TEST AND INTEGRATION CONCEPT FOR COMPLEX HELICOPTER AVIONIC SYSTEMS

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Abstract

Integration of the avionic system and the mission equipment of modern helicopters (like TIGER or NH90) requires flexible hardware and software tools: Various national and / or mission specific equipment configurations of a basic helicopter must be tested within a minimum change–over time. Experiences with the integration rigs and the test systems used at MBB are described. Advantages of the concept in use are discussed, general requirements on test systems for related applications (e.g. integration of civil helicopters etc.) are outlined.

Introduction

Test and integration of avionic systems for the TIGER and NH90 helicopter programs is influenced by two major constraints:

Both helicopters are developed in multilateral programs. As a result, its avionic systems are characterized by a common basic system layout and a variety of modifications due to different national requirements. Consequently integration tools for these systems must be designed in a way to allow quick retrofits for tests of the various configurations.

Digital avionics, built around a serial bus as the main data link, is used in favour of conventional solutions. This concept demands the application of high sophisticated test systems which can handle the various bus and digital data. Conventional laboratory test equipment will be used as additional test support only.

Development and Integration of Avionic Systems

An example for a modem avionic system design is depicted in Fig. 1.

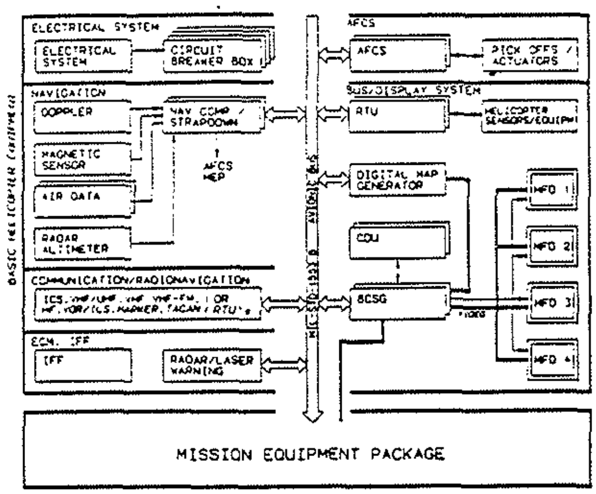

Fig. 1 TIGER Basic avionic System Architecture

It's major characteristics is the use of a dual redundant Bus according to STANAG 3838 (MIL–Std–1553 B) as the central data link. Most of all remaining data are also exchanged in digitized form. Data or video images are displayed on multifunction displays or the central display unit (data only). Conventional instrumentation is used for emergency mode flying.

The development of such a system architecture requires the balancing of customer requirements, the optimum technical possibilities and costs.

Stages of Development

Fig. 2 shows typical development stages for modern avionic systems as described above.

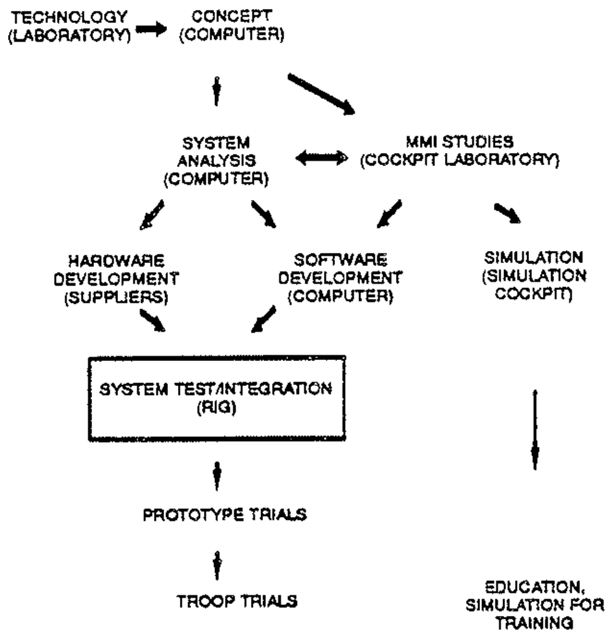

Fig. 2 Typical Development Stages for modern avionic Systems

The various steps of technology assessment in the laboratory, system analysis with computers, man/machine studies in a cockpit laboratory, software development on software testbenches, result in avionic hardware and software. Both are put together, integrated and tested as a complete system at the integration rig for the first time. The avionic system is then tested in various helicopter prototypes which are handed over for troop trials later on.

