

## Russia to Highly Discount (Donate) Mig-29's to LAF

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LAF is in desperate need to become the strongest military unit in Lebanon and its quest for heavy weapons was met with open arms by Russia and rebuffed by the USA. This could be a huge strategic mistake for the USA.

Defense Minister Elias Murr on Tuesday from Moscow confirmed Russia agreed to supply the Lebanese Air Force with Mikoyan Gurevich Mig-29 Fulcrums.

According to one Lebanese official the discount is so much that it is considered Aid to the LAF by Russia.

Murr said after his meeting with Russian Defense Minister Anatoly Serdyukov, "Russia has agreed to deliver to Lebanon 10 MiG-29 fighter jets."

For his part, Serdyukov said Russia "had received a list of the requirements of the Lebanese armed forces and is ready to examine them in the near future."

Murr discussed on Monday a detailed list of Military Equipment on the Lebanese Army's wish list with Russia's military cooperation chief, Mikhail Dimitriev.

A statement by his Dimitriev's office said Moscow expressed "full readiness to upgrade the army's defense capabilities."

Earlier this month, Friday December 5th, 2008 the Russian Air Force commander Col.-Gen. Alexander Zelin grounded all Mig-29's in its service. This is because of an accident that killed the pilot and because of other accidents by Mig-29's - one of which was at the same air force base in eastern Siberia.

This grounding is routine when accidents happen in any air force. Although some may argue that the maintenance man hours per flight hour on the Mig-29 are not competitive to Western Fighters, they sure are an improvement the Mig-29 has over the planes it replaced in the Russian Air Force.

The defense ministry said on Friday December 5th that a Mig-29 crashed in eastern Siberia near the Domna airfield in the Chita region at 0612 Moscow time (0312 GMT).

"Air Forces Commander Col.-Gen. Alexander Zelin ordered the suspension of MiG-29 flights until all the circumstances of the accident have been clarified," the statement said.

The pilot of another Mig-29 that crashed at the same location in October of this year ejected before the crash and was reported alive.

The Russian Mig Corporation, which is now part of the RAC - Russian Aircraft Corp - has been in dire need to sell its wares. The introduction of the Mig-29 in Lebanon may advance its sales to non-aligned countries. Currently Lebanon is attempting to get its military wares from all nations that are willing to supply it.

Earlier last year Algeria returned its recently purchased Mig-29's claiming that Russia had provided them with used ones. The newly formed RAC would love to show the world again that Russia delivers high quality, new and competitive aircraft and could use this opportunity with Lebanon for such an example.

Lebanon's weapons come from a variety of sources but mainly and officially from the United States. The problem is that the United States has historically not provided heavy weapons to the Lebanese and this is a point of contention to the western leaning personnel in the Armed Forces who desire Lebanese Army to be the strongest military unit in the country.

The nation has rallied around the LAF in the past and the UN has challenged for the future of the LAF to extend its strength along all its territory; thus the need for heavy weapons has become urgent.

It is not known what backdoor discussions have taken place with the United States. It is known that there are a number of requests made by the LAF for heavy weapons, including Fighter Planes. Fighter planes would help if another Nahar Al Bared terror strike should happen. Reports stated that the USA agreed to provide the LAF with older Cobra helicopters -

something that most analysts agreed would spend more time in the hanger being prepared/repared than in the air. As a matter of fact published open source info stated that the ones considered for Lebanon were grounded and not flyable and in Jordan.

Also, the fighting at Nahar al Bared last summer showed the weakness of the LAF and the Lebanese Air Force's inability to drop iron bombs on the Fatah Al Islam terrorists. Quite innovatively the LAF modified the Bell UH-1 Huey's to be elevated on the ground so as to mount 400-800lbs iron bomb on its belly and then to deliver that to the target - sometimes using handheld GPS devices.

In the past this military denial of weapons has almost always proved to be detrimental to our (USA) long term goals. Brazil met its denial by starting a weapons industry, S. Africa did the same. When President Clinton urged the Chinese to stop selling the Iranians missiles - the Iranians bought the whole factory and is now producing their own advanced versions.

Ironically the USA deeply desires to help Lebanon, unfortunately its repeating what lessons learned should have taught the decision makers years ago.

EFarres with his Military Analysis for CRNews, 12/16/2008.

Russian Aircraft Corp - MIG Website: <http://www.migavia.ru/eng/>

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An older promotional video of the famous russian aircraft Mig 29.  
{youtube}OfUvUqS8Peg{/youtube}

Promo video from Russian Channel One project Mig-29 TV Show  
{youtube}wCFKh2UrFFs{/youtube}

Nice Video about the Mig-29 Fulcrum interceptor, Made in Russia  
{google}-311083788519378497{/google}

Russian TV Channel 2 VESTI evening news aired on Jan 22nd 2007.  
New MiG29K for Indian AF. In the second part video from Bezhetsk AB - MiG31  
{youtube}5rJCKAQFMv8{/youtube}

AirShow of MiG-29K, in MAKS 2005  
{youtube}aG3pj1vwnd4{/youtube}

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Lebanon defense minister to talk arms in Moscow  
11:24 | 15/ 12/ 2008

BEIRUT, December 15 (RIA Novosti) - Lebanon's defense minister will pay an official visit to Moscow on Monday to discuss with his Russian counterpart the purchase of Russian heavy weaponry.

Meeting with a senior Russian defense official in Beirut last week, Elias Murr said "there are no obstacles to equipping the army."

A senior Lebanese Defense Ministry official was also quoted by local media as saying that there would be "no political conditions" attached to arms deals between Lebanon and Russia.

An unidentified Lebanese General Staff official said earlier that Beirut was seeking to buy heavy weaponry from Russia, including tanks, antitank rockets, air defense systems, armored vehicles and helicopters.

The United States has provided military assistance to Lebanon to help the fractured Middle East state fight terrorism and resist the Hezbollah Shiite military group that controls the country's south. However, U.S. support to the Lebanese Armed Forces has so far been limited to light weapons.

Some Pentagon and State Department officials have expressed concern about extensive military aid to a country where Hezbollah, which has close ties to Syria and Iran, continues to play an important role. Israel has also been lobbying against heavy weapons supplies to Lebanon, fearing they might eventually be used against it.

Lebanon was reported to have been in talks on arms supplies with China and Iran.

<http://en.rian.ru/world/20081215/118855565.html>

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Russia to 'donate' 10 MiG-29 jet fighters to Lebanon  
16:59 | 16/ 12/ 2008

MOSCOW, December 16 (RIA Novosti) - Russia will supply Lebanon with 10 MiG-29 Fulcrum fighters, Lebanese Defense Minister Elias Murr said on Tuesday after a meeting with his Russian counterpart, Anatoly Serdyukov.

Serdyukov said Moscow had received a weapons procurement list from the Lebanese armed forces which would be considered in the near future.

He added that the fighter deliveries would provide a fresh impetus to military cooperation between the two countries.

A member of the Lebanese delegation said the aircraft would be provided "as aid."

According to inside sources privy to the deal, the warplanes "will be sold at a hefty discount."

Media reports say the Lebanese Air Force is in a deplorable state with virtually no airworthy planes.

Currently the Air Force is equipped with Bell UH-1 Iroquois combat helicopters, developed back in the 1950s, and Robinson R44 Raven II civilian helicopters, all of which were supplied by the United States.

In 2007, Beirut took delivery of nine SA342L Gazelle helicopters from the United Arab Emirates.

<http://en.rian.ru/russia/20081216/118886270.html>

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Russia grounds MiG-29 fighters after crash 05 Dec 2008 13:37:22 GMT  
Source: Reuters

MOSCOW, Dec 5 (Reuters) - Russia's air force commander grounded all of the country's MiG-29 fighter jets on Friday after one of the aircraft crashed in eastern Siberia, the defence ministry said.

The pilot died when the jet crashed near the Domna airfield in the Chita region at 0612 Moscow time (0312 GMT), the defence ministry said on its [www.mil.ru](http://www.mil.ru) website.

"Air Forces Commander Col.-Gen. Alexander Zelin ordered the suspension of MiG-29 flights until all the circumstances of the accident have been clarified," the statement said.

A MiG-29 fighter crashed near the same airfield in October. The pilot ejected before the crash and survived.

The MiG-29, which is codenamed Fulcrum by NATO, is one of Russia's most advanced military jets. The 4th generation fighter was designed in the Soviet Union for an air superiority role. (Reporting by Dmitry Solovyov; editing by Philippa Fletcher)

<http://www.alertnet.org/thenews/newsdesk/L5545584.htm>

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Minister of Defence

Minister of Defence's personal flag

Anatoly Serdyukov was born on January 8, 1962 in Krasnodar region. Graduated from Leningrad Institute for the Soviet trade (1984). Later, he graduated from Saint-Petersburg State University, Law Faculty.

From 1984 to 1985 he served in the Armed Forces.

From 2000 to 2001 he occupied position of deputy head of the inter-district Inspection of the Taxes Ministry (St.Petersburg large-scale tax-payers).

In May 2001 he was appointed deputy head of St.Petersburg Tax authority, later head of St.Petersburg Tax authority of the Ministry of Taxes.

In March 2004 became deputy head of Russian Federation Tax Ministry.

According to the order of the Head of Government as of 27 July 2004 Anatoly Serdyukov was delegated the duties of head of Federal Tax Service.

Mr. Serdyukov was delegated the power and responsibilities of Minister of Defence according to the President's Decree on February 15, 2007.

Later, in connection with formation of new structure of the Government of the Russian Federation, the President signed a decree on May 12th 2008 appointing Anatoly Serdyukov to the position of Defence Minister of the Russian Federation.

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Key Data:

Crew 1 - pilot; Mig-29 Trainer - Crew 2

Dimensions:Length17.32m

Height4.73m

Wingspan11.36m

Weights:

Normal Take-Off Weight 14,750kg

Maximum Take-Off Weight17,720kg

Maximum Weight Combat Load3,000kg

Maximum Fuel4,300kg

Engines:

Engine2 x turbofan RD-33 engines Thrust8,300kg

Performance:

Maximum Speed Near Ground 1,500km/h

Maximum Speed at Altitude2,400km/h

Service Ceiling: 18,000m

Flight Range:

Near Ground 700km

At Altitude 1,500km

Take-Off Thrust-to-Weight Ratio 1:12

Maximum Operational G-Load 9g

Air Target Detection Range 60km

R-73 Air-to-Air Missile :

Maximum Launch Weight 105kg  
 Warhead 7.3kg, rod type  
 Guidance Cooled infrared  
 Length 2.9m  
 Diameter 0.17m  
 Fin Span 0.51m  
 Maximum Launch Range 20km  
 Minimum Range of Aft  
 Hemisphere Launch 300m  
 Target Acceleration g-Load 12g  
 Kill Probability Against a Fighter Target 0.6  
 Maximum Target Speed 2,500km/h  
 Target Altitude 0.02km to 20km

#### R-27 Medium-Range Missile:

Guidance System R-27R/T Semi-active radar / infrared  
 Maximum Launch Range R-27R/T41km / 32km  
 Launch Weight R-27R/T253kg / 245kg  
 Dimensions (Length x Diameter x Fin Span) R-27R/T4.08m x 0.23m x 0.97m / 3.8m x 0.23m x 0.97m  
 Warhead 39kg, rod type  
 Target g-Load 8g  
 Fighter Aircraft Target Kill Probability 0.7  
 Maximum Target Speed 3,500km/h  
 Target Altitude 0.02km to 27km  
 Maximum Vertical Separation Carrier Aircraft to Target 10km

#### R-60 Short-Range Air-to-Air Missile:

Manufacturer Vympel  
 Maximum Launch Range 10km  
 Guidance System Infrared, with photo detector cooling  
 Warhead 3.5kg, rod type  
 Length 2.09m  
 Diameter 0.12m  
 Fin Span 0.39m  
 Kill Probability Against a Fighter 0.5  
 Target g-Load 12g  
 Maximum Target Speed 2,500km/h  
 Target Altitude 0.03km to 20km

#### Featured Suppliers:

Saft, Industrial Batteries Group - Aircraft Batteries

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The MiG-27K fighter bomber aircraft is manufactured by RSK MiG and the Irkutsk Aircraft Production Association Joint Stock Company. The MiG-29, -30 and -33 are known by the Nato code name Fulcrum. The MiG-29K is the carrier-based version. There are in the region of 600 MiG-29 variants in service with the Russian Air Force.

The fighter is also in service with the air forces of Algeria (30 aircraft), Bangladesh (eight), Belarus (50), Bulgaria (20), Cuba (18), Eritrea (five), Germany (23), Hungary (21), India (70), Iran (35), Kazakhstan (40), Malaysia (16), Myanmar (ten), North Korea (35), Peru (18), Poland (18), Romania (15), Slovakia (23), Syria (50), Sudan (ten), Turkmenistan (20), Ukraine (220), Uzbekistan (30) and Yemen (24).

"The mission of the MiG-29 is to destroy hostile air targets within radar coverage limits."The 22 MiG-29 aircraft in the German Air Force have been leased to the Polish Air Force. The first five were handed over in September 2003 and deliveries concluded in August 2004.

16 new MiG-29Ks have been ordered (12 single-seat and four two-seater MiG-29KUB) by India to equip the INS Vikramaditya (formerly the Admiral Gorshkov) carrier bought from the Russian Navy. The first production MiG-29K made its maiden flight in March 2008 and is scheduled for delivery to the Indian Navy by the end of 2008.

The Indian Navy has plans to purchase a further 30 aircraft for its indigenous aircraft carrier, which is under construction.

In August 2004, the Defence Ministry of Sudan announced that they planned to acquire a further 12 MiG-29 aircraft, converting options under a contract for ten fighters placed in 2002. Deliveries on the original contract concluded in July 2004.

In January 2006, Algeria placed an order for 34 MiG-29 fighters and the upgrade of 30 aircraft in the Algerian fleet. 12 upgraded aircraft were delivered in 2007 but have not been accepted by Algeria, which cancelled the upgrade programme in February 2008.

The mission of the MiG-29 is to destroy hostile air targets within radar coverage limits and also to destroy ground targets using unguided weapons in visual flight conditions. The aircraft's fixed-wing profile with large wing leading-edge root extensions gives good manoeuvrability and control at subsonic speed including manoeuvres at high angles of attack. The maximum operational g-loading is 9g.

A two-seater version, MiG-29M2, took its maiden flight in 2001. A super-maneuvrable variant, MiG-29M OVT, with three-dimensional thrust-vectoring engine nozzles was successfully demonstrated at the Farnborough International Airshow in July 2006. The nozzle has three hydraulic actuators mounted around the engine to deflect the thrust. The aircraft is being offered to potential customers as the MiG-35.

"The Russian Air Force has begun an upgrade programme for 150 of its MiG-29 fighters." Upgrade programmes

The Russian Air Force has begun an upgrade programme for 150 of its MiG-29 fighters, which will be designated MiG-29SMT. The upgrade comprises: increased range and payload, new glass cockpit, digital fly-by-wire control system, new avionics, improved radar, KOLS infrared search and track (IRST) and an in-flight refuelling probe. The radar will be the Phazotron Zhuk-ME which is capable of tracking ten targets to a maximum range of 245km.

12 MiG-29 of the Air Force of Yemen are being upgraded to SMT standard. The first was delivered in October 2004.

EADS (formerly DaimlerChrysler Aerospace) is to upgrade 22 MiG-29 aircraft of the Polish Air Force. Modifications are needed to adapt the aircraft to Nato standards, prior to Poland's entry into Nato. EADS has performed similar modifications to the MiG-29s of the former East German Air Force. EADS has joined with RSK-MiG to offer modernisation packages for the MiG-29 and has signed an agreement with Romania for product support and modernisation.

EADS, Aerostar of Romania and Elbit of Israel have also launched an upgrade, MiG-29 Sniper, which includes modernisation and maintenance of the airframe and engines, and upgrades of the avionics with new Elbit digital mission computer and weapon systems, and installation of a glass cockpit.

In February 2004, RSK MiG signed an agreement to upgrade 12 MiG-29 of the Slovak Air Force. The upgrade included Rockwell Collins navigation and communications systems and BAE Systems IFF (interrogation friend or foe) system. Russian companies supplied the glass cockpit with multi-function LCD displays and digital processors. Deliveries completed in 2007.

In December 2006, India placed a contract with MiG to upgrade 66 of its older MiG-29 aircraft (which entered service 1986&ndash;1996). The upgrade includes new Klimov RD-33 engines, avionics and radars.

## Weapons

The MiG-29 fighter is equipped with seven external weapon hardpoints.

The aircraft can carry: up to two R-27 air-to-air medium-range missiles; six R-73 and R-60 air-to-air short range missiles; four pods of S-5, S-8, S-24 unguided rockets; air bombs weighing up to 3,000kg; and 30mm built-in aircraft gun with 150 rounds of ammunition.

"The MiG-29 has an information and fire control radar system." The R-27 medium-range air-to-air missile is supplied by the Vympel State Engineering Design Bureau, based in Moscow. The R-27 is available in two configurations: the R-27R, which has a semi-active radar homing head and inertial navigation control with a radio link; and the R-27T missile, which is fitted with an infrared homing head.

The missile can intercept targets with a speed of up to 3,500km/h at altitudes from 0.02-27km, and the maximum vertical separation between the aircraft and the target is 10km.

The Vympel R-73 missile is an all-aspect, short-range air-to-air missile known by the Nato codename AA-11 Archer. The missile has cooled infrared homing and can intercept targets at altitudes between 0.02 and 20km, target g-load to 12g, and with target speeds to 2,500km/h.

The Vympel R-60 (Nato codename AA-8 Aphid) short-range air-to-air missile can engage targets manoeuvring at an acceleration up to 12g. The R-60M has an expanded range of target designation angles to  $\pm 20^\circ$ , a heavier warhead and an upgraded infrared homing head with photodetector cooling.

### Targeting

The aircraft is equipped with an information and fire control radar system comprising: an N-019 radar developed by Phazotron Research and Production Company, Moscow; an infrared search and track sensor; a laser rangefinder; and a helmet-mounted target designator.

For longer-range air combat, the MiG-29 uses radar guidance for the R-27 missile.

Thales TopSight-E helmet-mounted sight and display (HMDS) is being fitted to aircraft for the Indian Navy.

### Engines

"The aircraft's fixed-wing profile with large wing leading edge root extensions gives good manoeuvrability." The MiG-29 is equipped with two RD-33 turbofan engines. The MiG-29 is the world's first aircraft fitted with dual-mode air intakes. During flight, the open air intakes feed air to the engines. While moving on the ground, the air intakes are closed and air is fed through the louvres on the upper surface of the wing root to prevent ingestion of foreign objects from the runway. This is particularly important when operating from poorly prepared airfields.

The engines provide a maximum speed of 2,400km/h at altitude and 1,500km/h near the ground and the service ceiling is 18,000m. The maximum range at altitude is 1,500km and 700km near the ground.

RD-33 engines for Indian Air Force MiG-29 aircraft are to be license-built in India, under an agreement signed in January 2007.

The mission of the MiG-29 is to destroy hostile air targets within radar coverage limits and to destroy ground targets using unguided weapons in visual flight conditions.

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The MiG-29 can carry two R-27R1 BVR missiles and four R-73E WVR missiles. Radar upgrades allow it to carry the new R-77 BVR missile.  
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The MiG-29 is internationally recognised as a high-performance combat aircraft, and has often been compared to the USAF F-16.  
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The MiG-29M cockpit.  
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A MiG-29A Fulcrum of the Czech Republic Air Force on exercise.  
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The MiG-29M deploying a cruciform braking parachute.  
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The MiG-29 can both travel at speeds of up to 2,400km/h at high altitudes and produce 16,600kg of thrust.  
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MiG-29 about to refuel in-flight.  
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Everything you need to know about the MIG-29 Fulcrum

## Fighter Aircraft, Mig-29/1

MiG-29, Part One  
By Easy Tartar

The MiG-29 "Fulcrum" ("Tochka Opori" in Russian) was designed and built to be a single-seat supersonic, all-weather, air superiority fighter representing, with the MiG-31 "Foxhound", the latest and perhaps last fighter production items from the Mikoyan Design Bureau. The primary role of the MiG-29 is to destroy air targets at distances from 60 to 200 kilometers (30 to 110 NM) at all altitudes, on all profiles, in any weather, and under all ECM conditions. In addition, the basic MiG-29 is capable of limited air-to-ground operations and in advanced versions, has been optimized to attack both stationary and moving targets with precision guided munitions.

The basic single-seat production MiG-29, designated as "Product" or "Model" "09", with nineteen prototypes, of which the first groups were numbered 9-01 to 9-11 and 9-12 to 9-15, while others were on the drawing boards. The new model quickly became the Fulcrum "A" to NATO analysts.

During the late 1960's, the Russian General Staff launched a requirements study for a "Perspektivnyi Frontovoi Istrebitel" or "PFI" (Advanced Tactical Fighter) which was directed at an advanced tactical fighter paralleling the development in the US for the "FX" that became the F-15. By 1971, the requirement split into a "Heavy" Program ("TPFI" with "T" meaning "tyazholiyi" for "heavy") and a "Lightweight" Program ("LPFI" with "L" meaning "Legkiy" for "light"). Development of the MiG-29 began to fulfill the "LPFI" which was described as the "Light Frontline Fighter Project".

The official "uncompromised design technical assignment", which was translated into a new operational requirement, was issued in 1972 to replace MiG-21 and MiG-23 assets in the tactical and air defense air forces. The new lightweight fighter was to undertake autonomous operations from austere sites to achieve air superiority over the tactical theater and provide limited escort and surface attack capabilities. Detail design work began in 1974 which resulted in the first 14 of 19 prototypes. The first example was flown on 06Oct77, by chief test pilot Alexander V. Fedotov, at the Ramenskoye flight test center. It was photographed in November 1977 by US intelligence satellites and given the interim designation of the "RAM-L". The second prototype flew in June 1978. Eventually the 2nd and 4th prototypes, propulsion test beds, would be lost in accidents (15Jun78 & 31Oct80 respectively) due to engine failures. The third prototype (03) was the first dual-seater MiG-29UB trainer and first flew on 28Apr81, again piloted by Alexander V. Fedotov.

Nevertheless, the Fulcrum entered series production in 1982 at Moscow's Znamya Truda plant, which will be discussed in detail later. The first operational unit was designated in August 1983, at Kubinka Air Base, near Moscow, with deliveries to Frontal Aviation units commencing in 1984 when the State Acceptance Trials completed. Initial production, testing, and modifications continued until 1985, and by 1986 the first export deliveries were made. On 13Feb85, the first flight of the model 9-14 variant was flown by test pilot Toktar Aubakirov with an air-to-surface attack avionics suite suspended in a pod. This prototype led the way to further multi-role upgrades which were realized in the MiG-29M prototypes. The first MiG-29M (MiG-33) flew on 25Apr86.

In total, over 800 were delivered to the Soviet / Russian Tactical Air Forces and around 500 airframes prepared for initial export customers. By 1989, it was serving in 12 different air forces around the world. Presently, it is the only Russian aircraft on operational duty in NATO and serves in 21 air forces. Brassey's reports that a total of 1216 MiG-29 single-seaters and 197 MiG-29UB dual-seaters were built by January 1985 (total of 1413). Since 1990, production was exclusively for export.

The MiG-29 design team was headed by Rostislav Belyakov assisted by A. A. Chumachenko, V. A. Lavrov, and M. R. Waldenberg. Bill Gunston summarized the MiG-29 design characteristics specified by the Russian Air Force in his book, "The Encyclopedia of Russian Aircraft 1875 - 1995", as incorporating an "integral aerodynamics with lifting fuselage disappearing into a large wing, two underslung engines with variable inlets, structure for a sustained 9 G's, multimode Pulse-Doppler radar, comprehensive fire-control and electronic warfare systems, and gun plus not fewer than six air-to-air missiles.

The West was given its first close look at the Fulcrum when the Kubinka Regiment deployed a six aircraft demonstration team to Finland in July 1986 and since then, the Mikoyan-MAPO organization in conjunction with the Russian Government, Export Organizations and Air Force, have made regular appearances at most of the world's air exhibitions and trade shows.

The first major MiG-29 structural improvements came with pre-production prototype Model 9-13 which included a slightly bulged spine and fatter upper fuselage with provisions for a larger No. 1 fuel-tank and additional avionics. This "fat back" version made its first flight on 23Dec80 and was flown by Test Pilot V.M. Gorbunov (Air International, May 1995, pg.272). Western designations for this variant actually vacillated back and forth from a "mod Fulcrum A" (variant 3) to the "Fulcrum C". Since no significantly new avionics suite was included and a rather limited production run was

accomplished (under 50), it remains today, at least in the open source world, the "Fulcrum A" even though the Russians credit it as the sub-block "MiG-29S" because an extensive retrofit program was made available for all MiG-29 users. Going further, the first three more advanced MiG-29SD prototypes flew in 1984, and the subsequent production run represented to the Mikoyan designers the maximum possible growth that would fill the basic MiG-29 airframe. After that a significant increase in gross weight would be required as well as internal bulkhead upgrades.

Since the basic "fat back" dorsal growth framework was utilized for the advanced carrier version, called the MiG-29K, there has been a continued debate over just how much additional fuel was included in the MiG-29"S" & "M" designs. Various Mikoyan and Russian publications address supplemental amounts of 75 (16.5), 130 (28.6), 175 (38.5), and 240 (52.8) liters (US Gal.). Since the degree of production article standardization has been poor throughout the entire MiG-29 fleet, there is a good chance that different production lines resulted in slightly different figures as the available volume was filled.

The MiG-29S brief production run was supplemented in the new re-organization of the Mikoyan Experimental Prototype Design and Construction Bureau, abbreviated the "Mikoyan OKB", and its merger with MAPO, the Moscow Aircraft Production Organization, with a product improvement program that was applied in stages and has been available even up until today. Hence the confusion of "how many" advanced models have been produced continues, but it is confirmed that "fat back" and "normal" MiG-29 Fulcrum A's have occupied the same Regiments and are treated by the pilots as basically the same machine in handling qualities. During one of the first Moscow airshow a formation takeoff and flight demonstration was made by an original production Fulcrum A with a "fat back" on its wing and then their positions reversed for the next performance. Therefore the "fat back" feature is seen on both Fulcrum A (retrofit) and Fulcrum C (production) fighters and the main differences fall back to weapon system, internal fuel, and system growth capability.

After the breakup of the Soviet Union (Dec 1991) all of the MiG-29 resources were re-distributed and shared with the separating republics leaving the Russian Air Forces (VVS) with just under 400 operational MiG-29 aircraft. Charles Dick (Director CSRC) noted in his paper "The Russian Army: Present Plight & Future Prospects" (22Nov94) that ColGen. P.S. Deynekin, Russian Air Forces Chief of Staff, summarized that the VVS is now left with only 37% of its original MiG-29 force. Today the actual serving MiG-29's in the VVS is estimated to be greatly under 300.

By the end of 1993 as production orders dramatically dropped, close to 100 x Fulcrum's could be found in storage, undelivered, but a small number (48) of upgraded "fat back" models were transferred into the hands of the Russian Air Force for operational evaluation. Some of the stored excess aircraft were used as attrition replacements due to the rising accident rate in the VVS (reaching 12 per 100,000 hrs) while others became export items. Soon, a small attrition replacement batch of 8 was sought by India, 41 were then ordered by Iran, 48 to Syria, and 18 new aircraft were produced for Malaysia. Despite Mikoyan optimism, only a few new customers appear to be forthcoming, although they are marketing world wide. The former Soviet Union (fSU) Warsaw Pact allies of Poland, Hungary, the Czech Republic, and the Slovak Republic have all been offered MiG-29's as payment for debts resultant from the pullout of Russian forces from their territories. Hungary and the Czech Republic took up the deal to carry over their air forces until a proper western re-organization could better prepare them for F-16 class aircraft. Not only did their economies need work, but the support and training infrastructure for aviation needed revamping.

General Designer and recognized academician, Rostislav Apollosovich Belyakov, took over the MiG Bureau in 1970 following the death of its founder, Anushavan "Artyom" Ivanovich Mikoyan (05Aug1905-09Dec1970). This was made possible because of Mikhail Iosifovich Gurevich's (12Jan1893-12Nov1976) retirement in 1964. Belyakov was a graduate of the Moscow Aviation Institute during World War II. He received a State Prize for design excellence in 1951, and was chief designer of the MiG-23 during the 1960's. Belyakov ran the Mikoyan establishment with four Chief Designers, of which Mikhail Romanovich Waldenberg and Anatoly Andreevich Belosvet were the most known in the West, and fourteen deputy Chief Designers. A new Department of Foreign Economic Relations was formed under Leonid Borisovich Leshchiner and his immediate deputy, Yuri Petrovich Golovin, and chartered to work with all of the potential export customers. These names are mentioned because they show up regularly at the major international air shows and exhibitions.

