PSA PEUGEOT CITROËN

Coupling between stamping results and crash simulation

N. Vallino

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Summary

- Why coupling stamping results with crash simulation?

- Taking process into account…
  - Fixed plastic strain value
  - Incremental stamping method
  - Inverse method: « One step »

- Some results
  - Side member impact
  - Citroën C3 Frontal impact

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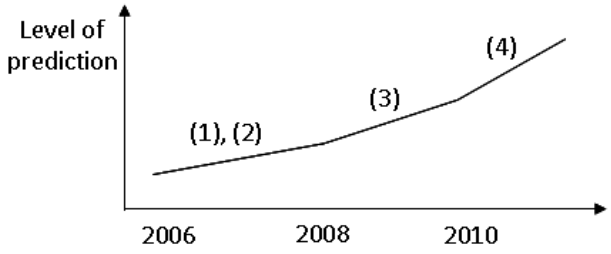
Why coupling stamping results with crash simulation ?

- Context
  - Bringing down car consumption : by reducing mass
  - LEAN engineering :
    - optimization of the design
    - Acceleration of times of development
  - Increasing performance in crash

- Some levers to improve the behaviour of simulation :
  - Element width (decrease from 12 mm to 5 mm) (1)
  - Element formulation (Belytschko, QEPH, Batoz) (2)
  - Material constitutive laws
    - Characterization (3)
    - Coupling stamping & crash simulation (4)



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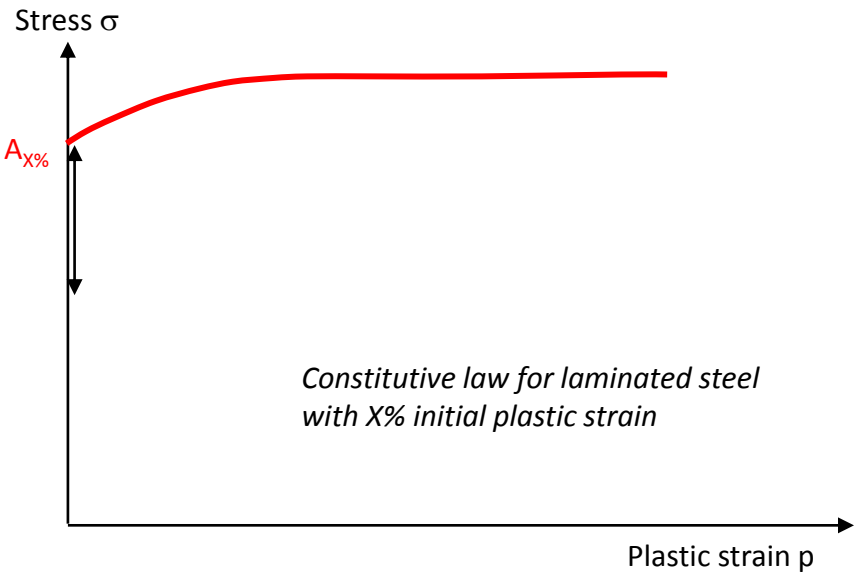
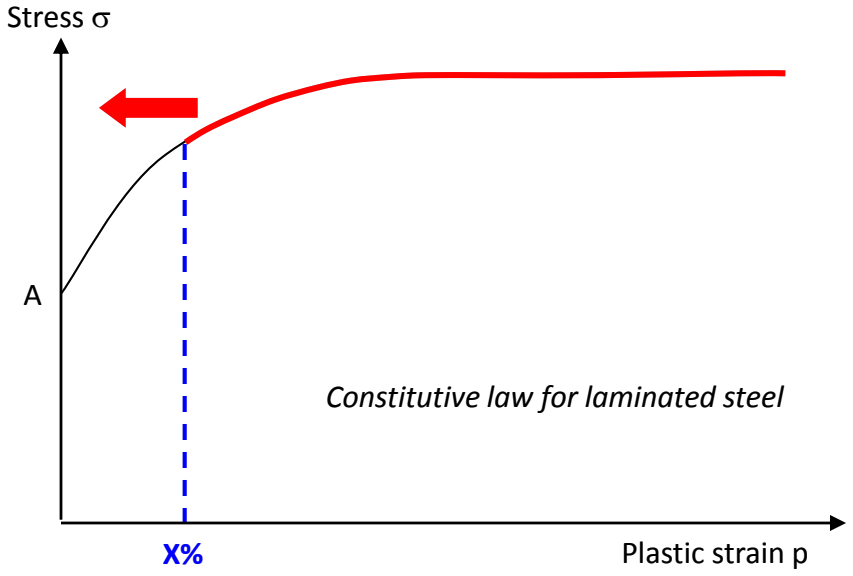
Fixed plastic strain value

- Use of material constitutive laws for the steel laminated sheet with fixed value of plastic strain to take into account the effects of the stamping process.





Fixed plastic strain value

- Advantages :
  - Easy to implement in our simulations.
  - No added time to set up the model.
  - Slight improvement of the elements behaviour

- Drawbacks :
  - Thickness variations not taken into account.
  - Difficult to choose an appropriate value of the initial plastic strain.

- Improvements expected
  - Taking into account the real values of plastic strains and thicknesses due to stamping process

