1st workshop on
science and technology of uhtc-based hot structures

october 28th and 29th, 2008
cira, via maiorise - capua (ce) italy

Computational Methodologies As A Support In Design Of Thermal Protection System For A Lifted Reentry Space Vehicle

AEROSOFT SpA

Ing. Donato NOCERINO ***R&TD Division Manager*** (donato.nocerino@aerosoft.it)
Ing. Giorgio FUSCO, Ph.D. ***CFD Division Manager*** (giorgio.fusco@aerosoft.it)

ABSTRACT

ABSTRACT

Aerosoft SpA, an italian engineering company that works on aerospace, automotive, rail and naval markets, has recently completed a Research Project (SIPROT) with the partnership of Centro Italiano Ricerche Aerospaziali about a design concept of a ceramics multi-layered thermal protection system (TPS) by means of computational commercial tools.

This experience has brought a knowledge on main requirements and validated methodologies to support TPS builders.

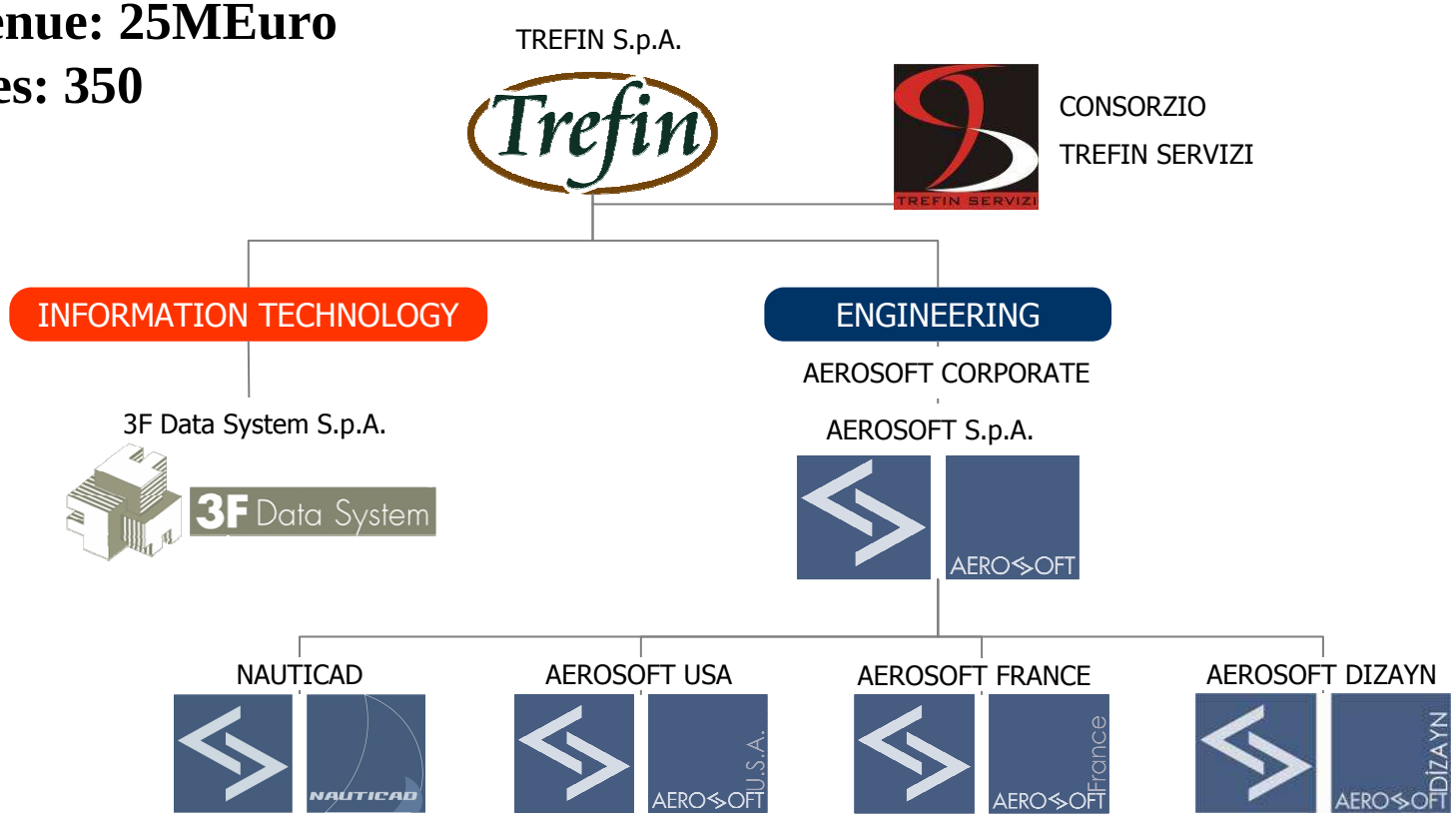
First of all the system requirements like reentry mission profile (velocity, mach, angle of attack vs time and altitude), the physical properties of the environment (standard atmosphere) and a defined geometry shape (USV nose-cap: sphere-cone of radius 0.1 m, cone of half-angle 20 degrees) have been set. Then a 3D validated aerothermochemistry numerical model for hypersonics flows (blunt-cone wind tunnel model ELECTRE taken as reference) has been implemented using a computational fluid dynamics (CFD) commercial software in order to forecast the heat flux at radiative equilibrium temperatures along the shape to provide necessary data to perform finite element thermal analyses at first and thermostructural analyses secondly.

