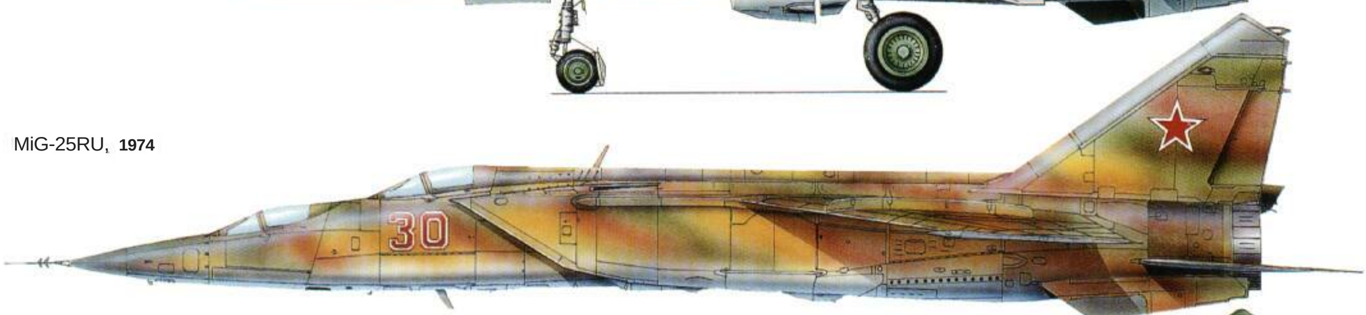
MiG-25P,**1974**



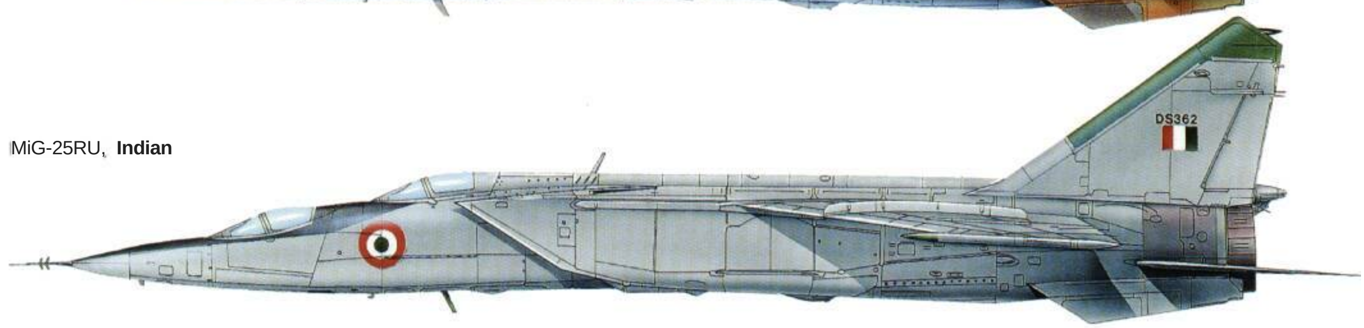
MiG-25RBV, 1972

MiG-25RU **prototype, 1969**

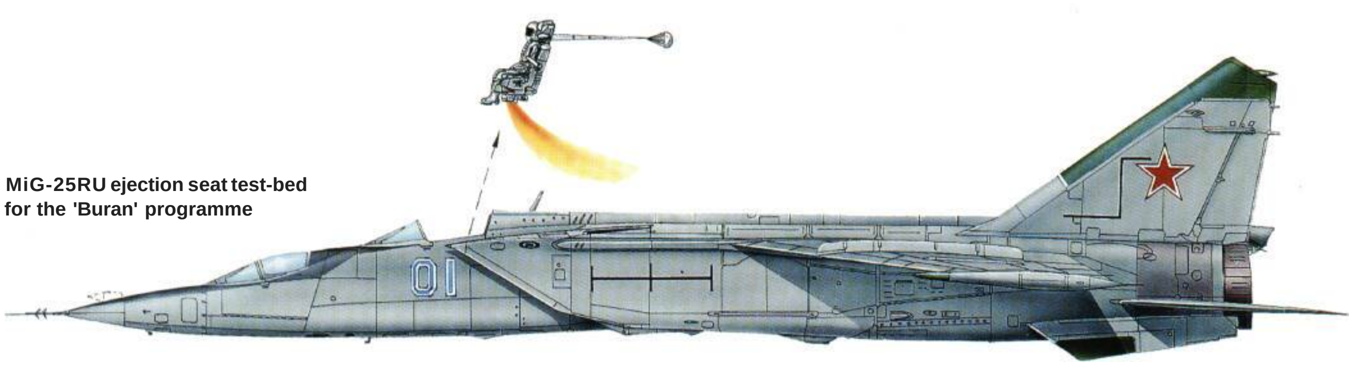
MiG-25RU, **1974**



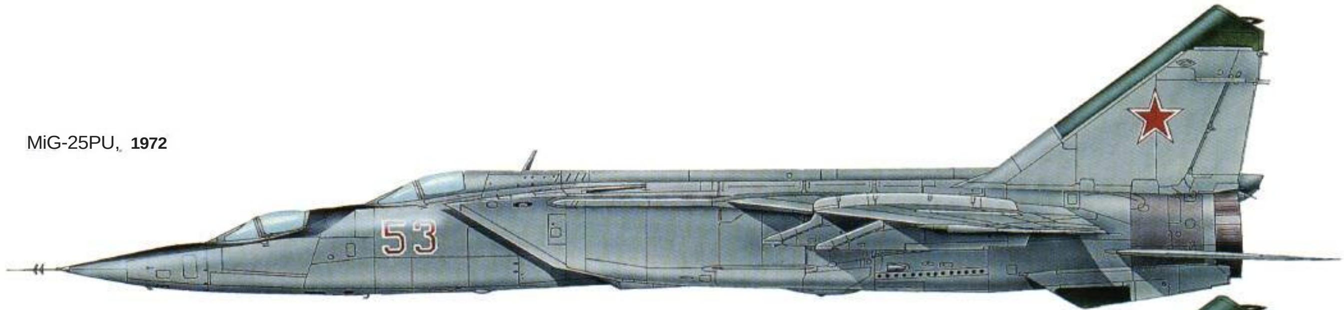
MiG-25RU, **Indian**



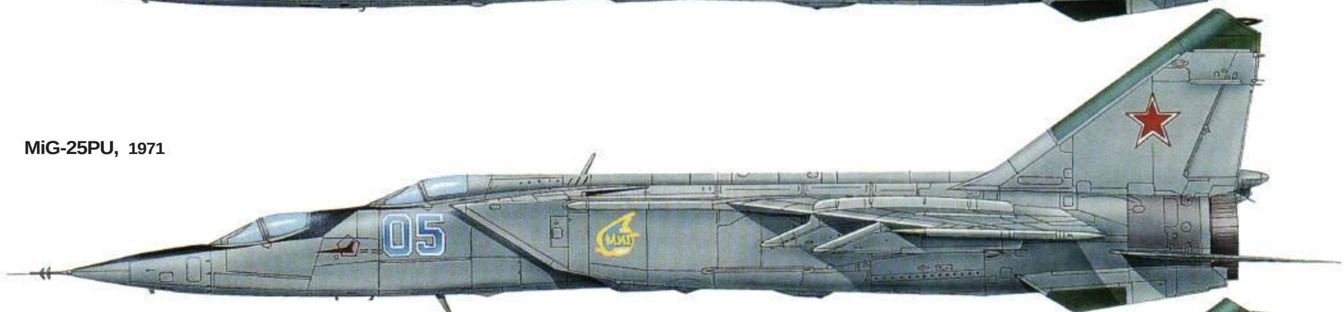
MiG-25RU ejection seat test-bed for the 'Buran' programme



MiG-25PU, 1972



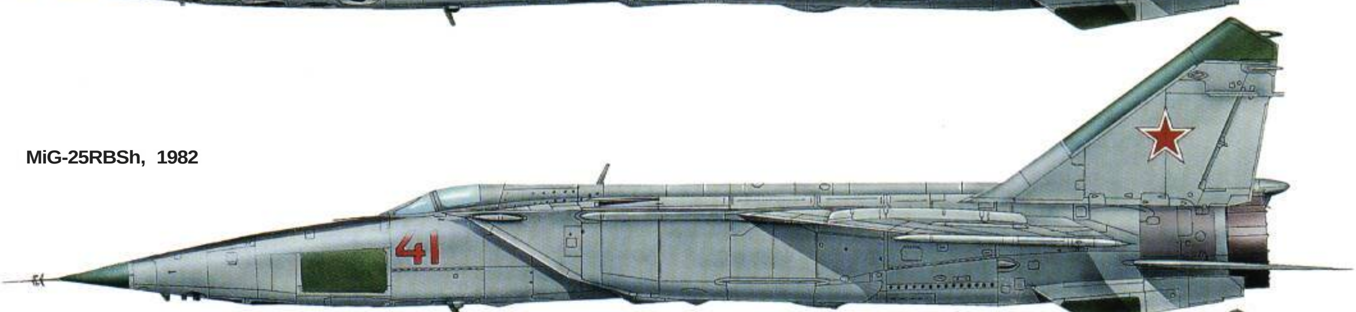
MiG-25PU, 1971



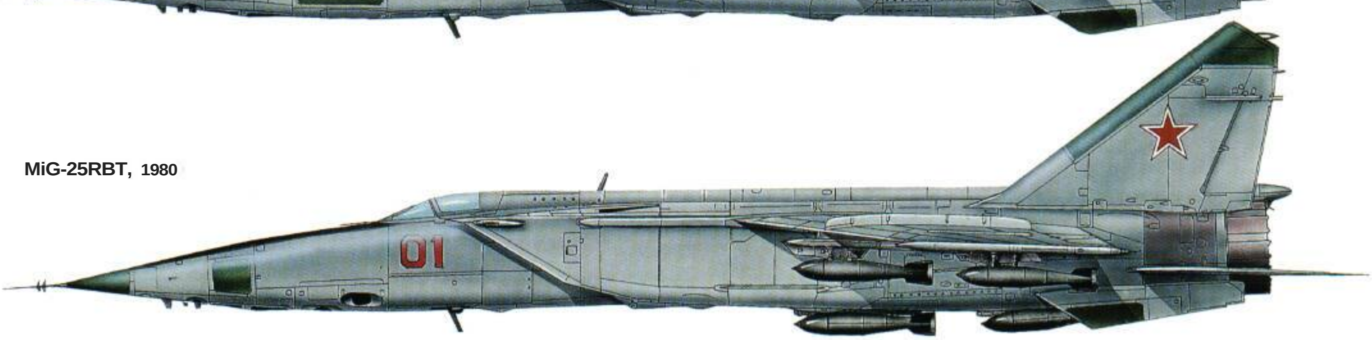
MiG-25R, 1970

MiG-25RB, Libyan

MiG-25RBSh, 1982



MiG-25RBT, 1980



MiG-25P

MiG-25P

Top: **Ye-155P-1, interceptor prototype.'** MiG OKB

Above: **Red 1155', the Ye-155R-1 - prototype of all the 'Foxbats' - paraded for a formal 'record' photograph against the distinctive concrete of Zhukovsky.** MiG OKB

Left: Ye-155R-3, **third reconnaissance prototype.** MiG OKB

Opposite page:

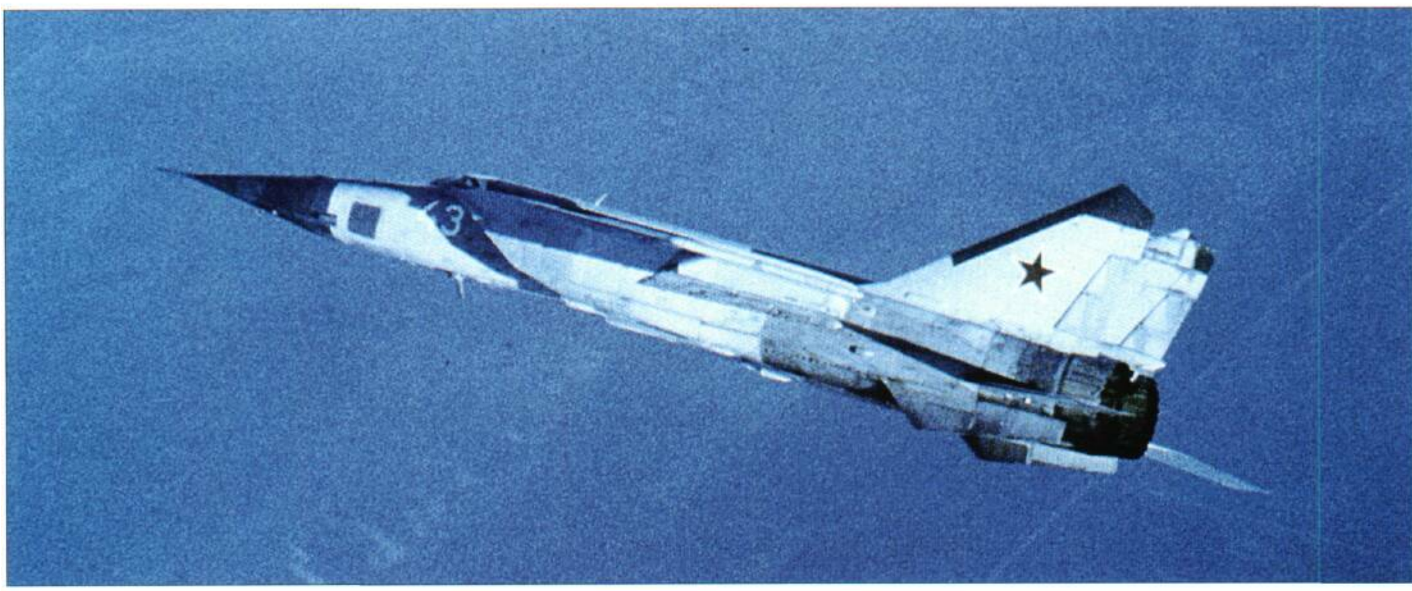
Top: MiG-25RBS, **an 'RB with 'Sablya-E' SLAR, entering service in 1972.** Yefim Gordon

Centre: **Camouflaged** M1G-25RBF **at Shatalovo.** Yefim Gordon

Bottom: MiG-25RBF **being towed at Lipetsk.** Yefim Gordon


25


20



Top: MSG-25PD of the Ukraine Air Force. Sergei Popsuyevich

Centre: **MiG-25BM, air defence suppression 'Foxbat-F'.** Sergei Skrynnikov

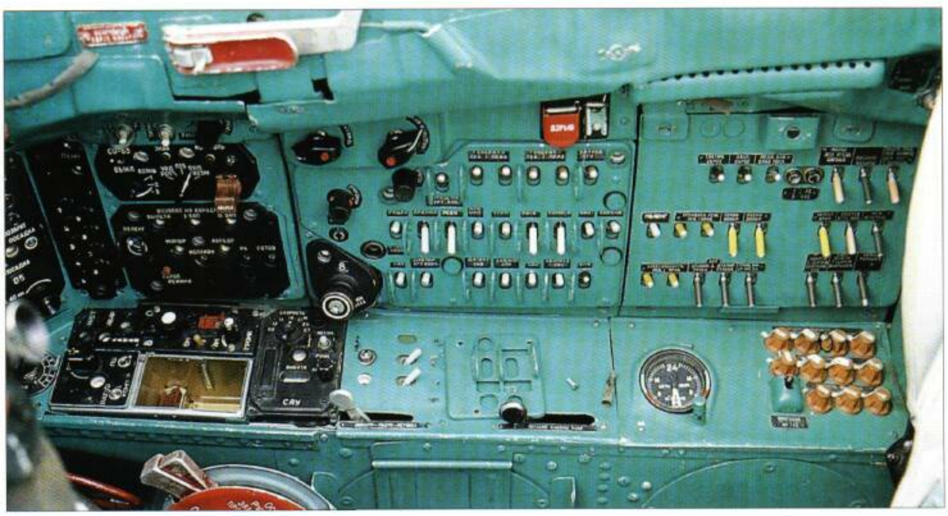
Above: **Camouflaged MiG-25BM at the Lipetsk combat training centre.** Yofim Gordon

Top: **MiG-25RBK and MiG 25RU at Shatalovo.** Yefim Gordon

Centre: **MiG-25RU at Shatalovo.** Yefim Gordon

Above: **MiG-25PU used in the 'Buran' space shuttle programme.** Yefim Gordon archive

MiG-25P cockpit, port panel.



MiG-25P cockpit, starboard panel.

Below left: **MSG-25P cockpit.**

Below right: **MiG-25RBF cockpit.**
All Yefim Gordon

From 'Bats to 'Dogs'

'Blue 831' the prototype Ye-155MP flew for the first time on 16th September 1975. MiG OKB

The MiG-25 programme influenced not only foreign aircraft design practices, but most of all the Mikoyan OKB's own designs. The 'Foxbat' served as a stepping stone towards a heavy interceptor unparalleled in the world. The Soviet leaders were interested in such an aircraft for the Voenno-vozdushniye Sily (WS - air forces of the USSR), and with good reason.

In 1968 the Central Committee of the Communist Party of the Soviet Union and the Council of Ministers issued a directive, ordering the Mikoyan OKB to design and build three versions (interceptor, strike and reconnaissance) of an aircraft designated Ye-155M. Initially the aircraft was merely an upgraded MiG-25; by the early 1970s, however, the objective was somewhat different.

The USSR had long been suffering from inadequate air defence of the polar regions. Air bases with powerful avionics and navigational facilities were few and far between in the north. The existing air defence radars could only detect low flying targets at close range. The Tupolev Tu-128 'Fiddler', the MiG-25PD and the Su-15TM 'Flagon' interceptors equipping the Protivovozdushnaya Oborona (PVO - air defence forces) units stationed up north were hampered by limited range and outdated weapons systems. Therefore, the Mikoyan OKB proposed developing the MiG-25PD into a long range interceptor capable of patrolling alone over the vast northern wilderness and defending industrial centres effectively.

The aircraft was to have long range and a cruising speed of about 3,000km/h (1,864mph) and be capable of destroying multiple targets - including cruise missiles - in a single sortie. The crew was to include a pilot and a navigator/weapons systems officer (WSO). The idea was supported by the government and the PVO command.

Three basic versions, designated Ye-155MP (Modifitseerovannyy Perekhvatehik - modified interceptor) were considered, differing only in wing construction as the fuselage, the lateral air intakes and twin fins remained practically unchanged.

- Version A had three-spar trapezoidal wings featuring small leading edge root extensions (LERXs),
- Version B featured swing-wings,
- Version C was a tail-less delta with an ogival wing of increased area a /a Tupolev Tu-144 'Charger' supersonic transport (and tested on the MiG-211 'Analog' test-bed).

Ye-155MP Interceptor with VG

One of the early Ye-155MP design studies was a cross between the MiG-23 'Flogger' and the MiG-25. The aircraft had air intakes a /a MiG-25 (with vertical ramps) but more aerodynamically refined. The crew of two was seated in tandem cockpits with aft-hinged canopies strongly reminiscent of the McDonnell Douglas F-4 Phantom II.

The variable-geometry wings and the tail unit with a single fin and rudder and a prominent fillet were quite similar to those of the MiG-23. To ensure adequate directional stability, two large folding ventral fins were provided, again reminiscent of the MiG-23. The aircraft had ordinary tricycle landing gear but the main units were unusual in having two small wheels in tandem to reduce runway loading, enabling the aircraft to operate from dirt or ice strips. The nose unit had twin wheels.

The aircraft was powered by two mighty Solov'yov D-30F-6 afterburning turbofans. The armament consisted of three or four long range air-to-air missiles semi-recessed in the lower fuselage. Additional short range missiles could be carried on pylons under the fixed wing gloves.

The variable-geometry wings not only improved field performance but increased on-station loiter time in some flight modes. However the sweep change mechanism increased

MiG-31 '374' in its 'demonstrator' colour scheme, has been displayed at a variety of worldwide airshows.

Model of the still-born Ye-155MF tactical bomber. Both Yefim Gordon

empty weight and complicated the wing box structure; besides, unlike the MiG-23, the aircraft was not designed for dogfighting (where swing-wings may confer an advantage). Thus, this version of the project was not proceeded with and abandoned.

Izdelye518-31 Interceptor

Another twin-engined two-seat interceptor was developed under product number (Izdelye) 518-31. Regrettably, no further information is available.

Ye-158 Interceptor

This preliminary design project was a twin-engined two-seater tail-less delta with an ogival wing, designated Ye-158. It never materialised.

Izdelye 518-55 Interceptor

The general arrangement group of the Mikoyan OKB's preliminary design (PD) section considered this version of the Ye-155MP under the project code '518'. Izdelye 518-55 was a cross between the MiG-25 and the eventual MiG-31, with the forward and centre fuselage of the latter and the tail unit of the former.

Four R-33 (ASCC AA-9 'Amos') air-to-air missiles were carried semi-recessed in the fuselage; the main landing gear units had twin wheel bogies with the wheels placed in line, as on the Swedish SAAB JA37 Viggen. The trapezoidal wings had large LERXs and a kinked trailing edge. This arrangement, which remained a project only, was fairly close to what the MiG-31 eventually looked like.

Ye-155MF Tactical **Bomber**

As the general arrangement group started work on the drawings of the Ye-155MP interceptor (the would-be Izdelye 83), someone had the notion of developing it into a tactical bomber capable of puncturing enemy air defences at high supersonic speed, neutralising enemy radars and hit high priority targets with bombs and air-to-ground missiles from high altitude.

The aircraft was designated Ye-155MF (F - Frontovoy - 'front line', ie tactical) and was quite similar to the would-be MiG-31, except for the wider forward fuselage with the two crew members seated side-by-side in similar manner to the Sukhoi Su-24 'Fencer' to give the navigator/WSO better visibility. The armament was carried on four wing hardpoints (typically four Kh-58 - ASCC 'AS-11 'Kilter' - ARMs) and in fuselage bays (12 x 250kg/550lb bombs). However, the Ye-155MF lost out to a more attractive project proposed by the Sukhoi OKB.

MiG-25MP (Ye-155MP) Prototype (Izdelye 83)

PD work on the much improved new version of the MiG-25P and 'PD had started in 1972.

After assessing numerous configurations the Mikoyan OKB chose the optimum one and started work on detailed drawings. At this stage the aircraft received Izdelye No.83. Despite a lower top speed and ceiling, the aircraft fitted the PVO's advanced interceptor requirements better than the old MiG-25PD.

The aircraft was designed around the D-30F afterburning turbofan - an uprated and much-improved version of the civil D-30 designed by P A Solov'yov in 1963 for the Tu-134 'Crusty' short/medium-haul airliner. Work on the D-30F began in 1972 almost simultaneously with the MiG-31 design effort.

The aircraft was to have an effective weapons control system based on the SBI-16 "Zaslon" (ASCC 'Flash Dance') phased-array radar. The crew consisted of a pilot and a navigator/WSO, which not only improved combat efficiency but also boosted the crew's morale during long sorties, especially over water.

Below right: **Pilot's instrument panel, MiG-31.**

Bottom right: **Details of the pilot's starboard panel, MiG-31.**

Below: **Navigator/WSO's panel, MiG-31.**
All Yefim Gordon

Besides, the second set of flying controls with a telescopic stick (!) and a retractable forward-vision periscope in the rear cockpit obviated the need for a separate training version (and enabled the WSO to land the aircraft should the pilot become disabled).

Design work on the Ye-155MP supervised by R A Belyakov took several years, culminating in a unique aircraft. Outwardly similar to the MiG-25P and 'PD, the MiG-31 had much refined aerodynamics, major structural differences, a new powerplant, weapons and avionics.

The MiG-31 was a fourth generation interceptor with enhanced capabilities. It was designed to intercept and destroy manoeuvrable and non-manoeuvrable targets (including low level ones) in the front and rear hemisphere, day and night, in visual flight rules (VFR) and instrument flight rules (IFR) conditions in a passive and active jamming environment while flying at high supersonic speeds.

The fuselage and air intakes acted as a lifting-body structure, providing up to 50% of the lift in certain flight modes. The relatively thin wings now had a three-spar structure (instead of two-spar as on the MiG-25) and featured camber and small LERXs. The extra spar was to eliminate the insufficient wing stiffness encountered on the MiG-25 both in text flights and in service conditions. The camber delayed wing-tip stalling at high 'alpha' (angle of attack) at subsonic speeds; the LERXs swept at 70° enhanced manoeuvrability at high alpha. To improve lift in loiter mode the wings were fitted with four-section leading-edge flaps; the trailing edge was occupied by two-section flaps with a maximum deflection of 30° and flaperons deflected ±20°. In subsonic cruise the flaps and flaperons were deflected 5° and the leading-edge flaps were drooped 1.3°. On take-off and landings, only full flap deflection (30°) was used.

