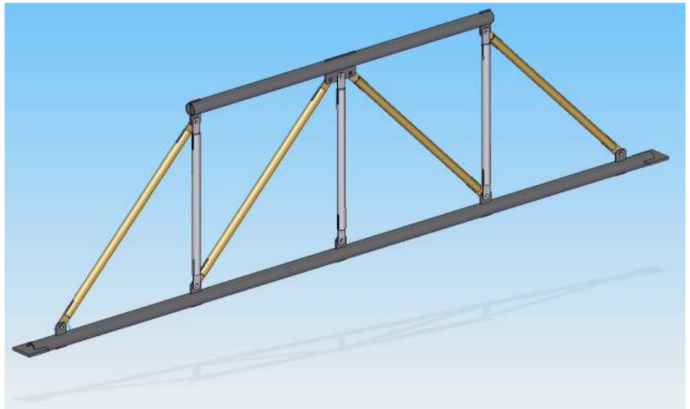
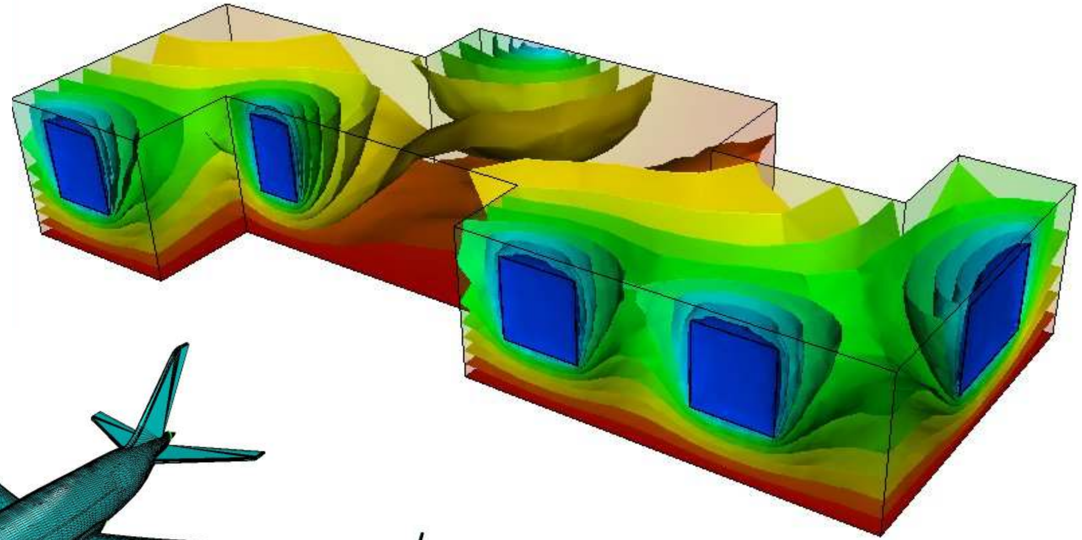
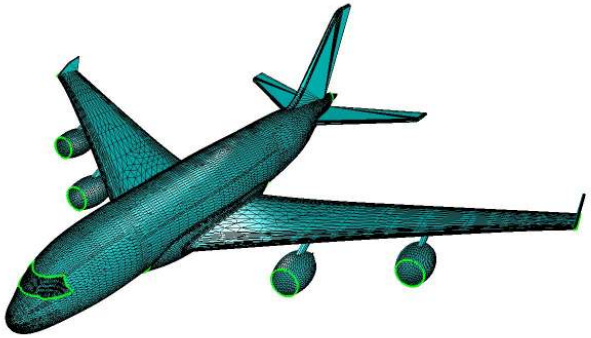


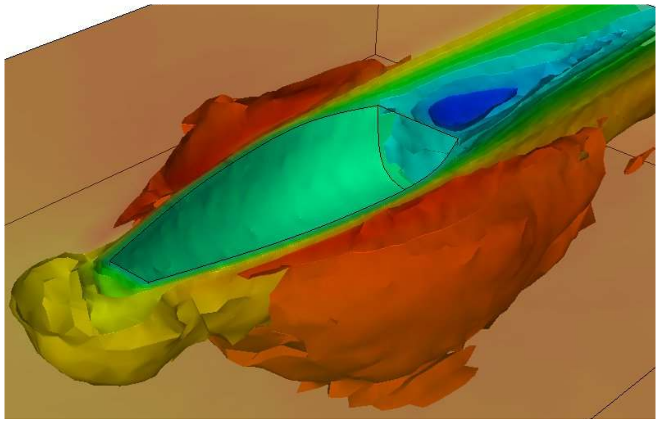


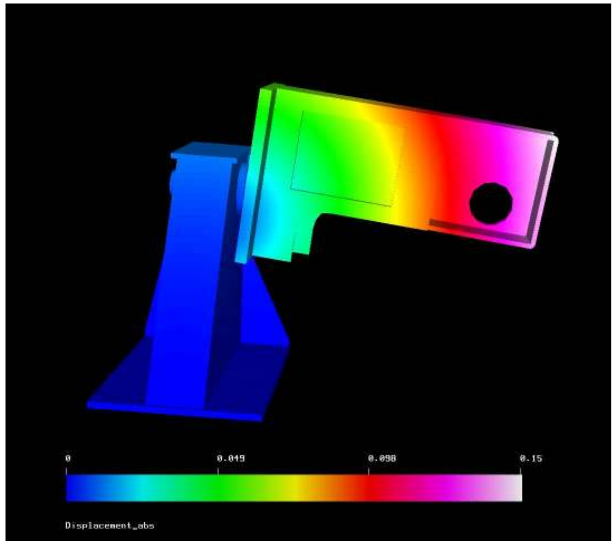


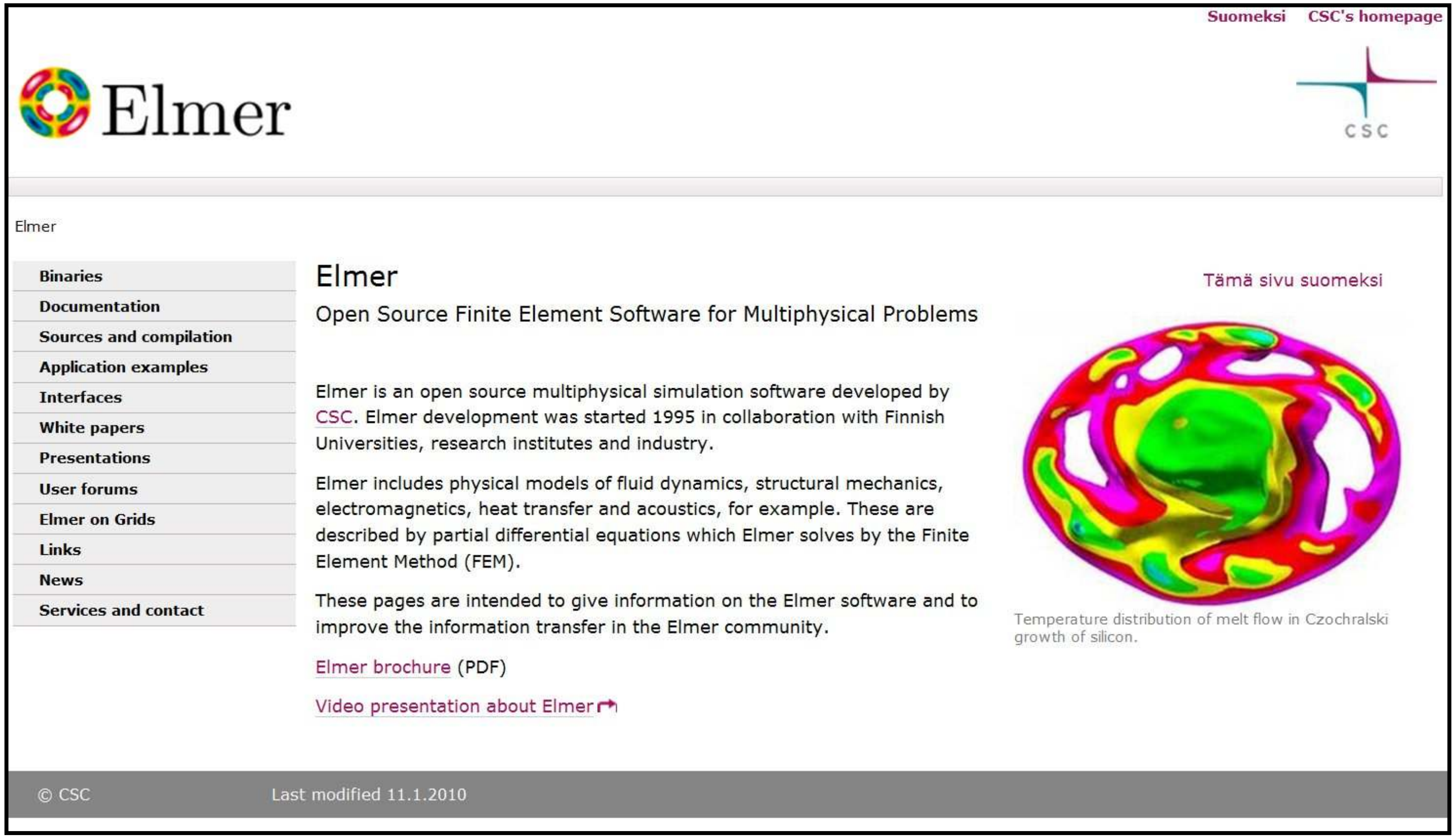
Elmer

STUDIO D'INGEGNERIA GARATTONI
di Garattoni ing. Fabio

via Aretino 3/B
47838 Riccione (RN)
E-mail: info@studiogarattoni.com
Mobile: 347 8472108
Phone/Fax: 0541 692213
www.studiogarattoni.com







Most important Elmer resources

http://www.csc.fi/elmer
Official Homepage of Elmer
Overview, examples, compilation, …
pointers to other sources of information

http://sourceforge.net/projects/elmerfem/
Binaries

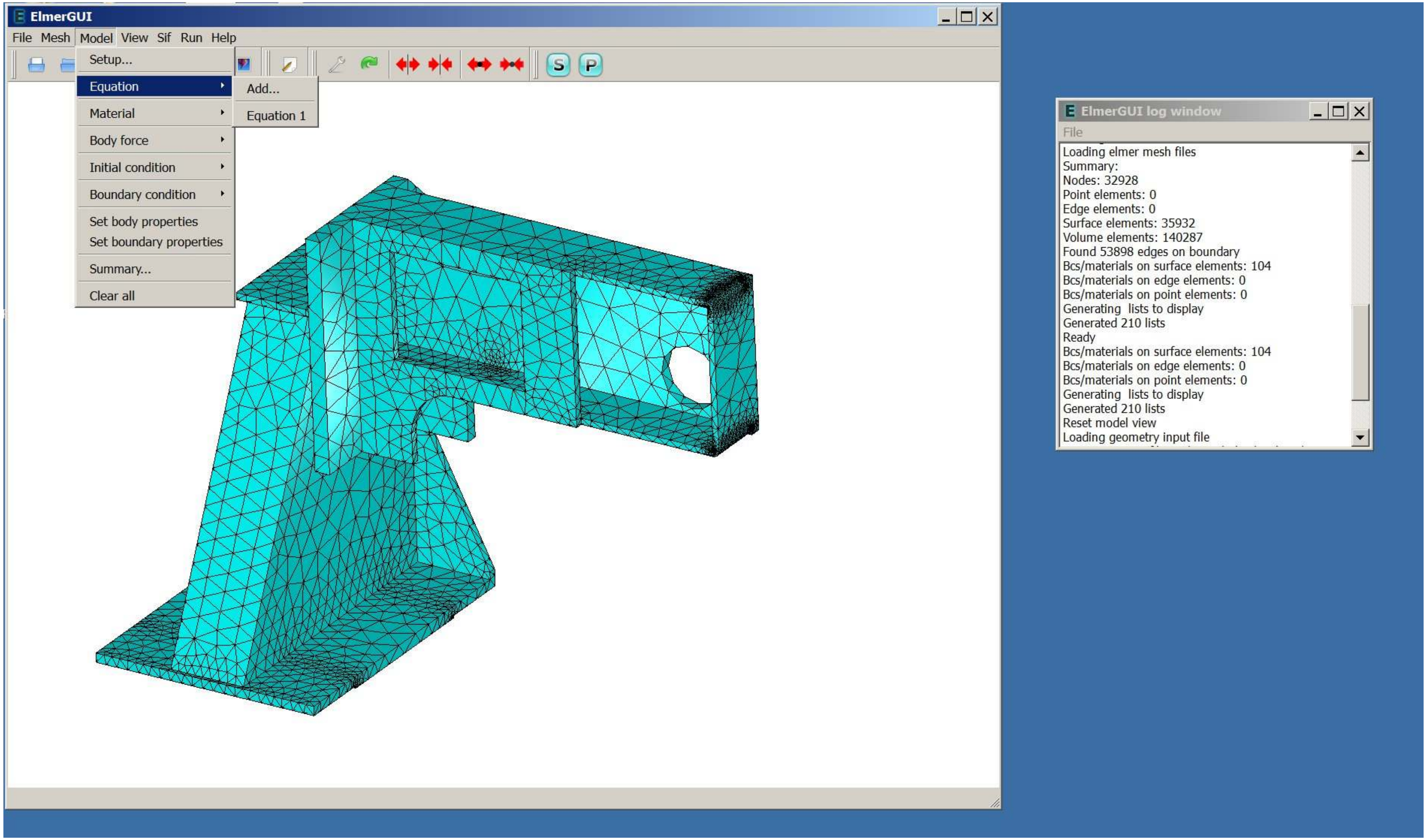
www.elmerfem.org
Discussion forum & wiki

Mikko.Lyly@csc.fi & Peter.Raback@csc.fi
Finnish university customers get the best support

Vantaggi e Svantaggi

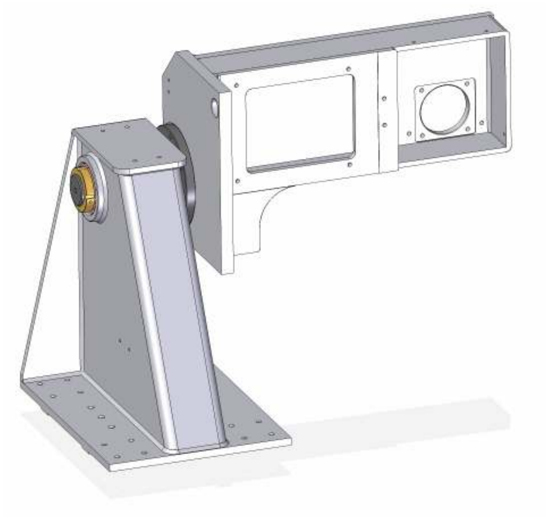
- ☺ Elmer è gratuito
- ☺ Possibilità di verificare e modificare il solutore
- ☺ Elmer offre molti metodi di calcolo numerico diretto e iterativo
- ☺ Le operazioni di assemblaggio delle matrici e di soluzione possono essere fatte in parallelo (calcolo parallelo)
- ☺ Piattaforma Windows. Ambiente Pre-post processore moderno

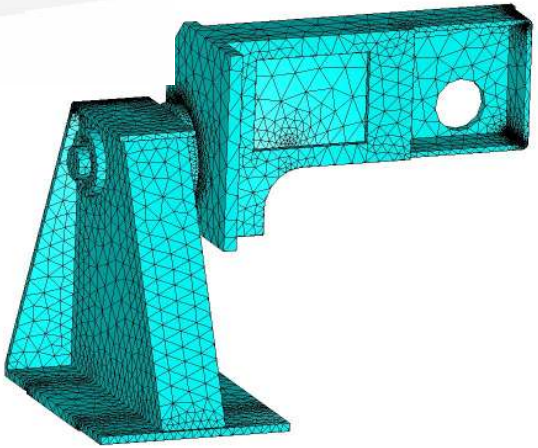
- ☹ I differenti aspetti del codice (solutore, interfaccia, documentazione) non sono allo stesso stadio di sviluppo
- ☹ Elmer non ha validi strumenti per la gestione di geometrie e meshature complesse. Formato file importati: step, iges

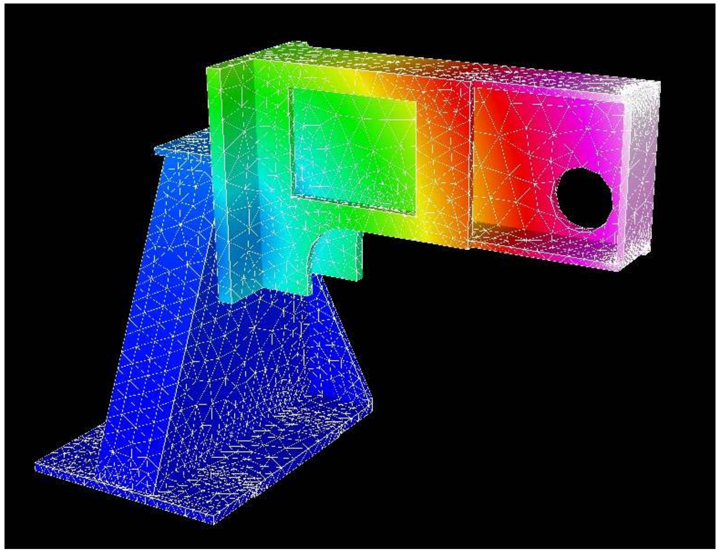

ElmerGUI
File Mesh Model View Sif Run Help
Setup...
Equation
Add...
Equation 1
Material
Body force
Initial condition
Boundary condition
Set body properties
Set boundary properties
Summary...
Clear all
ElmerGUI log window
File
Loading elmer mesh files
Summary:
Nodes: 32928
Point elements: 0
Edge elements: 0
Surface elements: 35932
Volume elements: 140287
Found 53898 edges on boundary
Bcs/materials on surface elements: 104
Bcs/materials on edge elements: 0
Bcs/materials on point elements: 0
Generating lists to display
Generated 210 lists
Ready
Bcs/materials on surface elements: 104
Bcs/materials on edge elements: 0
Bcs/materials on point elements: 0
Generating lists to display
Generated 210 lists
Reset model view
Loading geometry input file

