# EXPERIMENTAL STRENGTH AND FATIGUE ASSESSMENT OF A DISBONDED F/A-18 A/B/C/D INNER WING STEP LAP JOINT

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(IWSLJ)
Canada
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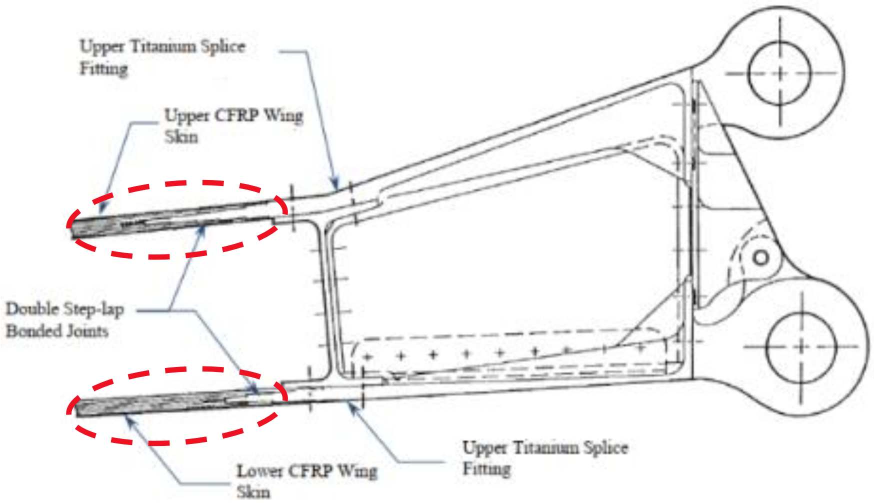
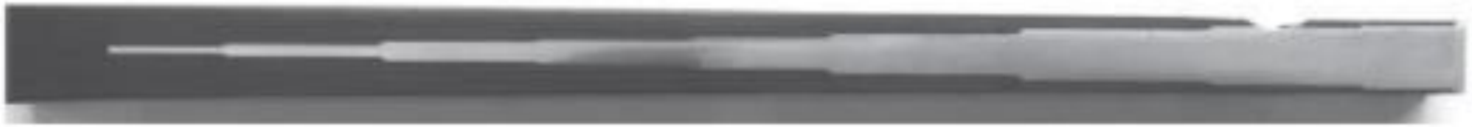
# Background

## F/A-18 Inner Wing

- Step lap joint used to transfer loads from C/F skin into the root titanium skin and root lugs.




outbd



# Background

## F/A-18 Inner Wing

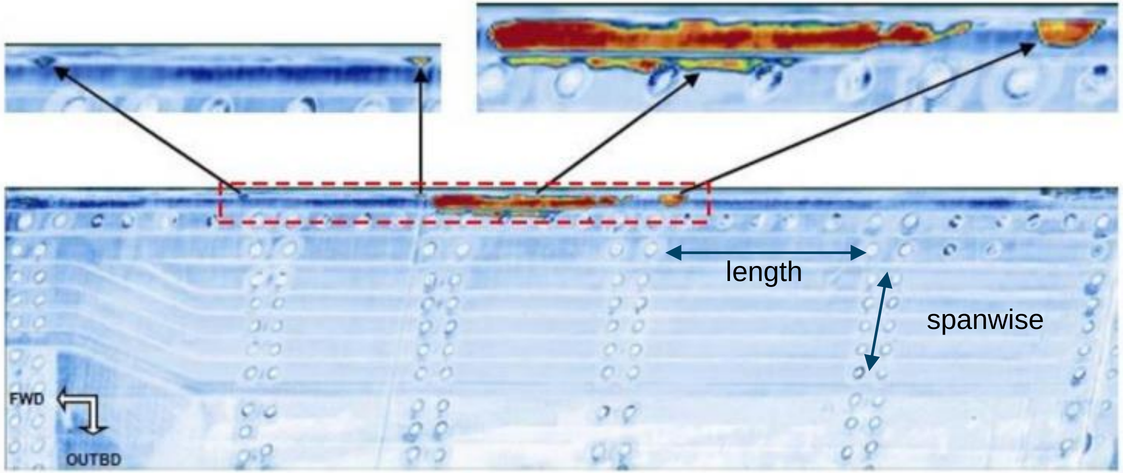
- Aircraft is aging, usage and environmental effects have been accruing since mid 80’s (37 years with potential of 41-47 year by retirement).
- Past study investigated the residual strength of SLJ after service life and after additional fatigue spectrum loading is applied[1]. The result of this investigation helped justify life extension; inspections put in place.
- Following this study, F/A-18 A/B/C/D operators have been inspecting their wings to assess the integrity of the SLJ.

