ORGANIZATION AND TECHNICAL STATUS OF THE NH90 EUROPEAN HELICOPTER PROGRAMME

J.P. Barthélemy
R.D. von Reth
NH-Industries
Aix-en-Provence, France

G. Beziac
Aérospatiale, DH
Marignane, France

Abstract

Following the signature by France, Germany, Italy and The Netherlands of a MOU, the 8/9 ton category helicopter NH90 is now entering into its full development phase.
NAHEMA will be the contracting NATO Agency and NH-Industries the prime contractor, with Aerospatiale, Agusta, MBB and Fokker as industrial partners. The lecture describes the ground and naval main missions to which the helicopter will be designed, its outstanding specifications and characteristics, and a selection of major technological features (advanced design composite rotor, fly by wire control system, modern avionics with dual digital bus and multifunction colour displays, etc.) complemented by a description of the architecture of the main subsystems, either general or specific of TTH or NFH versions, or provisions for further customizations.

Introduction

With the signature of 4 Nations, - France, Germany, Italy and The Netherlands -, on the MOU for the full development of the NH90 helicopter, a new major cooperative programme is born in Europe. The importance of the investment, and that of the huge potential market, justify such a cooperation. Moreover, on the side of the users, - the Armies, Navies, Air Force, from the 4 Nations involved -, this cooperation has already produced a remarkable result: a homogeneous expression of the needs for a basic vehicle configured in 2 versions for 7 users, each of them with a high degree of system's integration in order to achieve optimum mission fitness:
-a land based version, the TTH (Tactical Transport Helicopter)
-a naval version, the NFH (Nato Frigate Helicopter)

Hence, with the same basic design, serial production needs for the 4 Nations amount to:

	TTH	NFH	TOTAL
France	160	60	220
Germany	114(+120)	38	152(+120)
Italy	150	64	214
Netherlands	-	20	20
TOTAL	424	182	606(+120)

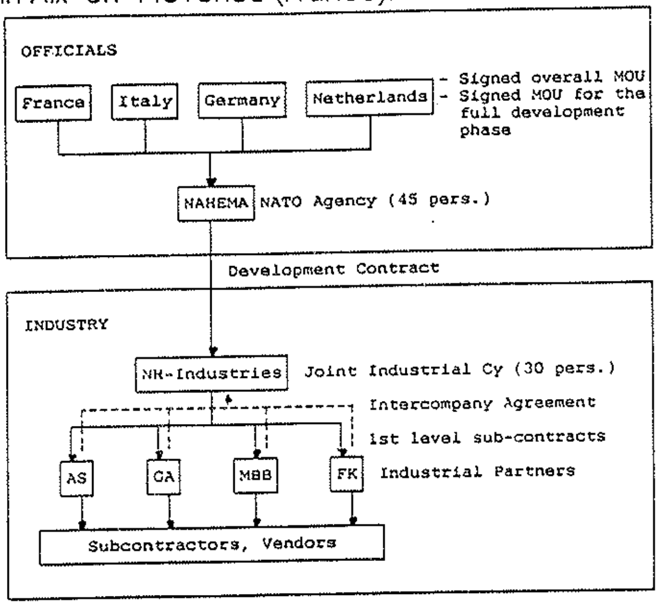
Figures to be complemented by other market segments for the NH90, and by exports.

Programme Organization

The signatory Nations have approved the foundation of NAHEMA, the Nato Frigate Helicopter Agency, which incorporates Officials representing the Authorities from member States. NAHEMA will be the contracting authority.
The industrial prime contractor, and counterpart of NAHEMA, will be NH-Industries SARL, functioning as a joint subsidiary from Aerospatiale, Agusta, Fokker and MBB, whose respective holdings will be in proportion to their participation in the project:

France	42.4 %
Italy	26.9 %
Germany	24 %
Netherlands	6.7 %

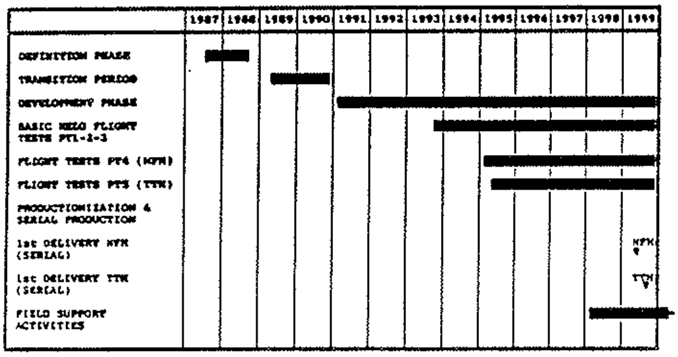
The head offices of both organizations will be in Aix-en-Provence (France).



Programme Planning

The development phase has been preceeded by preliminary studies (1981-1984) by a feasibility phase (1987-1988) complemented by a transition period, dedicated to the preparation of the development launch (1989-1990). The main activities in year 1991 where the negotiation of the entire development phase contract and the definition and implementation of the international organizations in charge of overall programme management.

The general schedule of the programme is presented hereunder.



NH90 Missions

Tactical Transport Helicopter (TTH)

Main Missions:
- Tactical transport of equipment and personnel, in particular a light combat vehicle and its crew.
- Heliborne operations.
- Search and rescue (SAR) missions in peace and war time.
- Special missions with different equipment (intelligence gathering, electronic warfare).

Secondary Missions:
- Tactical support for land-based armed forces.
- Fire fighting support.
- Flight training.
- VIP transport.

NATO Frigate Helicopter (NFH)

The mission of the Frigate based naval version can also be divided in two categories :

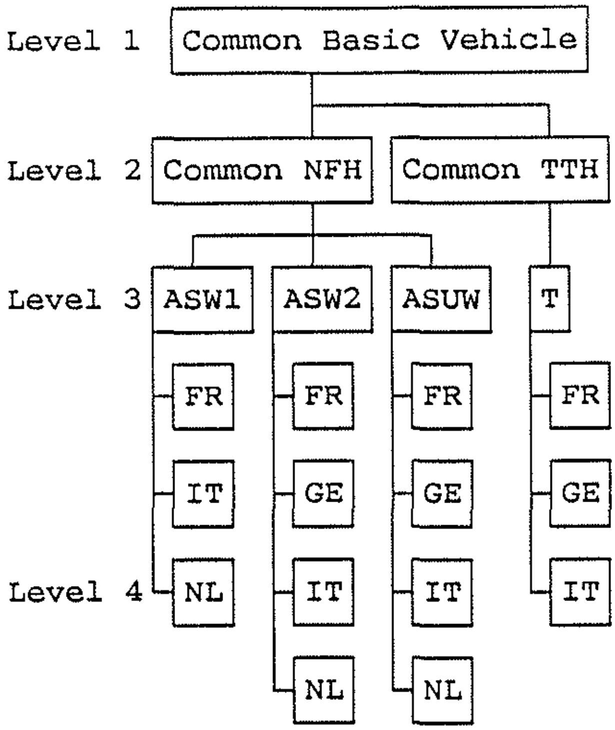
Main Missions:
- ASW: detection, classification, tracking and attack.
- ASUW: detection, classification, type identification, over the horizon targeting (OTHT).
- AAW support, self-defence capability, aircraft and anti-ship missile detection.

