



2nd Drag Prediction Workshop meeting

Orlando (Florida), 21st - 22nd June 2003

F6 model tests in the ONERA S2MA wind-tunnel

J.L. Godard

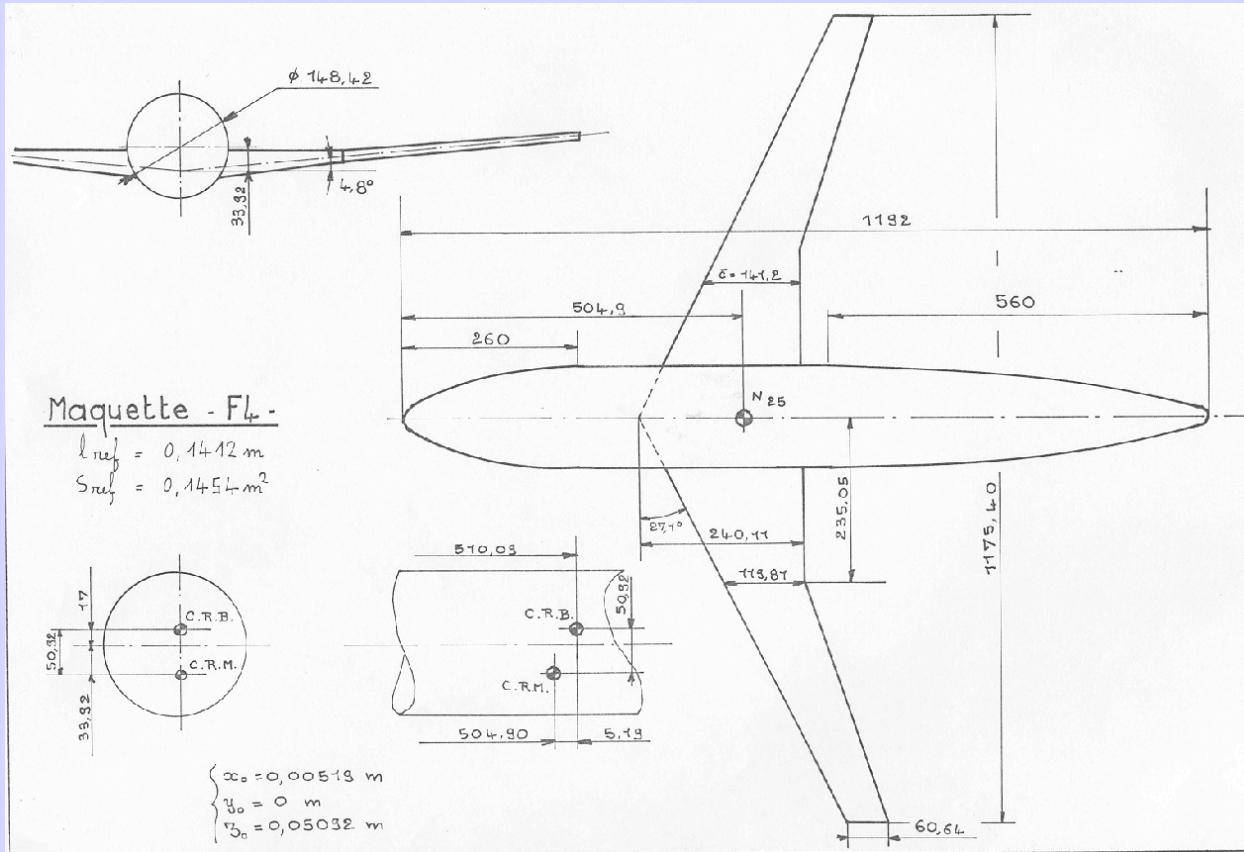
ONERA, Applied Aerodynamics Department

Outline

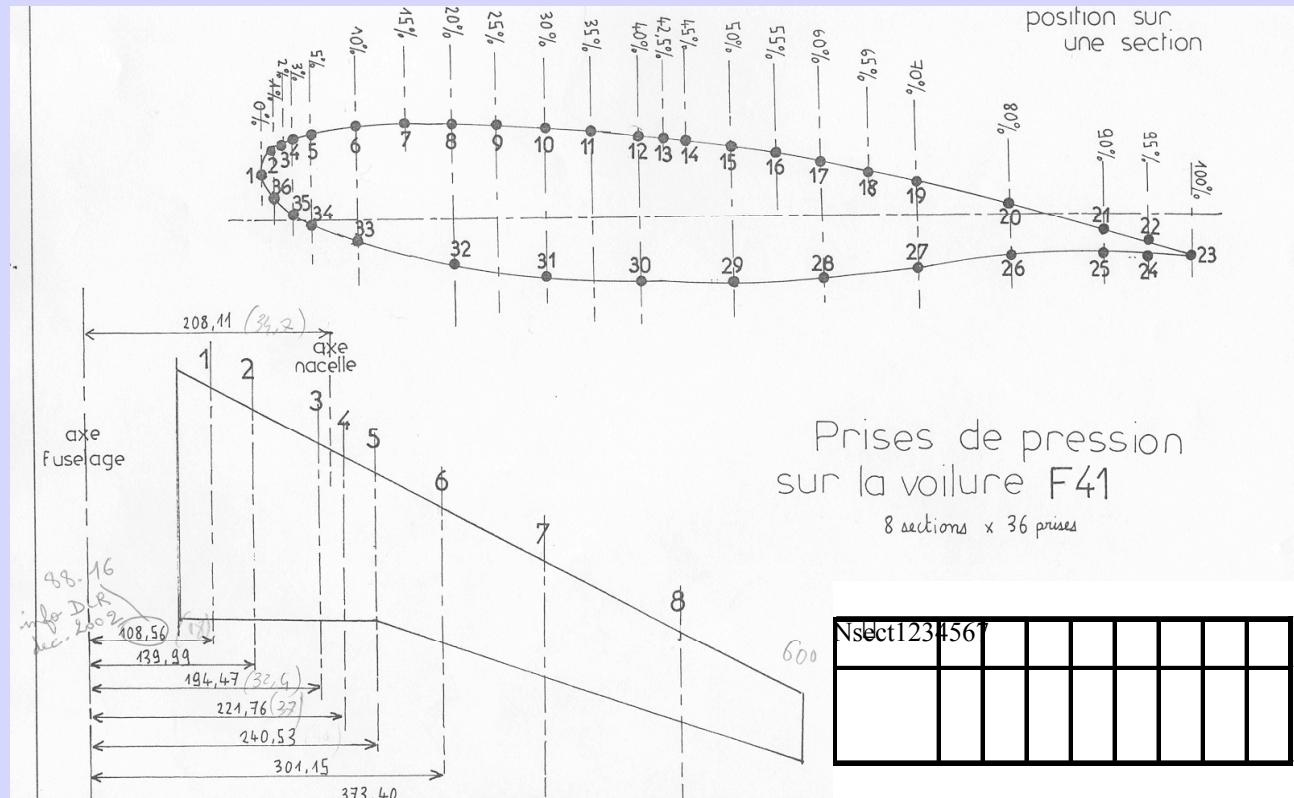
