CASE STUDY

Brüel & Kjær
BEYOND MEASURE

DCTA TESTS MODIFIED HELICOPTERS WITH IN-FLIGHT STRUCTURAL ANALYSIS

After the helicopters of the Brazilian Air Force were modified to carry a variety of payloads, DCTA needed to assess their structural performance. By analyzing the structural dynamics both on the ground and throughout all flight conditions, DCTA informed the updating of the aircraft's flight profiles – ensuring structural integrity in the field.

CHALLENGE

Quantify the impacts on an aircraft's structural performance from adding mounts and payloads

SOLUTION

Analyzing structural dynamics on the ground, and during a standard flight procedure that reflects the full operational flight envelope

RESULTS

Accurately updated flight procedures and operating profiles, to ensure safety despite increased vibration levels and changes in natural frequencies

BACKGROUND

Brazil's Air Force use their helicopters for multiple purposes. After modifications were added that enable helicopters to carry different armaments or observation pods, they needed to ensure the helicopter's airworthiness. The IAE division of DCTA was tasked to conduct the necessary testing.

Since the modifications could potentially influence the structural behaviour of the helicopter, it needed structural testing to ascertain and validate the impact of the modifications – especially vibrations at the tail, which is a highly critical component.

CHALLENGE

Adding mounts to a helicopter affects both the structural characteristics of the aircraft, and the airflow along the tail section and over the horizontal stabilizer of the helicopter. The payloads carried by the mounts such as machine guns, tube launcher pods, and camera pods also affect the structural performance and airflow of the aircraft in different ways.

The existing performance of the helicopter was already known and flight certified, so DTCA needed to test the aircraft with the newly added mounts and various payloads. This was to validate and understand the altered structural performance with the extra weight and aerodynamic effect of the new payloads.

It was therefore necessary to thoroughly test each possible new payload configuration, to compare the updated performance with the known modes of the helicopter. To ascertain the specific effects of the modifications, DCTA needed to look for coupling effects between the payload modes and the modes of the tail section.

About DCTA

Established in 1953, Brazil's Department of Aerospace Science and Technology (DCTA) is the national military research centre for aviation and space flight of Brazil.

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.

SOLUTION

To fully understand the impact of the modifications, DCTA performed operational modal analysis (OMA) on both the modified and unmodified helicopter during both on-ground and in-flight tests. They concentrated their attention on the tail section and on the helicopter's newly added mounts.

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. DCTA 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.

