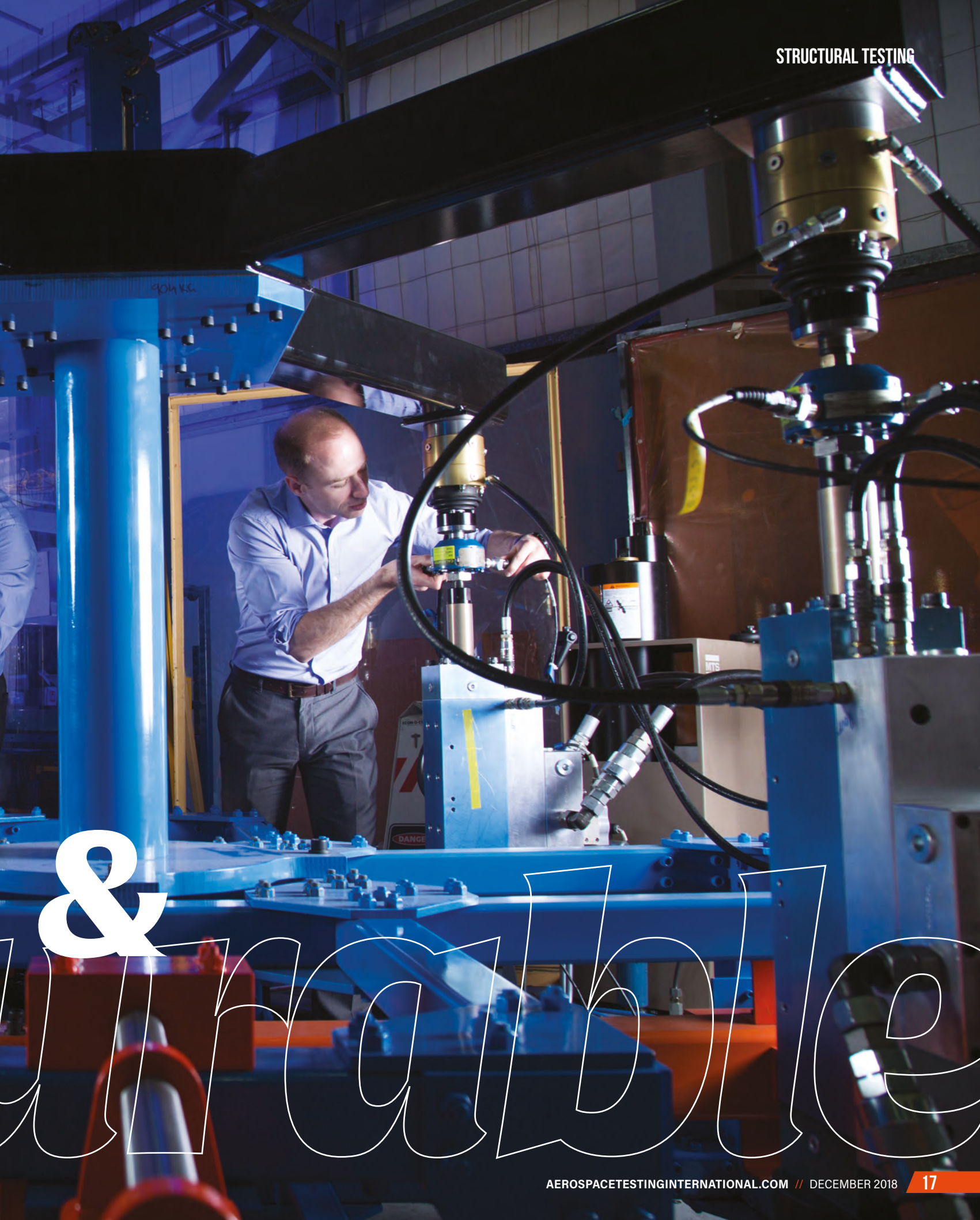
// NIGEL PITTAWAY

1 // Engineers adjust the prototype helicopter fatigue test rig

Research being conducted by Australia's Defence Science and Technology Group aims to slash the duration of full-scale fatigue testing

Predictable measure



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Australia's Defence Science and Technology Group has embarked on a study aimed at developing novel techniques to slash the time it takes to conduct the full-scale fatigue testing of helicopters. The project also has the potential to revolutionize the way fixed-wing full-scale fatigue testing is performed.

