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Seminal Advances in Cold Spray Additive Manufacturing and Repair

Abstract
The United States Air Force (USAF) guidelines for airworthiness certification of cold spray additively manufactured (CSAM) and additively manufactured (AM) parts and Cold Spray repairs are delineated in the USAF Structures Bulletin EZ-SB-1901. For limited-life CSAM and AM replacement parts and cold spray repairs, EZ-SB-19-01 explains that a linear elastic fracture mechanics (LEFM) based durability assessment plays a central role. Both MIL-STD-1530DC and the US Joint Services Structural Guidelines JSSG2006 require an ability to predict the growth of small naturally occurring cracks. The key word in this sentence is the word PREDICT.

Section 5.3 of MIL-STD-1530Dc explains that analysis is the key to both the damage tolerant design and the durability assessment of military aircraft. The National Aeronautics and Space Administration (NASA) Fracture Control Handbook NASA-HDBK-5010 and NASA-HDBK-5026, which addresses the Fatigue, and Fracture Control Requirements for Additively Manufactured Space-flight Hardware, say pretty much the same thing. In this context it should be noted that, Section 5.3 of USAF Mil Standard MIL-STD-1530D also states that the primary role of testing is "to validate or correct analysis methods and results and to demonstrate that requirements are achieved."

This paper will clarify how, for a given material, the effect of different build processes and their resultant microstructures and isotropy on durability and damage tolerance are captured by allowing for the variability in just two fracture mechanics parameters. We will then discuss (and illustrate) how to perform the small crack growth analysis needed for a durability assessment of cold spray repairs to corrosion damage.

An essential part of this presentation will be illustrating that crack closure concepts should not be used for assessing durability and hence should not be used for assessing the suitability of either CSAM or AM replacement parts or cold spray repairs.

Biography
Prof. Rhys Jones AC is a Companion of the Order of Australia: "For eminent service to mechanical and aerospace engineering, and to education as an academic, researcher and author, particularly in the area of aircraft structural mechanics, corrosion repair and airworthiness". This is the highest honour that can be given to an Australian Citizen. Professor Jones is currently an Emeritus Professor at Monash, and an Adjunct Professor at Swinburne University of Technology.

In 2008 Professor Jones's seminal paper on thermo-elasticity was chosen by the Australian Chief Defence Scientist as one of the "Top Ten" Defence Science publications in the period 1907-2007. He is a recipient of: The 1982 Institution of Engineers Australia Engineering Excellence Award, for his work on extending the operational life Mirage III aircraft; A Rolls Royce/Qantas Special Commendation for his

work on extending the operational life of RAAF F-111 aircraft; The 1989 Sir George Julius Medal, awarded by The Institution of Engineers Australia; A TTCP Defence Science Award for Defects in Composite Structures. This award was for his contributions to US, UK, Australian and Canadian Defence Science in the field of defects in composite structures. Rhys is internationally acknowledged as being a pioneer of the development of Cold Spray to ensure continued airworthiness. This work has led to two patents and to a text, co-authored with Dr. Champagne (US Army Research Lab, DEVCOM), on the subject area.