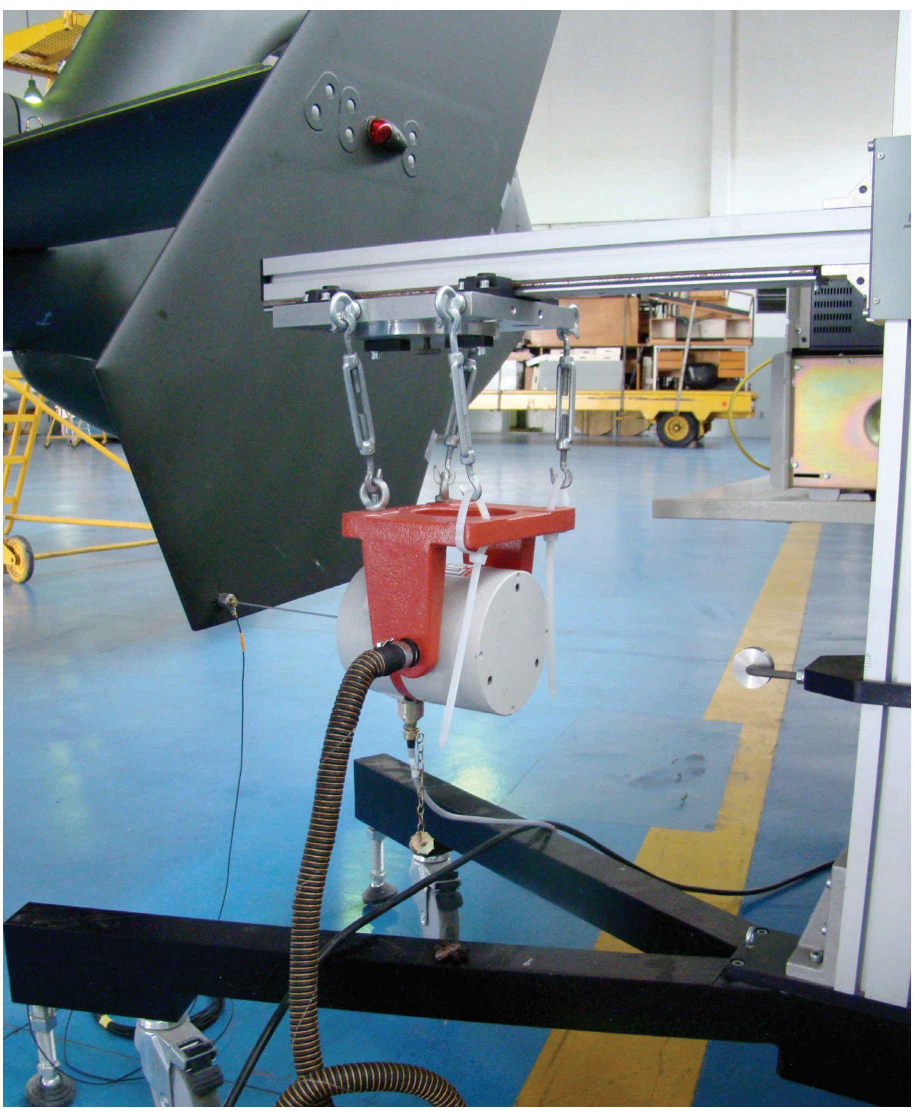
Ready for the flight test: Dr Edilson Camargo, leader of the group for dynamic tests (right) and Mr Domingos Strafacci, Technician specializing in dynamics tests (left)

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.

Flight test

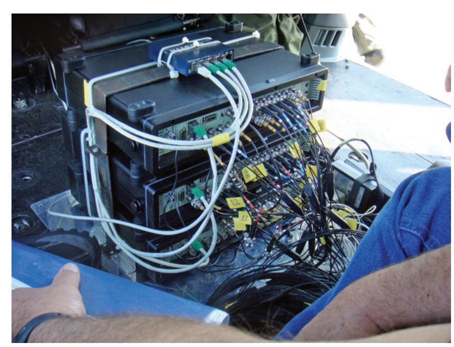
The scope of the flight test program was to verify the impact on the existing flight envelope of the helicopter, based on the different mount-payload configurations (armament and observation pods), and to assess the effects of their usage. To ensure comparable results, a fixed flight test plan covered the complete flight envelope: a range of operational factors such as heights from 2700 – 8000 ft., speeds up to maximum speed, and different pitch, roll and yaw manoeuvres. The pilot took the aircraft through this complete flight profile using different configurations:

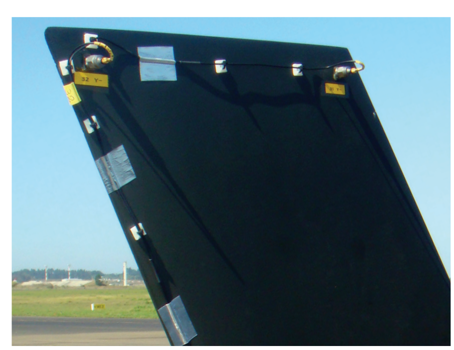
- Empty mounts
- Mount equipped with a machine gun installed on one and both sides
- Mount equipped with a launcher pod installed on one and both sides
- Mount equipped with a camera pod



On-ground testing to identify critical modes used a combination of an LDS V455 shaker, and a Brüel & Kjær Heavy Duty Impact Hammer Type 8207 for excitation

Some 30 modal accelerometers (Types 4514 and 4520) were mounted on the tail and the horizontal stabilizer of the helicopter





USING ONLY OPERATIONAL MODAL ANALYSIS FOR ALL TESTS – BOTH ON-GROUND AND IN-FLIGHT – GREATLY SIMPLIFIED THE COMPLETE TEST PROCEDURE AND CONSEQUENTLY REDUCED EXPENSIVE TEST TIME.

