Wind Tunnel Test with Pressure Sensitive Paint (PSP) in the aircraft structural load definition.

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Agenda

- Loads on Aircraft (Short definition)
- Pressure Sensitive Paint (Short description)
- Examples of PSP data used at SAAB
- Comparison PSP / CFD
- Advantages / disadvantages with PSP
- Future for PSP-Testing

Loads on Aircraft - Definition

- Loads for the complete aircraft is the compilation of all loads acting on the airframe of the aircraft i.e. external and internal loads
- Each load case producing a critical load anywhere in the airframe once in the approved envelope shall be represented as a balanced load case and used by the Stress department for static strength analysis.

- Flight loads (manoeuvres)
  - combination of mass loads and **air loads**

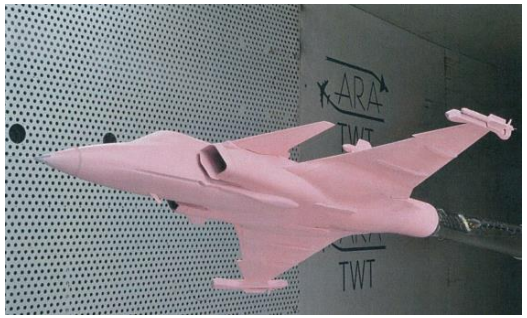
- Landing loads
- Ground handling loads (towing, braking, tethering, turning etc.)
- Store separation loads
- Temperature loads
- Other events (Air to Air Refuelling, gun firing etc.)
- Buffeting and vibrations (ex. Interference loads between stores)
- Local pressures on hatches etc.

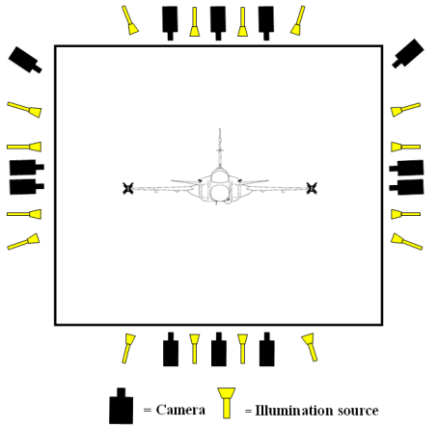
Surface pressure measurements

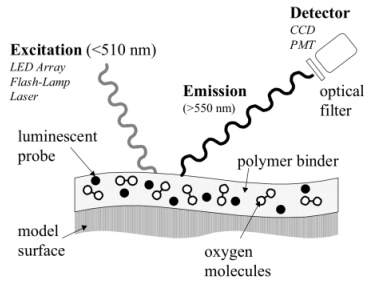
- Wind tunnel test with
  Pressure **S**ensitive **P**aint (PSP)

- Model painted with paint that fluoresces under UV-light depending on the surrounding oxygen density.

- Sensitive for
  - Illumination
  - Paint thickness
  - Dye concentration
  - Pressure

