TIGER
DEVELOPMENT STATUS OVERVIEW

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ABSTRACT

The Franco-German TIGER Antitank Helicopter Programme stays in full scale development for the basic vehicle and system areas as well as for the mission equipment packages.

According to the main development contract the development of these weapon systems PAH2, HAC, HAP includes furtheron flight testing of five prototypes in the various configurations up to their qualification as well as logistics- and series preparation development.

The first flight of PT1 was accomplished on April 27, 1991. With starting flight testing an essential development step is reached.

This paper focuses mainly on work presently being done, and thus related to first prototype and accompanying work for the second and third prototype, mainly dedicated to basic system testing.

INTRODUCTION

As a result of long time discussions the main development contract for the TIGER programme was signed in late 1989 between the German and French governments and industries.

The governments were represented by the "Deutsch Französisches Hubschrauber Büro", and the industry by EUROCOPTER, an Aero-spatiale-MBB Consortium, the two companies having a more than 25 years cooperation experience in a variety of aviation and space programs.

The HAP/HAC/PAH2 helicopter was named TIGER in December 1989.

The guiding concept philosophy of the program is the design of a common basic helicopter which allows utilizing different mission equipment items in its varied roles.

- PAH2 (Panzerabwehr-Hubschrauber) is the German antitank version and HAC (Helicoptère Anti-Char) is the French antitank version.
- HAP (Helicoptère d'Appui-Protection) is the French combat support version, which includes ground support and air-to-air capabilities.

Currently a total production rate of 427 helicopters, 212 PAH2 for Germany, 70 HAP and 145 HAC for France is assumed.

The main development contract is structured on a fixed price basis with the total amount of 2237 MDM, '86 e.c., and covers the development of the three weapon systems PAH2, HAP, HAC up to their qualification in 1996/98 including flight testing of five prototypes in the various configurations as well as logistics- and series preparation development.

The essential features of the new helicopter weapon system will be air-to-air and air-to-ground capability in day/night and adverse weather conditions.

Its mission effectiveness will be ensured by use of modern technologies in the vehicle-, system- and armament areas, such as e.g.

- modern rotors made out of composite material and with elastomeric bearings

- all-composite fuselage, designed for better survivability and operability
- integrated avionic system consisting of a distributed network of intelligent subsystems arranged in a basic avionic system and a mission equipment subsystem
- glass cockpit basically with four colour multifunction displays and two control display units
- pilot vision system with thermal imager and HMS/D's
- roof- or mast-mounted sights (depending on version) with IR, TV, DVO for RMS, LRF and tracking device
- fire-and-forget antitank TRIGAT missiles.

After achieving the significant milestone of the first flight with the first prototype, PT1, in time at April 27, 1991 the next prototyp, PT2, first take-off will be in late 1992, mainly dedicated to flighttest the basic avionics in HAP-configuration, whereas PT3 will take the complementary part in the anti-tank configuration a few months later.

Fig. 1: TIGER prototype 1

This paper will focus on the first prototype and PT1-flight test results as well as the running avionic system development activities.

TIGER first prototype

The first prototype, PT1, is dedicated to basic vehicle flight testings. In order to fulfill this task the prototype is configured according specification in the vehicle-field, whereas the basic avionic subsystems are replaced by conventional equipments.

Consequently the two crew stations have a PT1 specific cockpit lay-out different to the specified MFD-type glass cockpit.

