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ONE YEAR OF TIGER FLIGHT TESTS

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1 INTRODUCTION

The TIGER flight test programme has been undertaken according to the following general principles (see Ref. 1).

- 5 prototypes have been scheduled and three of those (PT1, PT2 and PT3) help develop the basic helicopter i.e. the vehicle and its avionics.
- PT4 helps develop the weaponry on the HAP version i.e. the French Army's ground support and protection version.
- PT5 helps develop the common Franco-German anti-tank version HAC/PAH2
- Futhermore, PT2 is to be retrofitted into an HAP version and PT3 is to be retrofited into and HAC version once the basic helicopter's development has been completed with those prototypes.
- Two test sites have been selected ; Eurocopter France's Marignane facility for basic flight tests and the HAP version's development; Eurocopter Deutschland's Ottobrunn facility for the HAC/PAH2 tests.
- The basic helicopter's flight development has been entrusted to an integrated Eurocopter France/Eurocopter Deutschland team designated Flight Test Integrated Team (FIT).

This paper presents the results obtained with the first prototype (PT1) from the first flight on April 27, 1991 to mid July 1992.

2 PT1 CONFIGURATION

PT1 has been designed and manufactured to fly in HAC/PAH2 external configuration i.e. with mast mounted sight and piloting visionics in the helicopter's nose, as well as in HAP configuration i.e. with a 30 mm cannon in the helicopter's nose and roof mounted sight.

Furthermore, dummies were provided of TRIGAT and HOT anti-tank missile pods as well as MISTRAL or STINGER air-to-air missile pods for in-flight carriage trials (see Fig. 1).

Rather than the production helicopter's basic avionics, PT1 is equipped with conventional instruments and an adapted SA 332 system of electrical generation. PT1''s test installation is built up around two computers ; the first, designated CATINA, acquires

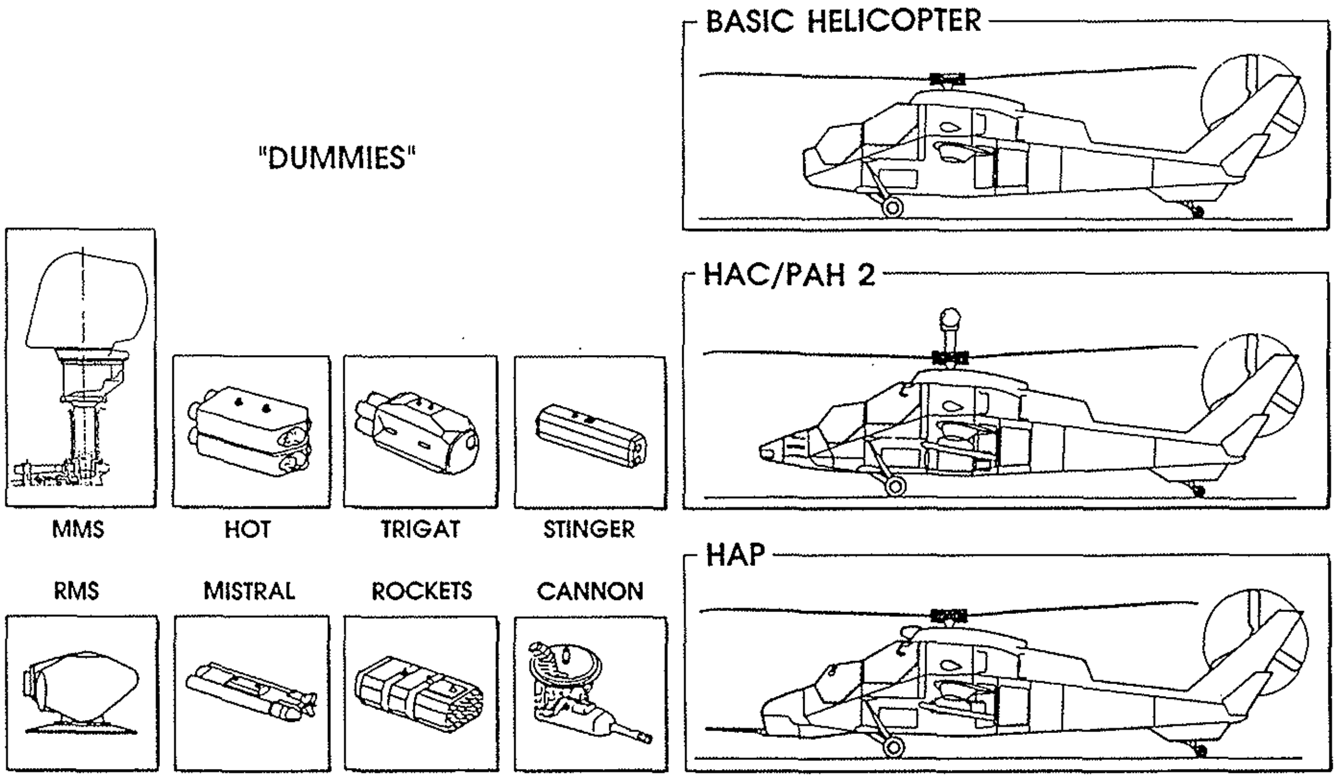

FIGURE 1 : EXTERNAL CONFIGURATION

parameters varying slowly i.e. attitude, altitude, speed and engine parameters ; the second designated SOCRATE acquires parameters varying rapidly i.e. stresses and vibrations.
Overall, the test installation allows the recording of approximately 600 parameters on board the helicopter, including 60 in rotating axis on the main rotor.
Digital messages are processed either in real time after transmission by telemetry, or off-line by the Eurocopter France Flight Test Department's calculation centre in Marignane. Every PT1 test flight has up till now been monitored by telemetry both for safety and test productivity improvement reasons.

3 FLIGHT HISTORY

PT1 has completed 91 flights in 94 hours including 54 hours in HAC/PAH2 configuration and 10 hours in HAP configuration. The key dates are :

- First flight on April 27, 1991
- Presentation at the Paris Air Show on June 13-22, 1991
- First flight with mast mounted sight (HAC/PAH2 version) on October 9, 1991
- First evaluation by French and German Army pilot's (CEV and WTD61) on December 12, 1991
- First flight in HAP configuration on June 11, 1992.

