Road safety through FEM simulations: concepts and criteria towards a 0-deaths strategy

Results and discussion

Phd. Eng. Monica Meocci

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The FEM Results

One finite element analysis allows us to observe and measure all the factors that characterize the real phenomenon and quantify the influence of each one.

Results form: **d3plot**

Post-processing activity

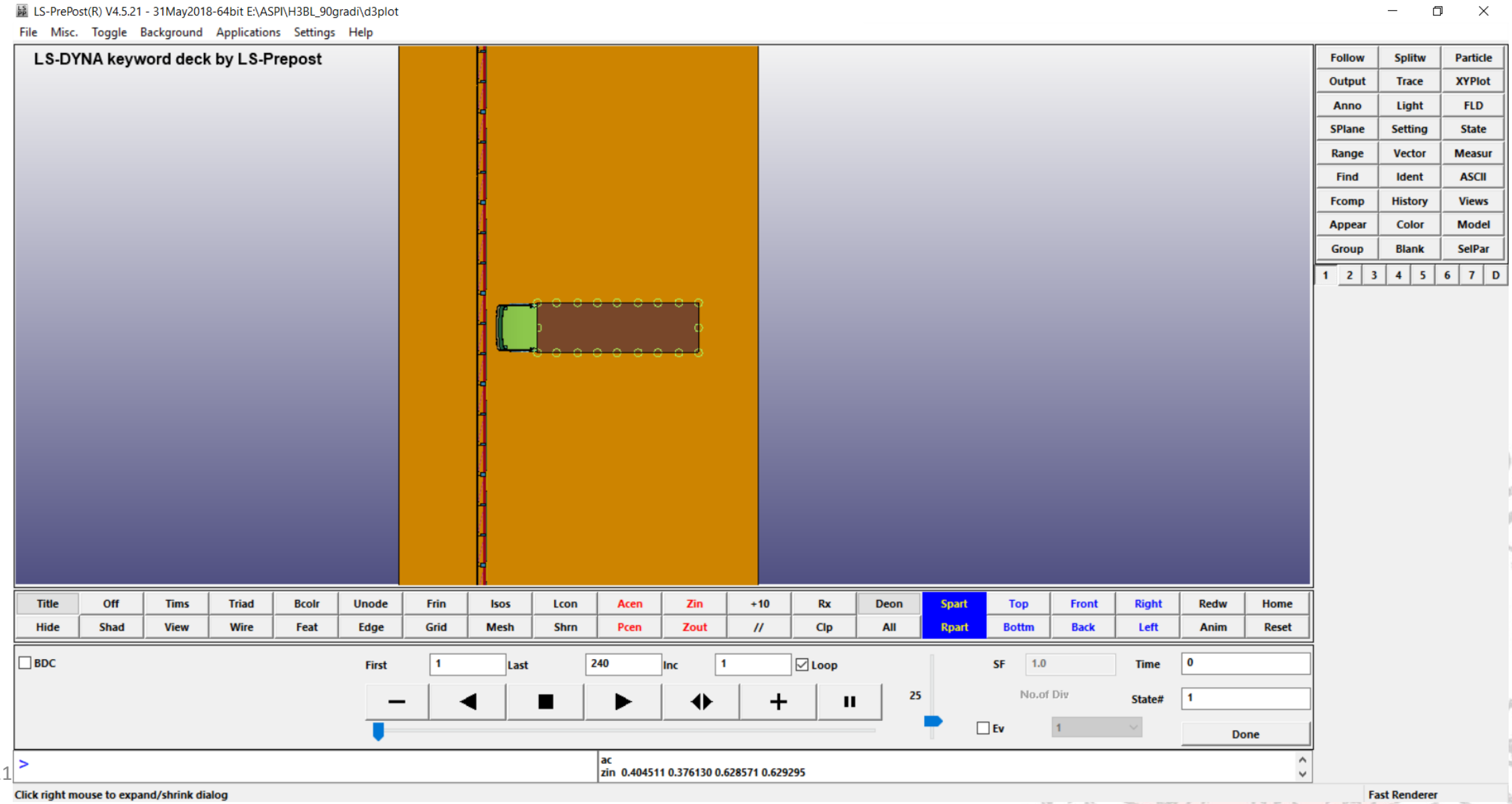
LS PREPOST

Video

Data…

- Energy
- Velocity
- Deformations
- Displacements

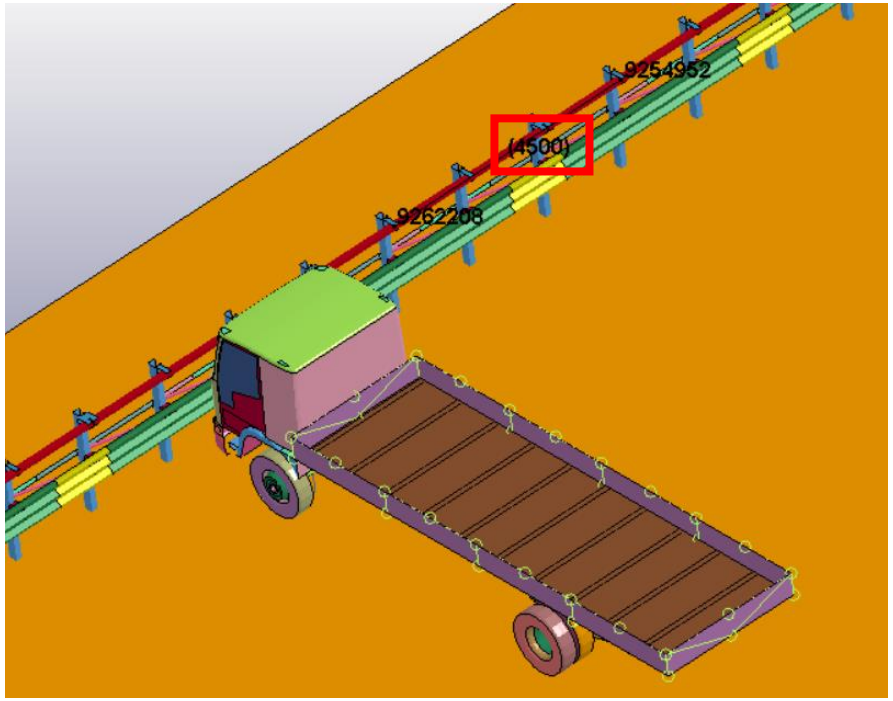
Post-processing

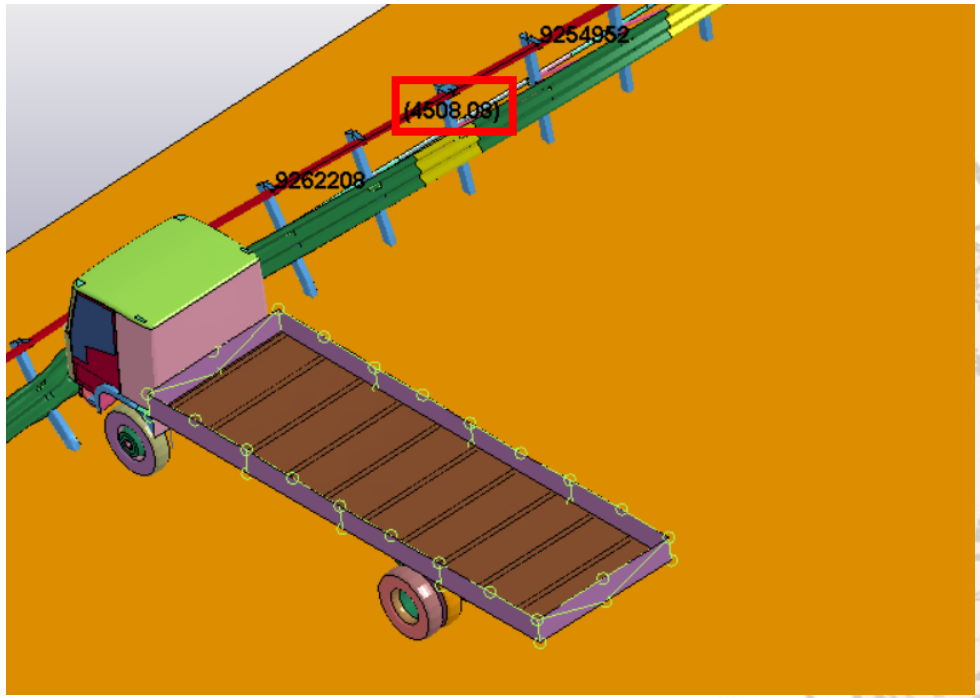


The FEM Results

In detail:

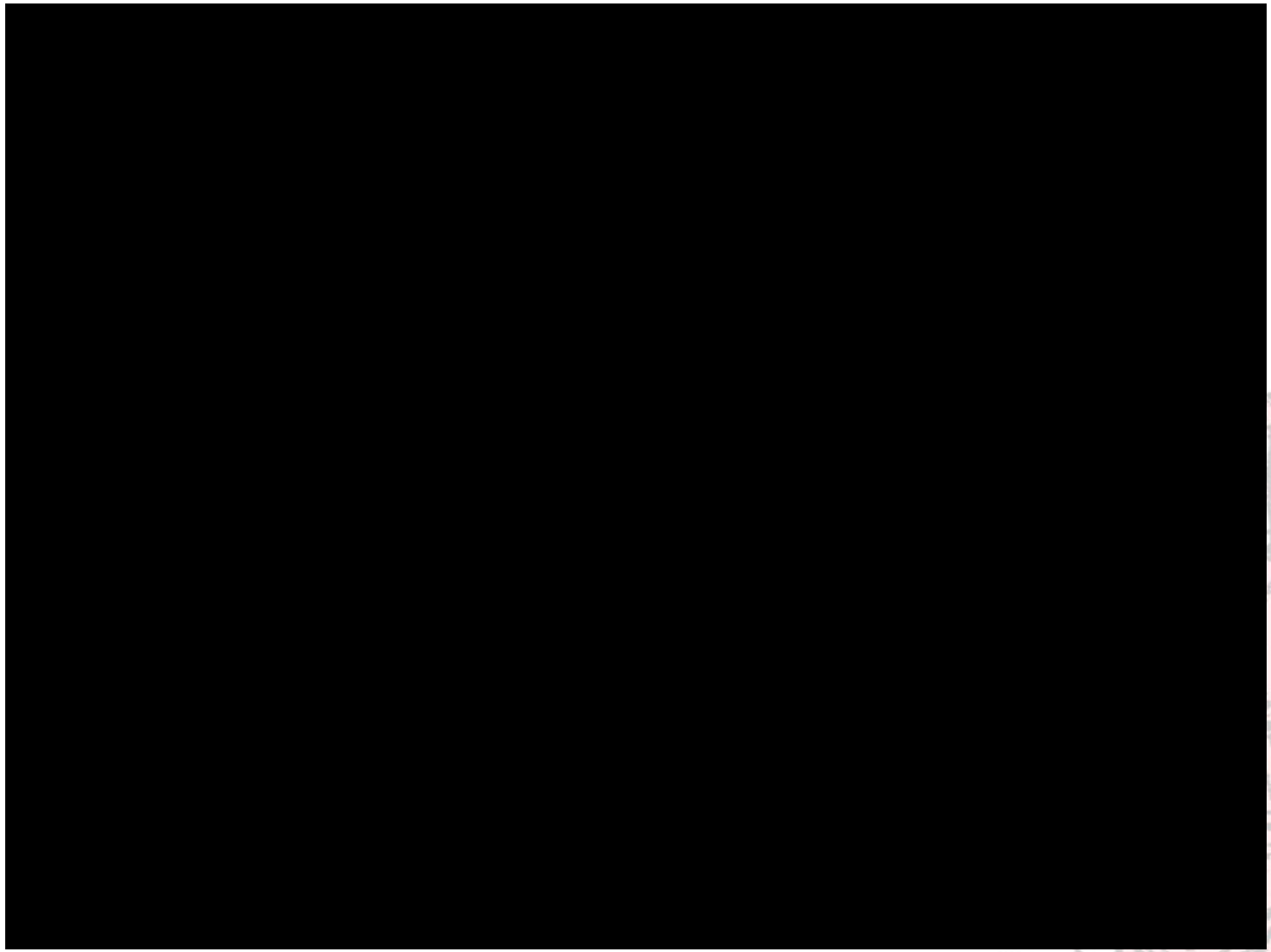
The post-processing tools have the main functionalities of CADs and therefore allow to obtain all the information on static and dynamic "geometries"
es. barrier displacement





Limit:
The outputs are locally (for each element)
…precision

The FEM Results



The FEM Results

In detail:

The SW generates result files for all the nodes that the user wants to record (to be defined during the modelling activity)

The output are the following:

- dynamic info (i.e. velocity, acceleration, …);
- static info (position, …);
- tensional info (stress, strain, …);
- energetic info (kinetic, potential, total …).

