

FATIGUE AND DAMAGE TOLERANCE TESTING OF GRIPEN 39E/F RUDDER

31st ICAF Symposium – Delft, 26-29 June 2023

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VTT

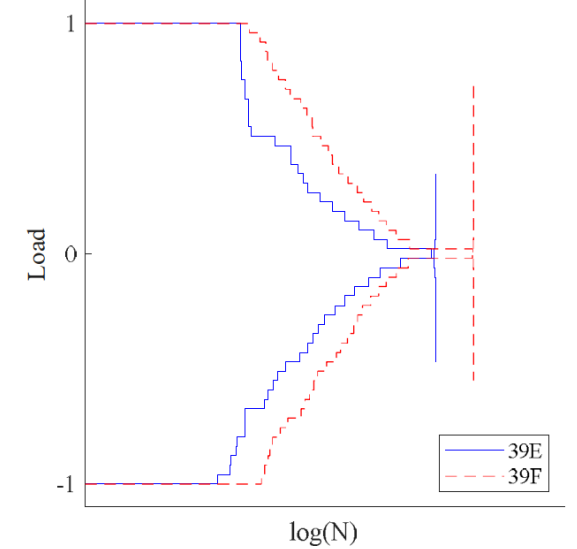
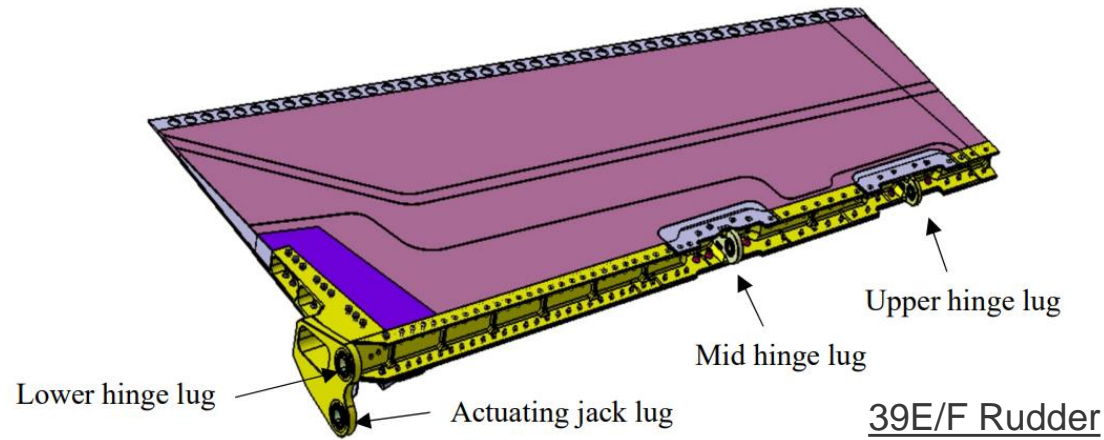
Background

- Gripen 39E is the single seater (many A/C)
- Gripen 39F is the 2-seater (fewer A/C)
- The same Rudder for 39E and 39F, but different load sequences
- From Fatigue and DT-analysis of the Rudder: 39E show full life but not 39F



