Full Scale Structural Testing of Gripen E/F

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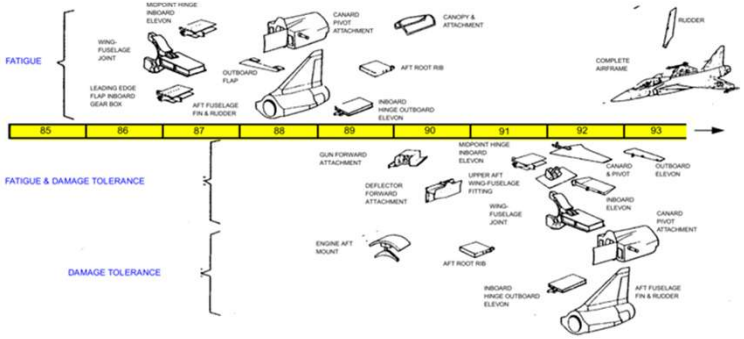
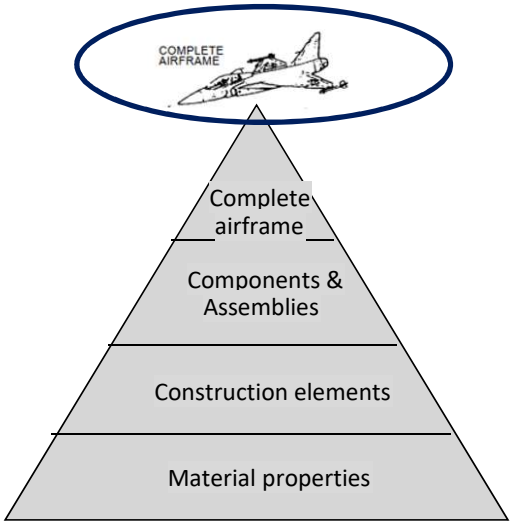
Structural Testing JAS 39 Gripen

- Validation and certification approach
  - primarily analytical
  - supported by testing
- For Gripen 39 versions A/B/C/D
  - extensive test verification program (1985-2010)
- For Gripen E/F further testing needed
  - changed design principles in primary load paths
  - new structural materials
  - modified operational profiles
- This presentation
  - Full scale structural testing of Complete Airframe



Fatigue and damage tolerance testing Gripen A/B



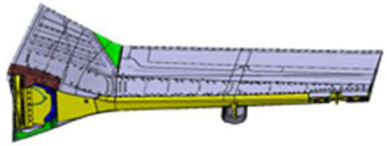
The Test Pyramid

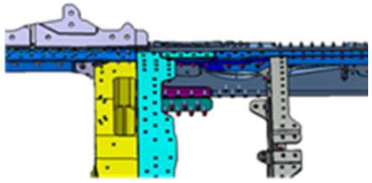
Full Scale Structural Testing Gripen E/F

- Full Scale Static Test Gripen E
  - testing completed 2019

- Full Scale Fatigue Test Gripen E and Gripen F
  - testing planned to start 2023 (Gripen E) and 2024 (Gripen F)

Covered in FT2019 presentation "Component testing Gripen E"





- Fatigue testing control surfaces
  - preparations is ongoing and testing is planned to start 2020
- Damage tolerance testing of full-scale assemblies
  - testing is ongoing

Full-Scale Static Test: Objectives

- Overall objectives
  - open the envelope for test aircraft 39.8
  - verify the static strength requirements
  - verify the stiffness / load distribution of the global FE-model

- Primary objectives are to verify the static strength of the
  - fuselage
  - wing and wing joints
  - fin and the fin attachment

  at ultimate design load

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Full Scale Static Test:Test Object & Test Set Up

- Airframe with fuselage, wings and fin.
- Dummies used for canards, control surfaces, engine, landing gears, weapon pylons, air-intake, airbrake

  Some of these parts are tested separately

- Test rig for full scale static test will be reused for full scale fatigue test
- 1200 strain gauges used for stress measurements
- 47 km cabling used between strain gauges and data collection system

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Full Scale Static Test: Time Line

Stress department

2012
Draft Test plan

2013-2014
- Definition of Dummies
- Load introduction
- FE-model of test object

2015-2016
- Strain gauges predictions
- Load Case selection
- Test Quality

2017-2019 Evaluation
2017: 80% Envelop opening
2018: 100 % Envelop opening
2019: Additional testing

