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THE MI 38: A NEW CIVIL MULTI-PURPOSE MEDIUM HEAVY HELICOPTER

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1 - FOREWORD

A new era of Franco-Russian industrial cooperation opened when exchanges commenced between the first Russian and the first Western European helicopter manufacturers.

A large number of subjects were discussed and several were selected, some of which some are currently going on, with the most significant and ambitious of those being the development of a new helicopter named MI38.

This medium-heavy helicopter can be considered as a meeting point between giant MIL helicopters and light medium EUROCOPTER helicopters

This project, which is a priority as far as Russian civil air transport is concerned, emerged naturally to unify Russian and French synergies and skills.

A framework agreement was concluded in December 92 and a new significant step was cleared in October 94 with the establishment of a Joint Venture Company named EUROMIL.

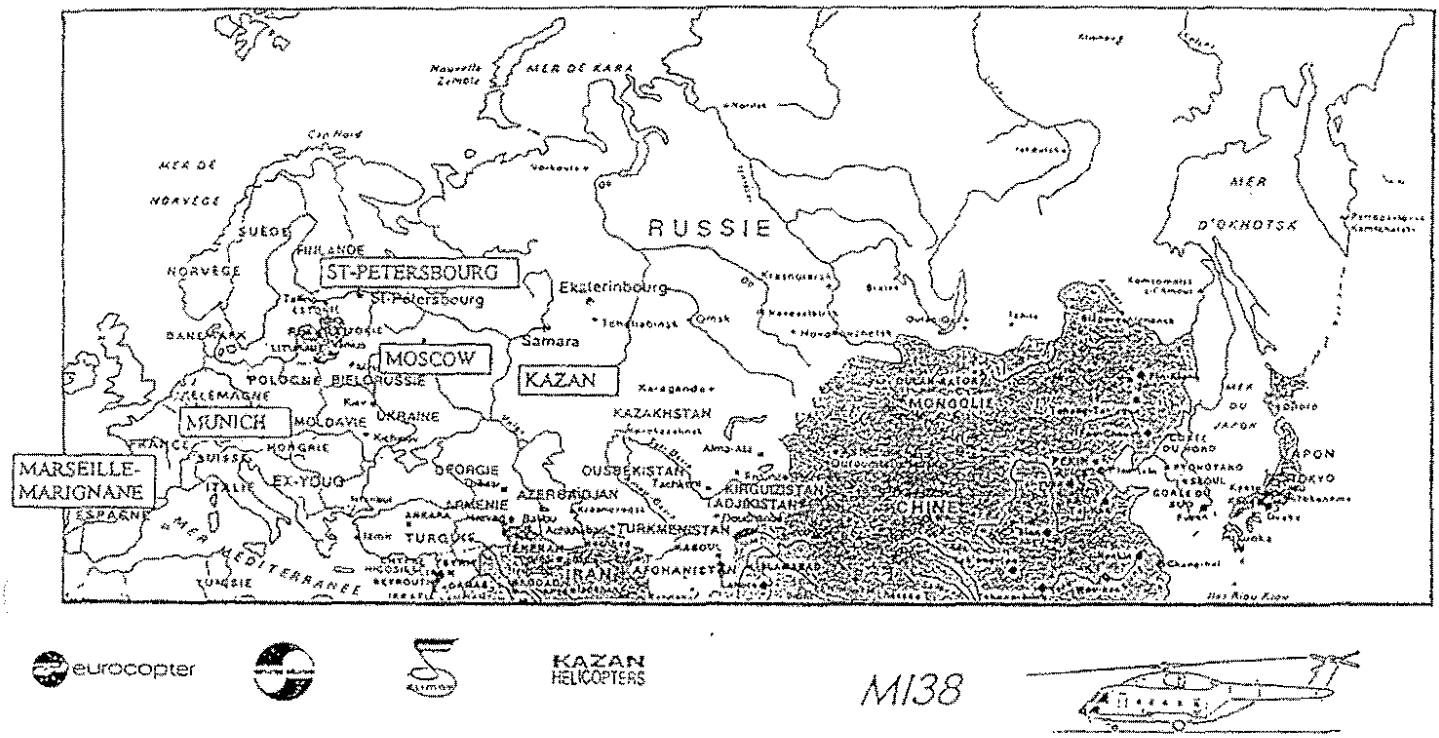


Figure 1

This paper presents some aspects of the MI38 technical characteristics, main milestones of the programme and organisation of our cooperation, with 4 major industrial partners, Eurocopter in Marseille-Marignane in the south of France and in Munich in Germany, Kazan helicopters in Kazan, Klimov Engine Co. in St-Petersburg and MIL design bureau in Moscow, in Russia.

2- PARTNERSHIP

In keeping with the general scope agreement dated Dec. 18th, 1992, the MI38 programme will be managed by a joint venture company operating under Russian Law, EUROMIL, the exclusive owner of the programme rights. The partners, EUROCOPTER, MIL, KLIMOV and KVPO will hold 25% of the share capital each.

Work sharing between the four partners and the Joint Venture Company (JVC) is summarized in the following table :

EUROMIL
Programme rights owner
Handle and coordinate activities between the partners
Obtain Russian and Western type certifications

MIL
In charge of global helicopter development, including vehicle design, manufacturing (partly) and tests
Coordinate vehicle development activities with Russian subcontractors.
Act as consulants to obtain Russian type certifications.

EUROCOPTER
Develop, industrialize and manufacture the cockpit with avionics, internal furnishings and part of the flying controls
Market and support (after customization) the aircraft sold outside of the CIS and Baltic States.
Act as consultants to obtain Western type certifications.

KVPO - KAZAN PLANT
In charge of global helicopter industralization and production
Manufacture prototype assemblies for MIL during the Development phase.
Market and support (after customization) the aircraft sold in the CIS and Baltic States.