The "Mikoyan OKB", was founded in 1939 on Leningradskiy Shassi (highway) with a series of buildings and a small factory for use in building prototypes. The OKB was at first, as the title implies, strictly an R&D facility that built prototypes. The Mikoyan flight test center is located at Zhukovskiy (called Ramenskoye, or abbreviated "RAM" by western intelligence and used in the intelligence designation of new aircraft such as "RAM-K", "RAM-J", etc.) and at Volga, on the Crimean peninsula, and other facilities on a temporary basis. There has always been the question of why did the US intell organizations recognize Ramenskoye as the name of the test facility when the Russians have always addressed it as Zhukovskiy. When the facility first opened the town of Ramenskoye was the nearest population center. There was a worker's construction camp, named Zhukovskiy, that eventually grew into a larger town and became the nearest population center and official Russian name for the facility.

The Mikoyan OKB could hand tool up no more than two prototypes at one time and usually there were strict security precautions in place. Aircraft manufacturing for flight test articles would move to two production facilities, the closest of which was the Moscow Aircraft Production Organization No. 30 (MAPO), known also as the GAZ-30 plant. The second

was the Nizhny Novgorod State Aircraft Plant or the "Znamya Truda" (Banner of Labor) factory which eventually re-organized under the corporate name of Sokol.

The MAPO facility is located in Moscow proper, on Botkinski Street, at the Khodinka bus stop. It is the oldest aircraft production facility in Russia, first utilized in 1909. During 1939, it was redesigned the State Aircraft Works No. 1. Today the factory is still run under Plant Director General Anatoly Sergyevich Manuyev who reports to Mikoyan's Chief Designer Waldenberg and Russian Air Force Plant Representative Colonel Viktor Isayenko (like a DPRO in the US). Note that Lenin's glass covered and pressurized casket was built here after his death in 1924.

MAPO employed at its peak up to 30,000 people with an additional 3,000 for non-aviation related production items. It covers over 618 acres of land and has 26,909,675 square feet of usable floor space (for more see Jay Miller's book, *The MiG OKB: A History of the Design Bureau and Its Aircraft*, Aerofax, 1991). Production of the MiG-21, MiG-23, MiG-27, and MiG-29 aircraft were all centered at this facility. Flight certification and delivery flights are conducted from Lukhovitsy airfield, which is close by and today occasionally hosts an international air display.

Once the aircraft are in production, the OKB is responsible for designing improvements based on requests and reports from the operational units designated by the air force. The overall design process is done in close collaboration with the Ministry of Aviation Industry (MAP), its Research Institutes (such as TsAGI the aero center), and the military customer.

Flight Testing is done in three stages, "plant testing" (no military) at Zhukovskiy, "design testing" (with a mix of military pilots) at environmental facilities all over the country, and "state testing" (extensive military participation) at designated military installations where the aircraft become certified for use by the Air Forces.

During a visit to colleges and defense plants in the United States, Rostislav A. Belyakov candidly voiced his opinions on the objectives and lessons learned from the MiG-29 development program and they were published in "Some Aspects of the MiG Aircraft Development", Mikoyan Design Bureau, 1989.

Analysis of the local war combat experience and the military aircraft combat progress trends revealed the need for the development of a new tactical fighter capable of both maneuvering dogfight and beyond visual range air combat.

Conceptual studies of the MiG-29 were performed in joint efforts with the Air Force, TsAGI, and other institutes. For the first time in Soviet aviation an aircraft's general layout was based on a so called integral configuration with all of the aero-elements creating lift.

The aircraft was designed with slight positive longitudinal stability, rather low wing loading, and high thrust-to-weight ratio. The aircraft wing had 3-D deformation and high-lift devices in the form of programmable leading and trailing edge flaps.

Austere airfield operations on natural ground was included along with the traditional airfield methods by means of main intakes closing during taxi, takeoff, and landing roll. Engine air in these operational modes is supplied through the upper part of the inlets.

Engine designers developed for the aircraft the RD-33 high performance turbofan with maximum thrust at 8300 kg (18,300 lbs). Composite materials were utilized to some extent in the airframe structure. The airframe manufacturing breakdown was oriented to the needs of mass-production manufacturing. It is constructed with a wide use of parts produced by numerically-controlled machines, structural modularization, and intensive use of automatic beam welding.

The aircraft is equipped with an integrated fire-control system comprising of three mutually supported subsystems namely radar, electro-optical, and optical sets. As a result, the aircraft is capable of launching air-to-air missiles with homing heads of different types. Special attention has been given to the reliability and maintainability of the aircraft, equipment, and weapons.

The MiG-29 represents a major new step in fighter aviation achieved through the proper layout of power plant and equipment, considerable expanding of the built-in-test, and in the future, the total elimination of any ground-test equipment during the quick turn around of the aircraft.

The MiG-29 was the first Soviet fighter to participate in international air shows and exhibitions since 1988 (England, France, Canada, etc.). The MiG-29 has substantial growth potential and we are naturally working on this.

**Mikoyan's Move into the Future:**

The Mikoyan Bureau was slowly "downsizing" into dormancy (not death) since the fall of Communism, but spurts of business, small national R&D stipends and the merging with MAPO, its key production facility, and the KAMOV helicopter design bureau, have assured its survival into the 21st century. The proper term for this association of a new Military Industrial Group (MIG) was MIG-MAPO, using the capital "I" in MIG. As you can see this immediately conflicted with the time-honored "MiG" designation for the original Mikoyan-Guryevich name. Hence the proper new term for this "joint

stock" corporate structure is MIG-MAPO, but with respect to tradition the MAPO-MiG designation is used. The main output of the MIG-MAPO organization will be the family of MiG-29 Fighters and Kamov Helicopters, but small aircraft projects are also under work as well as upgrade programs.

This new strategy of "joint venture" in the Russian aerospace industry was explained in the Oct 95 Interavia Magazine as an attempt to reorganize around holding companies consisting of financial institutions, industrial firms, and commercial aviation entities. It would focus attention on capitalizing international markets, securing government financial guarantees and fiscal incentives, revamping export legal regulations, and creating a flexible sales organization capable of competing with the West. These joint-stock holding companies were expected to eventually evolve into multinational corporations.

The Mikoyan solution focused on Aircraft Production Plant 30. The main production building is huge, well lighted assembly facility where aircraft are built-up on separate moveable cradle-stands (JDW, 15Apr89, pg.655). The sequence of MiG-29 production/assembly is fuselage skeleton, wings & tail sections, internal electronic systems, and then skin & panels. There is no evidence of automated production technologies, even after the restart effort was initiated for Malaysia.

In all, the new MAPO-MiG organization undertook urgent measures to cut down unprofitable subdivisions, ceased marketing activities in areas where there was a limited possibility for sales, removed duplication in the design and production facilities, reviewed the attitude towards cooperation and communication between vendors and enterprises, and brought together financial resources to work with potential customers. The present goal of MIG-MAPO corporation is to create an optimal "closed production cycle" that will produce all of the necessary components involved with over 300 enterprises that are involved in the production of all their air vehicles.

To survive in the future, MIG-MAPO must continue to support the further development of advanced fighters. Recently, when Sukhoi overturned a Mikoyan victory in Indonesia with the more capable Su-30 over the MiG-29SE, it became clear that competition would not just be external to Russia, but also from within. So in effect, the stops are off and the race is on because survival dictates it. The entire "conversion" effort of the Russian defense industry has failed, and the one thing that has been learned is that the only thing they are good at is the production of weaponry. The formula for survival that started with "privatization" and then downsizing (rationalization) with "merger" was only partly right. The point missed was that it was directed at re-newed military production.

MAPO has also made several attempts at foreign joint ventures focused on the support of export aircraft while utilizing investments to stockpile aviation parts and spares at the idle Mikoyan warehouses for world wide shipment, repair, and sale. Rostislav Belyakov mentioned in 1992, that the building surplus of airframes and engines stored in and around the GAZ-30 factory (over \$2 billion in resources at \$20 million each) could begin this inventory. But in 1995 the plant itself was virtually idle except for the one, hand-worked production line for Malaysia. Despite all of this, the MAPO strategy is to continue Russian military production. They will attempt to continue the MiG-31 product improvement line, market the MiG-29 in any of many possible configurations, generate sales of the MiG-21-93 upgrade kit, win the Russian Air Force jet trainer competition with their MiG-AT candidate, develop a light commercial transport, and secure development money for advanced prototypes.

Mikoyan's First Deputy General Designer, Anatoly Belosvet, carries the lead on what is said to be Russia's "first stealthy combat aircraft", the Model 1.42 "ATF'ski", which is characterized as a "multi-functional front-line fighter" (mnogofunktionalnyy frontovoi istrebitel ). Belosvet has been assuring the western press that it would make its first flight "very soon" for the past three years. The 1.42 prototype is being made of radar absorbent materials (RAM) and serves, according to Belosvet, "as the golden compromise between aerodynamics and stealth". The 1.42 is considered to be the ultimate replacement for both the MiG-29 and Su-27's in the VVS. Many problems have been encountered, the least of which was continual funding cuts. The Model 1.42 is the high speed taxi prototype and the 1.44 is considered to be the first flying example. Both were to be presented to the public by President Yeltsin at the Moscow MAKS Air Show in 1995. Yeltsin's failure to arrive at the ceremony has kept it under wraps.

Belyakov however, appears to have brought much of the bad luck upon Mikoyan. First he backed the coup against Yeltsin, and then, he simply became too depended upon his friends in Moscow's local political circles and in the Russian Air Force (VVS) to secure military contracts for continued work at his bureau, even though the VVS was not looking for more frontal aviation fighters. In 1988, all design bureaus changed over to State controlled budgeting and lost their "unlimited funding" status. Belyakov retired in bad health during 1995 and was replaced by the new General Director Vladimir Kuzmin, who was the General Manager of the MAPO production facility. Anatoly Belosvet, who is also getting on in years and requires constant care, still maintains a considerable amount of influence on what goes on.

Kuzmin was born in October 1937, and as a young adult graduated the Tomsk Military AA Artillery School and the Moscow Aviation Institute. In 1959, he began working at MAPO as an Assistant Foreman. In 1987, he was appointed Deputy Director for Production, and became the General Director of MAPO in 1991. Vladimir has been the driving force behind the MAPO-MiG merger and transformation. Under him, the MAPO-MiG line-up goes: The Deputy General Director / Commercial Director is Aleksandr Nikiforovich Bezrukov, subsidiary head (Director of Likhovitsky Machine Building Plant) is Vladimir Ivanovich Nungezer, First Deputy General Director / Chief Engineer is Victor Mikhailovich Puzanov, Advisor to the General Director on International Marketing & General Representative in Germany is Valeri

Vasiljovich Lioultchev, the Advisor to the General Director and Director of Strategic Analysis Services is Aleksandr Ivanovich Ageev, Deputy General Director for Production is Grigory Mikhailovich Nemov, the Technical Director is Ivan Ivanovich Butjko, and the Deputy General Director for Human Resources & Staff is Vjacheslav Michalovich Vinogradov.

As a comparison, Sukhoi's chairman Simonov, developed a style of first helping the generals find major funding pots in the State budget at the highest levels of Yeltsin's government, then in return, they would offer the R&D/production contracts to his corporation. Knowing that high inflation eats away at the ruble faster than people or industry can adjust, Simonov traded sport aircraft for used Toyotas. Then he used the appreciating Toyotas to trade for goods and services while continuing the work force salaries on the weakening rubles. This eliminated any new-product tax losses. Any dollars that were received were carefully banked in the West and the interest used. Therefore, Sukhoi has been "adapting" to the new world faster than Mikoyan.

There is another advanced design project at Mikoyan that is called Type 701, that was earmarked to be a replacement for the MiG-31 family of strategic interceptors and "mother-ships". Characterized as a "long-rangemulti-role interceptor" (mnogofunkstSIONalnyi dalniy perevkhvatchik), it was to be a dual-seat, big and fast tail-less delta-wing aircraft reaching into possible Supersonic Transport (SST) technology with commercial spin offs. But like everything else, it could never obtain the funding to get off the ground (beat inflation). Belyakov's political clout kept it from going completely "dead", although it will stay "very dormant" until adequate funding shows up.

At the Nizhny Novgorod facility, the Mikoyan Design Bureau celebrated its 60th birthday in 1992, as a center of aircraft production. But remember, this facility is still its own company, not associated with the MAPO-MiG merger. The plant is still producing, under contract, one MiG-31 "Foxhound" per month. The "Foxhound" is a long range interceptor/mother-ship. The plant has also been tooling up, at their own expense, for a couple of new MiG-31 variants that will service specific Air Defense Command requirements and the manned anti-satellite mission. Seven prototypes of the advanced MiG-31M have already been produced which offer an improved weapon system and integrated countermeasures system. Production of the MiG-29 has been suspended here, but refurbishment's and kit modifications are done continuously in small quantities. Nizhny Novgorod also is the production-modification facility for the MiG-21-93 upgrade program. Plant managers say they could pick up additional MiG-29 export orders if needed, since the assembly line still stands. The plant's commercial conversion efforts focus on building gliders and motorboats as well as furniture, ski poles, pots and pans.

In 1995, Klimov developed two advanced thrust-vector-control (TVC) engine designs for use with the MiG-29M, the RD-133 and the RD-333. This became very important after the Su-27 evolved to the Su-35 and then on to the vectored-thrust Su-37 and was successfully displayed in Moscow and at Farnborough. The RD-133 is based on the RD-33 fitted with axis symmetric nozzles while the RD-333 is a new fifth-generation engine. Flight testing with the MiG-29"M" (MiG-33) was to begin in late 1997 with the RD-133 as a flight demonstration program. The RD-333 would require R&D money which has yet to be forthcoming. The Sukhoi TVC program was in part funded by the additional purchase of Su-27's by the PRC. The new MiG-29"M" derivative will be called the MiG-35. Rumors are that this aircraft will be previewed at the Moscow Air Show (MAKS-97).

The RD-133 is a 18,600 lbs (8440 kg / 81.8 kN) thrust class engine in afterburner (wet/reheat). The present uprated MiG-29M RD-33 engine gives 19,392 lbs (8800 kg / 86.3 kN) of thrust. The RD-333 is intended to be of the 22,000 lbs (10,000 kg / 98 kN) thrust class and could be ready for ground tests in three years. Both engines are expected to have design lives of 2,000 hours (Flight International, 10-16Jul96, pg 16). Unlike the Su-35's AL-37FU engines, the RD-133 operates in both horizontal and vertical planes.

The thrust-vector engine program for the MiG-35 is being financed in part by the VPK-MAPO joint stock defense industrial consortium that Klimov is a member of. It now has priority over the basic MiG-29"M" program and will seek export customers. The MiG-35 is also expected to be heavier than the MiG-33 but will have performance similar to the Su-37. It is slated to be configured with the Zhuk-PH electronically scanned radar that can detect up to 24 targets and engage eight simultaneously matching the eight stations that can carry AA-12 (R-77 "Adder") missiles. The RD-133's will be shifted 920 mm to the rear of the aircraft (Jane's 05Jun96, pg 3), which will allow for 1500 kg (3300 lbs) of additional fuel. This is expected to double the 1430 km range attributed to the Malaysian MiG-29S.

The MiG-35 is also expected to have a longer wing, derived from the Naval MiG-29"K" (MiG-33) variant and has design options centered around canards and/or a refurbished leading edge wing extension. The MiG-35 could help Mikoyan get back on track if export customers are available and Iran can be expected to be one of the most sought after.

Mikoyan engineers estimated that by the end of 1992, the aerospace potential in Russia was only utilized to 60% of its capacity, in 1993 it is less than 15%, today less than 5%. But despite this, there are still over 100 prototypes of fighters, fighter-bombers, transports, helicopters, etc., all scrounging for precious development dollars from the State or any interested country. In this environment, MAPO's fate is far less certain than that of the more productive Sukhoi.

There were many Mikoyan commercial spin-off attempts. During the 1994 Farnborough Air Show, Mikoyan announced the formation of a joint company with the Singapore based Agio Countertrade Company that resulted in the MiG-Agio

Ltd. which will be registered in Singapore. Company objectives surround research and development, aircraft upgrade kits, and product support activities. One of its first projects appears to be the field upgrade of basic MiG-29's delivered to customers. Kits would include a new export version of the Zhuk radar for the MiG-29, an advanced IRST, Suppression of Enemy Air Defenses (SEAD) capability, satellite navigation, and western style instrumentation (Armada Magazine, Jun94, pg. 24).

In its marketing brochures, MIG-MAPO is characterized as a highly experienced and qualified aircraft manufacturing center that has produced over 40 types of high performance combat and civilian aircraft for over 70 years. Facilities include several aircraft production plants that are united under the Mikoyan name. MAPO has extensive laboratories and research support organizations to introduced the very latest in new materials and high tech processes with close links to the state research institutes and experimental centers. MAPO's export history, as Mikoyan, started in 1950, and is supported by continued demands from foreign customers for spares, retrofits, and new aircraft.

## MiG-29, Part Two

By Easy Tartar

The MiG-29 Legacy of Models, Missions, & Roles:

The MiG-29 was designed as a "progressive" model replacement for the air-superiority variants of the MiG-23 Flogger, namely the Flogger G & K models and the remaining MiG-21 bis Fishbed L/N clear air mass fighters. The design effort was initiated in secret during 1969, when the Soviet Air Force announced to the General Staff its formal "statement of requirements" for a new more powerful fighter, one that would challenge the best seen coming off the US production lines after the F-4 Phantom. The Mikoyan Bureau engineers then wrote a "Technical Assessment" specifying general performance parameters that could be achieved. Today the MiG-29 is marketed as a "superfighter", providing a state of the art machine with modern armament, superb aerodynamics, easy operations, and high reliability.

By the end of 1994, MAPO finally admitted that their advanced development program, that followed on after the basic MiG-29"B" was upgraded with the MiG-29"S" series kits ("SD", "SE", and "SM" versions) was slowly continuing in the form of their much improved MiG-29"M" and its potential export counterpart MiG-29"ME". The "M" itself evolved from the naval counterpart, the MiG-29"K", which had been canceled after loosing to the Sukhoi design. The main difference in the "SE" and "SD" versions is a new internal active jammer developed for the Naval "K". The "SM" is a further modified "SE" with a new radar featuring a synthetic aperture mode and PGM capability. Many features of these variants have been thoroughly tested and will be offered to any export customer in various model upgrade kits or in a new aircraft program. Today, it is expected that the MiG-29"M" development program will be continued under state funded programs.

Presently there are several MiG-29 models\* in service:

This is an attempt to identify the many known and unknown variants and models of the MiG-29 Fulcrum family. It is based on interviews, MIG-MAPO brochures and literature and public domain research. One of the best open source summary documents is the yearly March issue of Air Force Magazine.

Fulcrum A: MiG-29B (Variant 1, Product 9-12) the basic production land based single-seater that was identified in three sub-blocks. (1) the first 110 with rear ventral tail fins, (2) continued production with ventral fins removed in favor of extended-rudders and chaff/flare dispensers incorporated from extended fairings down from the vertical tails to the top of the wings, and (3) the implementation of a redesigned nose gear and pitot tube strake. Total internal fuel of 7384 lbs. (3200 kg, 1136 US Gal, or 4300 liters) with a 2610 lbs. (1184 kg, 402 US Gal, or 1520 liter) Centerline tank while 40% of the MiG-29 fleet have eventually been made capable of 2 x 1130 liter Wing Tanks (3949 lbs, 1792 kg, or 608 US Gal) external wing tanks. All models have a hydra-mechanical flight control system and FOD inlet doors. After the first 100 aircraft above-wing chaff/flare dispensers (30) each) were included and under-fuselage vertical ventrals were removed. Around 350 a/c operating in the VVS, with the basic MiG-29 radar

. The export variant for the Warsaw Pact countries was called the 9-12 and others the 9-12B. Many of these basic A models were upgraded to the "fat back" standard but continue as a Fulcrum A (variant 3) since no significant weapon system upgrades were done. The main difference in the "fat-back" versions are the ejection seat harness attachments which are the same as in the MiG-29K or MiG-33. The pilot sits in the seat and attaches the parachute risers to clips on his integrated harness that he puts on before flight, just as the Western pilots do. The SUV (OEPrNK-29E2) Weapons System includes the N-019 Pulse Doppler radar, called the S-29 "TOPAZ" with the export version the N-019E "RUBIN". The NATO designation is "SLOT BACK". The newer N-019/3A "ZHUK" (Beetle) RLPK-29E coherent, multimode PD Radar can be retrofitted. The KOLS (OLIS) laser range finder / IR search and track system tied with a pilot helmet mounted sighting system completes the weapon system. The infra-red search and track ball mounted on a three-axis gimballed turret protruding above the nose in front of the cockpit and incorporates a steerable laser range finder. The electronic warfare suite is centered around the SIRENA-3 radar warning receiver, two SO-69 type K-11E ECM transponder in the wing strake, and chaff/flare dispensers located on top of the wings. The aircraft is configured with RD-33 engines and the K-36DM/2-06 zero-zero ejection system.

&circ; The RLPK-29 (radiolokatsyonnyi pritselnyi kompleks) radar attack system includes the coherent Pulse-Doppler S-29 (N-019, NATO Slot Back ) look-down/shoot-down radar and its Ts100.02-02 digital computer. Search Range, fighter-

to-target, is of the 70 km (38 nm) class in the front hemisphere and 35 km (19 nm) in the rear hemisphere. Bomber sized targets are expected to be seen at twice the fighter ranges. The radar can show up to ten targets in search and can lock-on to the one of highest priority assigned by the computer. The radar search volume covers a cone  $\pm 67^\circ$  in azimuth and  $+60^\circ/-38^\circ$  in elevation. The MiG-29S is equipped with a more jam-resistant N-019M "Topaz" radar with an improved computer for tracking through the beam area and capable of firing on two simultaneously tracked targets with the AA-12.

&circ; The RLPK-29 radar supported by the OEP rNK-29 (optiko-elektronnyi pritselno-navigatsyonnyi kompleks) optical-electronic navigation-attack system, which comprises the OEPS-29 sighting system, SN-29 navigation system, Ts100.02-02 digital computer, SUO-29M2 weapons control system, and the SYel-31E2 data presentation system with ILS-31 Head-Up Display. The OEPS-29 (optiko-elektronnaya pritselnaya sistema) comprises the KOLS-29 Infra-Red / Laser-ranger and track system. Nominal IR tracking range of 18km (10 nm) in the rear-hemisphere with a range resolution of 3 meters (10 ft). The Shchel-3UM helmet mounted sighting and target designator is available for use with the R-60 and R-73 missiles. The SN-29 (sistema navigats) includes the ARK-19 radio compass, the A037/06 radar altimeter, A-611 marker beacon receiver, and the A-323 short-range navigation and instrument landing system. The E502-20/04 Turkus ground-to-air and air-to-ground data link for target indication from land-based radars is joined by the R-862 communication radio, SO-69M IFF transponder and the SRO-2 Parol IFF transponder with its SRZ-15 interrogator.

&circ; The SPO-15 (L006-LM/101) Beryoza radar warning receiver and the 20SP passive countermeasures system with 2 x BVP-30-26M (blok vybrosa pomekh) chaff / flare dispensers built into the upper surfaces of the main wing. Each dispenser contains 30 x 26 mm PPI-26 flares or PPR-26 chaff cartridges.

Fulcrum B: MiG-29UB (Variant 2, Product 9-03) combat dedicated dual-seat trainer without radar and with continuous canopy, but has imbedded training system and functioning IRST/helmet sighting system, weapons capability underwing stores pylons retained, but no chaff/flares, with approximately 70 delivered to VVS and a similar number to export customers. Still in limited rate production for (Variant 3, Product 9-51) the advanced jet trainer first flown on 29Apr81. Production began in 1982 at Gorkiy (Sokol). The airframe is 100 mm longer with the instructor's cockpit taking up a small amount of the number one tank capacity. Total internal fuel changes to 7000 lbs. (3175 kg, 1076 US Gal, or 4077 liters) with a 2610 lbs. (1184 kg, 402 US Gal, or 1520 liter) Centerline tank while some have been made capable of accepting 2 x 1130 liter Wing Tanks (3949 lbs, 1792 kg, or 608 US Gal) external wing tanks.

Fulcrum A: MiG-29SD (Variant 4, Product 9-12S) with "fatback" modification to the basic "A" model incorporating avionics modules for the Gardenyia-1 system. Total internal fuel continues to be 7384 lbs. (3200 kg, 1136 US Gal, or 4300 liters) which includes a 2610 lbs. (1184 kg, 402 US Gal, or 1520 liter) Centerline tank while most of the Variant 3 fleet have been made capable of 2 x 1130 liter Tanks (3949 lbs, 1792 kg, or 608 US Gal) external wing tanks. It has been rumored that this mod for the Variant 4 actually started the 20 US gallon more internal fuel argument due to the redesign of the number one fuel cell and reduced gun ammo from 150 to 120 rounds. This variant continues with the same basic NO-193A weapon system with minor improvements that included an improved new sighting system (IRST) combined with a better imbedded training system that allows for IR and radar target simulation. More built-in-test (BIT) functions, especially for the radar, was included in the EKTRAN to reduce dependence on ground support equipment.

Fulcrum A: MiG-29S (Variant 5, Product 9-12S) that continued with production "fat-back" fuselage, small internal fuel increase of 20 US Gal. (76 liters) to 4376 liters (7514 lbs, 3408 kg, or 1156 US Gal) and provisions for two 1150 liter (304 US Gal or 1975 lbs) wing tanks. Total max fuel capacity of 8196 liters (2165 US Gal or 14,074 lbs) with centerline tank included. Possible 4,000 kg. (8,020 lbs.) of stores. Max Takeoff Weight increased to 19,700 kg. (43,340 lbs.). Published max range of 1,565 nm (2862 km). Configured with the improved N-019M "Slot Back" Radar capable of ten TWS target files with two simultaneous engagement tracks the AVV-AE (R-77) "Adder" missile. The first prototype was flown on 3Dec80 by V.M. Gorbunov. The four-section leading edge flap was changed to a five section construction. The improved N-019M "TOPAZ" radar enabled the R-27ER radar and the R-27ET IR missiles which are larger varieties of the R-27R and R-27T original design.

Fulcrum A: MiG-29SE (Variant 6, Product 9-12SE) unique production models of the MiG-29S for the VVS and export with or without "fat-back" structural mod, additional fuel, and specific weapon system configurations with the N-019M/ME improved radar design with 10 target track and two target engagement capability with AA-12 missiles. Malaysia received the MiG-29SE version without the "fatback" extended dorsal spine. The single-seat version has a KCA-3 accessory to the electrical system, improved environmental control system (ECS), and a new active jammer linked to the radar warning receiver. Single and dual-seat aircraft have provisions for underwing fuel tanks, a new western IFF system, new tandem bomb racks for bigger air-to-ground loads, improved flight control system with roll limiter and greater rudder authority for higher AOA stability. Malaysia has asked for and received the AA-12 (R-77) missile software and suspension hardware. Provisions to incorporate the R-77 (AA-12 "Adder") missile are being worked out. Internal fuel capacity appears not to be upgrade by 20 US gallons but remains at the Fulcrum A basic total internal fuel of 7384 lbs. (3200 kg, 1136 US Gal, or 4300 liters) with a 2610 lbs. (1184 kg, 402 US Gal, or 1520 liter) Centerline tank while all have been made capable of 2 x 1150 liter Wing Tanks (3949 lbs, 1792 kg, or 608 US Gal) external wing tanks. Also, max gross weight appears to also remain at the Fulcrum A level of 36,800 lbs. but could be upgraded. The SD variant has an internal active electronic warfare jamming system.

Note what MAPO-MiG stated in their literature presented to the Philippine Air Force visiting delegation headed by LtGen Arnulfo G. Acedera, Jr., the Commanding General, who made several flights in the aircraft.

"Today, the MIG MAPO produces in quantity two up-to-date fighter versions, the MiG-29SE and MiG-29SM. The MiG-29SE is a light multi-role fighter optimized for gaining air superiority and for destroying ground (sea) targets with unguided air-to-surface missiles. This aircraft is equipped with an active jamming station providing facilities for self-defense against radar detection and heat-seeking weapons."

"The MiG-29SM is additionally armed with high-accuracy air-to-surface weapons enhance significantly its effectiveness and add to its multirole capability: the Kh-29T with a TV-Homing head and the KAB-500KR TV guided aerial bomb. Now the fighter is being tailored to the Kh-31A anti-ship missile with an active radar homing head and the Kh-31P antiradar missile with a passive radar homing head."

Basic aircraft weapons being offered:

- &circ; 9A-4071K (GS-301) 30mm aircraft gun
- &circ; suspension system for bombs and rockets
- BDZ-UMK2B girder holders
- APU-470, APU-73-1D, and APU-68-85E launching devices
- B-8M1 rocket pods
- &circ; ammunition types that are utilized by the MiG-29
- R-27R1 and R-27E guided missiles
- S-8 (80 mm) and S-24B (240 mm) unguided rockets
- 250 kg and 500 kg aerial bombs (maximum bomb load of 2000 kg)
- 30 mm aircraft gun rounds (HE and tracer) 150 per load

With these aircraft the following weapons were noted as being made available for their configurations to be delivered as options in accordance with the customer's request and a modernization schedule on the customer's territory.