39E Single-seater Aircraft

The Rudder and four options

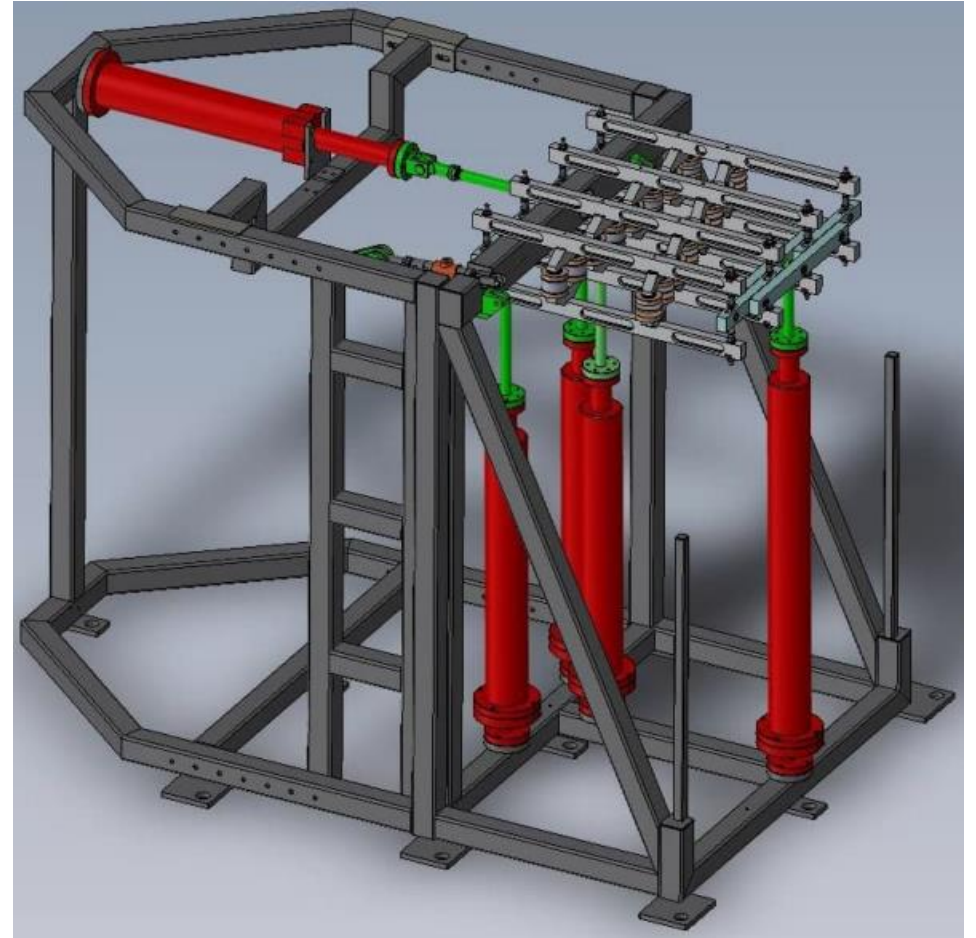


39E/F Jack Load Spectrum

1. Run the more severe 39F-sequence that will cover also 39E
2. Run two separate tests for 39E and 39F
3. Run the 39E-sequence first and continue with the 39F-sequence
4. Run the 39E-sequence first, then continue the 39E-sequence scaled with a factor 1.2

Test rig and test setup

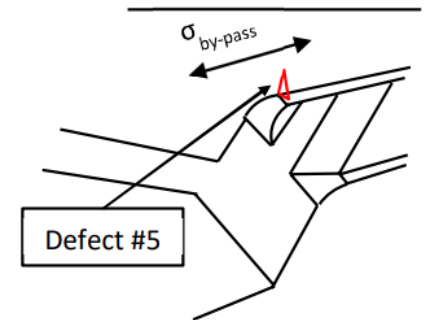
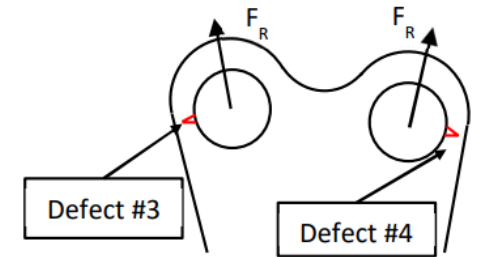
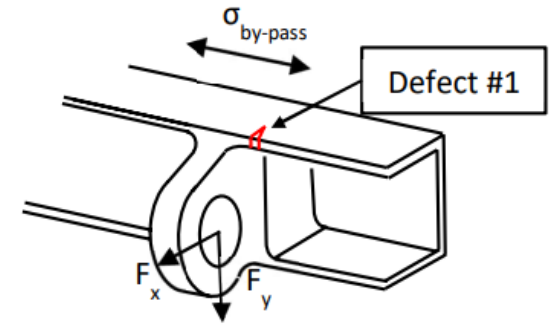
- The Rudder test was performed by VTT in Espoo, Finland
- Three actuators to apply air-loads via a whiffle tree and 16 pads on each side of the Rudder
- Two actuators to simulate the mid hinge reactions
- A load cell to monitor the reacting Jack load
- Displacement transducers and strain gauges
- Approximate 75 hours to run one design life