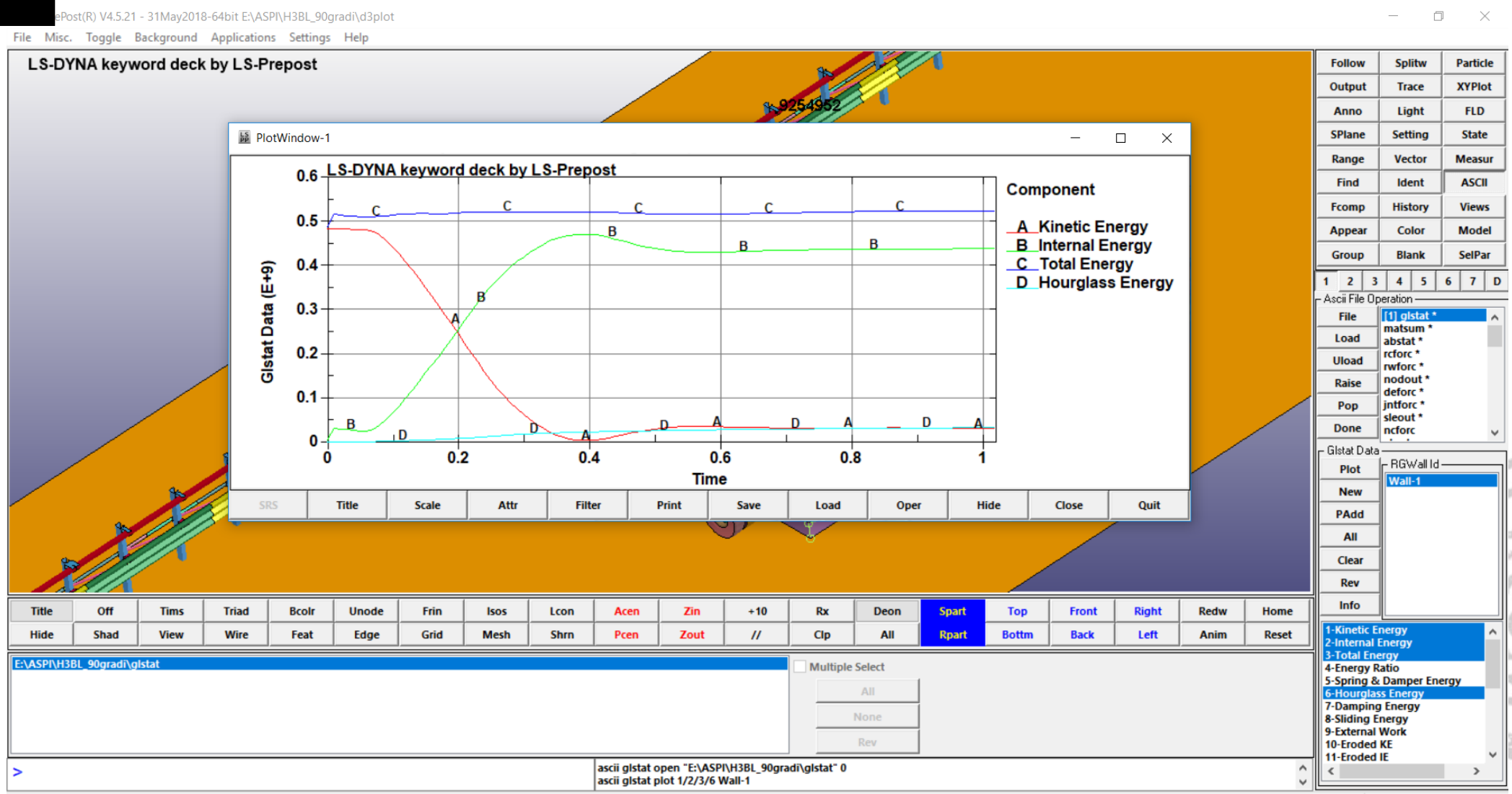
nodout

elout

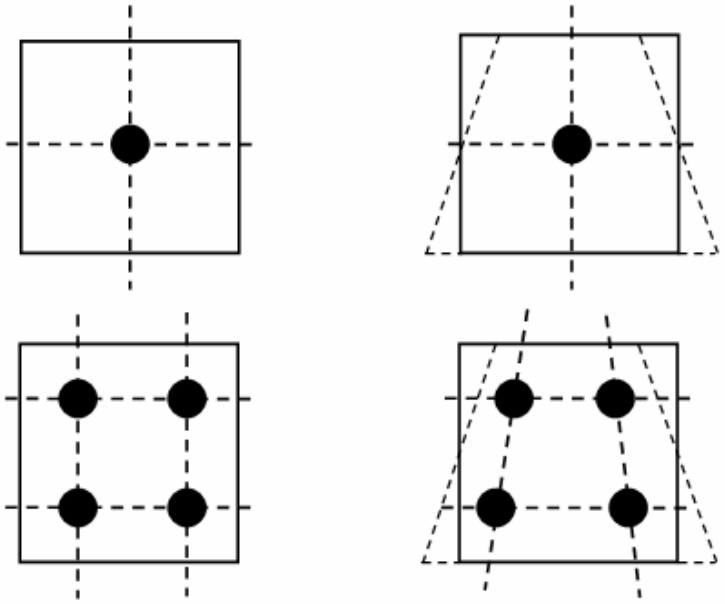
glstat

The FEM Results

glstat



Hourglass energy



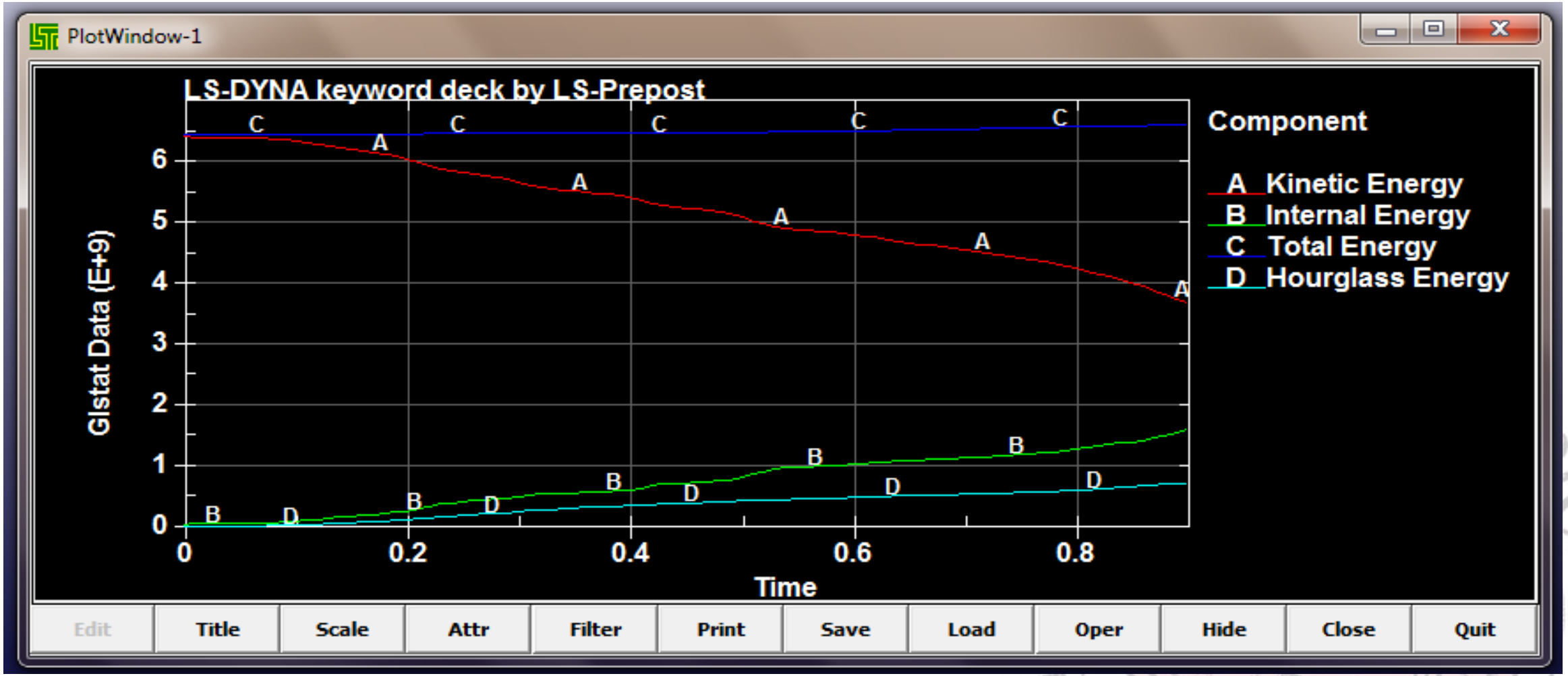
This phenomenon is amplified when a minimum number of integration points is imposed in a given element of the model.

In this way deformed configurations of the element may exist in which the points of integration do not move.

Therefore, using a single point of integration means that no variation is felt even if the element is deformed: it is a paradox since the element deforms without using energy.

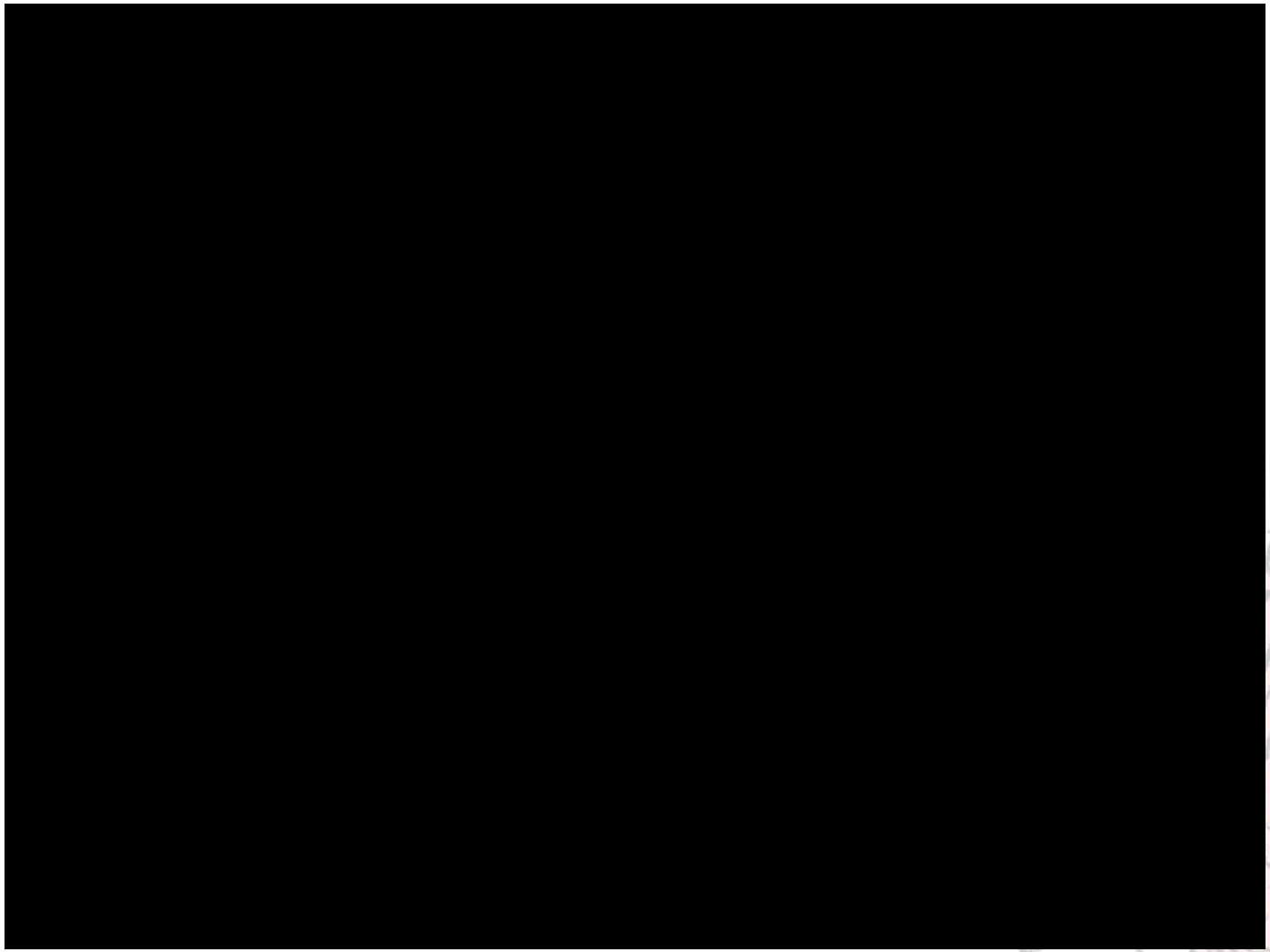
At the end of the simulation this phenomenon subtracts a certain amount of energy from the entire system, thus distorting the results obtained.

