13 th EUROPEAN ROTORCRAFT FORUM

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PAPER No. 114

HAP - PAH/HAC - PROGRAMME

J.C ARRIBAT

AEROSPATIALE HELICOPTER DIVISION

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1 – INTRODUCTION

With the recent French and German Ministers of Defence decision, years of discussions and negotiations end into the development of this German-French armed helicopter programme.

A major part of the causes of the programme delay came from insufficient harmonization between German and French requirements which led to a number of different versions that induced development cost increase which was no longer affordable within the framework of the available budget.

Induced by the two Ministers of Defence, a very important standardization effort has been made during the last year by Officials of the two countries with the participation of armies and industries which went to a fully common anti-tank version based on the same antitank armament sub system using the same visionic, with a high level of commonality with the Combat Support version (AIR to AIR ROLE) requested by the French Army.

This harmonization of the requirements permitted to reduce the development tasks, the number of prototypes, and the system integration work , and so to maintain the cost to an acceptable level.

It is envisaged to produce 427 helicopters : 212 for Germany, 215 for France.

2 – CONCEPT PHILOSOPHY

The concept has been structured to develop two weapon systems meeting their requirements for

- Day/night antitank mission, PAH/HAC
- Combat support mission, HAP.

The concept is based upon a basic vehicle and basic system avionics common to both versions.

The weapons and equipment specific to each version are arranged within a coherent assembly called MEP (Mission Equipment Package). Each weapon system therefore consists of the common basic vehicle and basic avionics on the one side and the corresponding MEP's on the other side, (see figure 1).

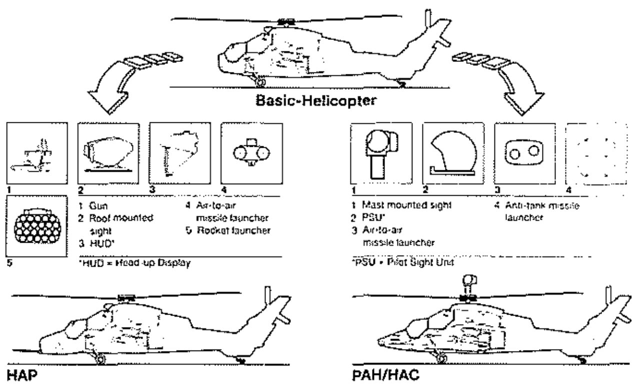

Fig. 1 : CONCEPT PHILOSOPHY

This structure, based on separate MEP assemblies, permits stepped integration. Moreover, this is clearing a way towards future possible versions.

ANTITANK VERSION (PAH/HAC)

The antitank version is shown on figure 2. The full size mock-up was presented at the Salon du Bourget in June 1987.

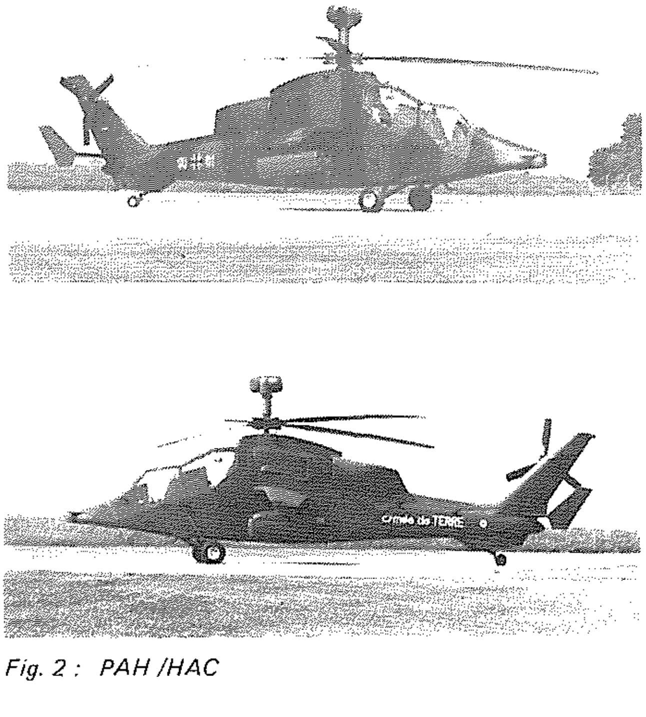

Fig. 2 : PAH /HAC

The antitank version is based on mission requirements for the German and French armies. It consists of antitank armament systems as well as self defense air-to-air missiles.

The helicopter is equipped with a weapon system support comprising four stations :

. Inboard stations . wire guided HOT 2/3 missiles or fire and forget ATGW3 missiles developed within the Euromissile Dynamic Group.
 The helicopter is capable of a combined weapon system (HOT on one side, ATGW3 on the other side).

. Outboard stations : self-defense A/A missiles (MISTRAL for France, STINGER for Germany).

Target observation, reconnaissance and identification are achieved using a gyro-stabilized gunsight mounted on top of the rotor (MMS) and comprising an IR lane, a television lane, a laser rangefinder and a missile tracking unit. Night flying is achieved using an IR camera installed in the aircraft nose, backed-up by a wide field-of-view gunner sight. The crewmembers are equipped with a helmet mounted sight and display providing flight control symbology and FLIR-image. The MMS images are displayed to an ocular at the rear crew station. The use of night vision goggles is provided for in emergency mode.