Test set-up before rudder mounting.
Figure courtesy of Arecap Ltd, A. Mattila

Test Procedure

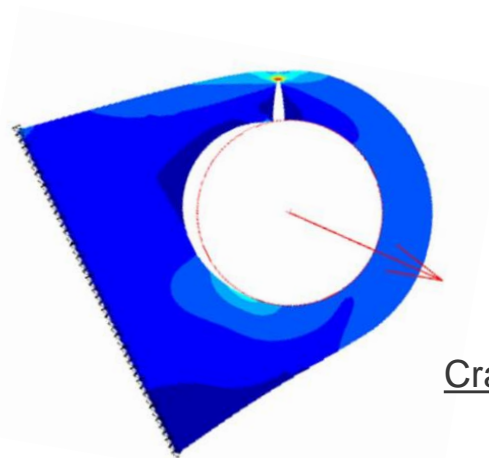
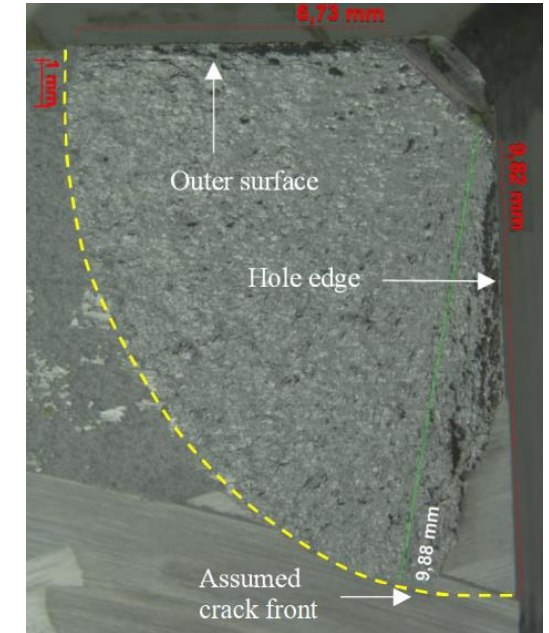
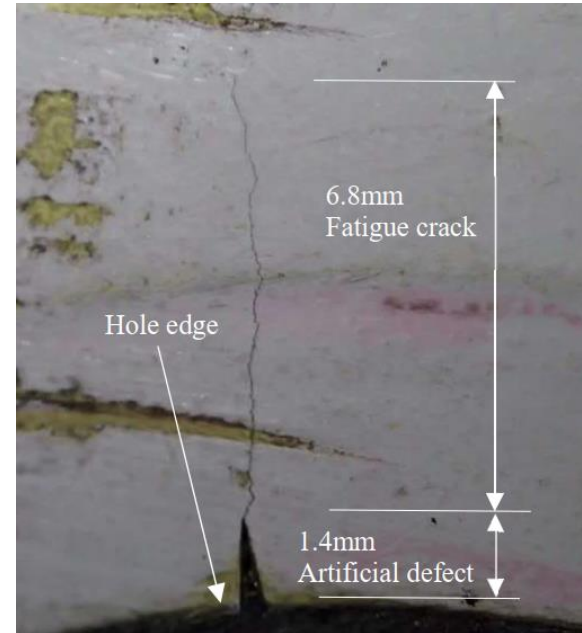
- Test Procedure, part 1 to verify 39E
 1. Run up to 2 Design Life with 39E-loads
 2. Introduce artificial defects
 3. Run up to 4 Design Life with 39E-loads
 4. Perform Residual Strength to 120%LL
- Test Procedure, part 2 to verify 39F
 5. Run up to 5.75 Design Life with 39E-loads scaled with a factor of 1.2
 6. Perform Residual Strength Test to 144%LL (1.2*120%)



