SYSTEM DESIGN FOR THE TIGER HELICOPTER

Dr. R. Schranner MBB UH Ottobrunn FRG
G. Dufour AS DH Marignane France

Abstract

The first activities in development of the avionic system of the TIGER helicopter (PAH2/HAC, HAP) were concentrating on the consolidation of system requirements and the system design. This led to the selection of suppliers for the main avionic subsystems, as computer, displays, navigation, flight control and electronic countermeasures system. The result is a selection of advanced technologies with rather low volumes and masses of equipment - a main consideration for such weapon systems. Through the introduction of standardization requirements not only large economical benefits but also technologically advanced solutions with considerable benefit for the user in the service phase may be achieved.

This paper presents the actual status of the system architecture of the TIGER as resulting from the subsystem selection. It will further give some of the main features for some important subsystems and equiments as the computing and display subsystem.

System Architecture

General Description

The general architecture has to take into account the functional requirements for the 2 variants (anti tank PAH2/HAC and protection HAP) and - at the same time - some national differences in comm/nav equipment. Thus, the avionic system of the TIGER is consisting of a distributed network of intelligent subsystems arranged in

- a basic avionic system, including the bus/display, communication, autonomous and radio navigation, electronic countermeasures and flight control subsystems.

- a mission equipment subsystem which includes for the anti tank variant the antitank subsystem (MMS, PARS3 and HOT armaments), the pilot vision subsystem (thermal imager and HMS/Ds), A/A subsystem (Stinger for PAH2, Mistral for HAC) and the EUROMEP management subsystem (computer and controls) and for the protection variant a 30 mm caliber gun, 68 mm BRANDT rockets, A/A Mistral missiles, roof mounted sight for the gunners, a head up display for the pilot, two helmet mounted sights and two redundant armament computers (ACSG).

The bus structure is based on MIL 1553B with two fully redundant controllers for each bus (BCSG for basic bus and MCSG for EUROMEP bus). In addition, the BCSGs are serving as main controllers of the basic avionic system to ensure the moding and monitoring of the overall system. Information from utility systems (e.g. hydraulics, fuel, electric, engines) is collected via 2 interface units (RTUs) to allow monitoring of those systems for operational purpose (by the crew during the mission) and maintenance purpose (by recording defects on a data carrier for post flight evaluation).

The development of the subsystems is fully launched after supplier selection through a tender during 1989. Examples of selected components and technologies include laser gyro, LCD for MFD and RFI, modular computers consistent with ADA as a HOL. Standards for environmental and EMC conditions were set to rather high levels, including NEMP/TREE and TEMPEST requirements.

Description of Subsystems

- NAVIGATION: The navigation subsystem is based on a strapdown system (3 axis laser gyro and accelerometers on Si basis) with doppler, radar altimeter and air data sensors as additional sensors. The raw sensor data are hybridized in the strapdown computer to provide the data for display and for manual and automatic flight control. Low Airspeed is calculated within the Strap down computers using flight control position sensors. EC is presently investigating the possible additional integration of a GPS system. Complex failure detection and localization is realized in this duplex system as far as possible to detect and - if possible - localize errors to provide maximum safety and availability.

- FLIGHT GUIDANCE AND CONTROL: The flight control system is based on mechanical controls. In addition a fully digital duplex flight control system with limited authority is available, which provides - apart from basic stabilization and command augmentation functions (CSAS) a variety of higher (autopilot) modes. Thus, the crew will be supported in all mission phases (cruise, transition, NOE, hover, etc.) by appropriate automatic functions in order to reduce workload. To ensure integrity (e.g. in case of bus failures) this subsystem is able to work independently from the main system using data that are directly supplied from the navigation computers. It also features extensive algorithms for error detection and localization (concerning sensor inputs, computer components and actuators).