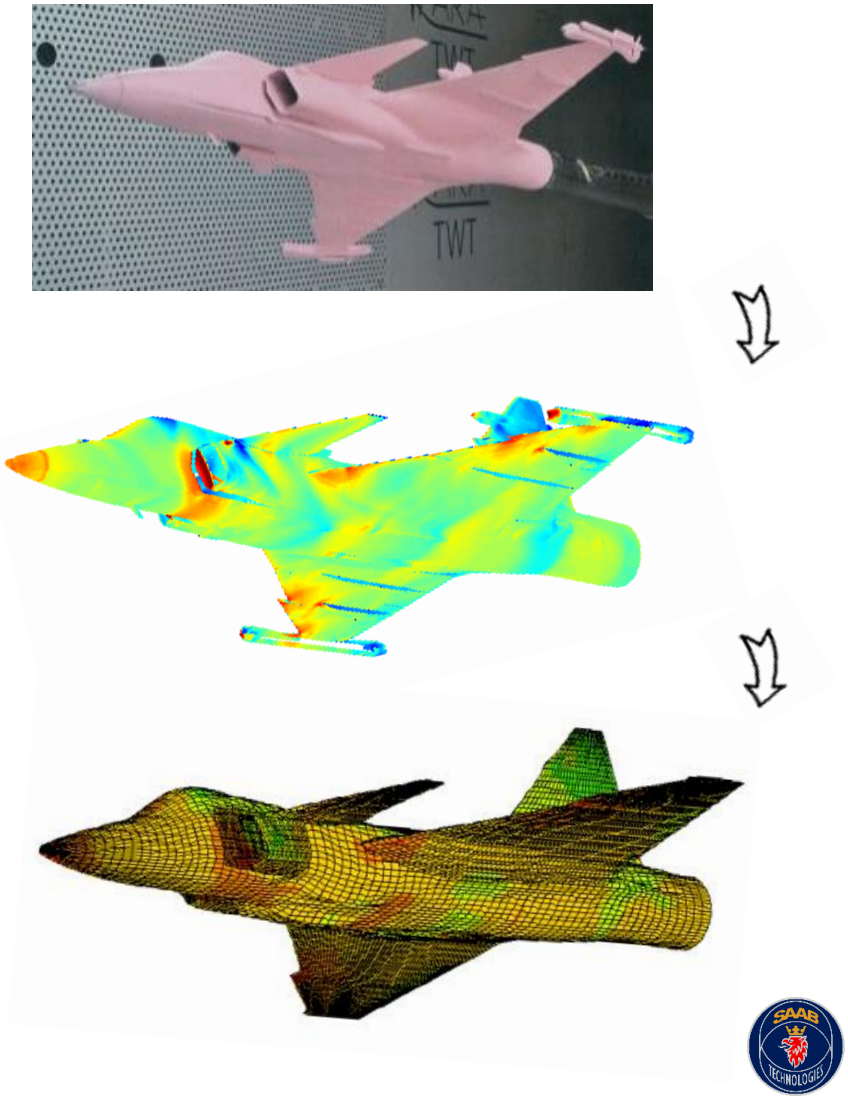






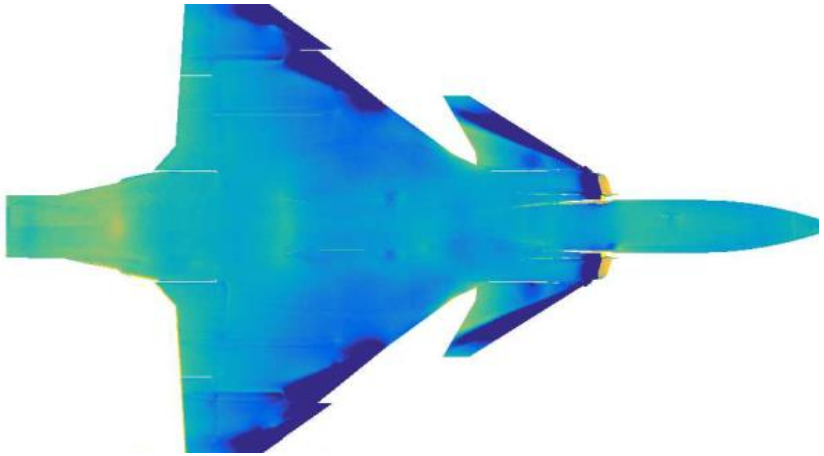
Digital Pressure Model (PSP -> FE-model)

- Pressure on mathematical model.
  - 2D pictures from cameras to 3D pressure on mesh
  - Work by wind tunnel institute
- Pressure on neutral matlab mesh.
  - Same mesh for all configurations.
  - Delta pressures
- Pressure on neutral format (SAAB in-house).
  - Spline functions

