Verification and validation of calculated structural loads with flight test

2019-10-08
FT2019, Aerospace Technology Congress, Stockholm

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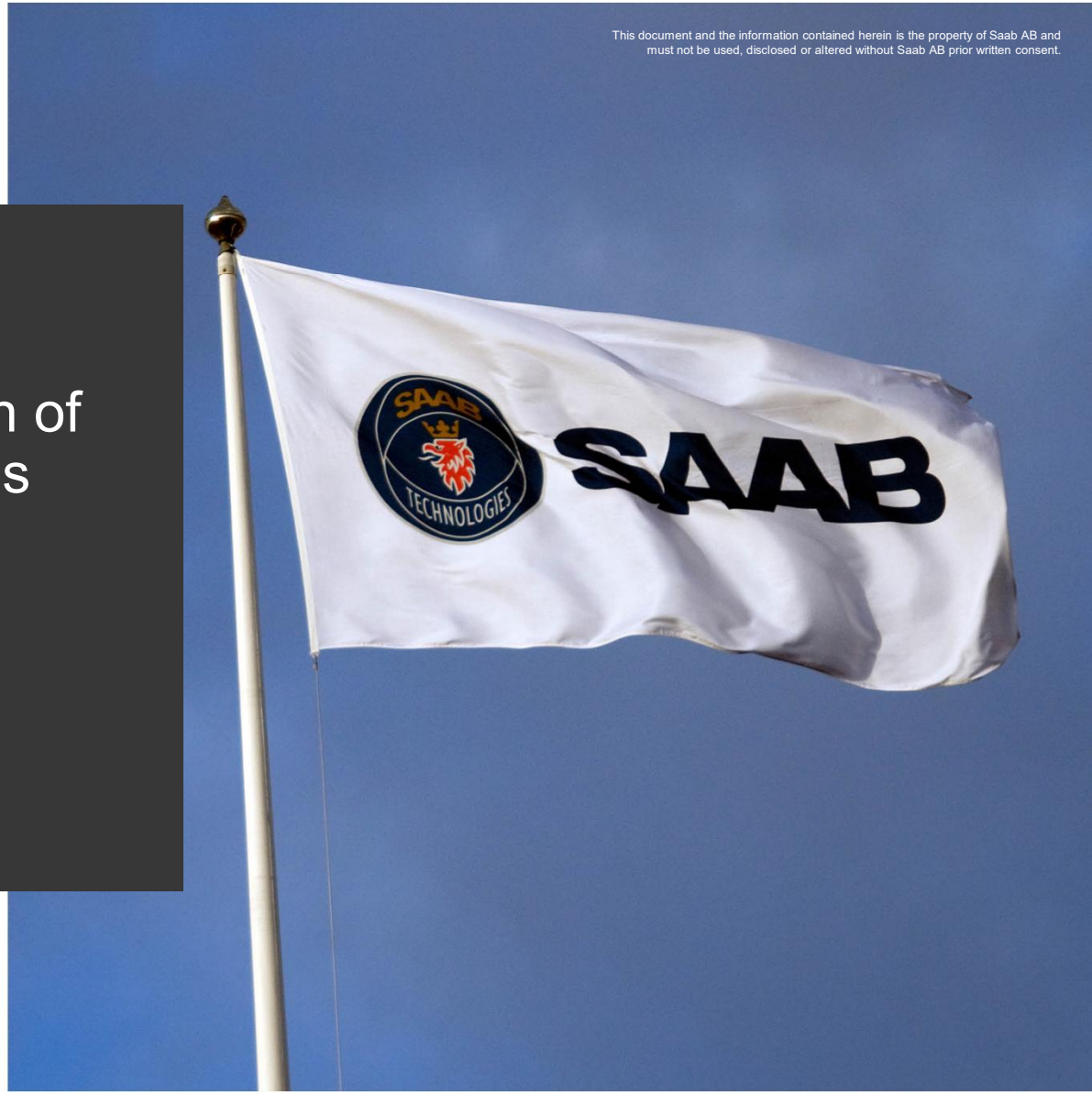

Agenda

- Loads acting on the airframe
- Pre flight test
  - Measuring points and manoeuvres
  - Gauge installation
- Post flight test
  - Balancing deviations
  - Gauge calibration
  - Mass distribution
  - Aerodynamic coefficients
- Effects of load deviations at different load levels
  - Limit loads
  - Fatigue loads
- Load registration system

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Loads acting on the airframe

- Flight loads (maneuvers)
- Landing loads
- Ground handling loads (towing, braking, tethering, turning etc.)
- Store separation loads
- Temperature loads
- Other events (Air to air refueling, gun firing, separation of countermeasures etc.)
- Local pressures on hatches etc.

