The Need for and Use of a Life Monitor System on a Modern Fighter Aircraft

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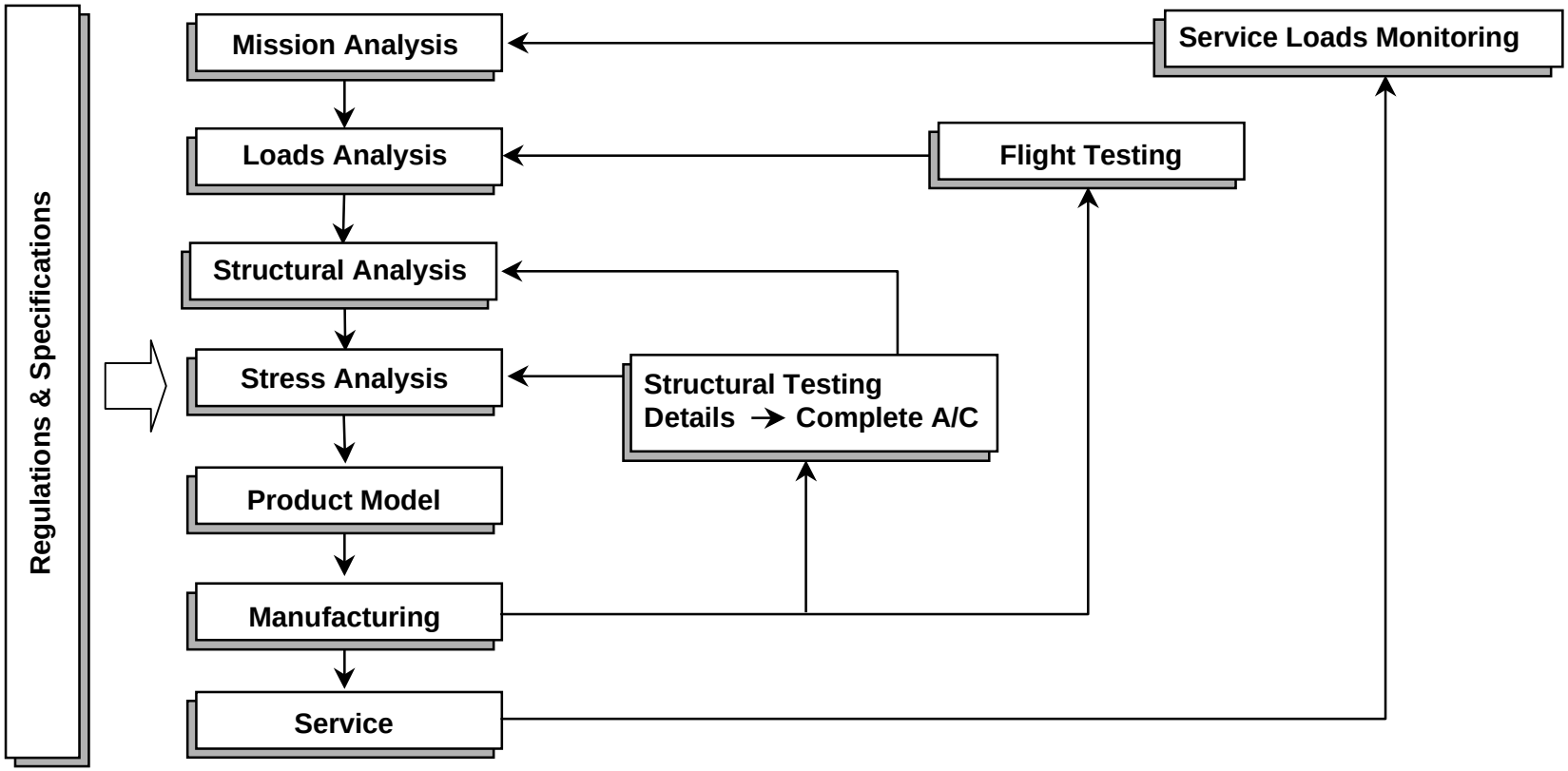
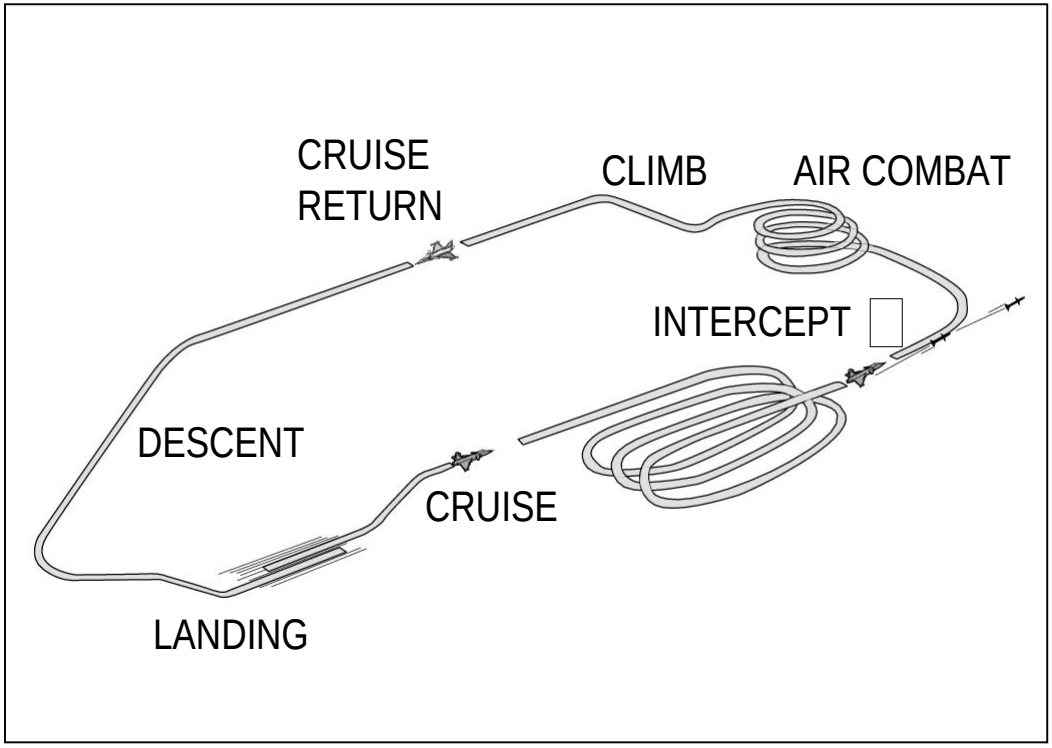
Durability & Damage Tolerance Management