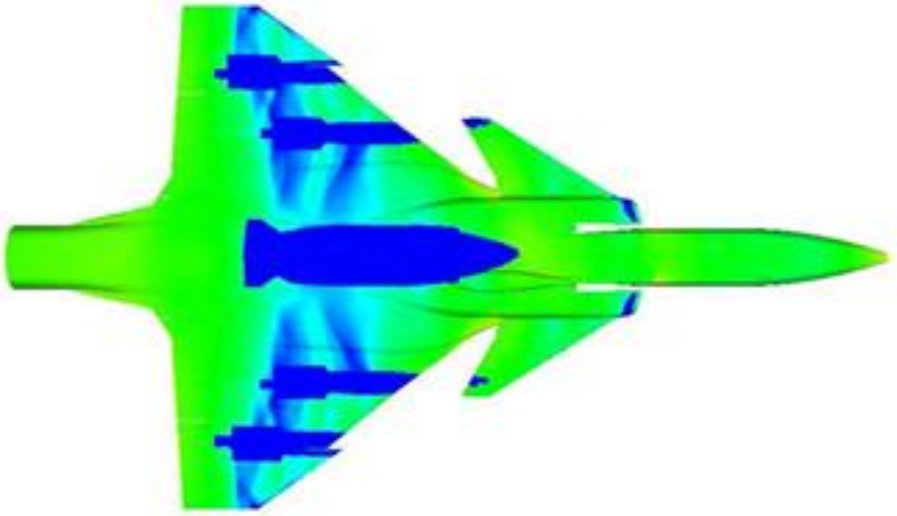


Examples of PSP data used at SAAB

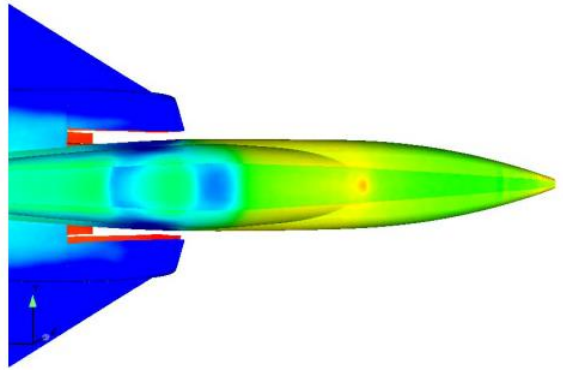
Example with good results from PSP



Geometry issues



Camera issues



