Ottimizzazione attraverso il CAE
- introduzione all'uso di Hyperstudy -

Tipi di analisi e Messa a punto di un'analisi

(immagini e esempi presi dai tutorial Altair University)

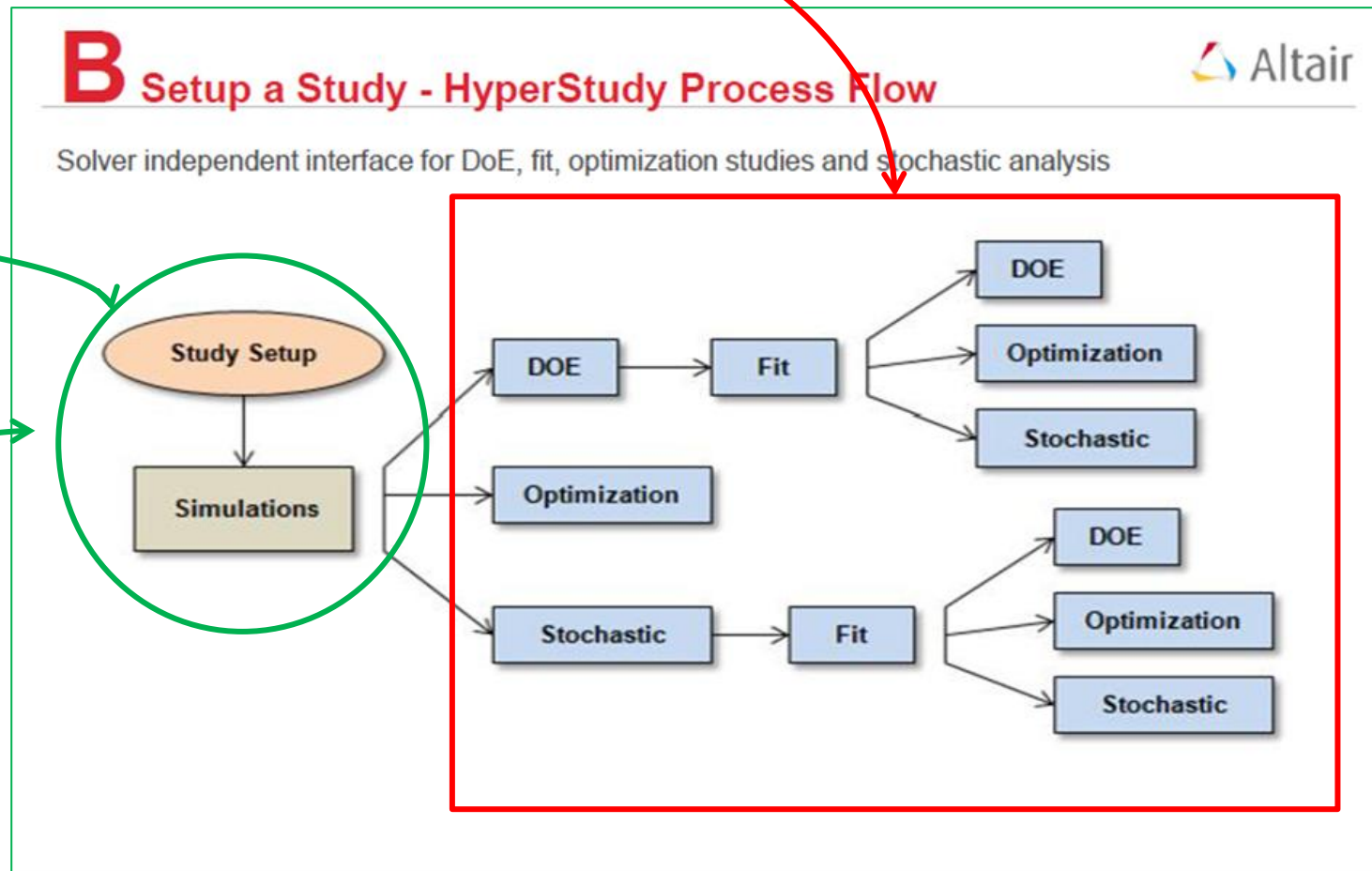
Gli “ottimizzatori” all’interno dei software CAE sono degli ambienti in cui si mette a disposizione dell’utente:

1- il motore di ottimizzazione (analisi DOE, metamodeling, ottimizzazione stocastica)

2- Il preprocessing dell’ottimizzazione (definizione funzioni obiettivo, variabili, vincoli, …)

3- le funzionalità necessarie all’iterazione del calcolo (preparazione file input, estrazione dati output)

4 - Il postprocessing dei risultati



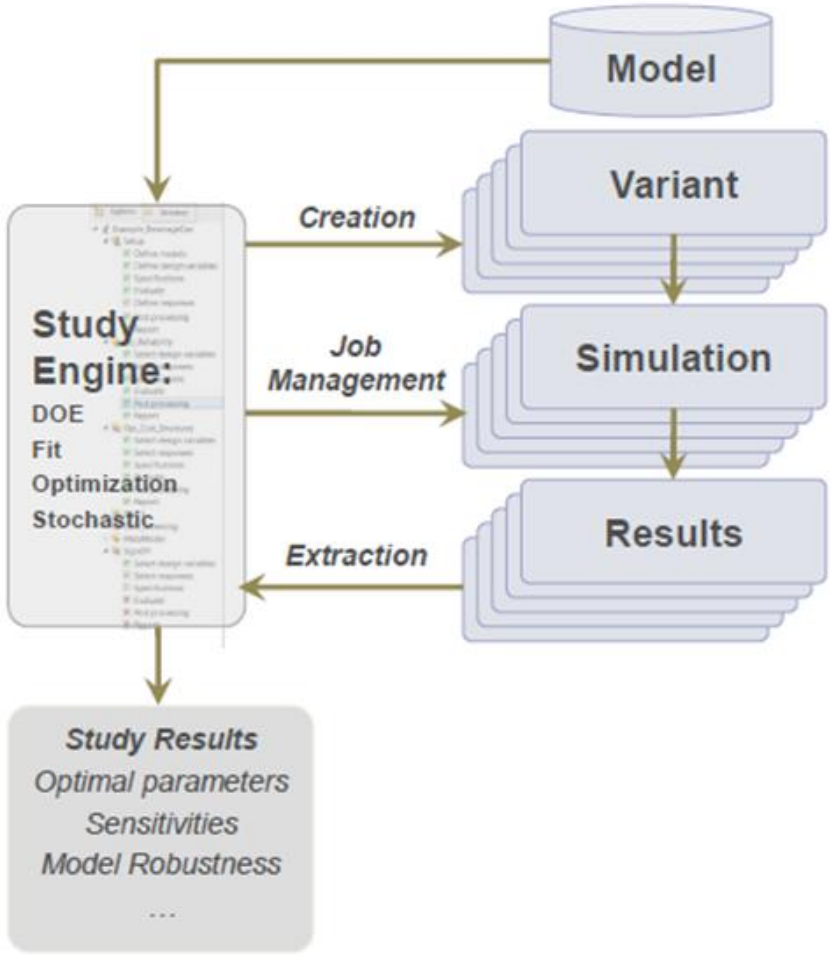
Il motore di ottimizzazione

A Introduction to HyperStudy - Study Setup & Approaches

- **Study**
  - Create/review the **Study** details and **Approaches**. You can also
  - Identify batch commands such as sequence and tasks, to execute for each approach.
- **Design of Experiments**
  - Parameter study
  - Identify significant system parameter
  - Understand system behavior
- **Fit (Approximation)**
  - Approximation of the model behavior
  - Define point of validation
  - Check the quality
- **Optimization**
  - Solver independent optimization of shapes and sizing parameters
  - Change design variables to optimize system response
- **Stochastic analysis**
  - Systematic statistical spread of system variables
  - Simulation is closer to reality
  - Determine statistical spread of system response
  - Robustness, reliability, ...

Funzionalità per l'iterazione del calcolo

Le funzionalità necessarie all'iterazione del calcolo di simulazione sono schematizzabili come in figura.
Generalmente l'analisi di set up preliminare serve a verificare che questo loop funzioni correttamente.
Il loop operativamente si chiama anche "lancio in batch" dell'ottimizzazione (o delle simulazioni). Il batch è tipicamente uno script che automatizza le chiamate al software di simulazione.



La preparazione dello script

B Setup a Study - Solver Execution Script

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- The role of the solver execution script in HyperStudy is to provide the name and location of the file which HyperStudy uses to execute the model.
  The scripts can be constructed in any language, and its contents can be as simple as a single line or a detailed set of commands.