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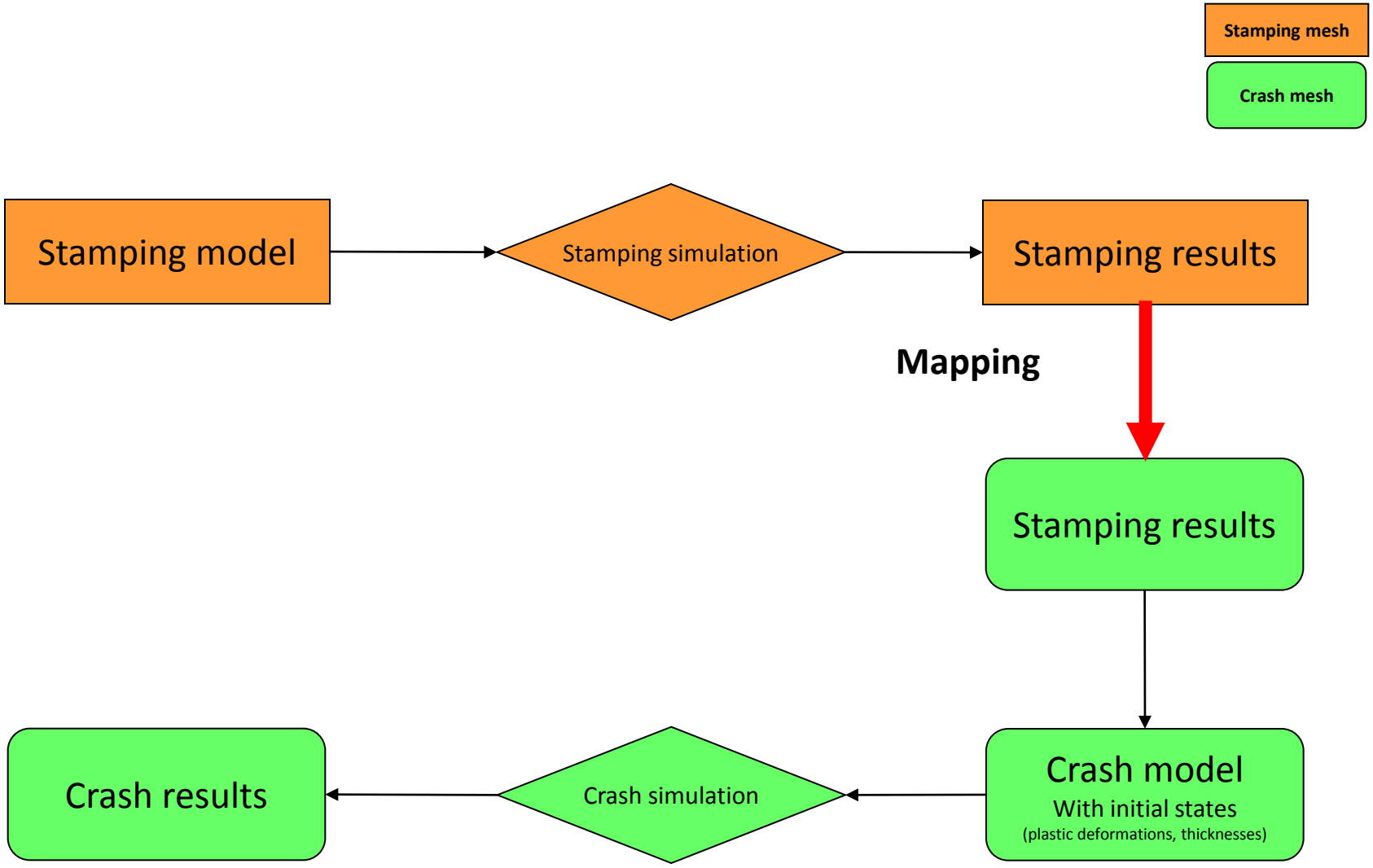
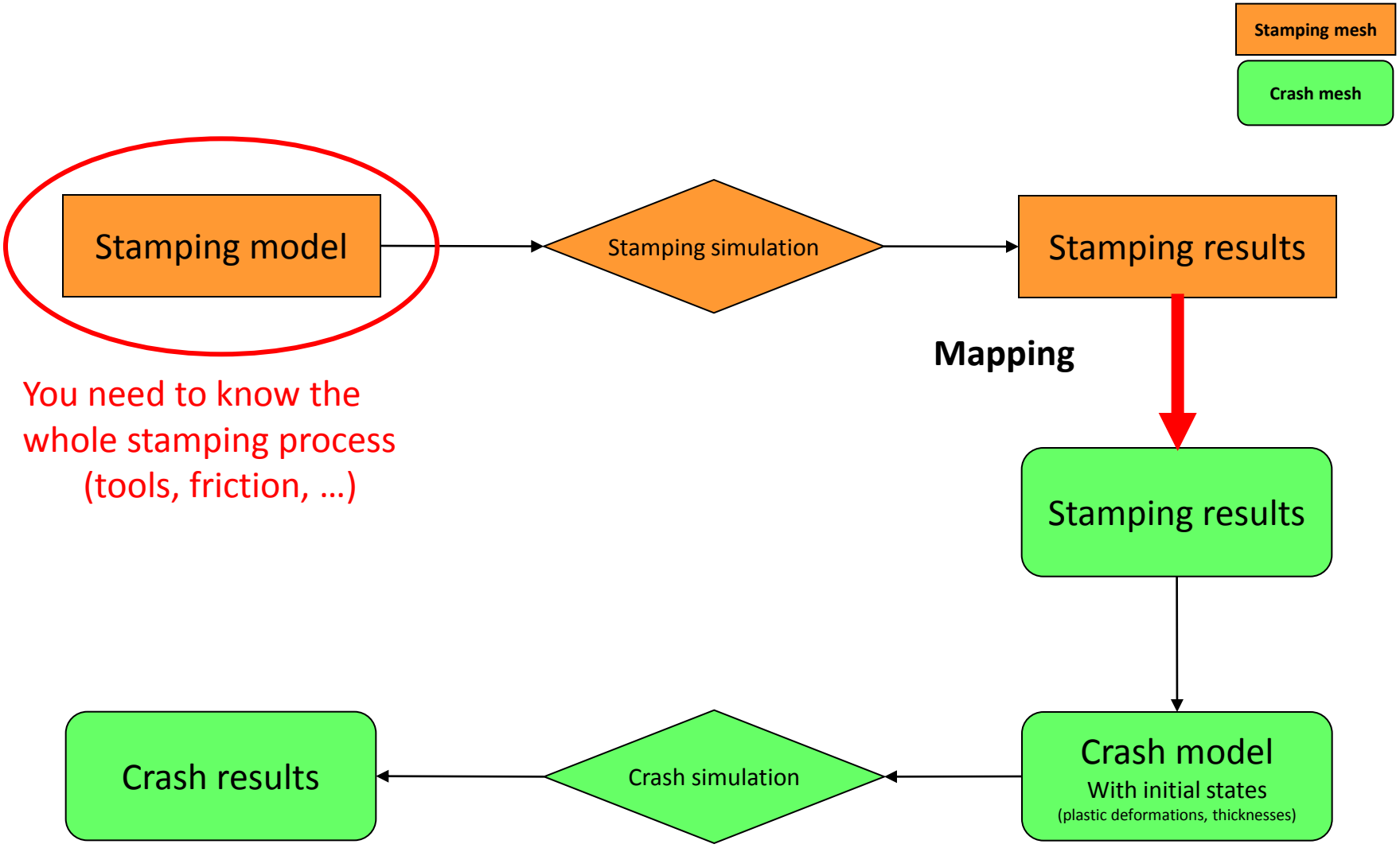
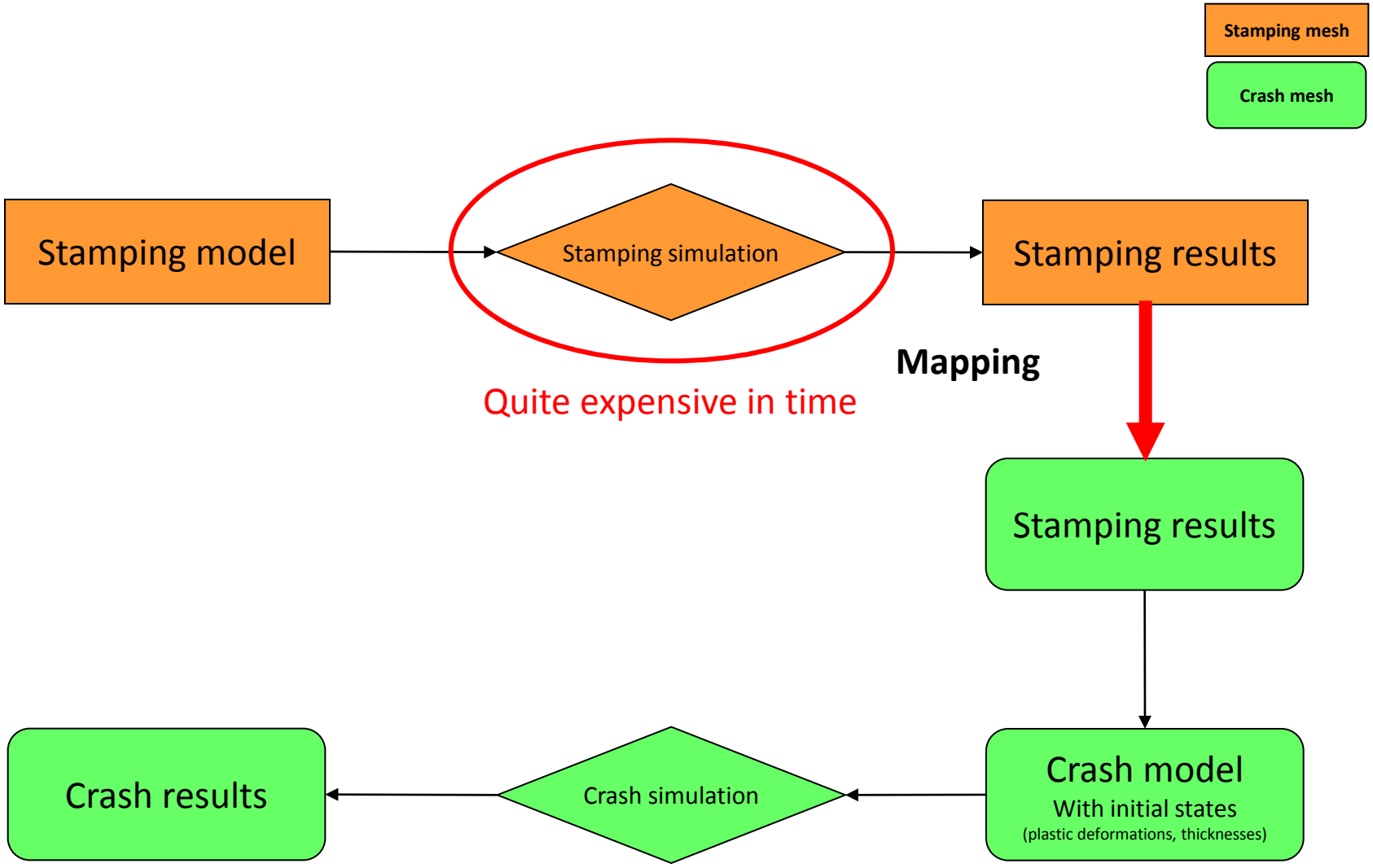
Coupling incremental simulation with crash



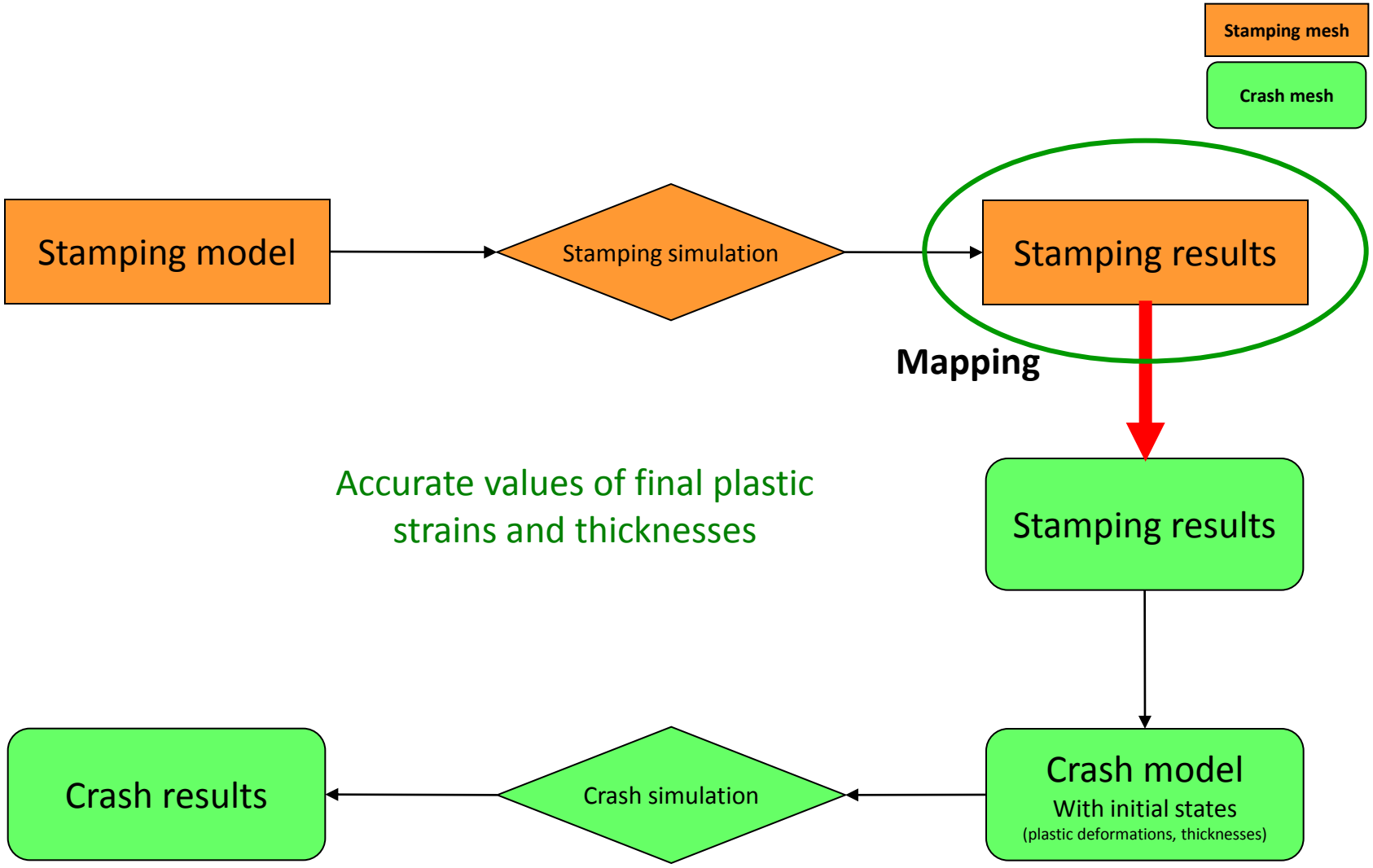
Coupling incremental simulation with crash