Test preparations | Testing/Evaluation | Inspection

2012
Design of test rig

2013
Reconstruction of test site

2014
Building of test rig

2015
Final assembly test object

2016
Installation of test object in test rig

2017-2019 Testing
2017: Testing started
2019: Testing completed

Structural testing department

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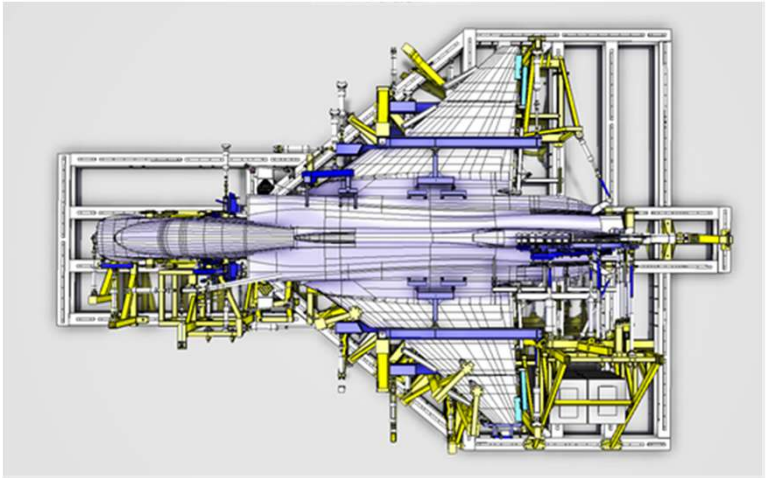
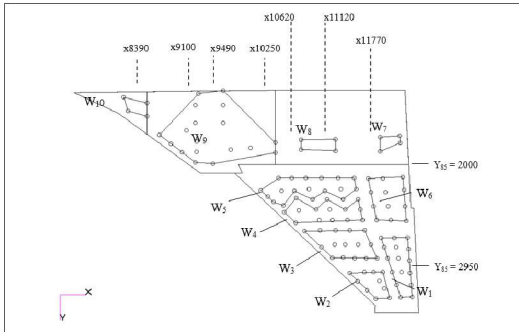
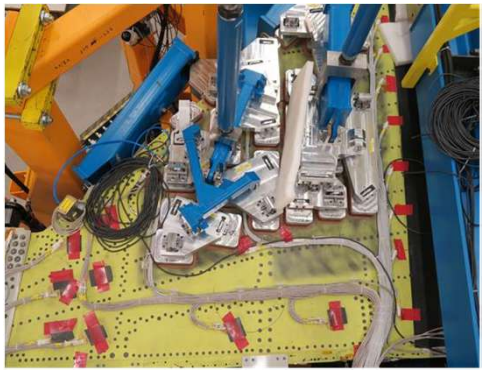
Full Scale Static Test: Loading System

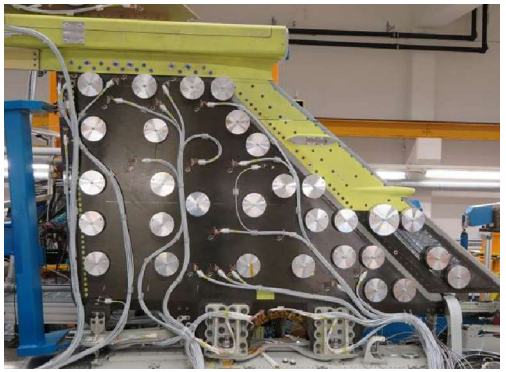
- 126 hydraulic actuators are used to apply load to the airframe
- Pressurized air in fuel tanks, cock-pit and air duct
- Bonded and bolted pads for load distribution in wing and fin areas







