Eurocopter's Research Activities on All-Weather Helicopters

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Abstract

In the Eurocopter Group two research programs in the field of all-weather capability for helicopters are funded by the governmental agencies. In Germany the research project "All-weather Capability for Rescue Helicopters" (AWRH) is funded by the German aerospace research programme LuFo of the German ministry of economy. The French research project which is called "Hélicoptère Tout Temps" (HTT) is funded by the DGAC (the National Civil Aviation Agency). Both programmes are harmonized with respect to target mission profiles, target environmental conditions, and target system concept.

The aim of these research and technology projects is to enable helicopters especially rescue and transport helicopters to perform their typical missions in bad weather conditions with low visibility in a similar way as under the current visual flight rules (VFR). A typical "Future HEMS Mission" is described in the paper, where the pilots will be guided and supported by appropriate sensors, precision navigation and a new Human-Machine-Interface (HMI). The Eurocopter Group is in discussion with the certification authorities to obtain acceptance of all-weather flights based on those advanced avionic systems.

To evaluate this "Future HEMS Mission" two testbeds have been equipped with sensors, navigation means and a special HMI. Results from the flight tests show the needs and requirements to perform such missions.

Introduction

The advantage of every helicopter is its ability to land not only on airports but also on small helipads, such as those at hospitals, or even in unprepared areas like accident sites close to a highway. Currently, these helicopter operations are limited by bad weather and night conditions.

Therefore, the Eurocopter Group approached the German ministry of education and research (BMBF) and the French civil aviation authority (DGAC) to support the research on the all-weather capability for helicopters. In 1995 the BMBF started to fund Eurocopter Deutschland for the project "All-Weather Capability for Rescue Helicopters" (AWRH) while Eurocopter in France was funded by the DGAC for the project "Helicoptère Tout Temps" (HTT). Both partner projects have the target to increase the flight envelopes of the fleet. This shall be achieved by a highly integrated avionic system which assists the pilot especially in bad-weather and night conditions. Reduction of pilot's workload and increase of flight safety are major requirements for the development of this avionic system.

Fig. 1: The EC Futura – testbed for the AWRH program.

Today two testbeds are airborne in order to perform test-flights for avionic and HMI aspects. The German testbed called EC Futura – a modified BK117 with EC135 cockpit structure - started in 1997 with flight tests of a laser obstacle warning system and a new defined symbology and MMI concept for the Primary Flight Display (PFD) including a special Approach Mode and for the Map and Navigation Display. Based on a typical rescue mission a certifiable mission concept was developed for IMC operations, was programmed into a dedicated flight management system and was demonstrated on the testbed. Nowadays different data and communication links are under investigation including satellite communication. Furthermore a TCAD system shall increase safety for the descent in IMC to an unprepared landing area.

Fig. 2: The testbed for the HTT program is a EC155.

The HTT testbed is an EC155 prototype equipped with a 4-axis autopilot. The commonly developed flight management system tested already on the AWRH in steep approaches shall be linked to the autopilot in the HTT to fly new helicopter (steep) approach- and landing-procedures reducing the noise level on ground and keeping the helicopter as long as possible outside the dangerous obstacle environment.

The research and development of new symbology and related procedures is done with the help of Eurocopter’s simulators.

Regulations for All-Weather Helicopter Flight – Difficulties and Future HEMS Mission

Regulations and Requirements

The existing flight rules in Europe provide no special rights for helicopters. Helicopters operating in IMC have to follow the rules of instrument flight (IFR). On that basis a helicopter equipped with an IFR cockpit can land in IMC on certified airports with the help of the ILS. As helicopters are not able to reach even the landing speed of fixed wing airliners they disturb the traffic flow at the airport. At the moment landing in IMC on certified helipads – for which an IFR approach is not established - is not allowed.

But future customers of an All-Weather Helicopter (AWH), in most cases want to operate there helicopter fleet from helipads (for instance at a hospital). Helicopters in operation for secondary Emergency Medical Services (EMS) missions or shuttle services have to fly from helipad to helipad – in any weather condition and day and night. The requirement for primary EMS and military and para-military missions is even higher: These helicopters have to fly to a traffic accident site or any unknown area, which is not prepared for landings, has no defined landing procedure, has an unknown obstacle environment and mostly no ground support equipment as approach lights, D-GPS correction data transmitter or ILS.

HEMS Operation as Basis for Research Activities

The typical mission taken as basis for the research activities in the frame of the AWRH program is a Helicopter Emergency Medical Service (HEMS) operation.