Mission Analysis

- **Previous Experience**
- **Expected Threat**
- **Future Tactics**



Mission Types
- basic training
- air-to-air
- air-to-surface
- reconnaissance

Mission Segments
- safety and function tests
- ground manoeuvring
- combat manoeuvring
- store separation
- gun firing
- landing

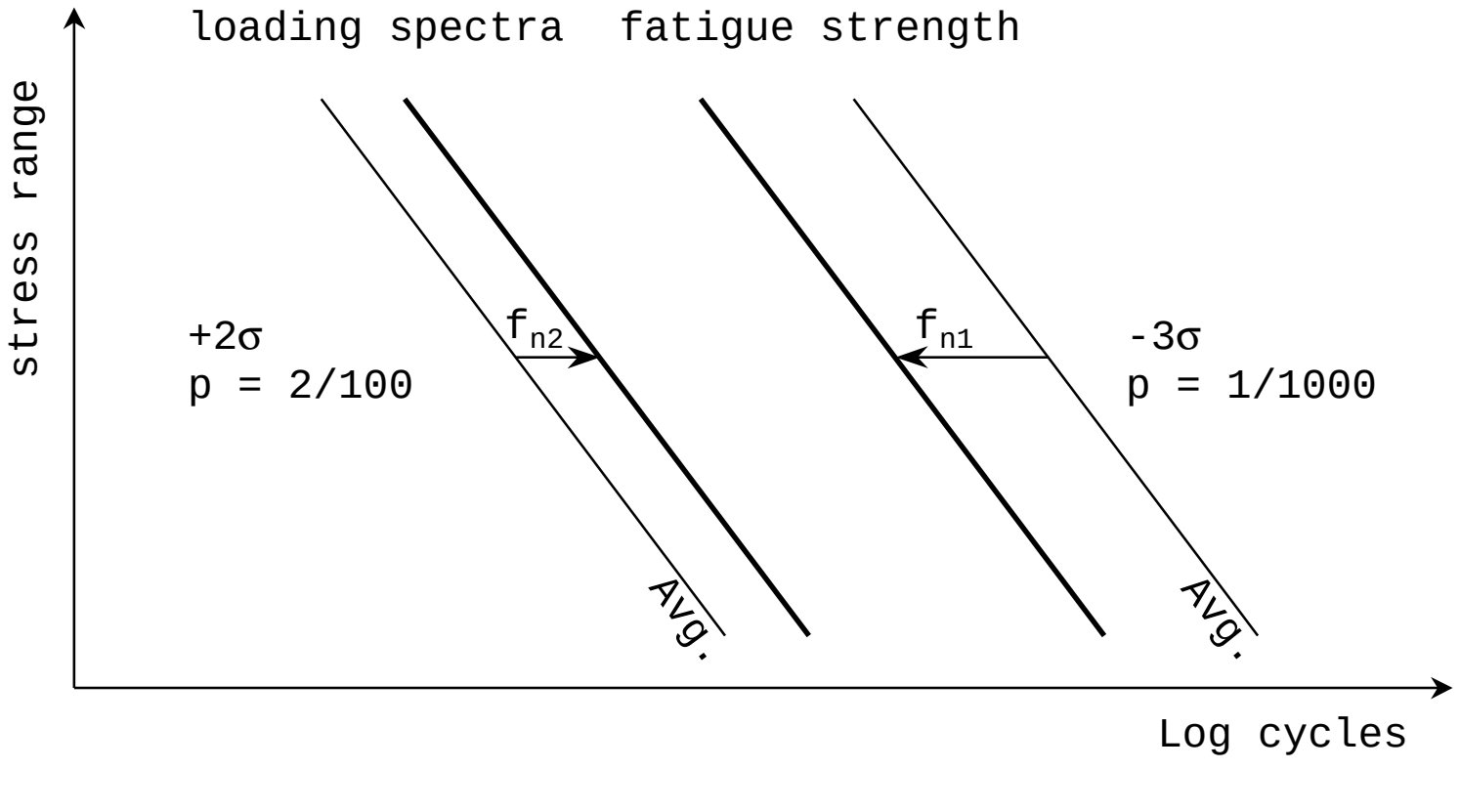
Design Parameters
- accelerations
- angular velocities
- speed
- altitude
- control surface deflections
- thrust
- fuel consumption
- store configurations

Product Specifications

- Service Life