COMBAT SUPPORT VERSION (HAP)

The combat support version (see figure 3) is based on the mission as defined for the French army. It consists in ensuring the protection of the antitank helicopters against the enemy's helicopters and light armoured vehicles.

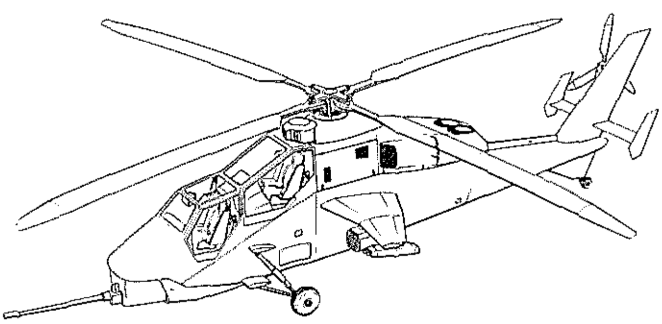

Fig. 3 : HAP - COMBAT SUPPORT VERSION (AIR-TO-AIR ROLE)

The weapon system comprises :

. A 30 mm wide angle gun turret mounted at the front of the aircraft.

. 4 A/A Mistral missiles mounted on the outboard weapon system support points.

The weapon support system arrangement is the same as on the antitank version : 4 support points.

The inboard points are designed to accept rocket pods taking 22-off 68 mm or 2"75 rockets, or fuel tanks for long range ferrying. It is possible to replace the A/A missiles at the outboard points with 12-rocket pods.

A gyro-stabilized gunsight installed on the roof is used for the detection, reconnaissance and identification of the objectives, as well as firing. This gunsight comprises 3 channels :

. Direct optical channel
. IR channel
. Television channel
. Laser rangefinder.

Moreover, the two crewmembers are equipped with a helmet sight for sudden lateral firing and the pilot has a head-up display permitting axial firing of the various weapons

This head-up display is also provided with an aircraft control symbology which permits head-up aircraft control.

The gun turret is controlled either via the main sight or by one of the helmet sights.

Night flying is achieved using the night vision goggles.

3 – THE TECHNICAL CONCEPT

As mentioned before, the basic helicopter is designed to end up as a specific weapon sytem by integration of the various mission equipment packages.

To fulfil the stringent operational requirements which lead to numerous equipment and to minimize helicopter weight and size, it was necessary to apply the most modern available technologies.

The main technical data (figure 4) of the two weapon systems are :

▪ Design optimized for antitank and combat support	
▪ Equipped empty weight	3300 kg
▪ Mission weights	5300–5800 kg
▪ Installed power (SLS)	2×950 kW
▪ Main rotor diameter – 4bladed	13 m
▪ Tail rotor diameter – 3bladed	2,7 m
▪ Stepped tandem cockpit, slope	19°
▪ Fixed, crashworthy landing gear, track	2,4 m
▪ System architecture with digital bus system acc.	MIL STD 1553 B

Fig. 4 : DESIGN KEY-POINTS

In the following a summarized view is given on the technical concept hightlights especially on

. system architecture for
 - basic helicopter
 and
 - MEP's
. design keypoints for the vehicle.

SYSTEM ARCHITECTURE

In order to achieve a maximum of commonality for the basic helicopter, the avionic system is shared in a basic and MEP-related portion.

The basic avionic consists of the subsystems/functions

. navigation
. communication
. AFCS
. countermeasures
. mission computer
. control- and display unit
. diagnosis/monitoring
. mission management.

The system architecture is based on a duplex bus acc. MIL STD 1553 B, governed by 2 identical redundant mission computers (figure 5). The most avionic subsystems are compatible to the bus. The connection of non compatible units is assured by RTU's.

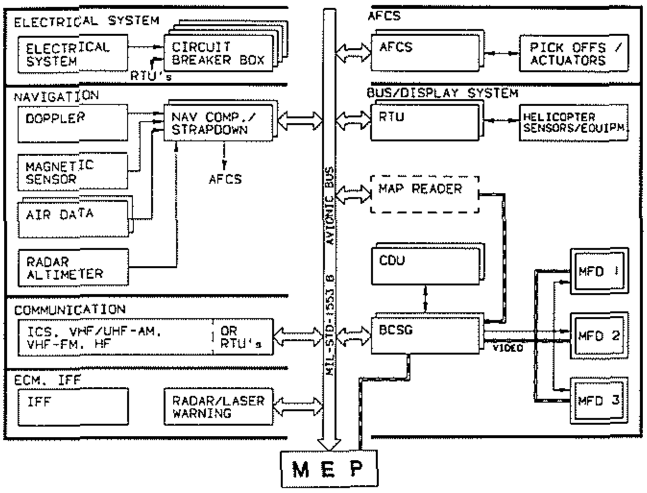

Fig. 5 : BASIC HELICOPTER SYSTEM ARCHITECTURE

Besides the control function for the bus system, an essential system function is the integrated monitoring and diagnosis with :

. in-flight monitoring of avionic and non-avionic subsystems
. pre-and postflight check assistance

and the conduction of mission management functions, e.g. mission planning, tactics, as well as performance checks.