1/5 ANALISI STRUTTUALE LINEARE

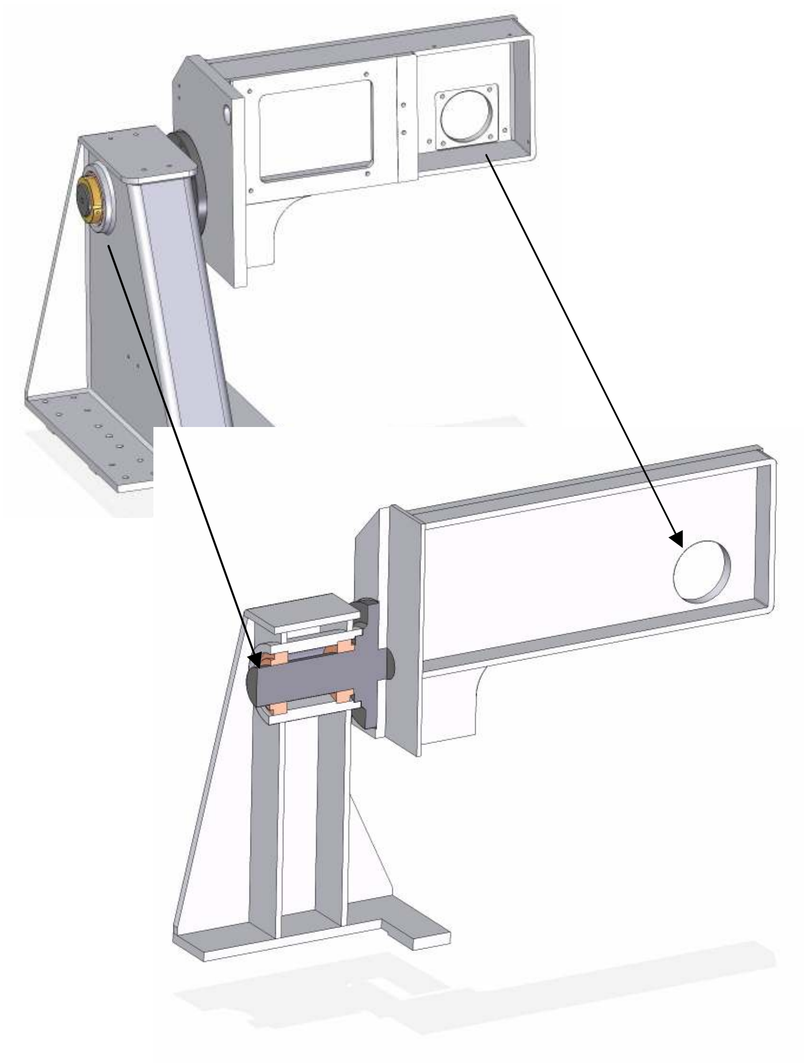
- Assieme colonna, perno di rotazione, cuscinetti, braccio supporto gruppo operatore
- Modello realizzato con CAD 3D Solid Edge







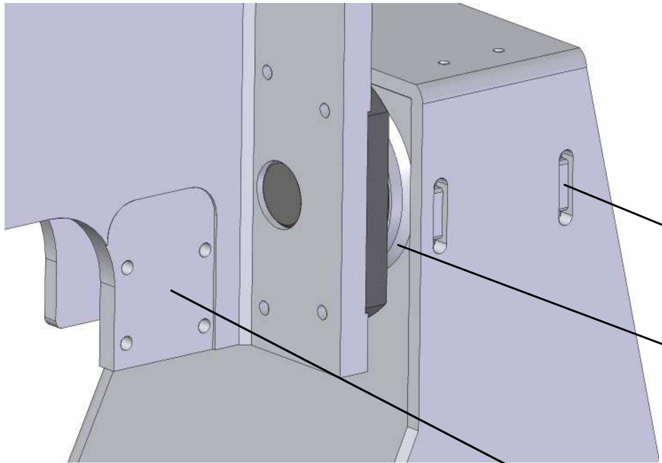
SEMPLIFICAZIONE GEOMETRIA



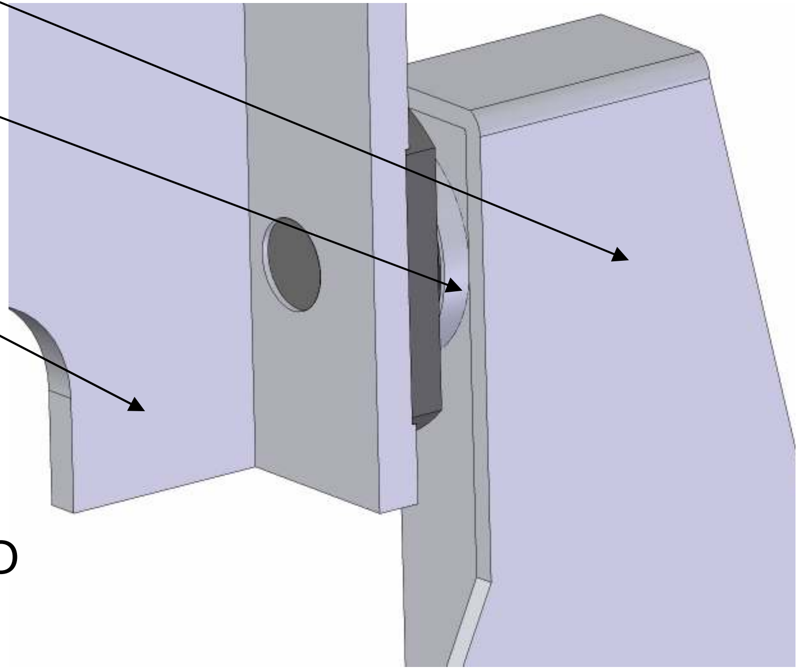
- ELIMINARE RAGGI DI RACCORDO
- FORI
- GIOCHI DI ACCOPPIAMENTO PER LA SALDATURA DEI PEZZI
- LAVORAZIONI NON IMPORTANTI DAL PUNTO DI VISTA STRUTTURALE
- PARTICOLARI NON STRUTTURALI
- CORDONI DI SALDATURA

- SOLIDIFICARE IN UN UNICO PARTICOLARE
- ESPORTARE IN STEP

SEMPLIFICAZIONE GEOMETRIA



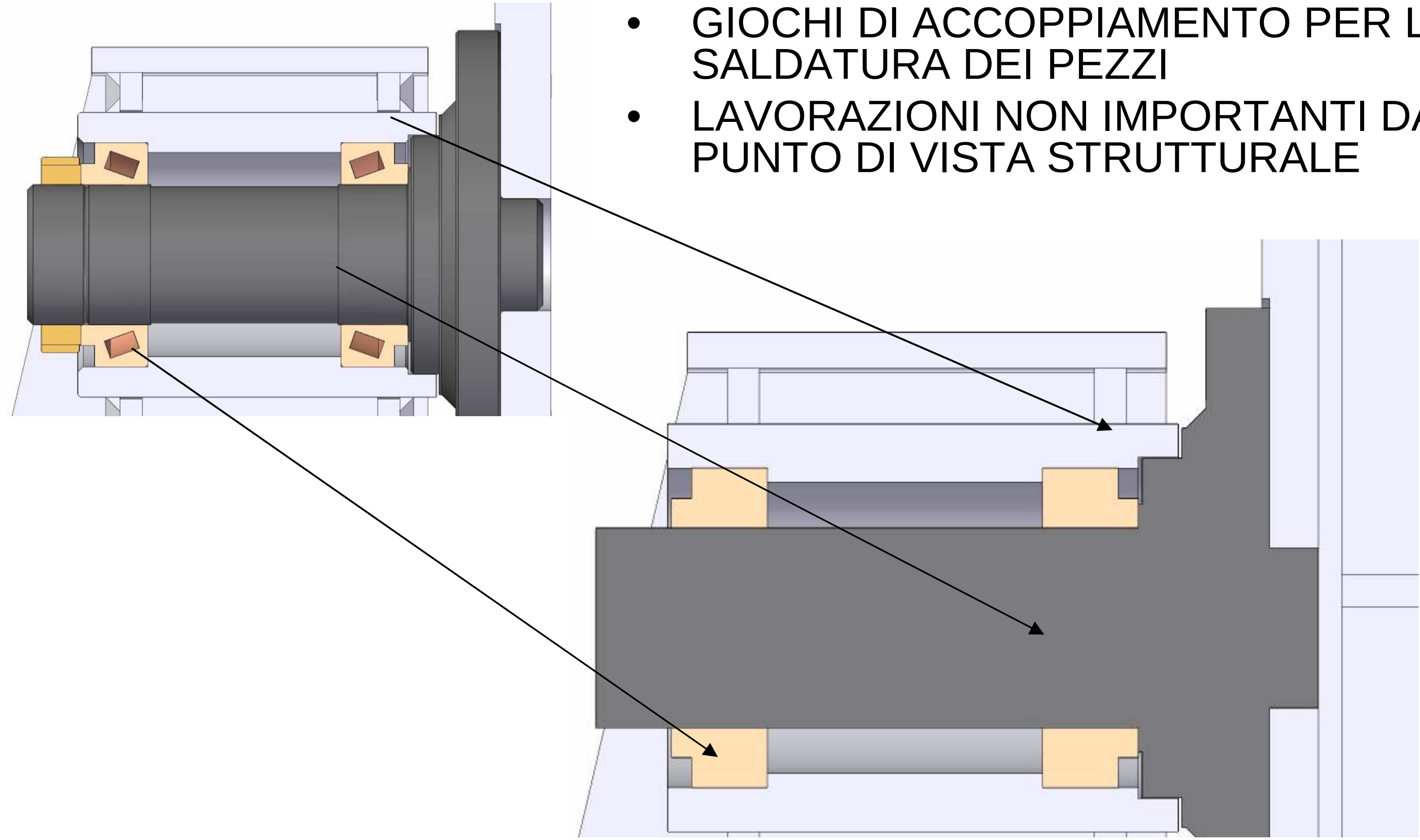
- LAVORAZIONI NON IMPORTANTI DAL PUNTO DI VISTA STRUTTURALE
- CORDONI DI SALDATURA



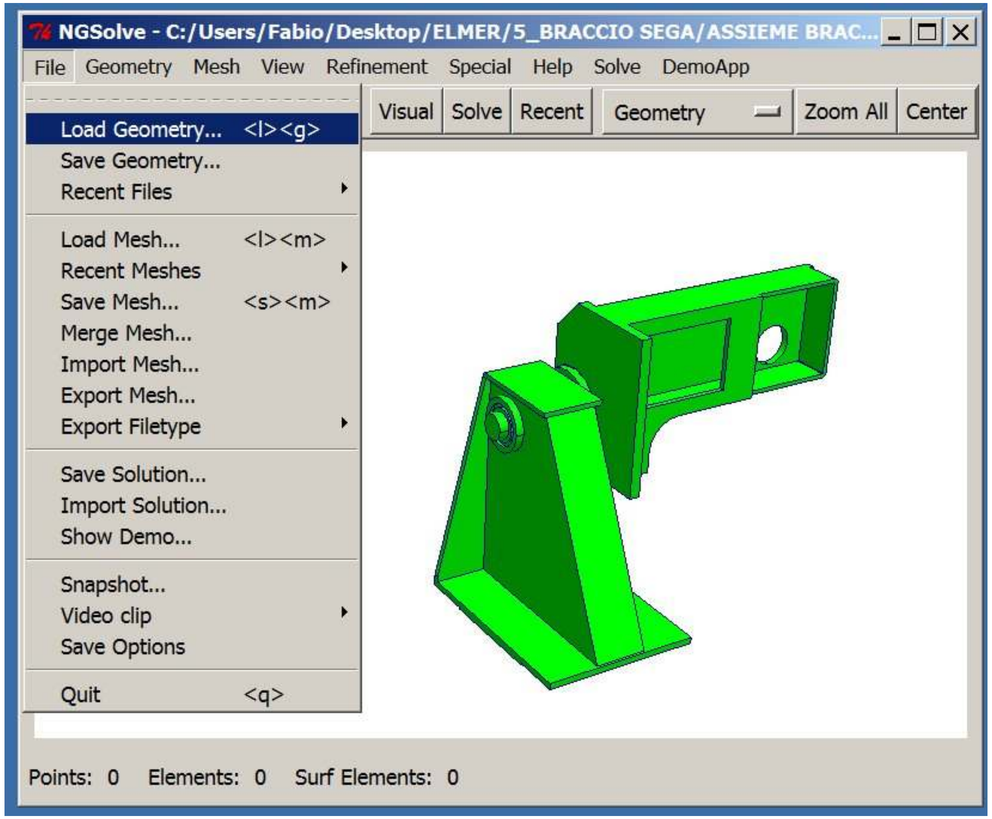
- ELIMINARE RAGGI DI RACCORDO
- FORI

SEMPLIFICAZIONE GEOMETRIA

- GIOCHI DI ACCOPPIAMENTO PER LA SALDATURA DEI PEZZI
- LAVORAZIONI NON IMPORTANTI DAL PUNTO DI VISTA STRUTTURALE



CREAZIONE MESH



PRIMO METODO: UTILIZZANDO NETGEN (OPEN SOURCE)