- **F6 model characteristics and instrumentation**
- **S2MA wind-tunnel and test set-up**
- **Data processing**
- **Test program and results**
- **Conclusions**

F6 model characteristics and instrumentation

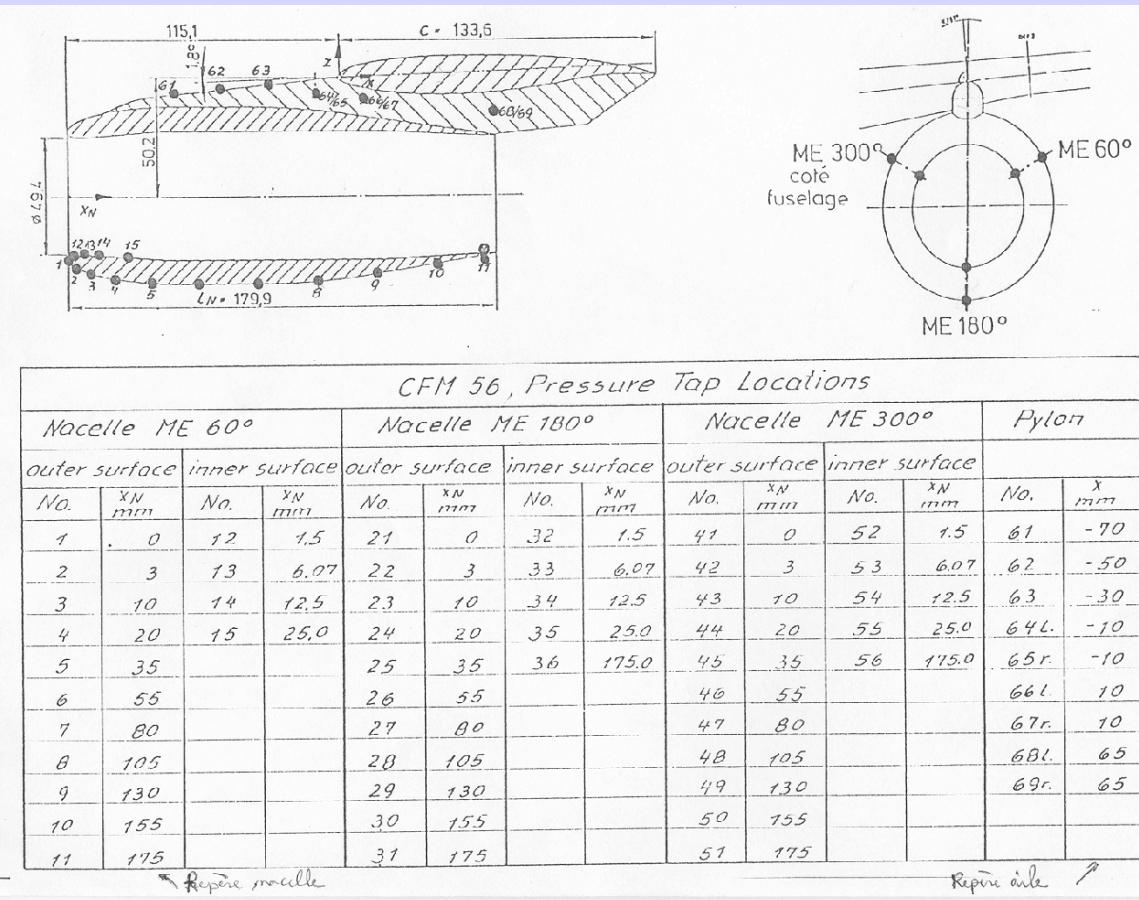
Geometrical characteristics of the DLR-F6 model