KLIMOV
Are in charge of global engine development, industrialization and production.
Act as consultants to obtain Russian and Western type certifications for the engine.
Support the engine worldwide

TABLE I

- MIL are the most experienced Russian design office' and employ high level engineers and technicians. MIL will be developing the future helicopter. MIL have been tasked with design, prototype manufacture, ground and flight testing.

- KLIMOV have been tasked with developing, finalizing and industrializing the TVa 3000 engine. This engine with contingency power close to 4000 Shp shall be the first Russian helicopter engine equipped with a Full Authority Digital Electronic Control (FADEC).

- KAZAN HELICOPTER PLANT (KVZ) located in Kazan are one of Russia's largest helicopter manufacturers and produce the MI 8-MI 17 line amongst other machines.
  KVZ will be industrializing and productionizing the helicopter components developed by MIL as well as customizing and commercializing the aircraft intended for the C.I.S. countries.

- EUROCOPTER will be developing a modern avionics system together with the electronic piloting, navigation and radio-communication equipment required for the most diverse missions. Eurocopter will rely on their partners, SEXTANT AVIONIQUE and SFIM, in particular, to satisfactorily design the modern multi-function system.

- A cooperation with Russian companies is being discussed to widen the links developed in this first extended Franco-Russian programme.

3 - MARKET REQUIREMENTS

The main potential markets are the on- and off-shore civil markets as well as the commercial logistic transport and multi-purpose public markets. Such missions led to the selection of a large size cabin allowing comfortable furnishings, a roomy airframe with wide access doors for large size loads and a tail ramp for light vehicle transport and easy loading.

The helicopter must be capable of operating in all kinds of severe environments e.g. salt spray, icing conditions, intense cold, desert areas, etc. The basic and optional equipments must be designed accordingly.

The final product must be a rustic, easy to use and maintain helicopter while the operating costs are kept as low as possible.

The performance levels will be optimized against costs and the most important technical parameters to be taken into account designwise, consequently, are:

- space and comfort in the cabin,
- easy maintenance and reliability,
- environmental toughness,
- performance in hover (logistic transport and cargo slinging mission),

Mi 38 is, according to market surveys, considered the best helicopter for the replacement of the current medium and heavy machines in the CIS. In addition, the MIL decision to form an advisory team with some of the main operators will give a chance to optimize the helicopter's arrangement and performance to meet their requirements.

Although Russia is going through difficult times at present, the future looks promising for at least for two reasons.

The first is the very hard climatic and geographical environment favourable to helicopter operation. Large parts of the neighbouring states e.g. Alaska or Northern Canada have similar climatic conditions with, in addition, rivers running from South to North, and these are transformed twice a year into huge swamps where helicopters are the only means of communication. Furthermore, the infrastructure is extremely difficult or impossible to develop.

The second incentive is the promising development of Central and Eastern Siberia. Oil and gaz reserves are amongst the largest in the world. Research, development, exploitation pipe building are high consumers of helicopter services both for cargo and passenger transport.

The analysis made by Russian and Western operators led to the definition of several reference missions.

- Transport of 5 metric tons of freight over a 500 km range
- Cargo sling transport of 6 metric tons
- Casualty evacuation up to 16 stretchers
- Transport of 30 passengers or 12 VIPs over a 800 km range
- Transport of light vehicles

Some versions are already under contract with the Russian government and include:

- a passenger transport version
- an off-shore version
- a multi-purpose version: casualty evacuation, rescue, cargo sling, etc.
- an air photography version

As regards the versions to be developed, the best industrial profits will be ensured provided a single version only is developed by the Partners and this will lead to a choice regarding the definition of this single version certified both in Russia and Europe. The certification scheme selected (primary certification in Russia followed by JAA Validation) will allow meeting this objective.

In conclusion, MI38 should represent a promising share of more than 300 civil helicopters.

4 - REGULATIONS

MI 38 is the first helicopter in the world designed to meet, from the early design stage, both the latest AP 29 Russian regulation and the JAR 29 European regulation. MIL and EUROCOPTER thus studied those regulations together in detail. Engine shall form the subject of AP33 and JAR E certifications.

This analysis took the past experience of both helicopter designers into account to have a common interpretation of regulations capable of meeting Aviaregister and JAA requirements. Preliminary design reviews were undertaken together, discussed with the Russian authorities during "Mock-up Commission Meetings" and implemented.

As far as the certification process is concerned, it is EUROMIL which should apply for the helicopter's certification; the Russian Type Certificate shall be a basis for validation by the Western authorities. MIL and EUROCOPTER will help EUROMIL obtain MI38 Russian and Western TCs respectively.The engine manufacturer (KLIMOV) will assist EUROMIL in obtaining engine TCs.

5 - *MI38* GENERAL CHARACTERISTICS AND ARCHITECTURE

The main concepts and overall architecture selected minimize risks and optimize design while taking into account the technical drivers required by the customers.

A large cabin with optimized dimensions thus affords space and comfort for all missions, dynamic components are designed for easy maintenance and reliability as well as high design life, the general sizing of rotors and engines offers good performances in hover.

In addition, autonomous operation far from any traffic control or service center is possible thanks to optimized avionics systems and logistic support analysis; the Aircraft Recording and Maintenance System helps scheduling maintenance operations

5.1 - VEHICLE DESCRIPTION

The MI 38 project has been tailored to customer requirements to produce a multi-purpose helicopter; it is therefore an homogeneous aircraft as regards general dimensions and suitably powered by the KLIMOV TVa 3000 engine at 15,600 kg gross weight.