Five defect positions of which #3 at the Jack actuator was most critical

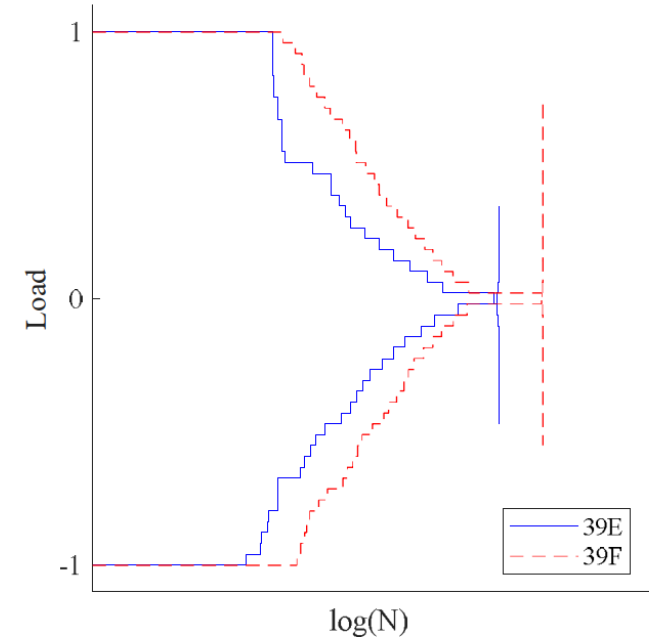
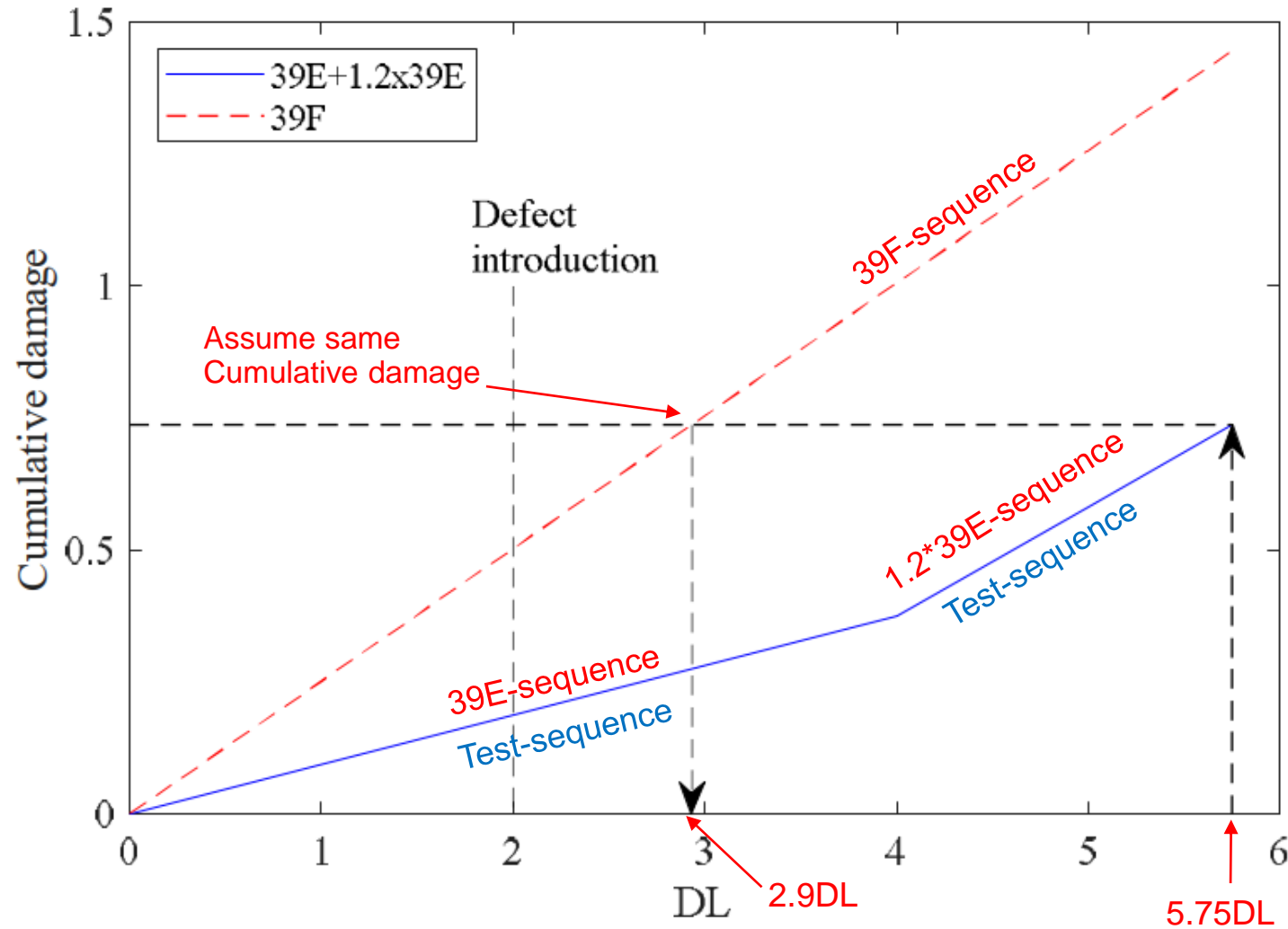
Test Results, defect #3, Jack Lug

