

# Safety CAE for Real World Occupant Protection in Cars

DYNAmore NORDIC USER' CONFERENCE  
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# OUR HERITAGE



“Cars are driven by people.  
The guiding principle behind  
everything we make at Volvo,  
therefore is – and must  
remain – safety”

Assar Gabrielsson & Gustaf Larson,  
the founders of Volvo





# DESIGNED AROUND PEOPLE



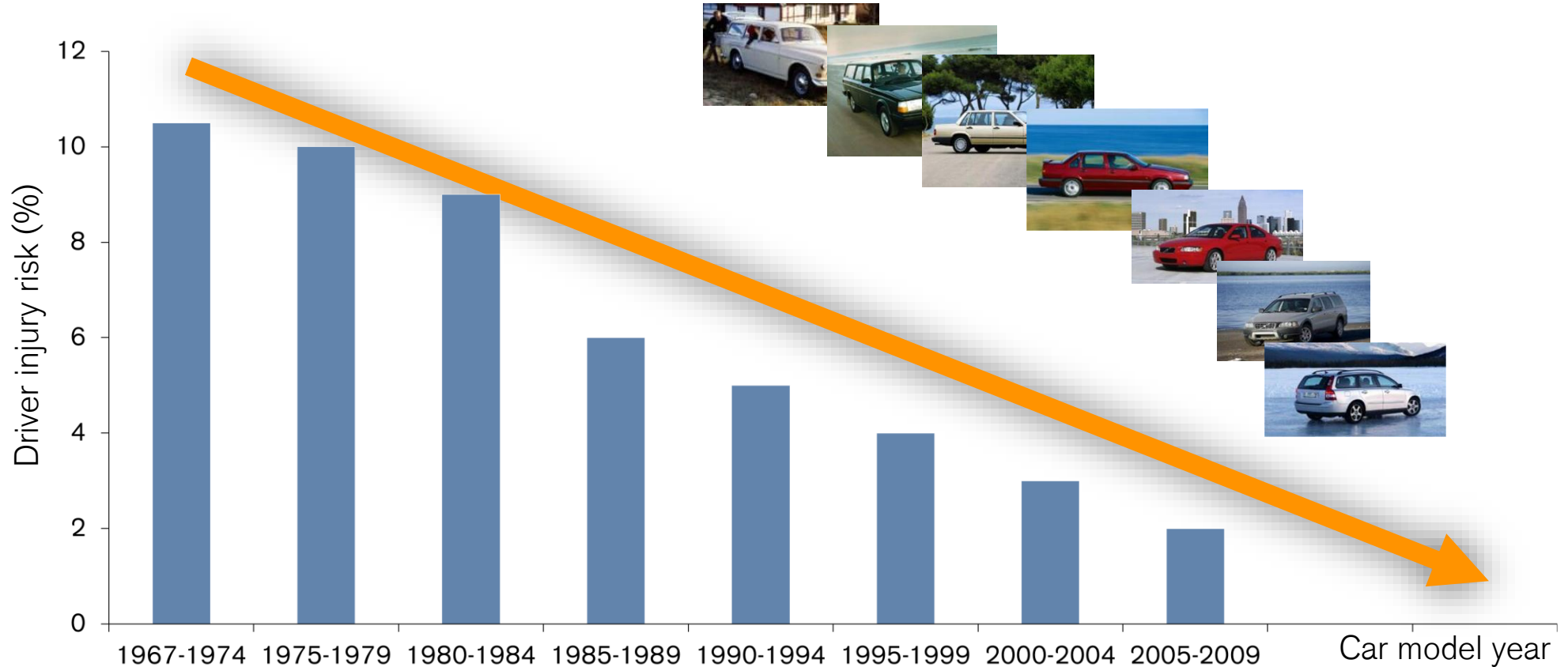
# OUR VISION



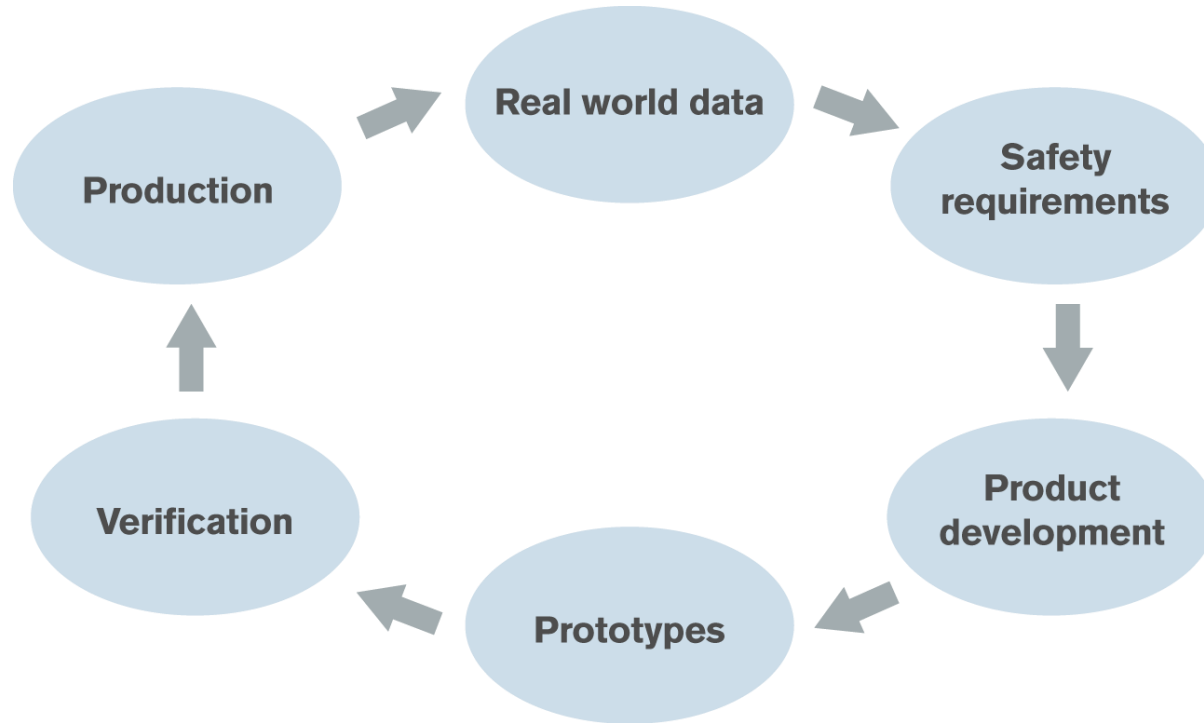
By 2020 no one should be killed or seriously injured in a new Volvo car.