Stages of Integration

Fig. 3 gives a more detailed view of the integration stages on a rig which finally lead to a flightworthy avionic system:

The avionic equipment or the avionic subsystems are first tested stand alone with special to type test equipment (STTE) which are developed together with the respective equipment. Various equipment are then integrated at the rig to subsystems. The sequence of these integration steps normally has to follow the dates of equipment deliveries.

The final step, when all hardware and software are available, is the integration in a systematic functional way to the complete avionic system on the rig, where all functional chains of the system are tested. These tests are an essential prerequisite to obtain the flight clearance for the avionic system.

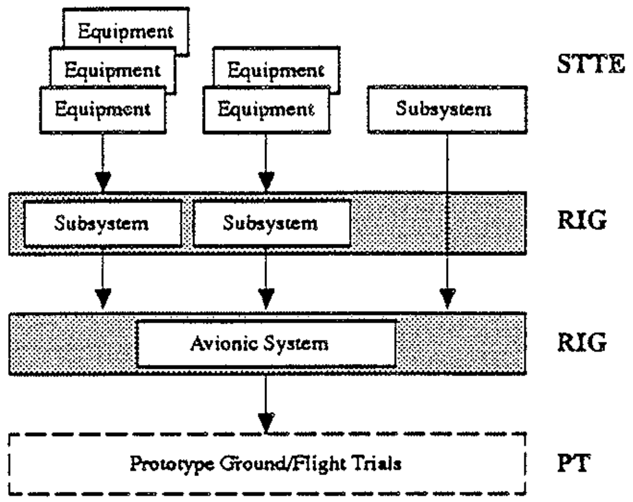

Fig. 3 Avionic Integration Stages

Besides these sophisticated final tests on system level a rig also has a lot more tasks e.g.:

- It is used to check the mechanical compatibility of all equipment and connectors.
- The electronic compatibility of all equipment can be tested.
- Experience can be gained for the definition of automatic maintenance and error retrieving software.
- All modifications or upgrades of the system software and hardware must first pass rig tests.
- Error simulation can be performed without safety restrictions.
- During and before helicopter prototype testing, the rig serves as flight test support facility.
- It can be used for demonstrations of the system functions and familiarization of crews.

Integration Tools

The most important integration tools for avionic integration purposes are: An integration rig for the installation and operation of the avionic equipment, patch panels which allow an access to all avionic signals and a test system for complex measurements and tests. Besides the test system various laboratory test equipment (e.g. MIL BUS tester, ARINC tester, audio generators, video generators, oscilloscopes, logic analyzers) for direct signal stimulation or measurements are used. Fig. 4 shows the placement of integration tools in the integration hangar for the TIGER.

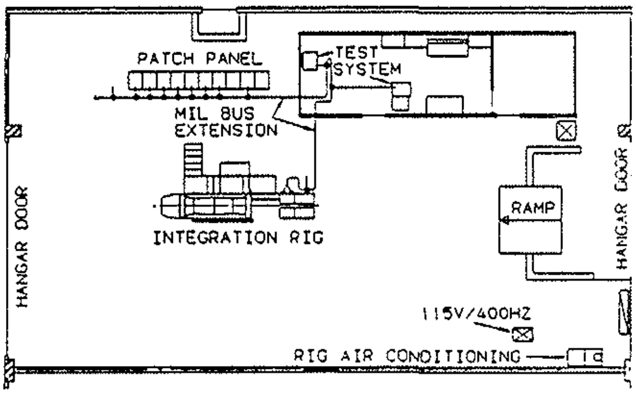

Fig. 4 Integration Equipment

Integration Rig

The integration rig for the TIGER (see Fig.5) represents the front and middle part of the helicopter where all avionic equipment and the mission equipment electronics can be mounted at similar places as in the prototypes. The cockpit area is built as in the original helicopter, modified BK 117 seats are used. A mast for the mounting of the gunner sight and a mounting frame for anti tank or air to air missiles will be added later.

