OGF 2009

Catania 2-6 March 2009

Workshop "Advantage of regional e-infrastructures in Grid Technology uptake by local scientific communities and SMEs"

Recent ENEAGRID Experiences in Industrial Applications

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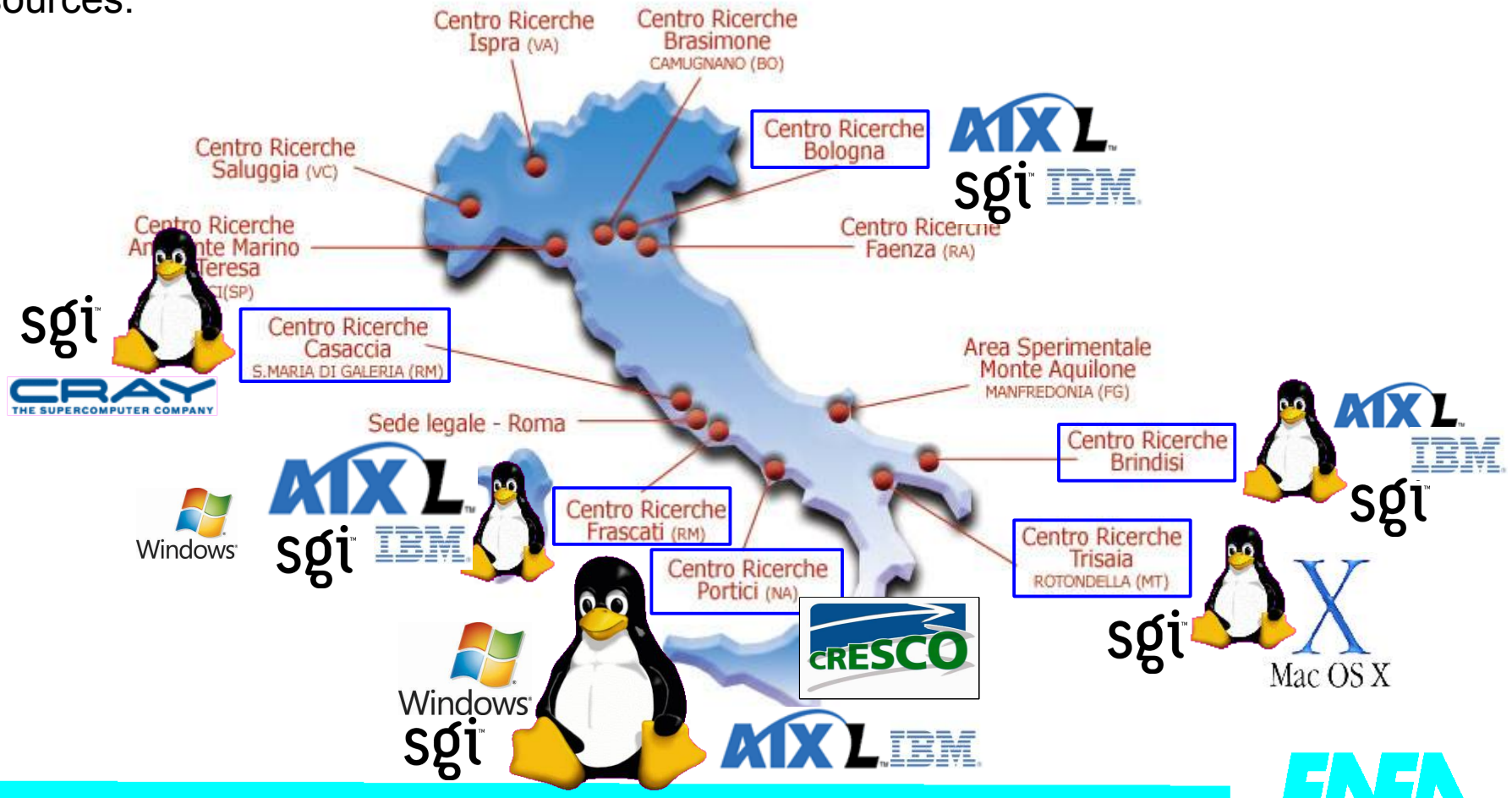
Motivation

Illustrate the examples of the utilization of ENEA-GRID computation resources by users from the industry and the related issues for a GRID infrastructure

- ENEA-GRID and its computational resource: CRESCO HPC system
- The computational requirements of research and industry users: a brief comparison
- The examples
- Conclusions

ENEA-GRID www.eneagrid.enea.it

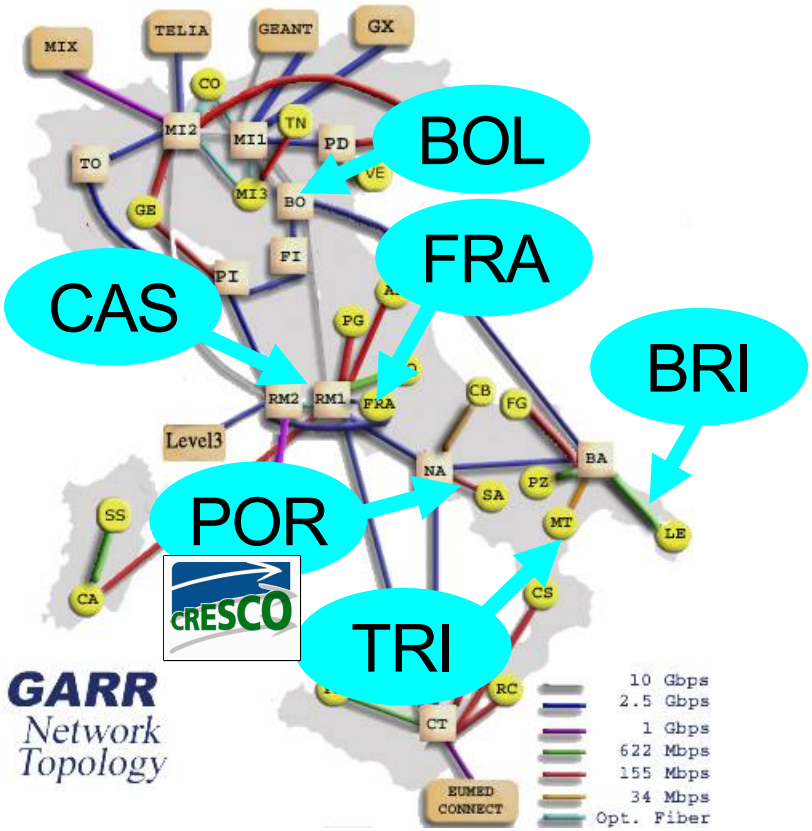
ENEA, the Italian Agency for New Technologies, Energy and Environment, has 12 research sites, 6 of them with computer centers. All ENEA main computational resources are integrated in the ENEA-GRID infrastructure which provides to ENEA researchers and their collaborators an easy access to the available multiplatform resources.



ENEA GRID and the Network

WAN connection is provided by GARR, the Italian Academic and Research Network Consortium: for ENEA
9 PoP, 18-2000 Mbps

Brindisi	150 Mb/s
Bologna	30 Mb/s
Casaccia	100 Mb/s
Frascati	1000 Mb/s
Portici	2000 Mb/s
Trisaia	18 Mb/s
Palermo	
Pisa	
Roma Sede	



ENEA-GRID Architecture

GRID functionalities (authentication, authorization, resource discovery & management) are provided by mature multiplatform components (ENEA-GRID Middleware):

Distributed File System : OpenAFS/Kerberos 5 integrated

WAN resource manager: LSF Multicluster [www.platform.com]

User Interface: Java & Citrix Technologies, now also Freenx

These production ready components have permitted to integrate reliably over the years (ENEA-GRID started in 1999) the state of the art computational resources.

ENEA participates in GRID projects (Datagrid, EGEE,EGEE-II & III, BEINGRID, PON projects, GRISU..) focusing on interoperability solutions with other middleware (gLite, Unicore): a gateway implementation method (Shared Proxy Approach for GRID Objects) has been developed and applied to interoperability with gLite based grids.