The tricycle landing gear featured novel twin-wheel main bogies: the tandem mainwheels did not have a common track (ie, the front wheels faced inboard and the rear ones outboard). This enabled the bogie to rotate and fold into a remarkably small space during retraction while decreasing runway loading considerably, thus enabling the aircraft to operate from dirt and ice strips. The mainwheel front doors doubled as -airbrakes and could be used in supersonic cruise at high altitude, but not at low level supersonic flight as the slipstream pressure was too high. Initially the so-called 'knock-knock-come-on-in' system was used to achieve maximum climb rates - ie., on the prototypes the mainwheel doors airbrakes were closed when the gear was down, opening only when the gear was in transit. This arrangement was to cut climb-out time by cutting drag during take-off, but was later abandoned.

MiG-31 B 'Blue 592' during testing from Akhtubinsk. Sergei Skrynnikov

A MiG-31B at the Akhtubinsk test centre. Yefim Gordon

The D-30F engines had a high turbine temperature and a high pressure ratio, giving a low fuel consumption in supersonic cruise both at high and low altitude. The engines had been tested on the modified MiG-25RB (Izdelye 99) described in Chapter Four.

The emergency escape system comprised two tried and tested K-36DM ejection seats with mechanically-activated ejection guns. Electrical actuation was dismissed.

Airframe, engine and radar design was complicated by numerous organisational stages which set the project back a great deal and delayed prototype construction. One meeting of the PVO top commanders held in 1975 noted that 33 government directives had been passed on the MiG-31 but the aircraft had not yet entered service.

The two MiG-31 prototypes were built at the Mikoyan OKB's experimental plant in Moscow. Simultaneously the Gorkii factory received technical data necessary for building a pre-production batch to be used in the trials programme.

The first prototype ('Blue 831' - Izdelye 83, aircraft No.1) was completed in mid-1975. It lacked radar, some avionics items and built-in cannon; the radar set was replaced by test instrumentation. In August Mikoyan chief test pilot (CTP) Alexander Fedotov, twice HSU, was appointed chief test pilot for the MiG-31 programme; S G Polyakov was leading engineer and V N Keechev the prototype's 'personal' technician.

On 16th September 1975 Fedotov made his first flight in 'Blue 831'. Factory trials got under way; soon, pilots Pyotr Ostapenko, Boris Orlov, Aviard Fastovets, Valeriy Menitskiy and Toktar Aubakirov and navigators Valeriy Zaitsev and Leonid Popov were flying the MiG-25MP.

The second prototype, 'Blue 832', had a complete avionics and weapons fit. The aircraft made its first flight from the Letno-Issledovatel'skii Institut (LII - Flight Research Institute) airfield at Zhukovsky in May 1976 at the hands of test pilot Ostapenko; later it was flown to Nauchno Isseldovatelyskii Institut (NiI - Scientific and Research Institute) VVS's Akhtubinsk facility for testing. Leonid Sveederskiy and Edward Kostroobskiy were the leading engineers of the prototypes.

Testing did not always progress smoothly. The chief source of trouble was the engines which were constantly modified to improve performance; the radar posed some problems as well. Yet the aircraft was far superior to all interceptors then in service with the PVO as regards range and weapons systems/avionics capabilities.

Thus, years before the trials programme was finished it was decided that the new aircraft should go into production in Gorkii. The production form was designated MiG-31.

MiG-31 Interceptor (Izdelye 01)

In 1977 the Gorkii aircraft factory launched the new MiG-31 two-seat heavy interceptor. The production aircraft, known as Izdelye 01, was fitted with a complete avionics and weapons suite, including a GSh-6-23 six-barrel Gatling-type gun with a high rate of fire, and had some structural differences from the prototypes (the MiG-25MP/Izdelye 83). The forward main gear doors/airbrakes remained down when the gear was extended. The airbrakes and aft main gear doors were recontoured, as were the wing fences, LERXs etc. Production aircraft were fitted with a modified SBI-16 'Zaslon' radar incorporating improvements based on early test results. The engines were also extensively modified and designated D-30F-6.

The first batch consisted of two aircraft. The short fuselage numbers (f/n) allocated by the Mikoyan OKB did not tie in with the horrendously long construction numbers of production aircraft. The first production MiG-31 completed in the late spring of 1977 (f/n 0101) was 'Blue 011'; the second machine off the Gorkii production line (f/n 0102, late 1977) was 'Blue 012'. 'Blue 011' was the first aircraft to conform aerodynamically to MiG-31 production standard. It lacked radar and was used for aerodynamic, static and fatigue tests. The second production aircraft was intended for performance testing.

Batch No.2 comprised three aircraft (f/ns 0201, 0202 and 0203), 'Blue 201', 'Blue 202' and 'Blue 203' respectively. Batch No.3 consisted of four aircraft; the second and third batches were likewise earmarked for the trials programme.

Powerplant problems persisted on the early production machines. Test pilot Boris A Orlov experienced an engine failure on 'Blue 011' and only just managed to bring the aircraft in. On examination, test pilots and Mikoyan reps were horrified at the extent of the damage: the engine had blown apart and fragments knocked out one of the hydraulic systems and various other equipment. 'Blue 011' was subsequently lost in a test flight out of Akhtubinsk; pilot Pyotr Ostapenko and WSO Leonid Popov ejected safely. The crew was lucky, too, as the aircraft had a near full fuel load and turned into a fireball immediately after they ejected. The reason once again was engine failure; it looked like the first production aircraft was jinxed.

Stage A of the trials (general flight and performance testing performed mainly by the OKB) was completed in December 1978. In the spring of 1979, Stage B began at Nil VVS. The state commission accepting the trials was headed by Air Marshal Yevgeniy Savitkiy, PVO Deputy C-in-C.

Additional OKB test pilots joined the trials programme even as the MiG-31 entered production. These included Aleksandr Krootov, Anatoly Kvochur and Roman Taskayev. Generally the flight tests progressed well, though there were still problems. On one aircraft piloted by Krootov fatigue cracks appeared in the fuselage after a sortie at 15,000m (49,200ft), Mach 2.6 and 5g. In another flight aimed at determining structural strength limits both afterburners disintegrated during low altitude supersonic cruise. The results of such sorties were carefully analysed by the designers and necessary modifications incorporated.

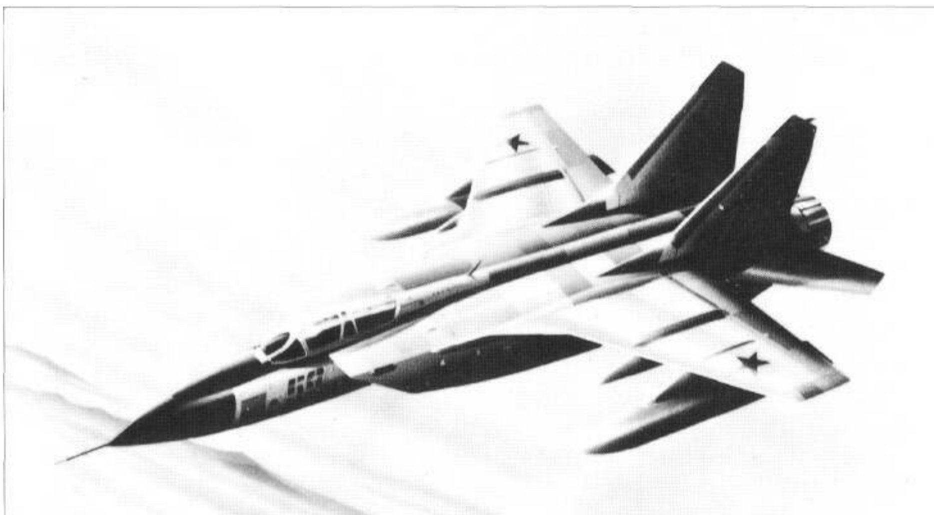
The test pilots' exceptional skill and courage were a great help to the designers, saving the test aircraft from destruction on several occasions. Good physical training was a must when the pilots took the aircraft to its limits. For example during maximum speed and ceiling sorties Anatoly Kvochur had to spend five hours strapped into the pilot's seat and clad in a pressure suit.

In early 1980 the trials programme was largely completed and an Act of Acceptance for Stage B was signed, marking the delivery of a few aircraft to a regular PVO unit for service trials. The MiG-31 was officially added to the PVO inventory in May 1981; however, the final Act of Acceptance was not signed until December. Deliveries to PVO units (primarily stationed in the Moscow PVO area, the northern regions and the Far East) commenced in 1982.

The MiG-31's introduction into service was marred by crashes and accidents. Besides the engines, one particular source of trouble was the fuel system. During one sortie pilot Valeriy Menitskiy and WSO Viktor Ryndin had an emergency on the eighth production aircraft ('Blue 303', f/n 0303). A fuel line broke at a welded joint due to a defective nipple used for ground-checking fuel pressure on the engine. The 80mm diameter pipe spewed fuel into the engine bay; a fire was miraculously avoided because the D-30F-6 had a lower casing temperature than the R15BD-300 in cruise. The fuel flow gauges indicated that uncommanded fuel jettisoning had occurred; the fuel dwindled rapidly, and finally the engines quit shortly before landing. Mesvitskiy ordered his WSO to eject but Ryndin said he would do so only if he had no other option and certainly not without his pilot. Menitsky made a successful emergency landing not far from the air base.

'Blue 303' and its delivery from danger enabled the designers to trace and eliminate the cause of the trouble, solving many flight safety issues. A major redesign of the fuel system followed; 'Blue 201', the third production aircraft (f/n 0201), served as atest-bed. However, the aircraft had been extensively used for testing before and was in poor condition; this resulted in a crash on 4th April 1984, in which Mikoyan CTP A V Fedotov and WSO Valeriy Zaitsev were killed. A faulty fuel flow gauge led the pilot to believe he was losing fuel fast. Fedotov began a manoeuvre to make a short cut back home, lost speed, and the MiG-31 flicked

MiG OKB test pilots pose in front of 'Blue 592'. Second from the left is CTP Valeriy Menitskiy. Sergei Skrynnikov



A Western artist's impression of the 'Super MiG-25'. As it turned out it was not far removed from reality. Yefim Gordon archive

into a spin. Fedotov ran out of altitude just as he seemed about to recover.

This tragic accident led to a series of tests to see how the aircraft handled in 'dangerous' flight modes. OKB test pilots Orlov, Aviard Fastovets and Valeriy Menitskiy participated, for example in spinning trials. This resulted in recommendations for performing aerobatics on the MiG-31. Menitskiy became Mikoyan's new CTP and made a major contribution to the type's successful introduction into service.

Production aircraft were equipped with zero-zero K-36DM ejection seats with an operational envelope far wider than their forerunner's. MiG-31 'Blue 305' (f/n 69700104801, also 0305) which made its first flight in Gorkii on 27th April 1979 at the hands of test pilot Kherodeenov, was used in a major structural strength test programme. The wing box, air intakes and engine bay bulkheads were beefed up, a modified brake parachute container and a new fairing between the engines were installed, and the radar was replaced by test instrumentation. Fitted with dummy R-33 missiles, this aircraft was tested at maximum speeds and g loads both at Zhukovsky and in Akhtubinsk, flown by Menitskiy, Igor, Volk, et al. Eventually it was also lost in a crash, test pilot Pyotr Gladkov and his WSO ejecting safely.

Full-scale production in Gorkii began in 1979. Despite the loss of several aircraft during trials, the MiG-31 worked up a good reliability record in actual service. Not a single case of engine fire was recorded thanks to the 'colder engines'.

The aircraft possessed unique capabilities, being the world's first production interceptor fitted with a phased-array radar. The radar was capable of detecting targets in the front and rear hemisphere over land and water, day and night in VFR and IFR conditions. It could track up to ten targets simultaneously and aim long range missiles at four targets at once within an area of 70° on either side, 70° above and 60° below the aircraft's course with full look-down/shoot-down capability. The retractable infra-red search and track (IRST) pod enabled it to make covert attacks without using radar. A display visualised other traffic and threats. The MiG-31 was equipped with ECCM gear.

