



**Renault
Group**

Light Commercial Vehicle Vibration Fatigue

2025 MAGNA ECS SIMULATION CONFERENCE

Summary

- 01 Introduction**
VEHICLE DURABILITY
- 02 Fatigue prediction process**
RENAULT MASTER L2H2 EXAMPLE
- 03 Fatigue prediction results**
RENAULT MASTER L2H2 EXAMPLE
- 04 Conclusion**

01

Introduction

VEHICLE DURABILITY



01 - Introduction

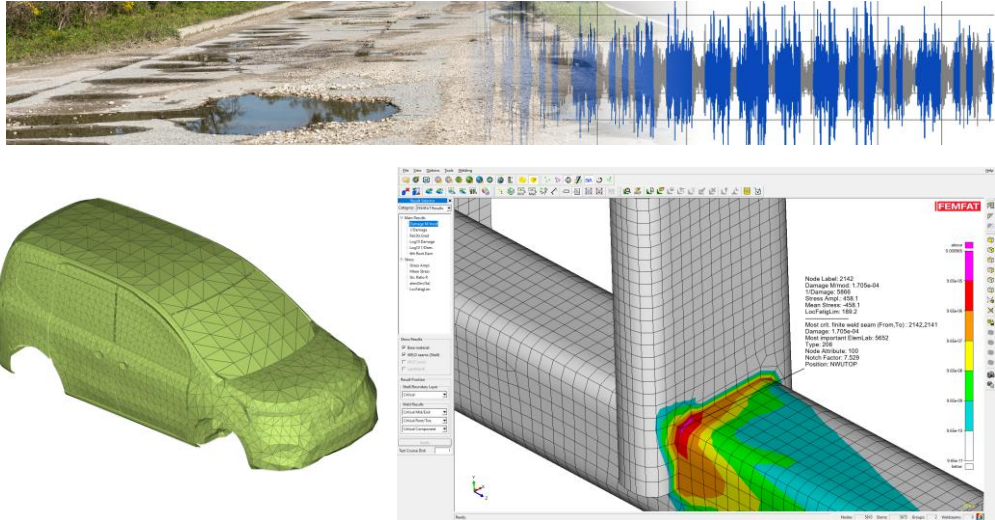
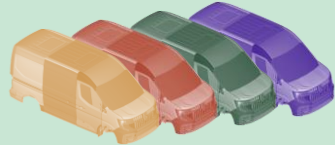
VEHICLE DURABILITY

Durability: ability for the vehicle body to last a long time without being damaged by road loads.

We can either speak in terms of life of the vehicle or in terms of damages caused to the vehicle.

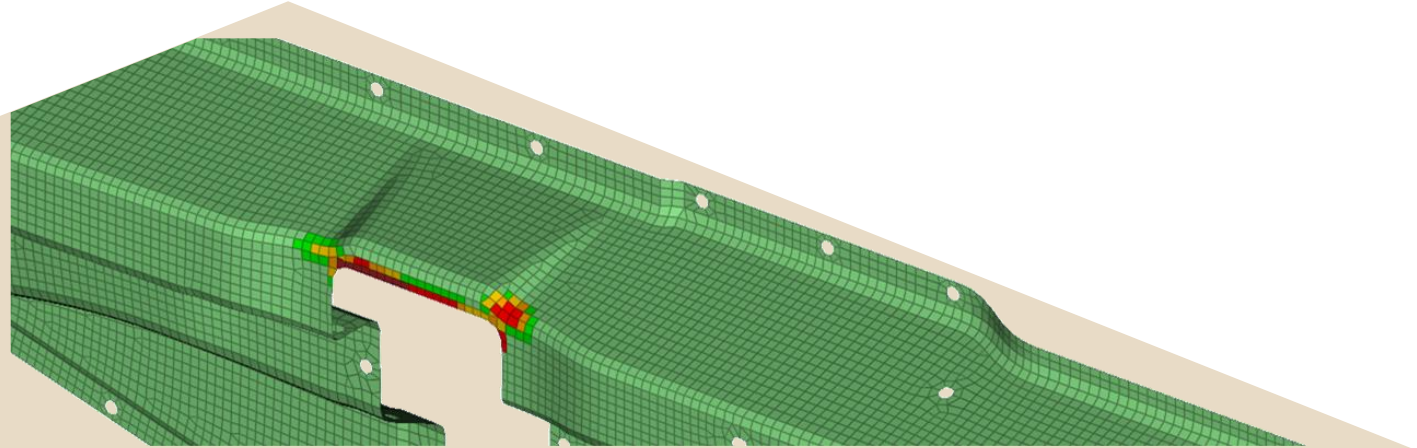


VEHICLE DURABILITY

Physical validation		Numerical validation	
			
-	\$\$\$ ⌚⌚⌚	Technical challenges to reach great representativeness	
+	Representative of reality	\$ ⌚	

VEHICLE DURABILITY SIMULATION

Fatigue prediction



Load excitation

CAE based

multi-body simulation

test based

generic

Assembly

panel

adhesive spotweld

bolted connection

seal

Mechanical response

linear

stress

gap

non-linear

static

dynamic

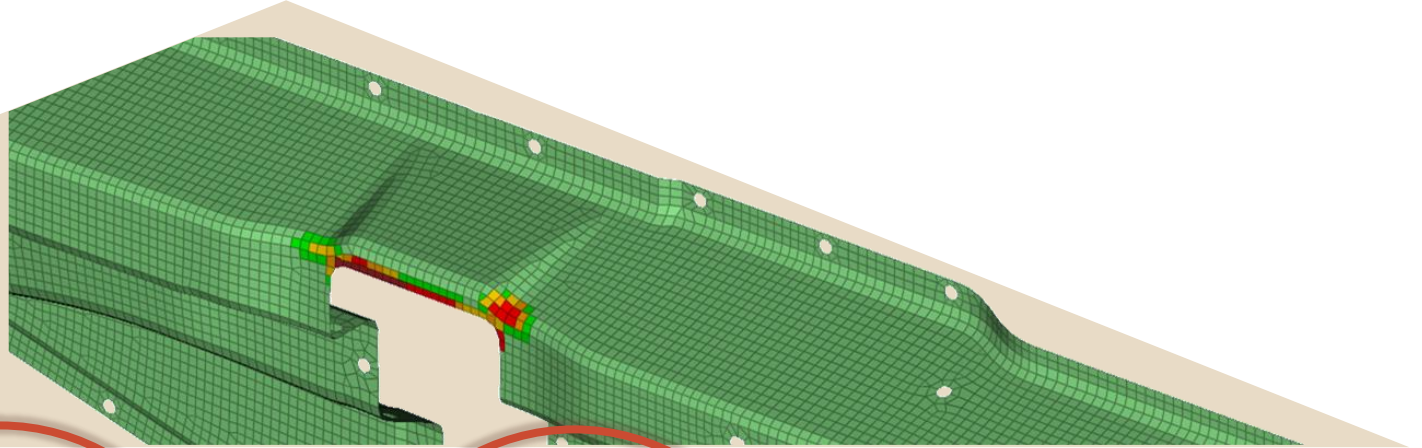
Material

test specimen

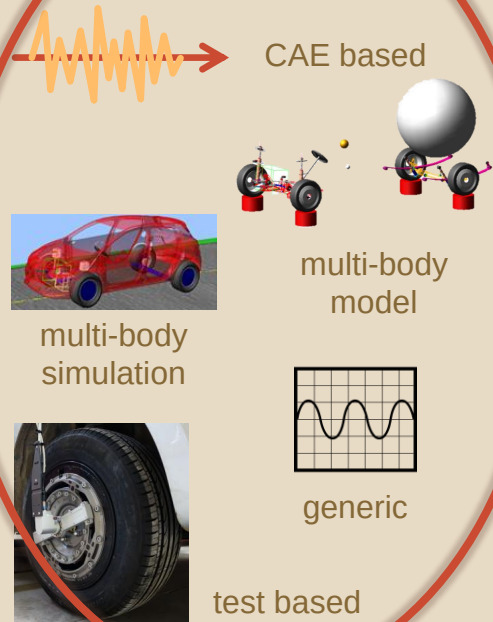
assembly characterization

VEHICLE DURABILITY SIMULATION

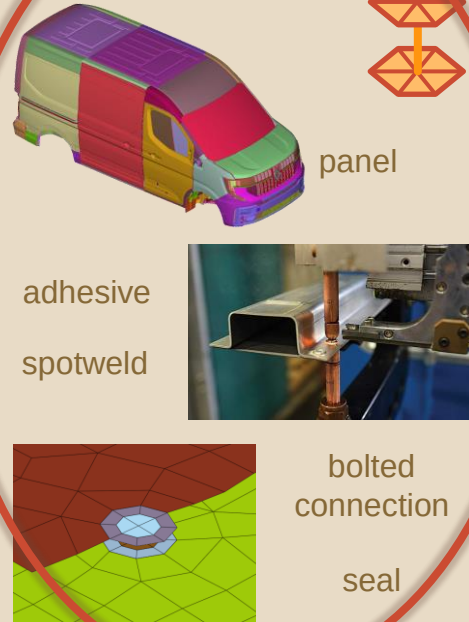
Fatigue prediction



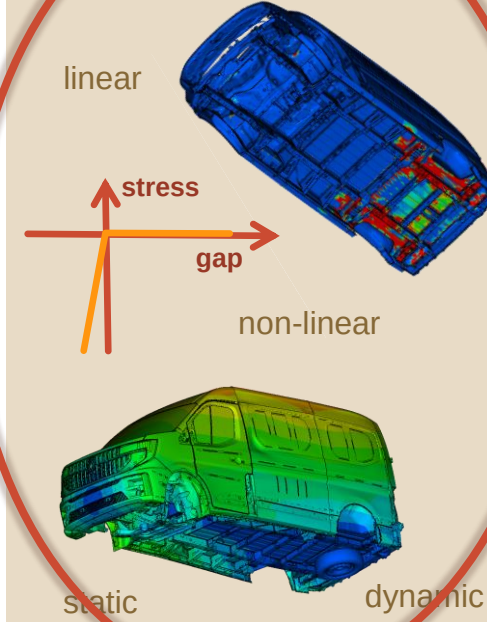
Load excitation



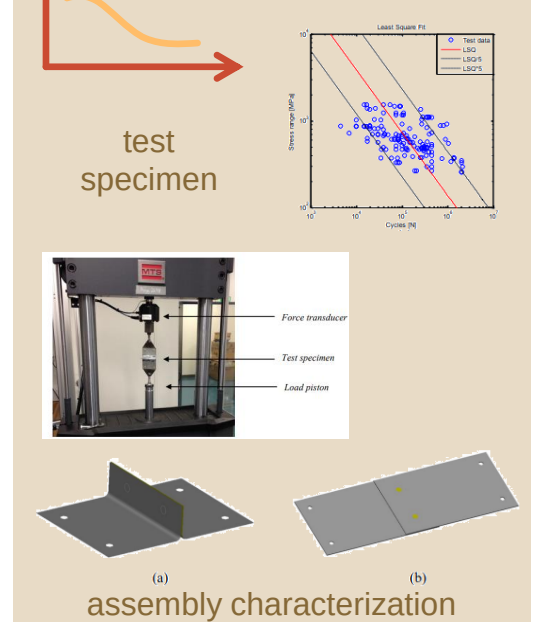
Assembly



Mechanical response



Material

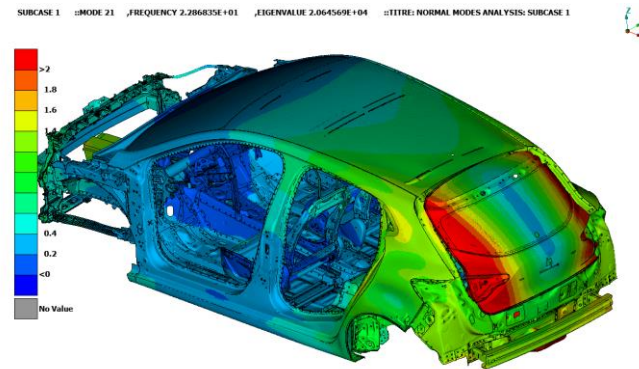
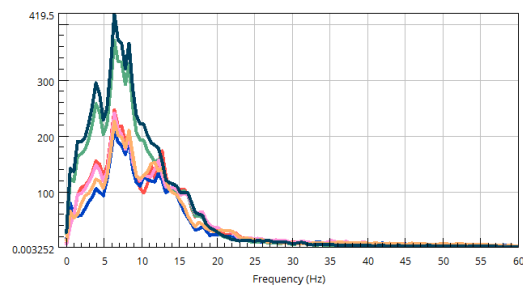