(1) Fatigue Life Assessment of F/A-18 A-D Wing-Root Composite-Titanium Step-Lap Bonded Joint, Waruna P. Seneviratne, John S. Tomblin, Travis Cravens, Madan Kittur,Nov 29-Dec 1 2011

# Problem Statement

## Many disbonds found in the fleet

- Some disbonds were subject to failure investigation and usage data review.
- SLJ appears to be statically resilient.
- Recurring inspections indicate disbond can grow or seems to grow.




Typical Disbond

CScan image provided by DND - Quality Engineering Test Establishment - Material Performance and NDE Team.

# Current Approach

Unclear what is the disbond size limit, how fast they grow and what is growth mechanism.

Several initiatives were put in place by operators:

- Screen and identify assets with disbonds.
- Understand the root cause of the disbonds.
- Develop a repair for small disbond.
- Better understand short and long term behavior of disbonds.

# Test Objectives

## Objectives of test are:

- Obtain data on potential damage growth of a disbond;
- Evaluate the residual strength of an inner wing component containing disbonds at the step lap joint; and,
- Evaluate the internal load distribution in the IWSLJ area.

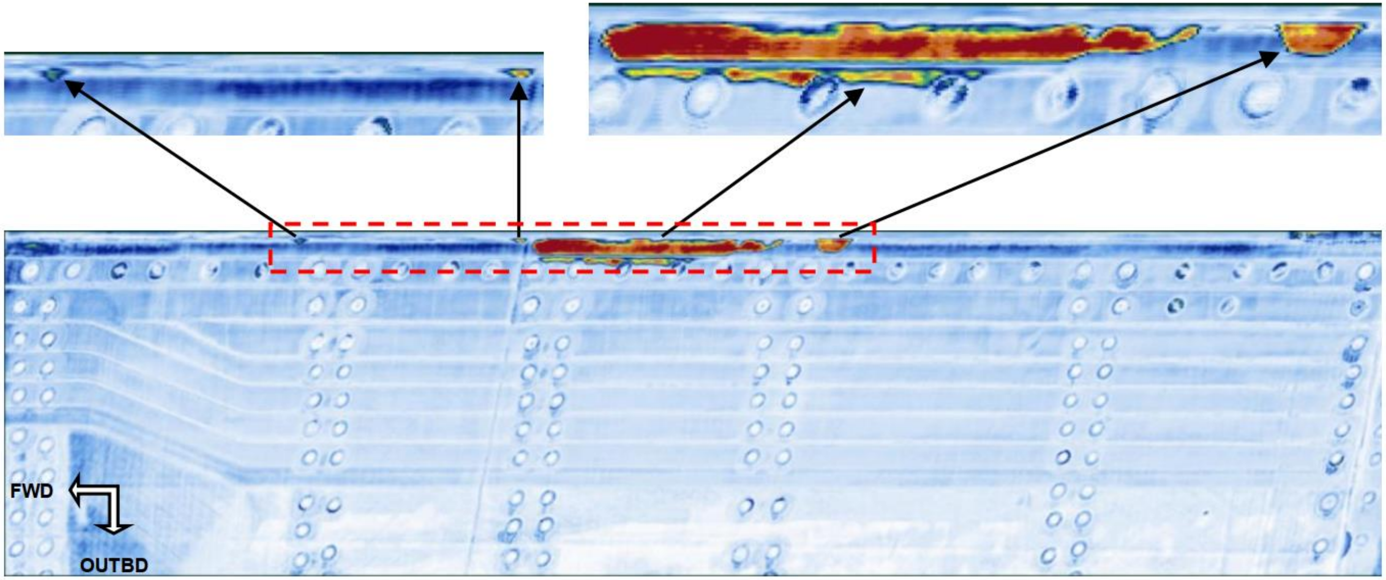
## Is a data gathering and learning exercise.