The helicopter is capable of performing these missions autonomously.

Secondary Missions:
- Vertical replenishment (VERTREP).
- Search and Rescue (SAR).
- Troops and personal transport, mine laying, etc.

Commonality and Mission Configuration

One important basis of the programme is the harmonization of requirements by the different forces of the participating nations and fulfilment of these requirements by using a basic vehicle with a high degree of commonality from which the TTH-Variant and the NFH-Variant can be derived by adding the variant equipment by further addition of the mission equipment mission configuration are obtained, which can be further customized either for secondary mission or special roles by national options. Figure 4 shows the NH90 configurations and as they are required by the participating nations.



Level 1: Basic Helicopter including common core system avionics and mission systems/equipment.
Level 2: Level 1 plus TTH respective NFH equipment.
Level 3: Level 2 plus mission equipment.
Level 4: Level 3 plus national fit.

Fig.4: NH90 Configurations and requirements by participating nations

NH90 General Specifications

The NH90 helicopter is required to meet very strict requirements imposed by the shipborne and land-based version users :
- Outside air temperature between -40°C and +50°C
- All-weather flying (rain, snow, hail, lightning, icing conditions) by day and by night
- Ceiling : 6000 m
- Starting, take-off and landing up to 4000 m-ISA +10°C
- Take-off in winds up to 45 kts from any direction up to 1500 m ISA +20°C
- Preparation for flight from ship up to sea state 6 by day and by night in instrument Meteoroligical Conditions (IMC)
- Overall dimensions, blades and tail boom folded, allow it to be stored in the frigate hangar
- Gross take-off weight of naval version less than 9.1 T.

Moreover, the NH90 shall be designed to ensure increased survivability due to :
- Its low detectability (acoustic, radar, IR)
- Its reduced vulnerability (mission completed after a 7.62 mm impact, flight continued for 20 minutes after being hit by a 23 mm HEI round
- Its crashworthiness as per MIL-STD 1290 (85%)
- Integration of the requirements regarding protection against NBC environment.

Finally, the reliability and maintenance aspects shall be taken into account from the start of the programme in order to minimize operating costs and to optimize operational availability.

NH90 Characteristics

General :

"Diamond" shaped fuselage central part with constant section 1.6 m wide sliding door on each side.

Cabin interior dimensions:
Length: 4 m
Width at floor: 2 m
Height: 1.58 m

. Airtransportability C130/C160
. Max TTH/NFH commonality
. Conventional configuration (main rotor+tail rotor)
. Four blades rotor
. Twin engine
. Provision for installation of rear ramp
. Manual/automatic folding of main blades and tail pylon
. Overall folded dimensions :
Height : 4.10 m
Length : 13.50 m
Width : 3.80 m

The basic layout and dimensions are shown in Figure 5.

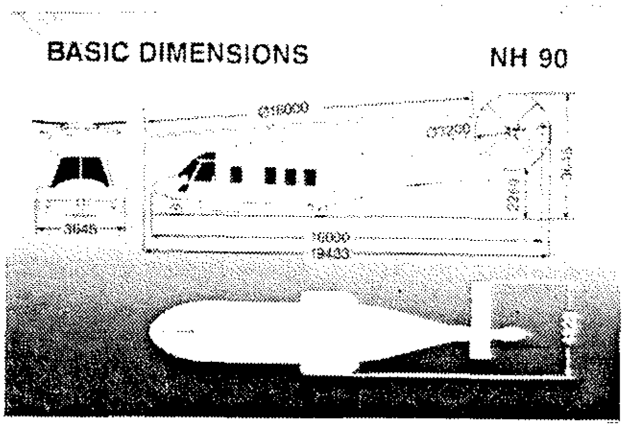


Fig.5: Basic Layout and Dimensions

Dimensions:

Main Rotor
Diameter 16.30 m
Blade chord 0.65 m
Number of blades 4
Rotation speed 256 rpm
Rotation direction : anti- clockwise (viewed from above)

Tail Rotor
Diameter 3.20 m
Blade chord 0.35 m
Number of blades 4
Rotation speed 1259 rpm

MGB
Limits:
With 2 engines operative2300 kW
With 1 engine in continuous operation 1550 kW
30 sec contingency power 1850 kW

External Dimensions
Total length with rotors operating 19.60 m
Fuselage length with tail rotor operating 16.81m

Blades and tail boom folded :
Length 13.50 m
Width 3.80 m
Height 4.09 m for 5.5 T

Main landing gear track 3.20 m
Distance between nose and main wheels :
TTH version 6.10 m
NFH version 6.18 m

Cabin Interior Dimensions
Length excluding rear ramp 4 m
Width at floor 2 m
Max height 1.58 m
Min height 1.53 m
Max volume 18 m3

Performance Data:

Two types of engine are capable of satisfying the mission performance specifications for the NH90 helicopter:

- The Turbomeca/Rolls Royce RTM 322

- The General Electric / Alfa-Romeo / Fiat Aviation CT7/6 derived from the General Electric T700 engine.

They are capable of delivering approximately 1500 kW MCP in standard conditions.

TTH Version (8700 kg ISA)
Dash speed (SL) 300 km/H
Max cruising speed (SL) 290 km/H
Normal cruising speed (SL) 250 km/H
Hover flight ceiling:
OGE: 3000 m
IGE: 3600 m
Max operating ceiling: 6000 m
Range in transport configuration 900 km
Transport capabity: 20 equipped troops or 9 stretchers or 2500 kg of freight or one light combat vehicle with crew.

NFH Version (9100 kg)
Normal cruising speed (ISA) 240 km/H
Flying time 60 NM from
base: 3 hours with 20 mn reserve (ISA)
Max endurance at 140 km/H (ISA): 5 H 15 mn
Endurance for ASW surveillance mission with sonar, 1 torpedo, 3 crew: 4 H + 20 mn reserve (ISA +10°C)

Weights :
Equipped empty weight:
TTH: 5300 kg in 14 troop helitransport mission configuration
NFH: 6200 kg in ASW surveillance configuration with sonar.
Fuel capacity:
TTH 1545 kg
NFH 1865 kg
Max slung load: TTH 4000 kg
Reference AUW:
TTH 8700 kg
NFH 9100 kg
Take-off weight in 14 troop transport mission configuration: TTH 8400 kg (1000 m ISA +15°C)
Take-off weight in ASW surveillance mission configuration with sonar, 1 torpedo, 3 crew NFH 8700 kg(SL, ISA +10°C).
Figures 6 and 7 show the TTH Variants loading troops and the Light Tactical Vehicle (LTV) respectively, whilst in Figure 8 the alternative armament with air to surface missiles and torpedoes are demonstrated.