Equipment in static pressure taps on the wing

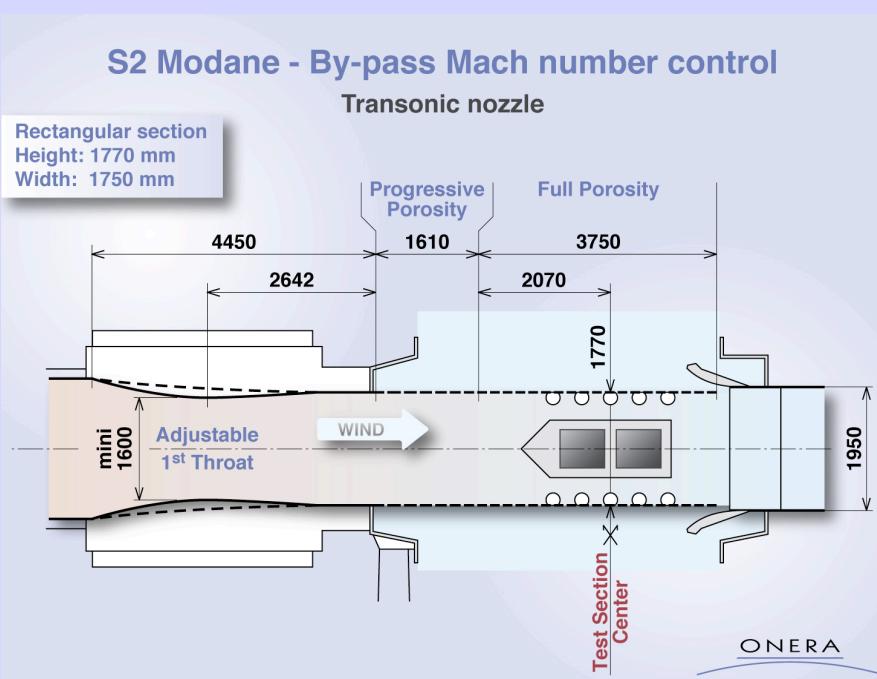


Geometry and instrumentation of the engine installation

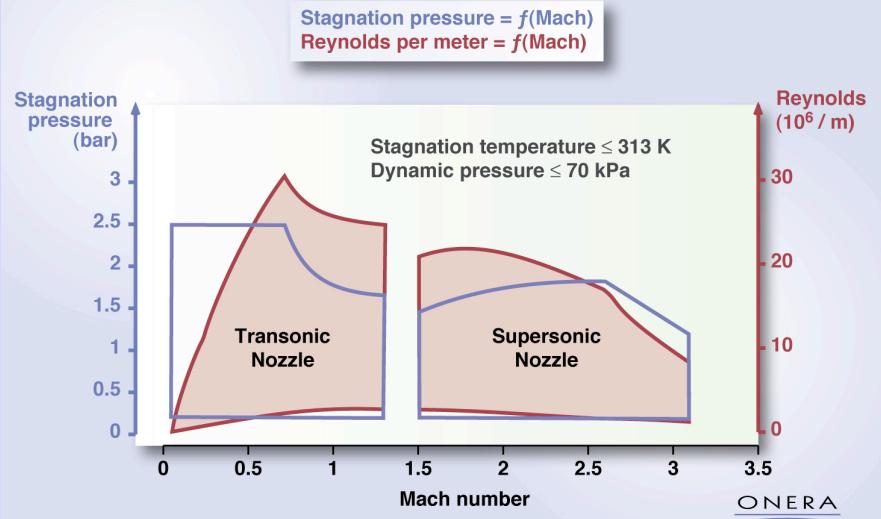


S2MA wind-tunnel and test set-up

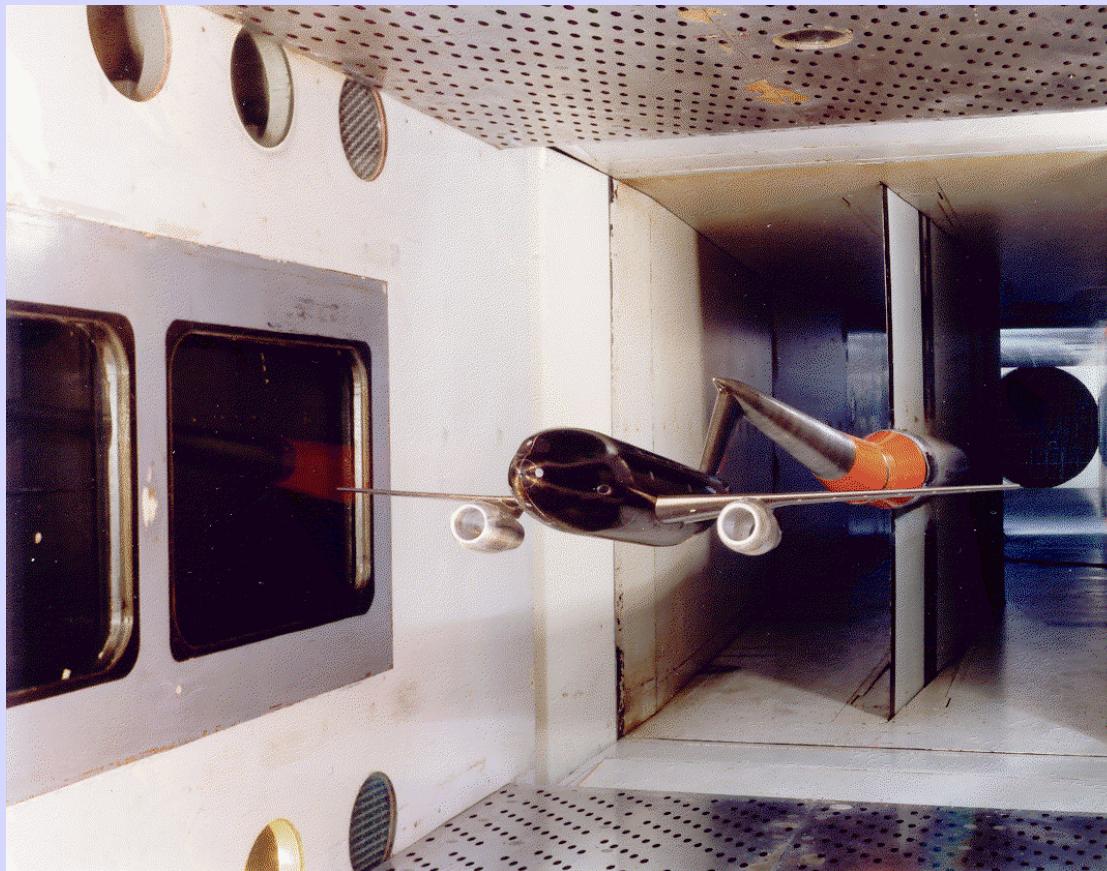
ONERA S2MA wind-tunnel characteristics



S2 Modane - By-pass Mach number control
Test range: Mach number - Pressure - Reynolds number



DLR F6 model in the ONERA S2MA wind-tunnel



DPW 21st-22nd June 2003 fig9

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Data processing

Corrections on total forces (fuselage-wing-nacelle or fuselage-wing configurations)

Corrections due to non-homogeneous flow in the test section:

- Free-stream Mach number from wall (measurement point) to wind-tunnel axis: for $M= 0.75$, $\Delta M= -0.002$
- Buoyancy correction: for $M= 0.75$, $\Delta CA= +6.1 \cdot 10^{-4}$
- Wind tunnel upwash: for $M= 0.75$, $\Delta \alpha= +0.038^\circ$

