SUPERTRAC

- EU-project, started January 2005 and will run for 3 years.
- Long term goal to develop new supersonic passenger aircraft.
- Need to accomplish a reduction in noise and fuel consumption compared to present supersonic aircrafts.
- One way is to reduce turbulent flow over the wings.
- SUPERTRAC: Delay and control transition from laminar to turbulent flow in the wing boundary layer at supersonic speeds.
- Advisors: Dan Henningson (KTH) Ardeshir Hanifi (FOI)
Partners

- 9 European partners
- ONERA, project manager, aeronautics and space research centre (France)
- Airbus, aircraft manufacturer, (UK)
- Dassault, aircraft manufacturer, (France)
- CIRA, aerospace research centre, (Italy)
- DLR, aerospace research centre, (Germany)
- FOI, research centre, (Sweden)
- IBK, consultants, (Germany)
- IST, university, (Portugal)
- KTH
Methods to delay transition

- **NFL**: Natural laminar flow
  - Optimization of wing profile to get a favourable pressure distribution.

- **LFC**: Laminar flow control
  - Suction of boundary layer on the wing.
Methods to delay transition

- **HFLC: NLF and LFC**
  - Suction at the beginning of the wing chord and wing profile optimization at the back.

- **Micro sized roughness:**
  - Arrangement of small bumps at the leading edge. Small bumps create chosen disturbance to take out unwanted disturbances.
Methods to delay transition

- Gasterbump:
  - Big bump on the leading edge. Prevents the turbulent boundary layer on the aircraft fuselage to contaminate the boundary layer on the wing.
Implementation of methods

Three wing profiles will be investigated with different methods to delay transition.

**Wing profile 1**
- Wing is 2.5D, infinite span (constant chord).
- Investigation of micro sized roughness.
- Program NOLOT is used for PSE-calculations developed by A.Hanifi and S.Hein.
- Wind tunnel tests in the sm2a tunnel at ONERA in Toulouse.
- Gasterbump evaluation with RANS calculations.

**Wing profile 2**
- Wing is 2.5D, infinite span (constant chord).
- Linear PSE calculations to find dangerous modes.
- Wind tunnel test in the Ludwieg tube at DLR in Göttingen.
Implementation of methods

**Wing profile 3**

- Wing profile with variable chord.
- No wind tunnel test only calculations.
- Including shape optimization.
- Combining experiences from previous tests.
- Investigate how the different methods affect each other.
Disturbance approximation

- Mean flow $Q$
- Disturbance $q$
- Total flow $= Q + q$
- Disturbance amplitude approximation

$$q = q'(x,y) \exp\left[i \int_{x_0}^{x} \alpha(x) \, dx + \beta z - \omega t\right]$$

- Crossflow vortices and TS waves.
- Crossflow modes grow where we have negative pressure gradient.
- TS modes grow where the pressure gradient is positive.
Non-linear PSE with micro sized roughness

- Only stationary crossflow modes have been considered.
- Crossflow modes are dominant on our profiles.
- Travelling crossflow modes is seen in high disturbance flows. Flight is low disturbance.
- Choice of dangerous mode, target mode, and suitable mode to take out target mode, killer mode. Killer mode represent roughness.
- Important to see effects on other mode than the killer and target mode.
- Difficulties to know where transition occurs. Can look at friction coefficient and rise of modes.
Linear PSE calculations, stationary modes

- Growth of disturbance shown with N-factor. Shows size of disturbance at a point compared to the beginning of the calculation region.
Nonlinear PSE, Killer B = 2 target B
Nonlinear PSE, Killer B = 11/6 target B
Partners, kick off Toulouse January 2005

Project web address: www.eonecert.fr/projets/supertrac/