A system definition is represented by a multi-layer CSiC-SiOC-AeroGel concept with design constraint on multi-use temperature limit and weight saving objective. The critical issue is represented by connection elements whose efficiency is mined by high temperatures and consequent large deformations. Massively finite element analyses have been used to investigate thermal loads and mechanical efficiency of these parts during a typical time dependent mission profile heat load. A trade-off between geometrical (thickness), material properties (density, heat capacity, conduction) and mechanical resistance achieved an optimal layering configuration of the TPS tile.

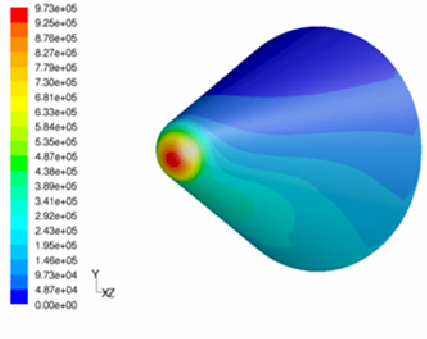
Before beginning the multi-layer TPS design concept a single-layer bread board finite element model has been validated with experimental data obtained during the project at the CIRA's Scirocco plasma wind tunnel (PWT) facility with excellent agreement. Therefore this project demonstrates a good knowledge transfer from high technology research and industrial reality also by means of mature enough CAE commercial codes if previously validated with referenced test-cases and experimental data.

AEROSOFT AND TREFIN GROUP: a 25 years story

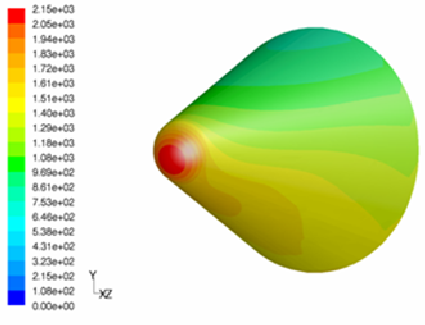
2007 revenue: 25MEuro
Employees: 350



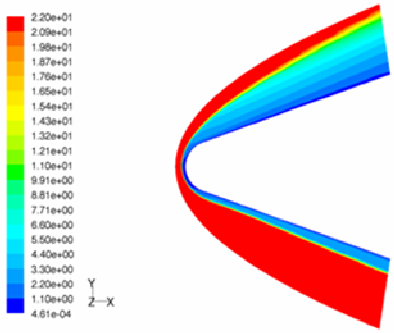
CFD USV Nose-cap



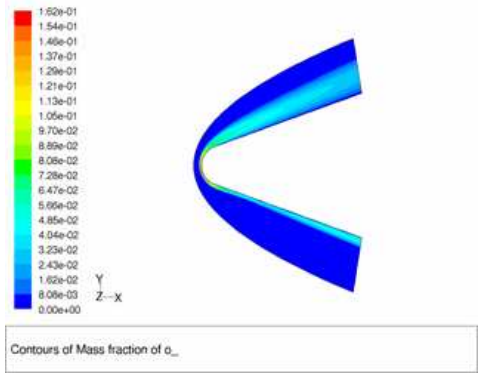
Heat Flux on nose wall (W/m2)