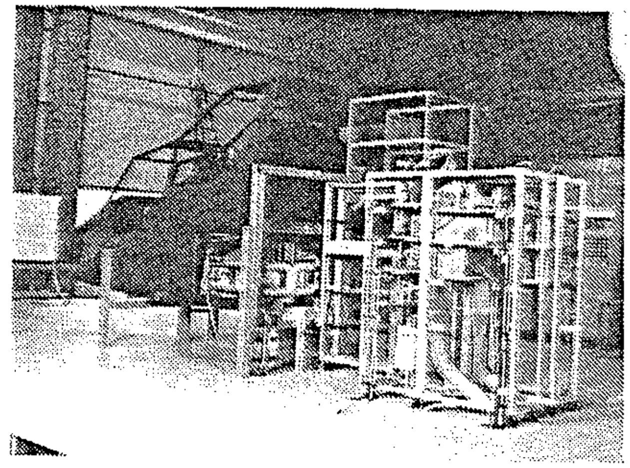

Fig. 5 TIGER Integration RIG

The helicopter power generators are substituted by a static 115V/400 Hz transformer which allows the introduction of transients into the electrical power control system system. The cooling of the avionic equipment is ensured by an external fan type air cooling. Connections to antennas at the rear part of the helicopter are led to a connector plate where antenna simulators or appropriate termination resistors can be connected.

The harness corresponds to the original helicopter harness with some minor modifications. It will be upgraded in order to allow the test of the German and French TIGER versions. The main difference between these versions is the use of French or German communication and radio navigation equipment and the air to air armament (STINGER or MISTRAL respectively).

The Integration rig is built into a hangar, all connection cables to the rig are routed underneath a double layer floor. Opening the hangar doors enables a view to the outside and allows tracking tests of real objects without adaptation optics for the mission equipment. Indoor tests can be performed with appropriate collimators.

Patch Panels

To get access to avionic signals e. g. ARINC BUS, Videos, Discrete, Analogs, RS422/RS485, Patch panels (see Fig. 6) together with appropriate coupling of signals are used. The measurement of MIL BUS 1553 B signals is described in the next chapter.

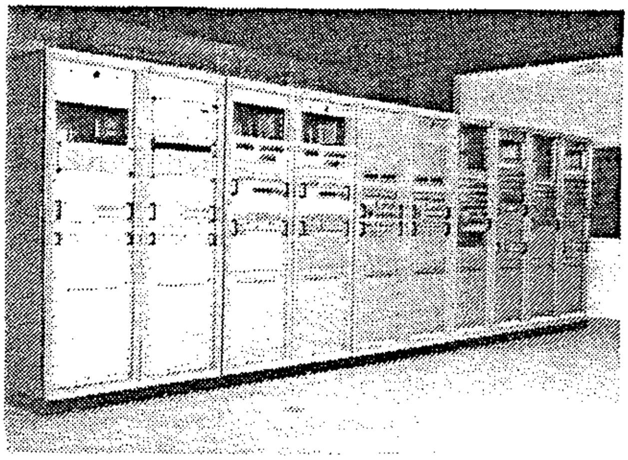

Fig. 6 Example of Patch Panels

The coupling of the patch panels to the harness of an avionic system may be done in different ways:

- Either by cutting the original harness and direct connection of measurement devices into the cables by means of bridge connectors
- or by leaving the original harness intact and use interrupted extension lines plugged into the equipment connectors with the avionic equipment mounted at the other end of the extension (principle see Fig. 7) in a patch panel.

