# "NH90 TTH:
# The Mission Adaptable Helicopter - The Mission Flight Aids"


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## Abstract:

The Tactical Transport Helicopter (TTH) is the NH90 version which is developed under a contract of the NATO agency, NAHEMA, representing France, Germany, Italy and the Netherlands. Three of these countries intent to use this version for many different missions in their Armies and Air Forces. The NH90 helicopter is under development since 1992 and had his maiden flight in Dec. 1995.

A presentation of the mission system and specific mission equipment will be given to show the status of this development. The mission system provides a high degree of flexibility due to architectural design and SW-layout. It may be adapted to different missions by easy changes of its configuration. Additionally the present development is also taking the necessary provision's for further extensions to more specialised missions which its vast cabin allows.

For the first time a transport helicopter is equipped with a high sophisticated mission flight aids which is part of the mission system. These mission flight aids provide the helicopter with an effective capability for day, night and adverse weather conditions. Especially the Vertical Situation Aids (VSA) - consisting of a modern FLIR, a visor-projecting binocular HMS/D including Image Intensifier Tubes (IITs) and an Obstacle Warning System (OWS) - will be described here in more detail. These three mission equipment's are highly integrated to give the pilots an on-line FLIR or IIT presentation projected on the HMS/D's visor overlaid by symbology. This allows a "looking-ahead" capability.


**NOTATION**

| | |
|---|---|
| AVT | Ausrüstungsversuchsträger |
| ATP | Acceptance Test Procedure |
| AZ | Azimuth |
| BK117 | Bölkow Kawasaki Helicopter |
| CCD | Charged Coupled Device |
| CDU | Central Display Unit |
| CoG | Centre of Gravity |
| CP | Control Panel |
| CRT | Cathode Ray Tube |
| CSAR | Combat SAR |
| DKU | Display and Keyboard Unit |
| DMG | Digital Map Generator |
| EC | Eurocopter |
| ECD | Eurocopter Deutschland |
| EL | Elevation |
| EU | Electronics Unit |
| EWS | Electronic Warfare System |
| FFL | Form Fit Liner |
| FLIR | Forward Looking Infrared (TI) |
| FOV | Field of View |
| HC | Helicopter |
| HMB | Head Motion Box |
| HMD | Helmet Mounted Display |
| HMS | Helmet Mounted Sight |
| HMS/D | Helmet Mounted Sight / Display |
| HSA | Horizontal Situation Aids |
| IHS | Integrated Helmet System |
| IHU | Integrated Helmet Unit |
| IIT | Image Intensifier Tube |
| IR | Infra Red |
| IRS | Inertial Reference System |
| LOS | Line of Sight |
| LRU | Line Replaceable Unit |
| LTV | Light Transport Vehicle |
| LTV | Light Tactical Vehicle |
| MCT | Mercurium Cadmium Telluride |
| MFA | Mission Flight Aids |
| MFD | Multi Function Display |
| MMI | Man Machine Interface |
| MRTD | Minimum Resolvable Temperature Difference |
| MTC | Mission Tactical Computer |
| MTF | Modulation Transfer Function |
| NAHEMA | NATO Helicopter Management Agency |
| NATO | North Atlantic Treaty Organisation |
| NH90 | NATO Helicopter of the 90th |
| NHI | NH-Industries |

| | | | |
|---|---|---|---|
| NOE | Nap of the Earth | SAR | Search and Rescue |
| NVG | Night Vision Goggle | TBC | To be confirmed |
| OM | Optical Module | TI | Thermal Imager (FLIR) |
| OWS | Obstacle Warning System | TTH | Tactical Transport Helicopter |
| PAH | Panzerabwehrhubschrauber (antitank h/c) | VISL | Visionics Laboratory |
| PoD | Probability of Detection | VSA | Vertical Situation Aids |
| PVS | Pilot Vision System | WXR | Weather Radar |
| QRC | Quick Release Connector | | |

## INTRODUCTION

The NATO Helicopter (NH90) is in the development phase since 1992. The four nations France, Germany, Italy and The Netherlands working together in the quarto-lateral NH90 programme. The maiden flight of PT1 took place on 18.12.1995, see Fig. 1. The NH90 version as Tactical Transport Helicopter (TTH) provides an effective NOE mission with day & night and adverse weather capability. The TTH-Mission gross weight is 8 700 kg and the dash speed is >300 km/h.