Today, HEMS missions are mainly flown during day in Visual Meteorological Conditions (VMC) by a crew, which is composed of a single pilot, a doctor and a physician. For helicopters, VMC means minimum 800 m flight visibility, 150 m cloud base and earth sight. Although these minimum requirements allow to perform the flight in most cases, flight safety is seriously impaired. Statistics support this fact by highlighting terrain/obstruction strike as a major cause of helicopter accidents.

The JAR-OPS 3 standard considers this problem and raises meteorological limits for single pilot crew helicopter HEMS missions considerably to 2000 m flight visibility at 150 m cloud base. This will increase safety to some extent, but will not prevent accidents due to obstruction strike.

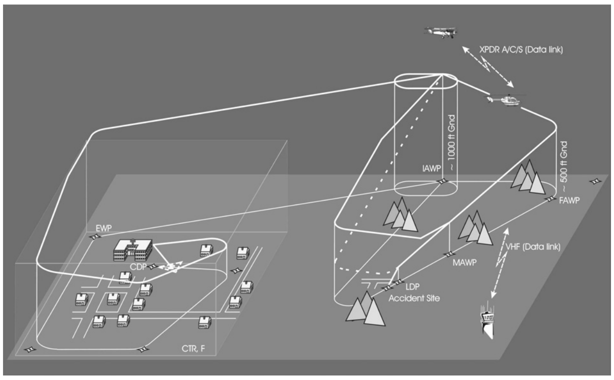

Fig. 3: Future HEMS mission

In general future HEMS missions will not be different from current missions. However, new technology will allow to extend primary rescue missions into night and Instrumental Meteorological Conditions (IMC). A potential HEMS operation comprises the following phases: Pre-flight phase, take off and departure, cruise to the accident site, approach and landing, flight planning to the hospital, cruise to the hospital, approach and landing, flight back to the hospital.

Future HEMS Mission – at the Helipad
In the first phase of this HEMS mission the crew is in standby at the operation base while the helicopter is parked on the helipad with the engines shut off. However, the avionics system remains powered. This enables the transmission of frequently changing or extensive data to the helicopter either by data link or by a data line. Such data comprise meteorological data, actual terrain/obstacle data, airspace data, navigation data and mission data.

Other data, which are less extensive and which the pilot needs to verify before the flight shall be input directly on the FMS, either by manual entry or by reading from a data carrier. These data are helicopter performance data, crew and fuel data.

On the mission alert the rescue crew proceeds to the helicopter. Meanwhile, the rescue co-ordination centre has transmitted the co-ordinate of the accident site to the helicopter via data link. The co-ordinate is transferred to the FMS, eliminating the need to type in the destination co-ordinate manually. The pilot only needs to check its correctness and initiate the trajectory planning. Then, the FMS plans the best trajectory considering pilot's constraints, airspace structure, terrain situation, meteorological conditions and helicopter performance and proposes a 3-dimensional trajectory from take off to touch down (including missed approach procedure). Also, the take off procedure at the accident site is calculated at this stage to guarantee a safe departure before the mission begins (expected payload is considered). The trajectory, which comprises a procedural departure, a straight and level en-route segment (if permitted by terrain and airspace structure) and a flexible field approach, appears on the Central Display (CeD) and on the FMS. The CeD displays the trajectory graphically and allows its modification by a cursor control device, while the FMS provides additional textual information and conventional trajectory adaptation. The pilot can examine the proposed trajectory with regard to obstacles, weather and airspace constraints and trigger modifications to it. Also, when he accepts the proposed route he is able to prepare himself for the flight and brief the approach profile to the landing site. After the start-up of the engines, the performance of the ground checks and the activation of the route for guidance, the helicopter is ready for the flight to the accident site. This whole procedure shall require less than 3 minutes from boarding to take off.

Future HEMS Mission – take off

Presumably, the operation base is protected by a special airspace, which restricts VFR traffic. Uncontrolled airspace class F is appropriate for this type of IFR operations, if the base is not protected by the CTR of a nearby IFR airport. This airspace will be activated, when the helicopter departs from the pad. Although the active airspace F shall grant protection from other aircraft, the pilot checks the airspace by the installed active traffic collision awareness equipment, which outputs traffic advisories in the vicinity of the aircraft.

When the departure sector is clear of traffic, the pilot performs a Category A take off to the Critical Decision Point (CDP), for which Visual Meteorological Conditions (VMC) are required. When the traffic clearance is assured and no weather hazard prevents the first part of the flight, he continues the departure along a fixed departure route. This route, shall be designed to minimise environmental impact and maximise flight safety.

On reaching the Exit Waypoint (EWP) the helicopter enters the en-route segment of the trajectory towards the accident site.