10% of the development hours were flown, in accordance with the contract, by mixed Official Services/Industry or Officials only crews.

4 MAIN RESULTS

4.1 Flight envelope

It can now be considered that the original flight envelope has been explored or, at least, that part of the flight envelope which could be explored in the weather conditions prevaling at Marignane.
Figure 2 presents, with pressure altitude/indicated airspeed coordinates, the envelope opened in level flight and dives.
Figure 3 presents the load factor envelope stabilized in level flight or descent as a function of indicated airspeed.
The points presented on Figure 3 are the load factors the main rotor servo-controls power allows on a single booster.
As regards low speeds, the manoeuvrability limits were explored in lateral flight up to 60 kt (Figure 4) and rear ward flight up to 50 kt.
A 6350 kg reduced mass was demonstrated in hover OGE and numerous flights were performed at 5.7 T all-up weight, which is thought to cover today every mission configuration of the heaviest version, HAC/PAH2.

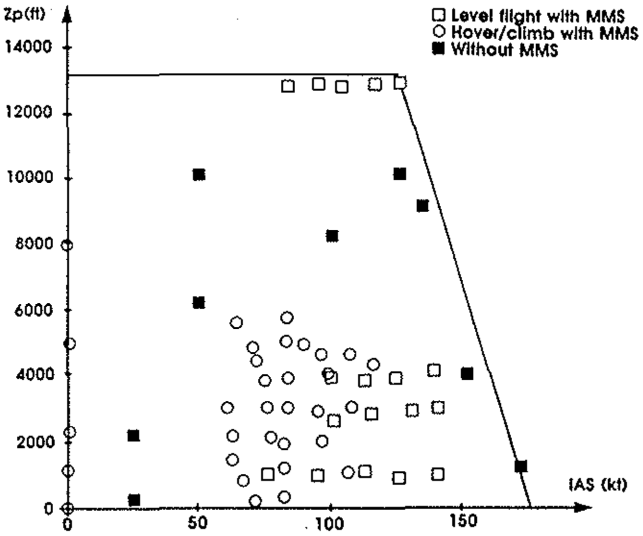

FIGURE 2 : FLIGHT ENVELOPE - ALTITUDE - INDICATED AIRSPEED