- ELECTRONIC COUNTERMEASURES: As a basis for future extensions a radar and laser warning system will be integrated. The development will be based on a bilaterally defined threat scenario with the potential of adaptation to national requirements. The detected threat information will be evaluated by the RW/LW computer who will provide condensed information to the crew (audio and visual). The basis system contains growth capacity for integration of defensive countermeasures. IFF transmitters (national equipment) are also part of the basic ECM fit.

- COMMUNICATION RADIO NAVIGATION: The tasks related to communication within the HC group or with external ground stations is normally quite demanding for the crew. The communication fit for the german and french helicopters is based on national radios. For PAH2 new radios (VHF/UHF, VHF-FM and HF) are developped to ensure integration into communication networks of the future armed forces networks - this includes data link functions apart from normal voice communication. For HAP/HAC , apart from VHF-FM which is a new developped equipment other transmitters are existing equipment (VHF-AM, VHF/UHF). In addition HAP-HAC are equipped with a set of radionavigation equipment: ADF, VOR/ILS, TACAN, Telerad Coder. The HC audio network is based on a common intercom system which will be developped to accomodate both national radio fits. Control of the radios is done via the central display and control system (mainly CDUs). Emergency frequencies are also accessible from a dedicated "Radio Frequency Indicator".

- TACTICAL SUBSYSTEM: In combination with the network and data link functions of the VHF-FM and HF and the digital map generator the PAH2 has capabilities for tactical mission planning and performance. Tactical data may be loaded on ground, transmitted via data link or inserted manually by the crew and will be displayed on top of a geographical raster map. With these capabilities the HC commander/gunner is provided with accurate and timely information.

- MISSION SYSTEM PAH2/HAC: The crew has access to various sighting subsystems for fire control and piloting and to various armament subsystems. Main armament for the PAH2/HAC are the HOT and ATGW3 missiles. For self defence against aerial threats each HC may be fitted with up to 4 A/A missiles (STINGER for PAH2, MISTRAL for HAC). The main sight for target acquisition and firing will be a mast mounted sight developped in the frame of the ATGW3 programme (OSIRIS with TI, TV and LRF). Its image may be displayed on MFDs in each cockpit or on the specific HID - the TI may be used as backup for piloting and may be displayed on the crews monocular HMD. For piloting the main sensor is a nose mounted TI (derived from the OSIRIS TI). Pointing devices for both crew members are HMS and for the gunner a hand controller/cursor. Presently, EC performs further investigations on the basis of german and french user requirements on the potential integration of a second sensor for piloting and binocular/biocular HMDs - possible solutions are IIT integrated into the helmet or an LLTV on the nose platform.

- MISSION SYSTEM HAP: HAP Mission System consists of three types of weapons: Gun, A/A Missiles, Rockets which can be operated through three types of sighting systems: HMS, HUD, gyrostabilized Roof Mounted Sight. The management of the Mission System and fire control calculations are performed by two redundant Armament Computers (ACSG). The gun is the new developped GIAT M781 30 mm caliber gun, installed in the nose of the H/C on a wide angular turret. Ammunition capacity is 450 rounds, rockets are 68 mm BRANDT programmable fuse rockets, which can be carried either on external stores (12 rounds containers) or on internal stores (22 rounds Containers). A/A missiles are the MATRA Mistral, as on HAC. Helmet mounted sights are available to both crew members for firing at short range targets - their head position detection system, developped by SEXTANT is also used by the PAH 2/HAC HMS/Ds. A Head Up Display is available to the pilot for axial or quasi axial firings. It is also used as head up display for piloting informations. Holographic technology is used for this HUD, which is developped by SEXTANT. The Roof Mounted Sight, developped by SFIM, is an adaptation of the Antitank VIVIANE gyrostabilized sight. It includes TV, TI and LRF and allows the gunner to perform precise firing at long range targets.