Future HEMS Mission - Cruise to the accident site
The en-route flight to the accident site takes place in lowest possible cruise altitude, which is defined at an altitude which guarantees a minimum height of 1000 ft above the highest obstacle in a 1200 m wide corridor along the route. The trajectory guides the pilot directly to the Initial Approach Point (IAP) of the approach procedure, when no restricted airspace and high terrain prevent this. In this case, the trajectory is planned around the restricted airspace or high terrain.

Traffic separation is granted by the pilot, who receives traffic alerts and indications from the traffic collision awareness equipment by aural alerts and warnings on the Central Display (CeD), on the Pilot Display (PiD) and possibly on the Head up Display (HUD). Additional clearly represented hazardous weather and terrain/obstacle in the vicinity of the helicopter supports the pilot in taking the correct decision to resolve the traffic conflict.

Short term avoidance of hazardous weather will be handled like traffic resolution, while long term circumnavigation of large phenomena will require a re-planning of the trajectory. For this, the pilot will define new constraints and start the in-flight re-planning of the trajectory. This approach guarantees the continued safety, since the safety critical aspects, like fuel state and terrain are considered in the planning.

Fig. 4: Pilot Display (PiD, right) and Central Display (CeD, left) in the AWRH testbed.

During this low workload flight phase the pilot can perform the approach briefing to the landing site by means of the CeD. The CeD provides all information, which he must know in order to establish a mental picture of the approach profile to come. An AFCS will relief the single pilot from the manual flying task and allow him to concentrate on the approach briefing.

When the helicopter passes the Initial Approach Waypoint (IAWP) the cruise ends and the approach to the accident site starts.

<u>Future HEMS Mission – Approach and Landing at the accident site</u>

After passing the IAWP, the helicopter starts its approach to the landing site. The design of approach procedure is compact to keep required approach time at a minimum. This compactness is achieved by a curved approach, which has been adapted to the prevailing weather and terrain/obstacle situation. However, to avoid a pilot's overload, the final approach will still be straight. Final approach length should be approximately 2 NM while a standard 3° descent angle with a maximum angle of 6° in difficult terrain situations should be envisaged. A tunnel in the sky alike symbology guides the pilot along the trajectory from the IAWP through the FAWP down to the MAWP, while the enhanced OWS checks permanently the obstacle situation ahead of the helicopter. In parallel the traffic collision avoidance equipment scans the airspace around the helicopter for other traffic and issues warnings to the pilot in case of a conflict. Reaching the MAWP the pilot must establish visual reference to the ground.

In case that the pilot is not able to continue visually, he will initiate a go around and follow the missed approach procedure, which has been generated by the system automatically and which takes him back to the IAWP on a safe trajectory. The calculated climb rate is based on maximum One Engine Inoperative rating and requires the pilot to use the maximum available power rating for the climb.

If he is able to continue the approach visually, he will fly to the Landing Decision Point (LDP), which is also provided by the system. After passing the LDP he decelerates the helicopter and touches down at the planned landing site. There, he shuts down the engines and stops the rotor.

<u>Future HEMS Mission – Flight planning to the hospital at the accident site</u>

After the engine shut-down the pilot assists the medical crewmembers, which classify the injuries of the patient and define, which ongoing medical help is required. With this information the pilot clarifies, which hospital will host the patient. The pilot will perform this negotiation on a specific FMS page, which runs as a slave of a cabin mounted medical terminal. Once the hospital is defined, the pilot can use the hospitals designator and perform the flight planning to it.

The flight planning will calculate a flexible take off and departure procedure for the actual meteorological conditions, obstacle situation and helicopter state. The take off will end at the CDP and followed by the departure trajectory. The departure trajectory will allow a safe flight to the EWP, even with One Engine Inoperative (OEI). At the EWP the helicopter turns to fly a straight and level leg (again, if permitted by terrain and airspace structure) to the IAWP. At the IAWP the approach to the hospital starts. The approach itself is considered as procedural approach, which is designed to produce least disturbance to the neighbourhood. For the planning, this approach is retrieved from the database.

When the planning is complete, the pilot checks the trajectory on the CeD and the FMS and prepares himself for the flight to the hospital. If he does not accept the planned trajectory, he will modify it to his requirements. However, any modification requires a re-planning to guarantee safety. After the pilot has accepted the proposed trajectory, he only needs to activate it to obtain the guidance to his destination.

When the injured person is boarded the pilot will start up the engines and begin the flight to the hospital.