- Ended the test after 5.75 Design Life
- Defect #3 was then 6.8mm
- Close to critical crack length
- Inspections with Eddy Current and Penetrant to detect crack growth



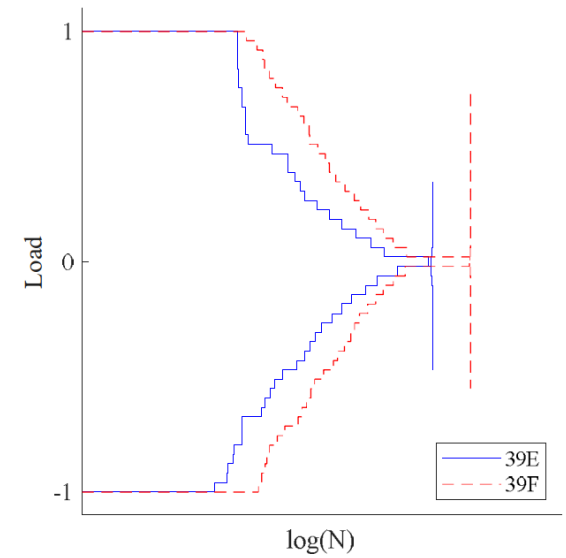
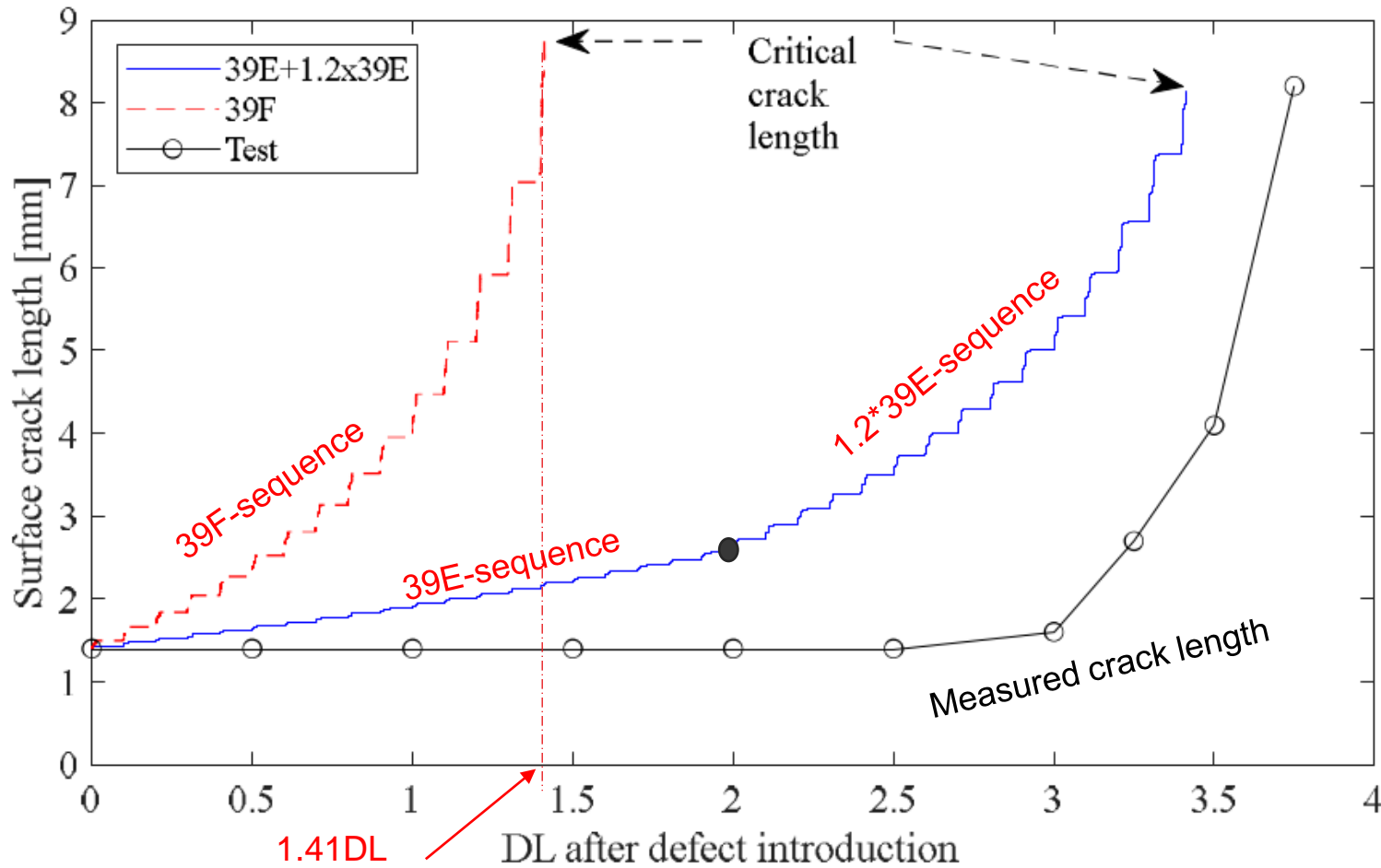
Crack #3 at Jack hinge lug

Fatigue damage analysis



39F Fatigue life analyzed to:
 $2.9/4=72\%$ of full life

Crack growth analysis



39F DT life analyzed to:
 $1.41/2 = 71\%$ of full life

Discussion/Conclusion

- The current test and analysis approach has verified full life for 39E sequence and at least 70% of full life with 39F sequence.
- Judging by the predicted cumulative damage, and predicted and measured crack growth rate, it is doubtful that 4 DL of safe-life and 2 DL of DT testing could have been reached either with 39F sequence or with continued testing with the 1.2x39E sequence.
- However, 70% of full life is substantial and is considered as an appropriate time to first in-service inspection.

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Thank You for Listening

The test team:

- Testing: Risto Laakso, VTT Technical Research Centre of Finland Ltd.
- Analysis: Allan Gustavsson, Saab AB
- Methods: Zlatan Kapidžić, Saab AB
- Test Lead: Jan Erik Lindbäck, Saab AB