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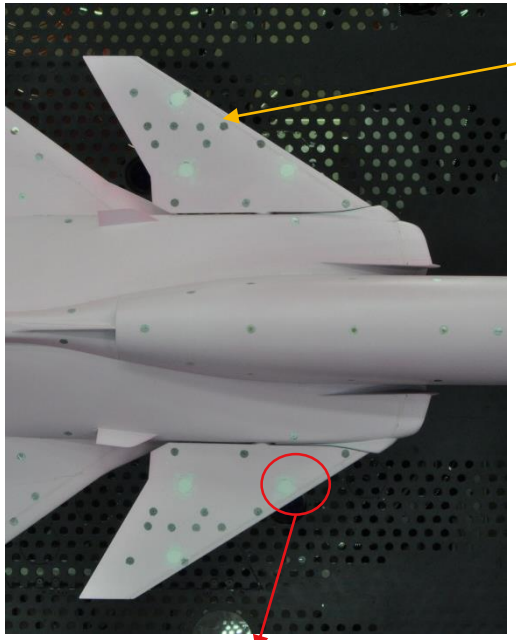
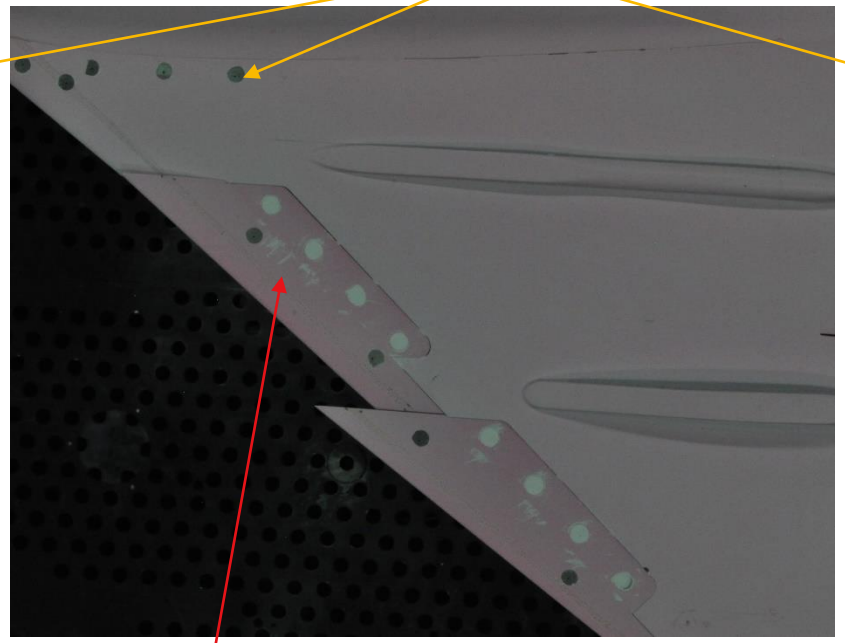
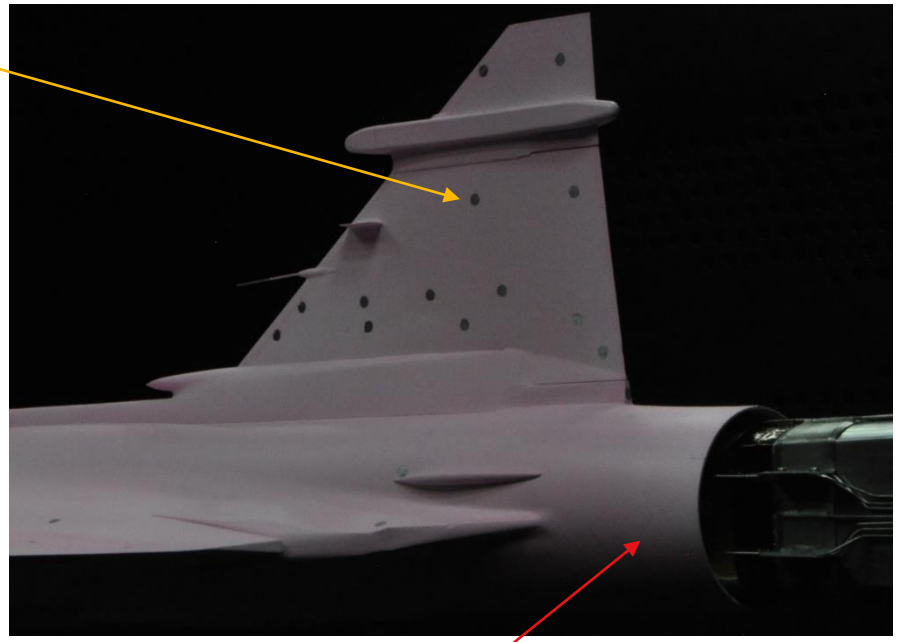
Paint and configuration problems

