Bird Strike Testing of the Saab JAS 39 Gripen E

Presentation FT2019

Peter Årebo
Saab Aeronautics / Etteplan Engineering Solutions

October 8th, 2019

Bird Strike Testing of the Saab JAS 39 Gripen E

- Contents of presentation:
  - Background to Bird Strike Testing
  - Testing of the JA 37 Viggen & JAS 39 Gripen A
  - Testing of the JAS 39 Gripen E
    - Identification of risk areas
    - Test series
    - Test set-up
    - Results
    - Comparison to simulations
    - Conclusions

Background to Bird Strike Testing

Eugene Gilbert, Bleriot XI, attacked by eagle, Pyrenees 1911
By Achille Beltrame - La Domenica del Corriere

F-111 A8-112, collision with a pelican, Amberley
11th April 2008 Photo: Darren Crick, RAAF

FAA on Bird Strikes:
US: > 13 000 / year
Cost: $900 million

Bird Strike Committee USA:
250 worldwide casualties since 1988

SAAB

Background to Bird Strike Testing

- Reason for causing damage:
  Relative speed difference
  - Kinetic energy: $W = \frac{m \cdot v^2}{2}$
- Endangered parts of a modern aircraft:
  - Engine
  - Windshield
  - Radome
  - Front fuselage with systems
  - Wing leading edge with systems
  - Fin leading edge

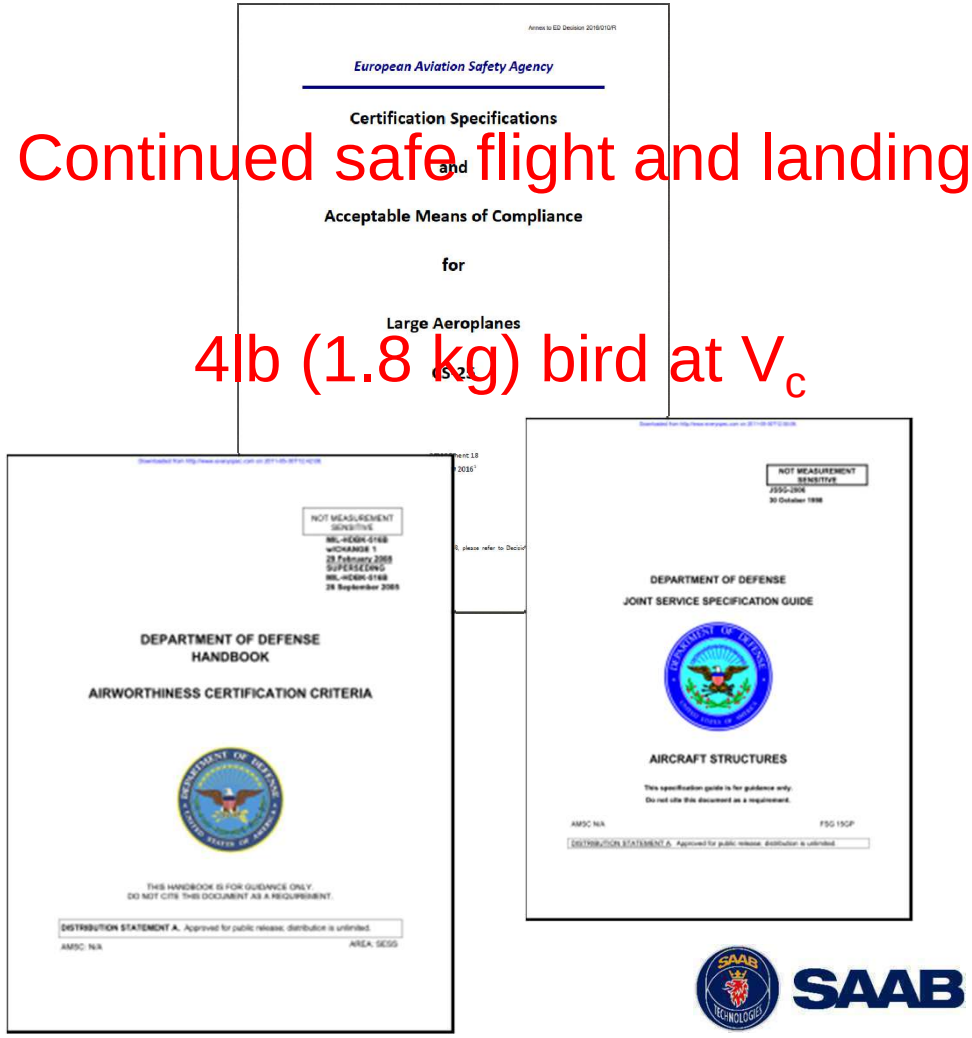
JAS 39-252 Collision with a flock of cormorants, Blekinge 18th August 2018
Photo: GKN Aerospace