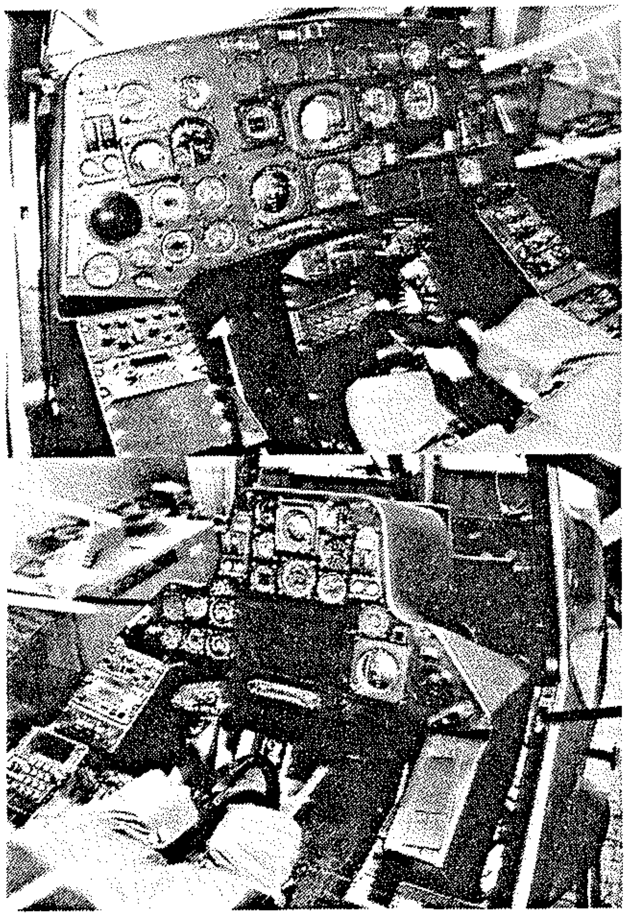

Fig. 2: PT1 Cockpit Lay-out

The equipment bays contain besides the standard vehicle type subsystems like trim, 4-axis preactuator, battery etc. the necessary flight test equipments.

They are arranged to enable the entire flight envelope, esp. with regard to configuration change from anti-tank type to HAP-configuration as well as weight and c.g.ranges.

The flight test equipment installation (FTI) is newly designed and was flight tested the first time in late '89. FTI used two data acquisition systems, each based on a dedicated computer corresponding to quasi static and dynamic parameters. Furtheron, it includes the supporting systems such as type recorder, crash recorder, telemetry system and crew station controls.

The *first flight clearance was given after having* completed a set of component and system tests in the both helicopter divisions and at the related equipment suppliers.

Besides the various tests necessary to show compliance with the requirements a universal modular test bench, Iron Bird, has been *built* to undertake tests of dynamic assemblies in high loading conditions in a representative configuration.

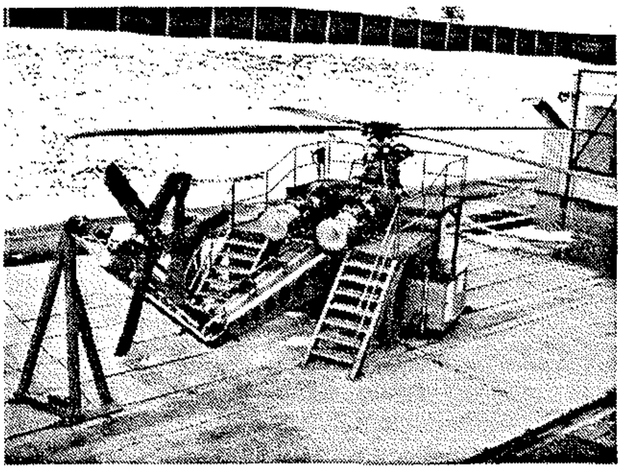

Fig.3: IRON BIRD,
Dynamic System Test Bench

Here a representative 50 h short endurance test has been conducted successfully prior to first flight.

PT1 flight test status

The PT1 test flight phase is subdivided in several parts. In the first part of flight test phase the prototype shows in the PAH2/HAC anti-tank configuration without mast mounted sight and not carrying external loads.

A second and a third test phase will follow in different configurations.

After completion of phase 1, *which was reached* beginning July '91, a lay-up period necessary for planned inspections also will include the transformation of PT1 into the complete, representative anti-tank configuration, carrying the mast mounted sight and according to flight test campagne the different types of launchers for *HOT, TRIGAT, Stinger or Mistral.*

A further lay-up phase will transform the PT1 into the HAP configuration, i.e. removal of anti-tank-type nose incl. PSU and mast mounted sight and installation of flightworthy mock-ups the nose mounted gun, roof mounted sight as well as the specific *launchers respectively.*

To carry out the first part of the preliminary phase 14 tests-tasks have been identified to be analysed.