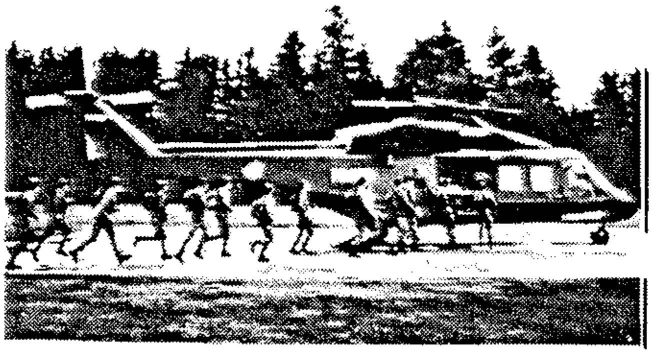


Fig.6: TTH Variant Loading Troops

Fig.7:TTH Loading the Light Tactical Vehicle (LTV)

Fig.8: NFH Mock-up with Alternative Missiles/Torpedoes

Use of Advanced Technologies:

The objective of the NH90 Programme was to build a new helicopter for the 90's with greatly improved operational performance compared to current production. The industrialists have proposed the use of advanced technologies, the most significant of which are shown in the diagram below:

1 Composite blades
2 Modern hub with elastomeric bearings
3 Modern tail rotor made of composite materials
4 Modern RTM 322 or CT 7/6 engines
5 Optional rear loading ramp
6 "Diamond" section composite fuselage
7 Selfsealing crashworthy tanks
8 Retractable landing gear with high energy absorption
9 Modular avionics with dual digital bus technology
10 Instrument panels with 8"x8" multifunction colour displays
11 Ministicks
12 FBW flight controls and higher harmonic control

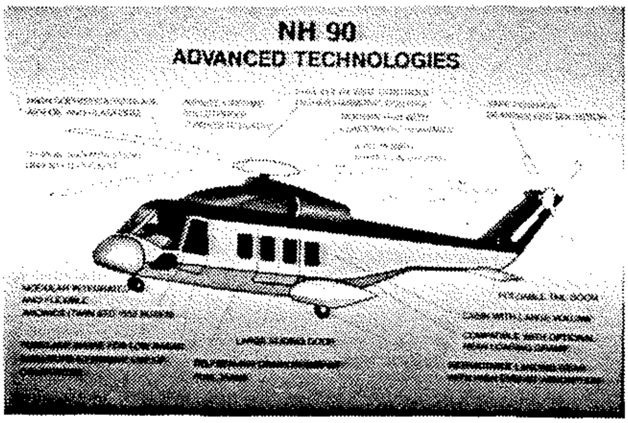


Fig.9: Advanced Technologies

The effects of the use of advanced technologies on operational performances are summed up in the table below:

NH90 Technology
. Composite rotors of modern design with advanced aerodynamic design blades
. Fuselage (extensive use of composite materials, "diamond" sheped section)
. Retractable landing gear with high energy absorption
. Self-sealing crashworthy tanks
. Modern design RTM 322 or CT 7/6 engines
. HHC of vibrations
. FBW controls
. Ministick flight controls
. Instrument panel with 8"x8" multifunction colour displays
. Modular avionics with dual digital bus technology
. Built-in night vision concept
. Equipment built-in tests/ health and damage monitoring systems

Advantage for military use
. Improved survivability and performance
. Radar discretion, spaciousness, optional rear loading ramp, improved survivability, operational flexibility, crashworthy capability
. Improved speeds, crashworthy capability
. Improved survivability
. Reduced fuel consumption
. Reduced vibratory level
. Improved handling quality, improved mission reliability, reduced vulnerability, piloting made easier
. Reduction of pilot's work load, improved ergonomy in cockpit
. Reduction of crew's work load, better instrument layout
. Improved reliability and modularity, more flexible links between systems and subsystems
. Designed for all-weather flying in tactical configurations
. Improved reliability, maintainability and availability

Of the above technologies, two are worth mention in particular i.e. the composite fuselage and the FBW controls.

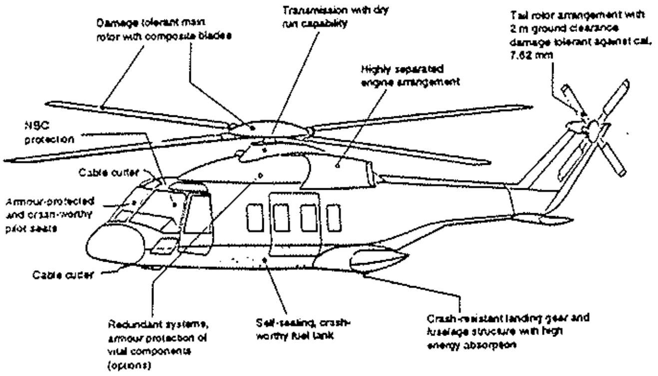


Fig.10: Technologies applied to NH90

Of these technologies, it seems appropriate to cover at least two in somewhat more detail, the composite structure and the FBW Flight Control System (FCS).

<u>NH90 Composite Fuselage Design</u>

Over the last twenty years, many structural parts of helicopter fuselages have been designed in composite materials because of their excellent properties in weight, stiffness, corrosion resistance and damage tolerance. However, these were for the most part secondary structures such as fairings, doors, stabilizer parts, etc.

Several research and development programmes carried out during the last ten years have shown the possibility of applying the composite technology to the main part of the fuselage and moreover, showed some remarkable improvements compared to conventional metal fuselages:

- Up to 30% weight saving for the experimental aircraft (20% feasible for series production).
- Manufacture of major assemblies using composite materials with a high level of integration.
- These components could be assembled on a relatively simple rig using rivets, bolts, etc.

In view of these facts, it has been decided to use an all-composite fuselage for new generation helicopters such as the NH90.

The use of composite materials greatly affects the airframe architecture: it considerably reduces the number of frames and spars.

The fuselage structure is broken down into 4 parts:

- Fuselage forward section (cockpit)
- Fuselage central section (cabin)
- Rear section (central section to tail boom connection)
- Tail boom/stabilizer assembly

Composite technology is used to meet the objectives set in terms of reduction in weight, corrosion resistance and impact resistance. The requirements for crashworthiness (MIL-STD 1290-85%), NBC protection and vulnerability are taken into account from the design stage. The shape selected consists of straight slanted sides with a view to reducing the radar signature.

The fuselage forward section comprises the bottom structure consisting of longitudinal beams, frames, skin panels and cockpit floor panels, nose gear well, provisions for emergency floatation gear, and the cockpit with canopy, doors, windows and radome. The fuselage lower central section comprises the front and rear fuel tank compartments, the electrical racks and the flight control bay of composite structure (frames, longerons, skin panels). It includes two 1.60 m wide, 1.50 m high lateral sliding doors. The fuselage upper central section is formed of the upper sections of the frames, longerons and skin panels and includes the attachment points for MGB and engines.