DYNAMIC RESPONSE

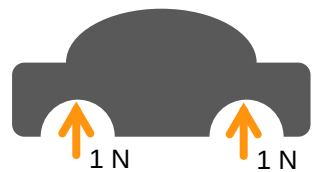
Passenger car vs. light commercial vehicle: Why does especially light commercial vehicle benefits from a dynamic approach to structural response?



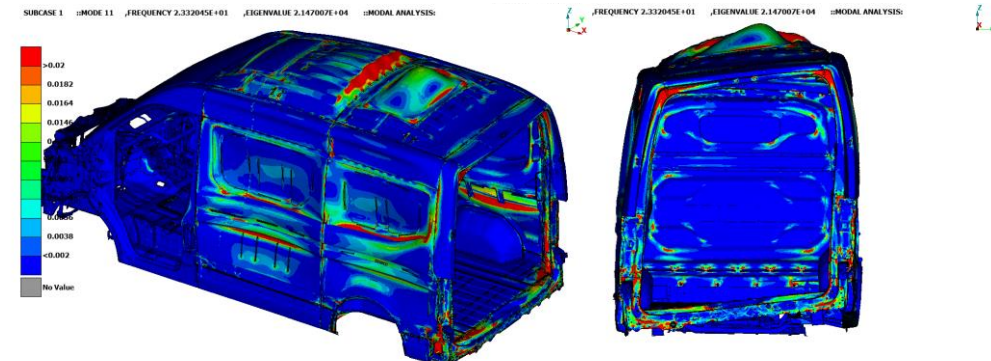
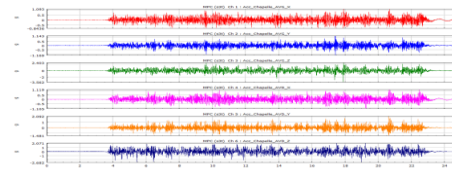
Rough road load frequency range:
between 0 Hz and 20 Hz



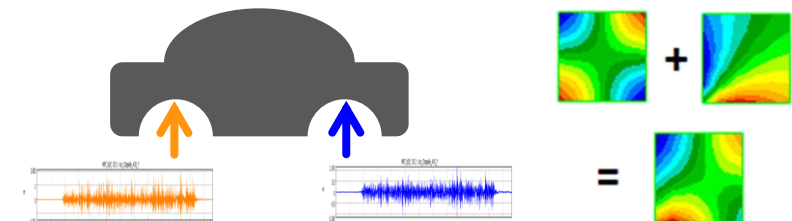
Passenger car (PC) structural modes > 20 Hz
 → Minimal dynamic response of the global structure withing the range of road load excitation
 → **Static based fatigue prediction** has proven sufficient accuracy



static unitary loads x road signal



Light commercial vehicle (LCV) structural modes < 20 Hz
 → Dynamic response of the structure to road excitation
 → **Dynamic based fatigue prediction** is preferable

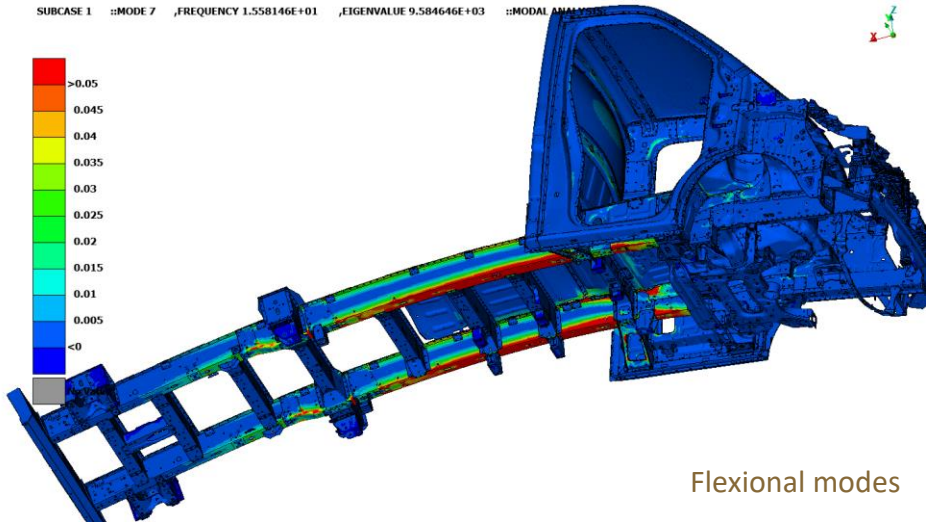


Time domain modal superposition response

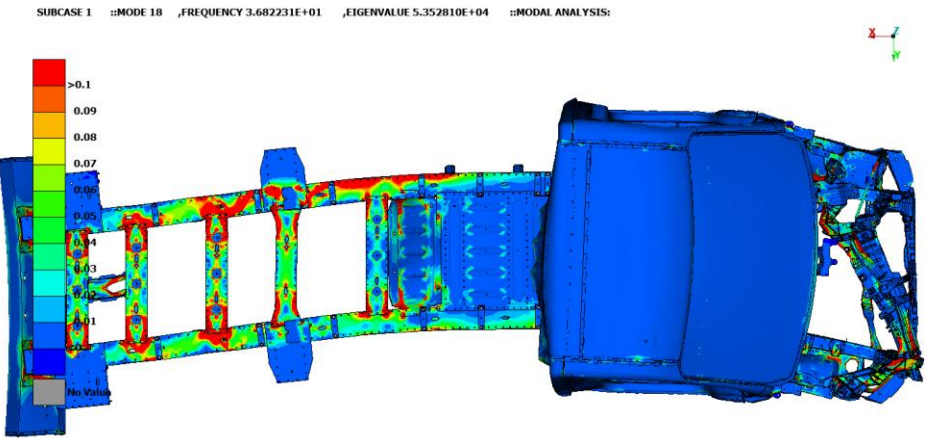
01 - Introduction



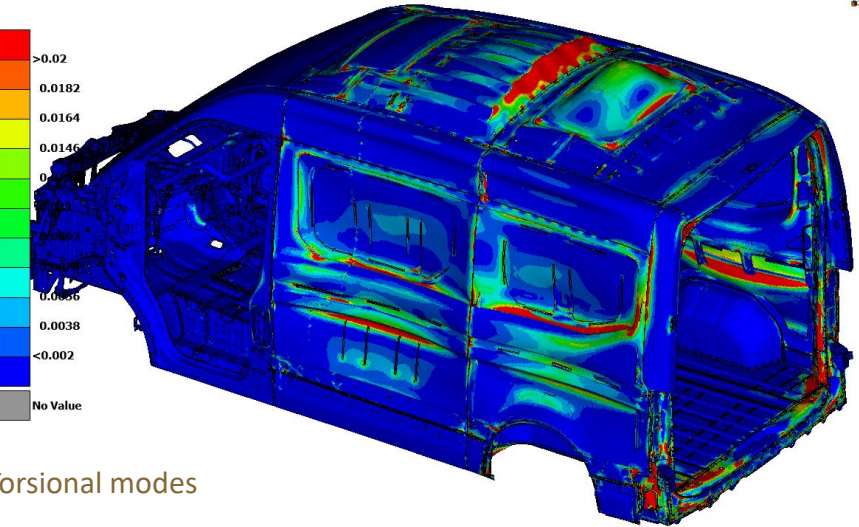
LCV STRUCTURAL MODE SHAPES



Flexional modes

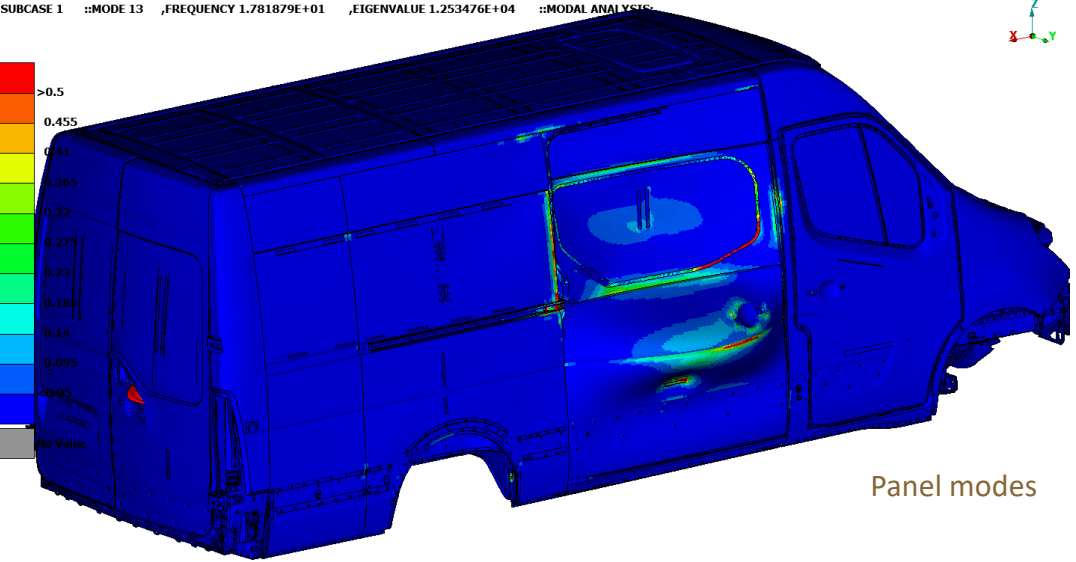


SUBCASE 1 ::MODE 11 ,FREQUENCY 2.332045E+01 ,EIGENVALUE 2.147007E+04 ::MODAL ANALYSIS:



Torsional modes

SUBCASE 1 ::MODE 13 ,FREQUENCY 1.781879E+01 ,EIGENVALUE 1.253476E+04 ::MODAL ANALYSIS:



Panel modes

01 - Introduction

STUDY CASE

Renault MASTER – L2H2

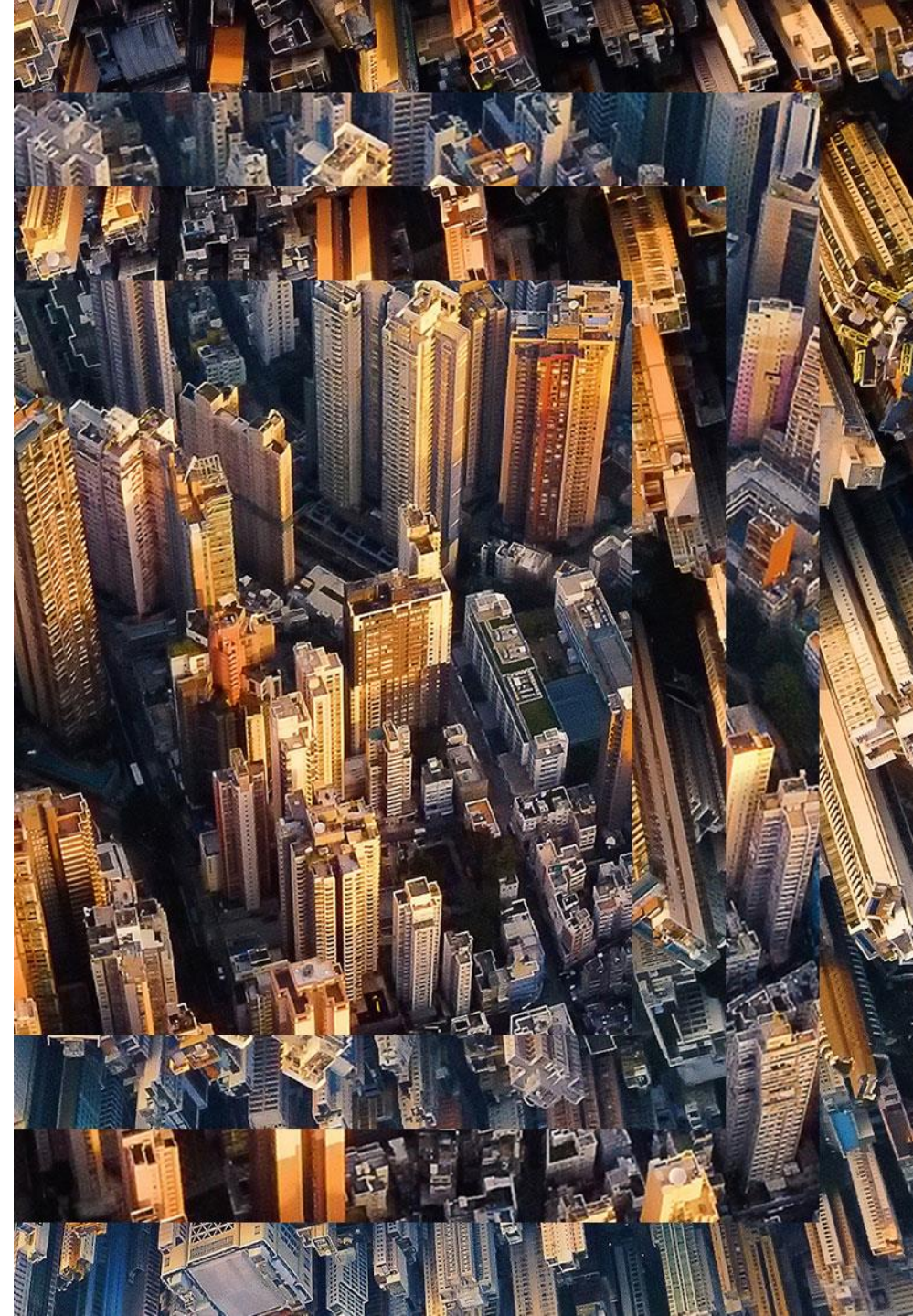
Study performed by MAGNA teams



02

Fatigue prediction process

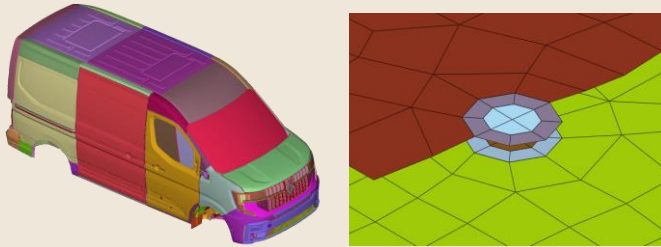
RENAULT MASTER L2H2 EXAMPLE



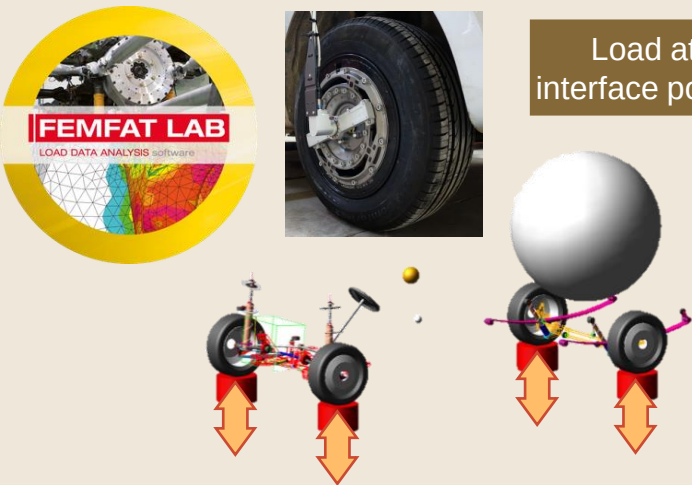
02 - Fatigue prediction process

VEHICLE DURABILITY SIMULATION PROCESS

Model & Assembly



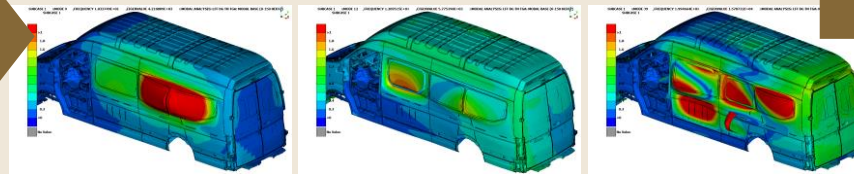
Road load excitation signal



Load at
interface points

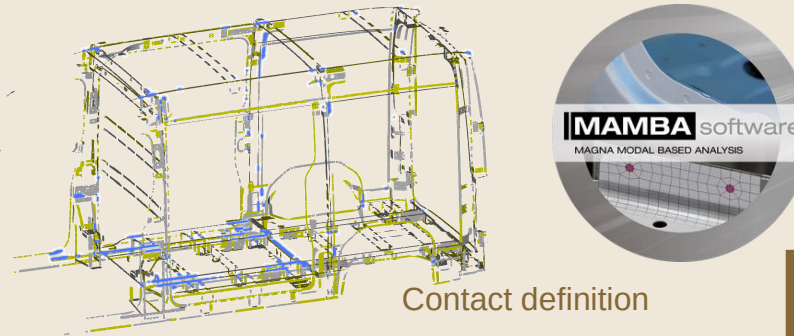
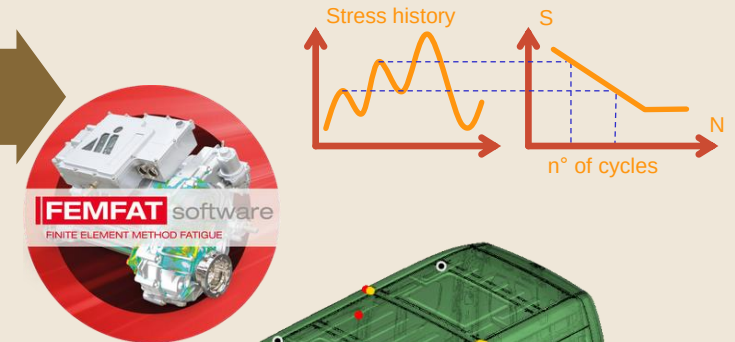
Structural calculation transient response