http://www.hpfem.jku.at/netgen/

IMPORTARE LA GEOMETRIA IN FORMATO STEP

VANTAGGI: MAGGIOR CONTROLLO DELLA MESH E MULTIBODY

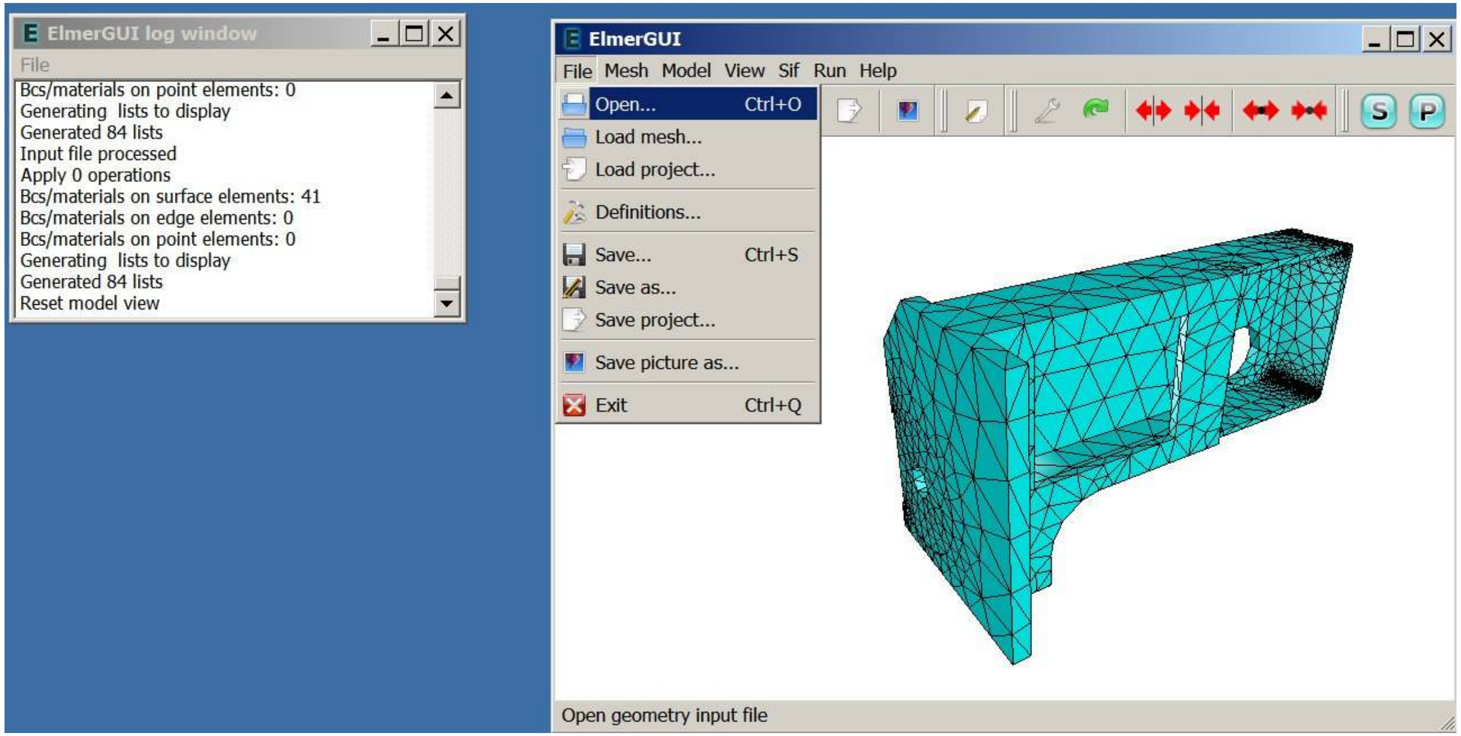
CREAZIONE MESH

UTILIZZANDO ELMER

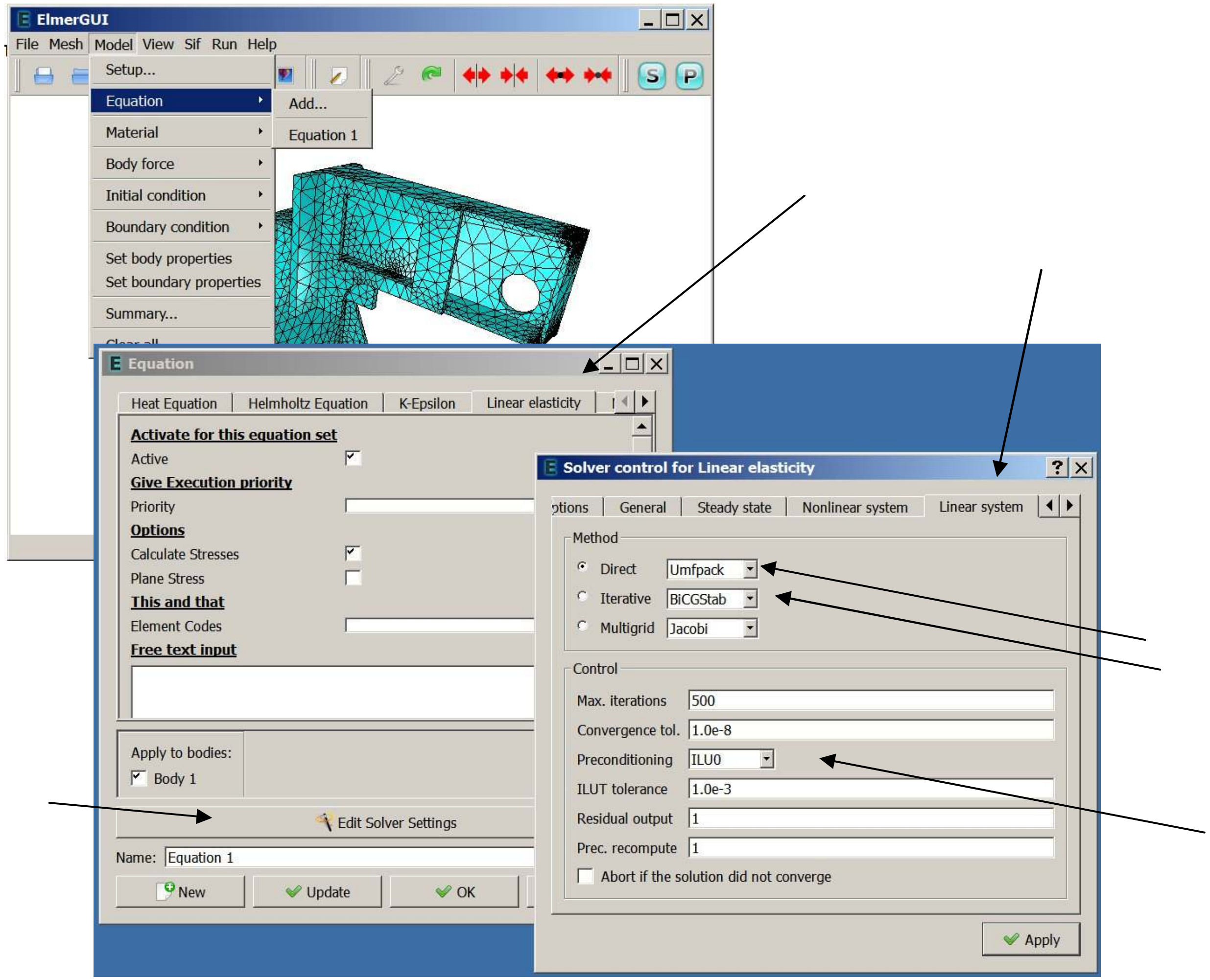
- PER PARTICOLARI SEMPLICI
- NO MULTI-NODY (NETGEN)

→

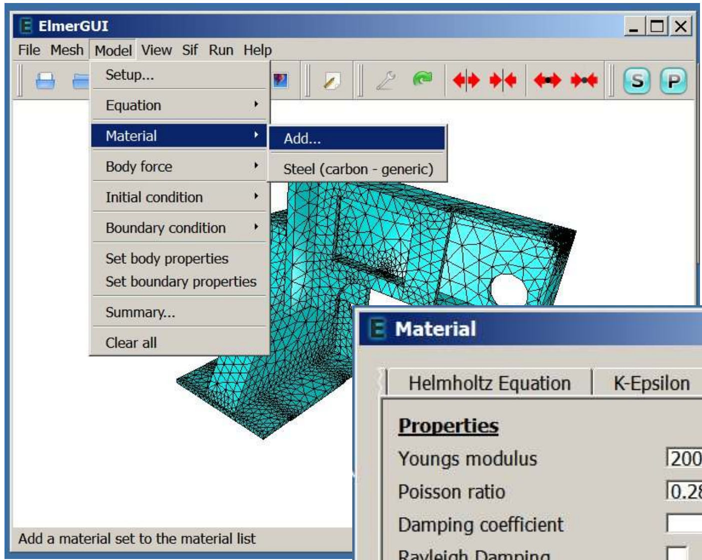
mesh.header
mesh.nodes
mesh.elements
mesh.boundary



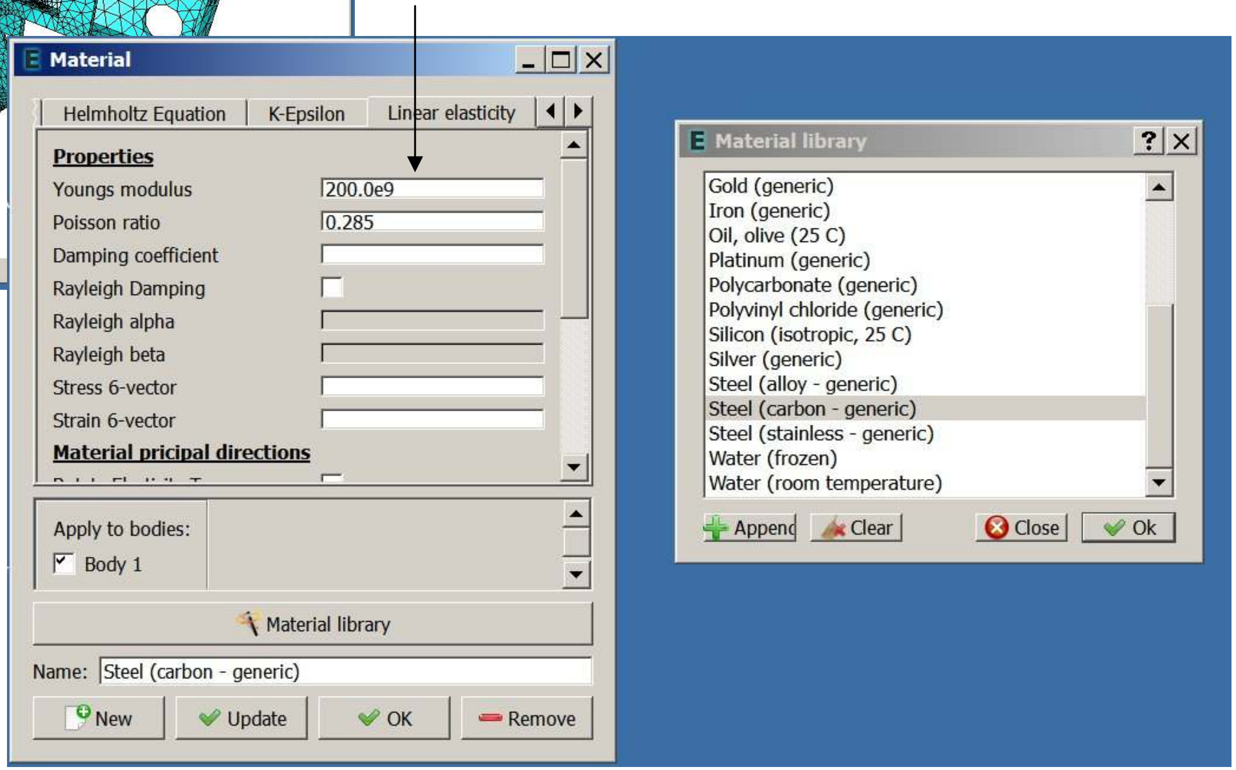
IMPOSTARE LE EQUAZIONI



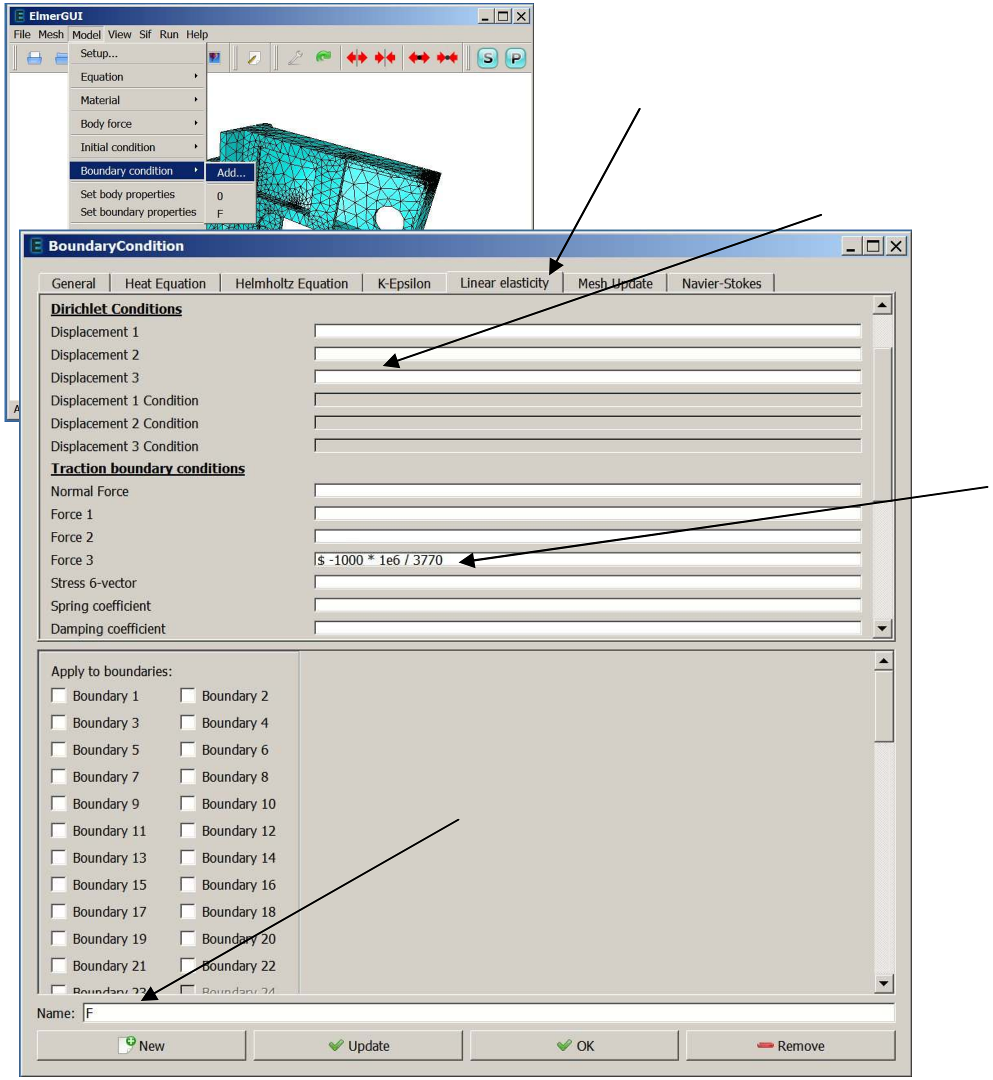
IMPOSTARE IL MATERIALE



- MODULO YOUNG = 200.0e9 Pa (Pa=N/m2)



IMPOSTARE I VINCOLI E LE FORZE

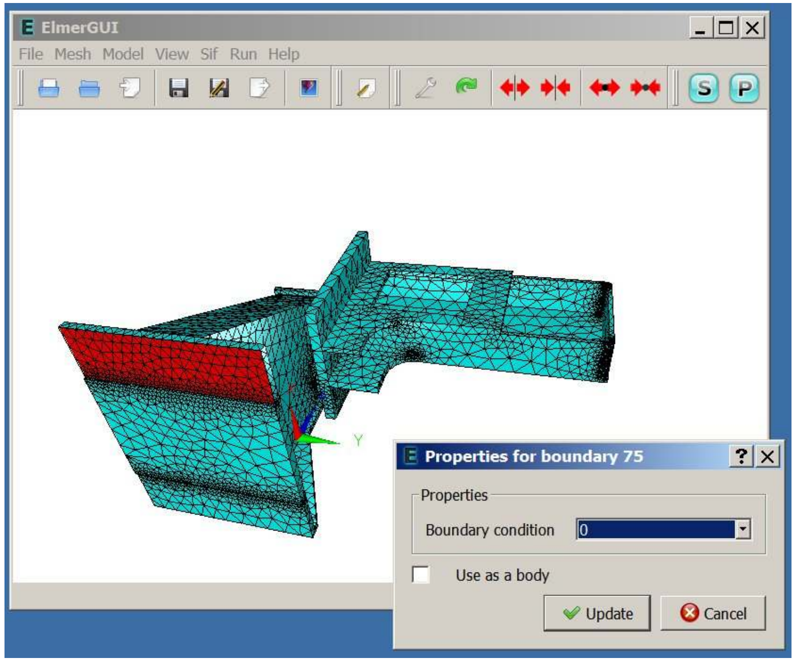


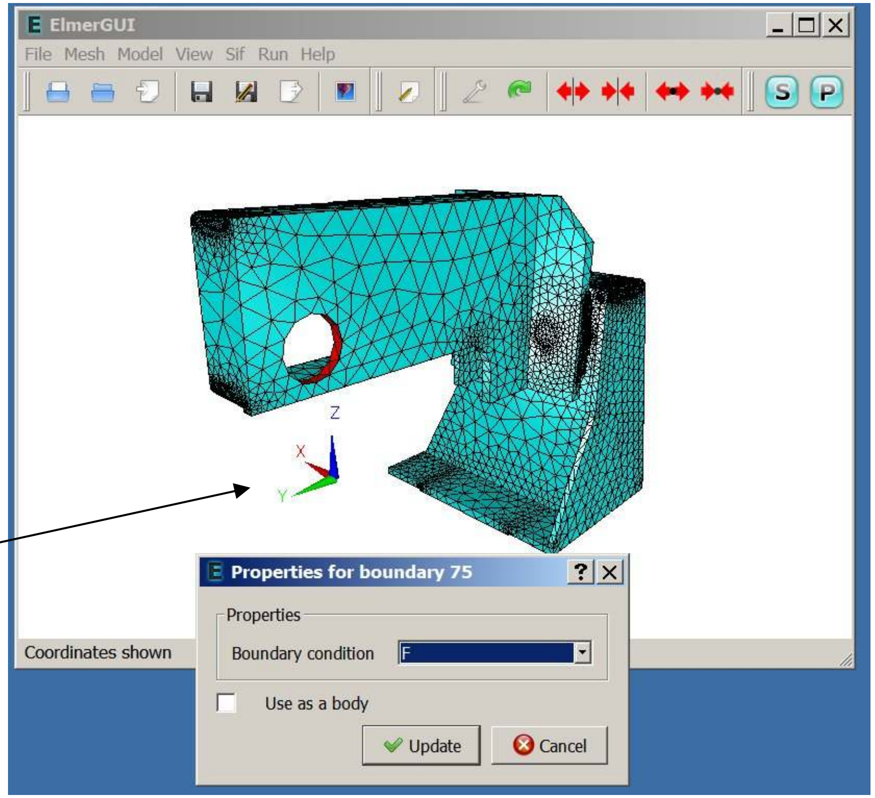
Creare prima i vincoli e le forze poi applicarli alle superfici

Forza su una superficie
Force 3 = $ F * 1e6 / A

F=1000N

ASSEGNARE I VINCOLI E LE FORZE





LA TERNA DEGLI ASSI

IMPOSTARE IL FILE DEI COMANDI (SIF = SOLVER INPUT FILE)

```
Header
CHECK KEYWORDS Warn
Mesh DB "." "."
Include Path ""
Results Directory ""
End

Simulation
Max Output Level = 4
Coordinate System = Cartesian
Coordinate Mapping(3) = 1 2 3
Simulation Type = Steady state
Steady State Max Iterations = 1
Output Intervals = 1
Timestepping Method = BDF
BDF Order = 1
Solver Input File = case.sif
Post File = case.ep
End

Constants
Gravity(4) = 0 -1 0 9.82
Stefan Boltzmann = 5.67e-08
Permittivity of Vacuum = 8.8542e-12
Boltzmann Constant = 1.3807e-23
Unit Charge = 1.602e-19
End

Body 1
Target Bodies(1) = 1
Name = "Body 1"
Equation = 1
Material = 1
End

Solver 1
Equation = Linear elasticity
Procedure = "StressSolve" "StressSolver"
Variable = -dofs 3 Displacement
Exec Solver = Always
Stabilize = True
Bubbles = False
Lumped Mass Matrix = False
Optimize Bandwidth = True
Steady State Convergence Tolerance = 1.0e-5
Nonlinear System Convergence Tolerance = 1.0e-8
Nonlinear System Max Iterations = 20
Nonlinear System Newton After Iterations = 3
Nonlinear System Newton After Tolerance = 1.0e-3
Nonlinear System Relaxation Factor = 1
Linear System Solver = Direct
Linear System Direct Method = Umfpack
End

Equation 1
Name = "Equation 1"
Calculate Stresses = True
Active Solvers(1) = 1
End

Material 1
Name = "Steel (carbon - generic)"
Heat expansion Coefficient = 13.8e-6
Heat Conductivity = 44.8
Sound speed = 5100.0
Heat Capacity = 1265.0
Mesh Poisson ratio = 0.285
Density = 7850.0
Poisson ratio = 0.285
Youngs modulus = 200.0e9
End

Boundary Condition 1
Target Boundaries(1) = 24
Name = "0"
Displacement 3 = 0
Displacement 2 = 0
Displacement 1 = 0
End

Boundary Condition 2
Target Boundaries(1) = 75
Name = "F"
Force 3 = $ -1000 * 1e6 / 3770
End

Boundary Condition 3
Target Boundaries(1) = 86
Name = "0"
Displacement 3 = 0
Displacement 2 = 0
Displacement 1 = 0
End
```

PERSONALIZZARE IL SOLUTORE

MATC contd.

