CASE STUDY

IAE Division of DCTA – Operational Modal Analysis on a Helicopter

Brazil
Aerospace & Defence
PULSE

The Brazilian Air Force tasked the IAE division of the Department of Aerospace Science and Technology (DCTA) with testing and validating the impact of modifications made to a medium-weight, multi-purpose helicopter – modifications that could potentially influence both the structural and aerodynamic behaviour of the helicopter.

Using Brüel & Kjær's PULSE data acquisition and analysis platform, Operational Modal Analysis (OMA) was carried out on both the modified and unmodified helicopter during on-ground and in-flight tests. These tests made it possible to identify any critical modes that would significantly influence the structural and aerodynamic behaviour of the helicopter with consequential maintenance and safety issues.

Photos courtesy of DCTA, IAE and the Brazilian Air Force

Brüel & Kjær

Introduction

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Comparison of the analysis on the modified and unmodified helicopter identified shifts in natural frequencies resulting from the modifications, as well as increased vibration levels when the payloads were attached. As a result of the tests, the Brazilian Air Force was able to update its flight procedures and the operating profiles of the helicopter.

About DCTA

The Department of Aerospace Science and Technology (DCTA) is the national military research centre for aviation and space flight of Brazil. It is subordinated to the Brazilian Air Force, The Ministry of Defence.

Established in 1953, DCTA coordinates all technical and scientific activities related to the aerospace sector and in which the Ministry of Defence has an interest. It currently employs several thousand civilian and military personnel.

The Institute of Aeronautics and Space (Instituto de Aeronaútica e Espaço, IAE) is a division of DCTA and develops projects in the aeronautical, aerospace and defence sectors. It is co-responsible for the execution of the Brazilian Space Mission.

Scope of the Testing

The modifications made to the helicopter included adding mounts for carrying a variety of payloads. The testing was made to validate and understand the possible interference of the added mounts with the known, existing modes of the helicopter.

The complete test consisted of on-ground and in-flight Operational Modal Analysis on the tail section and the helicopter's added mounts. Flight tests further validated the flight envelopes of the modified helicopter while carrying and using added payloads. All tests were carried out on both unmodified and modified configurations to enable a direct understanding of the effects of the modifications. Using only Operational Modal Analysis for all tests greatly simplified the complete test procedure and consequently reduced expensive test time.

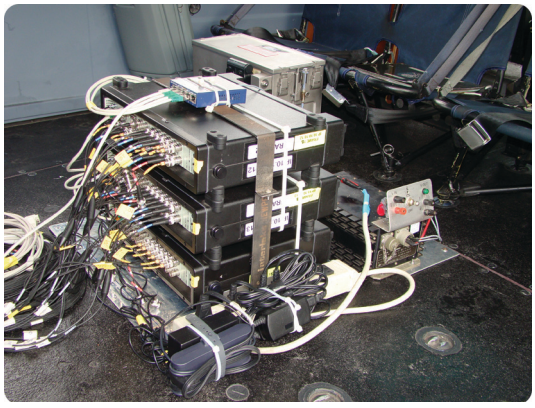
The actual aircraft modifications consisted of adding mounts for carrying variable payloads to bear different armament or observation pods. The mounts can hold machine guns, tube launcher pods, camera pods or be unoccupied. The added mounts and the different payloads affect both the structural characteristics of the aircraft structure and the airflow along the tail section and over the horizontal stabiliser of the helicopter. It was, therefore, necessary to thoroughly test each configuration to look for coupling effects between the payload modes and the modes of the tail section.

Equipment used for the Ground and Flight Test Programme

PULSE Multichannel Data Acquisition and Analysis Platform

Brüel & Kjær modal accelerometers Types 4514 and 4520 were mounted on the tail and the horizontal stabiliser of the helicopter. Cabling was routed to a 51-channel PULSE System (three 17-channel Type 3560-C front-ends) mounted in the cockpit.

Fig. 1
Some 30 accelerometers were mounted on the tail section of the helicopter (left); a 51-channel PULSE system was mounted in the cockpit for both the on-ground and in-flight tests (right)



Operational Modal Analysis

Operational Modal Analysis was carried out using the integrated package of PULSE LabShop, PULSE Modal Test Consultant Type 7753 and PULSE Operation Modal Analysis software Type 7760.

Operational Modal Analysis is an analysis tool for effective modal identification in cases where only the output is known. The software allows you to perform accurate modal identification under operational conditions and in situations where the structure is impossible or difficult to excite using externally applied forces.