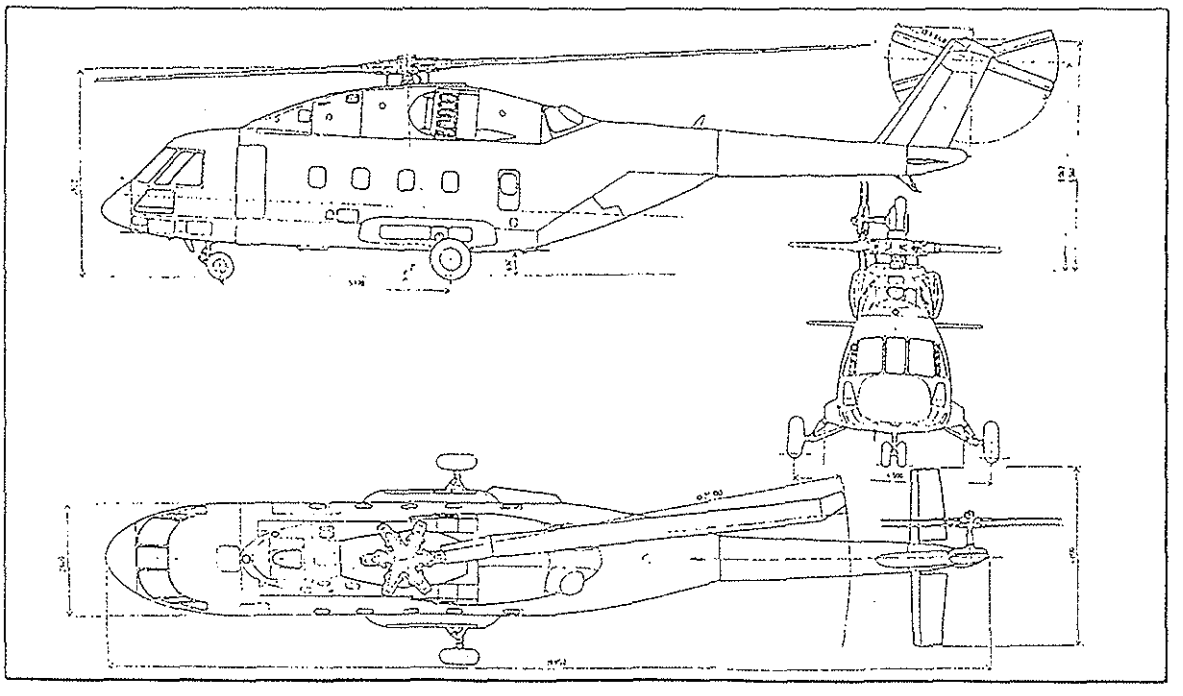


Figure 2 : *MI38* three view drawing

The following table presents a summary of the general characteristics and technologies selected for *MI38*.

	DATA	*TECHNOLOGIES*
FUSELAGE	2 pilots + 1 crew + 30 passengers	sheet metal, sandwich metal and composites
Cabin volume	29.5 m3	
MAIN ROTOR	single rotor	Composite blades
- Type	articulated	Metallic articulated rotor on spherical elastomeric bearing
- Number of blades	6	
- Diameter / Chord (m)	21.10 / 0.52	
- Tip speed (m/s)	215	
TAIL ROTOR	single rotor	Composite blades
- Type	scissors	Metallic articulated rotor, X-shaped with teetering hinge pusher
- Number of blades	4	
- Diameter / Chord (m)	3.84 m / 0.28	
- Tip speed (m/s)	215	
MAIN GEARBOX		Split torque 4 stages
- input shaft speed	15700 rpm	
- output shaft speed	195 rpm	
- twin engine input power	2 x 2500 SHP	
- single engine input power	1 x 3750 SHP	
ENGINES	2	Double centrifugal compressor, annular reverse combustion chamber, double gas generator turbine and power turbine, FADEC control system with mechanical back-up
- Type	TVa 3000	
- Power: 30 s rating	3750 SHP at 0m ISA	
Take-off	2500 SHP at 0m ISA+25°C	
FUEL SYSTEM - capacity	3796 l	6 fuel tanks under floor
A.F.C.S.	4 Axis	Digital dual duplex
COCKPIT	IFCS + V.M.S.	6 Displays of 6" size
BASIC EMPTY WEIGHT	8300 kg	
MAX GROSS WEIGHT	15600 kg	

TABLE II

Dimensions of the cabin is optimized to install very comfortably 30 passengers in off-shore equipment, with heavy luggage and room for coats and for toilets.

General dimensions			
Overall dimensions		*Cabin dimensions:*	
- Fuselage length	19.95 m	- Max width:	2.34 m
- Fuselage Width	2.40 m	- Height:	1.80 m
- Max. Width (hor. stab.)	4.90 m	- Length:	8.70 m
- Height at rotor head	4.78 m	- Volume:	29.5 m^3
Access dimensions:		*Landing gear:* (Fixed type)	
- Sliding door width:	1.45 m	- Wheel track:	4.50 m
- Sliding door height:	1.68 m	- Wheel base:	5.17 m
- Ramp width:	1.80 m	- Static ground clearance:	0.60 m

TABLE III

MI38 performance were adapted to worlwide missions, which are defined before. For these missions, good hover performance are requested, speed not being a driving factor.

For long distance transit, and in particular in Russia, a long range is important when refueling points are located quite far.

Hover Ceiling	2800 m
Max Cruise speed	275 km/h
Max Range	1300 km

5.2 - Tva3000 ENGINE DESCRIPTION

KLIMOV projected for MI38 a new engine able to challenge, in performance and technology, state of the art present worldwide engines. TVa3000 is therefore designed with an architecture allowing high pressure ratio and compact installation. In addition a Full Authority Digital Electronic Control system insures precise control, parameters management and health & usage monitoring of the engine.

The following figure presents a longitudinal cut of TVa3000 showing all main mechanical components.

