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TIGER Avionic Integration

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Abstract

The TIGER/GERFAUT weapon systems comprise specific versions for the three different helicopter versions HAC, HAP and PAH2. The various subsystems like Basis Avionic (different for HAP/HAC and PAH2) and Mission Systems (EuroMEP) for HAC/PAH2 and HAP–MEP for HAP) are developed and integrated at the EC premises in Marignane and Ottobrunn. The facilities "Primary Integration Rig" in Ottobrunn and "Secondary Integration Rig" in Marignane are designed and operated in a way, that three different weapon systems are integrated and that the flight test is supported using these two rigs only. The first experiences using these distributed facilities for first integration and flight test support are being reported.

1 TIGER Weapon Systems Description

The TIGER anti tank helicopter is developed under a bilateral (French/German) contract by the companies EUROCOPTER France (ECF) and EUROCOPTER Germany (ECD). For the various missions of the French and German armies, three different versions of the TIGER are foreseen:

- the GERFAUT or HAP (Hélicoptère d'Appui et Protection) is an escort helicopter equipped with a nose mounted turreted 30 mm gun, unguided rockets, MISTRAL air to air missiles for self defence, and a roof mounted sight.

- the TIGER HAC (Hélicoptère Anti–Char) is the anti–tank helicopter for the French army which may be equipped with TRIGAT, HOT or mixed, and for self defence with MISTRAL. The gunner uses a mast mounted sight and the pilot can use a nose mounted IR camera.

- the TIGER PAH2 (Panzerabwehrhubschrauber der 2. Generation) for the German army carries TRIGAT and HOT, but uses STINGER for air to air self defence and has also same sights as the HAC.

With some national varieties, the basic avionic system layout is designed around a MIL BUS according to MIL BUS 1553, and is common for all three helicopter types (see Fig. 1). It includes subsystems for display/control/monitoring (consisting of 4 multi function displays, 2 control and display units, and two bus controllers/symbol generator computers), aircraft monitoring, autonomous navigation, autopilot, radionavigation (French helicopters only), communication (French or German specific), identification friend/foe, radar/laser warning, radiation detection and measurement (French helicopters only) and a digital map generator (German helicopters only).

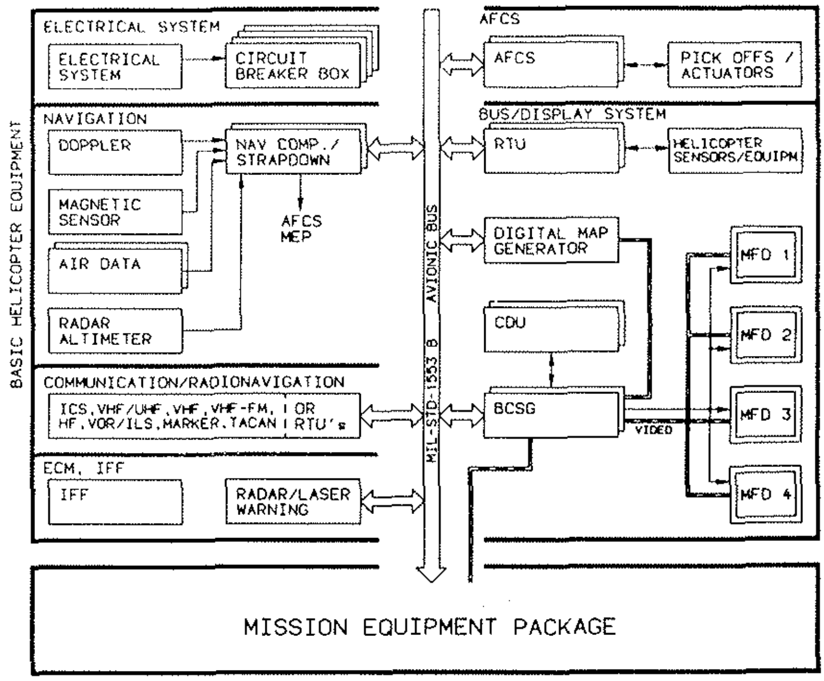

Fig. 1 **TIGER Basic Avionic System Architectures**

2 TIGER Basic Avionic Development Tools and Methods

The TIGER avionic system development, integration and test is performed in various systematic steps (see Fig. 2). Basis are the requirements of the customer which are described in system specifications (which include functional chain specifications). Starting from this concept documents the next three major development phases take place as iterating processes, i.e. they are closely linked and influence each other vice versa:

- Study of man/machine (MMI) interactions in a cockpit laboratory and on a cockpit simulator (SIMCO). Results of these investigations are format specifications for the various displays of the TIGER (e.g. Multifunction Displays, helmet mounted displays, head up displays, head in displays) and specifications of all controls.
- Development of avionic equipment, based on equipment specifications.
- System analysis with "teamwork" defines the requirements on the basic avionic software (S/W) and must take into account the MMI results and the equipment specifications. On the other hand, results from system analysis influence the MMI concepts and the requirements on the basic avionic equipment.

The S/W requirements are the input for the development of the ADA code which (after compilation and linking) is loaded to the TIGER bus controller/symbol generator computers (the BCSGs, i.e. which are the main computers) and pre tested on a software test bench (see chapter 3). Software development takes place in Ottobrunn (for BCSGs) and in Marignane for the mission computers (MCSG, ACSG).

On two integration rigs, the primary integration rig (PIR) in Ottobrunn, see Fig. 3 and Ref. 1, and the secondary integration rig (SIR) in Marignane, the S/W for the 3 TIGER versions is further integrated together with the avionic subsystems hardware (see Fig. 7) . These rigs also have to support the flight test of 4 TIGER prototype helicopters (PT2 – PT5) which is the last step of the development process.

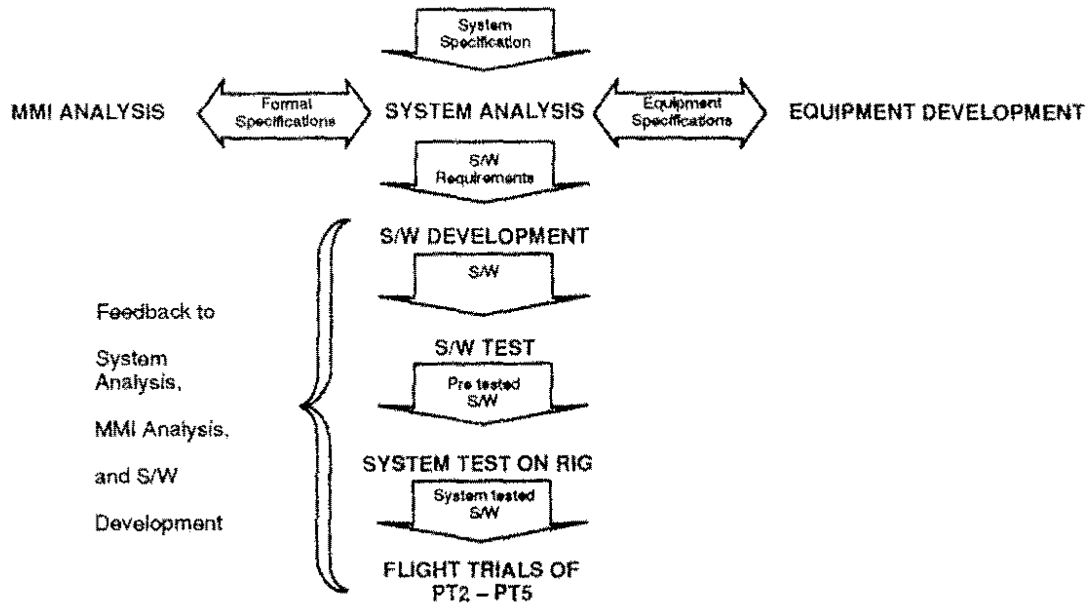

Fig. 2 Development Process for the TIGER Avionics and MEP Systems

Feedback from each development stage is given

- to the system analysis team in order to improve the functionality of the S/W,
- to the MMI team for improvement of symbology requirements which result from practical experience on flight or from rig assessments,
- to the equipment developers for modifications and improvement of their subsystems or equipment.

