The next-generation VH-71 presidential helicopter based on AgustaWestland EH101

All the president's helicopters

With the Presidential helicopter fleet now undergoing an intense testing program, the data acquisition system for rotor blade testing at AgustaWestland is an essential element

▮ Doug MacLennan & Johannes Mattes

The key criteria in the selection of the next generation of presidential helicopters was to ensure the safe transportation of the President of the United States of America, and effectively create an 'Oval Office in the sky'.

The AgustaWestland US101 was selected as the helicopter that best fulfilled these stringent demands. During the development of its military equivalent, the EH101 extensive rotor-blade testing was performed using HBM's MGCplus data acquisition system and catman®Enterprise measurement and analysis software.

In January 2005, the contract to provide the next generation of the US presidential helicopter was awarded to an industrial joint venture comprising Lockheed Martin and AgustaWestland. Under the agreement, Lockheed serves as prime contractor. The aircraft is manufactured in the USA by AgustaWestland in cooperation with Bell Helicopter.

The presidential version of the US101 is based on AgustaWestland's proven EH101 model, initially designed as a medium-lift, military helicopter. Operationally proven, the EH101 has demonstrated its safety features in a large variety of military missions internationally. Up to now, more than 100,000 flying hours serve as documented proof of the helicopter's reliability.

Lockheed Martin and AgustaWestland previously worked together in the manufacture of the EH101 version for the Royal Navy. This successful partnership is continuing in the USA with the new presidential helicopter. Systems integration will take place at Lockheed Martin's Owego facility.

The first test aircraft landed at Lockheed Martin's facilities in October 2006. This was followed by a substantial test program including a successful test landing on the White House lawn in January 2007. Test flights will continue throughout the year, also using additional test aircraft. The fleet of these helicopters will consist of a total of 23 US101 aircraft. Flights from the White House lawn are scheduled to commence at the end of 2009.

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The rotor blades are exposed to extreme loads

The sort of intense testing undertaken on the Presidential fleet of helicopters, is also undertaken on helicopters designed to fly under extreme conditions.

Rotor development and testing

As part of its rotor development program, chiefly for the EH101, AgustaWestland in the UK needed to upgrade the data acquisition system for its blade testing rig.

Blade testing is an important part of the helicopter development process. The blades are exposed to powerful forces and are therefore intensively tested for fatigue and damage. The dynamic motion of a rotor blade during operation is extremely complex and high demands are placed on the control and Data Acquisition (DAQ) systems for the test setup. To meet these requirements, contracted company HBM extended its catman®Enterprise DAQ software by adding a communications interface to the Moog FCS control system and by implementing an interface for general mathematical libraries. The requisite mathematical modules for this application were also implemented.

AgustaWestland has worked successfully with HBM for many years, so when it came to installing a new data acquisition system, the company became the chosen supplier. AgustaWestland opted for the MGCplus DAQ system with a CP42 communications processor and various amplifiers, chiefly in the eight-channel version, as well as the catman®Enterprise software.

The requirement to measure the rotor blade true bending moment is determined ostensibly by measuring stress and strain on the rotor blade surface with strain gauges. However, since the movement of a helicopter blade consists of several components, such as flap, lag and torsion, it is necessary to calibrate the contribution of stress and strain in bending moment for each component individually.

This process is performed in a way that each component is introduced to the test specimen and load steps applied. The output of such a loading process results in a coefficient for the crosstalk matrix, and it is this matrix that forms the basis for the 'crosstalk correction' that is necessary to measure true bending moment.

Once all component inputs are calibrated for each load case, up to eight different correction matrices are compiled; in the case of three input components, $2^3 = 8$, and because the calibration coefficients differ for each load case, the matrices have to be swapped in real time, during the data acquisition process if the load case input changes.

Additionally, in fatigue tests it is necessary to monitor the peak bending moments and because of the periodic movement of the blade, it is required that the positive and negative peaks can be detected. Furthermore, there are sometimes locations on a structure where it is not possible to place strain gauges. This might be due to the material or the physical setup of the test rig or it may be that a strain gauge has failed previously during testing. Therefore, it is necessary to be able to interpolate data, using the information from existing sensors and strain gauges, to the desired location. The measurement results from these functions are then used to optimise the load input of the control system, and therefore must be available on-line.

Online mathematics modules

HBM has extended the catman software by adding an interface to the Moog FCS control system and by adding an open mathematical interface, OOI (Open Online Interface), to the real-time DAQ kernel. These new math modules, together with the relevant interface, are implemented as add-ins for catman®Enterprise or catman® Professional, creating an online capability for the system, and the programs derived from it, that is clearly enhanced.

Moreover, it is easy to integrate additional custom mathematical functions, thanks to the structure of the open interface (OOI). No changes are necessary to the base software, thus the new features in catman have shortened the development and test times, contributing to greater cost efficiency. ▮

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MATHEMATICAL MODULES

Three mathematical modules were developed for AgustaWestland: First, the crosstalk correction module, based on matrix calculations, calculates inverse matrices from coefficients derived during the initial calibration. These are used for online crosstalk correction by library swapping to the necessary matrix, in real time, according to the current load input case.

Second was the peak value detection module, which detects the positive and negative peak values of available input channels. The output consists of the necessary 'x' and 'y' channel coordinates to create the envelope curve of peak bending moments.

Finally, the interpolation (Fit) module allows data to be interpolated on a regression basis. There is no limit to the number of fit-result channels and there are several fit-algorithm models available (e.g. $y(x) = ax + b$, $y(x)=a*\ln(bx)$ …).


Helicopter blades must function properly even under extreme environmental conditions