PULSE Modal Test Consultant Type 7753 provided geometry-driven data acquisition and seamlessly transferred data to the Operational Modal Analysis software for analysis and validation, providing an integrated, easy-to-use modal test and analysis system.

On-ground Excitation

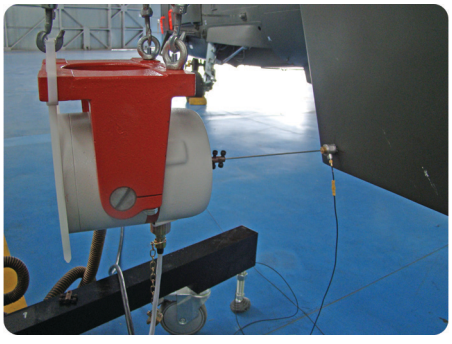
For the on-ground testing, an LDS V455 permanent magnetic shaker with power amplifier PA 1000 was used. Impact testing was performed using a Brüel & Kjær Heavy Duty Impact Hammer Type 8207.

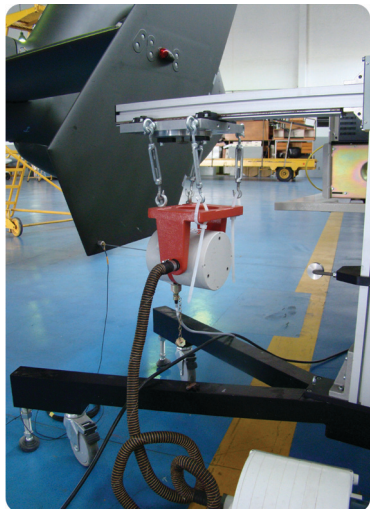
On-ground Test

The scope of the on-ground test was a full modal analysis on the tail section and the added mounts. These tests would predict and validate the structural effects on the modified helicopter to provide greater understanding of the possible interference of the added mounts with the known existing modes of the helicopter.

It was decided to provide excitation from both shaker and impact hammer – shaker testing for the tail section and hammer testing for the mounts. This is not the normal mode of exciting structures for OMA testing, but comparisons with previous classical modal analysis test results verified this test method by showing identical results for the critical modes of interest.

Fig. 2
Shaker tests were carried out as part of the on-ground testing to identify critical modes





Flight Test

The scope of the flight test program was to carry out structural analysis and to verify the impact on the existing flight envelope of the helicopter based on the different mount configurations and their usage. The change in structural modes from ground and in-flight testing of the same standard helicopter configuration could be compared with in-flight testing of the modified helicopter configuration.

To ensure comparable results, a fixed flight test plan was put in place covering the operational heights (2700 – 8000 ft), speeds (up to maximum speed), and different pitch, roll and yaw manoeuvres of the helicopter. This provided validation of the different armament and observation pods against the complete flight envelope.

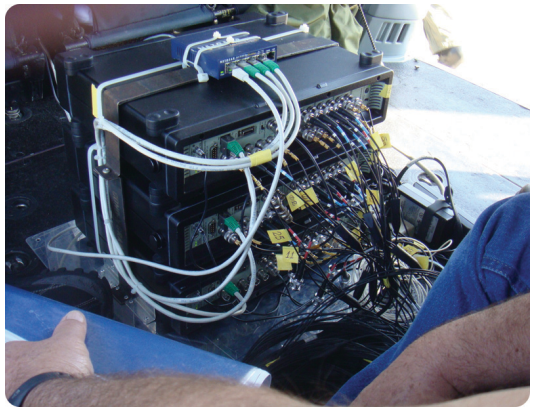


Fig. 3
Dr. Edilson Camargo, PhD and leader of the group for Dynamic tests (right) and Mr. Domingos Strafacci, Technician specialising in dynamics tests (left), ready for the flight test with the PULSE system wired up

The flight envelope was effectively validated by going through the complete flight profile using different configurations:

- Empty mounts
- Mount equipped with a machine gun installed on one and both sides
- Mount equipped with a launcher pod installed on one and both sides
- Mount equipped with a camera pod

The effects of launching rockets and using the machine gun (on one and both sides) were also tested, and taken into consideration.

Conclusion

Using PULSE and PULSE OMA for ground and flight tests allowed the Brazilian Air Force to update their flight procedures and operating profiles for the helicopter. It also allowed them to gain valuable knowledge of the best possible helicopter configuration to attain mission objectives, while maintaining optimum safety for the flight crews.

For details of the measurements and OMA results and conclusions, see "Operational Modal Analysis on a Modified Helicopter", presented at IMAC 2011 by E. Camargo & D. Strafacci (CTA) and N. J. Jacobsen (Brüel & Kjær).

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