Modal reduction



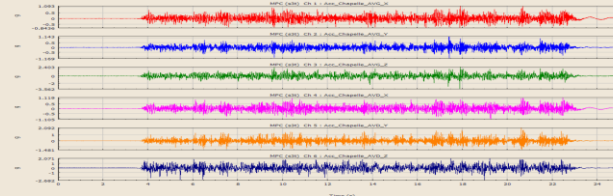
Modal
stress

Fatigue prediction



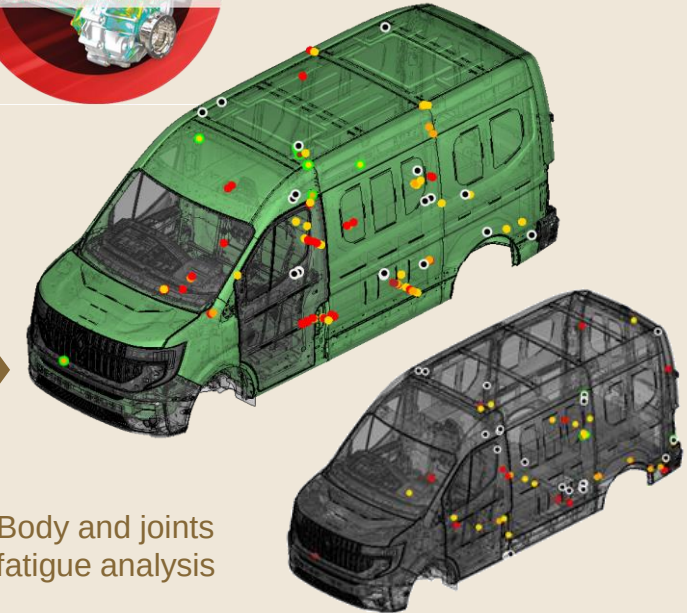
Contact definition

Dynamic
analysis



Modal
coordinates

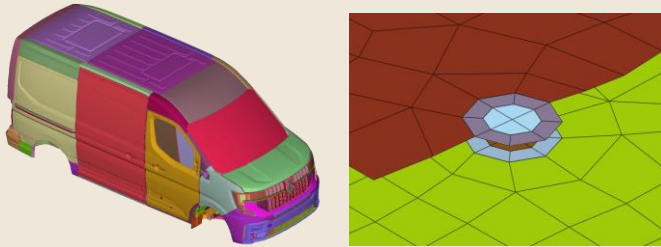
Body and joints
fatigue analysis



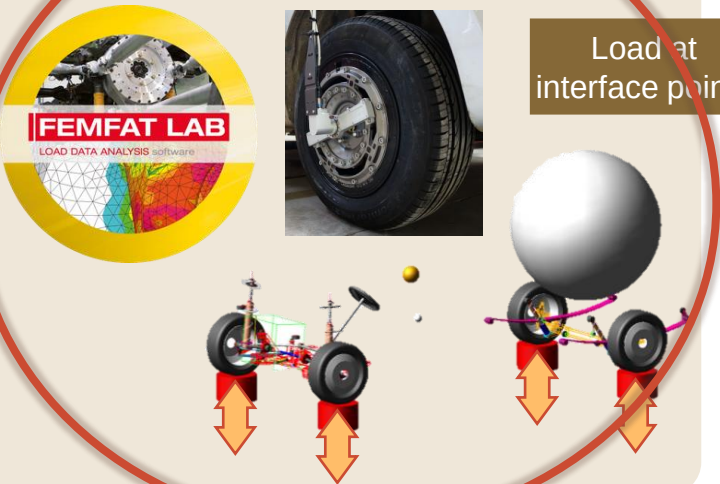
02 - Fatigue prediction process

VEHICLE DURABILITY SIMULATION PROCESS

Model & Assembly



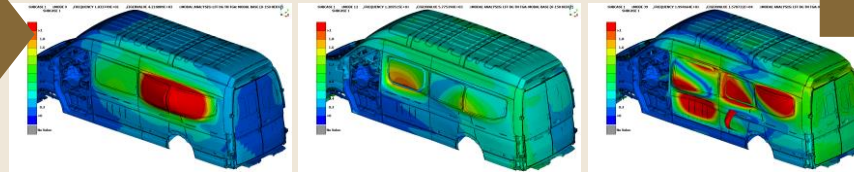
Road load excitation signal



Load at
interface points

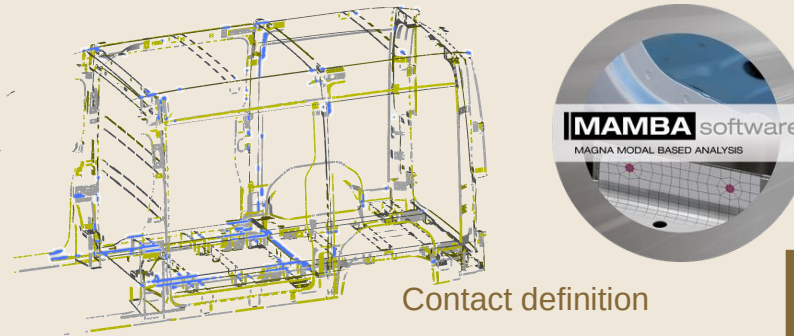
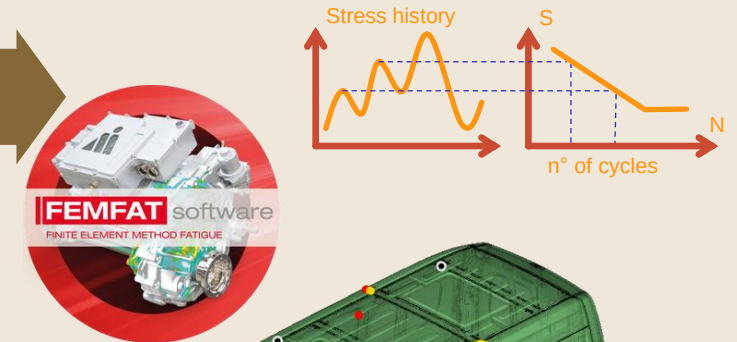
Structural calculation transient response

Modal reduction



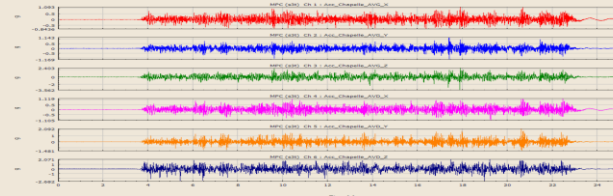
Modal
stress

Fatigue prediction



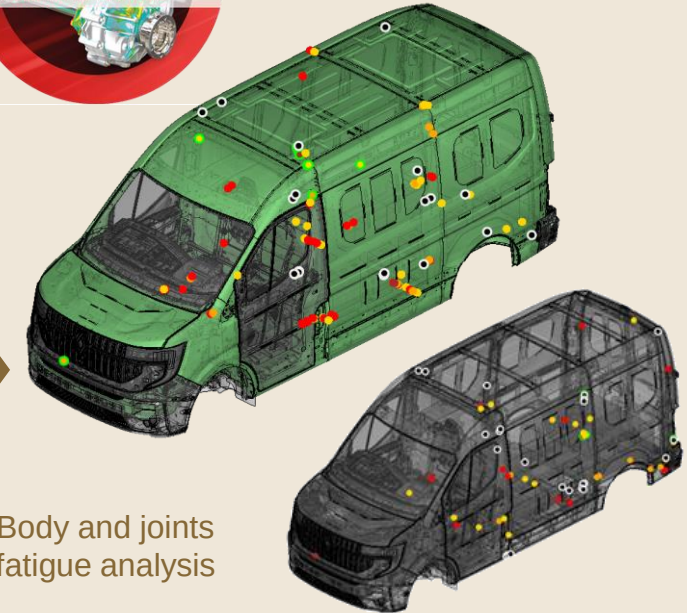
Contact definition

Dynamic
analysis



Modal
coordinates

Body and joints
fatigue analysis

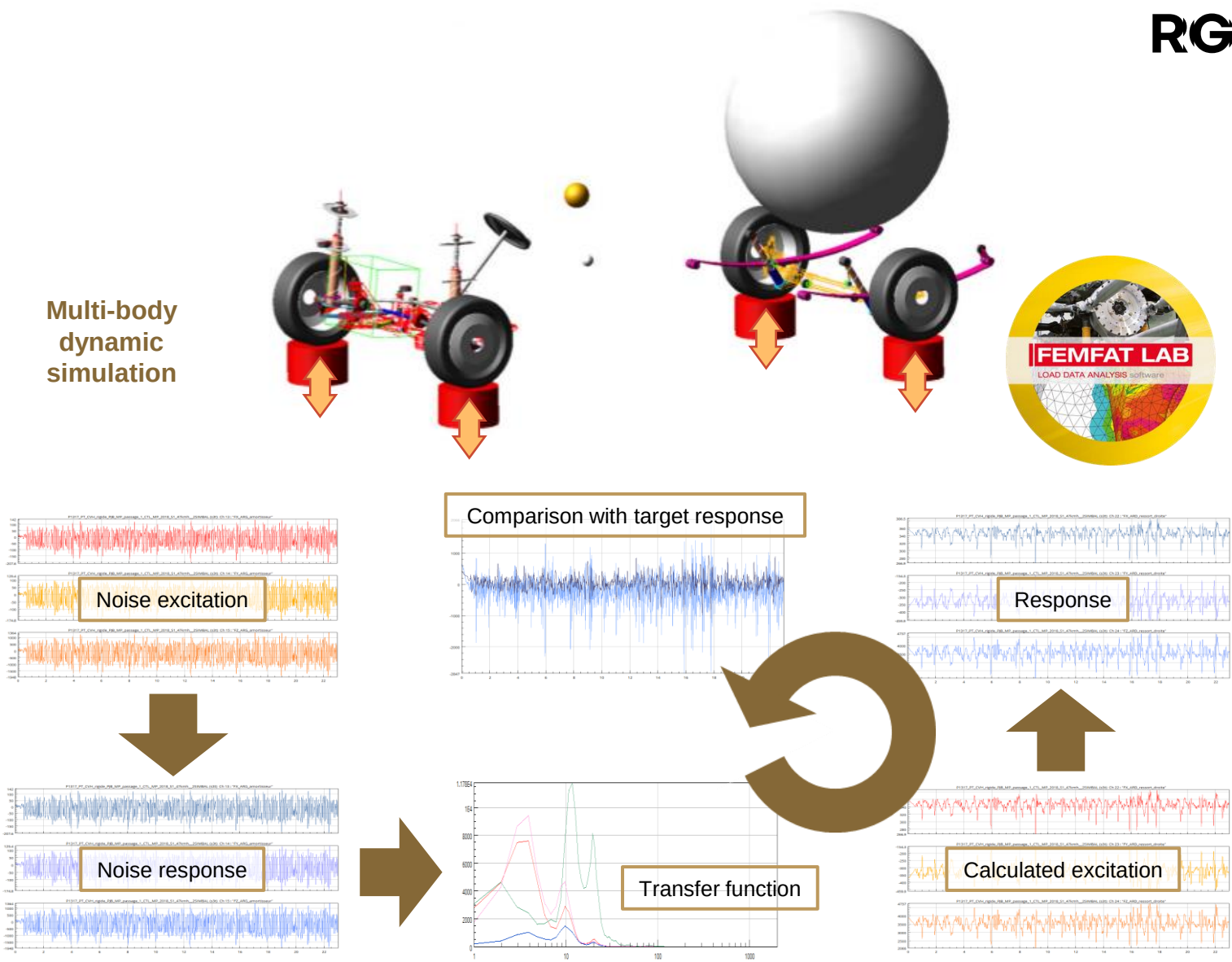


02 - Fatigue prediction process

ROAD LOAD EXCITATION SIGNAL



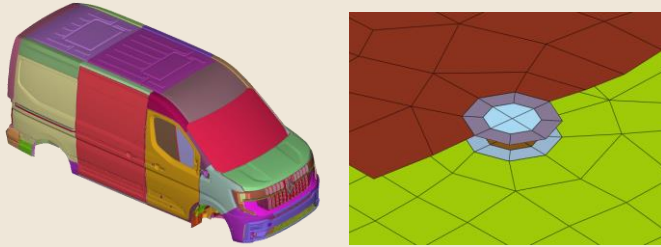
Road load acquisition = Target response
(wheel/body relative displacements + knuckle accelerations)