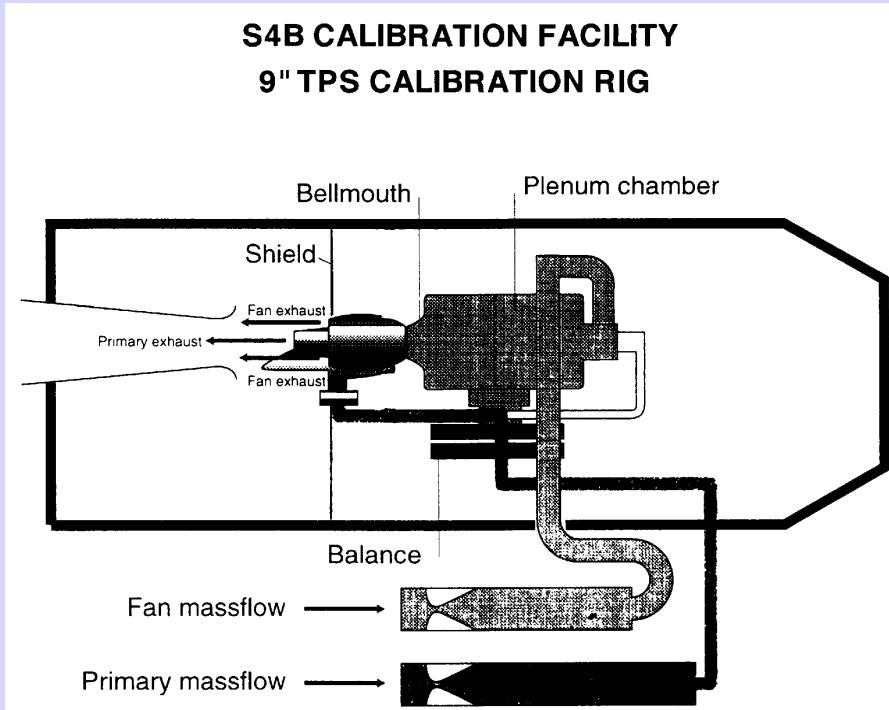
Corrections from wind-tunnel walls and model support:

- for $M= 0.75$, $CZ= 0.50$, $\alpha= 1.0^\circ$
-> $\Delta M= -0.0005$, $\Delta \alpha= +0.023^\circ$, $\Delta CA= +5.8 \cdot 10^{-4}$

Installation drag assessment

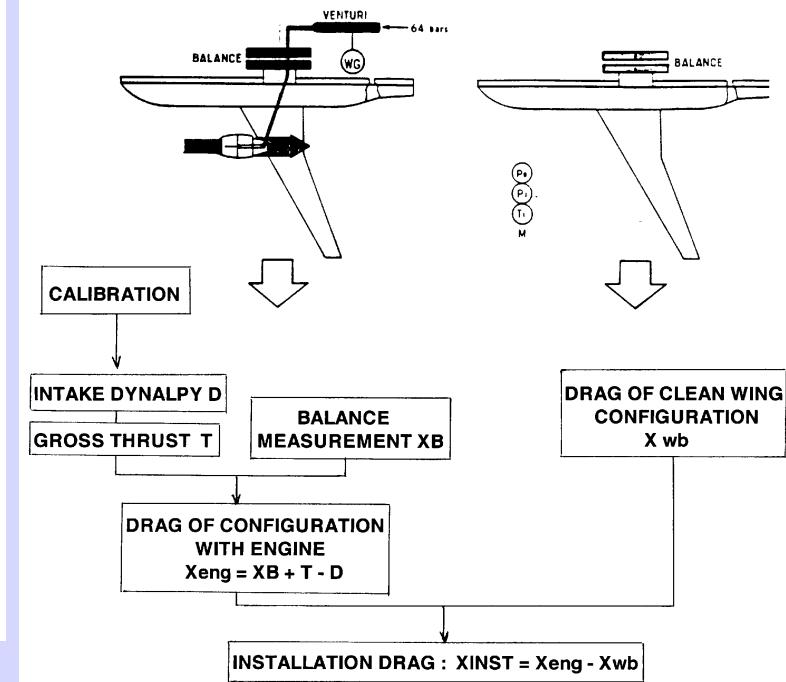
S4B test bench for nacelle calibration

Drag balance



DPW 21st-22nd June 2003 fig12

DETERMINATION OF THE INSTALLATION DRAG



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S2MA test programme and results

Summary of the S2MA test program

Configurations investigated:

- **Wing-Body-Pylons-Nacelles (WBPN)**
- **Wing-Body (WB)**

Aerodynamic conditions:

- **Mach number 0.60 to 0.85**
- **Lift coefficients 0.00 to 0.60**
- **Reynolds number Rec 3. 10^6**

(cruise conditions: Mach number 0.75, CL 0.50)

Measurement techniques:

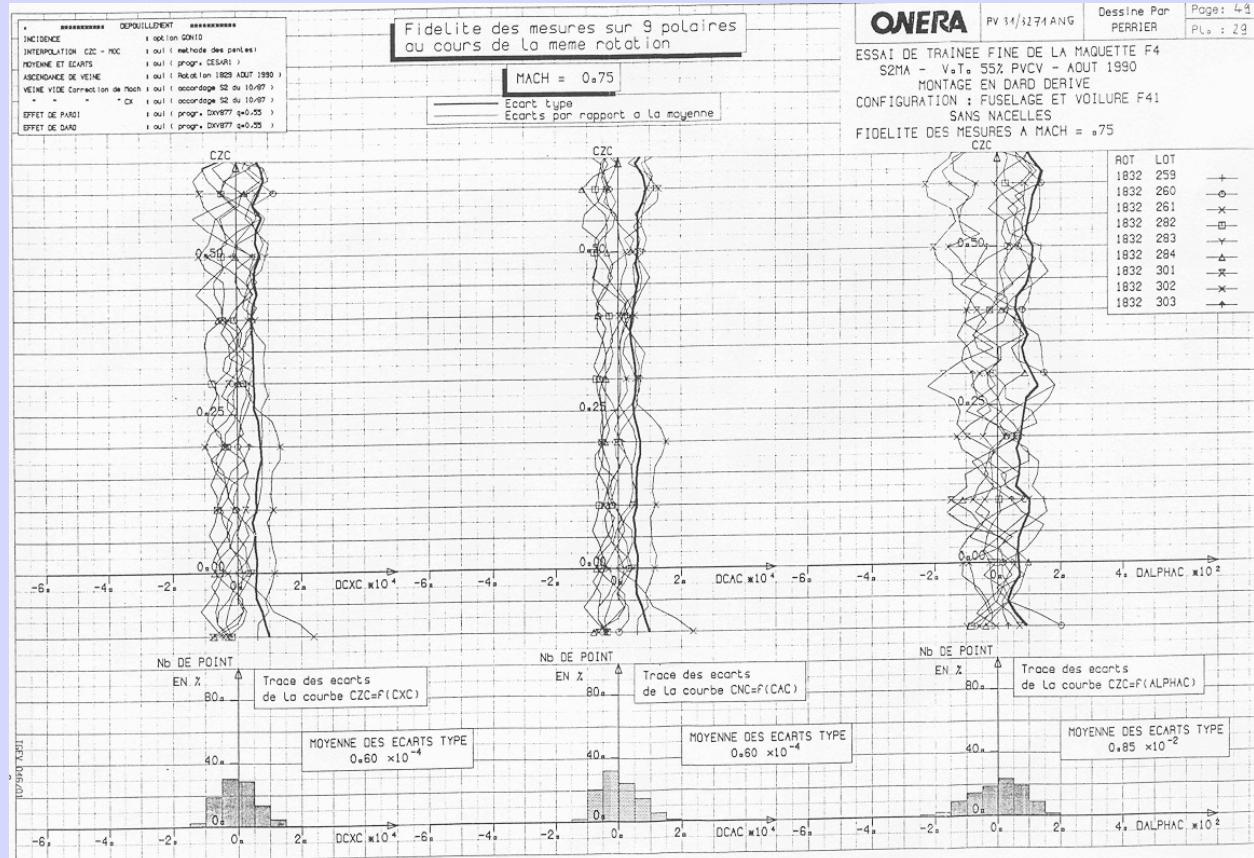
- **Total forces through a 6 component balance**
- **Static pressures on the model**