The control and display subsystem consists of 3 multifunction displays (MFD) and one control/display unit for pilot and gunner. The displays are generated by two symbol generators. Essential flight data are also displayed for the pilot by back-up conventional instruments.

The navigation subsystem consists of two identical strapdown units together with external sensors like airspeed-sensor, doppler radar, radar altimeter and magnetic sensor. The subsystems conducts the functions of autonomous navigation as well as flight path computation and supplies necessary data for AFCS and MEP's.

An integrated Radar-Laser warning subsystem is foreseen to recognize, identify and classify specific threats :
In addition, reserves are taken for additional active Counter Measures if requested later on.

The mechanical flight control subsystem together with a duplex digital AFCS leads to the required controllability and stability on the one side and supports with specific autopilot functions the mission effectiveness.

The antitank mission equipment package (Euromep) is architectured on the basis of a redundant bus acc. MIL STD 1553 B (figure 6). It comprises

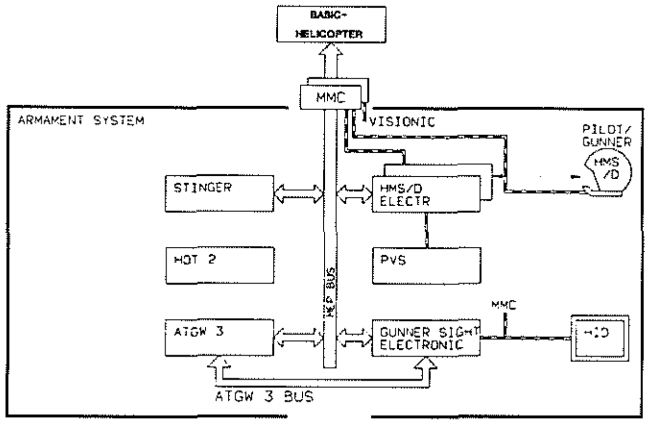

Fig. 6 : EUROMEP SYSTEM ARCHITECTURE

- the visionic with gunner sight, pilot night vision system and combined helmet sight and display
- armament with the antitank missiles HOT and/or third generation missile ATGW3/LR and selfdefense air-to-air missiles MISTRAL (F) or STINGER (D).

The mast-mounted gunner sight is a multi-sensor-system with channels in the optical and IR range and various fields of view (FOV) ; it is controlled by the gunner. The visionic is stabilized, includes target tracker for single and multiple targets as well as a laser range meter, further on a display with sufficient resolution for recognition, identification and attack. Most modern technologies, e.g. IR CCD's will ensure the high performance requirements.

The nose-mounted piloting IR-sensor (PVS) image is displayed and steered in the helmet sight display. With loss of the PVS a switch over to a redundant IR-image of the gunner sight is foreseen.

The combat support mission equipment package (HAP-MEP) is also based on a redundant multiplex data bus MIL STD 1553 B (figure 7) which interconnects the following systems :

- Firing control and bus management computer (redundant)
- Gunner's sight
- Head-up display
- Gun turret
- Rockets
- A/A missiles

- Pilot's and gunner's helmet sights
- Pilot's and gunner's armament control unit.

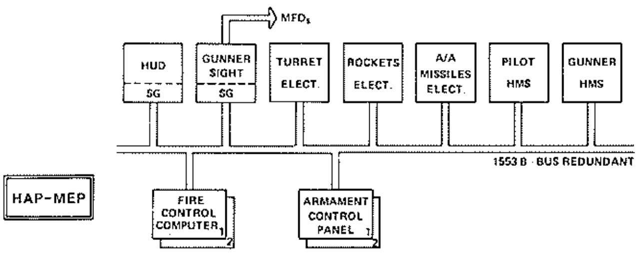

Fig. 7. ATTACK AND GROUND SUPPORT VERSION SYSTEM ARCHITECTURE

<u>Design key points for the vehicle</u>

Equal to the avionic systems also the vehicle is designed to achieve a maximum commonality between the different weapon systems.

The basic vehicle consists of the subsystems
- main rotor, tail rotor and transmissions
- engines
- fuselage/landing gear
- functional equipment.

The outer geometry and dimensions of the vehicle are shown in figure 8.

The cockpit is sized for tandem seating leading to a higher but more narrow silhouette and thus reduced detectability. The inner arrangement of the cockpit (fig. 9) according to the crew's workload has to be tuned with the outer requirements, i.e. to ensure and combine excellent visibility for the two crewmembers with the necessary internal space and minimized outside dimensions.

