Contents of Work Package 4-WP10: Optimized Design for Vehicle Body Applications

4-WP10: Optimized Design for Vehicle Body Applications

Coordinator of the WP

University of Pardubice, responsible person: prof. Ing. Bohumil Culek, CSc.

Participants of the WP

SVOS, Ltd.: Ing. Jaroslav Černý

ČVUT: Ing. Michal Vašíček, Ph.D.

Main Goal of the WP

Based on experimental measurements and numerical FEM analysis, to develop a new supporting frame of a special vehicle that would meet the strength and fatigue requirements for the considered extraordinary load.

Optimizing the strength of the rear (fifth) door structure of a passenger car.

Partial Goals for the Current Period

4-WP10-001 - FEM analysis of the design of a new supporting frame of a special vehicle. Optimizing frame strength.

4-WP10-002 - Evaluation of strain gauge measurement of mechanical stresses of the supporting frame of a special vehicle obtained from driving tests. Verification of the stress simulation and clarification of strength calculations.

4-WP10-003 – Solving the problem of stiffness of the structure of the rear (fifth) door of a passenger car, optimization of the structure for different parameters of cross-sections and densities.

Contents of Work Package 4-WP10: Optimized Design for Vehicle Body Applications

4-WP10: Optimized Design for Vehicle Body Applications

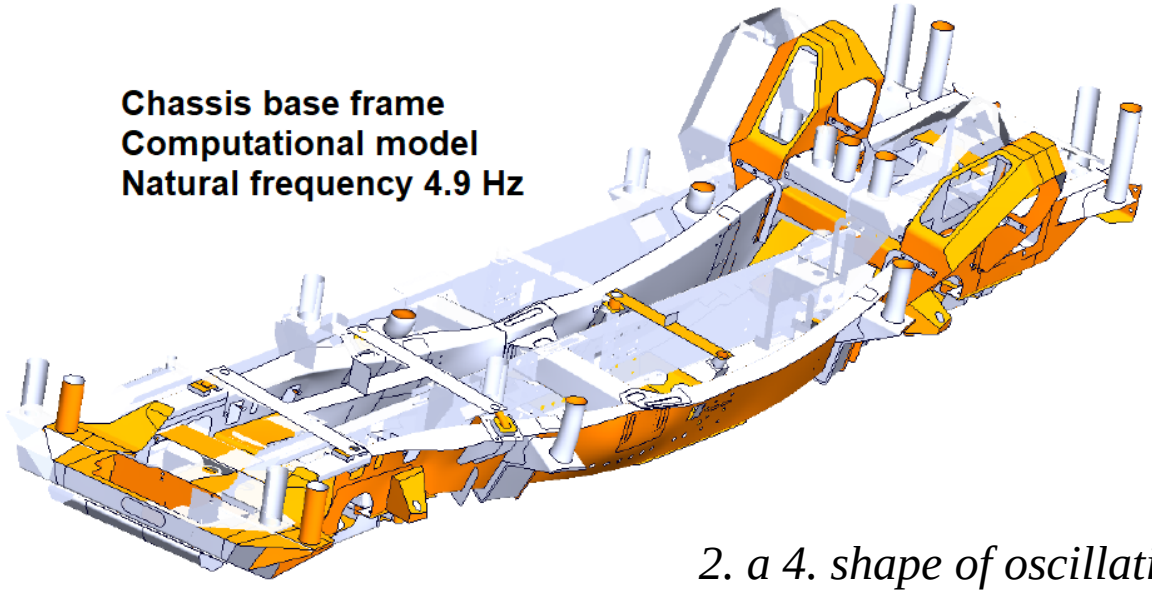
Official 4-WP10 Deliverables:

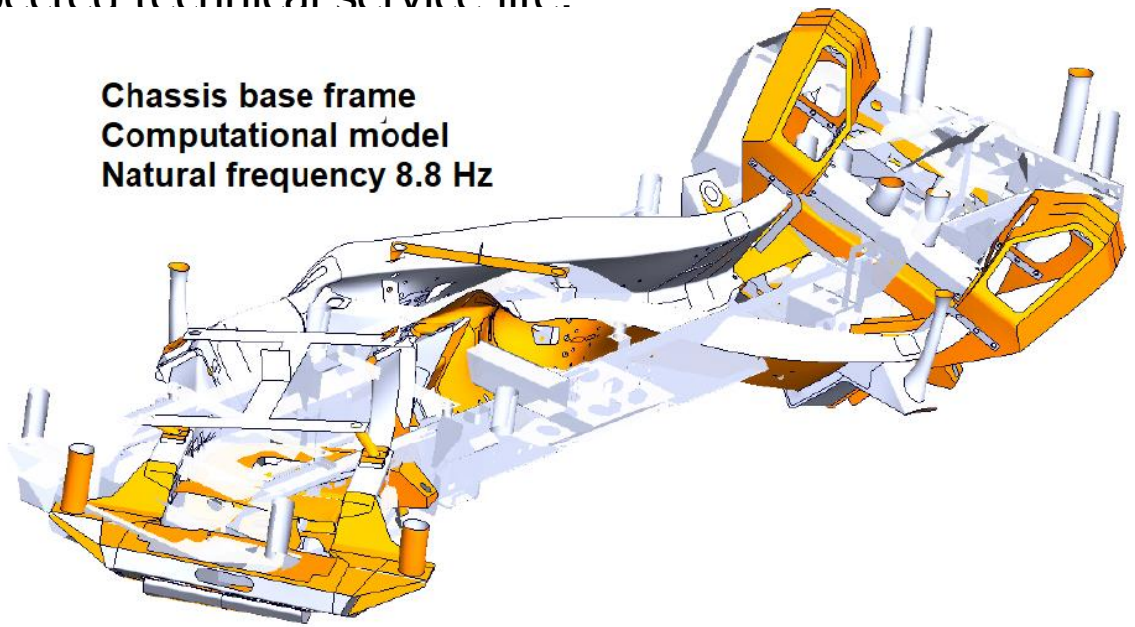
- 4-WP10-001 | **Functional sample of load-bearing part of the special vehicle**, G-funk, XII./2025, SVOS 0.9; UPa 0,1
- 4-WP10-002 | **Report of Analysis of Special Vehicle Support Frame Strength**, O, XII./2025, SVOS 0,2; UPa 0,8
- 4-WP10-003 | **Optimally lightweight tailgate structure of a passenger vehicle**, G-funk, XII./2025, SkodaAuto 0,8; CTU FME 0,2;