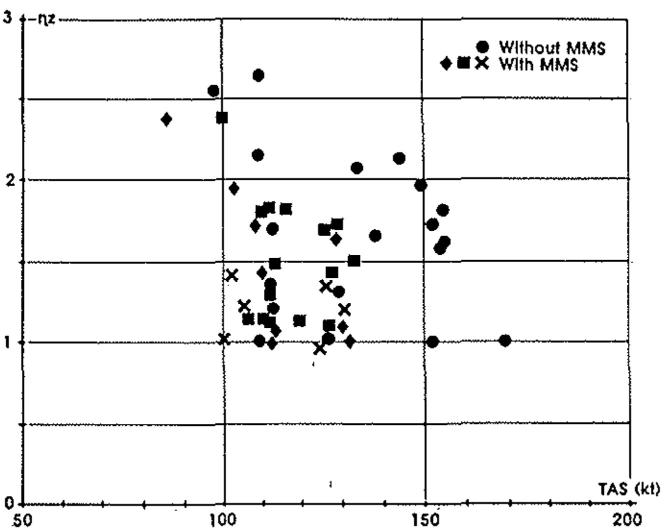

FIGURE 3 : FLIGHT ENVELOPE - LOAD FACTOR - TRUE AIRSPEED

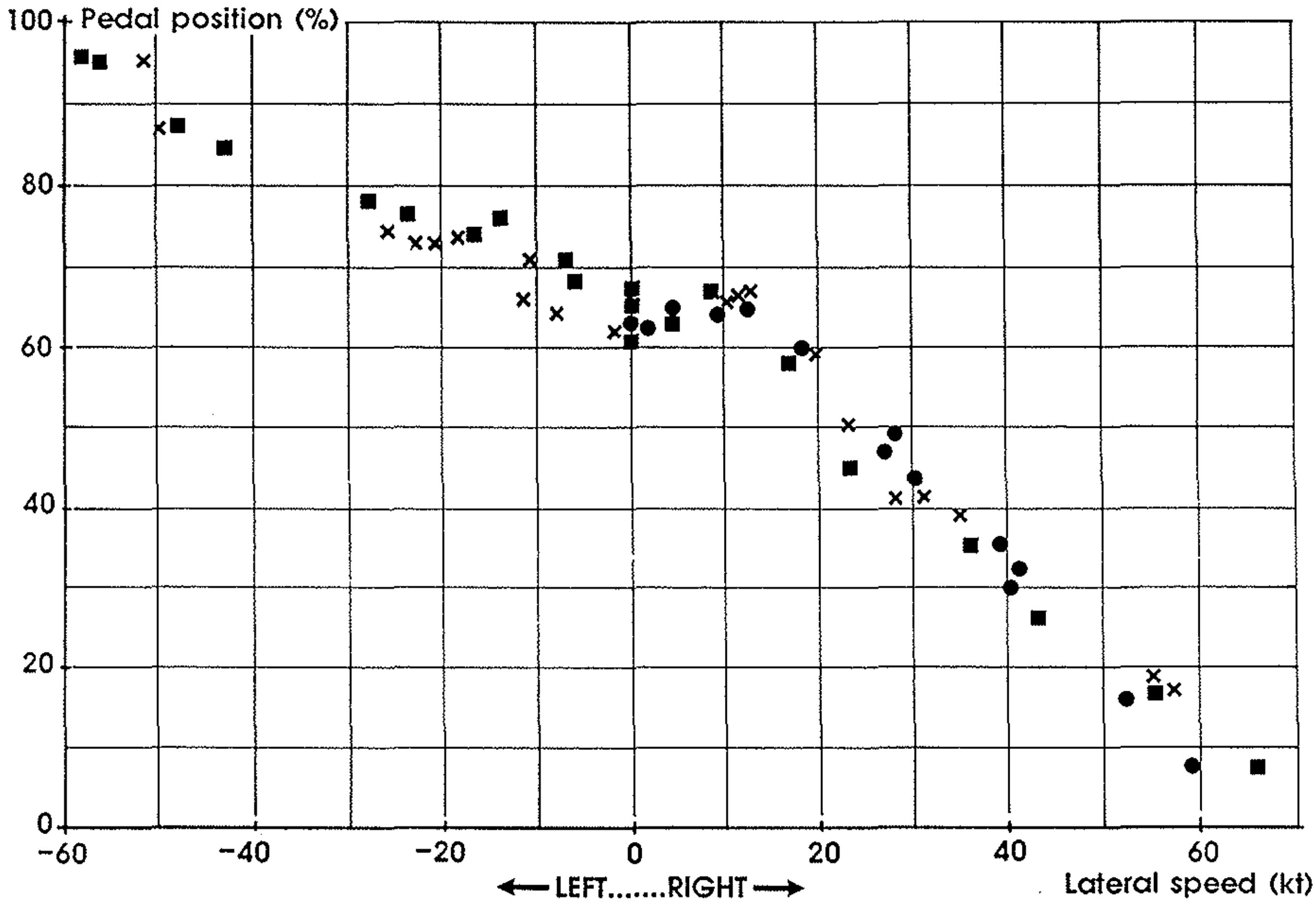

FIGURE 4 : SIDEWARD FLIGHT - PEDAL POSITION Vs LATERAL SPEED

4.2 Performance

It proved possible, after mounting of the mast mounted sight, to check that power required is in accordance with, or lower than, predictions with the mission equipment drag configurations.

Figure 5 presents a comparison between flight test and aerodynamic predictions.

The correlation is proved to be satisfactory, as a result of the extensive wind tunnel tests that were undertaken with a 1/8th scale model in Marignane in 1989 and 1990 (Figure 6).

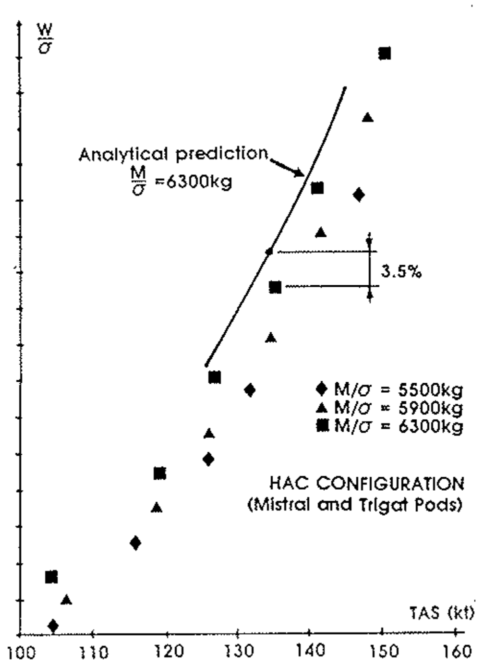

FIGURE 5 : LEVEL FLIGHT PERFORMANCE PREDICTION/TEST COMPARISON

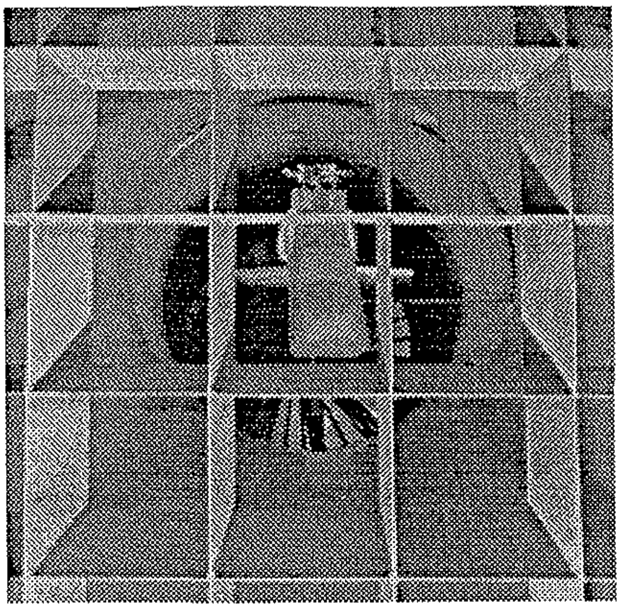

FIGURE 6 : TIGER 1/8th SCALE MODEL

4.3 Handling qualities

The longitudinal static stability was analyzed at several c.g. configurations, and was found to meet FAR 29 requirements. Furthermore, records were made of the dynamic helicopter behaviour with cyclic stick, collective and pedals fixed, which helped determine the time to double amplitude of the phugoid oscillations (See figure 7).