- **Cases:**
  - Direct call to executable
  - Basic solver script with arguments
  - Script with simple logic
  - Waiting for an output file
  - Solving on a remote machine

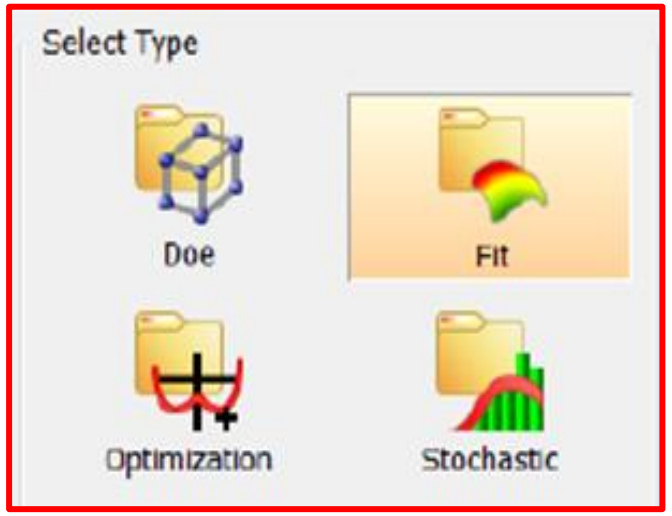
- **Note:**
  - More details under the **Online Help**

Cercando "solver script Files"

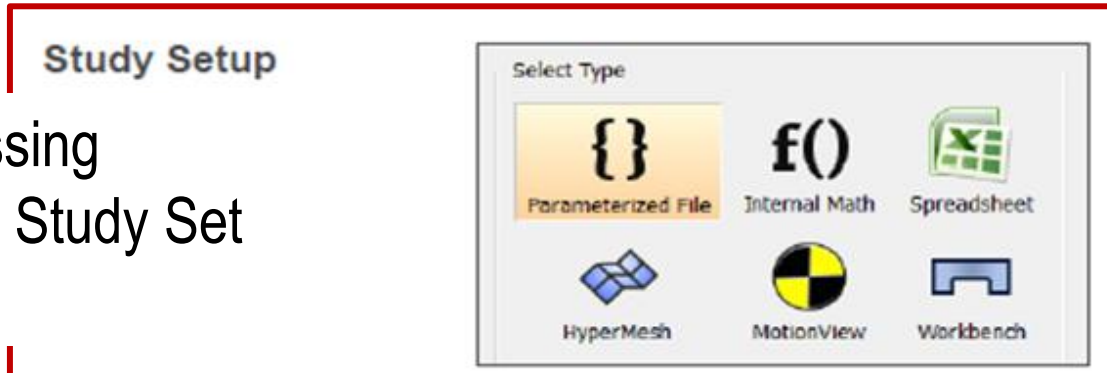
Panoramica sugli ottimizzatori

Hyperworks (ma stesso si può dire per LS opt e ModeFrontier) assiste nella preparazione ed analisi di diversi tipi di ottimizzazione,
nei lucidi successivi si riprendono gli schemi logici delle quattro tipologie:

-Analisi DOE per studi causa-effetto
- Creazione di fitting di metamodeling
- Studi di ottimizzazione
- Analisi stocastica



Per ciascuna preliminarmente occorre definire il preprocessing dell'ottimizzazione e verificare il loop di batch attraverso lo Study Set up (che salva tutto in un file *.xml)



A Introduction to HyperStudy - DOE Studies

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Wide range of DOE methods:

- Parameters screening
- Main effects & interactions
- Approximations

Execute solver:

- Sequential submission
- Parallel submission
- Submit job management system

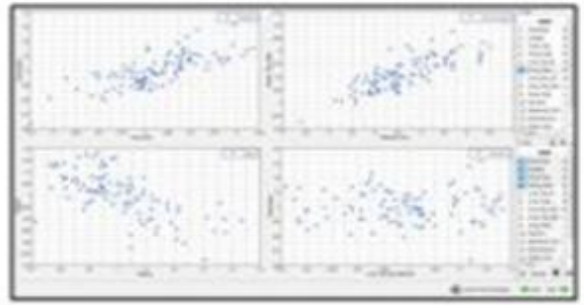
Post Processing:

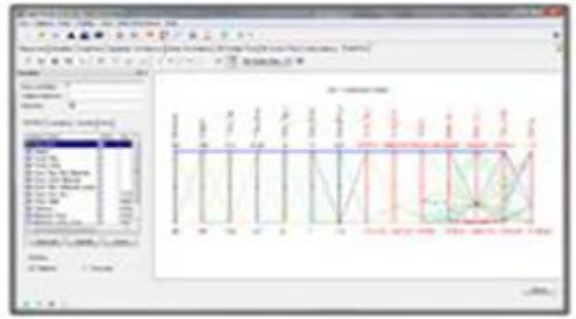
- Effect plots
- Linear regression
- Snake plots
- Advanced Data Mining

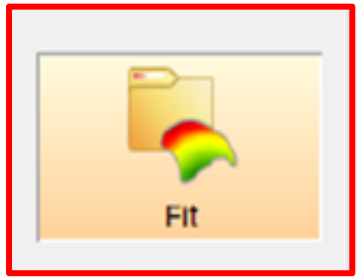
SAMPLE THE DESIGN SPACE

RUN JOBS

EVALUATE RESULTS







Introduction to HyperStudy - Fit Studies

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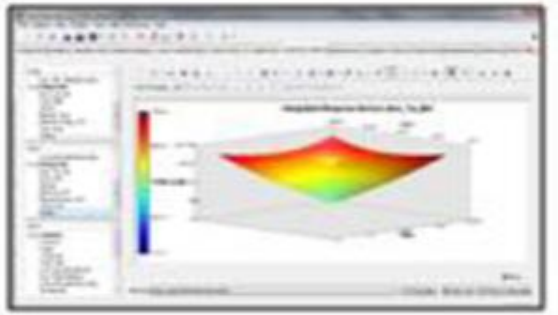
Generate surrogate model using DOE results for quick interrogation of design space

LOAD THE DESIGN POINTS

Use validation DOE to check approximation accuracy:

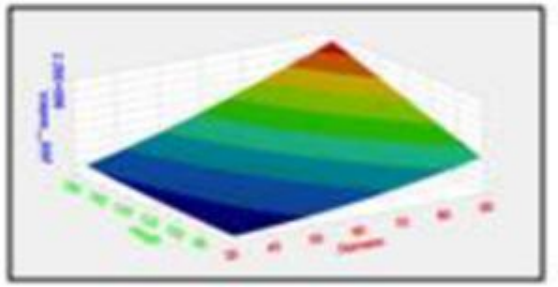
- See how predictions compare to known points

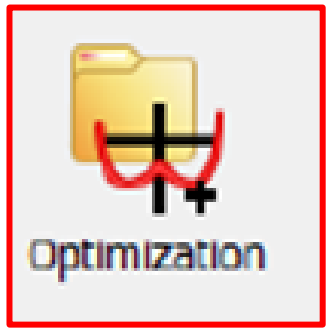
CREATE THE APPROXIMATION



Add additional points into the approximation to update accuracy

CHECK THE APPROXIMATION QUALITY





A Introduction to HyperStudy - Optimization Studies

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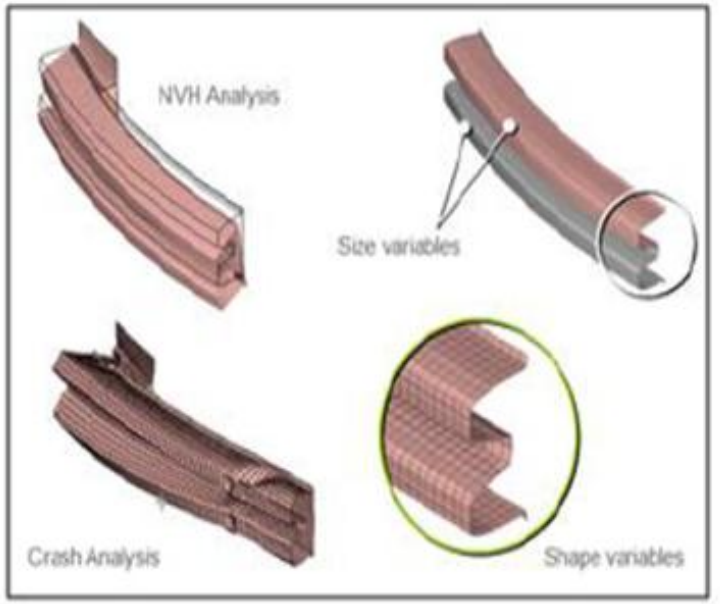
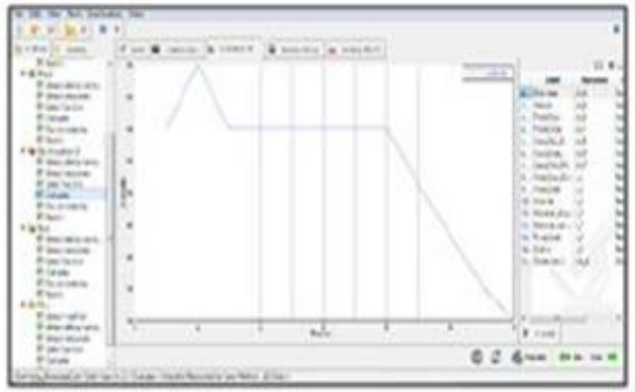
Find design variables values to achieve optimum responses:

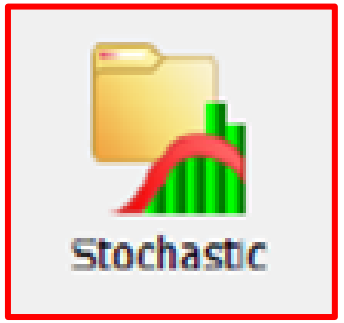
- Use solver or approximation to make predictions

Optimization types:

- Constrained & unconstrained optimization
- Multi-objective optimization
- System identification
- Discrete &/or continuous optimization
- Deterministic or Reliability-based







A Introduction to HyperStudy - Stochastic Studies

Altair

Stochastic studies:

- Investigate effect of input variation upon output variability
- Ensure robustness & reliability

Wide range of different variability methods:

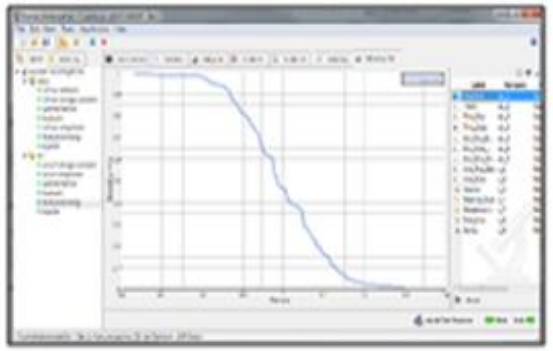
- Normal distribution, uniform, random, …

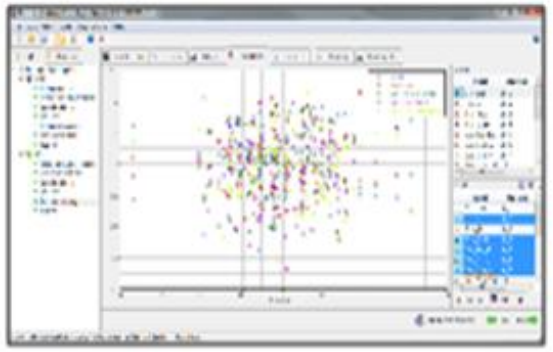
Solver execution:

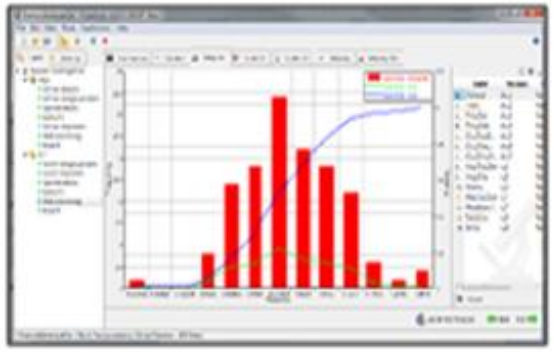
- Approximation or actual solver
- Parallel or sequential submission
- Submit to job management system

Post processing:

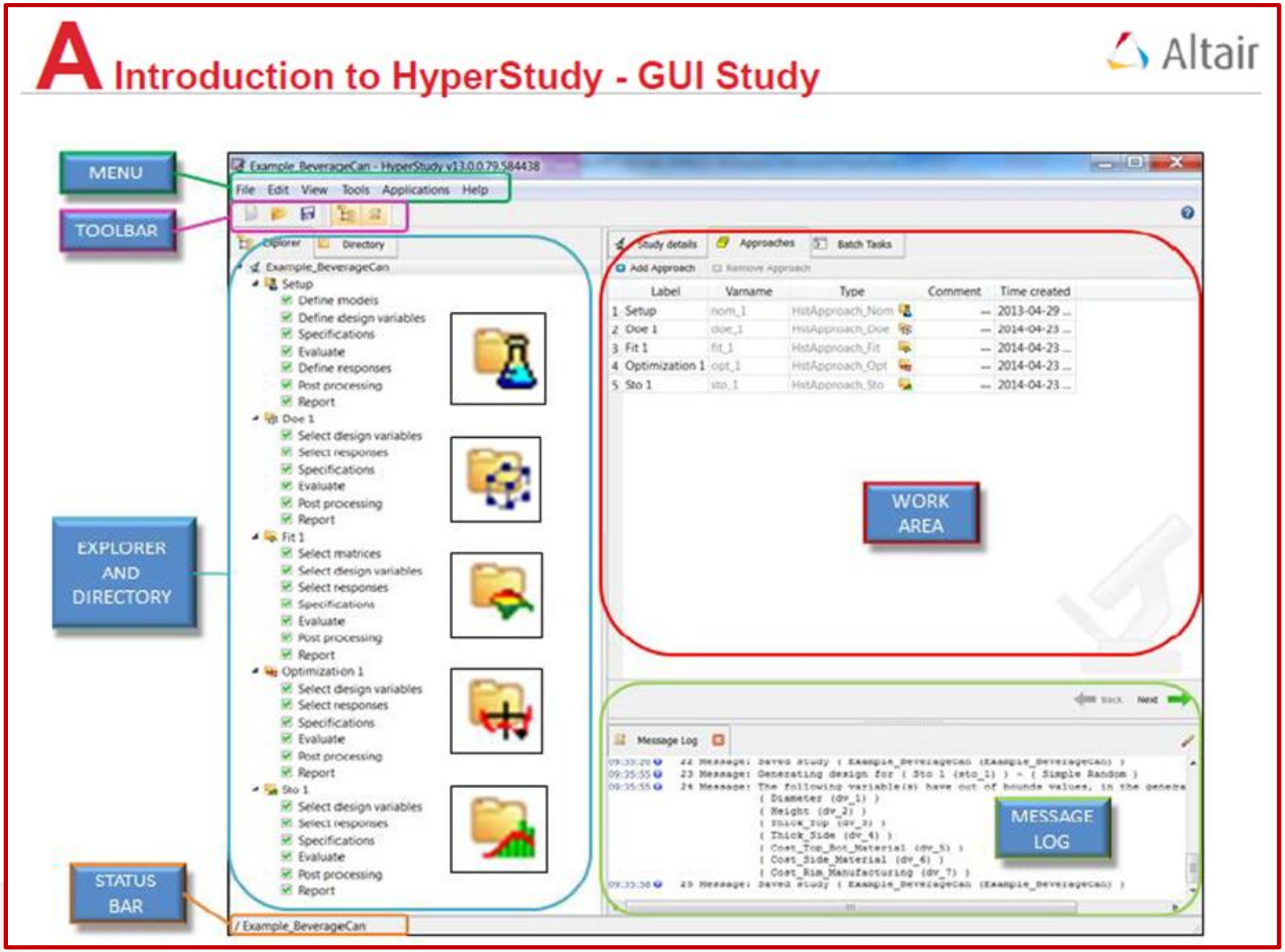
- Probability / Cumulative Distribution Function
- Scatter plots
- Statistics
- Probability of failure predictions



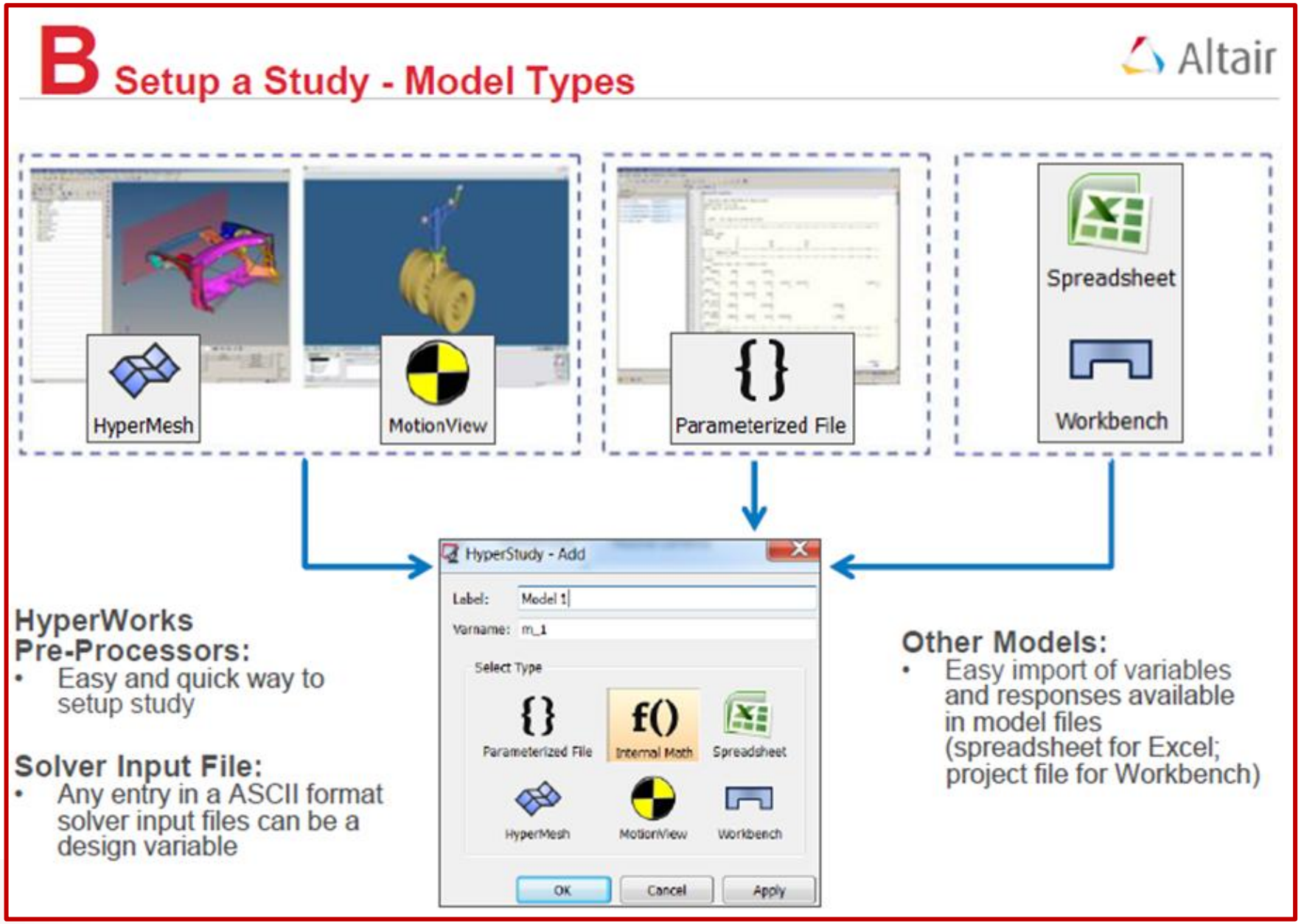




Hyperworks
L'interfaccia utente



Modalità di input dei dati di ottimizzazione (variabili e modello della simulazione)