&circ; H-29T air-to-surface TV-guided missile with an effective launch range of 30 km.

&circ; KAB-500KR TV-guided 500 kg aerial bomb with hitting accuracy 50 cm.

&circ; R-27T1, R-27ET, and R-27ER medium range air-to-air missiles

&circ; R-27TE1 and R-27RE1 air-to-air BVR missile with effective range from 60 to 120 km.

&circ; H-31P air-to-radar missile with effective launch range above 100 km.

&circ; H-31A air-to-ship missile with effective launch range up to 50 km.

&circ; RVV-AE active air-to-air missile known as the Russian version of the AMRAAM mechanized to engage two-targets at the same time

&circ; Cruise Missile with effective launch distance up to 200 km.

&circ; increasing the effective bomb load carrying capability from 2 to 4 tons

Main aircraft systems and subassemblies are identified as:

- &circ; engine RD-33
- &circ; ejection seat K-36DM/2-06
- &circ; ventral fuel tank 1500 litre (1 pcs)
- &circ; underwing fuel tanks 1150 litre (2 pcs)
- &circ; radar aiming complex NO19E
- &circ; optical & electronic aiming and navigational complex S-31E2
- &circ; Friend-or-Foe Identification System
- radar transponder SRO-2
- radar interrogator SRZ-15
- &circ; automatic control system SAU-451-04
- &circ; airborne guidance system equipment E502-20/04
- &circ; communications radio station R-862
- &circ; marker radio receiver A-611
- &circ; radio altimeter A-037/06
- &circ; aircraft ATC responder (with UNN block/K-42E) SO-69

- &circ; automatic radio compass ARK-19
- &circ; information reporting system ALMAZ-UP
- &circ; aircraft flight data recording system TESTER-UZ/LK
- &circ; integrated system of built-in control ECRAN 03ME01
- &circ; illumination warning system L006-LM/101
- &circ; passive jamming dissipation canisters BVP-30-26M (2 pcs)

Equipment available that operates in accordance with international standards that can be installed in these MiG-29's:

- &circ; flight and navigation deck instruments with indications in the Anglo- Saxon measuring system
- &circ; TACAN-AN/APN-118 tactical navigation system
- &circ; GPS satellite navigation system
- &circ; additional R-800L1 communication radio station with continuous tuning which ensures simultaneous radio communication (in combination with the R-862 radio station) using two independent frequencies and ensures emergency reception at 243 MgHz (GUARD Channel)
- &circ; SO-69M aircraft responder
- &circ; friend-or-foe identification system used in the purchaser's country

Fulcrum C: MiG-29S (Variants 8/9) production "fatback" with new radar and weapon system, improved flight control system, and room for further enhancements. The new upgraded radar is the NO-019M that could grow to a two simultaneous target engagement capability. There is also a gross weight beef-up with R-77 (AA-12) compatibility, or 8,820 lbs ordnance and ext stores, with less than 50 aircraft produced for VVS and no known exports yet an upgrade kit is available. Sub-block of Fulcrum C is the MiG-29SM aircraft with the SM being optimized for precision air-to-ground weapons. There is an additional 240 liters of internal fuel together with the 76 liters gained in the first re-arrangement of the LEX-fuselage volume bringing the total internal fuel to 7926 lbs (3595 kg, 1219 US Gal, and 4616 liters).

Fulcrum A: MiG-29 TVK (Variant 10), specially modified as carrier trainer with arresting hook, naval landing gear, refueling probe, but retained non-folding wings.

Fulcrum D: MiG-29K (variant 11 with "korabelnyy" = ship-based) naval development prototype, for ski-jump takeoff and arrested landings aboard the carrier Kuznetsov (former Tbilisi) that began development on 01Nov89. Two converted Fulcrum A's with folding outer wing panels, ESM wing tip antennas, sharp-edge slightly raised LEX, enlarged dorsal spine, increased chord-length horizontal tails with dogtooth edges, new RD-33K turbofans with 19,400 lbs. (86.3 kNt.) thrust, and new N-010 radar with single-curvature profile radome, eight underwing hardpoints, FOD doors replaced with retractable grids, and removal of overwing louvers. Increased internal fuel capacity to 6419 liters (1696 US Gal or 11023 lbs.), maintains two 1150 liter (304 US Gallon) wing drop tanks and centerline tank, equipped with retractable inflight refueling probe, strengthened landing gear, arresting hook, single larger over fuselage speed brake, no APU air scoop on rear fuselage, improved IRST with TV. Possible 4,000 kg. (8,020 lbs.) of stores. Max Takeoff Weight at 19,700 kg. (43,340 lbs.). First exhibited at Machulishche airfield at Minsk configured with air-to-air and air-to-ground weapons.

Fulcrum E: MiG-29M / ME (Variants 12/13/13S) greatly redesigned with quadruplex electronic fly-by-wire flight control system, "glass" HOTAS cockpit features, numerous airframe, weapons system and subsystem improvements featuring NO-10 "Zhuk" radar and a 1500 kg internal fuel increase combined with a max gross takeoff weight of 46,300 lbs. Total internal fuel is 10,979 lbs (4980 kg, 1689 US Gal, or 6394 liters). The "ME" represents a potential export model. The program was canceled after six produced, first prototype flown in late 1989. In 1995, the Russian Air Force agreed to complete the MiG-29M development phase and evaluate production for the VVS. Same airframe improvements of MiG-29K with RD-33K updated turbofans but without folding wings and arresting hook. Zhuk Radar with doubled processing power for simultaneous engagement of 4 tgt's in TWS with R-77 (AA-12), raid sort function, new terrain following and synthetic aperture ground map radar, autonomous laser guiding of ASM's, improved cooling of IRST gives 30 km range with TV tracker. The MiG-29M has become known as the MiG-33. The 9-13 and 9-13S variants have the Gardenia-1 active electronic jammer system built into the airframe.

Additional Variants: (Variants 14/15/16) (1) fibre-optics testbed, (1) variable two-axis nozzle thrust vectoring prototype, and (1) one advanced STOVL development aircraft. Kits exist for retractable and fixed refueling probes, advanced weapon system mods, and airframe growth. Note that the MiG-35 vectored thrust variant has suddenly surfaced and taken precedence over all other advanced design activities. The MiG-35 derives from the MiG-29M (MiG-33). The MiG-35 will also utilize the Zhuk-PH advanced electronically scanned radar that can track 24 targets and engage eight simultaneously. The MiG-35 could qualify as the Fulcrum F.

In the past, the Mikoyan OKB has produced several twin-engine fighter models with the MiG-19 perhaps the most famous and having the largest production run that included the PRC produced F-6 Series and Czech co-production. The F-6 remains operational in the Pakistan and Bangladesh Air Forces. Also the MiG-25 Foxbat and the Flipper, a twin-engine testbed that became the Chinese F-8 Finback. All with production runs in the hundreds. Therefore, many people ask why Mikoyan moved to twin-engine designs after the successful legacy of the single engine MiG-15, MiG-17, MiG-

21, and MiG-23/27 type fighters?

Simply stated, the twin-engine idea was fathered by the failure to achieve adequate thrust growth in single engine motors to carry the increased avionics loads being asked for by the military. There were claims of a new single engine MiG-33 or 35 design being offered to India, but Belyakov flatly denied there was ever such an aircraft when visiting the GDFW plant in 1989. However, new models, such as the naval MiG-29K and the advanced MiG-29M, were again expected to be re-designated the MiG-33 if they went into series production.

There have been some single engine derivative swaps in existing fighters utilizing MiG-23 and MiG-29 engines. One of the earliest attempts being the replacement of a Lyulka engine in the Su-17M Fitter, being exported to Peru in 1980, with the MiG-23's RD-29B engine. The result being a Su-22 Fitter F. Recently there has been a successful adaptation of the RD-33 to South African Mirage F-1's. But on top of this, Russian designers have always been confident that enough reliability could be designed into a single engine fighter.

Working from Bill Gunston's excellent encyclopedia again (page 224), the MiG-29 design specifics are defined for 40% aerodynamic lift from the central structure component comprising fuselage and inner wing between fins with initial wing leading edge at 73.5°. Outer wings with symmetric 4% profile, leading edge 42°, aspect ratio 3:5, tip chord 1270 mm, and a -2° anhedral. Hydraulic leading-edge maneuvering flaps computer-linked with plain trailing-edge flaps to vary wing camber throughout the flight envelope. Outboard hydraulic-powered ailerons with ground-adjustable trailing-edge strips. Twin vertical tails, 1690 mm from centerline, canted outboard at 6° with leading-edges at 47°50', with inset powered rudders that were extended in size beyond the flush trailing edge line of the tail after the first 100 aircraft. Also, the vertical tail structure was extended at its base to carry across the top of the wing and join the BVP-30-26M chaff/flare dispensers which also increased the effective keel-area that aided in spin recovery. The horizontal differential taileron/stabilator have a 50° leading edge, 7.78 meter span, and deflection limits of +15°/-35°.

The three-section, full-span (except tips) maneuvering flaps (20°) are assisted by the slotted trailing-edge flaps (25°), and ailerons (+25°, -15°, neutral, and +5°) with tabs. The vortex generators on the forward fuselage prevents aileron reversal at maximum angle-of-attack. The horizontal tail surfaces deflect +5°45' to -17°45' evenly or differentially. The twin vertical fins are canted 6° outward and the rudders deflect ±25°.

The flight control system uses mechanical links to power surfaces and computer driven tailoring for carefree handling in symmetric maneuvers. In rolling flight, there is an angle-of-attack limit of 26° with aileron authority progressively phased out, but in combat the pilot can physically override pitch and G-limiter. A typical sustained turn radius (at sea level) of 225 meters (738 feet) at 450 kph (246 kts) and 350 meters (1148 feet) at 800 kph (437 kts) can be achieved. Horizontal accelerations at Mach 0.85 of 11 m/sec<sup>2</sup> (36 ft/sec<sup>2</sup>) at sea level and 6.5 m/sec<sup>2</sup> (21.3 ft/sec<sup>2</sup>) at 6,000 meters (20,000 feet).

The MiG-29 is composed mainly of aluminum alloys with Al-Li skins over three spar wing boxes. The Number 1 fuel cell (2550 liter/674 US Gal) is located just ahead of the front spar which is an aluminum welded single component forming at the top of the inlet duct behind the louvers and forms a major part of the blended inboard wing. The door-type speed-brakes are located above and below the rear fuselage between the engines. There are four keel-beams, two between the engines and two outboard of which the latter are cantilevered at the rear to carry the vertical tails. There is overall 7° composite airframe structure with CFRP skins over the vertical tails, ailerons, flaps, rudders, and CRFP honey-comb on the aft part of the stabilator. Small specific areas utilize steel or titanium to meet strength and temperature demands.

Engines are separated leaving a deep and wide centerline channel. Rectangular inlets, 8° canted to match the taper of wing thickness, have fixed sharp 60° sloping lips which are well back under the wing for good recovery at extreme AOA. 100 mm gap for boundary layer and three upper hinged ramps to vary angle and throat area. The hinged front ramp, with 887 perforations, rotates fully down during engine start to completely close the inlet duct when aircraft weight is still on the nose gear oleo. Inlet air is obtained through five spring-loaded transverse louvers on the top of the inlet. During flight the front ramp could fail closed after a hydraulic failure, but up to Mach 0.85 required engine air could be obtained via the louvers.

Because of the Cold War "push and recover" logistics system, the Soviet war machine provided forward area support on a continual wartime basis. New aircraft and/or depot refurbished aircraft were programmed into the forward areas at a replacement rate consistent with a strict utilization-replacement cycle. Just about the time the aircraft would reach a minimum point in flight hours remaining, that is, the hours just above the required amount needed to actually fight a war (which was always kept on the aircraft), they would pull it out and send it back to the factory for a total refurbishment. This process was logical to the Russian military mind, both as a convenience and a safety factor, since combat generally afforded the same results and it guaranteed maximum production rates back home with adequate spare airframes. Spare aircraft were actually stockpiled at bases to ensure no problems in the readiness of the units by unforeseen losses. This type of replenishment assumed that almost all single engine failures would result in the loss of the aircraft. In fact, many single engine failures in the MiG-29, did end in the ejection of the pilot and not in the recovering the aircraft. This is one of the reasons why such careful engineering was put into the ejection systems. Redundancy of systems, focused on survival not just the completion of the mission, was only recently incorporated into Russian primarily because of the

requirements that accompanied the export of their MiG-29's and Su-27's.

Brassey's reports that the MiG-29 airframe service life is 2500 hours which could represent a 10 year lifespan at 250 hours per yer (20.8 hrs/month).

MiG-29 Flight Hours and Numbers:

Flying data for the Russian Air Force has been almost impossible to get. However, in August 1992, Colonel General Deinekin, CinC Russian Air Forces, presented a sortie summary (in hours) of one day's flying. The totals are broken out by each branch of service.

Russian Air Forces (VVS) 6798 (78.9%)  
 Russian Air Defense Forces (VPVO) 980 (11.4%)  
 Russian Naval Aviation (SNA) 432 (05.0%)  
 Strategic Rocket Forces (SRF) 409 (04.7%)

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 8619 hours

At there peak employment, there were less than 450 x MiG-29's operating in the Soviet Tactical Air Force (VVS) service. No MiG-29's were assigned to the National Air Defense Forces (Voyska-PVO). Considering what we know about their readiness, we can assume that on a daily basis the fleet was maintained at around 81% mission capable rate, which is an average of the Indian Air Force poor figures and Mikoyan's marketing promises.

Russian Conventional Forces Europe (CFE) data says that there are 372 x MiG-29's in the inventory of the Russian Air Forces today. If the VVS was maintained at its 3450 published inventory of combat aircraft, the 372 x MiG-29's represent 11% of the force structure. At 81% availability, we are looking at 301 x MiG-29's sharing 884 flight hours, or 2.94 hours per aircraft per flying day or about three sorties. Note that we are being optimistic because the Luftwaffe MiG-29 fleet in 1992, was recorded a 50% mission readiness rates per month for the year.

General Deinekin's numbers, represent one flying day's total. Let's face it, it may have been one of last real flying periods for the VVS considering how things are going now. It is clear that we are not sure about the total flight hours for a year or any period of time, but in our analysis of this one day's total, the 2.94 hours flown by a single MiG-29 equates to three 1.0 hrs. sorties. Average Luftwaffe MiG-29 sorties have been characterized by pilots as being no more than 1.0 to 1.2 hours long. An average Russian flying week is at least two days per week throughout an operational year of something less than 52 weeks, even considering cutbacks.

Russian aviation authority, Air Vice Marshal Tony Mason, mentioned in his paper The Soviet Air Forces: For Better or For Worse (CSRC, Nov 1990), that Air Defense units were restricted to 100 flying days per year and ammunition rationed. This is consistent with traditional VVS habits and serves our purposes. It takes at least one day of planning and scheduled maintenance to precede each flying day. It is because of this difference in the style of flying and maintaining the aircraft, that we do not have a clear apples-to-apples comparison of support activity numbers.

Therefore, we can conservatively estimate that a 52 week period, would net 104 flying days and a MiG-29 fleet of 301 machines could fly as much as 306 hours per year per aircraft. Also note here, that Indian Air Force literature mentions that they utilized their MiG-29's at about 100 flight hours per year, so that tells us our estimates are more than adequate to assume a adequately utilized Russian aircraft. We also assume that the MiG-29 fleet has been in place and flying in the VVS since 1985. Therefore, during the 10 years of flying operations, the MiG-29 fleet (in Russia) should have experienced no more than 921,060 flight hours.

The Indian Air Force reported that in 1992, they suffered a peak accident rate for the MiG-29 of 24 losses per 100,000 hours. When accidents increased, they appeared to follow a typical Russian solution method which was to stop flying for extended periods of time, all of which found the aircraft sitting on the ramp in full-up status benefiting the statistics but pilot proficiency continued to drop, placing them in a deadly accident prone spiral.

If the Russian Air Force was capable of cutting the Indian accident rate in half, that is to 12 aircraft per 100,000 hours (there is some verbal confirmation from sources on that range of numbers), then over the ten year period they would still have lost at least 110 airframes. Now with Belyakov's revelation that nearly 100 x MiG-29's were in storage all around the MiG plants, we can assume that the VVS had adequate replacement resources, but in the force structure downsizing many lost MiG's may have not been replaced or the units consolidated aircraft as they were disbanded.

Have the sortie and accidents rates remained the same or have they gotten worse..... or have they just quit flying.... which has been suggested by many western experts. Note that Peter Dye mentioned in his article on "Soviet Aircraft Maintenance" in Jane's Intelligence Review (April 1990, pg. 160-165) that the Russian Air Force, in general, was having

one accident every 5,000 flight hours, which translates to 20 accidents per 100,000 hours, and still well above our speculated 12 per 100,000. Therefore, we assume that the Russians could have realistically lost anywhere between 100 to 200 MiG-29's in accidents since 1985.

MilTech (6/95, pg 16) reported that.... "By 01Jan95, MAPO - the only manufacturer of the MiG-29 in the CIS States - had built 1,216 aircraft of the series. Over 300 of them are in service with the air forces of 14 countries outside the former Soviet Union." The article goes on to explain that "...upgrades have been so extensive, that it could be said that the current version retains nothing more than the airframe and the name of the original model." Now that is not completely true, because the Sokol facility in Nizhny Novgorod, is presently producing the MiG-29UB dual-seat trainer aircraft.

So now we can again ask, what is the total number of MiG-29's produced? The following summary is presented that identifies over 1,500 total airframes of all types and functions produced by MAPO-MiG and the SOKOL Production Facility. Compared with MilTech's 1,216 number, it might be reasonable. After the first 18 aircraft order to Malaysia were delivered and their 18 additional aircraft were ordered, there appeared to be around 80 more potential deliveries to India and Iran with attrition spares for other customers. The debt-for-aircraft programs in Eastern Europe would be directed at stored aircraft first, then production if the money was there. In some of the transfer deals, Moldova gave aircraft to Yeman, the Belarus provided aircraft to Peru, and the Russian Air Force gave Slovakia 26 machines right off their flight lines.

Today the listing includes 28 nations that includes South Africa with just engines (used in F-1 Mirages), the Czech Republic who has turned theirs over to the Polish Air Force, Moldova who has supplied Yeman, and Belarus who has supplied Peru. All combinations are possible.

Table 1: Total Mikoyan MiG-29 Production as of January 1997

Total MiG-29 Production Experience..... 1632

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 Export Production Inventory: 936  
 Developmental Prototypes 20 (14 +6C)  
 Surplus Aircraft in Flyable Storage 84  
 Present Russian Air Force Inventory 334 (304A/B + 30C)  
 Total "Fatback" Mod 1 Production 48  
 Total "Fatback" Mod 1 Kit Upgrades undetermined  
 Unreplaced Losses (est) 210

Belarus BeAF 045 remain of 071 aircraft delivered

60 x single-seat

11 x dual-seat

26 x to be or were transferred to Peru

00 x want to sell more

Bulgaria BuAF 034 aircraft delivered

18 x single seat

04 x dual-seat

12 x more a/c offer by Russia for debt repayment 3/96

Croatia CrAF 004 aircraft promised but not delivered

02 x single-seat from Russian AF

02 x dual-seat

Cuba CuAF 006 aircraft delivered

03 x remain operational

03 x used as spares

20 x ordered (18 + 2)

Czech Rep CzAF 000 aircraft remain of 17 delivered

09 x single-seat

01 x dual-seat

10 x a/c stored 01Jul94

20 x more were on order (18 + 2)

06 x single-seat received Dec95

01 x dual-seat received Jan95

10 x transferred to Poland 2/96

Germany Luftwaffe 024 aircraft delivered

20 x single-seat

04 x dual seat

08 x spares under consideration

Hungary HuAF 062 aircraft delivered

28 x single-seat

06 x original dual-seat

22 x Russian debt single-seat '94

06 x Russian debt dual-seat '94

26 x more debt payments under consideration

India InAF 110 aircraft ordered and delivered

65 x single-seat

59 x remaining with 6 accidents

05 x dual-seat

10 x attrition a/c by Dec 95

30 x more new a/c in 1996

Iraq IqAF 041 aircraft delivered

41 x delivered from 48 ordered

35 x single-seat

06 x dual-seat

25 x attrition

16 x remaining a/c in 1994

13 x single/3 dual-seat

08 x remain serviceable 2/96

all x reported being dismantled

07 x accidents

04 x downed by USAF missiles

02 x crashed during combat

07 x destroyed on the ground

04 x defected to Iran

01 x crash trying to defect in '95

Iran IrAF 034 aircraft delivered/annexed

14 x delivered from 14 ordered

12 x Single-seaters

02 x Dual-seaters

04 x Iraqi war escape a/c

16 x being delivered (14 + 2)

Kazakhstan KzAF 036 aircraft delivered

24 x single seat

04 x dual-seat

08 x delivered from Russian AF

14 x remain in service 1996

all flew 03Apr96 with 715th IAP @ Lugovoj

Korea DRP NKAF 014 aircraft delivered

11 x single-seat

03 x dual-seat

(more expected from VVS)

Malaysia RMAF 038 aircraft (36 + 02 static)

16 x single-seat

02 x dual-seat

02 x no-fly maintenance trainers

18 x new a/c with air-ref cap

Moldova MoAF 018 aircraft remain of 030 delivered

22 x single seat

08 x dual-seat

12 x transferred to Yeman

Myanmar/Burma MyAF 010 aircraft under consideration

04 x dual-seat trainers

06 x single-seat

Peru PuAF 026 aircraft ordered from Belarus

04 x delivered in '96, then hold on program

04 x dual-seat trainers

22 x single-seat

Poland PoAF 021 aircraft remain of 022 delivered

08 x single-seat

03 x dual-seat

01 x loss replacement

10 x Czech a/c delivered by 1/96

21 x total in service 3/96

Romania RoAF 018 aircraft delivered

16 x single-seat

02 x dual-seat

Russia VVS 334 aircraft remain active after 768 produced

704 x for the Air Force (VVS)

064 x for the NAVY (SNA)

601 x Fulcrum A & B

167 x dual-seat Fulcrum C

250 x remained in the Far East Districts

236 x remained in the Ukraine

030 x transferred to Moldova

030 x transferred to Uzbekistan

030 x transferred to Turkmenistan

036 x transferred to Kazakhstan

071 x transferred to Belarus

026 x given to Slovakia in '96

Slovakia SIAF 016 aircraft remain after 26 delivered

12 x single-seat

06 x from Russia in '93 for debts

05 x single-seat

01 x dual-seat

15 x remain in service by Jan95

07 x single seat on order Nov95

01 x dual-seat on order Nov95

26 x a/c received from VVS

South Africa SAAF 000 aircraft delivered, none ordered

40 x RD-33 engines for Mirage F1

Syria SyAF 048 aircraft delivered out of 120 desired

90 x ordered

30 x more under consideration

01 x Regiment / 3 x Squadrons

Turkmenistan TrAF 30 aircraft delivered

024 x single-seat

006 x dual-seat

Ukraine UkAF 180 remain from 236 aircraft delivered

158 x single-seat

014 x dual-seat

008 x dual-seat in May96 deal

Uzbekistan UzAF 30 aircraft delivered

024 x single-seat

006 x dual-seat

Yeman YeAF 012 transferred from Moldova

10 x single-seat

02 x dual-seat

05 x remain after civil war

Yugoslavia SbAF 016 aircraft delivered

14 x single-seat

01 x single-seat loss

01 x dual-seat

Total 1270 total 936 non-Russian & export aircraft

334 Russian aircraft

MiG-29, Part Three

By Easy Tartar  
MiG-29 Design Legacy:

### Later model MiG-29 (MAPO-MiG)

Basic fighter configurations have been historically developed at TsAGI (Central Aero & Hydrodynamics Institute). However, the current MiG-29 & Su-27 designs were developed at Sukhoi during a time when both bureaus were undergoing changes and tried to mix their talented teams with new blood. Russian designers have stated that the original general layout of the MiG-29 was developed by students at the Moscow Aeronautical Institute (MAI) under the tutelage of the former head of the Sukhoi Design Bureau. Detailed design work was passed on to the Sukhoi Bureau. The resultant configuration was evaluated by TsAGI, who in turn, tasked the Mikoyan Bureau to share in prototype development. The accepted design terms of reference were moderately separated twin-engines, twin-tail, blended fuselage and low wing loading.

Despite these particular bureau characteristics, Mikoyan had to stay within the constraints imposed by TsAGI. The unique design heredity of both Mikoyan and Sukhoi was then preserved. In the case of Mikoyan, there was a wide mix of materials and fabrication methods utilized in their aircraft. MiG-21/23 & 29 aircraft use highly refined welded steel center fuselage boxes that are produced with the best quality in the Soviet aerospace industry. These boxes are configured to carry several concentrated attachment loads for the wing, main landing gear trunnions, fuselage longerons, engine mounts, and internal gun mounts.

The rugged Mikoyan landing gear are obvious on both the MiG-29 and the MiG-31. The first noteworthy undercarriage characteristic is the even distribution of loads on the tires for rough field towing and sod field operations. The MiG-29 has larger, low pressure tires, filled to around 10 atmospheres, with a special ply that reduces their footprint. The MiG-31 has a tandem, dual-wheeled arrangement that is staggered or offset from each other to distribute footprint.

From the beginning, the MiG-29 was designed with simplified field maintenance and servicing in mind despite the fact that complexity was increasing. Most modifications to production aircraft have been to improve the "ilities". The latest change was described by Mikoyan engineers as steps to eliminate all system inspections during combat turns, thus allowing pilots to turn and load their own aircraft at dispersal sites. The on-board check-out capability is centered around the EKTRAN system, which could be thought of as the first Russian attempt at meaningful on-board diagnostics. Cockpit mounted panels and switches provide the interfaces.

Until the introduction of the Su-27 and MiG-31, long "range" and its associated "fuel load" have always been lacking on Soviet fighters in relation to their Western counterparts. But, "range" has always been more of a factor for the Soviet/Russian Air Defense Forces rather than the Tactical Air Forces because the later would always leap-frog to more forward bases. Poor engine specific fuel consumption (sfc) rates were usually blamed because Russian engine design stressed reliability & maintainability first, then "sfc". The MiG-29 has shown a bit of a reversal in this trend where its reliability has proved to be a disappointment and the "sfc" quite good. RD-33 engines also have their accessories on top, in line with the plane of the wing. This decreases cross-sectional area and wave drag. That means you have to drop the engine to get at the accessory package, which is just the opposite to what is done with the F-4 Phantom.

Designed with a strong emphasis on maneuverability, including sustained Ps (specific excess energy) equivalent to any modern fourth generation fighter from the west, the MiG-29 suffers from an extremely limited combat radius with a fuel quantity less than 23% of its published normal clean takeoff weight, which measures around 15,000 kg (33,000 lbs). There is a large 1500 liter (396 gal./2576 lbs.) center-line tank that is common to all MiG-29's and on later production examples, two wing mounted 1150 liter (304 gal./1975 lbs.) external tanks that utilize the same inboard radar missile stations. This exchange of the R-27 (AA-10) missile station for range/loiter removes the fighter's beyond visual range (BVR) missile capability. Advanced models have an option for two additional missile stations per wing allowing for the carriage of both BVR missiles and wing tanks, if advanced R-77 (AA-12) missiles are utilized.

The air superiority configuration of almost all operational MiG-29's consists of six missiles, a center line tank, full gun, and chaff/flares loaded on over-wing dispensers. The MiG-29 enjoys the combination of an advanced airframe design with two powerful RD-33 turbojet engines that produce a maximum speed in excess of 2.3 Mach. The max gross takeoff weight is at 18,500 kg. (40,785 lbs.), which is 500 kg (1100 lbs) above the first 100 series produced aircraft. The 38,472 lbs. normal combat configured takeoff weight leaves very little for growth. Takeoff Speed is specified at 260-280 kph. with takeoff distance running 1200 meters (3937 ft). A clean airshow style takeoff run with reheat could be accomplished at 250 meters and with dry power it would extend to 600-700 meters. Landing Speed of 250-260 kph while landing with the Drag Chute 600-700 meters. Max Landing Weight was noted to be 15760 kg (34,744 lbs). Service ceiling is published at 17,000 meters (56,000 ft.) with a maximum rate of climb 330 m/sec (65,000 ft/min) at sea level.

An exchange of 1150 liter wing tanks for radar missiles (AA-10) on the inboard most wing stations, actually nets around the same takeoff weight. Two wing tanks provide 3380 lbs of fuel to add to the centerline tank's 2576 lbs. Wing tanks can

be jettisoned easily, centerline tanks are generally only dropped in an emergency. When considering the present gross weight limits of production MiG-29's, advanced models have been pushed up to 19,500 kg. (42,990 lbs.), but to fully exploit additional wing stations the maximum gross weight would have to increase even further to around 20,000 kg. (44,000 lbs.). MAPO has stated that new or existing MiG-29 customers could purchase these upgrades for their aircraft.