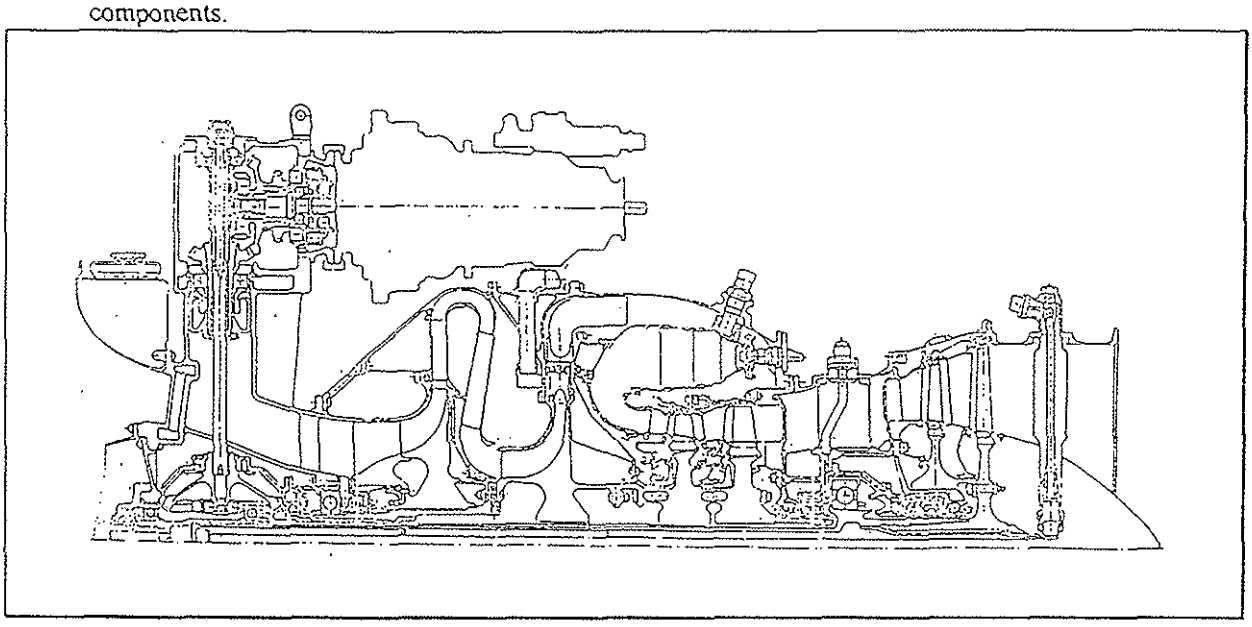


figure 3: *TVa3000* cut view

General architecture of the engine consists of 2 centrifugal compressors driven by a 2 stages gas generator; combustion chamber is of reverse type, and a 2 stages power turbine insures, through a crossing shaft, a front power output, power transmission to the main gearbox.

TVa3000 is divided into 7 modules: Gas generator, power turbine, exhaust, shaft assembly, accessory gearbox, oil tank and FADEC. This allows easy removal and maintenance.

Centrifugal compressors are titanium made. Gas generator turbine is cooled. An air system insures starting of the engines, controlled automatically by the FADEC. Engine is fixed on the turbine floor with struts; an engine-MGB shaft transmits power from the engines to MGB without reduction gearbox at 14915 rpm.

Control of the engines is performed by a FADEC and a hydromechanical back-up per engine. The control system is designed for many functions, among which: automatic fuel control at all ratings, torque sharing, overspeed protection, auto-relight, surge protection, self test, automatic power check, engines parameters management,....

Main characteristics of the engine are summarized in the following table:

OEI power	30" (kW/SHP) 2' 30'	2758 / 3750 2648 / 3600 2133 / 2900
AEO power	Take-off Max.Cont.Power	1838 / 2500 1545 / 2100
SFC @ Take-off (g/kW.h//g/SHP.h)		279 / 205
Airflow at TOP (kg/s)		8.38
Dimensions Lxlxh (mm)		1545 x 690 x 982

5.3 - MI38 AVIONICS ARCHITECTURE

The MI 38 systems have been specifically designed to meet the needs of the most demanding customers and even by keeping ahead of the most stringent regulations enforced by the various certification authorities; the master word is safety and the driver operational effectiveness.

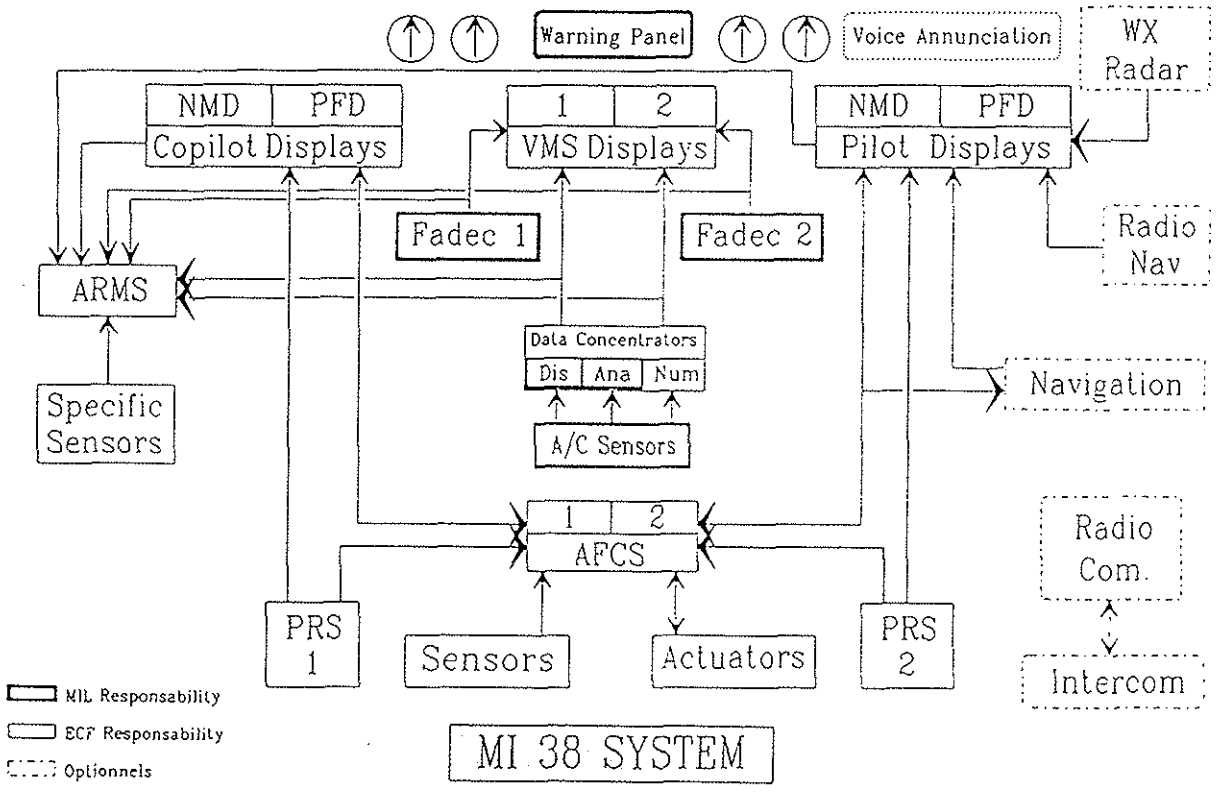
The basic system selected for MI 38 is intended to symplify the pilots' workload with: :