## Will help validate past decisions were sufficient (risk management) and support more informed decisions.

# Test Article

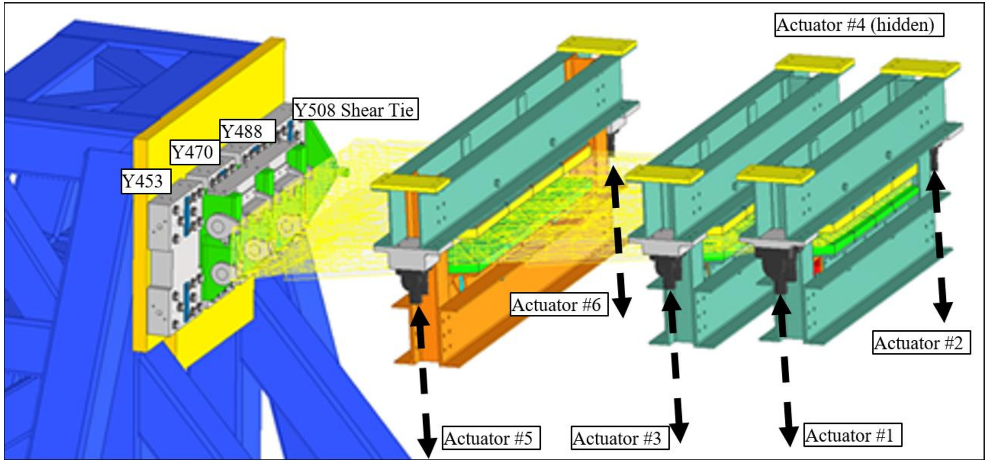
## Wing has a representative fleet disbond.

- Skin panels fully inspected. Lower skin has a disbond while upper skin does not.
- Visual inspection of internal structure performed.



# Test Setup

- Wing is inverted.
- Rig capable of reaching ultimate load with some additional MS.
- Contour board strong points (pylon fitting and wing fold).
- Dummy bulkhead lugs replicate real fuselage lugs.
- Lug alignment check and installation performed as on real aircraft.



# Test Sequence & Spectrum

**Calibration Phase**

| | | |
|---|---|---|
| Apply Zero G condition | Unit loads for each Actuator | Apply loads for W037, W059 and CHW001 |

**Phase A - Cyclic**

| | | |
|---|---|---|
| Apply 1 occurance of: 1.00 X (Peak 67.7% X CHW001 & Valley -7.1% CHW001) | Apply 2,000 occurance of: 1.00 X (Peak 67.7% X CHW001 & Valley -7.1% CHW001) | Frequent inspection and data review. |

**Phase B - Cyclic**

| | | |
|---|---|---|
| Apply 1 occurance of: 1.05 X (Peak 67.7% X CHW001 & Valley -7.1% CHW001) | Apply 2,000 occurance of: 1.05 X (Peak 67.7% X CHW001 & Valley -7.1% CHW001) | Frequent inspection and data review. |

**Phase C - Cyclic**

| | | |
|---|---|---|
| Apply 1 occurance of: 1.10 X (Peak 67.7% X CHW001 & Valley -7.1% CHW001) | Apply 2,000 occurance of: 1.10 X (Peak 67.7% X CHW001 & Valley -7.1% CHW001) | Frequent inspection and data review. |

**Phase D (Residual Strength Test)**

| | | |
|---|---|---|
| Apply once W037 at slightly more than Ultimate. | Apply once W059 at slightly more than Ultimate. | Apply once CHW001 at slightly more than Ultimate. |

## Swiss Wing Root Bending Moment (WRBM) exceedance plot was used to determine cyclic loads.

- Swiss spectrum captures other fleets.
- Reference peak and valley WRBM corresponds values that occur once per hour.
- A total of 6,000 peaks and valley will be applied.

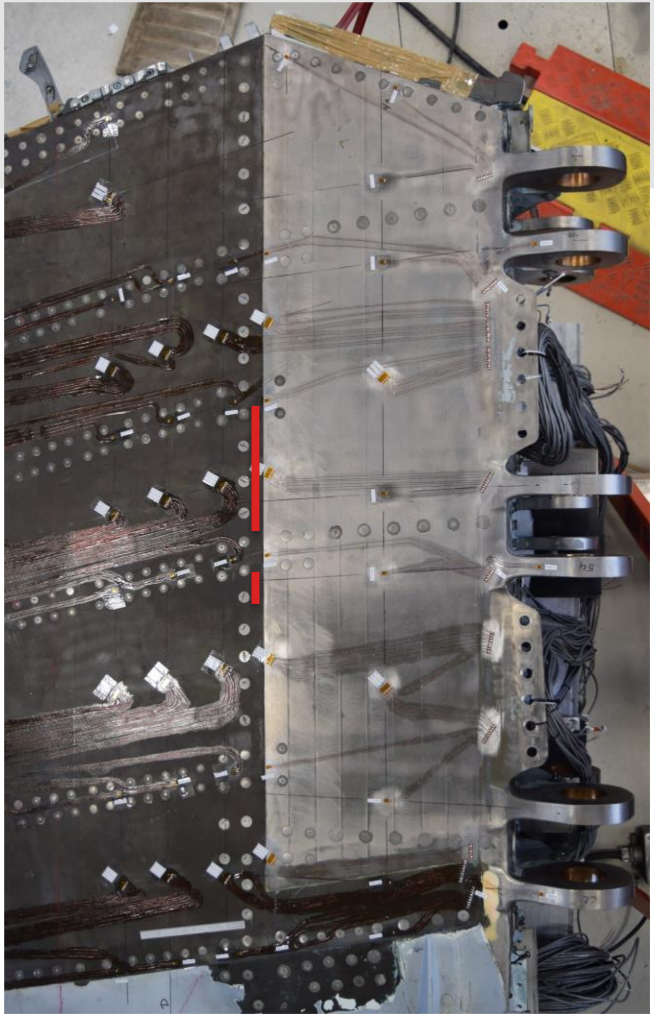
## Residual Strength Test loads are OEM & Swiss design conditions.