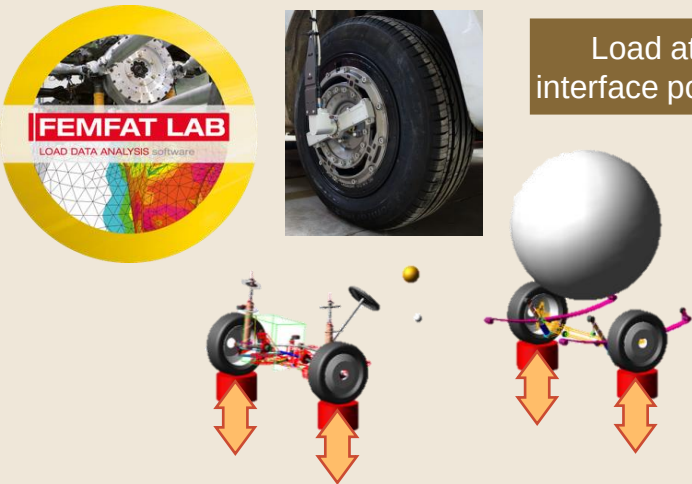
02 - Fatigue prediction process

VEHICLE DURABILITY SIMULATION PROCESS

Model & Assembly



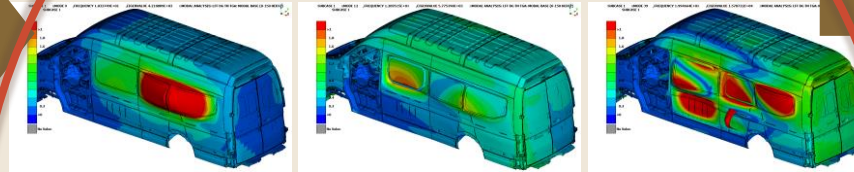
Road load excitation signal



Load at
interface points

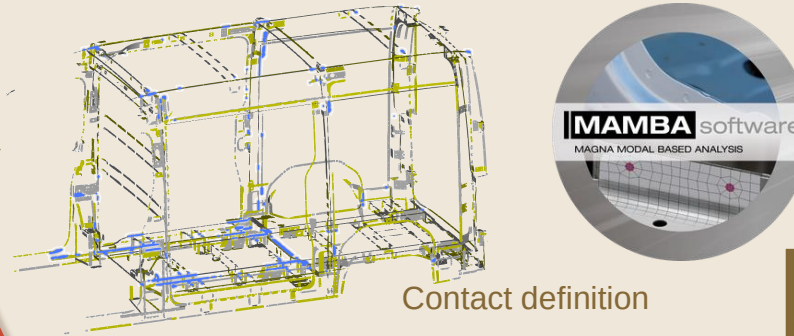
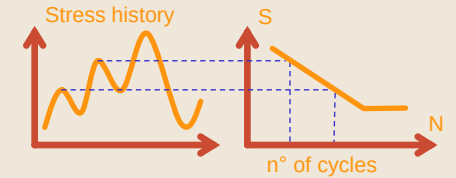
Structural calculation transient response

Modal reduction



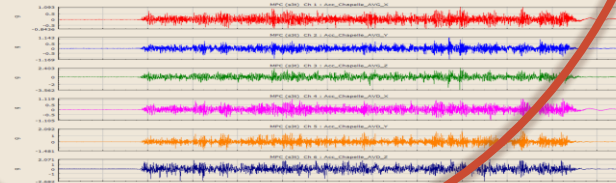
Modal
stress

Fatigue prediction



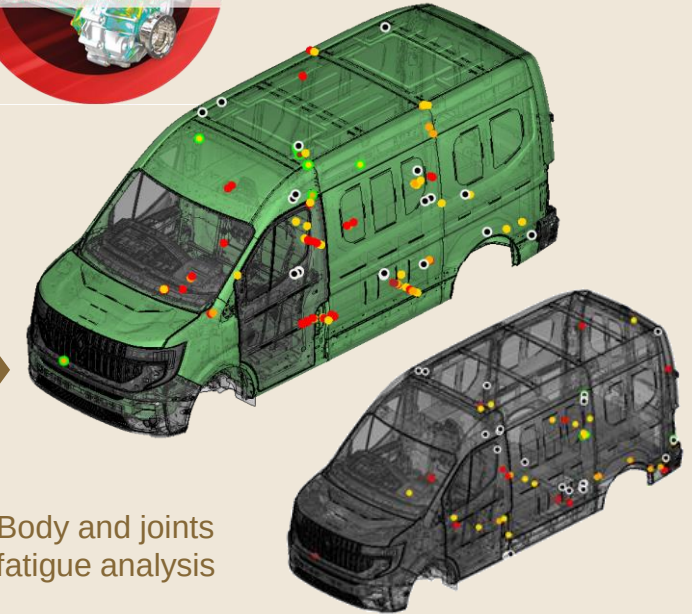
Contact definition

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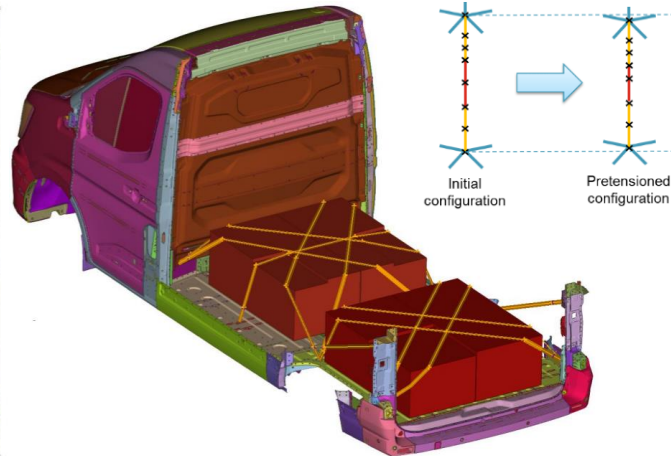


02 - Fatigue prediction process

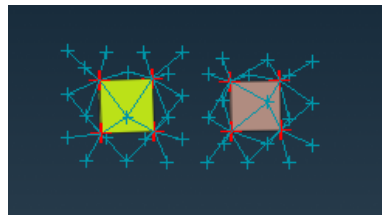
STRUCTURAL RESPONSE

RENAULT MASTER L2H2 study:

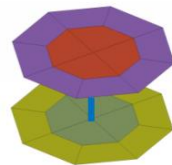
MAGNA collaboration and improvement on RENAULT model



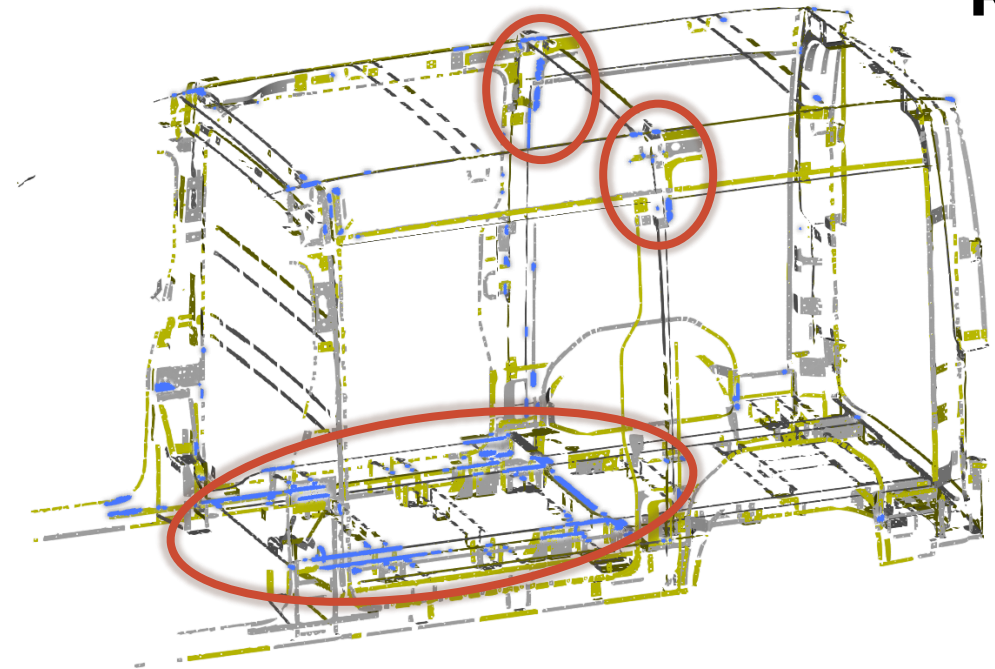
Addition of tension belt in the model + pretention



FEMFAT Nugget
(CQUAD-CBAR-CQUAD)

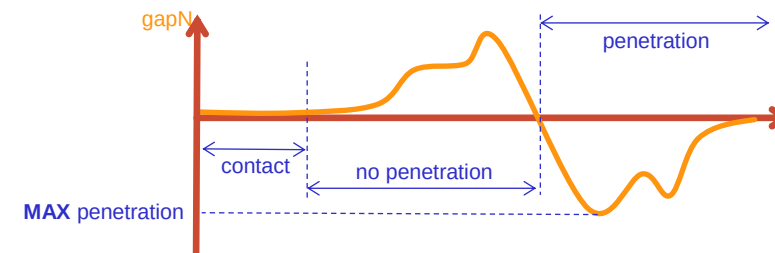


Use of FEMFAT nugget spotweld model for spotweld damage prediction



Dynamic contact consideration

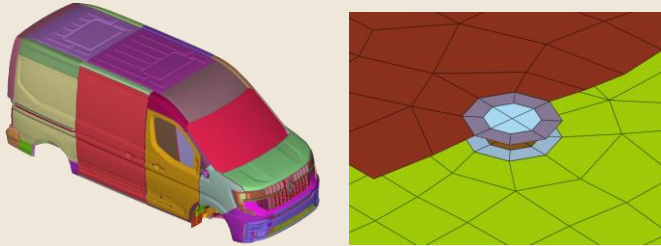
- Automatic detection of potential contact pairs
- Time history penetration calculation → maximum penetration
- Contact pairs with maximum penetration are activated for dynamic analysis
 - Modal stresses
 - Modal coordinates



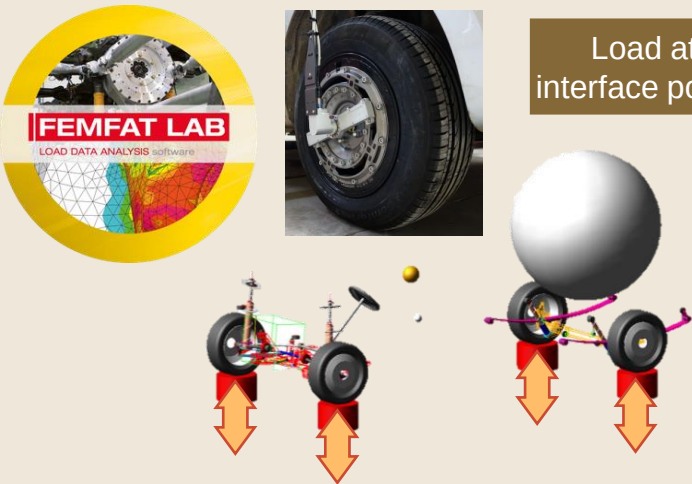
02 - Fatigue prediction process

VEHICLE DURABILITY SIMULATION PROCESS

Model & Assembly



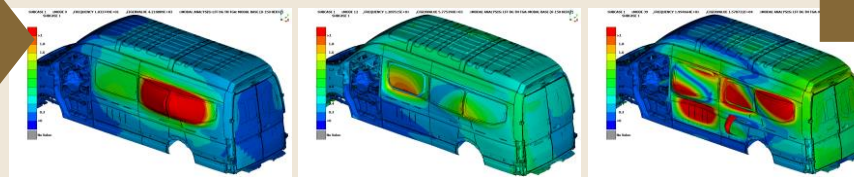
Road load excitation signal



Load at
interface points

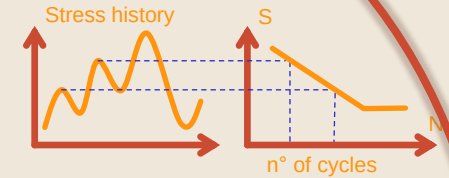
Structural calculation transient response