- Inspection Free Life

Design Requirements

- Failure Risks
- Safety Factors



Allowances for uncertainties in Service Loading

Defence Standard 00-970

When the service loading of individual details is unmonitored it is necessary to apply a factor to allow for this uncertainty.

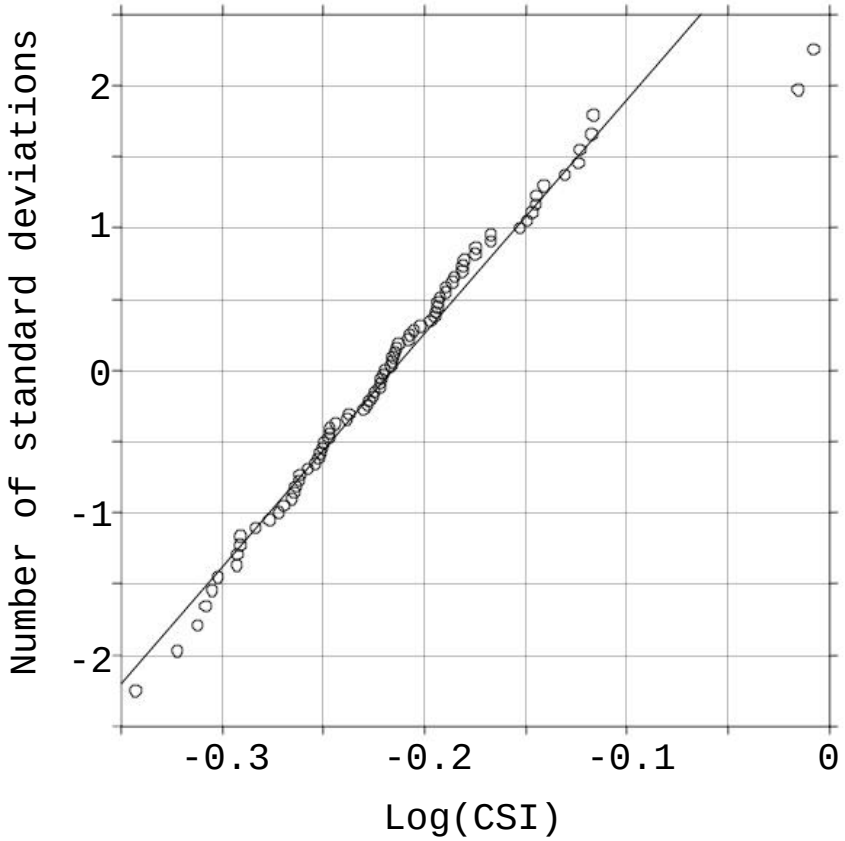
It is customary to to use a factor of 1.50 on life.

$$f_n = 10^{n\sigma}$$

Variability in Load Factor n_z

Load factor variations in a fleet of 81 AJ37 Viggen aircraft monitored during a period of 5 years.