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Measure points and manoeuvres

Flight test is done for verification of the loads model.

Measure points in a loads perspective

- Flight data (altitude, velocities, accelerations, load factors, angles, fuel mass, throttle etc.)
- Main parts (wing, fin, fuselage, landing gears, engine attachments, control surfaces and actuators)
- New structure (ex. Dorsal/ventral units, stablets)

Manoeuvres to get the critical loads of main structure parts.

Gauge installation

Limitations

- Space/accessibility
- Cabling possibilities
- Recording channels
- Weight and CoG
- Cost (Assembly, material, analysing, documentation)
- Permanent installation or does the aircraft has to be restored

Possible reductions

- Only measure one side (ex. left wing)
- Only measure one direction (ex. Fz) instead of six
- Use multiple aircrafts

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Balancing deviations

Two main ways of balancing

- Load factors (Nx, Ny, Nz), roll rate (Wx) and rotational accelerations Ex, Ey, Ez
- Angles (AoA, AoS and control surface deflections)

Which load gives the largest contribution to the total loads on every structural part?

Gauge calibration

- When was the gauge last calibrated?
- At which flight/ground condition where they zeroed?
- Gauge change due to temperature

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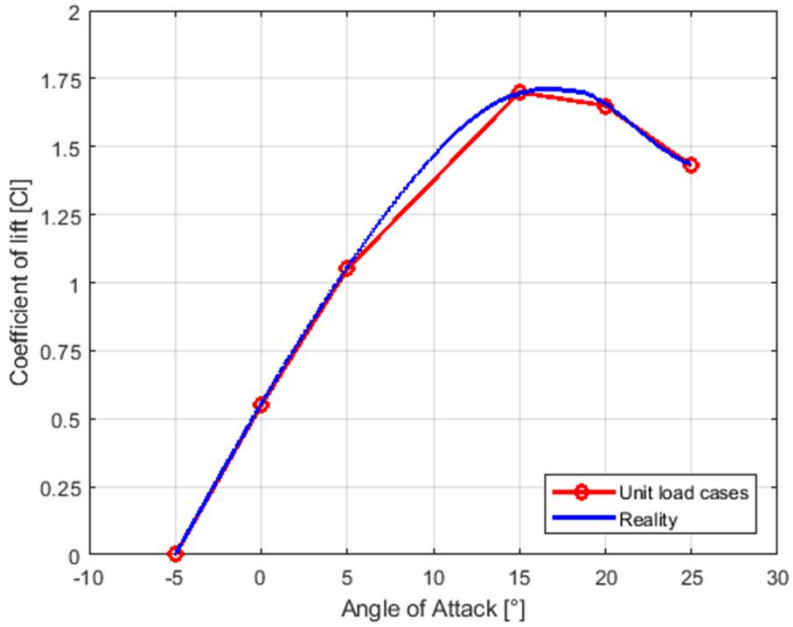
Mass distribution

- Aircraft empty weight and centre of gravity
  Is the FE-model based on the test aircraft or the serial aircraft?
- Fuel position and consumption
  How much fuel in each tank?
  Emptying sequences?
  How could the fuel move during different manoeuvres?
- External stores

Aerodynamic coefficients

Do they match with the wind tunnel test?

- Design change since the wind tunnel test
- Wind tunnel tests for a small amount of flight conditions
- Wind tunnel test for unit cases and not for combined flight cases



Effects of load deviations at different load levels

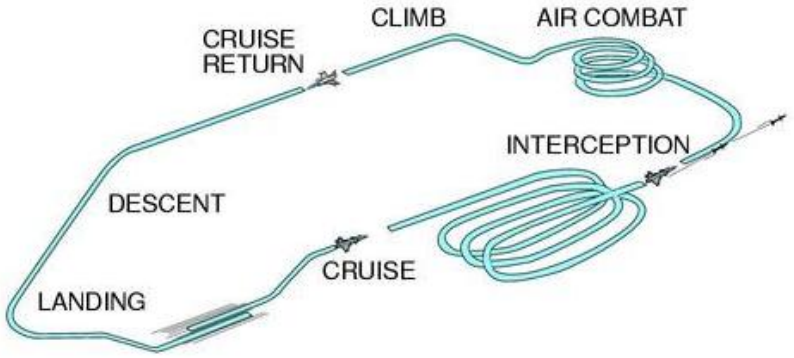
Loads close to the load limits

- Measured loads higher than calculated loads
  - Flight envelop restrictions
  - Weight restrictions
  - Updated flight control system with reduced flight performance
  - Verify the structure with other tests, ex. full scale structural test
- Measured loads lower than calculated loads:
  - Structure unnecessarily heavy
  - Limit weights could be increased
  - Increased envelope
  - Heavier stores could be used