- simple numerical evaluation:

```
Viscosity Exponent = Real MATC "1.0/3.0"
```
or
```
Viscosity Exponent = Real $1.0/3.0
```

- as a function dependent on a variable:

```
Heat Capacity = Variable Temperature
Real MATC "2.1275D03 + 7.253D00*(tx - 273.16)"
```

- as a function of multiple variables:

```
Temp = Variable Latitude, Coordinate 3
Real MATC "49.13 + 273.16 - 0.7576 * tx(0) - 7.992E-03 * tx(1)"
```

- as function defined before header:

```
$ function stemp(X) { _stemp = 49.13 + 273.16 - 0.7576*X(0)
                                          - 7.992E-03*X(1) }
```

```
Temp = Variable Latitude, Coordinate 3
Real MATC "stemp(tx)"
```

PERSONALIZZARE IL SOLUTORE

User Defined Functions

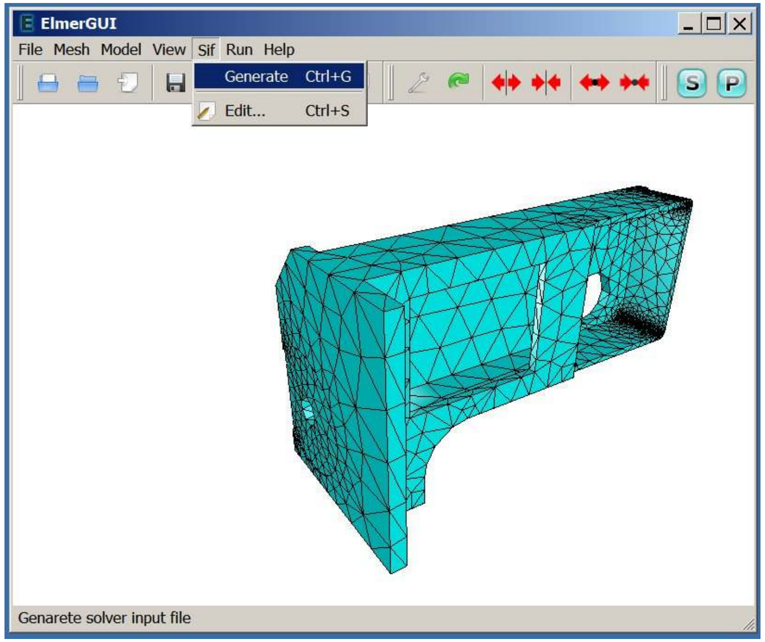
Example: $\rho(T(^{\circ}C)) = 1000 \cdot [1 - 10^{-4} \cdot (T - 273.0)]$

```
FUNCTION getdensity( Model, n, T ) RESULT(dens)
USE DefUtils
IMPLICIT None
 TYPE(Model_t) ::  Model

 INTEGER ::  n

 REAL(KIND=dp) ::  T, dens

 dens = 1000*(1-1.0d-4(T-273.0d0))

END FUNCTION getdensity
```

compile: `elmerf90 mydensity.f90 -o mydensity`

SIF:
```
Density = Variable Temperature
Procedure "mydensity" "getdensity"
```

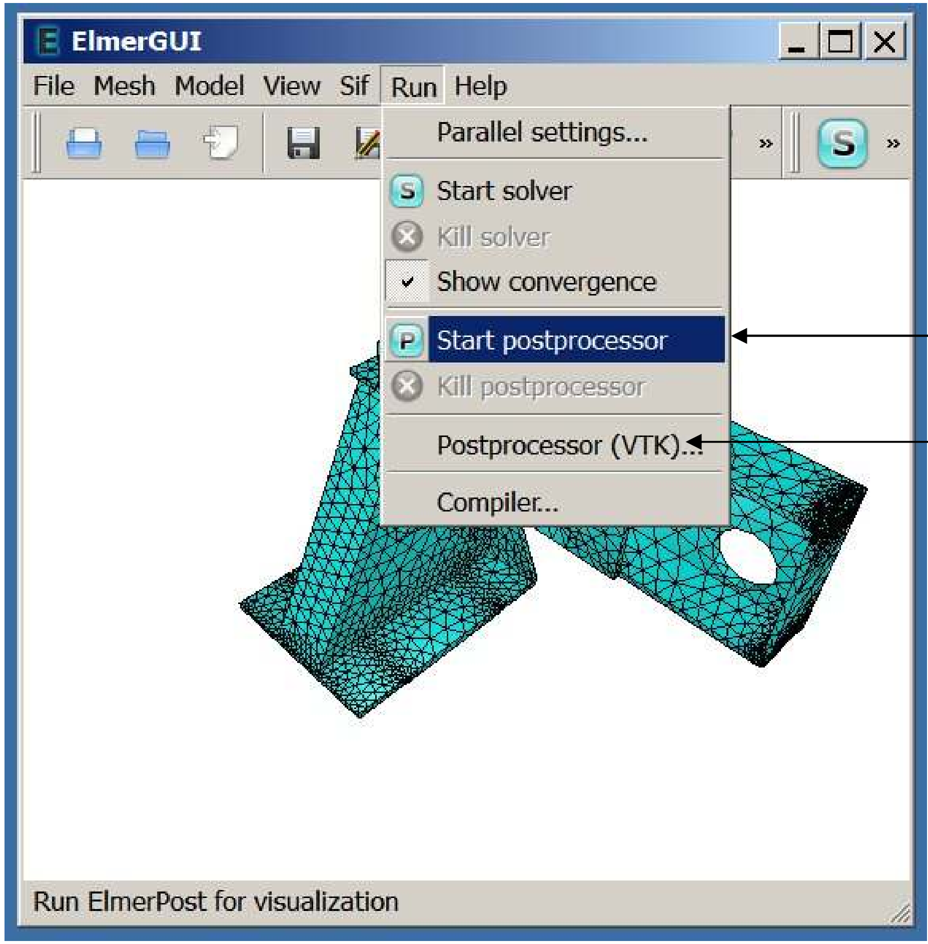
GENERARE IL FILE DEI COMANDI (SIF)



1. SIF\GENERATE
2. FILE\SAVE PROJECT
3. RUN\STAR SOLVER

ElmerSolver: *** Elmer Solver: ALL DONE ***
ElmerSolver: The end
SOLVER TOTAL TIME(CPU,REAL): 87.83 87.83
ELMER SOLVER FINISHED AT: 2011/01/03 17:21:11