Hourglass energy



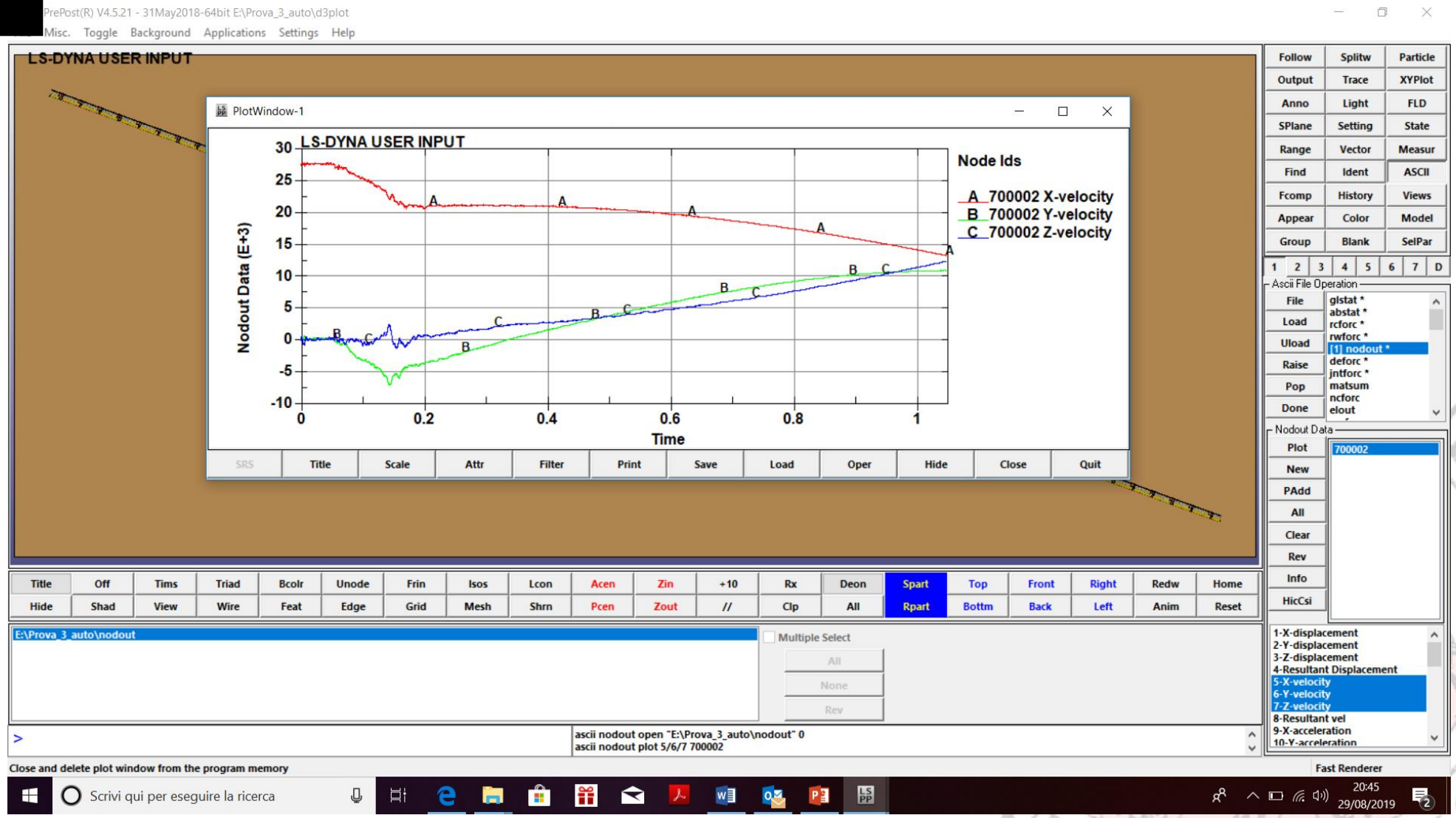
The FEM Results

nodout



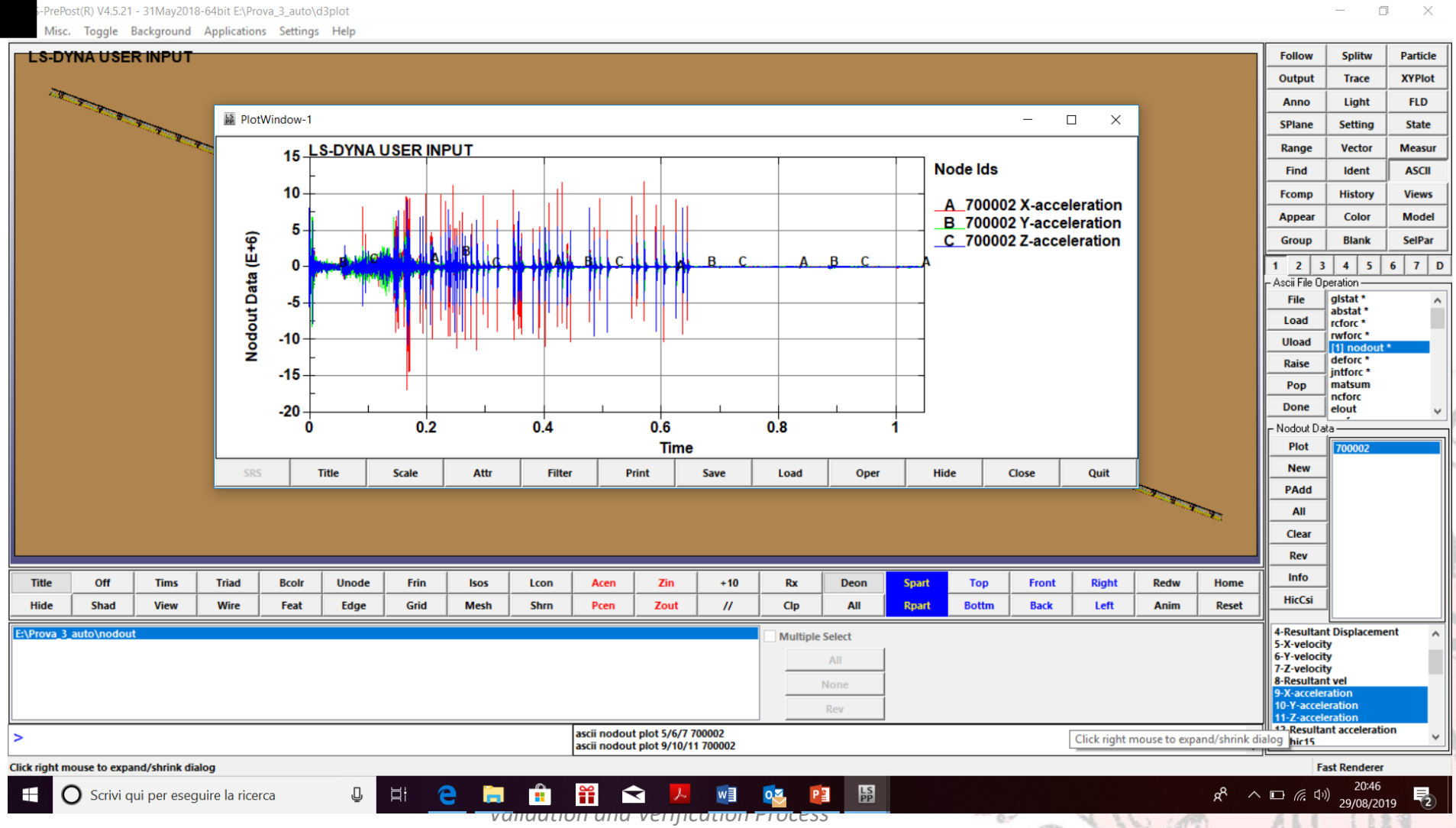
The FEM Results

nodout



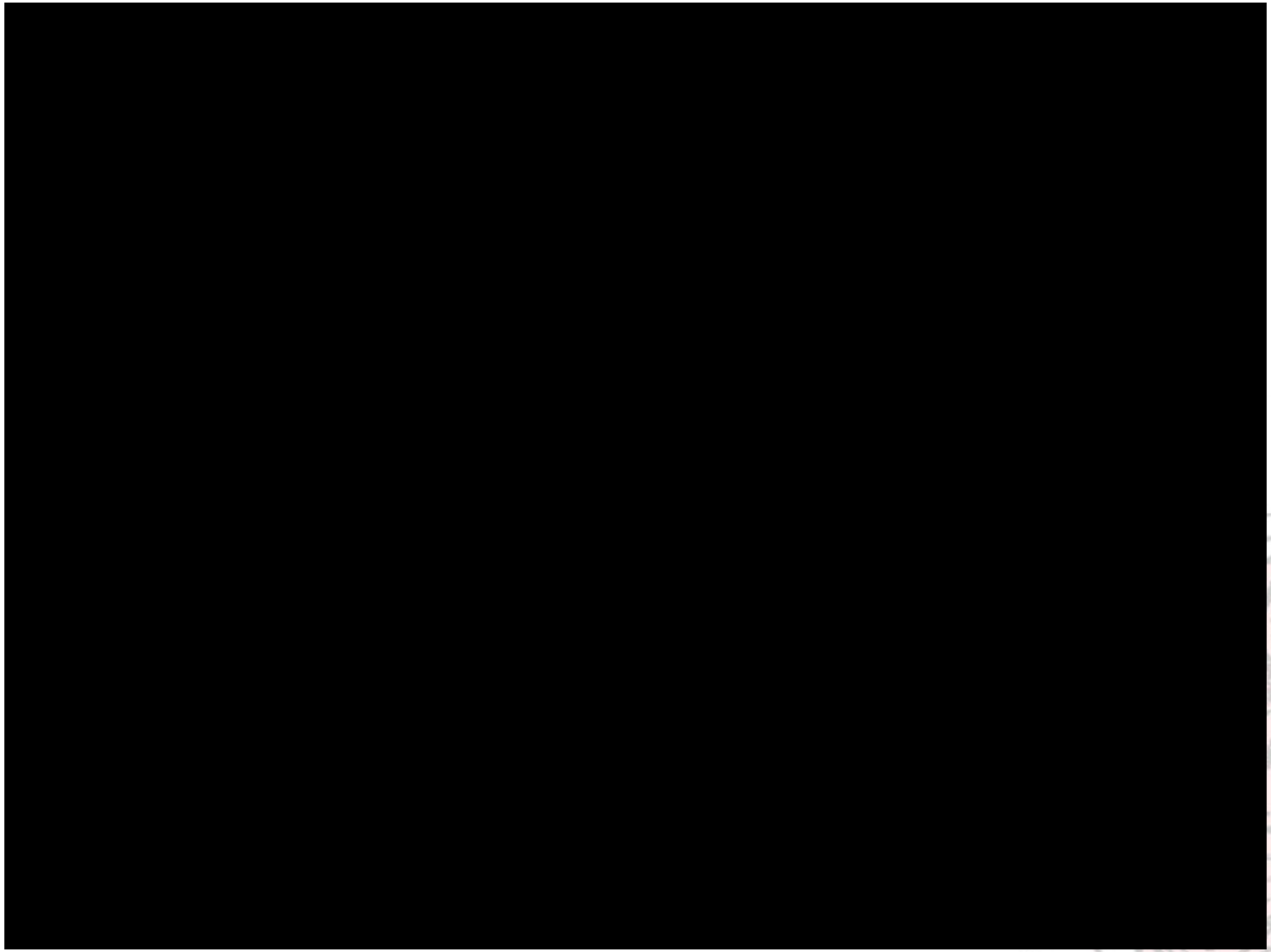
The FEM Results

nodout



The FEM Results

eleout



A practically example

objective

Design a temporary barrier for opening by-passes during winter season

needs

Design a new barrier → referring to the existent device of Autostrade per L'Italia SpA.

State of the Art

Selection of the «best device» between the existing one

Modeling of the «starting» device

Define the new requirements

Define the new geometry

Analyze the behaviour of the new device

A practically example

Definition and design a device allowing to protect the ends of the temporarily open bypasses;

Geometric requirements:

- maximum length: 5.00 m in order to leave the space for snow clearing in the middle of the bypass;
- maximum width of 0.62 m equal to the maximum width of the foot of the New Jersey traffic barrier;

Other requirements:

- ability to withstand the impact of a heavy vehicle provided by the TB 51 test (bus with a mass of 13,000 kg at a speed of 70 km/h and angled by 20 °) for both directions of travel;
- redirective.
- possibility of being installed and removed in a short time, if necessary.