Table 2: MiG-29 Combat Configuration Gross Weight

Operating Weight Empty .....	24,030lbs. (10,900 kg)
Normal clean Takeoff Weight.....	33,000 lbs.(14,970 kg)
Internal Fuselage/Wing Fuel .....	7,868 lbs. (3,569 kg)
4 x R-73 (AA-11) Missiles @ 232 lbs. each ....	464 lbs.(210 kg)
4 x R-73 missile rail/launchers @ 75 lbs.....	300 lbs.(136 kg)
2 x R-27 (AA-10) Missiles @ 560 lbs. each.....	1,120 lbs.(508 kg)
2 x R-27 missile rail/launchers @ 75 lbs .....	150 lbs.(68 kg)
170 rds of 30 mm @ 900 grams each.....	337 lbs.(153 kg)
1 x Centerline Fuel Tank & Pylon .....	420 lbs.(190 kg)
Centerline tank fuel (1500 liter).....	2,576 lbs.(1,168 kg)
chaff/flares in dispensers .....	105lbs. (48 kg)

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 Combat Configuration TOGW 38,472 lbs. (17,450 kg)

According to a Russian General Staff plan in 1992, ("Russian Airpower-The First Year Spring 1992 to Spring 1993, Blueprint for the Future", Major Brian J. Collins, USAF, 28Oct93, CSRC), it would try to maintain its 3,450 combat aircraft (CFE Treaty Limit of Equipment, CFE-TLE) allocation under present agreements. This ratio formula also allowed its closest neighbor, the Ukraine, to have 1,090 combat aircraft, which is more than any single Western European nation. This translates to only a 14% cut in Russian inventories and a 27% cut for the Ukraine. At that time, the Russian Tactical Air Forces (VVS) ended up with 14,000 aviators and 2,000 combat aircraft and 3,000 helicopters, so in over a year they had dropped another 1,500 airframes moving the reduction to over 30%.

VVS plans called for retaining the MiG-29 as a short-range fighter and the Su-27 as its long-range counterpart. However the future of the MiG-29 has remained a political question because of its limited abilities vis-a-vis the Su-27 and not having the money for upgrades or new airframes. Meanwhile, demands remain for more close air support (CAS) aircraft such as the Su-25 Frogfoot, deep interdiction platforms such as the Su-30/34 (Su-24 "Fencer" replacement), a multi-role fighter bomber already chosen to be the Su-35, and attack helicopters for Army aviation.

Reports from the Conflict Studies Research Center (CSRC) at RMA Sandhurst say that except for very small numbers, the VVS has stopped buying new fighter aircraft in 1994, and pilots struggling to get as little as 50 flight hours per year. One celebrated courts martial noted officers logging non-existent flight time on the aircraft with ID numbers the same as those mounted on pylons at the base front gate in order that they could continue getting flight pay. There are, however, some developmental aircraft prototypes (all Sukhoi) being delivered to the testing organizations and a few MiG-31's to the Air Defense Forces.

In the Flight International (15-21 Jun94, pg 22), ex-Mikoyan Deputy Designer, Alex Velovich (see Code One, April 1993) reported from Moscow that Russian Prime Minister, Victor Chernomyrdin, has held discussions with the Chinese to overcome an impasse which has stopped the second batch buy of Su-27's. Chernomyrdin visited Beijing and tried to help negotiate on behalf of the Chinese who were stuck with a demand from the Russian State Arms Export Agency, Rosvooruzheniye, who has insisted on being paid mostly in cash (US dollars). The PLA wants a follow-on 24-26 aircraft with an eventual license for manufacture and payment based on goods-barter, not cash.

Russia's withdrawal from a "barter" or "counter-trade" solution also delayed the signing of the MiG-29 contract with the Malaysian Air Force, but it was finally signed in Kuala Lumpur on 07Jun94, by Deputy Prime Minister Oleg Soskovets with Malaysian Deputy Prime Minister Anwar Ibrahim. According to Vladimir Kuzmin, then General Manager of the MAPO Production Plant, less than half of the value of the contract would be paid in barter goods (around 25% palm oil, clothing, & fabric). The original agreement with Malaysia was worth \$600 million for 18 x Fulcrums, and the Russians would honor a \$220 million offset arrangement. All eighteen aircraft (16 single-seat and 2 dual-seat) will be delivered within 12 months which is why we have seen the re-start of the production line in Moscow move so quickly. This should also loom in the western leaderships mind of what could happen if the Russian nation mobilized again. The industry sits waiting, it is not dead and removed.

A no-cost pair of MiG-29's have already been provided to a joint-venture customer service center for maintenance technician training and research. A MiG-29 simulator is being produced by CAE Electronics, a Canadian company. The Malaysians are expected to get the full weapons fit for the MiG-29 and the importance of the sale has raised the possibility of helicopter and transport sales. Regionally, Mikoyan would now be in a better position to seek sales in Thailand, China, Indonesia, the Philippines, and Vietnam.

The Malaysian MiG-29's were at first considered to be a "fat back" Fulcrum A mod 1. By the time the aircraft started delivery in July 1995 it became clear that the RMAF MiG-29's would be basic Fulcrum A (non-fatback variety), but with MiG-29S flight control, suspension, and weapon system upgrades. Unique to Malaysia is the new reliability gear box on the engines and the flight control roll limiter and rudder enhancer. Malaysia's requirement for a multi-role fighter brought in a new MiG-29 multiple-ejector rack, similar to the one seen on the MiG-25 Foxbat, that will carry four 250 of 500 kg. bombs or stores. In the air-to-ground mode, the RMAF MiG-29's utilizes laser or radar ranging for a "Dive-Toss" type solution. No pure "CCIP" or "CCRP" like modes have been seen.

In an interview with Chris Pocock (Aviation International News) at the 1995 Dubai Air Show, Kuzmin stated that all 18 Malaysian jets were delivered on time and that each aircraft has now surpassed 100 flying hours as the RMAF pilots undergo intensive training. He also said that not one negative word has been said by the RMAF HQ or MoD.

The MiG-29S/SE/SD/SM "Fulcrum A" and "Fulcrum C":

The second pre-production MiG-29 (model 9-13) was built with the "fatback" provisions. It made its first flight at the hands of Test Pilot V.M. Gorbunov on 23 Dec 1980. NATO originally called it the Fulcrum C and the designers could not agree on just how many gallons of extra fuel were added (16 to 53 guess). The bulged spine also led to conjecture about active jammers and improved ground-attack capability whereas the additional fuel was stored in the modified #1 fuel cell and the redesigned LEX.

In late 1992, the MiG-29"S" was considered "in-service" (IOC) with the Russian Air Force. It was later found that only 48, less than one Regiment, was delivered to the VVS directly from Mikoyan and they were immediately posted to East Germany, at Eberswalde (Finow; 16th Guards Division, 787th Regiment). Meanwhile, "fatback" upgrade kits were being installed on Fulcrum A aircraft returning to Mikoyan for retrofit. These events continued the mystique that the aircraft were in "mass production" and the confusion over "A" or "C" variants. All Fulcrums were pulled out of Germany in 1993.

Chief Designer Waldenberg, praised the MiG-29S as one of the two newest Mikoyan models just being introduced for export world wide. The following descriptions of the MiG-29S (SE, SD, and SM) and the MiG-29M will attempt to explain the many modernization options being offered to MAPO-MiG customers. Designations will be applied when they are known.

The core difference in the upgraded Fulcrum A with the "fat back" modification and the production MiG-29S start with the improvements in the flight control system where four new computers provide better stability augmentation and controllability with an increase in AOA and G-limits. The MiG-29S adds 2° more to the maximum angle-of-attack (AOA). Its improved mechanical-hydraulic flight control system then allows for greater control surface deflections.

The production MiG-29S further increased the internal fuel due to new fuel cells in the wing-LEX/fuselage interface area (1500 liters/2576 pounds). It also can carry the 1150 liter (304 US Gal. / 2060 lbs.) external fuel tanks under each wing and the traditional centerline tank. Inboard underwing hardpoints are upgraded to allow for a tandem pylon arrangement (like a Multiple-Ejector-Rack) for a larger ordnance payload of 4,000 kg. (8,820 lbs.). The overall max-gross weight has been raised to 20,000 kg. (44,000 lbs.). The GSh-30-1 cannon also had its expended round ejector port modified to allow for firing while the centerline tank was still attached.

Underwing missile hardpoints can be increased from the normal six (three on each wing) to eight, and all carry the new R-77 (AA-12 "Adder") active-radar long range air-to-air missile or a mix of air-to-ground missiles. In JDW (19Sep92, pg18) Waldenberg was quoted as saying that this MiG-29 improvement would allow for missiles like the R-27E (AA-10 "Alamo") which has 1.5 times the range of the basic model R-27 "Alamo" due to its larger rocket motor. These long-burn variants have previously been only found on the Su-27 Flanker. Waldenberg also could not say how many aircraft would be produced, but he did confirm that the 48 delivered MiG-29S aircraft would remain in operational units of the Russian Air Force. He went on to say that he was constantly marketing the upgrade package.

The MiG-29S improvement kit also provides for an even more advanced Phazotron NO-019M radar which then gave the aircraft the designation MiG-29"SD". Initially the MiG-29S (Fulcrum A) had just a new sighting system (IRST) combined with a better imbedded training system that allowed for IR and radar target simulation. More built-in-test (BIT) equipment, especially for the radar, was included in the EKTRAN to reduce dependence on ground support equipment. Revised weapon system algorithms in the MiG-29SD and software combined with an increase in processing capacity allows for the tracking of up to ten targets and the simultaneous engagement of two with the RVV-AE missile.

While the MiG-29SD can carry air-to-ground ordnance and has an internal jammer, it is the MiG-29"SM" variant that has the improved avionics necessary to carry and employ precision guided weapons, such as the X-29TE (Kh-29 "Kedge" AS-14) missile. Thus the multi-role nature of the MiG-29 gets introduced.

The SE/SD/SM improvements in the MiG-29S, combined with the development money made available for the naval MiG-29K, gave MAPO the incentive to forge ahead with the MiG-29M "Super Fulcrum".

## The MiG-29M "Fulcrum E":

The MiG-29 "M" is the 11th Fulcrum variant being marketed as a further improved model. It actually covers every possible design area that could be improved, but to date, it will not be a part of the new Russian Air Force (JDW, 07Dec91, pg1110). In many ways it is the "land-based" version of the naval MiG-29K, and of course, there would be a MiG-29ME export version which already has been offered to India. The dimensions are practically the same as the MiG-29S family, but the airframe and avionics are substantially different, even greater than the changes from the F-16A to the F-16C. It was the export nature of the MiG-29M that led to the debate over whether or not to rename it the new MiG-29, or a MiG-30 or 33, but Waldenberg insisted that the MiG-29 label was famous enough and the original designation should be maintained. Waldenberg was quoted as saying (JDW, 22Aug92, pg5) that the MiG-29M would have an export price of around \$30 million. He also stated that the six MiG-29M prototypes were all flying by the end of 1992. Both the MiG-29S and the MiG-29M first appeared at the 1992 Farnborough Air Show. The first of the six prototypes flew in 1986 and by 1989, one flew with an uprated 19,400 lbs (8800 kg / 43.05 kNt) RD-33K engine that was developed for the naval variant.

Anatoly Belosvet said in Dubai (1995) that flight tests on the MiG-29M were effectively completed and the Russian Air Force certified the aircraft ready for series production. But a production decision will not be forthcoming until they complete their evaluation of the Sukhoi Su-35. With the new fly-by-wire control system, new Zhuk radar, and 1500 liters more internal fuel, Belosvet says that the MiG-29M is 1.5 as good as the basic MiG-29.

The MiG-29M Fulcrum E has a new fuselage structure, internal equipment, new wings, distinctively larger tail-planes with saw-tooth leading edge, and fins. The improved aerodynamic configuration is characterized by a repositioned, enlarged, and sharper wing-leading-edge-extensions that provide double the lift of earlier MiG-29's for increased handling at low speeds, a fallout of the shipboard requirements. Lower effective wing loading is also obtained, although leading edge slats still program full-up or full-down according to AOA thresholds and cockpit switch positions.

There is a welded aluminum-lithium center section wing-box backed-up by thicker welded steel in front of the main landing gear (MLG) which appears to be for a beef-up of the structure and the landing gear. But the use of the lithium-aluminum welded alloys in the forward fuselage allows for needed weight reductions and added fuel volume.

Internal fuel volume has been increased another 2576 lbs. (396 gal./1168 kg./1500 liters) to 10,444 lbs. (1607 gal./4737 kg./6082 liters) with an additional 1.76 cubic feet of avionics space. Honeycomb composite materials are also widely used. The chaff and flare dispensers have been relocated from the top of the wing to an integral housing under a panel on the upper side of the fuselage.

The airframe has a more tapered radome with a nose lengthened around 7.5 in (20 cm), a wider and longer dorsal spine, a longer canopy, a slightly changed wing position (aft) more rounded wing tip trailing edges, and a new ramp without suck-air louvers on top. The FOD doors that used these vents have been removed in favor of a more effective screen system in the duct itself, similar to the Su-27 and first seen on the Naval MiG-29K. The inlet redesign also increased mass flow at takeoff. The landing rollout distance has been decreased by modifications in the air brakes and brake parachute as well as a strengthened undercarriage. The effects on range/payload by eliminating of the upper air ducts and the sacrificing of trim and longitudinal stability have been compensated for by the fly-by-wire control system. Large easy-to-remove hatches give unobstructed access to the equipment.

There is an even longer/wider dorsal spine, a reduced gun load to 150 rounds (30mm), increased span ailerons, bulged wingtips with fore/aft ECM antennas, eight underwing hardpoints, larger airbrake above the fuselage, and full provisions for precision guided munitions and advanced BVR weapons. Twin vertical tails are properly positioned to enhance high "AOA" stability. The reshaped nose houses a completely upgraded weapons system featuring the N-010 radar, a newIRST with TV and integral laser designator. The frameless canopy is longer and has increased visibility over the nose by 15%. And a new high-tech "glass" cockpit offers the latest display and computer technology available in Russian aerospace.

Concerning the cockpit upgrades, Waldenberg said that the MiG-29M has a HUD and two CRT displays, but no primary flight instruments were displayed on them. Those flight-data tasks were still being done by mechanical-electrical devices. The pilot will fly with a center-stick column that has half it's feel-force reduced. The displays themselves are quite impressive. They utilize a stick-grip and throttle-handle actuated three-position switch option at each identified perimeter location. This is combined with some of the most sophisticated raster scan techniques in the displays to insure that the complex Russian letters and symbols get correctly drawn.

The new "Zhuk" ("Beetle") radar is a dual-mode system for both air-to-air and air-to-ground operations. There are the full eight wing stations (four under each wing) which can all carry the RVV-AAE (R-77) missiles. TV, laser, and active RF guided air-to-ground guided weapons are carried. The Infrared Search and Track System (IRST) has been upgraded to include a TV capability. High reliability features have been given priority to allow pilots with limited flight time to overcome failure situations through simple procedures.

The fact that the HUD is not a primary flight instrument in any Russian aircraft plus the fact that primary aircraft attitude is referenced off of a fixed wing-line horizon standard and not the actual world horizon greatly complicates the integration of the cockpit and the ability of the pilot to grasp a real world look outside. Of all factors that separate the Russian style of flying from the Western style, the "gyro-reference standard" is the greatest, and short of total automation, continues to prevent the Russian designers from getting a complete understanding of man-in-the-loop system fusion.

The MiG-29M is the first Fulcrum with a full quadruplex fly-by-wire flight control system that, according to Waldenberg, combines both analog and digital devices incorporating multiple redundancies and utilizes relaxed static stability. Maneuvering performance has been maintained but there has been a substantial increase in permissible angle-of-attack (AOA) over the present 30° and acceptable G-loading. He also mentioned his continuing distrust in full-digital systems, taking note of JAS-39 Gripen and F-22 crashes. The SOS-3 stall/limiter system allows for unrestricted use of high AOA which is automatically combined with a roll/yaw limiter a graduated 17 kg. (38 lbs.) stick-force inducer. There are no control limits imposed where G-limits do not exist, thus allowing for slow speed scissors and tail slides. Spins are impossible to enter unless the limiter is turned off. Engines are considered unrestricted (100% efficient anti-surge system) throughout the operation envelope and on the edges exhibiting record accel rates from idle to max thrust with any weapons being employed. Takeoff T/W has been maintained at 1:1.

The MiG-29M is considered to be a true multi-role aircraft with many new standoff air-to-surface weapons incorporated. The detection range of the radar has not been increased, but its versatility and resistance to jamming is much greater. The air-to-air capability of the Zhuk Radar includes tracking of up to ten targets with the simultaneous engagement of 2 to 4 targets whether in look-up or look-down environments. The air-to-surface modes include active beam mapping, synthetic aperture, electronic magnification and image freeze, as well as compensation packages for unguided armaments. There is a new infra-red receiver, an enhanced laser range finder, a laser spot detector (including externally generated), and a carriage of up to four semi-active laser guided air-to-surface rockets. TheIRST has a television channel with a magnified range capability. The helmet mounted sight has been made lighter. In the cockpit there are two multi-functional displays and a new HUD. All weapons can be operated from the flight control levers (stick and throttle). Wing pylon stations have been incised from six to eight. The centerline station has been retained. The maximum bomb loading is 4.5 tons (9,000 lbs.).

There is an advanced defensive radar illumination, analysis, and launch-alert warning system tied to an active jamming system. The aircraft can also guide and operate the well publicized Kh-25MP (AS-14) and Kh-31P (AS-17) air-to-surface and anti-radiation missiles respectively. There can also be loaded at least eight air-to-air missiles, the latest of which (R-77) is the counterpart to AMRAAM. It includes inertial with radio corrected navigation and final active homing. Up to four "Alamo" semi-active air-to-air missiles (R-27) can be loaded, two of which could be the extended range ("long-burn" motor) models. The new NO-010 radar however, was reported as being a disappointment to the Russian Air Force, after they found its target detection capability less than needed to properly employ the longer range R-27E and R-77 "Adder" missiles. This may be one of the reasons for the popularity of the Sukhoi Su-35 and Su-30 "Flanker" derivatives.

MAPO-MiG data estimates that the average operating time for the MiG-29M is 9.0 hours, and operational availability is about 90%. The average preparation time for an aircraft is 30 minutes and for subsequent flight around 15-25 minutes. Servicing requirements amount to 11.5 manhours per flying hour. A squadron of 20 aircraft will require 250 maintenance personnel.

Jane's Defense Week (9Dec95, pg12) reported that the Indian Air Force will take delivery of its last MiG-29M in mid-December. Vadmir Kuzmin, head of MAPO-MiG, said that the 10 x MiG-29M's are equipped with medium range missiles and an enhanced radar capable of 10 targets and simultaneous attacks on 2 of them. However, the continued discussion describes more the MiG-29SM than the true advanced MiG-29M.

Table 3: Summary of MiG-29M Fulcrum E improvements:

Normal Max TOGW: 15,000 kg. (33,068 lbs.)  
 Increased Max TOGW to: 20,000 kg. (44,000 lbs.)  
 Normal Internal Fuel Load: 3,990 kg. (8800 lbs.) 5,125 liters (1,354 gal.)  
 Increased Internal Fuel Load: 4,737 kg. (10,444 lbs.) 6,082 liters (1,607 gal.)  
 Airframe Service Life: 3000 to 4000 hours  
 Maximum G loading to: 9.0  
 Negative G limit: 17 seconds (voice warning)  
 External Fuel Tanks: 1, 2, or 3 in combat  
 Takeoff Speed: 260-280 kph.  
 Rate of Climb at SL: 330 m/s (65,000 ft/min)  
 Weapon Wing Stations: 6 with growth to 8  
 A/A Wpns Modernization: new R-77 (AA-12)  
 A/G Wpns Modernization: PGM's (EO/TV/Laser)  
 Cockpit Avionics: western modernization

Engine Overhaul Cycle: increased to 750 hrs.  
 Engine Overhaul Growth: increase to 1400 hrs.  
 Max (wet) Thrust in A/B 8,300 kg.  
 Max Take-off T/W 1:1  
 Max level flight at SL 1500 kph.  
 Max level flight at altitude: 2400 kph.  
 Max Mach Number at alt: 2.3  
 Service Ceiling: 18,000 m. (60,000 ft)  
 Max Flight Range clean: 1,500 km. (820 NM.)  
 Max Flight Rnge/ CL Tank: 2,100 km. (1148 NM.)  
 Max Flight Rnge/ 3 x Tk's: 2,900 km. (1586 NM.)  
 Accel time at 1000 m (3280 ft) 600 to 1100 kph 13.5 seconds  
 1100 to 1400 kph 8.7 seconds

MiG-29, Part Four  
 By Easy Tartar

The German Luftwaffe MiG-29 Experience:

Former East-German MiG-29 taxies

In April 1991, LtGen. Jörg Kuebart, became the Chief of Staff of the new post-Cold War consolidated German Air Force (Luftwaffe) after serving two years as the Deputy Commander and Chief AAFCE. His initial description of the MiG-29 was that it was "...a good fighter airplane, and it is relatively easy to maintain. But it carries one very big disadvantage - depending upon the Soviets for industrial support. At present our flying rate is going down, because we lack spare parts. We have been involved in extensive talks with the Soviets, but as of today I haven't received any spare parts (Armed Forces Journal International, Dec91, pg 49)."

"We intend to make only minimum modifications necessary to be able to fly the aircraft safely in Western air space..... TACAN, IFF, and a second emergency horizon. In addition, the instruments and panels must be inscribed in English."

Chief Mikoyan Designer Rotislav Belyakov, and his deputy, Mikhail Waldenberg, always tried to out do each other on the marketing circuit with the "tactical" exploits of the MiG-29. We have to examine this because MAPO has deliberately mislead potential customers with "data" they say was officially generated by their MiG-29's serving with the German "Luftwaffe" in NATO. Data that is sometimes not there or taken far out of context.

After the 1994 Farnborough Air Show there was one such description of how the MiG-29 was performing in the new Germany. Belyakov and Waldenberg gave Luftwaffe MiG-29's credit for winning "BVR duels" against USAF F-15's and F-16's despite their use of ECM. They praised the MiG-29's well maintained radar, powerful transmitter, and "long range target detection capability" with a very small radar cross section, high ECCM hardening, and more capable BVR missiles. They did admit, however, that the MiG-29 reaches a 9G capability only after the fuel volume is internal. It was also assumed, by them in their calculations, that the Sparrow missile did not get a radar semi-active midcourse update against a maneuvering target, which is wrong. In reality, the German Air Force MiG-29 experience against other NATO aircraft has been only allowed in deliberately controlled training situations, more to educate pilots than to assess superiority. The Luftwaffe feels caught between intense political pressure by the Russians to validate the MiG-29 in a NATO environment, as well as the natural desire by the NATO pilots to "fight" the Fulcrum flown by better trained pilots.

Initially the newly assimilated East German MiG-29 Wing (JG.3 changed later to JG.73), at Preschen still manned by its original cadre, proved unsatisfactory according to NATO standards, in both airmanship and tactical know-how. Only after existing Luftwaffe F-4, Tornado, and F-15 exchange pilots re-built the squadron, did a more realistic use of the MiG-29 occur.

To say that the communist trained East Germans were innovatively hampered by their own dielectric approach to training and operationally shackled by Russian authority as to "when" and "how much" to fly, would be a gross understatement. NATO pilots were quite amazed and confused over the fact that most of these East German "elite" pilots appeared not "care" about flying and had little interest in doing anything innovative with their training once they did get a chance to fly.

At the NATO F-16 Fighter Weapons Instructor's (FWIT-89) symposium, with a select gathering of Instructor Pilots (IP's), not just from NATO, but all over the world, the first face-to-face discussions were made with the Commander and tactical flight leaders of the Preschen Wing. The results were heart-breaking for those US & European trained pilots who sacrificed so much to stay on the razor's edge, although it was a relief to realize that clearly the Western approach to training was far superior. The average NATO pilot in that room had a far greater comprehension of the MiG-29's

capabilities than did any of the MiG pilot's themselves. Almost all of the visitors spoke German and more than half Russian. There were no communication gaps, it was a straight forward pilot-to-pilot talk. The results were simple, the MiG pilot's perceived their flying tasks as a second or third priority to their personal agendas, which were first and foremost.

This must have impressed the Luftwaffe enough to be concerned about their security reliability. Soon after that, the decision was made to release almost all of the ex-East German pilots from the service and the units were re-organized or disbanded. But once the political decision was made to keep the MiG-29's in the German Air Force, the pressure from the Russian military and aerospace industry became intense as they tried to find any data that would support their claims of parallel or better suitability of the MiG-29 to NATO aircraft. In fact, what they are trying to do, was to take western experience with the MiG-29 and leverage it in the export marketplace. Fortunately, but not surprisingly, it has not been believed.

#### Luftwaffe MiG-29 Maintenance / Support Observations:

Although Luftwaffe MiG-29's were dispersed to hardened shelters, maintenance was performed in several large hangers found at the Preschen main base and this concept continues at Laage Air base where they are presently garrisoned. Peacetime conditions allow them to continue operations from a central ramp area with associated hangars. Ground support, test, and repair equipment are generally concentrated in these hangars.

A 12-year service period was planned for the Luftwaffe MiG-29 aircraft. Their analysis of the aircraft concluded that it is very dependable, but the dependability was achieved at the expense of requiring short overhaul intervals. The frequent overhaul costs were high because they included failures and repairs, manpower, limited spares, and operating money. Therefore, the logistics support effort of the MiG-29's become significant for just 24 aircraft.

Under the German concept of maintenance, inspections and overhaul repairs for engines and airframes were accomplished at the squadron level in these central hangers. The 24 x MiG-29 aircraft, which for NATO was just a slightly larger squadron sized unit, become the on site Wing and the Base level organization. In effect, the unique basing arrangement offered a depot level environment for these 24 x MiG-29's. This is a practical approach which keeps all resources under German physical control. However, the technical data provided was all in Russian and required Russian speaking personnel.

The Luftwaffe inherited 30 x RD-33 engines which were all due for major overhaul. The initial aircraft servicing contract was let to the Dresden based Elbe-Flugzeugwerke Ltd. by the German MoD. 13 x additional RD-33 engines were also procured and short term recoup programs were devised. By making modifications to the turbine section to reduce operating temperatures in peacetime (equates to reduced thrust for the pilots) the Luftwaffe hoped to extend the life of the engines, reduce their support costs, as well as increase the overhaul interval from their original 350 hour prediction to 700-750 hours, depending on engine age. This innovation did not address combat demands upon the engine. Consequently, one may infer that a combat engine setting will be incorporated in the engine modification kit to facilitate higher performance under wartime conditions. For peacetime training, this lower thrust setting was used, but it still gave the Fulcrum respectable performance.

Airframe special inspections are usually required at 800 hours. Innovations are being made by the Luftwaffe to extend the inspection interval by 300 hours and to reduce the intensity of the inspection. The Luftwaffe had to overhaul all aircraft within 4 years even with the extended interval and revised inspection work package. The result of these overhauls has been an extension of the service life to the year 2003.

Airframe avionics updates were necessary to meet German national and international air traffic standards (ICAO). They were scheduled and completed by the end of 1994, thus allowing the Luftwaffe to fly their MiG-29's inside and outside of German airspace without escort. Upgrades included converting MiG-29 communications (radios), navigation aids, and re-instrumenting the cockpit to an English standard used by the West. The MiG-29 weapon system was somewhat simplified in that the laser ranger was de-activated, because it posed an airborne safety hazard to other pilots and ground personnel.

Maintenance support personnel were screened and identified from the former DDR Air Force (NVA) members. Enough quality maintenance personnel were found to create an initial support cadre for the MiG-29 unit but follow-on personnel would have to be trained on-the-job.

Translation of technical information into the German language was a difficult problem. The Russians delivered their technical and flight publications in Russian, not the familiar English as done with normal export customers. Of the 70 manuals and documents which were only available in Russian, the translation took two years to complete.

The Luftwaffe also found in 1992 that 300 pieces of ground support equipment, test sets, and special tools were not kept in serviceable condition by the former owners and required repair. This expensive and important equipment had to be repaired in order to support the MiG-29. Little maintenance on the equipment was accomplished since 1988. In five years

almost all of their support equipment had degraded to the point of becoming unusable.

But, with all the above said, don't make the mistake of thinking that the Luftwaffe's MiG-29 wing is not capable of performing its mission. It works harder, but the pilots and men have integrated the Fulcrum successfully into a NATO role. The NATO Tactical Air Meet 1995 (TAM-95) demonstrated their proficiency and competence.

The Indian Air Force (InAF) MiG-29 Experience:

The Comptroller and Auditor General of India published on 31 March 1993 the results of an in depth study on the operational performance and reliability of the MiG-29 aircraft. This study was first reported in Aviation Week & Space Technology during 25 July 1994 (pg.49), and has been obtained by author from Mr. Pushpindar Singh, of the Society of Aerospace Studies, New Delhi.