# SAFETY EVOLUTION FOR BELTED DRIVERS IN VOLVO CARS



# THE CIRCLE OF LIFE



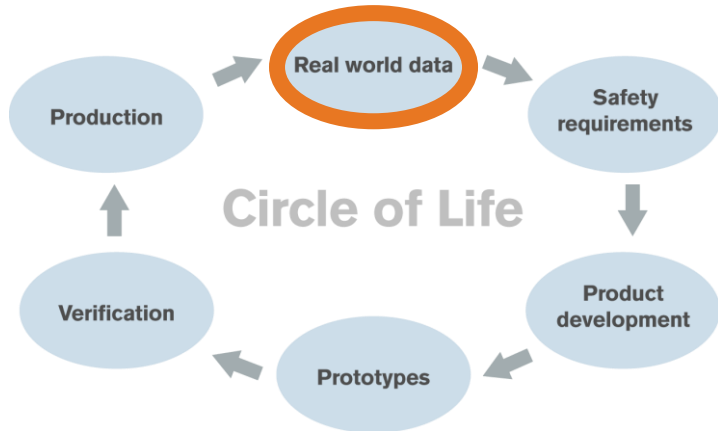


# VOLVO'S TRAFFIC ACCIDENT RESEARCH TEAM



Established 1970

- On-call 24/7
- In-depth studies of accidents
- Statistical accident collection



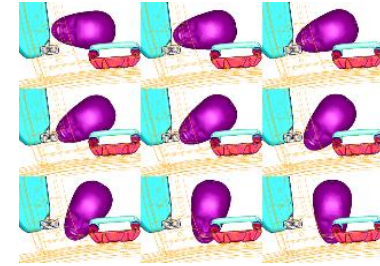
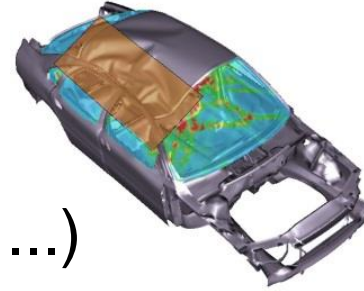




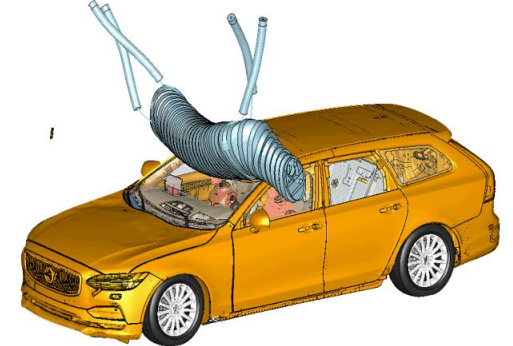
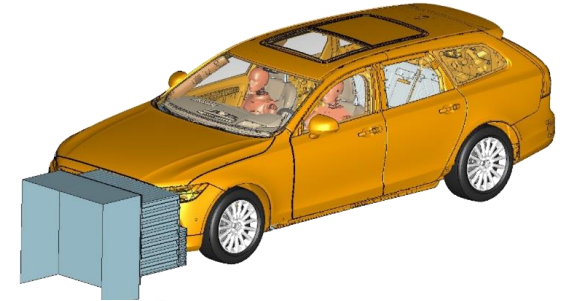
Not far from Volvo Cars office, Gothenburg, Sweden  
October 13, 2009