Background to Bird Strike Testing

- ✈ Civilian Certification Requirements:
  - FAA Code of Federal Regulations 14, part 25-571 (14 CFR part 25.571)
  - EASA CS-25.631
- ✈ Military Certification Requirements:
  - MIL-HDBK-516B change 1
  - JSSG-2006 (Joint service spec. guide)

Continued safe flight and landing

4lb (1.8 kg) bird at V_c



Background to Bird Strike Testing

- JAS 39 Gripen Testing:
  - ASTM F330 Issue 10; ”Standard Test Method for Bird Impact Testing of Aerospace Transparent Enclosures”
- Test objectives:
  - No loss of the Aircraft
  - No incapacitation of the pilot
  - No ingestion of debris into the engine

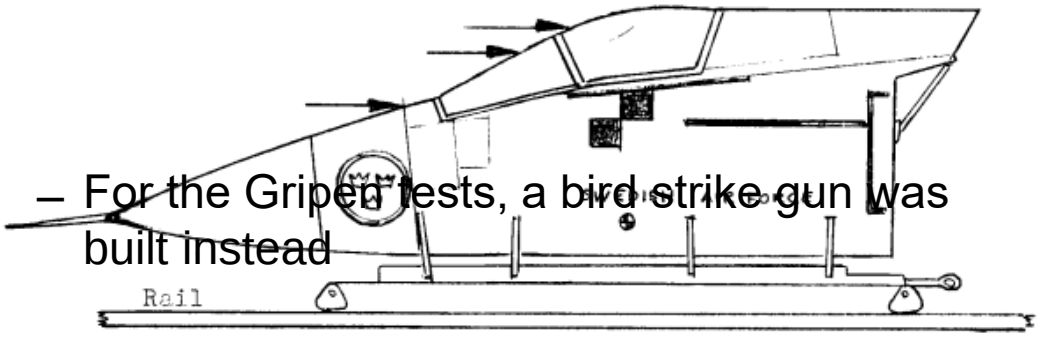
AW109 (Hkp 15) Collision with a wood grouse, Sveg 3rd February 2017, Photo: SHK

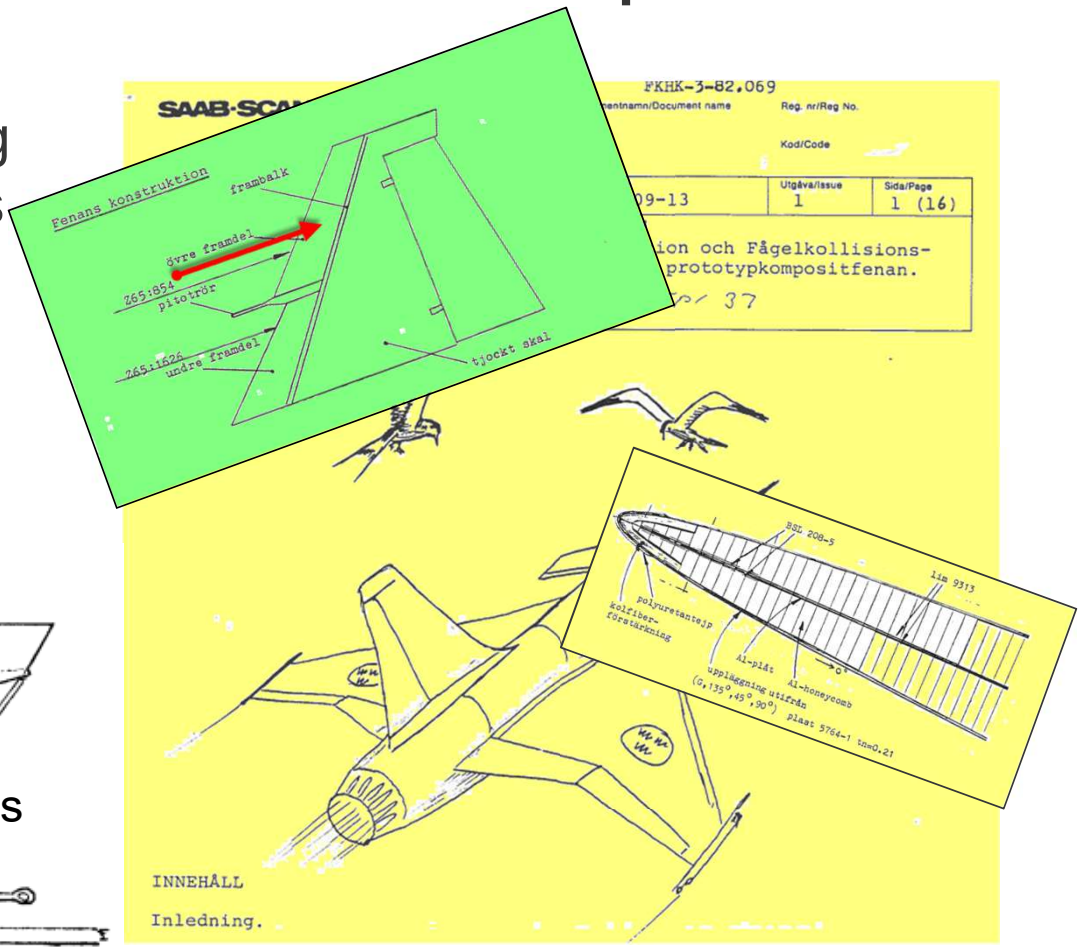
- Requirements on JAS 39 Gripen:
  - Agreement between SAAB & FMV (Swedish Defence Material Administration)