ENEA-GRID computational resources

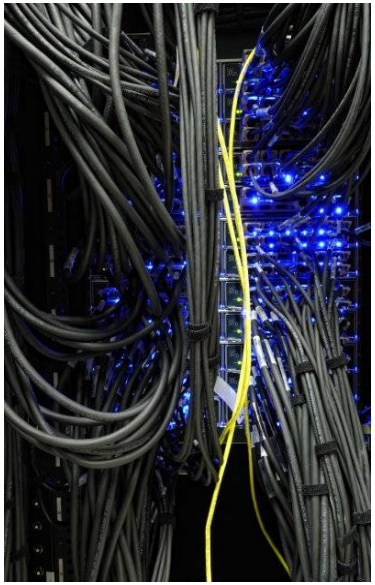
Hardware

- Most relevant: CRESCO HPC system, located in Portici (NA) rank #125 in Top500 June/2008 (rank #2 in Italy) 17.1 Tflops, 300 hosts, 2720 cores, InfiniBand 4xDDR

- Others: ~100 hosts ~650 cpu
  - AIX: IBM SP5 256 cpu (12 p575 1.5GHz, 16 cpu + 1 p595 1.9 Ghz, 64 cpu, 1.5 Tflops); SP4, 96 cpu
  - SGI Altix 350 (IA64) 32 cpu & Onyx
  - Cray XD1 24 cpu
  - Linux clusters 32/x86_64; Apple cluster; Windows servers....

Software: commercial codes (fluent, ansys, abaqus..); computational environment (Matlab, IDL,..), research codes (CPMD, MCNP.....)

CRESCO HPC system (1)



CRESCO (Computational Research Center for Complex Systems) is an ENEA Project, co-funded by the Italian Ministry of University and Research (MUR) in the framework of PON 2000-2006 call 1575. In operation since spring 2008.

www.cresco.enea.it

CRESCO HPC system (2)

A general purpose facility based on leading multicore x86_64 technology. Three sections:

Section 1: 672 cores: large memory requirement

42 fat nodes IBM x3850/x3950-M2, 4 Xeon Quad-Core Tigerton E7330 processors (2.4GHz/1066MHz/6MB L2), 32 GB RAM (4 extra-fat nodes with 64 GB RAM, 2 coupled node(x3) 48 cores/192 GB, 1 coupled node (x2) 32 cores /128 GB.

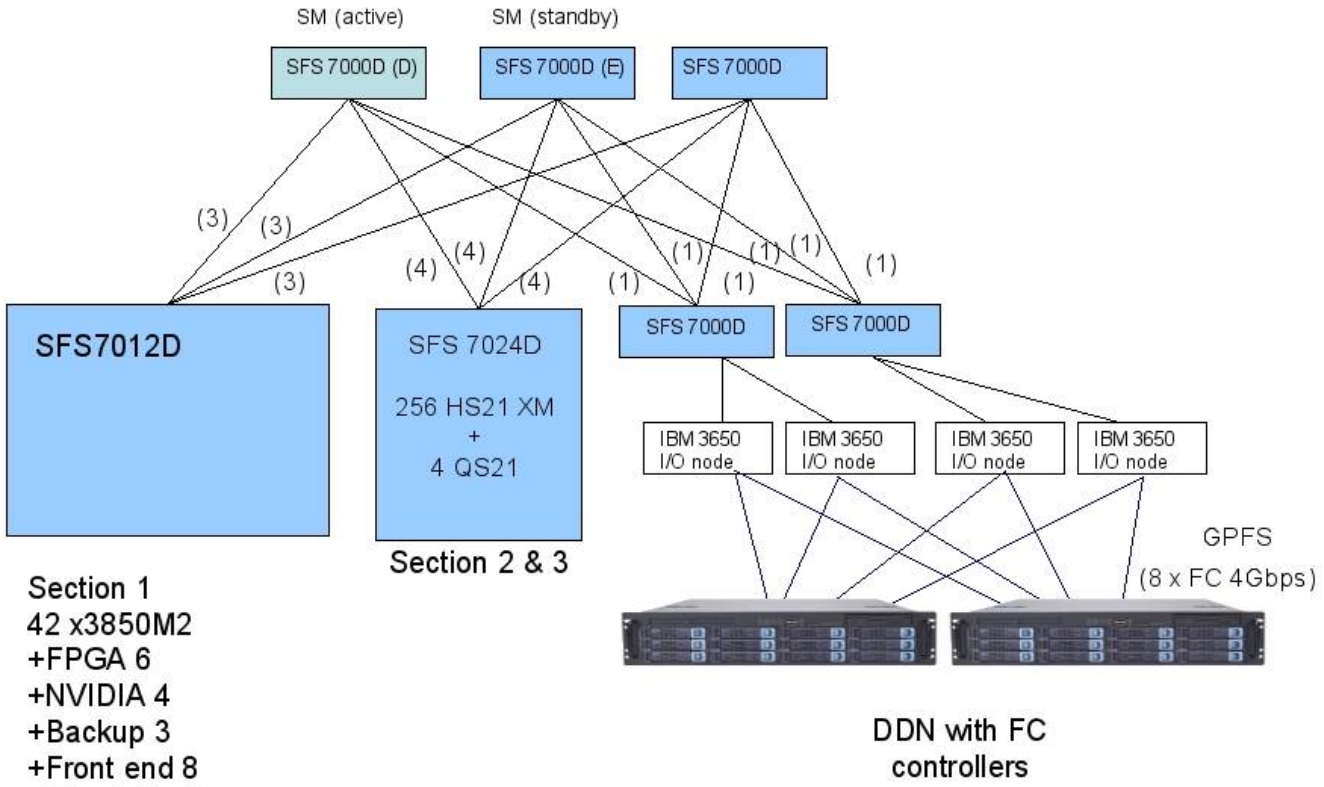
Section 2: 2048 cores : high scalability

256 blades IBM HS21, Xeon Quad-Core Clovertown E5345 processors (2.33GHz/1333MHz/8MB L2), 16 GB RAM

Experimental section: cell, FPGA, GPU

- 4 blades IBM QS21, 2 Cell BE Processors 3.2 Ghz
- 6 nodes IBM x3755, 4 sockets AMD Dualcore 8222, FPGA VIRTEX5 LX330
- 4 node IBM x 3755, 4 sockets AMD Dualcore 8222, NVIDIA Quadro FX 4500 X2 video card

CRESCO Infiniband Network



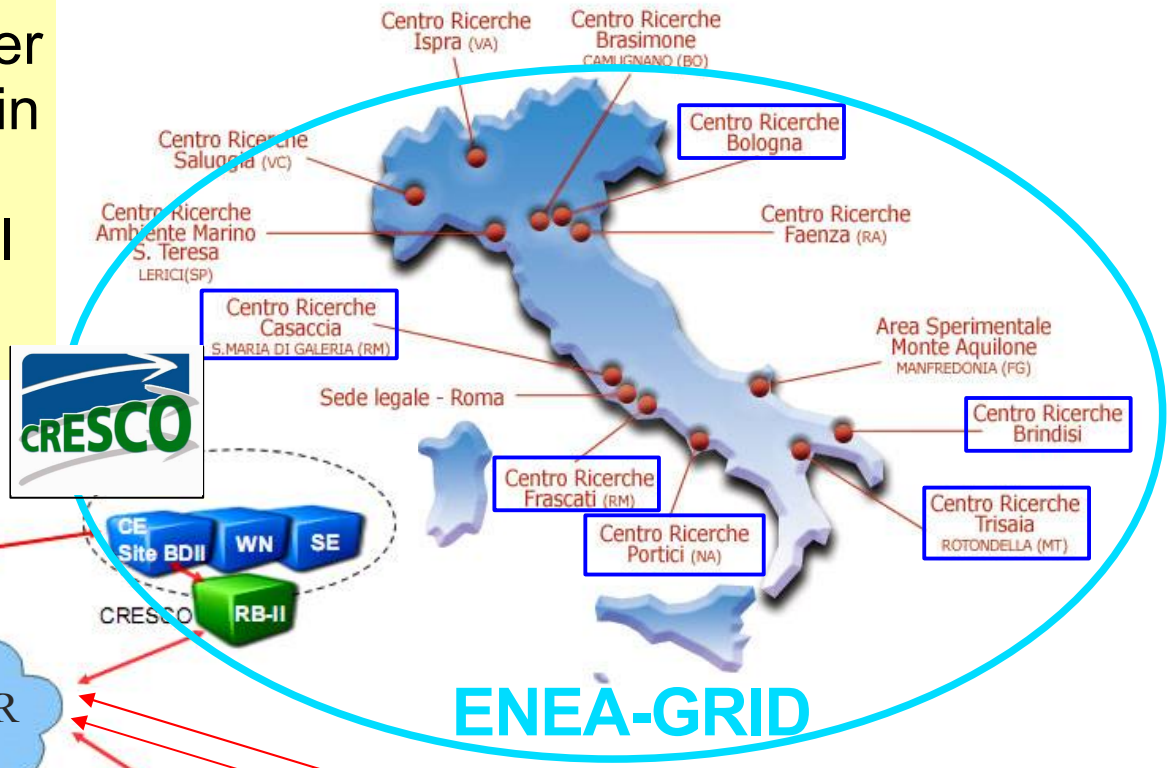
CRESCO Storage:

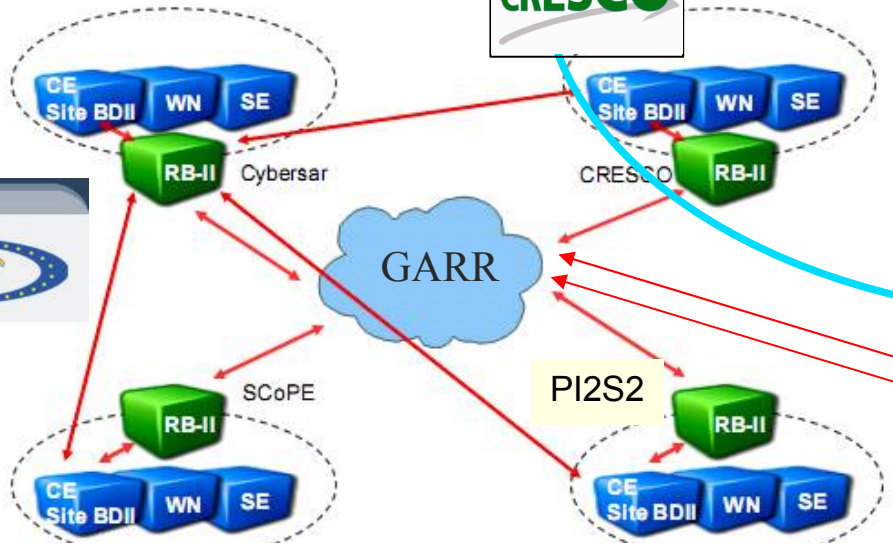
DDN S2A9550

180 TB raw; 120 TB GPFS

ENEA-GRID
interoperability in Southern Italy

CRESCO HPC system interoperates with the other main computational sites in Southern Italy: PI2S2, Cybersar, SCOPE, SPACI with a gateway to gLite





SPACI

GriSù

www.grisu-org.it

ENEA-GRID and Research

- Requirements
  - Computing power: High Performance / High Throughput Computing
  - Systems at the state of art of computational performance
  - Reliable and stable user environment
  - User support (access, infrastructure integration, resource availability and monitoring)
- ENEA-GRID & Research: ENEA Examples
  - Computational Chemistry
  - Nuclear Fusion, plasma stability
  - Climate/Weather/Ocean Simulations
  - Pollutant Athmospheric Diffusion
  - Combustion Simulation
  - ....

ENEA-GRID & Industry

- Additional specific requirements/issues
  - Access to proprietary codes “Certification issues” (license management)
  - Reduction in simulation time, also at the price of weak problem scalability
  - Sinergy between proprietary and open source codes (e.g. OpenFoam vs Fluent)
  - Security and tracebility
  - Intellectual property protection
  - SLA, charging model,....
- Some examples with the following companies
  - AVIO
  - AnsaldoEnergia/AnsaldoRicerche
  - AAPS Informatica
  - CETMA

ENEA-GRID
&
AVIO

Ing. E. Lambiase (Avio Spa)

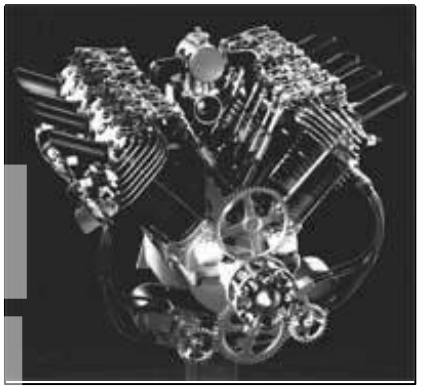
History…

1908 Avio starts its activity in Fiat

1915 Starting from the Great War Fiat design and build airplanes

1969 Fiat focuses on engines leaving the airplane sector to Aeritalia

1976 Fiat Aviazione becomes an independent company



1994 FiatAvio include all the space activity from Fiat group

1996 FiatAvio includes Alfa Romeo Avio

Luglio 2003 FiatAvio becomes Avio aerospace propulsion

Avio S.p.A. in Italy

Sangone (Torino)

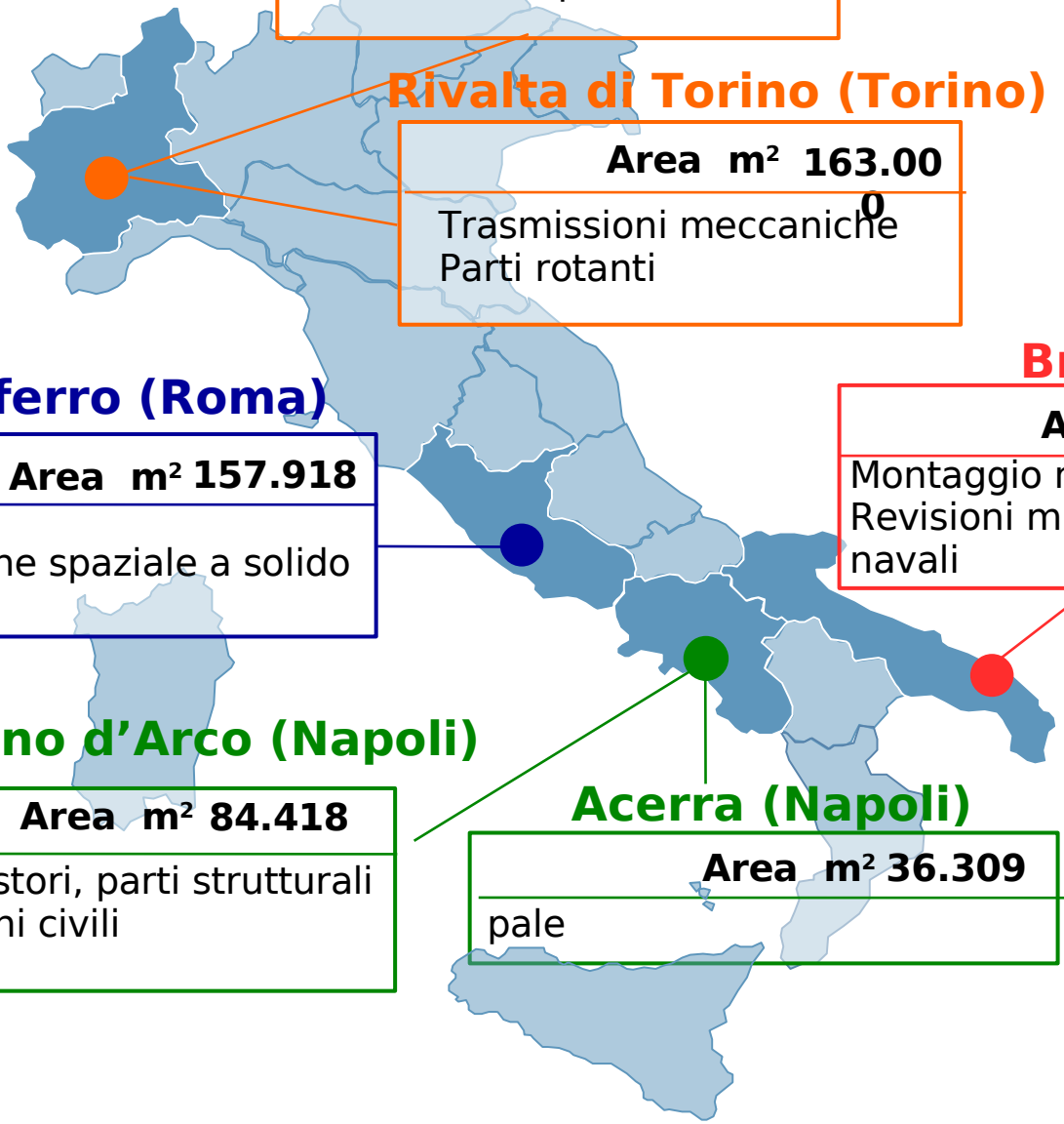
Area m² 12.200

Test e sviluppo:
motori e componenti

Rivalta di Torino (Torino)

