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FROM THE SOURCE

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The RAN's Seahawk helicopters have seen SPD repairs (mobile SPD unit pictured) used on non-structural parts since 2009.

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Additive Materials
a game changer for aerospace sustainment

PATRICK DURRANT | SYDNEY

Outright replacement of an aerospace part that has suffered metal loss, due to corrosion, wear, impact or erosion can be an expensive and time consuming ordeal but additive metal technologies (AMT, colloquially known as 3D printing) can provide timely, cost benefit outcomes while restoring and even improving functionality and structural integrity.

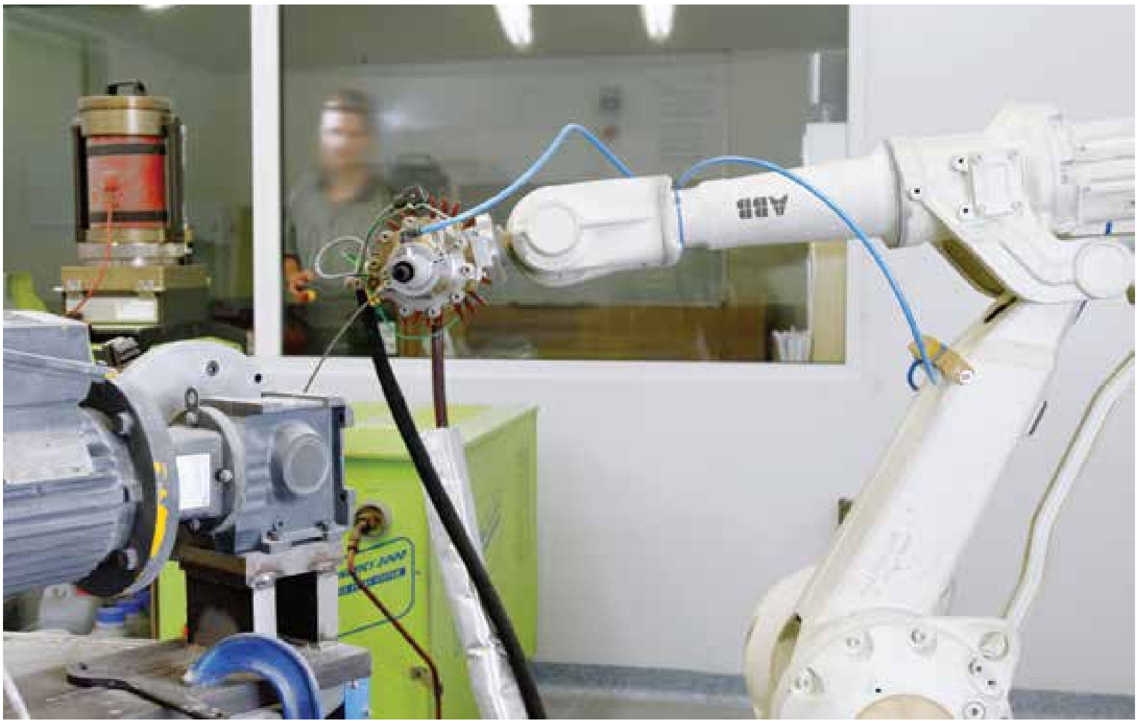
IN A recent independent report produced in 2013, the annual cost of corrosion for the Australian Defence aerospace sector was quoted as $228 million. In a June 2007 a report to US Congress by the Under Secretary of the Department of Defense (Acquisition, Technology and Logistics) estimated the annual cost of corrosion associated with US DoD systems to be between $US10 billion and $US20 billion. This report also outlined the need for research into repair processes that restored damaged material to an acceptable level of integrity and functionality.

Neil Matthews, Senior Manager Research and Technology at RUAG Australia said that the need to engage in additive metal technologies will increases as computer aided design tools and computer aided manufacturing programming of highly sophisticated machines becomes the norm in aerospace design and production leading to weight optimised designs.

"The next generation of aircraft such as the F-35 JSF will possess components and structure that will have little or no excess material," Matthews explained to *ADM*.

RUAG Australia has led a 10-year program of research and development of Supersonic Particle Deposition (SPD) technology, and its technical efforts and outcomes have been instrumental to sustainment of the ADF's aerospace capability. The company's first SPD application for a component repair was conducted on a Navy Seahawk helicopter main transmission in November 2009.

"This transmission module is still in-service and has accrued in excess of 1,300 flight hours without any degradation of the deposition or any adverse effect on the substrate," Matthews said.



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RIGHT: A fixed SPD unit at work.

BELOW: Internal bore Laser Cladding process parameter validation.

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> **"Corrosion related issues represent up to $228 million annual spend on ADF aircraft."**

"The cost savings to the RAN as a result of the implementation of SPD repair solutions on their Seahawk fleet has been shown to be in the order of $6 million over five years."

SPD, also referred to as Cold Spray, is a technology in which metal powder particles, are accelerated to supersonic speeds in a high pressure expanded gas flow, and impact a solid surface with sufficient energy to cause plastic deformation and bonding with the underlying material. Bonding is a result of high strain rate deformation and adiabatic shear instabilities at the bond interface. In essence, one substance is smashed against the other with such force where they bond rather than deforming.

Some benefits of the process, according to Matthews, are no heat affected zone, interface oxides or thickness limitations.

