Your partner in computing

Development of Mobile Security Barriers

M. Šebík, M. Popovič, M. Drdlová

16th LS-DYNA Forum 2022

11. – 13. 10. 2022

The authors wish to express their gratitude and sincere appreciation to the authority of Ministry of the Interior of the Czech Republic, project PID: VI20192022129 for financial support.

SVS FEM - Who we are?

- **ANSYS Channel Partner for Czech Republic and Slovakia**

Software provider	Hardware provider	Technical support	Trainings	Software customization	Projects

Why do we need barriers?

Vehicle is one of the most easily accessible weapons these days.

2002 Lyon car attack, France
2006 UNC SUV attack, University of North Carolina, USA
2008 Jerusalem vehicular attack, Israel
2011 Tel Aviv truck attack, Israel
2016 Nice truck attack, France
2016 Ohio State University attack, USA
2016 Berlin truck attack, Germany
2017 Melbourne car attack, Australia
2017 Westminster attack, London, United Kingdom
2017 Stockholm truck attack, Sweden
2017 London Bridge attack, England,
2017 Barcelona attacks, Barcelona, Spain
2017 New York City truck attack, USA
2018 London, United Kingdom
2019 Tokyo car attack, Japan
…
END ?

Barriers to stop hostile vehicle

Barriers

Permanent

Temporary

SVS FEM

What temporary barriers in public spaces currently lack?

- Safety

What temporary barriers in public spaces currently lack?

- Safety
- Mobility

What temporary barriers in public spaces currently lack?

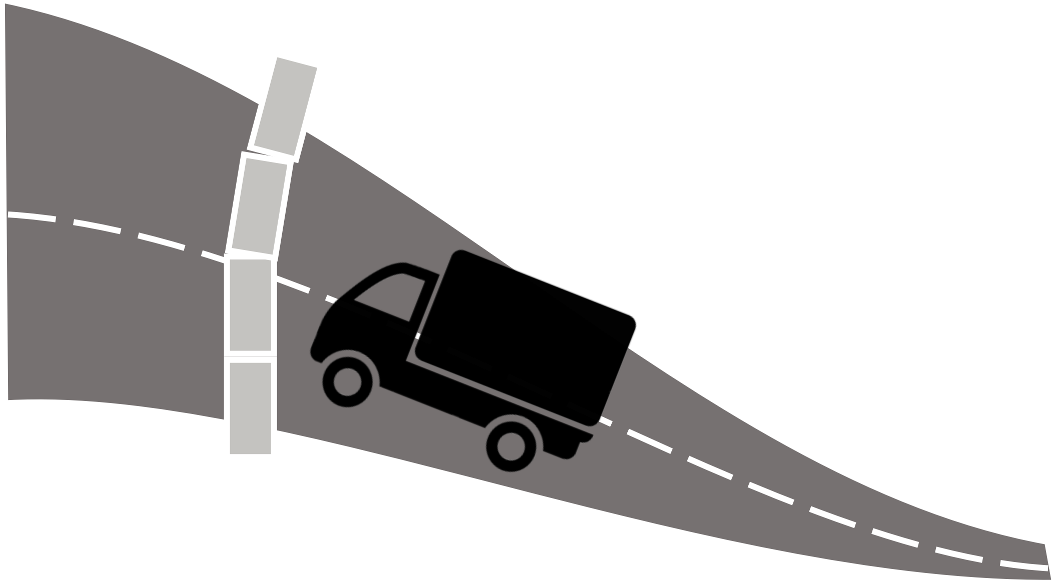
- Safety
- Mobility
- Suitability for urban areas

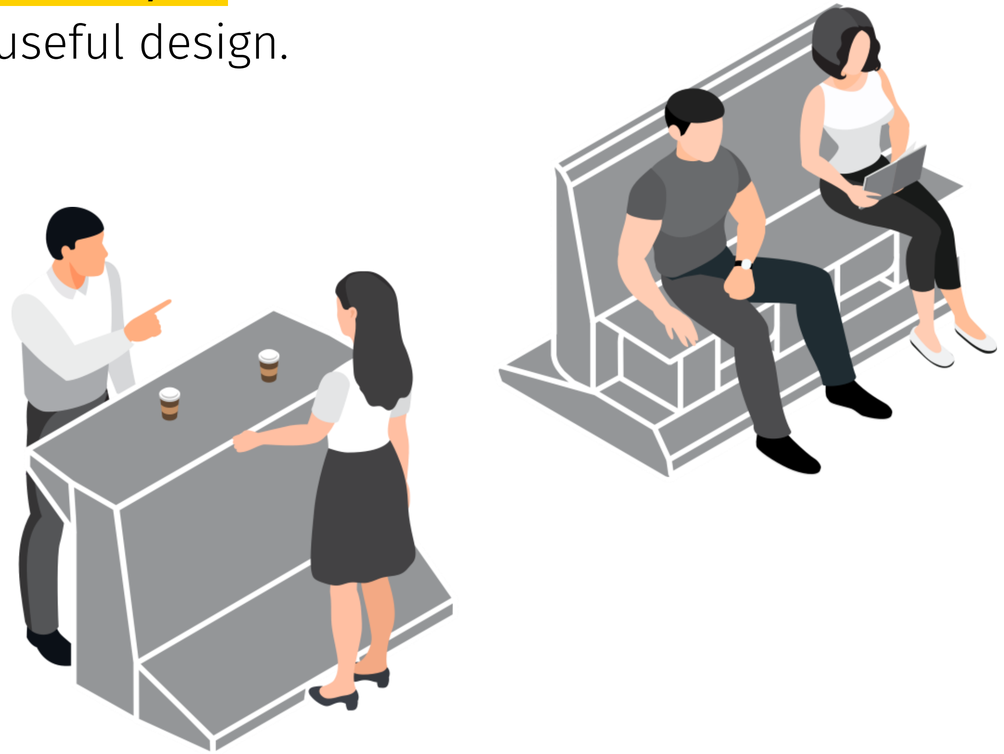
  + secondary purpose (table, bench, ...)

SVS FEM

GOAL: New mobile security barriers

- **Safety**
  - Thoroughly tested barriers (both in simulations and experiments)
- **Mobility**
  - No attachment to the ground or surroundings
- **Suitability for urban areas + secondary purpose (table, bench, …)**
  - No spikes dangerous to the pedestrians. Aestethic and purpuseful design.