# Instrumentation (1/3)

38 rosettes and 144 uniaxial gauges installed on:

- Skin panels.
- Internal structure.
- Root lugs and shear tie

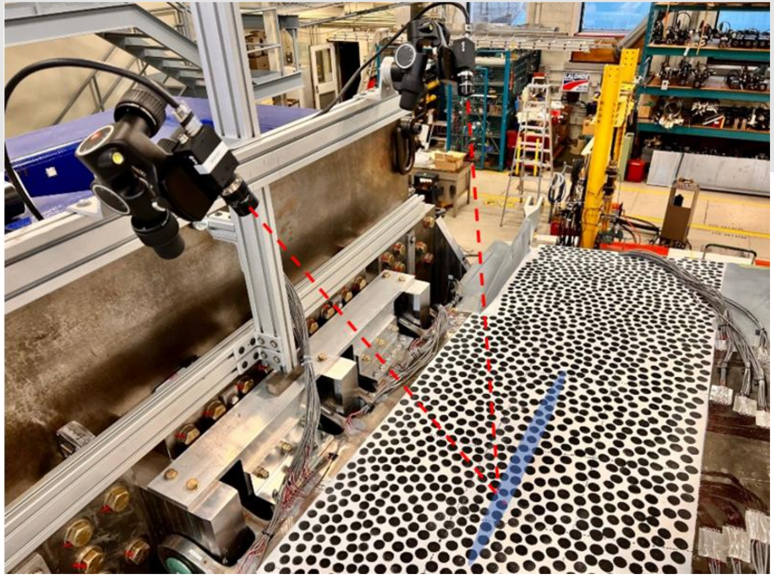
6 displacement transducer at actuators.

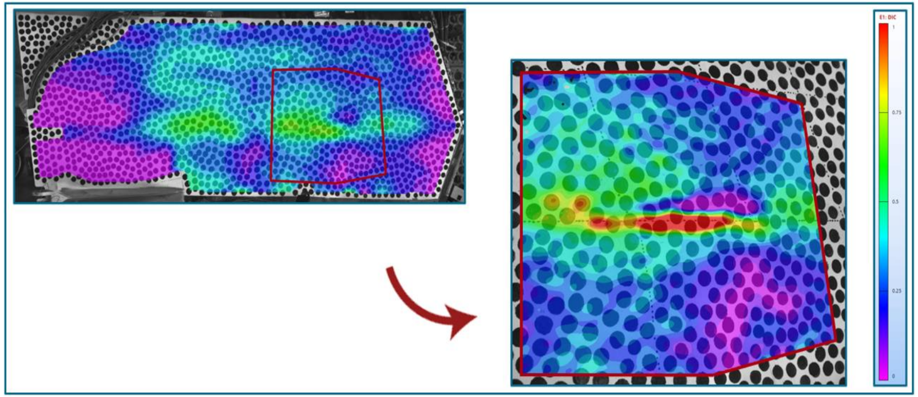


# Instrumentation (2/3)

## Optical strain measurements using digital image correlation

- Global strain field: Ceiling mounted cameras.
- High Mag. strain field: Cameras mounted to fixture.