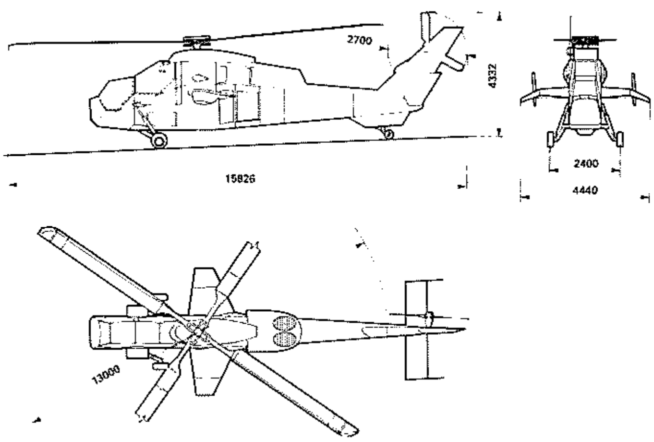

Fig. 8 : THREE-VIEW DRAWING (BASIC HELICOPTER)

Further on the layout takes account of the human engineering rules concerning instrument reading and access to the controls as well as visibility and go-in/out capability. The glazed surfaces are plane in order to minimize detection.

The new technology four-bladed hingeless main rotor consists out of a simple two-plated star carrying elastomeric bearings, necessary for blade pitch movements as well as interfacing with the all composite blades (see figure 10). The flapping offset is 10 %. The rotor system is able to withstand small caliber shots and is designed to provide low radar reflection.