1.0 kg bird at 1100 km/h

Testing the JA 37 Viggen & JAS 39 Gripen A

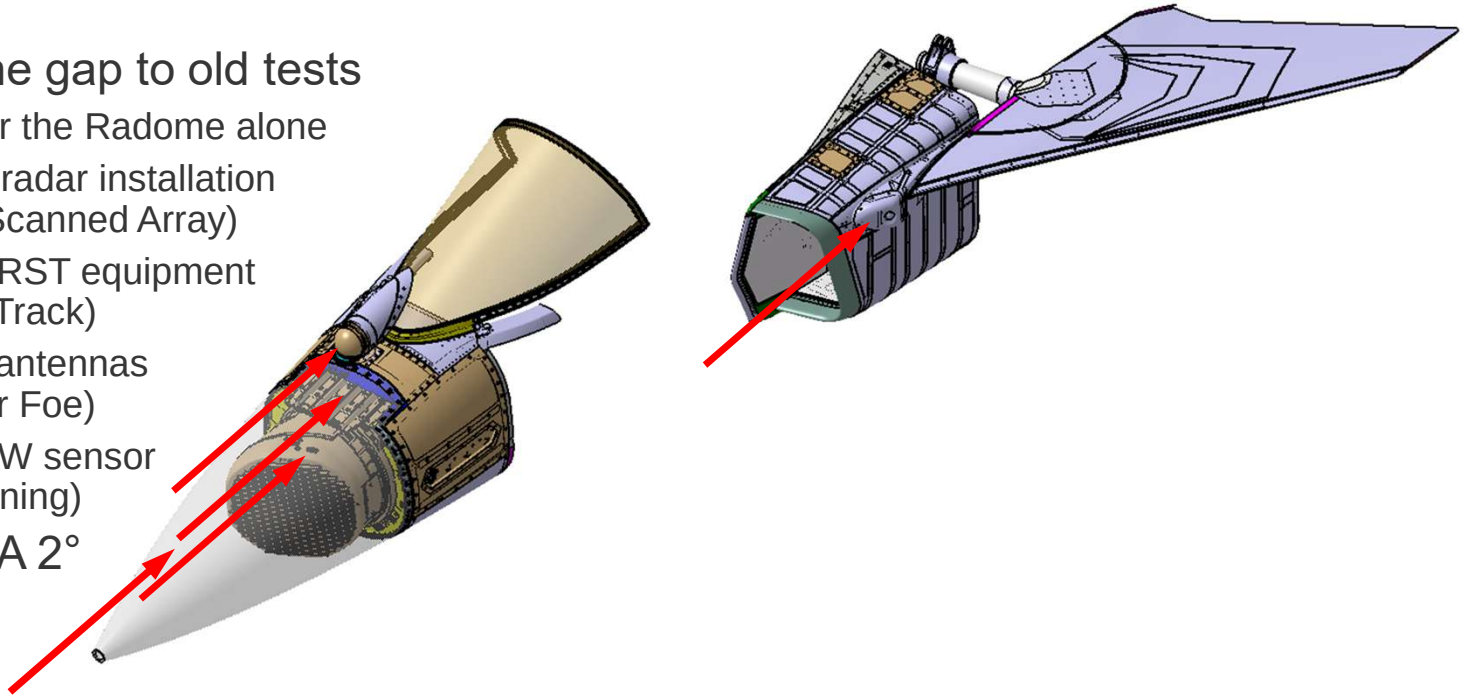
- Wide range of tests performed during the 1980s, including Bird Strike Tests
  - The tests are used to verify the requirements on all Gripen versions
  - How to justify the introduction of new systems based on old tests?
  - For the Gripen tests, a bird strike gun was built instead





Testing the JAS 39 Gripen E

- New systems of the Gripen E:
  New tests
  - 7 tests defined to fill the gap to old tests
    - One verification test for the Radome alone
    - One test for the AESA radar installation (Active Electronically Scanned Array)
    - Two tests for passive IRST equipment (Infra-red Search and Track)
    - Two tests for new IFF antennas (Identification Friend or Foe)
    - One test for a new MAW sensor (Missile Approach Warning)
  - Tests performed at AoA 2°
  - Speed: 1100 km/h
  - Two rigs or one?