POST-PROCESSORE

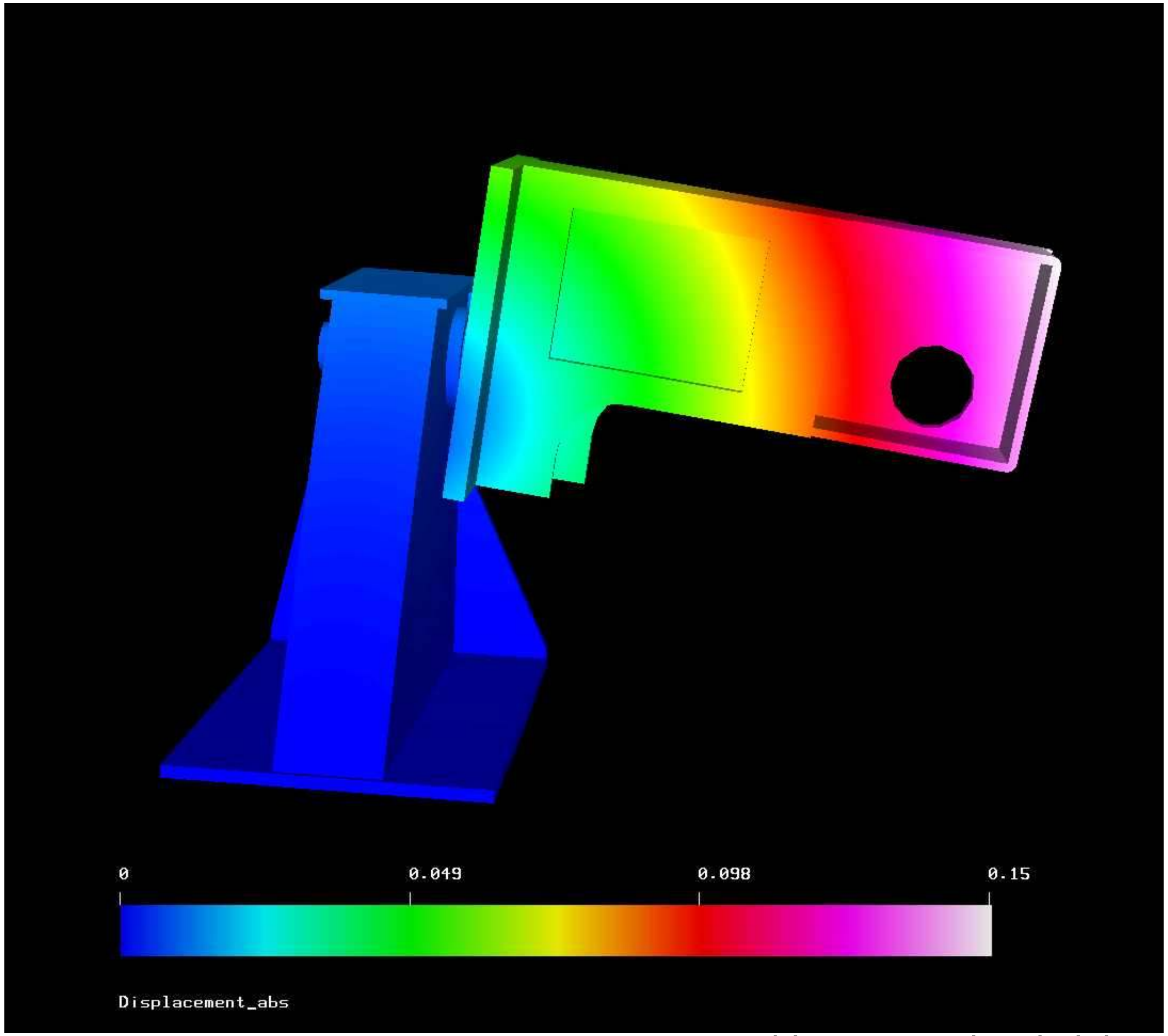


DUE POST-PROCESSORI

- TENSIONI
- VON MISES
- SPOSTAMENTI
- ANIMAZIONI

TENSIONI ALL'INTERNO DELLA STRUTTURA

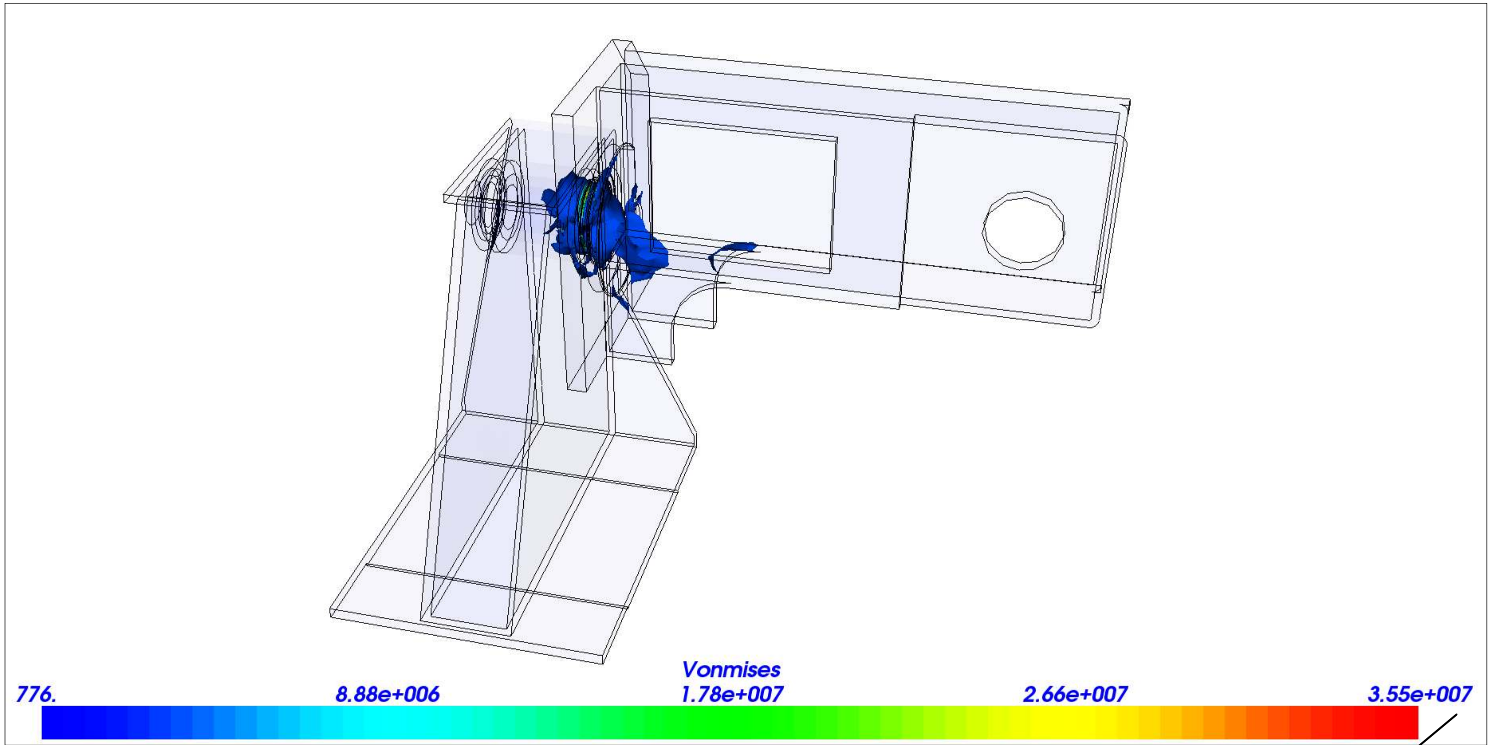
POST-PROCESSORE



ANALISI SPOSTAMENTI

SPOSTAMENTO TOTALE = 0.15 mm

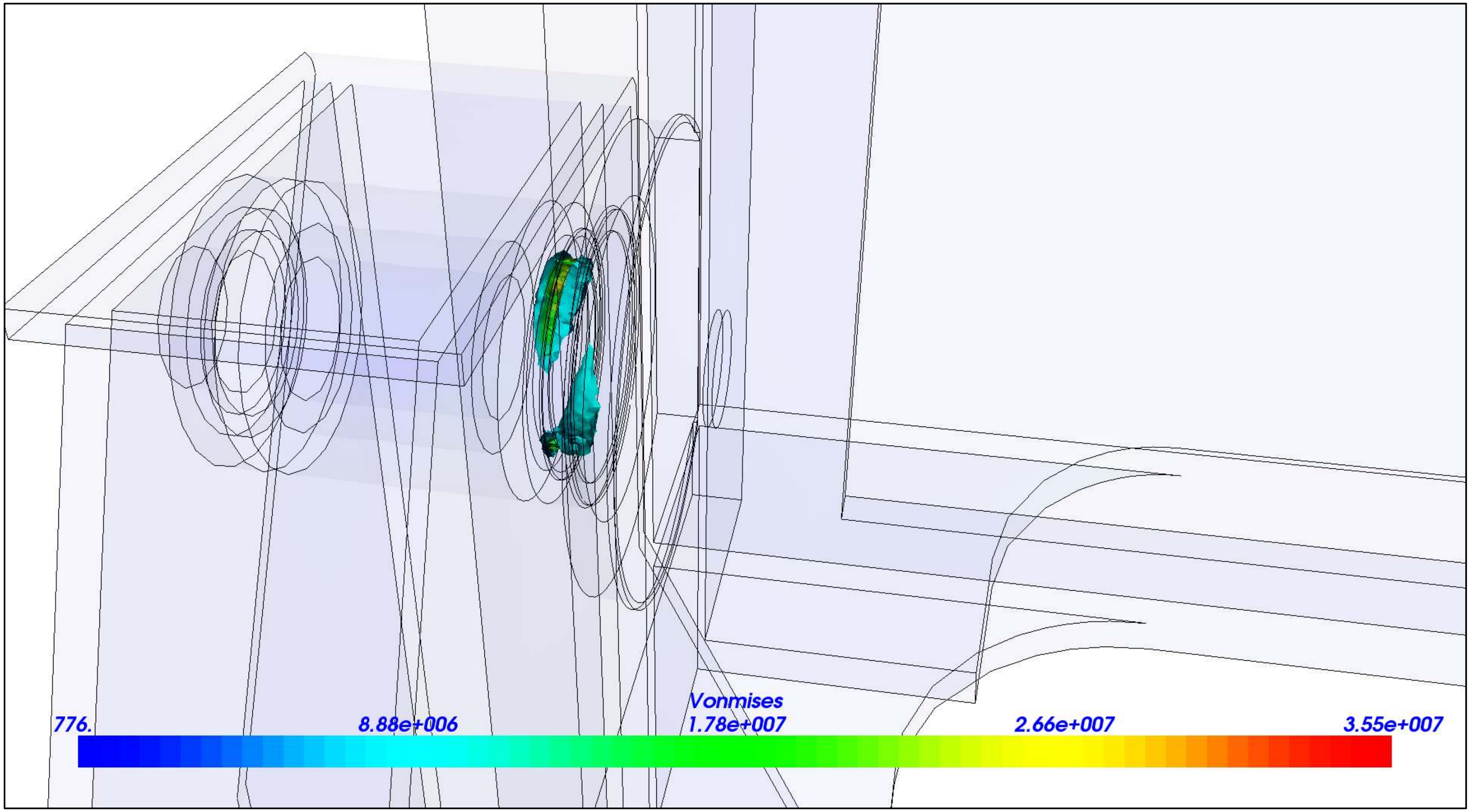
POST-PROCESSORE - VTK



ANALISI TENSIONI

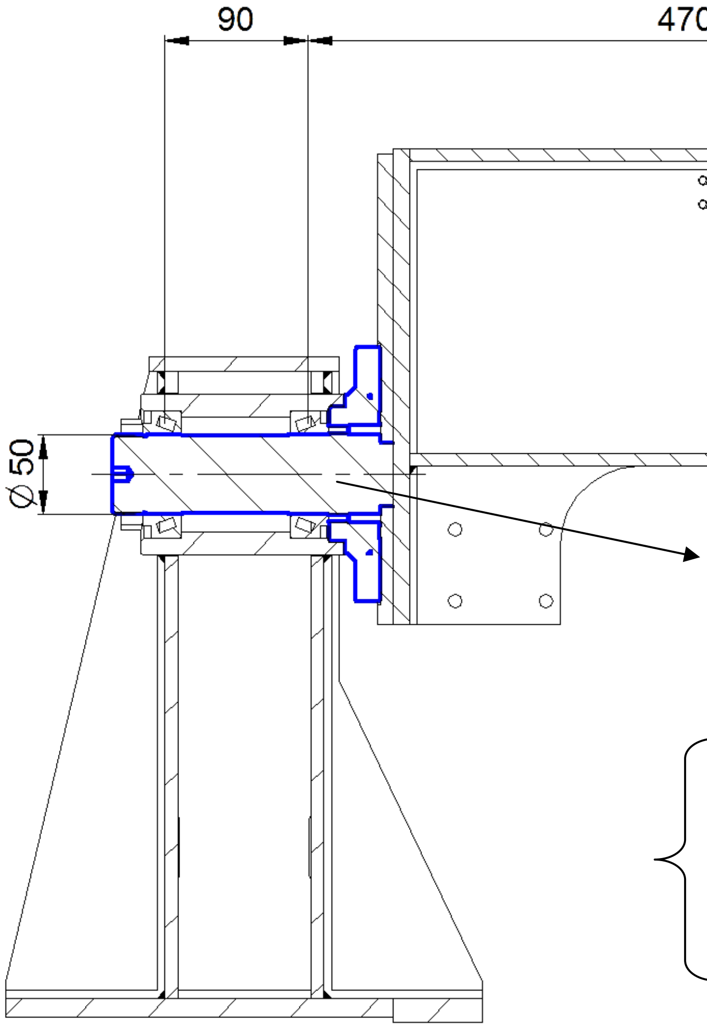
- 3.5e7 Pa = 35 MPa
- TENSIONE DI SNERVAMENTO ACCIAIO DA COSTRUZIONE S235 = 235 MPa

POST-PROCESSORE - VTK



CAMBIANDO IL MINIMO DA 776 A 1e7 SI EVIDENZIA LA ZONA CRITICA

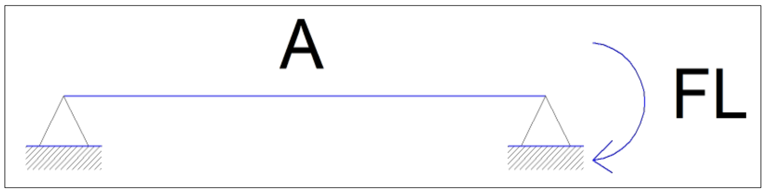
CALCOLO MANUALE



ABBASSAMENTO DOVUTO **SOLAMENTE** ALLA FLESSIONE DEL PERNO

$$F = 1000N$$

$$I_{d=50} = \frac{\pi}{64} d^4 = 306640 mm^4$$

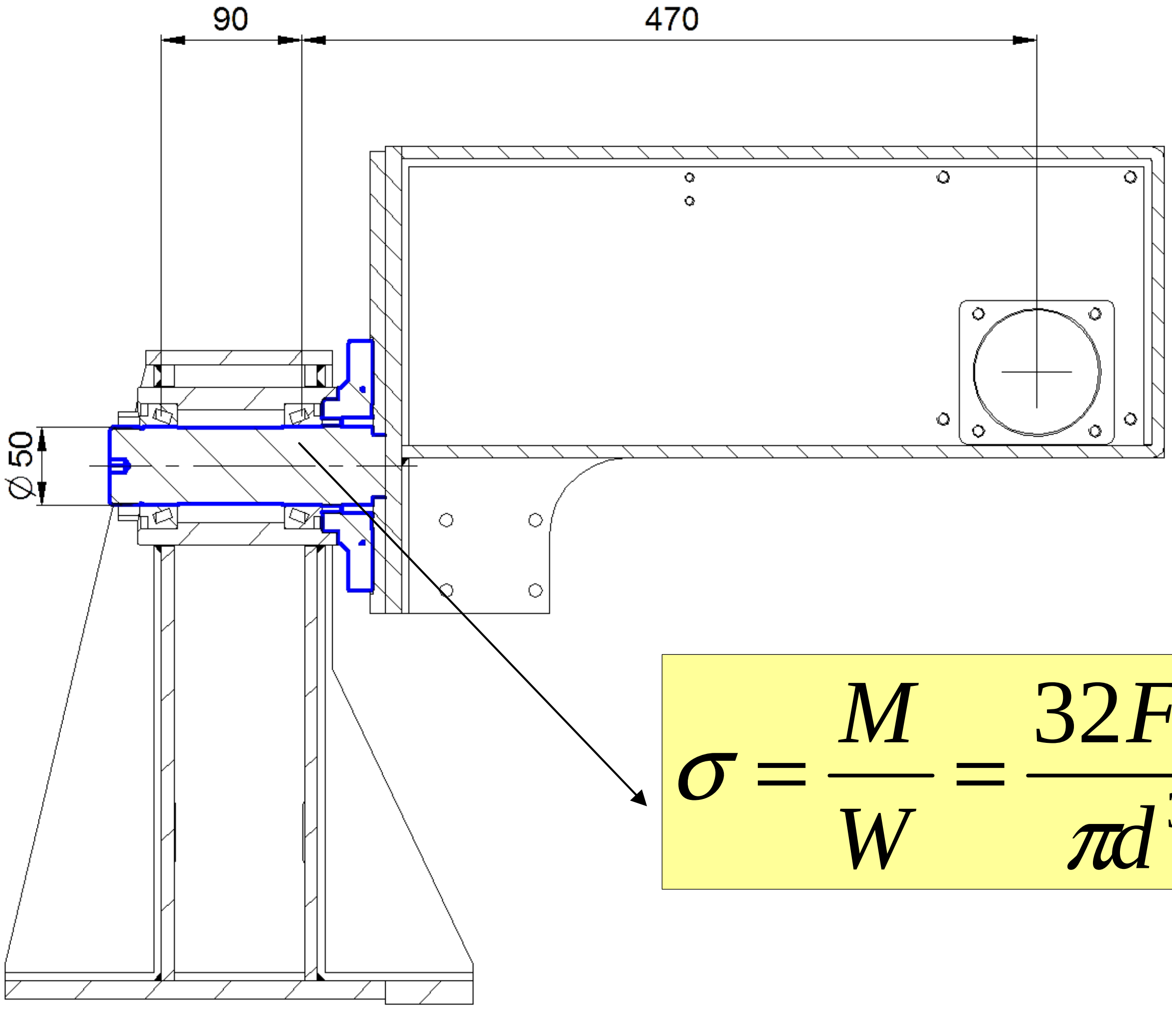


$$\begin{cases} f = \varphi L \\ \varphi = \dfrac{MA}{3EI} \\ M = FL \end{cases}$$

$$f = \frac{FAL^2}{3EI} = 0{,}11 mm$$

$$\varphi = 0.00023 \ rad \leq 0.0005 \ rad \ (rulli\_conici)$$

CALCOLO MANUALE

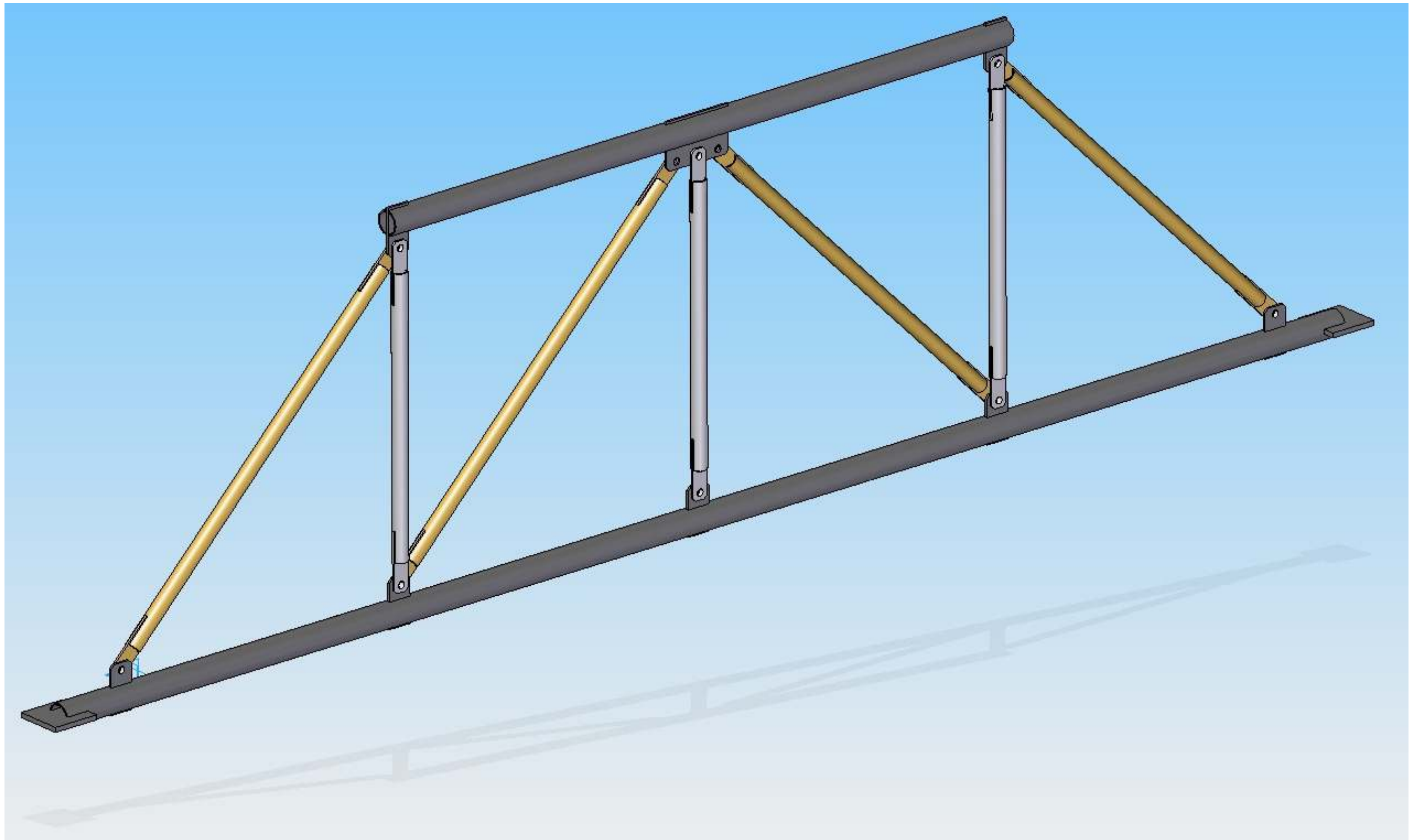


TENSIONE MASSIMA DI FLESSIONE NELLA SEZIONE DEL CUSCINETTO

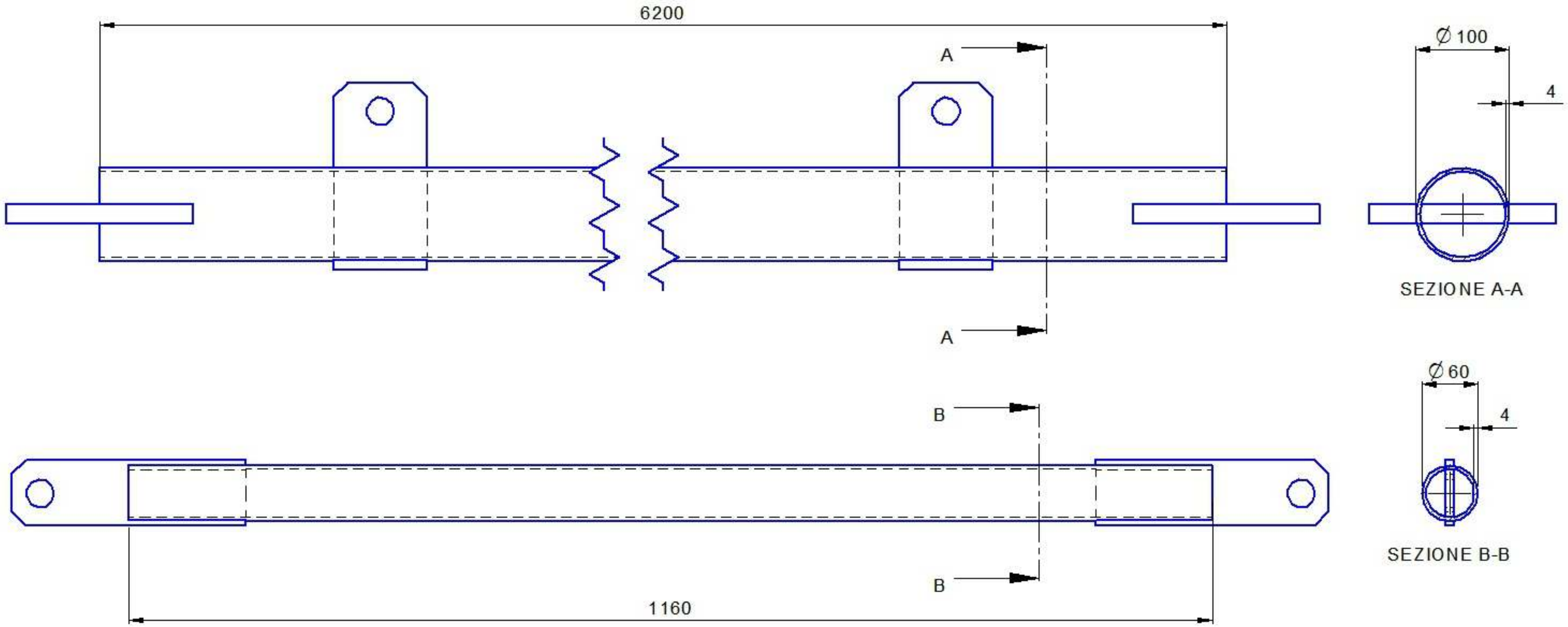
$$\sigma = \frac{M}{W} = \frac{32FL}{\pi d^3} = 38MPa$$

2/5 ANALISI STRUTTUALE LINEARE

- Riduzione/semplificiazione di una struttura realizzata con cad 3d Solid Edge
- **Solo** per calcolo degli spostamenti e deformazioni.