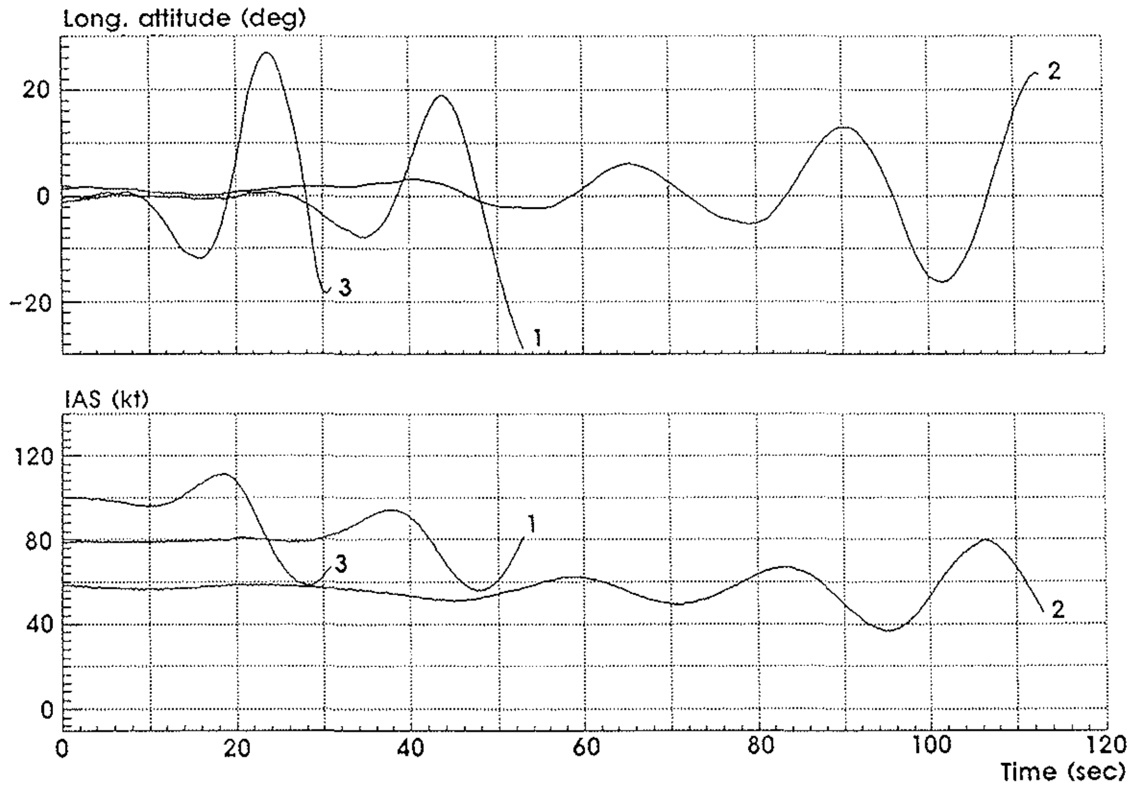

FIGURE 7: PHUGOID

Longitudinal static and dynamic stability were, generally, considered satisfactory from the beginning of the flight trials with the horizontal stabilizer in the initial (aft) or forward position and, as explained in this paragraph, different factors e.g. maintenance will be taken into account upon the final selection of this stabilizer position.

Transverse handling qualities were analyzed by studying the helicopter's behaviour at different stabilized sideslips (dihedral and weathercock effects). The contribution of the horizontal stabilizer's endplates has, in particular, been quantified during numerous flights without endplates. All flight tests to date have been flown without any form of automatic stabilisation. However, a SEXTANT analog AFCS, different from the production helicopter's digital AFCS, is fitted and foreseen to study the helicopter's dynamic behaviour and should help check the validity of the gains predicted before the PT2 and PT3 flights.

The TIGER's NOE combat ability was contractually characterized by typical manoeuvres designated «agressive manoeuvres» or «mission task elements». Most of these are derived from Ref. 2 and are, for example,

- Acceleration time from 0 to 60 kt forward
- Deceleration time from 0 to 60 kt forward
- Acceleration time from 0 to 30 kt sideways
- Deceleration time from 30 to 0 kt sideways

Other manoeuvres involve flying a «dolphin» manoeuvre, switching from +2 to 0g, and slaloming between imaginary stakes over a 15 m wide side band (Figure 8).

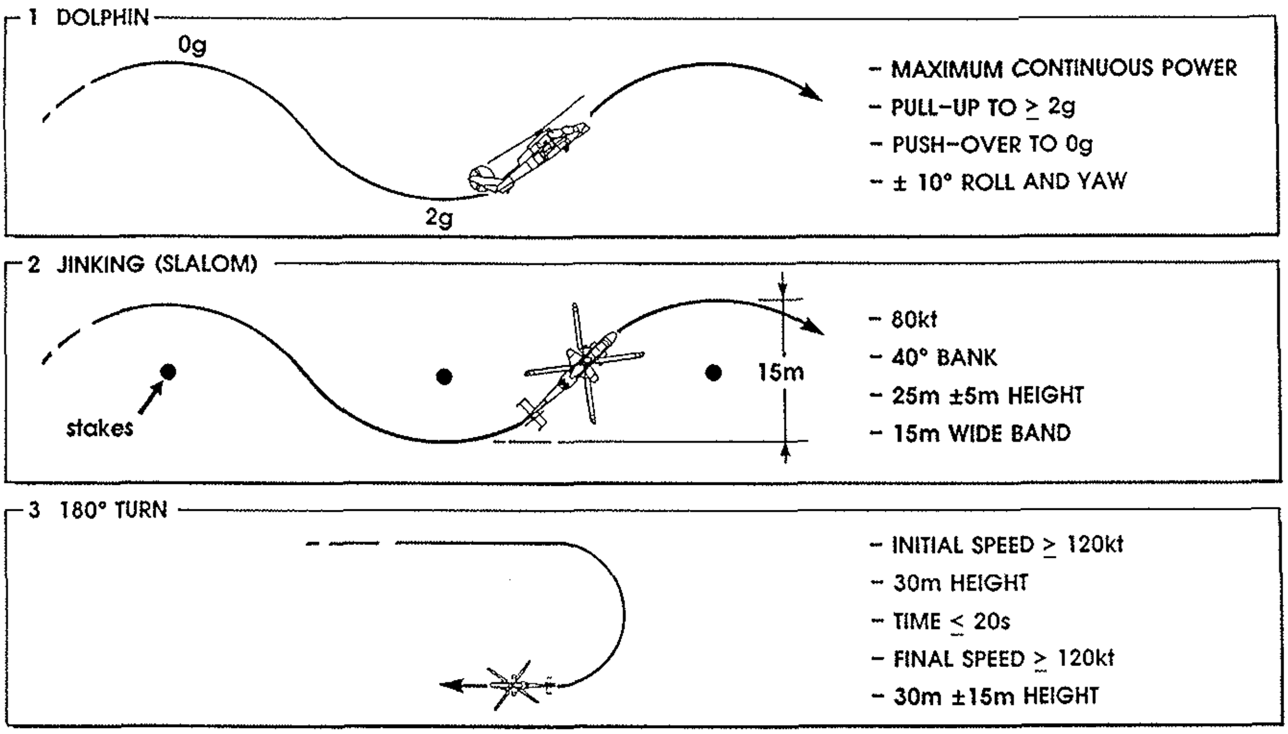

FIGURE 8 : AGRESSIVE MANOEUVRES (MISSION TASK ELEMENTS)

These manoeuvres were performed with PT1, and the ease with which they can be performed shall have to be assessed by operators on the Cooper-Harper scale.