Bonded pads in wing area

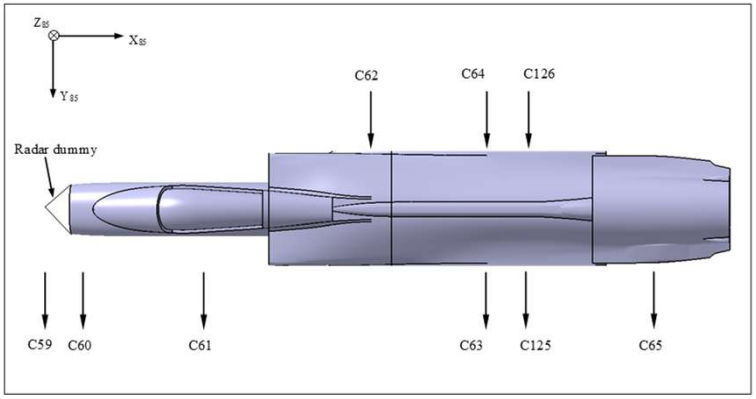


Bolted pads in fin area

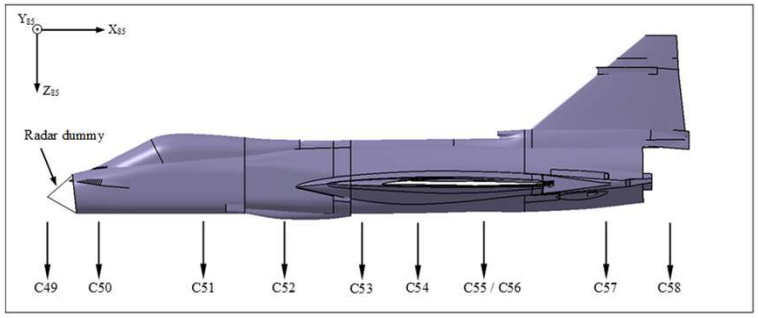
Full Scale Static Test: Load Cases

Load cases selected to meet objectives of the test

- Envelope opening load cases
  - to open the flight envelope for test AC 39.8.
- Load cases to allow complete flight envelope
- Overload cases
  - to test specific areas above ultimate load
- For each load case a number of actuators are used to balance the test object



Actuators applying Fy loads in the fuselage



Actuators applying Fz loads in the fuselage

Full Scale Static Test: Impact Damages

- BVID impacts on composite structures
  - indent depth 1 mm or to cut-off energy 50J
- Simplified fatigue testing
- Residual strength test to UL = 180% LL
- Measurements of strain and damage sizes

Results:

1. No damage growth after fatigue testing
2. No damage growth after residual strength test

Figure 4 - Test setup for impact tests on the fin.

Position	Impact energy [J]	Dent depth [mm]	Damage size [mm^2]
Wing 1	50	0	15x14
Wing 2	50	0	10x10
Fin 1	17	1.45	55x40
Fin 2	24	1.46	65x50

Full Scale Static Test: Results / Findings

- Full flight envelop verified
  - Metallic structures verified to 150% LL
  - Composite structures verified to 180% LL
- Load distribution of the global FE-model verified
- Overload capacity for pylon- and MLG attachments demonstrated
- Overall the testing went very well with few unexpected happenings
  - Example: Internal attachments for the fin reached higher stresses than expected → re-designed
  - Example: Test revealed a need for minor design improvements for a few specific frames
  - Example: Investigation of friction effect in NLG bearing structure

Full-Scale Fatigue Test of Gripen E/F Airframe

- Overall objectives
  - verify structural life
  - gradually increase permitted operating life
  - identify unforeseen fatigue sensitive areas

- The test procedure includes:
  - flight simulation testing
  - measurement of strains, deformation and load
  - visual inspections
  - NDT (Non-Destructive Testing)
  - tear down
  - evaluation of test results