Reproducibility of total force measurements

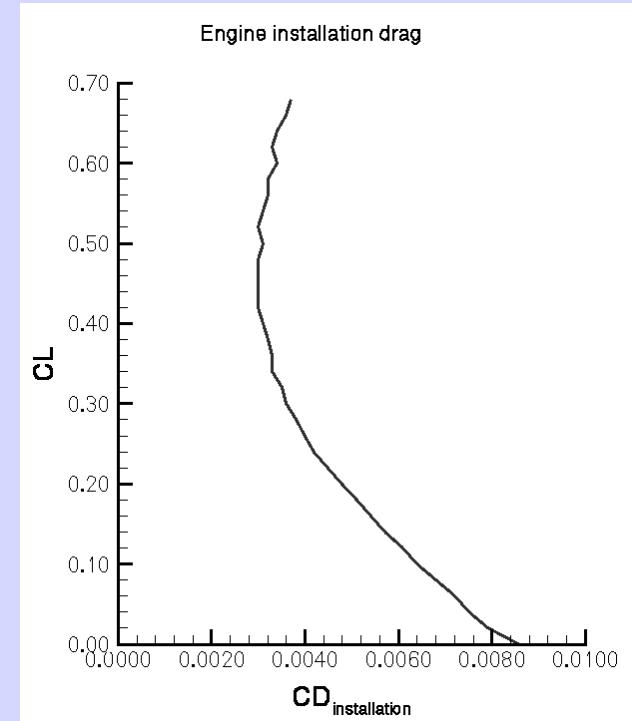
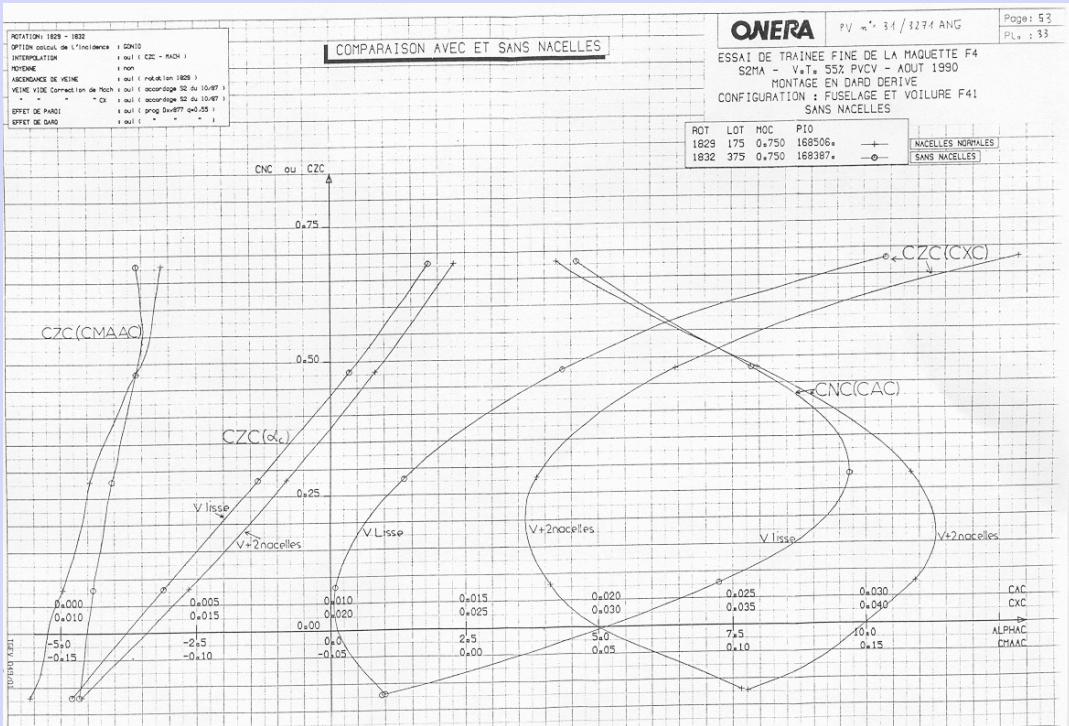
drag