Area m² 163.000

Trasmissioni meccaniche
Parti rotanti



Colleferro (Roma)

Area m² 157.918

Propulsione spaziale a solido

Brindisi

Area m² 48.403

Montaggio motori militari
Revisioni militari, Package navali

Pomigliano d'Arco (Napoli)

Area m² 84.418

Combustori, parti strutturali
Revisioni civili

Acerra (Napoli)

Area m² 36.309

pale

16 sites, ~ 4,800 staff

7 in Italy: Torino (2), Colleferro (Roma), Brindisi, Pomigliano d'Arco (Napoli), Acerra (Napoli), AvioFix (Lecco)

2 in South America: (Guyana francese)

1 in Nord America: (New Jersey)

1 in Netherland: (Eindhoven)

1 in Poland: (Bielsko-Biala)

4 office sites: Rome (Italy), Beijing (Cina), Varsavia (Poland), Bruxelles (Belgium)

Spacecraft Propulsion

Ariane 5

Vega

Ariane 5

criogenic propulsion

tactical propulsion

Aster

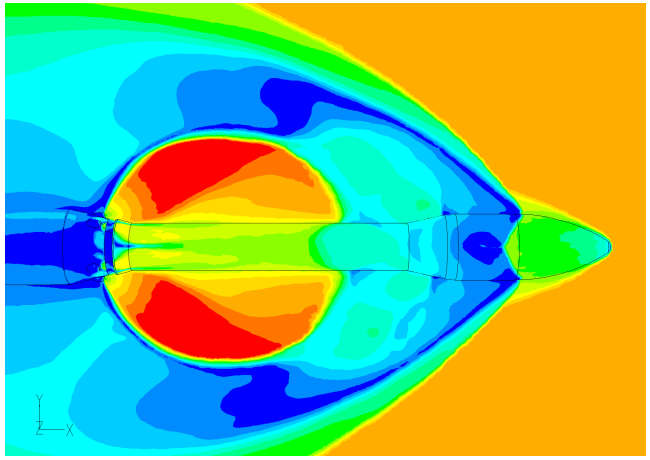
The only provider in Europe, also through its joint ventures, of “complete solid rocket motor” for launchers

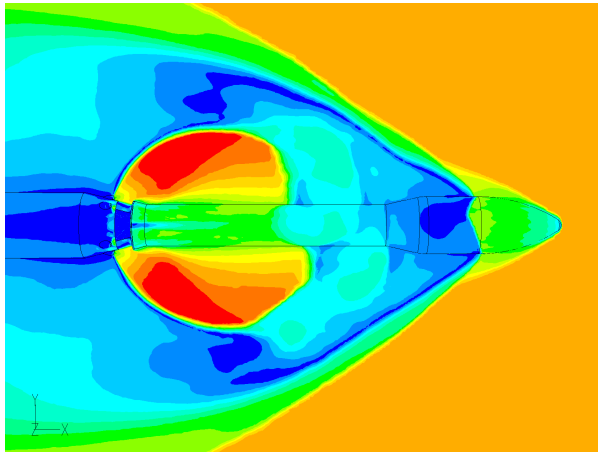
CFD on ENEAGRID (1)

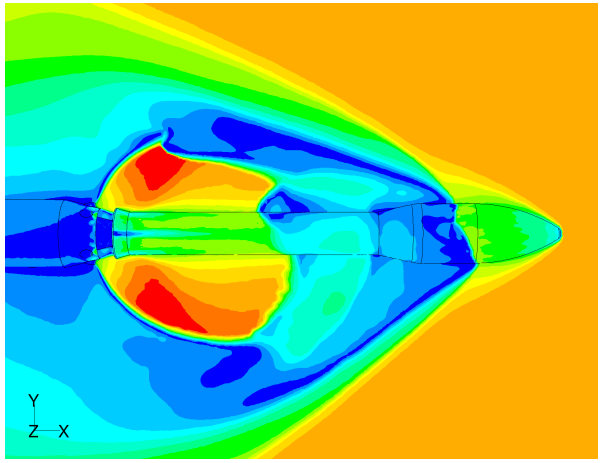
Separation of the 1° stage of Vega launcher has been fully CFD analysed

Ten 3D simulation with turbolent flux, using Fluent code on ENEA-GRID computational resources have been performed

	Tempo macchina per 1 CFD [gg]		Guadagno tempo [%]
Celle di calcolo	AVIO hardware (4CPU)	ENEA Grid (16CPU)	
2,000,000	55	30	45%





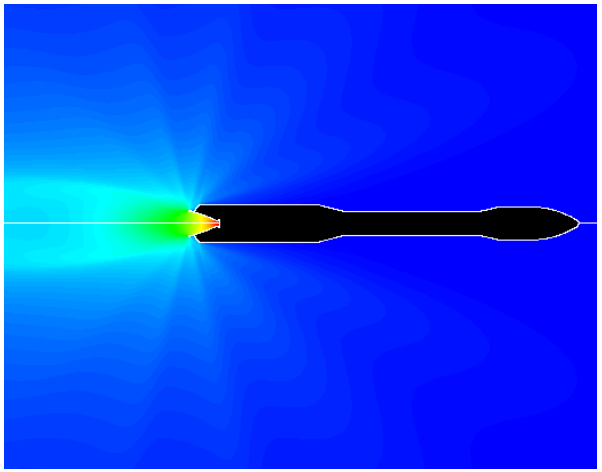


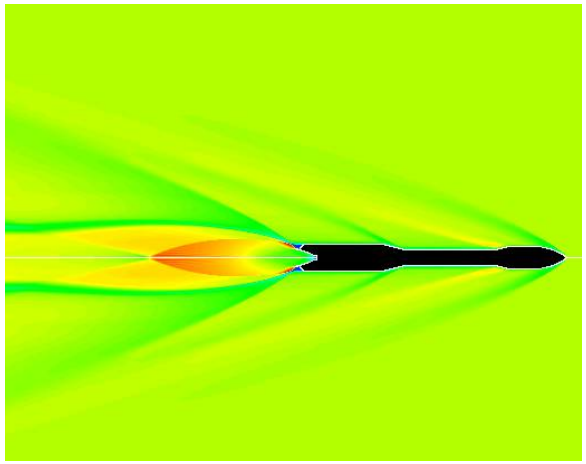
CFD on ENEA-GRID (2)

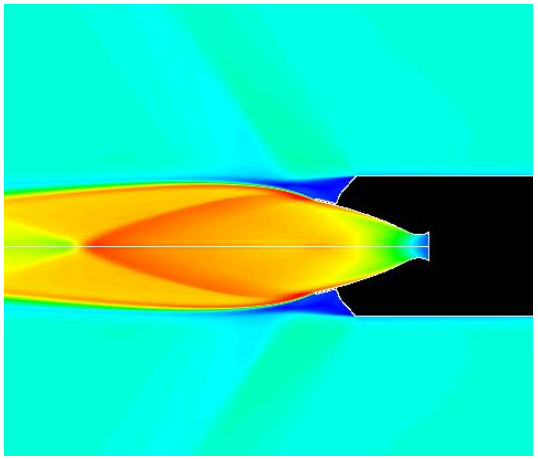
Three CFD analysis have been devoted to the evaluation of the radiative thermal load at the base of the first Vega stage in different flight confîditions.

A bi-phase (gaseus phase and + solid allumina particles) approach has been adopted with the radiative model.