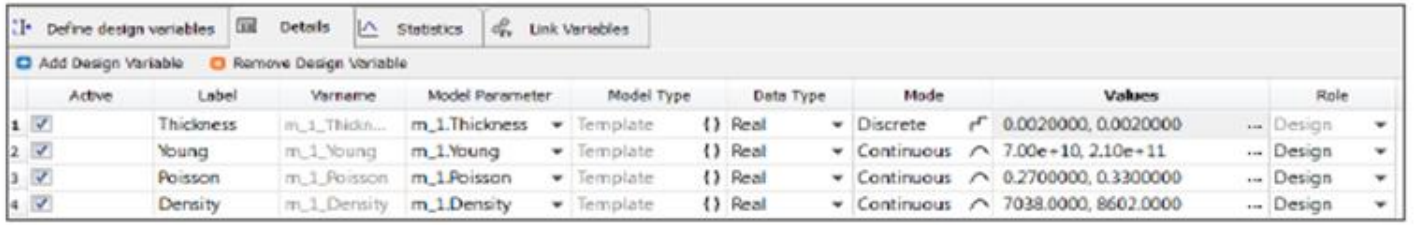
Definizione delle variabili

B Setup a Study - Variables Definition

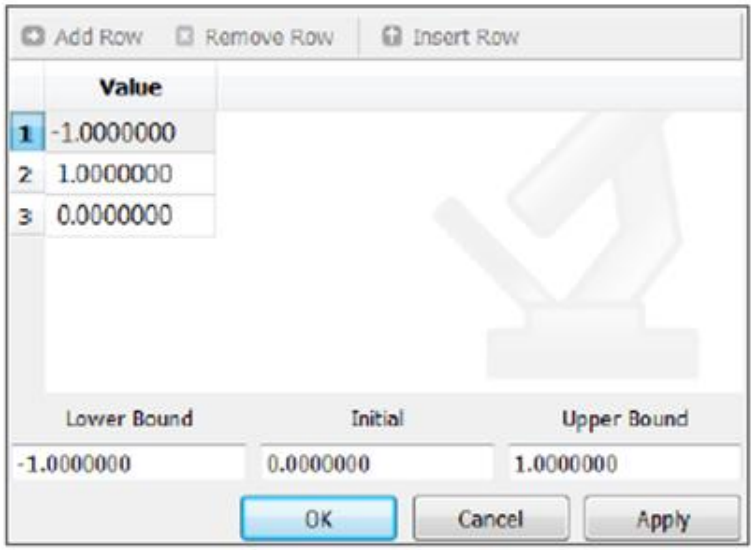
Altair

Discrete and Continuous Variables

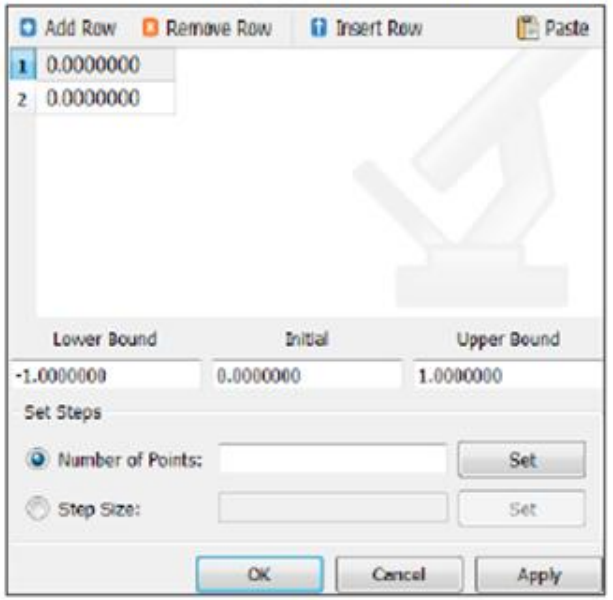
In HyperStudy you can define continuous or discrete variables:



- ***Continuous variables*** can take any values between a lower and upper bound



- ***Discrete variables*** can only take values defined by the user such as Young's modulus, number of bolts, specific values of thickness

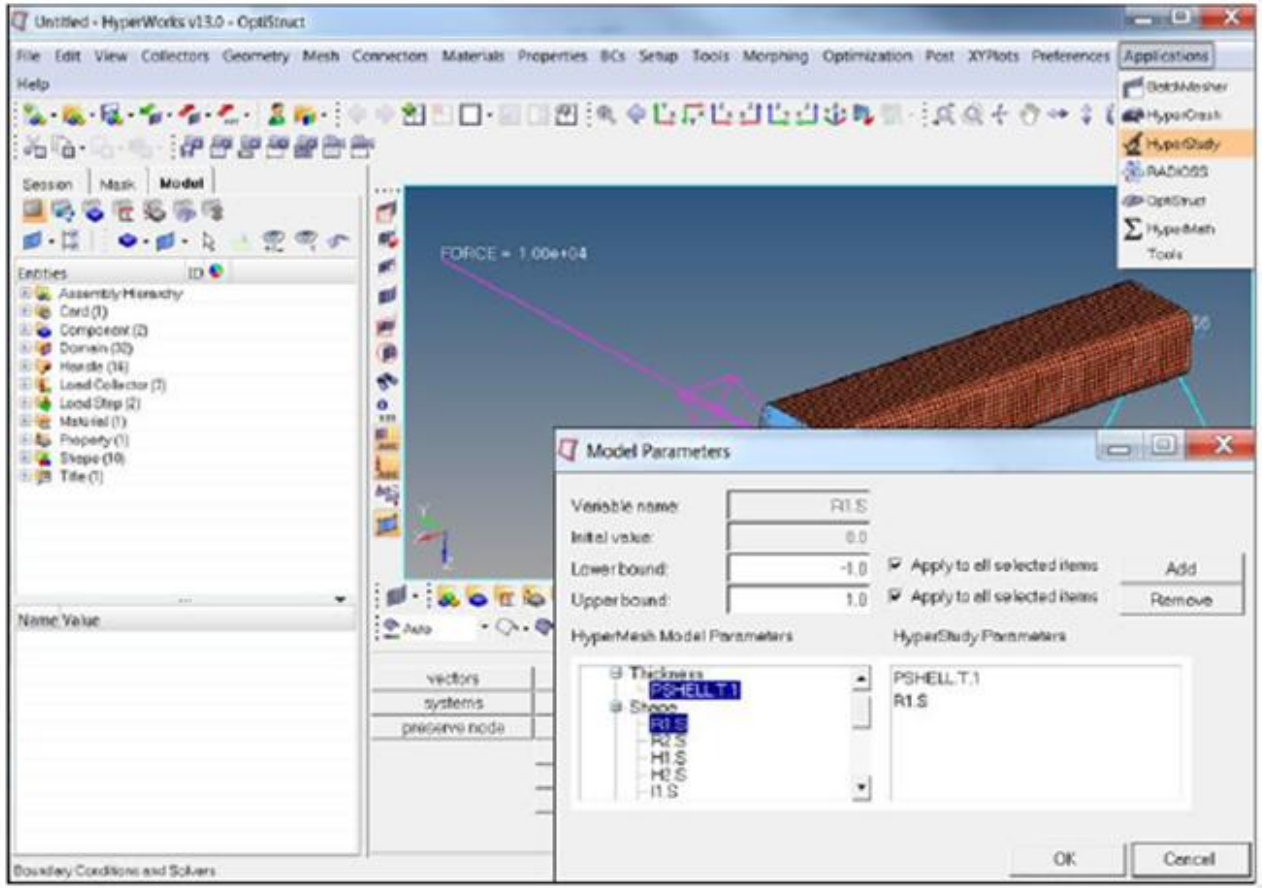


Le variabili devono consentire la parametrizzazione del modello di simulazione.
Come primo passo occorre scegliere il simulatore
(la sua scelta è necessaria anche per la scrittura dello script per il batch file)

B Setup a Study - HyperMesh Model Parameterization

Altair

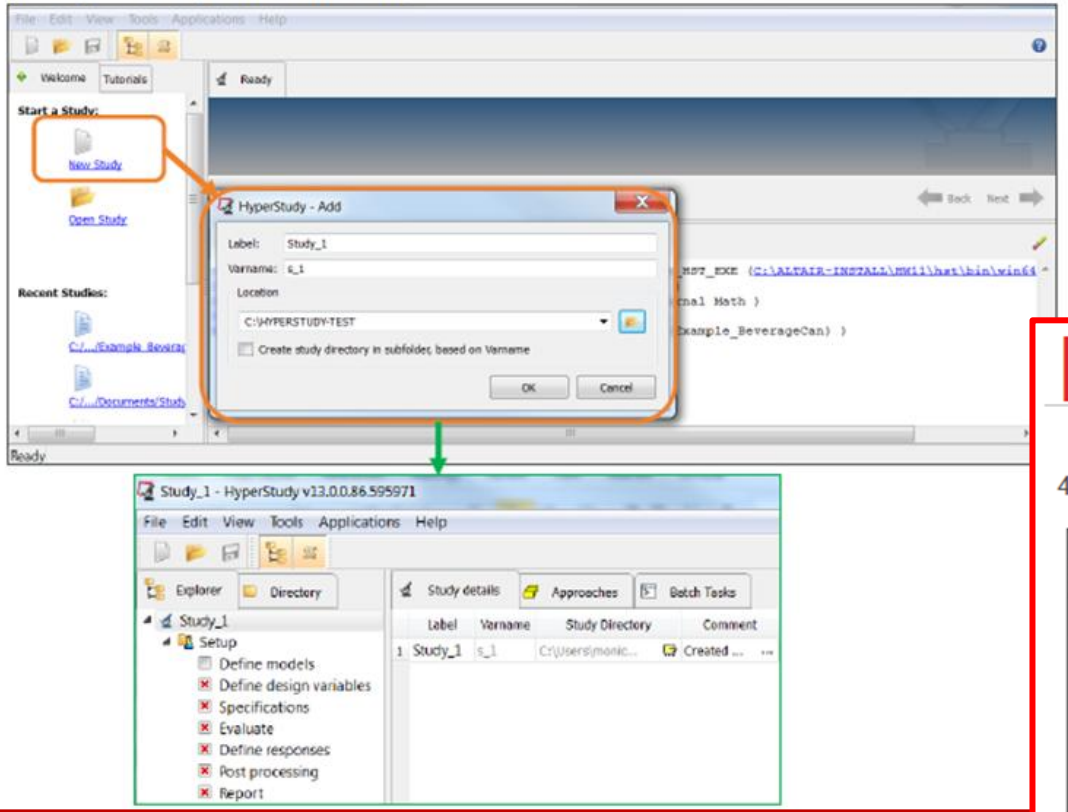
1) Import valid solver input deck into HyperMesh
2) Start HyperStudy from the **Application** pull-down menu
   - **Supported Solver Profiles**
     - Ansys
     - Abaqus
     - LS-Dyna
     - Nastran
     - OptiStruct
     - PamCrash 2G
     - RADIOSS