Activities in 4-WP10: Optimized Design for Vehicle Body Applications

4-WP10-001:

- Based on the results comparison of the measured mechanical stresses during the driving tests and the calculated stress values during the FEM simulations was the verification of the simulation set-up process carried out. Subsequently, the strength calculation analyzes of the newly proposed variants of the supporting frame construction are carried out. Based on mentioned analyzes, the structural modifications of the frame in such a way that it meets the expected dynamic load in extreme operating conditions, as well as overall fatigue during the expected technical service life.



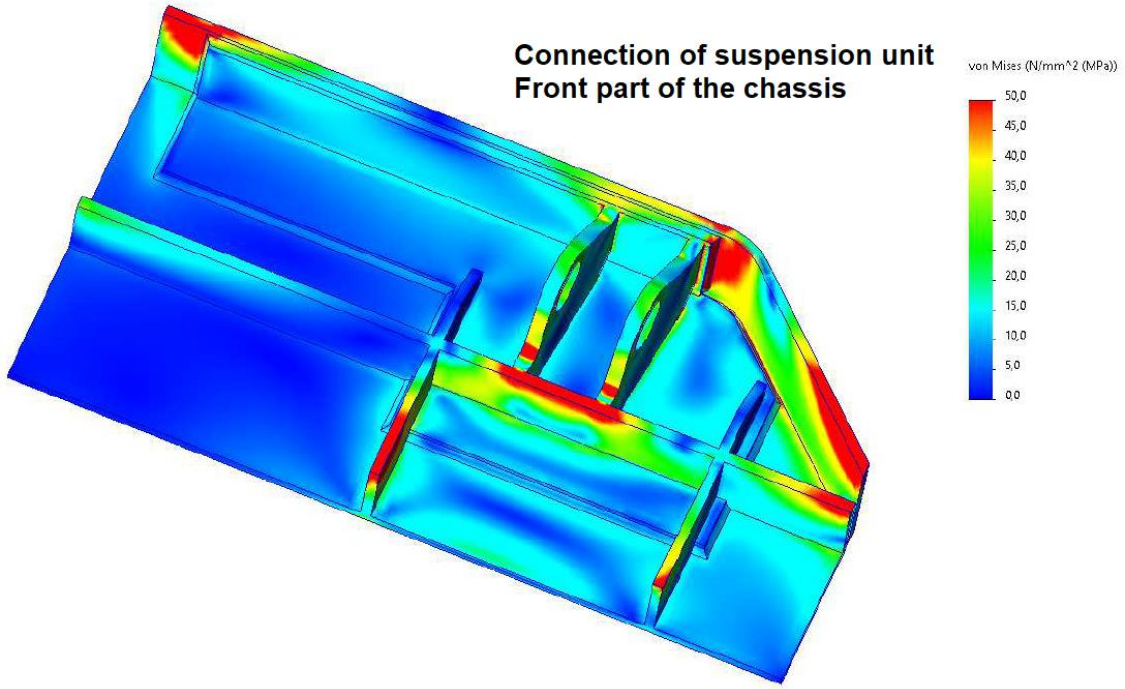


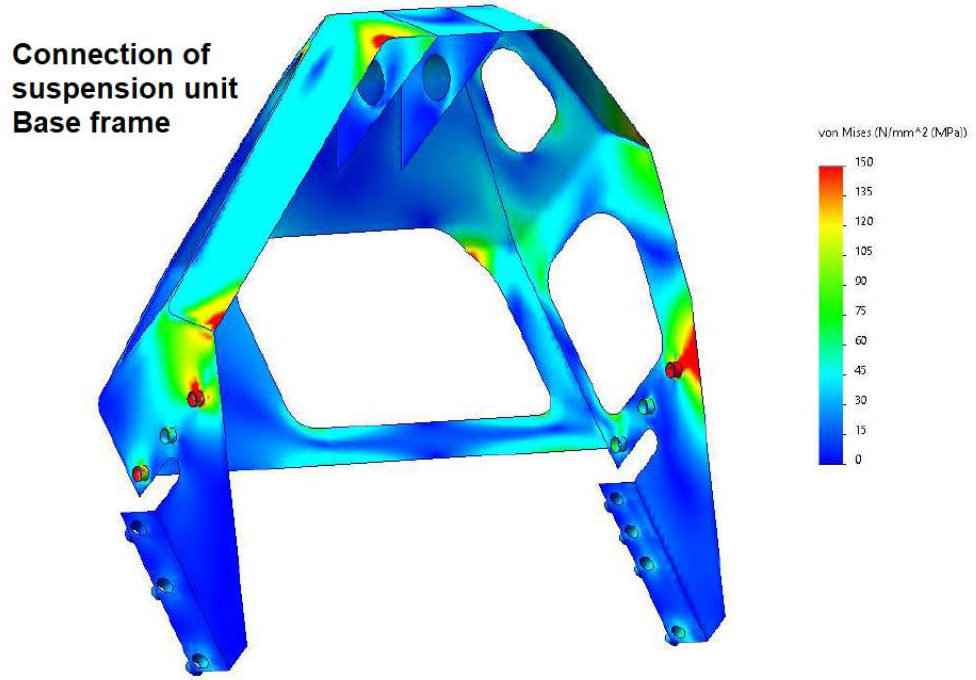
2. a 4. shape of oscillati