	Tempo macchina per 1 CFD [gg]		Guadagno tempo [%]
Celle di calcolo	AVIO hardware (4CPU)	ENEA Grid (8CPU)	
400,000	15	7	53%



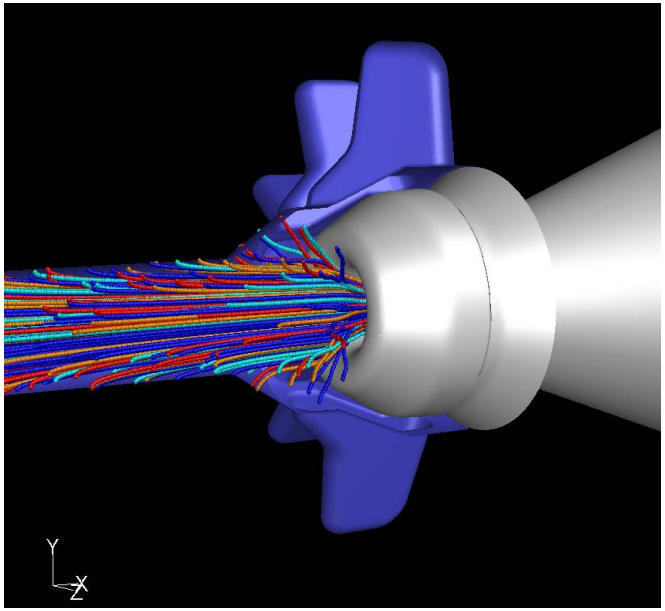


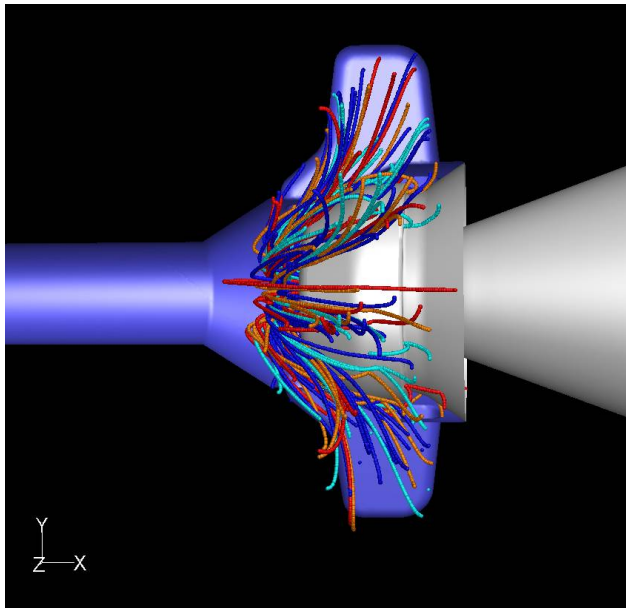


CFD on ENEA-GRID(3)

A CFD analysis has been performed to evaluate the mechanical interaction between allumina particles at the nozzle submergence inside the third stage of the Vega launcher engine.

	Tempo macchina per 1 CFD [gg]		Guadagno tempo [%]
Celle di calcolo	AVIO hardware (4CPU)	ENEA Grid (8CPU)	
1,500,000	25	10	60%





ENEA-GRID
&
AnsaldoRicerche/AnsaldoEnergia

Ing. M. Cioffi (CRIS Napoli)

HPC AND GAS TURBINES DEVELOPMENT TOOLS

AnsaldoRicerche
Una Società Finmeccanica

AnsaldoEnergia
A Finmeccanica Company

Gas Turbines Development

FINMECCANICA

MARKET REQUIREMENTS:

- Decrease emissions.
- Increase Major Overhaul Interval.
- Increase fuel flexibility.

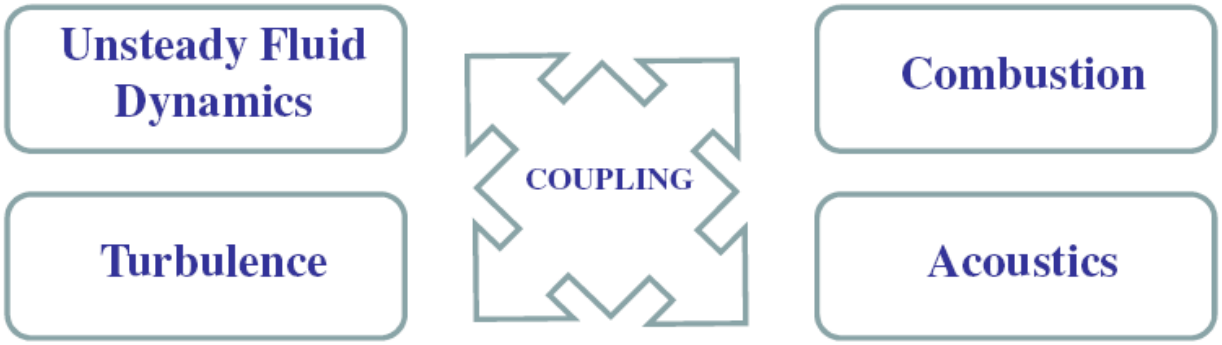
PRODUCERS STRATEGIES:

Combustion Dynamics modelling has become the major issue in power systems R&D.

Technical Issues

FINMECCANICA

Combustion chamber instabilities (i.e. humming phenomena) numerical simulation.



TURBULENCE:

Large Eddy Simulation (LES) numerical technique has become the most reliable numerical method to understand humming phenomena.

LES is quite computer expensive: 100÷1000 more classical RANS (Reynolds Averaged Navier Stokes).

LES Modelling and HPC Numerical Approaches

FINMECCANICA

Due to the Gas Turbines combustion chamber geometrical characteristics and to the main azimuthal acoustic mode it is necessary to simulate the overall 3D combustion system (computational grid with O(1E6) ÷ O(1E7) cells).

PRESENT GOAL:

- Execution of LES 3D model of a complete combustion chamber by decreasing the run time by a factor of 100.
- Smart use of HPC HW and SW solutions.

Preliminary tests are in progress on CRESCO ENEA machine by an Ansaldo-ENEA research agreement.

AnsaldoRicerche
Una Società Finmeccanica

AnsaldoEnergia
A Finmeccanica Company

ENEA-GRID
&
AAPS BU Engineering

V. Stirparo AAPS

AAPS: the Company and the CAE Depart.

AAPS INFORMATICA since 1994 operates in the Information & Communication Technology field offering its services both to public and private sector..

Since 2002 AAPS has started the activity of a CAE business unit for software development and consulting in the field of computer aided engineering.

Software development (Go-NURBS, Go-Mesh)

Staff ~50

Turnover 2008: 2.5 M€

Sites: Avellino, Mercogliano (AV), Monza, Roma

www.aapsinformatica.com

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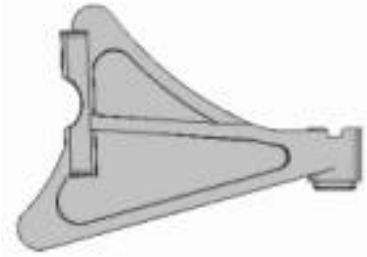
info@centrostudiatlantis.it

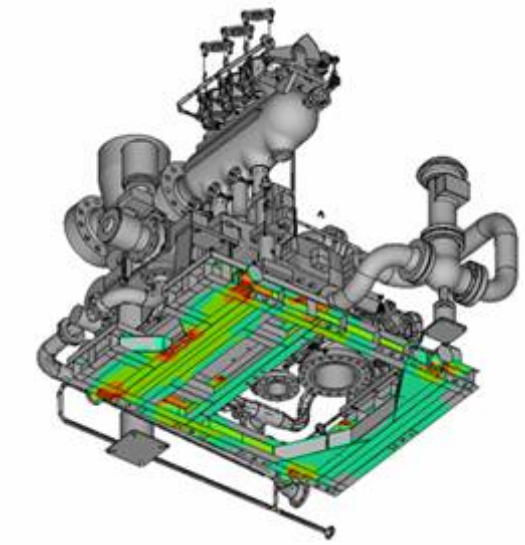
AAPS CAE Department: General Overview

The CAE department can perform structural, thermal and fluid dynamic analysis and provide solutions to linear, non-linear, explicit and multi-body dynamics problems. Our staff is skilled in the use of most relevant software:
GO-Mesh, Hypermesh, MSC-Nastran, Abaqus Implicit/Explicit, LS-Dyna