Effects of load deviations at different load levels

Frequently occurring loads
(used for fatigue calculations)

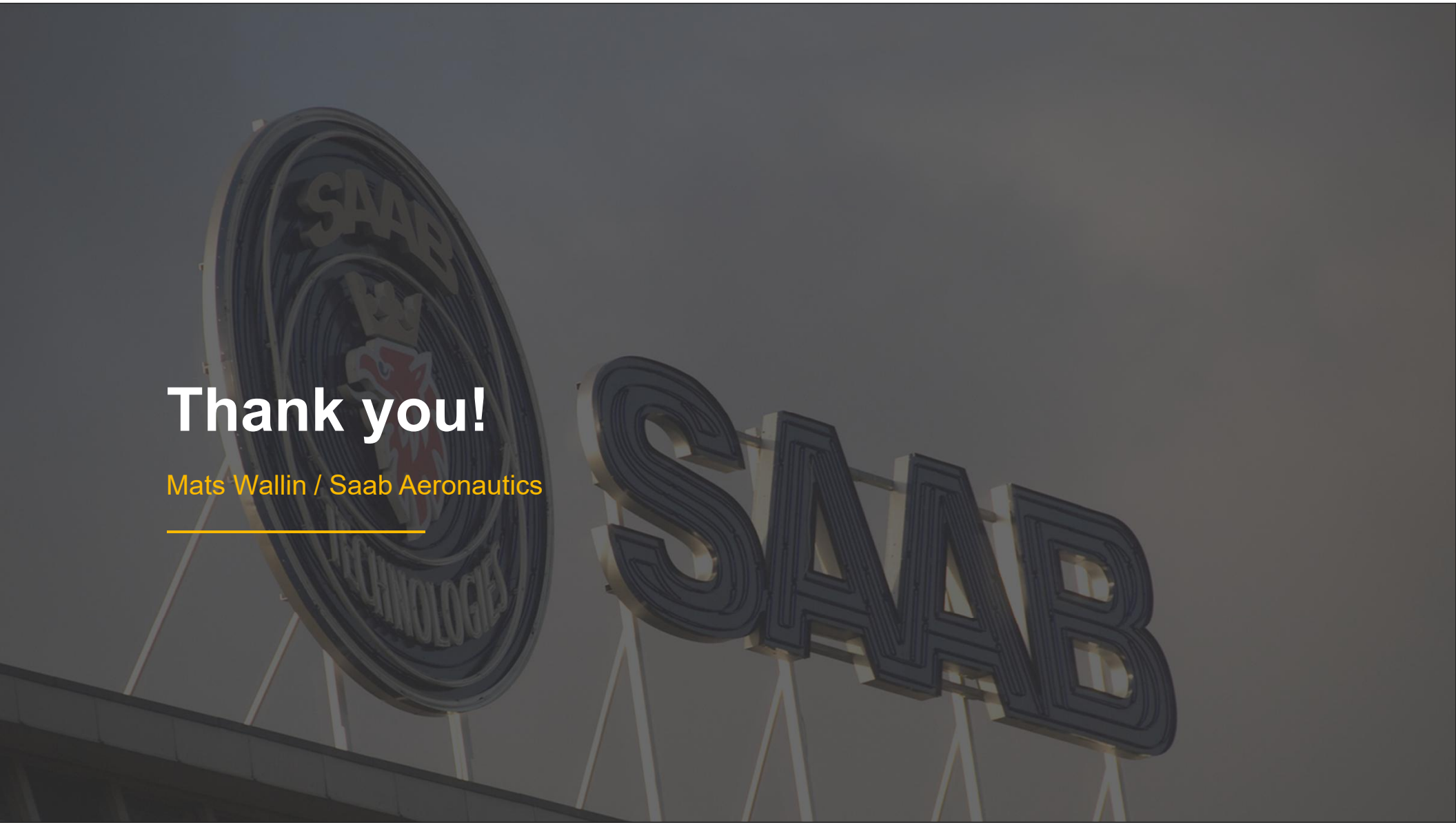
- Measured loads higher than calculated loads
  - The airframe won't last the entire life
  - Structural parts needs to be changed before planned and won't fit service intervals
- Measured loads lower than calculated loads
  - Increased aircraft life
  - Structural parts with lower lifetime than the aircraft could be changed later
  - Too heavy aircraft
  - Too short inspection intervals



Load registration system

Flight tests are used to calibrate the load registration system MGSS.

This is important to know the life consumption of every structural part of every airplane in the fleet.



Thank you!

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