Future HEMS Mission – Take off and departure from the accident site

Identical to the pre-departure procedure at the hospital, the pilot checks the sky for conflicting traffic before he lifts off the helicopter. When a take off can be safely performed, the pilot carries out a Category A take off to the CDP. Hovering at the CDP, the pilot confirms that the departure trajectory is clear of obstacles, traffic and hazardous weather. Then, he continues the take off and departs the accident site along the planned departure trajectory. Arriving at the EWP, this phase ends and the en-route phase starts.

Future HEMS Mission – Cruise to the hospital

This phase can be compared with the en-route flight to the accident site. During the flight, the physician and doctor aboard the helicopter will use the medical terminal to transmit the rescued persons health condition to the hospital by data link. This allows the hospitals medical staff to prepare the required medical care, which additionally safes valuable time. Replanning of the route in case of selction of an other hospital is possible.

Coming closer to the hospital the pilot reviews the approach to the hospital. As this approach follows prescribed fixed tracks, the pilot can use either paper maps or the CeD and FMS for his briefing. Passing the IAWP, the en-route phase ends and the approach phase starts.

Future HEMS Mission – Approach and landing at the hospital

During the approach the helicopter flies around noise sensitive areas in a continuous descent with a constant descent angle and a constant speed. Descent angle and speed are defined to provide best achievable comfort to the injured person, hence, for a comfortable descent rate, approach angle shall be shallow and speed low. However, for helicopter control and performance aspects, approach speed shall not be lower than v_y. Arriving at the MAWP the pilot must establish visual reference to the ground and continue visually. If sufficient visual cues are available he continues to the LDP and carries out the landing. After touch down, he shuts off the engine and disembarks the patient.

This above described “Future HEMS Mission” was taken as basis for the definition of the AWRH system and the respective selection of equipment.

Expected changes of the Regulations and First Steps

Some of the above mentioned phases of the “Future HEMS Mission” as the take off procedure are already feasible and foreseen by law, some not – as for example the approach procedure in IMC to an unprepared area or even to a helipad.

Eurocopter’s target is to find solutions for each of these phases, in order to increase the operation capabilities of its fleet. As some of the above mentioned mission requirements are disabled not by technical possibilities, but by law, comprehensive proposals have to be made by Eurocopter to the air traffic control authorities. Therefore Eurocopter is in contact with the German DFS and the French DGAC and has joined respective working groups.

A first approach in the direction of “sensor-based landing under IMC in unprepared area” is done in Germany with the certification of GPS-based Non-Precision-Approaches (NPA) at some airports. The next step is the certification of GPS NPAs at helipads. To reach that target, Eurocopter Deutschland is joining a working group with the German Helicopter Armed Forces and the DFS. In July 2002 the first helipad in Bückeburg was certified for GPS NPA for test and verification purposes. It is planned to propose a certain procedure for the approval of helipads in Germany for GPS NPA until end of 2004 similar to the procedures in the United States.

Precision approaches under IMC on helipads and into unprepared areas shall follow. These procedures require transponders for all air vehicles as well as an extremely high system and sensor reliability with a failure rate better that 10^{-9} – a challenge also for the avionic suppliers.

Eurocopter’s experience

Extending current HEMS missions into night and IMC causes several challenges as flight at low altitudes with no or limited ATC coverage, approaches and departures in unprepared landing sites and nearly all weather operation. These challenges require the installation of equipment, which provides information about these aspects to the pilot at every time and assist him with the task of granting the safety.

The analysis in the frame of the research project AWRH showed that the following equipment is required (see also chapters “Future HEMS Mission”):

- enhanced Flight Management System (FMS)
- enhanced Human Machine Interface (HMI)
- Obstacle Warning System (OWS)
- Traffic Collision Awareness Equipment
- Weather Detection System
- Data Link

Requirements for this equipment are under investigation theoretically, in simulations and partially already in flight test campaigns within Eurocopter’s AWRH and HTT projects.

The Development and Test Environment
Having specified the equipment and the software all tests start in the rig. The rigs – one for the AWRH and one for the HTT – are real working tools used to test functions and interfaces.

Fig. 5: The HTT rig provides all HMI features specified for AWH missions.

The rigs are equipped mostly with original hardware as the display system with symbol generators, the HOCAS functions, the flight management system and the HUD. The system architecture is identical to the one realised in the helicopter thus enabling to port software directly from the rig and the simulator into the helicopter. In case of the HTT the flying hardware built into 19”-racks can be connected directly to the rig as even the harness is rebuilt exactly in order to have short installation times of the computers into the helicopter.

Fig. 6: AWRH simulator featuring a system architecture which is fully compatible with that of the helicopter (hardware and software).

Helicopter data are simulated by the Eurocopter standard ANAIS system, which is in use on the NH90 and Tiger rigs as well.