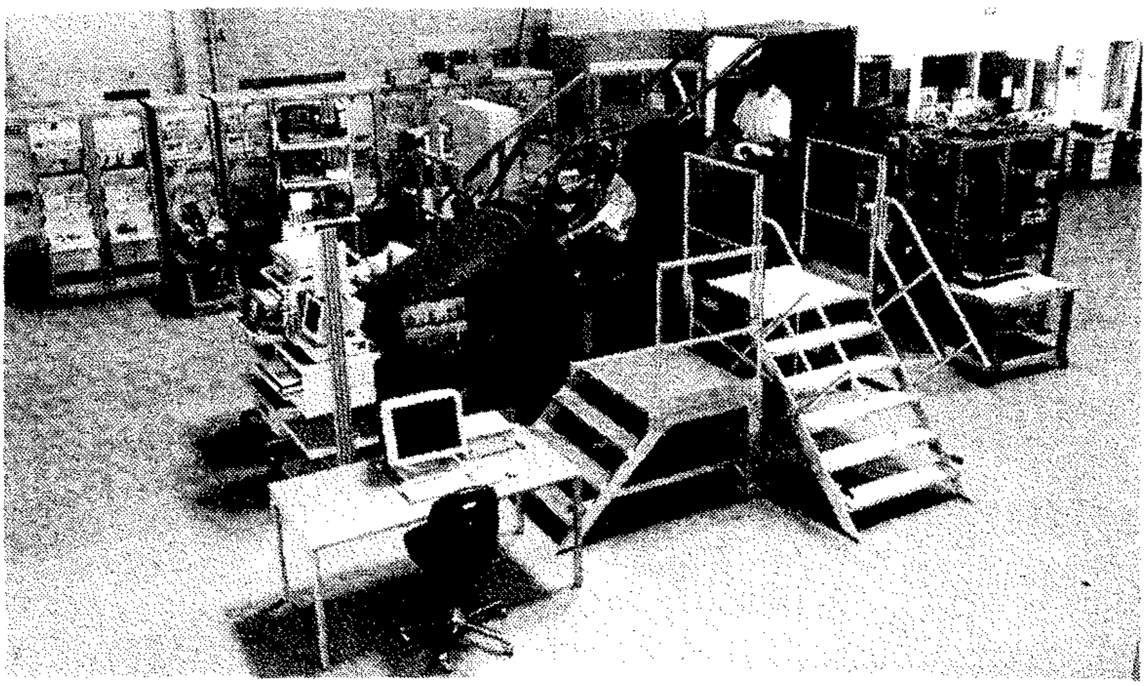

Fig. 3 The Primary Integration Rig (PIR) in Ottobrunn

3 Basic Avionic Integration Concept

The integration concept for the TIGER basic avionics (see Fig. 4) is based on a four step approach which is carried out on the software testbench (SWTB), PIR and SIR, and on the helicopter prototype:

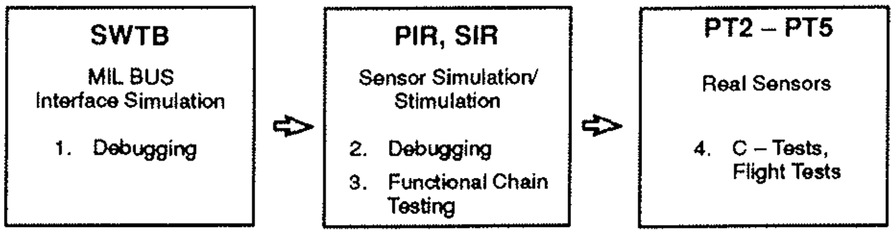

Fig. 4 TIGER Basic Avionics S/W Integration Concept

- First step is the debugging of the S/W at the SWTB with simulation of all equipment functions via MIL BUS RT simulation
- Next, the S/W is run on an emulator at the PIR. This second step of debugging is done in an environment with real avionic equipment sensors which are stimulated or simulated by test means.
- After the official release of the S/W, it is tested at the PIR (for PT4 at the SIR) according to "engineering test orders" which are based on the functional chain specifications and the S/W requirement specifications
- The last integration step before flight test are the ground tests (C tests) on the prototype helicopter