Variation expressed in terms of a crack severity index CSI



$\sigma = 0.061$

$f_{+2\sigma} = 10^{2*0.061} = 1.32 < 1.50$

Variability in Service Loading

Possible causes

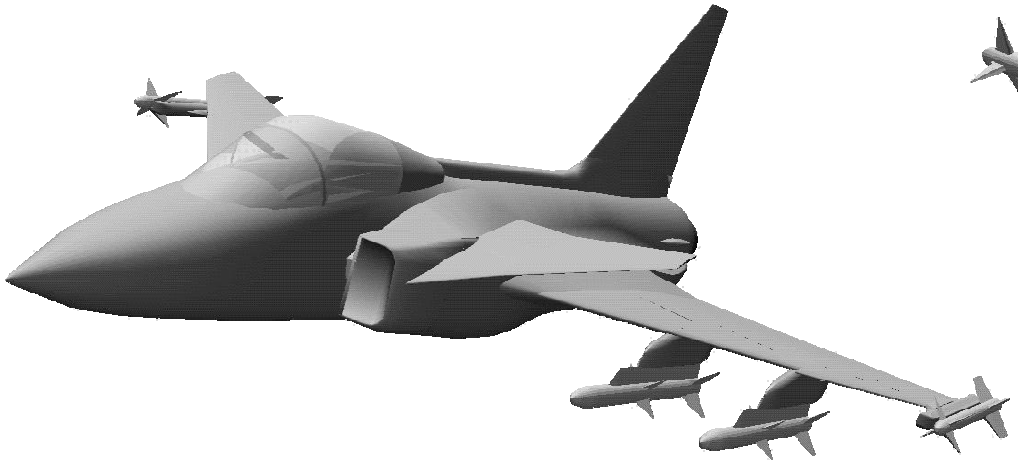
- Multi-Role / Swing-Role
- Service in several air forces
- Flight control system revisions
- New armaments

Flight Control Laws

Aerodynamics

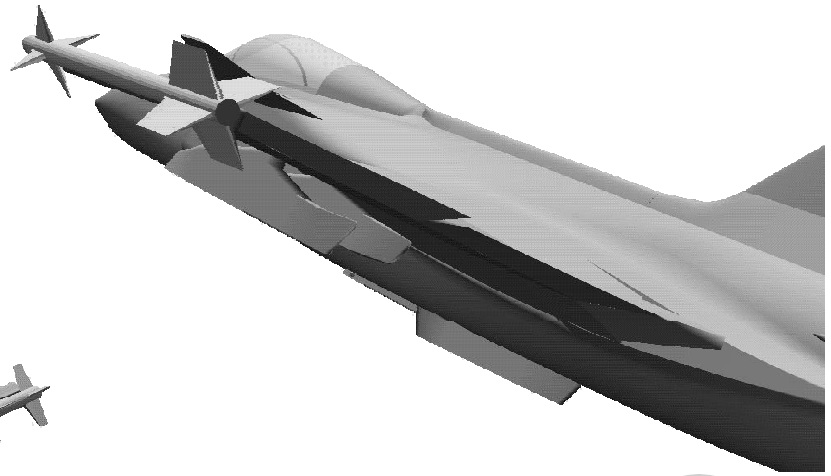
Aerodynamic changes through flight control laws update