After having done the development work all functions were tested on the rig. In case of the AWRH the rig is directly connected to a development simulator providing a full cockpit with the AWRH display system and HMI features. In this simulator all mission of the above described “Future HEMS Mission” can be simulated here. In that stage of the development the test pilots and customer pilots have been involved to assess the symbology, the functions and the HMI at all. The simulator is also used to train the pilot for each task of the flight test before entering the helicopter.

The Testbeds EC Futura and HTT
The system architecture in both test helicopters was designed compatible to each other where the HTT provides already interfaces to “Avionique Nouvelle” - Eurocopter’s family concept for the whole civil helicopter range. In the system architecture selected for research purposes the display system is grouped around two Silicon Graphics work stations used free programmable symbol generators. The standard communication and navigation equipment is interfaced by a modular signal conversion system called NECS translating these data into CAN bus messages. The advantages of the CAN bus are very high reliability, low component weight, cheap assemblies, real-time capability and simple, application-specific programming. Another important argument in favor of using the CAN bus on the AWRH was the fact that the helicopter architecture can be readily adapted to that in the simulator as well as the laboratory environment.

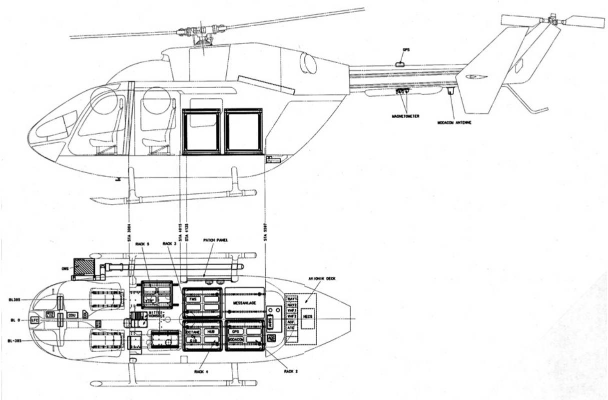

Fig. 7: Installation of the test equipment in the AWRH.

The equipment for the test setup was installed in stiffened 19” racks in the cargo compartment. This also established compatibility with the test setup in the laboratory. The operator has a console with a keyboard and a display from which he can operate and monitor the test system during flight testing (Fig. 8). On a second display at his right hand he can monitor either the pilot’s PiD or CeD.

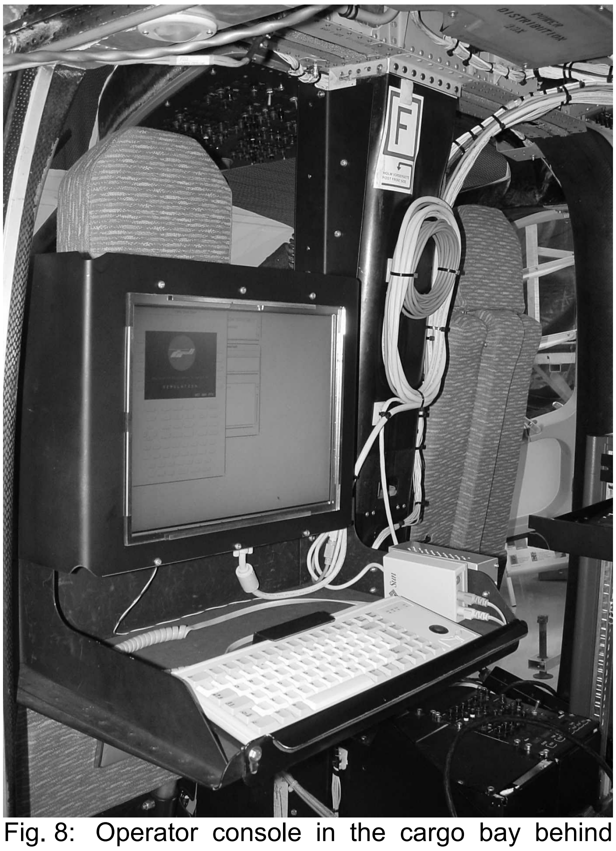

Fig. 8: Operator console in the cargo bay behind the co-pilot’s seat.

To install the obstacle warning system, a multifunctional platform was mounted on the helicopter’s skid frame. The wiring for the test equipment is completely separate from the helicopter’s basic wiring. For safety reasons, the entire test system can be switched off by the pilot, while the operator has the possibility of switching off individual units. The test data are stored partly on video tape, partly on hard disk.

Together with the AWRH test setup, a measurement system was installed in the experimental helicopter which can collect and record helicopter-relevant data and transmit them to the tower by telemetry.

