

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)



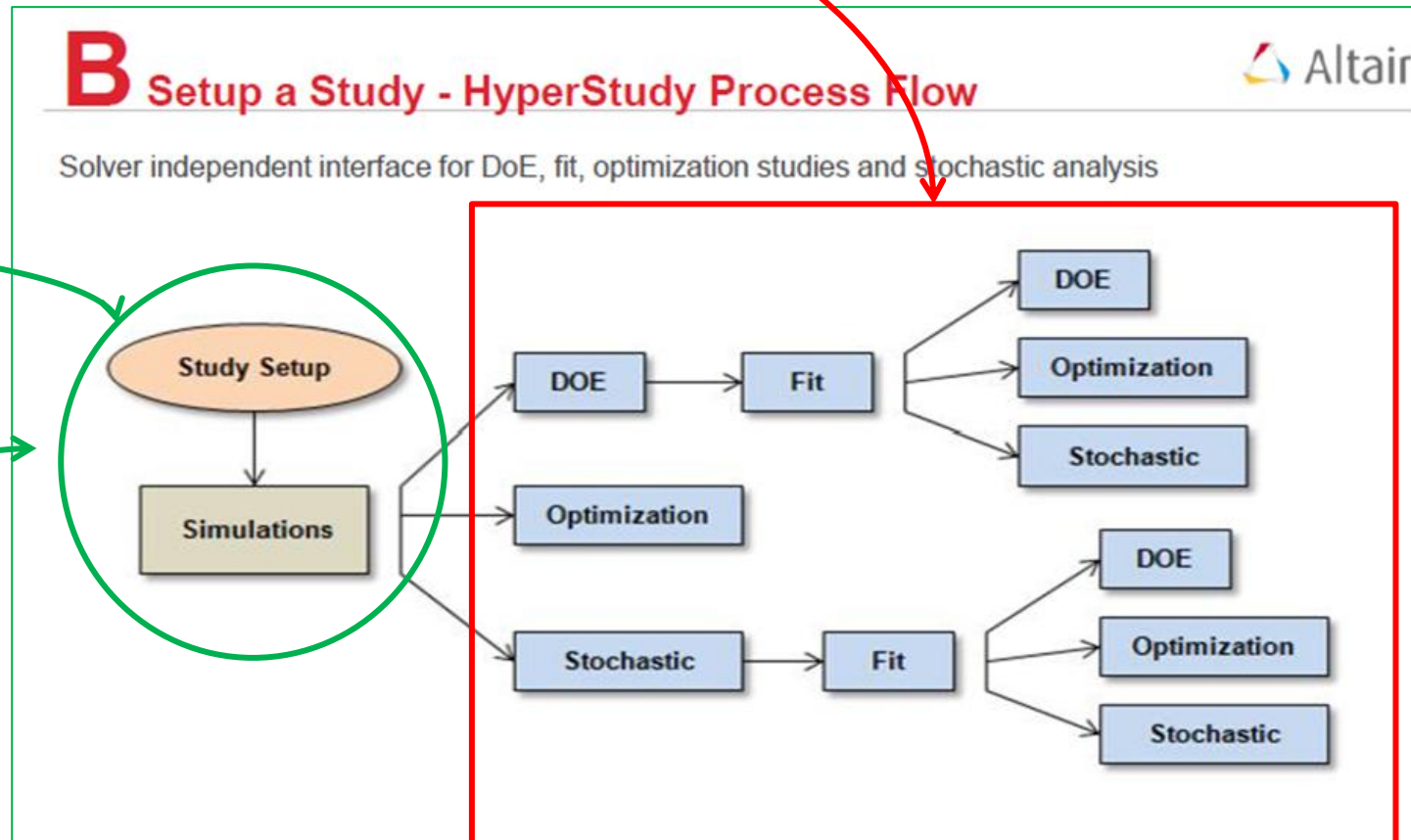
Gli “ottimizzatori” all’interno dei software CAE sono degli ambienti in cui si mette a disposizione dell’utente:

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, ...

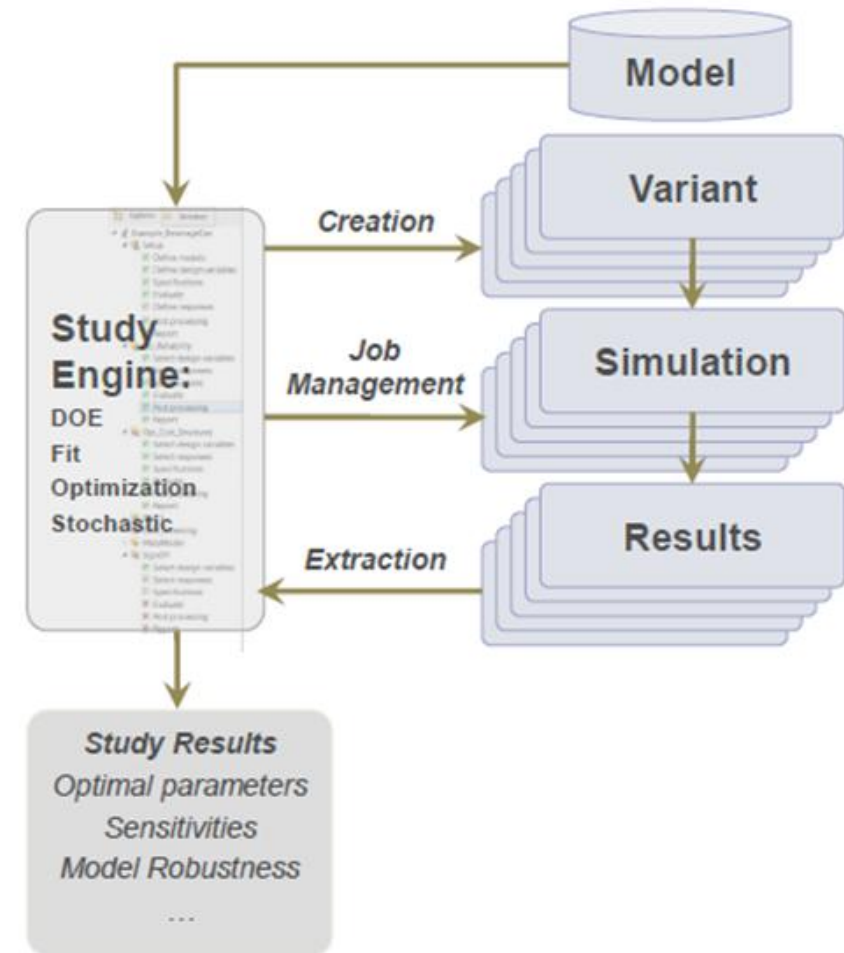


Funzionalità per l'iterazione del calcolo

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.