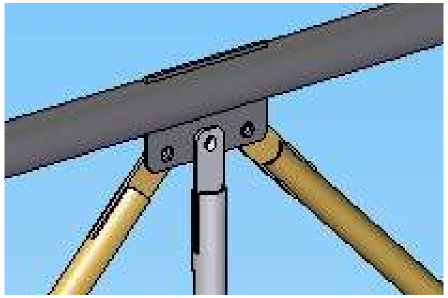


SEMPLIFICAZIONE GEOMETRIA



STRUTTURA FORMATA DA TUBOLARI E PIATTI SALDATI, FORI E RACCORDI. DIFFICILE REALIZZARE LA MESH

SEMPLIFICAZIONE GEOMETRIA



SI PRESENTANO DUE TIPI DI
COLLEGAMENTO DA MODELLARE

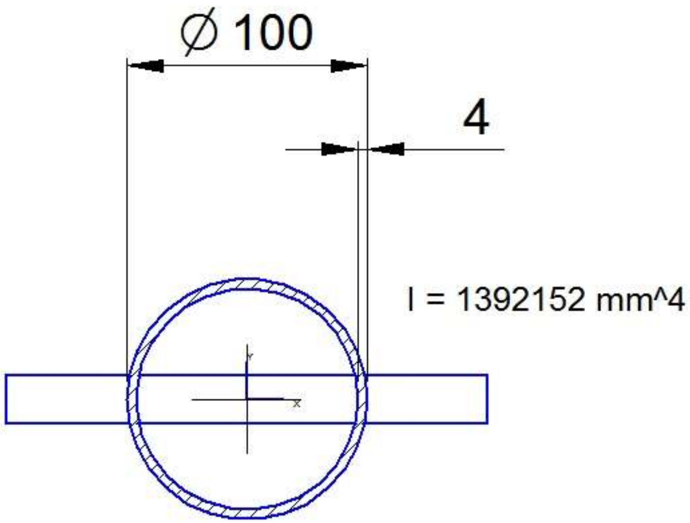
COLLEGAMENTI CON CERNIERA
LE ASTE SONO CARICATE SOLO ASSIALMENTE
(STRUTTURA ISOSTATICA)

LA SEZIONE EQUIVALENTE HA LA STESSA AREA

COLLEGAMENTI IMBULLONATI O SALDATI
LE ASTE SONO SOTTOPOSTE A SFORZO NORMALE E MOMENTO FLETTENTE
(STRUTTURA IPERSTATICA)