# SAFETY REQUIREMENTS



- **Legal requirements** (FMVSS, ...)   
robustness, large safety margins
- **Rating requirements** (EuroNCAP, IIHS,...)   
robustness, progressivity
- **Real-life based requirements** (internal)   
based on field observation





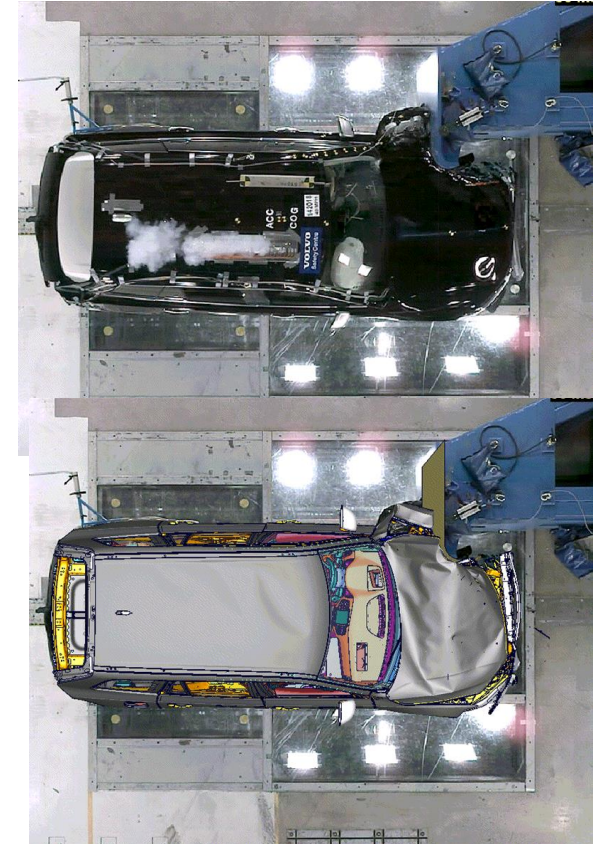
# GOOD RATING IS BASED ON REAL-LIFE

IIHS Small Overlap rating test 2012:

- Rigid barrier,
- 25% overlap
- 40 mph impact speed

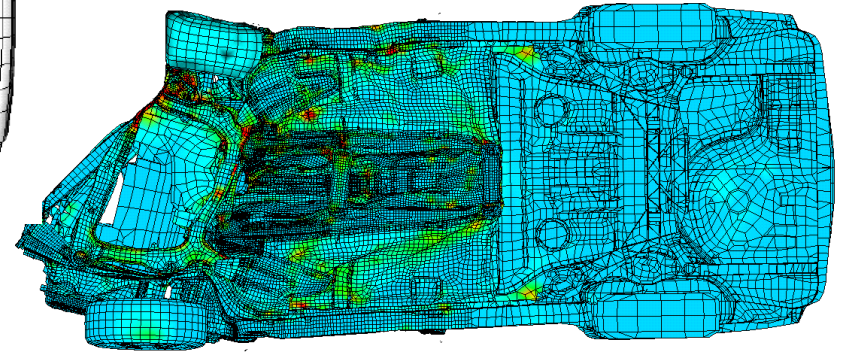
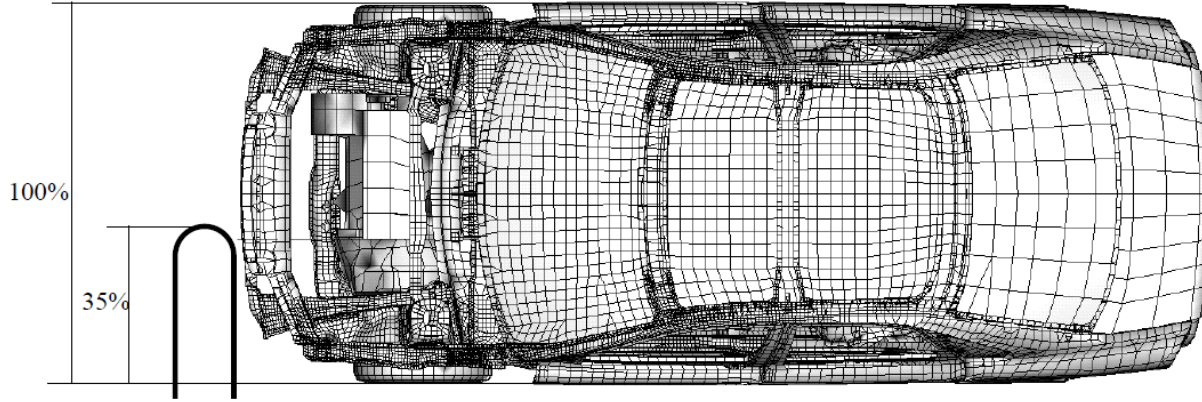
Adrian Lund, IIHS: “Structurally, the Volvo S60 was best”  
“Volvo has performed similar small overlap tests [...] since the late 1980s”