Modal reduction



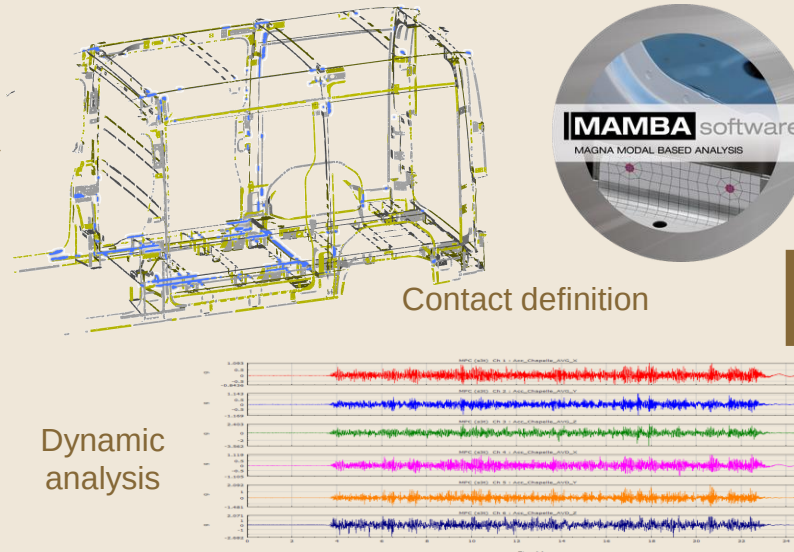
Modal
stress

Fatigue prediction

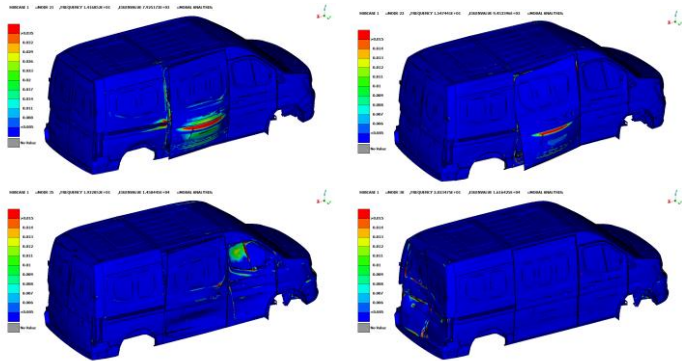


Modal
coordinates

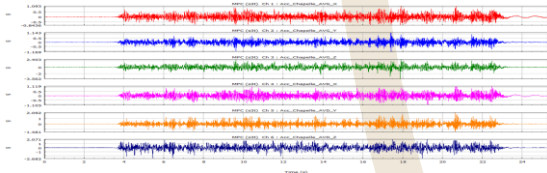
Body and joints
fatigue analysis



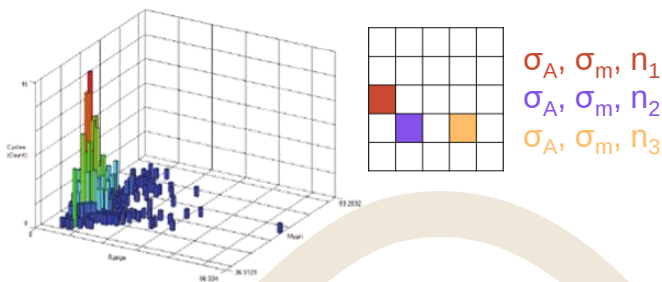
FATIGUE CALCULATION



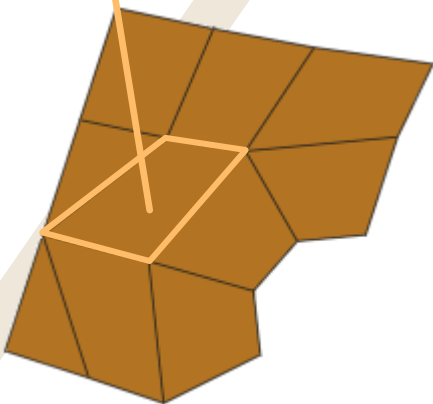
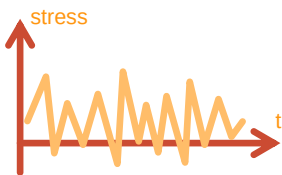
Modal stresses



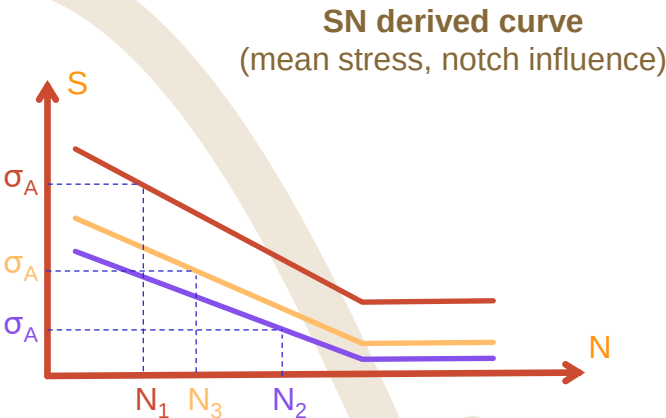
Modal coordinates



Rainflow



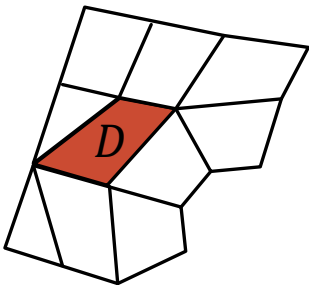
Element stress history



SN derived curve
(mean stress, notch influence)

Miner's rule
Cumulative damage

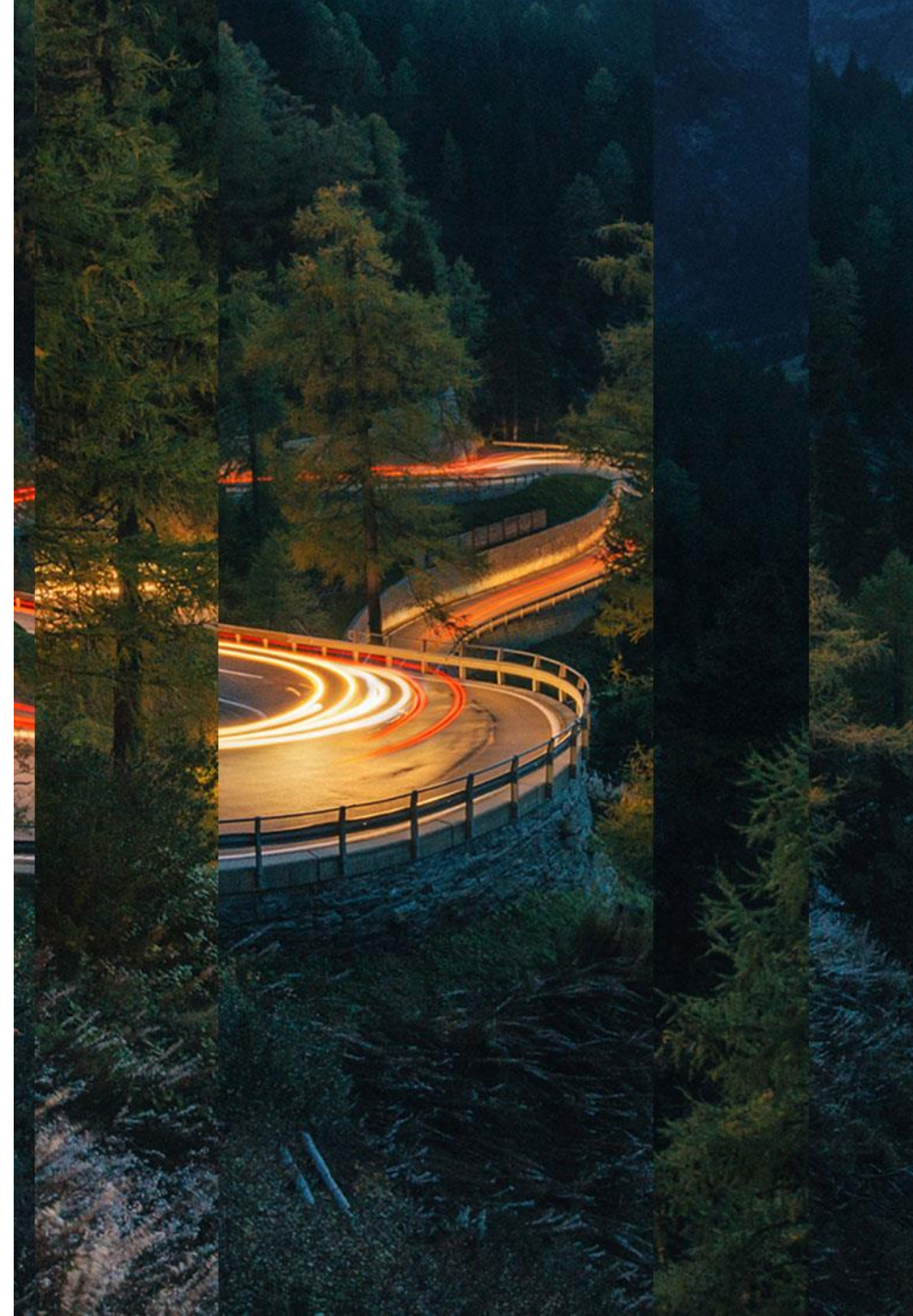
$$D = \sum_i d_i = \sum_i \left(\frac{n_i}{N_i} \right)$$
$$D = \frac{n_1}{N_1} + \frac{n_2}{N_2} + \frac{n_3}{N_3}$$