Testing of the JAS 39 Gripen E

✈ Test Set-Up:

- Data acquisition system:
  Dewesoft – Sirius 64 channels 200 kHz
- Camera system:
  4 st Photron SA – up to 20 000 fps
- Lighting system:
  4 st Gun-Lux LED Maxi Brut 1200
- Bird Strike Gun:
  Tempered barrel to 20°C
  Calibre 150 mm, 24 m long

× 8

× 4

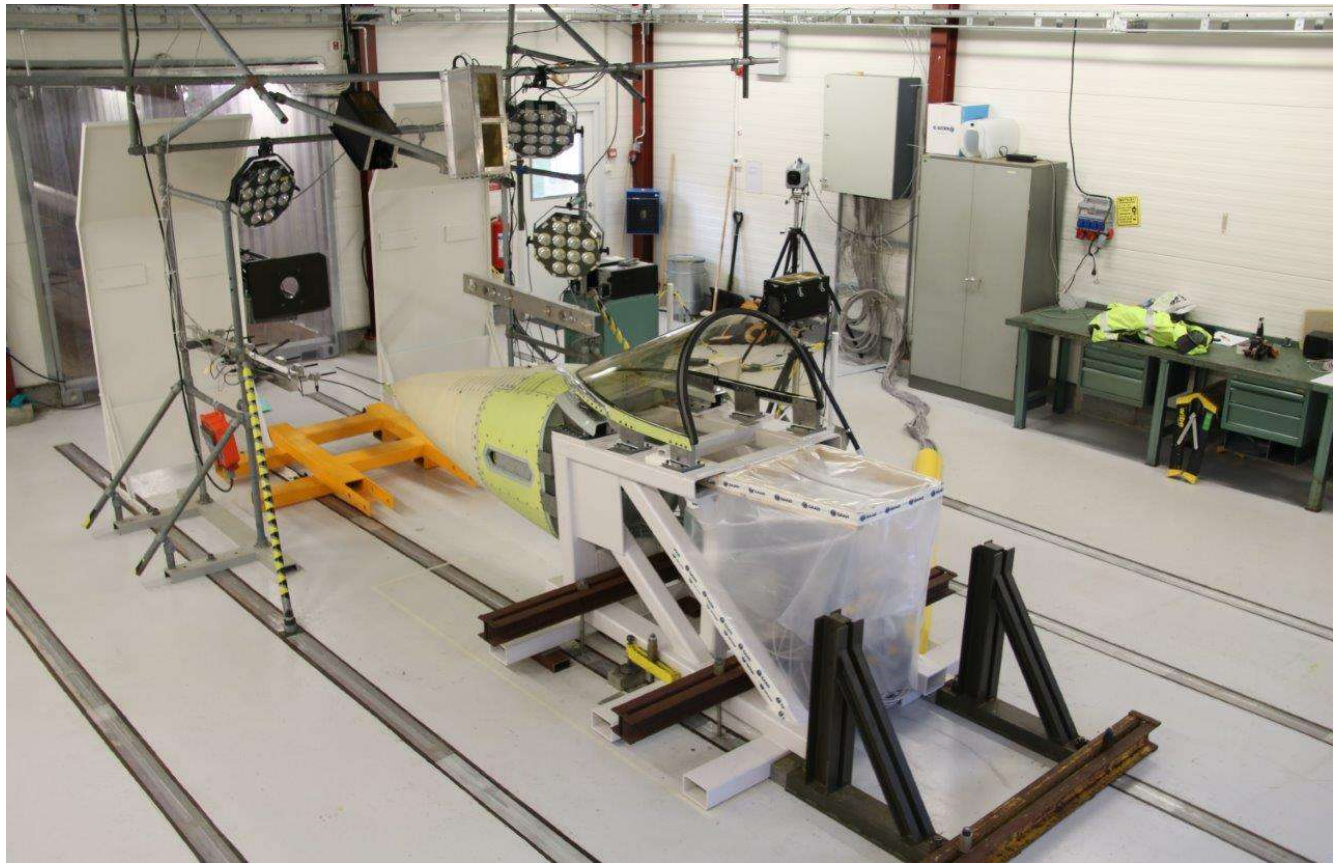
× 4

× 1

SAAB

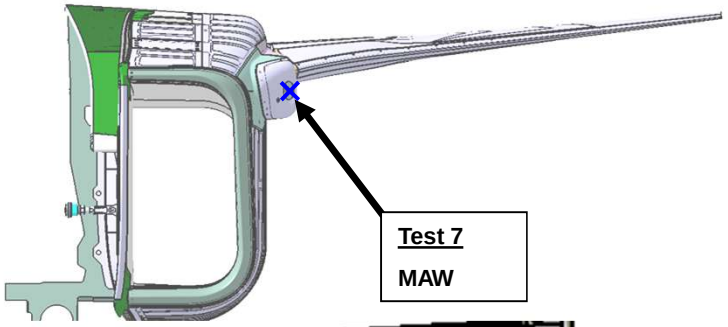
Testing the JAS 39 Gripen E

- Front Fuselage
  Test Object & Rig:
  - Rig: Stiff frame supporting the test object
  - Radome
  - Windshield
  - System installations for the specific test
- Instrumentation:
  - Strain gauges
  - Accelerometers
  - Thermocouples