Known as the Helicopter Advanced Fatigue Test – Technology Demonstrator (HAFT-TD, pronounced 'Half-Ted'), the major five-year project also involves the Royal Australian Navy (RAN) and the US Navy's Naval Air Systems Command (NAVAIR) at Patuxent River in Maryland.

The work is being performed at the Defence Science and Technology (DST) Group's facility at Fishermans Bend in Melbourne, Australia, and is due to be completed in 2022. The research will be used to inform the US Navy's proposed Service Life Assessment Program (SLAP) for the Sikorsky MH-60R Seahawk 'Romeo' helicopter. If successful, the results of the HAFT-TD program could reduce the downtime for inspection and structural repair of the MH-60R's airframe, greatly increasing the flight hour limit and increasing availability throughout the helicopter's service life.

2 // The US Navy has supplied a retired MH-60R airframe to help develop the test rig

200 YEARS
Time it would take to replicate all the loads on a Seahawk helicopter using current fatigue testing methods

2 YEARS
Length of time to which the HAFT-TD project aims to reduce full-scale fatigue testing for a Seahawk helicopter

"We hope to conduct the full-scale fatigue test of a helicopter within two to five years"

TESTING GOALS

Although a helicopter's dynamic components – such as its main and tail rotor assemblies, engines and drive train – are all subjected to rigorous testing by the OEM, full-scale fatigue testing of the airframe is not traditionally conducted. Knowledge of a helicopter airframe's structural integrity is for the most part built up from years of operation and corrective maintenance.

The main and tail rotor blades of a helicopter generate a huge number of high-frequency loading cycles on the airframe as they pass over or across it – as many as tens of thousands of cycles per flying hour. Traditional methods of testing use hydraulic actuators to induce loads on an airframe test article at a maximum of one cycle per second. Several studies have shown that replicating all of the loads required on an MH-60R airframe using current methods would take over 200 years.

HAFT-TD is exploring ways to increase the rate of hydraulic actuator cycling and to identify which loads are important to replicate and which can be safely ignored. The ultimate goal is to reduce the full-scale fatigue test of the Romeo airframe significantly to between two and five years.

"On one hand we have fixed-wing full-scale fatigue testing, where we rely heavily on the prognostic capability that the current method gives us, and on the other we have the helicopter, where we currently rely heavily on analytical methods. We don't really have any test validation data for them," explains Loris Molent, acting research leader for DST's Aerospace Division at Fishermans Bend.

"So it's not surprising when cracking is discovered on in-service helicopters. A helicopter may spend quite a long time during its service life on the ground having

MORE TESTS FOR SEAHAWK

The Helicopter Advanced Fatigue Test Technology Demonstrator project is not the only involvement that Australia's DST Group has with the Seahawk helicopter – in terms of both the Romeo and its predecessor, the S-70B-2.

The Small Engine Test House (SETH) at its Fishermans Bend facility is being upgraded to accommodate a GE T700-401 engine from an SH-2G(A) Super Seasprite, donated by the Royal Australian Navy.

The work on the SETH facility will be finished in June 2019. The DST Group will then use it to research engine performance using alternative fuels and to develop engine health technologies. Researchers will also look at technologies such as novel engine sensors (for example, wear debris sensors) and develop and validate vibration algorithms.

The DST Group also has a long history in corrosion management and monitoring technology and is working on improving sensors initially developed by the US Navy. A corrosion monitoring system has recently been developed for the Seahawk airframe that measures a full set of corrosion-inducing parameters in addition to temperature and humidity. The system is currently being tested on one of the Australian Defence Force's NHI MRH-90 Taipan helicopters and later trials will involve the MH-60R.

cracks in the fuselage repaired. We think we should be able to do better."