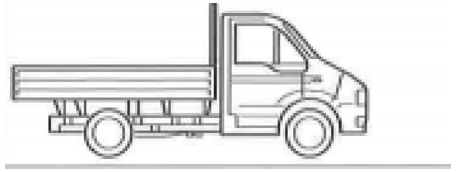


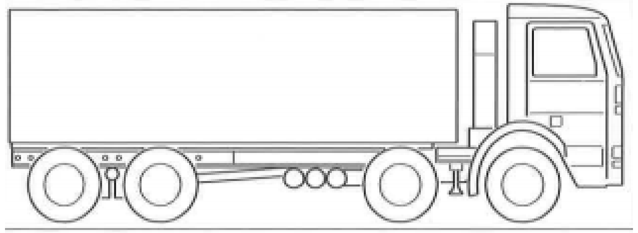
SVS FEM

Challenges

FE Model – vehicle

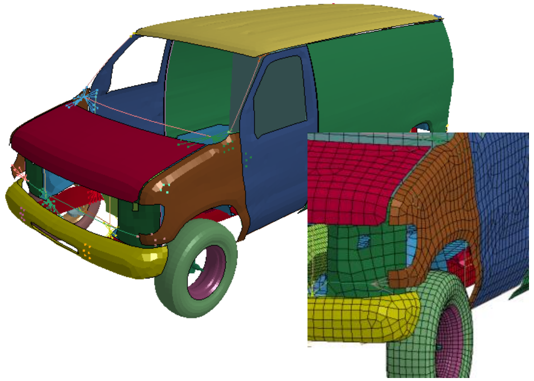
- Categories: N1, N3 (CWA 16221)
- Long simulation time (often over 1 sec)
- Full model + Reduced model (3 - 4x faster computation)

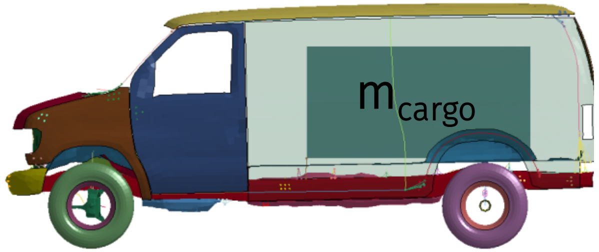




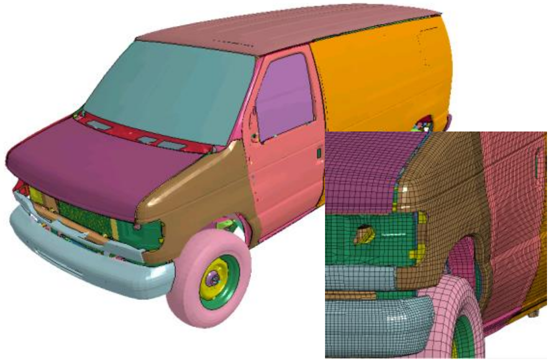
N1

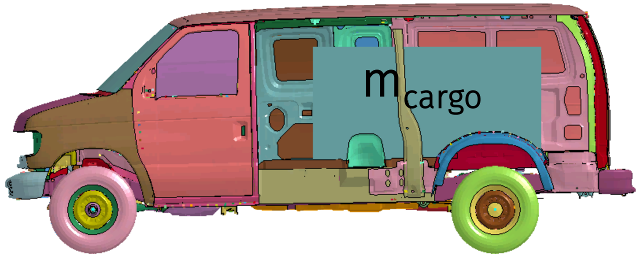
Reduced model





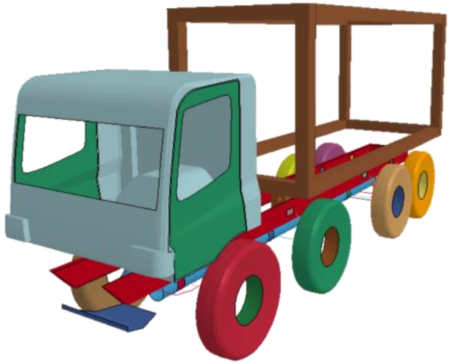
Full model

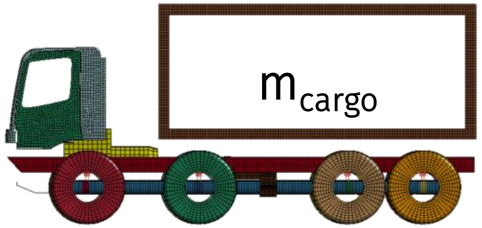




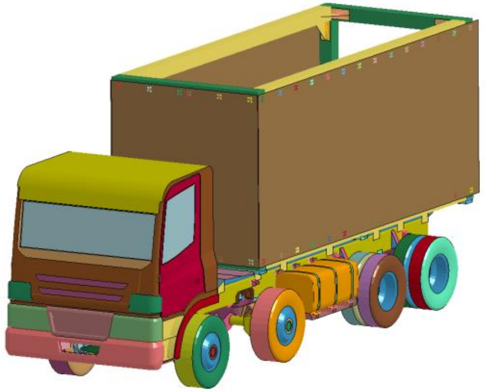
N3

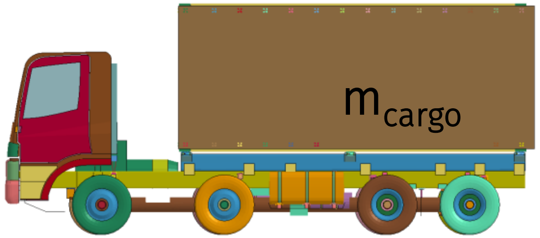
Reduced model





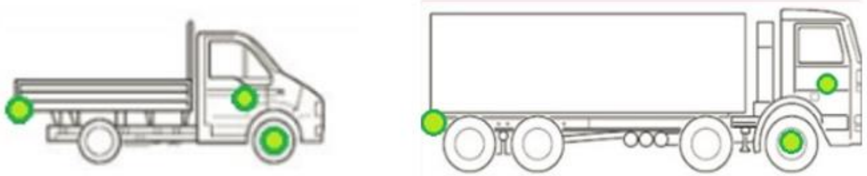
Full model



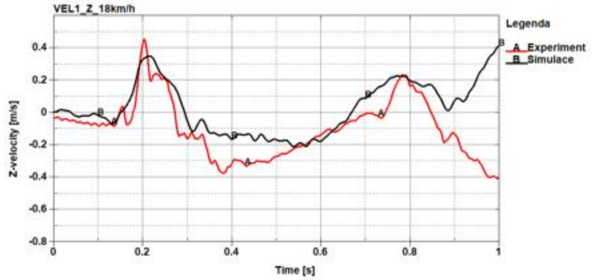


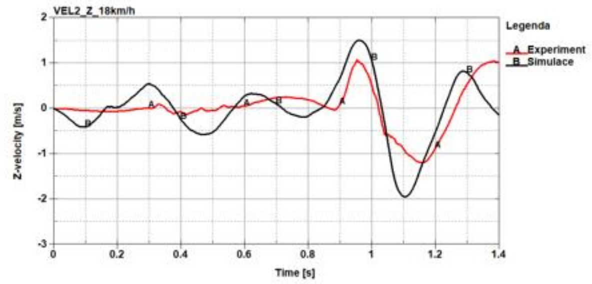
Vehicle model testing CEN/TR 16303

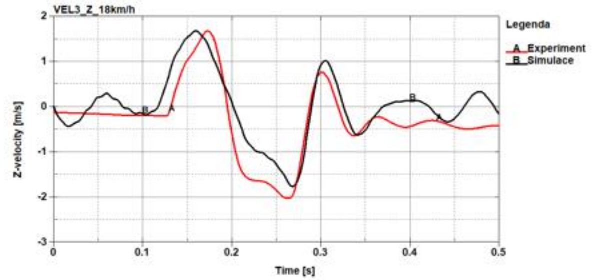
- Computational stability
- Comparison with experiment
- Tests:
  - Vehicle in idle
  - Linear track
  - Curb test
  - Rigid wall test