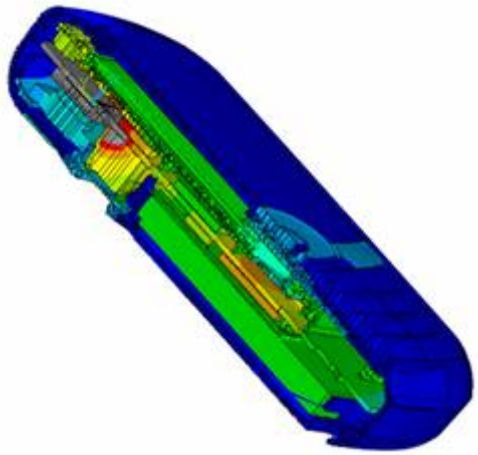
Automotive
Front Crash Test



Automotive
Stress Analysis



Engineering
Turbine Baseplate Analysis



Mobile Phone
Thermal Analysis

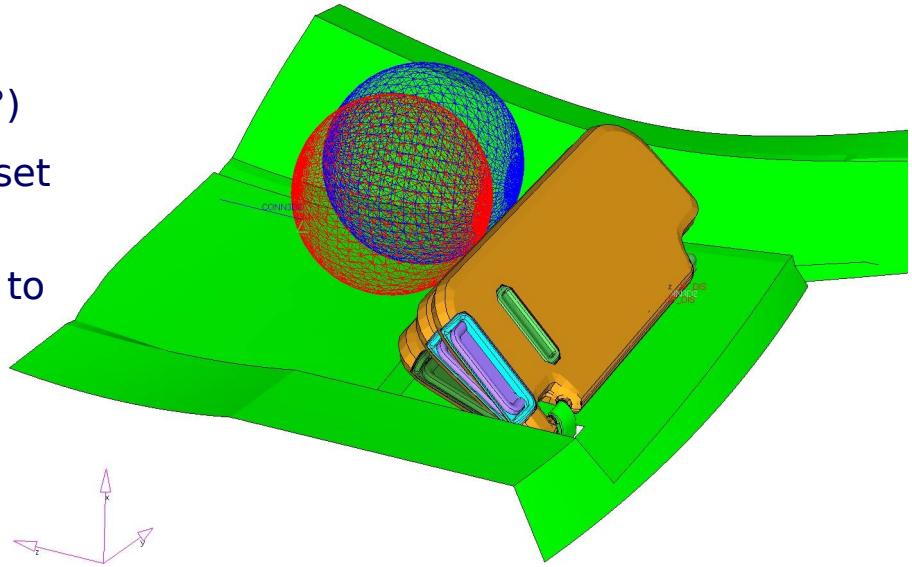
AAPS INFORMATICA
partner per soluzioni d'avanguardia.

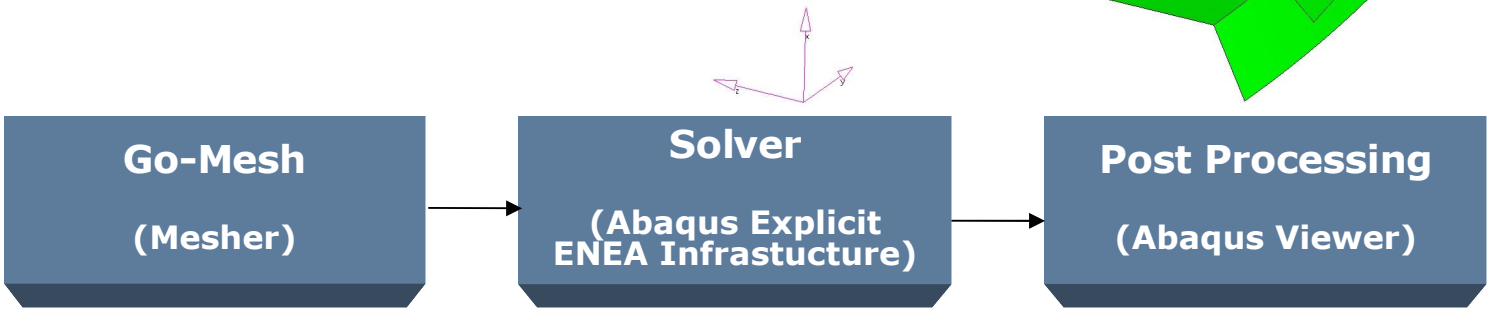
AAPS CAE Department: General Overview

The case study refers to Sun Visor Omologation following ECE21 rules

Analysis performed ECE21:

- 3 different Sun Visor positions (20°, 30°, 40°)
- 2 different head position (central, 70mm offset y+)
- impact speed 6.7m/s (24.1km/h) –according to ECE21



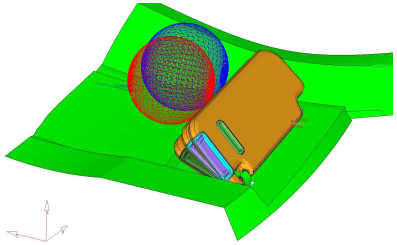


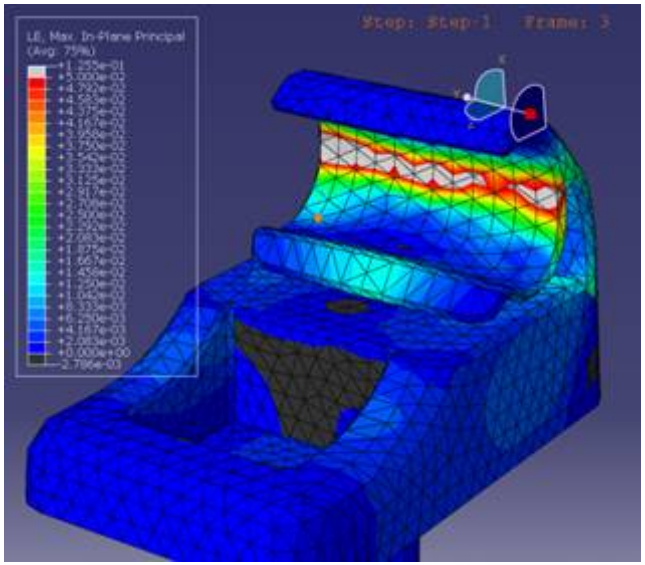
Workflow used for the Case Study

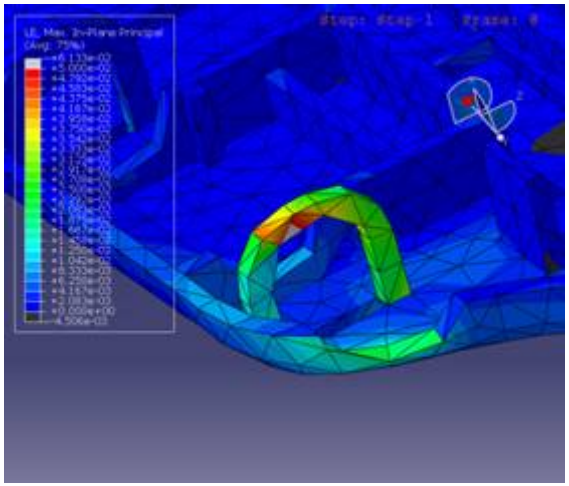
AAPS CAE Department: General Overview

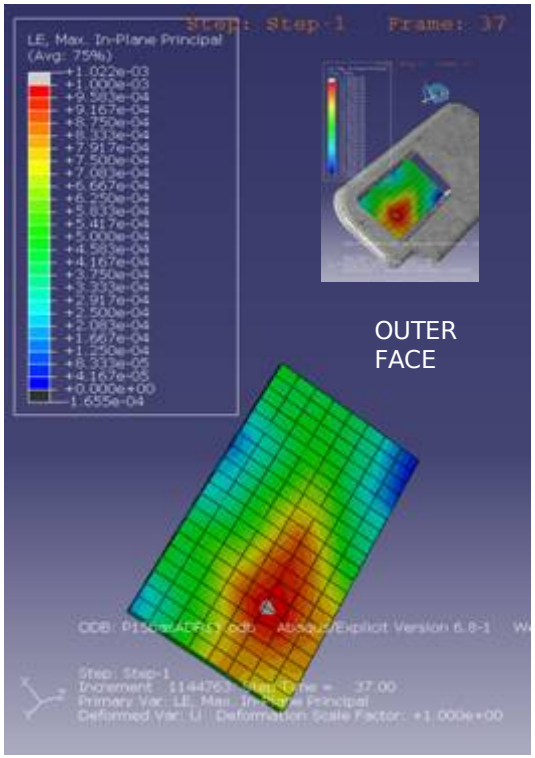
Analysis performed ECE21:

- 3 different Sun Visor positions (20°, 30°, 40°)
- 2 different head position (central, 70mm offset y+)
- impact speed 6.7m/s (24.1km/h) –according to ECE21









Stress Analysis for different Sun Visor components

AAPS INFORMATICA
partner per soluzioni d'avanguardia.

ENEA-GRID
&
CETMA

D. Bardaro CETMA, Brindisi

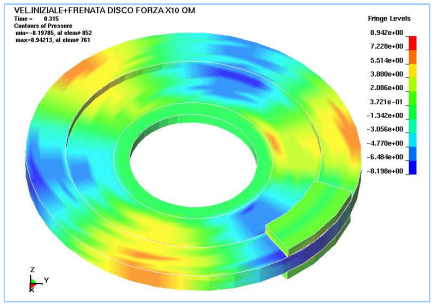
CETMA is a private and non-profit research center specialized in development of innovative products and processes, through the integration of specific competences in materials engineering, industrial design and computer science engineering.

