Progress on the Pathway to a Virtual Fatigue Test - Submitted to ICAF2019

Dixon, Ben[1], Burchill, Madeleine[1], Main, Ben [1], Stehlin, Thierry[2], Raphaël, Rigoli[2], Jackson, Phillip [1]
[1]*Defence Science and Technology Group, Australia*
[2]*RUAG Aviation, Switzerland*

During the 2017 ICAF, Albert Wong of the Defence Science and Technology (DST) Group issued "A Call to Arms" [1], to the ICAF and wider aerospace community: to build a "coordinated multi-nation multidisciplinary collaborative effort" with the aim "to contribute to progressively closing the gaps between fatigue test results and model predictions." The benefits of consistent improvements to the accuracy of analytical predictions are many, including: (i) ability to optimise design thus allowing improved performance and efficiency, (ii) lower certification costs, and (iii) reduced maintenance cost and improved availability for the operator. This is true for both the civil [2][3] and military aviation [4] industries. For DST Group's Aerospace Division, a virtual fatigue test is the end goal, which would provide Defence an agile and affordable means by which aircraft structural fatigue certification can be carried out.

This paper outlines the initial work program, that is designed to meet the intent of this *call*, and some of the early outcomes. The work program is based around a series of challenges, with the aspiration to "make every FSFT[1] a learning experience" [1]. Key to success, is the development of a collaborative network, that shares technical data and experimental results, undertakes impartial reviews of blind predictions and publishes key lessons learnt for the benefit of the Aerospace community. The process, requires details relevant to the tests including the structural configuration, material and manufacturing specifications and test loading spectra to be available, and researchers within the Aerospace community are invited to predict the results of the tests and contribute to the publication of any assessments against the test data. These challenges are designed to provide a proving-ground for different analytical methods. Furthermore, the forensic examination of the results is expected to provide valuable learnings that will direct future improvements of the analytical fatigue life prediction methods, including:

- relative assessment of the accuracy and consistency of different methodologies;.
- evaluation of the sensitivity of fatigue predictions to a range of inputs; and
- identification research initiatives that could deliver the most benefit to the community.

A number of fatigue predictions have been made by DST Group [5][6] and Swiss [7] researchers for the first of these challenges issued by DST (*DST-TITANS-1*), which is illustrated in Figure 1. This challenge concerned fatigue cracking in the radius of a coupon replicating the fuselage-to-wing shear tie post geometry of a combat aircraft. Results from a comparison between blind predictions and fatigue test data demonstrated, amongst other factors the importance of:

- accurate stress intensity/geometry factors (β), and
- high quality short crack growth rate data for the applicable material.

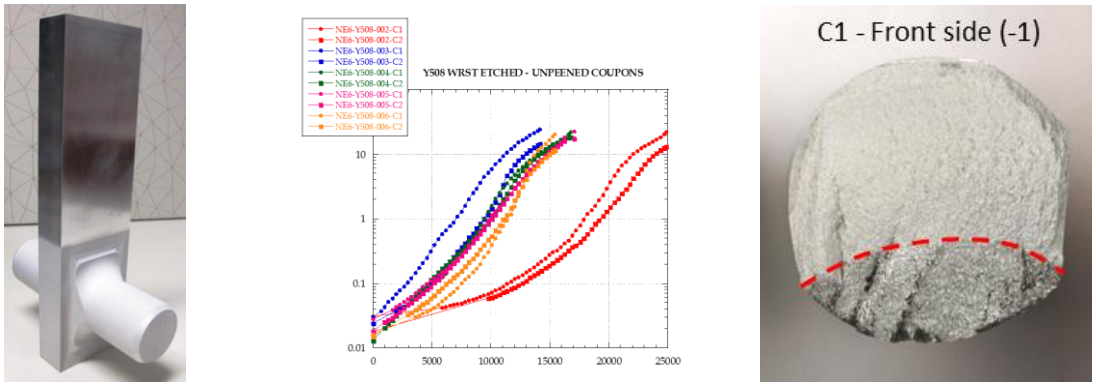

Figure 1. Details of the first DST-TITANS-1 challenge, crack growth predictions of a test coupon based on the aft wing shear tie geometry.

[1] Full Scale Fatigue Test

A collaborative online space has been established at the Australian Government GOVTEAMS portal (*https://www.govteams.gov.au*) to enable the multi-nation multidisciplinary collaborative effort. It is being used by DST Group to share the essential data associated with each challenge, provide a collaborative space for discussions and post results and evaluations. The site provides an opportunity to have both open and closed communities. Collaborative efforts are encouraged at any level and any arrangement, both within this portal or elsewhere – with the aim to publish publicly the key findings to drive the technology advances in the industry as a whole.

Table 2 details the current planned work program, including four further *DST-TITANS* challenges. It lists the dates when the details of these challenges will be available on the online collaborative space, along with the deadlines for blind predictions. DST Group will continue to report on the progress of the program and the results of its own local efforts against the challenges at future ICAF conferences. Other collaborators are encouraged to publish their own efforts against the challenges and their insights from the results, either individually or in collaboration with DST and/or others.

Table 1. List of upcoming DST challenges, which can be downloaded from https://www.govteams.gov.au.

Challenge name & details	**estimated dates**		
	data posted on portal	**predictions due test & results released**	**final report published**
DST-TITANS-2 Material - AA7050-T7451 Spectra - high frequency dominated spectra Test article - hourglass coupons, test section 40x6.35mm	01/12/2018	01/06/2019	01/12/2019
DST-TITANS-3 Material - AA7075-T7351 Spectra - military transport aircraft Test article - flat panels, precracked holes, test section 300x6.8mm	01/12/2018	01/06/2019	01/12/2019
DST-TITANS-4 Material - AA7075-T7351 Spectra - military transport aircraft Test Article – integrally stiffened panels, precracked holes, test section XXxXXmm	01/06/2019	01/12/2019	01/06/2020
DST-TITANS-5 Material – AA7050-T7431 Spectra – compendium of aircraft spectra Test article - hourglass coupons, test section 40x6.35mm	01/06/2019	01/12/2019	01/06/2020

Keywords: Crack Growth, Fatigue Digital Engineering, Virtual Fatigue Test, Digital Twin,

[1] Wong, A.K. (2017) Blueprint TITANS: A Roadmap towards the Virtual Fatigue Test through a Collaborative International Effort 29th ICAF Symposium – Nagoya, 7–9 June 2017
[2] https://www.aviationtoday.com/2018/09/14/boeing-ceo-talks-digital-twin-era-aviation, accessed 12/10/2018
[3] https://www.airbus.com/newsroom/press-releases/en/2018/04/airbus-confirms-its-digital-leadership-with-a-growing-number-of-.html, accessed 12/10/2018
[4] U.S. Department of Defense, (2018) Digital Engineering Strategy, Office of the Deputy Assistant Secretary of Defense for Systems Engineering, Washington, D.C
[5] Main, B., Russell, D., Barter, S., Choi, J. and Jones, M., (2017) Component Testing of the F/A-18A/B Y508 Wing Root Shear Tie. USAF ASIP Conference, 27-30 November 2017, Jacksonville, Florida
[6] Main, B., Evans, R., Walker, K., Yu, X. and Molent, L. (draft), Lessons from a Fatigue Prediction Challenge for an Aircraft Wing Shear Tie Post, Journal of Fatigue
[7] Stehlin, T. and Rigoli, R. TITANS: Y508 Wing Root Shear Tie Predictions, F/A-18 International Structural Integrity Forum, FISIF PMM#18, 04 – 07 June 2018, Melbourne, Australia