- canard foreplanes vs. elevons
- inner vs. outer elevons



Load Alleviation

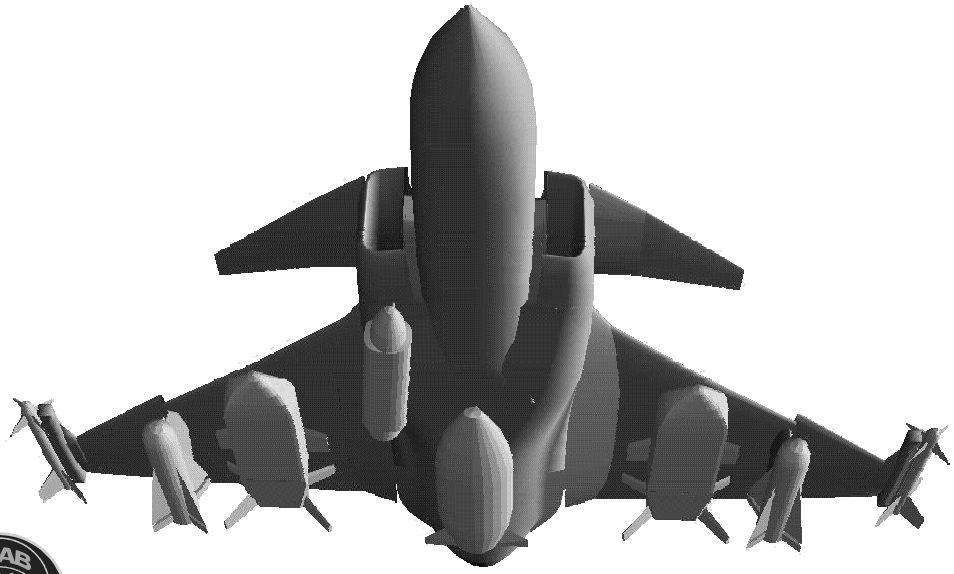
Alleviation of wing bending moment through elevon split



Armaments and Tactics

New weapons

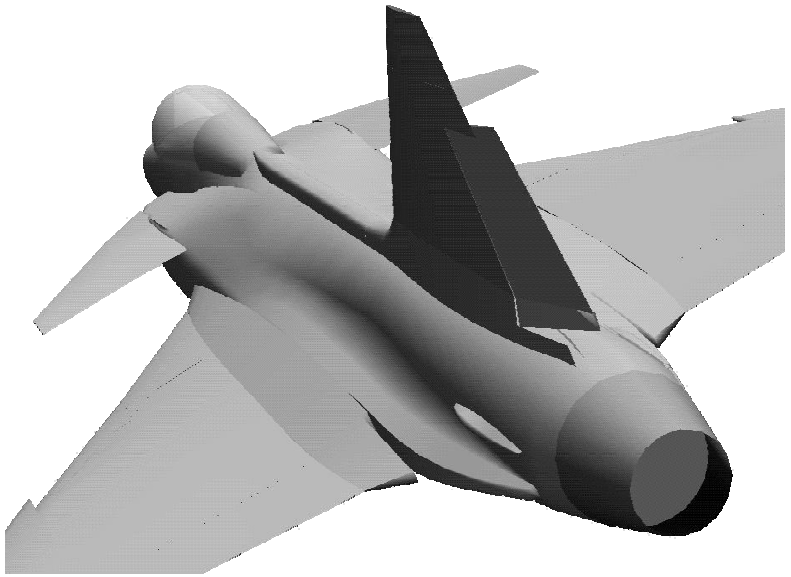
Changed loading of weapon pylons and their attachments to wing structure