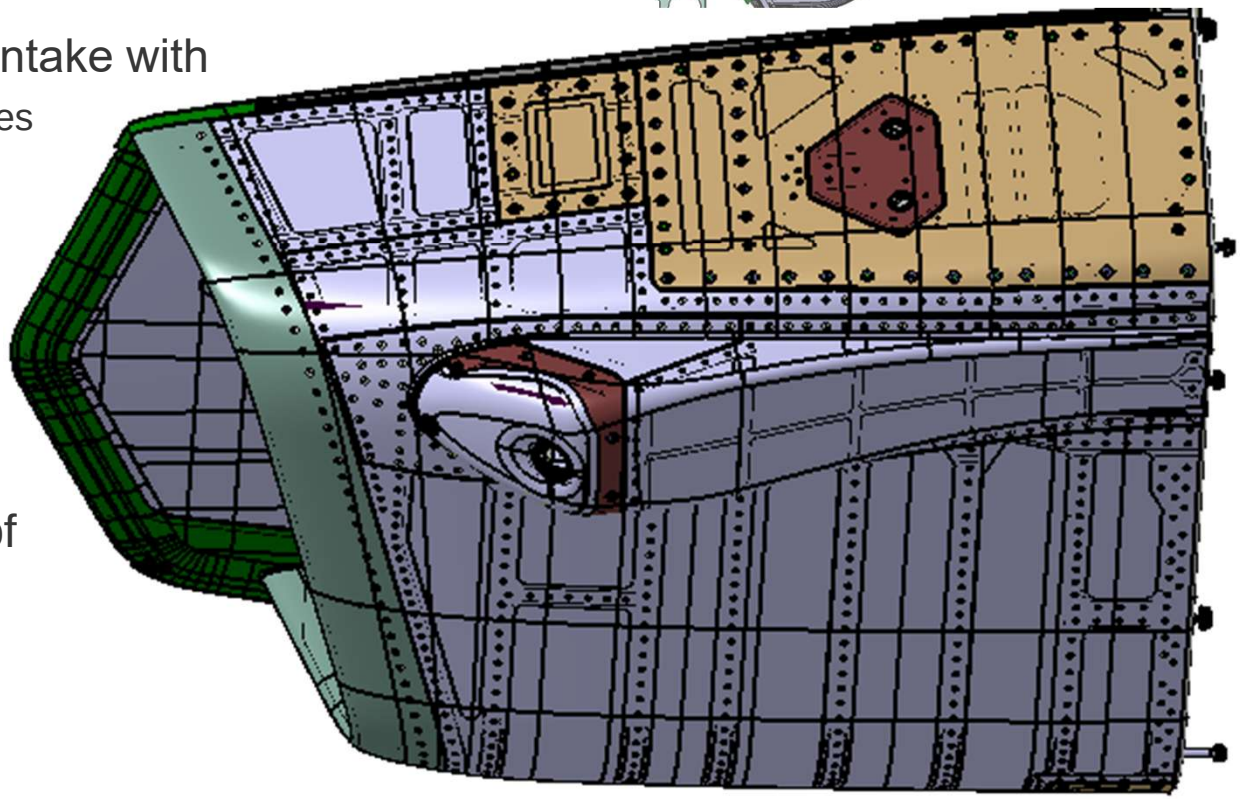


SAAB TECHNOLOGIES SAAB

Testing the JAS 39 Gripen E



- ✈ MAW Test Object & Rig:
  - Instrumented Gripen E Air Intake with
    - 52 Channels for Strain Gauges
    - 10 Accelerometers
    - Thermocouples
    - MAW Mock-up
    - System Mock-ups
  - Modified Gripen C Canard
  - Additional challenge:
    Prove that there is no risk of jamming canard



× 1

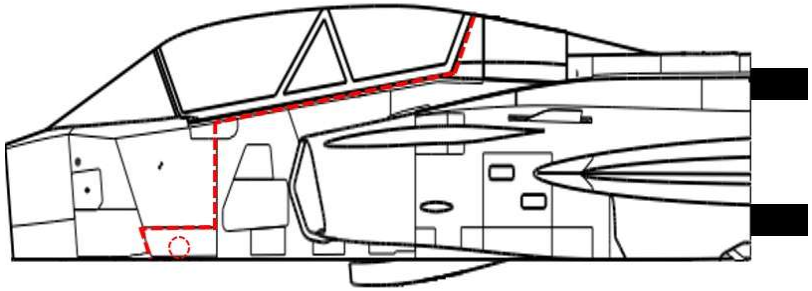
SAAB

Testing of the JAS 39 Gripen E

- MAW Test Object & Rig:
  - JAS 39-802
  - The last Gripen B to fly for the Swedish Airforce
  - Has flown for Empire Test Pilots' School (ETPS) of the UK
  - Scrapped fuselage used for previous testing