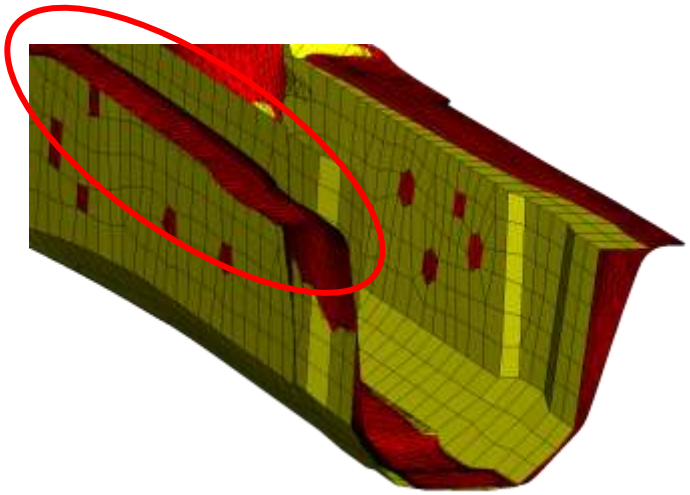
Coupling incremental simulation with crash



Coupling incremental simulation with crash



Coupling incremental simulation with crash



Stamping mesh

Crash mesh

Stamping model

Stamping simulation

Stamping results

Mapping

Mapping can lead to problems linked with the difference of geometry between stamping and crash meshes

Stamping results

Crash model
With initial states
(plastic deformations, thicknesses)

Crash simulation

Crash results

Coupling incremental simulation with crash

- Advantage
  - Accurate values of final plastic strains and thicknesses

- Drawbacks
  - You need to know the whole stamping process. Usually, these informations are unknown at the early stage of the development scheme
  - The simulation is quite expensive in time, especially to simulate all the parts of the body in white
  - You need to map information from stamping mesh to crash mesh. Due to the springback effect, the stamping part and the crash part geometries may be not coincident which makes the mapping more difficult.

and

  - You need experience in stamping process : it is not always the case of crash engineers

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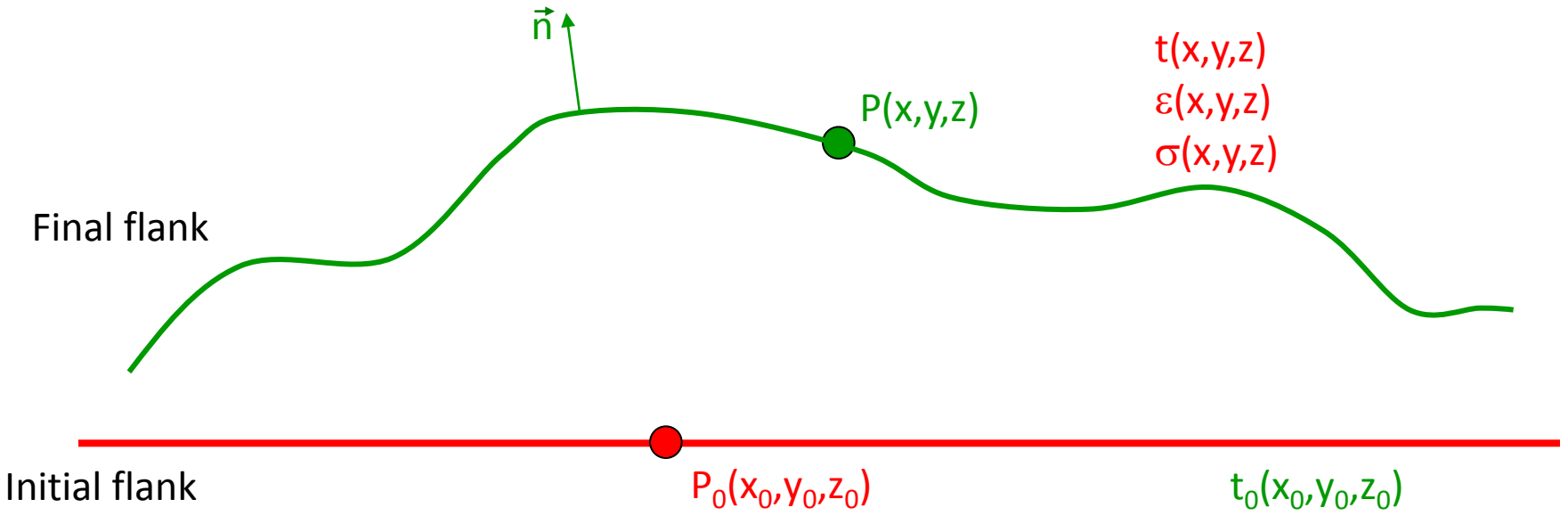
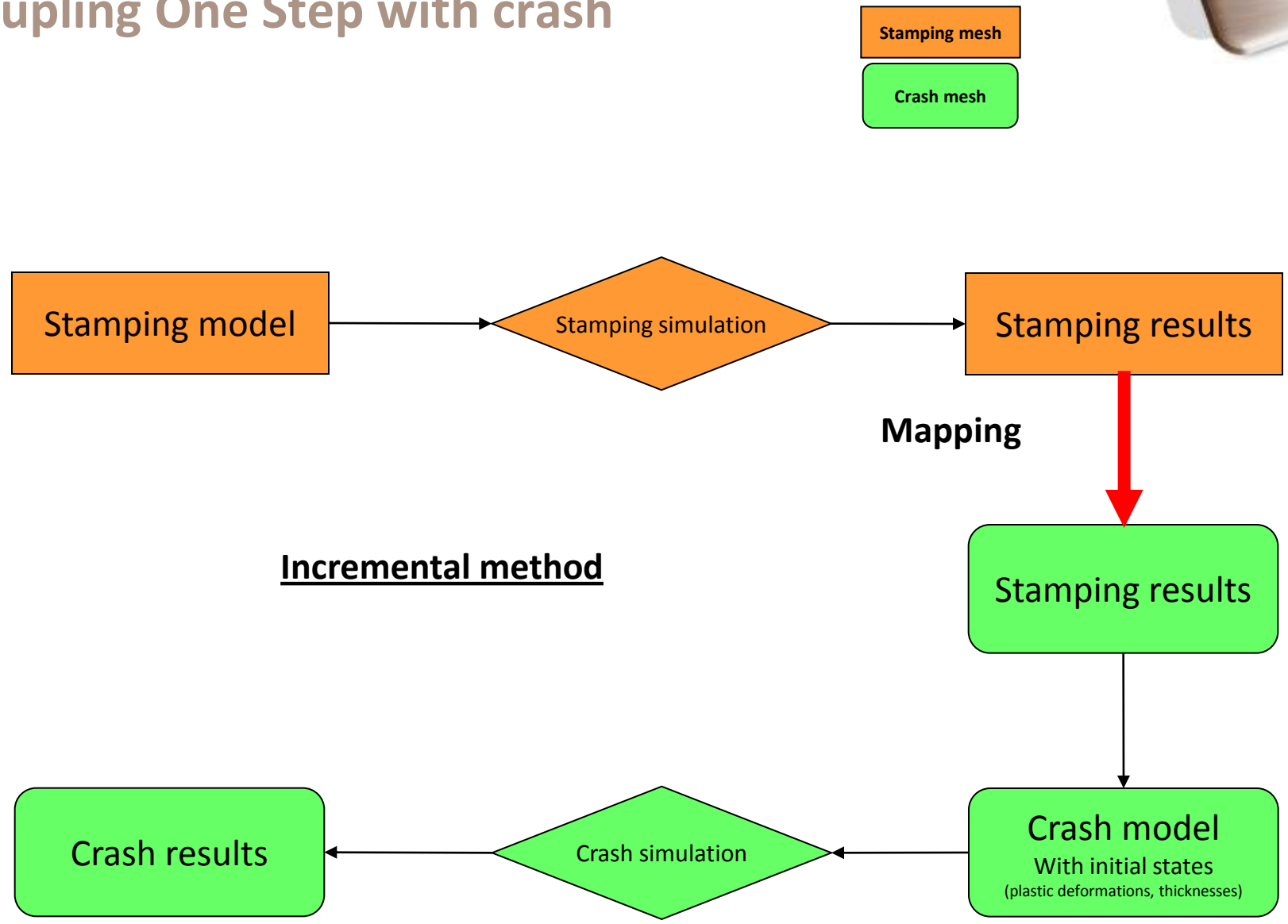
One step: inverse method principles