B Setup a Study - HyperMesh Model Parameterization

Altair

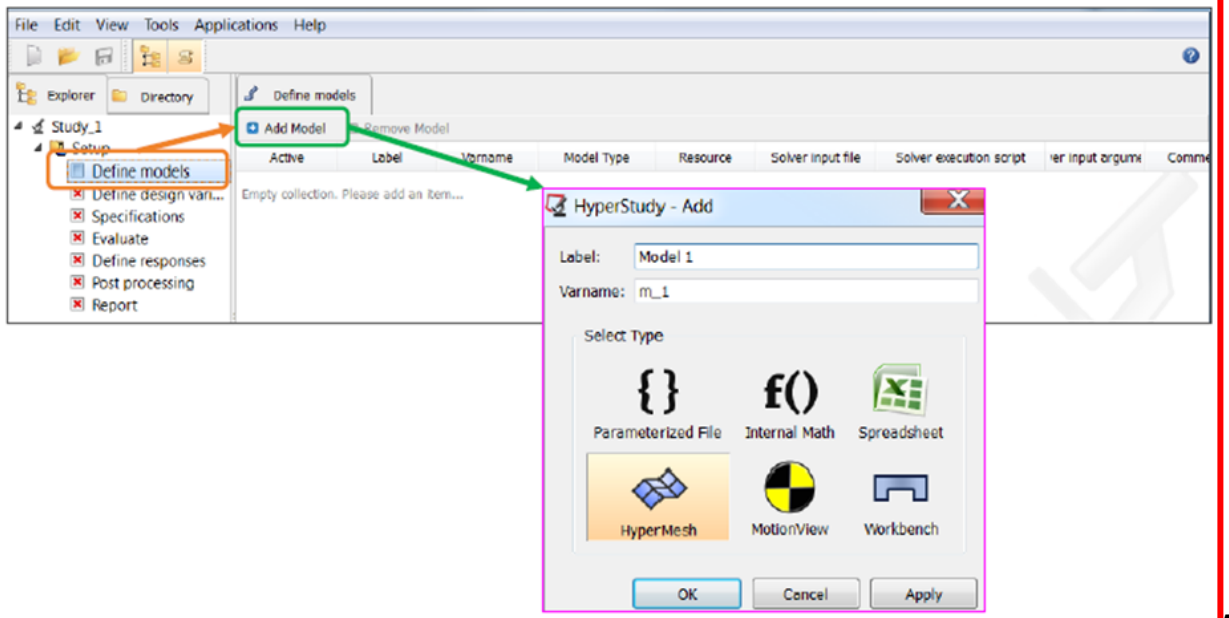
3) Add a New Study, Define Study Name (Label and Varname) and Location of the study directory (Do not use space or special characters!)



B Setup a Study - HyperMesh Model Parameterization

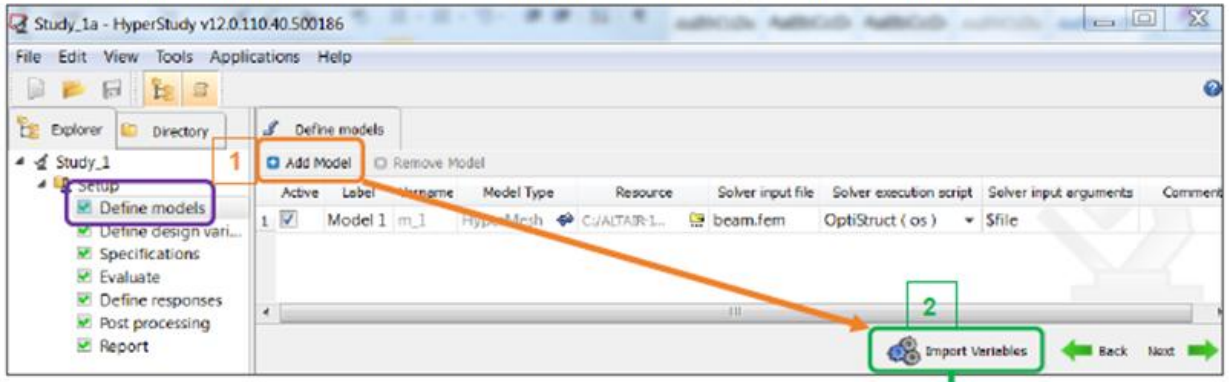
Altair

4) Define Model → Add Model: choose HyperMesh as Model Type.



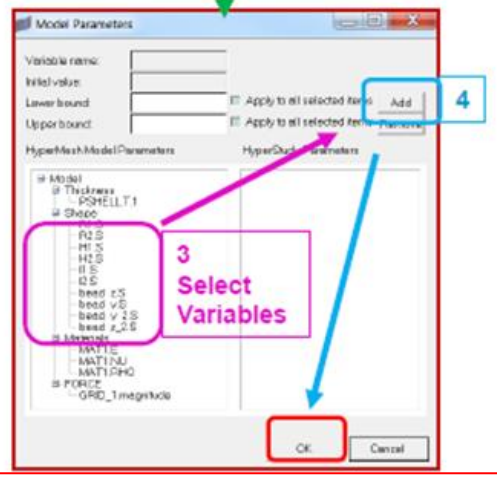
B Setup a Study - HyperMesh Model Parameterization

5) Define Model Parameters → Import Variables: choose HyperMesh Variables to Add.



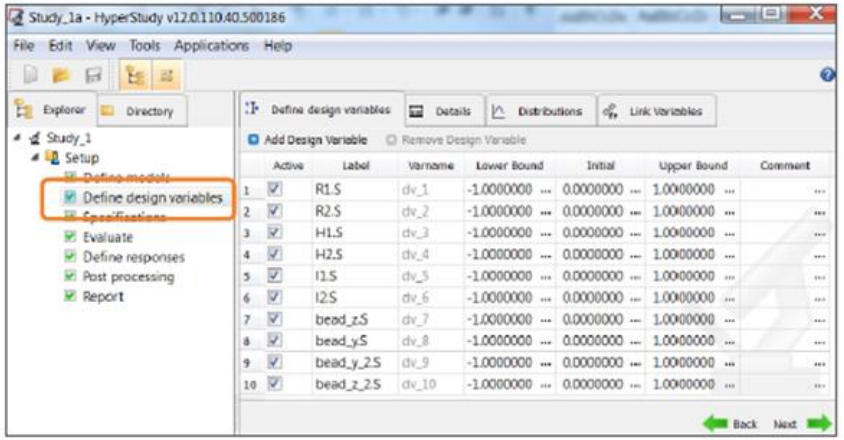
Access to the following entities (depending on the user profile):

- Shell thickness
- Spring stiffness
- Concentrated mass
- Composite Properties
- Materials
- Forces
- Shapes (HyperMorph)

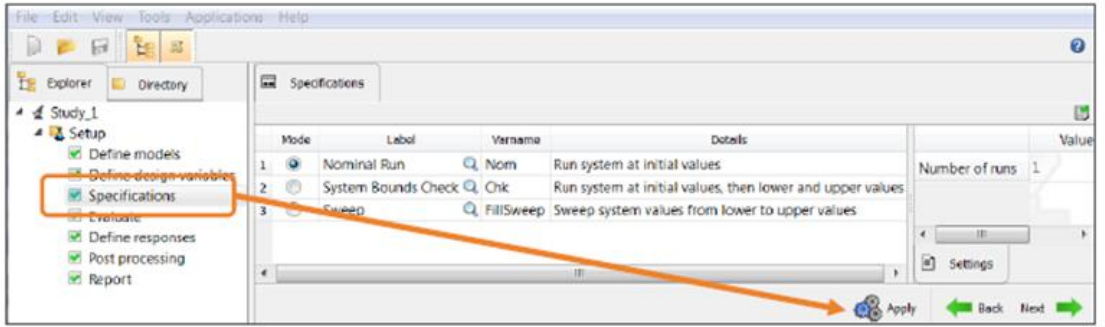


B Setup a Study - HyperMesh Model Parameterization

6) Define Design variables → Select and/or Add Design Variables.



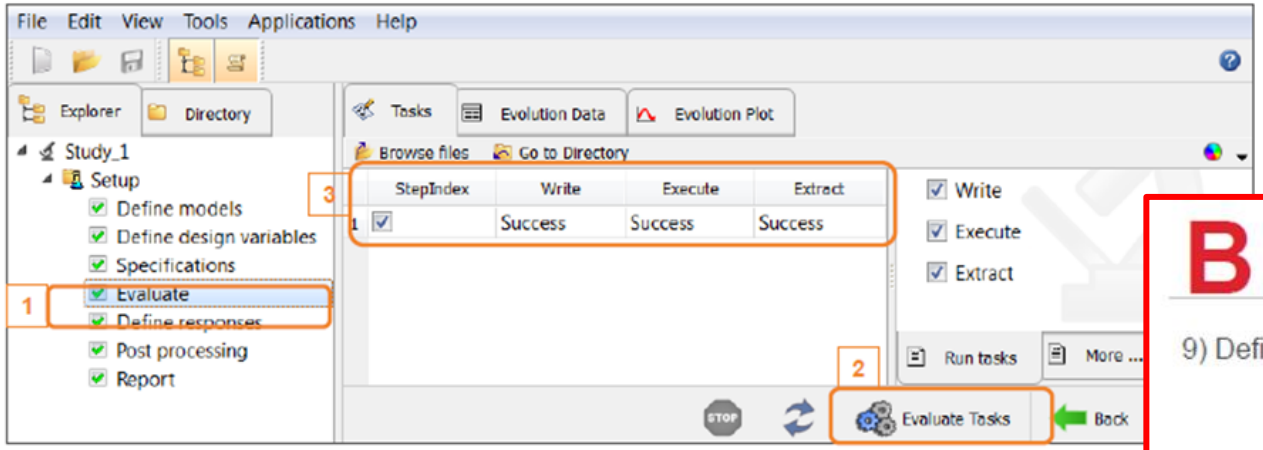
7) Study Run: Select Specifications → Nominal Run as Mode (Apply)