Usually the weapon load comprised four long range R-33 missiles with inertial guidance and course correction at the early stage of the trajectory and active radar homing at the final stage; this was the first air-to-air missile to use such a guidance system. Alternative weapon fits comprised two R-40TD (R-40T, or AA-6 'Acrid') AAMs or four R-60M (AA-8 'Aphid') dogfight missiles.

A unique weapons control system took care of the mission, enabling the aircraft to operate as an airborne command post (ABNCP). A flight of four MiG-31 s, the lead aircraft acting as ABNCP, could trade target information over a strip of terrain 800km (500 miles) wide. The interceptors could split multiple targets between themselves, or pass some of them on to the leader of another patrol if there was more than they could chew. All radio communication was automatically on channels protected from electronic eavesdroppers. Three MiG-31 s patrolling an area could provide 360° coverage. Besides, a MiG-31 could direct up to three of its fellow MiG-23P 'Flogger', MiG25PD, MiG-29 'Fulcrum' or Su-27 'Flanker' interceptors, obviating the need for them to use their own radars and thus reveal their position.

This multi-role capacity was largely conferred on the MiG-31 by the second crewman. The WSO was required first and foremost to efficiently manage the rather complex weapons control system. He took care of all the preparations for aerial combat, the pilot making the ultimate decision to engage. The WSO was also the navigator, plotting and correcting the aircraft's course, processing data on the on-board computer and selecting targets. He could also fly the aircraft if need arose.

For the first time in Soviet Air Force history interceptor groups were capable of operating semi-autonomously, given continuous or initial data on the target(s). Thus, the aircraft could be used to cover areas where air defence radar coverage was incomplete (eg in the far north). Automatic air-to-air data link enabled the PVO units to organise the actions of individual aircraft and combat formations while setting maximum intercept range at 720km (447 miles) from base.

The noticeably improved fuel economy in subsonic cruise gave the pilots greater confidence about making it home after a sortie, especially if the mission took them out over 'the briny' or a long way from the base. Yet the 'Foxhound' had some serious deficiencies - an engine failure increased the good engine's fuel consumption, cutting range drastically.

Another nasty feature discovered at an early stage was the aircraft's high landing speed. At a landing weight of 26,600kg (58,641 lb) the approach speed was 285km/h, rising to 300 km/h (177 to 186mph) if the aircraft had a heavy fuel load and unexpended missiles.

MiG-31 Structural Details

Structurally, the MiG-31 airframe is broadly similar to the MiG-25. It is made of aluminium alloys capable of withstanding working temperatures of 150°C; areas which are subject to high thermal loads are made of titanium and stainless steel. Steel accounts for 50% of the structure, with titanium and aluminium making up 16% and 33% respectively; the remaining 1 % is other materials.

The MiG-31 is an all-metal monoplane with cantilever shoulder-mounted wings, rectangular-section lateral air intakes, low-mounted slab stabilisers and twin fins. Airframe structural elements are mainly connected by means of automatic and semi-automatic spot and argon-arc welding.

The control system is mechanical with cables and push-pull rods.

Fuselage

Oval-section monocoque with flattened sides and pointed nose, built as a one-piece unit with removable access panels for engine and equipment servicing.

Technologically the fuselage consists of numerous welded and riveted panels and is divided into the forward fuselage (nose probe to frame No.3), bay aft of cockpits (frames Nos.3 to 4), air intake section (frames No.2 to 6), fuel tank bay (frames No.4to 12), aft fuselage (framesNo.12to14).

The fuselage has 57 frames and webs; the principal load-bearing frames are Nos.1 to 6, 6B, 7, 9, 10, 10A and 11 to 14. The fuselage is made of VNS-2, VNS-5, EI-878, SN-3, EI-703, VNL-3 and VL-1 high strength stainless steel, D19and VAL-10 aluminium alloys and OT4-1, VT-20, VT-21L and VT-22 titanium alloys.

The forward fuselage up to frame No.4 is made chiefly of riveted aluminium and includes a dielectric radome, a radar set bay (web No.1 to frame No.1), cockpits (frames Nos.1 to 3) and an avionics bay aft of the cockpits (frames Nos.3 to 4).

The tandem cockpits are pressurised and fitted with ejection seats. Each cockpit is closed by a separate aft-hinged canopy which can be partially opened at taxi speeds up to 30km/h (18.6mph). The WSO's canopy is fitted with a retractable forward-vision periscope, enabling him to fly and land the aircraft.

The side quadrants of the front cockpit windshield, the glazing of the canopies and the section between them is made of 10mm heat-resistant SO-200 Plexiglas. The optically flat front panel of the windshield is a 36mm sandwich of three layers of silica glass with electric de-icer film. The cockpits are separated by a 10mm panel of AO-120 Plexiglas.

The cockpits are also separated by a sloping bulkhead (frame No.2), the aft cockpit terminates in a likewise sloping bulkhead (frame No.3). The bulkheads serve as attachment points for the ejection seat rails.

The detachable fibreglass radome is fixed to web No.1 by nuts and bolts. Bays below and aft of the cockpits contain avionics and communications equipment, as well as part of the electric system components. The nose landing gear unit is housed in a bay between frames Nos.1 A and 3; the fuselage sides incorporate attachments for the air intakes and crane handling lugs.

The centre fuselage between frames Nos.4 and 12 is a welded structure of high strength stainless steel and incorporates attachments for the wings, air intakes, main gear units, engines, fins and missile ejector racks.

The MiG-31 's air intakes are much larger and more complex than on the MiG-25. These are stressed-skin structures with load-bearing removable panels. The intake ducts start at frame No.2 and extend along the fuselage sides to frame No.6. The forward portions of the intake ducts are of rectangular cross section with sharp edges, the side panels slanting aft in profile. Intake cross section is adjusted by movable lower lips and upper ramps to adjust airflow to airspeed and height. Each ramp's actuators are controlled by the ARV-27 automatic control system.

The upper part of the centre fuselage and the space above the intake ducts houses fuel in seven integral tanks (the centre fuselage is referred to as the fuel tank section). The lower portion of the centre fuselage houses fuel system components.

The centre fuselage is the section subject to the greatest stress and strain - as it is, it absorbs the load from the wings, tail unit (via the aft fuselage) and landing gear, external aerodynamic loads and air pressure in the intake ducts and fuel tanks. It is the main structural section the entire airframe is built around. The fuel tank section incorporates ten principal frames (Nos.4 to 6, 6B, 7, 9, 10, 1 OA, 11 and 12) and is made of high strength stainless steel (VNS-2, EI-878, VNS-5, SN-3 and VNL-3).

The aerodynamically shaped fuselage spine housing the control runs extends from the cockpits to the brake parachute container. Hydraulics, pneumatic

'Blue 202' from the second production batch of MiG-31 s - note the calibration markings on the nose. MiG OKB and air-conditioning equipment is located along the fuselage sides.

The aft fuselage incorporates attachment points for the fins and stabilisers (frames Nos. 13 and 14) and fittings for the afterburners and some engine accessories. The brake parachute container is located between the fins and houses two cruciform parachutes with a total area of $50m^2$ ($538ft^2$). These are extracted by two drag chutes each, with an area of 0.05 and $1.5m^2$ (0.5 and $16ft^2$) respectively.

Three equipment bays insulated with ATM-3 heat insulation are located in the upper aft fuselage between frames Nos. 12 and 13, Nos 13 and 14 and Nos.14B and 14V. These house control, fuel and hydraulic system components.

The tailcone consists of a centrebody welded from EI-703 steel and a detachable outer portion. The fuselage has a total length of 20.62m (67ft 7'/£in) and a cross section of $5.7m^2$ ($61.3ft^2$).

Wings

Relatively thin trapezoidal three-spar swept wings featuring camber and small LERXs. Wing span is 13.456m (44ft 4in), leading edge sweep 41°02', LERX leading edge sweep 70°30'. Total wing area (including centre section but excluding LERXs) is $61.6sm^2$ ($663ft^2$), the wing panels accounting for $41.0m^2$ ($441ft^2$); aspect ratio is 2.93, taper 3.14, incidence 0°, anhedra!5°.

Wing sections are thin and with a sharp leading edge - TsAGI P44M at the roots and TsAGI P101M at the tips. Thickness-to-chord ratio is 3.7% at the roots, 4.1 % at mid-span and 4.48% at the tips.

The wings are fitted with four-section leading edge flaps (deflected 13°), split flaps 2.682m ($8ft9^1$/^in) long (max deflection 30°) and split flaperons 1,7m (5ft 6in) long (maximum deflection ±20°). The flaperons may droop 5°, in which case they are deflected 15° up and 25° down.

The wings are attached to the fuselage by six fixtures; each wing contains two integral fuel tanks. The wings have three spars, stringers, ribs and skins made of VNS-2 and VNS-5 high strength stainless steel and OT4-1 and VT-20 titanium sheet. Besides the three spars, the front false spar and rear stringer are the main longitudinal structural elements of the wings. The trailing edges of the flaps and flaperons have skins riveted to ribs and stringers. Each wings has two attachment points for a weapons pylon and two more for a 'wet' drop tank pylon (this can also carry dogfight missiles).

Tail Unit

Riveted slab stabilisers with a span of 8.75m (28ft 8^1/£in), area $9.82m^2$ ($105.7ft^2$), leading edge sweepback 5-°22', anhedral 1°25'. The leading edges are covered with titanium skin and are left unpainted.

The twin fins are canted outboard 8° and have a total area of $15.6m^2$ ($167.9ft^2$); leading edge sweepback is 54°. They have a riveted structure and are identical, except for the leading edges and tip fairings. The spar box of each fin doubles as an integral fuel tank. The rudders are attached to the fins on three hinges each. The removable fin tip fairings are made of glass fibre and cover aerials. The leading edges are also removable; the port fin leading edge is riveted from D19 aluminium, while the starboard fin leading edge is glass fibre.

Two ventral fins canted outboard 12° are attached to fuselage frames Nos. 12 to 14. They are likewise of riveted structure and have dielectric forward sections.

Landing Gear

Hydraulically retractable tricycle type. The nose unit with twin KT-176 wheels (size 660 x 200mm) and mudguard retracts aft. Forward-retracting main units have twin-wheel bogies with staggered KT-175 wheels (size 950 x 300mm). During retraction each bogie rotates forward around leg to lie horizontally in fuselage. All wheels fitted with brakes. The forward pair of mainwheel well doors double as airbrakes with a total area of $1.39m^2$ ($14.9ft^2$), which can be deflected 39°. Wheel track 3.638m (11ft $10/_2$in), wheel base 7.113m (23ft 4in).

Powerplant

Two Solov'yov D-30F-6 afterburning turbofans (Izdelye 48) rated 9,140 to 9,270 kgp dry and 14,965 to 15,510 kgp with reheat (20,401 to 20,691 lb st and 33,404 to 34,620lb st respectively). Bypass ratio is 0.55 dry or when in 0.52 reheat. SFC 0.72kg/kgphr dry or 1.9kg/kgphr reheat. Engine dry weight is 2,416kg (5,326lb).

Fuel is contained in seven integral tanks in the fuselage, four more in the wings and two more in the fins. A 2,500 litre (549lmp gallon) drop tank can be carried on each inboard wing pylon. Normally the aircraft carries 13,700 litres (3,013 Imp gallons) of fuel in fuselage tanks Nos.2 to 5, the wing tanks and half-filled drop tanks. Minimum mission fuel is contained in fuselage tanks Nos.3 and 4 and the wings.

Tanks Nos.1 and 2 occupy the space between frames Nos.4 and 6; tank No.3 is located between fra-Nos.6 and 7, tanks Nos.4 and 5 between frames Nos.7 to 11, and tanks Nos.6 and 7 between frames Nos. 11 and 12B. A coolant tank adjacent to fuel tank No.7 is located between frames Nos. 12 and 13.

Armament

The main weapons fit comprises four R-33 long range air-to-air missiles carried semi-recessed in the fuselage on AKU-410 ejector racks. The missiles have active radar homing, an initial weight of 480kg (1,058lb), including a 47kg (103lb) HE/fragmentation warhead, and a range of 120km (74.5 miles).

Alternative weapons fits are: three R-33 missiles in fuselage bays and two R-40TD (R-40T) missiles on underwing pylons (the fourth R-33 is replaced by an APP-46TD control system pod for the R-40s); four R-33s and two or four R-60 dogfight missiles on underwing pylons.