LA SEZIONE EQUIVALENTE HA LO STESSO MOMENTO D’INERZIA

SEMPLIFICAZIONE GEOMETRIA



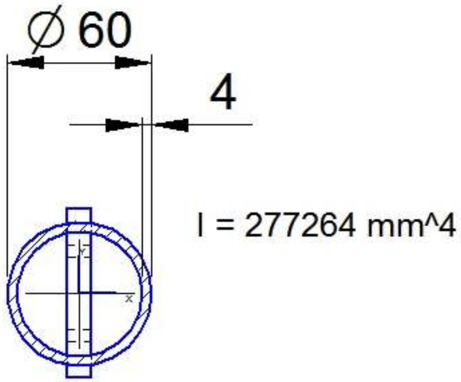
SI SOSTITUISCE LA SEZIONE TUBOLARE
CON UNA QUADRATA PIENA

$$I = \frac{l^4}{12}$$

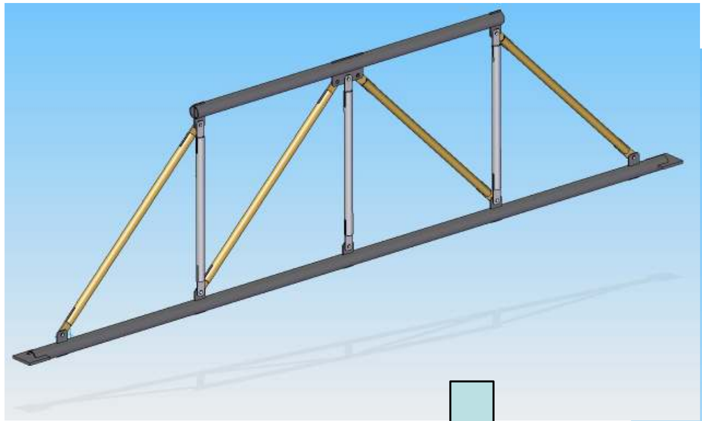
MOMENTO D'INERZIA FLESSIONALE

$$l_1 = (12 \cdot 1392151)^{0.25} = 63{,}93\,mm$$

$$l_2 = (12 \cdot 277264)^{0.25} = 42{,}71\,mm$$



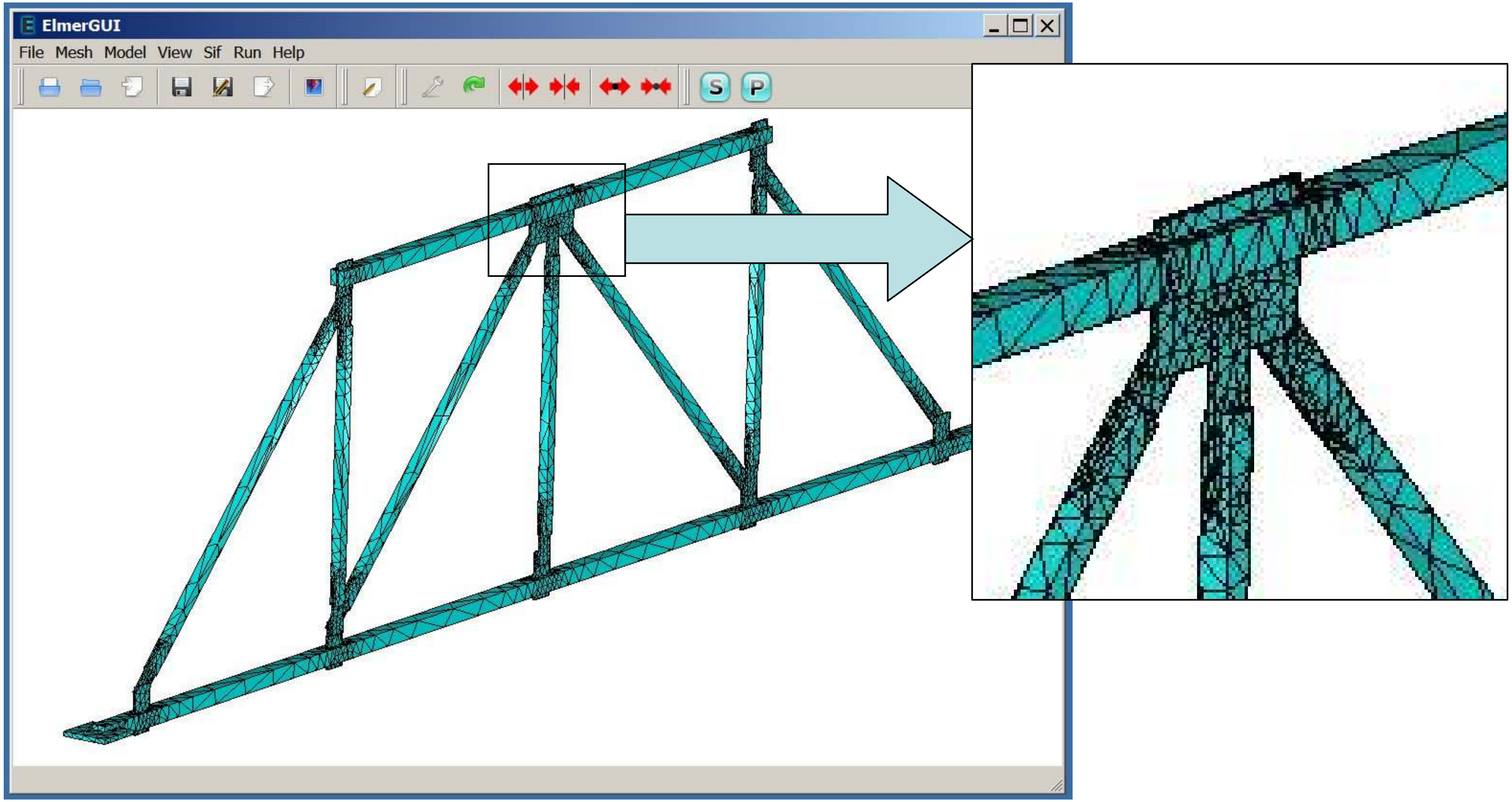
SEMPLIFICAZIONE GEOMETRIA



STRUTTURA SEMPLICE PER LA MESHATURA AUTOMATICA

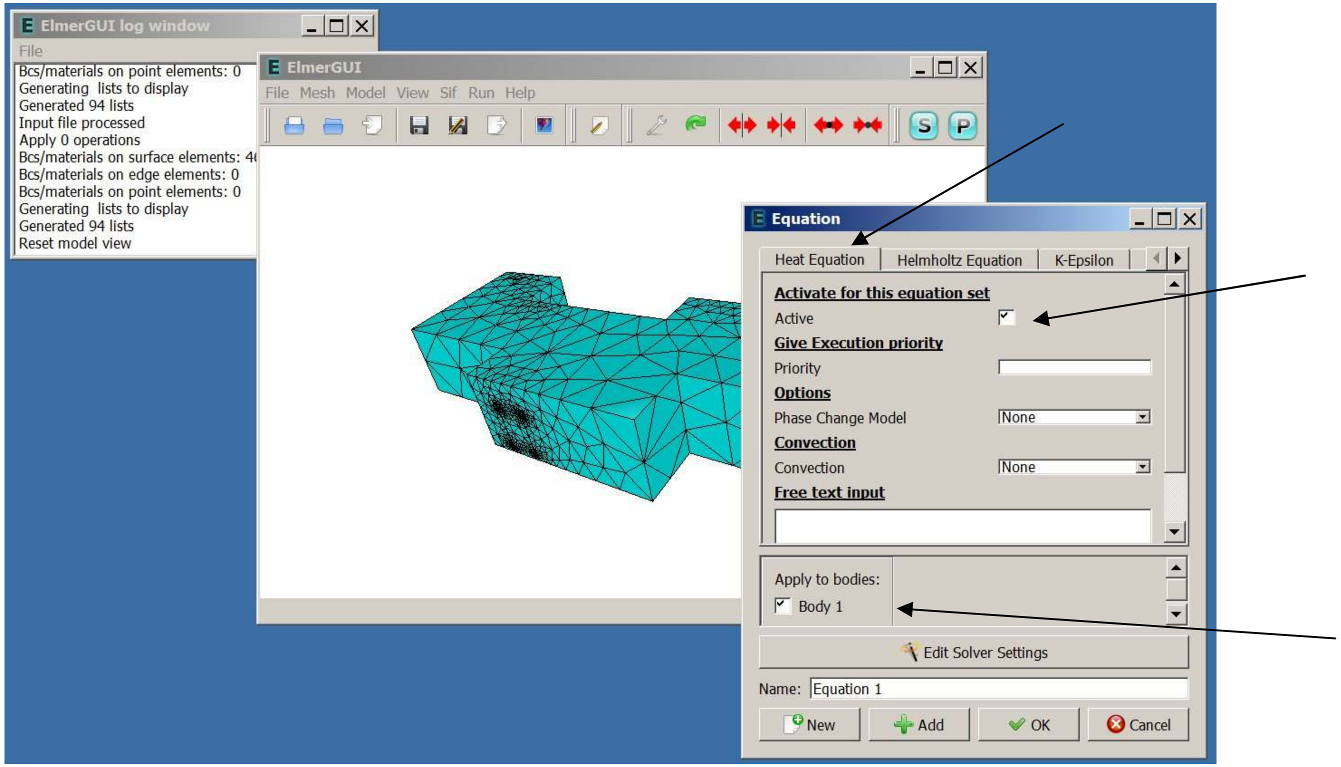
STESSA FLESSIONE DELLA STRUTTURA REALE

CREAZIONE MESH



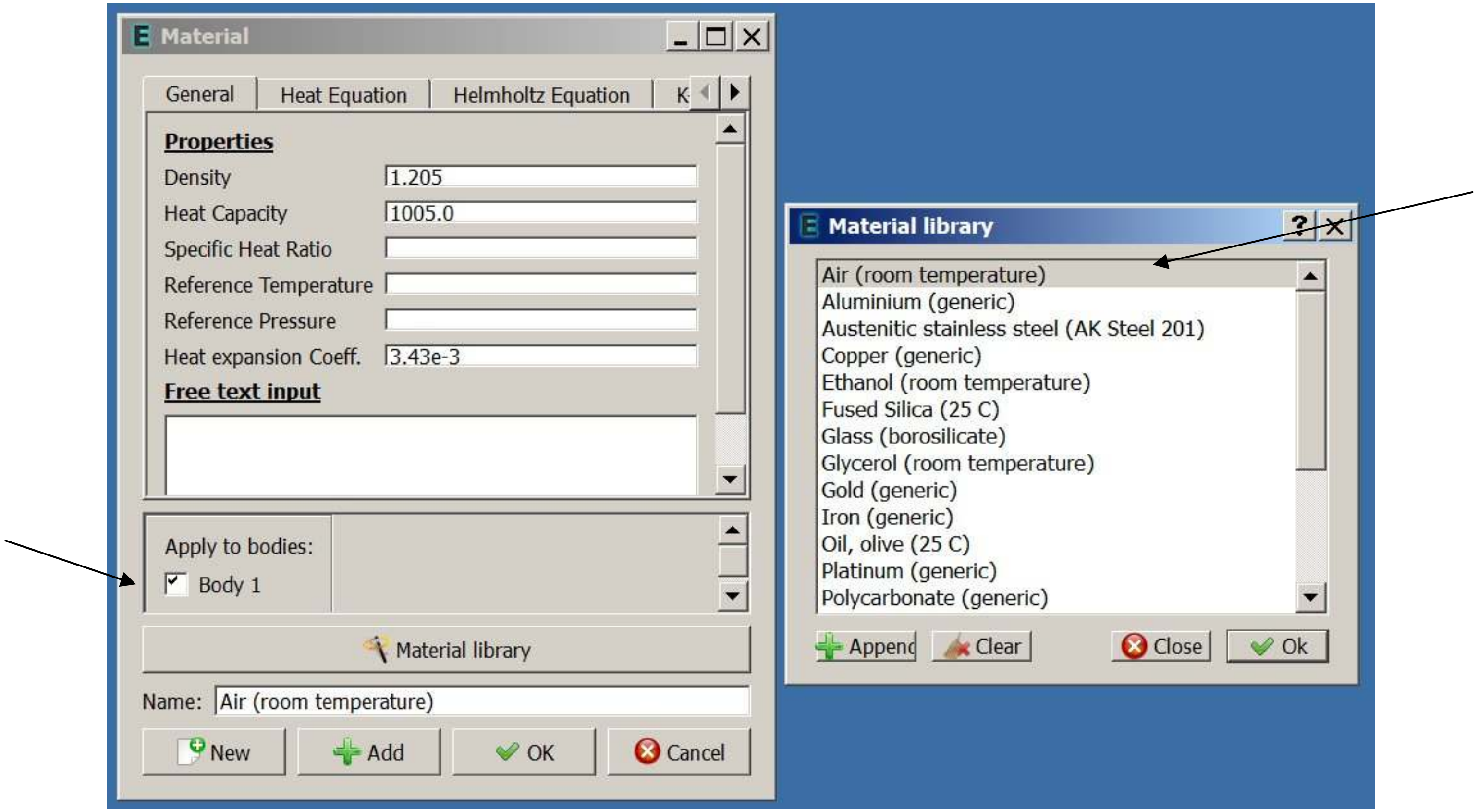
3/5 DISTRIBUZIONE TEMPERATURA

COME SI DISTRIBUISCE LA TEMPERATURA NELL'ARIA ALL'INTERNO DI UNA STANZA CON RISCALDAMENTO A PAVIMENTO

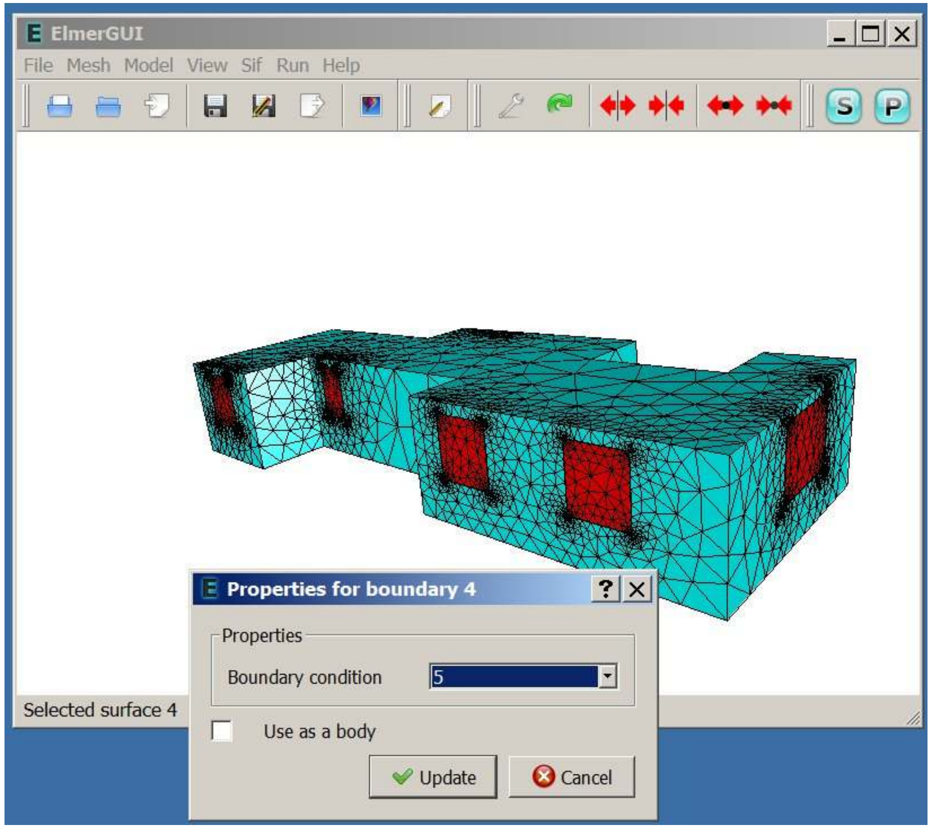


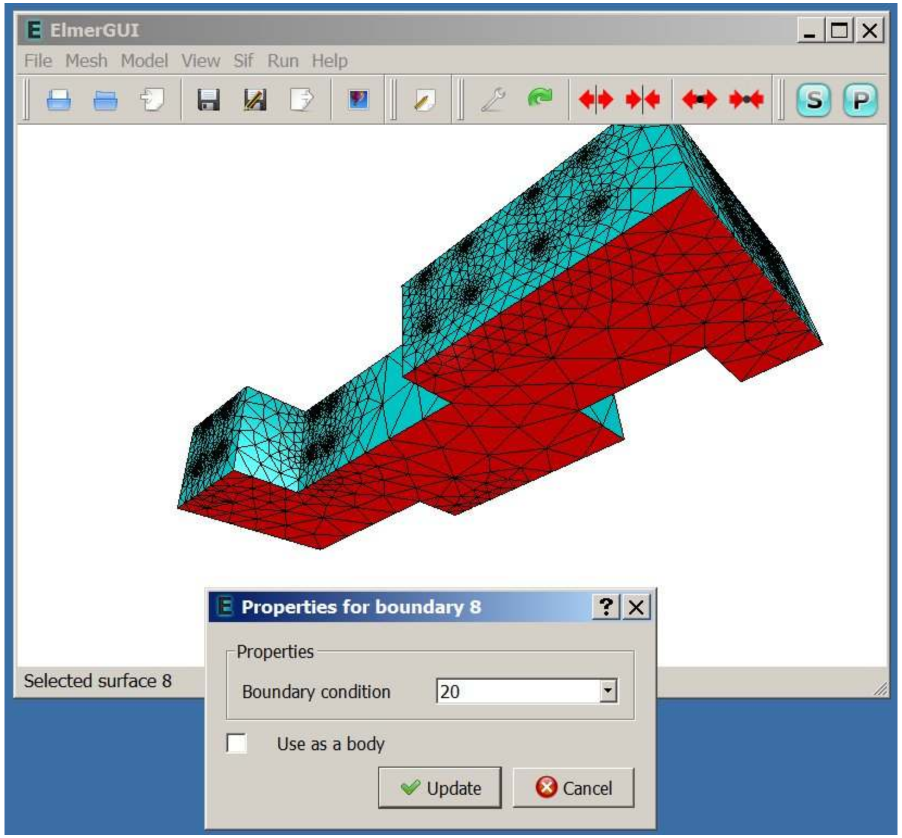
IMPOSTARE IL MATERIALE

- SI CONSIDERA L'ARIA ALL'INTERNO DELLA STANZA



ASSEGNARE I VINCOLI



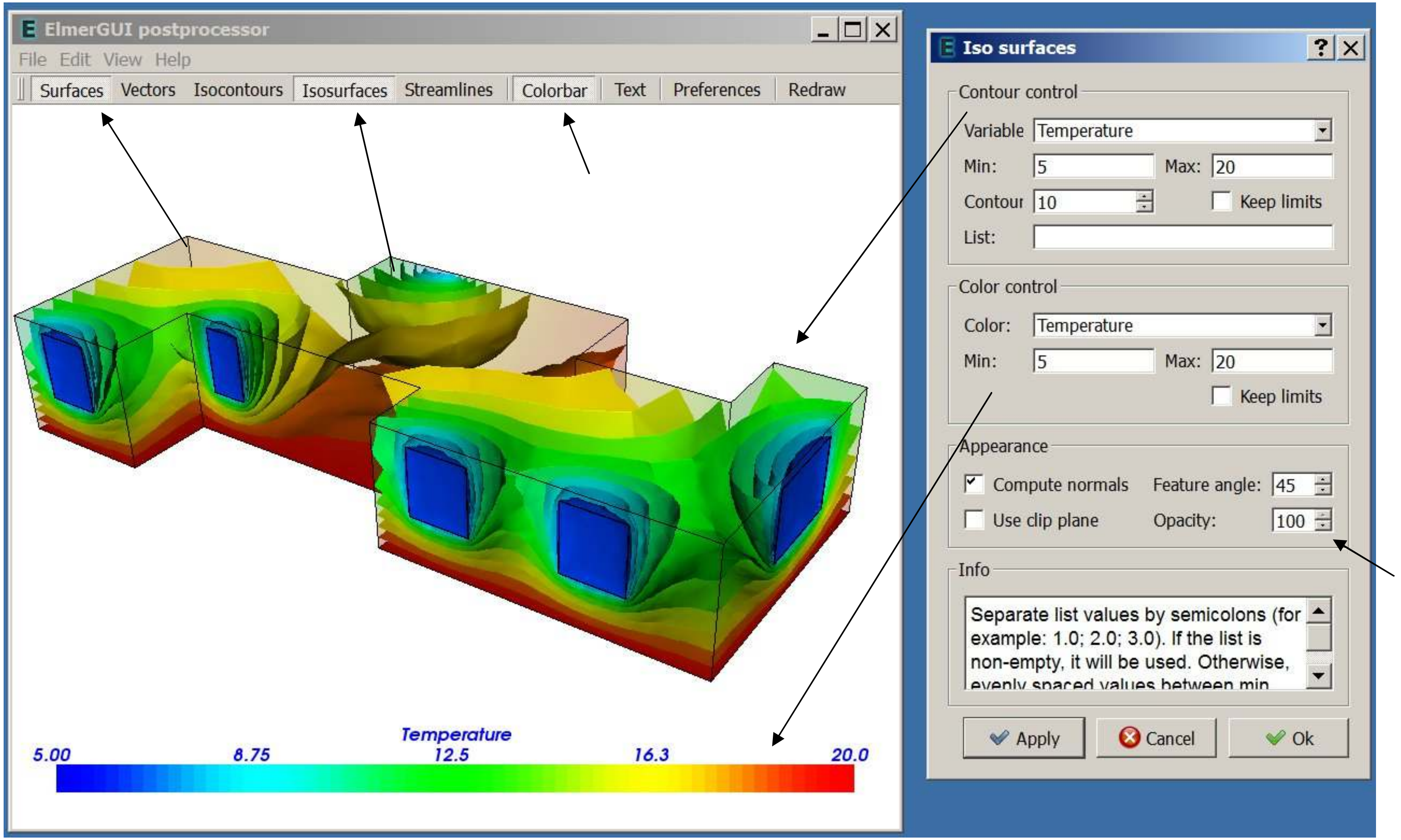


GENERARE IL FILE DEI COMANDI (SIF)

1. SIF\GENERATE
2. FILE\SAVE PROJECT
3. RUN\STAR SOLVER

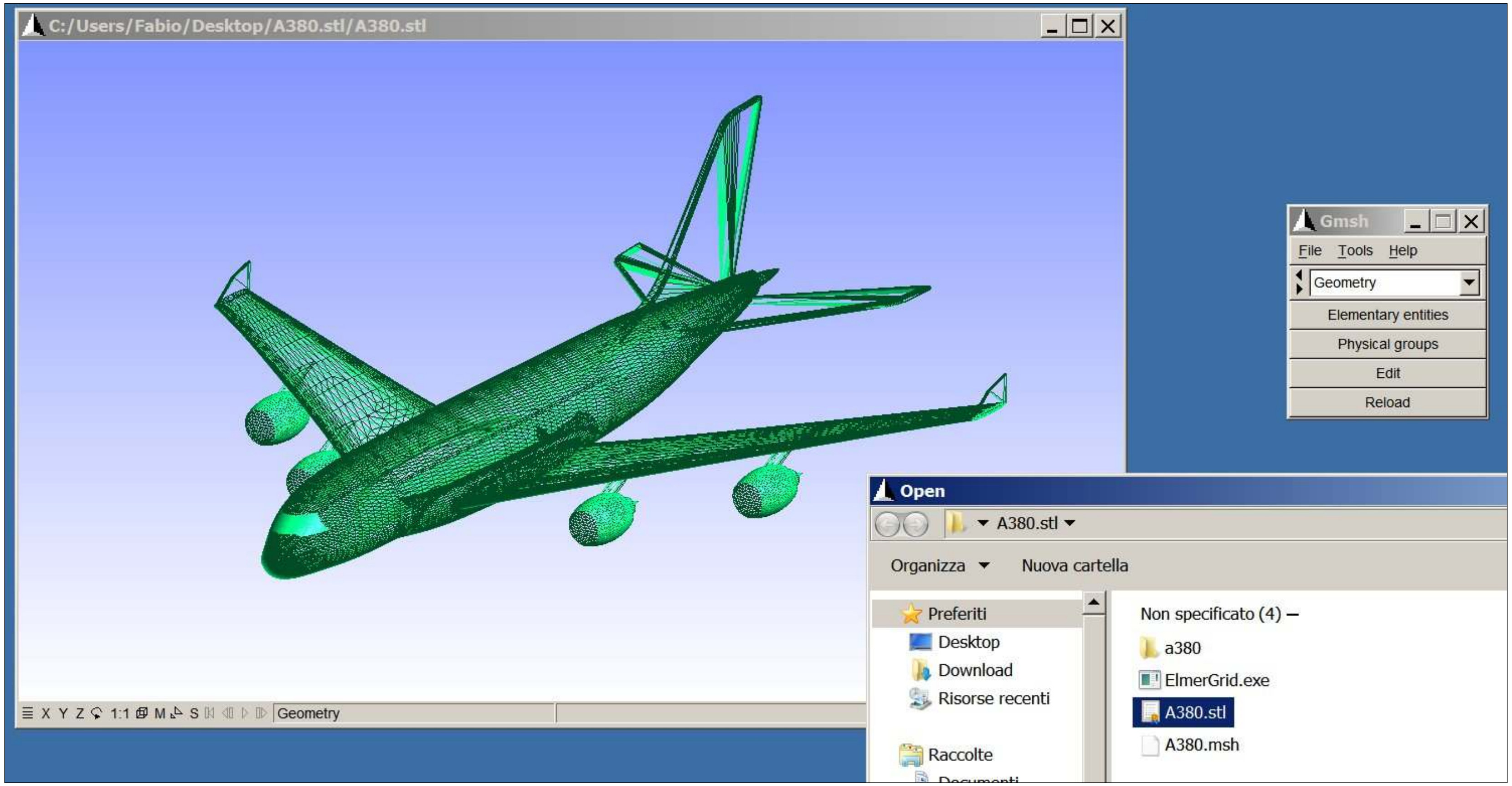
ElmerSolver: *** Elmer Solver: ALL DONE ***
ElmerSolver: The end
SOLVER TOTAL TIME(CPU,REAL): 87.83 87.83
ELMER SOLVER FINISHED AT: 2011/01/03 17:21:11

POST-PROCESSORE VTK



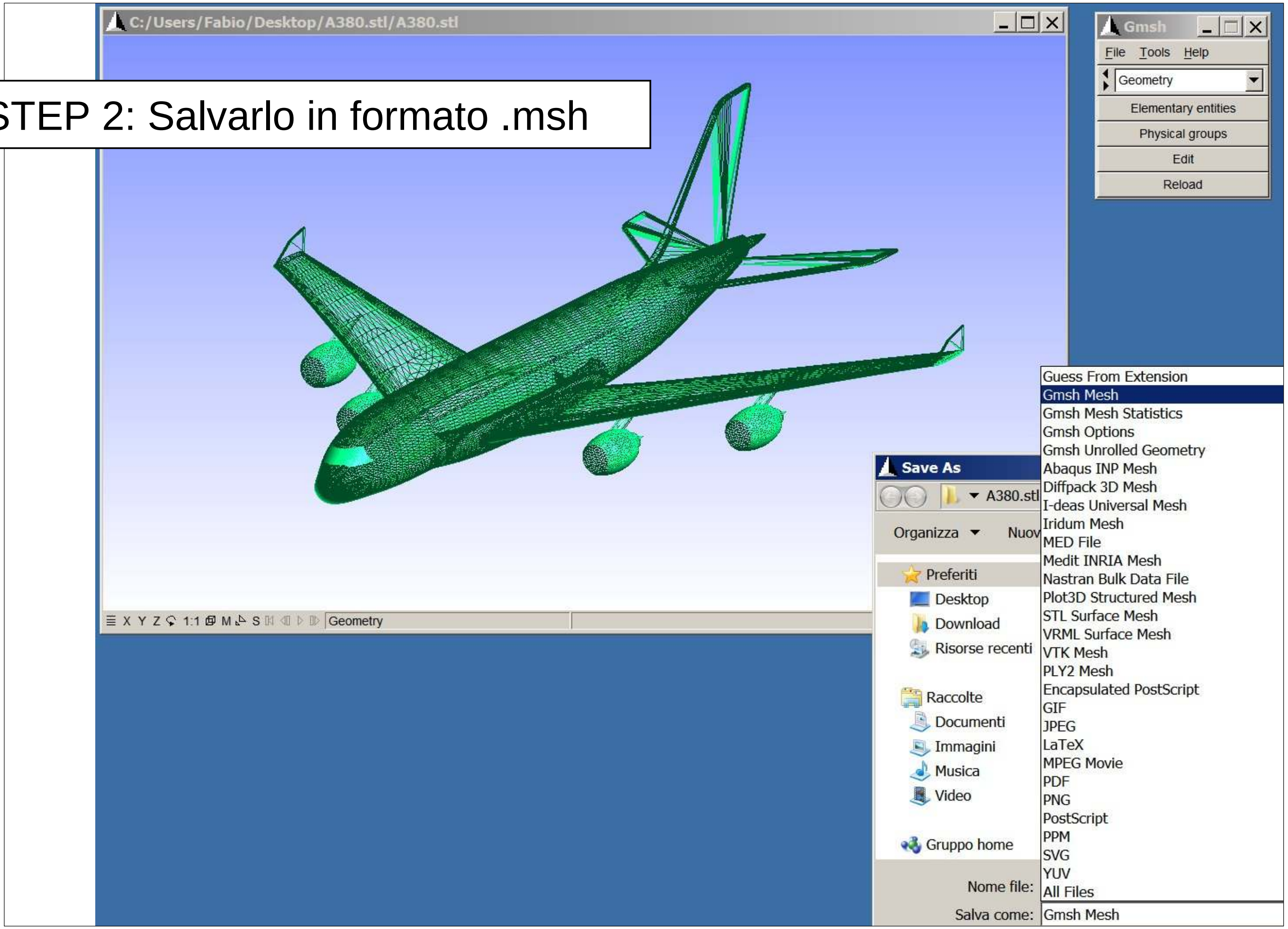
4/5 IMPORTARE MODELLI IN FORMATO STL

STEP 1: Importare il modello in formato STL nel programma GMSH 2.5.0 (per Windows)