B Setup a Study - HyperMesh Model Parameterization

Altair

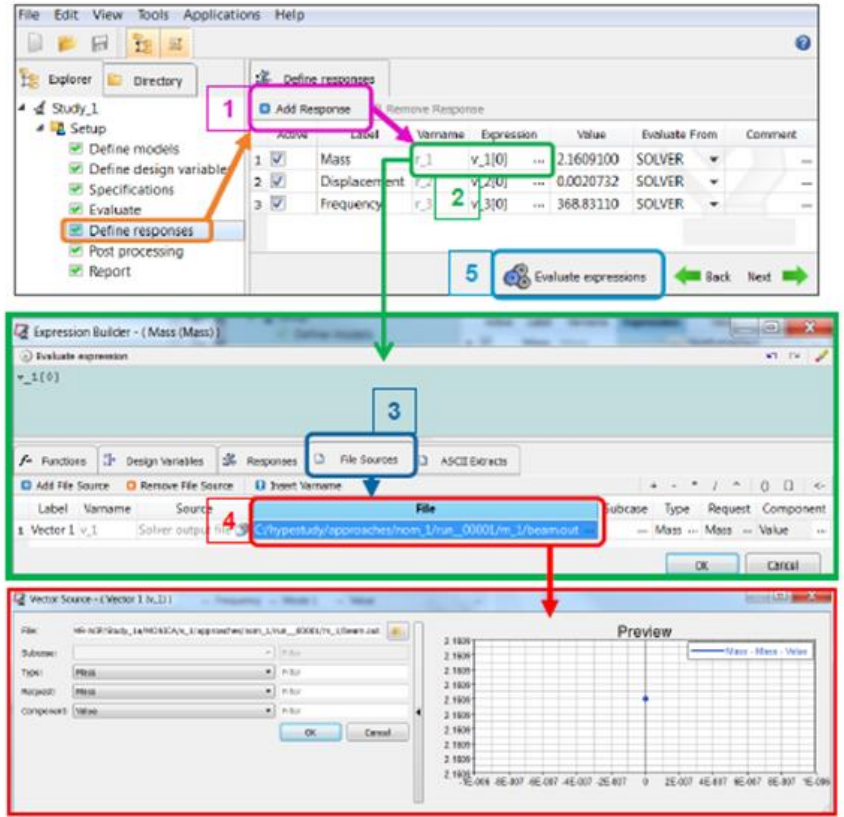
8) Study Evaluate→ Select Write/Execute/Extract.



B Setup a Study - HyperMesh Model Parameterization

Altair

9) Define Responses: Expression builder and Evaluate Expression



Definizione delle risposte (o obiettivi dell'analisi)

B Setup a Study - Create Responses (Definition)

Altair

Responses are measures of the system.

They are the entities you want to analyze during a DOE, Optimization or Stochastics study.

- It can be simple measures: mass, node displacement/velocity/acceleration, element stress,…
- Or advanced responses which are mathematical functions based on results data: max displacement of all elements, fatigue criteria, mean root square between two curves,...

In HyperStudy, responses are created with the ***Response Expression Builder***.

B Setup a Study - Create Responses (Definition)

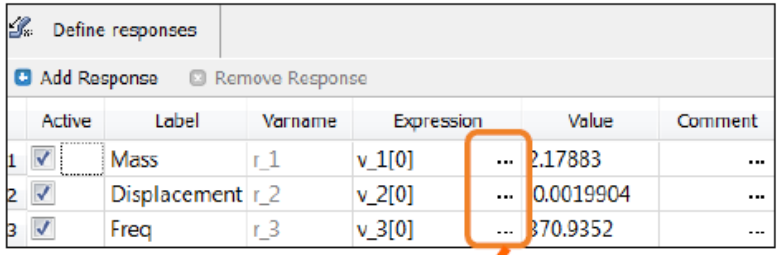
Altair

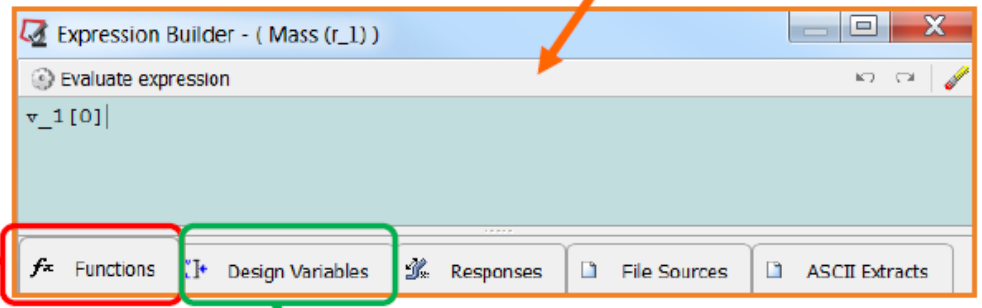
Expression Builder

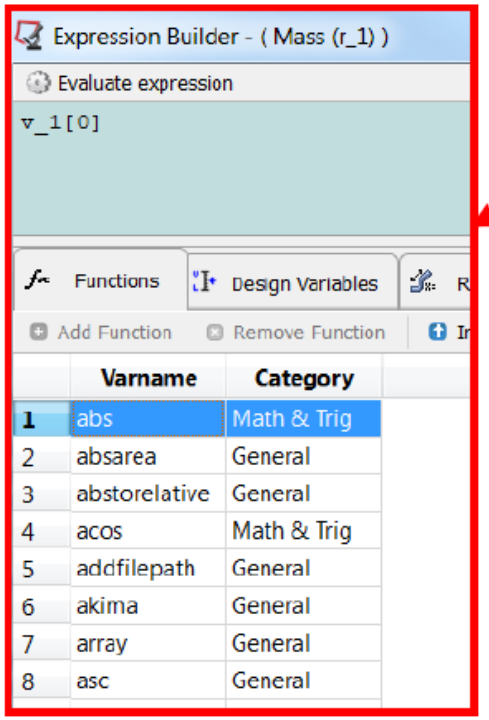
Define responses by building a mathematical expressions involving:

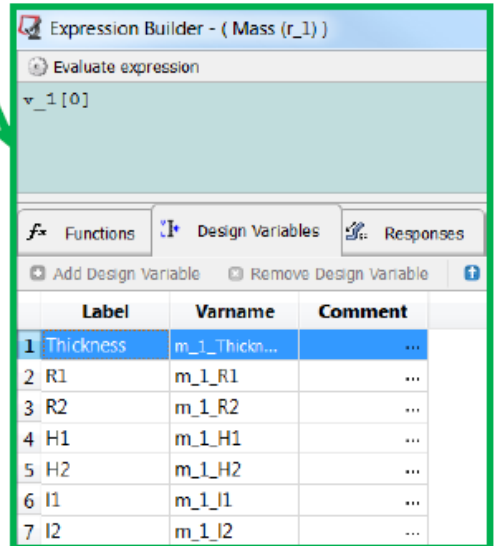
- Functions
- Design variables
- Previously defined responses
- File Sources (Vectors: results values)
- ASCII Extracts (Parsing an ASCII file)

Il response expression builder







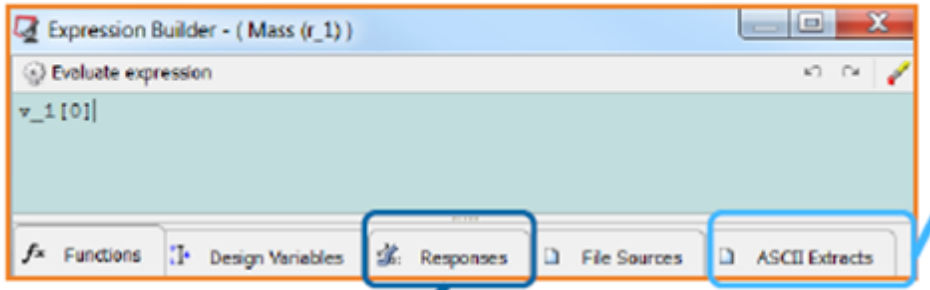


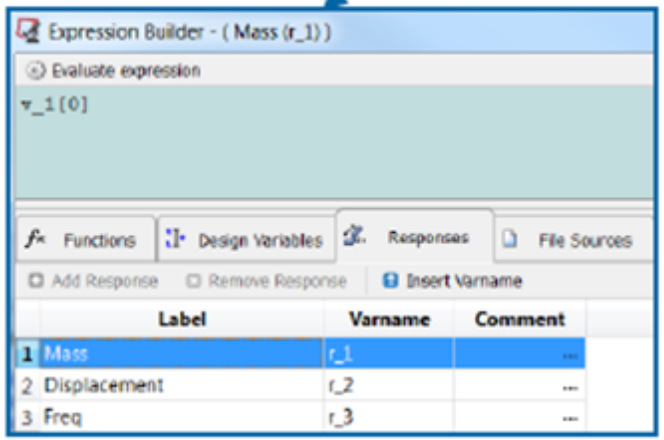
The Design Variables tab lists the design variables in the current study alongside their Varnames.

Il response expression builder

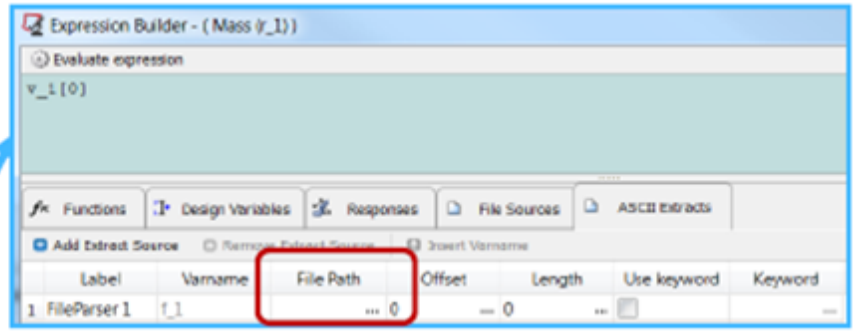
B Setup a Study - Create Responses (Definition)

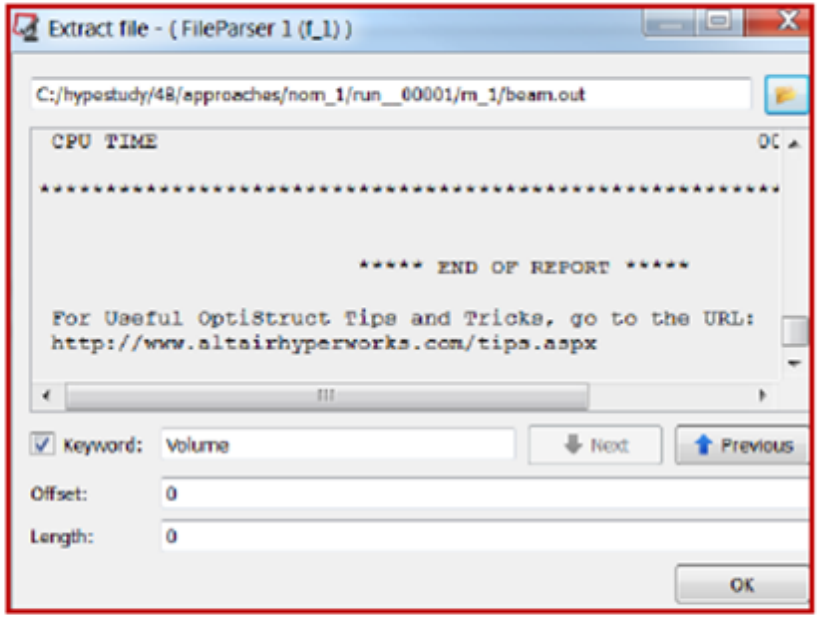
Expression Builder





The Responses tab lists the previously defined responses in the current study alongside their varnames.