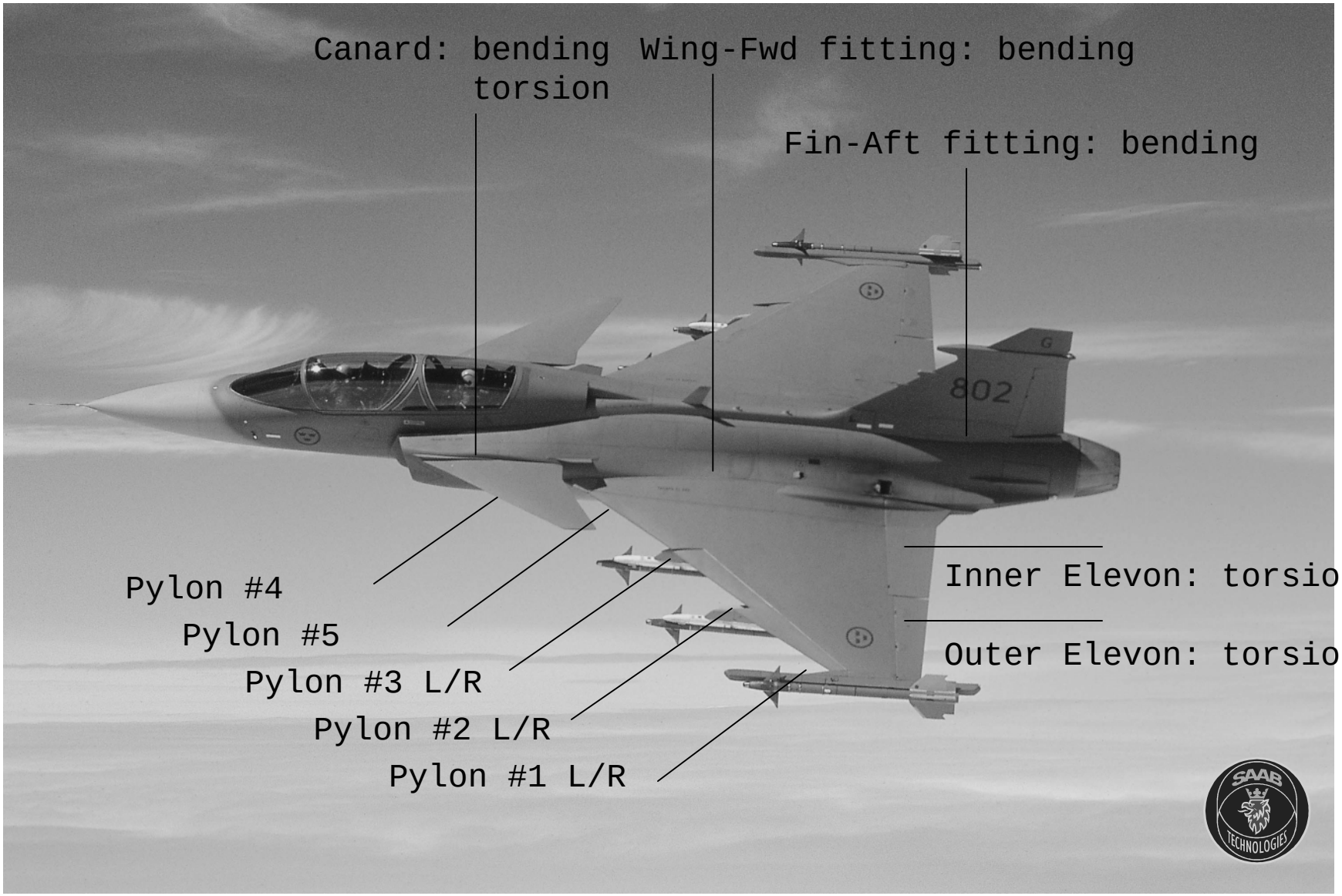
New manoeuvers

Severe loading of fin and rudder during side-slip manoeuvers (aiming)

- fin bending
- rudder torsion



Monitored structure and entities
JAS39 Gripen

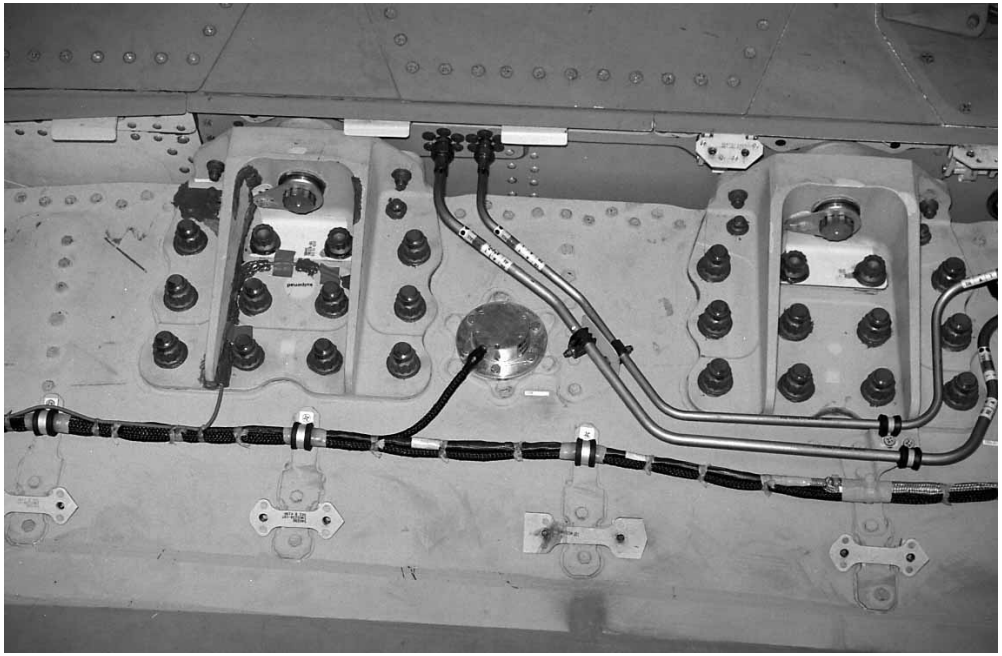


Loads Monitoring Principles

- **Direct measurement of strain**

+ direct measurement of strain in critical locations
+ no needs for configuration control
+ vibration loads can be obtained