03

Fatigue prediction results

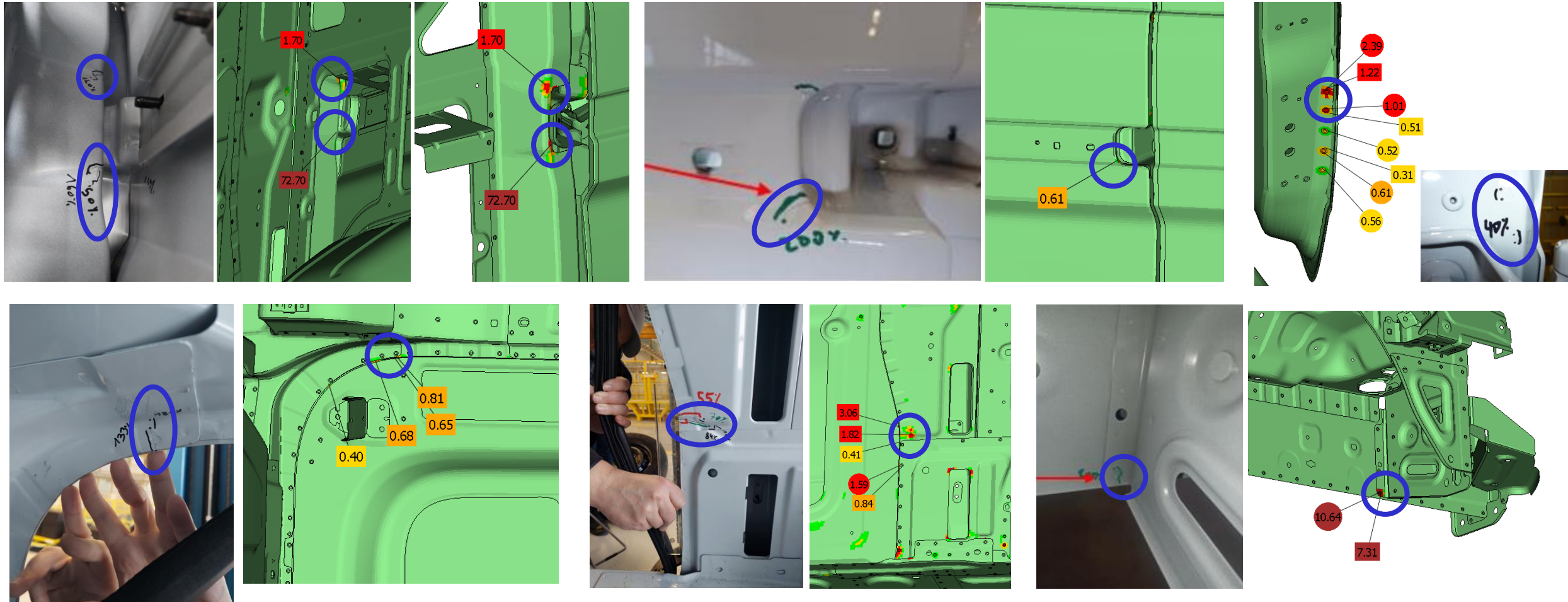
RENAULT MASTER L2H2 EXAMPLE



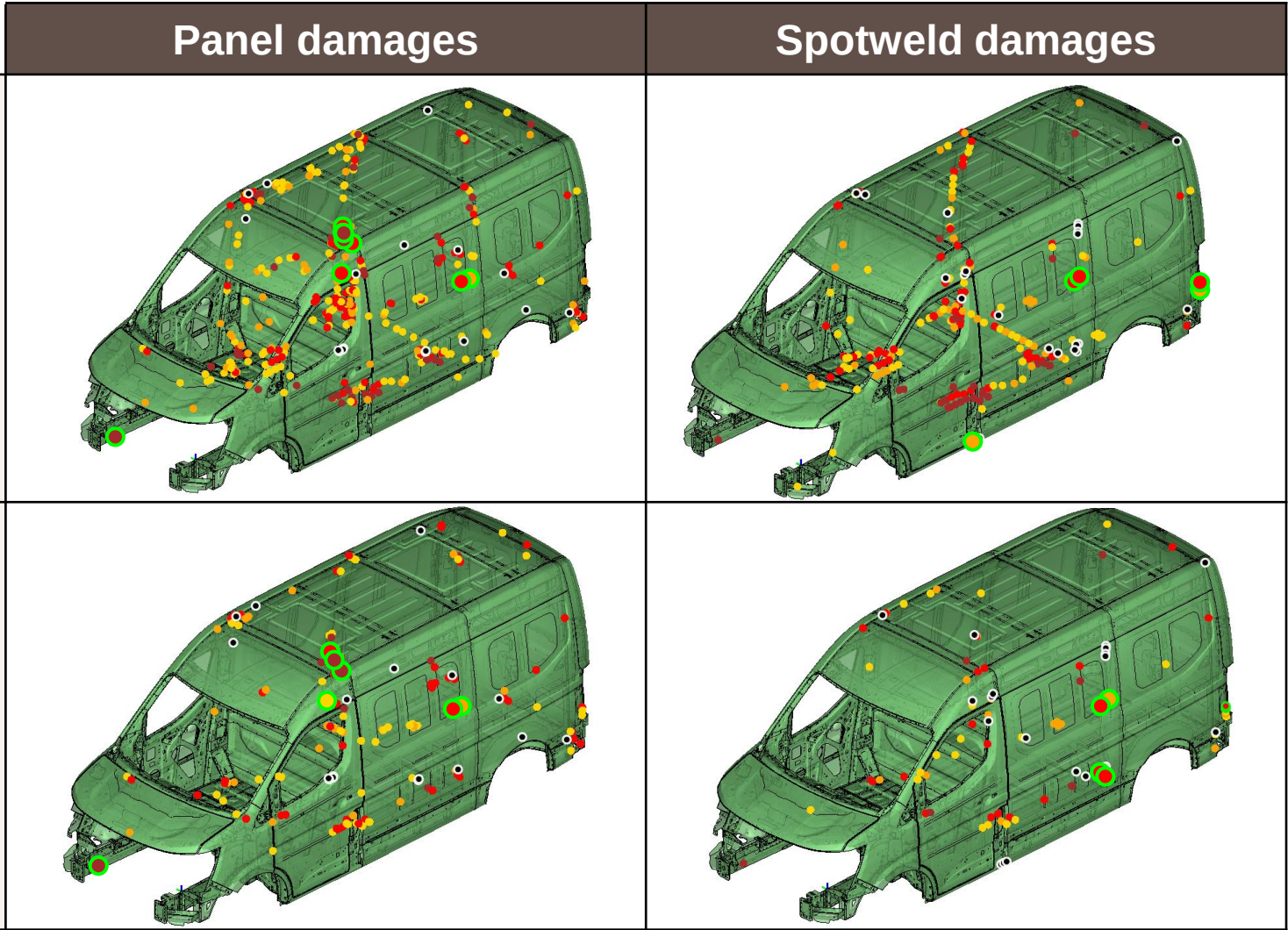
03 - Fatigue prediction results

DAMAGE CALCULATION USING FEMFAT

Correlation with physical test failures → detection of the main structural failures



DAMAGE CALCULATION USING FEMFAT



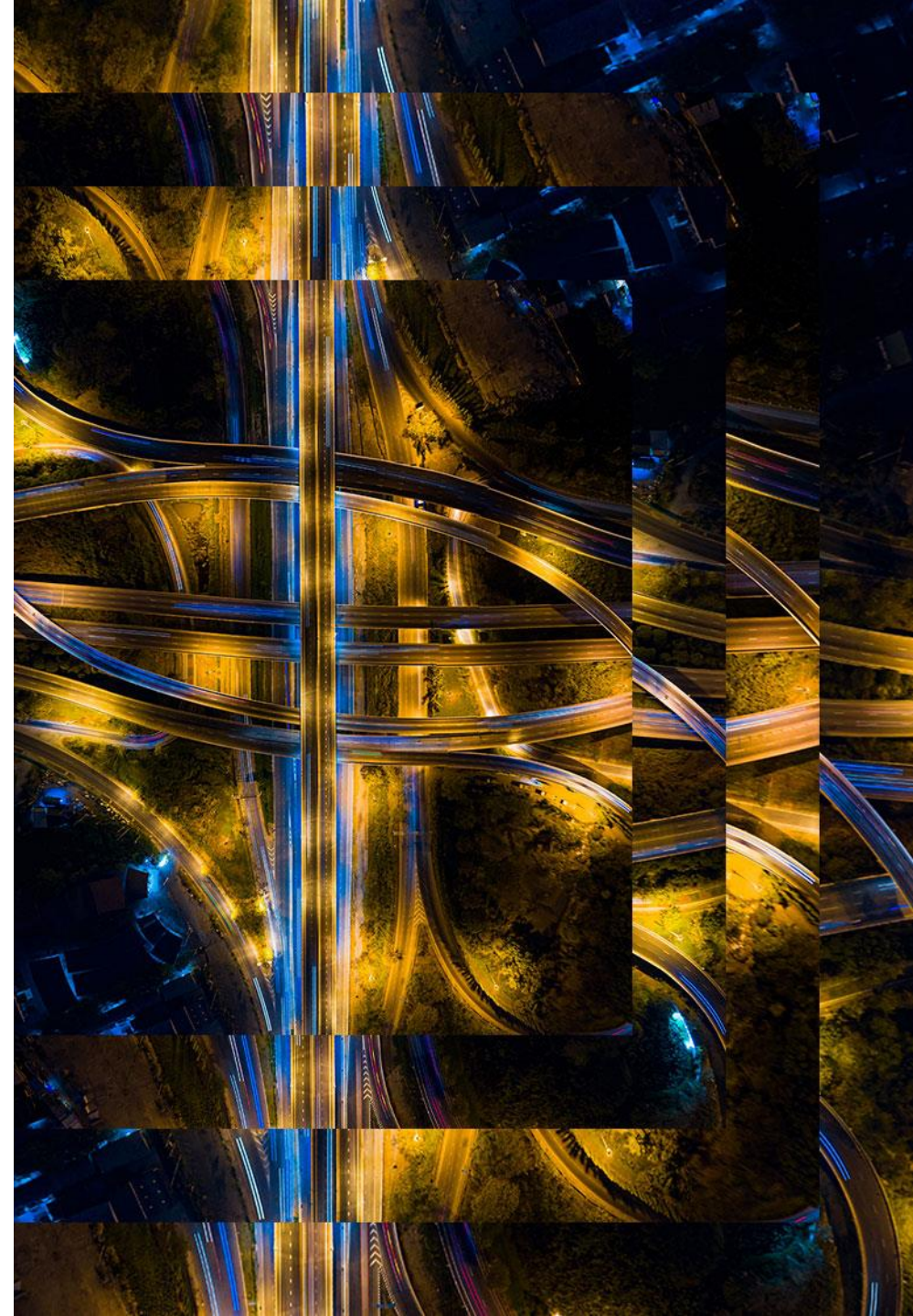
- Damages detected by the simulation – not detect in physical test
- Damages detected by the simulation that **correlate with test failure**
- Damages detected in physical test – not reproduced by the simulation

Impact of
non-linear
MAMBA
solution

➔ Great reduction of the number of false detection with the consideration of contacts