The mission requirements for the NH90 TTH have been defined by NAHEMA and Industry at the end of the 80th and beginning of the 90th. The helicopter NH90-TTH is capable of flying different missions during day and/or night. The NH90 TTH is designed primarily as a tactical transport helicopter for delivery of 14 combat ready troops and/or materials from a pick-up zone on friendly territory to a landing zone on friendly territory possibly close to the forward edge of the battle area, but in principle outside direct threat from the enemy.

With special equipment other missions can be performed such as:

- heliborne operations (transport of a LTV)
- SAR in peacetime
- electronic warfare
- airborne command / parachuting
- casualties rescue
- VIP transport

Taking into account the new military tasks as UN operation in civil wars, additional mission requirements are raising up. Therefore investigations are made on future versions of the TTH i.e. to fulfil electronic warfare missions, mine detection and to have improved self defence. Different versions of transport capability are defined: 14 - 20 troops or >2500 kg of cargo or up to 12 stretchers or a light tactical vehicle with crew.

The crew workload is reduced by maximum integration of flight control system. The NH90-TTH has a basic and a mission avionics. The Mission Flight Aids (MFA) as part of the mission avionics is an advanced system. The helicopter sensors measures the threat radiation's passive and active. Therefore the protection is high even against Radar, Laser, EMI and NBC radiation's.

On the Mission-Bus are two main subsystems: Mission Flight Aids (MFA) and Electronic Warfare System (EWS).

The MFA includes a piloting-FLIR with a steerable platform, two binocular Helmet Mounted Sight & Display (HMS/D) with Image Intensifier Tubes (IIT) as sensors, an Obstacle Warning System (OWS), a Weather Radar and a Digital Map System.
The Vertical Situation Aids (VSA), which is part of MFA consists of the FLIR, HMS/D and OWS i.e. the piloting aids for the pilot in NOE flight. They will be described in this paper in more detail.

The **FLIR** with a 30° x 40° piloting Thermal Imager (TI) is installed in the nose of the helicopter (HC). It includes a steerable platform, positioned by the LOS angular data, measured by the HMS, see Fig. 1. The Pilot Visionic System (PVS = FLIR and two HMS/D) comprises two binocular HMS/Ds: one for the pilot and one for the co-pilot.

Fig. 1: Prototype 1 of the NH90 during its 40 minute maiden flight on December 18,1995 at the Eurocopter plant in Marignane, France.

The **binocular HMS/D** consists of a new light weight helmet shell equipped with an individual form fit liner, intercom and an Optical Module (OM) which includes two Cathode Ray Tubes (CRTs), two Image Intensifier Tubes (IIT) and optics. For displaying the information Visor Projection is provided. The visual information includes flight symbology. High accuracy is required for the Helmet Mounted Sight (HMS) in a large Head Motion Box (HMB). This HMS steers the nose mounted FLIR platform. The platform with the FLIR and the HMS/D are working close together as an PVS.

The **OWS** is required for the detection of different obstacles during NOE missions. The OWS is specified as a fixed forward sensor using eyesafe Laser technology with intelligent signal processing in the electronic for cable and other obstacle separation, as well as different modes of obstacle presentation. Its FOV is equivalent to the one of the FLIR. Nearly 100% probability of detection (PoD) is required. At the moment no OWS is selected. The reasons are the lack of PoD fulfilment and the high Man Machine Interface (MMI) requirements.

Eurocopter (EC) has since a long time much experience with MFA on BO105, PAH1, BK117-AVT, Dauphin, Ecureuil, Gazelle, Super-Puma and TIGER. Eurocopter Deutschland (ECD) is responsible in this NH90 programme for the TTH version to select, to procure, to develop in co-operation with the suppliers, to install, to test and to qualify the MFA.