- a synthetized data display,
- a dual-dual automatic flight control system,
- assistance in case of failure,
- preventing mechanical damage that was up till now unpredictable.

Moreover, this system is intended to provide a significant maintenance support and an appreciable reduction in operating costs.

The following three subsystems meet the above criteria :

- *Integrated Flight Control System* : *IFCS,*
- *Vehicle Monitoring System* : *VMS,*
- *Aircraft Recording and Maintenance System* : *ARMS.*



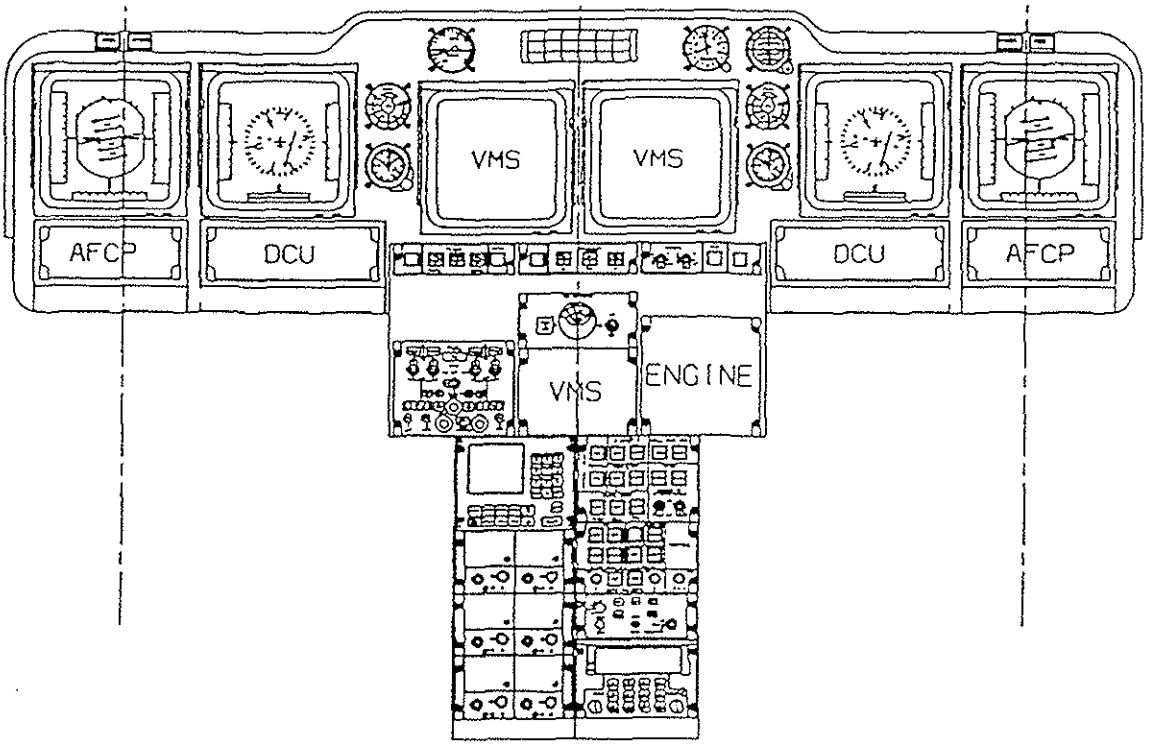
MI38's system architecture is based on ARINC 429 data links with the exception of specific equipment e.g. weather radar for which special standards are defined.

a - The *IFCS* is an integrated piloting aid system that allows automatic flight control with a high level of safety and reliability. The IFCS is made up of two identical and independent semi-systems with cross-monitoring. *Each semi-system* is made up of three subsystems :

- the Primary Reference System (PRS) processes data from various sensors (pressure, temperature, heading sensors), and delivers information to the other two subsystems. Moreover, it ensures hybridization with external navigation equipment such as Doppler, GPS etc.

- the Automatic Flight Control System (AFCS) performs 4-axis automatic flight control, processes the flight envelope and power margin data, provides some sensor monitoring functions and activates series and parallel actuators acting on the yaw, roll, pitch and collective channels.