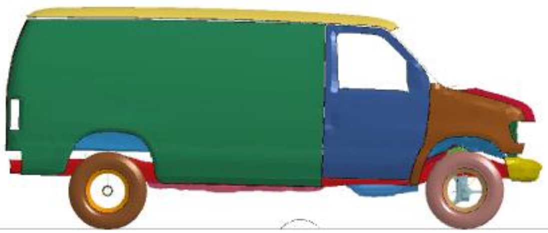


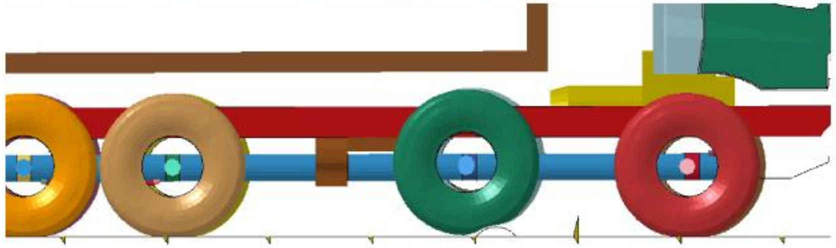
Accelerometers





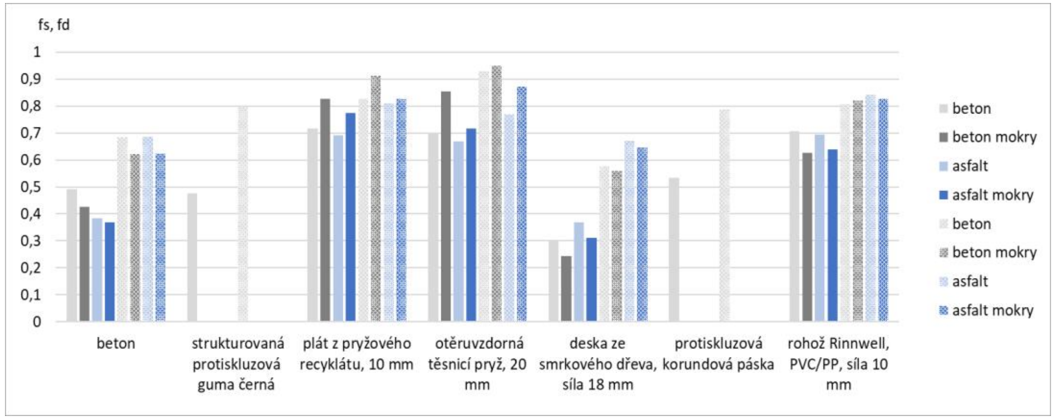






Friction measurement

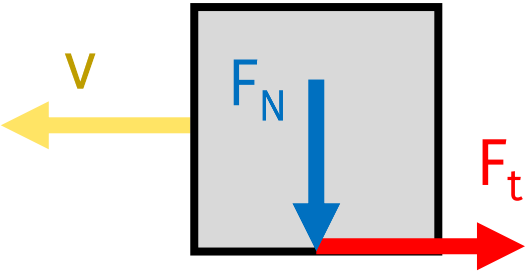
- Various pairs of materials
- Both dry and wet conditions
- Static and dynamic values



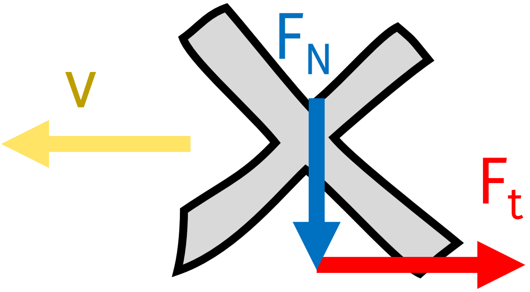
SVS FEM

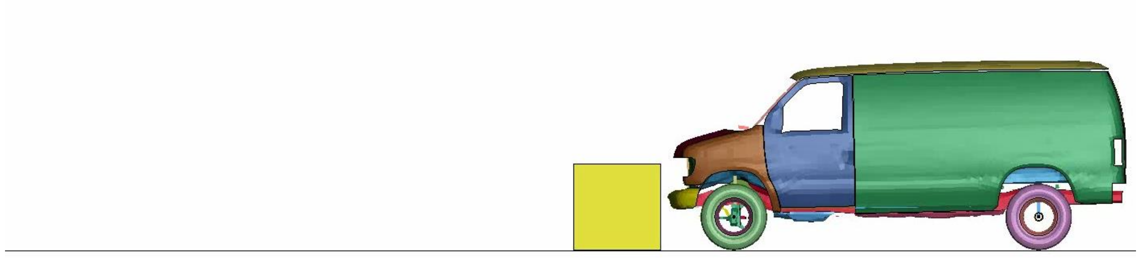
Ground penetration issue

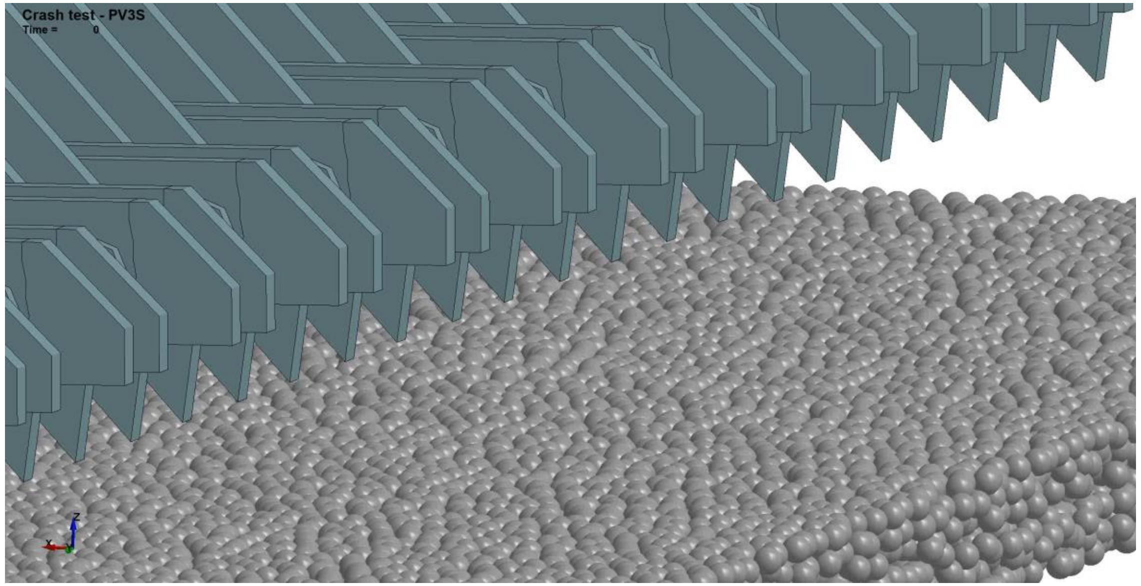
- Common approach: rigid ground + friction given by static and dynamic coefficient, table etc.
  - Not sufficient for spiky barriers