'Blue 96', an early production MiG-31.
Yefim Gordon

A GSh-6-23 or GSh-6-23M 23mm six-barrelled Gatling-type gun with linkless feed is mounted in a fairing above the starboard mainwheel well. The gun has a rate of fire of 8,000rpm and a capacity of 260 rounds. The weight of fire is 200g, muzzle velocity is 700m/sec. When the gun is not in use the muzzle is closed by a door to reduce drag.

Avionics and Equipment

The MiG-31 has both radar and IR targeting capability which enables it to fire four R-33 missiles at four separate targets in a single attack. The system includes an RP-31 (SBI-16) 'Zaslon' phased-array radar with a normal target detection range of 180km (111 miles) and a target tracking range of 120km (74.5 miles), an 8TP infra-red search & track (IRST) unit and a tactical situation display.

Aerial targets can be detected at a range of more than 300km (186 miles). The radar can track large targets (bombers) at up to 200/120km (124-74.5 miles) in the front/rear hemisphere and small targets with an RCS of about 2m^2 (21.5ft^2) at up to 90/70km (56/43 miles) respectively. It has a horizontal coverage of 140° (or 240° in some modes) and a vertical coverage of +70°/-60°. Hence, the SBI-16 confers a look-down/shoot-down capability, including targets incorporating stealth technology, helicopters and cruise-missiles. It can track ten targets simultaneously while guiding R-33 missiles at four of them. Threat priority allocation is done by the 'Argon-K' computer. The radar can also track a crossing target within ±70°. The radar antenna has a diameter of 1.1m (3ft 7in) and is fixed.

The STP IRST pack is installed in a retractable pod under the forward fuselage, swinging out only when in use. It is linked with the radar and enables the aircraft to make covert attacks (ie without revealing its position by using radar), providing target information for the R-40TD and R-60M missiles. It also enhances the aircraft's capabilities in an environment laden with ECM. The IRST unit's field of view is 120° horizontally and +6° to-13° vertically.

The avionics suite includes the BAN-75 command link equipment, the SAU-155M automatic flight control system, the APD-518 secure data link system, the RK-RLDN secure digital data link, the 'Argon-K' computer, the R-862 UHF radio, the R-864 HF radio, the RIU register/indication device, the P-591 audio (speech) warning device indicating dangerous flight modes and critical failures, the SPO-1 SSL radar homing and warning system (RHAWS), the SRO-2P IFF transmitter and SRZ-2P IFF receiver, the SO-69 ATC receiver, the Tester-UZU flight data recorder, the ARK-19 automatic radio compass, the SPU-9 intercom, the MS-61 cockpit voice recorder, the RV-15 radio altimeter and RPM-76 marker beacon receiver.

The APD-518 digital secure data link enables a flight of four aircraft to swap data generated by their radars if the aircraft are within 200km (124 miles) of each other. It also enables other aircraft with less sophisticated avionics, such as the MiG-25, to be directed to targets spotted by the MiG-31. The RK-RLDN digital command line is for communication with ground command centres.

A large circular tactical situation display and two rectangular multi-function displays (cathode-ray tubes) are installed in the WSO's cockpit. The pilot's cockpit has a PPI-70V colour head-up display (HUD).

The MiG-31 is equipped with an NK-25 navigation suite comprising a duplicated IS-1-72A INS built around the 'Manyovr' (Manoeuvre) digital processor, an A-312 'Radikal-NP' or a A-331 SHORAN set, also an A-723 'Kvitok-2' (Receipt) LORAN set, a Tropik' LORAN set with an error margin of 0.13-1.3km (0.08-0.8 miles) over a 2,000km (1,242 mile) stage, and a 'Marshroot' (Route) LORAN set with an error margin of 1.8-3.6km (1.1-2.2 mile) over a 2,000-10,000km (1,242-6,213 mile) stage. The navigation suite enables the MiG-31 to operate in the Arctic theatre of operations.

Wing pylon-mounted R-40TD ДАМ on the 'demonstrator' 'White 374'. Yefim Gordon

Poor quality photograph, but a rare view of a MiG-31 with drop tanks. Victor Drushlyakov

MiG-31 with Flight Refuelling (IzdelyeOIDZ)

The MiG-31 was receiving constant upgrades and improvements. Early operational experience with the type, especially up north, showed that the MiG-31 suffered from insufficient range. MiG-31 :s based at Monchegorsk near Murmansk hac to escort maritime reconnaissance and anti-submarine aircraft on missions ranging up to 1,000km (621 miles) but this range was clearly inadequate. Indeed, during the test stage Air Marshal Yevgeniy Savitskiy, Chairman of the state acceptance committee, had aired the idea of possibly extending the MiG-31 's 'kill' range to the US borders!

To cure the range problem a version fitted with a probe-and-drogue refuelling system was developed. The retractable probe offset to port was located in front of the windshield. The probe was extensively tested on converted MiG-25s described in Chapter Three; both port side and starboard locations were tried.

The first MiG-31 to be fitted with a refuelling probe was f/n 1603. The probe was in fact a 'dummy', being non-operational - it could be extended and retracted but was not connected to the fuel tanks. The aircraft was used to practise making contact with the tanker. The designers had to decide whether a micro-control system like the one on the MiG-25 refuelling system test-beds was needed. It turned out that it was not, since the turbofans' controls allowed the aircraft to manoeuvre into position and make contact with the drogue quite easily. Yet the system was installed anyway to make pilots more comfortable and increase safety during refuelling manoeuvres.

The next aircraft to feature a refuelling probe was a production MiG-31 (f/n 3608). In this case the probe was fully operational although the aircraft lacked some equipment items enabling the crew to monitor the automatic fuel transfer.

The first fully-equipped aircraft with a new fuel metering system was 'Blue 592' (f/n 5902). The aircraft was also fitted with a LORAN system. This and other aircraft were tested by Mikoyan OKB and Nil WS test pilots at Akhtubinsk, the former absorbing the greater part of the workload. Toktar Aubakirov flew long missions up north, testing the navigation system for sensitivity to magnetic anomalies. Roman Taskayev flew over the North Pole during one of the sorties, landing at Anadyr air base on the Chukotka peninsula. On the return trip the same crew flew non-stop to Moscow along the entire northern coastline, staying in the air for nearly nine hours. Test pilots Taskayev and Aubakirov and test navigator Leonid Popov made several non-stop flights from Monchegorsk to Anadyr via the North Pole, covering over 8,500km (5,280 miles) in autonomous navigation mode and refuelling twice along the way: Flight time was 8 hours 40 minutes; the missions included two simulated intercepts, including one over the North Pole. No malfunctions were encountered.

It is well known that even with flight refuelling an aircraft cannot stay up indefinitely because of crew fatigue etc. Despite this, in training sorties the MiG-31 could very effectively intercept targets at a range of 2,200km (1,367 miles) from the home base.

MiG-31 main landing gear. Yefim Gordon

The probe-equipped version of the MiG-31 was known as Izdelye 01DZ (DZ - Dozaprvka, refuelling). It entered production in 1990 and stayed in production for a year until superseded by the MiG-31 B. The production run was only 45 aircraft or so. Except for the flight refuelling system, Izdelye 01 DZ was identical to early production MiG-31 s.

MiG-31 ('White 374', f/n 3704?) with refuelling probe piloted by Mikoyan CTP Valeriy Menitskiy participated in static and flying displays at Le Bourget, Farnborough, ILA (Berlin) and MosAero Show/MAKS international airshows, wearing a distinctive blue/grey colour scheme.

MiG-31 B Interceptor (Izdelye 01 B)

Besides extending the MiG-31's range, the Mikoyan OKB and associated 'companies' were working on upgrading the weapons system. Two basic areas could be traced; the first was the MiG-31 M carrying an all-new weapons system. However, this called for lengthy testing and the verification date was far from clear, to say nothing of production. Thus, a mid-life update (MLU) for the basic MiG-31 was devised in parallel.

The update programme was largely precipitated by a big security leak. In 1985, one A Tolkachov, a hired agent of a Western intelligence agency, was arrested by the KGB in Moscow. Investigation showed that he had supplied the west with valuable data about the MiG-31's weapons and avionics. Tolkachov was tried and found guilty, but the damage was already done; in fact, his actions were even more acrimonious than the notorious Belenko defection. This forced the designers to speed up the introduction of a new weapons system on the MiG-31.

The result was the MiG-31 B (Izdelye 01 B) with an improved radar (with better ECM protection) and upgraded R-33S missiles. The weapons load remained the same, but the improved avionics (especially the digital processor) and missiles enhanced the aircraft's capability roughly by 30%. The updated aircraft entered production in late 1990.

MiG-31 BS (Izdelye 01 BS)

As the MiG-31 B started rolling off the production line in Gorkii, early production MiG-31 s (Izdelye 01) were progressively updated to the new standard at the plant; this included retrofitting a refuelling probe. The converted aircraft were known as MiG-31 BS (Izdelye 01 BS - Stroyevoy, operational).

Development MiG-31

Like their colleagues at the Mikoyan OKB, the designers at the Gorkii factory tried to improve the interceptor. The structure of the factory's design bureau did not allow for the creation of a 'blank sheet of paper' aircraft, so the designers chose to modify an existing one. At the suggestion of the plan's designer-in-chief, Mindrov, MiG-31 'Blue 503' was built with major structural modifications to the fuselage and changes to some systems and avionics. The fuel system was one of them - the bulkheads separating fuselage tanks Nos.1 and 2 and tanks Nos.5 and 6 were deleted.

However, the OKB decided that the modifications gave no advantages. In fact, flight tests showed that performance and handling was worse - eg the aircraft's eg had shifted, causing stability problems. Yet the aircraft was not entirely a dead duck - it was later converted to a test-bed underthe MiG-31 M programme.

MiG-31 M Interceptor (Izdelye 05)

A much-modified version of the MiG-31 emerged in 1985. The aircraft was intended for long range interception using air-to-air missiles and for directing a group of earlier-model interceptors to targets.

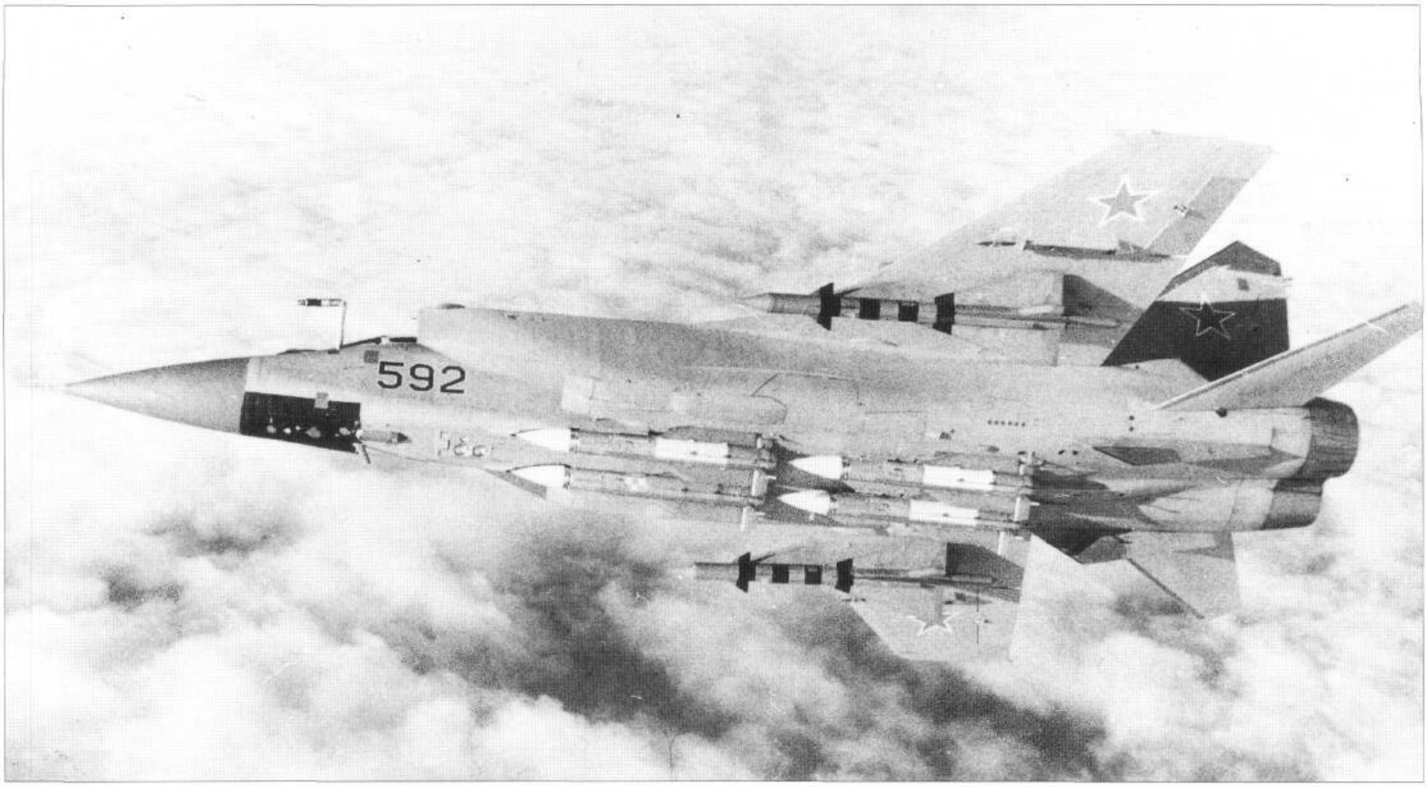
The MiG-31 M had a new weapons system featuring a more powerful 'Zaslon-M' radar and six ultra-long range R-37 AAMs with a range of up to 300km (186 miles). The capabilities of the new radar were half as much again or even twice as good as those of the original 'Zaslon'.