4.4 Vibration level

The TIGER's main rotor is of the hingeless type with a flapping hinge offset equivalent to 10%. Because of the mission equipment requirement for low vibration level, a filtering system designated SARIB is fitted and is extensively described and validated in (Ref. 3 and 4).

After some flapping weight adjustments, excellent results were obtained at 4 per rev and 8 per rev as a function of speed (Figure 9) and load factor (Figure 10) ; SARIB also proved fairly insensitive to rotor speed, at least in the speed range authorized by the engine governor and the autorotation speed range. PT1 complies with the specifications throughout the operating envelope explored today, both in the HAC version with mast mounted sight and HAP version with a 30 mm cannon in the nose.

In order that the mast mounted and roof mounted sight operate satisfactorily, the vibrations cannot be too severe, for both linear and angular accelerations.

Two types of mast mounted sight supports, differing mainly in their rigidity, were tested in 1992, with the intention of validating the ground test results and to establish a data base necessary for the design of a support optimised to meet the environmental requirements (See Figure 11).

4.5 Ground resonance

All aircraft loading configurations have proved to be free of ground resonance.

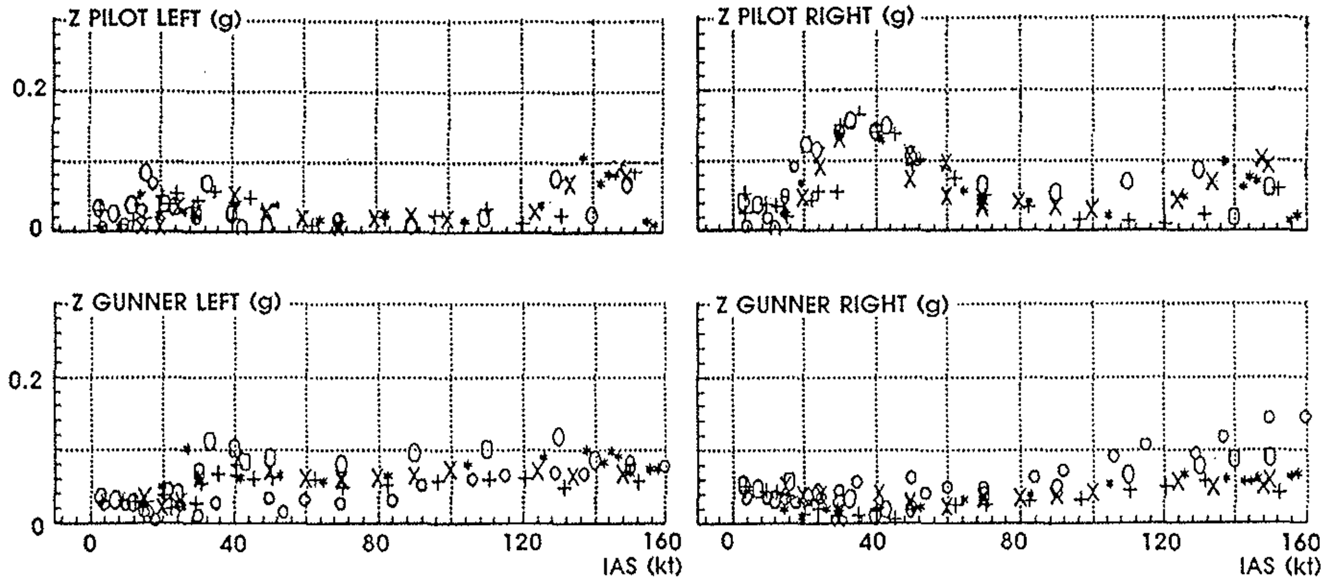

FIGURE 9 : COCKPIT VIBRATION (4/REV) Vs INDICATED AIRSPEED

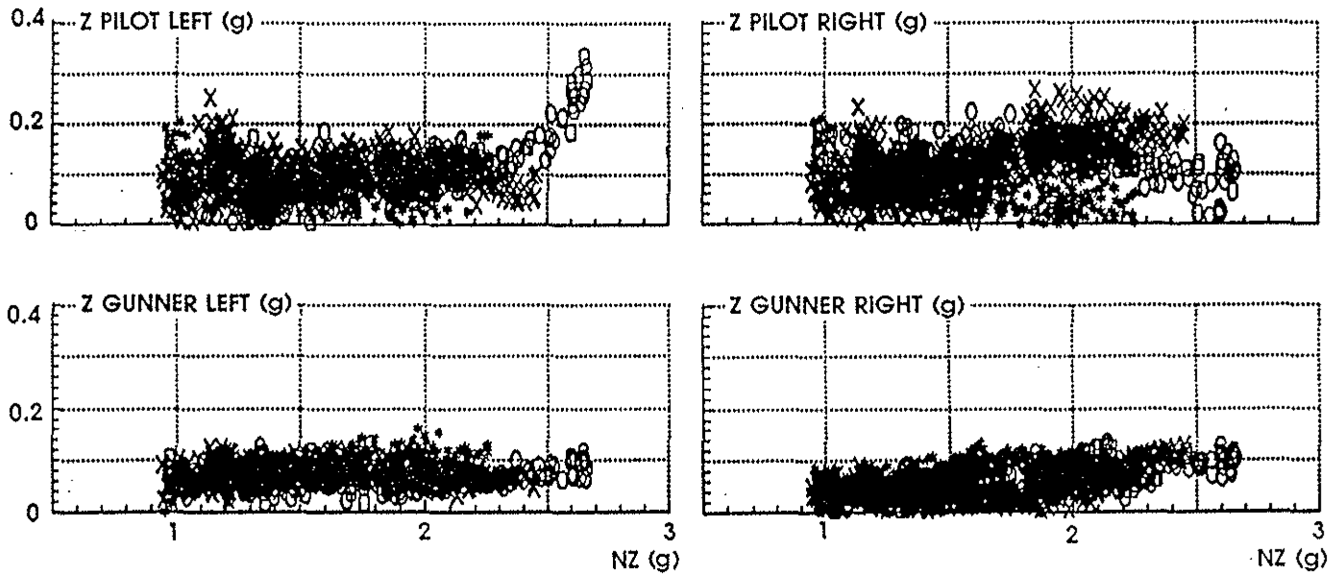