Activities in 4-WP10: Optimized Design for Vehicle Body Applications

4-WP10-001:

- Evaluation of the dynamic response (natural frequency) along with specifying the stresses in critical areas of the modified frame is a necessary basis for later arrangement of experimental tests and determination of fatigue life.



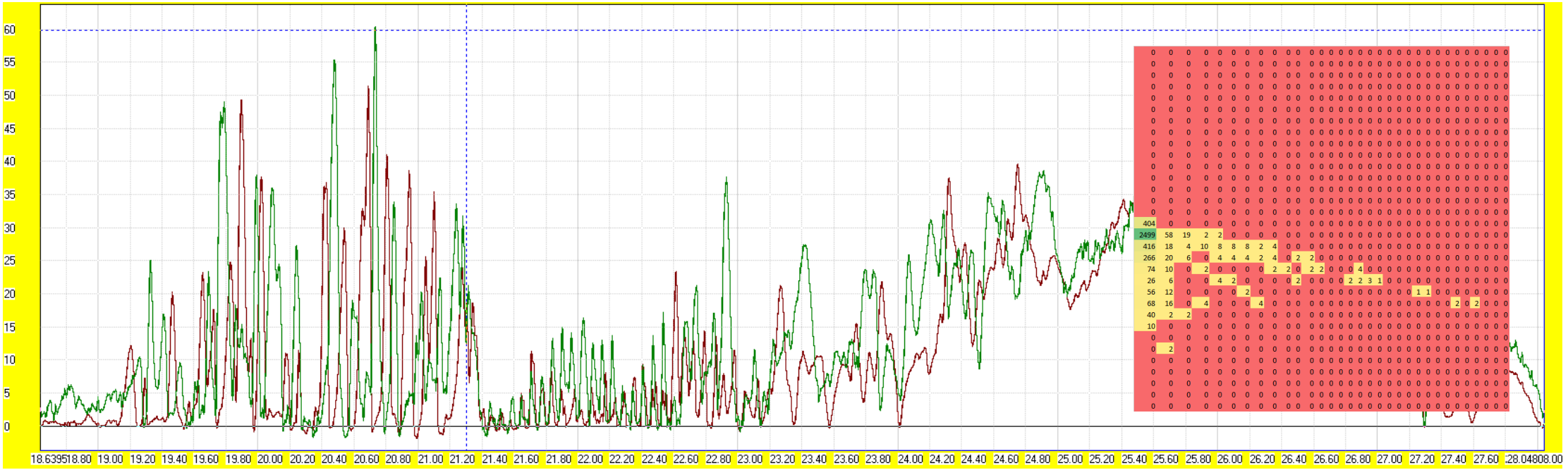


Detail of the suspension unit – stress concentration

Activities in 4-WP10: Optimized Design for Vehicle Body Applications

4-WP10-002:

- Measurements of mechanical stresses at selected locations of the frame of a special vehicle (see example of stress recording) were processed by the two-parameter method of Rain Flow. The results of this processing will subsequently be used to estimate the fatigue strength of the frame.