## THE OPERATIONAL REQUIREMENTS

In any case the TTH shall have the capability, to fly during day and night and in all weather conditions. These conditions are specified as:

- At night: with at least Night-Level 4 > 0.7 mLux and sometimes Night-Level 5, as defined in FINABEL 1-R-9, 1978
- All weather conditions: maximum extinction coefficient of 1.0 $km^{-1}$

Depending on the mission task and the conditions with regard to weather condition or enemy threat, the crew has to select a certain flight altitude for each mission segment.

To improve low detectability and thus the safety of the flight, the natural cover of the topography is used. The NOE track leads close to and between obstacles as hill, trees, power poles and wires. As a consequence, the pilot has to look continuously for a compromise between three parameters: ground speed, flight altitude and distance to obstacles.

On its own, the FLIR sensor on the platform have some limitation during a 24 hour missions. The absolute temperature characteristic or the emissivity of natural materials will vary over a 24 hour period (ref. 3 - 6). A thermal zero contrast (wash-out effect) during rainfall or a so called cross over effect is observed, especially at dawn and during twilight. Then the foreground is not detectable against the background, so that, for example, pylons can become very dangerous for the HC crew.

Therefore, the combination of the two visual aids, IITs and FLIR, which are based on different physical principles, is better suited to fulfil the increased requirements of adverse weather conditions during day and night. These two visual aids can be combined in the binocular HMS/D with binocular vision (two CRTs and two IITs on the helmet). The crew can switch between the IIT image and the TI image almost without delay. Additionally, flight symbology can be superimposed on the images.

At night or reduced visibility (adverse weather), especially when flying NOE, the safety of the aircraft has to be maximised with regard to obstacles. To achieve this, the crew is supported by the use of the VSA. The VSA helps the pilot to see obstacles also during night and bad weather conditions with the aid of IITs and FLIR. Additionally the OWS provides warnings in case of obstacle threat for the helicopter.

## SYSTEM ARCHITECTURE

The NH90 TTH Avionics System is subdivided into two parts: the Core System and the Mission System. Both of them are based on dual redundant STANAG 3838 digital databuses. These two independent buses are called Core Bus and Mission Bus.

The TTH Core System is composed of the following subsystems:
- Aircraft Management Subsystem
- Control and Display Subsystem
- Communication and Identification Subsystem
- Navigation Subsystem

The TTH Mission System provides the following functions:
- Mission Flight Aids
- Electronic Warfare
- Additional Communication
- Tactical Control
- Up/Down Loading Tactical/Mission Data
- Mission System Management

Fig. 2: Overall block diagram of the MFA in the NH90 TTH

Fig. 3: System architecture of the VSA

The Mission System Management is performed by two redundant Mission Tactical Computers (MTC 1 and 2). These MTCs include the bus controllers for the Mission Bus and are the links to the Core Bus. The Mission System will be operated by the pilots through the Control and Display Units (CDUs) and the Multi Function Displays (MFDs), which are part of the Core System and by the dedicated control panels of the subsystems.

The functions of the Mission Flight Aids (Fig. 2) are performed by the Horizontal Situation Aids (HSA, Fig. 3), which consist of the Weather Radar (WXR) and the Digital Map Generator (DMG), and the Vertical Situation Aids (VSA), which consist of the Helmet Mounted Sight and Display (HMS/D), the FLIR and the Obstacle Warning System (OWS). Each of the five subsystems of the MFA are directly connected to the Mission Bus. The control and mode-switching of the subsystems is either done by the control panels or via the DKUs.