At the recent 17th Australian International Aerospace Congress, which coincided with 2017 Avalon Air Show, Matthews and Monash University's Centre of Expertise Structural Mechanics head Professor Rhys Jones won the Best Written Paper Award for their paper on additive metal solutions to corroded wing skins in operational aircraft.

The paper demonstrated that SPD repairs can restore structural integrity and eliminate conventional external patch repairs to skin corrosion, for embedded scarf repairs, and for external patch repairs to inhibit intergranular cracking (IGC).

"In fact, analysis reveals that SPD repairs on compression surfaces where there is up to a 50 per cent loss of material between the risers can essentially restore the load carrying capacity of the wing, even in the case of Stress Corrosion Cracking (SCC) in the risers," Matthews said.

Both Matthews and Jones are regarded as world leaders in the field of AMT and they argue SPD is effective not only for repair but also as a preventative measure – metal alloys used for SPD not only provide geometry restoration but better anti-corrosive properties.

"SPD can also be used to apply a thin layer of coating material across corrosion-prone joints or over riveted fasteners, thus preventing moisture ingress, corrosion initiation and the potential subsequent outcome of multi site cracking under fasteners," Matthews said.

LAD technology

In December last year, RUAG Australia's submission for Laser Cladding Repair Technology was selected for further development under Round 20 of the Capability and Technology Demonstrator (CTD) Program.

Round 20 was highly competitive, with seven CTD proposals being selected from a total field of over 130 proposals. The RUAG proposal focused on reducing the cost of ownership for aircraft component maintenance and improving aircraft availability by utilising innovative repair technologies.

Laser Cladding, also known as Laser Additive Deposition (LAD) is another member of the AMT family and is an innovative processing technique used for repairing metal structures. A stream of powder is fed into a focused laser beam as it is scanned across the target surface, leaving behind a deposited coating of the feed stock material that is fused to the substrate. The required geometry is built up layer by layer.

High bond strength, a smooth surface finish and a controlled localised heat input are some of the benefits of LAD, according to Matthews.

"LAD also overcomes some of the limitations of SPD such as a 'line of sight' technology which primarily limits the application to external surface applications."

SPD has been utilised extensively for both RAN Seahawk and RAAF F/A-18 sustainment with LAD applications starting to be incorporated. More on this technology and how the ADF has benefitted can be seen in the *From the Source* interview with RUAG's Managing Director John Teager in the June 2017 edition of *ADM*, also available online.

RUAG Australia has collaborated with a host of partners both within Australia and internationally as it has developed the technologies, from Defence airworthiness authorities and program offices to industry OEMS and primes as well as universities and other research organisations such as DST Group and the Defence Material Technology Centre.


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Certification

In order to achieve the certification and implementation of the two technologies a four stage certification program was established starting with a definition of a baseline. This involved development of a certification baseline document, test specifications and an acceptance test strategy.

"The test regimes included corrosion, mechanical properties, residual stress, fatigue, impact resistance and deposition adhesion and porosity qualification," Matthews said. Laboratory demonstrations followed, with results showing that the mechanical properties of the substrate were retained with no deleterious effects. An application demonstration under actual repair conditions was also required; potential risks were identified and resolved including OH&S and environmental impact.

"Finally, a technology implementation required acceptance by the airworthiness authority of repairs, formalisation of repair procedures and the release of the product against quantifiable quality standards," Matthews said.

Once certified, implementation of the AMT repair solution initially focused on geometry restoration (restoring a damaged/reworked component to its original dimensional configuration) as this was assessed as being a low risk but highly cost effective utilisation.

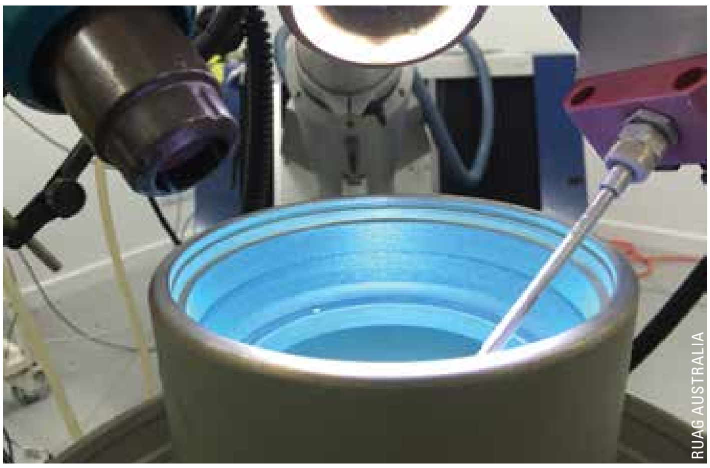
Matthews said this type of application would be applied when there is significant residual substrate structure to carry design loads.

"The next phase of implementation is to utilise AMT for structural integrity restoration and/or enhancement," Matthews said to *ADM*.

A considerable amount of experimentation has already been conducted by Matthews and Jones in the area of structural Integrity applications and much of this work has already been published in international journals.

The work undertaken by RUAG Australia in AMT also provides a pathway to engage in the generation of three dimensional printed parts for aircraft sustainment.

In further developing AMT technologies and their potential application, RUAG is continuing its national and international collaboration efforts. RUAG's many partners include Defence airworthiness authorities and Program Offices, industry OEMS and Primes as well as universities and other research organisations such as DST Group and the Defence Material Technology Centre (DMTC).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TOP: RUAG Australia's Laser Cladding System.

LEFT: Laser Cladding application for the internal geometry recovery of an F/A-18 Main Wheel hub that would have otherwise been scrapped.