DEVELOPING A FULL-SIZE RIG

The HAFT-TD program is focusing on two areas to reduce the time it takes to conduct full-scale testing. Researchers at Fishermans Bend are exploring ways to increase the cycle time of hydraulic actuators and the ability to control them precisely, using a specially designed six degrees of freedom (6DOF) demonstration test rig. If this proves successful, a full-size test rig will be built and used to apply loads to a real MH-60R airframe in a predictable, measurable and representative manner.

Second, a loading spectrum reduction activity is underway to conclusively identify the most important loads on the helicopter. "Part of the research is trying to determine if they occur in the hover, when it is banking, or a combination of maneuvers." Molent says. "The aim is to reduce the spectrum from many millions of load lines to maybe several hundred thousand. That would enable testing to be done in a shorter time.

"A full-size test rig will be built to apply loads to a real MH-60R airframe in a predictable, measurable and representative manner"

"Coupling that with a cycling rate of up to 10Hz, we would hope to be able to conduct the full-scale fatigue test of a helicopter within two to five years.

"That's the main objective and it's quite a difficult challenge we have set for ourselves."

US NAVY PARTNERSHIP

The HAFT-TD project has came about thanks to the very close relationship that has existed between the Australian Defence Force (ADF) and the US Navy for many years. The DST Group and NAVAIR have partnered on a number of mutually beneficial projects, including the Boeing F/A-18A/B Hornet strike fighter program.

The Royal Australian Air Force (RAAF) has operated the Hornet since the mid-1980s, albeit from land bases rather than aircraft carriers. The service also operates several other US Navy aircraft types, including the Boeing F/A-18F Super Hornet, EA-18G Growler and P-8A Poseidon. In coming years the RAAF will also acquire the Northrop Grumman MQ-4C Triton unmanned maritime patrol platform and the Royal Australian Navy is already a major operator of the MH-60R helicopter. The DST Group was also a major partner in the Hornet

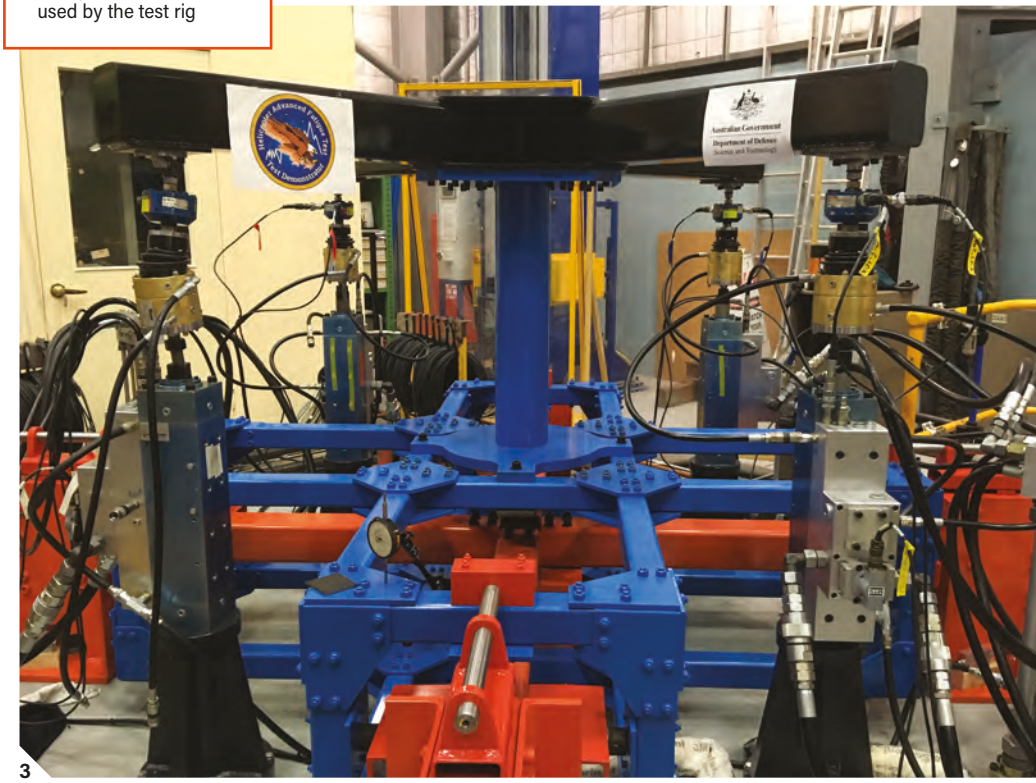
AWARD-WINNING TESTING

The DST Group's prior work on the Hornet International Follow On Structural Test Project (IFOSTP) was the first time aerodynamic buffet loads had been superimposed on steady-state maneuver loads. The program provided a wealth of information for the management of Hornet fatigue issues.