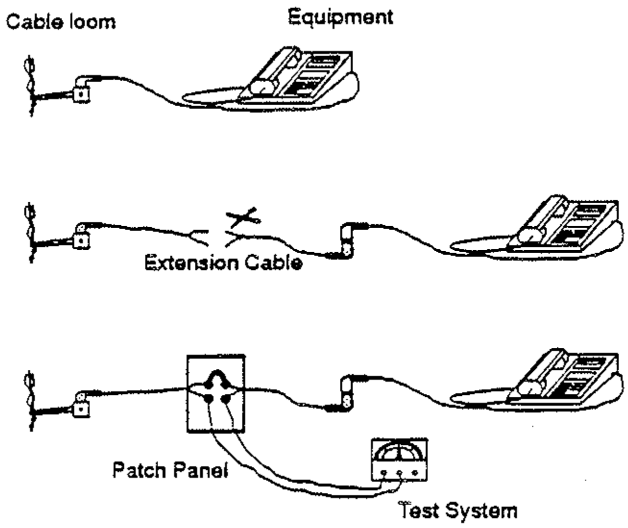

Fig. 7 How does a Patch Panel work?

The connection principle of Fig 7 has the advantage that an original harness of the helicopter can also be used for the rig and no internal wire shielding must be interrupted. It is especially useful for systems with discrete or BUS signals where long extension lines from the rig to the patch panels and the test system do not cause signal disturbances. It is also possible to use the patch panels for special ground tests at the prototype helicopters.

For signals where the cable length is critical as e.g. digital video, direct connection to the harness with active probes must be chosen for measurements.

MIL BUS 1553 B Surveillance

Monitoring or stimulation data frames of MIL BUS 1553 B needs a different approach: The MIL BUS consists of a central line (wave resistance: 77 Ohm). In the TIGER or the NH90, the bus controller and all remote terminals are coupled to that line via transformers and so called "long stubs" (wave resistance 3000 Ohm). These stubs may not exceed a cable length of 6m and therefore cannot be as easy interrupted or extended as described above for other signal types. The concept of getting access to MIL BUS data is therefore realized as shown in Fig. 8.

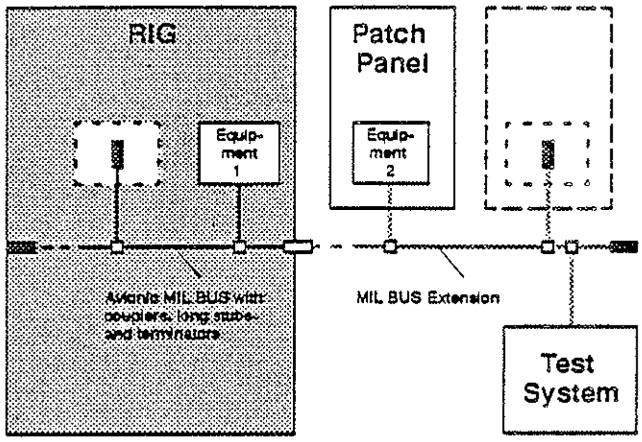

Fig. 8 Concept of MIL BUS 1553 B testing

The helicopter MIL BUS is extended and routed to the test system and the patch panels where the equipment under test are mounted. Stubs not in use are terminated by appropriate resistors.

Test System

The real time test system used for integration of the TIGER avionic system has the tasks to

- validate and monitor interface data flow (digital, analog, bus)
- simulate sensors/equipment interface data
- stimulate sensor inputs
- react on predefined events
- simulate data of flight test instrumentation records for flight test support

In this respect, "real time" means that the test system stores and processes all input/output data in the exact time sequence they occur in the avionic system. The computing performance of the test system exceeds the maximum internal data flow of the avionic system by several times.