FIGURE 10 : COCKPIT VIBRATION (4/REV) Vs LOAD FACTOR

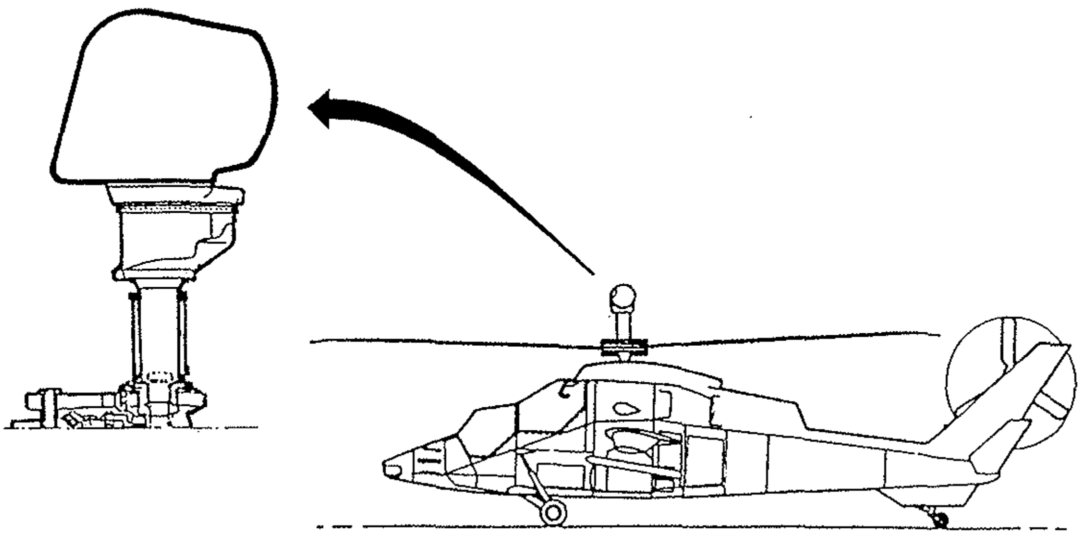

FIGURE 11 : MAST MOUNTED SIGHT SUPPORT

5 PROBLEMS ENCOUNTERED AND PT1 MODIFICATIONS

5.1 Horizontal stabilizer position

It had been decided, when the helicopter was being designed, to position the horizontal stabilizer very far aft on the fuselage to meet the following two objectives :

- Very low and even zero negative lift in hovering flight, because the stabilizer is not concerned by the main rotor induced airflow

- High longitudinal stability efficiency with a lever arm set to the maximum (tail unit - rotor centre distance).

The drawbacks of this decision became apparent from the first flights. When the helicopter moves from hover to forward flight, the airflow induced by the main rotor is impinges on the tail unit and causes the fuselage to pitch nose up the pilot must then move the cyclic stick forward to counter this pitch-up moment. Overall, a significant change is noted, as shown on Figure 12, in the longitudinal attitude and moment at 1 per rev in rotating axis on the main rotor mast. It was thus decided to move the horizontal stabilizer forward (See Figure 13). Flight tests demonstrated that pitch-up is cancelled and the mast moments are reduced with the stabilizer forward (See Figure 12). To date, the horizontal stabilizer's size and position optimization has not yet been completed, because the objective is to define an optimum configuration both for the HAP and HAC version with their different armaments.