The differences in testing on SWTB and on PIR are depicted in Fig. 5. At the SWTB only the Bus Display and Monitoring Subsystem (BMS) is connected. It is composed of the Bus Controller/Signal Generator (BCSG), the central display units (CDUs), and the four multifunction displays (MFDs). All other MIL BUS subscribers (dotted lines in Fig. 5) are simulated by a test system (LORAL). If required for tests, an emulator of the BCSG CPU can be connected.

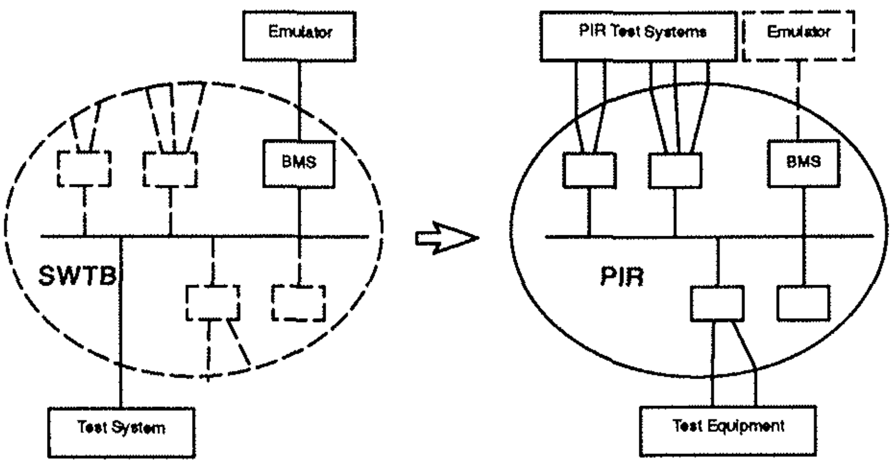

Fig. 5 Test Methods on SWTB and on PIR

On the PIR all MIL BUS participants and the remaining avionic system components are installed and connected with an original helicopter harness. The replacement of the BCSG CPU with an emulator is made only during the debugging phase at the PIR.

Major advantage of this integration concept is the possibility to modify the S/W directly with the BCSG emulator at the PIR. Subsequently these modifications can be verified in the real avionic environment.

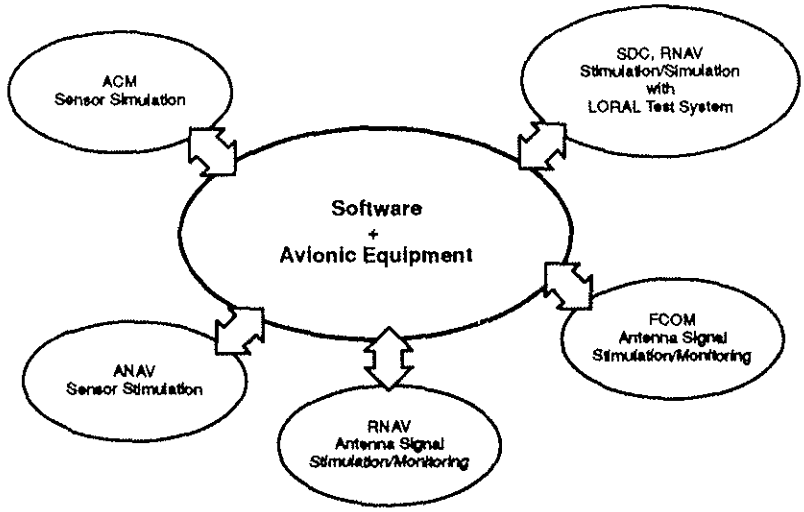

Fig. 6 Test Method for PT2 Avionics on PIR

Prerequisite for such a procedure is the ability for flexible stimulation of the avionic equipment interfaces (i. e. the various sensors or the sensor simulators), see Fig. 6. This has been realized by the use of MIL BUS, ARINC, and discrete interface boards on various PCs. It is also possible to reuse the respective test setups during the prototype ground tests. For a system test (which includes at the moment the coherent simulation of sensors of the Strapdown computers and the radionavigation subsystem), the LORAL test system is used.