To date after 30 flights over 3 months 30 hours of flight testing have been conducted on prototype one since first flight on April 27, 1991.

Fig. 4: PT1 During First Flight

These 30 h of flight testing represent around one third of flying hours, which are planned for the three preliminary phases of basic flight tests.

The flight testing is conducted within an integrated team of MBB/AS-experts at Marignane. Close to this place the agencies have arranged themselves in parallel in an integrated test team in the flight test center CEV at Istres. In a close cooperation they follow the industry flight test campagnes and participate by information flights and lateron within the approval/qualification process.

As planned prototype 1 is used to open and expand the flight envelope over the initial ranges of speed, weight, etc.

The main results obtained on the PT1 for its first flights are grouped in the items

- stresses
- dynamics
- engine behaviour
- flying qualities
- performances.

The first flights have been around hover and low speeds below 50 km/h. Analysis of loads and stresses as well as an unexpected 3 Ω oscillation made some changes in PT1 configuration necessary to extend the flight envelope:

- adaption of the vibration isolation system SARIB by changing the flapping masses

- changing the second blade flapping mode by inserting Tungsten weights in foreseen tuning chambers.

- changing the stabilizer setting.

With these changes the today achieved flight envelope is mainly characterized by

- level flight	HIGE, HOGE, flights up to 170 kt
- lateral flights	up to 40 kt
- turns	30° bank at 140 kt 50° bank at 120 kt
- climb/ descent	2000 ft/min
- autorotation	2500 ft/min
- weights	4500 - 5500 kg

It has to be mentioned remarkable that the high speed of 170 kt was reached only one month after maiden flight.

Specific performance flights will be conducted in the following phases in complete representative configurations.

Specific altitude and temperature flights will be part of the next campagnes.

Actually there is the detailed flight test analysis of the first preliminary phase running. A first result shows the potential to reduce the tail plane, which will bring down shaft bending moments and stresses as well as weight at the right place.

The approach to evaluating the TIGER's handling and flying qualities involves both a qualitative pilot assessment of the helicopter handling characteristics and a quantitative comparison with the applicable flying qualities specifications.

The TIGER'S qualities are evaluated as being very stable within the whole flight envelope, the easy handling being remarkable. A foreseen stability augmentation system (SAS), planned to cope with potential "twitches" from the hingeless FEL-rotor, is not needed at this stage. Improvements in handling qualities are envisaged for transition flights with regard to the tail plane investigations.

Vibrationwise the actual levels are evaluated and measured as being acceptable (<.2 g) to very low (<.1 g) except for transition at the gunner seat. Fine tuning of SARIB and blades will certainly lead to further improvements.

<u>Supporting test activities</u>

To get the PT1 first flight clearance 201 specific documents had to be delivered showing the corresponding results for components and subsystems.

Due to the fact that qualification tests are not finalized at this step of development a variety of components and subsystems has got a timewise or/and performancewise limited clearance.

In parallel to the flight testing those development test activities are going to be continued. For the structure mainly environmental testings for hot and wet conditions are scheduled, preparation of bird strike trials, further experimental substantiation of critical load cases and verification of finite element model for the entire fuselage, continuation of EMI/Lighning tests, specially needed for composite structures. Static and fatigue testing with the complete fuselage are foreseen later in the programme.

The dynamic system is going on to be tested on *the Iron Bird (see Fig.3) in order to demonstrate* a 200 h endurance test. Furtheron environmentalwise representative tests for the accessory drives and conceming MGB reliability are scheduled.

Component- and subsystemwise the supporting tests are running e.g. for the main gear box (MGB) on the back-to-back rig mainly dedicated to get more longterm experience by specifically loaded endurance tests as well as representative results for dry-run capabilities, lubrication behaviour, oil compatibility.