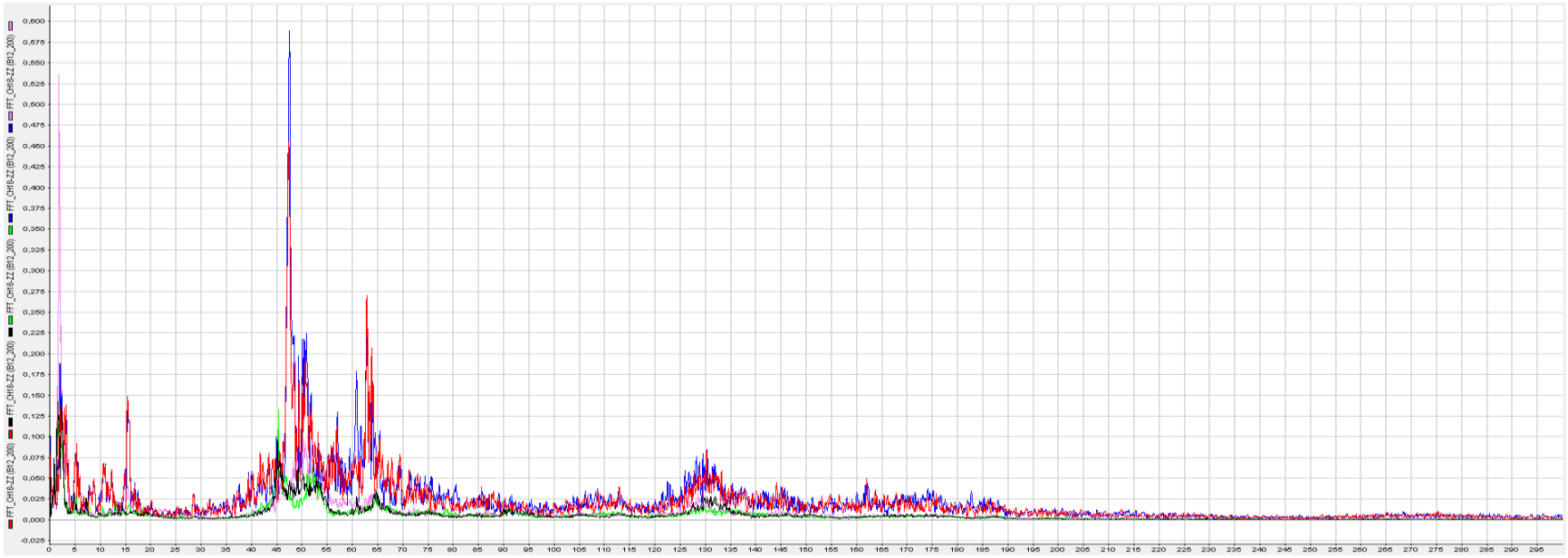


Stress record and its Rain Flow matrix

Activities in 4-WP10: Optimized Design for Vehicle Body Applications

4-WP10-002:

- Measuring the acceleration (vertical, transverse, longitudinal) of the special vehicle body was a necessary basis for verifying the suitability of the numerical calculation. Comparing different suspension combinations (tire inflation + air spring) in different driving modes had to correspond to the theoretical response.

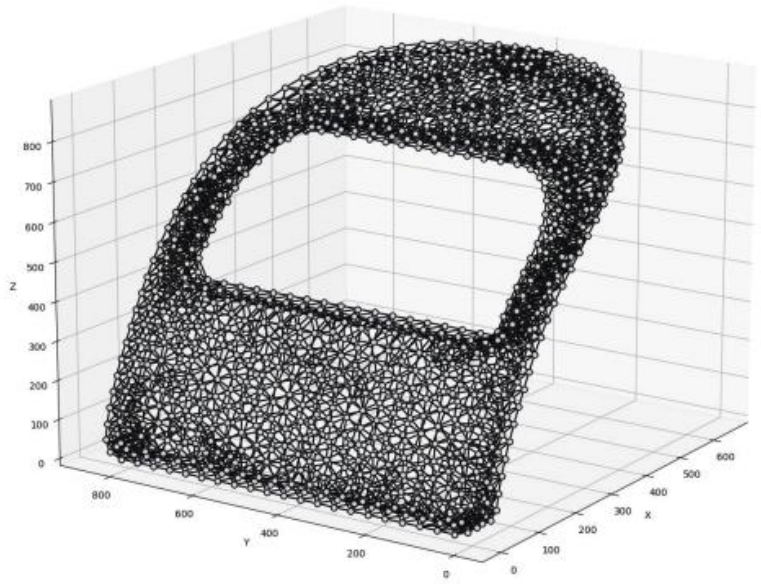


Example of vertical acceleration record of the superstructure under different loading modes and different suspension combinations

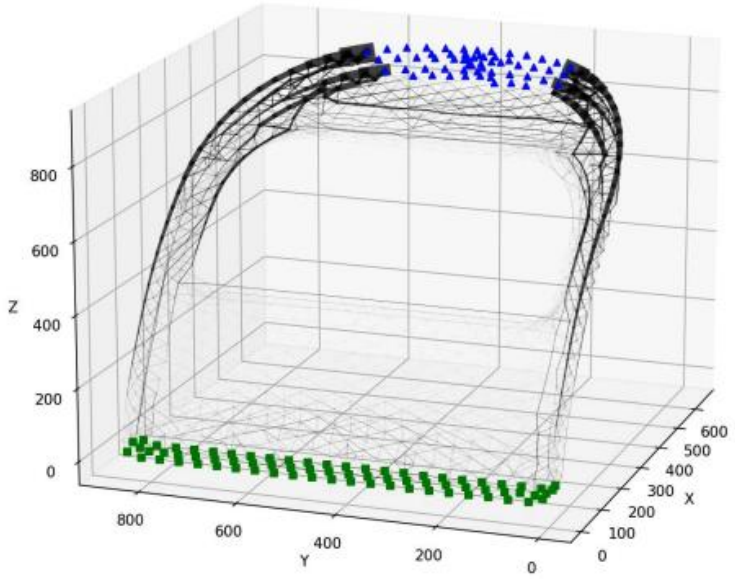
Activities in 4-WP10: Optimized Design for Vehicle Body Applications

4-WP10-003:

- Completed CAD import and meshing, used preprocessing in Abaqus, created own script
- Solving the stiffness problem (construction optimization based on the static load state)



Discretization of the design space



Boundary conditions applied to the discretized design space

Fulfillment of goals and deliverables of 4-WP10: Optimized esign for Vehicle Body Applications