RESULTS

The change in structural modes from ground and in-flight testing of the standard helicopter configuration was compared with ground and in-flight testing of the modified helicopter configurations. Comparison of the analyses 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.

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

As a result of the tests, the Brazilian Air Force was able to update its flight procedures and the operating profiles of the helicopter, to ensure safety when using different mounts and payloads.

CONCLUSION

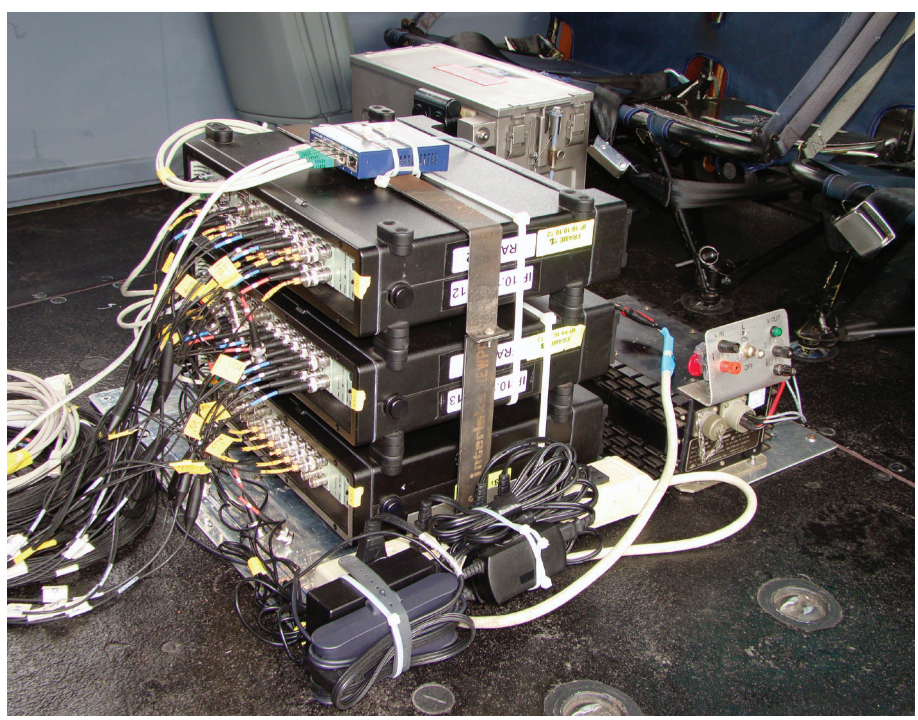
All tests were carried out on both unmodified and modified configurations to enable a direct understanding of the effects of the modifications. These tests made it possible to identify any critical modes that could significantly influence the structural and aerodynamic behaviour of the helicopter with consequential maintenance and safety issues.

Using only operational modal analysis for all tests – both on-ground and in-flight – greatly simplified the complete test procedure and consequently reduced expensive test time.

The tests gained the Brazilian Air Force valuable knowledge of the best possible helicopter configurations to attain their mission objectives, while maintaining optimum safety for the flight crews. With the information from DCTA, they were able to update the flight procedures and operating profiles for the helicopter.

OMA

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. However, it can also be performed using artificial excitation with a hammer or vibration exciter.



A 51-channel PULSE data acquisition system was mounted in the cockpit for both the on-ground and inflight tests

Photos courtesy of DCTA, IAE and the Brazilian Air Force.

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