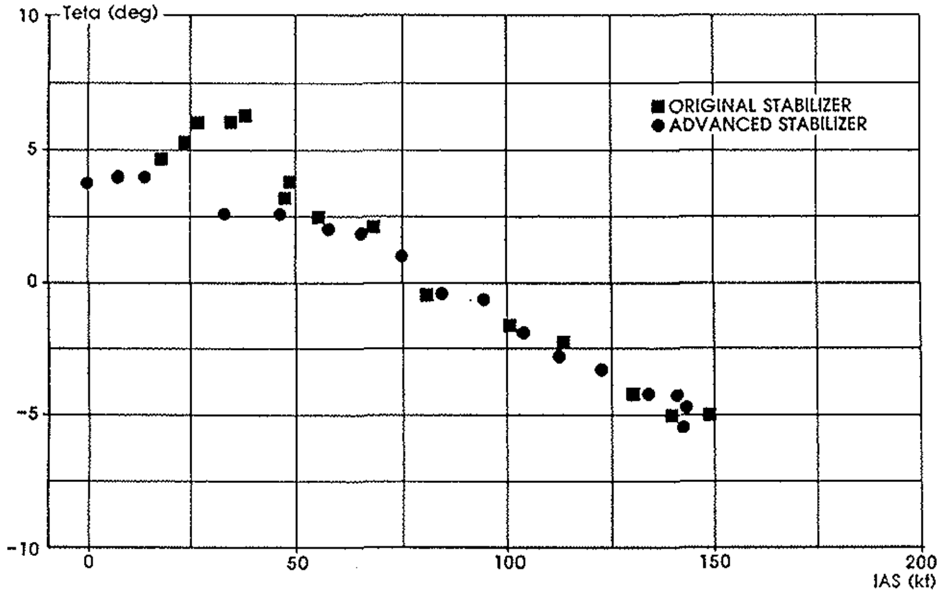

FIGURE 12a : LONGITUDINAL ATTITUDE

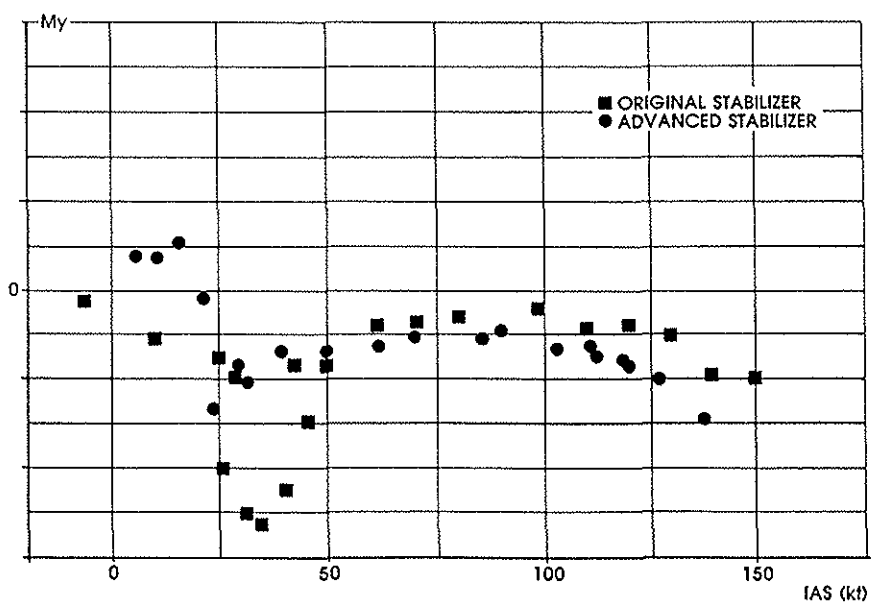

FIGURE 12 b : MAST BENDING MOMENT (1/REV)

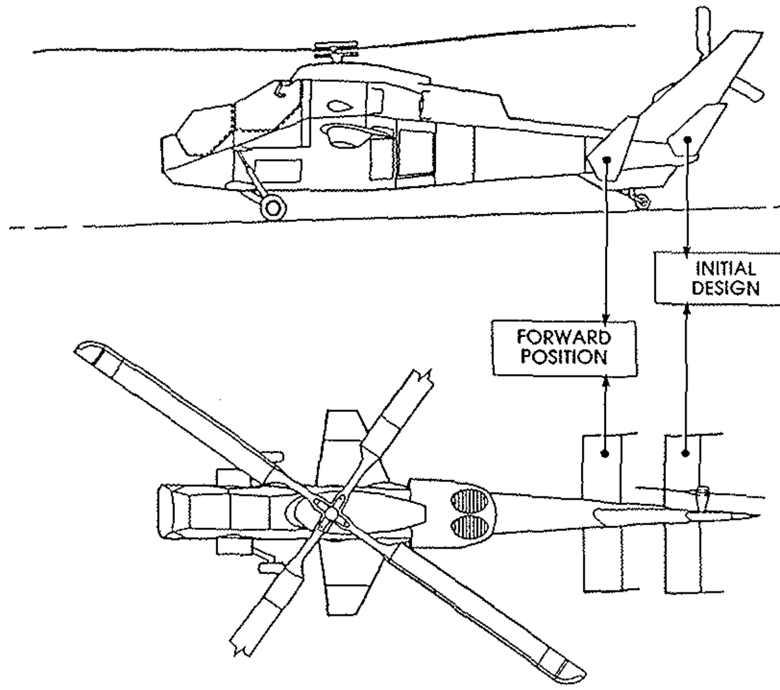

FIGURE 13 : STABILIZER LOCATION

5.2 Tail shake

This phenomenon, well known on every modern helicopter prototype, is generated by the separate air flows running from the centre of the rotor or some parts of the fuselage that excite the tail of the helicopter, and on TIGER, more specifically, the vertical fin. This results in unsteady vibrations of relatively low (1 per rev approx.) frequency especially felt in descent. As far as TIGER is concerned, the airframe mainly responds to the 2nd lateral mode (2 modes mode) of the fuselage (See Figure 14) where the helicopter's nose and the pilot are subjected to significant movements while the gunner remains unaffected.