axial force

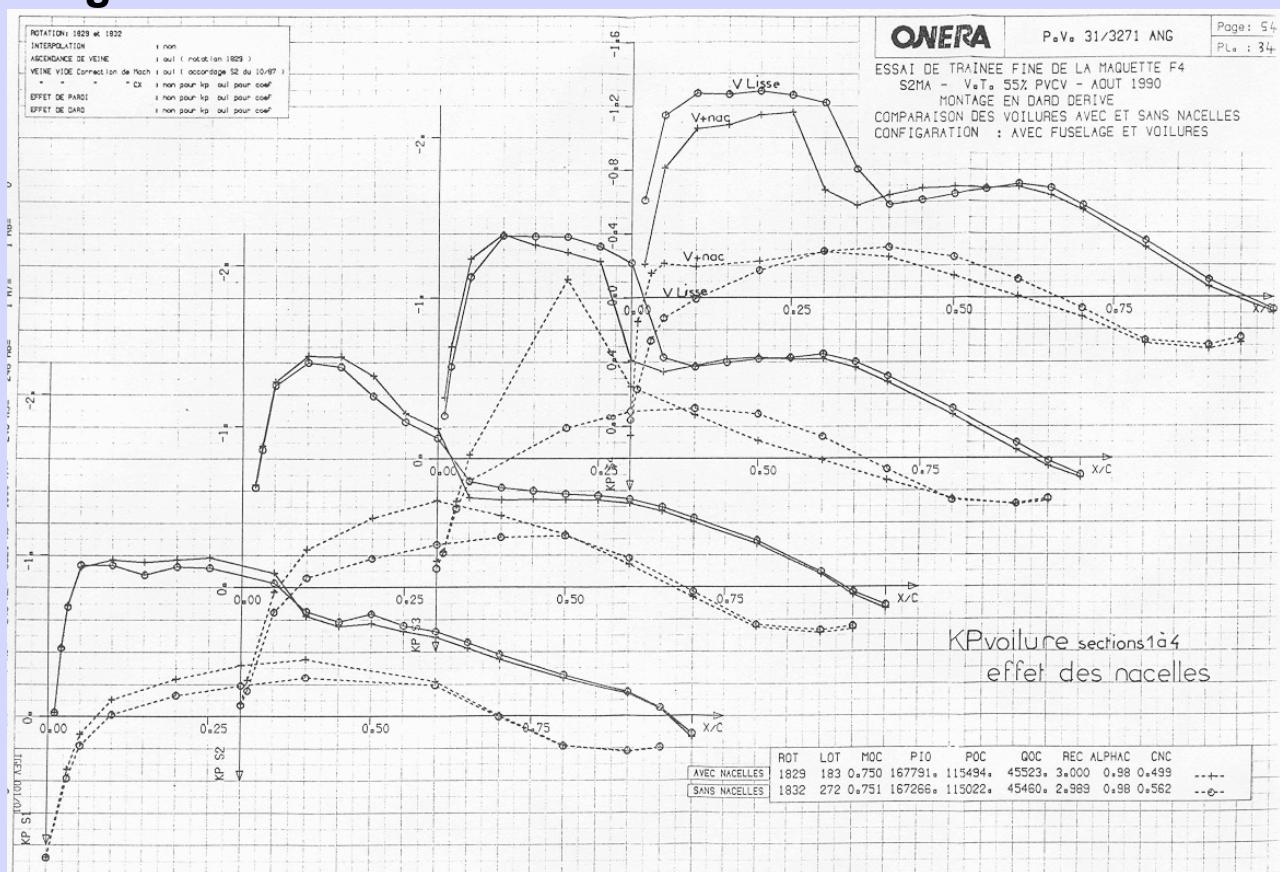
incidence



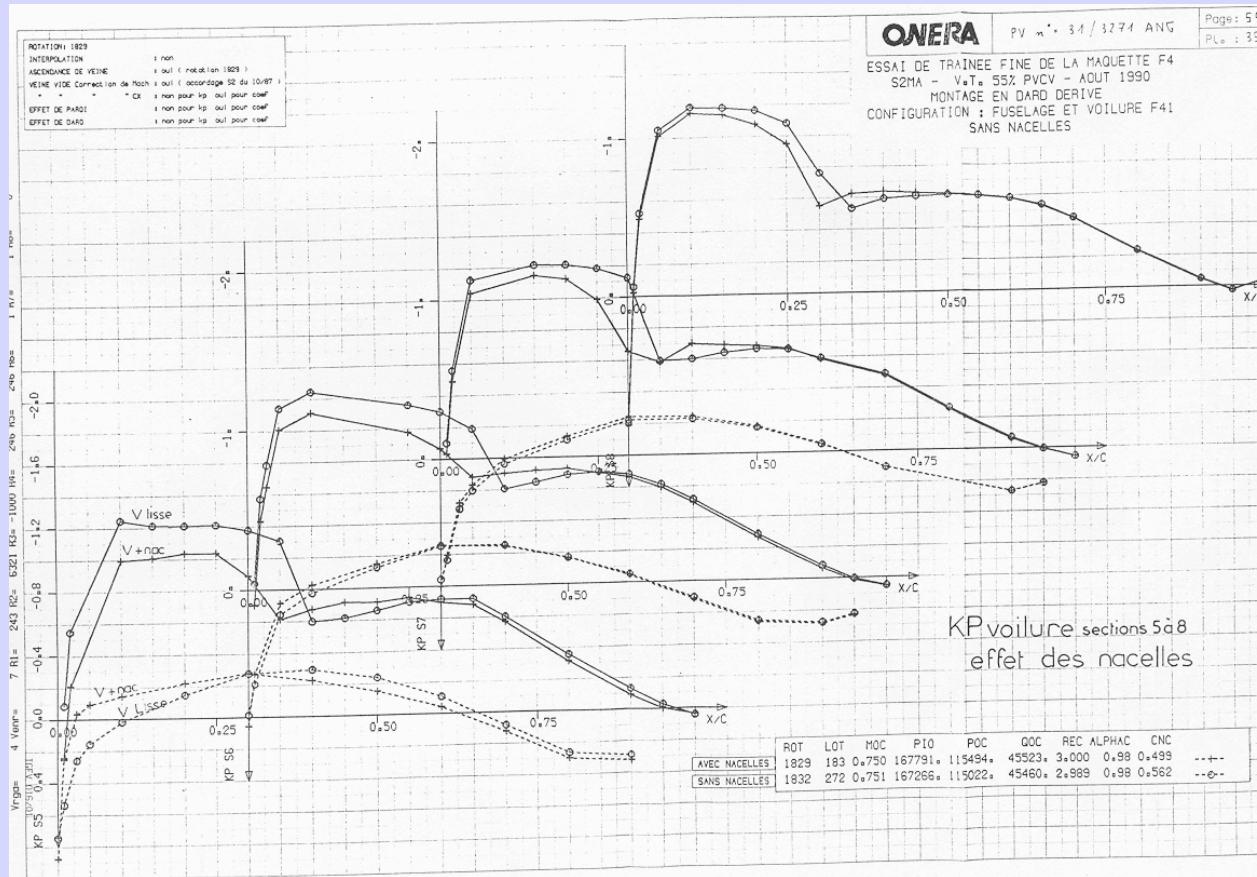
Influence of nacelles installation on total force measurements



Influence of nacelles installation on wing pressure distributions internal wing



Influence of nacelles installation on wing pressure distributions external wing



Conclusions

- Performance tests were executed on the DLR-F6 model in the ONERA-S2MA wind-tunnel for the investigation of engine installation effects
- High quality drag measurements were done for this type of test, with in particular a good reproducibility
- The engine installation effects on total forces and static pressure distributions were clearly identified