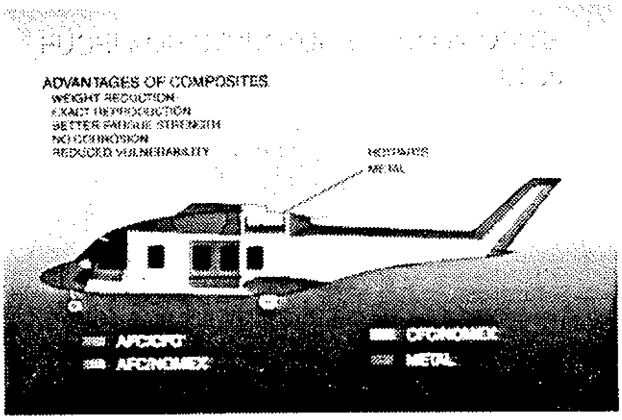


Fig.11: Materials used for NH90 composite structure

For stressed parts, either monilithic or NOMEX sandwich structure carbon fibre will be used.

For parts not subjected to high stresses (e.g. doors, access panels, fairings). NOMEX sandwich structure aramide fibre will be used.

The use of metal is limited to the engine deck, load-bearing elements and some stiffeners. For these, a titanium/aluminium alloy will be used (Figure 11).

The fuselage rear section is shaped to allow the installation of an optional ramp for embarkment of a 2 T vehicle.

The tail boom/stabilizer assembly will be provided with a manual (TTH) or automatic (NFH) folding system in order to meet requirements for use on ships (Figure 12).

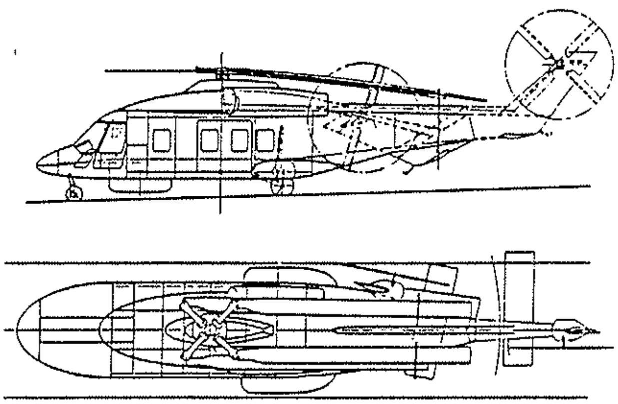


Fig.12: NH90 in Folded Conditions

The structure is designed to absorb the stresses transmitted by the landing gears and to allow installation of equipment as required by the users:
- Rescue hoist
- Lifting hook
- Harpoon locking and traversing system
- Sonar
- Emergency floatation gear
- Heavy Stores Carriers

Fly-by-Wire Flight Control System (FCS)

The FBW technology has been selected to meet the operational requirements of an 8 to 9 tonnes helicopter designed to operate on a battlefield of the 21st century.
TTH missions require all-weather day and night troop transport capabilities. To do this, the helicopter must be able to fly at low altitude, close to the Nap of the Earth, to avoid detection by enemy radar and thus to prove less vulnerable. Flight quality must therefore be better than that of current 8 to 10 tonnes class helicopters and this is provided by the FBW system which ensures improved control authority and better stability. Likewise, the ministick concept makes for greater flying accuracy and improved crew confort.
Although not as demanding as TTH missions, the NFH missions are also highly stressful for the pilot. They must be carried out in difficult weather and in any operational conditions and involve hovering over high seas as the helicopter comes in to land on the frigate deck.
In addition to the operational requirements, the industrialists have also imposed the following design objectives:
- The system must be "dual fail" safe, in other words it must remain fully operational after a second failure.
- Since the flight control system significantly modifies the basic helicopter's dynamic responses, failure of this system must remain highly improbable.
- The system must be of modular design and incorporate built-in test capabilities (BIT).
The selected quadruplex flight control system is designed to meet the conditions imposed.
The Higher Harmonic Control of vibrations which adapts the level of vibrations transmitted to the airframe according to the various mission configurations, can be easily integrated into the system using two computers (to ensure redundancy in case of failure) which generate the signals applied to the blade pitch servocontrols.
A block diagram of the system is shown in Figure 13.
1 Autopilot computers
2 Pilot/copilot flight controls
3 FBW Computers
4 Swash-plate
5 Stationary link
6 Blade pitch servocontrol
7 Servovalves
8 HHC computers
9 Trim actuators
10 Position sensors
11 Mechanical
12 Electric
Compared to a conventional mechanical flight control system, the use of the FBW system along with the HHC (Higher Harmonic Control) system has the following advantages:
. Mission reliability meets with NH90 requirements; handling quality is not affected by FBW system failures.
. Easier piloting through the use of FBW controls which make for improved handling quality.
. Simpler flying through the use of flight control laws which prevent spurious coupling between controls and helicopter responses.
. The use of ministicks.
. Reduced vulnerability to ballistic impacts.
. Weight saving of approximately 60 kg (due mainly to the use of the HHC) which is particularly significant in keeping the NFH version weight within the imposed envelope.
. Improved maintainability since there are no mechanical parts requiring maintenance or adjustment.
. Reduced pilot training time.
The use of FBW controls confers on the NH90 the qualities required to meet the specifications as substantiated for new generation helicopters (roll agility, fail-safe stability, gust hold). Moreover it satisfies the specific requirements relative to NOE for the TTH version and critical mission phases for the NFH version.

However, to meet transport requirements the helicopter has been designed with a more voluminous fuselage than other current 8 to 10 tonnes helicopters (Super Puma and Blackhawk), which means that the longitudinal instability to which helicopters are normally prone is increased, especially in weapon carrying configurations.
To remedy this, it would be necessary to increase the size of the horizontal stabilizer, however experience has shown the limits of this solution since it accentuates the adverse effects of rotor/stabilizer interactions at low speeds.

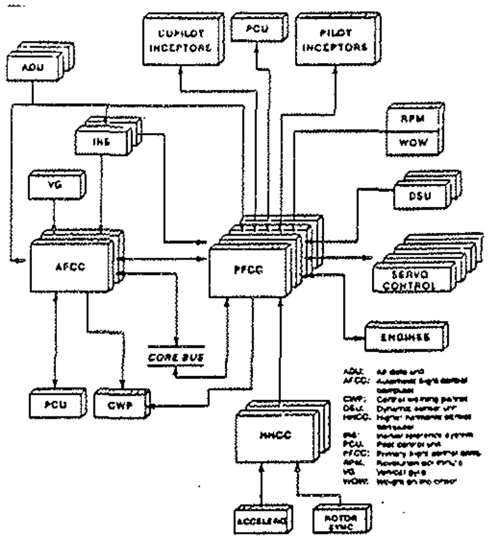


Fig. 13: FCS Architecture

NH90 General Description

The composite fuselage and the FBW system are the most remarkable technologies used for the NH90 helicopter. Below is a short description of the other main components.

Main Rotor

The 16 m diameter main rotor is the 4 blade type with de-icing system and a hinged hub with elastomeric bearings. It rotates anti-clockwise when looking down.
The main blade air foil of the QA3 family was developed jointly by Aerospatiale and ONERA with a 12% to 9% taper and a parabolic tip beyond 0.95 R (R: blade radius). The composite blade consists of a foam-filled 2-box glass fibre spar and a NIDA honeycomb rear section. The carbon + glass fibre skin is covered with conductive paint to minimize the radar signature. The leading edge is protected by an anti-erosion nickel shield which *shrouds the built-in de-icing system.* This blade design is a satisfactory compromise between weight, erosion resistance, radar signature and tolerance to 23 mm HEI projectiles.