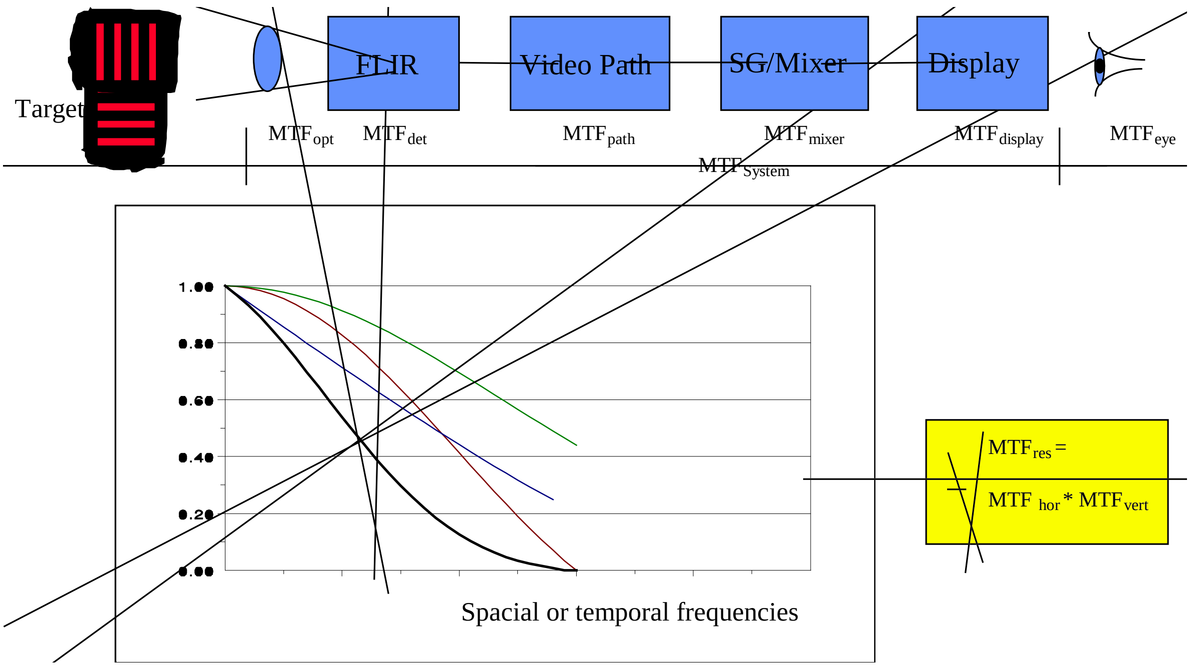


Fig. 4: Principle of the video path and the system MTF

To ensure no degradation of the thermal image, a careful design of the complete video path from the entrance lens of the thermal imager to the observer's eye have to be done. The main blocks of this path are shown in fig. 4. Each block is characterised by its Modulation Transfer Function (MTF), in other words in the capability to process and transfer signals depending on spatial frequencies. The MTF analysis method allows simple multiplication of all single MTFs to obtain the complete resulting MTF of the entire path. The diagram in Fig. 4 shows typical component-MTFs of optics, detector and display. Cabling and SG/mixer MTF are specified and assumed to be negligible. The system MTF represents the resulting end-to-end MTF.

## SENSORS OF THE MFA

### FLIR

General description

The FLIR Sensor (Forward Looking Infra Red) is an electro-optical sensor installed at the nose of the HC. It is a part of the MFA and comprises 3 LRUs: Thermal Imager (TI), Platform (PF) and Control Panel (CP). It is provided by Alenia in co-operation with Leica and AEG (Fig. 5).

Detector

The heart of the TI is the IR CCD detector with a row of 288 by 4 detectors. The Mercury Cadmium Telluride (MCT)-detector device is sensitive in the 8 to 12 µm band and has been developed in France and Germany. The IR scene is scanned with one sweep of a horizontal scan mirror. 288 lines correspond to one frame of the STANAG 3350B Video Standard. A second sweep with one line vertical offset will complete the entire video frame.

Thermal Imager and Platform

The TI is a new development and represents today's state of the art technology. The TI contains all detector- and video-electronics. The platform (PF) supports the TI and allows the elevation movement. The lower part of the platform is turnable and allows the azimuth movement. The upper part of the platform holds gimbal-, interface- and power electronic and provides interface connectors to the avionics system. The Control Panel is connected to the PF via serial link RS 422 to control all operational functions as shown in Fig. 6. As all other control panels in he NH90 TTH the panel illumination is NVG compatible according to MIL-L-85762A.