4 Weapon System Integration

Fig. 7 shows the planned configurations for integration of the 3 different weapon systems on the helicopter prototypes PT2, PT3, PT4 and PT5 together with the pass through on the two integration rigs PIR and SIR, and the test benches EIB (EUROMEP Integration Bench) for the pre integration of parts of the HAC/PAH2 mission system (EUROMEP) and the MHIR (MEP HAP Integration Rig) for the pre integration of the HAP mission system.

The major task of the SIR is the integration of the HAP weapon system (i.e. the basic avionics plus the MEP HAP) which is then flight tested on PT4 and on the retrofitted PT2 (PT2R). Besides this, the SIR supports the flight tests for the PT2 and the PT3. The SIR will exist in two configurations: SIR1 is representative for the basic avionics only, and will later be upgraded to a complete HAP weapon system configuration (SIR2).

First task of the PIR (PIR1) is the integration and test of the basic avionic system. PIR1 will also be upgraded and will then (as PIR2) be used for integration and flight test support of the PAH2 (flying on PT5) and the HAC (flying on PT3R) weapon systems. I.e. PIR2 must be flexible to allow switching between both configurations.

MHIR and EIB both are stand alone integration benches for the MEP HAP and major parts of the EUROMEP respectively. All interfaces to the avionic system are simulated. With these additional integration facilities workload is taken from the major integration rigs and parallel testing is made possible.