Current State of Deliverables and Fulfillment of Goals

- 4-WP10-001 | Functional sample of the supporting part of a special vehicle, G-funk, XII./2025, SVOS 0,9; UPa 0,1 – proceeds according to plan:
  - FEM analysis of the chassis frame of a special vehicle(UPa, SVOS)
  - Design modifications of the winch holder and reinforcement ribs(UPa)
  - Fabrication of frame of the special vehicle , assembly of the entire car(SVOS)
- 4-WP10-002 | Report of special vehicle support frame strength analysis, O, XII./2025, SVOS 0,2; UPa 0,8 – proceeds according to plan:
  - Depending on FEM calculations, identification of measuring points, gluing of strain gauges and acceleration sensors(UPa)
  - Driving tests on the SVOS test track (UPa, SVOS)
  - Driving tests in the Vyškov testing area(UPa, SVOS)
  - Preliminary evaluation of test records (UPa)
- 4-WP10-003 | Optimally lightened design of the tailgate of a passenger car, G-funk, XII./2025, ŠkodaAuto 0,8; ČVUT FSI 0,2 – proceeds according to plan :
  - CAD import and meshing, Beam-based Topology Optimization.

Fulfillment of goals and deliverables of 4-WP10: Optimized Design for Vehicle Body Applications

List of Due Deliverables and Their Added Value

- **4-WP10-001** – Modification (reinforcement) of the chassis frame of the special vehicle, front winch installation, type SuperWinch Talon 18.
- Other frame modifications of the special vehicle:
  - damper brackets
  - Reinforcing ribs of the front part of the frame
  - Hatch hinge torsion element

The mentioned modifications to the frame lead to an increase in the useful properties of the special vehicle and thus to its higher competitiveness.

Current contribution of 4-WP10: Optimized Design for Vehicle Body Applications

Assessment of the Contribution of Deliverables

- The solution to the dynamic strength of the frame of a special vehicle using high-strength steel can be used in the construction of the load-bearing parts of any means of transport.
- Optimizing the design of the rear (fifth) door of a passenger car results in weight reduction and thus a benefit for environmental protection.
- The synergy within this project can be seen in these WPs: 3-WP10, 4-WP05, 4-WP9 and the potential for other projects is in Transport 2030.

Current contribution of 4-WP10: Optimized Design for Vehicle Body Applications

Assessment of the Formal/Administrative Goals of the Work Package

Ensuring formal and economic parameters in 2024 is not threatened.

The University of Pardubice and SVOS are proceeding according to plan.

Current contribution of 4-WP10: Optimized Design for Vehicle Body Applications

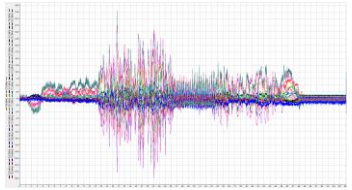
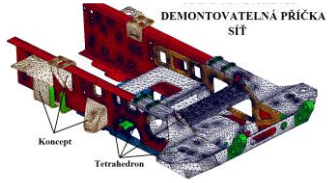
Acknowledgment

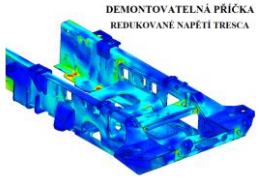
This research has been realized using the support of Technological Agency, Czech Republic, programme National Competence Centres II, project # TN02000054 Božek Vehicle Engineering National Center of Competence (BOVENAC).

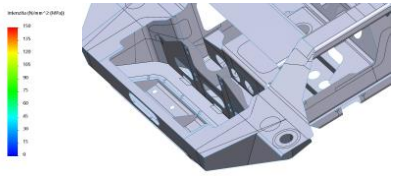
Výtah prací 2023-2024 za 4-WP10: Aplikace optimalizovaného návrhu konstrukce vozidla

UPCE+SVOS: návrh konstrukce a experimentální testy

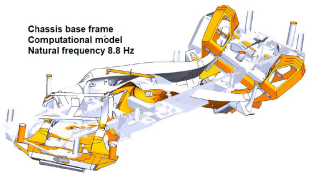


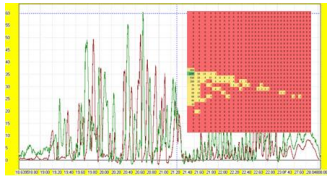
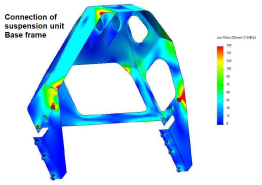



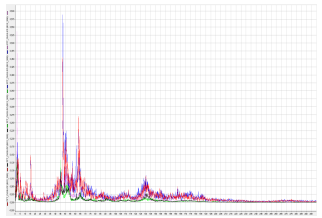
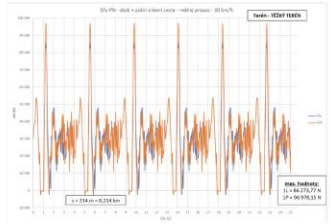




Experimentální tenzometrické měření na stávajícím vozidle, prvotní návrh MKP modelu, Optimalizace MKP modelu



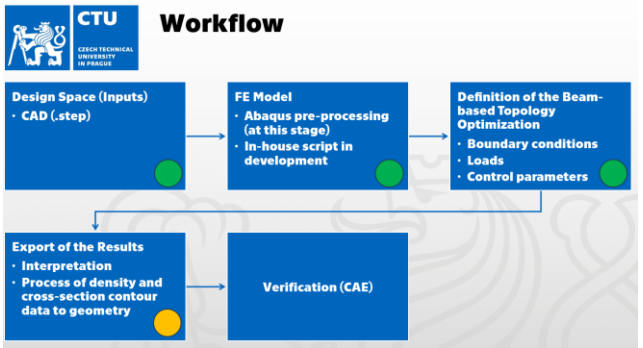



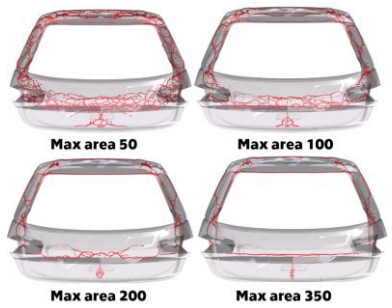




Hodnocení výsledků experimentů, MKP optimalizace, konstrukční návrhy

ČVUT+Škoda Auto: 3D návrh a optimalizace MKP

Návrh CAD modelu, implementace CAD modelu do MKP. Citlivostní analýza.