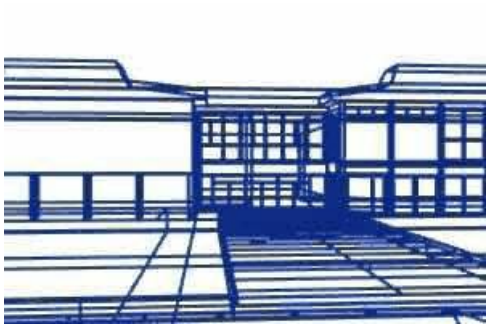
The shareholders are:

ENEA
Università del Salento
D'Appolonia
Infobyte
Telcom
Alfa Edile
Cemit
Igeam

CETMA DEPARTMENTS

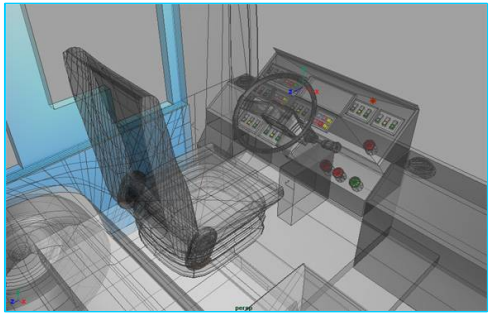
Materials and structures engineering





Information Technologies

Industrial & Communication Design



CETMA – ENEA GRID Activities

PROCETMA Project - Potenziamento delle attività di Ricerca e delle Opere infrastrutturali per il Supercalcolo, la Simulazione e Visualizzazione del consorzio CETMA

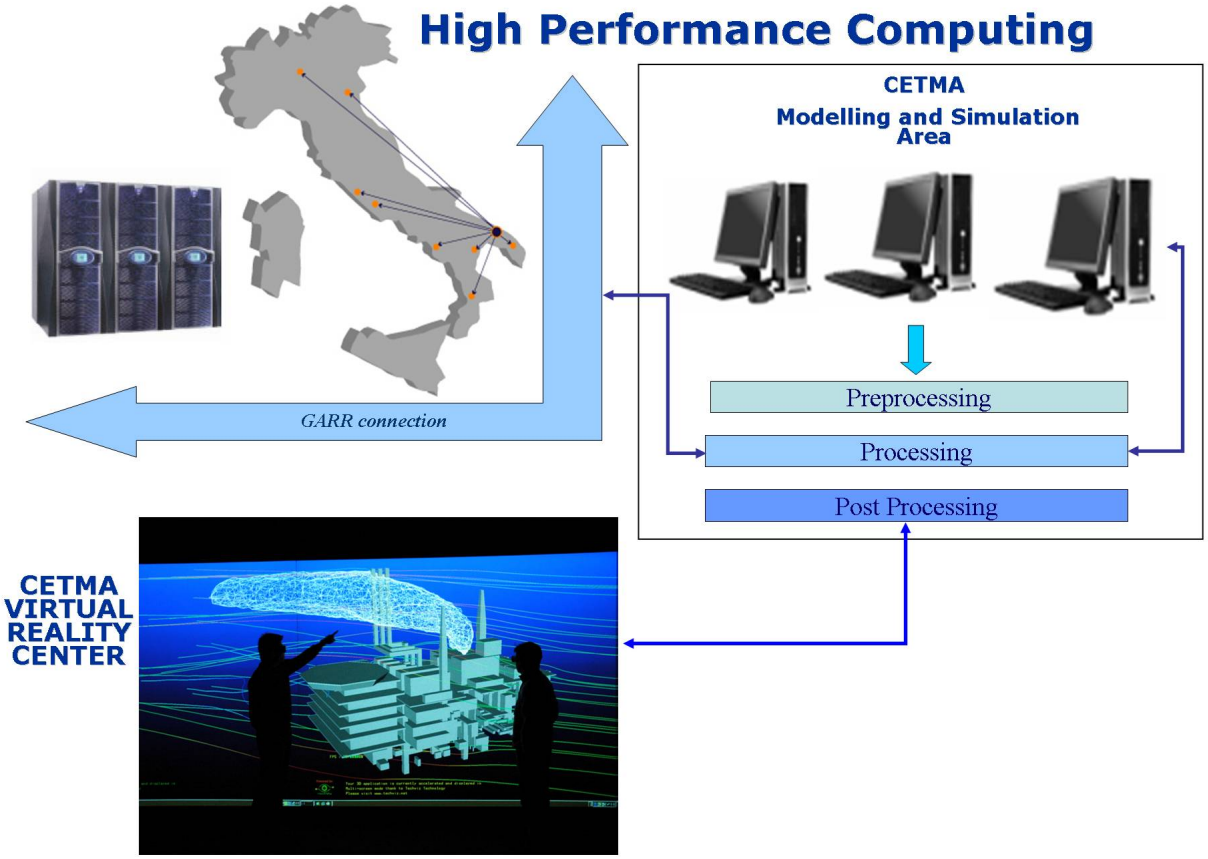
CETMA / ENEA Activities – CFD (Computational Fluid Dynamic Analyses) and Grid Computing

CRESCO Project – Computational Research Center for Complex Systems

CETMA Activities – Development of numerical modelling strategies to perform complex structural analyses and to simulate sintering processes

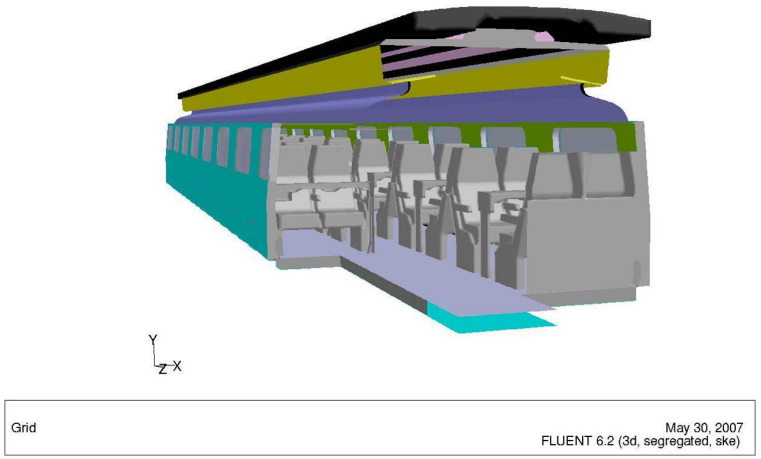
Porting Cetma-ENEA Grid

The aim of the activity is to connect the ENEA grid infrastructure to the single design work stations and to the CVRC (CETMA VIRTUAL REALITY CENTRER) located at CETMA site.
Post processing and full understanding of the results is allowed through the capabilities of the virtual reality environment provided by the CVRC while reduction of running time is obtained through the parallel computing environment provided by the Grid.

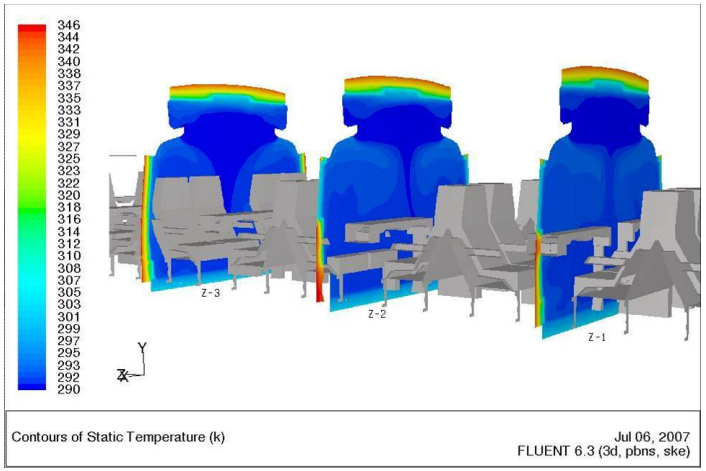


Layout of the various phases of the porting CVRC-Grid ENEA

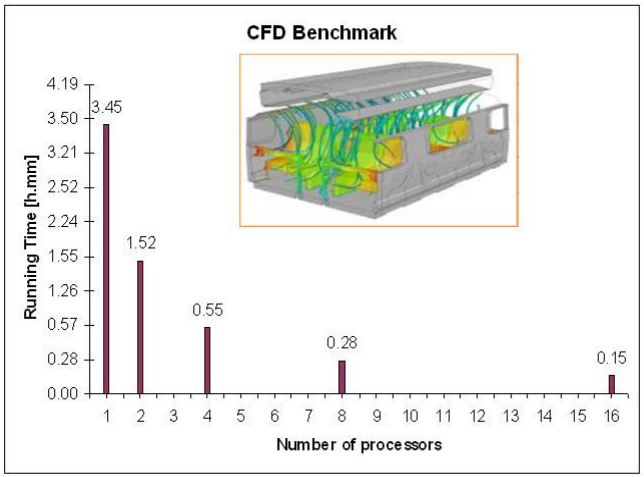
CFD case study 1: Thermal Fluid Dynamic ANALYSIS OF A PASSANGER COACH