vs





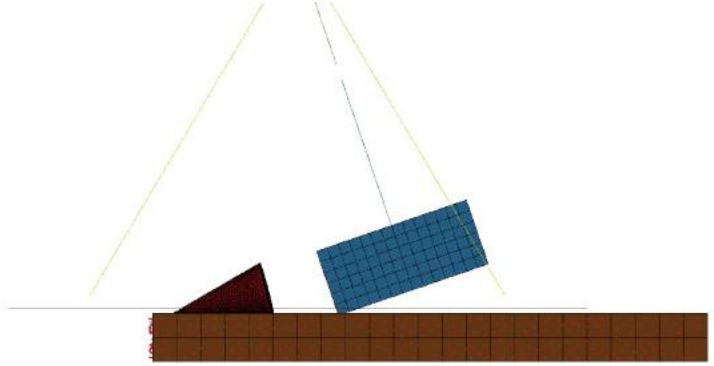


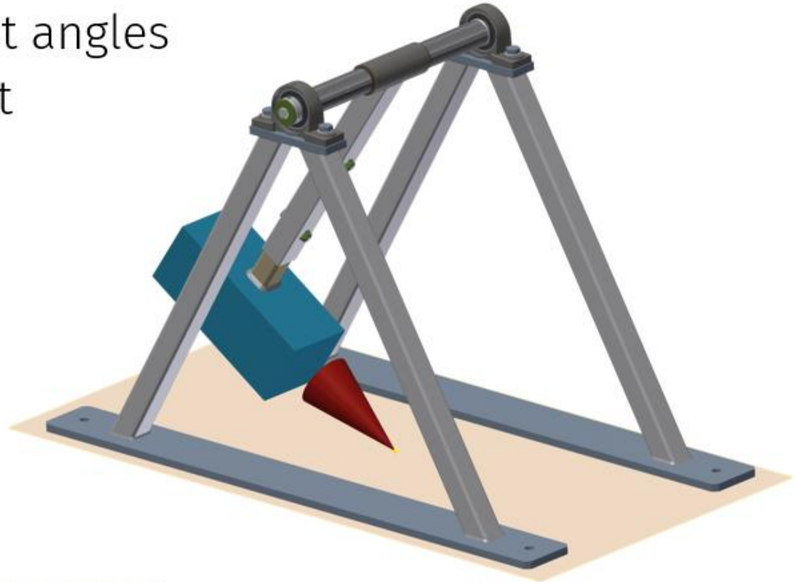
DEM model

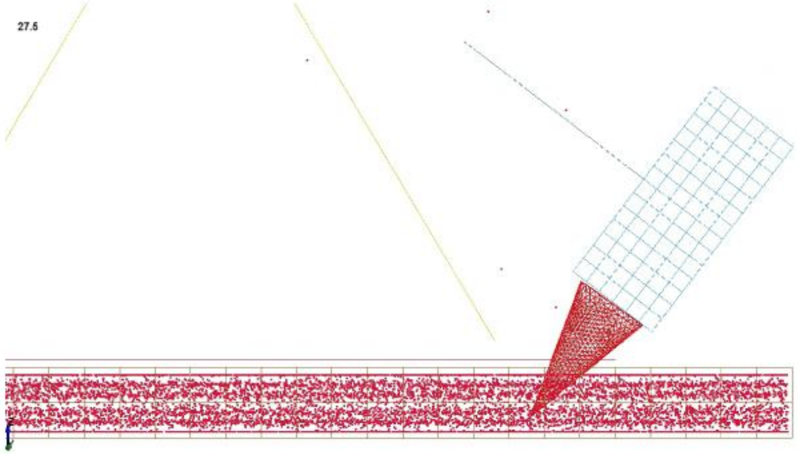
- More suitable for spiky barriers which penetrate ground during its movement
- Expensive in terms of computation

Ground surface indentation test

- Need for calibration of penetration of barrier spikes through ground surface
- Experiment is focused on barrier – ground interaction at various impact angles
- Failure criteria and failure of DEM bonds could be set based on the test