The R-37 missile developed by the 'Vympel' (Pennant) scientific and production association had not only much better performance that the R-33 carried by production MiG-31 s but a totally different guidance system, making use of the missile's dynamic instability to increase manoeuvrability. An active radar homing system was used on the final stage of the trajectory. As before, the missiles were semi-recessed in the fuselage underside but in three rows of two missiles (instead of two). As a maximum load option, four R-77 (RVV-AE) AAMs rated for 12g manoeuvres and with a range of 100km (62 miles) could be carried on four underwing pylons. Since the aircraft was not designed for dogfighting, the gun was deleted. The 'M had a new optico-electronic system comprising IRST and a laser range finder.

The new weapons system called for major structural changes. The 'Zaslon-M' radar had a larger antenna diameter, necessitating a bigger radome. To give the pilot an adequate field of view, bigger radar notwithstanding, the nose ahead of the cockpits was canted down 7°.

Both canopies were modified. The forward cockpit received a one-piece curved windscreen to improve visibility. The WSO was in claustrophobic conditions. Since the MiG-31 M (unlike the earlier versions) did not have a second set of flying controls in the aft cockpit, the WSO's canopy windows were made smaller and recontoured and the periscope was deleted. The fuselage spine aft of the cockpits was made much deeper all along.

Since the aircraft's MTOW had risen, uprated D-30F-6M engines were installed. The LERXs were enlarged and had a curved leading edge



'Blue 592' was the first fully equipped IFR-capable MiG-31. Yefim Gordon archive

instead of a straight one. Large cigar-shaped electronic support measures (ESM) pods fitted with small triangular stabilising fins at the aft end could be installed at the wingtips. The fins and fin fillets were also reshaped.

Various systems modifications were made; eg the refuelling probe was moved to starboard. Most of the systems changes, however, concerned avionics; the WSO's cockpit had four rectangular multi-function displays.

The PVO top command displayed a keen interest in the aircraft, as the stated performance figures were very impressive indeed, surpassing everything then in service with the PVO. The aircraft could track and destroy more targets in a single sortie than a 'regular' MiG-31 or MiG-31 B and 'BS or control a flight of early model MiG-31 s.

Thus, a test batch of MiG-31 Ms was commissioned at the Gorkii plant. The first was a static test airframe (Izdelye 05 - Stateecheskoye, f/n 050101). The first prototype was the second airframe, 'Blue 052', and subsequently crashed during a test flight. When the second prototype (ie the third airframe, 'Blue 053') was completed it turned out that an extra 'Zaslon-M' radar had been manufactured, with no airframe to which to fit it. All flight test MiG-31 Ms left the plant fully equipped, but the 'eyes without a face' situation was quickly remedied by converting the one-off MiG-31 'Blue 503', which the factory 0KB had unsuccessfully modified at its own risk.

A complete MiG-31 M forward fuselage was built at the Mikoyan experimental plant in Moscow, delivered to Gorkii and mated to the fuselage of 'Blue 503', with some associated modifications (eg to the fuselage spine). The result was a cross between a MiG-31 M and a 'regular' MiG-31, but many equipment items were not common to either version. The aircraft retained the old 'straight' LERXs, while the fin fillets were virtually non-existent. The aircraft, which had effectively become a systems testbed, was then re-coded 'Blue 051'(!).

The first prototype, 'Blue 052', made its first flight on 21st December 1985, flown by test pilot B H Orlov and WSO (test navigator) L S Popov. The other prototypes - 'Blue 053', 'Blue 054', 'Blue 055', 'Blue 056' and 'Blue 057' - were flown to Akhtubinsk for testing one-by-one as they were completed. The aircraft had minor differences; eg, 'Blue 053' and 'Blue 056' had ordinary wingtips whilst 'Blue 057' was fitted with finned ESM wingtip pods.

All in all, seven flight test aircraft were built (including the hybrid 'Blue 051'). As noted, MiG-31 M 'Blue 052' was lost during tests, another ('Blue 051') was subsequently scrapped for sapres at Zhukovsky. The static test article (Izdelye 05) was tested to destruction.

In March 1992 the latest indigenous combat aircraft were shown to the military leaders and top statesmen of Russia and some other CIS republics at Machulischi air base near Minsk. The static line-up included the final MiG-31 M prototype, 'Blue 057'. In August 1995, the same aircraft made its very brief public debut at the MAKS-95 airshow in Zhukovsky.

A short while earlier, in April 1994, the Russian President Boris N Yeltsin sent a telegram to the Mikoyan OKB and other organisations involved in the MiG-31 M programme, extending his congratulations on a successful test. The test in question was really something special, being the world's first instance when an interceptor had destroyed a target flying more than 300km (186 miles) away. The aircraft was a MiG-31 M and the missile an R-37.

Work on the MiG-31 M is currently continuing and the aircraft has actually entered production; however, none have been ordered by the Russian Air Force due to funding problems. If the MiG-31 M becomes operational it will give the PVO the ability to cope with modern high-technology threats, including 'stealth' aircraft. Having several times the potential of earlier types, a handful of these aircraft will provide adequate protection of Russian airspace.

MiG-31 D Development (Izdelye 07)

In 1987 the Mikoyan OKB built two prototypes of an experimental version designated MiG-31 D, or Izdelye 07. Predictably, the first prototype was 'Blue 071' and the second 'Blue 072'.

The entire standard weapons system was deleted and the recesses for the R-33 missiles faired over, as the aircraft was to carry one large specialised missile.

The aircraft had enlarged curved LERXs a /a MiG-31 M and sported large triangular endplate fins at the wingtips like the MiG-25P prototypes. These were called 'flippers' and designed to increase directional stability when carrying the large missile externally.

MiG-31 D 'Blue 072' was tested by Mikoyan pilots, operating out of Zhukovsky. The trials programme lasted several years but was suspended in the early 1990s without the new missile being operationally deployed.

Production MiG-31 B showing the stowed refuelling probe. Yefim Gordon archive

MiG-31 M 'Blue 057' makes the type's 'unofficial' debut at Machulshi air base, March 1992. Yefim Gordon archive

MiG-31 E Export Version

An export version of the MiG-31 B was developed under the designation MiG-31 E. It is fitted with a suitably downgraded 'Zaslon' radar and carries four simplified R-33 missiles and two to four short-range AAMs on underwing pylons. The avionics are altered, too, especially the ECM equipment.

The MiG-31 E can be used to guide fighters (eg MiG-21, MiG-23, or MiG-29) to their targets. Thus, a handful of MiG-31 Es can dramatically enhance the air defence capabilities of a nation operating other Soviet fighters.

A MiG-31 E prototype ('White 903') is currently on test with the State Flight Test Centre named after Valeriy P Chkalov in Akhtubinsk.

MiG-31 Ejection Seat Test-bed

A production MiG-31 ('Red 79') was converted into an ejection seat test-bed firing the experimental seats from the aft cockpit. Outwardly the aircraft differed from standard MiG-31 s only in having cigar-shaped wingtip pods reminiscent of the ECM pods of the MiG-31 M, albeit without fins; these housed cine cameras capturing the ejection sequence.

Other recognition features were black calibration markings on the air intakes and 'nose-art' in the shape of a bald lion's head. (A possible clue to the latter is that, in Russian, 'bald lion' is Lysyy Lev which abbreviates as LL - commonly used as an abbreviation for Letayuschchaya Laboratoriya - research aircraft, flying laboratory or test-bed!)

The aircraft is employed mainly by the Akhtubinsk test centre. It was part of the static display at the MosAeroShow-92 at Zhukovsky in August 1992. In September 1995 'Red 79' made a demonstration flight at Akhtubinsk, including a dramatic live seat firing on take-off as part of the celebrations to mark the Nil VVS's 75th anniversary.

MiG-31 Practical Fighter-Bomber

In 1995 the Mikoyan OKB unveiled yet another version of the MiG-31 at the 41st Paris Air Show - the MiG-31 F (Frontovoy - 'front-line', ie tactical) multi-role tactical aircraft featuring updated weapons and avionics. The aircraft will be capable of using most types of air-to-ground missiles now used by the Russian Air Force.

The MiG-31 F can operate as a 'Wild Weasel' defence suppression aircraft, destroying enemy radars with Kh-31 P and Kh-25MP ARMs; it can carry out anti-shipping strikes with active

Hybrid MiG-31 **'Blue 051' languishing at Zhukovsky.** Yefim Gordon

'Blue 072', the second MiG-31 D, displaying the wingtip 'flippers'. Yefim Gordon archive

radar-guided Kh-31A missiles. Other AGMs can be used - eg two Kh-59Ms or three guided Kh-59s (both TV-guided) or three more lightweight missiles (Kh-29L or Kh-29T). Alternatively the aircraft can carry guided bombs: three 1,500kg (3,300lb) KAB-1500L (laser-guided) or KAB-1500TK (TV-guided) bombs or light 500kg (1,100lb) KAB-500KR bombs. To this end the aircraft is fitted with a TV or laser designator pod. The maximum bomb load is 9,000kg (19,800lb) in the form of six FAB-1500s.

For air-to-air combat the MiG-31 F retains the 'Zaslon' radar and the ability to carry R-37, R-77 and R-73 AAMs. A mixed weapons fit is also possible (eg four Kh-31 anti-shipping missiles off fuselage stations and four R-77 AAMs on wing pylons).

Structurally the MiG-31 F is virtually identical to the pure interceptor version, and the powerplant is also the same. MTOW, however, is increased to 50 tons; range in subsonic cruise is 2,500km, rising to 3,000km (1,553 to 1,864 miles) with drop tanks; supersonic range is 1,200km (745 miles). In speed the MiG-31 F is comparable to the 'pure interceptor': top speed at high altitude will be 3,000km/h, cruising speed 2,500km/h (1,864 and 1,553mph).

The export version of the planned MiG-31 F - the MiG-31 E - will have provisions for Western avionics and armament which will be integrated with Russian components.

The 'Dog' in Service

The West got wind of the MiG-25MP's existence in 1976 when Lt VI Belenko divulged that a two-seater version of the M1G-25P was under development. The new interceptor was allocated the NATO code name 'Foxhound' reflecting its 'Foxbat' ancestry.

When the trials programme ended in late 1980, the first production MiG-31 s had been delivered to PVO units and the type had achieved initial operating capability. By then the air defence situation in some areas of the USSR was causing alarm. Lockheed SR-71A reconnaissance aircraft had been bugging Soviet defences for a long time, systematically intruding in the Far East (especially the Kamchatka peninsula) and in the north, intruding into Soviet airspace as far as Arkhangelsk. Incursions by USAF recce aircraft based at Kadena in Japan, and carrier-based aircraft were becoming increasingly more frequent. The MiG-23P 'Flogger' and Su-15TM 'Flagon' interceptors making up the backbone of the PVO in the Far East were no match for the latest USAF hardware (McDonnell Douglas F-15C, Grumman F-14A/D and McDonnell Douglas F/A-18), to say nothing of the SR-71.

This prompted the PVO top command to dispatch four MiG-31 s with highly skilled crews to the Far East. The group actually arrived at Sokol air base on Sakhalin barely a week after the notorious incident on 1st September 1983, when a Korean Air Lines Boeing 747-230B on flight KAL007 out of Anchorage strayed into Soviet airspace and was shot down into the sea. The appearance of the MiG-31 s caused the USAF to curtail not only over flights of Soviet territory but flights over international waters near Soviet borders.