A practically example

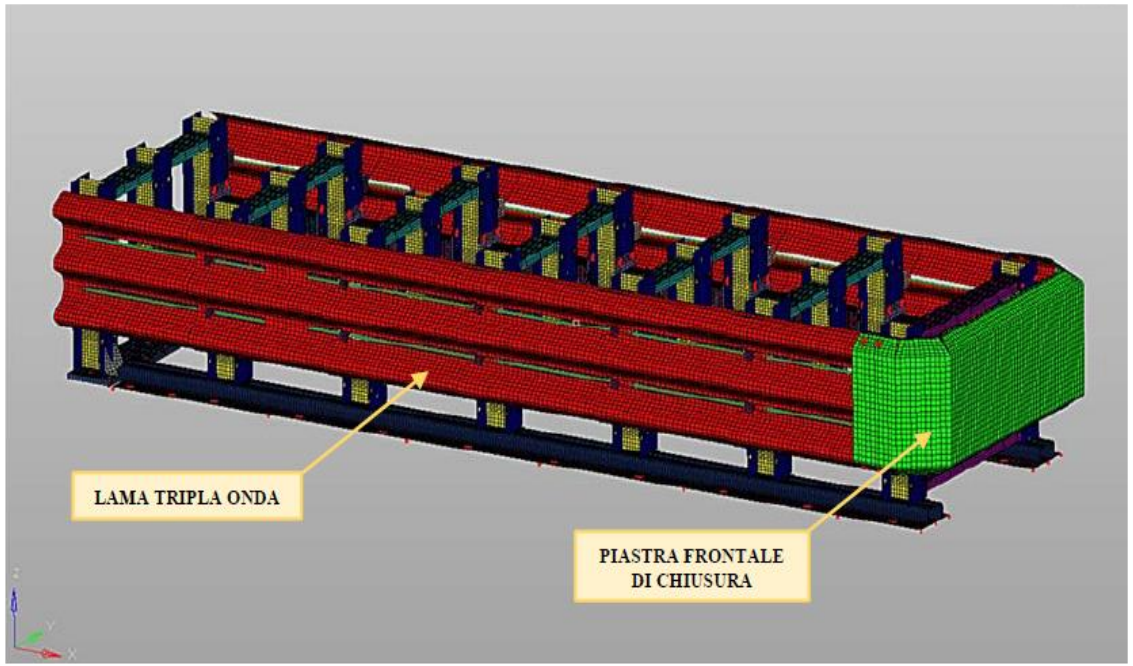
Definition and design a device allowing to protect the ends of the temporarily open bypasses;

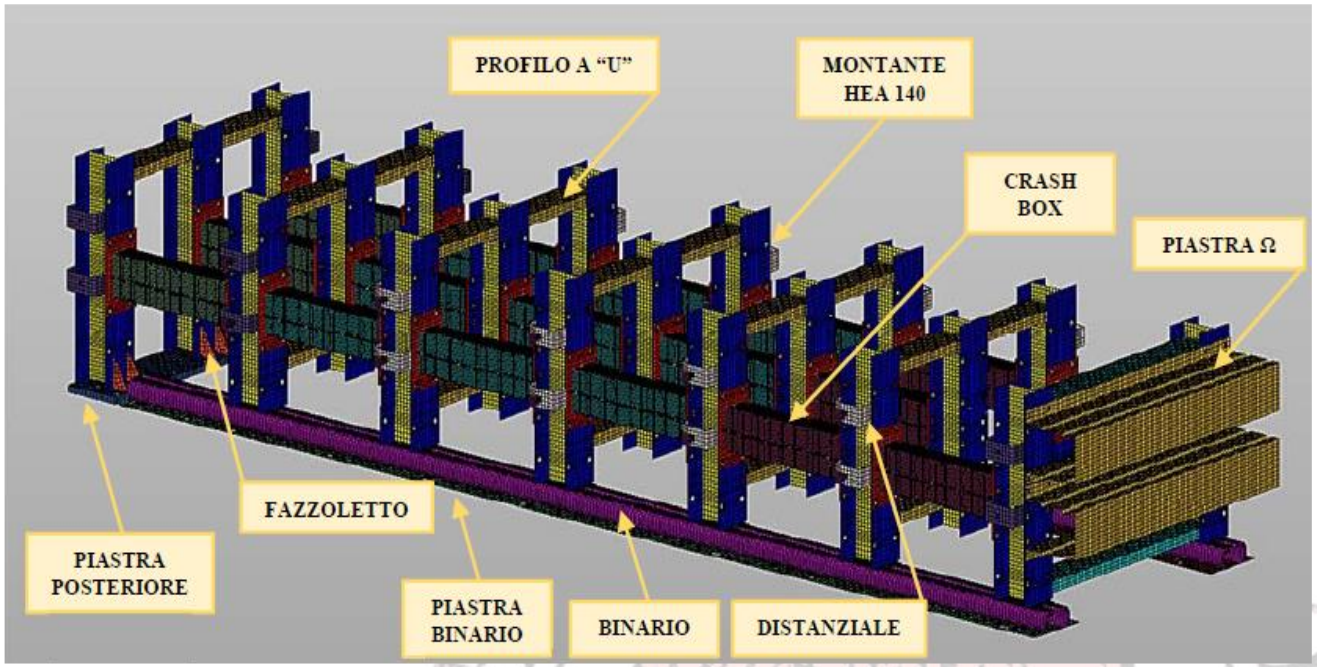
«starting» device

Dimensions:
Length 4164 mm
height 713 mm
width 1323 mm.

A practically example

FEM model of starting device





A practically example

Modelling activity:

- modelling of the average surface of all the elements then characterized with two-dimensional elements of shell type;
- modelling of the real solid of all the elements then characterized with three-dimensional elements of solid type;
- modelling of bolted connections by means of one-dimensional beam type elements;
- modelling of rigid connections by means of rigid one-dimensional elements.

A practically example

- Come per gli altri modelli è stata utilizzata una mesh con formulazione di tipo Belytschko-Tsay. Gli elementi utilizzati hanno una forma regolare al fine di limitare i possibili fenomeni di instabilità legati alla formazione di volumi negativi.
- Gli elementi shell di dimensione minore sono 12x12 mm, quelli di dimensione maggiore non superano 25x25 mm.
- Gli elementi solid utilizzati per la modellazione del binario hanno invece non superiore a 10x10x10 mm.
- Gli elementi beam sono stati modellati con le reali dimensioni delle connessioni (bulloni e/o punti di saldatura) tramite essi rappresentati.
- Le saldature sono state modellate dando continuità strutturale agli elementi uniti nell'ipotesi che non costituiscano i punti deboli della struttura. Le unioni bullonate sono state rappresentate tramite elementi beam collegati a rigid-

A practically example

The smaller shell elements are 12x12 mm, the larger ones do not exceed 25x25 mm.

Belytschko-Tsay formulation was used

The solid elements used have a size not exceeding 10x10x10 mm.

The beam elements have been modelled with the real dimensions of the connections (bolts and / or welding points).

The welds have been modelled giving structural continuity to the elements joined in the hypothesis that they do not constitute the weak points of the structure.

The bolted joints were represented by beam elements connected to rigid-bodies built on the various components of the device so as to allow a modelling able to simulate also the eventual breaking of the bolting for cutting and/or traction.