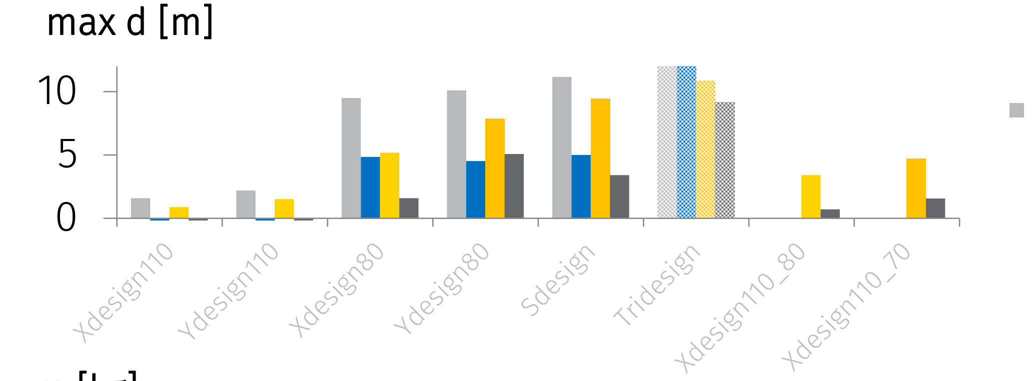


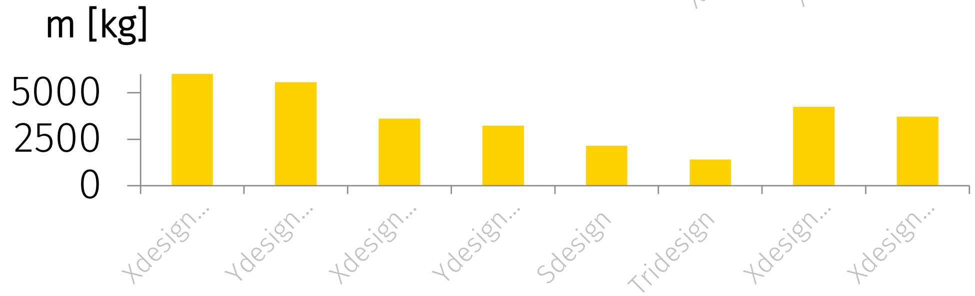


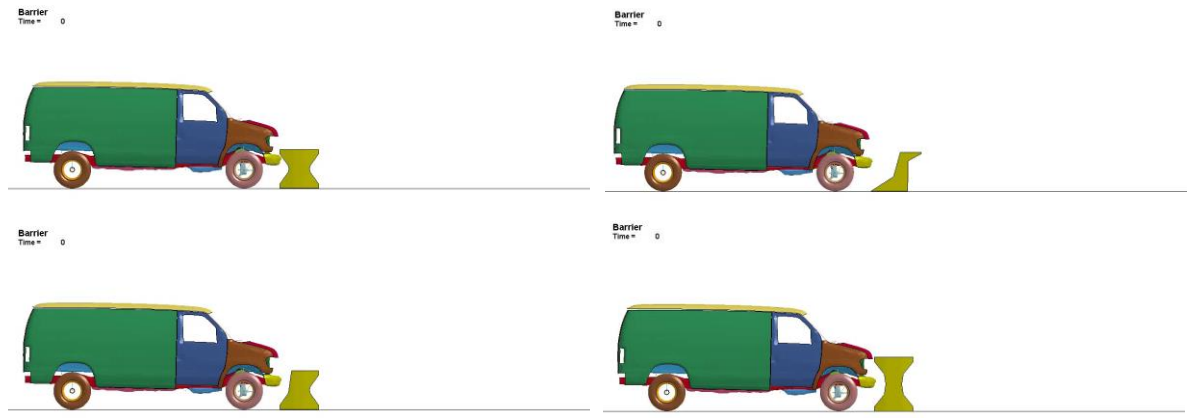
Simulation-driven development

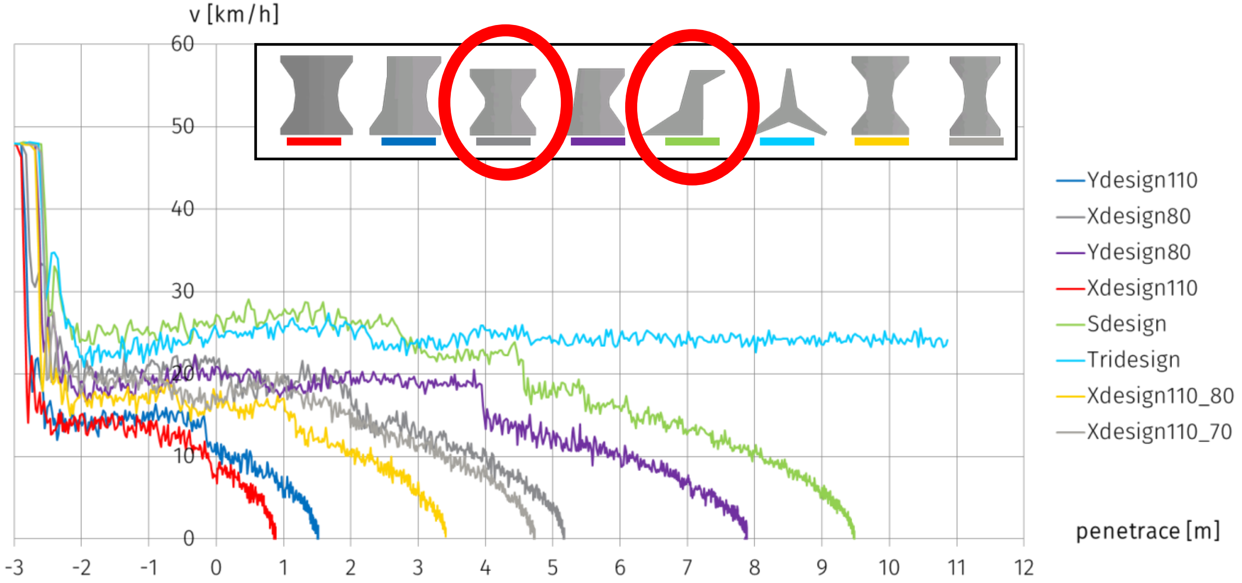
Initial shape testing

- Category N1
- Reduced model for fast results of multiple scenarios
- Impact angle 0 deg
- Rigid ground surface
- Impact velocity 48 km/h
- Evaluation of penetration distance
- Various scenarios of barrier – ground contact
  (friction 0,4 – 0,8, restitution 5% - 100%)