65 x MiG-29 single-seat and 5 x dual-seat trainers with 48 x spare engines (sparing factor of 0.7/aircraft) were delivered between 1986 and 1990 at a total program cost of approximately \$600 million that included initial spares and support. These aircraft were the first MiG-29's to ever leave the Soviet Union and were not up to the weapons system standard of those that went later to the Warsaw Pact allies. The aircraft were sent disassembled by sea, and re-assembled, and test flown in India. By 1990 three squadrons were operational. Two Flight Data Ground Processing Units were included to help pilots debrief their utilization of flight controls and systems. Expectations were that single-seat aircraft would fly 15 hours per month (180 hrs/yr) and dual-seat aircraft 20 hours per month (240 hrs/yr).

There were extensive problems encountered in operational and maintenance due to the large number of pre-mature failures of engines, components, and systems. Of the total of 189 engines in service, 139 engines (74%) failed prematurely and had been withdrawn from service by July 1992, thus effectively shutting down operations. 62 of these engines had not even accomplished 50% of their 300 hours first overhaul point. Thus the desired serviceability showed a steadily decreasing trend.

Engineering reports mainly attribute RD-33 failures to design/material deficiencies causing discolored engine oil (8), cracks in the nozzle guide vanes (31), and surprisingly, foreign object damage (FOD). The eight material deficient engines (discolored oil) were repaired by the contractor under warranty provisions, but the engines had to be recycled to the manufacturer. The thirty-one engines with cracks in their nozzle guide vanes were fixed in the field by contractor teams and adjustments were made to the entire engine fleet. But even though the incidents reduced the occurrences of the cracks, they continued. But the FOD situation is the most interesting, especially after the inlet FOD doors received world press coverage, but there were other concerns about production quality control that led to problems.

Since the Indian Air Force received early model Fulcrum A's, some just after the 200th production article, there were quality control deficiencies that resulted in numerous pieces of FOD (foreign object damage) and tools being left behind after final construction inside of the aircraft. Remember that the Fulcrum skeleton is made first and then the skin is riveted over top, in the way aircraft were made in the fifties and sixties in the West. Nuts, bolts, tools, etc. all made their way to the engine bays and inlet ducts and when they were loosened up after accelerations they damaged engines and equipment.

On top of all this, it was discovered that the unique FOD doors on the MiG-29's inlets were not stopping material from getting into the engine ducts. Since the doors retracted "up" into the inlet, debris that was kicked up by the nose wheel lodged on or at the bottom of the door seal and then was ingested into the engine when the door opened during the nose gear lifted off the ground during takeoff.

This problem was known from the earliest days. After the first four MiG-29 prototypes were evaluated, the nose gear was moved further back, but nose wheel "mud-flaps" or guards were still required to protect the engine from flying debris. It took until 1988 before all delivered aircraft were so equipped, therefore the initial batch of InAF aircraft had to be locally retro-fitted with mud guards and that activity was not completed until June 1992. All costs were supposed to be reimbursed by the contractor but Mikoyan reneged and left the InAF with \$300,000 in liabilities. In subsequent MiG-29K/M models the FOD doors were replaced by screens that closed "down", forcing any debris out of the louvers repositioned to the lower side of the inlet duct.

The Indian Air Force procurement contract was concluded in September 1986, and the first engine was expected to go into overhaul in 1989. However, four engines prematurely came up for overhaul and no repair facility had been prepared. As time went on, 115 of the 122 engines (94%) prematurely failed and had to be re-cycled through engine depots in Russia at great cost. Backlogs were created and only 79 (65%) engines returned on schedule. Even when a regional Indian repair facility was completed in August 1994, the high failure rates continued and the majority of broken engines had to be sent back to Russian depots. Self-sufficiency was achieved in 1994, only after the operations tempo was significantly reduced on a permanent basis. In the process of refurbishing failed engines, the total technical life of most of the engine fleet was effectively reduced from 800 hours / 8 years to 400 hours / 4 years, at a minimum.

Non-availability of radar and weapon system components also resulted in the grounding of seven aircraft for a period of

six to twenty months. Two may have been damaged for life due to cannibalization. Besides this, a large number of subsystems and computers experienced unpredicted failures in the last four years which adversely effected the operational readiness of the squadrons. Some of the computers were field-repaired by specialists from the manufacturers, others were replaced. These repair costs were all in excess to the initial contract costs. It was noted that the 10 additional computers, which were imported, cost the InAF around \$806,000. Two Flight Data Ground Processing Units quickly became unserviceable during their warranty period and have been lying un-utilized and un-repaired for over two years.

The InAF Headquarters also noted in March 1991 report that a severe shortage of product support equipment had resulted in the decline of fleet availability by 15-20%, which in turn, took negative effect on operational readiness and mission requirements.

So in general, lessons learned from this first out-of-country operation of a Russian front line fighter were:

1. The MiG-29 had intensive problems in operation and maintenance since its induction due to premature failure of engines, components, and systems. 74% of the engines failed within five years, were out of supply pipeline for three years, and reduced aircraft availability by 15, to 20%. This led to a decision to restrict flying efforts and therefore compromised operational and training commitments.
2. There were significant shortfalls in the performance of the MiG-29 fleet resulting in operational and training inadequacies. The shortfall ranged from 20 to 65% in respect to combat aircraft availability and 58 to 84% in trainers between 1987 - 1991.
3. There was a mismatch between induction of the aircraft (1987) and the establishment of its repair facilities (end of 1994). Until that time engines had to be continually sent to manufacturers abroad at great monetary cost, reduction of one-half total life, and a significant stretch of schedule.
4. Non-availability of critical radar components and spares resulted in the grounding of significant numbers of aircraft. Five aircraft were out of action for over six months while two were in the hanger for over two years. Unserviceability of computers and the inability to fix them cost excessive amounts of money to rectify.
5. The pilot debrief Ground Data Processing Unit, imported at high cost, was left lying around unserviceable and unused since its reception in August 1990.
6. The lack of nose wheel mud guards had to be solved by importing upgrade kits and expensive local re-design after material deficiencies could not be overcome.

With a regional support capability in place (regardless of how tenuous it was) and having one of the few respectable MiG-29 operating legacies, the Indian aerospace companies, especially Hindistan Aeronautical Ltd. (HAL), and the InAF became natural partners for MAPO in consummating the sale of MiG-29's to Malaysia. They were offered the opportunity to get involved with providing training and logistics support for the new Malaysian MiG-29 program. India, of course, gives greater credibility to MAPO in convincing customers that the MiG-29 is a viable fighter candidate for Pacific Rim nations. It remains to be seen, however, what solutions the new joint venture brings to the Indian Air Force problems.

#### The MiG-29 Combat Legacy:

If we examine the actual combat performance of the MiG-29, the data shows a more subdued track record despite zealous reports from MAPO-MiG. During the Gulf War, the only enemy fighter to be shot down by an Iraqi MiG-29 was another Iraqi fighter. A MiG-23 who happened to be the guy's wingman and unfortunately the MiG-29 pilot hit the ground after killing it. Meanwhile the USAF downed 4 x MiG-29's during the war (all with AIM-7 Sparrow's) and a fifth one crashed as a result of a maneuvering suicide during an engagement with an F-15. The F-15's wingman downed a MiG-29 with an AIM-7. Seven more MiG-29's were destroyed by air-to-ground munitions or coalition ground forces and four defected to Iran. After the Gulf War, during the Northern Watch patrols over northern Iraq, a USAF F-16 downed a MiG-29 with an AMRAAM (AIM-120) missile.

In other theaters, the new Federal Yugoslav Air Force (Serbia proper), designated the "RViPVO" (Ratno Vazduhoplovstvo i Protivvazdušna Odbrana), on 08 Oct 91, attacked Croatian's Presidential Palace in Zagreb with 2 x MiG-29's delivering 57mm air-to-ground rockets. This was the first report of MiG-29's being used in the air-to-ground role since fighting began against Slovenia in June 1991. Soon after that, one MiG-29 was lost to ground fire. The RViPVO assembled their MiG-29 and MiG-21 bis (Fishbed K) units at Batajnica Air Base and they represent Serbia's best air defense resources. The MiG-29's are assigned to one squadron (the 130th LAE) and are locally designated type L-18 and NL-18 aircraft. They are kept in reserve to protect the leadership in Belgrade from NATO PGM equipped aircraft.

Moldova leased 12 of its 30 x MiG-29's with pilots and maintenance crews, some Iraqi, to help South Yeman fight its civil war. Seven were shot down or destroyed on the ground with the remaining five rendered unserviceable.

Likewise, Cuban MiG-29's have also become virtually unserviceable due to spares shortages. Recent estimates note that only three Cuban Fulcrums are still operational. They did however, get one airborne in early March to shoot down two Cessna Skymasters off the coast of Cuba.

So at least 22 x MiG-29's have been downed or destroyed in combat having flown only a couple hundred missions. The only MiG-29 air-to-air victory was a fratricide and at least two pilots killed themselves maneuvering the aircraft at low altitude which could be partially attributed to the way the aircraft's weapon system is mechanized and its "un-friendly" cockpit that features a heads-down gyro reference. Also, over the years three MiG-29's have been lost in accidents at Air Shows in France and England.

It is most interesting that MIG-MAPO officially denies any combat activity or losses with the MiG-29. In fact they boldly state that the Coalition victory was made possible because the Iraqi MiG-29's did not have wide-scale participation. The source noted by MAPO was the "Krasnaya Zvezda" newspaper article of 18Aug95. The MAPO-MiG literature states:

"MiG-29's have not participated in real combat operations. Even the several dozens of MiG-29's placed in service in the Iraqi Air Force were ferried, during the Desert Storm operation, to Iran in 1991. But the modeling of various outcomes of the Gulf War, developed by experts, allowed them to come to the conclusion that the non-participation of MiG-29's in wide-scale combat actions on the Iraqi side was one of the main reasons for a quick and comparatively easy victory of the multinational armed forces of the Coalition."

#### MiG-29 Mission Sampler:

During the Cold War the following "fighter escort mission" scenario was common. The MiG-29 would start from an airbase considerably closer to the FEBA (forward-edge-of-the-battle-area) than its Su-27 partner, around 100 NM. It would carry the standard six missiles and a centerline tank. Total takeoff fuel would be around 11,000 lbs. Consider a 500 kts., 5,000 ft., escort profile, with an air-combat package of 2000 lbs., held in reserve. The Fulcrum could manage a 125 NM. escort run. The combat reserve would translate to an additional 30 to 50 NM., if unused. If the escort condition slowed the MiG-29 to 300 to 350 kts. cruise, then the range would increase to almost 200 NM. Additional MiG-29's on a "Fighter Sweep" from the same base would be used to support the route of the escorting fighters. They could go out 50 NM., loiter for 30 minutes, and then vector at 1.2 Mach from 90 to 100 NM., with enough fuel to still engage with one missile attack. In general terms, F-16C's with the same six missile configuration (using AIM-120's and AIM-9's) and centerline fuel tank could do the same profiles and missions as the MiG-29's, but they could also do them having departed from bases twice as far from the FEBA, i.e., around 200 NM. This scenario describes closely the situation that air forces from NATO and the Warsaw Pact would have faced across the inner German frontier.

#### The MiG-29 Thumansky RD-33 Engine:

The MiG-29 utilizes the RD-33 family of aircraft two-spool bypass turbojet engines that feature air flows mixed in a common afterburner, variable area nozzles, and a modular design which facilitates maintenance. RD-33 engines now serve in 22 nations: Belarus, Bulgaria, Cuba, Czech Republic, Germany, Hungary, India, Iran, Iraq, Kazakhstan, Korea, Malaysia, Moldova, Poland, Romania, Russia, Slovak Republic, South Africa, Syria, Ukraine, Yemen, and Yugoslavia. Only South Africa does not use the MiG-29, but has reconfigured the RD-33 in their F-1 Mirages. V. Chernyshev Machine-Building Enterprise literature, builder of the RD-33 engine, discuss engine replacements for the Cheetah and early model Mirage III/V's.

Historically Russian fighter engines have been designed for high performance and short life spans. Since they were designed for real war conditions and not the convenience of peacetime, they had relatively short Mean Time Between Overhauls (MTBO) of a few hundred hours and/or short total life spans. Since aircraft were rotated out of rough forward areas as their limited operating time expired, maintenance was rarely done in these areas and engines were produced in larger quantities thus lowering unit costs. It also kept the engine manufacturers closer to war rate production levels as opposed to the slowly responsive, market oriented, peacetime rates. Hence their design quality, manufacturing quality, technology and performance levels, all steadily improved. Characteristics of the RD-33 engine are listed below.

Table 4: RD-33 Engine Characteristics

Inlet Diameter 730 mm  
 Length 4250 mm  
 Fan Stages 4  
 Compressor Stages 9  
 High / Low Pressure Turbines 1 / 1  
 Max Sea Level A/B (wet) Thrust: 18,300 lbs (8,300 kg / 81.4 kN)  
 Specific Fuel Consumption @ Max Thrust 2.05 kg/kg-hr  
 Max Sea Level Mil-Pwr (Dry) Thrust: 11,240 lbs (5,098 kg / 49.9 kN)  
 Specific Fuel Consumption @ Mil Thrust 0.77 kg/kg-hr

Inlet airflow at max thrust 168 lbs/sec (76 kg/sec)  
 Max Turb Inlet Temp (°K) Takeoff 1530  
 Max Turb Inlet Temp (°K) in Flight 1680  
 Bypass ratio & pressure ratio 0.49 & 20:1  
 Specific Weight 0.127  
 Weight of 2 x RD-33's 6613 lbs. (3000 kg)  
 Engine + Accessory Package 3305 lbs. (1500 kg)  
 Engine Thrust / Weight Region 7.4 to 8.0  
 Response Time, idle to full A/B 4 sec  
 Total Air Compression Ratio (fan & comp) 21  
 Maximum Flight Mach number 2.35 Mach  
 Maximum Indicated Airspeed 800+ knots (1500 kph)  
 Max Service Ceiling 56,000 ft (17,069 m)  
 Max Velocity Suction Head 11,000 kg/m  
 Ground Idle Fuel Flow 26 lbs / minute  
 Max afterburner at Sea Level (0.9 M) 2500 lbs / minute  
 Max afterburner at 30,000 ft (0.9 M) 700 lbs / minute  
 Engine Change (claim) 2.0 hours

The FOD protection doors are controlled automatically from engine start. As soon as hydraulics come on line, from a given engine, the door closes. During start, taxi, and takeoff the door is kept closed by hydraulic pressure and is controlled by a compressed nose gear strut switch. After nosegear unstick during takeoff (around 200 kph), the inlet doors open and are then controlled by airspeed & engine demand for air. The louvers function by gravity and required air being sucked into the inlet. They are made of composite materials, have 887 perforations, and respond to the slightest change of air flow demand. If the engine inlet doors fail closed the aircraft can continue flight but is limited to 0.8 Mach or 800 kph in speed. Once open, the doors become part of the three-ramp variable inlet geometry scheme. Downstream from airflow there are three exits for air from the ramp perforations. The inlet doors, once adapted with nosegear mud-flaps, have actually eliminated the problem of external FOD on Russian airfields. Likewise, they cannot be manually deployed by the pilot. Advanced models use screens as mentioned. The new Sarkisev engines (RD-33K) are equipped with full authority digital electronic engine controls (DEEC). Engine power input has been increased but overall fuel specifics have not been improved.

The two fundamentally different approaches have come together in Malaysia where the Russians are expected to deliver RD-33 engines featuring a considerable longer life span, and much extended MTBO's. MAPO is also offering to provide a test program to assess at what point this western mimic logistics and support approach will not work any more, thus forcing them to reverse course, on behalf of customer, and recover the program in a more traditional Russian style. Malaysia has received two MiG-29's in 1992, for just such testing program as well as maintenance training duties. Malaysia has asked to start with an MTBO of 750 hours. They would be assisted by the Indian Air Force who to date have only been able to maintain their engines at a 200 hour MTBO rate.

RD-33 design history dates back to the early 1970's when Pratt & Whitney and General Electric were working towards the F-15, F-16 and F-18. The Russians selected, what they say, was a similar configuration approach for the RD-33; a two shaft low bypass ratio turbofan (0.4 : 1), with a four stage fan without inlet guide vanes, but with an inlet cruciform supporting structure for the front fan bearing. The high pressure compressor features nine stages, of which the first three have variable geometry stator vanes giving a pressure ratio of 20:1. There is also the annular combustion chamber, two single staged turbines, and an afterburner that burns both fuel and core flow with by-pass air in a mixture. Hydromechanical controls on the engine have built in diagnostics for ease of maintenance. The RD-33 has eleven modules with all HP and LP blades capable of being replaced.

Russian efforts at attaining improved maintainability and reliability were reviewed in a MilTech article (Aug93, pg. 63), produced on the MiG-29 that said the mean time between maintenance operation (MTBO) for the MiG-29 in 1989 was 7.8 hours, by 1990 it rose to 9.4 hours, and at present is tabulated at 18.6 hours. Combat readiness of Russian units was said to be now over 90%. The article goes on to say that because of the militarized economy of that time, the amounts and frequency of inspections as specified in the aircraft manuals were well beyond that required to maintain high readiness and efficiency due to the availability of spares, test equipment, and consumables. This is hard to believe, but with the limited amount of flying there might have been a way to keep ready aircraft on the ground and in a "up" status for long periods of time.

A recent V. Chernyshev (RD-33 manufacturer) add says that the German Air Force has found that the RD-33 MTBO can be held at 700 hours if the engines are properly maintained (MilTech 12/94, pg. 18). With this experience or hype, Mikoyan is confident that they can quickly bring the service life of the MiG-29 up to 4000 hours with mod provisions taking this to 6000 hours. Likewise the overhaul cycle of the RD-33 engine for all customers could be quickly lifted from its original 350 hours to 700 hours to first overhaul and life out to 1400 hours. The new German Air Force has been working together with DASA and V. Chernyshev to set-up modern computer-based MiG-29 supply system that would further increase their engine MTBO to 1200 hours.

In practice however, because of the relatively low total flight hours, under a million hours for all MiG-29's, the RD-33 failed far more often than advertised and the Russian supply system could not keep up to the customer demand and turn around time required, as experienced by the Indian Air Force. Every overhaul began to cost the InAF Force over \$480,000 dollars.

Simply put, the original war-based Soviet logistics system pumped completed engines and new aircraft into the forward area at rates consistent with projected utilization that always kept in reserve the hours necessary to fight the NATO war. It was a system of long trains and thousands of aircraft crates and engine coffins, but very few isolated parts and even fewer trained technicians. As you can see this entire system is now transitioning towards a western based concept with very little regard for an exact audit or tracking of component production, refurbishment, inventory, storage, retrieval, and transportation.

When we first learned at Farnborough 1988, that the RD-33 engine weighed 3305 lbs., it bothered many engineers. It was said to be too heavy for a single-engine fighter and too light for a twin. The un-installed thrust-to-weight was 7.47:1 and the installed around 5.53:1, more like a GE J-79 than a F-100. Modern engines were supposed to have eight or nine to one uninstalled thrust-to-weight ratios. But the Russians, while working with older engine technology and manufacturing techniques, were ready to pay a weight penalty because they knew they could use other available high technology in composite manufacturing to make up for it. They were also being hard pressed to get into production a higher performing fighter to counter the F-15 and F-16. Correspondingly that penalty re-directed the weight saving efforts by the design team. The MiG-29, therefore, obtained a high percentage of composite structure because of weight savings needed to offset heavier engines that were uncharacteristically heavy by western standards. The RD-33 then, may have more in common with the J-79 level of technology than the F-100.

Engine Oil Sampling was directed at 100/150 hour level maintenance inspections with an average consumption rate listed at 1.76 lbs/hr (0.8 kg/hr). Oil Level check gauges are located in the left wheel well. There is a high pressure quick dis-connect refueling point located just inside of the left landing gear well. The quick disconnect attachment point immediately splits into two fuel lines, one to the wings and the other to the fuselage tanks. However, all advanced and naval variants of the MiG-29 have been fitted with retractable fuel problems. Just forward of the high pressure refueling point in the landing gear door (remember left side of the aircraft looking forward), is a drop down fastener door that is located just under the strake near the gear well that exposes the computer access panel for the INS Loading and additional maintenance test switches. There is a white matrix of 3 x 3 white keys, and adjacent to the right is another 4 x 4 matrix of black keys. There are other switches there also.

Spool-up from idle to full afterburner takes a flat four seconds, even though the pilot's check list on takeoff requires a mandatory 10 seconds to wait and watch indicators. The "linear" type of throttles, that are power boosted, moved very easily when the boost system is on, but is very hard when off. The transition from MIL to A/B zones is almost un-noticeable, except for a quick knuckle grab "up" to clear the detent stops on the forward side of the throttle grip, which is effortless and smooth.

Table 5: MiG-29 Fuel System Summary: (@ 6.5 lbs/US gal)

Model Var.	Lbs.	Kg.	US Gal.	liters
Internal Fuel:				
Fulcrum A (1)	07384	3200	1136	4300
Fulcrum B (2)	07384	3200	1136	4300
Fulcrum A (3)	07384	3200	1136	4300
Fulcrum C (4)	07514	3408	1156	4376
Fulcrum C (5/6)	07384	3200	1136	4300
Fulcrum C (7/8)	07926	3595	1219	4616
Fulcrum A (9)	07384	3200	1136	4300
Fulcrum D (10)	11023	5000	1696	6419
Fulcrum E (11/12)	10979	4980	1689	6394
External Fuel:				
1 x Centerline	02610	1184	0402	1520
1 x Wing Tank	01975	0896	0304	1150
2 x Wing Tanks	03949	1792	0608	2300
3 x Ext Tanks	06559	2976	1010	3820

#### RD-33 Engine Start:

For normal day-to-day operations from a flight line, RD-33 Engine start is accomplished primarily from stored air/nitrogen with battery ignition. There is however, an onboard 98 hp GTDE-117 APU (rarely used) and a battery electronic-spool capability. The APU is fed air via an inlet projecting above the rear fuselage with its ventral exhaust air is vented through the centerline tank if fitted. Engines can be started with bleed air from an external impingement air-start cart or from an

operating engine bleed air crossover-valve switch. There are 3 x four-liter bottles of pure oxygen at 150 atmospheres pressure for the pilot's life support system that can be used for emergency engine starts at altitude.

The MiG-29 regenerates its bottled pneumatic replacement air from engine bleed. These pneumatics run canopies, engine starts, emergency braking, and emergency landing gear/flap extension. Nitrogen air is serviced before each flight by a standard nitrogen cart. The pilot would go through a brief cockpit check-out, then work on the start switches on the right side console bulkhead. An air/nitrogen crank would commence with the battery automatically engaged for ignition. Idle is reached 12 to 13 seconds after the throttles are cracked, idle fuel flow is 772 lbs/hour (350 kg/hr). In scramble situations the number two engine could be started while taxiing. The inlet doors rapidly close as engines come on line and the auxiliary over-inlet louvers sucked open.

All external connections are done with NATO standard interfaces to the aircraft. The APU appears to be the weak-link in the engine start arena. Ground crews complain about it during air shows and it has an exhaust vent that is routed through the rear portion of the centerline tank.

MiG-29 Maintenance Servicing:

The MiG-29 has two 3000 psi hydraulic systems that back each other up as in the MiG-23, but no third system as in Western aircraft. There seems to be a real sacrifice in survivability doing things this way, but it is consistent with the Russian mentality towards aircraft life during war.

Aircraft and Engine "CHECK CYCLES" are categorized by "HOUR-LEVEL" Checks, however the engines get scheduled monthly calendar checks and inspections regardless. Remember, in the Indian Air Force, 74% (139) of the 188 failed prematurely before the 300 hour cycle level. Of those that failed, 40% (56) did not achieve half the predicted 300 hour cycle life. Hence the Indian maintenance cycle was dropped to 50 hours.

Operational maintenance is categorized according to:

1. pre flight checks
2. through flight checks
3. post flight checks

Aircraft and Engine "Checks" are organized according to "Hour-Level" Inspections and Actions. Engines however, get monthly calendar inspections, whether they need them or not.

1. Every 60 days there is an inspection cycle that is done on the aircraft without test equipment but utilizing the on-board built in test (BIT) system and a visual inspection of all systems. The BIT check takes 1/2 a man day, or four man hours.

2. The 100 HOUR LEVEL CHECK
  - at 45 min per sortie, i.e., after 133 flights or every two months
  - takes 5-6 days
  - BIT check plus everything short of component removal
  - Engine uses tester unit run against special chart

3. The 200 HOUR LEVEL CHECK
  - Equipment removal and failure replacements
  - same volume of items on 100 Hr Check for engine
  - "other" maintenance not explained
  - engine oil samples are taken every 100 & 150 hours

4. The 300 HOUR LEVEL CHECK
  - engine-only checks
  - Intermediate level (JEIM) inspection
  - TBO not yet determined

5. The 400 HOUR LEVEL CHECK
  - Includes all systems

Ground Test Equipment: Squadron Breakout for 20 Aircraft

Test Equipment

- (6) Mk-912 Tester Units for onboard equipment checks at the 100 Hour Level
- (1) Engine Tester Unit
- (1) INS Tester Unit
- (2) Sighting Systems Tester Units
- (1) Armaments Systems Tester Unit

- (1) Manual Tester unit for miscellaneous equipment
- (1) BIT check adapters
- Ground Support Equipment
- (1) Power supply
- (1) Hydraulic stand
- (1) Vehicle with oxygen bottles
- (1) Vehicles with air bottles
- (1) Pressurization/air conditioning unit
- (1) R27 missile Tester unit
- (1) R60 missile Tester unit
- (1) R73 missile Tester unit
- (1) Rockets and Bomb Tester Unit
- (1) Gun system Tester

No support requirements or maintenance tasks were mentioned for the Chaff and Flare dispensers that are located on the above wing structure extending forward from the vertical tails. There are weather guards that crew on to the dispensers and must be removed before flight.

#### MiG-29 Communication / Inertial Navigation System:

Normal VHF voice and data communications on the MiG-29 are done through pre-set radio receivers that have limited channel selections put in by the ground maintenance crew. Over the years, several western comm-nav units have been installed into MiG-29 aircraft for use with Western air forces and in Western air traffic environments. German MiG-29's were updated with these systems and MAPO-MiG offers them to any customer requiring them. The full extent of these Western equipment mods will not be discussed here. A Western GPS receiver has even been installed on the canopy bow above the radar scope on some MiG-29's attending overseas air shows.

There is an inertial navigation system that is loaded from a bay door below the aircraft by a maintenance officer, not from the cockpit. The "pop-open" panel, is located just under the left strake, forward of the main landing gear well. It has two key-boards under this cover, a 3 x 3 and a 4 x 4, which allow coordinate entries by a ground crewman.

The INS is aligned automatically after engine start with generator power on. It requires 12-13 minutes for systems check out. There is a three minute rapid alignment which sounds like a stored alignment. Accuracy drift is listed as 4 km/hr. There are three airfield (home, destination, & alternate), three navigation waypoints, and three points of interest that can be stored in the system. There is no airborne update capability until the MiG-29M advanced cockpit.

The INS system is programmed to read from a 36° x 36° grid sector and data is accessible to the cockpit only via inputs to the primary gauges and displays. There is a constant read-out of range to waypoints/airfield and in the "LANDING" mode, the aircraft autopilot will accomplish a self-contained approach and let-down to final approach on the coordinates of the selected recovery base. The pilot tunes the MiG-29 to an assigned data-link frequency for his navigation, mission, or landing needs, but the aircraft is not coupled via the datalink to its autopilot as in the MiG-23. An autopilot mode will fly the aircraft on a pre-planned nav-route with data-link back-up steering, but there is no pilot "hands-off" flying by the ground controller. The autopilot will fly the pilot to a point on the final approach to a selected recovery base. Given that everything works perfectly, the pilot still must drop the landing gear, flaps, and then land the aircraft. It even programs in the expected holding patterns.

There are no Western style mission planning systems associated with the MiG-29. No data cartridge loader or integrated map display is utilized. MiG-31 strategic interceptors and Su-30 strike-fighters have electronically installed map systems, but nothing yet has been seen in the MiG-29. The MiG-29 requires its maintenance department to manually install flight data from the operations department into the aircraft. Another reason why there is a planning and maintenance day before each flying day.

On the planning day on a Russian base, MiG-29 pilots normally write out each navigation leg and the associated navigation switch-actions, if any, required during their entire flight to be reviewed by their superiors. As you can guess, the factor of "variability" is seriously decreased by the amount of work necessary to script and store a mission, therefore, most training missions are "canned" and used over and over.

#### MiG-29, Part Five By Easy Tartar

The Navigation Panel coordinates the integration of available navigation systems (RSBN, Radio Compass, Data-Link, etc.), especially those required for recovery at its assigned air base. The pilot has transponder codes set automatically for each recovery base as well as data link frequencies. All of these associated panels are located nicely in the right

forward part of the cockpit and have references on the "NAVIGATION" Mode in the HUD.