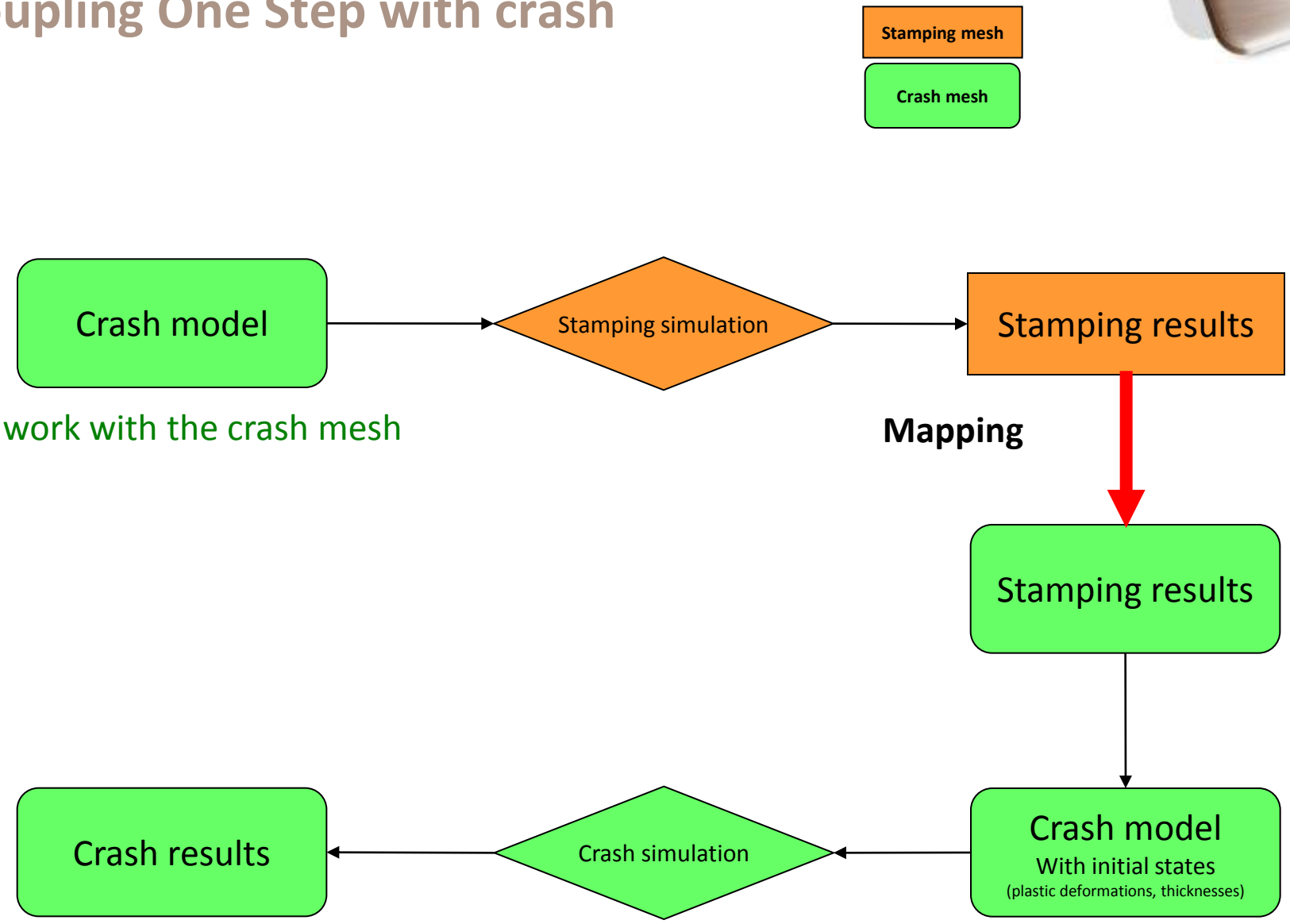


	Known quantities	Unknown quantities
Initial flank	Initial thickness $t_0(x_0,y_0,z_0)$	Shape Position of points $P_0(x_0,y_0,z_0)$
Final flank	Shape Position of points P(x,y,z) Loading direction n	Final thickness t(x,y,z) Final strains ε(x,y,z) Final stresses σ(x,y,z)

Coupling One Step with crash



Coupling One Step with crash



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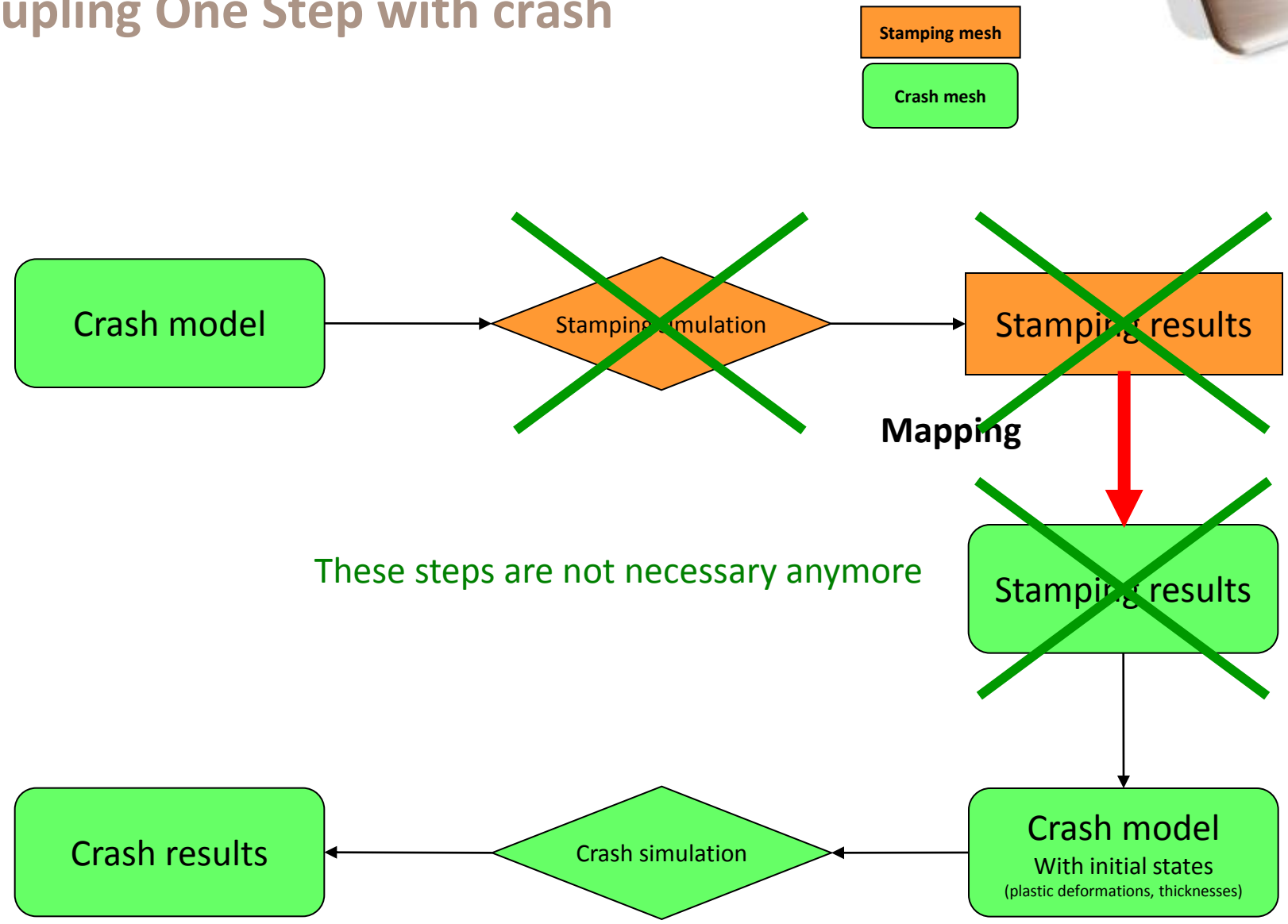
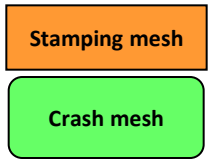
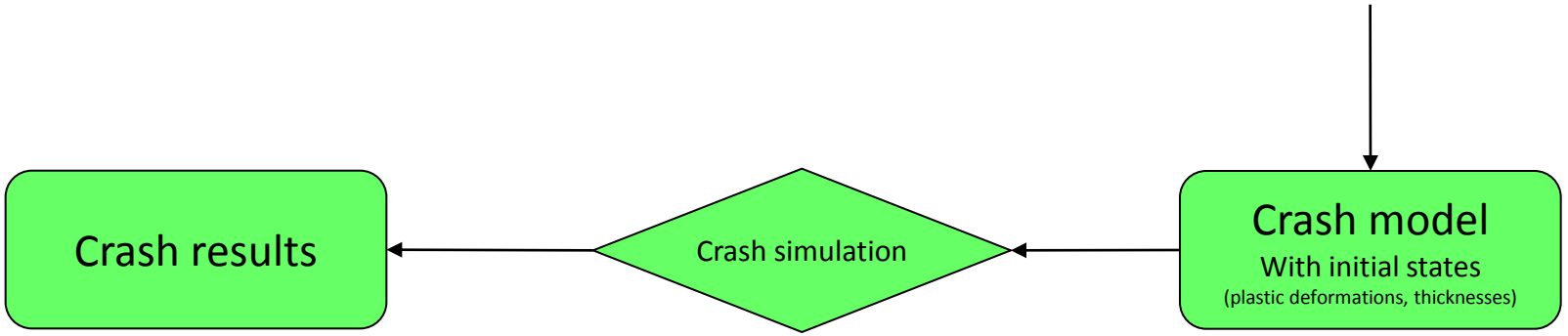