- CONTROL AND DISPLAY SUBSYSTEM: This subsystem performs the global task of monitoring and control of the avionic and main nonavionic subsystems. The core of the system are 2 redundant main computers (BCSGs), 2 data acquisition units (RTUs) and 2 redundant mission computers (MCSGs for PAH2 and HAC, ACSGs for HAP). The main interface to the crew are 2 CDUs and 4 MFDs. The SG functions for the MFDs is integrated in the BCSGs, for HMDs in the MCSGs (resp. for HUD and HID in the ACSGs). The RTUs acquire the data of most nonavionic subsystems (electric, engine, hydraulic subsystem, etc.) and provide them for failures or exceedances and display (on crew request or in case of detected anomalies). The MCSGs (or ACSGs) are monitoring and controlling the mission subsystems and provide to the BCSGs the essential information for control and display. The BCSGs are monitoring the complete system - using the data provided by the individual subsystems (including RTUs and A/MCSGs) and generate the interface to the crew - the crew interacts with the system mainly via CDUs and the keyboards on the MFDs. Detected failures will be indicated to the crew but will also be recorded for post flight evaluation by the maintenance crew. Pre and post flight checks are supported by CDU menus to detect and locate failures beyond the capabilities of the failure monitoring during normal system operation. Thus, the crew has access to all essential HC, navigation and tactical information and is not loaded with several routine tasks (as system monitoring). This is the basis to get rid off a variety of cockpit instruments in favor of the 2 MFDs and 1 CDU per crew station. Some instruments however remain for first engine startup, emergency purpose and to ensure higher integrity and availability of the system.

- BUS IMPLEMENTATION: Due to extensive preprocessing in the subsystems the amount of data that have to be exchanged on the bus are limited. In addition, some direct digital lines are provided for safety and time delay reasons (e.g. NAV to AFCS and MEP). This allows to use the MIL 1553 B bus. Busload estimates range from 25 to 35% which provides sufficient growth for development and future upgrades. The bulk of the bus data is generated by the transmission of navigation data to various users (appr. 10-15%).

- TIGER COMPUTER FAMILY: To reach a technically consistent and at the same time economic solution MBB and AS have specified and tendered a family concept for the main computing elements. The solution that was selected is the concept of Litef/VDO/SEXTANT (LIVOTHEC) for 5 computers (BCSG, MCSG, ACSG, RTU and CDD) that are now in full development. Each computer is based on a variety of common modules. The realization of such a computer family may be considered as a first step from a conventional LRU concept towards higher standardization and modularization of avionic systems. Other (more ambitious) programmes in this direction are known in the US (PAVE PILLAR) and Europe. Presently, these technologies are not yet so mature and widespread that they may be applied with low risk (and cost) in an ambitious development programme. Thus, we consider our approach as a first step using well known and available technologies - but even this approach allows further improvements to use the typically rare and scattered space for integration of avionic equipments on board of helicopters. In addition, this concept provided substantial economic benefits which - in the series phase - will also be useful for the services regarding logistic aspects.

Man Machine Interface

The cockpit is designed for 2 crew operation. However, pilot and gunner can perform nearly all tasks with few exceptions that are required during the mission (e.g piloting, communication, navigation, system operation and monitoring, A/A combat). The main exception being the A/T operation that can only be performed by the gunner using specific controls and displays. The other displays and controls are thus duplicated in both cockpits, including collective and stick.

The cockpit is based on the extensive use of colour MFDs, 2 per crew station, to display all required system, flight and sensor information and one CDU per crew member to control the avionic systems and insert comm/nav data. A minimum set of conventional instruments is available to ensure integrity.

In the PAH 2/HAC version to ensure head up operation during day and night flight pilot and gunner are equipped with an HMS/D that presents flight symbology overlayed on a FLIR image (if selected). The HMS/D is also the primary targetting and display device in A/A combat. For A/T operations the gunner can use a high resolution CRT installed in HID which can be positioned in front of his eyes.
In the HAP version, informations necessary for head up piloting are displayed on the HUD, which is also used for axial firing of the weapons.

Control of armament operations is performed for A/A tasks with controls on collectives and sticks mainly (HOCAS), for A/T tasks the gunner has 2 grips with main armament and visionic controls for realtime operation.