- the Display System comprising two color Smart Multimode Displays (SMD) which display flight and mission data on 6" x 6" color screens containing their own processing and symbol generator. They also concentrate data from external radio and navigation systems and permanently monitor the system by storing the failure events in flight.



b - The *VMS* functions are designed to provide the crew members with every parameter necessary to control the engines as well as the various vehicle systems and, should a system failure be detected, by providing guidance for corrective actions.
The VMS is made up of 2 color displays, 6 x 6 inches wide, of the same type as those used for the IFCS and located on the central instrument panel: a Control Unit (VMCU) which is the dialogue interface between the crew members and the VMS, and dual digital, analog and discrete data concentrators for the parameters received from the different aircraft sensors on specific digital ARINC 429 lines. It also includes an aircraft weight and balance calculator as well as a display of the current aircraft weight and center of gravity,

c - Safety improvement is one of the aircraft manufacturers and certification authorities' common concern. Consequently, preventing such risks has led to the selection of a health monitoring system for the recently certified aircraft. This system called *ARMS* (Aircraft Recording and Maintenance System) has the following main functions :

- Health monitoring: a permanent vibration analysis of the major components (engines, gears, transmission, ...) as well as oil debris monitoring will allow detecting incipient failure directly on the part before any significant damage is generated.

- Usage monitoring: operating, taxiing and flight time, engines cycles, exceedance of limitations (Nr, Tq, T4, Ng, Nf, ...) will be accounted. This monitoring will help optimize maintenance actions by computing damage occuring in the major mechanical items.

- Status monitoring: the acquisition of on-board system failure indicators will help enhance the knowledge of failure modes of the parts. This knowledge will be used to improve diagnostics and reduce false removal rates.

- Recording: Crew voice and mandatory flight data parameters will be recorded in a crash resistant box. These shall be replayed again after accidents to determine their causes.

ARMS will also include aircraft sensors i.e. accelerometers for mechanical parts vibration parameters acquisistion, tachometers, chip detectors etc.a ground station to analyze the data collected in flight, the flight report establishment, the helicopter maintenance management, the coherence with the fleet management, and the aircraft configuration status.

6 - *MI38* TECHNOLOGY

MI38 preliminary design started in the late 80s and technologies were selected during design reviews held in 1991 and 1993. Therefore MI38 benefits from state of the art technologies selected by technical committees of the programme, and with Eurocopter concerning its share. Having already spoken about avionics, this chapter develops a selection of helicopter vehicle technologies.

6.1 - STRUCTURE

Structure architecture is rather classical, with technological choices adapted to each component, taking into account technical characteristics of the materials, industrials means available or to be invested, and costs in hours or in procurement.

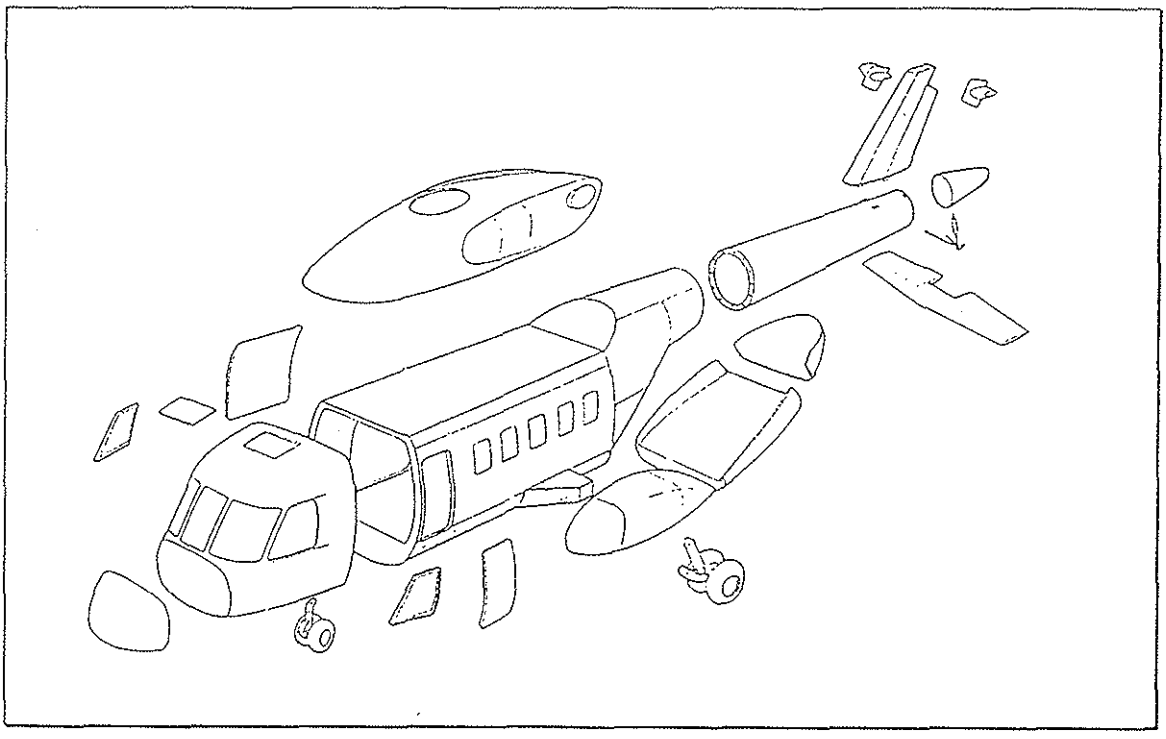


Figure 4

Structure is composed of four main modules: Cockpit, center fuselage, tail and cowlings.

Concerning the cockpit, canopy and all secondary structure, radome are made of composite fiberglass. Windshield is electrically heated. Side windows are jettisonable and an exit is cut out in the ceiling of cockpit passage, to give access to upper cowlings or in case of emergency.

Central structure is built with classical machined aluminium frames, with aluminium sheet metal skin. Fairings and secondary structure are either fiberglass or aramid.

Tail boom technology is not yet chosen; two concepts remain in competition, one solution being classical aluminium sheet metal, the other being carbon fiber. The horizontal stabilizor, which is movable, is composed of a metallic spar, and composite honeycomb filling and skin.