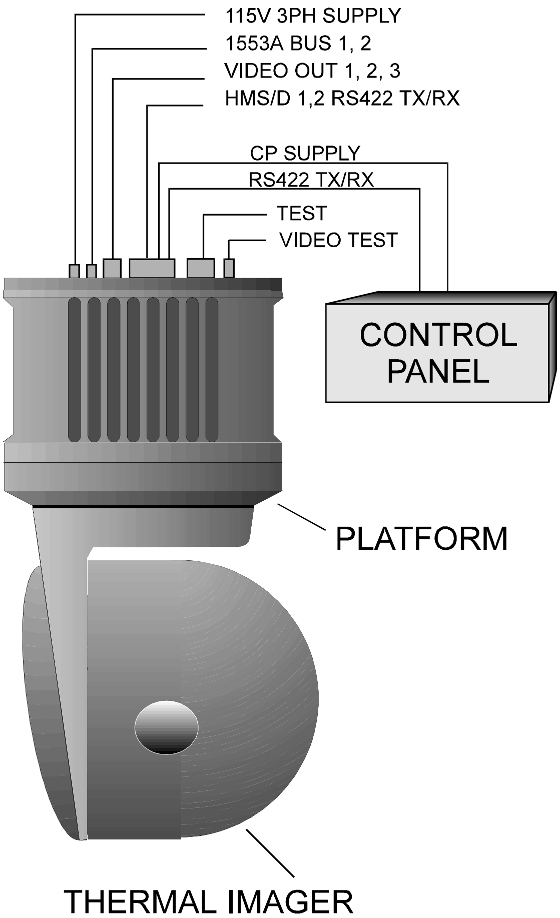


Fig. 5: The 3 LRUs of the FLIR Sensor and the principal links to the mission system

| Main Technical Data | |
|---|---|
| Field of View | 30° by 40° |
| Platform angular limits | AZ ±90°, EL +45° and -70° |
| slew rate | 60°/s |
| slew acceleration | 1000°/s² |
| Roll-axis | fix |
| Dimensions | 295x485x225 mm³ (WxHxL) |
| Weight | 21 kg |
| Power Voltage | 115VAC 400Hz |
| Power consumption | <320VA normal, 420VA max. |

The table above shows the top level parameters. Highlights of the TTH FLIR are:

- ⇨ Very low weight and volume - compared to others Piloting FLIRs in the same performance class
- ⇨ No active stabilisation necessary for this FOV
- ⇨ Automatic gain and level with histogram evaluation
- ⇨ Flexible serial links to MIL BUS, to HMS and to Control Panel with possibility for easy modifications
- ⇨ Advanced software design
- ⇨ Look into turn co-ordination (see below)

Fig. 6: FLIR Control Panel

**Key parameters of the FLIR Sensor are:**

| Main Operational Functions/Data |
|---|
| • provides analog Video signals to HMS/Ds and MFDs<br>• slaving to the LOS of the HMS, manual and automatic steering with look into turn capability or fix forward position<br>• autoadjustment of gain and offset<br>• Polarity allows contrast inversion of hot and cold objects<br>• automatic de-icing |

Look into turn function

In case of HMS failure or other reasons the crew can select the automatic look into turn steering mode. In this mode the FLIR evaluates actual NAV data from the HC and calculates a smooth movement of the FLIR LOS with the following features:

| EL steering |
|---|
| The horizon is kept in the upper 1/5 of the image; this is independent of banking and pitch angle of the HC, but limited to the end stops of the FLIR and aids the pilots spatial orientation. |

| AZ steering |
|---|
| Depending to the radius of the flown curve the LOS will be moved towards its centre. Limit is half the horizontal FOV (20°) to avoid pilots disorientation. |

**Binocular HMS/D with IITs**

General Description

The binocular HMS/D is developed by Sextant in co-operation with Alenia and VDO. It will provide the pilot and copilot with visual aids for missions during day and night and/or adverse visibility conditions. The Bi-HMS/D is part of the MFA subsystem. There are two sets of Bi-HMS/D equipment for each TTH-helicopter:

- one Bi-HMS/D equipment set for the pilot (HMS/D-P)
- one Bi-HMS/D equipment set for the copilot (HMS/D-C)

The two HMS/D equipment sets will be independent from each other.

| **Main Operational Function/Data** |
|---|
| • Functions of the basic helmet: head protection and intercom<br>• HMD functions: FLIR or IIT image and symbology presentation, vision under low light level conditions<br>• HMS function: measurement of the pilot's or copilot's head position, computation and output of LOS pointing direction and head roll angle<br>• Flight-Symbology generation in each HMS/D-electronics including Roll-compensation |