- Slight modifications made to interfaces to accommodate the Gripen E Air Intake & Gripen C Canard

× 1

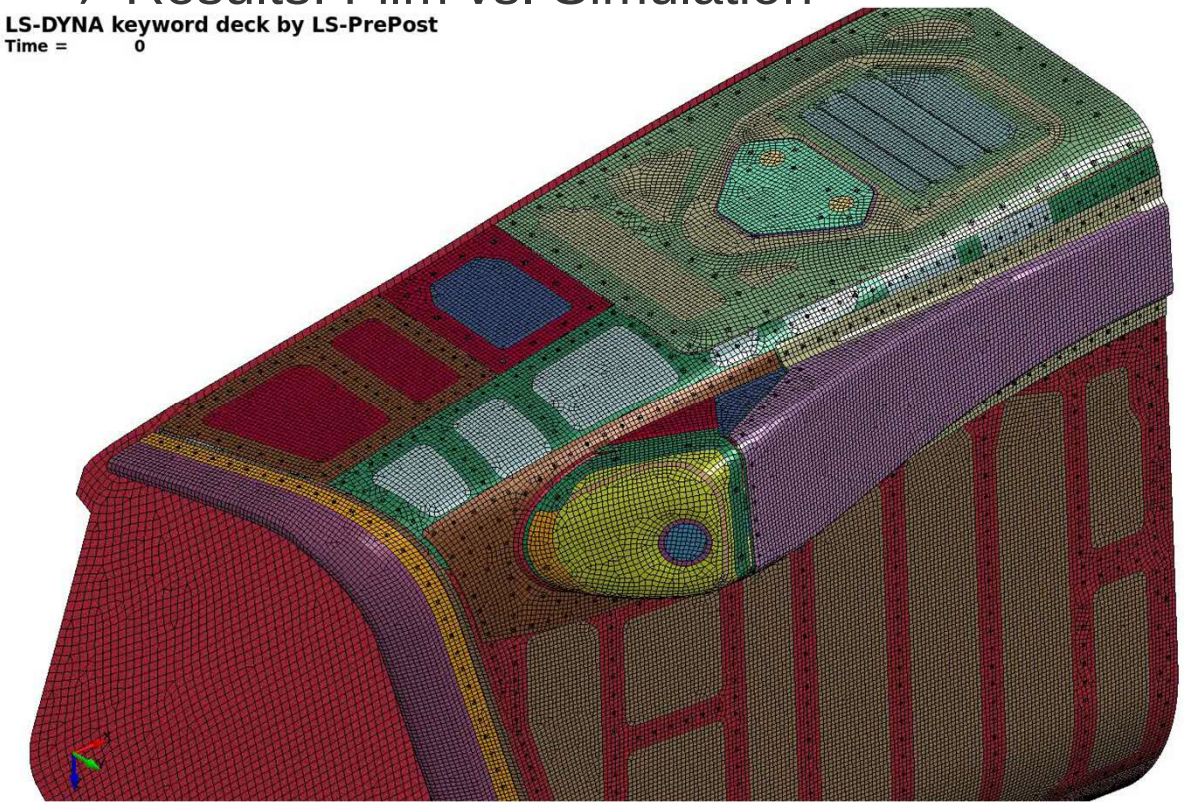


Testing of the JAS 39 Gripen E

✈ MAW Test Object & Rig:

Testing of the JAS 39 Gripen E

- ✈ Results: Film vs. Simulation



Testing of the JAS 39 Gripen E

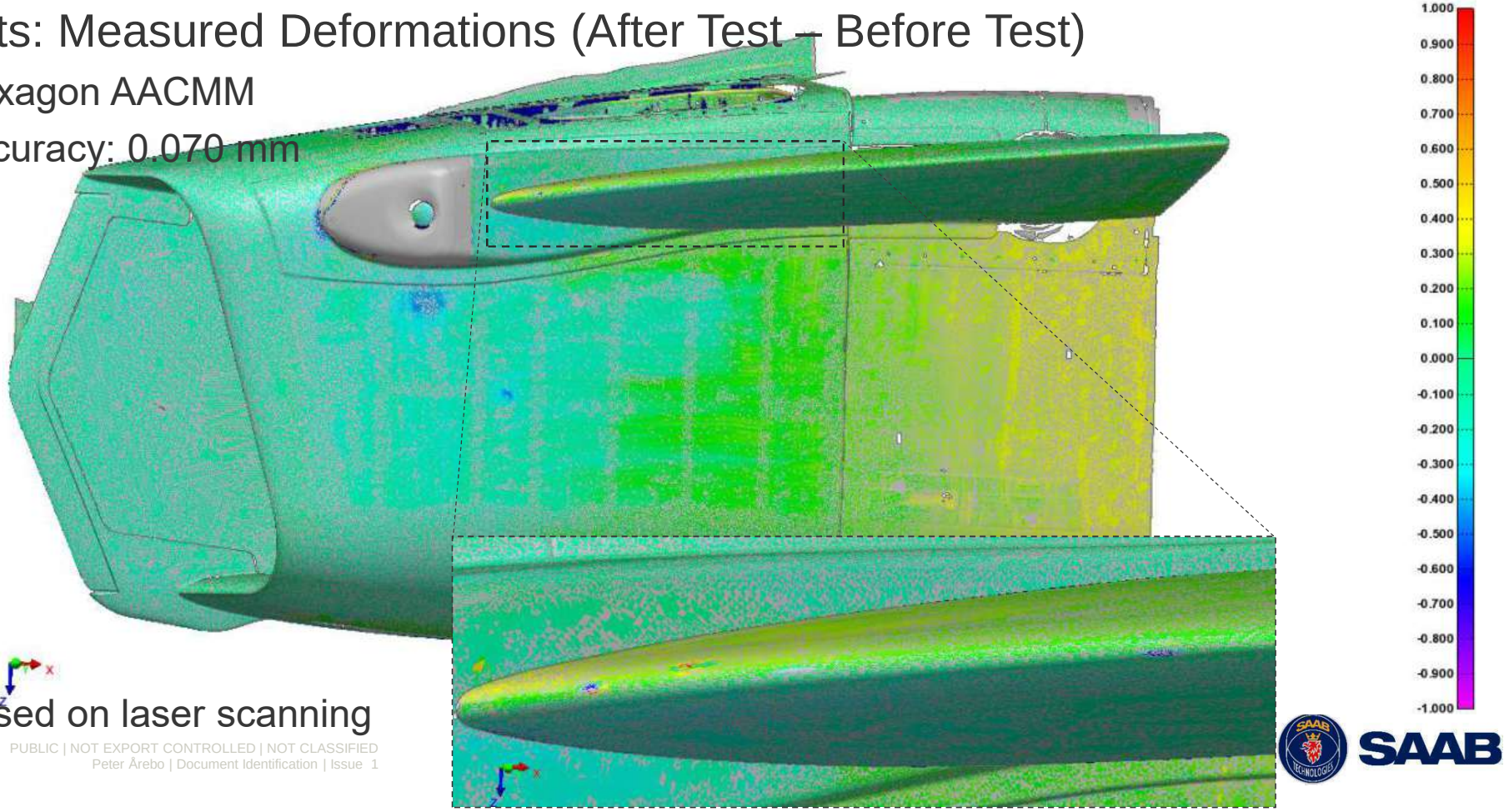
- ✈ Results: Film vs. Simulation

Testing of the JAS 39 Gripen E

- Results:
  - A bird strike to the MAW installation causes large damage to the covers, but no penetration into the air duct.
  - The released debris is safely diverted away from the fuselage and interface to the Canard.
  - Only scratches caused on the Canard leading edge.