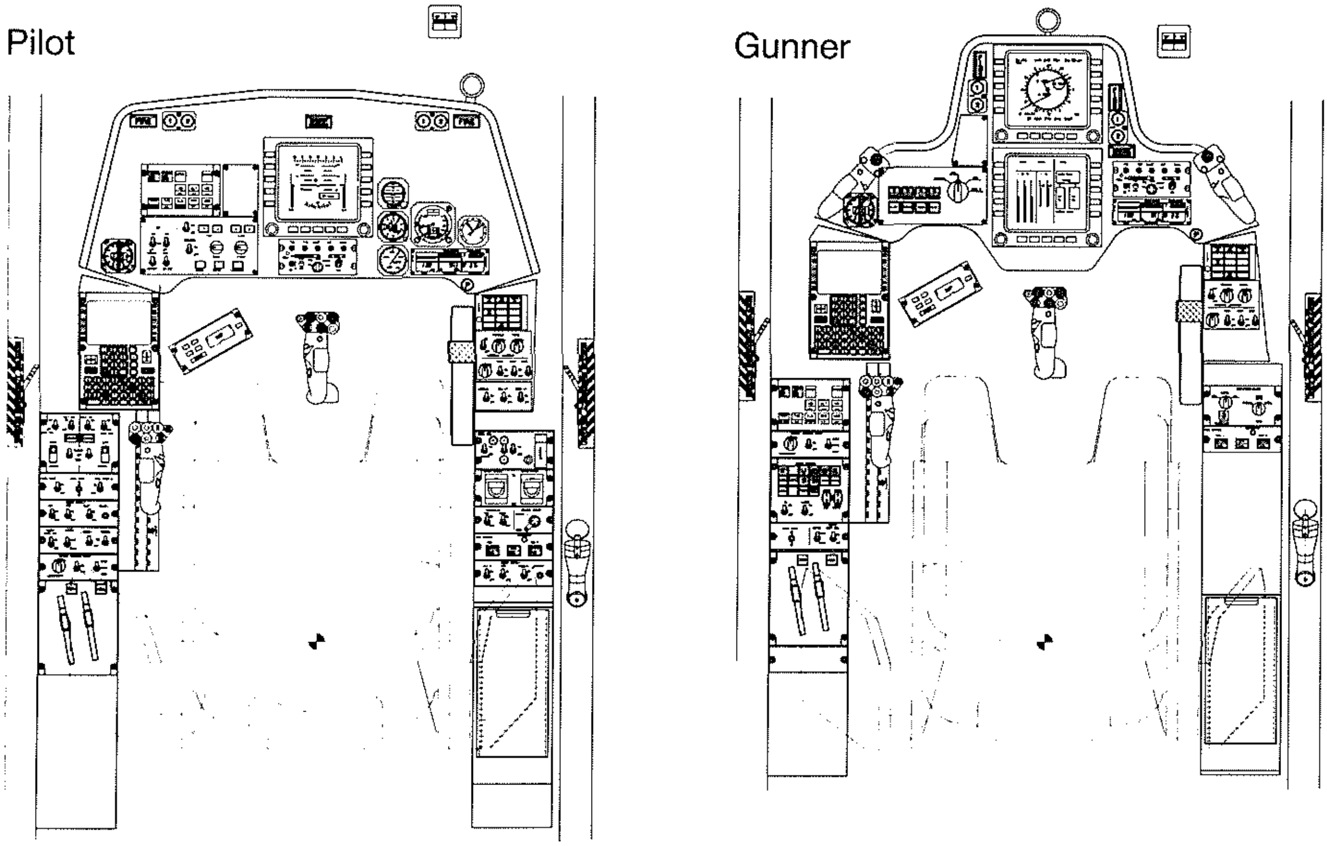

Fig. 9 : COCKPIT DESIGN PAH/HAC

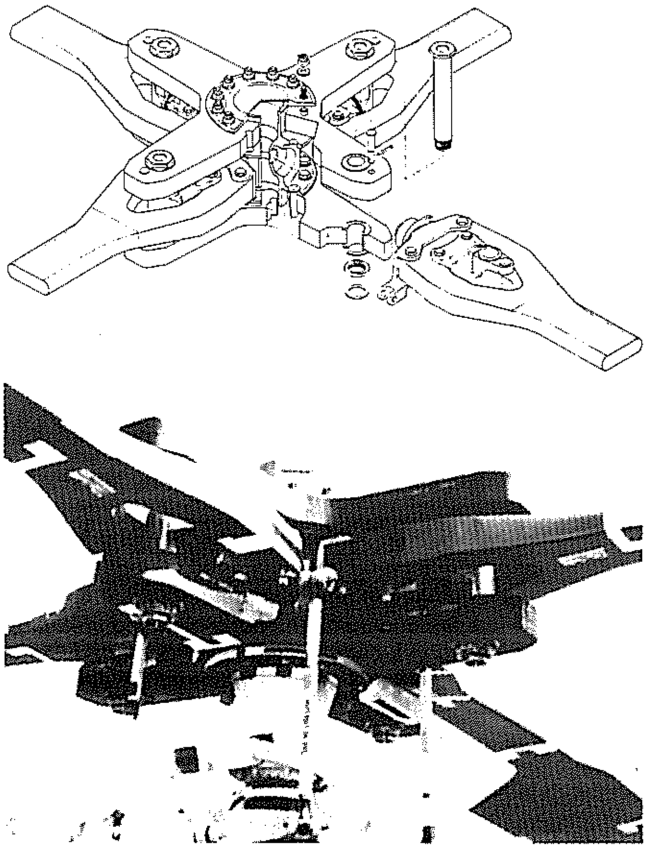

Fig. 10 : MAIN ROTOR SYSTEM (FEL-ROTOR)

The main rotor blades are sized according modern French/ German airfoil families, here DM-family, featuring a very high maximum lift coefficient.

The blade chord is such that the blade loading is low in order to accept high load factors and thus a good manoeuvrability.

The 2.70 m dia. three-blade spheriflex tail rotor (fig. 11) is sized to confer to the helicopter high manoeuvrability in yaw. The tail rotor composite blades have dissymmetrical OA airfoils.

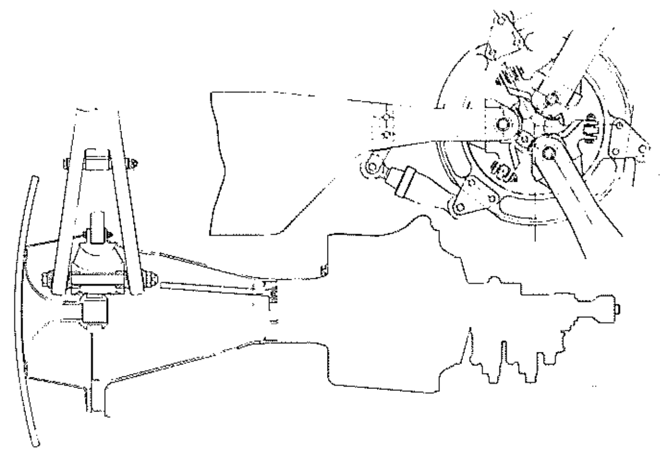

Fig. 11 : TAIL ROTOR

The helicopter is equipped with two MTM 390 gas turbine engines (950 kW each) which can deliver a thermodynamic power of 119 % in an emergency case. This new technology engine (2 compression centrifugal stages, 2 generator turbine stages, 1 power turbine stage) is characterized by a low weight and a low fuel consumption. It is equipped with a reducing gear box giving an 8000 rpm rotation speed on the output shaft (fig. 12).

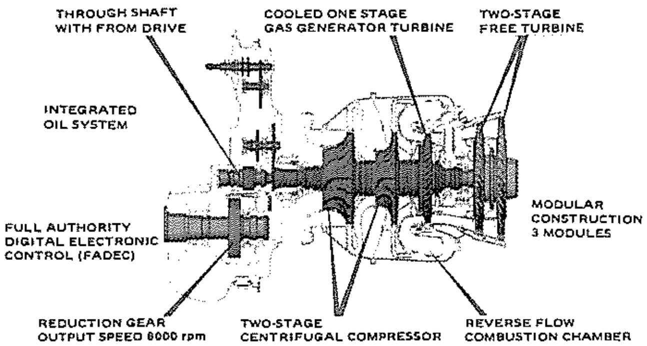

Fig. 12 : MTM 390 ENGINE

This choice was made in order to reduce the vulnerability of the main transmission output by avoiding shafts rotating at high speed in this non redundant component.

The engine exhaust pipes are provided with IR suppressors which cover the hot internal parts of the engine and dilute the exhaust gases with ram air.

The main gearbox (see fig. 13) comprises three reduction stages :

- a bevel gear stage for transmission of movement to the centre
- a summing gear stage
- an epicyclic gear stage.