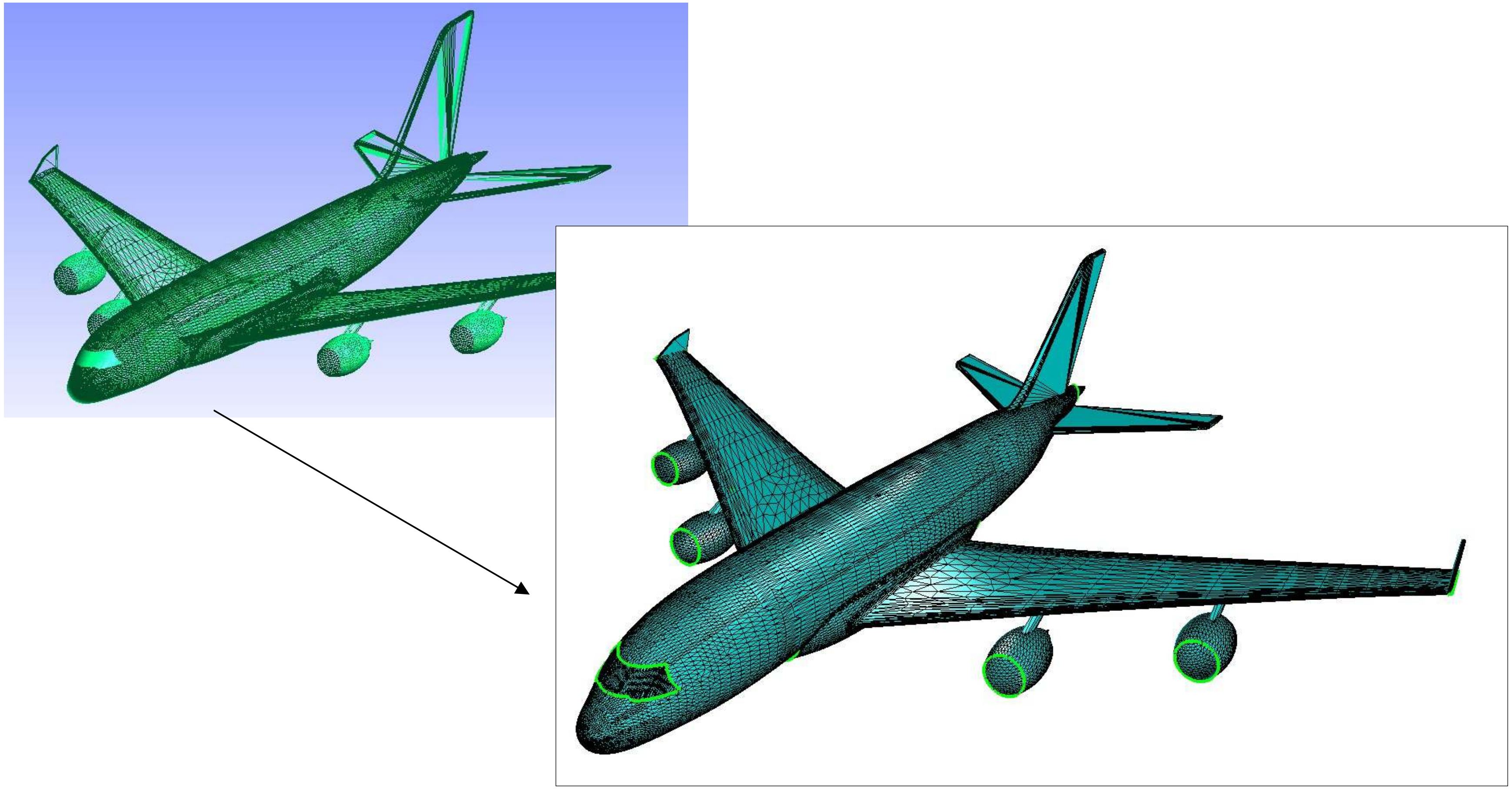
IMPORTARE MODELLI IN FORMATO STL

STEP 2: Salvarlo in formato .msh

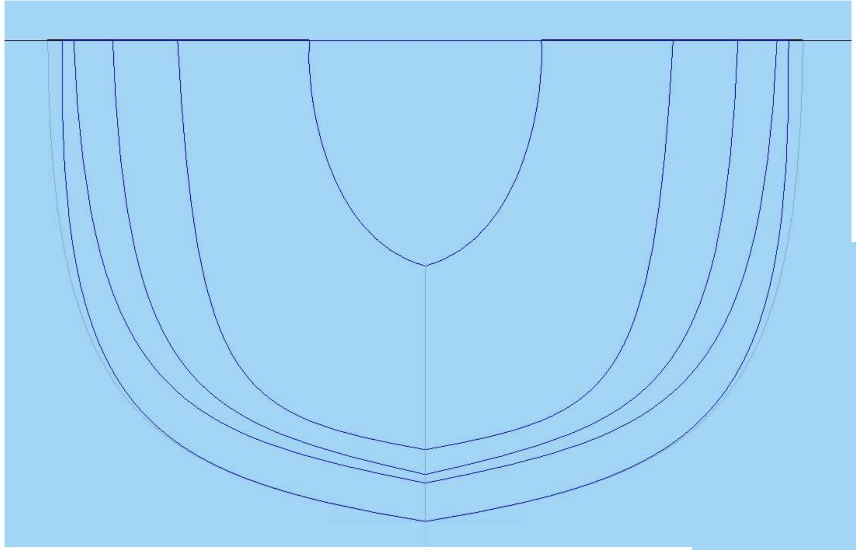


IMPORTARE MODELLI IN FORMATO STL

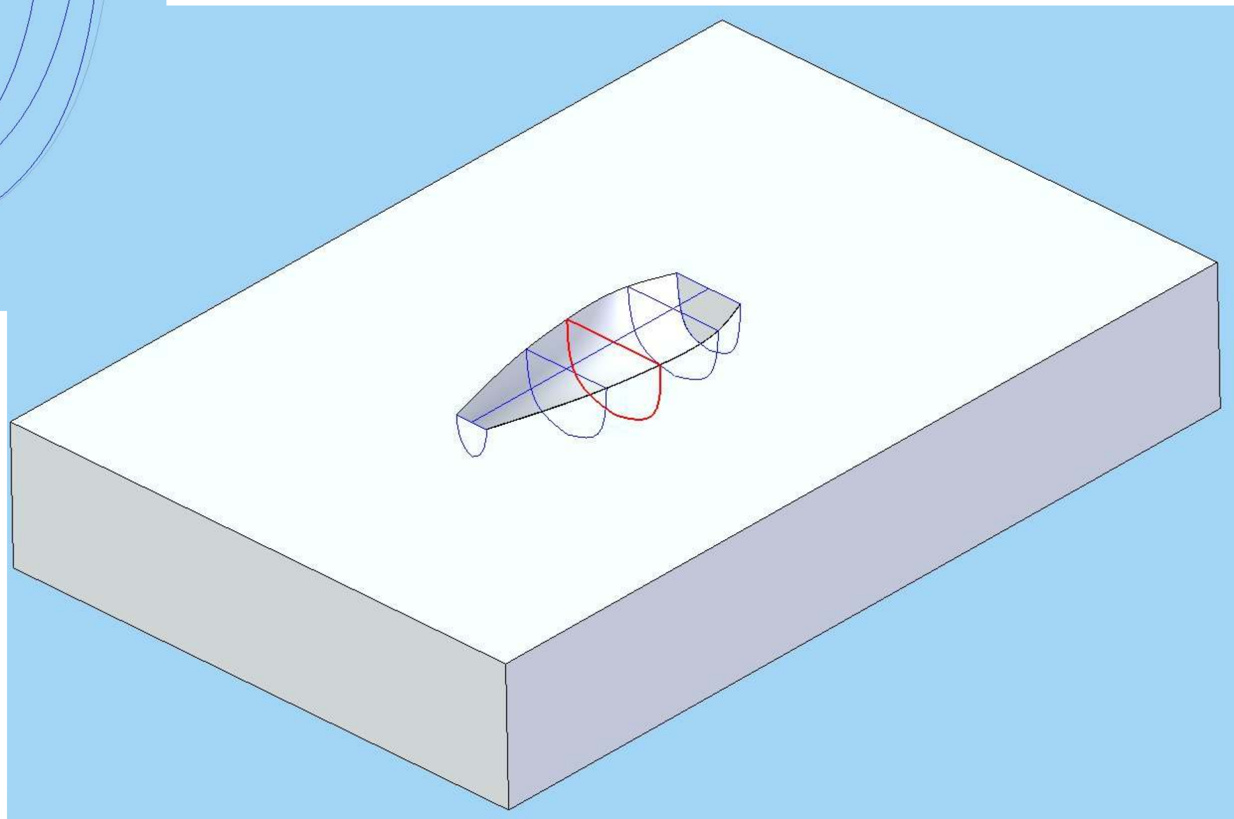
STEP 6: Aprire il modello con ELMER



5/5 FLUIDODINAMICA – NAVIER STOKES

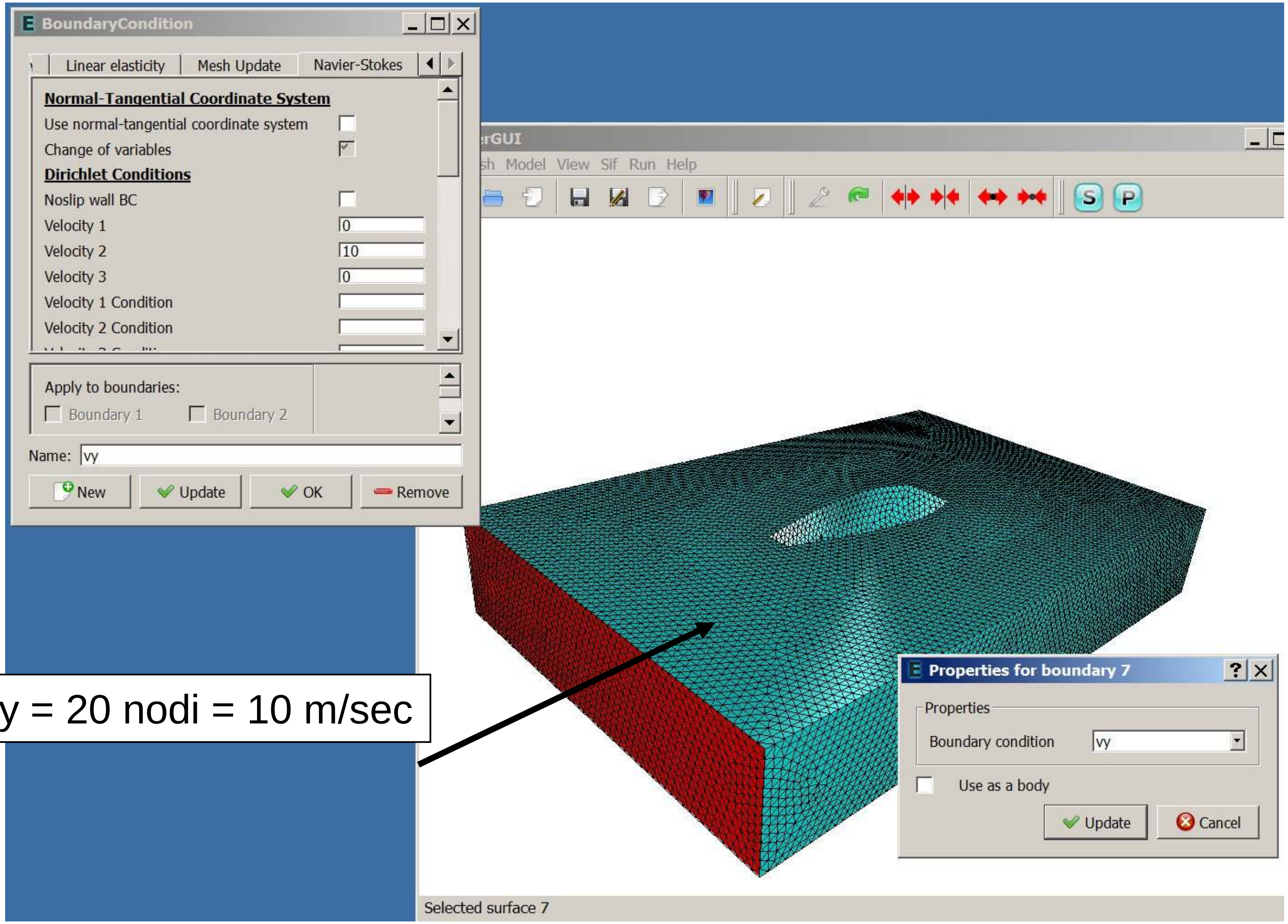


DEFINIZIONE PROFILO



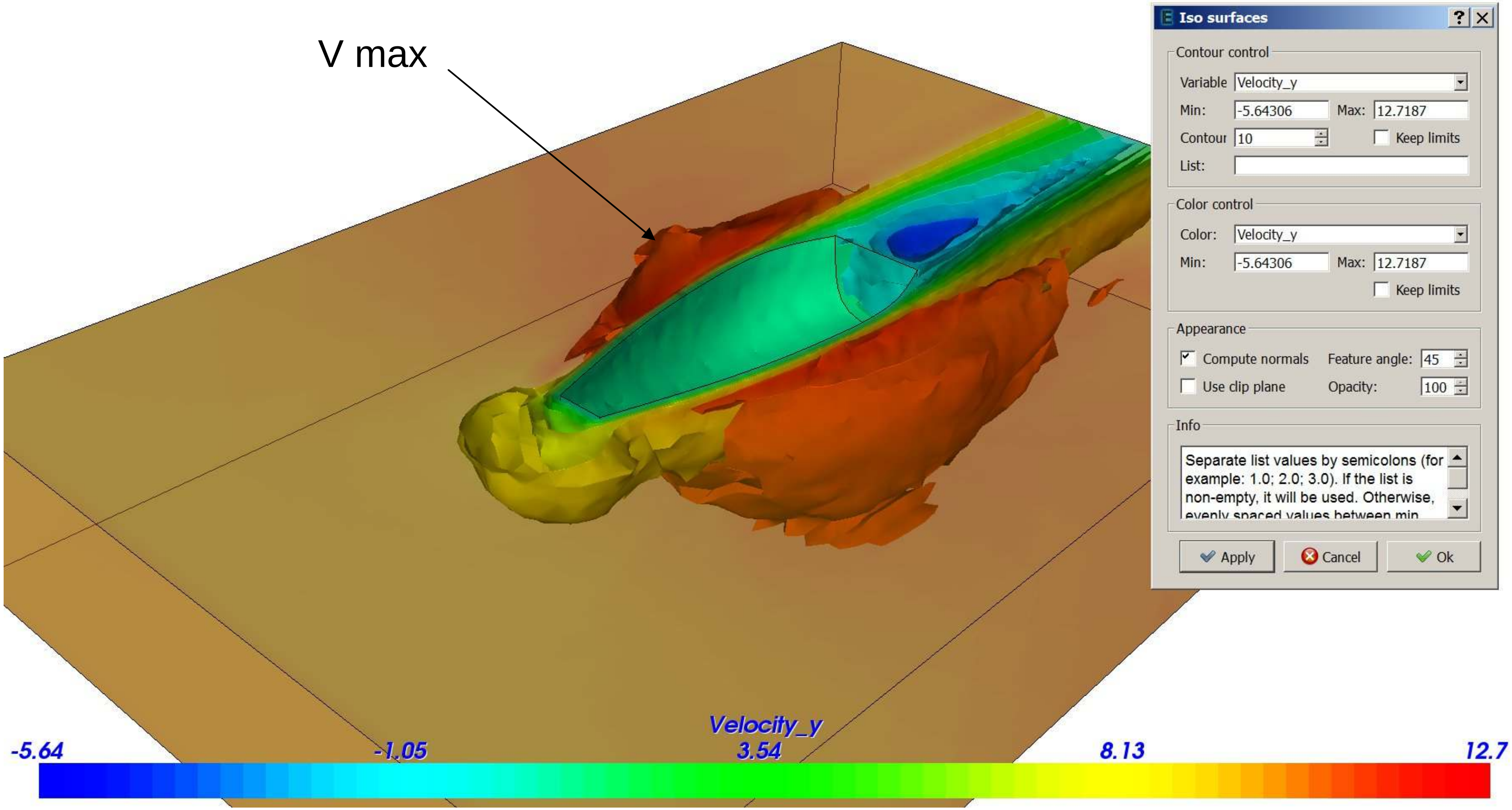
VOLUME DI ACQUA

FLUIDODINAMICA – NAVIER STOKES

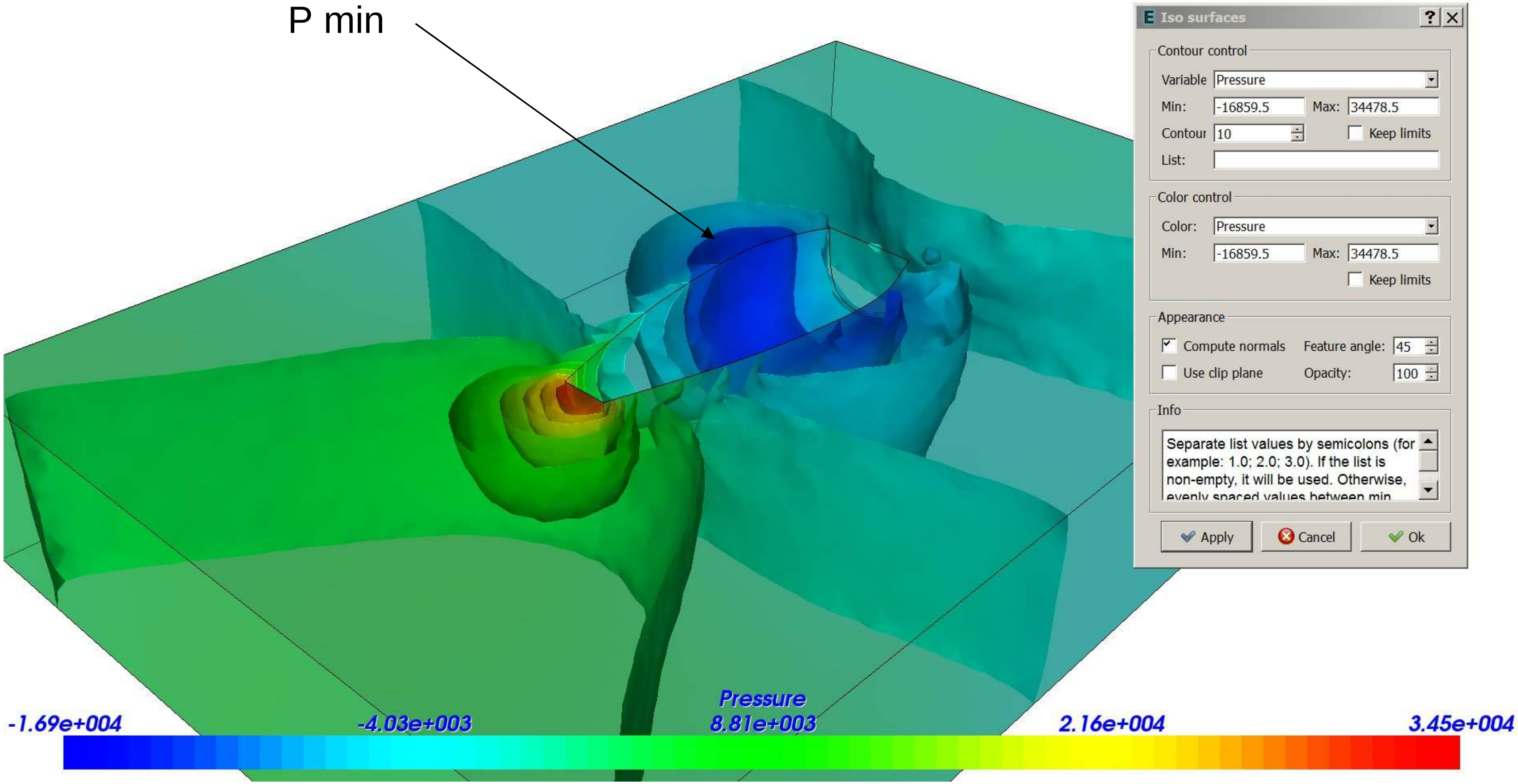


Vy = 20 nodi = 10 m/sec

FLUIDODINAMICA – NAVIER STOKES



FLUIDODINAMICA – NAVIER STOKES



FLUIDODINAMICA – NAVIER STOKES