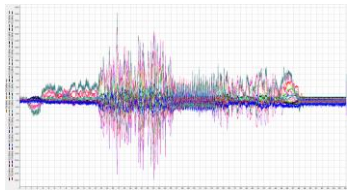
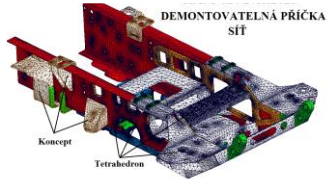


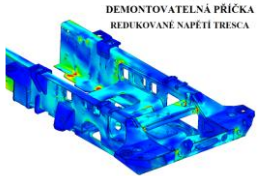
Optimalizace tuhosti, interpretace výsledků s ohledem na technologii výroby

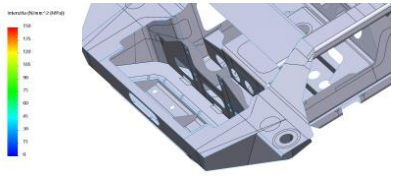
Results of 4-WP10: Optimized Design for Vehicle Body Applications – achieved 2023 -2024

UPCE+SVOS: structural design and experimental tests

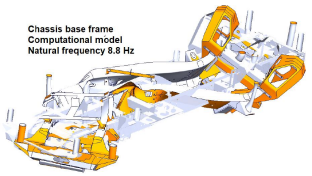


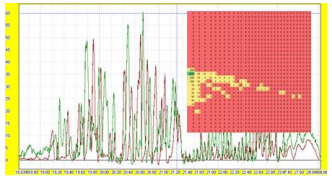
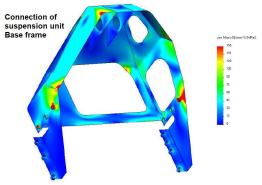



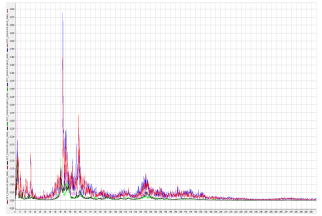
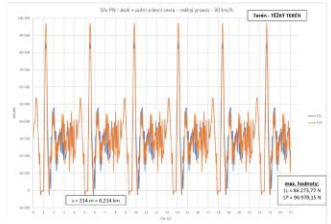




Experimental strain gauge measurement on an existing vehicle, initial design of the FEM model, Optimization of the FEM model

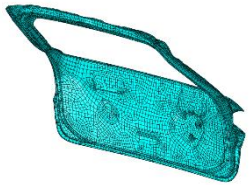


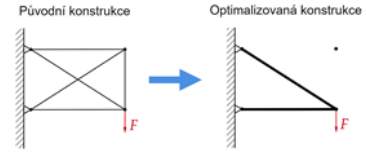



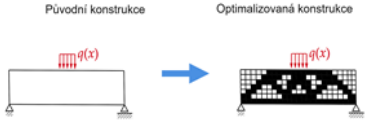




Evaluation of experimental results, FEM optimization, structural designs

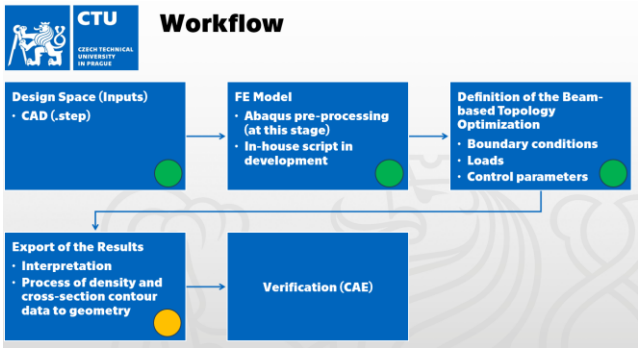
ČVUT+Škoda Auto: 3D design and optimization of FEM

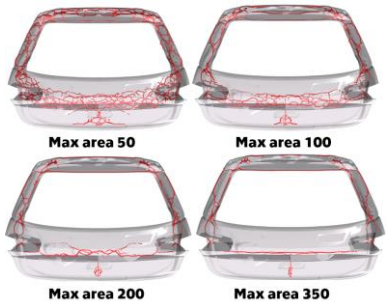





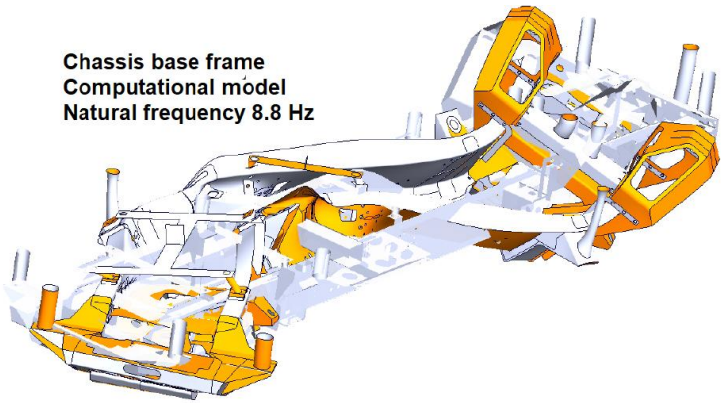
CAD model design, implementation of CAD model into FEM. Sensitivity analysis