In 1998 the AWRH testbed, an BK117 A3 got a cockpit structure of the EC135 which provides much better view to the landing point when performing steep approaches. The converted experimental helicopter, now called “EC Futura”, successfully completed its maiden flight on July 13, 1999.
On August 24, 1999 the full functionality of the AWRH avionics system was demonstrated in the helicopter. Phase 1 of the AWRH project was successfully concluded with an extensive test flight and an evaluation of the entire AWRH avionics system. During this test flight, a complete mission was performed involving the flight to a traffic accident with an outdoor landing and a return flight through an obstacle corridor.

FMS and Map system
The “brain” of the All-Weather Helicopter (AWH) system is a highly sophisticated Flight Management System (FMS). Following the overall aim of the project to develop the technology for the AWH missions the FMS must provide the following functionality:

- Support new types of operations efficiently, in addition to existing standard VFR and IFR flights
- Provide a rapid on-board flight planning from take-off to landing.
- Consider for the planning a difficult terrain situation, a complex airspace structure, adverse weather phenomena and pilot requirements.
- Make best use of the available helicopter performance.
- Assure flight safety by monitoring safety critical parameter and provision of warnings
- Increase the pilots situational awareness.
- Support pilots decision making process
- Ease the pilots task to operate the FMS and limit the required head down time
- Provide guidance commands to the pilot and the AFCS

The FMS splits into two main topics, which are the Human Machine Interface (HMI) and the data processing. The HMI is dealing with the CDU's outline (Fig. 9) and operation philosophy, the page structure, display and keyboard dialogue. The data processing part comprises extensive investigations on flight planning, navigation, guidance, performance calculation and interfaces.

At the moment the definition of the detailed FMS functions for the target system is ongoing with the help of simulation in the AWRH and HTT simulator.

Flight and Navigation Symbology

Once calculated a trajectory for the flight inside the FMS the pilot needs to get the actual guidance information as well as the standard helicopter flight information. That information is provided by two displays, the Piloting Display (PiD) and the Central Display (CeD).

Fig. 9: New layout for the FMS CDU.

The PiD in front of the pilot comprises two main modes: the Primary Flight Display (PFD) -mode and the Approach (APP)-mode. The PFD mode (Fig. 10) used during en-route displays an indicated air speed indicator, artificial horizon, combined BaroAlt, RadAlt and DH indicator, engine power indicator, HSI, vertical speed indicator, ground speed indicator as well settings like DME, NAV source and DH. It includes also navigation and guidance indications as a next waypoint bug.

The APP-mode (Fig. 11) is used for the approach and landing phase. It provides in addition to the information of the PFD-mode obstacle, terrain and map information, from the terrain data base and the obstacle warning system. It is realised by displaying a 3-D-map presentation where the PFD-symbology is overlaid. During approach to the landing point the pilot will be guided by "tunnel"-symbology. The tunnel is calculated by the FMS considering all constraints known by the FMS.

The CeD is used for route monitoring and planning. The pilot can also select between two modes, the 2D Map mode (Fig. 12) and the Vertical Profile mode. The 2D Map mode shows a ICAO map as a moving map. As overlay the pilot sees the planned route or can even plan new waypoints and routes. The active route is marked in cyan while a planned route is yellow. Route editing is done via FMS CDU and the joystick in the interseat console.

Fig. 10: PiD in the mode Primary Flight Display.

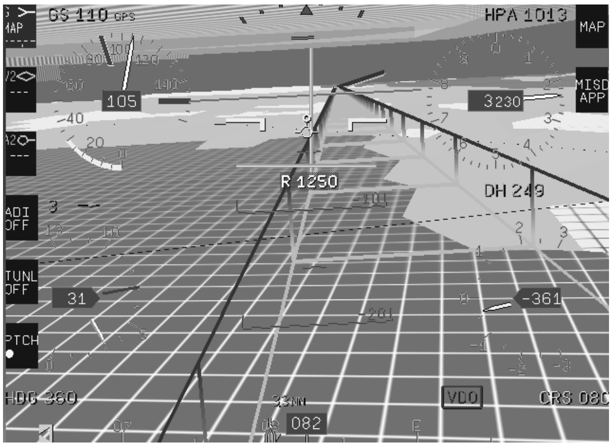

Fig. 11: Tunnel view in approach mode (APP).

Steep Approach and Tunnel Symblogy
Using the above described tunnel symbology several flight campaigns have been performed to assess the HMI. After training in the simulator, the pilots had to fly different approaches with angles of 3°, 6° and 8° using first standard GS and LOC symbology and then the new tunnel symbology. Speeds between 40 KIAS and 70 KIAS have to be flown. In some trials a "Go around" was tested.