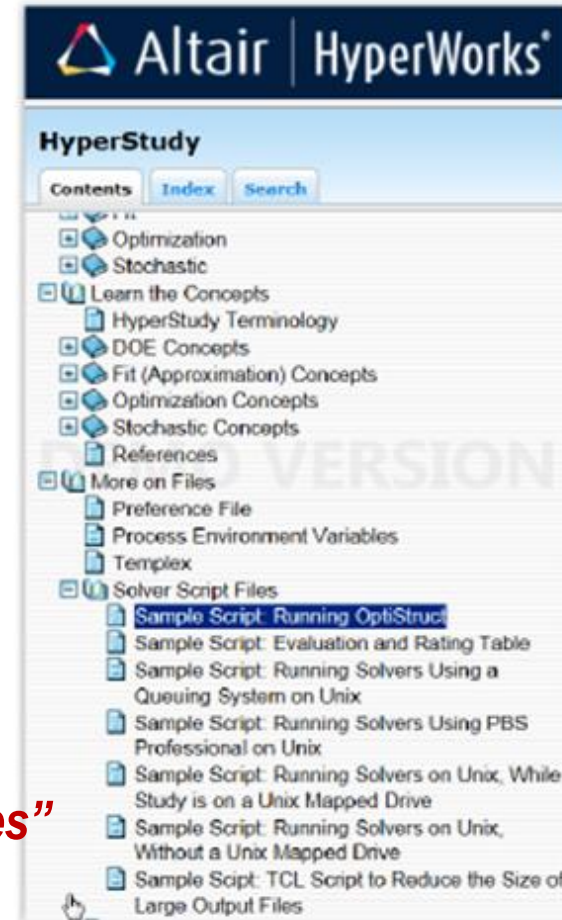


B Setup a Study - Solver Execution Script

- 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**



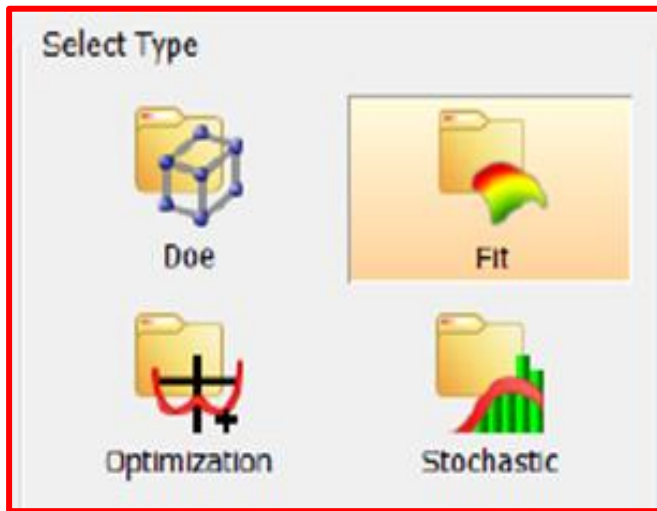
Cercando "solver script Files"

La preparazione dello script

Panoramica sugli ottimizzatori

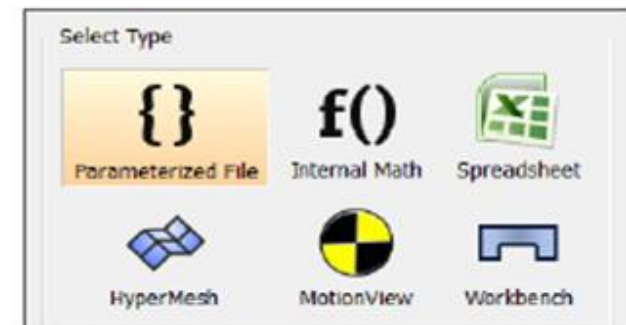
Hyperworks (ma stesso si può dire per LS opt e ModeFrontier) assiste nella preparazione ed analisi di diversi tipi di ottimizzazione, nei lucidi successivi si riprendono gli schemi logici delle quattro tipologie:

- 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 Setup (che salva tutto in un file *.xml)

Study Setup





A Introduction to HyperStudy - DOE Studies



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

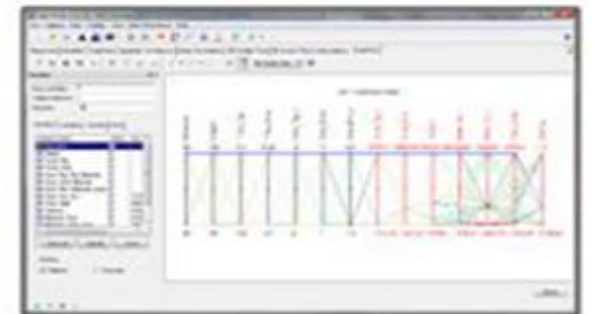
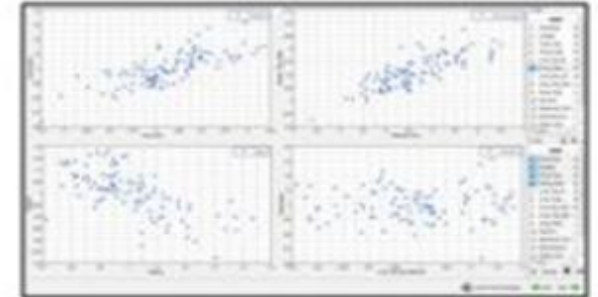
SAMPLE THE
DESIGN SPACE

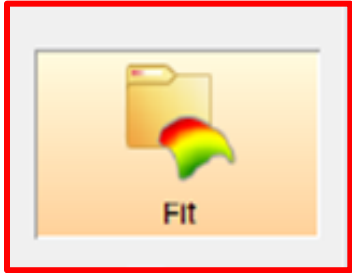


RUN JOBS



EVALUATE RESULTS





A Introduction to HyperStudy - Fit Studies



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

Use validation DOE to check approximation accuracy:

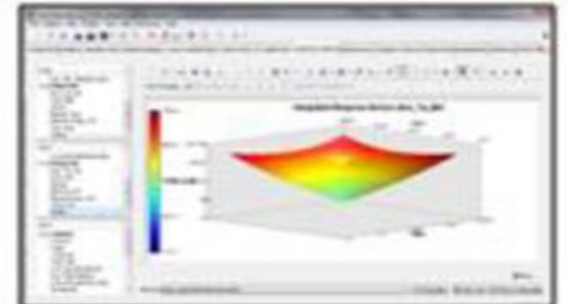
- See how predictions compare to known points

Add additional points into the approximation to update accuracy

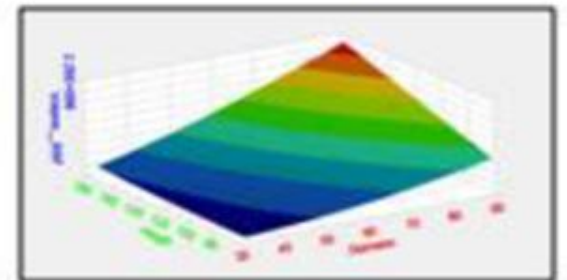
LOAD THE DESIGN POINTS

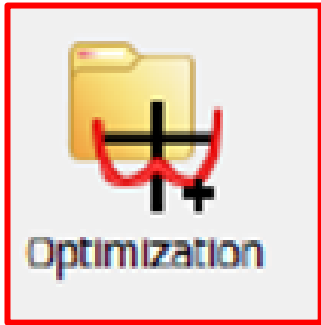


CREATE THE APPROXIMATION



CHECK THE APPROXIMATION QUALITY





A Introduction to HyperStudy - Optimization Studies



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

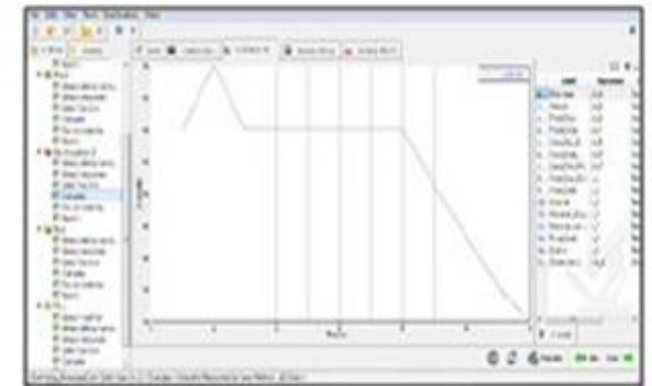
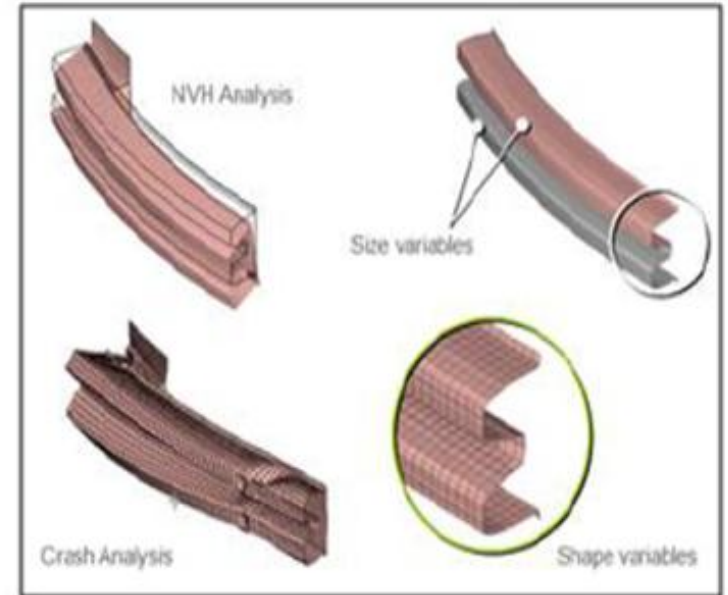
DEFINE DESIGN VARIABLES, OBJECTIVES AND CONSTRAINTS