- needs scheduled calibrations
- no other locations than those instrumented can be monitored
- strain gauges can be damaged

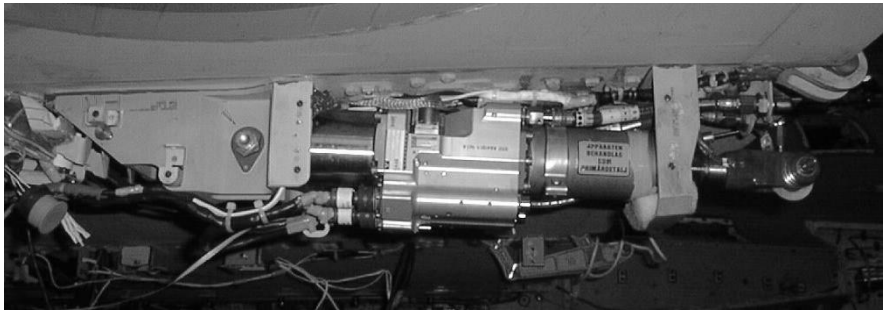


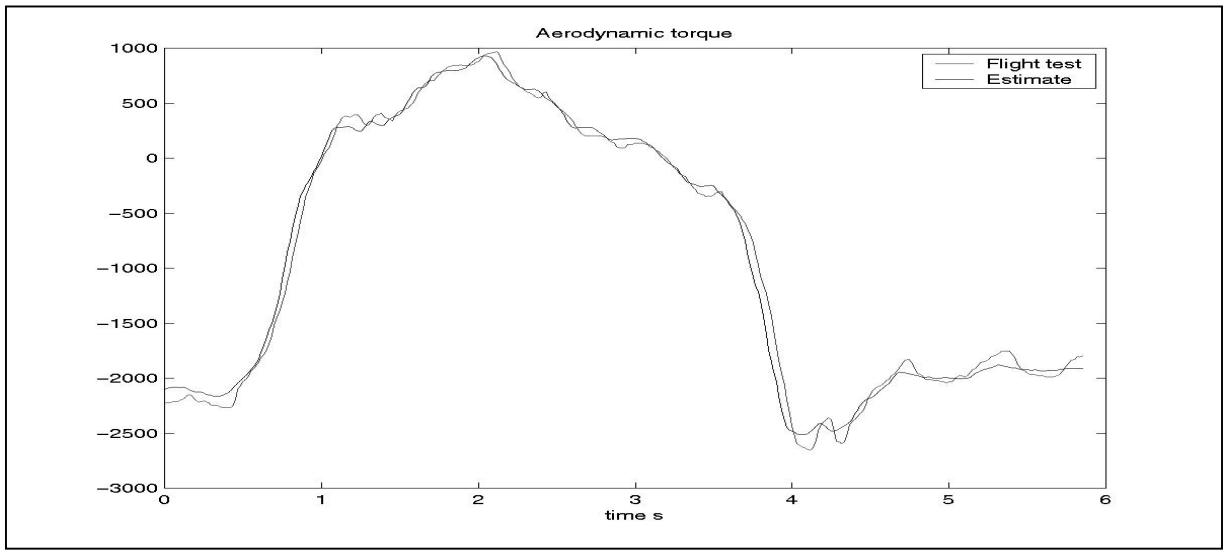
Loads Monitoring Principles

- **Calculation of loads from flight parameters**

+ every location covered by the loads model can be monitored
+ do not need calibrations
+ can monitor loads where strain measurements are impractical

- needs configuration control
- rely upon an (semi-)analytical loads model
- vibration loads are difficult to monitor