MiG-29, "Warning Screen" ("EKARAN"/ "RHFB") System:

A rather primitive systems check device has been installed on all modern Russian fighters and is described here for the MiG-29 aircraft. It semi-automatically checks the integrity of on-board systems, both in the air and on the ground. It is called the "EKARAN-03ME01" or "WARNING SCREEN" and is the maintainer's built-in interface device to the aircraft's sub-systems. Understanding the EKARAN will give us an idea "how" the Russian maintainers and aircrew work through failures and organize repairs. Therefore, it is presented here in some detail.

The EKARAN provides indications of failures of on-board systems in recorded format during flight and in addition includes provisions for automatic checks on the ground. The EKARAN System is functionally tied (hard wired) to the on-board systems of the aircraft. The Logical Control Unit (Russian Acronym: "BLU" or ",GE") produces an analysis of signals received from an Integral Systems Checks (Russian Acronym: "VSK" or "DCR") System of onboard aircraft equipment. There is a "priority list" and "readouts" are displayed on a "Universal Signal Indicator Panel" (located just above the RWR display on the right side of the front bulkhead...ed.). At the same time, the EKARAN produces signals for a control software program to execute ground checks. The Logical Control Unit (BLU) has marks (preset indications) organized in a "sequential diagram" (cyclogram) that "questions" the onboard systems to see if they are "READY" or "NOT READY". It runs an analysis on the received "answers" from the Integral Systems Check (VSK) and looks at the individual (weapon system) sensors to determine if they also are within operating parameters. The "Warning Screen" (EKARAN) System works in several Modes:

"SELF-TEST" ("SK") "CR"  
 "GROUND CHECK" ("NK") "YR"  
 "IN FLIGHT" ("PK") "KR"  
 "RECORD CHECKS" ("DK") "LR"

The data entered from the systems checks is recorded and transferred in an alpha-numeric format onto a special "metallic" tape. This gives the technicians the ability to build an analysis of the flight and to objectively evaluate the technical status of the aircraft. If the check parameters of the individual systems exceed normal limits or indicate a failure from one or another, then the sensors produce electric "signals" that make it known. The Logical Control Unit (BLU) receives the systems status "data" and indicates to the pilot on the displays screen what "failures" have occurred.

The "failure" indications are displayed by a one-time turn "ON" of a flashing luminescent light with an associated aural warning. If after a period of time, the pilot does not respond to the indication, he is then prompted to do so by an aural alarm of "Look at the Warning Screen". The information remains on the display screen as long as the pilot does not push the button entitled: "WARNING SCREEN CALL", or a failure of a higher priority occurs. Once pushed, along with the absence of any additional incoming "fault" signals, the display frame disappears and the indicator screen shows the word "MEMORY" which stays on until the disappearance of the danger signals.

The "MEMORY" indicates that the registered "faults" are stored into a memory that is organized according to the priority of the failures and initiated once the button "WARNING SCREEN MEMORY" is depressed. If a higher priority fault or failure is sensed, the signal for the lower priority does away into the memory "queue" and the higher priority problem is displayed on the indicator panel.

The other, less important failures, can be called up by depressing the "WARNING SCREEN CALL" button several times as it cycles through the queue. The memory and the queue listing of faults and failures are printed on the magnetic tape but without time of occurrence marks.

The "text" of the information displayed on the indicator panel, which is automatically placed on the magnetic tape, is now in the permanent memory of the Logical Control Unit (BLU) for subsequent processing after the aircraft lands. The tape is prepared for removal 20 seconds after the right main landing gear strut is sensed to compress via the "STRUT COMPRESSION ON RIGHT LANDING GEAR" signal switch. The recorded information on the Logical Control Unit (BLU) is then compared with the pre-flight ground checks of the systems and sensors and prepared in a format for analysis.

The EKARAN System has a "SELF TEST" Mode that checks, in coordination with the Logical Control Unit (BLU), the "fitness for work" (integrity) of the Basic Aircraft Systems. The "WARNING SCREEN CALL" button is depressed to switch into this mode. The Aircraft support systems such as Battery, Flight Control, & Navigation Systems are left "OFF". In this case, the display face lights up "FAILURE", but there is no failure of a system, it is self test. With each unit turned on, 15 seconds after the "WARNING SCREEN CALL" button was depressed the words "SELF-TEST" and "WARNING SCREEN READY" are displayed on the panel consecutively.

The "GROUND CHECK" Mode (NK) is initiated through the execution of the "pre-flight preparation" routine. Textual instructions are displayed to the operator about the conduct of the "manual" and "visual" operational checks. According to the "WARNING SCREEN", all of the aircraft system tests are divided into groupings; "automatic tests" and "tests at the

discretion of the pilot".

The pilot, in going through his checks on the working "suitability" of the aircraft's systems, taps into the system via the EKTRAN as indicated by the time and sequence on recorded checklist. If the pilot cannot do a "hands on" check (system removed) or if he is unable to execute the commands properly, then "FAILURE" is displayed on the indicator panel and the sequence of systems checks continues. This "notation" gives some evidence about operator errors. The complete verification check lasts around 11-12 minutes. In the event that a system failure is discovered then the memory "frame" with the name of the failed system appears on the indicator panel for two seconds and after that the process of system checks continues.

In order to turn "ON" the "WARNING SCREEN" system in the GROUND CHECK (NK) Mode, it is necessary to turn "ON" and "OFF" the emergency battery, flight control system, and navigation systems and then press the "WARNING SCREEN" button. In this way it is certified that the check mode. Automatic checking of the onboard systems is fed through the "cyclogram" into the memory of the "WARNING SCREEN" System. The "cyclogram" is built up taking into account the warm-up time and the "exit" from the operational mode of each system check.

The "FLIGHT CHECK" (PK) Mode is turned on automatically when the "START ENGINES" Mode is pushed and there is a removal of the message "COMPRESSION RIGHT STRUT LANDING GEAR" or through the retraction of the landing gear. In the "FLIGHT CHECK" Mode the "questioning" of the various systems is accomplished through algorithms.

Overview of the MiG-29 Radar and Weapons System:

The Fulcrum Weapon System (integrated opto-electronic navigation/sighting system) may be in theory one of the world's best tactical avionics suites for fighter aircraft because of its sensor mix, but in practice it has a long way to go. In the interest of putting more "initiative" in the hands of their pilots, Russian engineers designed the MiG-29 as a "Semi-Automatic" weapon system with many "Manual" sub-modes that require pilot actions. After evolving the MiG-23 Flogger into a fully "automated" system, run via data link from the ground GCI station, it was clear that neither the proper tactical situation awareness (SA) nor the big-picture synergism could be maintained without the active participation of the pilot and his formation partners.

Using the Russian terminology, the MiG-29 has three main "sighting channels", or sensor systems, to search, acquire, and track airborne targets via radar and laser energy, infra-red, optical passive homing, and visual queuing by the pilot. The MiG-29 weapon system operates in two major "command modes", semi-automatic and manual, which are determined by the amount of pre-mission planning and off-board support given to the aircraft and pilot during the mission. The ground/air based early warning, surveillance, command, and intelligence systems all feed the MiG-29 through the LAZUR data link system and directs the pilot via "Fulfill Commands" to take all the necessary actions to complete his mission. The LAZUR takes over the control of many of the difficult weapon system management tasks such as antenna/scan selection, emitter activation, proper intercept headings/altitudes to the target, weapon arming, etc. The MiG-29 also has "internally generated" automatic modes run through the auto-pilot and navigation computer for return to base options and improving aircraft stability.

When looking at the MiG-29 from its manual switch-action construction, there are numerous modes and sub-modes initiated through three main weapons panels, the stick and throttle grips, and several auxiliary panels.

The Main Sensor Management Panel (Integrated Modes Panel), located to the left of the HUD/Gunsight (windshield indicator) on the main front instrument bulkhead, is the primary weapon system selection panel. The onboard Radar, its associated IRST (optical locator laser station: OEPNK-29-E2), and Helmet Mounted Sight (helmet-mounted target designation system: SHLEM) operate both independently and in combined modes. To fully exploit all weapon system modes requires manual switch actions by the pilot from these various panels and boxes. The overall quality of cockpit mechanization in all production MiG-29's may not be at the level of the F-4 Phantom, however, after the time is taken to understand learn the actions, the pilots perform well and react quickly, but the cumulative effects keep them well behind modern western aircraft.

One of the earliest descriptions provided on the Fulcrum Fire Control System was done in a short article in Jane's Defense Weekly (01Oct88, JDW, pg. 819), "Latest Details of Fulcrum FCS". Deputy Designer General Mikhail Waldenberg, was pictured with his three Farnborough pilots and commented on how the Fulcrum's fire control system was composed of a coherent pulse Doppler radar that worked in conjunction with an infra-red search and track (IRST) sensor that housed an integral Laser Ranger (LR). Both radar and IRST can be augmented by a Helmet Mounted Sight System and visual dogfight modes in the systems themselves. There is a "COOPERATION" switch that allows the radar and IRST to work with or without the other. The latest version (in the MiG-29M) of the IRST includes a television EO tracker with laser ranger and ground target designator combined with the Helmet Mounted Sight System.

The PHAZOTRON Scientific & Production Company designed and perfected most of the Russian fire control systems and have been responsible for the systems in the MiG-17, 19, 21, 23, 25, 29, and 29M fighters, the Su-9, 11, 15, YaK-28/141, Tu-128 and the new Su-35/37 aircraft over the last 35 years. Note that they do not produce the MiG-31 or basic

Su-27/33 weapon systems. The Ryazan State Instrument Factory is the specialized mass production facility for most of these high quality radio engineering devices and equipment that supports the "NO19E", "NO19/3E", "NO19EA", and "NO19ME" series radars on the MiG-29. The BRLS is the common electronic components for the radars themselves. The ERP constitutes the kit for the squadron level analysis, adjustment, and main component regular or combat repair. The ARP is the overall aviation repair enterprise and deals with medium scale and major repairs of the components and assemblies.

PHAZOTRON's Main Line of Production Airborne Radars:

- TOPAZ update of NO-19 radar, a multifunction, multimode coherent PD
- ZHUK multifunction, multimode coherent PD with A/A & A/G modes
- KOPYO (lance) multimode/function coherent PD with A/A & A/G modes

PHAZOTRON's upgrade & export packages are advertised as:

- the KOMAR radar (mod KOPYO) for the Su-22, PRC F-7II, and A-5
- the KOMAR radar pod for the Su-25 or other attack aircraft
- the SUPER KOMAR radar for the proposed FC-1 PRC fighter
- the PHATOM radar jointly with Thomson CSF from France
- the KOPYO and SUPER-KOPYO radar for the MiG-21 family
- the FG-27 radar (mod of the ZHUK radar) for the export Su-27
- the TOPAZ & TOPAZ-P modernized version of the N-O19 radar for the MiG-29 and meant for both MiG-23 and MiG-29 upgrades

The ZHUK has three variants, the basic, ZHUK-27 and the ZHUK-PH (electronically scanned) while the KOPYO has also the SUPER-KOPYO, each with a few more features.

Table 6: MiG-29 Radar Designations (produced by Phazatron)

ZHUK ZHUK KOPYO  
TOPAZ

basic 27/PH K/SK A/P

-----  
Associated Aircraft Su-27  
Su-30/35 MiG-21/23 MiG-29/23

MiG-29K/M F-7/FC-1  
TGT Detection Rng: FWD-QTR (km) 70 100/165 57/75 60/80  
AFT-QTR (km) 40 55/60 35/35 40/45  
Scan Coverage (+/-) 20/60/90 20/60/90 10/30 15/25/70  
Elevation Coverage (bars) 2/4 2/infinite 2/4 4/6  
Freq Band X X (?) X X  
Number of TWS Target Files 10 10/08 8/8 10  
Number of Simultaneous Attacks 2 4/6-8 2/2 1/2  
Peak Power/Average (kW)/(kW) 5/1 5/1 5/1 5/1  
Cooling air/liq air/liq air/liq liq  
Reliability (man-hrs MTBF) 120 150/200 120 100  
Weight (kg) 250 220 165/100 350  
Volume (cubic dm) 800 800 500  
Weapons Compatible With R-27R R-27R R-27R1 R-27R1  
R-27T R-27T R-27T1 R-27RE1  
R-27RE R-27RE RVV-AE R-27T1  
R-27E R-27AE R-73E R-27TE1  
R-73 R-27EM R-60MK R-27E1  
R-73 X-31 R-73E  
X-31 R-60MK

Table 7: MiG-29 Radar Designation Breakdown:

\* Note that all designations are not official but used in this document to maintain some form of order on the many minor and major changes in the MiG-29 series

Aircraft NATO Call Radar  
Designations TWS Tgt/Engage S/T Ranges  
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MiG-29B Fulcrum A N019A "Slot Back A" 10/ 1 70 / 40  
(variant 1) (ZHUK)

MiG-29E Fulcrum A N019E "Slot Back B" 10 / 1 80 / 45  
(variant 3) (ZHUK)

MiG-29SE Fulcrum A N019EA "Slot Back B" 10 / 1 60 / 40  
(variant 4) (TOPAZ)

MiG-23 Flogger K N019EA "Slot Back C" 10/ 1 80 / 45  
(upgrade)  
(TOPAZ)

MiG-29UB Fulcrum B ....none  
(variant 2)

MiG-29SD Fulcrum C N019ME "Slot Back D"  
(variant 7) (TOPAZ) 10 / 2 80 / 40

MiG-29SM Fulcrum C N019ME "Slot Back D"  
(variant 8)  
(TOPAZ) 10 / 2 80 / 40

MiG-29K Fulcrum D N019M "Slot Back E"  
(variant 10)  
(ZHUK PH) 10 / 4 80 / 50

MiG-29M Fulcrum E N019M "Slot Back E" 10/ 4 80 / 50  
(variant 11) (ZHUK PH)

The PHAZOTRON production facility is the Ryazan State Instrument Making Factory #32, located at Kalyeva Street, in Ryazan, 390000 Russia (7-0912-772-327 with fax at 7-0912-762-212). The Ryazan facility has specialized in the mass production of high-tech, highly intelligent, and high quality radio engineering equipment for over 50 years. The MiG-29's "airborne radar station" carries the component module designation of BRLS and includes the "NIO19E", "NO19EA", and "NO19ME" series production radars.

Ryazan's literature discusses the following tasks for its radar development:

- \* detection and interception of aerial targets which fly at altitudes from 30 to 23,000 meters (100 to 76,000 feet) in free air space or against the background of the earth.
- \* secret tracking of several targets and the simultaneous attack of two- targets at head-on crossing routes as well as from side or the rear semi- sphere at different approach speeds, equal speeds, and also when the target is pulling away from the fighter.
- \* target aiming and guiding of the onboard missiles using thermal guidance heads, radium guidance heads, and non-guided missiles.
- \* automatic focusing on visual targets while employing effective piloting methods, guiding the shooting weaponry and bombing equipment as well as carrying out maneuvers under close-range conditions.
- \* heightened reliability of the built-in self-control systems which will guarantee reductions in maintenance expenses for the BRLS.

Ryazan also makes the support equipment for the MiG-29 radars. It is interesting to note here that in Hungary, at the superbly professional Kecskemét MiG-29 Regiment, there stood three new avionics support support carts in the new hangar. The carts, which were designed to do analysis and repair on the avioncs components were idle because there was nobody on the base trained to use them. It was noted that the Russians wanted \$100,000 per technician for a training course plus the expenses of a team to do the course at the user's base.

The Ryazan literature describes the support kit as sets of specialized exploitation and repair equipment (ERP) for the provision of repairs of the "NIO19E", "NO19EA", and "NO19ME" series production radars.

- \* the ERP set as a part of the technical exploitation unit in aviation enterprises (TECh AP) or aerodrome laboratories

designed for the analysis, adjustment, and regular repair of the main components and products for the "NIO19E", "NO19EA", and "NO19ME" series production radars by using the group set of spare components at a 1:40 ratio.

\* the ERP as a part of the aviation repair enterprise (ARP) designed for the analysis, adjustment, and regular medium-scale and major-scale repair of all components and joints for the "NIO19E", "NO19EA", and "NO19ME" series production radars which have been damaged in combat or usage within the ARP. The set is used in conjunction with a group set ZIP also at a 1:40 ratio.

The modernization of the MiG-29 from the BRLS to the ZHUK radar station is viewed by Ryazan as providing for an expanded combat capability of the MiG-29 and would introduce the following advanced features:

- \* the detection and secret tracking of targets in the air and against the background of the earth (or at sea) with the transmission of the target location data to the missiles equipped with active medium range guidance heads, semi-active radium guidance heads, thermal guidance heads, non-guided missiles, and shooting weaponry.
- \* the acquisition and track of several targets and consequent simultaneous attack with several missiles
- \* the swift vertical search for and automatic focusing on visual targets, together with the provision of the necessary maneuvers in close-range combat.
- \* the provisions for flight at low altitude with automatic terrain avoidance
- \* the mapping of the earth sea and ground surface with actual beams (low-level expansion) and synthesising aperatures for high level resolution.
- \* the enlargement of a selected area of a radar generated map and the freezing of the image
- \* the measuring of the coordinates of the target, chosen on the earth's surface or sea, with the transmission of the target location data to the air-to-air & air-to-ground missiles, SVB, and aviation bombs.
- \* easier to use in combat and easier to maintain on the ground

The modernization of the MiG-21 and MiG-23 fighters with the KOPYO ("Lance") derivative of the BRLS has brought the possibility of new business to Ryazan and offers a significant upgrade to the aircraft. The KOPYO can be readily combined with the digital and analog equipment installed on the original fighters for ease in integration.

unfortunately the russian letters don't transfer when the modes are listed (...) in para's

The MiG-29 Control Stick:

Sitting in the cockpit, with the stick in front of you, the control column appears rather normal but actually represents Russian fighter tradition that goes back to the MiG-15. The stick is higher then normal, that is the pilot holds on at his chest level, not low between his legs where he could rest his arm on his right thigh. The high stick requires great strength over long flights and most people who have shaken hands with Russian pilots understand this point.

Across the top of the stick are the traditional two buttons and the centered Trim Knob. On the left the "AUTOPILOT" Engage Switch and on the right a purely Russian "FLIGHT-LEVELING" switch. Actually the Grumman A-6 Intruder may be the only Western aircraft with such a switch. The Autopilot Switch engages the AFCS and in certain Navigation Modes actually commands the aircraft into a pre-designated flight profile, usually a return to base mode. It does not however, link the MiG-29 up to complete coupled GCI commanded flight profile via the onboard datalink as the MiG-23 does. There is an emergency AFCS release "beaver-tail" lever-switch at plams reach on the front of the stick column.

On the left side of the upper stick, optimal to the pilot's thumb, is the slew control for the radar/IRST acquisition "box". In later aircraft it also slews the optical seeker head of weapons to lock-up on their targets. In conjunction with this acquisition slew switch is a Lock-Up - Designation Switch on the Throttle.

The small white button immediately to its right located on the center of the stick is the "INTERROGATE" switch. This allows the pilot to manually use the SRZ-15 interrogator on any target locked-up by the radar to determine if it is a friendly aircraft. Friendly aircraft will respond with their SRO-2 transponder in the proper mode and code. The result of a confirmed friendly response is a "S" symbol centered at the top of the HUD and Radar Scope and a disable of any automatic firing pulses to the onboard missiles. This safety interface can be overridden by the pilot by using the "MANUAL PREP" switch action on the Main Armament Control Panel.

There is a large "beaver-tail" lever arm that comes up from the control column base which allows the pilot to grab with his extended fingers while his palm still rests on the stick. This squeeze effect is the aircraft's pneumatic braking system.

Further down the column is the control lever which serves as a "pinkie switch" for the nose wheel steering that activates the steering motors and works in conjunction with the brake peddles. So taxiing the MiG-29 is no easy task alternating between the pneumatic brake and the nose wheel steering. In older MiG's there was no nose wheel steering and actual differential aircraft braking had to be used.

#### The Heads Up Display (HUD) & Helmet Mounted Sight System:

On the Heads-Up-Display (HUD) the pilot's head position for the Helmet Sight System is referenced off of two IR scanners. A left scanner "A" (vertical scan) and a right scanner "B" (horizontal scan) that project patterns that are received on a receptor located on the mask or helmet sight itself. The Helmet Sight Reticule fits comfortably over the right eye.

Even though the pilot easily scan at least  $\pm 120^\circ$  with his head, off boresight limits of the helmet sight for target acquisition would seem to be identical to the limited  $\pm 65^\circ$  for the IRST and radar. Pilots brief that it works with the A-11 Archer out to  $\pm 45^\circ$ , which is aligned with the gimbals limits of the missile. If the AA-11 can be uncaged then it should track the target to  $\pm 70-75^\circ$  or greater after lock-on. The concept of "select" a missile, "get tone", then "uncage" and "fire" doesn't seem as straight forward as in Western aircraft.

The Helmet Sight System (HMS) is utilized to point/que all of the IR weapons. The electro-optical IRST and laser ranger has a  $\pm 65^\circ$  azimuth field of regard;  $+60^\circ$  up and  $-15^\circ$  down. But it utilizes the same three  $\pm 25^\circ$  sectors. The radar has a  $\pm 65^\circ$  of azimuth,  $+54^\circ$  up and  $-36^\circ$  down general envelope.

The "TEST" Switch (NTCN), projects a grid display page on the HUD glass which also acts as a back-up air-to-ground weapons delivery depressed reticle gunsight with an "X" at the aircraft boresight line. This becomes the primary air-to-ground strafe display.

MiG-29, Part Six  
By Easy Tartar

MiG-29 during maintenance checks

#### The MiG-29 Main Armament Control Panel:

The Weapons System Mode Selection Panel or Main Armament Panel is located in the upper left area of the front cockpit bulkhead. It is adjacent to the lower HUD structure where the helmet sight IR head-positioning sensors are located. The switches and knobs on this panel and with other weapon system panels throughout the cockpit do not seem to have been "human engineered" in a central order or scheme, they are each positioned for independent purposes although they share in the operation of various modes. Little thought must have been given to the "intergration" of the switches, clusters, and separate panels.

However, the Main Armament Control Panel is the pilot's starting point when dealing with the business end of the Fulcrum. It brings together the N-019E "radar aiming complex" and the S-31E2 "optical / electronic aiming and navigation complex". This panel allows, through pilot switch actions, the selection of sensors and modes. The panel basically allows the pilot to select the radar or IRST modes he chooses to use, arm up his weapons, identify firing preferences, and manually control the main scan envelope of the radar or IRST. These are hard wired circuits and not software driven.

#### Main Armament Control Panel

On the far left side of the Armament Control Panel is the large MASTER ARM (UKFDY-JNRK) toggle-switch with the normal ON/OFF selections. In defector Alex Zuyev's book, Fulcrum: A TopGun Pilot's Escape from the Soviet Union (Warner, 1992), he is bringing the reader through his combat check list while flying the MiG-29, and mentions on page 21 that ... "At the upper right-hand corner of the main instrument panel, I deliberately pointed my finger to verify that the master arm switch was definitely OFF." Interesting comment, was it a misprint or deliberate "misinformation". The Master Arm is on the pilot's left side. Or was he confused about an indication on the video attack presentation pictured on the CRT that assures the pilot the missiles are selected and armed.

Note that Captain Alexander Zuyev defected with his MiG-29 on 20 May 1989 to the Turkish Black Sea airport at Trabzon and is considered one of the most qualified Russian pilots to join the West since Viktor Belenko. The US Government, however, never got its hands on the aircraft because it was returned by Turkey.

The Main Armament Control Panel rotary Mode selector knob has the following options:

- NAVIG Navigation Mode
- PITCHUP Air-to-Ground Mode
- RDR Radar Modes
- IR IRST Modes
- CC ACM IRST Mode
- HELMET Helmet Sight Mode
- OPT Optical Display with IRST Mode
- Fø Boresight Radar & IRST

The "IR GAIN"/"HELMET BRIGHT" (ECBK/NG-ZHR/IK) rotating rheostat knob works the "gain" or "brightness" of the IR symbology and the reticle features involved with the Helmet Mounted Sight System. It rotates brighter clockwise and have other "light" sources under its control.

The two-position "SALVO"/"SINGLE - 0.5 SALVO" (PFKG-JLBY-0/5R-NF) switch controls whether or not the missiles and gun fires at a prescribed rate or a maximum rate. In "SALVO", two missiles will be launched, 1.6 seconds apart, with each trigger squeeze and the gun will fire a burst limited only by ammunition. In "SINGLE"/"0.5 SALVO" there will be only one missile launched per trigger squeeze and the gun will limit itself to 1.6 second bursts. The "SINGLE/0.5 SALVO" selection is the primary mode of choice today with the re-united German Air Force, Russian doctrine would want to use the other setting stressing higher Pk values with two missiles launched for a controlled encounter.

If we return to Alex Zuyev's book, he mentions an interesting point about shooting missiles.... don't shoot one unless you are prepared to deal with an asymmetric load. Something not always considered in the West, but one that Lockheed had to deal with when the AIM-7 became part of the F-16 loadout. Therefore, Alex wanted to fire two missile to preserve the stability of the aircraft. Then comes the age-old Russian tradition of shooting two to maximize the Pk of the particular shot opportunity. Clearly, asymmetry can adversely effect your dogfight maneuvering capability. It is also interesting that in Russian military literature we find almost no discussion on "necessary" and "un-necessary" back up shots, or using a "shoot-look-shoot" method instead of letting missiles go impairs.

The two place "MANUAL-PREP"/"AUTO" (GJLU/HEXY/-HEXS) toggle switch can be seen to some degree as the old "interlocks" switch in the F-4. It sets up the hard-wire path to the trigger. In this case it is just the Master Arm and Trigger in "MANUAL PREP", versus the fire control system computer in "AUTO" combined with the onboard IFF interrogation system. Switching to "MANUAL" allows the pilot to technically "override" the weapon system interlocks that prevents missile firing while the attack computer is processing a solution. The pilot could then fire a missile without a Radar Lock-On, or Out of Range by just selection the Missile Trigger and having the Master Arm Switch "ON". "AUTO", of course, places the "command" of the firing sequence firmly in the hands of the computer. The "AUTO" Mode, meaning that firing circuits are run through the weapons computer, however the pilot would have to lock-up the target and select whether he wanted the automatic IFF interrogation (at lock-on) of friendly aircraft included in the logic by selecting "FRIENDLY" a Control Stick thumb-button. Radar interrogation of all targets is done by the computer automatically and a symbol for friendly or hostile is presented on the HUD with the attack presentation. .

Russian fighters have developed, since their first radar missiles, a technique that is supposed to give them the quickest shot off the missile rail if the system achieves both a radar lock-on and a confirmed interrogation of not "FRIENDLY", not necessarily a confirmed "HOSTILE". The MiG-29 export models can only determine aircraft of their own IFF make up. This technique was talked about by Viktor Belenko when he flew the MiG-25 and Alex Zuyev in the MiG-29. In the F-4 Phantom there was an Interlocks "ON"/"OFF" switch that would not allow a Sparrow missile to fire unless it met the computer solution, Interlocks "OFF" of course allowed the pilot to fire at will.

The pilot, in conjunction with the "FRIEND/FOE" selection on the Stick Grip, selects "FOE", and then actually continues flying with his missile trigger depressed and the Master Arm ON. For the MiG-29 this is an especially fast tactical mode when utilizing the radar and/or IRST in any of their dogfight auto-acquisition modes. The Helmet Mounted Sight system could also work in this manner. This cuts one or two valuable seconds off the firing sequence.

During the first night of the Gulf Air War, a "stream" of eight Strike Eagles (F-15E's) were making their way towards an attack into Western Iraq. It was one of the few times when the Iraqi Air Force had risen to the challenge and was aggressively trying to locate and shoot down the attacking formations. The Eagles were navigating on LANTIRN FLIR imagery as well as their internal systems and were aware that a MiG-29 and an attached MiG-23 were both searching for them trying to find the line of Eagles running in about 7-10 NM. trail. One of the last F-15E's watched (on radar and FLIR) as the MiG-29 came down the line of Eagles from the high left side with the MiG-23 is 3-5 NM. trail. Suddenly he must have finally gotten a radar or IRST contact because the MiG-29 turned sharply down and actually flew right in front of the previously targeted F-15E who was arming up, but at the same time not making any obvious moves or lock-ups. As the MiG-29's nose came around a missile came off and ran smack into his MiG-23 wingman coming down in trail. The aircraft blew up in a large fireball. The MiG-29 pilot then must have gotten disoriented because he flew right into the ground. After action speculation on this event noted the Russian "habit" of flying around with the trigger squeezed waiting for the auto-acquisition modes to grab a target and shoot a missile. Why the MiG-23 didn't respond to the MiG-29's interrogation as a FRIENDLY could possibly mean that they had their IFF's turned off, or the MiG-29 was not

interrogating, or the pilot selected "MANUAL PREP" and fired at the first locked target. The next point was the interior MiG-29 cockpit instrumentation at night in unusual attitudes. The "gyro issue" was noted.