The HMD will be a binocular display system - integrated into both the pilot's and copilot's helmets - which enables the presentation of an image, generated by two Cathode Ray Tubes (CRTs) and an image generated by two IITs at night. The CRTs presents the FLIR image and/or symbology. The symbology will be superimposed onto the FLIR image (during day or night) or display symbology only (during day). To display the FLIR video the display will have the capability to operate in raster mode. To display symbology the display will have the capability to operate in stroke/cursive mode. To display FLIR video with symbology overlay the display will have the capability to operate in combined raster/stroke (or hybrid) mode with independent brightness control. Display of OWS information will also be considered. It will be possible to superimpose symbology also to the IIT imagery.

The FLIR or IIT imagery with (or without) symbology alone will be presented as an exact overlay against the outside world using visor projection technique with the visor being semi-transparent.
The position and orientation of the helmet will be measured continuously using the HMS-function to determine the pointing of the pilot's and copilot's LOS. LOS data will be used for slaving the FLIR platform. The measured head roll angle will be used for FLIR-image derotation.

Before starting for a TTH mission the crew has to boresight the HMS. This means the alignment of the HMS with the reference axis of the HC co-ordinate system with regard to AZ, EL and ROLL. One Boresight Reticle Unit (BRU) will be installed for each crew member in the cockpit. The boresight symbology in the HMD is fixed to the HMD-Reticle.

In addition to the display functions the following functions related to the basic helmet will be provided:

- Protection of the helmet's wearer against impact, penetration and noise.
- Intercom (earphones, microphone)
- Fitting and comfort to the wearer's head
- Protection against battlefield lasers will be provided by the clear visor
- Protection against bright sunlight will be provided by a tinted visor (sun visor)
- Adjustment function of the basic helmet

Each Bi-HMS/D equipment set will comprise the following major assemblies (LRUs):

- Basic helmet (BM) including magnetic HMS-receiver, FFL (Form Fit Liner), Intercom, interface to OM, retention system
- Optical Module (OM) with CRTs, IITs, optics, visors and umbilical cable for electrical interface to CMO with QRC and battery box.
- Cockpit Tracker Module (CTM) is part of the magnetic HMS radiator
- One Boresight Reticle Unit (BRU) for AZ, EL boresighting
- Connection Module (CMO) close to helmet located inside the cockpit
- Electronics Unit (EU) including the symbol generation
- Control Panel (CP) with switches and controls for HMS/D functions and mode selections

Fig. 7: Visor projected binocular HMS/D (SEXTANT)

Fig. 8: The Bi-HMS/D control panel

<u>The control panel</u> will contain the following controls:

| | | |
|---|---|---|
| 1 | Mode | OFF - STBY - Clear - IIT - FLIR |
| 2 | Symbology | OFF - Full Symb. - Decluttered Symb.1 - Decl. Symb.2 - Decl. Symb. with OWS overlay 1 - Decl. Symb. with OWS overlay 2 |
| 3 | Brightness Symbol. | High <---> Low |
| 4 | Brightness Video | High <---> Low |
| 5 | Contrast Video | High <---> Low |
| 6 | Boresighting | AZ, EL - OFF/ ACKNOWL. - CHECK |

Other remaining functions will be realised on the CDU: e.g. Test image or Selection left-right-both CRTs.

| **Main Technical Data** | |
|---|---|
| Bi-HMD-FOV | FLIR: 30° by 40°; IIT: 40° $\phi$ |
| Exit Pupil | 15 mm x 10 mm |
| HMS-Field of regard | AZ $\pm$120°, EL +45° and -70° |
| HMS-accuracy | 0.15° for 1$\sigma$ |
| HMS-EMB | 600(x) x 600(y) x 450(z) $mm^3$ |
| EU-Volume | ARINC 600, 4MCU |
| Weight | approx. 12 kg per equipment incl. helmet with max. 2.2 kg |
| Power Voltage | 115VAC 400Hz |
| Power consumption | < 180VA |

The table above shows the main parameters of the Bi-HMS/D.