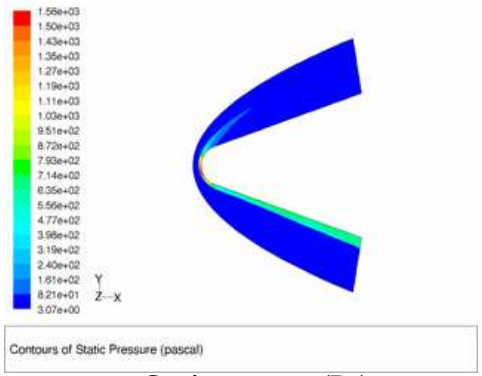
Nose wall Temperature (K)



Mach Number



Atomic Oxygen mass fraction



Static pressure (Pa)

Example of output results available for each WP

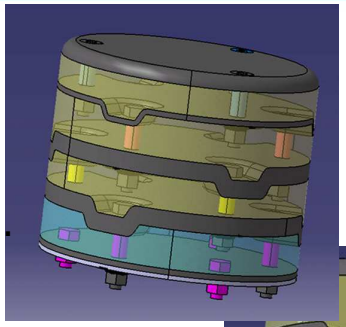
- Wall heat flux and radiative eq. Temperature
- Fluid field mach number
- static pressure
- Mass fraction of O, O2, N, NO

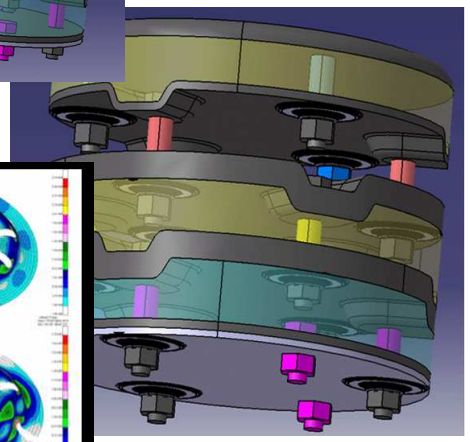
TPS Breadboard Thermal FEA

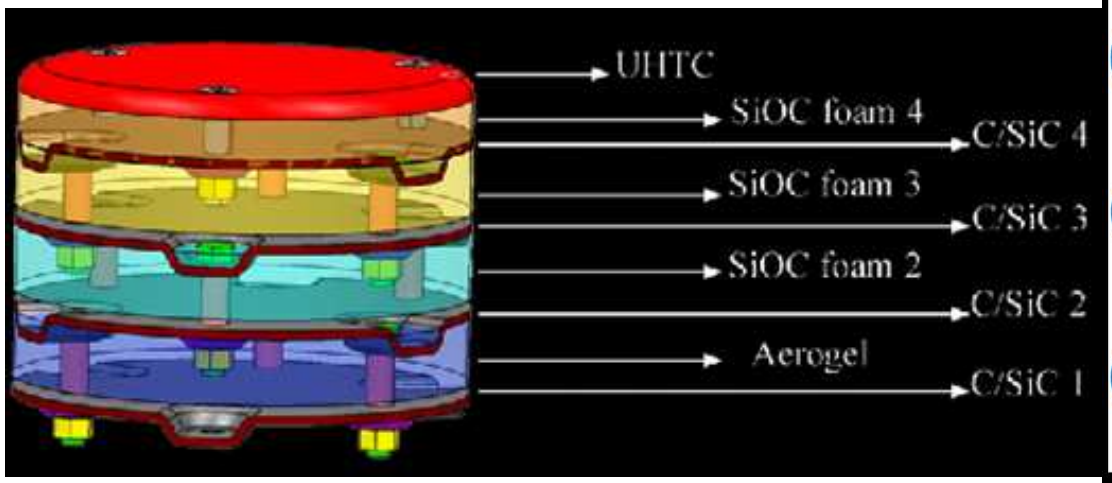
The multi-layer TPS concept is based on a capacitor-resistant thermal circuit.

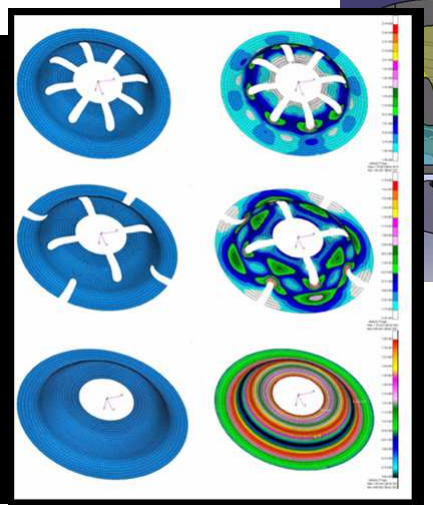
The TPS's core should trap heat and release it softly without overcome the temperature limit of each compounding material.