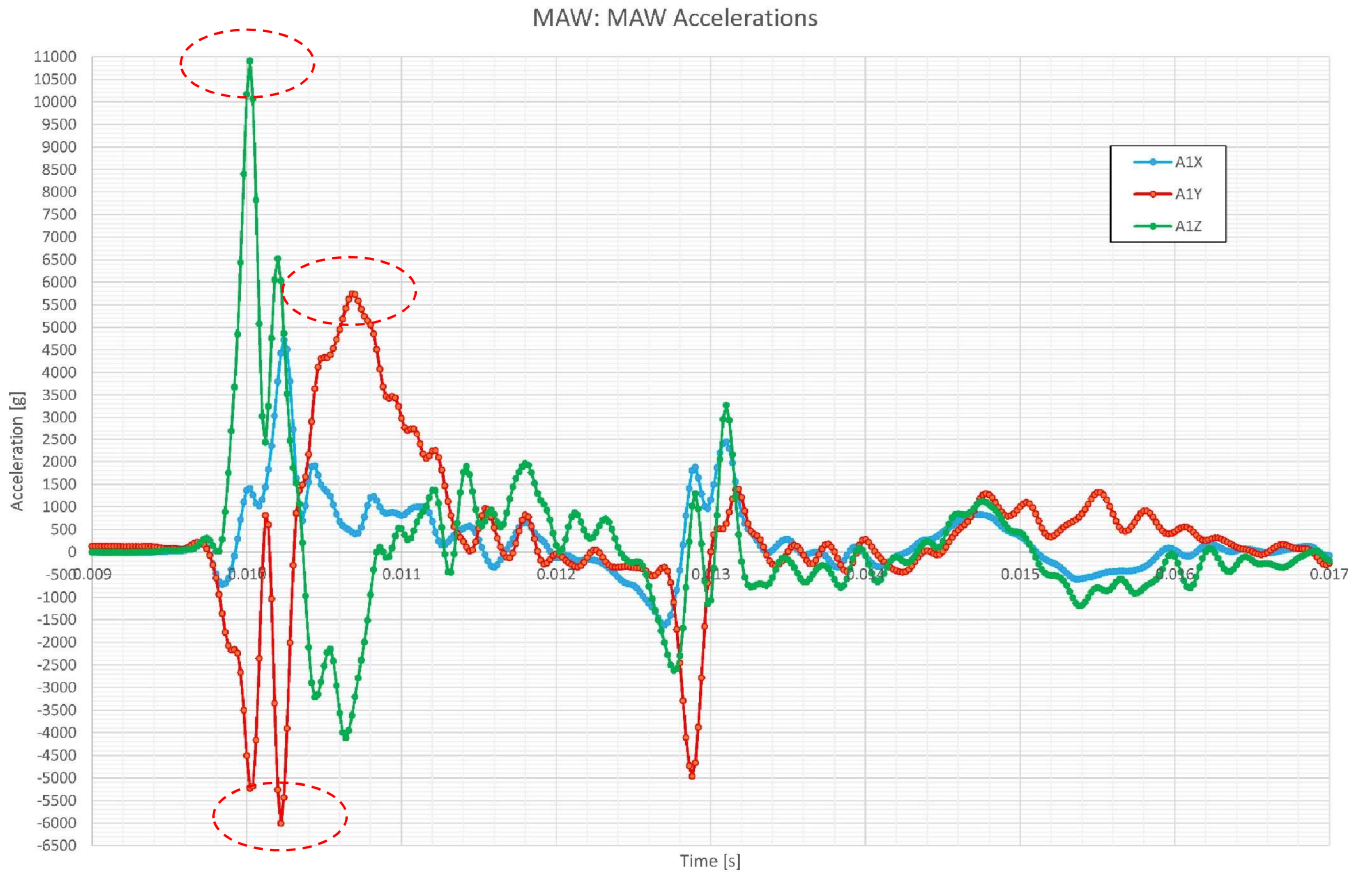
Testing of the JAS 39 Gripen E

- ✈ Results: Measured Deformations (After Test – Before Test)
  - Hexagon AACMM
  - Accuracy: 0.070 mm
  - Based on laser scanning



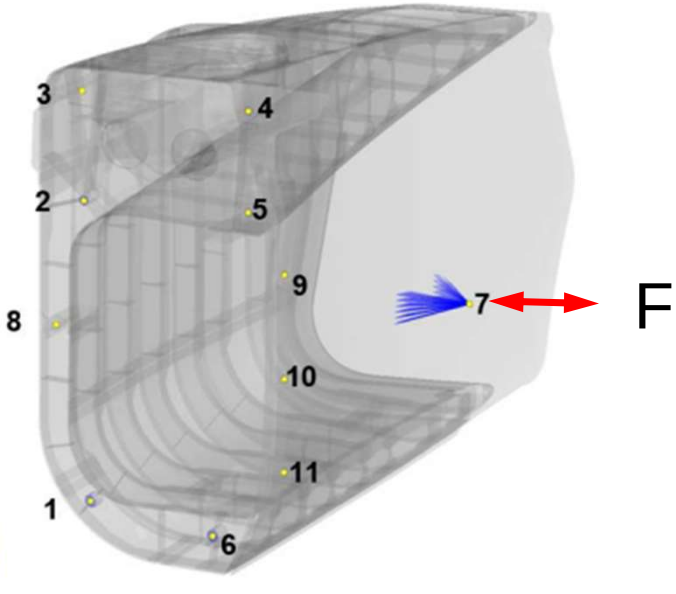
Testing of the JAS 39 Gripen E

- ✈ Results:
  - Accelerations to the MAW
    - ~ +11 000 g along axis
    - ~ ± 6 000 g lateral



Testing of the JAS 39 Gripen E

- Results: Test compared to Simulation
  - Forces in connection studied
    - Tension: Simulation overestimates test by 48%
    - Compression: Simulation overestimates test by 109%
  - Note:
    - The connection is not in the strike zone ←→ less refined modelling
    - High strain rates are involved ←→ data is scarce
    - Simulations are intended to cover all bird strikes, not a specific bird



- Conclusions:
  - Simulations provide a good understanding of the failure sequence
  - A dynamic FE-model give conservative stress results, unless specifically tuned
  - FE-models can be suitable for extrapolating results for slightly altered parameters.
- Tests are still required

SAAB

Testing of the JAS 39 Gripen E

Thank you for your attention!