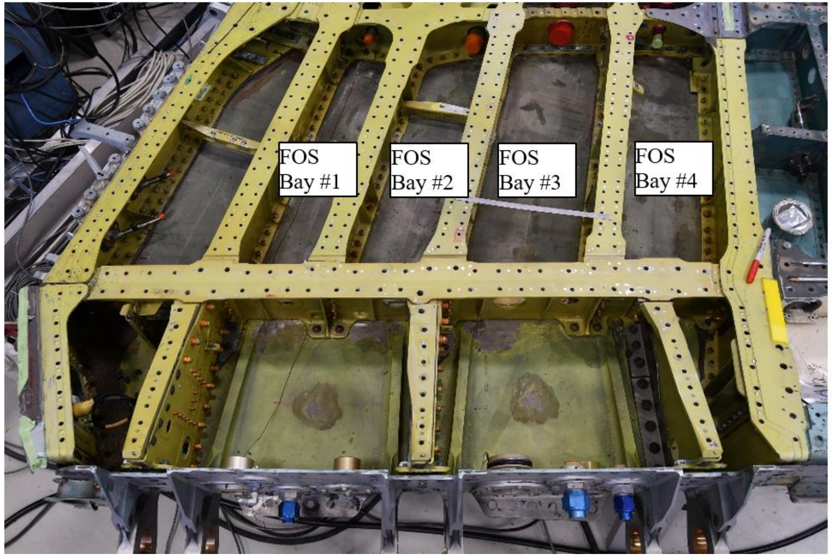


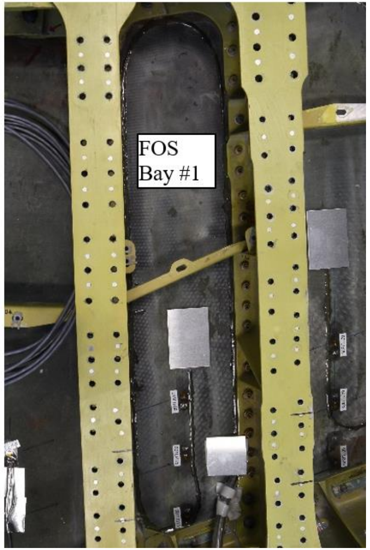


# Instrumentation (3/3)

## Optical strain measurements using fiber optic sensors

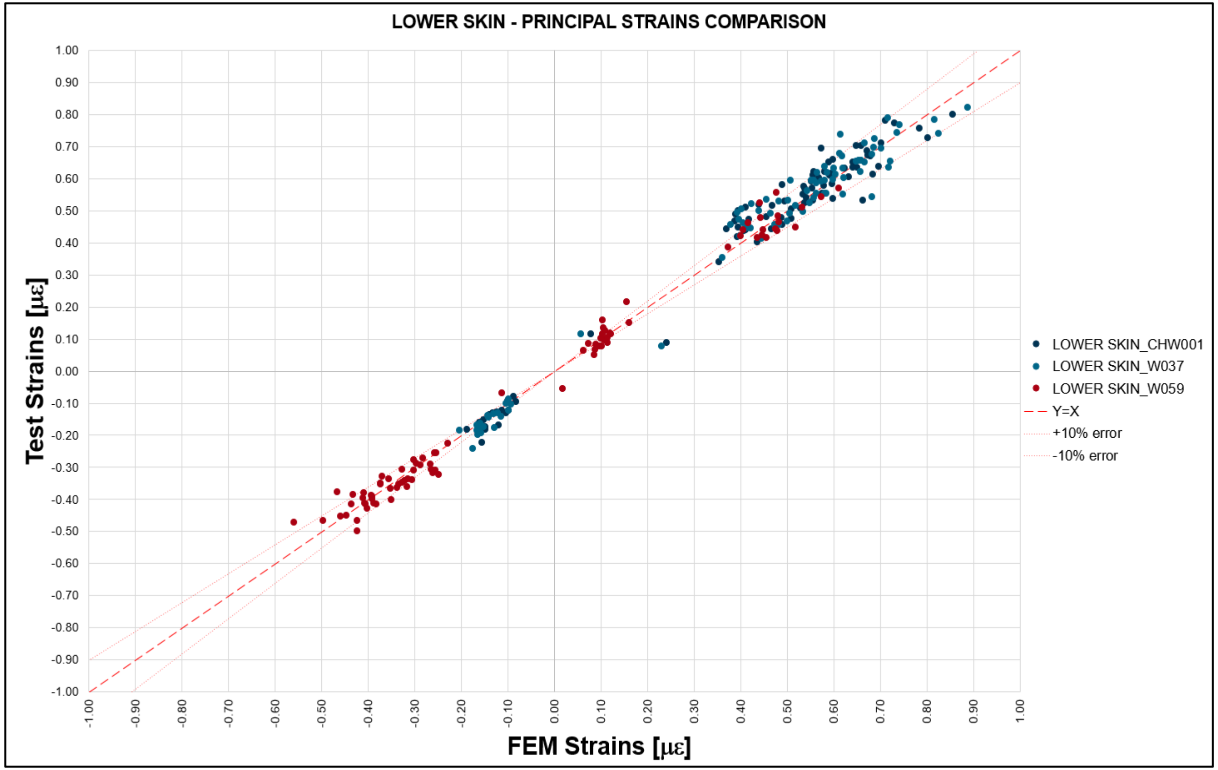
- Inside wing box near spars.