The Extracts tab is a parser for ASCII result files. Use the file browser to open the ASCII file

Il response expression builder

B Setup a Study - Create Responses (Definition)

Altair

Expression Builder

File Sources (Vectors) allows for selection of result values from result files from solver runs.

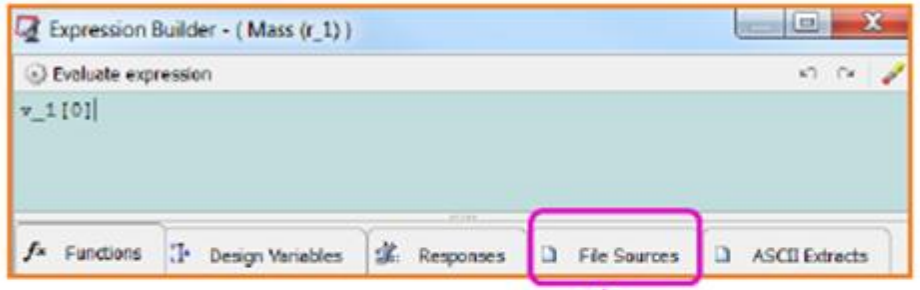
Choose Type, Request and Component Results are stored as vectors.

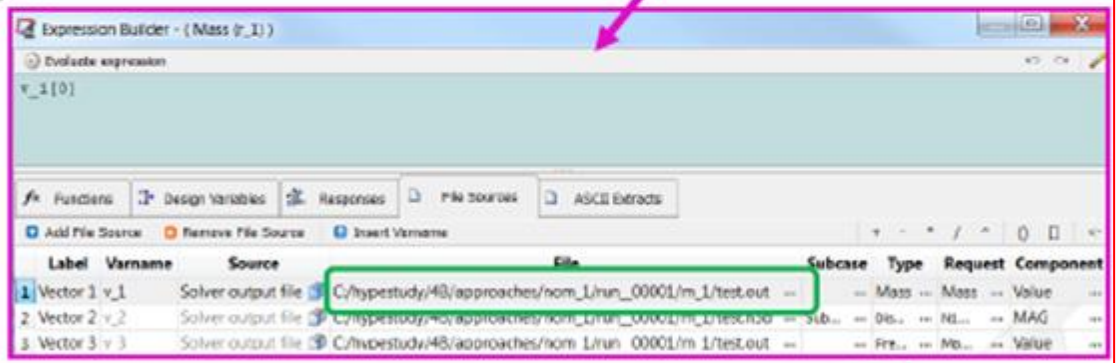
Study requires response to be a scalar value:

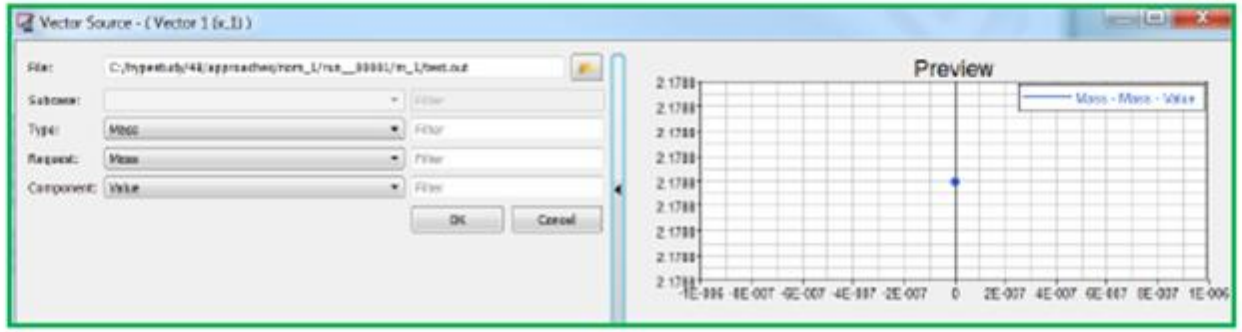
- use Templex functions as min(), max(), integral(), …

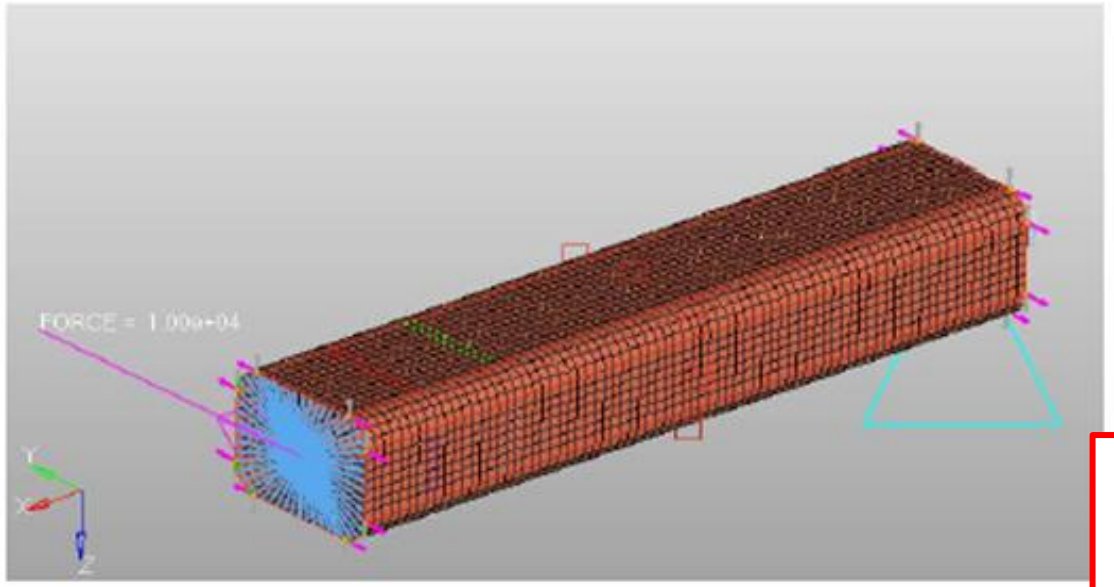
- Define column with [..]

- e.g. v_1[0], v_1[numpts(v_1)-1]









Esercizio di Study Setup

B Setup a Study - Exercise 1a

Altair

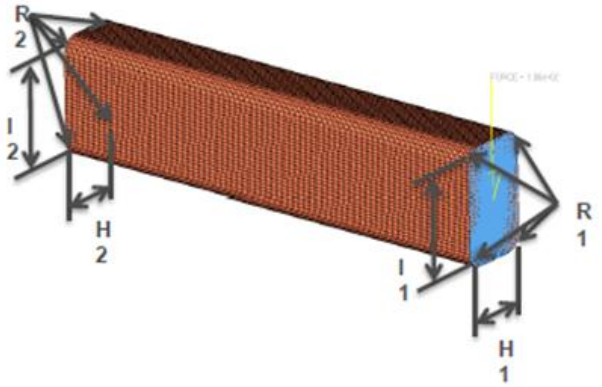
Input file:
beam_shape.hm

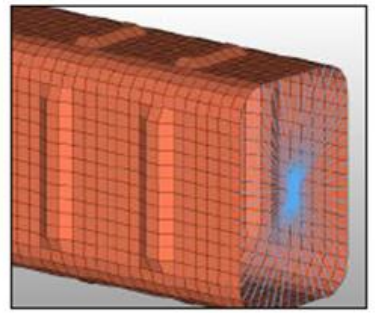
Description:
This is a OptiStruct model with 2 loadcases:
Units are m,Kg,s, Pa

Goal :
To define Th, size and shape variables with HM link

Define variables:
R1,R2 [0]
H1,H2 [0]
I1,I2 [0]
4 Bead along Y and Z [0]
Shell Thickness [0.02 m]

Define responses:
Mass [2.1609kg]
Y-Displacement at node 19021 [-0.00207311 m]
1st Frequency [368.835]





Il file è su elearning2

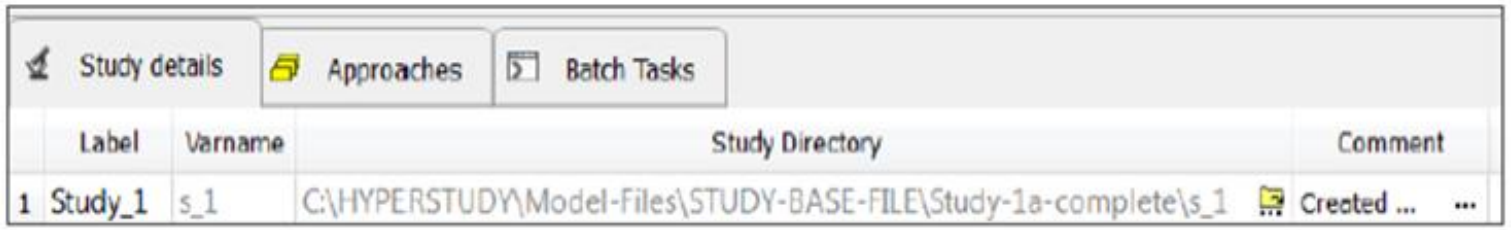
B Setup a Study - Exercise 1a Major Steps

Altair

1) Open HyperMesh Desktop and Set the User Profile: ***OptiStruct***

2) Load HyperMesh Desktop database model (***beam_shape.hm)***

3) Start ***HyperStudy*** from ***Applications*** pulldown menu and ***create*** a new Study.