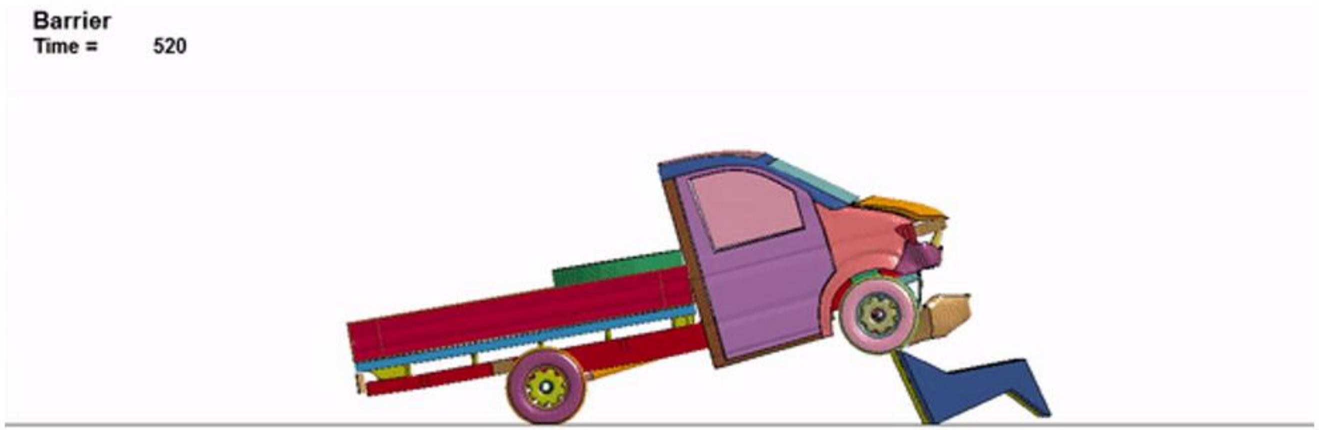


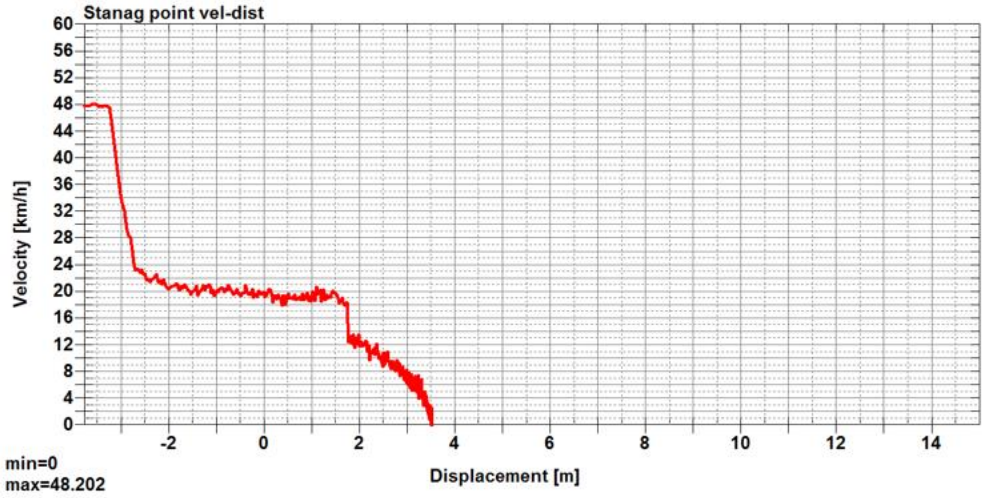
SVS FEM

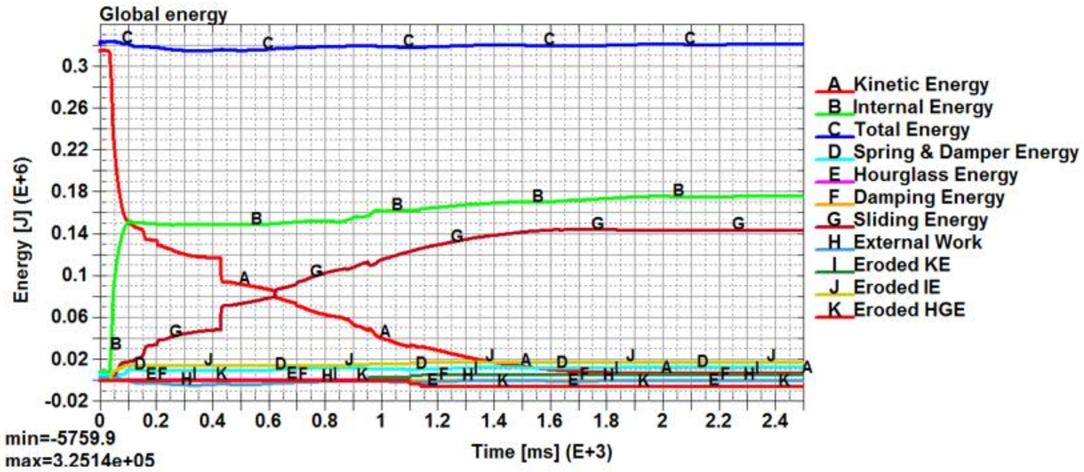
Simulation x Experiment: N1

- S design – 2 blocks

v_{impact} = 48 km/h





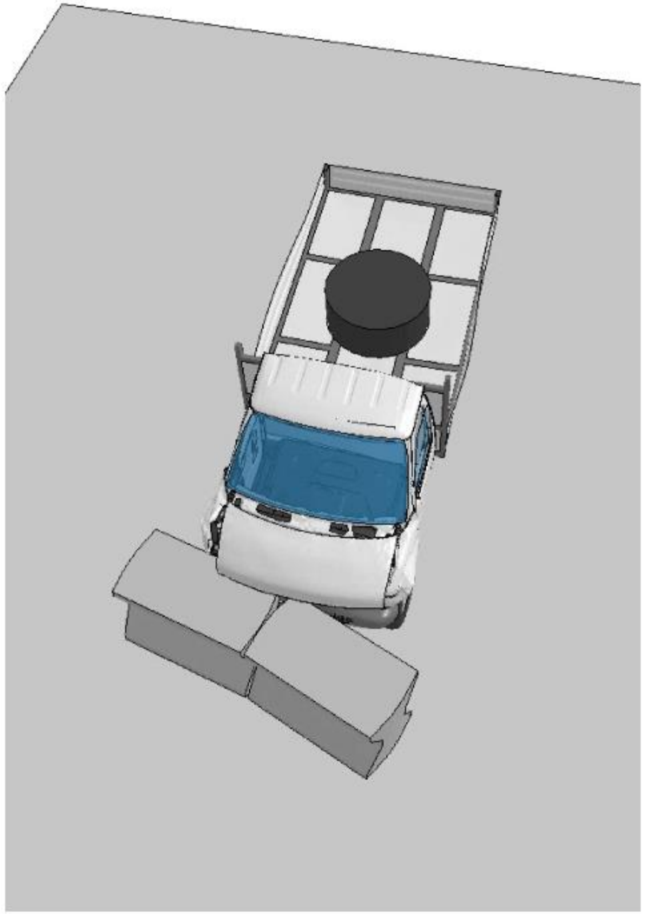


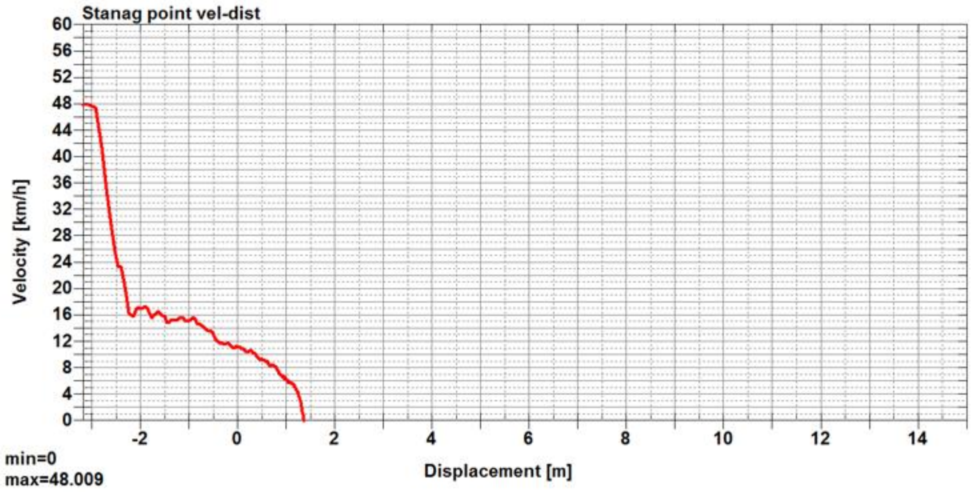
	Simulation [m]	Experiment [m]	Difference absolute [m]	Difference relative [%]
Penetration	3,55	3,05	+0,50	+16,4
Barrier displacement	6,52	5,81	+0,71	+12,2