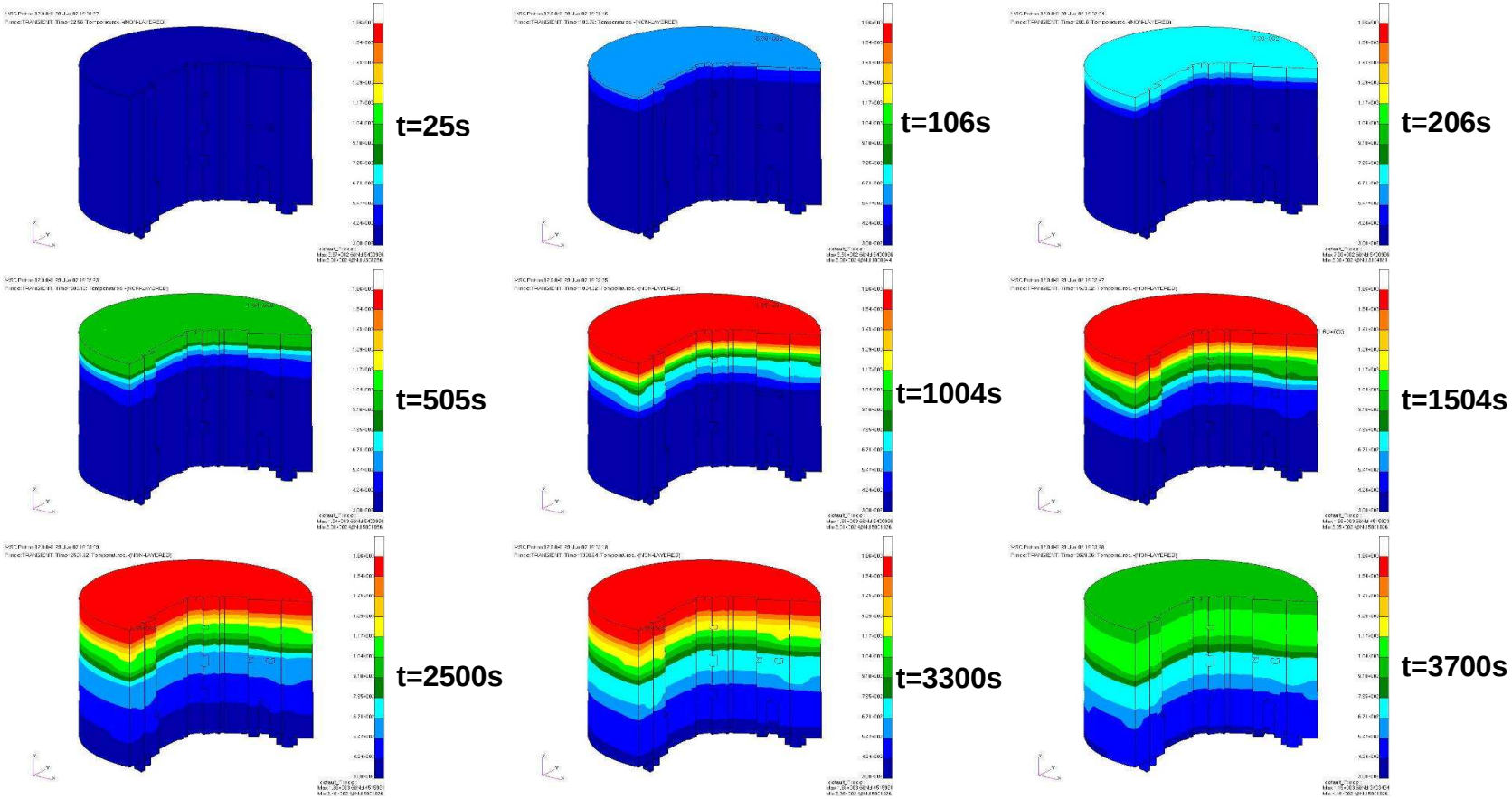
An energy balance approach is necessary for a right dimensioning









Spring Clip Study

TPS Breadboard Thermal FEA Temperature [300 K, 1660 K]