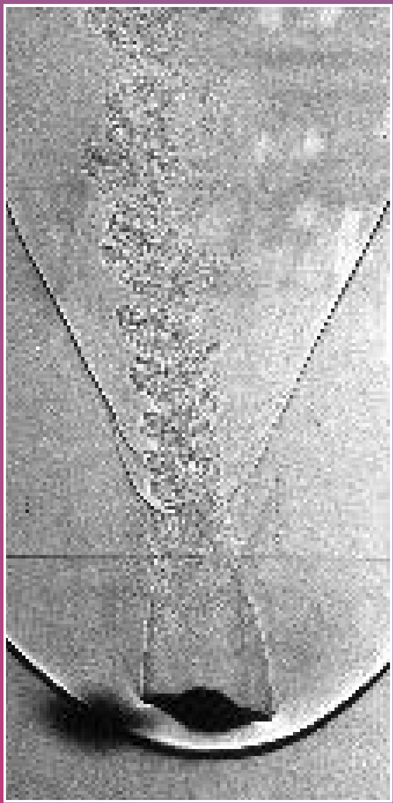
Investigation of generic space probes

by **Claude Berner**, French-German Research Institute (ISL), Saint-Louis, France

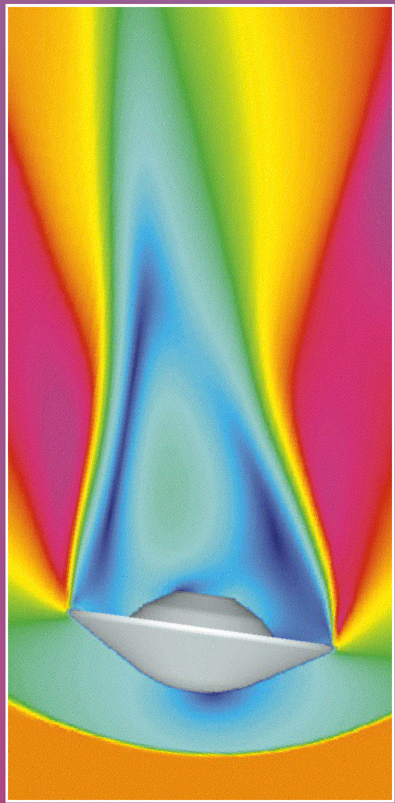
In the future, ISL intends to use CFX in order to create aerodynamic databases that are needed for early analysis in space projects

Planetary scientific exploration probes are the perfect example of a one-shot system that has to work the first and only time that it is used. Where space probes are designed to enter the atmosphere of a planet, aero-braking initially decelerates the vehicle, before parachutes are deployed and instrumentation gathers and transmits data during the controlled descent.

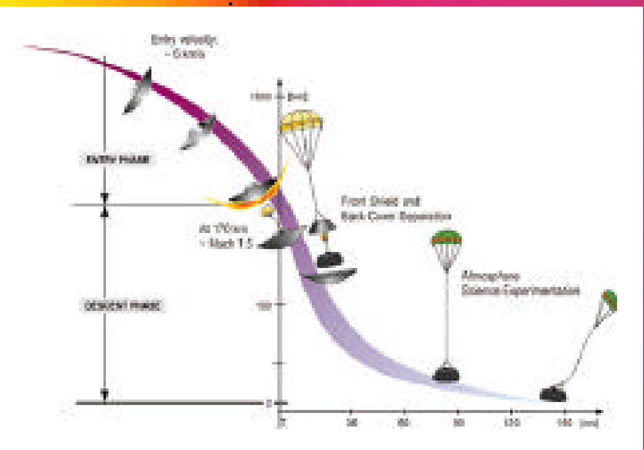
At ISL, CFX is generally used to evaluate the basic aerodynamics of configurations such as projectiles, missiles and space probes. For the latter, previous experimental studies have shown that dynamic instabilities can be generated during the braking phase, with oscillations that adversely affect parachute deployment. It seems that these instabilities are closely related to the nature of the rear flow field patterns and/or the unsteady characteristic of the near-wake recirculation region. Therefore, two configurations with different base geometries were investigated: one with a solid base, the other with a base cavity. The models had a reduced scale of 1/40 compared to existing space configurations. Validation of the code was performed by comparison with experimental free flight results obtained at the US Air Force Aeroballistic Research Facility at Eglin AFB, FL.



Free flight shadowgraph at M=2.05



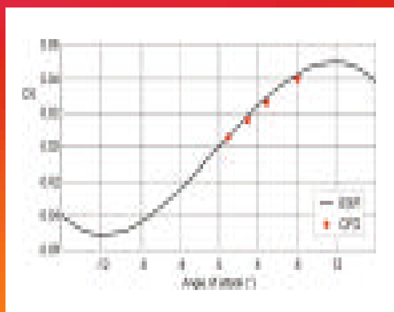
Predicted Mach number contours - M=1.997, α=8°



Example of an entry profile of a space vehicle

For the present study, CFX was used especially to provide a better insight into the base flow physics and to determine the static aerodynamic coefficients such as drag, lift and pitching moment. Flow solutions were calculated for Mach numbers between 0.8 and 2.0 and for angles of attack up to 8 degrees. In all cases computations gave a faithful representation of the flow field whose main features are remarkably well predicted. Agreement between the computed and experimental aerodynamic coefficients was excellent. Indeed, the average difference between CFD and free-flight results was calculated to be 1.6% for the axial force coefficient, 2.1% for the normal force coefficient and 4.9% for the pitching moment coefficient.

These results show that ISL now has a code that can be used as an effective tool to predict the aerodynamics of blunt planetary probes, in terms of flow features and aerodynamic coefficients. In the future, ISL intends to use CFX in order to create aerodynamic databases that are needed for early analysis in space projects and to understand the origin of the dynamic instabilities, as well as for the design and optimisation of new base geometries.



Predicted and measured normal force coefficient, M=1.997