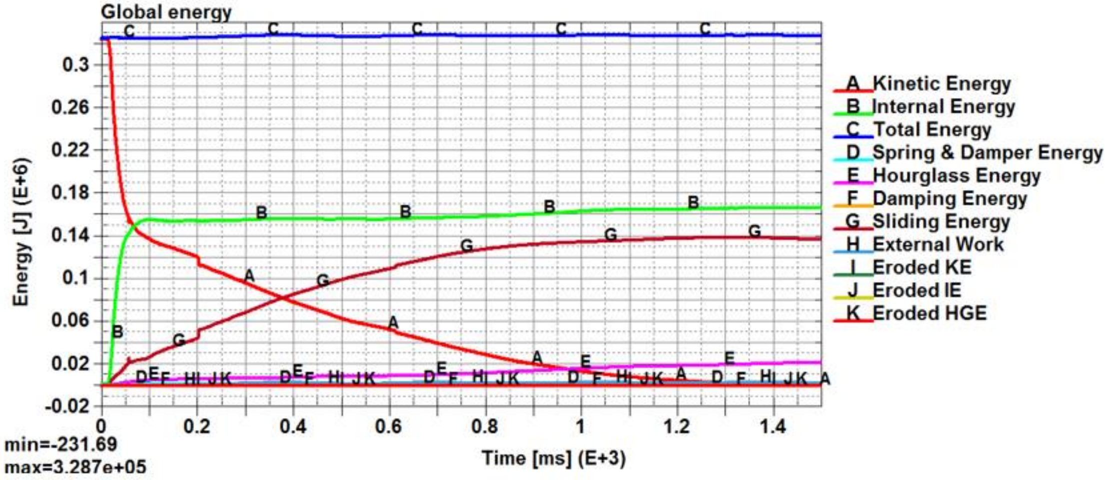
Simulation x Experiment: N1

- X design – 2 blocks

v_{impact} = 48 km/h







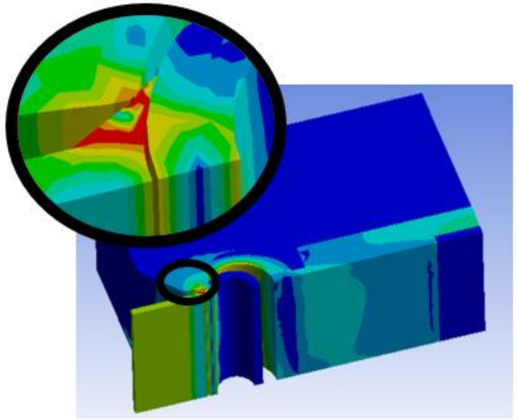
	Simulation [m]	Experiment [m]	Difference absolute [m]	Difference relative [%]
Penetration	1,37	2,70	-1.33	-49.3
Barrier displacement	5,06	5,90	-0.84	-14.2

SVS FEM

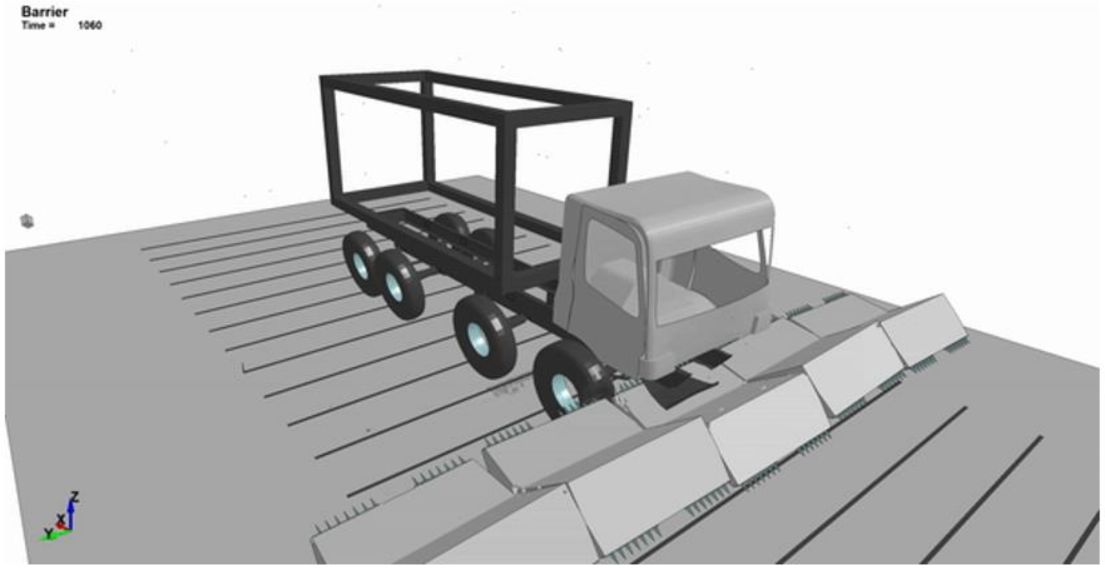
Simulation x Experiment: N3 (8x8 vehicle 30 t) 48 km/h

- S design „big“ - 5 blocks

v_{impact} = 48 km/h



- Weld failure in a link between the blocks
- Vehicle was actually stopped by a single block
- Penetration 12,35 m