The three position ZONE Switch (PJYF), directs the azimuth positioning of the antenna scan. The Scan pattern of the antenna is theoretically  $\pm 65^\circ$  in azimuth,  $+54^\circ$  elevation up, and  $-36^\circ$  elevation down. The  $130^\circ$  total azimuth scan is actually divided up into three sectors of  $\pm 25^\circ$  each, with about  $10^\circ$  of overlap from the CENTER to the LEFT or RIGHT Scan. In most western aircraft, the radar scan is controlled automatically or by direct pilot action through hands-on switches or slewing-thumb buttons that provide general antenna positioning inputs. The MiG-29 antenna is manually positioned by this Azimuth Scan Switch and vertically by a separate elevation control knob on another panel. The most interesting factor about MiG-29 radar scanning is that the resultant display, which is projected on the gun sight glass and optically repeated on the cockpit installed CRT, is oriented always to the scan-center and not the actual boresight-nose of the aircraft. That is, on a right directed scan, a target that is 10 right of the right-scan centerline is displayed as being  $10^\circ$  Right on the center of the Gun Sight Glass, not  $50^\circ$  right in line with its actual position.

The Scan or Zone (PJYF) Switch allows the pilot to select a "LEFT-CENTER-RIGHT" search-scan for both the radar antenna and the IRST ball. Original Fulcrum N-019 radars scan a  $\pm 25^\circ$  or  $50^\circ$  total scan-volume in anyone of the three scan selections. The CENTER Scan volume runs  $25^\circ$  either side of the aircraft centerline. The LEFT Scan starts at Left  $15^\circ$  from the aircraft centerline and ends  $65^\circ$  off the centerline. Hence there is a  $10^\circ$  overlap from the CENTER Scan and a full left side look angle of  $65^\circ$ , but the antenna does not return to  $0^\circ$ , it stops at  $15^\circ$  Left of the aircraft centerline. The same goes for the RIGHT Scan situation. This version of the MiG-29 radar does not make a full  $\pm 130^\circ$  forward hemisphere scan,  $65^\circ$  to either side of the nose. The best azimuth coverage it gets is  $\pm 25^\circ$ , but in any one of three sectors which must be manually selected.

The MiG-29, does not fully auto-couple the aircraft's flight control system with its ground control site as does the MiG-23 Flogger, but the MiG-29's weapon system is "commanded" by the ground GCI controller through datalink "directive queues" on the instruments and displays. The GCI controller may however, control some of the Radar's modes, direct a lock-up on a selected target, command the afterburner be engaged after, and just about everything else but fly the aircraft and fire the missiles in the sense that the trigger needs to be pulled by the pilot.

The Weapons Integration / Armament Control Panel:

The Weapons Integration/Armament Control Panel, sometimes simply called the Air-to-Ground Panel, is located forward of the throttles on the left console; the last panel before the vertical main instrument bulkhead. Most importantly, it is where the "COOPERATION" Switch is located. This is the second switch from the left on the forward line of switches. With this switch engaged, in the "COOPERATION" position the Radar will automatically switch to a medium PRF mode with a 50 Km scope with a large square acquisition box and operate with both Radar antenna and IRST Ball functioning together in scan and elevation. Regardless of what mode you are in on the Radar Operating Panel or the Main Armament Panel, either "Radar" (HK) or "IR" (NK) mode, the "COOPERATION" switch action throws the Radar into this joint mode automatically.

Initially, in the Luftwaffe, this was the only way to get ranging information while utilizing the IRST, i.e. through the Radar, because the laser was being evaluated for eye-damage potential and disabled.

With the "COOPERATION" Switch in the OFF position, the Radar and IR systems work separately according to Main Armament panel selections. Even when "cooperating" with the IR system, the Radar can be shut down into "STANDBY" at anytime by a switch action on the Radar Modes Panel. and rests at aircraft boresight. The IR ball also rests at boresight when the Radar operates alone.

The basic MiG-29 can employ air-to-ground stores such as the 57mm B-8M1 rocket pods, 250 kg & 500 kg gravity bombs, dispensers, and napalm or large single-station S-8 & S-24B unguided rockets. These weapons are fired or released via the "Missile Trigger" on the stick accompanied by the following switch actions: on the Weapons Integration Panel, the "AIR/GROUND" switch to "GROUND" and "RETARD/NO-RETARD" switch to what is needed for the weapon. On the Main Armament Panel the Weapon System Mode Knob rotated to the "PITCHUP" (RFMH) position, the "ARM/SAFE" (DPHSD/YTDPSP) switch to "ARM". Radar, not laser ranging appears to be utilized in the "PITCHUP" mode, but there is definitely no CCIP (continuous computed impact point) like mode.

When the "PITCHUP" (RFMH) mode is selected on the Main Armament Panel, the "COOPERATION" Switch reverts to the "RETARD"/"NO RETARD" mode that would effect the fuze arming and fin-retard selection of many air-to-surface weapons. The "PITCHUP" Mode generates a "Dive Toss" type presentation on the HUD. A target coordinate can be placed in the Navigation Computer and pulled up as a waypoint in the Navigation Mode to present a relative position cue (circle) with steering information on the HUD depicting the target location not adjusted for navigation in-accuracy. Once at the target location, the "PITCHUP" Mode gives a bomb-fall reference line with a target aim-point pipper that correlates to the position of the radar antenna for air-to-ground ranging. The aircraft is placed in a dive to the target which is placed under the pipper, the "BOMB-MISSILE-TRIGGER" is depressed and the the aim-point is stored and tracked by the radar antenna while processing data for a dive-toss release are done and the bombs are dropped during the pull-out to meet

the computed ballistics. The same release point can be reached by passing over the target point and doing a loop back into the bomb run from the opposite direction. Actually designating the target as you pass over it is a possibility in advanced variants.

For in-close air combat and strafing, the single-barrel 9A-4071K (GSh-30/1) aircraft cannon with 170 x 30 mm rounds is fired by using the "GUNS-TRIGGER", Master "ARM", and "SALVO" selection switches. Today the ammunition loading has been reduced to 150 rounds to accommodate early system upgrades requiring structure volume. If air-to-air modes are utilized by the radar and/or IRST, the gun presentation is for air-to-air gunnery with radar and/or laser ranging. As a backup there is a funnel, manual wing-span high aspect gun sight mode produced when the "GUN-TRIGGER" is initiated and no lock-up is available. Air-to-ground strafe can be done utilizing the Dive-Toss bomb fall line and pipper or the "TEST" manual depressed reticle grid from the HUD.

The original prototype 09-01 was fitted with a two barrel GSh-23L (similar to that found on the MiG-21 and MiG-23) and alternately a new twin-barrel GSh-30 at the front of the left wing root with magazine inboard and collector box outboard. The final single-barrel 30 mm gun was selected because it saved critical volume needed for fuel and avionics and because the laser/radar ranging system offered the Russian Air Force its most accurate gunnery platform ever. Tests concluded that only a few rounds could achieve a kill and hence the 170 round load was reduced to 150.

There are also two very interesting switches on the left-most location of both the upper and lower rows on the Air-to-Ground Panel. The upper switch appears to be a "RESET" (C,HJC) switch, necessary when the hard-wire circuits dead-end. The lower switch is the a "DATALINK GUIDANCE" basic "ON/OFF" switch for the two-way Lazur System utilized by the ground control installations. The Datalink frequency and mode selections are done from panels located on the right side of the cockpit.

The EMER-RELEASE (FDFH-CMHJC) Switch allows for the immediate jettison of both wing mounted 1500 liter external fuel tanks. There are published speed and G-limitations. There is no Master Jettison Switch for all stores at the same time. The Weapons Integration Control Panel deals with external wing air-to-ground stores which in later aircraft would include wing tanks. The Centerline Tank is released through a Jettison Button located on the inboard side of the control stick column. The over-wing chaff/flare dispensers and wing-mounted missiles are jettisoned from a white colored verticle switch panel on the front bulkhead, and individual missiles can be blasted off unguided by selecting the MANUAL PREP position + SALVO + ARM + MISSILE TRIGGER and hold the trigger down until everything leaves the aircraft. Selective firing can be done by using the INBOARD / OUTBOARD Switch + 0.5 SALVO + MANUAL PREP + MISSILE TRIGGER.

The Station Selection Switch, located on the upper left console (near drag chute "button"), that gives an "INBOARD/OUTBOARD" (DYENH/DGTYL) choice of weapon stations. The "INBOARD" selection are the two most inboard missile stations which are also the wing-tank stations. In a western context they might be considered Stations 3 & 5. The "OUTBOARD" selection involves the four outboard missile stations which are generally dedicated for IR guided air-to-air missiles of the Aphid (R60/AA-8) or Archer (R73/AA-11) type. Or air-to-ground stores. These could be referred to as Stations 1,2,6, & 7.

#### The Armament Wing Station Select Switch

When the "PITCHUP" air-to-ground Mode is selected on the Main Armament Panel, or "MANUAL PREP" thus disconnecting the computer's command over the firing sequence, the pilot can select the weapons station he wants to work with, but he does not actually "step through" missiles or air-to-ground stores as he could do in most western aircraft. He can choose, for instance, whether he utilizes his Radar or IR missiles, thus overriding the armament computer's decision.

#### Six A/C Wpns Stations

..1...2.....3.....4.....5.....6...7...

My station numbering

..6...4.....2.....1.....3...5...

Russian numbering

TANK TANK

TANK Fuel Tanks

R27R1

R27R1 Alamo A

R60.....R60 .....R60

R60.....R60.....R60 Aphid B/C

R73E...R73E.....R73E

R73E.....R73E...R73E Archer A/B

C-8....C-8

C-8....C-8 57mm Rocket

Pods

FB250  
 FB250 250 kg GP Bombs  
 FB500  
 FB500 500 kg GP Bombs  
 B8M1....B8M1.....B8M1  
 B8M1.....B8M1.....B8M1 B8M1 rocket pods  
 S8.....S8.....  
 .....S8.....S8 S8 unguided  
 rocket  
 S24.....S24.....  
 .....S24.....S24 S24 unguided  
 rocket

Note that the two key wing stations (3 & 5) are responsible for BVR missiles (R-27R1), Dogfight Missiles (R-73E), 250/500 kg. bombs, Rocket Pods, and External Fuel Tanks which severely limit the mixed load options. Also note that the Russians do not use the same station reference numbers. Their's start with the inboard stations at 1 & 2 with odd numbers on the left, facing forward to 1-3-5 and 2-4-6, with no number for the centerline. Note also, that with no way to identify the centerline station.

There is also a switch on the Air-to-Ground Panel labeled "ENABLE" (YFDTL), which is always found taped over and is non-existent on most non-Russian aircraft. It could provide the necessary electric power to arm a special or nuclear weapon implying that the MiG-29 could carry a nuclear store.

As we probe further into the MiG-29, especially from a Western mindset, the point continues to come up over how can the pilot get command of all aspects of the weapon system in the aircraft and do things "his way". Of course, this is the most alarming thing about the MiG-29, it does not allow for this, but as we started to uncover, there are various manual mode options that can be used to gain control of some aspects of the weapon system. From the Russian mindset, none of that flexibility is necessary to perform the mission.

In most western aircraft, the radar scan is controlled automatically or by direct pilot action through hands-on switches or slewing-thumb buttons that provide general directive inputs. The MiG-29 antenna is manually positioned by this Azimuth Scan Switch and vertically by a separate elevation control knob on another panel. The Scan pattern of the antenna is theoretically  $\pm 60^\circ$  in azimuth,  $+54^\circ$  elevation up, and  $-36^\circ$  elevation down. The most interesting factor about MiG-29 radar scanning is that the resultant display, which is projected on the gun sight glass and optically repeated on the cockpit installed CRT, is oriented always to the scan and not the nose of the aircraft. That is, on a right directed scan, a target that is 10 right of the right-scan centerline is displayed as being  $10^\circ$  Right on the Gun Sight Glass, not  $50^\circ$  or  $60^\circ$  right from the nose of the aircraft.

The Infrared Search & Track with Laser Ranger (IRST/LR):

The S-31E2 IRST and Helmet Sight are selected by switch actions that start from the "IR" setent and continue clockwise to "HELMET", on the Weapon Select Panel. Note that the "HELMET" selection detent is beyond the "IR" selection, therefore placing the Helmet Sight Mode selections under the control of the IR side of the weapons system switching mechanisms.

A Laser Ranging (LR) system is used in conjunction with an IR Search and Track sensor. The laser is turned on anytime the Helmet sight system is selected through switch action "HELMET", anytime the "GUN-TRIGGER" is selected, and when the radar fails tracking a target when the "Integration Switch" is activated.

The laser is guaranteed to provide range inside 8 km (5.6 NM). When the "GUN-TRIGGER" is selected on the Weapons Selection Paddle Switch on the Stick (Missiles/Guns), and "IR" is selected on the Main Armament Panel, the Laser Ranger and the IRST both operate in a "free" mode locking up on the first, and hottest, target. The range which is computed by the laser is displayed on the HUD, not on the Helmet Sight Reticle. The max slant range of the laser is given as 14 km (7.7 NM) and it is considered generally very reliable in VMC conditions out to 8 km (4.4 NM). Laser "CEP" is considered to be 1 meter (3.3 ft) which seems to be reasonably the "range-error" at 8 km (4.4 NM).

The Helmet Sight projects both symbols and numbers for tracking targets and aiming weapons on a transparent glass in front of the helmet. The IRST has an angular resolution better than a radar solution and is considered better than any in the West. In clear (VMC) weather, the IRST is the favored target tracking system in all aspects since it can see out at ranges that matches good eyesight, which we have come to understand to be the 14 km assessment with a more practical 7-8 km practical estimate. The MiG-29 FCS automatically senses any degraded performance of the IRST due to environmental conditions (clouds, rain, etc.) and will switch on the radar to complete the tracking solution.

The laser measures range for the GS-301 GUN, and it is 10 times more accurate than a radar GUN solution. It was noted that in the early tests the GUN system was so accurate that the FCS computer would shut it off after 4-6 rounds. Have no

idea if the fire control computer assess probability of Kill.

The 0.1 micro second pulse length implies that there is a 100ft pulse of laser energy, which is considerably smaller than any of the more damaging lasers which can have pulse lengths of several miles. It would more than likely be in a 5 Watt power class and would be capable of around 2-4 pulses per second. If during laser range tracking the laser breaks lock (clouds, haze, etc.) the radar is mechanized to turn on immediately and continue tracking.

The two main types of lasers that are used, the "Yag" and the "Glass" variety each represent certain levels of capability. The "Yag" generally runs pulse lengths of 0.02 milli seconds and puts out around 10 pulses per second whereas the "Glass" variety is in the ball park of the 0.1 micro second pulse length. Both produce the same wavelength laser at 1.06 microns. The "Glass" is considered to be able to produce 2-4 pulses per second.

In the MiG-21/23 family up to the Fishbed J/K/L/N and Flogger E with the J-Bird Radar, the use of the Nr-23 twin-barrel gun is mostly manual because the radar minimum range was around 600 meters (1968 ft) and at the maximum boundary for good air-to-air gunnery for the 23 mm gun. Therefore the Russians knew for some time that they did not have reliable gun systems, especially in a maneuvering environment. A situation rectified by the MiG-29's Laser Ranger.

Air-to-air Gunnery can be optimized by improving radar performance in close, improve the range of the guns, utilize laser ranging, or all the above. Evolving through the MiG-21 with its "J-Bird" radar, the MiG-23 series with the "High Lark" and then finally on to the "Slot Back" radar with the MiG-29, the Mikoyan engineers have created an excellent director gun system.

The switch sequencing in these earlier aircraft to achieve a air-to-air weapons utilization was numerous. Power Supply to external store stations, Gun Camera ON, Gun Sight ON, Homing Missiles Selected (fixed reticle) over Gyro Gun Sight, Inboard/Outboard stations Selected, Radar ON/OFF (transmit), Air-to-Air or Air-to-Ground Selected, Rockets or Air-to-Air Missiles, Firing or Bombing Selection, Auto and Manual Selection, and finally radar modes had to be selected and jettison or emergency switches set up along with engine Emer-Start sequencing which was eventually made automatic with missile firing. All of this thinking had to go into the MiG-29 in some improved manner, and it was. Laser ranging then seems to have given the Russians, first, a positive and reliable "GUNS" capability, then the back-up to the radar in VMC conditions.

The Russian Air Force used an "external base method" of manual ranging and angles approximation for manual gunnery situations inside of 600 meters range and optimized for the 400-200 meter envelope. The gun sight was placed into a fixed reticle mode ("Homing Missiles" instead of "Gyro") and target aspect would have to be approximated. The Lead Angle would be determined from 0 to 140 mils based on the manual "mil-rings" on the gunsight that would respond to aspects from 0° (tail-on) to 90° (beam). They actually created formulas for the determination of Lead Angle. The fixed reticle method reflects steady state closure at constant 4-6 G's with lead on a turning target. An alternative "Fuselage Method" can be applied when the target "wing span" can be determined and placed into the respective gun sight ring. Wing span, and thus size of the target determines a factor of "fuselage length equivalent lead", up to two times the length. Wing spans of 10-14 meters (33-46 ft) and 14-18 meters (46-59 ft) are utilized in the existing gun sight rings.

In the MiG-29, the manual "GUN" back-up mode utilizes a selectable wing span knob applied to a "funnel" presentation that is quite effective, with or without ranging.

With the HELMET Sight, once engaged, the IRST moves with the pilot's head to its gymbal limits. When the pilot sees a target and puts the double-circle cue of the HMS on it, he actuates a throttle "LOCK-UP" Switch. The IRST locks-up on the target. The pilot now has to go back to the HUD and check for range to the target, if he wants it, on the 10 km scale. If the radar assesses that the target is inside of 14 km (7.7 NM) it will tell the Laser Ranger to get working, and it is supposed to provide range info by around 7-8 km (3.8-4.4 NM).

When the radar is "ON" it becomes the primary weapons mode and is used supported by the Data Link system and close GCI control. The Helmet Sight does not slave the Radar antenna because that would interfere with the two-way feedback from the Data Link. Also, it would seem consistent with Soviet thinking that the radar would not be turned on until it was needed or being used to launch a missile. The HMS could then be the pilot's "manual" (man-in-the-loop) back up to the auto and close control GCI modes of intercept.

There is a good chance that the MiG-29 pilot would be flying under direct or indirect data link command with the radar OFF, and his only real backup would be through the HMS in case of a bad intercept, or the arrival of an unknown target.

The max slant range of the Laser is 14km (7.7 NM) and the Russians guarantee it out to 8 km (4.4 NM). Up to 15km (8.2NM) detection capability for the IRST versus a Military Power Target was indicated in Mikoyan discussions. From 4-8km (2.2-4.4 NM) the IRST autotracks the target with the help of the Laser ranger, and the results are displayed on the HUD with symbols, not on the HMS.

It can be assumed then, that there is a full "covert" attack capability in close. With full radar tracking the IRST can track

further out. When visual contact is made inside of 7km, the helmet sight can slave the laser ranger and get a range read out of the target on the HUD. The auto mode uses radar auto track with IRST and laser ranging. With the IRST tracking the target in AZ & EL, and the Laser Ranger getting Range information there is displayed on the HUD a full track presentation. The weapon system can then bring up the CW illumination and fire an AA-10a Alamo radar missile or uncage the head of an IR Aphid or Archer missile.

The MiG-29 Radar Modes Panel:

The N-019 Radar has a primary modes function panel located on the left side of the main cockpit bulkhead just up from the Air-to-Ground Panel where the Cooperation switch is located and just down from the Main Armament panel adjacent the HUD.

There are several Radar Modes of Operation that are mechanized quite differently than anything found in Western Fighters. The most interesting is the manual selection of antenna look-angle (up or down) by a rotary detent switch and not a thumb-wheel on the stick or throttle. GCI information is relayed to the pilot who then places the antenna to the elevation block where the target is expected or found. Elevation is expressed in degrees up and down from the nose boresight.

Once the Pilot selects "Radar" on the Main Armament Control Panel there are five primary radar modes selectable from the "Radar Modes" switch and one special mode is available when the "Cooperation" switch is initiated on the Weapon Integration (Air-to-Ground) Panel. The special combined radar/IRST mode overrides all of those selected on this panel except for Close Combat. It is also important to turn the Radar ON/OFF (JNRG) switch to "ILLUMINATE" (BPK) out of the "DUMMY" (PRD) position which is a standby warning position that keeps the radar prepared for immediate operation. The MiG-29 pilot will generally turn on his radar before takeoff but keep it in "DUMMY" until needed or instructed to use it. The ground GCI data link cannot turn the radar ON or OFF, it is strictly a pilot switch action.

Sensor Search Modes

Radar Modes Panel (Rdr Selected on Main Armament Panel)

Free Search (CG) [SP]

Encounter (D) [E]

Pursuit (L) [P]

Automatic (FDN) [AUTO]

IR Side of the Main Armament Panel: IRST

(HK) [IR-STROBE]

Integrated Weapon Armament Panel:

Combined Rdr/IRST (DPVL) [COOP]

Air Combat Modes

Main Armament Panel:

IRST Close Combat (M MJQ) [CC]

Radar Mode Panel

Rdr Close Combat (NG M MJQ) [CC]

Control Stick Column

Gun Trigger (YJ) [Manual Guns]

The Encounter "E" (HKC-D) Mode utilizes "High-PRF" for optimal forward quarter intercepts. It generates a 150 km (82 nm) scope presentation and utilizes a horizontal-oriented rectangle acquisition box. The doppler sub-banks can see targets registering in Vc (closing or opening doppler) from 220 kph to 2200 kph (120 kts to 1203 kts).

The Pursuit "P" (HKC-L) Mode utilizes "Medium-PRF" for optimal rear hemisphere target tracking. It generates a 50 km (27 nm) scope presentation and utilizes a square-shaped acquisition box. The system requires at least a  $\pm 50$  kph closure/opening to register a target on the doppler sub-banks. Pilots report that there are more false alarms but less ground clutter.

The Free Search "SP" (HKC-CG) Mode also utilizes "High-PRF" for optimal forward quarter intercepts. It generates a 150 km (82 nm) scope presentation and utilizes a smaller horizontal-oriented rectangle acquisition box. The doppler sub-banks can see targets registering 200 to 2200 kph in closure. Free Search is mechanized to reject all chaff and clutter utilizing the higher doppler sub-bank register for minimum closure seen.

The Automatic "AUTO" (HKC-FDN) Mode utilizes an intermittent mixture of "Hi and Medium PRF" for the optimal incorporation of the Track-While Scan (TWS) capability of the Radar. It generates a 100 km (55 nm) scope and utilizes a larger horizontal-oriented rectangle acquisition box. There is very little clutter seen and the TWS mode is less susceptible to chaff and jamming but does create many false alarms. Actual target motion traces are registered on the scope display longer. The system will step or jump through the next-priority target up to ten times and remain with the one that has the most direct closure to the aircraft. In order to initiate the Track-While-Scan function, the second toggle

switch along the bottom of the Radar panel, the "Radar Missile Fuzing and TWS" (GGC-PGC) switch, must be in the upper "Forward Hemisphere Position" most position. The term "Automatic" is a result of the fact that the system is virtually computer controlled and working automatically to determine the highest closure (Vc) threat. It will eventually auto-lock on this target providing a full-track presentation on the HUD and radar display. Pilots report that there is a poor, one in ten success rate, with this mode against known targets that can be seen in the Encounter Mode. It overloads the computer, catches too long on the many false alarms, and reduces contact range. However, it is used best in weather conditions or against large formations where a "raid assessment" by closure could be useful.

The "CC" (Radar Close Combat Mode) utilizes a + 45°/-14° vertical scan mode (VSM) that is 6° wide ( $\pm 3^\circ$ ) and provides an auto acquisition of a target from 250 m to 10000 m (820 ft to 5.5 NM) in range. Note that the "CC" switch action on the Main Armament Panel would only be for the IRST, but it would produce a similar scan pattern. This vertical scan mode is not slewable, therefore the pilot must maneuver the aircraft's vertical lift vector to intersect the target's flight path. The "CC" switch will override all other radar modes including the combined Radar/IRST mode initiated by the "Cooperation" switch on the Air-to-Ground Panel. Remember that the "Cooperation" switch itself overrides any Radar Mode selected by the Radar Modes switch except the "CC" mode.

Advanced Fulcrum models and retrofit kits allow for the introduction of the AA-12 (R-77) "Adder" Missile which has been characterized as being equivalent to the American AMRAAM. To best utilize the active radar capability of the AA-12 and modification to the MiG-29 weapon system was made for the Malaysian Air Force and is being marketed world wide. The "SNP-1/SNP-2" switch was installed on the Radar Panel and is utilized in conjunction with the Track-While-Scan mode. Two highest threat targets can then be identified and passed off to two separate missiles waiting on the rails.

The switches along the bottom of the Radar Modes Panel (HT{BVS HKC) represent sophisticated circuitry in the radar processor. The "COMP" (RJVK) switch initiates an increased sensitivity for side-lobe compensation and is expected to reduce it by 33% at a slight loss of radar max range capability. The Track-While-Scan and Hemisphere Fuzing switch has a more complicated function. During any radar full single-target track situation, the pilot can "help" the computer present the proper fuzing instructions to the AA-10 missile if he chooses the closest target engagement aspect as "FHS" (KKC) for forward hemisphere or "RHS" (KC) for rear-hemisphere. When the radar is in the "AUTO" (FDN) Mode, the pilot can select "FHS" (KKC), again and start the radar processor stepping through possible targets looking for the highest closing velocity threat.

The "AJ/CAJ" switch on the right produces the "anti-jam" and "acquisition-on-jam" equivalent switch actions. "AJ" (FG) works to reduce radar susceptibility to jamming and "CAJ" (FGR) attempts to move the radar track gates towards a known jamming pulse.

MiG-29, Part Seven  
By Easy Tartar

The Listed Radar ECCM Features of the MiG-29 Radar are:

1. Low Sidelobe Antenna spillage
2. Monopulse Antenna
3. Wideband High Speed Frequency Agility
4. A Guard Channel
5. Long Pulse Compression
6. Low Peak Power
7. Wide Instantaneous Beam Width
8. High Range Resolution
9. Working TWS Mode
10. Low/Med/High Coherent PRF features and modes
11. High & Medium PRF Mix (160-200 kHz up to 3.5° BW)

The Radar/IRST Display Characteristics:

The Radar (HK) and IR (V) search, track, air combat, and back-up mode representations are displayed on the HUD and repeater scope in similar formats which differ only by variations in range-scales, symbols, and weapons.

Mode English Range Scale PRF ACQ-SYM  
Free Search [SP] 150 km Hi horiz-rect  
Encounter [E] 150 km Hi horiz-rect  
Pursuit [P] 050 km Med square  
Automatic [AUTO] 100 km Mix horiz-rect  
IRST [IR-STROBE] 010 km IR vert-rect

Rdr/IRST [COOP] 050 km Mix/IR large square  
 IRST CC [CC] 010 km IR 4° by 30° vol  
 IRST/HMS [HMS] 010 km IR ±45° to ±60°  
 Rdr CC [CC] 010 km Hi 6° by 55° vol  
 Gun Trigger [Man Guns] none none funnel/man-ws  
 Gun Rdr Lock [Rdr Guns] 1000 m Hi director LCOS  
 Optical [Op] 010 km none slew circle  
 Test [TEST] none none man dep ret

The HUD/scope display in the MiG-29 always includes the airspeed and altitude read-outs in the upper left/right areas. In the upper middle is generally a linear moving compass heading indicator. Small diamonds depict the direction of change and other symbols directed points to go to that are sent in via the data link from GCI. The aircraft symbol is in the geographic center of the display always flying in relation to a fixed horizon line showing actual wing position not horizon motion. Range is depicted along the left side of the display and marked according to the range utilized by the mode. Acquisition symbols are boxes of various size and dimensions which give the pilot a clue as to what mode he is in. Acq Symbols are moved by the stick cursor and the lock-up is achieved by the designation switch on the out-board throttle.

During a full-track presentation target range is indicated on the range scale on the left side with a large pointing arrow. Target symbols on the scope do not reflect range and steering circles reflect lead-collision points, not actual target position.

The MiG-29 Lazur Data Link System:

The Lazur Data link System is a two-way system, GCI-to-Fighter and Fighter-to-GCI. It is composed of the SAU-451-04 automatic control system, the E502-20/04 airborne guidance system, the R-862 radio, A-611 marker radio receiver, SO-69 ATC responder with the UNN block/K-42E kit, the ARK-19 radio compass, the TESTER-UZ/LK flight data recorder, and the ALMAZ-UP information reporting system. The MiG-29 appears to have no Fighter-to-Fighter capability yet. Transmitted target information is displayed on the HUD display which is the primarily display, then on the radar scope and appropriate cockpit instruments. The "GUIDANCE" switch on the Air-to-Ground Panel must be "ON". A Data Link Frequency needs to be selected and a Data Link Mode selected from the "GCI SITE", "AIR TRAFFIC", or "TERMINAL" options. The system operates in the VHF frequency band and is effectively line-of-sight limited.