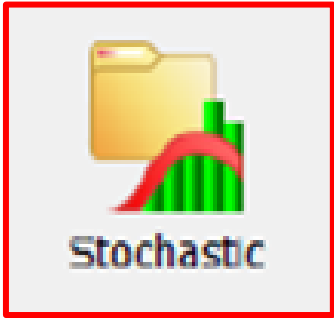


RUN OPTIMIZATION



EVALUATE RESULTS





Stochastic

A Introduction to HyperStudy - Stochastic Studies



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

DEFINE INPUT DISTRIBUTIONS



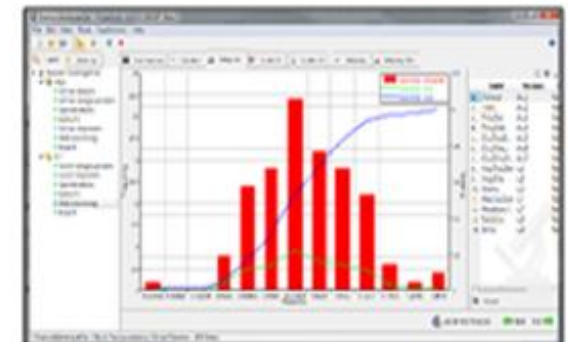
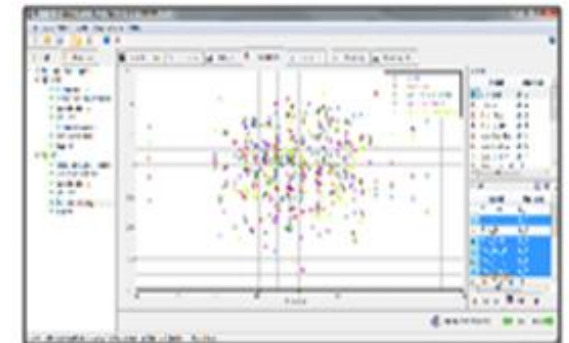
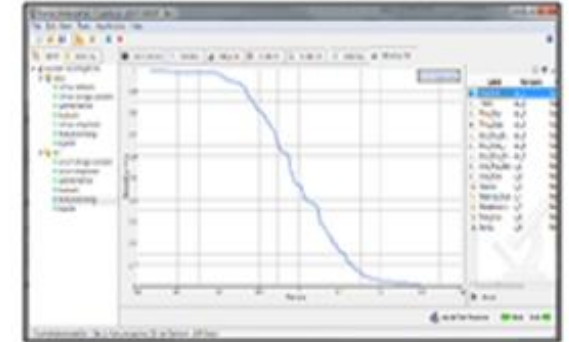
SELECT SAMPLING METHOD



RUN STOCHASTICS



EVALUATE RESULTS



A Introduction to HyperStudy - GUI Study



Hyperworks L'interfaccia utente

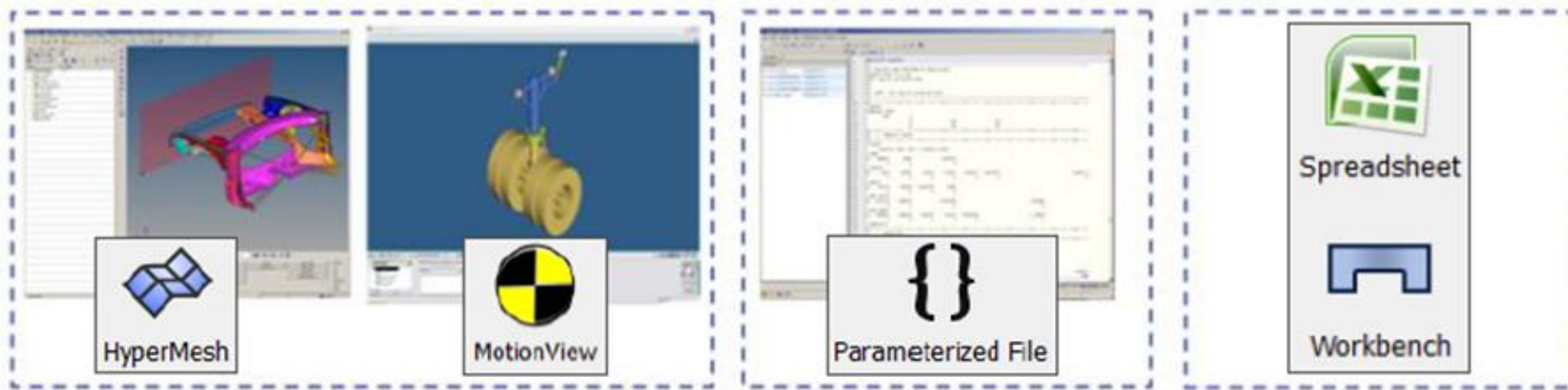
The screenshot shows the HyperStudy v13.0.0.79.584438 interface. The window title is "Example BeverageCan - HyperStudy v13.0.0.79.584438". The menu bar includes File, Edit, View, Tools, Applications, and Help. The toolbar contains icons for file operations and analysis. The Explorer and Directory pane on the left shows a tree view for "Example_BeverageCan" with sub-items: Setup, Doe 1, Fit 1, Optimization 1, and Sto 1. Each sub-item has a list of tasks with checkboxes and a corresponding icon. The main Work Area on the right displays a table of approaches and a Message Log at the bottom.

Label	Vname	Type	Comment	Time created
1 Setup	nom_1	HstApproach_Nom		-- 2013-04-29 ...
2 Doe 1	doe_1	HstApproach_Doe		-- 2014-04-23 ...
3 Fit 1	fit_1	HstApproach_Fit		-- 2014-04-23 ...
4 Optimization 1	opt_1	HstApproach_Opt		-- 2014-04-23 ...
5 Sto 1	sto_1	HstApproach_Sto		-- 2014-04-23 ...

```
09:33:20 22 Message: Javeda study ( Example_BeverageCan ( Example_BeverageCan ) )
09:35:55 23 Message: Generating design for ( Sto 1 ( sto_1 ) ) = ( Simple Random )
09:35:55 24 Message: The following variable(s) have out of bounds values, in the genera
( Diameter ( dv_1 ) )
( Weight ( dv_2 ) )
( Thick_Top ( dv_3 ) )
( Thick_Side ( dv_4 ) )
( Cost_Top_Rot_Material ( dv_5 ) )
( Cost_Side_Material ( dv_6 ) )
( Cost_Rim_Manufacturing ( dv_7 ) )
09:35:56 25 Message: Javeda study ( Example_BeverageCan ( Example_BeverageCan ) )
```



B Setup a Study - Model Types

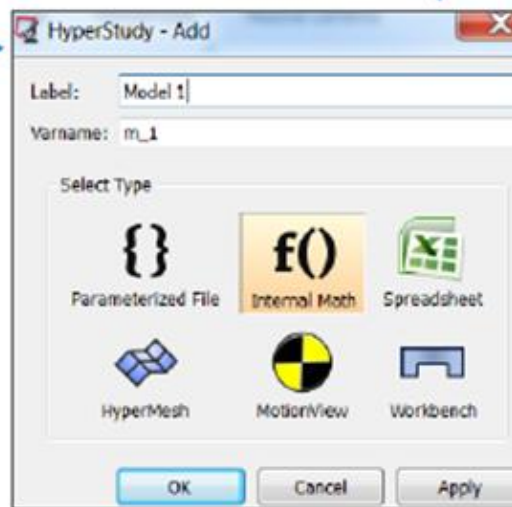


HyperWorks Pre-Processors:

- Easy and quick way to setup study

Solver Input File:

- Any entry in a ASCII format solver input files can be a design variable



Other Models:

- Easy import of variables and responses available in model files (spreadsheet for Excel; project file for Workbench)

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



B Setup a Study - Variables Definition

Discrete and Continuous Variables

In HyperStudy you can define continuous or discrete variables:

Active	Label	Varname	Model Parameter	Model Type	Data Type	Mode	Values	Role	
<input checked="" type="checkbox"/>	Thickness	m_1_Thickn...	m_1.Thickness	Template	{}	Real	Discrete	0.0020000, 0.0020000	Design
<input checked="" type="checkbox"/>	Young	m_1_Young	m_1.Young	Template	{}	Real	Continuous	7.00e+10, 2.10e+11	Design
<input checked="" type="checkbox"/>	Poisson	m_1_Poisson	m_1.Poisson	Template	{}	Real	Continuous	0.2700000, 0.3300000	Design
<input checked="" type="checkbox"/>	Density	m_1_Density	m_1.Density	Template	{}	Real	Continuous	7038.0000, 8602.0000	Design

Definizione delle variabili

- **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

Value
1 -1.0000000
2 1.0000000
3 0.0000000

Lower Bound: -1.0000000 Initial: 0.0000000 Upper Bound: 1.0000000

Value
1 0.0000000
2 0.0000000

Lower Bound: -1.0000000 Initial: 0.0000000 Upper Bound: 1.0000000

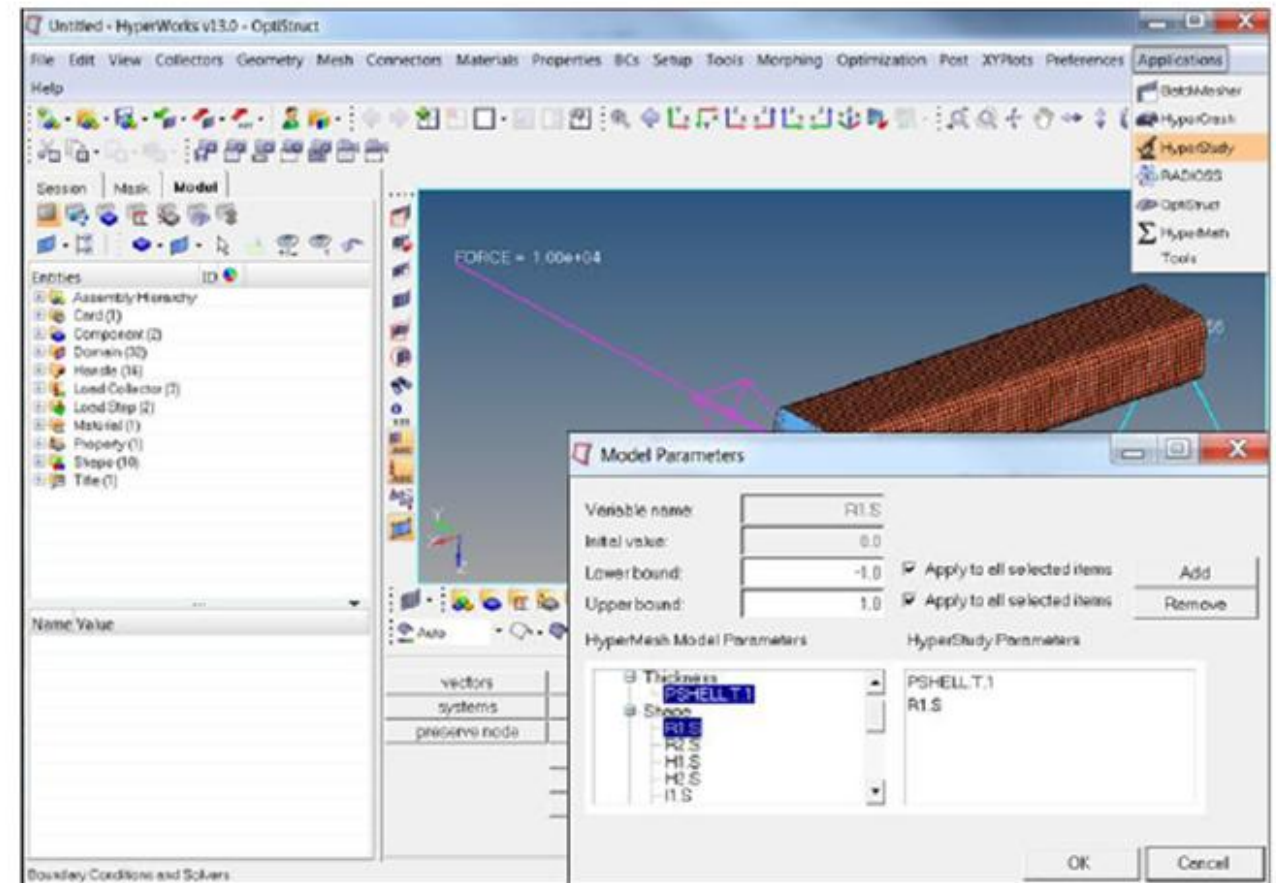
Set Steps

Number of Points: [] Set

Step Size: [] Set

B Setup a Study - HyperMesh Model Parameterization

- 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



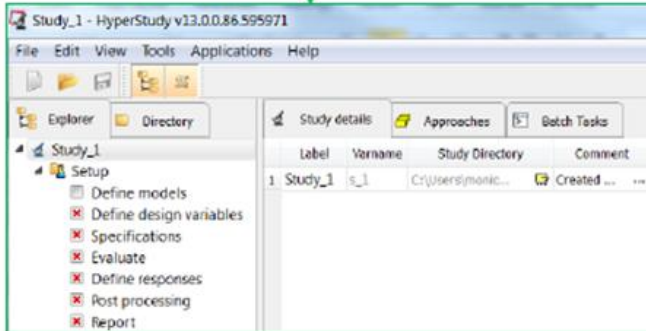
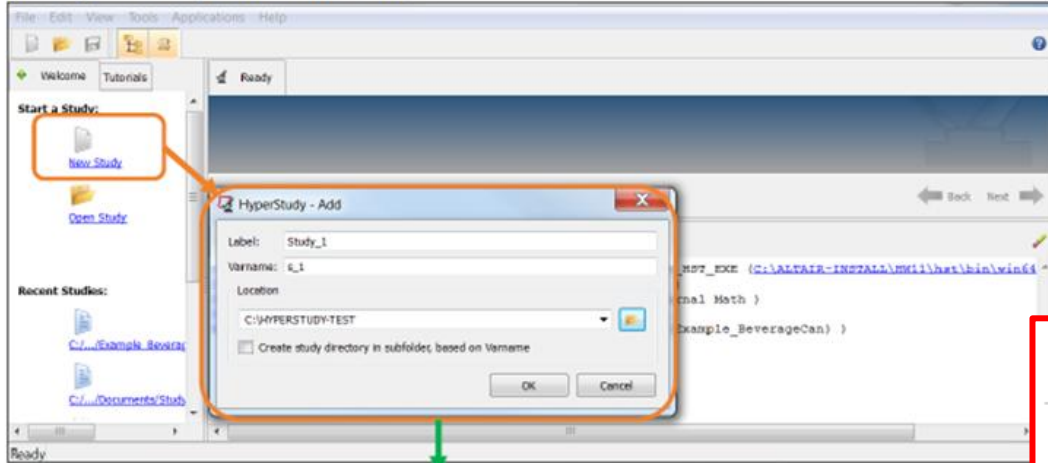
Le variabili devono consentire la parametrizzazione del modello di simulazione. Come primo passo occorre scegliere il simulatore (la sua scelta è necessaria anche per la scrittura dello script per il batch file)