It was much the same in the far north. The MiG-31 s based at Monchegorsk would scramble almost every day to ward off nosey 'guests'. Gradually, however, these 'red alerts' grew less and less frequent.

The MiG-31 had its international debut at the 39th Paris Air Show (13th/23rd July 1991). A production aircraft fitted with a dummy refuelling probe and painted in a special 'publicity' colour scheme took part in the static and flying display. Visitors to the airshow were allowed to see the aircraft's radar and weaponry. The display flights were performed by test pilot Valeriy Menitskiy and WSO Yuriy Yermakov. From then on the 'Foxhound' was a regular guest at airshows in Canada, the United Arab Emirates, Germany, etc. The MiG-31 is regarded as the best interceptor in its class, being way ahead of the competition as to take-off weight, weapons and top speed.

Currently, the MiG-31 B and 'BS is the main version in service with the PVO; in fact, the type makes up a majority in their fighter inventory. By mid-1995 the Nizhniy Novgorod (previously Gorkii) aircraft factory 'Sokol' (Falcon) had produced about 500 MiG-31 s without refuelling system (Izdelye 01), MiG-31 s with said system (Izdelye 01DZ) and MiG-31 Bs (Izdelye 01B); at least 320 remain in service with the PVO.

MiG-31 (Izdelye 01/01DZ) - Leading Data

Length, incl nose probe	22.668m	74ft Sin
Wing span	13.456m*	44ft 2½in
Height	5.15m	16ft 10½in
Wing area, including centre section		
- minus LERXs	61.6m^2	663ft^2
- minus centre section	41.0m^2	441ft^2
Fuel - full, with drop tanks	23,500 litres	5,169 Imp gal
- full, no drop tanks	18,500 litres	4,069 Imp gal
-normal	13,700 litres	3,01 Simp gal
- in drop tanks, two x	2,500 litres	1,099 Imp gal
Thrust-to-weight ratio §	0.76	
Specific wing loading §	666kg/m^2	136lb/ft^2
Maximum speed		
-above 17,000m	3,000km/h	1,864mph
- at sea level	1,500km/h	932mph
Cruising speed -supersonic	2,500km/h	1,553mph
- subsonic	900km/h	559mph
Landing speed		
- at 26,600kg (58,641 lb)	280-285km/h	173-177mph
Maximum Mach number	2.83	
Service ceiling - with four R-33 and 2,300kg		
(5,070lb)offuel	20,600m	67,585ft
Max range - with four R-33		
- at VCR = Mach 2.35	1,400km	869 miles
- without drop tanks	2,150 to 2,400km	
	1,335 to 1,491 miles	
- with drop tanks	2,850 to 3,000km	
	1,770 to 1,864 miles	
Ferry range	3,300km	2,050 miles
Intercept range - supersonic	720km	447 miles
- subsonic, no drop tanks	1,200km	745 miles
- with drop tanks	1,400km	870 miles
- with drop tanks and		
one refuelling	2,000km	1,242 miles
Endurance - unrefuelled	2.6 hours	
- with refuelling	6 to 7 hours	
'g' limits with less than 6,000kg		
(13,227lb)offuel	5g	
Take-off run		
- at 37,100kg (81,790lb) take-off weight		
	950m	3,116ft
Landing run		
-at 26,600kg (58,641 lb)and with		
brake 'chutes deployed	800-900m	2,624-2,952ft

* Different manuals state different figures - 13.464m.
§ At normal Take-off weight.

The main units operating the type are the 153rd IAP (Istrebeetel'nyy Aviapolk - fighter regiment) at Morshansk, the 786th IAP at Pravdinsk, the 180th IAP at Gromovo, the 174th IAP at Monchegorsk, the 72nd IAP at Amderma and the 518th IAP at Talagi. MiG-31 crews are trained in the PVO Fighter Weapons Centre at Savostleyka.

In late May 1992 Russia and China struck a deal envisaging the delivery of 24 probe-equipped MiG-31s to China's People's Liberation Army Air Force (PLAAF). The first five were to be delivered by June 1992. Licence production by SAIC (Shenyang Aircraft Industry Company) was also considered; the first licence-built 'Foxhound' was to have been rolled out in late 1994, with production continuing into the year 2000 at a rate of four per month. However, the whole deal appears to have been put on hold with the Chinese courting other Russian types instead.

The MiG-31 represents a highly capable aircraft which has provided Russian air defence with a considerable improvement in terms of performance, range, combat capability and via its ABNCP capability, unparalleled flexibility and independence. During early 1997 there were reports in the Western aviation press that ever-tightening defence budgets within Russia might force the disbandment of the PVO as an autonymous defence force. Should the PVO be merged into the command structure of the VVS, there could well be severe repercussions on the future of the MiG-31 fleet.

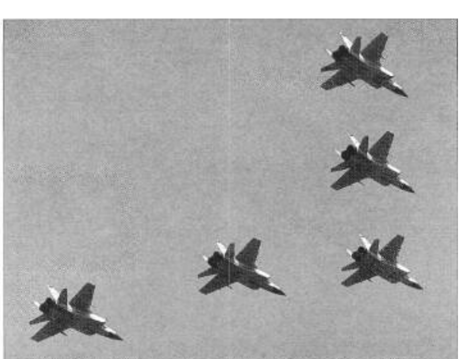
Shortened flying hours had also brought about a distrubing number of accidents (with a MiG-31 of the 6th Air Defence Army crashing on 15th January 1997 killing both the pilot and the WSO) most of which seemed to be caused by lack of currency.

Thus the decline in the very circumstances that brought about the MiG-25 and the MiG-31 looks set to terminate the 'Foxhound' as a production programme long before it deserves. The world situation could also bring about the demise of the air arm - the PVO - that requested and helped to formulate these superb weapons systems in the first place.

Wingtip pod details on test-bed 'Red 79'. Yefim Gordon

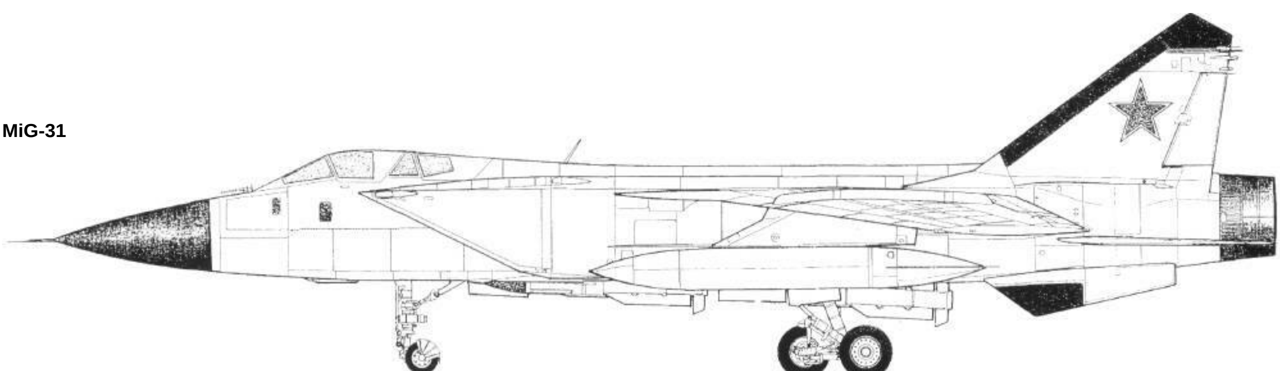
Semi-recessed R-37 missiles under the belly of MiG-31M. Yefim Gordon

Five MiG-31Bs in formation, part of the military in Moscow, May 1995. Yefim Gordon

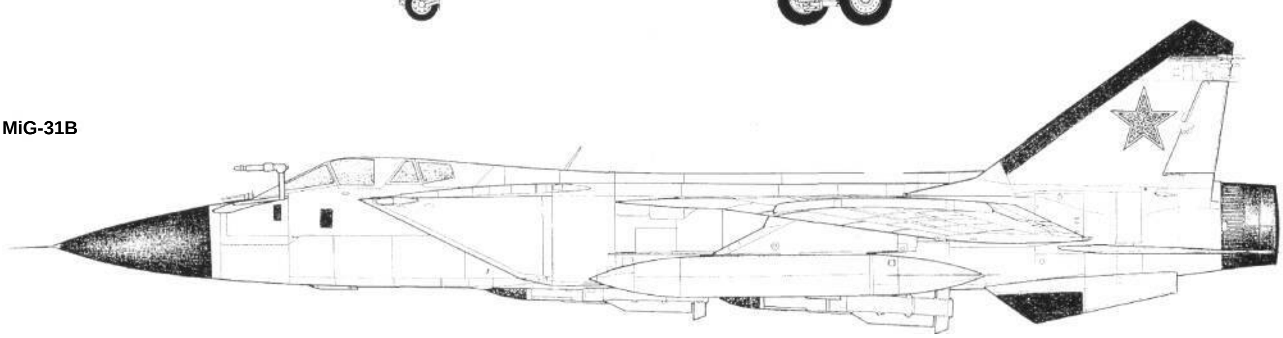


Operational MiG-31 '24' caught over the Baltic. Yefim Gordon archive

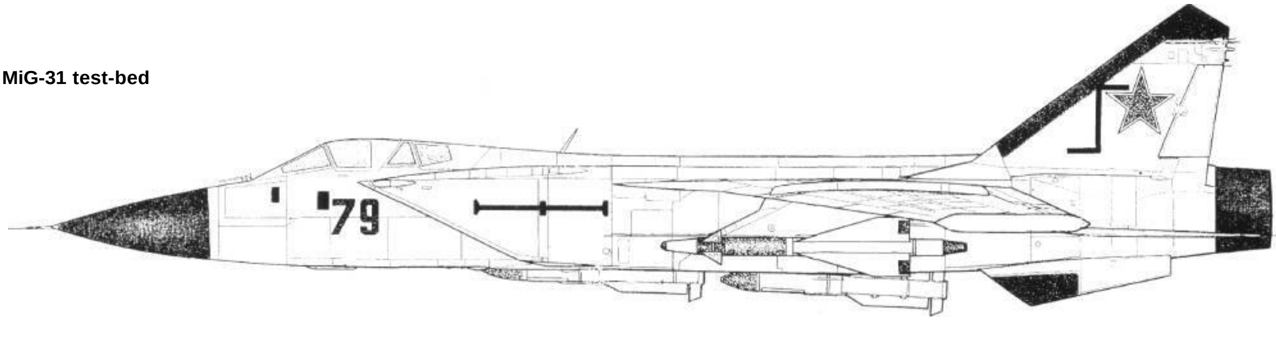
MiG-31



MiG-31B



MiG-31 test-bed



Drawings by Oleg Put'makov

Top: Early MiG-31 testing underway at the Gorki! plant. Victor Drushlyakov

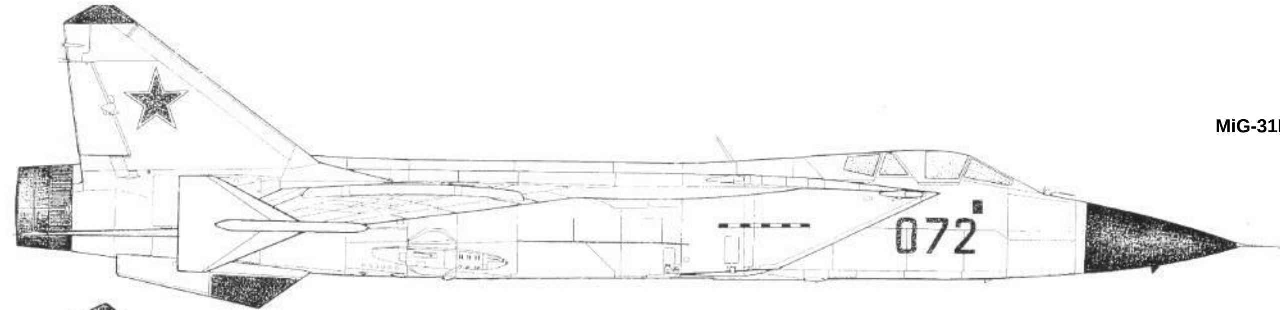
Left: **View of the Ye-155MP 'Blue 831'.** Yefim Gordon archive