For the TIGER an off the shelf test system (System 500 from LORAL) has been chosen. Besides this stationary mounted test system a second, moveable system is available which has a reduced number of interfaces but a similar user surface.

Validation of Interface Data Flow

The origin task of the test system is to validate the correct intercommunication data of the various avionic equipment. Access to these data, which may have completely different formats, is given via the patch panels. In case of trouble shooting, the test system has in addition the task to generate and/or to manipulate a data flow in a defined manner. As a consequence it must be able to react on system or user defined events.

Simulation of Environment/Equipment Data

An other important feature of the test system is the stimulation or the simulation of missing sensor signals.

As the rig is fixed on ground, environment sensors (e.g. engine data.), as far as they are installed, show only fixed values. For system tests, which may require the simulation of defined flight states, the test system must generate "coherent", i.e. meaningful, data sets for various sensor inputs.

The data of sensors which do not have an electronic input (e.g. pressure, temperature, altitude, etc.) or which are not installed in the rig must be replaced by the test system: The test system must either generate their complete data flow to the avionic system, or must trigger the respective simulation/stimulation functions of the sensors special to type test equipment.

Some "stupid" signals as e.g. "door closed" will be simulated by conventional laboratory means.

Test System Performance

The performance of a test system is strongly determined by the number interfaces which can be handled. For avionic system tests it is reasonable to monitor only those interfaces at the same time which are relevant to the function under test. This concept leads to a reduced number of test system interfaces. For the TIGER integration the following interfaces are available:

2 MIL BUS 1553 B
(dual redundant BC, BM and RT operation)

16 ARINC 429 receiver

8 ARINC 429 transmitter

12 RS 422/485

64 Analog Input

64 Analog Output

256 Discrete Input

256 Discrete Output

In addition, an IRIG time code card, which can add absolute time stamps to a data flow and an IEEE 488 interface, allowing data exchange with standard laboratory equipment completes the system.

Mass storage for off line operation is enabled by a 1.2 GByte SCSI disc. Graphic display and operation of the system is done by two DEC 2100 RISC workstations.

It is ensured that the test system performance which is determined by its internal bus (4 Mwords/sec) is always better than the performance required from the avionic system. E. g. for analog interfaces, the sampling rate of 100 Ksamples/sec for 32 channels is fast compared to the slow variation of avionic sensor signals and is at the same time far below the internal test system processing speed. A fully loaded MIL BUS 1553 B causes a data rate of 62.5 Kwords/sec, which is again slow compared to the internal test system bus speed.

Test System for Civil H/C

Although modern avionic systems of civil helicopters are starting to use digital avionic equipment, their systems are less complex than in military applications. As a general rule, the budget for civil development and integration is very restricted.

Both constraints demand for low cost test systems with a maximum of performance. Some requirements for such a test system can already be deduced from our experience with the LORAL system:

As the simulation of environment/equipment is less complicated due to reduced number of sensors and equipment in a civil helicopter, a PC based test system may be sufficient. The functionality of most of the avionic interfaces (serial busses, MIL BUS 1553, analog, discrete etc.) are commercially available as AT computer compatible slot cards. Laboratory equipment, linked to the PC via IEEE 488 bus can supplementary be used.

The main disadvantage of this concept is the lack of an arbitration controller for the AT bus. Therefore it may be difficult to get real time performance when cards of different suppliers are used. The AT bus is also not prepared to combine tag bits to data words in order to get fast access to them. A possible way to partially overcome this restriction, is the use of an AT based test system for the generation of environment/ sensor simulation, whereas an off the shelf bus tester has the task to validate the avionic data flow.

Conclusion

The test means for the TIGER basic avionic system offer the required flexibility for the integration of the various national versions of this helicopter at the same test rig. The use of an off the shelf test system aviods any development risks of a "selfmade" solution.

A similar concept will be applied for the integration of NH90 avionic components at MBB.