Canada and Australia both operate their Hornet fighters from land bases in a similar manner. IFOSTP was a joint venture between the two countries to establish the fighter's safe economic life. Under the agreement, Canada conducted testing of the Hornet's center fuselage and inner wing, while DST's focus was on the aft fuselage and empennage. A new structure was purchased from the assembly line for the purpose.

At the time, the IFOSTP was the largest structural test program undertaken by engineers at the DST Group. Full-scale structural testing began in 1995 and involved 24,000 hours of representative test flying. Loris Molent took over as project manager of the program in 2000 and the following year the DST Group, the RAAF and the Institute for Aerospace Research, National Research Council, Canada, were jointly awarded the Von Karman Award by the International Council of the Aeronautical Sciences.

According to the DST Group, "Many new test techniques were pioneered and an invaluable set of operational data was collected to support the aircraft for RAAF service."



3 // Researchers in Australia are increasing the cycle time and improving the control of the hydraulic actuators used by the test rig

International Follow-On Structural Test Project (IFOSTP) with Canada (see sidebar: *Award-winning testing*), which included the structural testing of an F/A-18A/B aft fuselage as well as it tail section at Fishermans Bend.

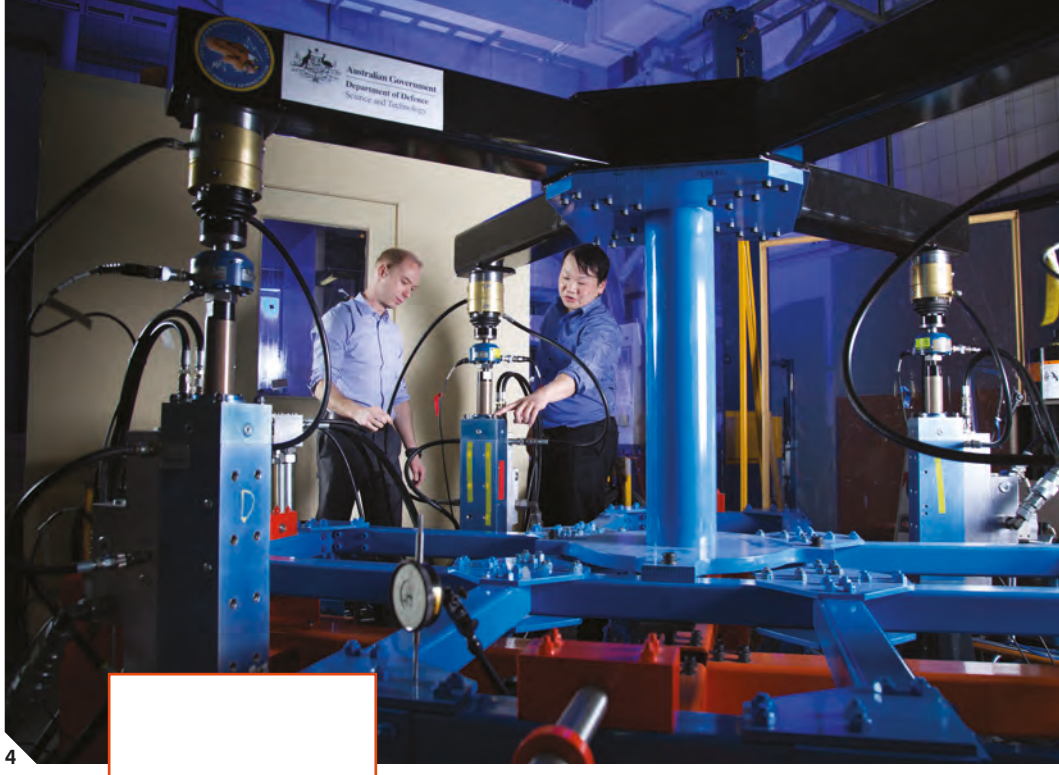
"Under the IFOSTP, DST was the first organization to simultaneously test real-time buffet and steady-state maneuver loads," says Molent. "Based on that experience, the US Navy considered that if DST could do that buffet testing – which could be at up to 64Hz – on the vertical tail of a Hornet, we could bring that experience to bear on a helicopter.

