

AI-Driven Additive Friction Stir Deposition for Aircraft Structure Repair

From Knowledge
to Competitiveness

Portugal-US Partnerships 2026 Summit

MIT Portugal
Program

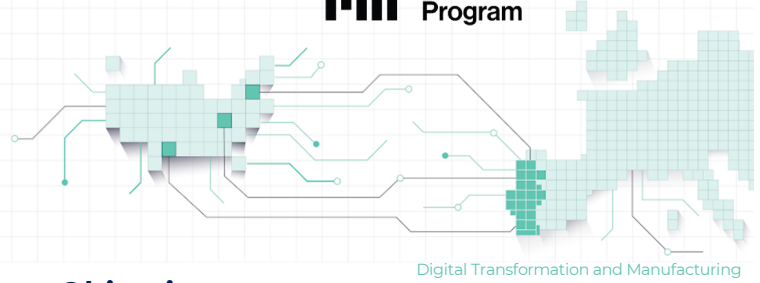


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Digital Transformation and Manufacturing

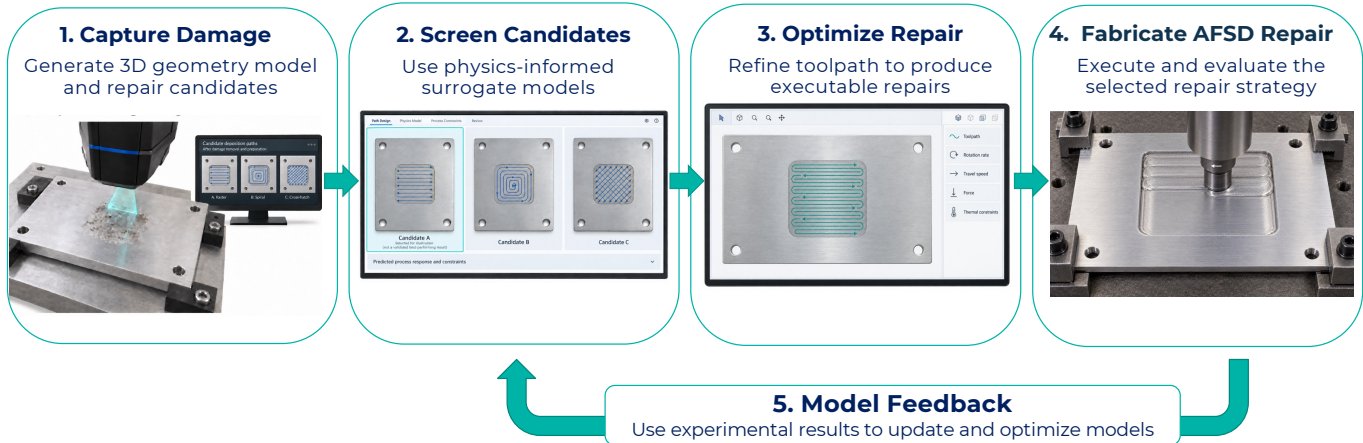
Motivation

Current aircraft repairs require significant manual labor and often add weight. Improving repair efficiency while minimizing mass is paramount to enabling more effective and scalable aircraft maintenance repair and overhaul (MRO).

Objective

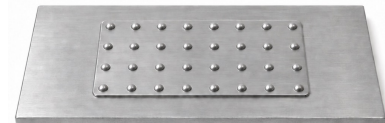
Develop and validate an AI-guided additive friction stir deposition (AFSD) framework to automate structural repair definition, generate viable repair strategies, and minimize added mass while satisfying structural performance requirements.

Envisioned Workflow for AI-Guided Repair



Mass Considerations for Repair

Riveted Patch Repair



The total repair mass is equal to the sum of the patch

mass plus the total rivet mass

$$M_{\text{repair}} = A_p t_p \rho + n_r m_r$$

A_p = patch area

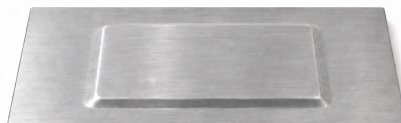
t_p = patch thickness

ρ = material density

n_r = number of rivets

m_r = mass of rivets

Raised AFSD Repair



The total repair mass is equal to the AFSD patch

$$M_{\text{repair}} = A_{\text{AFSD}} t_{\text{AFSD}} \rho$$

A_p = patch area

t_{AFSD} = AFSD patch thickness

ρ = material density

Flush AFSD Repair



There is no added repair mass

$$M_{\text{repair}} = 0$$

Research Hypotheses

- AI-guided AFSD repair can reduce the manual effort required to convert aircraft damage into an executable repair definition.
- Raised AFSD remains lighter than a riveted patch repair when:

$$\rho A_{\text{AFSD}} t_{\text{AFSD}} < \rho A_p t_p + n_r m_r$$

Therefore, for a given repair, AFSD can retain a mass advantage over a riveted repair even when the AFSD patch thickness is equal to the riveted patch.

Research Gaps

- A validated method for translating aircraft damage into a feasible AFSD repair has not yet been determined.
- The time and cost savings associated with automated AFSD repair have not yet been quantified.
- AFSD geometry and thickness required to satisfy fatigue & structural requirements must be developed.
- A pathway connecting optimized AFSD repair performance to FAA relevant requirements remains to be established.

References

- [1] Federal Aviation Administration, *Acceptable Methods, Techniques, and Practices—Aircraft Inspection and Repair*, AC 43.13-1B, 1998, Change 1, 2001, Chapter 4: Metal Structure, Welding, and Brazing.
- [2] Kroes, M. J., Watkins, W. A., Delp, F., and Sterkenburg, R. *Aircraft Maintenance and Repair*, 7th ed., McGraw-Hill, 2013.
- [3] Avery, D. Z., et al. "Evaluation of Microstructure and Mechanical Properties of Al-Zn-Mg-Cu Alloy Repaired via Additive Friction Stir Deposition." *Journal of Engineering Materials and Technology*, 144(3), 031003, 2022. DOI: 10.1115/1.4052816.

Workflow and repair images are conceptual renderings, not experimental results

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