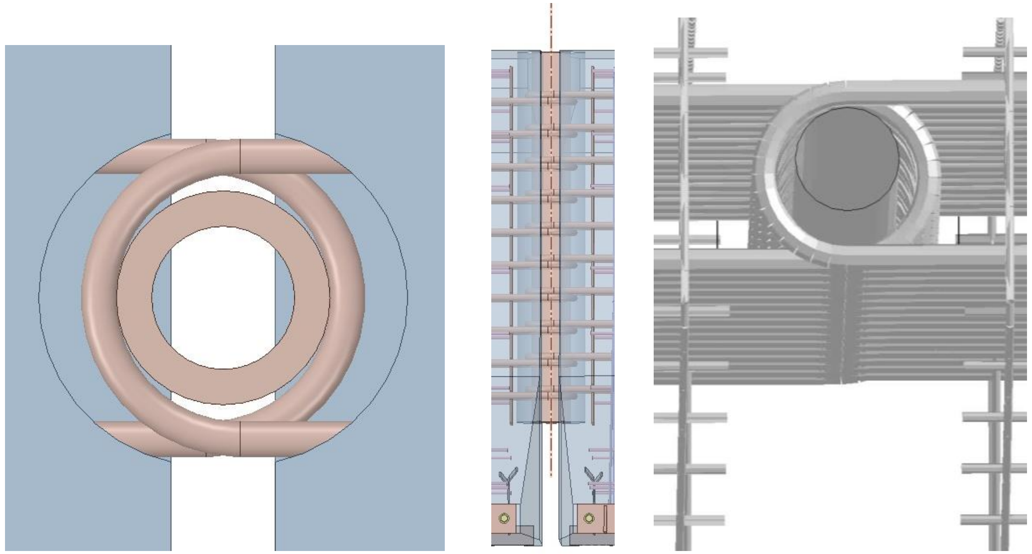


N3 link enhancement

- New simulations focused on increasing strength of the links
- No welds

Link 2nd generation

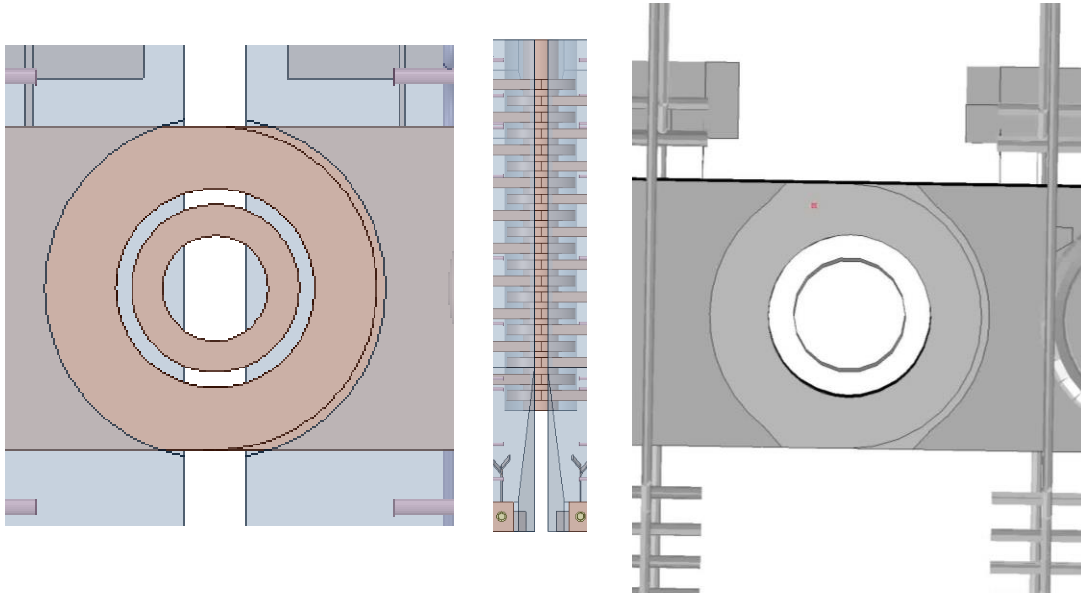
Central tube + common reinforcement bars



Link 3rd generation

Winner

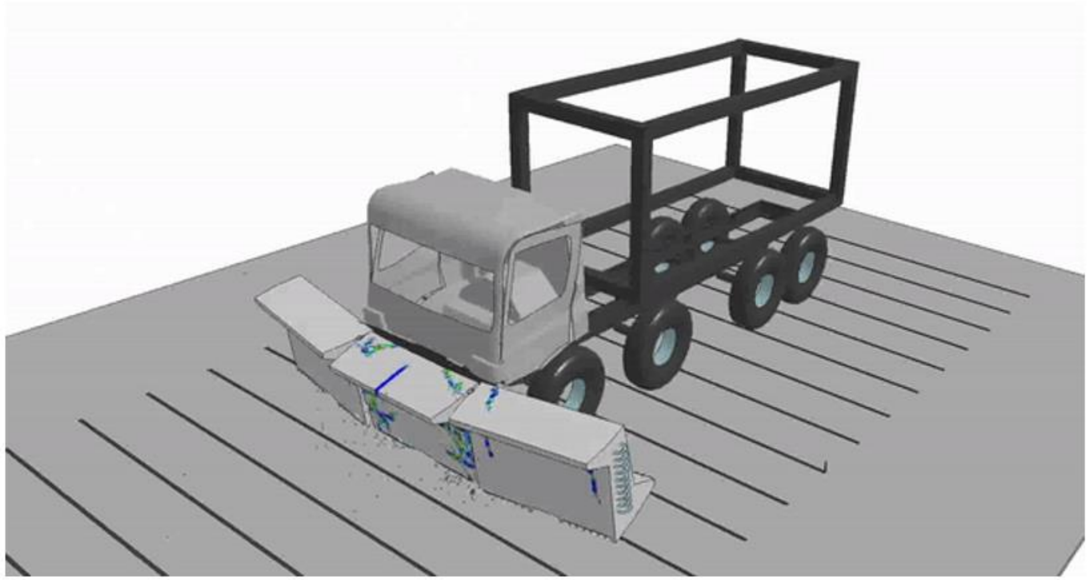
Central tube + steel plates
2,7 times stronger design

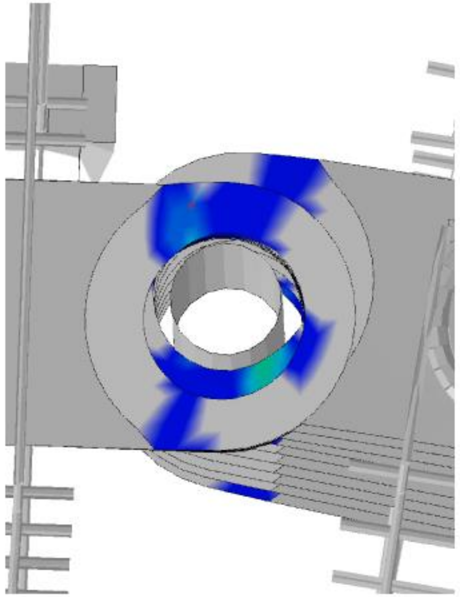


SVS FEM

N3 crash test simulations with the new links

- S design „big“ - 3 blocks
- New simulations focused on the initial impact only
- Multiple cracks predicted on concrete body
- Links should withstand the impact with negligible plastic defomation





N3 crash test experiment with the new links

- S design „big“ - 3 blocks
- Links were able to withstand the impact
- Penetration 8,2 m
- Barrier displacement 8,4 m

SVS FEM

Testing the secondary purpose

- The barriers were presented at IDET 2021, Brno – International Defence and Security Technologies Fair

Enter the Augmented Reality with us!

- **Just load the QR code on your phone.**

SVS FEM

Thank you for your attention

Marek Sebik

SVS FEM

www.svsfem.cz