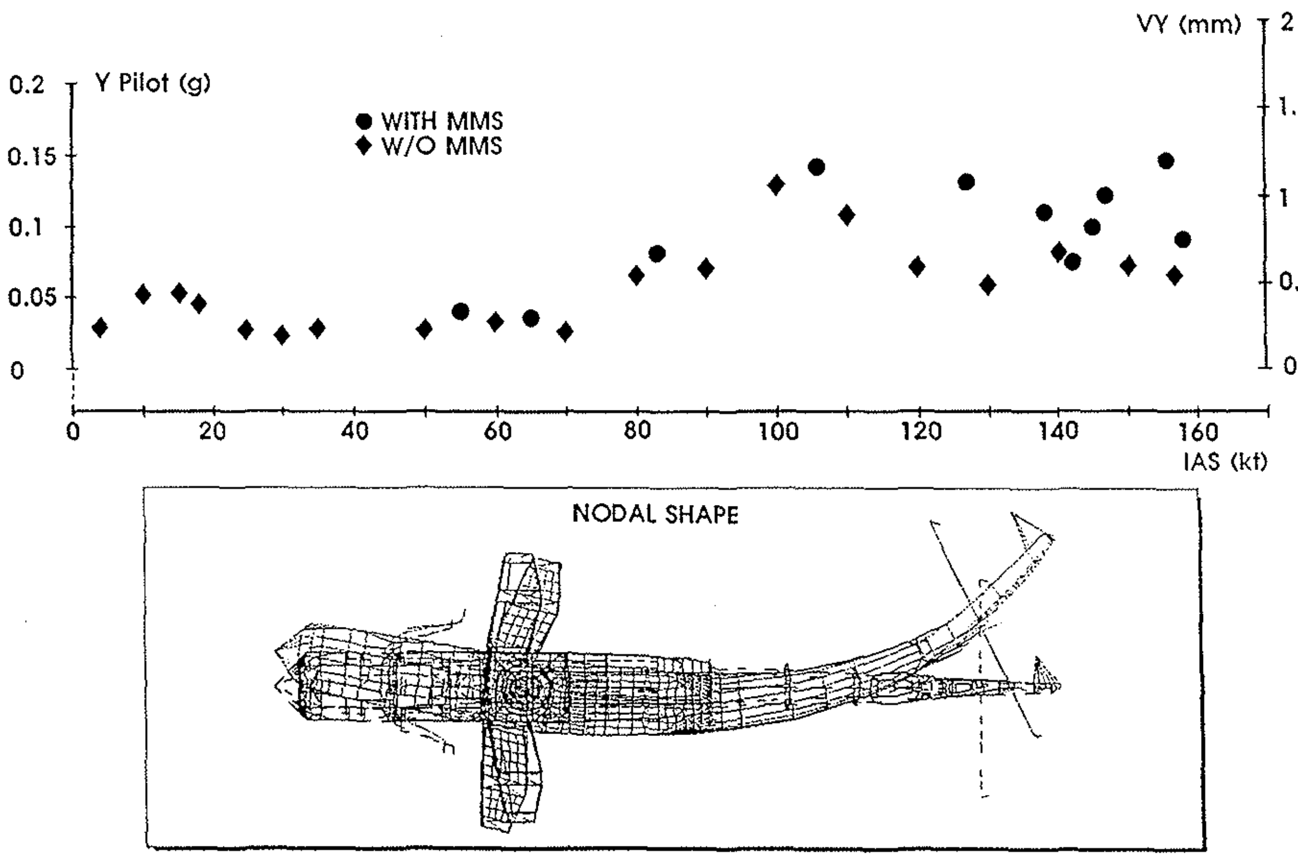

FIGURE 14 : TAILSHAKE VIBRATIONS (FREQUENCY 1/REV)

The solution to this problem was a systematic wind tunnel scan in total pressure and turbulence intensity downstream of the rotor centre. This helped locate the turbulent vortices and their impact on the vertical fin. These tests were confirmed with smoke displays (oil injection into the exhaust pipes) in flight. The wind tunnel study was judged to be satisfactory. It became possible to optimize the MGB cowling with a mock-up until the size of the turbulent vortices was reduced and moved away from the centre of the vertical fin (See Figure 15). Once PT1''s MGB cowling had been modified accordingly flight tests confirmed the improvement recorded in the wind tunnel.

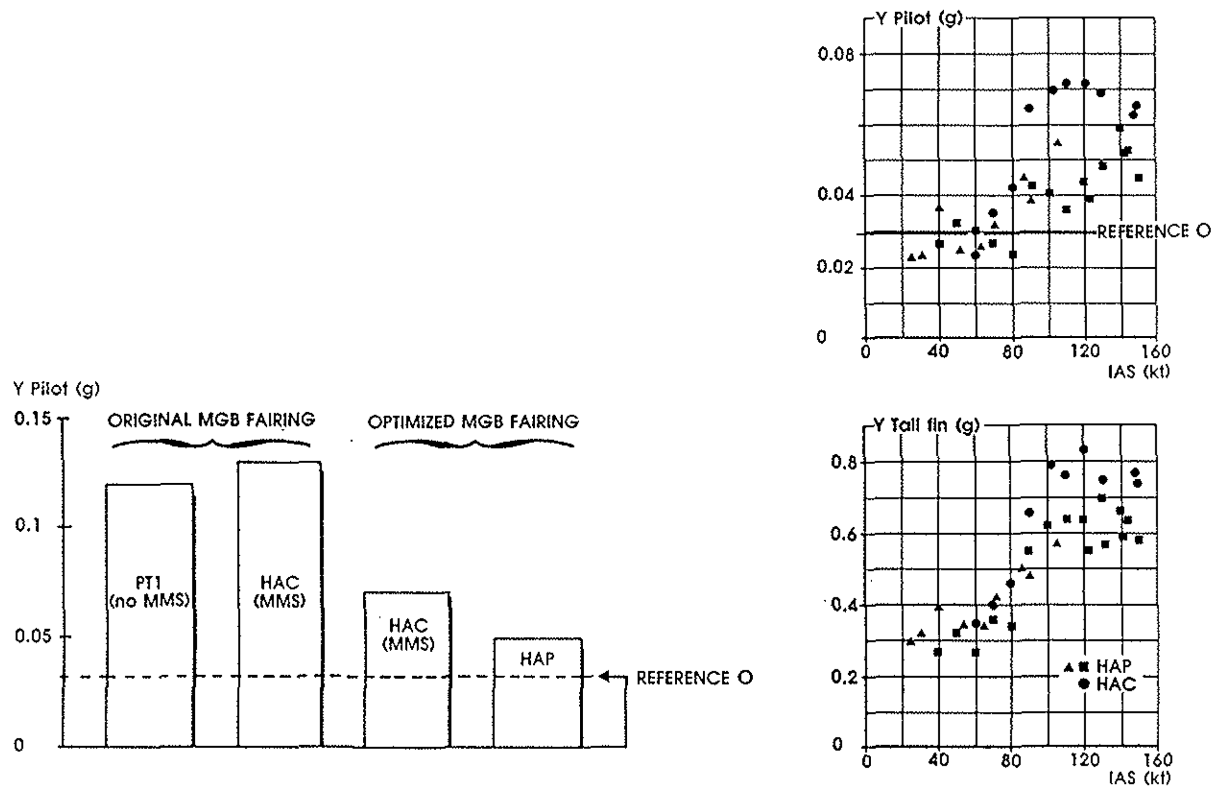

FIGURE 15 : TAILSHAKE VIBRATIONS IN LEVEL FLIGHT

6 CONCLUSION

One year of TIGER frist prototype flight tests helped explore to a large extent the operating envelope. The versatility of this prototype as regards armament configurations helped progressively to define optimum solution for both the ground support and protection (HAP) and the anti-tank (HAC/PAH2) versions. The original challenge, which involved having a basic vehicle strictly identical for both versions, is being met. The modifications that were made regarding handling qualities and tail shake are proving positive. There remains now for the flight test team the challenge of handling a new avionics update beginning with PT2''s first flight.

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