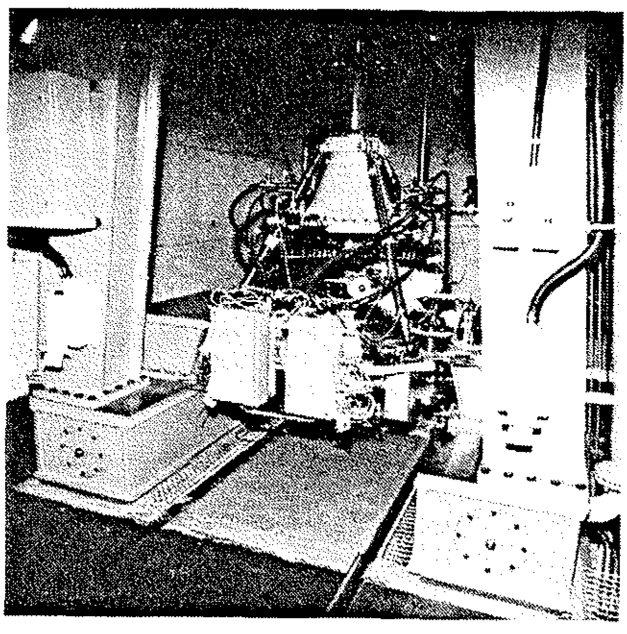

Fig.5: MGB, Back-To-Back Rig

Lateron during development also the necessary qualification and certification tests will run on this rig.

Concerning the flight control subsystem the endurance tests at the suppliers test facilities are continued, whereas at MBB the specific components and their behaviour in standard and extreme conditions are *going to be investigated* at the flight control and hydraulic test rig. It is to be mentioned here that the complete flight control system is composed out of the mechanical part and a redundant duplex AFCS-part with stabilization- and autopilot-functions.

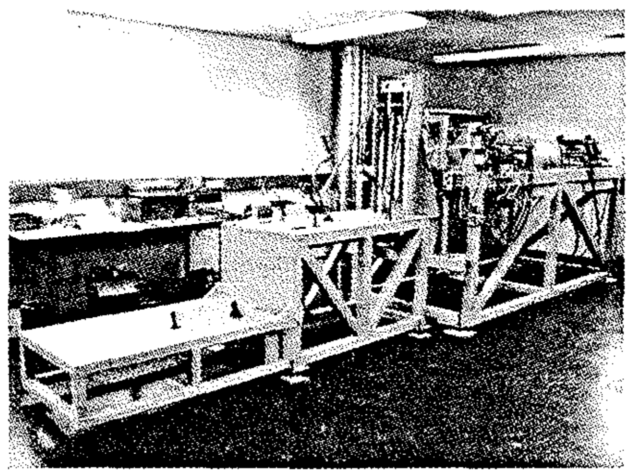

Fig.6: Flight Controls Testrig

The PT1 is equipped with the mechanical part only consisting out of mechanical controls, rods, main-rotor actuators, tail rotor actuator, preactuators and trim. In addition a PT1-specific mini-SAS with reproducable control-input generation *is installed as a so-called* FTI-equipment.

Depending on flight test analysis necessary rotor improvements are being investigated. In addition activities are launched with regard to lifetime assessment or weight reduction of elastomeric bearings or in the specific parts of the rotors, e.g. for the hub plates or blade root and transition area.

