Development of a Lighting Strike Simulator with In-Situ Loading

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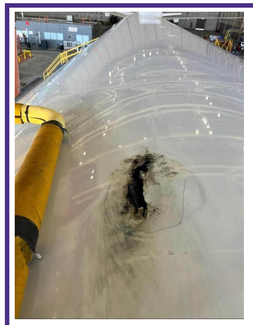
Background

- Lightning strikes present a significant threat to aircraft operations. A typical commercial aircraft is struck 1-2 times a year which amounts to once every 5,000 flight hours, posing a serious safety risk.
- Current testing methods for lightning strike performance do not account for service loading conditions.
- This project combines artificial lightning strikes on loaded samples to provide more realistic material performance data, leading to safer and more efficient operations.



Lightning strike damage on an American Airlines Boeing 787 en route to Dallas, TX.

Lightning strikes a KLM Boeing 777 departing Amsterdam

An Emirates Airbus A380 struck by lightning over London

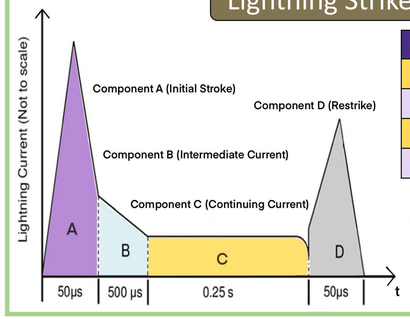
- Composite airframes are nonconductive; hence, manufacturers must include lightning strike protection systems (LSPs) to mitigate damage and comply with strict safety regulations.
- This entails additional structural weight, diminishing the weight saving characteristics of a composite structure.

Innovation

This project will design and fabricate an artificial lightning strike simulator that also replicates in-flight mechanical stresses, enabling the evaluation of composite materials used in the aerospace industry. This one-of-a-kind system would be installed at the UW Advanced Composite Center in Seattle.

Project Description

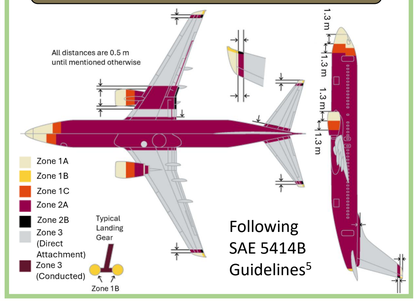
Lightning Strike Waveform



Component	Current Amplitude
A	200 kA +/- 10% Peak
B	2kA +/- 10% Average
C	200 ~ 800 A
D	100 kA Peak

SAE ARP 5412 defines four current components comprising the lightning current waveforms recommended for evaluating direct effects.

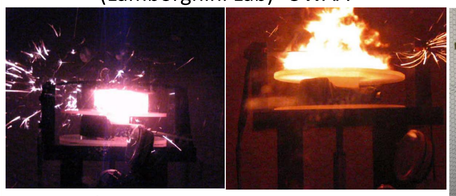
Aircraft Zoning



Following SAE 5414B Guidelines[5]

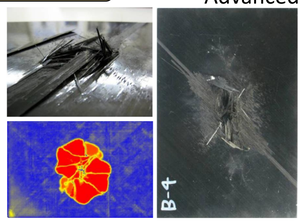
Previous Work

Artificial Lightning Strike Simulator, ACSL (Lamborghini Lab)- UWAA

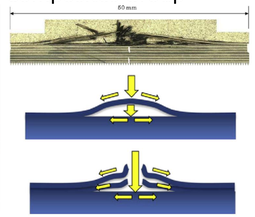


Left, Centre[1]: Frames extracted from a video recording of a 50 kA strike on a CFRP Sample.
Right[2]: Lightning Strike Generator

Japan Aerospace Exploration Agency, Advanced Composites Group



Images and C-Scan of a CFRP Sample subjected to 40kA Lightning strikes[3]



Possible Damage Mechanism of CFRP Samples[4]

Current Progress

Load Application

- Simple Pulley System
- Bench Vise inspired Mechanical System
- Design of a custom UTM
- Commercial System (Hydraulic Press)

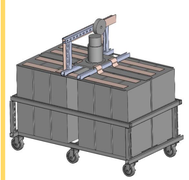
A Harbour Freight Hydraulic Shop Press was chosen with a maximum force capacity of 500kN.

Sample Size

Analysis: Force, Damage Area, Buckling, Thickness, Lay Up

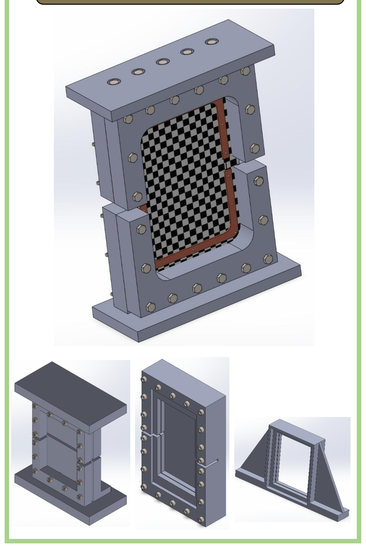
Important Characteristics
Thickness: 2.8 mm
Dimensions: 17 cm x 25 cm
Region of Interest: 15 cm x 20 cm
Number of Plies: 16
Layup: $[45/0/-45/90]_{2S}$

Capacitor Cart Design



- Houses 12 HV Capacitors
- Mobile
- Vertical Orientation of Ignitron

Fixture Design



Anticipated Impact

Boeing

- Robust testing system available for use by Boeing at any time
- Availability of Material performance data to enhance safety guidelines, efficiency and industry applications.

Industry

- Strike Generator available to be used by Small/Medium aerospace enterprises.
- Benefit to the entire PNW supply chain.

Environmental and Safety Impact

- Lower CO_2 emissions through better design and fuel efficiency
- Reduced risk of severe lightning strike damage by optimizing LSP methods.

Path Forward

Design finalization and delivery to Boeing for review, focusing on meeting safety requirements and performance goals	Fabrication of the lighting strike simulator at the UW Advanced Composite Center that meets high safety standards
Demonstration of the simulator's in-situ loading capabilities on various composite panels	Presenting design recommendations to Boeing, incorporating the influence of mechanical stresses

Acknowledgements

References

Background Images Courtesy: New York Post, The National, Airliners.net
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3: Hirano, Y., Katsumata, S., Iwahori, Y. and Todoroki, A., 2010. Artificial lightning testing on graphite/epoxy composite laminate. Composites Part A: Applied Science and Manufacturing
4: Ogasawara, T., Hirano, Y. and Yoshimura, A., 2010. Coupled thermal–electrical analysis for carbon fiber/epoxy composites exposed to simulated lightning current. Composites Part A: Applied Science and Manufacturing
5: Katunin, A., Krukiewicz, K., Herega, A. and Catalanotti, G., 2016. Concept of a conducting composite material for lightning strike protection. Advances in Materials Science