Control of nonavionic systems is mainly performed using conventional controls located on control panels on the side consoles.

It is understood that the cockpit displays and controls are designed to ensure NVG compatibility.

Activities on MMI are mainly geared towards 3 main activities:

- mechanical layout and anthropotechnic investigations on class I and II mockups
- definition of formats, symbology and control logic of multifunction displays and controls

- evaluation of handling characteristics of the HC including mechanical and digital flight control systems.

To perform these investigation and to incorporate user requirements a joint task force (Consulting Crew CC) has been set up gathering pilots from industry and official services to support engineering departments.

Mockup activities were mainly performed during the last years and were aimed at assessing geometrical dimensions and layout of consoles, flying controls performing Cooper-Harper ratings. This led to recommendations for the design and manufacturing of the cockpit section for the prototypes.

Piloted simulations to assess handling and flying qualitaties and to give design guidelines for AFCS control laws are performed mainly last and this year in the MBB simulation centre. This is consisting of a dome with a 6 channel projection system (GE COMPUSCENE IV), the data base and field of view being adapted to low level helicopter operations.
Control and display definition is being performed for HAP by AS in cooperation with french official services and simulation centres (CEV Istres and CELAR Rennes) and for PAH2/HAC including basic helicopter by MBB in cooperation with AS and the CC.
Extensive investigations performed during the last years in the frame of french national contracts for HAP are now introduced into the bilateral programme and harmonized with the requirements for the antitank variant.
Starting from industry proposals and paperwork tools are used ranging from graphical workstations for fast prototyping and laboratory simulation (ViCo at MBB, CHEOPS at AS) to cockpit simulation (SimCo at MBB) and mission simulation (MBB simulator and CEV/CELAR). High commonality in hardware and software was considered to ensure rapid interchangeability of results between various stages of simulation. The results of this work are the basis for symbology specifications for the symbol generators and SW specifications for

the operational SW of the mission computers.

Integrated Monitoring and Test System

In order to improve mission availability and allow the TIGER operating, as far as possible, independently of ground maintenance facilities, a two level on condition maintenance concept has been adopted.

The Avionic system monitors permanently in flight the avionic and H/C equipment in order to alert the crew on occuring failures (and record these failures for later ground processing). It also provides a maintenance function, allowing maintenance personnel to perform tests on ground in order to identify the avionic LRUs (and in most cases SRUs) which have failed. The engines also provide through the avionic system life cycle informations, allowing on condition maintenance.

EC is presently investigating solutions to incorporate an additional monitoring system for mechanical tranmissions in order to extend on condition maintenance to these parts.

Development Environment and Tools

An important aspect in the development and integration of modern avionic systems is the availability and use of development tools. Such tools range from analysis and tools to prototyping and simulation as well as software design/development and system integration.

- For system analysis and design Structured Analysis supported by TEAMWORK is applied by MBB and AS. Basis for this analysis are the user requirements on the system which clearly have to be expressed in plain language and are translated into requirements on the system using such methods and tools. As a result requirements on equipments/subsystem and operational software are derived.

- As a standard for development of system (or operational) SW ADA is now widely accepted and was selected also for the TIGER programme. Meanwhile several ADA compilers and run time systems are available on the market that are able to fulfil the real time requirements of avionic systems. In order to ensure a consistent development environment additional supporting tools are required. The solution that was selected by AS and MBB for the TIGER project is the RATIONAL development facility in conjunction with the ALSYS target system. This provides a consistent environment for design, coding and testing on host and target level and includes facilities for project and configuration control and documentation iaw DOD 2167A.

- For integration of the avionic system integration rigs are build up at MBB and AS. Iaw the project worksharing the MBB rig will support mainly the basic system and antitank weapon system integration whereas the AS rig will support mainly the basic system flight tests and HAP weapon system integration. Successful test and validation on such rigs is the basis for flight testing the relevant system functions.