Pressure holes





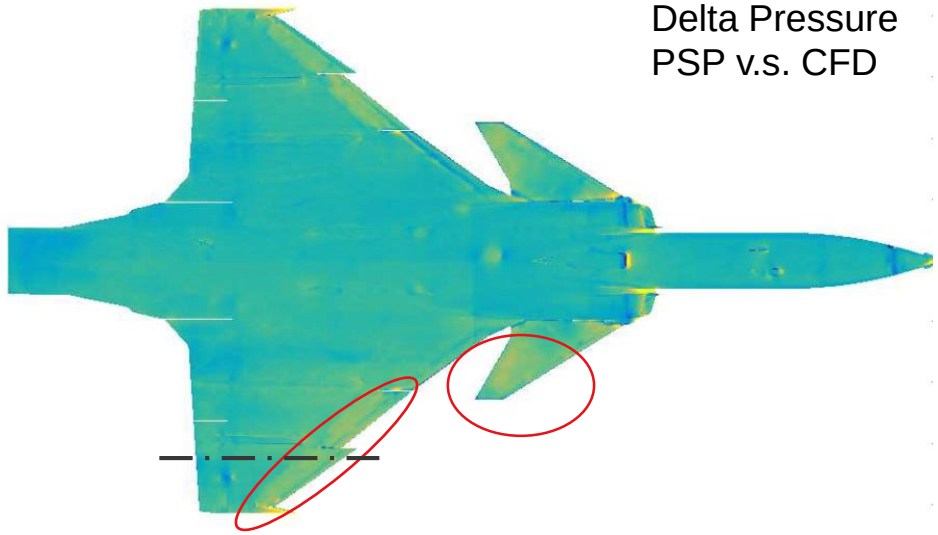


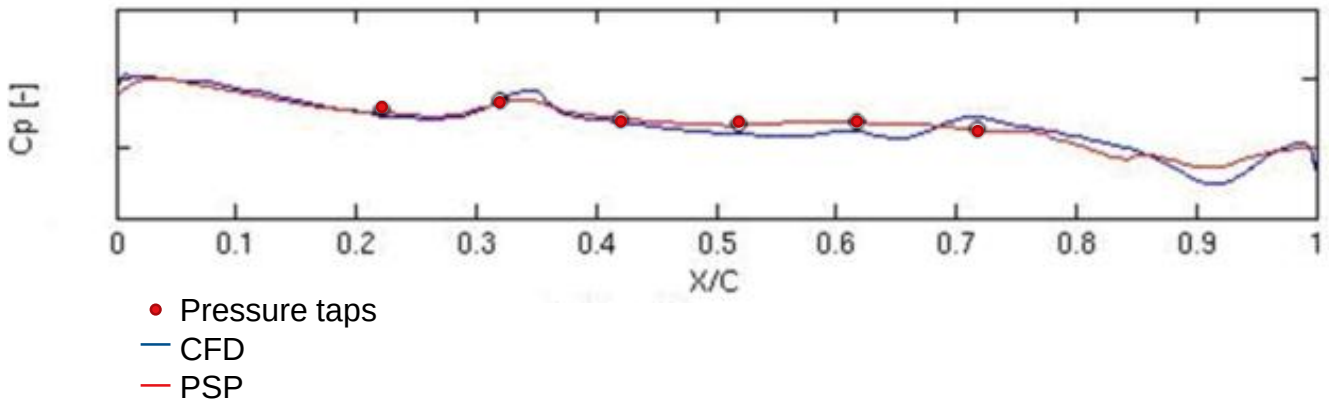
Degradation of paint due to configuration changes. Screws etc.

Modified geometry to fit the wind tunnel sting

Comparison PSP/CFD

- General good correlation PSP/CFD
  - Sometimes differences
  - Selection of areas and points for creating pressure mesh on loads model very important
  - Good knowledge of model and model errors are important
  - Used data can be a mix of PSP, CFD and pressure taps





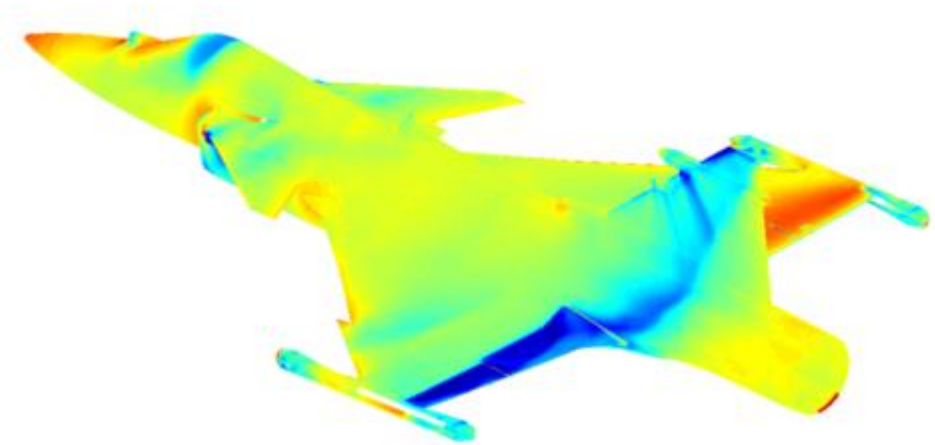
Advantages / disadvantages with PSP

- Advantages
  - More detailed data compared to pressure holes
  - Same wt-model as aero data model
  - Works in a wide span of mach numbers and angles (alpha, side slip …)
  - Relatively quick
  - 1-2 weeks of test
  - Quick configuration changes
  - 1-2 month with post processing of data at vendor.

- Disadvantages
  - Data can be noisy (low pressure levels)
  - Cant see ”behind” hidden areas
  - Aging of paint (need for repaint during long wt test programs)
  - Model changes can have negative effect on paint
  - Sensitive process (paint, cameras, light …)
  - New test can bee needed:
    - During post processing errors can be found
    - During post processing data points can be missing
  - Few actors on the market
  - **User of data need to have a good (deep) knowledge of the PSP process**

Future for PSP-Testing

- CFD will be more used
- PSP will be used together with CFD data
- PSP will also be used to verify the CFD data
- Will give a higher level of majority until flight test can be performed



- Work is ongoing to also measure model deformations during the wind tunnel test
- Work is also ongoing with dynamic PSP (time dependent).
    - Can be use for buffeting investigations etc.

Thanks