Coupling One Step with crash

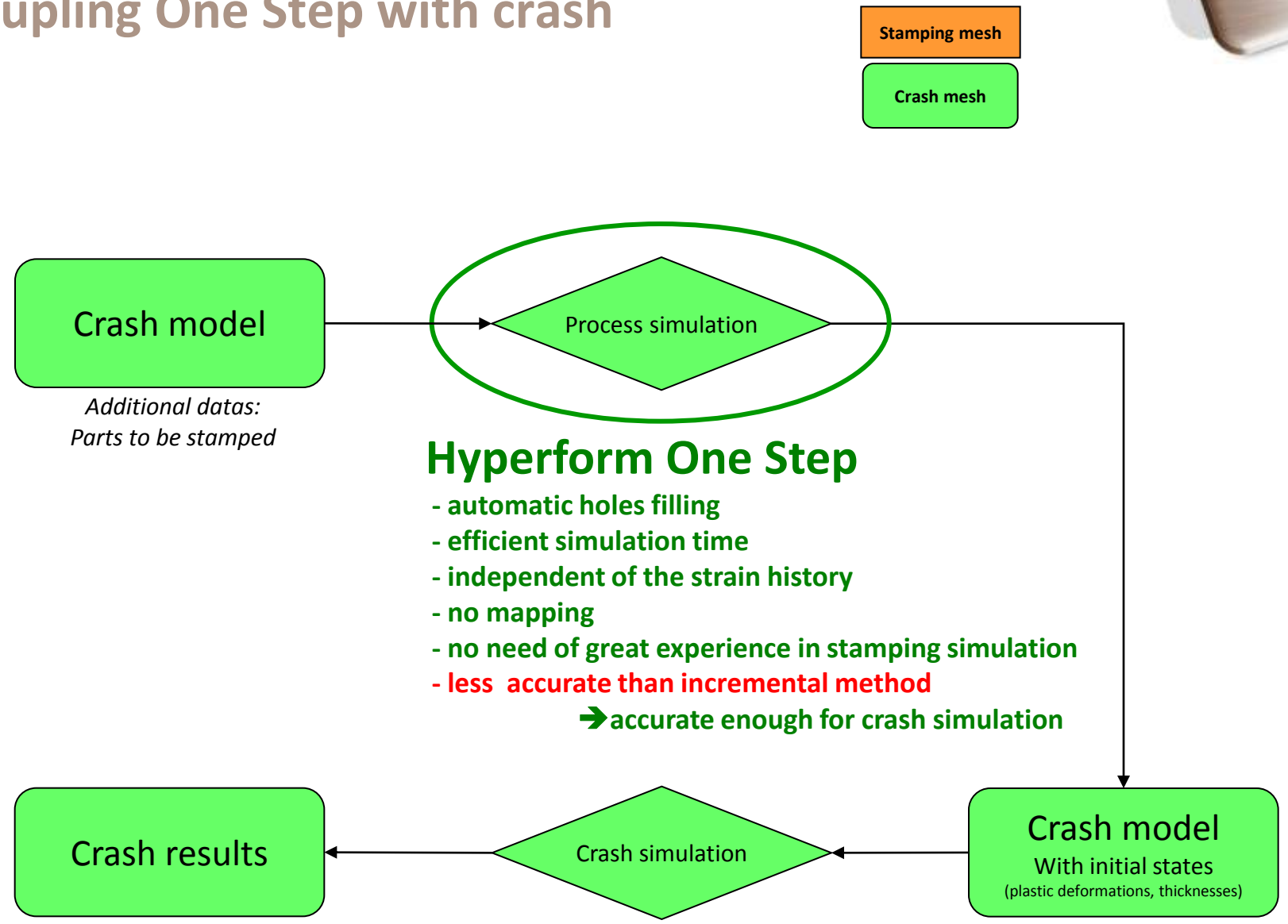


Crash model →

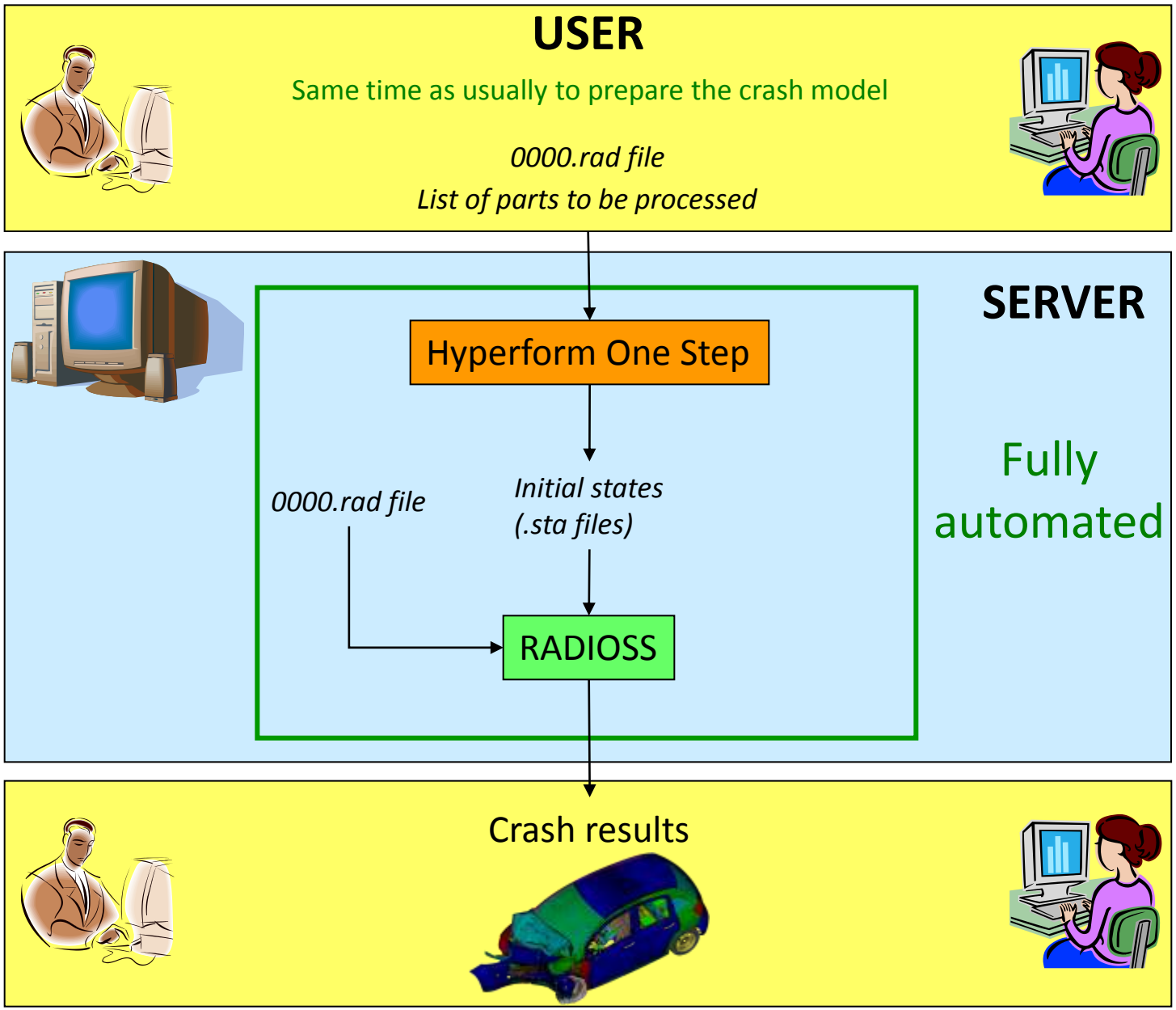
How the process is taken into account?



Coupling One Step with crash



From the user point of view…



Coupling One Step with crash

- Advantages
  - We keep the crash mesh from the beginning until the end
  - Efficient simulation time
  - No added time to set up the model
  - No need to have great experience in stamping process

- Drawbacks
  - Less good precision than incremental methods : but sufficiently accurate for crash simulation.

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Application on side-member impact (1/4)

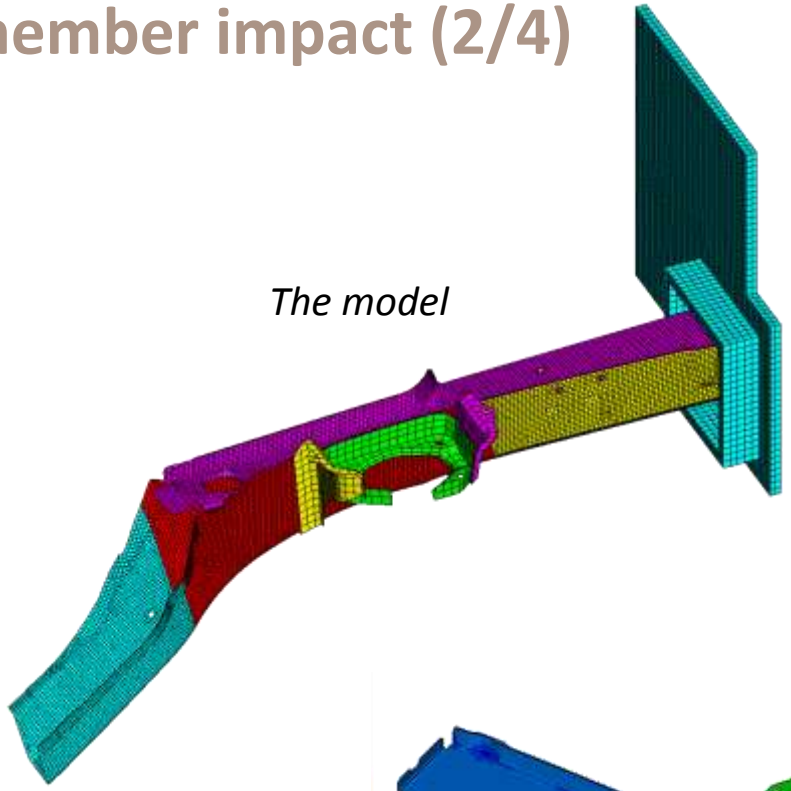
- The side-member:

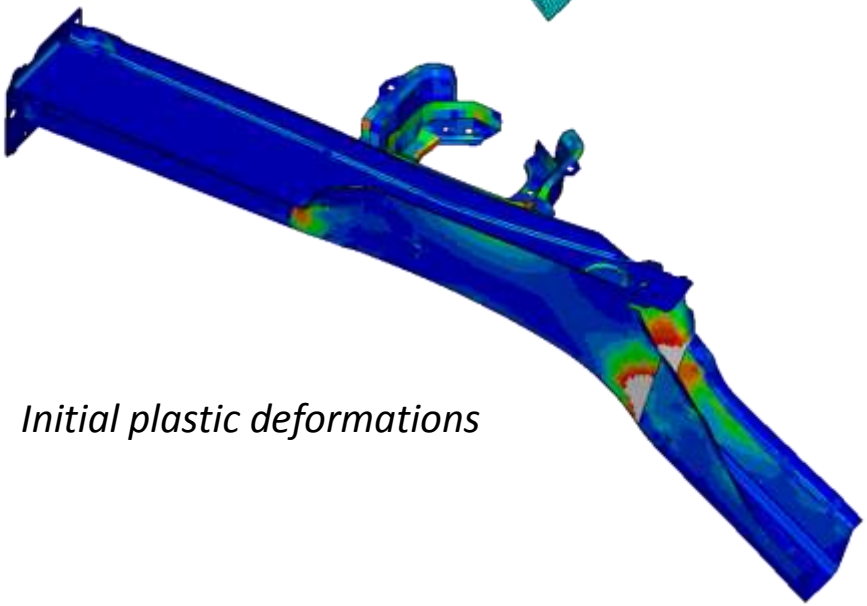
- Deformed side-member

Application on side-member impact (2/4)

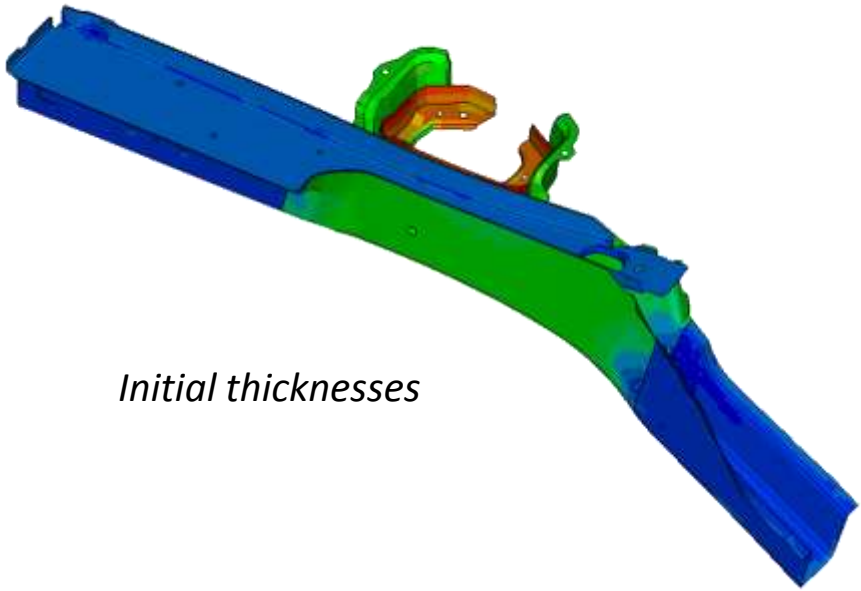
Simulations performed with:
Hyperform One step V10
Radioss V10

The model



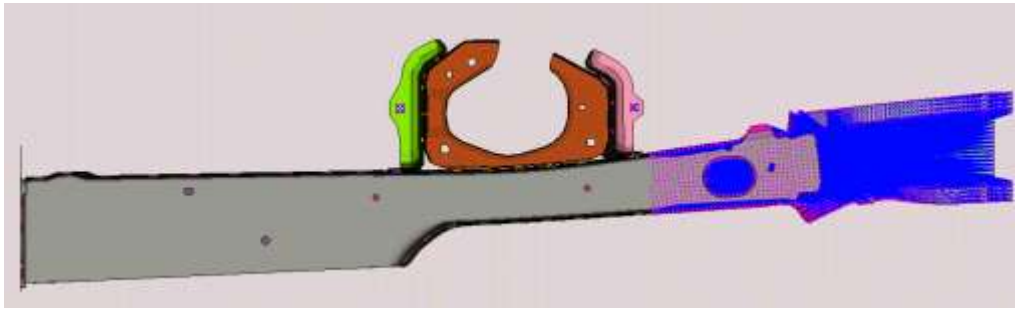


Initial plastic deformations

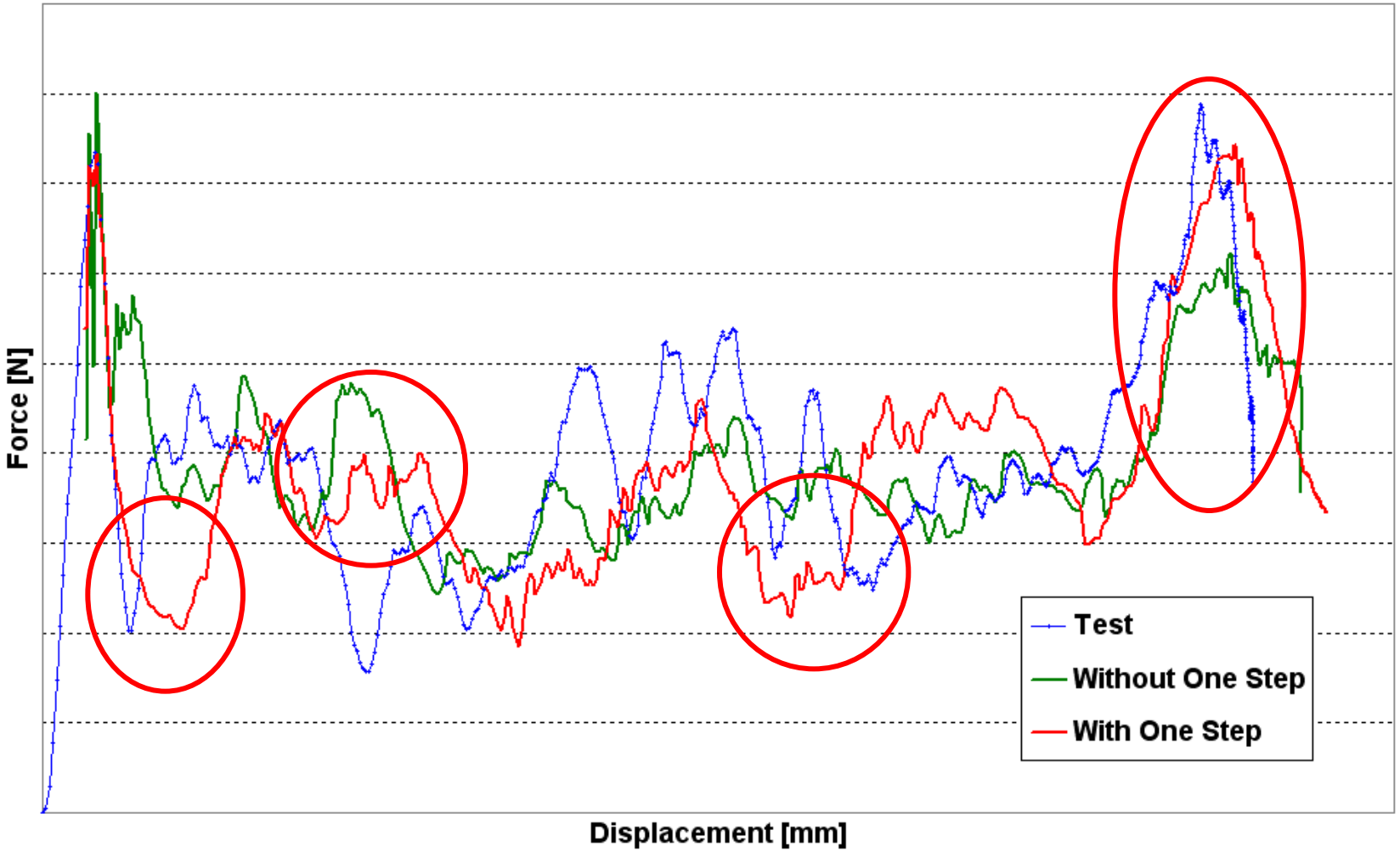


Initial thicknesses

Application on side-member impact (3/4)

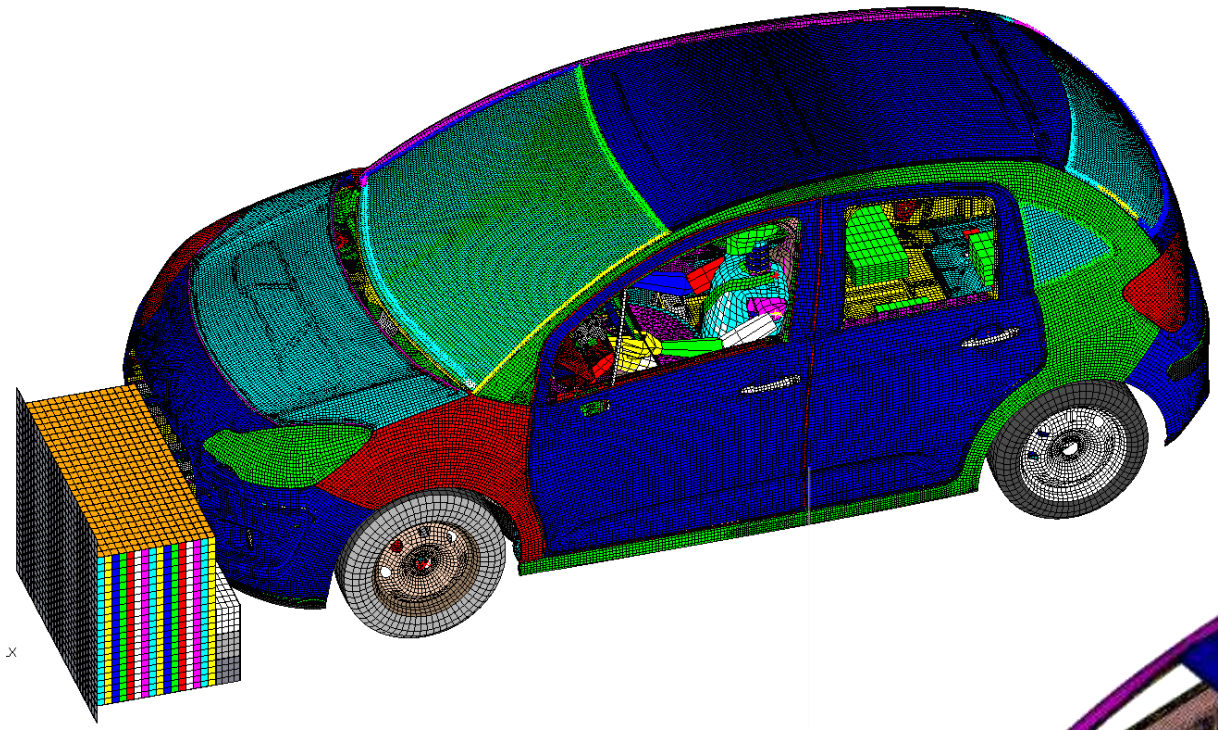


Application on side-member impact (4/4)