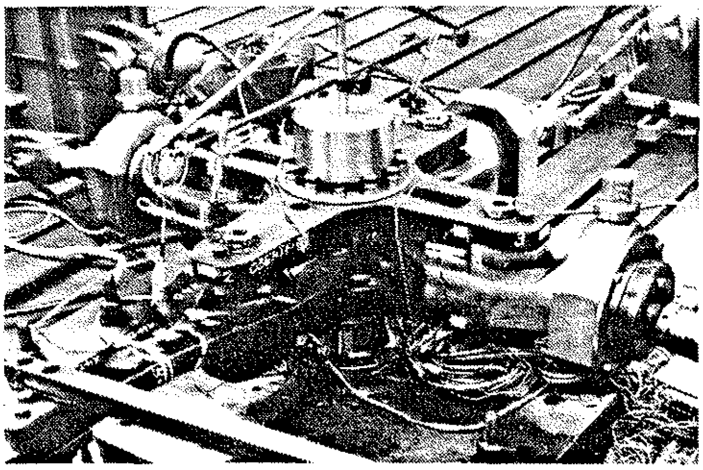

Fig.7: Hub Structure
Fatigue Test Bench

Next prototype activities

As shortly described above the next PT1 flight test activities are going to be conducted in the complete anti-tank configuration, i.e. with MMS and launchers accordingly.

Besides the continuation of first phase flight test campagnes concerning the investigation of stresses, dynamic behaviour and handling and flying qualities this second phase is mainly dedicated to

- study the MMS-behaviour itself, i.e. sight specific stresses and vibrations
- study the MMS-induced effects on the helicopter itself, i.e. SARIB-behaviour, flow-wake effects
- drag identification
- performance flights
- further extension of flight envelope.

The second next phase is going to repeat these campagnes in the HAP-configuration.

Concerning PT2 it is reminded that the exterior configuration of this prototype corresponds to the HAP-version; i.e. the helicopter will be equipped with mock-ups of nose-mounted gun, roof-mounted sight and launchers accordingly.

Whereas the vehicle-part of PT2 will be equipped according specification, there will be some deviations for the avionic systems and functionalities.

According to the availability of some equipments or their reduced performance as well as in compliance with the sequence of the flight test programme the first SW-version will have reduced functionality.

The PT2 avionic system essentially will consist out of

- bus/display subsystem
- AFCS with basic modes active, upper modes (AP-function) are needed one year later earliest
- radio com/nav subsystem in a simplified configuration
- autonomous navigation in a degraded configuration
- electronic counter measures not active

The essential flight phases planned for the first year of PT2 activities are:

- preliminary flight tests to verify the correct operation of the vehicle
- opening of the HAP flight envelope taking into account the results previously acquired from PT1 flights

- systematic operational tests of the basic system with

  * vehicle monitoring (piloting data and mechanical, hydraulic and electrical subsystems)

  * check of primary flight data

  * check of vehicle data display logics

  * failure simulation in order to check the operations of alarms

  * evaluation of the display quality in various environment conditions (light, vibrations, temperatures)

  * operation of AFCS and radio/ communication controls

It is to be mentioned that the basic avionic system is tested and validated on the Primary Integration Rig (PIR) installed at MBB, whereas a Secondary Integration Rig (SIR) is available at AS, which allows to carry out on ground tests which were previously carried out in flight, for analysis purposes.

<u>TIGER avionic system development status</u>

The TIGER avionic system design is characterized by its general architecture for the basic avionic system and for the mission equipment subsystems of the anti-tank variant (PAH2, HAC) as well as of the protection variant (HAP).

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 simulation to software design/development and system integration.

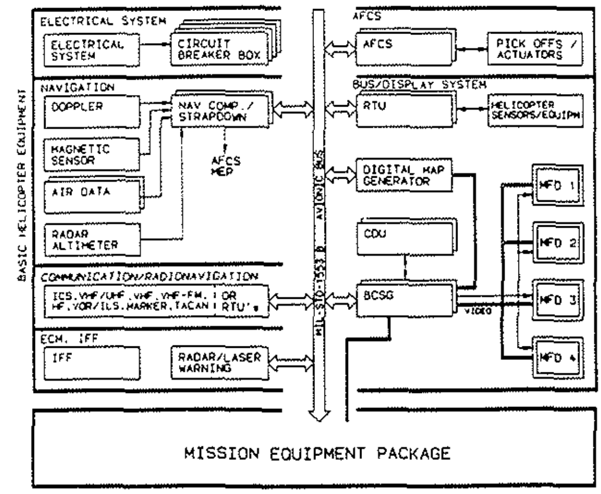

Fig. 8: Avionic System Architecture

Today the avionic system development has reached the first subsystem integration activities. The previous necessary typical development steps started from user requirements analysis. Based upon general formulated requirements in the weapon system specifications and on results elaborated in national contracts, especially for HAP mission equipment package, 15 functional chain specifications as well as specifications for system moding and control (SMC) and display and control managment (DMC) have been established.