As the AWRH testbed is not equipped with an modern AFCS the handling of the helicopter required high workload by the pilots. Nevertheless the tracks of the approaches with tunnel symbology were much more accurate than those with standard GS and LOC symbology. The tests were completed with simulated IFR tunnel approaches. Further tunnel approaches have to be done on the HTT using the full functionality of the 4axis AFCS on this helicopter.

Obstacle Warning Systems (OWS)
One of the main tasks of the AWRH project was to gain experience with active obstacle warning systems. First planning's were based on the assumption to get a mm-wave Radar OWS. The advantage of mm-wave Radar's is the ability to look through fog and clouds. As such a system is not yet on the market, the trials started with a Laser based OWS.

The laser OWS showed its potential in detecting high tension wires, the most dangerous obstacles for helicopters. These could be detected in nearly all angles of incidence, between trees and in front of different backgrounds. Eurocopter developed a special wire detection algorithm to extract wire-obstacles out of the information provided by the OWS. Even in real bad weather conditions wires have been detected. But the drawback of the Laser OWS was also experimentally confirmed during these test flights. In some unpredictable cases parts of clouds and fog were detected as obstacles. That means that the OWS was unable to look through these fogy things. If really dangerous obstacles would be behind it, the OWS could not detect them. In the next step the serial OWS from EADS company Dornier called HELLAS will be flown on the HTT.

Monitoring the world market some other OWS are under development, driven by the requirements of the European NATO transport helicopter NH90 and other international helicopter programs. These are the Goodrich Laser OWS in the United States, the Marconi Laser OWS in Italy, the Amphitech Radar OWS OASYS in Canada and The BAEsystems Laser OWS in Australia.

Traffic Collision Awareness Equipment
Looking at the "Future HEMS Mission" concept, a traffic collision awareness equipment like TCAD or TCAS is very helpful to increase the flight safety in the departure phase from the helipad. During en-route through uncontrolled airspace and approach it is absolutely mandatory! There is no other way to separate the aircraft's in uncontrolled airspace than the obligation for everybody to use the transponder (Mode C).

On the AWRH a TCAD system from Ryan was installed recently – one antenna under the nose – looking downwards and backwards, one on the hydraulic system cowling looking upwards and forward. The traffic information from the TCAD goes via serial interface into the AWRH system, where the advisory and warning symbology is generated and superimposed onto the 2D Map (CeD). In the HTT project algorithms are under investigation to automatically calculate collision avoidance routes applicable for helicopters.

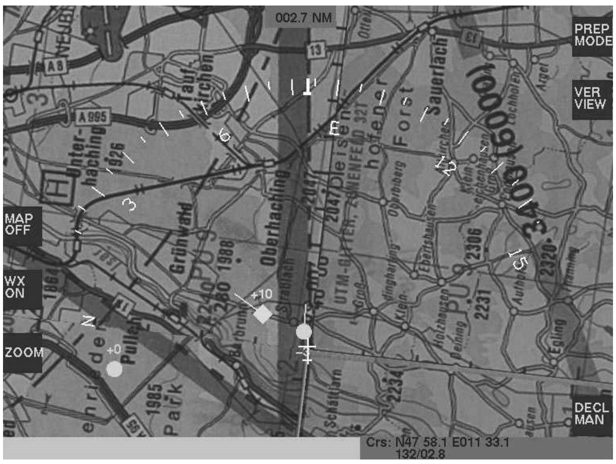

Fig. 12: 2D Map on the CeD with TCAD symbology.

GCAS
Thinking of fixed wing aircraft in bad weather conditions CFIT accidents are the most dangerous ones especially when flying in mountainous areas. Helicopters operate normally the whole flight quite close to the terrain. Therefore ground collision avoidance is one of the main safety issues. To certify a Ground Collision Avoidance System (GCAS) implies a reliable and actual terrain data base. As the safety margin in altitude for fixed wing aircraft can be set much higher than a helicopter ever wants to fly data bases for helicopters have to be more detailed.

In the AWRH Eurocopter has programmed a GCAS for helicopter application as a function inside the route-planning algorithm of the FMS. The advantage compared to existing systems is that the pilot has not to switch between the different presentations like GCAS, TCAS, WX and NAV, to get all information. The route monitoring algorithm is working in the background and checks for any obstacle or constraint of the route and generates an appropriate warning for the pilot.