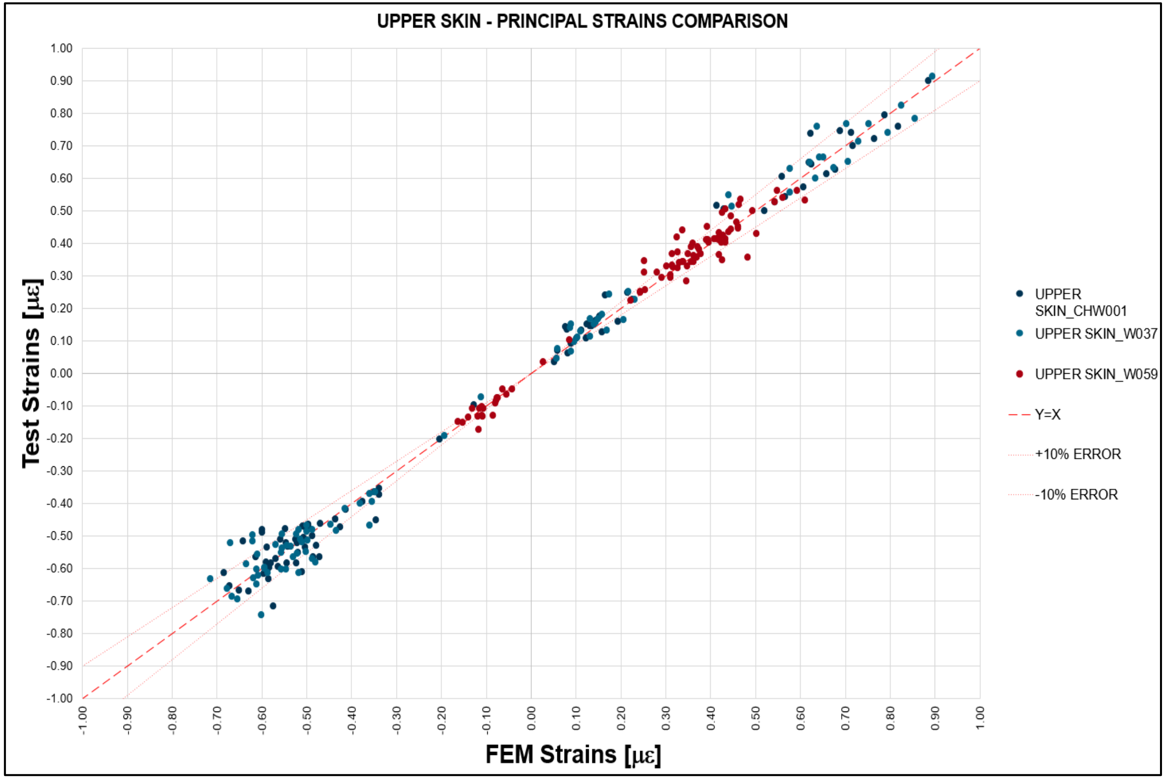
# Measurement Validation

Overall good strain correlation between FEM and test.