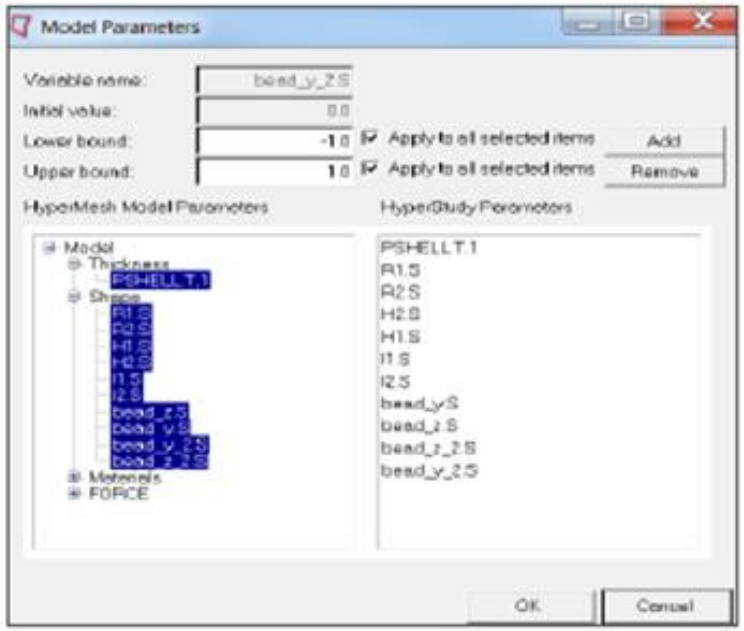
4) Add a model (HyperMesh Model) to the study

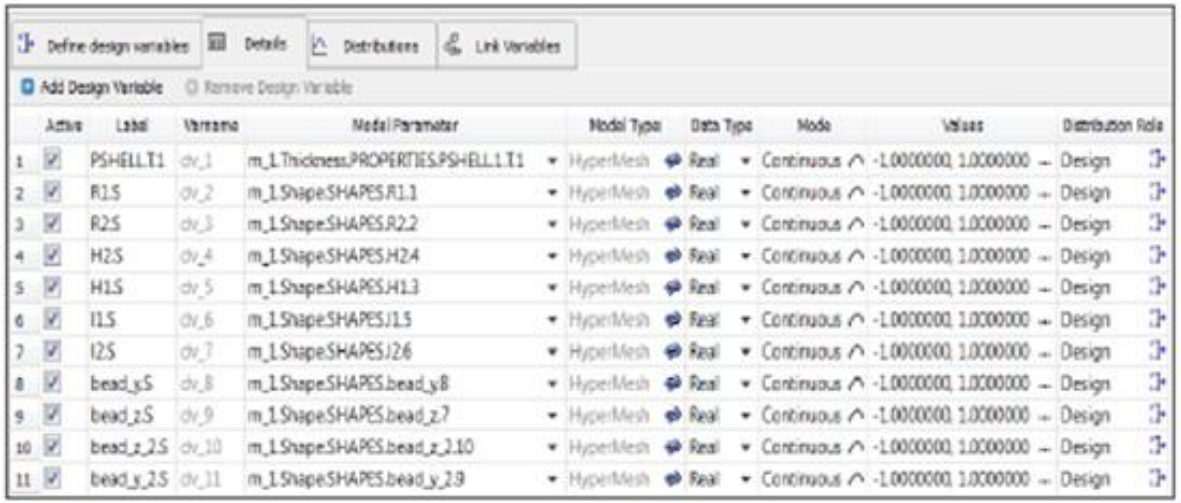
B Setup a Study - Exercise 1a

Altair

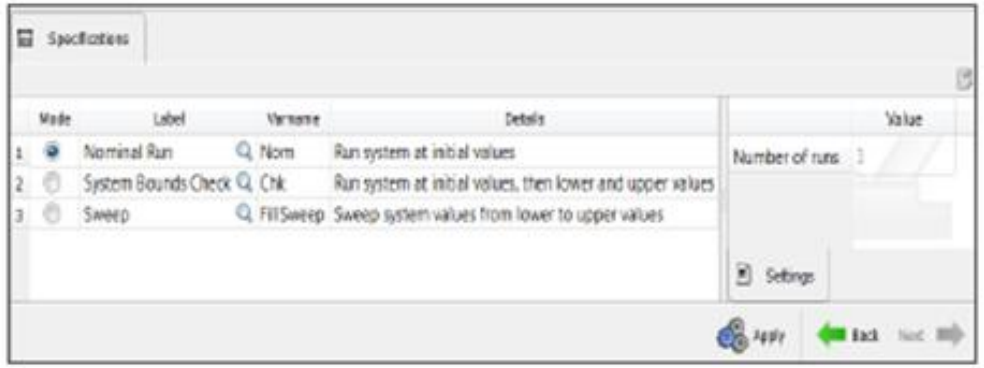
5) Add Model Parameters:

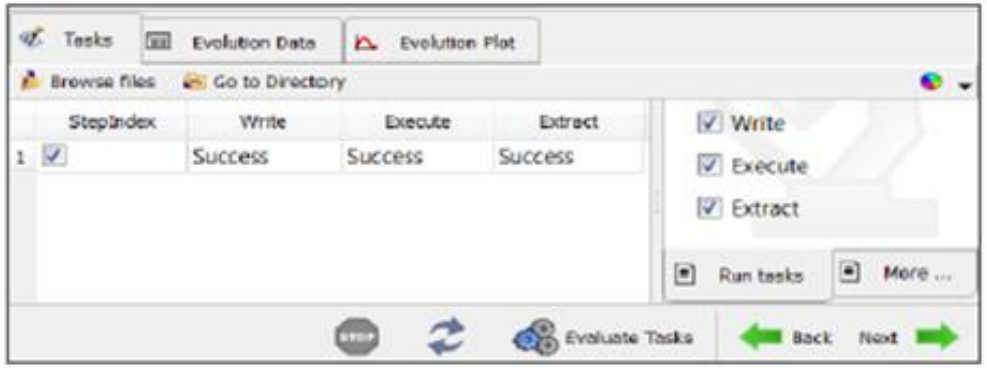
- Define Design Variables: Import Model Parameters from HyperMesh, pick the Design Variables to add.





6) Submit the nominal run: Specification tab (Apply & Evaluate)



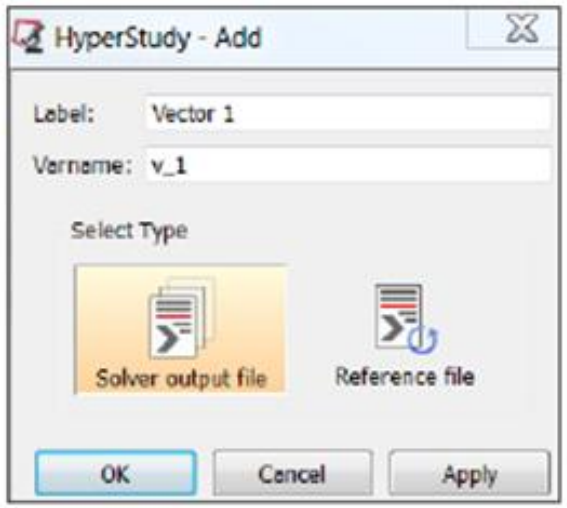


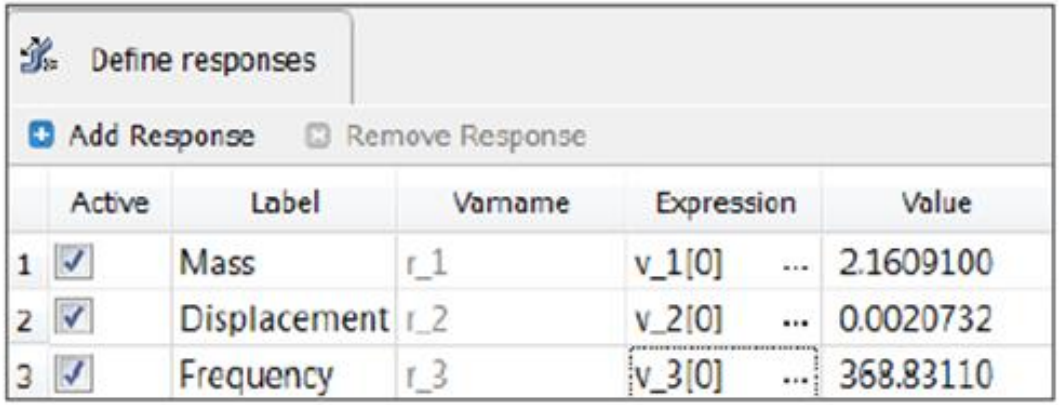
B Setup a Study - Exercise 1a

Altair

7) Create 3 responses and compare the response values

Response Name	Vector	Vector Resource File	Subcase	Type	Request	Component	Evaluated Expression
Mass	Vector 2	beam.out	(N/A)	Mass	Mass	Value	2.16091
Displacement	Vector 2	beam.h3d	Subcase 1 (Static)	Displacement (Grids)	N19021	MAG	0.002073
Frequency	Vector 3	beam.out	(N/A)	Frequency	Mode 1	Value	368.83





8) Save the study

- In the ***File*** menu, select ***Save*** . If this study has not yet been saved, a ***Save As ...*** dialog box will pop up requesting a name for the **Study archive** Study archive (*.hstx) . Enter **Study_1a.hstx** for the study name and click ***Save*** to save the study file in the Study Directory.