"The US Navy is a natural partner for the program and we know each other quite well. That's the genesis of the HAFT-TD project."

However, Molent points out that there are major differences between IFOSTP and HAFT-TD. "It's safe to say that the US Navy was very keen to engage and have us focus on the helicopter problem, but there are differences between the two programs. IFOSTP, for instance, was an open-loop control system, whereas HAFT-TD will be a closed loop system, and that's a challenge on its own.

"With the open loop control system it takes some time for the airframe to get up to speed. While it's doing that it is accruing damage that we're not accounting for. It's sweeping through its dynamic response until we reach the desired state.

"We do not want to do that with HAFT-TD. We want to switch it on and have it run at, say, 8Hz, so that it won't take much to get it up to its natural frequency. In a closed loop each channel is controlled individually, but with feedback, so they won't influence one another."



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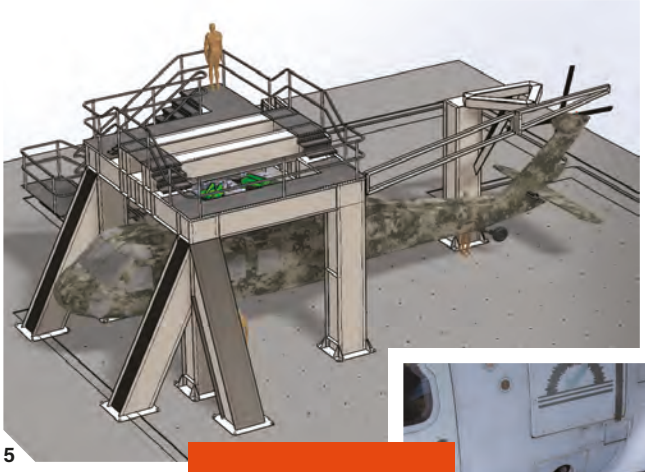
4 // The rig will have six degrees of freedom to recreate the loads on a real airframe



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5 // The HAFT-TD test rig could be used for full-scale fatigue testing of helicopters within five years

6 // The results of the study will be used for service life assessment

SIX DEGREES OF FREEDOM

Funding for HAFT-TD has been provided by the Australian Defence Capability Acquisition and Sustainment Group (CASG) and the USA's NAVAIR. The formal agreement to begin the test work was signed in November 2017, but DST began work on risk mitigation activities 18 months earlier.

Those risk mitigation activities are what led to the development of the 6DOF rig, which has been operating at Fishermans Bend for several months. The rig will help develop the complex control system required for the testing. Its cruciform shape is a crude representation of the helicopter structure.

"We're trying to load it with six degrees of freedom, because that's what we're going to need to do with the real airframe. To do that we need to control the actuators separately at very high rates and with very high levels of accuracy," Molent says.

"It has to be successful if we want to transition from the cruciform to the real airframe. The helicopter fuselage will be subject to bending, twisting and yaw, so we want to be able to simulate those load actions into the real airframe."

To accomplish this next stage of the technology demonstration, the US Navy has supplied a retired MH-60R airframe – one of the prototypes that was modified from an earlier SH-60B Seahawk and dubbed 'Bromeo'. This helicopter arrived at Fishermans Bend in March 2018. The future schedule is to design the full-size test rig, with lock-in scheduled for the first quarter of 2020 and testing to begin early in 2021.

"After the five-year program we're hoping to provide the US Navy with confidence that it can write a requirement for a full-scale fatigue test of Romeo into the SLAP, which is something it is not able to do now," Molent concludes.

"We hope that whatever technology we develop will also transition to OEMs, so that in the future all helicopters can take advantage of the benefits derived from full-scale structural fatigue testing." \\

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