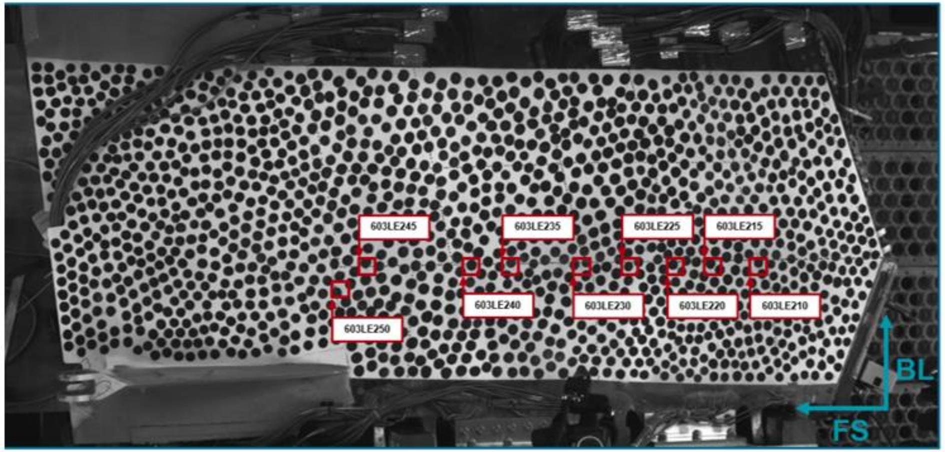
# Measurement Validation

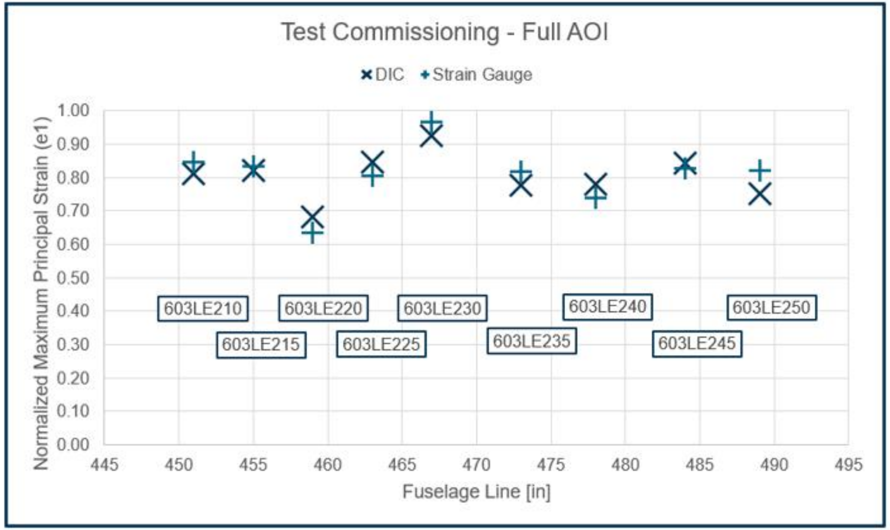
Overall good strain correlation between FEM and test.



# Measurement Validation

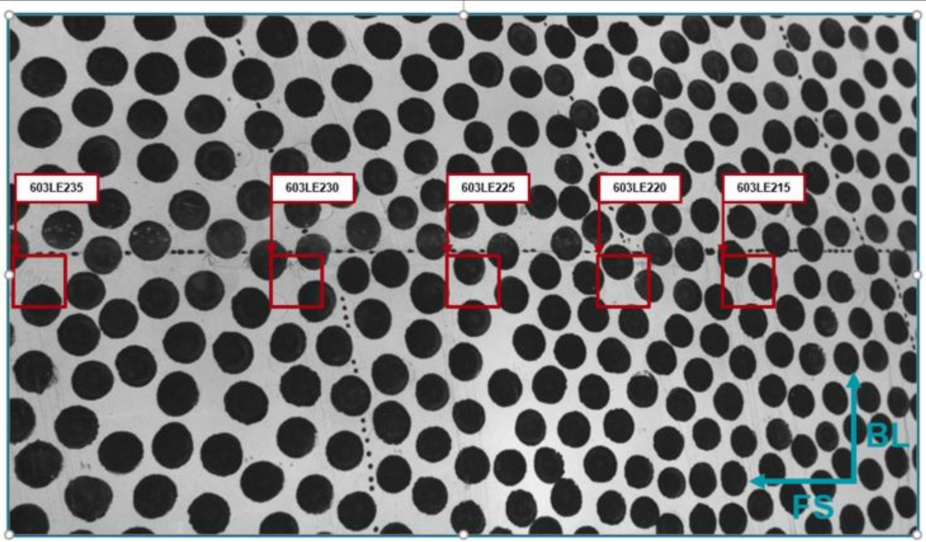
Overall reasonable agreement was achieved with the low magnification DIC