In this phase MMI-aspects have been taken in consideration by using different simulation tools, VICO (virtual cockpit) at MBB for part task simulation of the basic system and CHEOPS at AS for HAP-MEP.

Fig.9: "CHEOPS" Lab. Simulator

In the next steps the MMI-aspects, essentially definition of formats, symbology and control logic of MFD's and CDU's are validated in several loops using full representative piloted simulators with outside world simulation.

To assess handling and flying qualities and to give design guidelines for AFCS control laws piloted simulations were performed mainly the last years in the MBB simulation control. This is *consisting of a dome with a 6 channel projection* system (GE compuscene IV).
A TIGER specific cockpit simulation (SimCo) was developped to operate autonomously or within the dome.

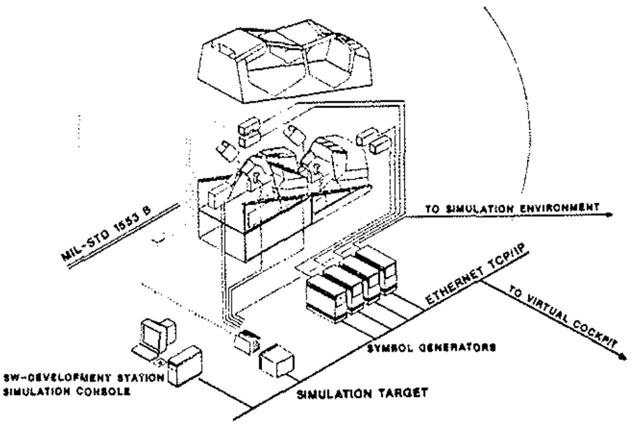

Fig.10: Simulation Cockpit "SimCo"

Control and display definition was being performed for HAP by AS in cooperation with French official services and simulation centers (CEV Istres and CELAR Reimes) and for basic *helicopter and PAH2/HAC by MBB in* cooperation with AS and experts from official services, grouped in a joint-task force (CC, consulting crew).

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.

System analysis and design is done using tools like TEAMWORK, SAO, HOSTESS by MBB and AS. As a result requirements on equipments, subsystems and operational software are derived.

As a standard for development of system-/operational SW ADA was selected. To ensure a consistent development environment appropriate supporting tools have been selected, here the RATIONAL development facility in conjunction with the ALASYS target system. This provides the consistent environment for design, coding and testing on host and target bench.

Having equipment hardware and software available the systematic integration to the complete avionic systems starts.

For integration of the avionic systems rigs are built up at MBB and AS. According worksharing the MBB-rig PIR (primary integration rig) will support *mainly the basic system and anti-tank system* whereas the AS-rig SIR (secondary integration rig) will support mainly the basic flight tests and HAP weapon system integration.

Besides the testrig of all functional chains of the system, i.e. validating the dialogue between the various equipment and SW, the further tasks of the rig are also to check the mechanical and electronical compatibility, to perform error simulation by simulation/stimulation of different signal qualities, to gain experience e.g. for definition of automatic maintenance and error retrieving software.

The entire integration equipment is mainly composed of the integration rig itself to operate the equipments, patch panels which allow an access to all avionic signals and a test system for complex measurements and tests.

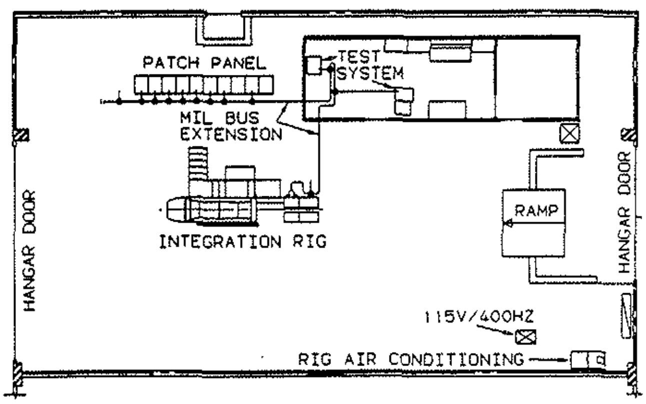

Fig.11: PIR Arrangement

The TIGER prime integration rig PIR represents the front fuselage in the original structure and the middle part in a geometric representative equipment bay arrangement.