Phase 1: Planning and Starting
Year 1-4

Phase 2: Static testing, Fatigue testing, Inspection
Year 5-10

Phase 3: Tear Down
Year 11

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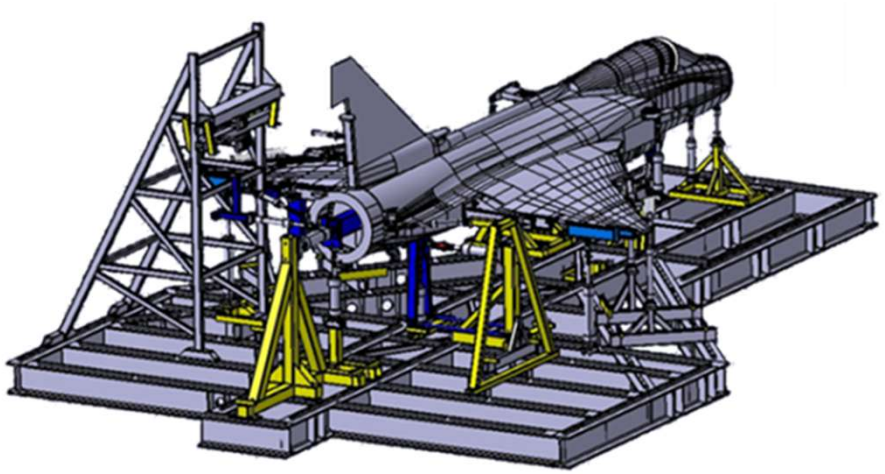
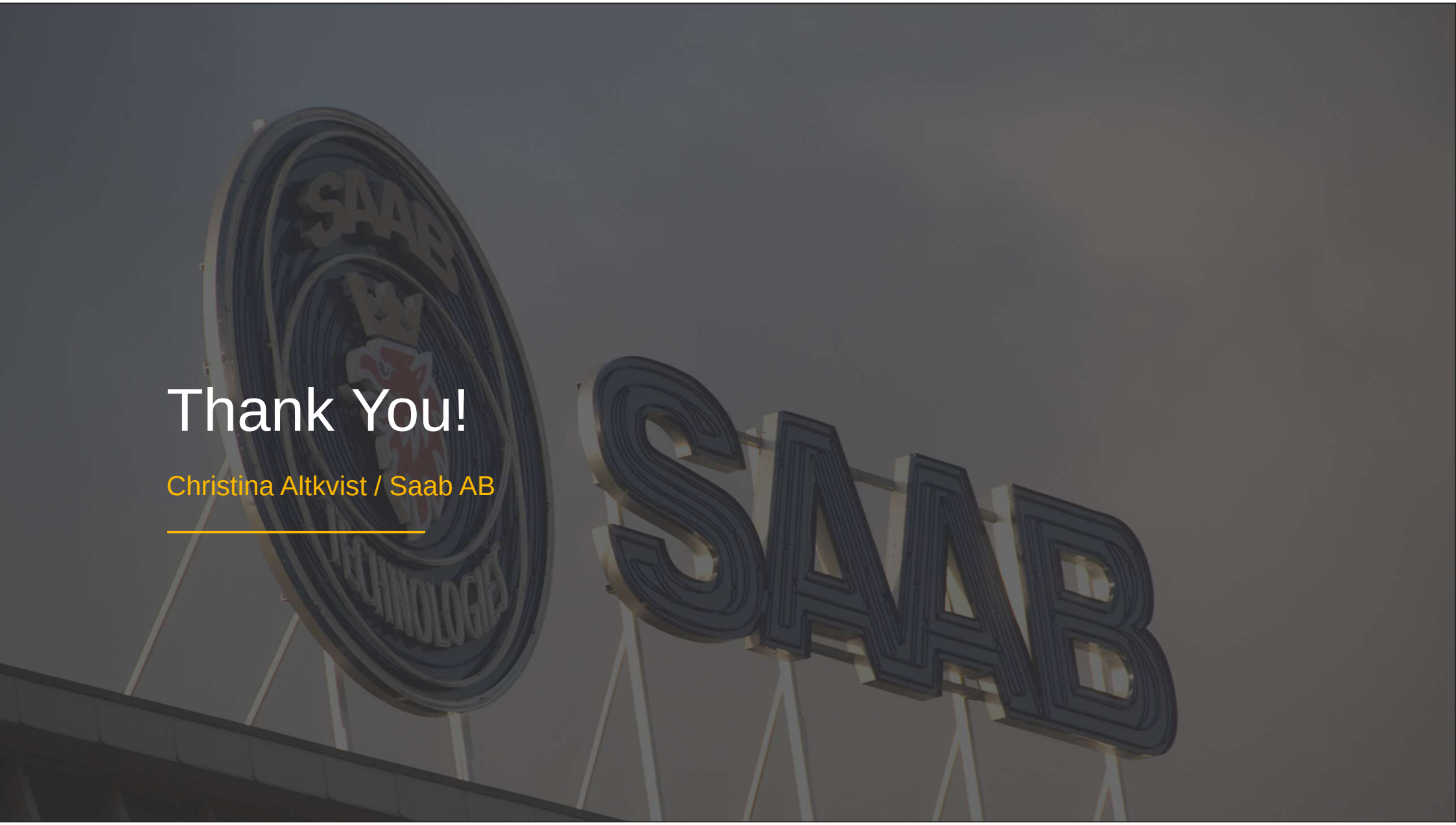
Full-Scale Fatigue Test of Gripen E Airframe

- Test object and test set up similar as for Full-Scale Static Test
  - Airframe with fuselage, wings and fin
- Test object is representative of Gripen E, series version
- Same test rig as for full scale static test
- Equipped with ~500 strain gauges
- Structural life proved through testing
  = 4 x design life





Thank You!

Christina Altkvist / Saab AB