A practically example

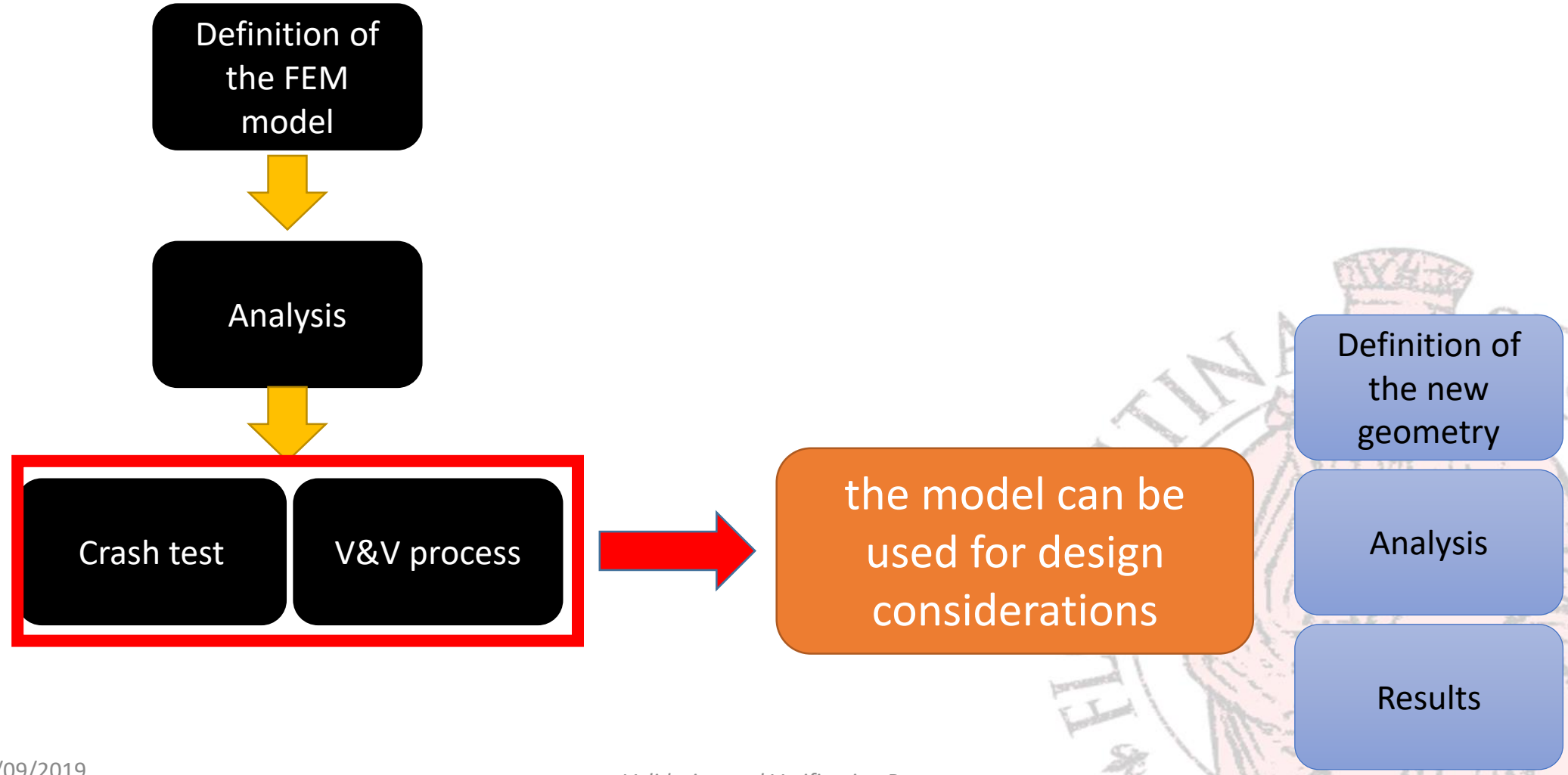
Material charecteristics

Materiale	r [t/mm3]	E [N/mm3]	n [-]	f_y [N/mm2]	E_{tan} [N/mm3]	e_u [-]	C	P
Acciaio S235 JR	1.890e-9	2.100e+5	0.3	235	822	0.22	90	4.5
Acciaio S275 JR	1.890e-9	2.100e+5	0.3	275	571	0.19	90	4.5
Acciaio - bulloni 8.8	1.890e-9	2.100e+5	0.3	640	1367	0.12	90	4.5

M24

An elasto-plastic material with an arbitrary stress versus strain curve and arbitrary strain rate can be defined by the user.

A practically example

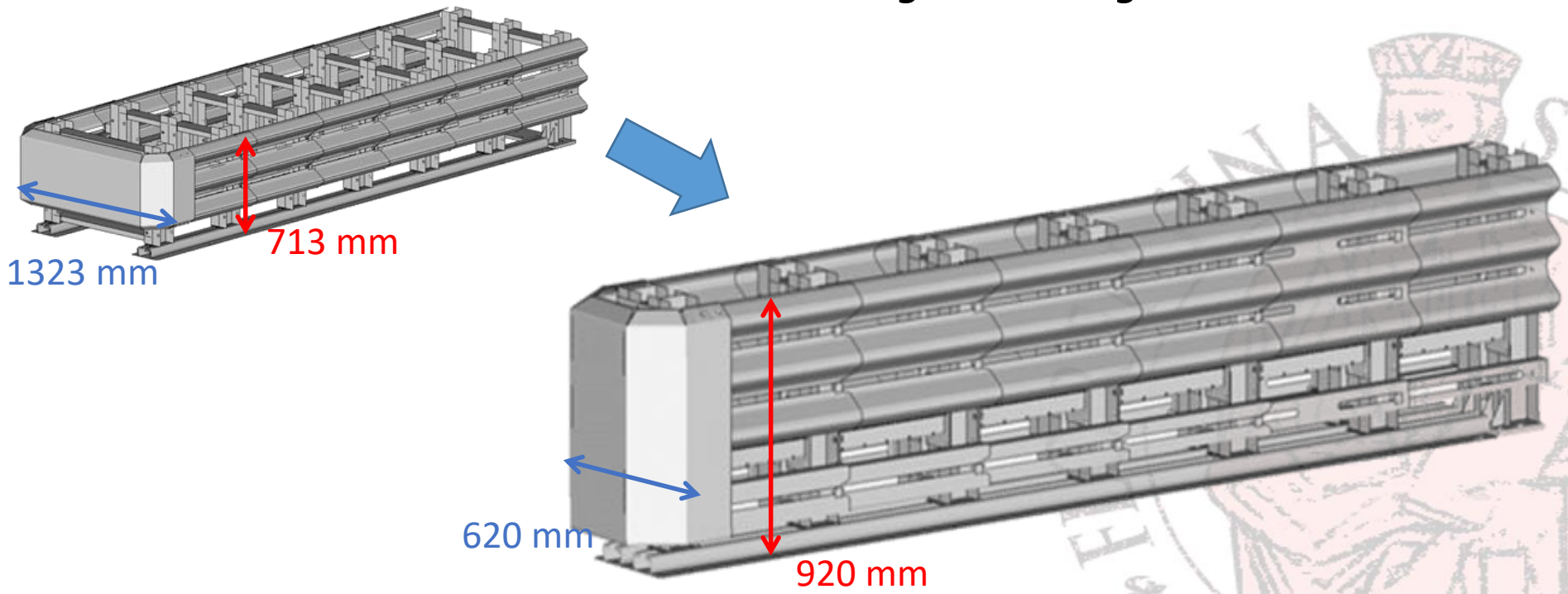


A practically example

New DEVICE

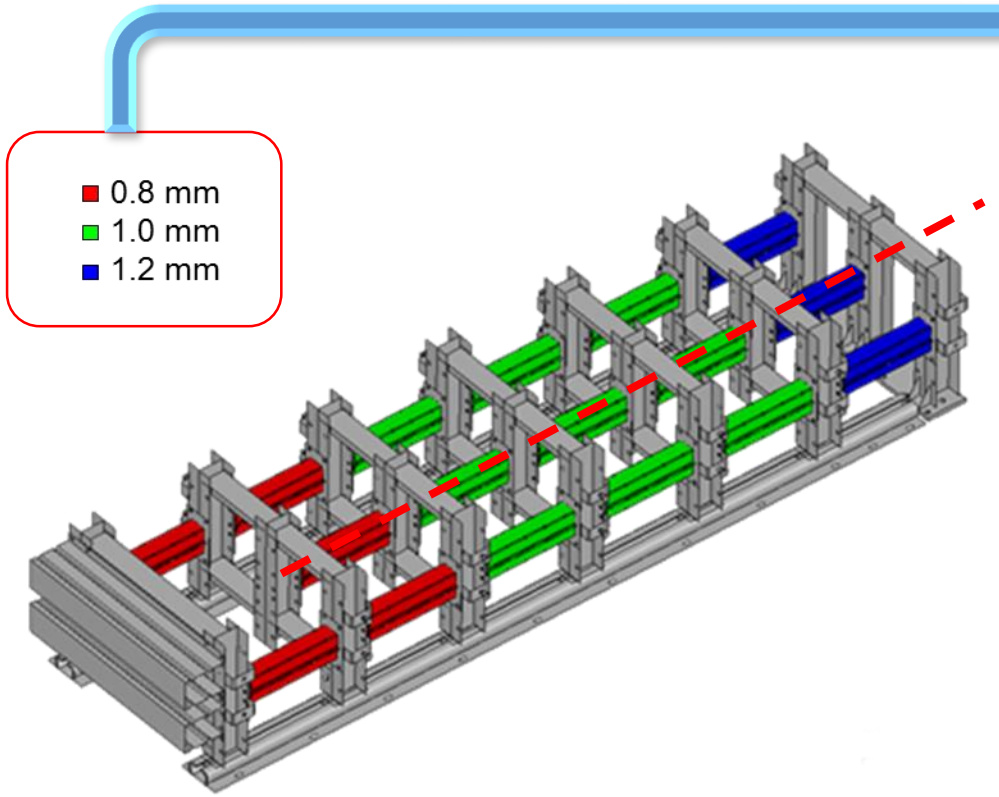
Dimensional requirements:

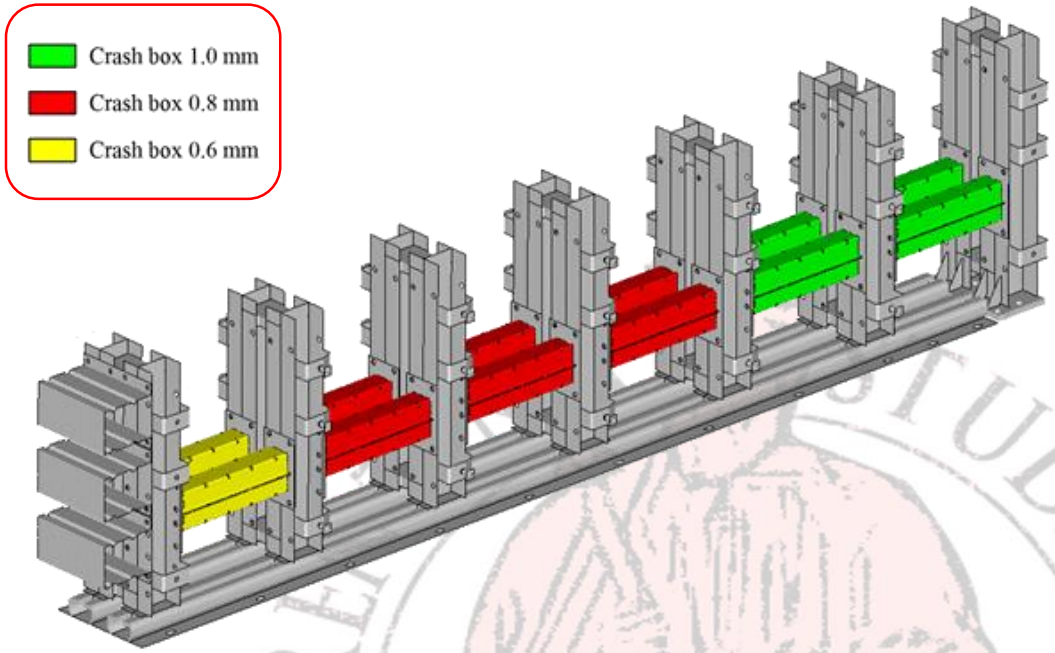
- ***Width: from 1323 mm to 620 mm;***
- ***Height: from 713 to 920 mm;***
- ***Lenght: unchanged***