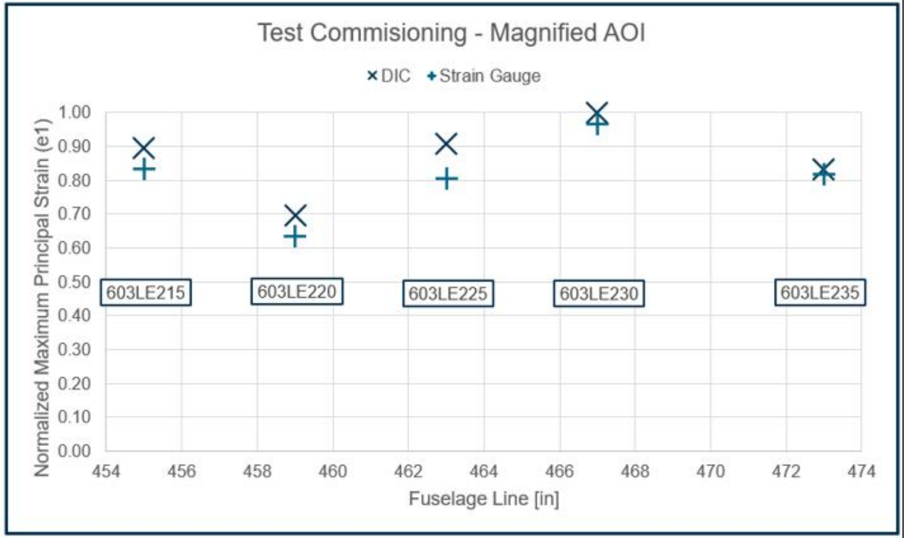


# Measurement Validation

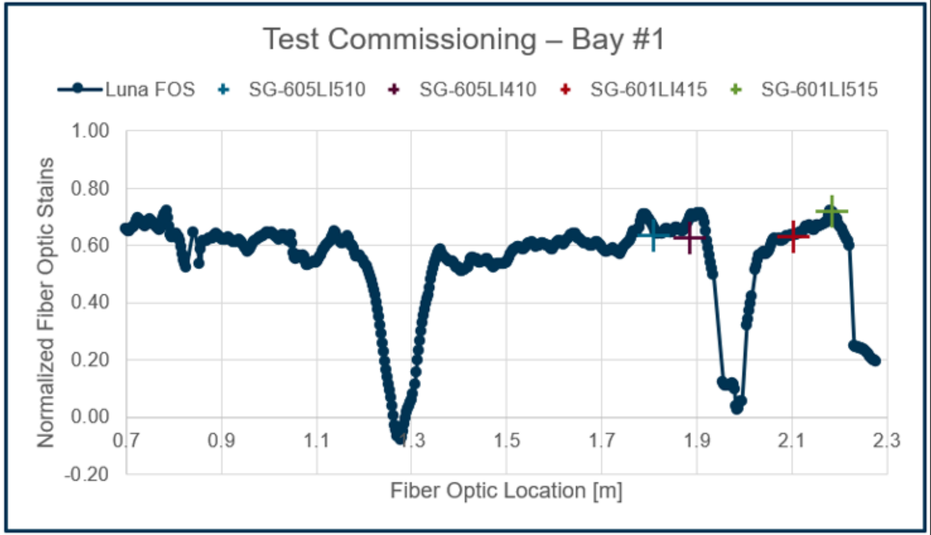
Overall reasonable agreement was achieved with the high magnification DIC

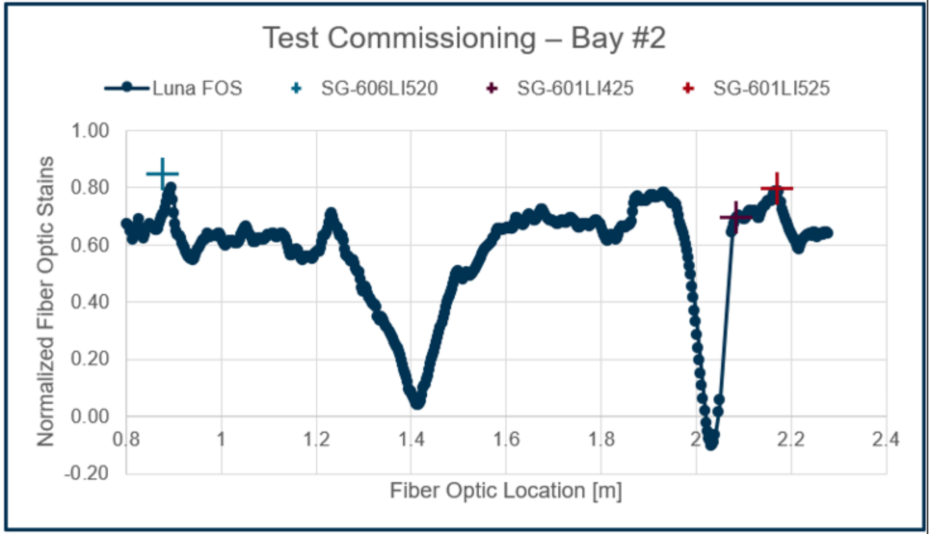


# Measurement Validation

FOS provides accurate measurements and mapping process has accurately located the position of key strain gauges on the inner surface of the lower wing skin



# Conclusion

The commissioning phase showed that all sensor systems were providing accurate data and that the test article was behaving as expected.

NRC started cycling early January 2023. Test is currently at end of Phase C.

Interpretation of cyclic phase will start this summer.

Next steps will depend on test interpretation.

# Acknowledgements

This test would not have been possible without the financial support the Canadian Department of National Defense, the Swiss Federal Office for Defense Procurement (Armasuisse) and the United States Navy (USN).

This test is the result of a strong collaboration between F/A-18 A/B/C/D operator that regularly meet under the F/A-18 International Structural Integrity Forum (FISIF) and Composite and Repair Engineering Development Program (CREDP). This forum helped forge the concept and strategy used for this test.

Technical engineering support provided by RUAG AG which generated and consolidated the feedback into a comprehensive test requirement document. RUAG AG is also validating and interpreting the test results.

NRC team which is executing the test plan.

National Defence

armasuisse

Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

RUAG

# Thank you

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