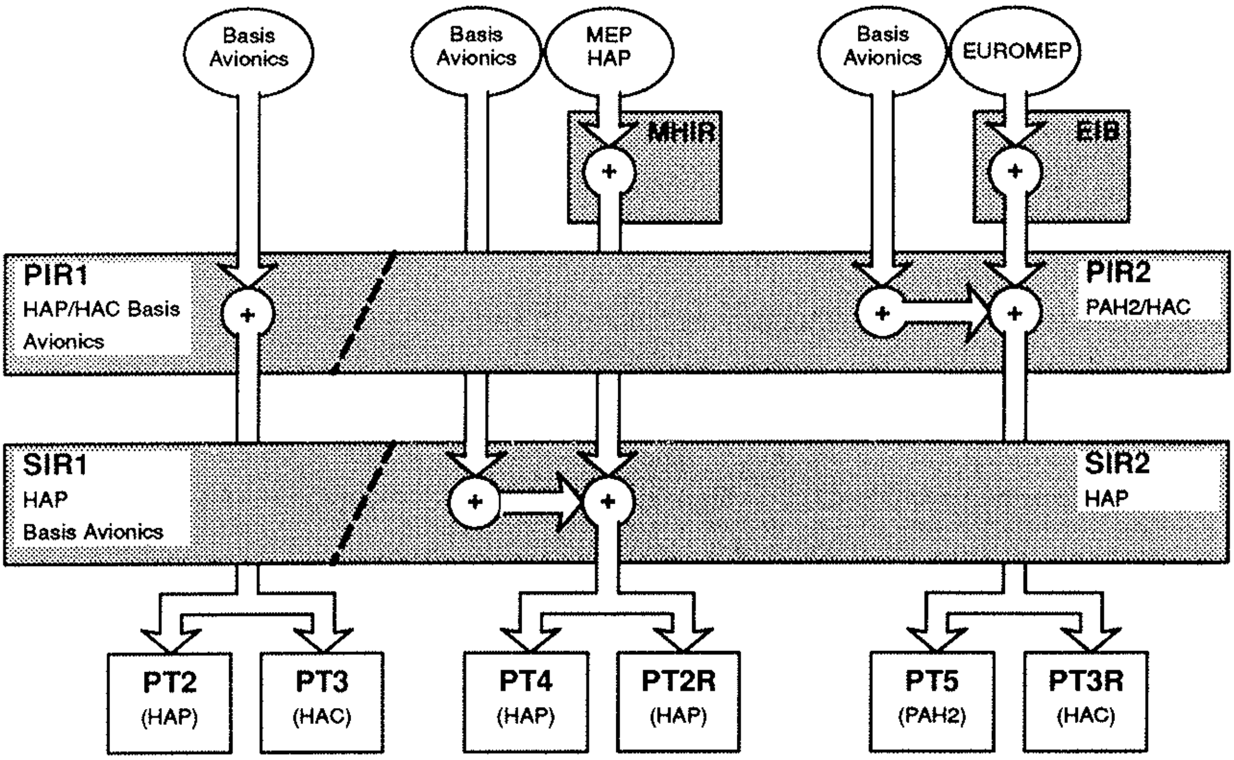

Fig. 7 TIGER Weapon System Integration Stages

The detailed procedure of flight test support by the rigs is shown in Fig. 8: Flight test results are either recorded with the flight test equipment (FTI) or result from pilot's debriefing. After thorough analysis on SIR (or PIR), eventually supplemented by equipment testing with STTE (if an equipment defect is assumed) or helicopter ground test, the test results are reported. Defect equipment will be exchanged, S/W bugs and also suggestions for the improvement of the man/machine interface are put into a report data base and will be incorporated (after assessment by specialists) into a new S/W release.

For minor S/W modifications a rapid change procedure applies: The S/W is corrected, tested on the PIR and the modified S/W is loaded to the helicopter computers.

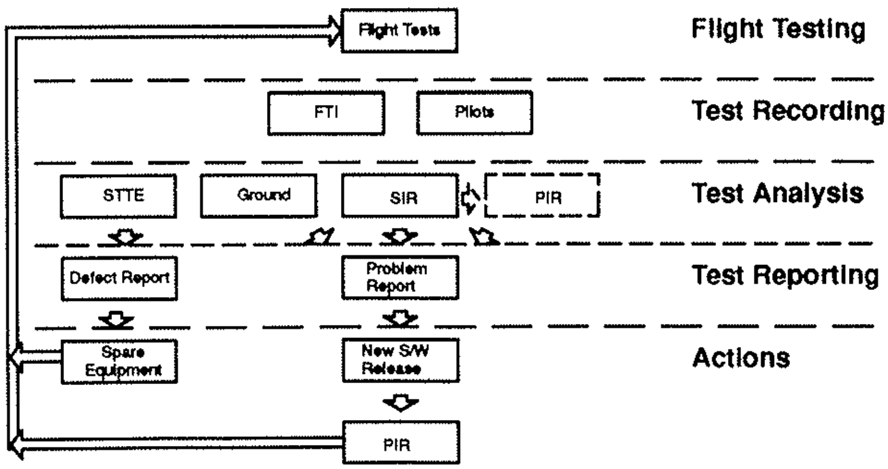

Fig. 8 PT2 Flight Test Support with Integration Rigs

5 Integration Experiences

Several experiences result from the integration done for PT2 at the various facilities so far:

- Most important was that the software has been tested as early as possible in the realistic environment of the rig under very close cooperation of software developers and the tests team. This has led to the detection and quick debugging of problems which were not detected on the SWTB due to lack of 100% simulation of interface behaviour.

- *Familiarization by the test pilots and the official authorities during integration tests on the rig has led* to a high degree of confidence to the avionic system.

- Configuration management of software and/or avionic equipment problems detected during testing at various facilities is a prerequisite for efficient improvements and repairs: An common reporting database was developed for this purpose (see Fig. 9). Access to this database is given to all test facilities in Germany and in France. An assessment of all reports is made regularly, resulting in:

  - changes the S/W requirement specifications or interface requirement specifications (a typical example is the variation of a threshold limit), or
  - repair of S/W bugs, or
  - repair/modification of equipment, or
  - modification of equipment specifications.