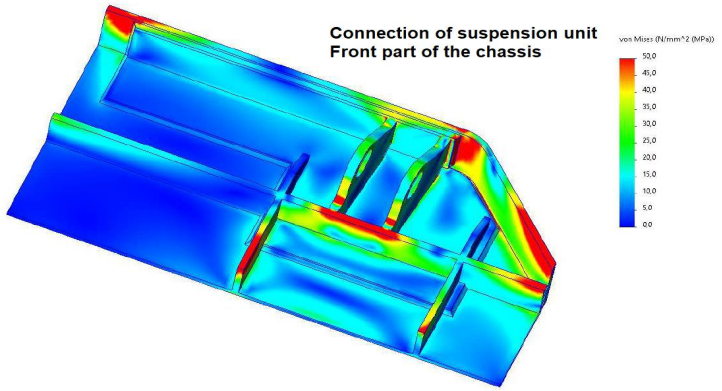


Stiffness optimization, interpretation of results with regard to production technology

Výtah prací 2024 za 4-WP10: Aplikace optimalizovaného návrhu konstrukce vozidla

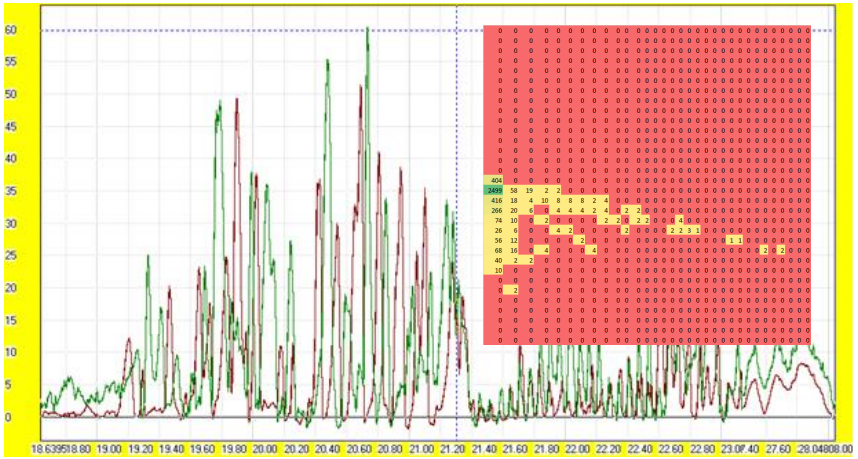


Dynamické výpočty – tvary vlastních kmitů

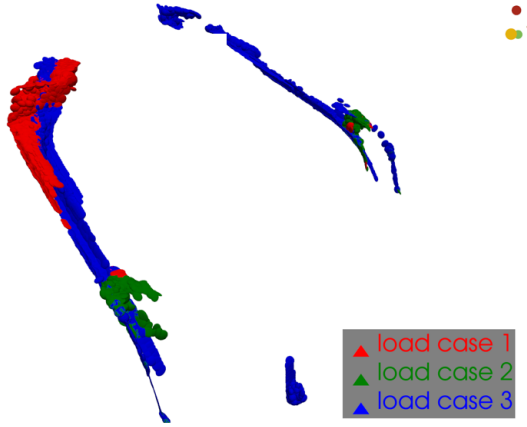


Pevnostní výpočty modifikovaného rámu s ohledem na únavu

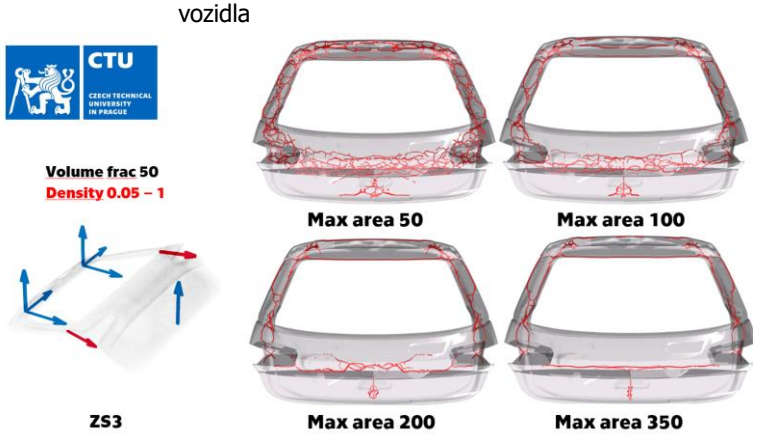
Hodnocení tenzometrického měření měření mechanického napětí v pojezdu speciálního vozidla



Ukázka záznamu naměřených mechanických napětí na konstrukci nosného rámu speciálního vozidla a hodnocení 2D Rain Flow