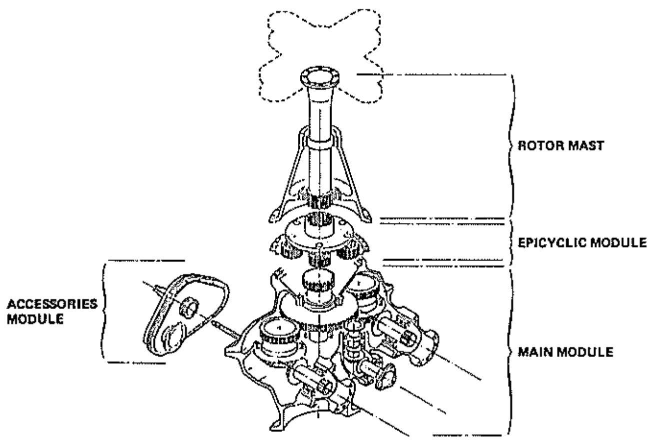

Fig. 13 : MAIN GEAR BOX

The MGB drives the main rotor, the tail rotor and also

- two hydraulic pumps supplying the servocontrols
- two 20 KVA alternators
- a compressor for the air conditioning system.

The lefthand input is equipped with a declutching system which permits one of the two alternators and the air conditioning system compressor to be driven when the helicopter is on ground, rotor stopped.

The main gearbox is designed to operate 30 minutes after complete loss of the lubrication oil.

The major dynamic components are connected to the structure via a SARIB-type suspension system absorbing the vibrations.

Flight controls are mechanical. They comprise the duplex primary hydraulic servocontrols controlled by the autopilot and the trim, and the duplex main hydraulic servocontrols to generate the control loads towards the rotors.

As mentioned above, it is supported by a redundant duplex AFCS with stabilization and AP-functions, (see figure 14).

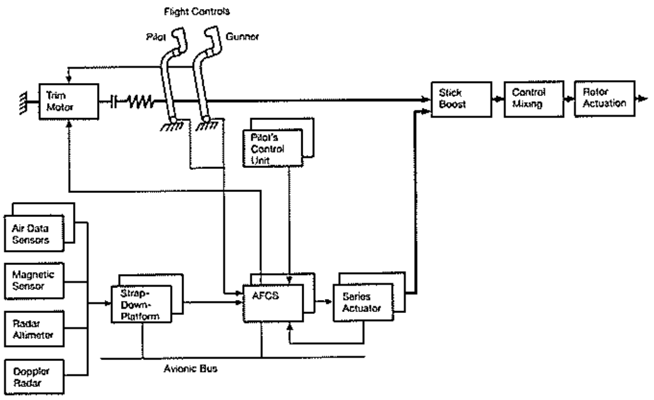

Fig. 14 : FLIGHT CONTROL SYSTEM

Also for the airframe, composite materials have been used as much as possible in order to reduce weight. The rear section, the cockpit and the weapon system support wings are made out of carbon mainly. The fairings are made out of fiber glass or kevlar (figure 15).

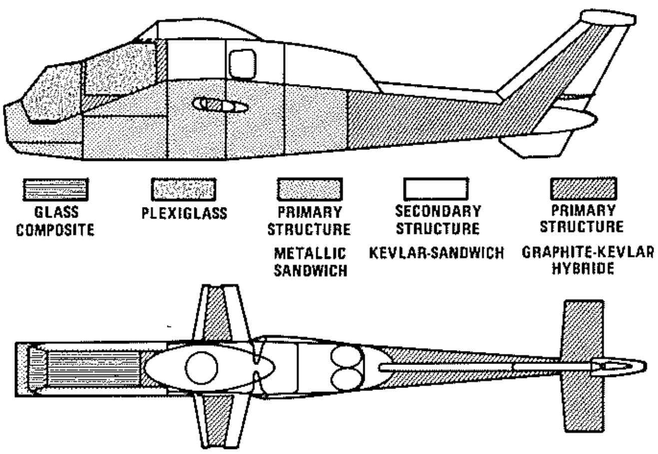

Fig. 15 : AIRFRAME MATERIALS

The antenna integration meets a double objective : reduction of the aerodynamic drag and easy decontamination cleaning after a flight in NBC environment.

The airframe is fitted with various wide lateral doors permitting easiest access to the electronic equipment as well as the ammunition boxes.

The ARINC 600 standard has been retained for the electronic equipment with corresponding plug-in type connectors permitting extremely rapid removal.

The landing gear is not retractable and the wheels are largely sized in order to reduce the pressure on ground. This landing gear is crashworthy and can fully absorb loads induced by an impact speed of 6 m/s. The track (2.4 m) has been chosen to ensure stability on ground slopes until 12°.

4 – OPERATIONAL FEATURES

To conduct the mission task the PAH / HAC as well as HAP have to overcome the threat to the maximum extent possible.
This only can be achieved by

. high weapon effectiveness
. active and passive measures to minimize vulnerability
. advanced technology features.

The overall weapon effectiveness is assured by

- attentive conversion of the requirements out of German and French experiences into optimized concept
- optimization of the concept in size and effectiveness with 6 - 8 antitank missiles and 4 air-to-air missiles in the antitank mission and 30 mm gun and air-to-air missiles and/or unguided missiles in the combat support role
- application of all today existing findings relative to battle performance and mission success at minimal vulnerability
- use of newest technologies for armament, avionics, equipment as well as for the vehicle itself.