The main rotor hub is the Spheriflex type of a design similar to that fitted on the Super Puma MK II. The head, mast and sleeve are made of titanium. Four laminated elastomeric spherical bearings ensure freedom of movement of the blades and transfer loads from the blades to the hub. Each blade is attached to the hub plate through a drag damper. Figure 14 shows the main rotor hub.
The rotor head design is compatible with the de-icing and blade folding systems used (manual for TTH, automatic for NFH). The rotor head/mast assembly is mounted into the MGB through two bearings.
The rotor head structural parts have an infinite service life and are of "fail-safe" design. Apart from the swash-plate bearing, no lubrication is required.

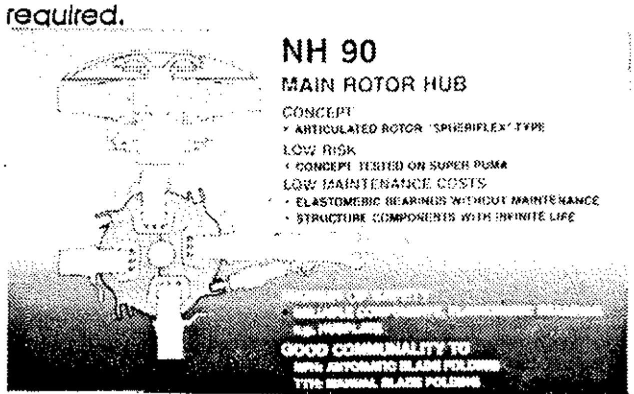


Fig. 14: Main Rotor Hub

Tail Rotor

For cost saving reasons, the tail rotor and the TGB are directly derived from the assembly fitted on the Super Puma MK II. The rotation direction and the tail rotor position are as originally planned in the NH90 feasibility study.
As for the main rotor, the tail rotor is the SPHERIFLEX hinged type with laminated elastomeric bearings and drag dampers. The 3.20 m diameter rotor is equipped with four 0.32 chord composite blades with yoke fittings for attachment to the hub body through laminated bearings. The rotor is the soft-in-plane type (i.e. 1st drag mode $< 1\Omega$, where Ω = rotation speed) which requires as a drag damper to be fitted for each blade. Figure 15 shows the tail rotor assembly.

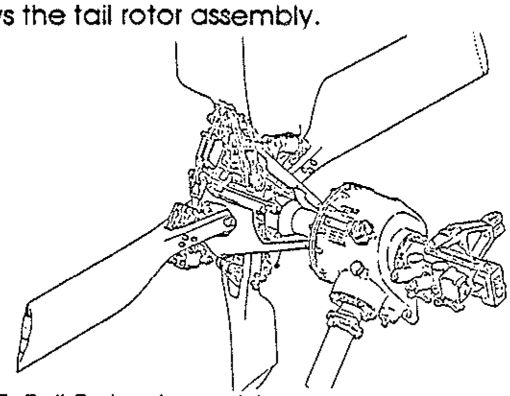


Fig.15: Tail Rotor Assembly

Transmission System-Powerplant

The two RTM 322 - 01/2 or General Electric CT 7/6 engines governed by a Full Authority Digital. Electronic Control (FADEC) system are installed aft of the MGB in semi-pod configuration in order to facilitate maintenance. An APU is installed between the two engines in order to ensure starting at very low temperatures and permit on-ground avionics tests with engines stopped (Figure 16).

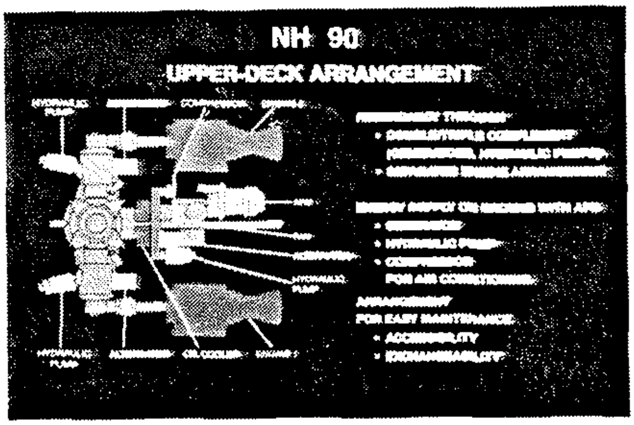


Fig.16: Upper Deck Arrangement

The MGB includes 3 reduction stages between the input at 20900 rpm and the output at 256 rpm :
- First and second reduction stages: bevel gears
- Third reduction stage: epicyclic

Power Output (at full speed):
2300kW with 2 engines operative
1550kW with 1 engine operative
1850 contingency power with 1 engine operative.
This system is a satisfactory compromise between weight, compactness, reliability and vulnerability. The ancillary equipment (alternators, hydraulic pumps, fan) are mounted on the central accessory gearbox to which the APU is connected.
The assembly meets the modularity and vulnerability requirements set by the users and permits on-condition maintenance through the use of a Health and Damage Monitoring System.

Main and Nose Landing Gears. The aircraft will feature a retractable tricycle landing gear with trailing arm nose wheel for easier handling on ground and on ship deck. It is designed to withstand hard landing conditions (4 m.sec) on ship deck (NFH) and to meet MIL-STD 1290 requirements (85%) for the TTH version.
The nose gear is the twin wheel type and retracts rearwards.
The main landing gear is the trailing arm type with independant shock absorbers and a single wheel at each leg.

Systems

General Systems/Core Avionics Systems

Figure 17 shows the constituents of the general systems and core system avionics.

GENERAL VEHICLE SYSTEM/EQUIPMENT	FLIGHT CONTROL SYSTEM	CORE SYSTEM AVIONICS
.Electric System .Hydraulic System .Fuel System .E C S .A P U .Deicing System .Pilot seats .Furnishing	.Primary Flight Control System (PFCS) .Automatic Flight Control .System (PFCS) .Higher Harmonic Control (HHC)	.Aircraft Management System (AMS) .Navigation .Communication/ Identification .Displays and Controls

Fig.17 General Systems/Core System Avionics

General Systems

Some of the main characteristics of the general systems intended for use on the NH90 are summed up below.

Electrical System

AC power generation: 3 x 40 KVA generators
DC power generation: 3 x 250 A converters
20 Ah battery for APU starting capable of ensuring 15 minutes flight safety in case of total failure of the power generation system.

Hydraulic System: 3 independent 207 bar systems:
- 2 for the FBW system
- 1 for the accessories

Air Conditioning:
- Air cycling system.
- Heating/cooling of avionics, cockpit and cabin.
- Ventilation of avionics in case of cooling system failure.

De-Icing System :
- Electric for: Main rotor, tail rotor, air intake, pitot head, wind shield;
- Pneumatic for: Horizontal stabilizer.