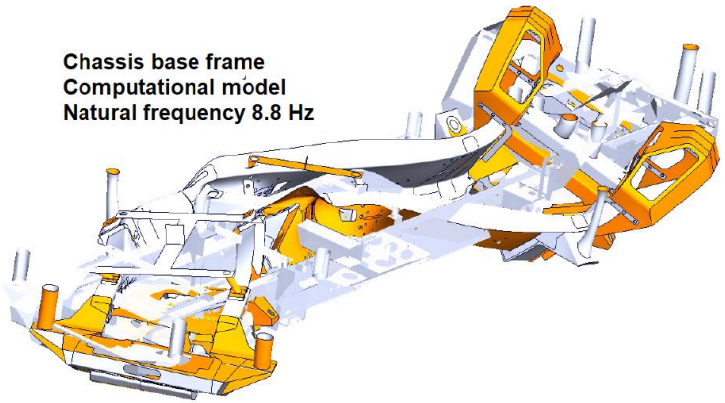


Řešení úlohy tuhosti

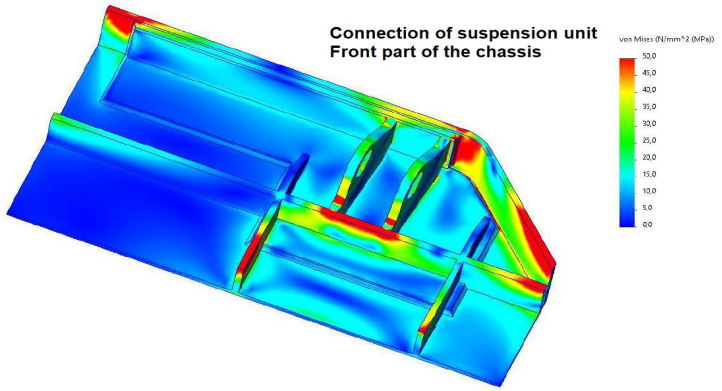


Interpretace výsledků s ohledem na technologii výroby

Results of 4-WP10: Optimized Design for Vehicle Body Applications – achieved 2024

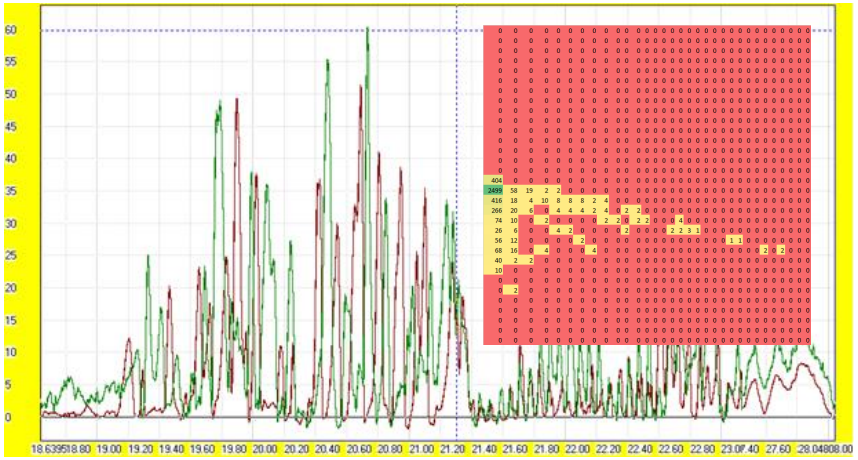


Dynamic calculations – natural oscillation shapes

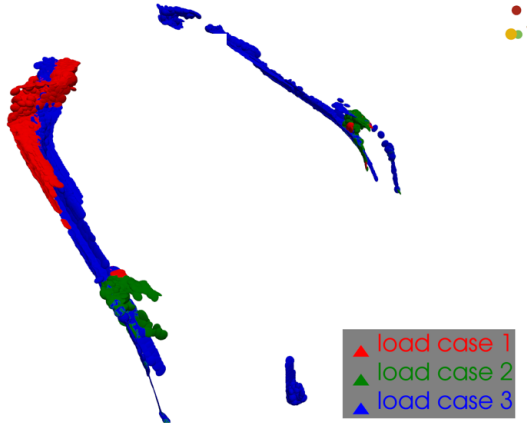


Strength calculations of a modified frame with regard to fatigue

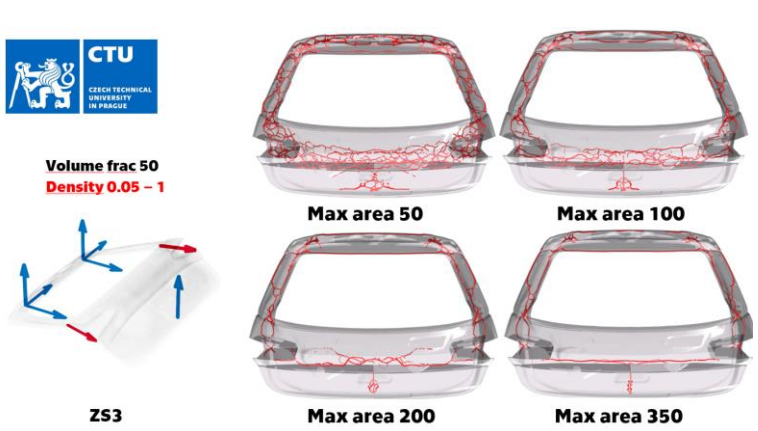
Evaluation of strain gauge measurement of mechanical stress in the travel of a special vehicle



An example of stress record obtained by strain gauge measurement on construction of supporting frame of the special vehicle and application of 2D Rain Flow method



Solving the stiffness problem



Interpretation of results with regard to production technology