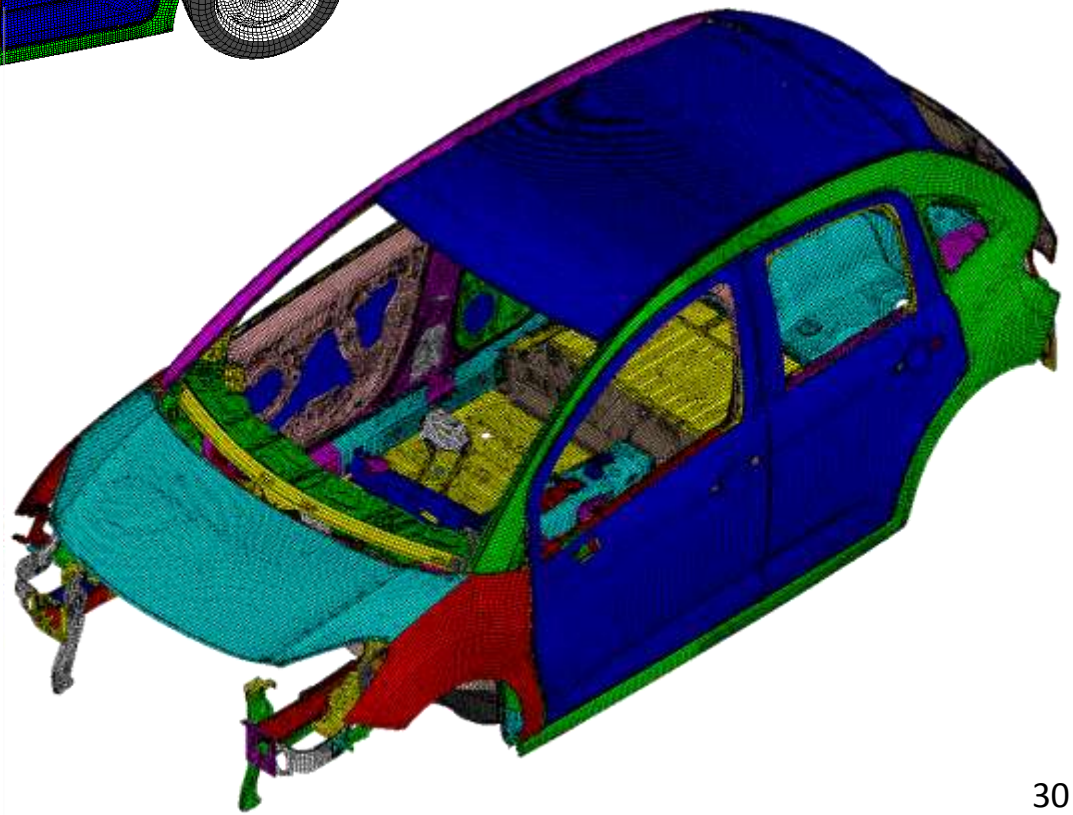
Better matching between « one step » simulation and tests results

Application on Citroën C3 (1/3)



Frontal impact
Full vehicle model

Number of parts: 2251
Number of node: 1 046 507
Number of elements: 1 030 069



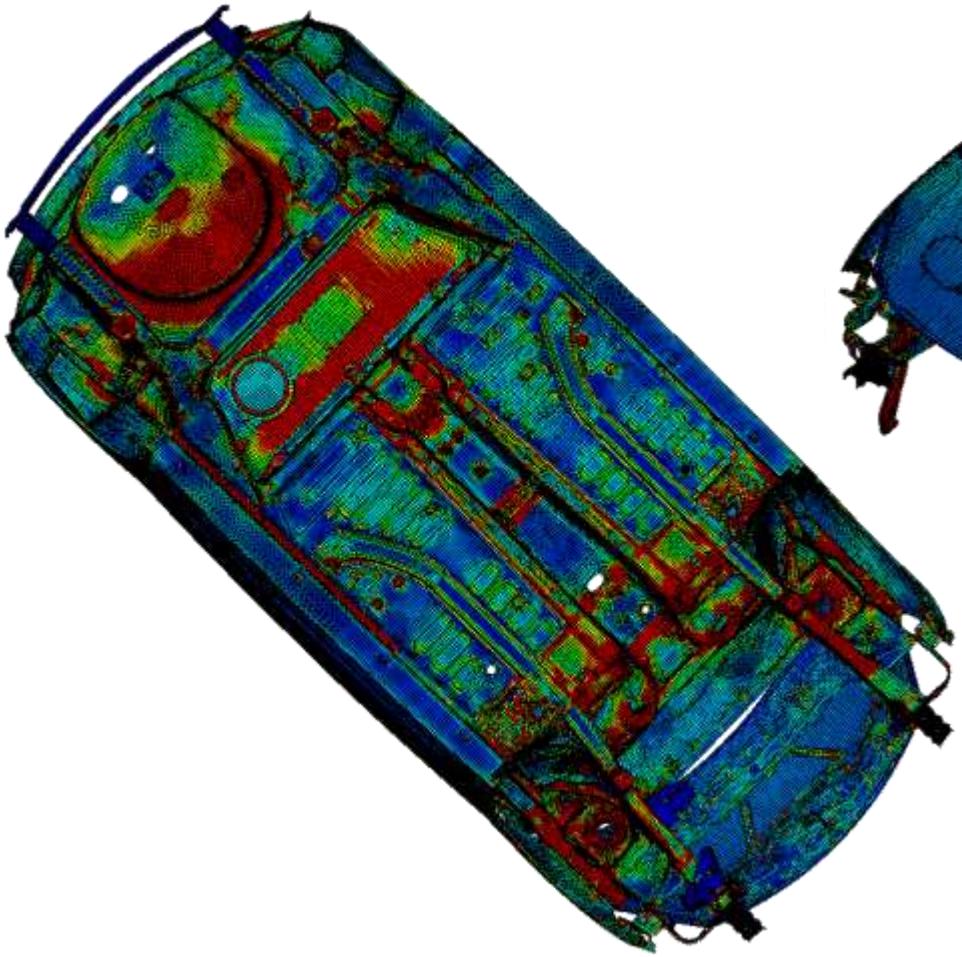
« One step » treated Parts

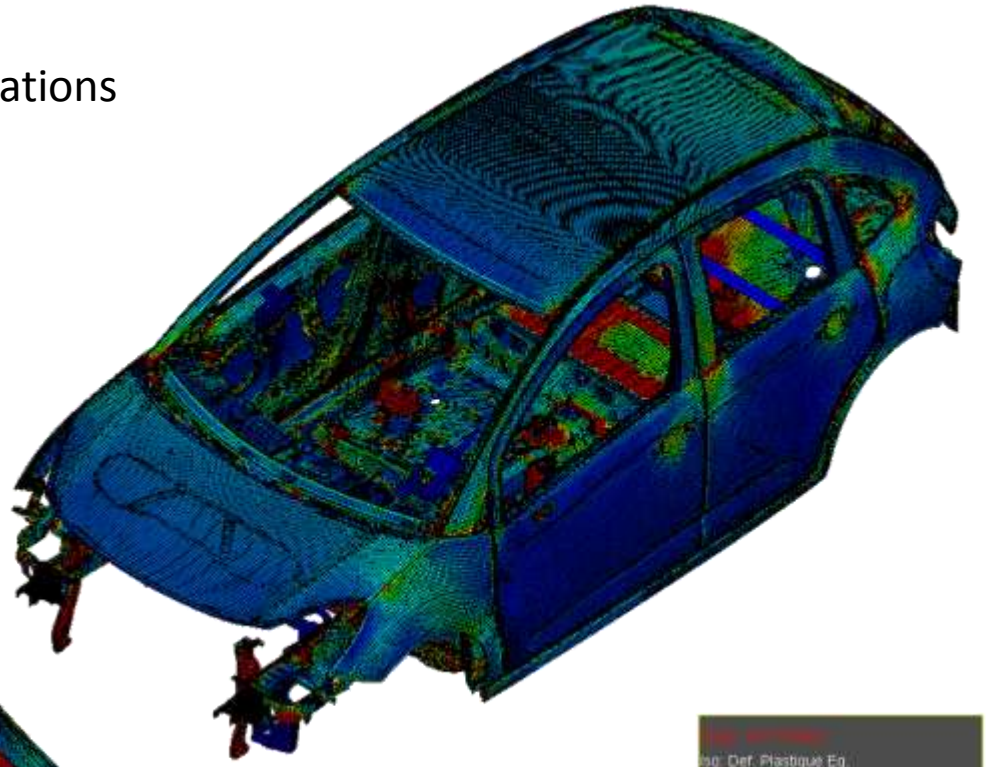
Number of parts: 281

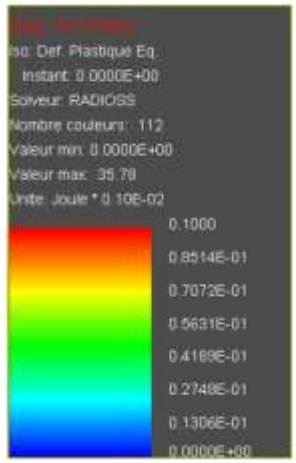
Application on Citroën C3 (2/3)