B Setup a Study - HyperMesh Model Parameterization



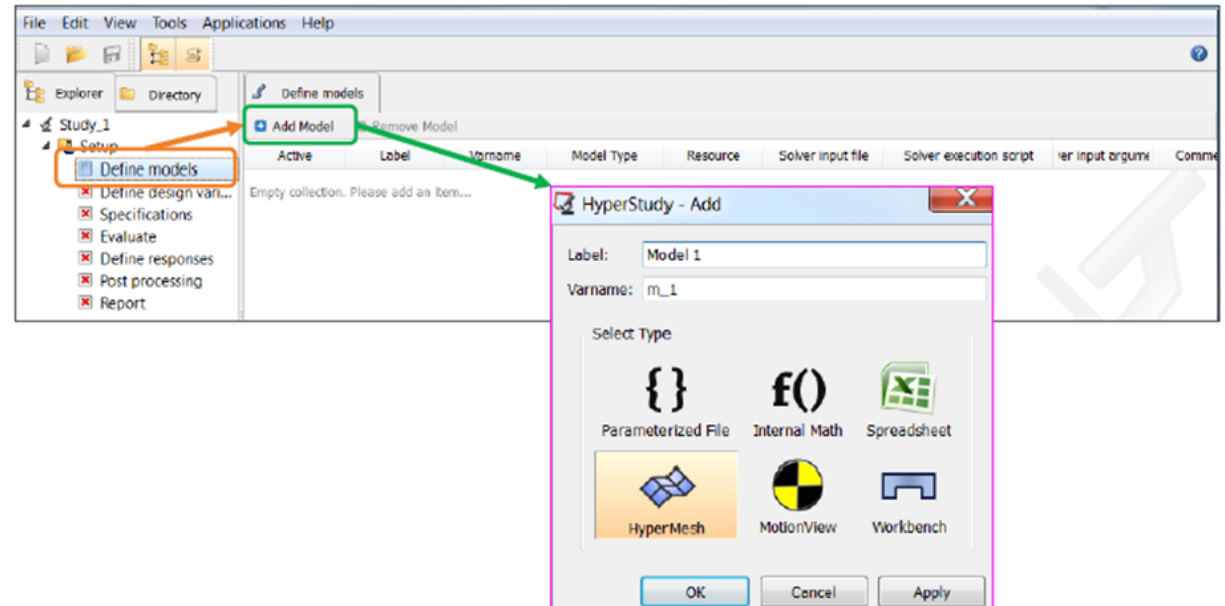
3) Add a New Study, Define Study Name (Label and Varname) and Location of the study directory (Do not use space or special characters!)



B Setup a Study - HyperMesh Model Parameterization



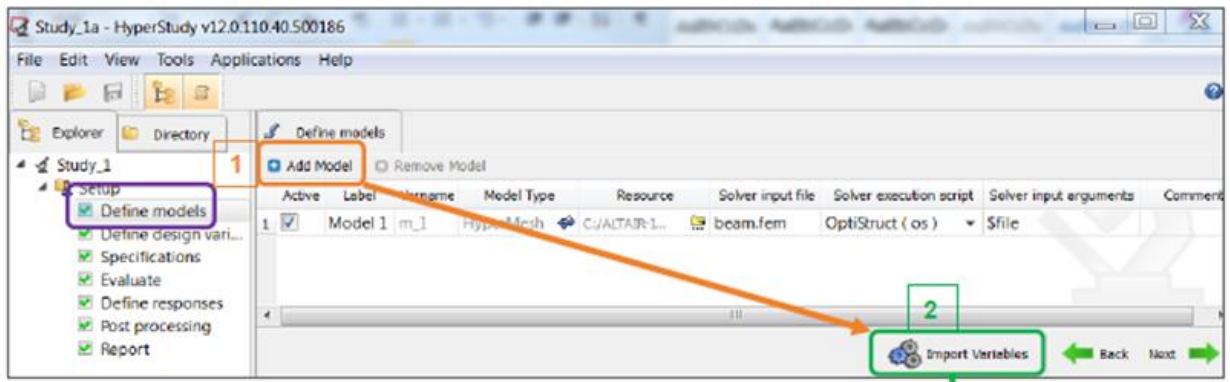
4) Define Model → Add Model: choose HyperMesh as Model Type.



B Setup a Study - HyperMesh Model Parameterization

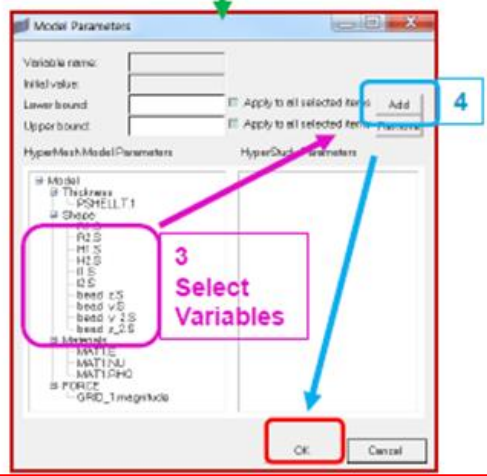


5) Define Model Parameters → Import Variables: choose HyperMesh Variables to Add.



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

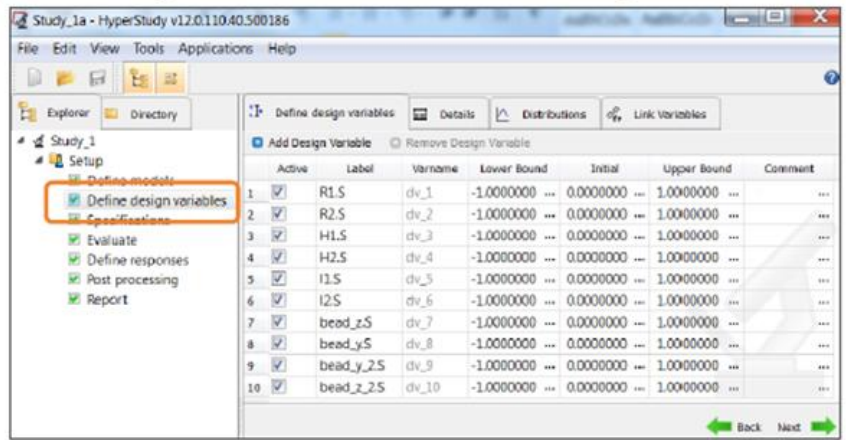
- Shell thickness
- Spring stiffness
- Concentrated mass
- Composite Properties
- Materials
- Forces
- Shapes (HyperMorph)



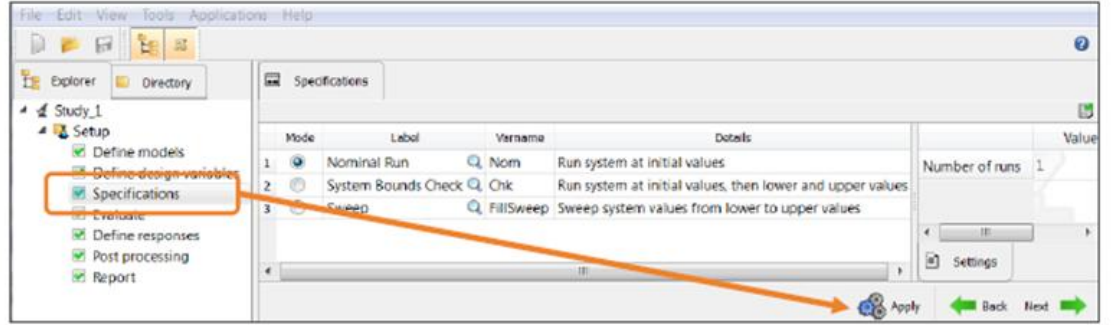
B Setup a Study - HyperMesh Model Parameterization