Fuel System:
7 tanks for TTH version: capabity 1545 kg.
8 tanks for NFH version: capacity 1865 kg.
- Crashworthy up to 14 m/s
- Self-sealing for 12.7 calibre impacts on TTH version

- Possibility of on-ground pressure refuelling and vertical refuelling in hover flight for NFH version.

Mission Systems/Equipment

Figure 18 shows the constituents of the Avionics Systems/Equipment.

COMMON-MISSION SYSTEM/ EQUIPMENT

. Rescue Hoist
. Cargo Hook
. Heavy Store Carrier
. Miscellaneous

TTH-Mission Systems/ Equipment

. Third crew seat
. Wire strike protection
. IR Suppressor
. Armouring
. Troop seats
. Piloting Vision System
. Obstacle Warning
. Tactical Control System
. Electronic Warfare
. Weather radar

NFH-Mission Systems/ Equipment

. Automatic folding
. Floatation
. Armaments
. Light store carrier
. Deck handling
. Tactical radar/ IFF Interrogator
. FLIR
. Sonics
. M A D
. Tactical Control System
. Data Link 11/ Crypto
. Electronic Warfare
. Stores Management

Fig. 18 Mission Systems/Equipment

Systems Architectures

General System Architecture

The general architecture of the systems satisfies several criteria which have determined design from the start of the feasibility studies.

Maximum NFH/TTH commonality

Decentralization of data processing in the different subsystems in order to limit data transfers.

Attaining a high growth potential in order to respond to system development during the helicopter service life.

Systems redundancy, in particular for the most critical functions which are related to helicopter flight safety.
Moreover, system structure shall be designed such that the critical functions are not dependent on other less critical functions.
Based on these considerations, a federative architecture was selected, built around 2 redundant 1553B digital buses, one for the core avionics and common to both versions and one for the mission avionics specific to TTH or NFH version.

A computer provides a bridge between the two buses; this solution was possible in view of the small volume of data transferred between the two buses.
Selection of this type of architecture makes it possible to:
- Develop core avionics and mission avionics separately.
- Qualify the core avionics independently of the mission equipment connected to the mission bus only.
- The modern ADA language has been selected for the software. However, the use of a federative architecture makes its possible to use other languages in the subsystems even if the central computer is programmed in ADA.
- The naval system is built around a flight control function, a tactical coordination function and a detection function. The system is designed to allow tactical coordination from the cockpit. Depending on Naval Forces requirements, a fourth station may be added. System design allows for this without having to modify the three other stations and while remaining compatible with maximum TTH/NFH commonality. The proposed system architectures for the TTH and NFH are shown in Figures 19 and 20 respectively.

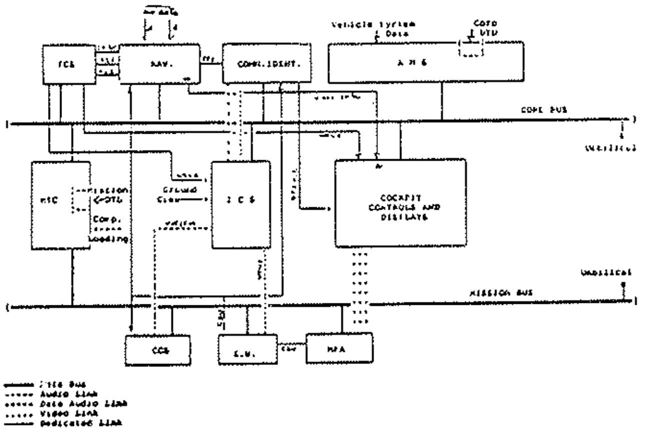


Fig.19 TTH System Architecture

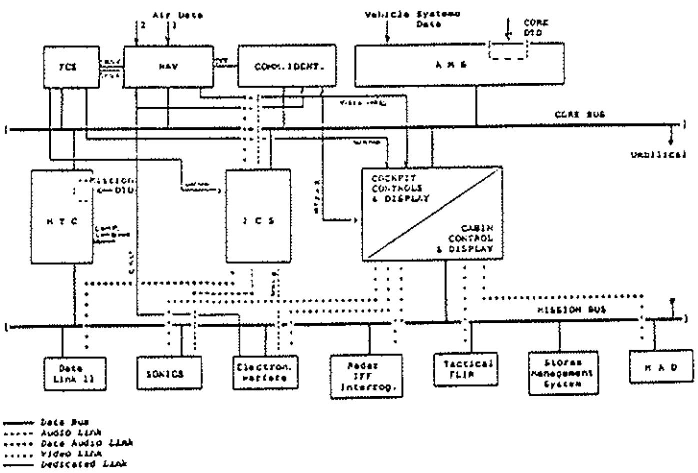


Fig.20 NFH System Architecture

Core System Avionics

This ensures the following management functions:
- Basic helicopter management
- Control and display units management.
- Internal & external communications management.
- Helicopter guidance and navigation management.

It interfaces with the crew, the helicopter, environmental data, the mission system and the flight control system as shown in the architecture diagram.
The redundant avionics management computer (AMC) controls the subsystems in the core system and data transmission on the Core Bus. It monitors the status of the entire on-board system.
The plant management computer (PMC) monitors the basic helicopter.
The navigation system includes in particular 2 inertial reference systems, a Doppler Velocity Sensor (DVS) and a Global Positioning System (GPS).

TTH Mission System

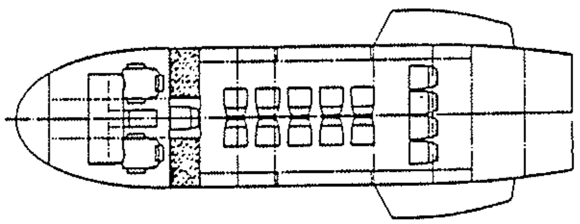
The TTH mission system is built around a redundant digital bus managed by the redundant MTC.
The following subsystems are connected to the mission bus:
Mission Flying Aids: - Pilot Night Vision System (PNVS) consisting of a stabilized platform equipped with a FLIR. The FLIR image can be displayed on one of the multifunction monitors or on the Helmet Mounted Display (HMD). Movement of the FLIR platform can be bound to the pilot's head movements.
- Night vision goggles.
- An obstacle avoidance system interfaced to the head-down displays.
- A weather radar used in particular to generate images of the overflown terrain.

The electronic warfare subsystem includes: - Hostile fire indicator and radar and laser emission receivers associated to IR and electromagnetic chaff launchers.
- Communication control system, an additional tactical VHF/FM radio.
- Digital Map Processor.
- Mission Tactical Computer (MTC) which synthesizes data to generate tactical image display.

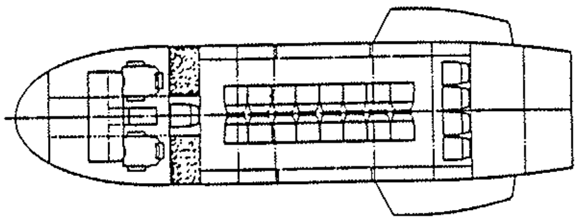
Note that the data transfer between the core bus and the mission bus is covered out by the MTC.