The information displayed with 54 symbols or directives, some are listed below:

- \* closure speed command go-to
- \* continuous distance to prime selected target
- \* fixed distance to targets indicated
- \* end of intercept (flight recovery) command
- \* end of intercept (change target) command
- \* engine power setting commands
- \* afterburner activation (what stages if any?)
- \* interceptor aspect commands (go-to)
- \* interceptor altitude commands (go-to)
- \* interceptor course commands (go-to)
- \* interceptor speed commands (go-to)
- \* interceptor turn commands (go-to)
- \* missile warm-up (AA-10) commands (approx 3 minutes)
- \* target assignment commands for priority
- \* target elevation delta (±) commands
- \* target true bearing commands for pointing
- \* target vertical speed (snap-up) command
- \* target range, look angle, speed, G, etc.

Chaff and Flare Dispensors:

The MiG-29 single-seat fighters are equipped with two BVP-30-26M chaff/flare dispensors which have been located above the wing surfaces directly in line with the vertical tail surfaces. There are 30 dispensor chambers per side for a total on the aircraft of 60 holes. There are covers over the dispensor "cluster" boxes that are bolted on and removed on the ground before a combat mission, but kept on for ferry and training. The individual chambers are tilted forward about 30° thus allowing both chaff and flares to be disperse and "bloomed" prior to passing beyond the aircraft. The dispensors themselves can be jettisoned from the aircraft and are done so by utilizing a vertical switch panel directly in the center of the main instrument panel. Early MiG-29's had three toggle switches, but present models have one selection toggle for LEFT / RIGHT / BOTH, and the JETTISON BUTTON. There is also a small window with two count-down scrolls from 30 to 0 to read the number of remaining chambers.

## Chaff/Flare Dispensor Jettison

The chaff/flare dispensers are deliberately operated manually off of a throttle finger switch. The Throttle Switch is a single button located under the speed brake double action switch. It is single action switch, thus whatever is ground loaded, and in whatever sequence, gets dispensed. The number and interval of dispensed chaff bundles or flares is preset in a ground loaded chip that is unique to each type aircraft. The "manual" pilot-directed dispensing by switch action was treated as an advantage by the Russians when talking to potential buyers for reasons that I am not sure, but I do believe that they think that the US relies too much upon "automated" systems and that they expend the limited chaff/flare load too fast, too soon. The future Russian systems, however, appear to champion integrated approaches linking the dispensers into a more sophisticated "radio electronic opposition complex".

### The Radar Homing & Warning Receiver (SIRENA-3):

During the Fersten Fieldberg, FRG, 1987 Summer NATO Safety Officer's Course, where both Pakistani and Indian pilots attended, two F-16 FWIT Instructors (Dutch AF Officers) attempted to question an Indian Air Force Officer about the MiG-29 he flew and its capabilities. They were astonished about how disturbed he was over the Pakistan Air Force getting the F-16 and yet equally surprised over how much relative merit he gave to the F-16 over the MiG-29, saying that he felt that the F-16 was the better maneuvering aircraft of the two. But he was convinced that the MiG possessed a much more formidable weapons system, especially because of its "threat warning system" which would not allow the F-16 to get anywhere near the MiG-29 without alerting it well before the MiG-29 could get inside the firing envelope of the AIM-9L. The implication was that the MiG-29 RHAW device was so accurate and so capable, that no F-16, or any NATO aircraft for that fact, could approach unseen or at least without warning while its radar was on.

The L006-LM/101 SIRENA-3 radar illumination warning receiver antennas are located on both the leading edge of the wing strakes for coverage in the front hemisphere, and on the wing tips and port fin to cover the rear hemisphere for the MiG-29. Two larger antennas for the SO-69 type K-11E ECM active jammer are located also located in the leading edges of the wing strakes on some aircraft. The RWR is configured to provide, in general:

- relative bearing to threat emitter
- type of emitter
- mode of radiation
- prioritization as a threat
- relative range via power determination
- location above or below the threat

### In Conclusion:

The MiG-29 weapon system is a good example of the "mindset" differences that carry through the way we both relate to and train our pilots and allies, thus forming two camps; a western and an eastern. On paper the applications look the same. However, it is not just like the Dallas Cowboys swapping playbooks with the Washington Redskins. It is more like a European World Cup soccer team swapping their playbook with a US NFL football team. They are both playing "football", but it is not the same "football", nor the same playing field, nor the same ball, equipment, or rules.

As we rely more and more on software (abstract, conceptual, visionary, thought provoking, option intensive, reprogrammable software) and the "man" who uses it to drive our advance cockpits and system diagnostics we find less need for brute force hardware, absolute structure, and menus that restrict the thinking process. We have crossed the threshold where too many options are always viewed as disorder and freedom of expression as chaos. The eastern mindset in fighter design has reached the pedestal of high technology but still cannot make up its mind. The western approach wraps the fighter plane around the individual, the eastern method places him in a system to function in conjunction with it.

### Appendix A: Air-to-Air Weapons for the MiG-29:

The MiG-29 has 6 to 8 underwing hardpoints that utilize the BD3-UMK2B pylons and the APU-470, APU-73-1D, and APU-68-85E launching devices.

#### 30 mm Gryazev/Shipunov GSh-30-1 (9A-4071K) Internal Gun System:

- single barrel gun built into the port LERX
- 1500 to 1800 rounds/minute firing rate (25 to 30 rounds per second)
- 860m/sec (2822 ft/sec) muzzle velocity
- shell weight 400 grams
- bullet weight 900 grams
- Max Effective Range:  
1200 to 1800 meters (3937 to 5906 ft) vs air targets  
200 to 800 meters (656 to 2625 ft) vs ground targets

- 170 rounds capacity with 150 rounds loaded

R-60 (AA-8) "APHID" Missile Family:

R-60T APHID A APU-60-I/II launcher with active radar fuze

R-60M APHID B APU-60-I/II launcher with electro-optical fuze

R-60MK APHID C APU-60-1DB1 launcher with IRST & Helmet Sight System

R-60U training

purpose: short range IR homing

missile to replace ATOLL

design bureau: Vympel

development: early 1980's

1st Air tests: in 1989

length: 2.09 m. (6.87 ft.)

diameter: 120 mm. (4.72 in.)

wingspan: 490 mm. (19.29 in.)

missile wt: 43.5 kg. (93.69 lbs.)

warhead wt: 6.0 kg. (13.23 lbs.)

envelope: 200 to 7200 m. (0.2 - 4.0 NM.)

Range calculations: Tail-On: 600 m to 8.0 km (1969 to 4.4 NM.)

Head-On: 1.5 to 12.0 km (0.82 to 6.6 NM)

miss dist/kill radius: 1 meter (3.3 ft)

time of flight limit: 23 sec.

target maneuvering loads: 12 G

seeker gymbol limits:  $\pm 20^\circ$

seeker field of view:  $2.5^\circ$

antenna look angle:

guidance: Proportional Navigation

but it does have a  $\pm 10^\circ$  blind spot at

the null  $180^\circ$  TCA

a/c launch limits: -0.5 to +8.0 G

thermo-electric cooling: 1.70 to 2.85  $\mu\text{m}$ .

2.75 to 3.40  $\mu\text{m}$ .

3.27 to 4.88  $\mu\text{m}$ .

missile accel off rail: 200 to 900 m./sec./sec.

(656 to 2953 ft/sec/sec)

Notes:

The first tactical light weight missile designed exclusively for fighter-to-fighter close-in combat was the R-60 ("Aphid"/AA-8). The missile was needed to augment the cannon in close-in situations and was required to work from a minimum range of around 1000 feet out to the limits of cannon range around 9000 feet. The concept of a "dogfight" missile was not yet as clear with the Russian pilots as it was in the West. The original need was to kill a target that unfortunately was allowed to get close, or just showed up there. Due to the obvious maneuvering situation that results when aircraft get inside of visual range of each other, a requirement was let for a more G-capable missile with higher off-boresight lock and track capability. The R-60 also went through several generations of improvements and actually became the first missile to be incorporated with the new helmet mounted sighting system in the MiG-29.

R-27 (AA-10) "ALAMO" Missile Family: (known as Izdeliye 470)

Su-27 Variants:

R-27R AA-10a Alamo A SB-SA APU-470 pylon

R-27T AA-10b Alamo B SB-IR

APU-470 pylon

R-27RE AA-10c Alamo C LB-SA APU-73-1D pylon

R-27AE AA-10c mod Alamo C mod LB-SA APU-73-1D pylon

R-27EM AA-10c mod Alamo C mod LB-SA APU-73-1D pylon

R-27E AA-10d Alamo D LB-IR

APU-73-1D pylon

MiG-29 Variants:

R-27R1 AA-10a mod Alamo A mod SB-SA APU-470

launcher rail

R-27T AA-10b Alamo B SB-IR

R-27T1 AA-10b mod Alamo B SB-IR for

MiG-29S/SE

R-27RE1 AA-10c mod Alamo C LB-SA for MiG-29S/SE  
 R-27TE AA-10d mod Alamo D LB-IR for  
 MiG-29S/SE  
 R-27TE1 AA-10d mod Alamo D LB-IR for MiG-29S/SE

Length: R-27R: 4080 mm (13.386 ft)  
 Diameter: R-27R: 230mm(9.055 in)  
 Missile Wt: R-27R: 254 kg (560 lbs)  
 Miss Dist/Kill Radius: R-27R: 11.5 m (37.73 ft)  
 Time of Flight: R-27R: 60 sec  
 Seeker Gymbol Limits: R-27R:  $\pm 55^\circ$   
 Antenna Look Angle: R-27R:  $\pm 50^\circ$   
 Guidance: R-27R:  
 Proportional Navigation  
 Missile Envelope: R-27R: Max Range (1.4 Mach/40Kft/5sq-m Tgt)  
 Head-On: 61 km (33.5 NM)  
 Tail On: 21 km (11.5 NM)  
 Min Range (1.4 Mach/40K ft/5sq-m Tgt)  
 Head-On: 02 km (01.1 NM)  
 Tail -On: 500-600 m (1640-1968 ft)

R-73 (AA-11) "ARCHER" Missile Family:  
 R-73M1 off-boresight version utilized with helmet mounted sight  
 R-73M2 training missile shape with seeker head  
 R-73E APU-73-1D pylon  
 R-73U

purpose: highly maneuverable dogfight missile  
 design bureau: Vympel  
 development: early 1980's  
 first airborne tests: 1989  
 first delivered IOC: 1992  
 propulsion: single regime PATT solid propellant  
 rocket, can be made larger  
 guidance: complex controls with  
 movable vanes, fins fore and aft of fixed  
 cruciform surfaces at the nose control  
 surface at the trailing edge of  
 each tail fin 4 x thrust-vectoring cont-vanes in rocket motor  
 stream/efflux

control surface: fins  
 jet vanes  
 length 2.9 m. (9.5 ft)  
 diameter 170 mm. (6.7 in)  
 wingspan: 51 cm. (20.1 in.)  
 rudder span: 38 cm. (14.96 in.)  
 missile wt: R-73M1: 105 kg.(232 lbs.)  
 R-73M2:  
 110 kg. (243 lbs))  
 warhead wt: 7.4 kg. (16.32 lbs.)  
 envelope: 300 m. to 40 km.  
 (985 ft. to 22 NM.)  
 max range: R-73M1: 30 km. (16.4 NM.)  
 R-73M2: 40Km. (21.8 NM.)  
 miss dist:  
 kill radius:  
 time of flight limit: 23 sec.  
 max speed of target: 250 kph (11367 knots)  
 maneuvering tgt. loads: 12 G  
 seeker gymbol limits:  $\pm 20^\circ$   
 seeker field of view:  $2.5^\circ$   
 antenna look angle:  
 auidance: Porportional Navigation  
 a/c launch limits: -0.5 to +8.0 G  
 thermo-electric cooling: 1.70 to 2.85 mm. 2.75 to 3.40 mm.

missile accel off rail: 200 to 900 m./sec./sec.

#### Notes:

The R-73 ("Archer"/AA-11) third generation highly-maneuverable missile that has become the world's foremost IR guided dogfight missile. The Vympel R-73 is now operational with the MiG-23MLA (Flogger K) and all models of the MiG-29 (Fulcrum) and Su-27 (Flanker). All of these aircraft incorporate helmet mounted sighting systems. The R-73 has been designed to be fitted on new attack helicopter types such as the Mi-28 (Havoc) and the Ka-50 (Hokum). It is a lock-on before launch with gymbol limits exceeding 40° during acquisition and 70° off boresight after lock. It is of basic aluminum alloy construction (axial-symmetric cruciform scheme with small elongated tailfins) with the following component sections: seeker, aero-rudder actuators, autopilot, prox-fuze, warhead, solid-propellant motor, aero-surfaces, and thrust vectoring control vanes. The unique combination aero and exhaust-gas maneuver control represents the world's first operational thrust vector missile providing an exceptional maneuver capability during the powered flight phase. Fixed stabilizers and AOA transducers are installed in the nose just aft of the seeker before fixed canard control surfaces. During the high impulse solid-rocket motor burn, the missile is controlled by the canards, joined in pairs on each control channel and by the four in-flow jet exhaust vanes which also work in pairs. The fixed tail-fins have ailerons on their trailing edges mechanically coupled to each other for roll stabilization. After motor burn out, and there is no indication of post boost cruise burn, missile control is provided only by the aerodynamic surfaces. All of the missiles gas actuators are fed by a power pressure accumulator that bleeds overboard and is estimated to be of a lower pressure than Western missiles due to reduced aerodynamic loadings on the optimized control surfaces. There is a 7.4 kg. (16.3 lbs.) rod-type warhead fitted with a dual active-radar proximity and contact fuze. The R-73 is fitted to a common launcher rail that holds an internal cooling bottle.

The R-73 seeker is capable of being fired without any limitations of "G", "AOA", or aircraft attitude. The seeker-head can be cued to the target by matching the look angle of the locked up aircraft radar and/orIRST, or the sighting line of the pilot's eye through the helmet sight. Guidance to the intercept point is performed according to proportional navigation methods. The missile can engage targets maneuvering up to 12 G's. The minimum and maximum intercept ranges against non-maneuvering targets are published as 300 meters (984 feet) to 30 kilometers (16.4 NM). There has been a lot of press about a possible rear-firing air-to-air missile and Sukhoi released information about a reversed missile pylon for the R-27T ("Alamo B" AA-10b) IR short-burn version. The R-73 appears to have a better aero-chance because of its variable control exhaust jet vanes. Applications are being directed at bombers, transports, and deep strike aircraft.

#### R-77 (AA-12) "PBB-AE/PBB-AE" Missile Family:

R-77 ` AA-12 AAM-AE (PBB-AE) AKU-170 launch pylon  
R-77M AA-12 mod PD - longer range version  
R-77 AA-12 mod IR Imaging seeker  
R-77E AA-12 mod possible ARM variant

purpose: long range autonomous air  
interception against bombers, fighters,  
cruise missiles, PGM's, and other missiles design  
design bureau: The Spetztekhnika Group that includes  
NOVATOR Experimental Machine

first seen: the AAM-AE was displayed at the MosAeroshow '92 and the Zhukovsky Flight Research Institute. In 1993 the missile was show at the Paris Air Show and at the Machulishche Military Display near Kiev

first delivered IOC: 1992

propulsion: single regime PATT solid propellant rocket, can be made larger guidance/seeker: inertial way-point, datalink update, active radar terminal

speculated anti-radiation growth capability

speculation IR multi-window growth capability

control surface: 4 x elongated cruciform wings aft  
of the missiles CG

4 x movable tail-mounted grid-fins

length 3.6 m. (11.8 ft)

diameter 200 mm. (10 in)

wingspan: 40 cm. (15.75 in.)

rudder span: 70 cm. (27.56 in.)

launch mass/weight: 175 kg. (386 lbs.)

warhead mass/wt: 35 kg. rod plus multi-cumulative

fuzing: laser-proximity

max range head-on: 100 km. (54.7 NM.)

max range tail-on: 300 m. (984 ft.)

extended envelope: 150+ km (93 mi) for use against AWACS targets

max speed of target: 3700 kph (2023 knots)

max G of target: 12

## Notes:

Work on the R-77 began in 1982, and the work was considered quite significant and secret since it represented their first fully multi-purpose missile for both tactical and strategic aircraft for fire-and-forget employment against everything from hovering helicopters to high speed, low altitude aircraft. Gennadiy Sokolovski, Vympel Design Bureau General Designer, said that the R-77 can be used also against medium and long range air-to-air missiles such as the AIM-120 AMRAAM and AIM-54 PHOENIX as well as SAM's such as the PATRIOT. Latest generation fighters are to utilize the R-77 from internal carriage where the control fins and surfaces will fold flat until the missile is catapulted clear of the aircraft for motor ignition.

The Russian AAM-AE (R-77) "AMRAAMski" [Russian RVV-AE, RVV-AE] is a new air-to-air missile that had its first delivery to fighter units in late 1992 as the AAM-AE. It continues in series production. It is designed to be used against aircraft, cruise missiles, surface-to-air missiles, and air-to-air missiles.

The AAM-AE (R-77) incorporates an active radar seeker and is described as an all-aspect, all-weather, fire-and-forget weapon that can be employed in a countermeasure environment. The missile's 20 centimeter diameter does give it a large radar cross section which is further enhanced with its four tail-mounted grid-fins.

One of the R-77's most interesting features is its grid-type control surfaces. Sokolovski said that the development for this control concept took three years of theoretical work and testing. Drag and radar "signature" are more pronounced than might be expected from conventional surfaces, but the supersonic performance outweighs the drawbacks. The density of the grid, which allows for numerous aero-surfaces to fly in the relative wind, the total surface area is increased providing better maneuverability for less weight and size.

During the initial flight phase after launch, the R-77 is controlled by an inertial auto pilot with occasional data link updates from the launch aircraft's radar on changes in spatial position or G of the target. During the terminal phase, the missile shifts to an active-radar mode. Over short distances, the missile will launch in an active mode. The host radar system maintains computed target information in case the target breaks the missile's lock-on. If the seeker is jammed, it switches automatically to a passive mode and homes on the source of jamming (HOJ).

In another version of the R-77, a terminal IR homing seeker is offered. It is not the already The use of IR tracking in the terminal mode might be logical because at the extended ranges the data link between the launch fighter and the missile might be interrupted, or the host radar may not detect jamming. The R-77 has a laser fuze and an exploding rod (bar) warhead that is capable of destroying the variable sized targets from other missiles and PGM's to bombers (AW&ST, 24Aug92, pg 62 and JDW, 27Nov93, pg26-27).

R-77 mod (extended range AA-12) "HDD-FT-KL / HDD-FT-KL"  
 R-77 mod integral rocket-ramjet motor with four long intakes in-line  
 with tail control surfaces and could attain ranges of 100-150 km  
 Surface-to-Air (SAM) variant under consideration  
 The PD/PD is for povyshenoy dalnosti = extended range

## Notes:

The R-77M, would be directed against intermediate ranged targets. Older model aircraft with their older radars are supposed to be capable of incorporating the R-77 missiles. The R-77M is considered to be a combined rocket/ramjet propulsion holding the official designation of RVV-AE-PD. The PD is for povyshenoy dalnosti, which is for "improved range" which is considered around 160km. Even a more advanced variant, with a larger booster for perhaps a surface-to-air role, designated the R-77E, which could be exported, is being considered.

## Appendix B: Air-to-Ground Weapons for the MiG-29

## KAB-500Kr

purpose: PGM export TV guided weapon  
 guidance: TV/EO guided, lock before launch  
 length: 3.05 m  
 weight: 560 kg  
 altitude band: 500 - 5000 m  
 release speed: 550 - 1100 kph  
 average CEP: 4 m

## KAB-1500Kr

purpose: PGM export weapon  
 guidance: TV/EO guided, lock before launch

length: 3.05 m  
weight: 1100 kg  
warhead wt:  
altitude band: 500 - 5000 m  
release speed: 550 - 1100 kph  
average CEP: 2 to 20 m

#### KAB-1500L / 1500F / 1500L-PR

purpose: PGM export weapon, destruction of stationary ground targets like military/industrial bunkers & reinforced concrete shelters  
guidance: Semi-active Laser Guided Bomb  
production: 1992  
length: 4.6 m  
diameter: 580 mm  
tail span: 850 mm folded  
1300 mm open  
weight: 1500L @ 1500 kg  
1500F @ 1500 kg  
1500L-PR @ 1560 kg  
warhead type: 1500L/F @ Blast  
1500L-PR @ Blast-Piercing  
launch altitude: 1000 to 5000 m  
release speed: 550 to 1000 kph  
average CEP: 7-10 m  
penetration: soil @ 10-20 m  
reinforced concrete @ 2 m

#### KAB-500R

purpose: PGM export weapon, destruction of stationary ground targets like military/industrial bunkers & reinforced concrete shelters  
guidance: IR Guided Bomb  
production: 1992  
length: 4.6 m  
diameter: 580 mm  
tail span: 850 mm folded  
1300 mm open  
weight: 1500L @ 1500 kg  
1500F @ 1500 kg  
1500L-PR @ 1560 kg

warhead type: 1500L/F @ Blast  
1500L-PR @  
Blast-Piercing  
launch altitude: 1000 to 5000 m  
release speed: 550 to 1000 kph  
average CEP: 7-10 m  
penetration: soil @ 10-20 m  
reinforced concrete  
@ 2 m

#### KAB-500KRU

purpose: PGM export weapon  
guidance: laser guided bomb, lock  
before launch  
length: 1.83 m  
weight: 560 kg  
warhead wt: 85 kg  
altitude band: 500 - 5000 m  
release speed: 550 - 1100 kph  
average CEP: 4 m

#### Kh-25ML AS-10a "KAREN"

Kh-25MR AS-10b

Kh-25T AS-10c

purpose: semi-active

laser/optical/RF/command guided ASM  
guidance: Kh-25ML Laser Spot Tracking  
Command Guidance  
Kh-25MR Radio (RF)  
Command Guidance  
Kh-25T EO/TV  
optical guidance  
Kh-25 Imaging IR  
guidance  
developed: in the late 1960's  
length: 3.80 m (13.35 ft)  
span: 2.63 ft  
diameter: 10.75 in  
total wt: 300 kg (660 lbs)  
warhead wt: 90 kg (198 lbs)  
max speed: 860 m/sec, 2.35 Mach  
max range: Kh-25ML 1.3 to 12.5 miles  
Kh-25MR 1.3 to  
6.0 miles  
altitude band: 100-15000 m  
aircraft: MiG-23/27, Su-22,  
Su-30/33/34/35, Su-25, and Su-24  
(onboard laser  
designator on nose of Su-25T)

Kh-25MP AS-12 "KEGLER"  
Kh-25MP anti-radiation (ARM) variant of the AS-10 KAREN  
length 14.29 ft  
span 2.63 ft  
diameter 10.75 in  
total weight 660 lbs  
Warhead Wt 198 lbs  
Max Mach 2.35  
Max Range 1.3 to 20.0 miles

Kh-59 AS-13 "KINGBOLT"  
purpose: extended range pilot guided PGM to  
supplement short range AS-10  
guidance: EO/TV Guided weapon with the ARK-9  
Data Link Pod  
propulsion: two-stage solid propellant rocket motor  
developed: in 1970's  
length: 17.71 ft  
span: 4.10 ft  
diameter: 15.00 in  
total weight: 660 lbs (1765 lbs)  
warhead wt: 330 lbs  
max speed: 2.35 Mach  
max range: 1.25 to 125 miles (37 miles)  
aircraft: Su-22, Su-24, Su-25, Su-30/34/35, M  
iG-29M/S

Kh-29TE AS-14a "KEDGE"  
Kh-29T AS-14b  
Kh-29L AS-14c  
Kh-29ML AS-14d

guidance: interchangeable laser spot/electro-optical tracking heads host aircraft would require a laser designation system  
or a cockpit video CRT  
Kh-29T/TE with EO/TV Guided  
Kh-29L with Semi-active  
Laser Guided  
Kh-29MP with Passive Radar

Homing  
 design:  
 manufacture:  
 IOC: 1982  
 length: 3.9 m (12.79 ft)  
 diameter: 15.75 in  
 span: 3.60 ft  
 weight: Kh-29TE @ 690 kg (1520 lbs)  
 Kh-29T @ 680 kg (1500 lbs)  
 Kh-29L @ 660 kg (1455 lbs)  
 Kh-29MP @ 680 kg (1500 lbs)  
 warhead wt: 320 kg (250 kg GP bomb as warhead)(705 lbs)  
 max range: 1.85 to 18.5 miles  
 launch alt: 650 to 16,400 ft  
 max speed: 2.35 Mach  
 aircraft: MiG-23/27, Su-30/33/34/35, Su-24,  
 Su-25, MiG-29M, F-1 Mirage

Kh-31A mod 1 AS-17a "KRYPTON A"  
 Kh-31A mod 2 AS-17b "KRYPTON B"  
 Kh-31P mod 1 AS-17c "KRYPTON C"  
 Kh-31P mod 2 AS-17d "KRYPTON D"  
 Kh-31X AA- "KRYPTON E"

purpose: Kh-31A mod 1: antiship missile  
 with active radar seeker  
 Kh-31A mod 2: extended  
 range version of mod 1  
 Kh-31P mod 1:  
 antiradiation missile with passive radar seeker  
 Kh-31P mod 2: extended  
 range variant of mod 1  
 guidance: Kh-31A mod 1: inertial point with  
 active radar terminal seeker  
 Kh-31A mod 2: inertial  
 point with active radar terminal seeker  
 Kh-31P mod 1: inertial  
 point with passive radar seeker  
 Kh-31P mod 2: inertial  
 point with passive radar seeker  
 designer: ZVEZDA Missile Industry of  
 Spetstechnika Group  
 manufacture: STRELA  
 propulsion: integral rocket booster with ramjet  
 sustainer (4-inlets disposed around  
 the body, 12° AOA limit)  
 First seen: Dubai 1991  
 length: Kh-31A mod 1 4.7 m. (15.42 ft.)  
 Kh-31A mod 2 5.23m. (17.17 ft.)  
 Kh-31P mod 1 4.7 m. (15.42 ft.)  
 Kh-31P mod 2 5.23 m. (17.17 ft.)  
 span: 1.15 m. (3.77 ft.)  
 diameter: 30.96 cm. (12.19 in.)  
 weight: Kh-31P @ 650 kg (1433 lbs)  
 Kh-31A @ 600 kg (1323 lbs.)  
 warhead wt: 90 kg. Blast Frag. (198 lbs.)  
 range: Kh-31A mod 1 @ 05 to 50 km. (3 to 31 miles)  
 Kh-31A mod 2 @ 05 to 69 km. (3 to 43 miles)  
 Kh-31P mod 1 @ 10 to 150 km. (6 to 93 miles)  
 Kh-31P mod 2 @ 10 to 200 km. (6 to 125 miles)  
 profile: considered to high cruise 40,000 ft. @ 5.0 Mach  
 launch alt: 165 to 49,200 ft  
 speed: 2.9 Mach with terminal impact speed of >1.0 Mach  
 aircraft: MiG-27, MiG-29/33, Su-30/33/34/35,

Su-25, Su-24, Su-22  
exports: Cuba (1992)

### Kh-35 AS-20/SS-N-25 "HARPOONSKI"

purpose: low altitude subsonic cruise, anti-ship standoff missile air-launched & surface-launched versions  
design/manufacture: joint development with East Germany & Zvezda OKB  
first seen: December 1988, East German Navy Sassnitz fast attack boat in Baltic, August 1992, Zhukovskiy Show in Moscow  
guidance: inertial on 1st leg, with both active radar and IR/thermal imaging terminal at 5 to 10 meters over the water  
propulsion: boosted launch to air-breathing turbofan  
length: 3.75 m. (12.29 ft.)  
diameter: 41.9 cm. (16.50 in.)  
span: 1.3 m. (4.27 ft.)  
weight: 600 kg. (1060 lbs.)  
warhead wt: 145 kg. HE Blast (320 lbs.)  
speed: 485 km/hr, 0.95 to 1.05 Mach  
range: 5 to 130 km. (3 to 80 miles)  
launch height: 200 to 5000 m. (650 to 16,400 ft.)  
aircraft utilized on: MiG-29M/K, Su-27/30/33/34, Su-24, Su-25KT, and all bomber platforms (Tu-142M) & attack helicopters  
variants: surface-to-surface armament for ships, shore-based combat vehicles and as a target of the Harpoon type

### Appendix:

LFI "Legkiy Frontovoy Istrebityel "  
(Light Frontline Fighter Project)

LRMI "Mnogofunktsionalniy dalniy perevkhvatchik "  
(Long-Range Multi-Role Interceptor)

MFI "Mnogofunktsionalnyy frontovoi istrebitel "  
(Multi-Functional Front-line Fighter)

MiG Design Bureau named for Anushavan "Artyom" Ivanovich Mikoyan  
(05Aug1905-09Dec1970). and Mikhail Iosifovich Gurevich  
(12Jan1893-12Nov1976)

MiG-MAPO Joint MiG and MAPO Design, Production, Support, Training,  
Upgrades, and Refurbishment Consortium

TsAGI Central Aero & Hydrodynamics Institute

VPK-MAPO Joint Stock Defense Industrial Consortium

End of study

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