Cowlings are made of sandwich composite materials, either organic or fiberglass. Firewalls and fire compartments floor and borders are titanium made.

Landing gear is fixed and made of high resistance steel.

Special care was given to fuselage in order to minimize drag, by a good aerodynamic shape.

6.2 - MAIN ROTOR

Main rotor is 6-bladed, which are composite technology. The spar is made with fiberglass filament winding, the leading edge is electrically de-iced, external blade covering is composite and trailing edge carbon fiber made.

Hub construction ismainly metallic; hub concept is built around 6 spherical elastomeric bearings. A central spherical bearing relieves each elastomeric bearing from shear loads. A laed lag hydraulic damper insures dynamic stability.

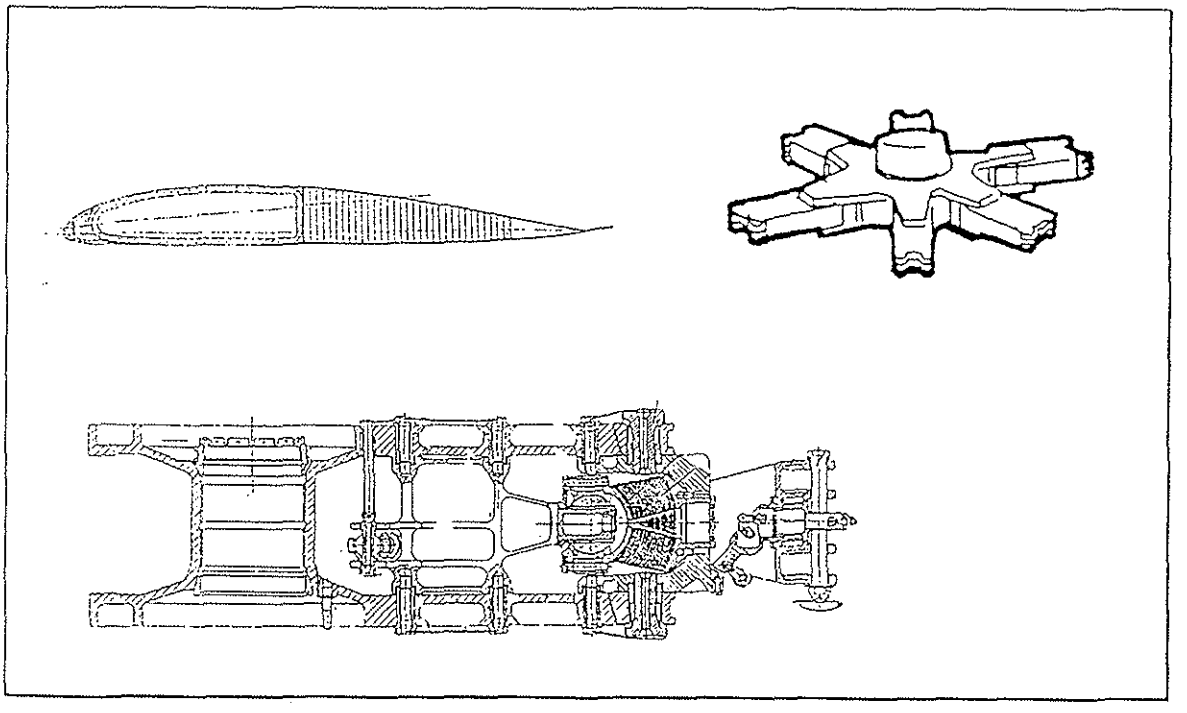


Figure 5: Main rotor design

This design was already tested and give to this size of helicopters a good flying qualities and dynamic behaviour. A small flapping hinge offset minimize hub moments and prevents from installind sophisticated vibration isolation. The new composite blade allows to tune precisely blade frequencies in flap, lag and torsion, and avoid bad couplings with nP of the rotor.

6.3 - POWERPLANT

Engine installation is designed to resist to worth environmental conditions, in Russia and worldwide, without compromising reliability and performance.

This target led MIL, in close cooperation with Klimov and Eurocopter, to design a multipurpose air intake, with an electrically driven by-pass. Sand filters of vortex type, with an electrically driven extraction fan, insures air cleaning in front of the engine. This device is modular and is therefore proposed as optional. It can be removed and replaced by a grid.

This system allows obtaining minimal installation losses in clear conditions, in particular in cruise where a ram pressure effect is obteined when the by-pass is opened, and be very well protected against sand, snow , icing conditions,....