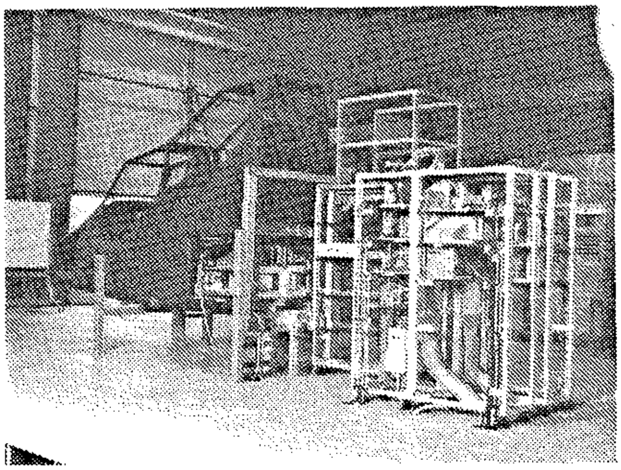

Fig. 12: TIGER Integration Rig, PIR

After having conducted the first basic avionics integration phase the PIR will be equipped with the anti-tank mission equipments of EUROMEP in order to have a full mission integration rig for PAH2/HAC.

In a similar way the AS-rig for basic system flight test support, SIR, will be linked with the HAP-MEP integration rig, named MHIR, in order to have the full HAP weapon system rig available.

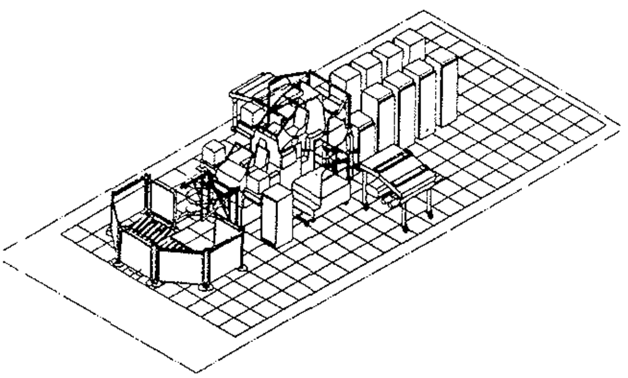

Fig. 13: SIR Scheme

The successfull test and validation on such rigs is the basis for flight testing the relevant system functions.

Before and during flight testing on the prototypes the rig will serve as flight test support facility, it will be used also to demonstrate system functions and for familiarization of crews.

Conclusion

With having successfully started the flight test phase the TIGER programme is in the decisive development phase.

The preliminary first flight test results show expected good results, as an example max. speed of 170 kt reached just one month after first flight.

Whereas the continuation of PT1-vehicle flight testing is going on in complete anti-tank configuration and later in HAP-configuration the major importance is to be attached to the system activities. There the PT2 is in the process of finalization. Vehiclewise the final assembly works have started. Systemwise the avionic system integration tests started recently with some delay due to equipment availability.

The PT2 will be ready for first flight after having conducted the sequence of final assembly activities including functional testings, safety visit by the officials and validation of the basic avionic system on the rig. The first flight is scheduled in around one year from now.

A second prototype, PT3, will support the basic avionic flight testing in an anti-tank configuration.

The mission equipment packages for HAP will be flight tested on PT4 and a retrofitted PT2, for HAC on a retrofitted PT3 and for PAH2 on PT5. These first flights are scheduled for late '93 and '94.

There is still the great challenge to meet this programme with its specific technical, contractual and cooperative aspects.