TTH Specific Equipment

Equipment added to the basic helicopter to obtain the basic TTH version plus equipment specific to each TTH mission.
This includes in particular:
- IR suppressors to reduce IR detectability.
- Cable cutters.
- Retractable searchlight.
- Hook for slung loads up to 4 tonnes.
- 400 kg folding hoist with 60 meters of cable.
- Emergency floatation gear with 4 inflatable floats.
- Weapon support pod.
- High crashworthy capacity seats for 14 troops transport version or slightly lower crashworthy capacity seats for 20 troops transport version (see Figure 21).



14 + 1 Troops



20 + 1 Troops

Fig. 21 Seat Arrangement for Transport of 14 and 20 troops

NFH Mission System

As for the TTH, the NFH mission system is built around a STANAG 3838 dual bus arrangement managed by the mission tactical computers. In addition, a video system displays the images at the different crew stations. A console is installed in the cabin for the mission sensor operator and the copilot who synthesizes the tactical situation. A second console can be installed in the cabin for use in training missions, for example.
The NFH mission system includes a large number of passive and active sensors:
For Surface Surveillance: - A 1.8 m diameter 360° sweep tactical radar mounted below the fuselage able to detect small targets (e.g. periscopes, snorkels, floating antennas), detect and classify surface ships in heavy sea clutter, and perform automatic target tracking.

- A tactical FLIR used to search for and identify targets in war and peace time and as a flying tracking.
Target identification is ensured by an IFF system coupled to the tactical radar and a FLIR operating over short ranges.
- Electronic warfare equipment consisting of an ESM system to detect, analyse and identify radar emissions, jammers and chaff launchers.
For Submarine Surveillance: - Acoustic subsystem consisting of active and passive detectors for target surveillance, search, detection, classification and tracking.
- Low frequency sonar.
- Sonobuoys with automatic launcher.
- A magnetic anomaly detector (MAD) subsystem for target detection or immediate relocalization before firing the helicopter weapon system.
For Combat and Self-Defense: The following are used in association with the above equipment:
- The Weapon System mounted in the multi-purpose heavy stores carrier, anti-surface missiles for surface targets, torpedoes for ASW targets and air to air missiles (optional).
The Tactical Control Subsystem is the core of the NFH mission system which is used to control and manage the mission subsystems, to synthesize the tactical situation based on the data from the on-board sensors and the data link with the other ships, and for tactical navigation.
This subsystem also manages and displays the mission data (display of images generated by the sensors) and the tactical situation. It consists mainly of:
- A redundant tactical mission computer.
- One or two operator stations in the cabin (sensors station) with display on 2 large colour consoles (Figure 22).
- Specific NFH mission control equipment on the copilot's side of the cockpit (TACCO Station) (Figure 23).

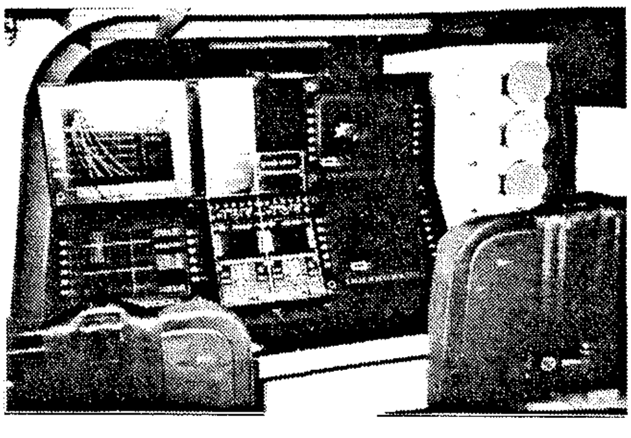


Fig. 22 Cabin Station

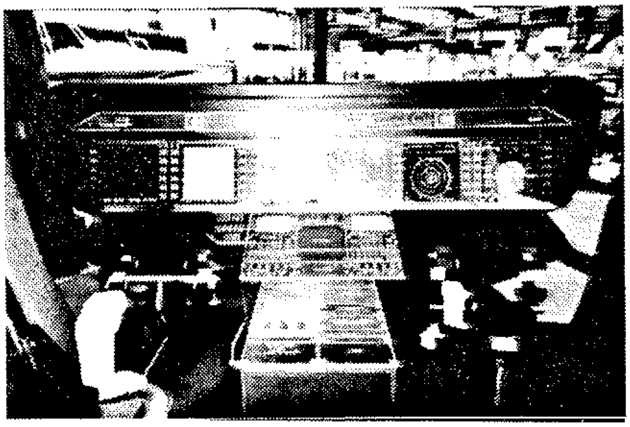


Fig. 23 Instrument Panels and Console

NFH Specific Equipment

Equipment added to the basic helicopter to obtain the basic NFH version plus equipment specific to each NFH mission.
This includes in particular:
- Automatic main rotor blades and tail boom folding.
- Emergency floatation gear (same as TTH version).
- Additional 320 kg capacity tank installed aft of the fuselage.
- Vertical replenishment capability.
- Rescue hoist (same as TTH version).
- Harpoon for locking on to ship's grid compatible with SAMAHE type deck handling system.
- Multi-purpose heavy stores carrier (same as TTH version).
- Hook for slung loads (same as TTH version).
- Crashworthy operator seats in cabin.
Figure 24 Shows the basic layout of a NFH mission configuration.

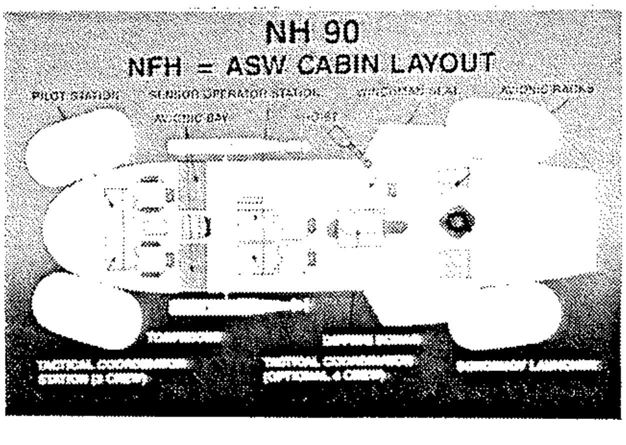


Fig. 24 Basic Layout of NFH Configuration

Operational Characteristics

Input of Design Characteristics on Mission Performance

Cabin design: - Large volume: 4.0 m long (excluding ramp) x 2.0 m wide at floor x 1.58 m high.
- 2 large side doors (1.6 m wide, 1.5 m high), manoeuvrable in flight.
- 1.8 m wide rear ramp for French transport versions.
- Safety rails in the floor and the ceiling to attach:
9 stretchers, or
VIP equipment, or
Naval equipment.