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



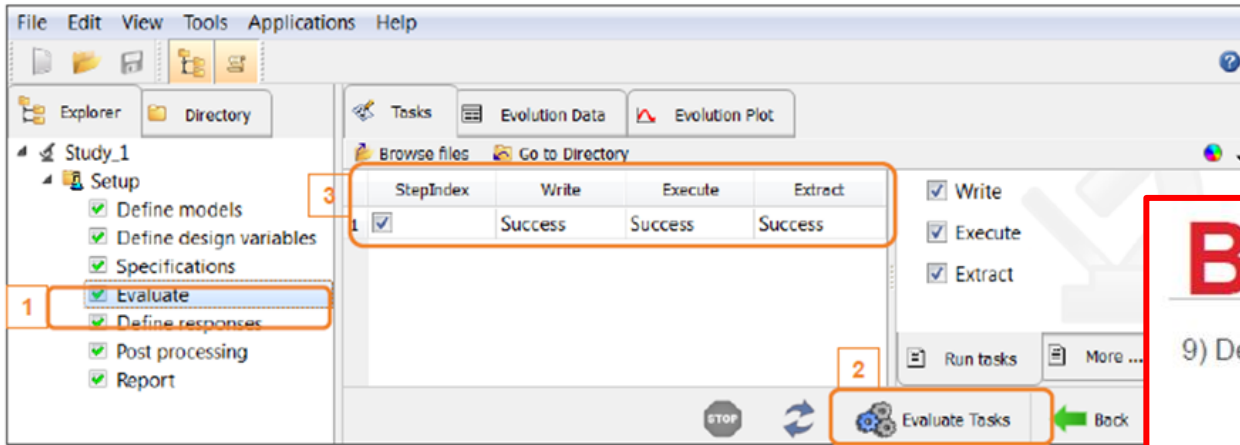
7) Study Run: Select Specifications → Nominal Run as Mode (Apply)



B Setup a Study - HyperMesh Model Parameterization



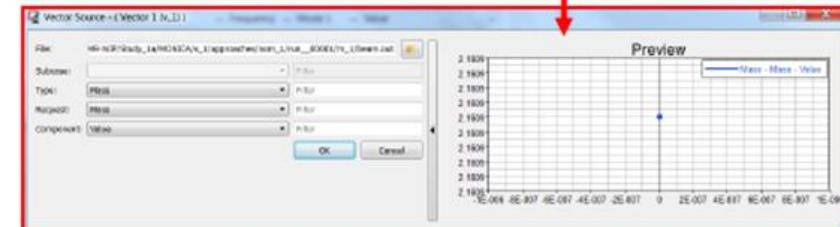
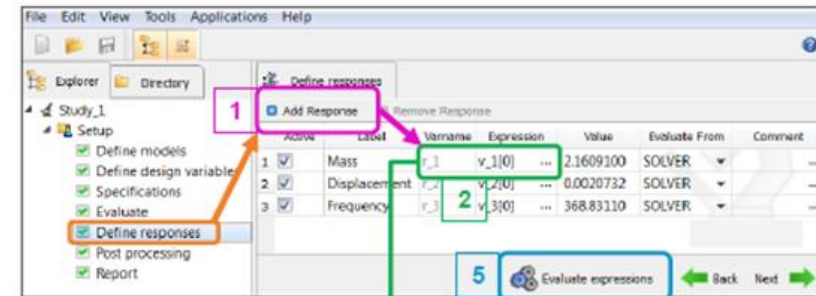
8) Study Evaluate → Select Write/Execute/Extract.



B Setup a Study - HyperMesh Model Parameterization



9) Define Responses: Expression builder and Evaluate Expression



B Setup a Study - Create Responses (Definition)



Definizione delle risposte (o obiettivi dell'analisi)

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)

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)

Active	Label	Varname	Expression	Value	Comment
<input checked="" type="checkbox"/>	Mass	r_1	v_1[0]	2.17883	...
<input checked="" type="checkbox"/>	Displacement	r_2	v_2[0]	0.0019904	...
<input checked="" type="checkbox"/>	Freq	r_3	v_3[0]	370.9352	...

Expression Builder - (Mass (r_1))

Evaluate expression

v_1 [0]

Functions Design Variables Responses File Sources ASCII Extracts

Expression Builder - (Mass (r_1))

Evaluate expression

v_1 [0]

Functions Design Variables Responses

Add Function Remove Function

	Varname	Category
1	abs	Math & Trig
2	absarea	General
3	abstorelative	General
4	acos	Math & Trig
5	addfilepath	General
6	akima	General
7	array	General
8	asc	General

Expression Builder - (Mass (r_1))

Evaluate expression

v_1 [0]

Functions Design Variables Responses

Add Design Variable Remove Design Variable

	Label	Varname	Comment
1	Thickness	m_1_Thickn...	...
2	R1	m_1_R1	...
3	R2	m_1_R2	...
4	H1	m_1_H1	...
5	H2	m_1_H2	...
6	I1	m_1_I1	...
7	I2	m_1_I2	...

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

Il response
expression
builder

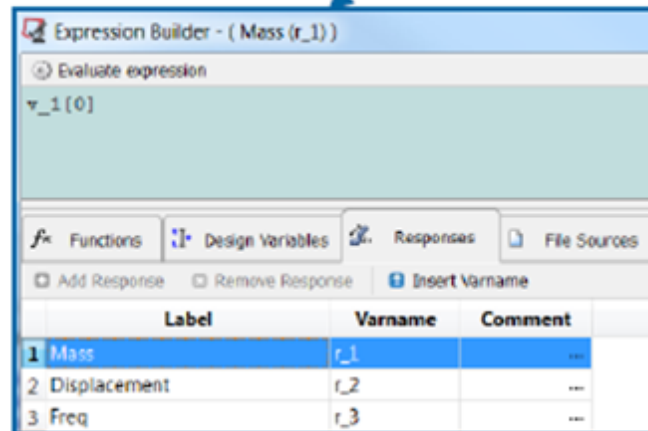
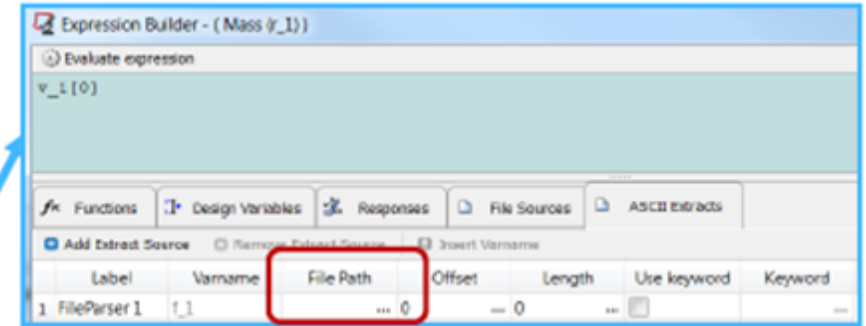
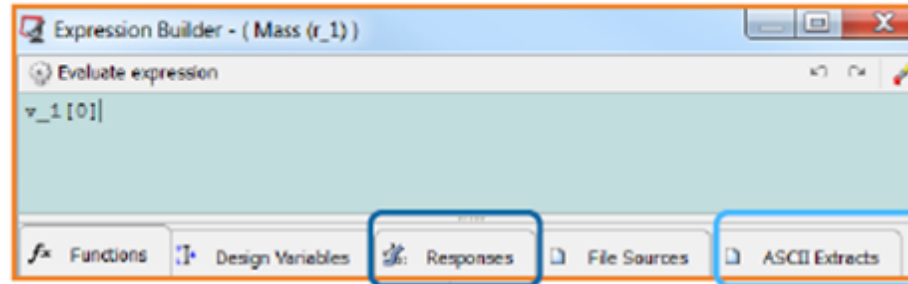


Il response expression builder

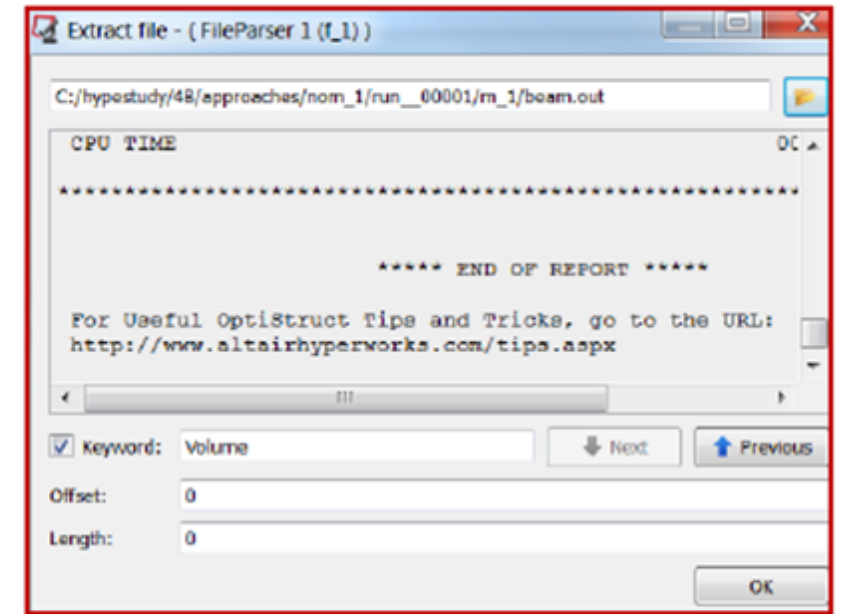
B Setup a Study - Create Responses (Definition)