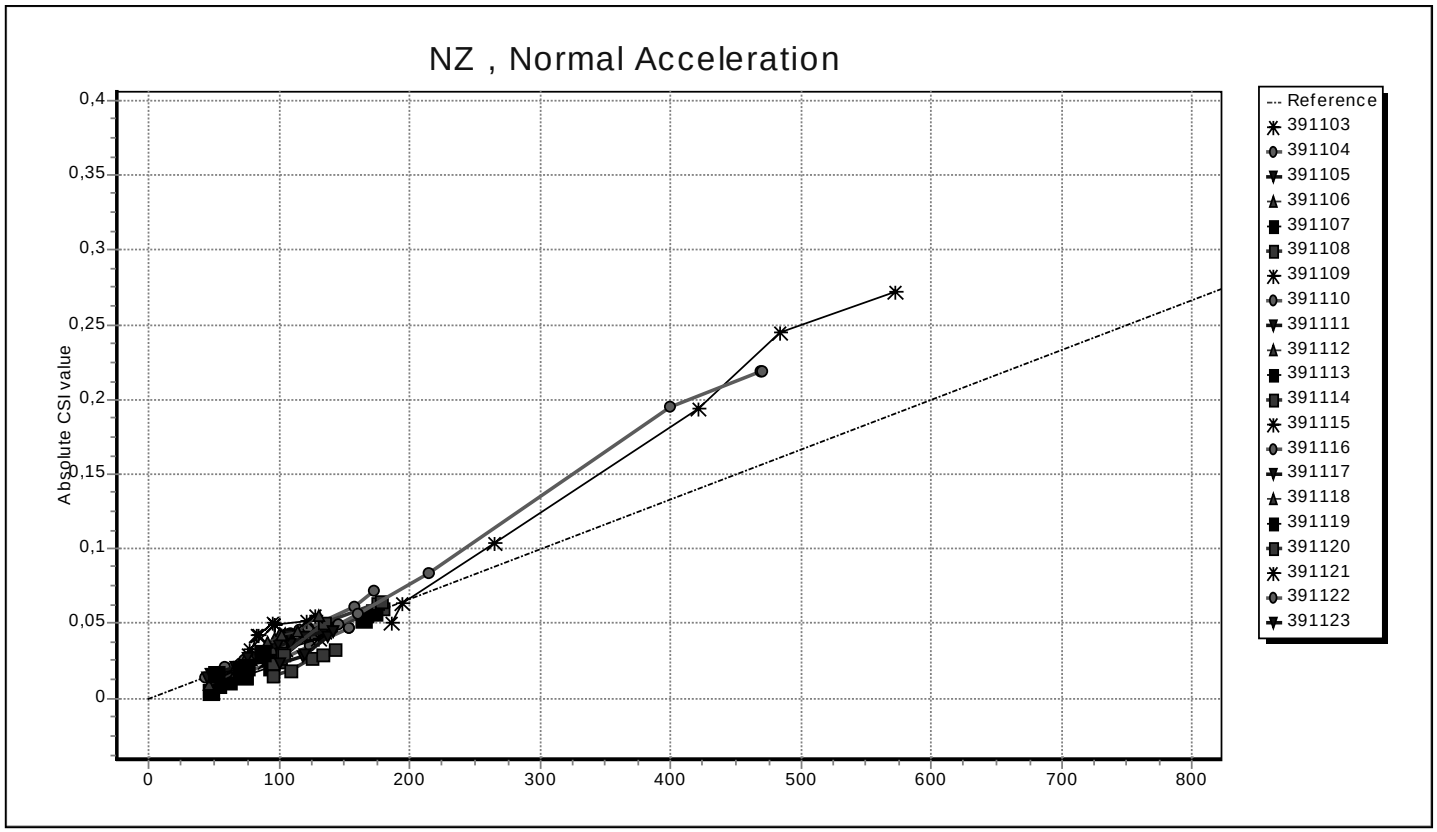


Fatigue/Crack Severity Index

$$CSI = 1/CSI_{design} \cdot \Sigma(\Delta\sigma_{eff})^m \cdot n$$

where $\Delta\sigma_{eff} = \sigma_{max} - \sigma_{op}$

$\sigma_{op} = \sigma_{op}(\sigma_{max}/\sigma_{yield}, R, history, ...)$



Summary

- Multi-Role type aircraft will encounter a large variability in fatigue loading.
- Several options in the future to alter aircraft loads and spectra by software changes of the flight control system.
- New armament may change the loading of pylons and their attachments to wing structure.
- Several monitored entities beneficial for condition-based maintenance.
- Fleetwide loads monitoring will enable the maximum fatigue life to be achieved by each individual aircraft.