Provisions for Installing Miscellaneous Equipment:
a) Basic equipment includes:
- Electric rescue hoist
- 4000 kg hook load
- Emergency floatation gear
- De-icing system
- APU powered air conditioning system.
b) Land-based version equipment:
- Helitransport
- Tactical transport of a light combat vehicle and its operators
- Search and rescue (SAR) in peace time
- Search and rescue (SAR) in war time
- Special missions
c) Naval version equipment:
- Autonomous submarine detection, identification and attack (ASW).
- Surface target detection, identification and attack (ASUW).
- Rescue missions (SAR, transhipment).

General Helicopter Definition: The helicopter has been designed to be capable of:
- Missions by day/night/in bad weather conditions
- Missions in icing conditions
- IFR flying with one pilot only in comfortable conditions due to low vibratory level, internal noise damping and powerful air conditioning system.

Improving Survivability

High Self-Protection level, ensured by redundancy of basic survival systems:
- 2 crew members with duplicated controls and instruments
- Twin engines
- Systems redundancy:
FBW system: x 4
Hydraulic system: x 3
Electrical system: x 3
Avionics system: x 2

Design Impact Resistance: - Composite main and tail rotor blades (with 2-spar box structure for main blades)
- Composite airframe
- Wide space between engines
- Gear boxes capable of 30 minutes operation without oil
- Self-sealing fuel tanks protected against ballistic impacts
- Segregated power transmission systems
- Separate circuit routing

Impact Resistance by Armour Plating: - Crew seats
- Vital components (e.g. servocontrols)

Good Hard Landing Resistance: - Very good power response with one engine
- Landing gear with high energy absorption capacity (up to a vertical drop speed of 6 m per second without structural damage)

Good Crashworthiness: - Crashworthiness design for landing gear, airframe and seats
- Pilot's seat with 12 inch vertical travel
- Fuel system protected against fire caused by projectiles

Reasonable NBC Protection: - NBC filter on air conditioning system
- Cockpit compatible with the use of NBC suits
- Electrical wiring systems resistant to electromagnetic pulses (specification 200 V/m and 400 V/m for vital systems)
- Airframe dimensioned for pressure and heat wave

Minimized Detectability: - "Diamond" shaped fuselage, composite fuselage and blades make for low radar signature
- Reduced IR emissions (mainly through engine IR suppressors)
- Reduced external noise by design of rotors, gear boxes and engines

Improved Operational Capacities:

Systems Architecture: - Basic avionics bus common to every variant
- Mission equipment bus allowing for high adaptation flexibility
- Built-in self testing, warning and diagnosis systems
- High growth potential allowing installation of additional or improved equipment
- Adapts to threat changes and task definitions with the possibility of replacing complete subsystems without excessively costly procedures by separation into basic avionics bus (critical for flight safety) and mission bus.

Cockpit: - Cockpit ergonomy integrates the most advance techniques
- Automatic, centralised avionics management
- Multiplexed colour display systems (8"x8" screens)

- Compatibility with night vision equipment
- Compatibility for personal NBC protection equipment

Flight controls: - Electric signal transmission with quadruple redundancy
- Digital signal processing
- Redundant automatic flight control system (AFCS) with operating modes suitable for the most varied missions
- Controls with ministicks for better cockpit ergonomy

Mission Equipment: - Potential European standardization through the participation of four customer countries
- Implementation flexibility through use of the mission bus
- Structural provisions for fitting optional equipment installed from the beginning of the programme.

NH90 - Advantages Over Other Helicopters in Its Class

The other current helicopters in the 8 to 10 tonnes class are the AS 332 Super Puma and the Sikorsky Black Hawk and Sea Hawk. These aircraft are constantly developing and are likely to see other improvements. However, they have reached the ultimate stages of development of a helicopter family design that dates back twenty years.

The NH90, on the other hand, is in the first stages of a product family that will be the mainstay of the 8 to 10 tonnes range for several decades thanks to its growth potential.

In comparison to other current helicopters, the present NH90 presents numerous advantages due to the basic helicopter design and the equipment used, for example:
- Improved performance (ISO configuration)
- Large volume fuselage with provision for fitting a rear ramp
- Dimensions with blades and tail boom folded allow it to be stored in a hangar on the frigate originally designed for the LYNX helicopter
- Improved handling quality through the use of FBW controls
- Modular avionics design makes for high equipment flexibility
- Growth potential
- Reduced vibratory level in cabin through the use of the HHC concept
- Improved flying ergonomy and reduced crew work loads (FBW concept, ministicks)
- Reduced vulnerability and detectability by the choice of adapted concepts and materials
- Latest generation equipment (e.g. night vision system, all-weather flying)
- Improved reliability, availability and maintainability.

Conclusion

This document has shown the advantages offered by the NH90 helicopter as regards operational capacities through the use of modern technologies and equipment.

Moreover, this helicopter programme is the first to bring together the major European helicopter industries, with the exception of Westland who played an active part up to the definition phase. With orders from France, Italy, Germany and the Netherlands right from the start, it can offer a common basic version for land-based tactical transport missions and a common frigate-based version. Of modern design and improved operational capacities in comparison with other current aircraft in its class, its unit cost nevertheless remains comparable with the other current aircraft at ISO configuration.

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LYNX - A 50 YEAR PRODUCT ?

J C BARKER - CHIEF ENGINEER (LYNX/W30)
WESTLAND HELICOPTERS LIMITED

1. This paper describes the development of the Lynx helicopter over the last twenty years to illustrate the costs and benefits of continued development and modification of existing helicopters rather than early replacement by new designs. Key features are identified, discussed, and where possible, quantified.

2. The Westland Lynx is a product of an agreement signed by the French and British Governments in 1967. Although not the subject of this paper, the agreement is worthy of study in that it involved development of three helicopters, jointly manufactured, but with Aerospatiale having sole technical responsibility for the Puma and Gazelle and Westland having the same for Lynx. Both nations bought and operate all three products and the joint manufacture continues to this day.

The Lynx was designed from the start to meet two differing rigorous military requirements. A Navy variant would fulfil the requirement for a frigate or destroyer based helicopter to replace the Wasp and Alouette, whilst similar Army or Utility machines would meet the needs of land based forces. The two Lynx have a high degree of commonality in their basic structures, dynamic components and the Rolls Royce Gem engine which was specially designed for Lynx. Their main differentiating features are:-

Navy Lynx	Army Lynx
Tricycle Long Stroke Undercarriage	Skid Undercarriage
Automatically Engaging Deck Lock (Harpoon)	
Folding or Fixed Tailcone	Fixed Tail
Nose Mounted Radar	
Torpedo/ASV Missile Carriers	NATO Flange Carriers
Sonar Provisions	
Triple Hydraulic System	Dual Hydraulic System

These features and the detailed fits of communications and navigation systems were the result of the specifications laid down by the launch customers (and funding sources) - the UK and French Forces.

The Lynx first flew in 1971 and entered service in 1976. The present worldwide fleet of 330 has accumulated almost 700,000 flying hours and the 180 Naval Lynx have made over 400,000 deck landings. Present operators are the British Army, the Royal Navy, five other European maritime forces (soon to be six) and three non European navies.