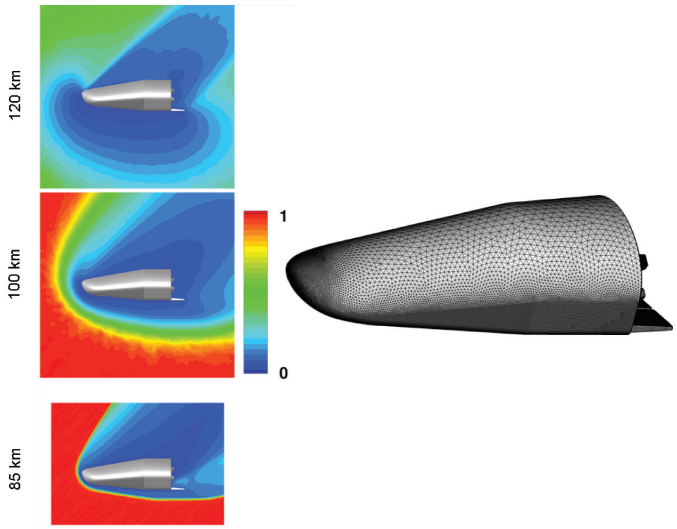
# AEROTHERMODYNAMICS

The VKI is developing home made tools and is using several commercials and/or research partner tools reproducing all the physic encountered during the re-entry of a space vehicle in the atmosphere. This includes the rarefied flow at high altitude with ITAM's DSMC solver RGDAS. The continuous regime reproduced with CoolFluid and/or CFD++. Stability may be assessed by VKI's VESTA tool. Transition may be addressed by DNS on simple geometry (solver developed in CTR by O. Marxen) and for industrial geometries is treated with intermittency transport model in RANS solvers (CoolFluid and/or CFD++).

## AEROTHERMODYNAMICS IN THE RAREFIED REGIME: DIRECT SIMULATION MONTE CARLO

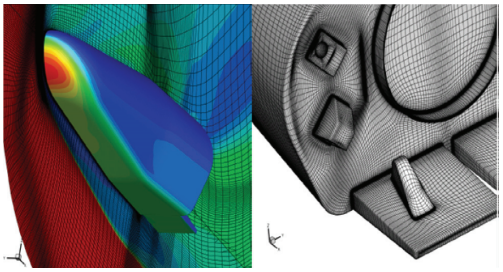
The DSMC method aims to solve the rarefied regime thanks to the Boltzmann equations solved by following the motion of representative numerical molecules. Each numerical molecule represents a number of physical molecules on a grid fine enough to resolve the local mean free path. Up to 800 millions numerical molecules may require the access to the VKI's High Performance Computing cluster. The vehicle is IXV from the European Space Agency.




**Normalized Mach for the re-entry of IXV**

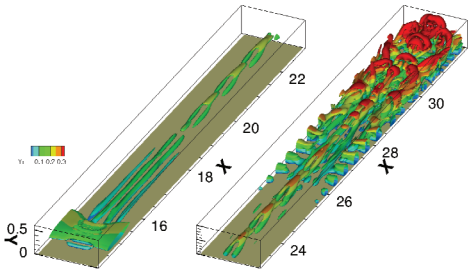
## AEROTHERMODYNAMICS IN THE CONTINUOUS REGIME: NAVIER-STOKES SOLVER WITH CHEMICAL NON EQUILIBRIUM

The continuous regime requires advanced structured meshes. In order to reproduce the physic induced by the corridor of re-entry and the type of trajectory several physical mechanisms have to be modeled. This may require reproducing the chemistry of several species or the transition from laminar to turbulent. All these aspects are addressed in the current VKI's research.

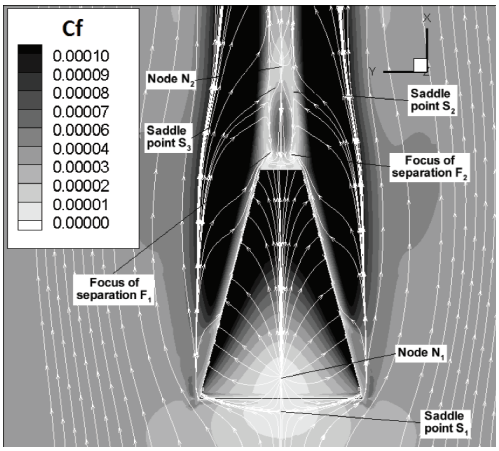


**Navier-Stokes simulation of IXV at M=20 with 5 species**

## HYPERSONIC TRANSITION




**Roughness induced transition at M=10 by DNS**




**Roughness induced transition at M=6 by RANS**


Contact
Prof. Jean-Marie Buchlin
buchlin@vki.ac.be
Phone: +32 (0)2 359 96 14