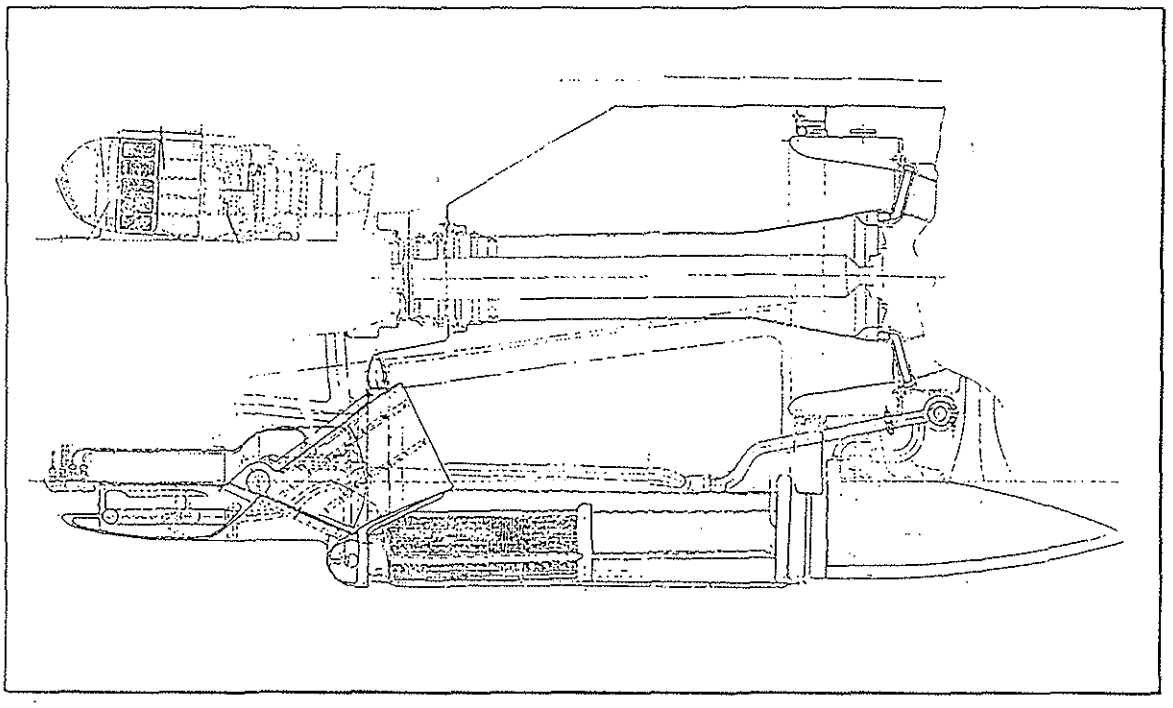


Figure 6: Air intake configuration

Fuel is also heated through a fuel-oil exchanger.

Front shape of the air intake is optimized to trap water and smooth airfloww in front of it.

Everything is also made to increase reliability of the engines in all severe environmental conditions.

7 - *MI38* PROGRAMME STATUS AND GENERAL SCHEDULE

MI38 is progressing within EUROMIL framwework and each partner company is dealing with its work share.

As already explained, the cooperation has been active for more than two years since the framework agreement was signed in December 1992 and, more recently, since EUROMIL was established in October 1994.

The helicopter programme is now roughly at the end of its design phase while some components are more advanced. To give an example, the first fuselage has been already built in Kazan and the other partners are doing their utmost to move forward by their own means.

The main milestones are presented in the following chart:

==> Five prototypes are being built

==> The first prototype will fly early in 1998 followed by the second and third one at 6 month intervals to develop the basic helicopter,

==> The fourth and fifth prototypes will help develop the customized Russian versions and the main optional equipments to be sold worldwide,

==> First deliveries should take place in 2002.

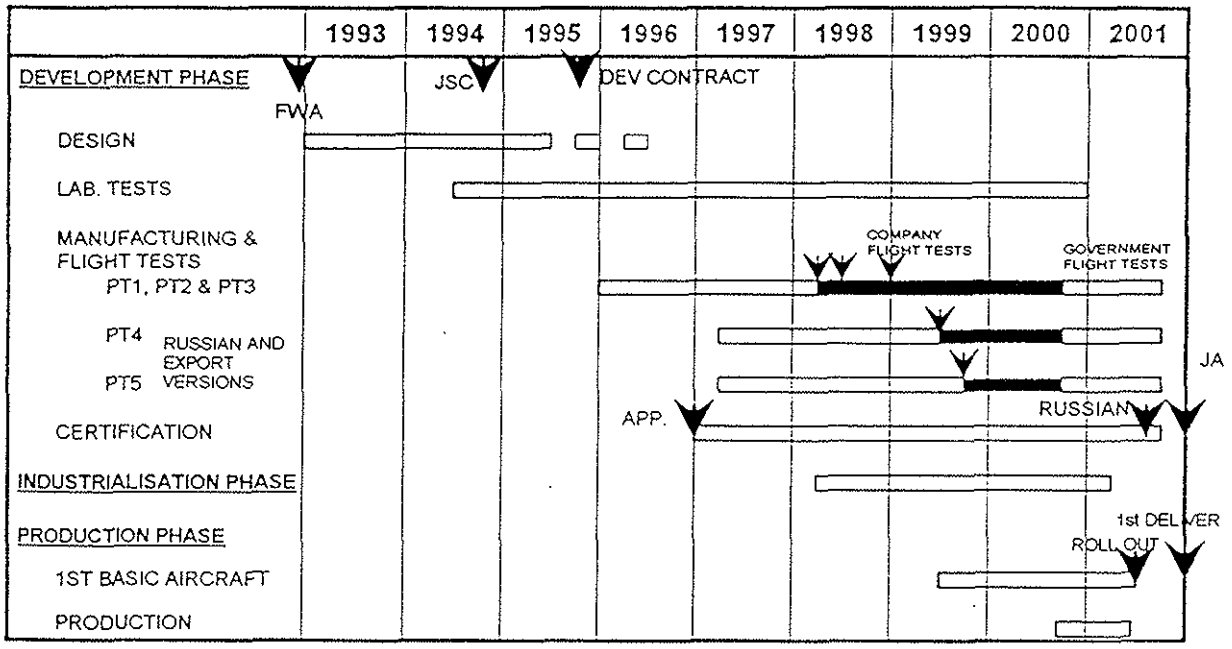


Figure 7 : *MI38* Master schedule

Since the concepts and technologies selected have already been tested or proven, this development program presents minimum risks of which the challenge this Western-Russian cooperation with different experiences and cultures and permanent design-to-cost considerations poses is the first.

All flight tests will be performed in Moscow, with an integrated team for avionics developments and western certification witness.

8 - CONCLUSIONS

The success of the MI 38 programme is for us a true challenge intended to propose to our future customers the best product adapted to their hope, a greater safety, lesser maintenance aircraft for a particularly hostile environment.

The introduction of advanced technologies based on digital displays and computers will make the most complex missions successful.

This first helicopter programme in western-russian cooperation wil rebuilt ancient relationships for the best success of civil helicopter world.