Bottom: **Formal pose in classic Russian style of 'Blue 831'.** Yefim Gordon Archive

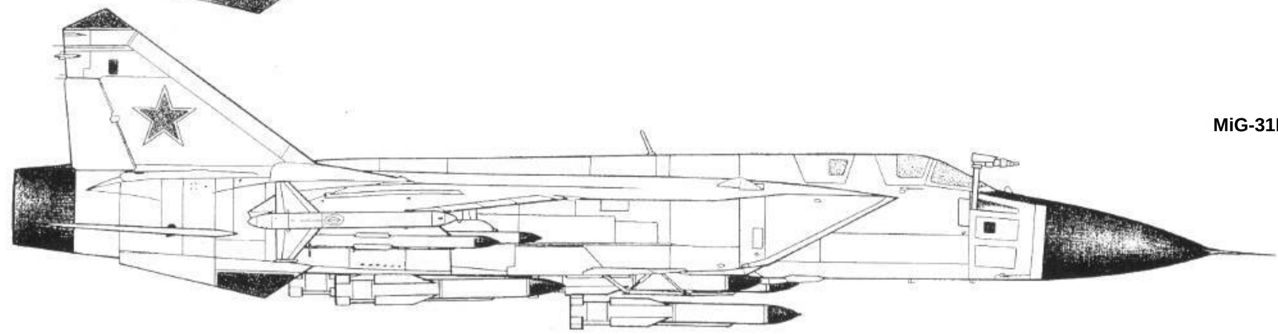
Top: **With calibration markings on the nose, 'Blue 202', from the second batch of MiG-31 development aircraft.** MiG OKB

Above: **'Blue 232' part of the development fleet** Yefim Gordon archive

Bottom: **A familiar performer at** airshows, **the IFR-probe equipped MiG-31 'White 374'.** Yefim Gordon



MiG-31D

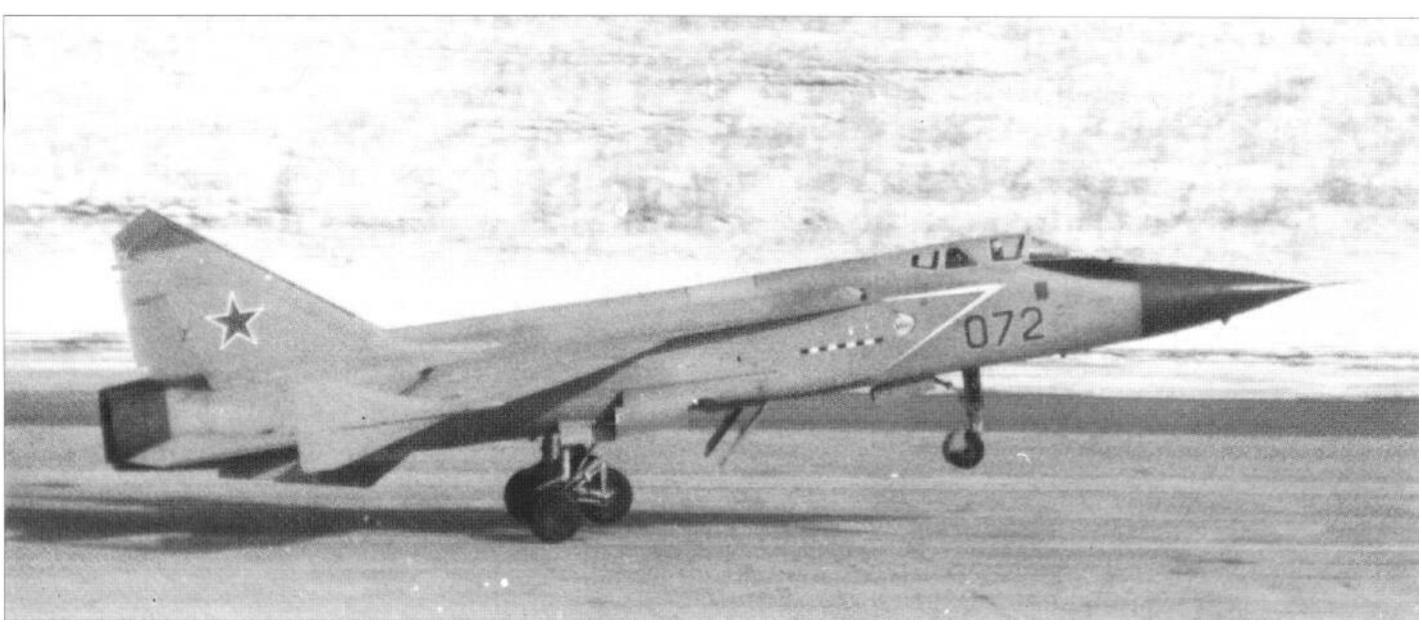


MiG-31M

Above: **Take-off view of the second prototype MiG-31D, under test at Zhukovsky.** Yefim Gordon

Left: **The seventh MiG-31M, 'Blue 057', at Zhukovsky in 1995.** Yefim Gordon

Below: **Take-off view of the second prototype** MiG-310. **under test at Zhukovsky.** Yefim Gordon



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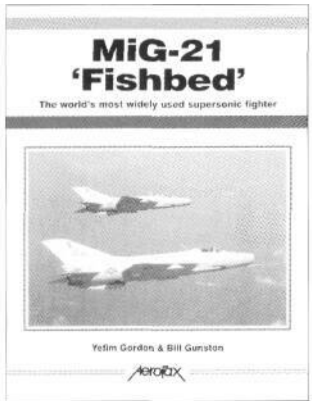
Most widely used Supersonic Fighter

Yefim Gordon and Bill Gunston



The ubiquitous MiG-21 is unquestionably one of the greatest fighters of the post-Second World War era. It was Russia's first operational Mach 2-capable interceptor, and a stepping stone for many nations to enter the age of supersonic air combat. Access to the files of the MiG design bureau and other previously inaccessible sources reveal the secrets of the fighter that has flown and fought in more countries than any other supersonic jet.

Softback, 280 x 216 mm, 144 pages
335 b/w and 46 col illusts, plus colour artwork and scale plans.
1 857800427 **£16.95/827.95**

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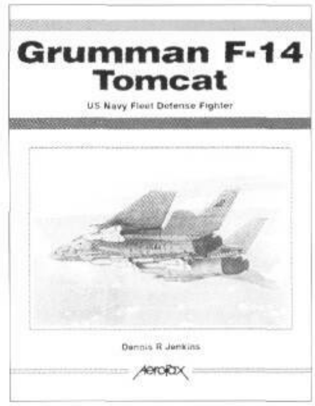
GRUMMAN **F-14 TOMCAT**
Leading US Navy Fleet Fighter

Dennis R Jenkins



Entering US Navy service in 1972, the Tomcat is still one of the classic jet fighters of all time. It remains a formidable weapon system and is still in widespread frontline use with America's carrier air wings. This work describes all variants, including the so-called 'Bombcat' attack version and the very capable F-14D. Colour schemes, aircraft production details, squadrons and markings, are all covered, also close-up details of cockpits and weaponry.
Due *for publication 1997 (3rd qtr)*

Softback, 280 x 216 mm, 88 pages
151 b/w, 39 colour, 22 line illustrations
1 85780 063 X **£12.95/US $21.95**

Aerofax
TUPOLEV Tu-95/Tu-142 'BEAR'

Yefim Gordon and Vladimir Rigmant

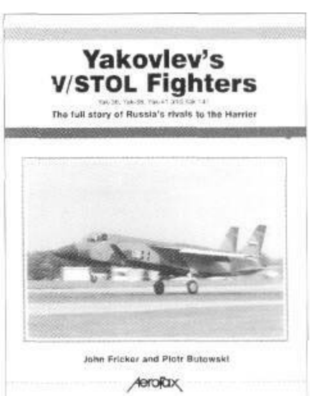
During the 'Cold War' Tupolev's Tu-95 'Bear' strategic bomber provided an awesome spectacle. It was the mainstay of the USSR's strike force, a reliable and adaptable weapons platform. Additional roles included electronic/photographic reconnaissance and maritime patrol, AEW and command and control.

The authors have had unparalleled access to the Tupolev archives, taking the lid off a story previously full of speculation.
Due *for publication 1997 (3rd qtr)*

Softback, 280 x 216 mm, 128 pages
c220 b/w and colour photos, diagrams
1 85780 046 X **£14.95/ US $24.95**

Aerofax
YAKOVLEV'S V/STOL FIGHTERS

John Fricker and Piotr Butowski



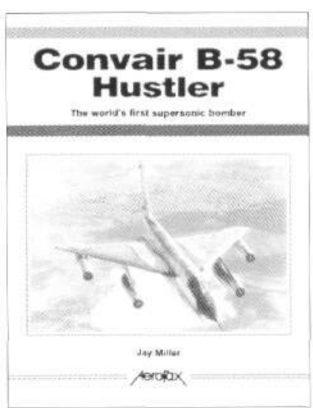
The story of Russia's programme to achieve a supersonic VTOL jet fighter has now been told, beginning with the earliest experiments through to the astonishing 'Freehand' and on to the agreement between Yakovlev and Lockheed Martin to help the development of JAST, the USA's next generation tactical fighter.

Using material never before seen in the West, this book tells the story of a programme that has to an extent, until recently, been shrouded in secrecy.

Softback, 280 x 216 mm, 44 pages
90 b/w photos, diagrams etc
1 85780041 9 **£7.95/ US$12.95**

Aerofax
CONVAIR B-58 HUSTLER
The World's First Supersonic Bomber

Jay Miller



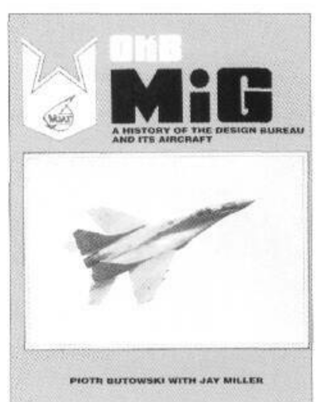
Instantly recognisable with its delta wing and 'coke bottle' area-ruled fuselage the B-58 was put into production for the US Air Force in the 1950s.

First published in 1985, this revised edition, which takes a retrospective in-depth look at this significant aircraft, from design studies, through development and comparatively short service life to, and beyond retirement, includes yet more amazing material, and 80 new illustrations.
Due for publication 1997 (3rd qtr)

Softback, 280 x 216 mm, 152 pages
415 b/w, 17 colour, 100 line illusts.
1 857800583 **£16.95 / US $27.95**

0KB MiG
A history of the design bureau and its aircraft

Piotr Butowski, Jay Miller



Beginning with a comprehensive overview of Soviet military aviation, the text methodically moves from the births of Mikoyan and Gurevich through to the founding of the MiG design bureau during 1939, its war years, and the period of greatest importance, beginning with the advent of the MiG-15 and the Korean War and continuing via the MiG-17, -19, -21,-23, -25 and-27 to the MiG-29 and MiG-31 era. A highly acclaimed work that also includes details of many little known prototypes.

Hardback, 280 x 216 mm, 248pp
800 photographs, over 100 drawings
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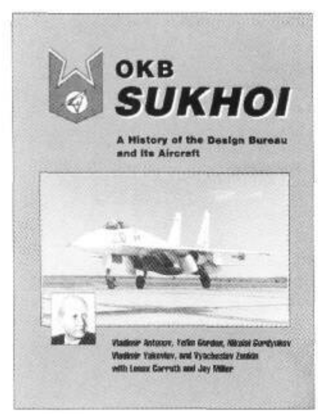
0KB SUKHOI
A history of the design bureau and its aircraft

Vladimir Antonov et al



Another famous Soviet aircraft design bureau is thoroughly documented in this book, which has been prepared with the co-operation of the Sukhoi bureau, and with extensive access to their records and photo files. A massive amount of unpublished information, illustration and drawings is included on this important military aircraft designer. Each aircraft type is reviewed in detail, including prototypes, testbeds and projects. Appendices detail the test pilots and major personalities

Hardback, 280 x 216 mm, 296pp
645 b/w, 23 col, 104 line illusts
1 857800125 **£29.95/ US$49.95**

Index

In order to make the index as easy to use as possible, references to oft-quoted items such as the MiG 0KB, PVO, VVS etc have been omitted. Product (Izdelye) numbers, aircraft equipment and systems designations etc are not indexed. Similarly, references to Ye-155 prototypes, MiG-25s and MiG-31s are not included here as they are widespread throughout.