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)



Expression Builder

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

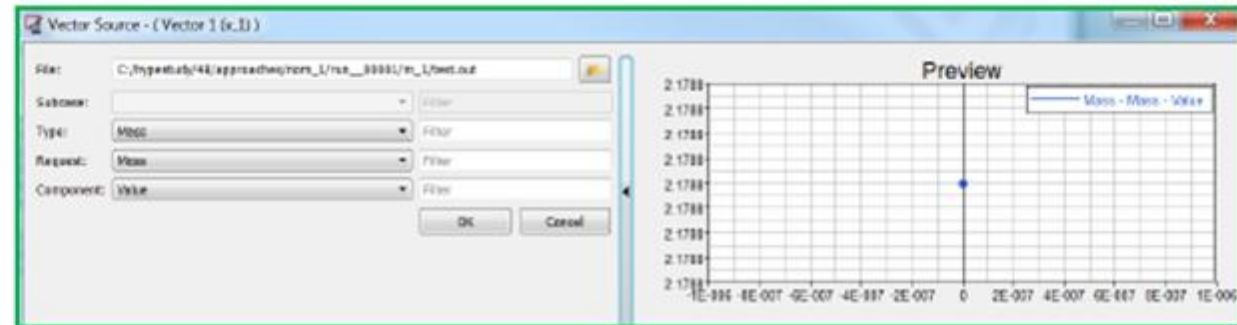
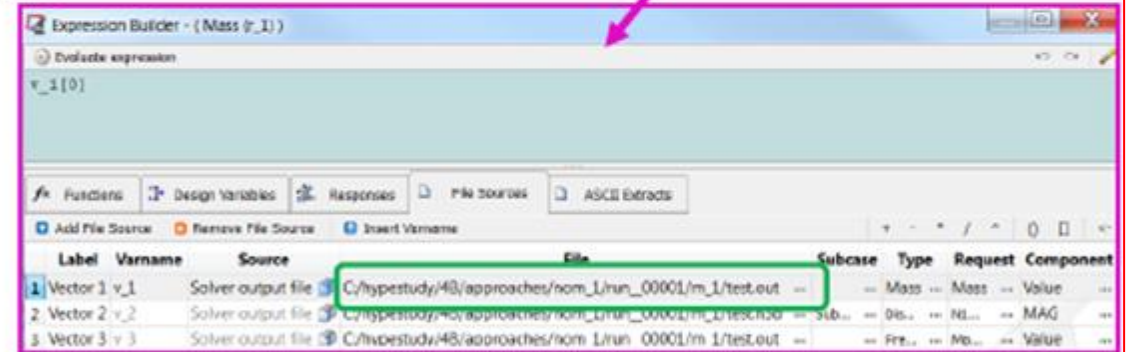
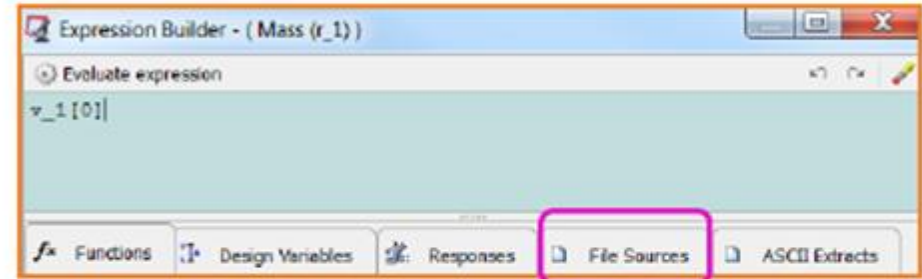
Choose Type, Request and Component Results are stored as vectors.

Study requires response to be a scalar value:

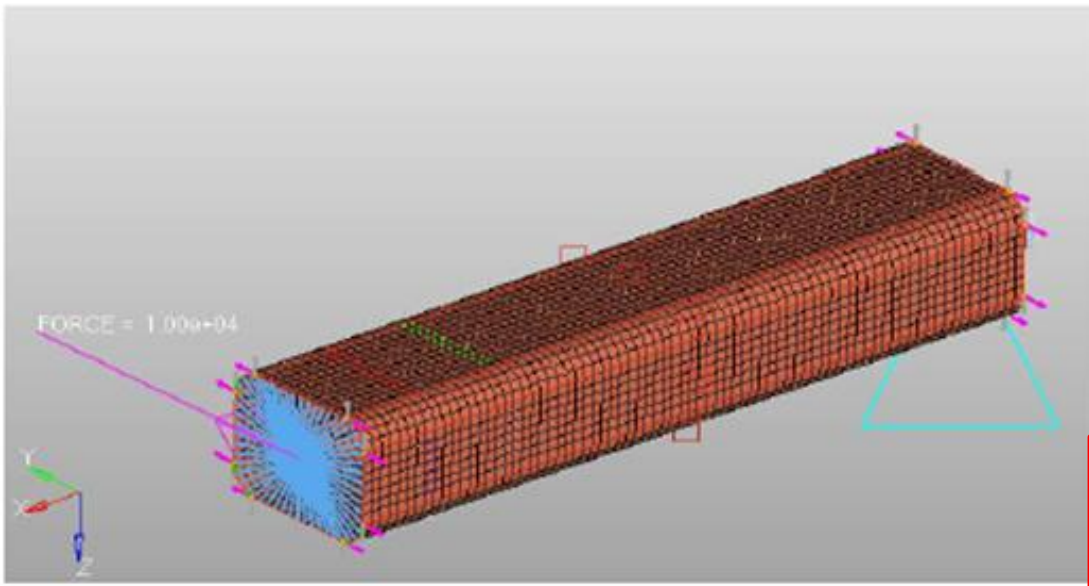
- use Tempex functions as $\min()$, $\max()$, $\text{integral}()$, ...

- Define column with [...]

- e.g. $v_1[0]$, $v_1[\text{numpts}(v_1)-1]$



Esercizio di Study Setup



B Setup a Study - Exercise 1a



Input file:
beam_shape.hm

Description:

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

Goal :

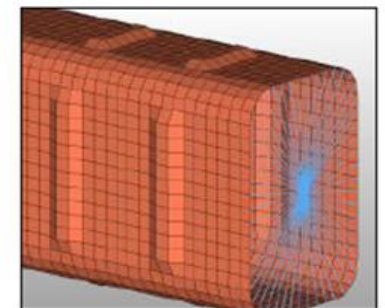
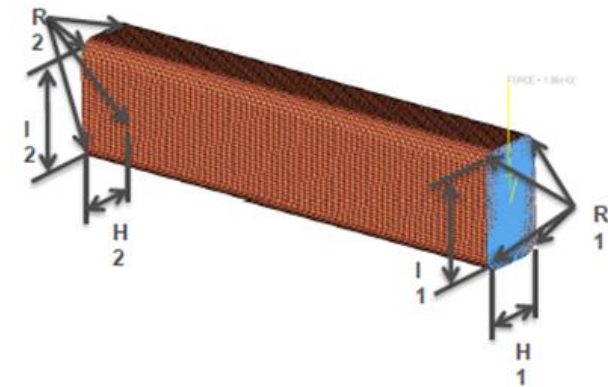
To define Th, size and shape variables with HM link

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]

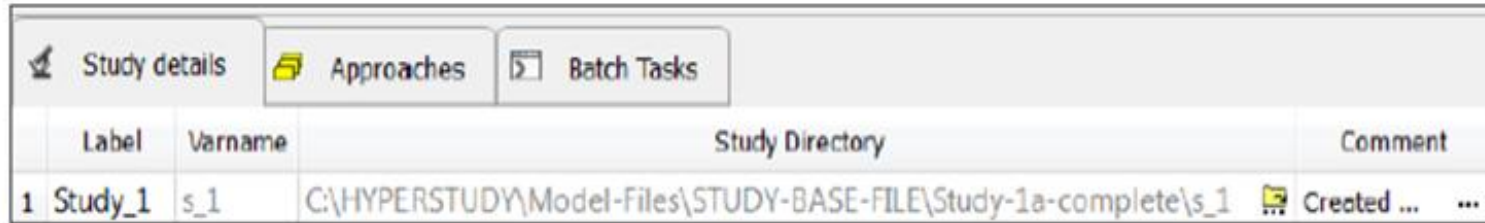


Il file è su elearning2



B Setup a Study - Exercise 1a Major Steps

- 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.