04

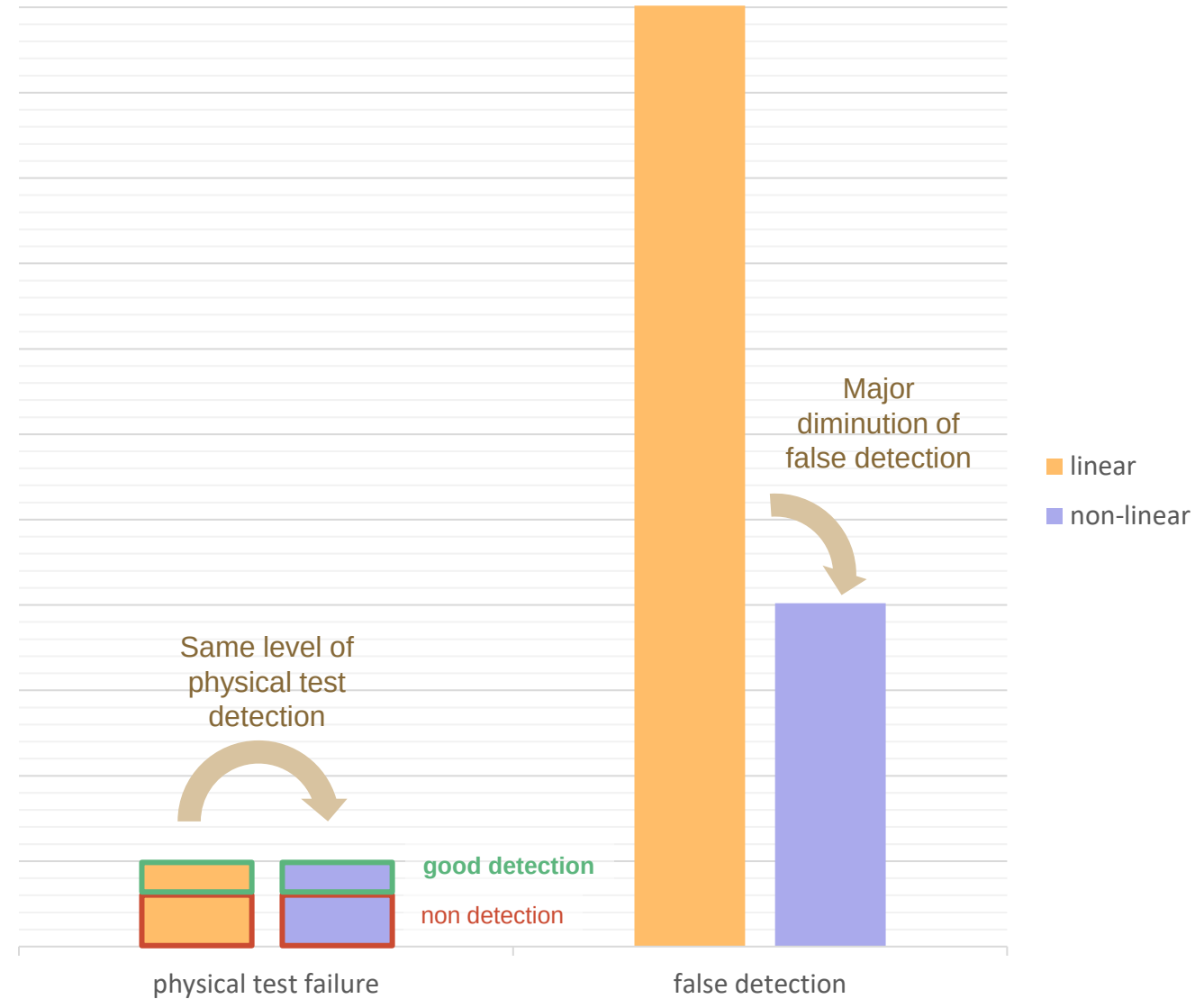
Conclusion



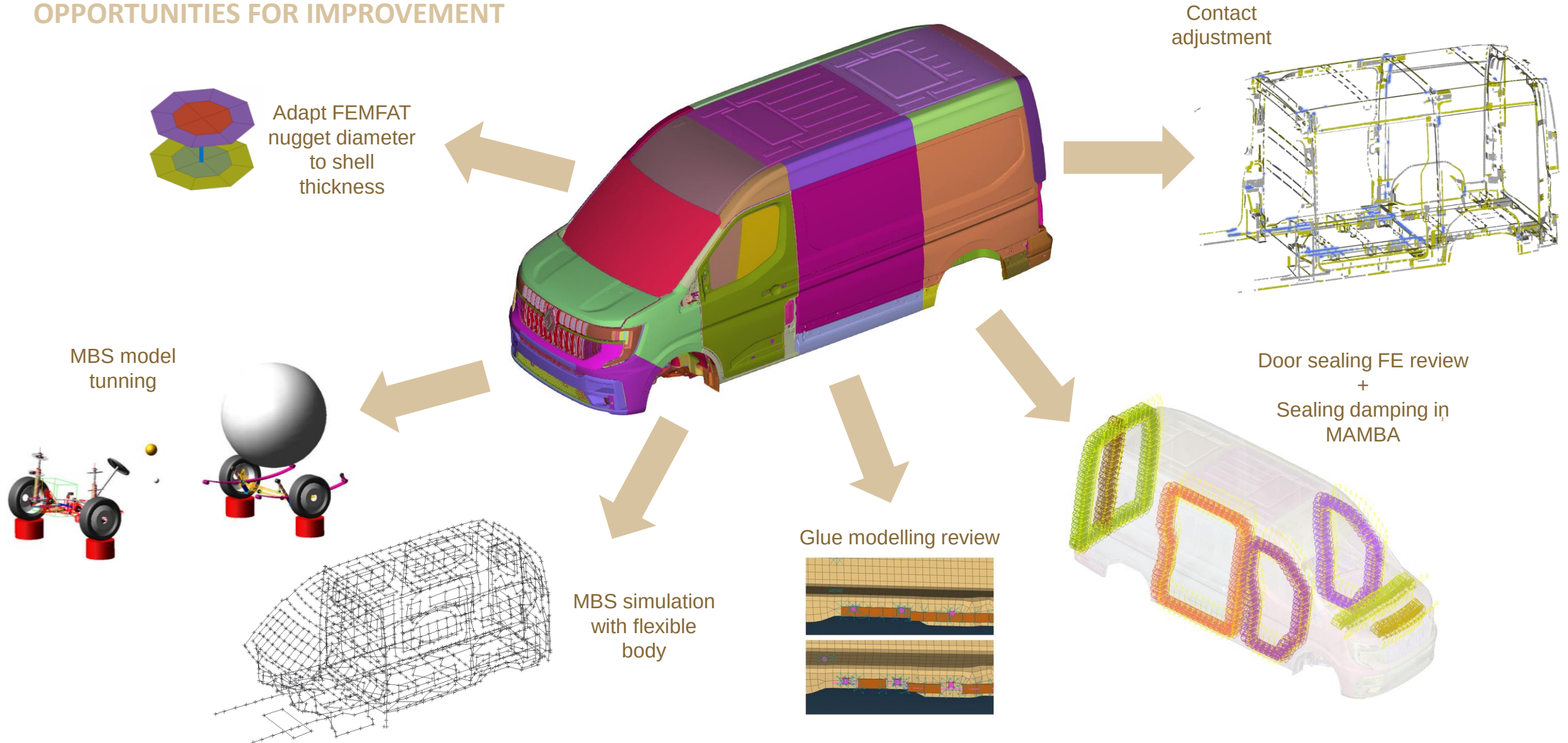
04 - Conclusion

RENAULT MASTER L2H2 STUDY

- The dynamic-based fatigue prediction detects the main physical test failures.
 - The addition of non-linear consideration (contact and belt pretention) doesn't deteriorate the level of good detections.
 - The addition of non-linear consideration (contact and belt pretention) greatly diminishes the portion of false detections.
- **Next:** improve results by:
- Reduce further the number of false detections
 - Increase the ration between good detections and non detections



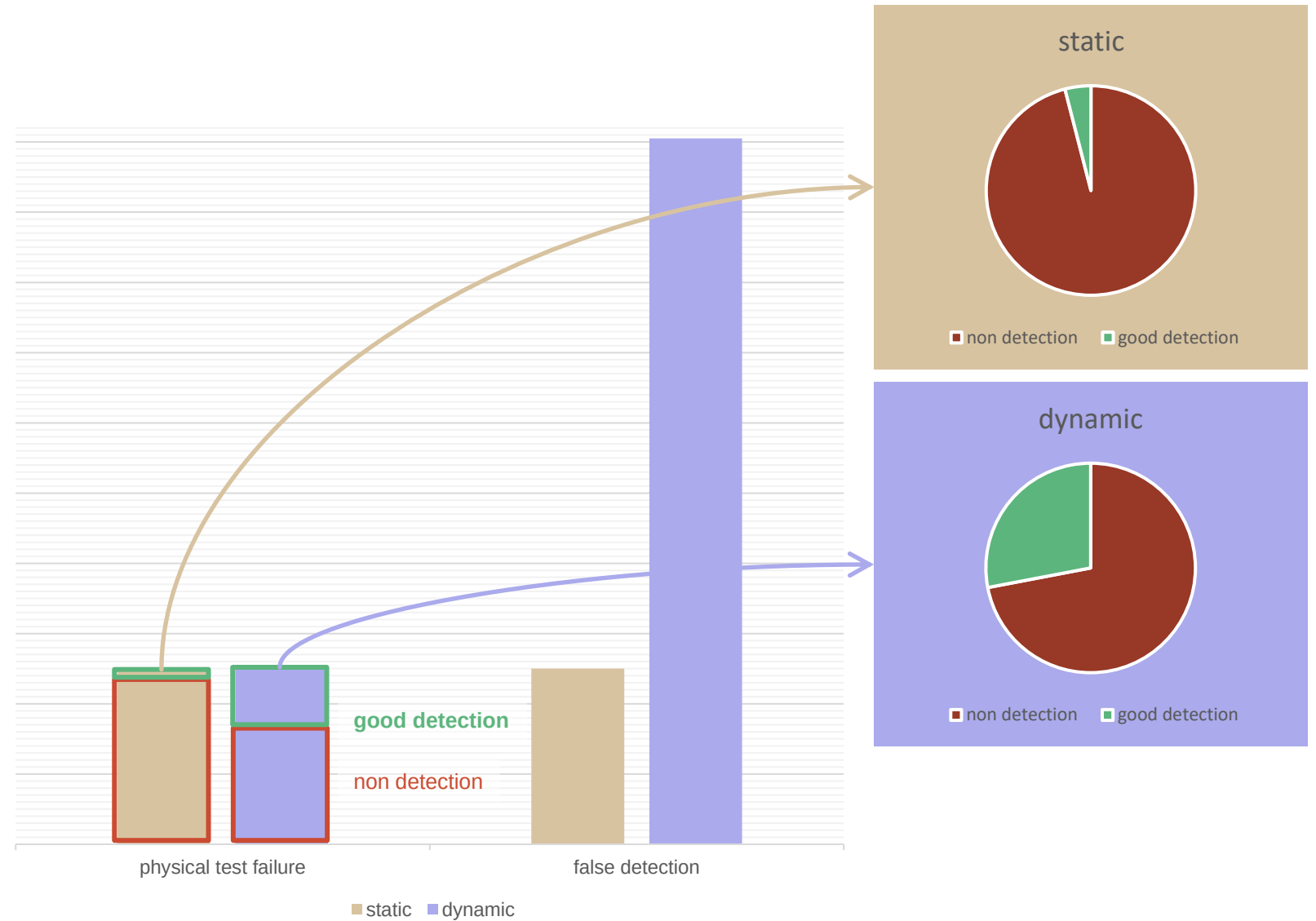
OPPORTUNITIES FOR IMPROVEMENT



04 - Conclusion

DYNAMIC APPROACH

- Standard **static based** approach can't reproduce main structural failures
- **Dynamic based** response is essential to correctly describe the body behaviour and capture hot spots.





Thank you



Renault Group

Appendix