D-GPS
The basis of the guidance by the new FMS is an accurate positioning system, to precisely localise the helicopter at every time. For GPS NPAs a IFR certified GPS is the right mean. For the "Future HEMS Mission" – civil or military – more precise systems are under investigation. Actually, a D-GPS from OmniStar is in flight test on the AWRH. The OmniStar system provides GPS correction data via an own satellite system. The correction data are calculated by a ground segment for global regions and sent via satellite to the user. In the user's receiver the GPS position is improved by interpolating the correction data for the actual position. The advantage of the system is good coverage and availability all over the world. Furthermore Eurocopter is investigating more complex navigation systems using and combining all navigation means available on the helicopter to calculate a good position with very high reliability.

Data Link
In nearly all phases of the "Future HEMS Mission" the helicopter requires a data communication link to ground stations. Therefore different systems are under investigation on the AWRH. A VHF-link showed to be usable only in the vicinity of the ground station and never at the accident site where the rescue helicopter has to go to. The German Modacom – a data link designed for the railway – showed also insufficient performance due to data-speed and coverage problems.

Therefore three new systems have been installed on the helicopter. The Orbcomm and the Inmarsat C system are satellite communication system providing a good coverage. They will be used for data communication e.g. to transfer the destination co-ordinates or weather information to the helicopter. The third system is the GSM - well known from the mobile phones - and usable for data and voice communication. The flight tests with these new systems are just in preparation.

De-Icing
Real all-weather capability shall also foresee de-icing means. Nevertheless it is even better never to fly into icing areas. Therefore systems are under development to provide an early ice warning to the helicopters pilot. One of this systems shall be a remote sensing equipment which shall be able to detect icing areas several kilometres ahead the helicopter. Other systems measure the ice accretion rate on the helicopter at the engine's air intake thus allowing the pilot to fly in light icing conditions. Eurocopter is also involved in a research project with the target to measure ice accretion at the rotor blade's leading edge. Knowing at which place on the rotor blade the ice is accreting the respective heater mats can be powered for an adequate time, thus sparing electrical power. and enabling the helicopter to fly in every icing condition.

EC Future Products

As mentioned in the chapter about regulations and the "Future HEMS Mission" some steps have to be done by the certification authorities to allow to "All-Weather Helicopters" flying in nearly every weather condition and to land at helipads and even in unprepared areas. But also the equipment has to be developed and improved step by step to feature all the functions specified in the frame of Eurocopter's AWH research activities.

A first "AWH"-package will provide a set of stand-alone equipment installed on an IFR certified helicopter. The set can comprise TCAD, GCAS and OWS. Retrofit kits shall be available to improve the existing fleet. In a second and a third step the all-weather system will provide more and more integrated functions grouped around and inside an intelligent FMS. The FMS route planning and monitoring algorithms will generate navigation and guidance information safe enough to even control the automatic flight control system of the helicopter.

Abbreviations

2/3 D	2/3 dimensional
AFCS	Automatic Flight Control System
APP	Approach Mode
ATC	Air Traffic Control
AWH	All-Weather Helicopter
AWRH	All-Weather Rescue Helicopter
CAN	Controller Area Network
CDP	Critical Decision Point
CDU	Control and Display Unit
CeD	Central Display
CFIT	Controlled Flight Into Terrain
DFS	Deutsche Flugsicherung GmbH
DGAC	National Civil Aviation Agency in France
D-GPS	Differential GPS
DME	Distance Measurement Equipment
EADS	European Aeronautic Defence and Space Company
EMS	Emergency Medical Services
EWP	Exit Waypoint
FAWP	Final Approach Waypoint
FMS	Flight Management System
GCAS	Ground Collision Avoidance System
GPS	Global Positioning System
GS	Glide Slope
GSM	Global System for Mobile Communication
HEMS	Helicopter Emergency Medical Service
HMI	Human Machine Interface
HOCAS	Hands on Collective and Stick
HSI	Horizontal Situation Indicator
HTT	Hélicoptère Tout Temps
HUD	Head Up Display
IAP	Initial Approach Point
IAWP	Initial Approach Waypoint
ICAO	International Civil Aviation Organisation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
KIAS	Knots Indicated Air Speed
LDP	Landing Decision Point
LOC	Localiser
MAWP	Missed Approach Waypoint
NAV	Navigation
NPA	Non Precision Approach
OEI	One Engine Inoperative
OWS	Obstacle Warning System
PFD	Primary Flight Display
PiD	Primary Display
TCAD	Traffic Collision Awareness Device
TCAS	Traffic Collision Avoidance System
VFR	Visual Flight Rules
VHF	Very High Frequency
VMC	Visual Meteorological Conditions
v_y	Speed of best climb rate
WX	Weather Radar