The active measures (fig. 16) to minimize vulnerability can be summarized by

- HIGH FIRE POWER
- AGILITY AND MANOEUVRABILITY - EXCESS POWER
- HIGH ACCELERATION AND DECELERATION CAPABILITY
- MAST MOUNTED SIGHT FOR PAH/HAC
- MINIMIZED DETECTABILITY
- OPTIMIZED COCKPIT REDUCING CREW WORKLOAD
- RADAR - LAZER WARNING
- CAPABILITY FOR ADDITIONAL ELECTRONIC COUNTER-MEASURES

Fig. 16 : ACTIVE MEASURES TO MINIMIZE VULNERABILITY

. high offensive and defensive fire power, i.e. modern avionics and visionics as well as HOT's and infrared fire- and forget missiles against ground targets ATGW3/LR and air targets (STINGER/MISTRAL)
. agility, i.e. excellent manoeuvrability due to powerful main and tail rotors and excess power
. high acceleration and deceleration capability
. protected operations by use of a gunner sight above the rotor (MMS) ; extreme NOE-flight capability ; operations within impassable terrain and big ferry range capability

- . minimized detectability by shaping, specific choice of materials and specific lay-out of dynamic system and propulsion system
- . optimized cockpit, i.e. "glass"-cockpit with coloured MFD's and CDU, possible only by consequent application of modern avionics and consequently reduced pilot's and gunner's workload.
- . Radar-Laser warning
- . Capability for additional electronic counter-measures

The passive measures (fig. 17) to minimize vulnerability are to be seen in

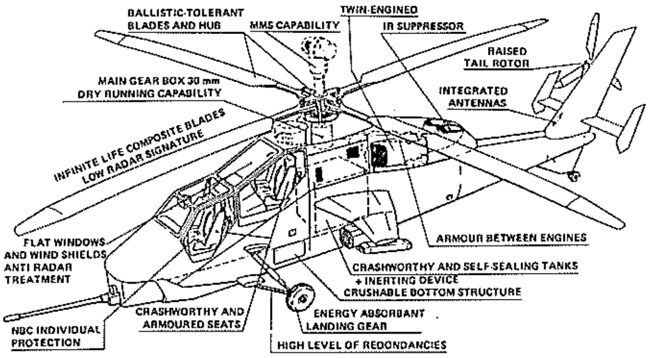

Fig. 17 : PASSIVE MEASURES TO MINIMIZE VULNERABILITY HAP-PAH/HAC

- ballistic tolerance by redundance : two crewmen cockpit with double controls , twin engined ; redundancy for control-hydraulics, fuel system, electric system and essential avionics, e.g. in bus system, navigation and AFCS
- ballistic tolerance by armoured protection, e.g. armoured seats
- ballistic tolerance by constructional means : high degree of composites in fuselage concept, all composite rotor blades, dry run capability for the transmission system and self sealing fuel cells
- extreme emergency landing capabilities : high OEI-performance by specific superemergency rating ; landing gear with high emergency absorbing capability ; OEI-restart capability
- crashworthiness : for landing gear, fuselage seats and fuel system
- balanced NBC protection by NBC-suit compatible cockpit, NEMP protection for essential avionic equipments, specific measures in helicopter lay-out.

The specific technology features (fig. 18) can be summarized as follows :

- . most modern armament with HOT 2, ATGW3, weapon mix capability, air-to-air missiles (MISTRAL or STINGER), 30 mm nose mounted gun, unguided rockets
- . visionics based upon newest IR -technology IRCCD
- . avionics with consequent use of digital technologies for data bus and HOL, coloured MFD's and control units, BITE, decentralized intelligence with great flexibility and growth potential
- . Cockpit : low workload "glass"-cockpit optimized by use of manned simulation facilities, a major tool in developing innovative systems
- . Rotor systems : hingeless main rotor (FEL) made out of composites and thus fail-safe, free of maintenance, reduced radar signature ; newest airfoil-generation and geometry lead to performance-improvements and reduce noise level ; exceptional controllability but good stability
- . propulsion system : modular concept, dry run capability of the transmission system ; APU-mode by one engine with rotor stopped ; vibration isolated transmission suspension system (SARIB)
  modern fully independently equipped engine concept with digital control (mechanical back-up) LTC and BITE-connexion, IR-suppression.
- . flight control system with digital AFCS with the functions CAS, i.e. support of control inputs, SAS, i.e. stability improvements, T/F, i.e. trim and forcefeel-simulation as well as various autopilot-modes
- . fuselage : ballistic tolerant constructions either by AL-sandwich or composite materials ; ARAMID for secondary structures ; crash-tolerant design.