	Label	Varname	Study Directory	Comment
1	Study_1	s_1	C:\HYPERSTUDY\Model-Files\STUDY-BASE-FILE\Study-1a-complete\s_1	Created ...

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



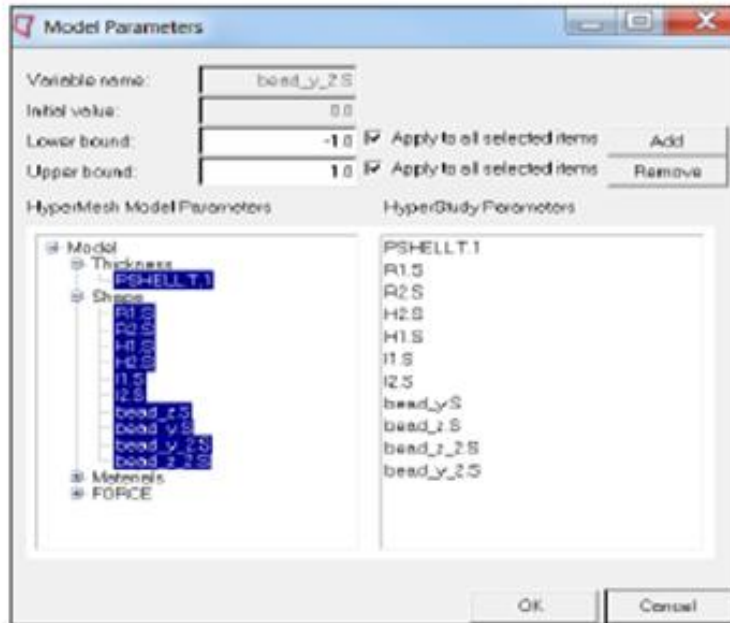
Active	Label	Varname	Model Type	Resource	Solver input file	Solver execution script	Solver input arguments
<input checked="" type="checkbox"/>	Model 1	m_1	HyperMesh	C:\HYPERSTUDY\Model-Files\Study-1a-base-files\beam_shape.hm	beam.fem	OptiStruct (.os)	\$file



B Setup a Study - Exercise 1a

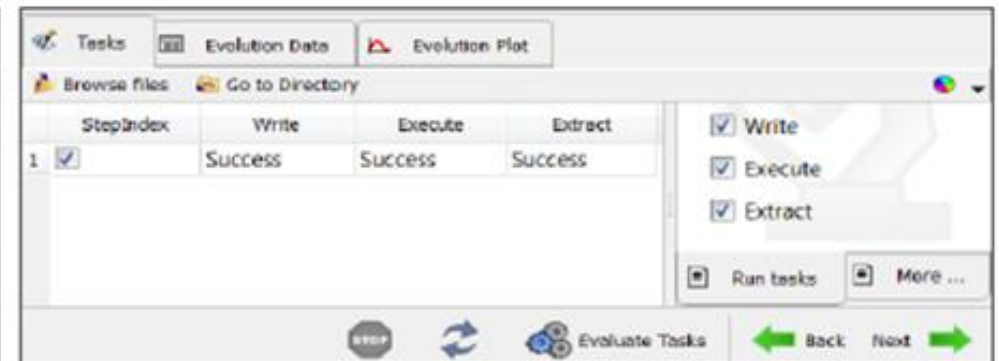
5) Add Model Parameters:

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



Active	Label	Vname	Model Parameter	Model Type	Data Type	Mode	Values	Distribution Role
<input checked="" type="checkbox"/>	PSHELL.T1	dv_1	m_1.Thickness.PROPERTIES.PSHELL.T1	HyperMesh	Real	Continuous	-1.000000, 1.000000	Design
<input checked="" type="checkbox"/>	R1.S	dv_2	m_1.Shape.SHAPES.R1.1	HyperMesh	Real	Continuous	-1.000000, 1.000000	Design
<input checked="" type="checkbox"/>	R2.S	dv_3	m_1.Shape.SHAPES.R2.2	HyperMesh	Real	Continuous	-1.000000, 1.000000	Design
<input checked="" type="checkbox"/>	H2.S	dv_4	m_1.Shape.SHAPES.H2.4	HyperMesh	Real	Continuous	-1.000000, 1.000000	Design
<input checked="" type="checkbox"/>	H1.S	dv_5	m_1.Shape.SHAPES.H1.3	HyperMesh	Real	Continuous	-1.000000, 1.000000	Design
<input checked="" type="checkbox"/>	I1.S	dv_6	m_1.Shape.SHAPES.I1.5	HyperMesh	Real	Continuous	-1.000000, 1.000000	Design
<input checked="" type="checkbox"/>	I2.S	dv_7	m_1.Shape.SHAPES.I2.6	HyperMesh	Real	Continuous	-1.000000, 1.000000	Design
<input checked="" type="checkbox"/>	bead_y.S	dv_8	m_1.Shape.SHAPES.bead_y.8	HyperMesh	Real	Continuous	-1.000000, 1.000000	Design
<input checked="" type="checkbox"/>	bead_z.S	dv_9	m_1.Shape.SHAPES.bead_z.7	HyperMesh	Real	Continuous	-1.000000, 1.000000	Design
<input checked="" type="checkbox"/>	bead_x_2.S	dv_10	m_1.Shape.SHAPES.bead_x_2.10	HyperMesh	Real	Continuous	-1.000000, 1.000000	Design
<input checked="" type="checkbox"/>	bead_y_2.S	dv_11	m_1.Shape.SHAPES.bead_y_2.9	HyperMesh	Real	Continuous	-1.000000, 1.000000	Design

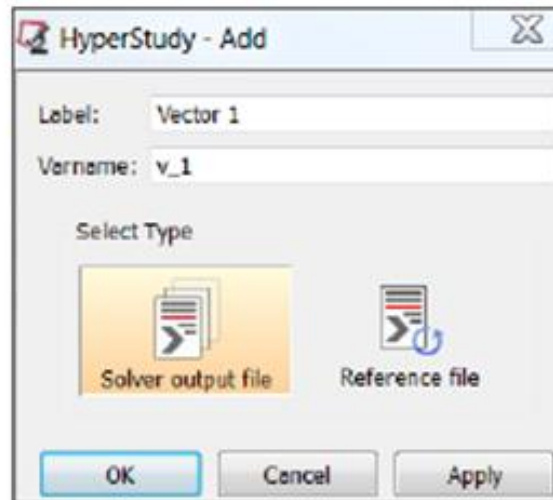
6) Submit the nominal run: Specification tab (Apply & Evaluate)



B Setup a Study - Exercise 1a

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



	Active	Label	Varname	Expression	Value
1	<input checked="" type="checkbox"/>	Mass	r_1	v_1[0] ...	2.1609100
2	<input checked="" type="checkbox"/>	Displacement	r_2	v_2[0] ...	0.0020732
3	<input checked="" type="checkbox"/>	Frequency	r_3	v_3[0] ...	368.83110

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.