A practically example

New DEVICE





Reduction of the number of crash boxes resulting from the dimensional change

A practically example

EN 1317-3:2010 – CRUSH CUSHION 80/1

Il dispositivo di progetto è stato analizzato nelle seguenti configurazioni:

- ***TC 1.2.80: frontal impact (1300 kg, 80 km/h);***
- ***TC 2.1.80: frontal impact with offset 25% (900 kg, 80 km/h);***
- ***TC 4.2.80: side impact (15°, 1300 kg, 80 km/h);***
- ***TC 5.2.80: side impact(165°, 1300 kg, 80 km/h).***

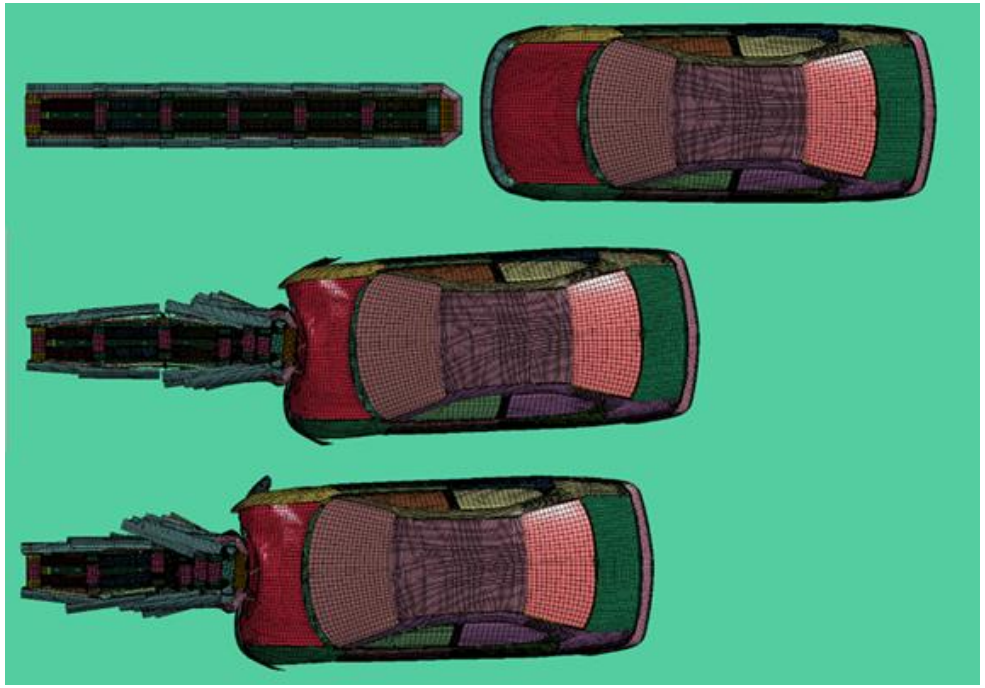
Symmetrical behavior

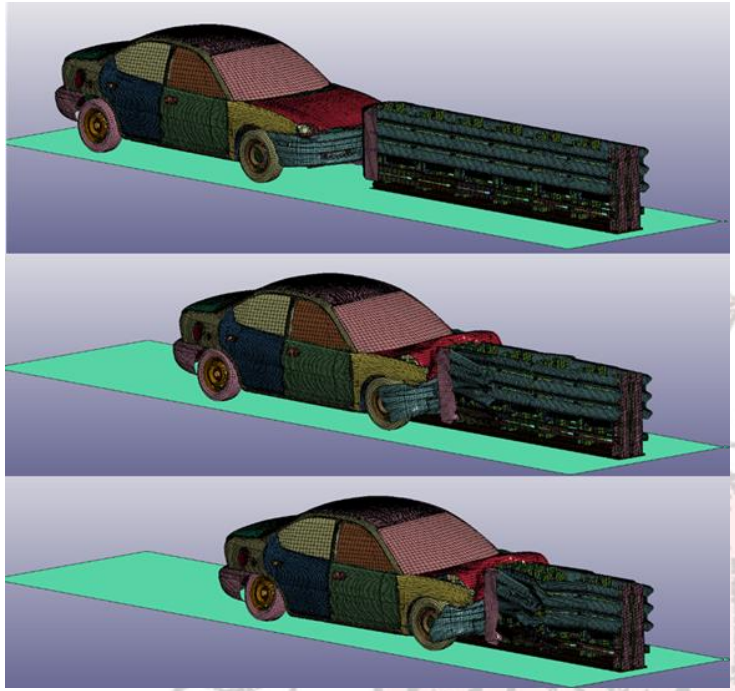
VALIDATION:

Internal consistence prEN 1317-3:2010

A practically example

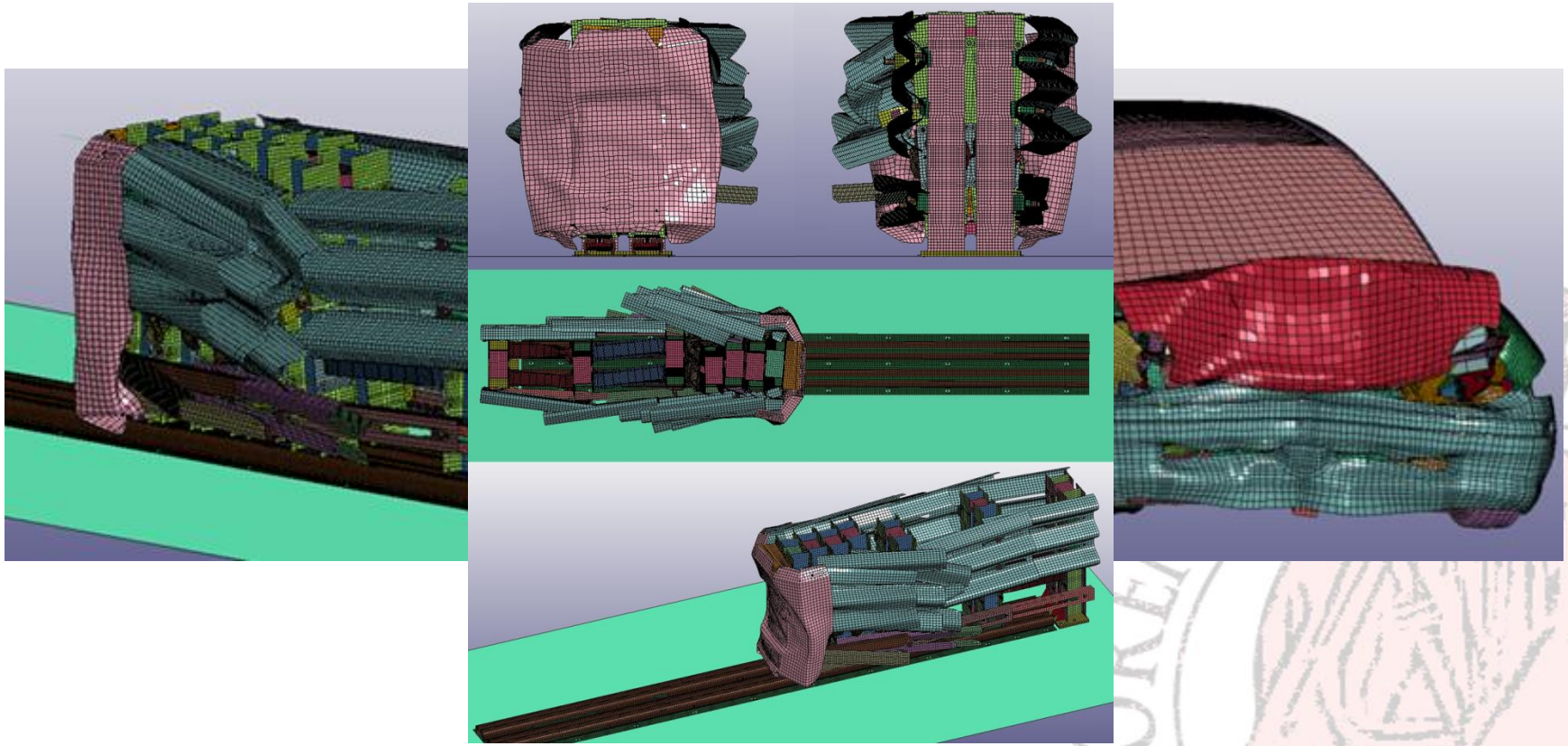
TC 1.2.80





A practically example

TC 1.2.80



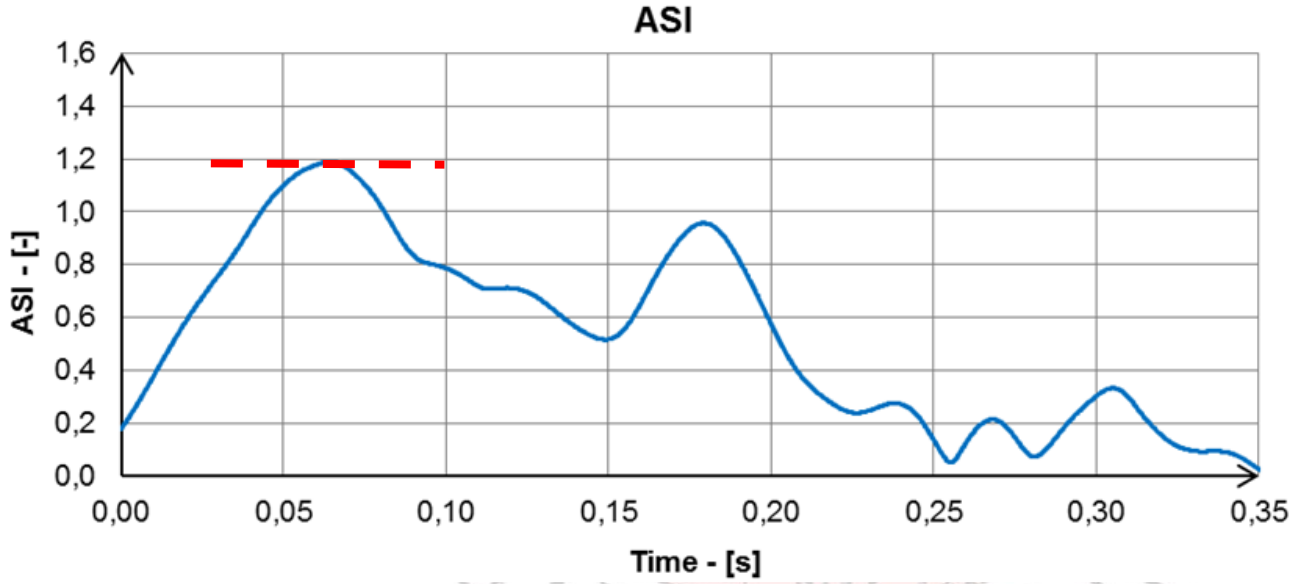
A practically example

COMPORTAMENTO CRITICO	ESITO DEL TEST VIRTUALE
Contenimento	SI
Ribaltamento	NO
Zona redirettiva	Classe Z1
Malfunzionamento degli elementi longitudinali	NO
Penetrazione di parti all'interno del veicolo	NO
REQUISITI GENERALI	ESITO DEL TEST VIRTUALE
Spostamento laterale permanente	Classe D1
SEVERITÀ DELL'URTO	ESITO DEL TEST VIRTUALE
ASI	1.2

TC 1.2.80

Behavioural analysis complying to EN 1317-3:2010

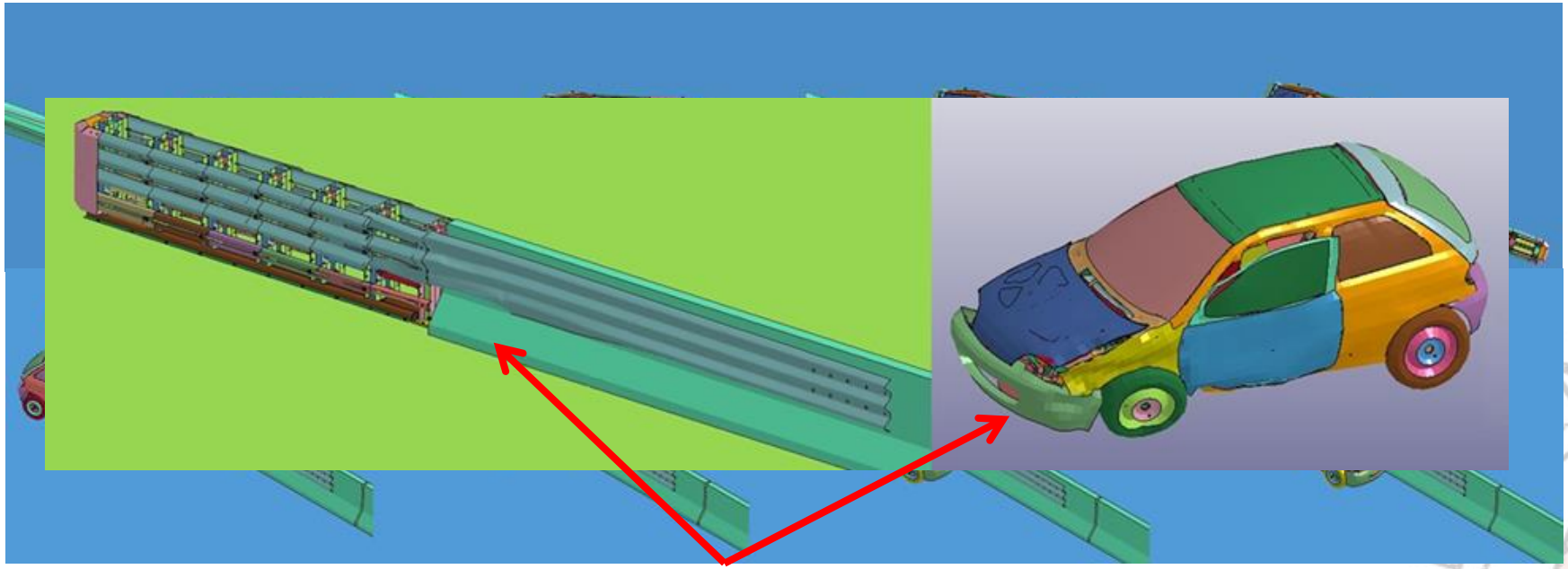
CLASSE B – ASI 1.2



A practically example

transition

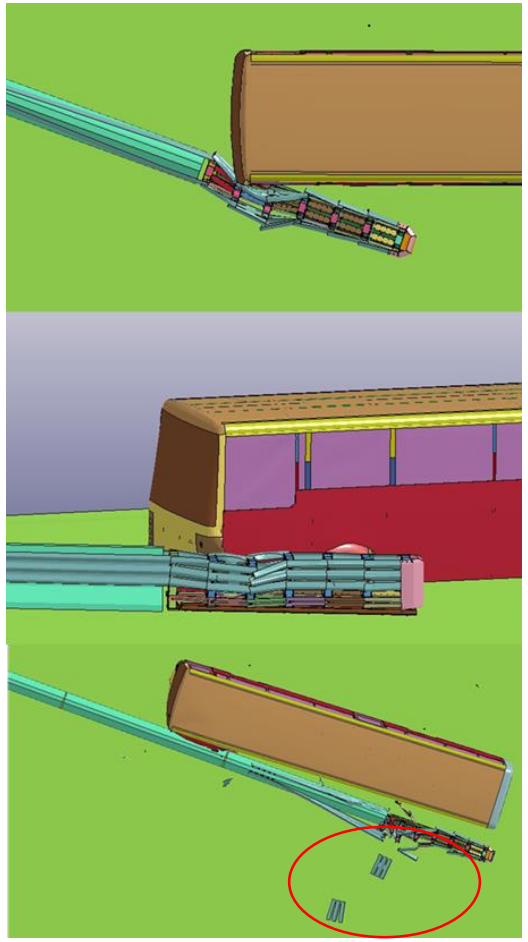
TB 11



Impact damages

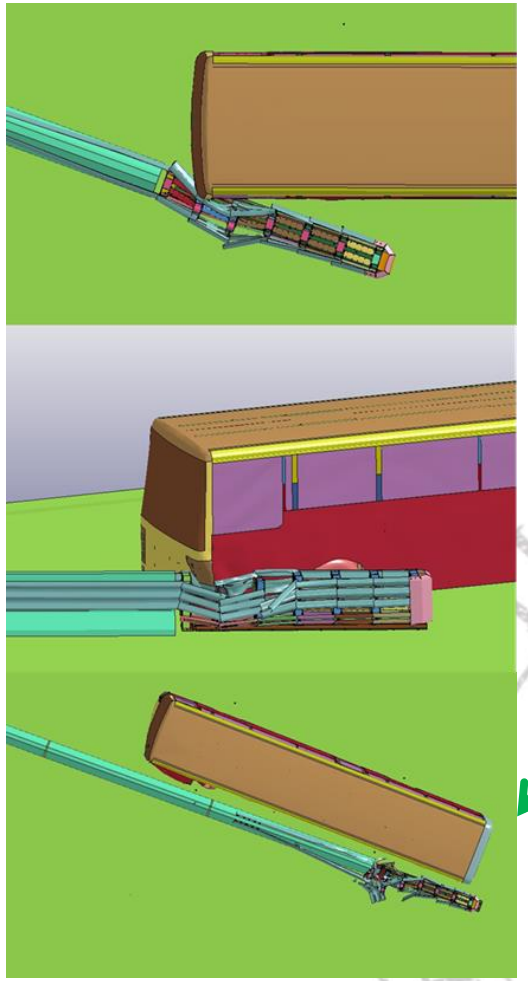
ASI B – 1.1

A practically example

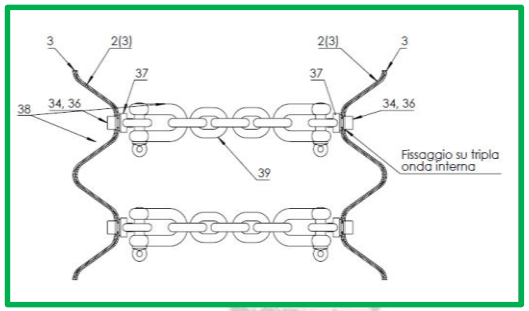


TB 51

without restraint



transition



with chain

A practically example

Some CASE STUDY ANALYSIS