Citroën C3

initial plastic deformations







Simulations performed with:
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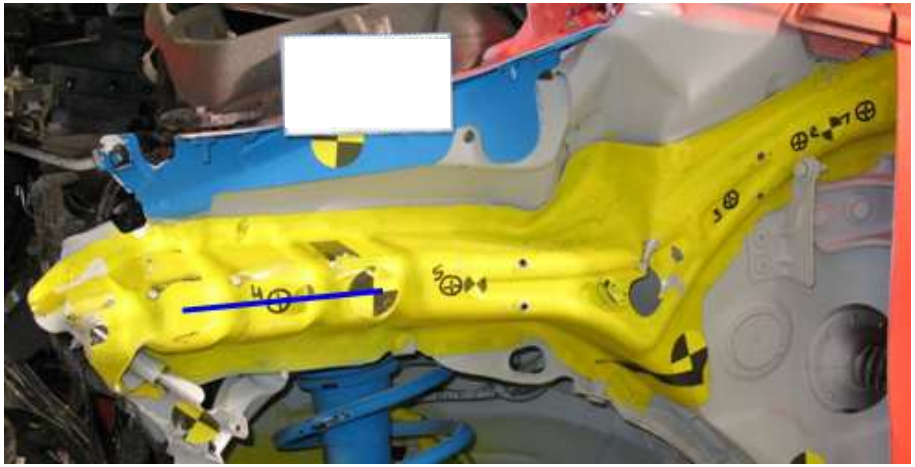
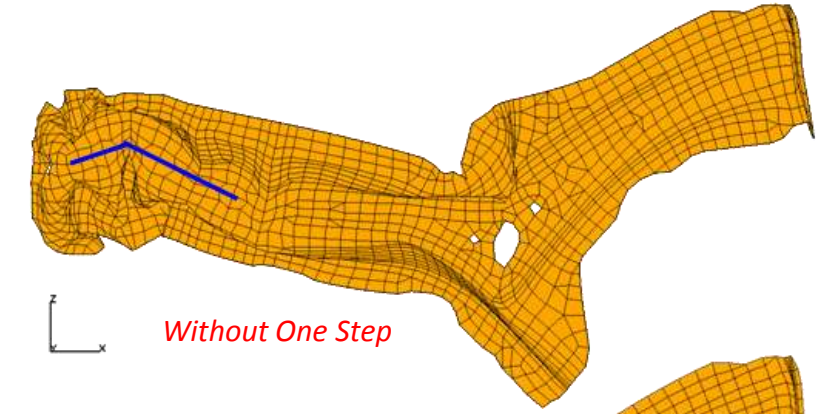
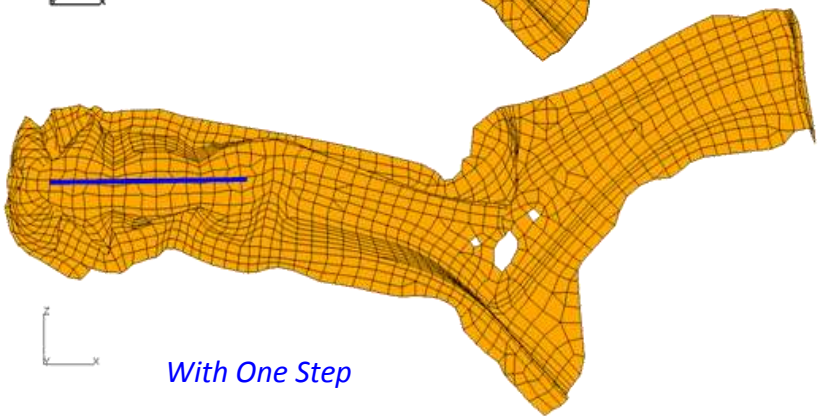
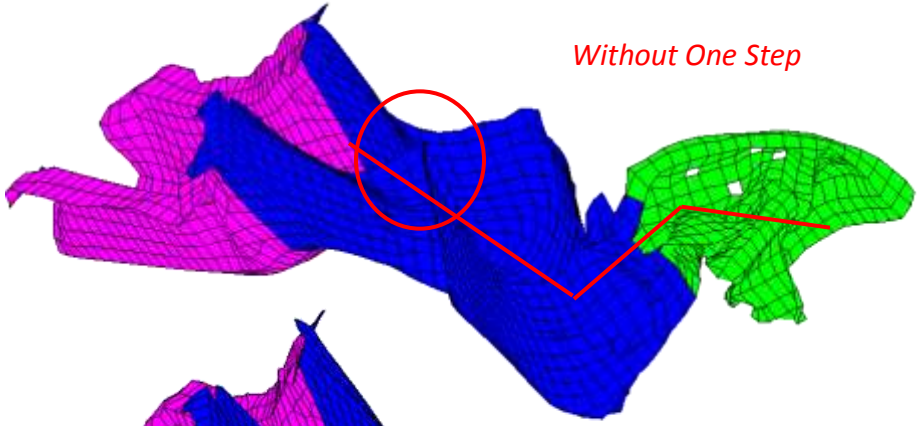
Radioss V10

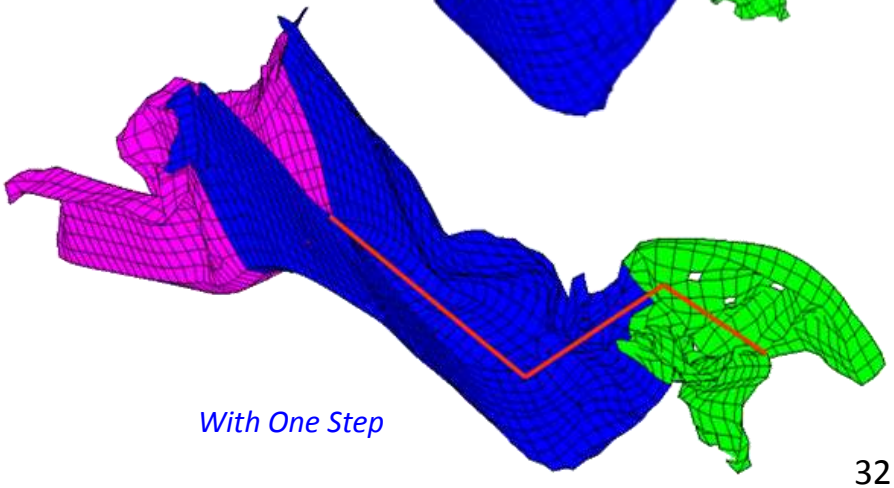
Application on Citroën C3 (3/3)





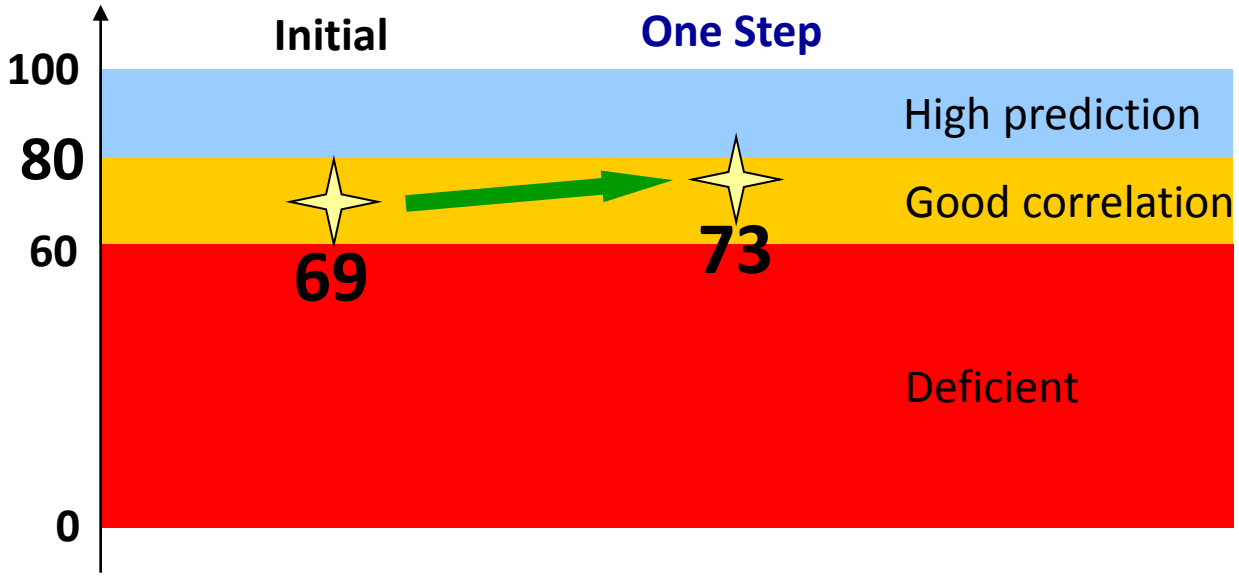






Indicators

At PSA Peugeot Citroën, we use indicators to quantify the level of predictivity of our simulations :



➔ Using Hyperform Onestep we have improved our trust in this type of simulation.

Conclusion

- Key points of the One Step Method :
  - First results of the Coupling « one step » inverse method with crash show a better level of predictivity for many kinds of simulations : frontal, side, rear, reparability, ...
  - The One Step Method doesn’t involve added time to set up the model
  - Times of simulation are compatible with a car project schedule.
  - No experience is needed for a crash engineer to use this method.

Thanks for your attention!

Any question?

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Performing stamping simulation with Hyperform One-Step