- MOST MODERN ARMAMENT - WEAPON MIX CAPABILITY
- VISIONICS BASED UPON NEWEST I.R.-TECHNOLOGY (IRCCD)
- DIGITAL AVIONICS - BUS - COLOURED MFDs BITE
- LOW WORKLOAD COCKPIT OPTIMIZED BY MANNED SIMULATION FACILITIES
- ROTORS :
  - FAIL SAFE - MINIMUM OF MAINTENANCE
  - NEWEST AIRFOIL GENERATION AND GEOMETRY
  - LOW AURAL AND RADAR SIGNATURE
  - EXCEPTIONAL PERFORMANCES, CONTROLLABILITY AND STABILITY
- DRIVE SYSTEM :
  - MODULAR CONCEPT - DRY RUN CAPABILITY
  - APU MODE BY ONE ENGINE, ROTORS STOPPED
  - VIBRATION ABSORBER SUSPENSION
- ENGINE :
  - LOW FUEL CONSUMPTION AND WEIGHT
  - FULLY INDEPENDENTLY EQUIPPED CONCEPT
  - DIGITAL CONTROL (MECHANICAL BACK-UP)
  - LIFE TIME COMPUTING AND BUILT-IN TEST CONNECTION
  - I.R. SUPPRESSOR
- DIGITAL AFCS ADAPTED TO THE MISSION
- LOW WEIGHT FUSELAGE : BALLISTIC AND CRASH-TOLERANT DESIGN

Fig. 18 : TECHNOLOGY FEATURES

5 – WORKSHARING

MBB and AEROSPATIALE have set up a common company for the development : EUROCOPTER GIE and its subsidiary EUROCOPTER GmbH. This latest company will be the prime contractor of the programme and will subcontract the work to the two mother companies.

Both companies are thus bound up with each other on all aspects of the programme whatever is the work sharing between them.

For the subsystems which can be developed in a relatively isolated manner, a sharing has been made betwwen AS and MBB, but for the development activities needing participation of both companies, the work will be performed in integrated teams involving AS and MBB specialists, for instance avionics system and flight tests.

This common commitment shows the willingness to create an efficient cooperation between Aerospatiale and MBB in the helicopter industry, not only for this program but also for the future.

For serial production each company will have its assembly line and the components will be manufactured along the work sharing scheme presented in figure 19.

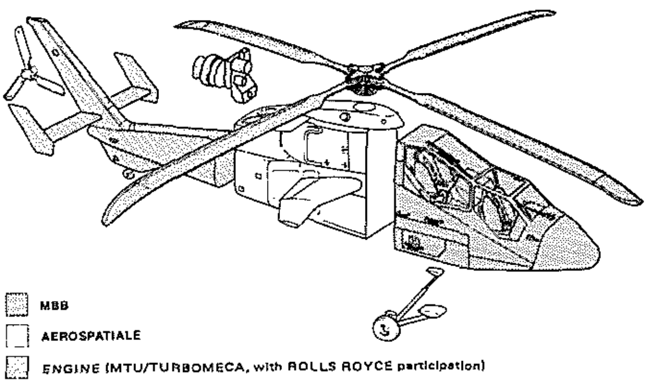

Fig. 19 : WORK SHARE MBB/AS

6 – PLANNING (fig. 20)

The development is based on 5 prototypes :
The first prototype will be used to develop the vehicle. The next two prototypes will be used, in a first stage, to develop the basic system. One of them would then be converted into an HAP version and the other one into a HAC/PAH version.
The last two prototypes will be directly produced as HAP and PAH versions. They will be used for the troop tests after their development.

The first production helicopters will be available in 1997. However, it should be noted that the HAC/PAH helicopters will be first equipped with HOT missiles only and will be capable of the ATGW3 missiles as from 1998.

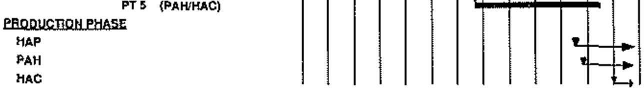

Fig. 20 : TIME SCHEDULE

7 – TO CONCLUDE,

Owing to the will of the French and German Ministers of Defence and to the help of the different parties (Official Services, Military Staffs and Industries), we have now a really common concept fullfilling the need for future weapon system, involving the most advanced armament and technologies.

Through such a cooperation, the financial development effort is lower for each country, the quantity effect reduces the unit costs and the new developed technology increases both industries experience.

MBB and AEROSPATIALE believe that this project will be the nucleous of a further and more extensive cooperation in the helicopter field in Europe.

ABBREVIATION LIST

HAP	Helicoptère d'Appui-Protection
PAH	Panzer Abwehr hubschrauber
HAC	Helicoptère Anti-char
MEP	Mission Equipment Package
ATGW3	Anti-tank Guided Weapon of 3th generation
A/A	Air-to-Air
IR	Infra Red
SLS	Sea Level - Standard atmosphere
AFCS	Automatic Flight Control System
RTU	Remote Terminal Unit
MFD	Multi Fonction Display
IR CCD	Infra Red Charge Coupled Device
MGB	Main Gear Box
NBC	Nuclear Biological Chimical
MMS	Mast Mounted Sight
NOE	Nap of the Earth
CDU	Control Display Unit
OEI	One Engine Inoperative
NEMP	Nuclear Electro Magnetic Pulse
HOL	High Order Langage
BITE	Built-in Test Equipment
FEL	Faser Elastomer - Lager
APU	Auxiliary Power Unit
CAS	Control Augmentation System
SAS	Stability Augmentation System