Highlights of the TTH-HMS/D are:

- ⇨ Selection of FLIR or IIT images and superimposed Symbology without time delay
- ⇨ Very low weight including the helmet and low volume
- ⇨ Optimised Centre of Gravity of basic helmet
- ⇨ Visor Projection and large exit pupil
- ⇨ Brightness and resolution uniformity without vignetting
- ⇨ Flexible serial links to MIL BUS, to FLIR and to Control Panel
- ⇨ High HMS-accuracy and low delay time
- ⇨ Advanced software design

## OWS

The purpose of the OWS is to detect obstacles in front of the aircraft, which otherwise cannot be seen with the other visual means as naked eyes or eyes aided by either FLIR or IITs. When flying low level or NOE, the OWS shall assist the flight crew and reduce the workload.

Current army aviation operations are conducted primarily under Visual Flight Rules (VFR) conditions. Even under VFR conditions, NOE and Contour flight exercises have shown repeatedly, that wires and wire-like objects are very hard to see. It has also been shown, that even if the wires are seen, they are difficult to be avoided because of the lack of perspective in looking, at a long, thin object.

| **Main Operational Functions/Data** |
|---|
| • 3 parts: Sensor head - Processing - MMI |
| • Active detection of obstacles with scanning LASER system |
| • Eye safe |
| • Generates acoustic and visual warning |
| • Pitch compensation of LOS |
| • Obstacle classification |
| • Discretion mode |

The OWS will be based on the LASER-RADAR principle: A short laser pulse is emitted. If there is an object, the laser light will be partly reflected depending on the albedo and the illuminated size of the obstacle's surface. The elapsed time till arrival of the pulse in the receiver is evaluated in terms of range. Azimuth and elevation angle are given by the position of the two axis scanner. The scanner performs a certain scan pattern, which covers at least the entire required field of view (FOV). Along the scan pattern there were set single laser points, which have to cover the FOV with a ratio of < 1:20. This ratio is called fill factor.

The FOV is adapted to the HMS/D FOV of 30° x 40°. Additionally the LOS of the OWS can be varied in azimuth and elevation by ±15°. The adjustment in elevation allows the OWS, to compensate pitch angle of the helicopter during acceleration or flare manoeuvres and also during flight depending on speed. The LOS compensation in azimuth enables the OWS, to look into curves when turning left or right.

The OWS is eye-safe up from the optical window. So the ground crew cannot be injured by the laser beam.

| **Main Technical Data** | |
|---|---|
| Field of View | 30° by 40° |
| FOV range | ± 15° in Az and El |
| Detection range | > 500 m for 5 mm-wires |
| Max. range | 2.000 m |
| Volume | 400x400x400 (WxHxL) |
| Weight | < 21 kg |
| Power Voltage | 115VAC 400 Hz |
| Power consumption | < 400VA |

The OWS will have a low detectability due to the very short and directed laser pulses. In case of enemy threat the OWS provides a special discretion mode. Running in this mode the laser reduces emitting power.

The detection range is specified for 5 mm wires in a distance of 500 m under certain conditions depending on visibility, extinction coefficient and incident angle. The maximum range is limited to 2.000 m by a time gate.

Fig. 9: OWS control panel

An OWS consists not only of the sensor head, but also of the signal processing unit and the Man Machine Interface (MMI), which are both just as important as the front end.

In the signal processor unit of the OWS the separation and classification of the obstacles is processed. The obstacles will be extracted from the background clutter. Then they will be classified according to the obstacle definition (i.e. wire or tree) and memorised in a danger priority list. The information of obstacle classes is also available for the digital map, where the obstacles can be displayed as symbols. To be safe of obstacles also in hard turns, a so called "History Function" has been introduced. All detected obstacles within ±150 m left/right of the flight path shall be stored for about 20 seconds depending on the H/C's speed. Obstacles, which are on the left or right side of the H/C, but outside the FOV, shall be displayed as a symbol, if they are higher as the instantaneous flight altitude. When flying a hard turn, the obstacles on the side of the H/C can be displayed immediately out of the memory before appearing in the FOV of the OWS. Additionally obstacles can be displayed in the HMD when the pilot is turning his head out of the FOV of the OWS to the left or right.