  The contents of this database was also presented to the customer who got a very clear impression of the S/W performance and limitations by that way.

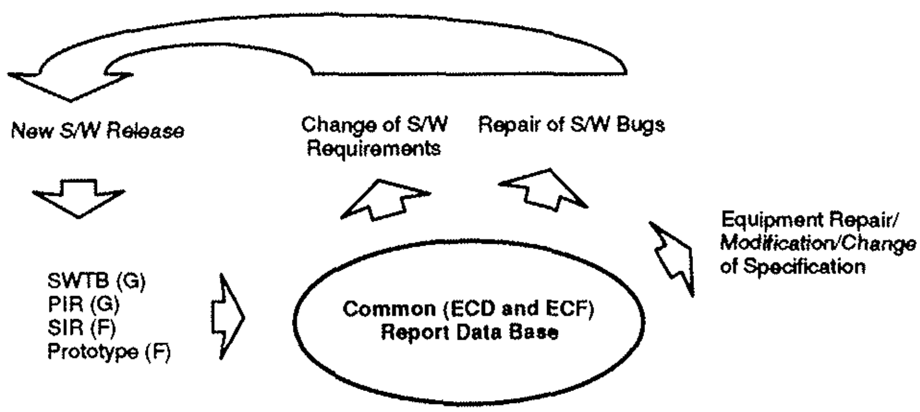

Fig. 9 **Management of S/W Problems by ECF and ECD with a common Report Database**

- S/W debugging and testing in this very early stage of development can be done very efficiently and in a very short time with decentralized test systems. Nevertheless for the final weapon system semi automatic test setup generation (using an avionic parameter data base) and tests are the target. This will be achieved with the MONA LISA test system on SIR and with the LORAL test system on PIR.

6 PT2 Avionics – Flight Test Experience

Until September '93 two TIGER helicopter protoypes are flying. PT1 is used for the test of the vehicle. The second TIGER prototype (PT2, see Fig. 10)) has a HAP (GERFAULT) configuration and is the first testbed for the basic avionics S/W.

The avionic functions which have been realized for the first flight of PT2 include:

- French Communication
- Radionavigation
- Autonomous Navigation (basic functions only)
- Automatic Flight Control (basic modes only)
- Aircraft Monitoring
- Display Control and Monitoring
- Identification Friend Foe

Fig. 10 PT2 during Flight Test in Marignane

The basic avionic software runs on one bus controller/symbol generator. The mission system is not yet installed.

In order to get a flight clearance for the avionic system, the software functionality was assessed by the French CEV on the primary integration rig. Only minor deviations from the format specification of the multi function display symbology were detected. These were not considered to have any influence on safety aspects or on flight tests.

Flight tests on PT2 are carried out since its first flight in 22nd of April 1993.The most remarkable result of these tests with regard to the basic avionic system is, that no new S/W problems were found, but only suggestions for the improvement of the man/machine interface was made by the pilots. This is due to the facts that,

- the integration rig is completely representative for the avionic system
- the test coverage of the avionic system (including S/W) functionality is nearly 100% during the various integration steps
- the S/W is highly reliable even in the present early stage of development

As an other consequence of this good outcome it was so far not necessary to involve the secondary integration rig in France into the support of the flight tests as it had been planned before.

7 Conclusion

The procedure for development and testing the TIGER avionic system has so far led to very good results. The described methods and tools will therefore also be applied for future cooperation in the TIGER program and in other programs as e.g. the NH90 development.

An other experience of the bilateral TIGER program is the outstanding good cooperation of the two companies EUROCOPTER DEUTSCHLAND and EUROCOPTER FRANCE which results in close relationships between the various development teams in France and in Germany for which this common paper is also an example.

References

1. H. Gölzenleuchter, L. Dietl, Test and integration concept for complex helicopter avionic systems, Seventeenth EUROPEAN rotorcraft forum, Paper No. 91 – 16.1, Sept. 1991