3D CFD Model

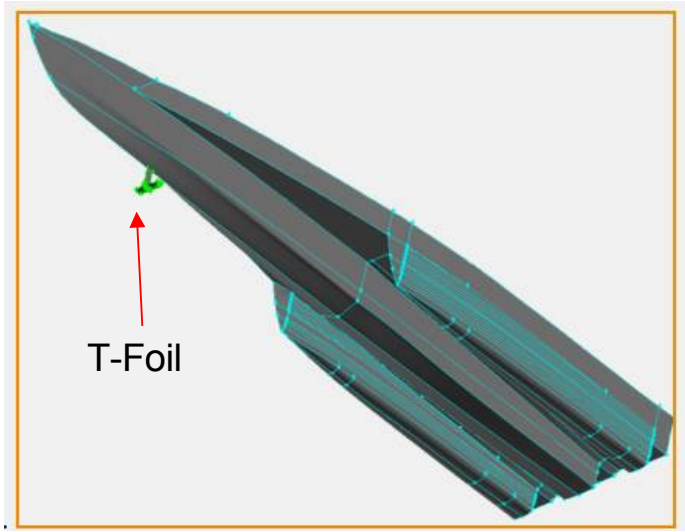


Air Temperature Contours

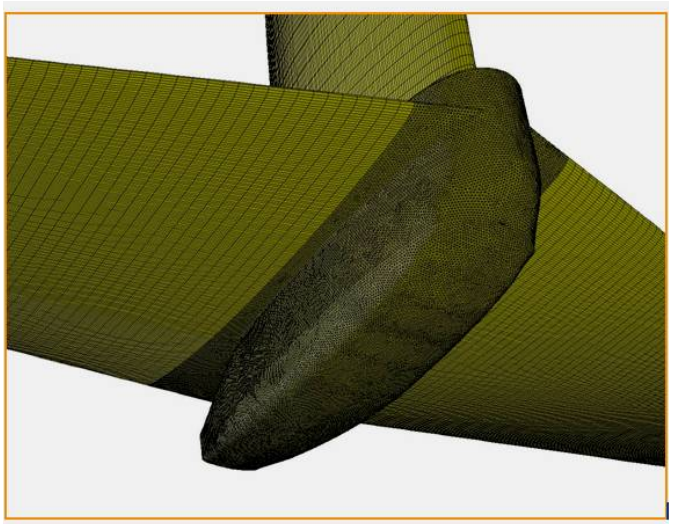


HPC: reduction of running time for a 3D CFD model when the number of processors increase (from 1 to 16)

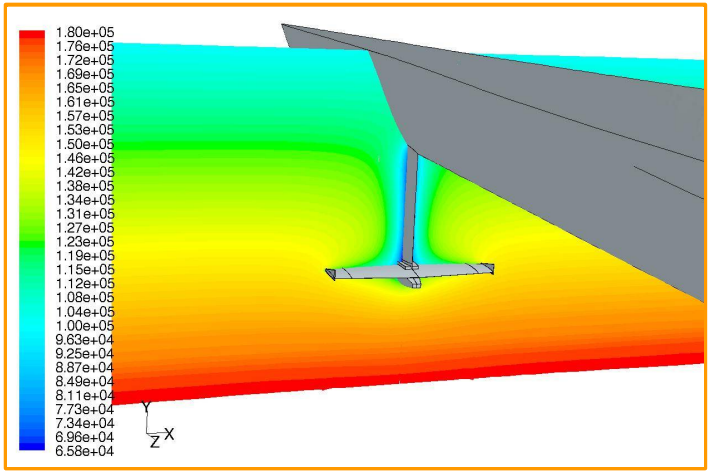
CFD case study 2: hydro-dynamics analyses of Fast Ship T-Foil system



3D Model: trimaran + T-foil



Detail of T-foil mesh



Results: pressure contour (Pa): flap 0° , cruising speed 31.5 knots

Mesh: 15 Millions of cells with dimensions ranging from 1 mm to 550 mm

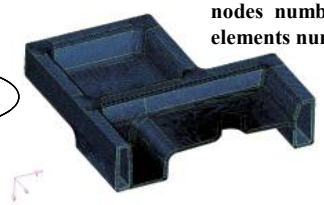
Need of HPC: ENEA GRID

The analyses were carried out using 16 CPUs on ENEA GRID with a total running time of 70 h.

Structural analysis case study: Development of numerical models for the simulation of ceramic components during sintering

FE solver was used to simulate and visualize the system deformations during sintering. Some tools were developed to achieve better results: user subroutines to correctly represent the constitutive material law and macro to allow post-processing for mould design.

Pre Processor



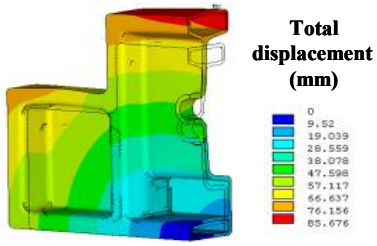
nodes number: 1272783
elements number: 792674

Solver

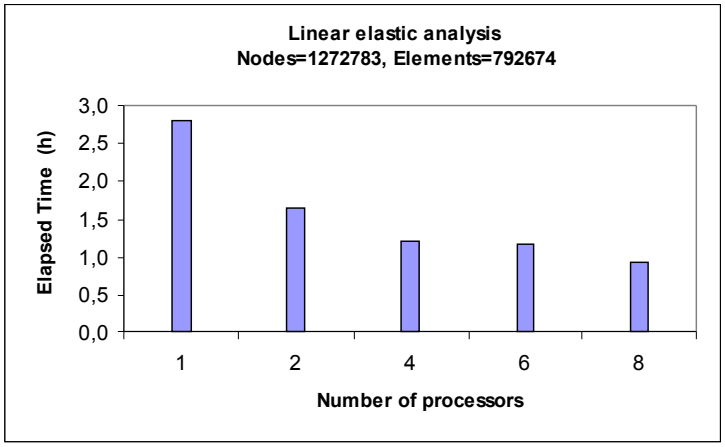
Olevsky costitutive law for ceramics materials

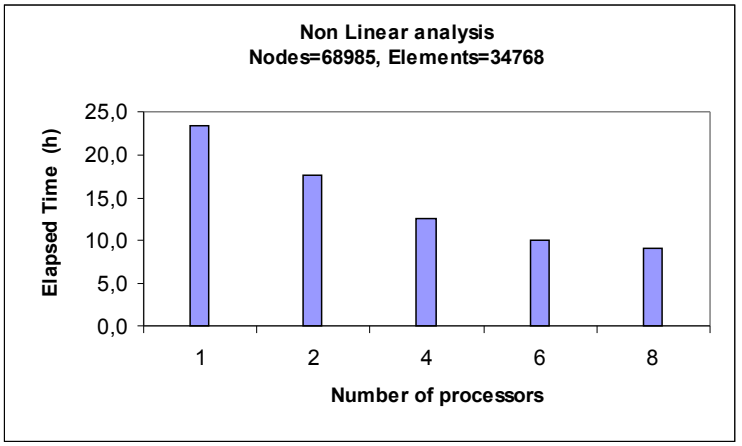
$$\sigma_i = \frac{\sigma(\overrightarrow{W})}{W}\left[\varphi\dot{\varepsilon}_i + \left(\psi - \frac{1}{3}\varphi\right)\dot{e}\delta_i\right] + P_L\delta_i$$

Post Processor



Design of new ceramic shapes (washbasin) through numerical simulation





HPC: reduction of running time for linear and non linear mechanical analyses when the number of processors increase (from 1 to 8)

Conclusions

- ENEA has acquired some experience in providing access to industry users to its computational facilities organized into ENEA-GRID
- Requirements of the industry users pose demanding request to a GRID infrastructure.
- At the moment the issues have been solved on a case by case approach, taking advantage of some of the features provided by ENEA-GRID components.