Fig. 10: Visualisation of the history function. All obstacles within the dark grey box are stored. The light grey triangle is the FOV of the OWS.

Fig. 11: View to the left with the HMS/D. Also obstacles out of the FOV of the OWS can be displayed.

## HOW TO USE THE MFA VSA - THE MMI ASPECTS

### HMD-Display Modes and presentation

The HMD is the main display for piloting. Pilot and copilot independently can select their display modes consisting of symbology and a sensor image.

The flight symbology for the HMD is generated in the symbol generator allocated in the respective HMS/D-EU. Therefore both symbol generators have a direct connection to the IRS (Inertial Reference System). The flight symbology can be supplemented by the OWS symbology. The entire symbology can be switched off, or can be used in a HMD direct view mode without a sensor image or as overlay for the FLIR, the IIT or the OWS-Video image.

The steering of the FLIR is done by the crew member, who has the Piloting Priority. The other crew member can get exactly the same FLIR-image on Multi Function Display (MFD) as the piloting crew member (as a copy). The HMD display modes are independent from the MFD display modes.

Fig. 12: Optical path of the HMD

**Symbology projection**

The system incorporates symbology projected into one or both eyes for day/night application. The HMS/D incorporates a binocular arrangement with two separate IITs and separate left and right CRTs, thus enabling full flight symbology or an outside world scene seen via a TI, both to be displayed in the helmet. The technique of presenting information to a pilot in this manner is complex and requires the pilot's eyes and brain to integrate the information displayed, to produce a single and not a double image. An example of symbology is shown in Fig. 13.

Fig. 13: An example of the HMD-Symbology

**OWS Modes and Presentation**

The MMI for the OWS is the third part in the functional chain of an obstacle warning system. The difficulty of the MMI part is, to transfer a lot of information to the crew by visual and acoustic means without causing excessive demand. Therefore it is the aim of a good MMI, to minimise the number of symbols and to display a clear presentation.

There are several possibilities, to display the obstacle information to the pilot. Well known is the so called line of safety presentation, showed in Fig. 10 and Fig. 11. The helicopter is on a safe flight path, if the h/c-symbol of the flight symbology lies over the line of safety. Three dimensional obstacle presentations, as for example tunnel in the sky, are under investigation. If the OWS-processor can classify obstacles, a WIRE and TREE presentation can be used. In the WIRE mode only wires are displayed as symbol lines depending on their priority of danger. In the WIRE&TREE mode additionally vertical medium sized obstacles as trees, power poles, buildings etc. are symbolised. In a third mode, the VIDEO mode, the entire information acquired by the OWS is displayed as a raster video image with the WIRE&TREE and the flight symbology as overlay.

Fig. 14: 1) Outside view with eyes, FLIR or IIT
2) WIRE mode on HMD shows only wires
3) WIRE&TREE mode
4) VIDEO mode with WIRE&TREE symbology

## CONCLUSIONS

Due to cost reduction in the NH90 only off the shelf equipment will be installed. For the VSA-equipment (Vertical Situation Aids) the status of the selection phase is as follows: the FLIR (Alenia, Leica and AEG) and the Bi-HMS/D (Sextant, Alenia and VDO) have been selected, while the OWS selection is pending. There are several OWS under test on helicopters, but no equipment fulfils the NH90 requirements with 100% PoD up to now.

On the Mission-Bus are two main subsystems: Mission Flight Aids (MFA) and Electronic Warfare System (EWS).

The Vertical Situation Aids (VSA) consist of a low weight piloting FLIR, Bi-HMS/D including symbol generator and OWS. This modern Pilot Visionics Systems has day and night flight capability with two different type of sensors: a FLIR and IIT. The IITs are integrated into the binocular helmet and the FLIR is installed into the helicopter nose. The helmet LOS will be measured by an electro-magnetic tracking system to steer the FLIR-platform. Two binocular HMS/Ds: one for the pilot and one for the co-pilot are used in the NH90 cockpit.

## ACKNOWLEDGEMENTS

These quadro-lateral NH90 programme was launched by NAHEMA, Aix-en-Provence, France. NHI is responsible for the development of the NH90 helicopter.

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