VOLVO S60	<b>G</b> ood
VOLVO S80	<b>G</b> ood
VOLVO XC60	<b>G</b> ood
VOLVO XC90	<b>G</b> ood





# SMALL OVERLAP CAE 1997



**VOLVO S80 Gen 1 in SPOC :**

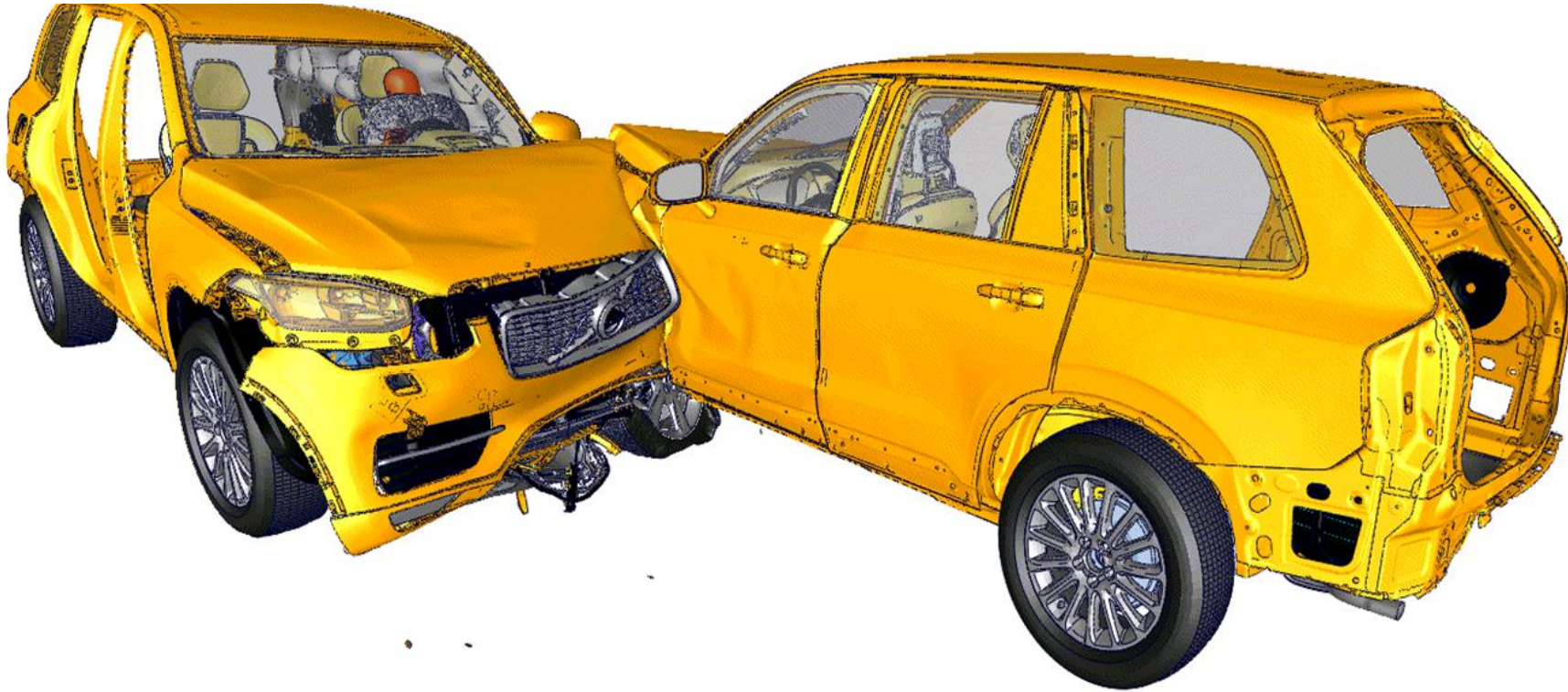
- Severe Partial Overlap Collision
- Rigid barrier, 35% overlap
- Impact speed: 40 mph

**Ingrid Planath-Skogsmo, Hans Norin, Stefan Nilsson**

**“Severe Frontal Collisions with Partial Overlap - Significance, Test Methods and Car Design”**

**SAE Technical Paper 930636, 1993.**

# CAR-TO-CAR SMALL OVERLAP FRONTAL IMPACT



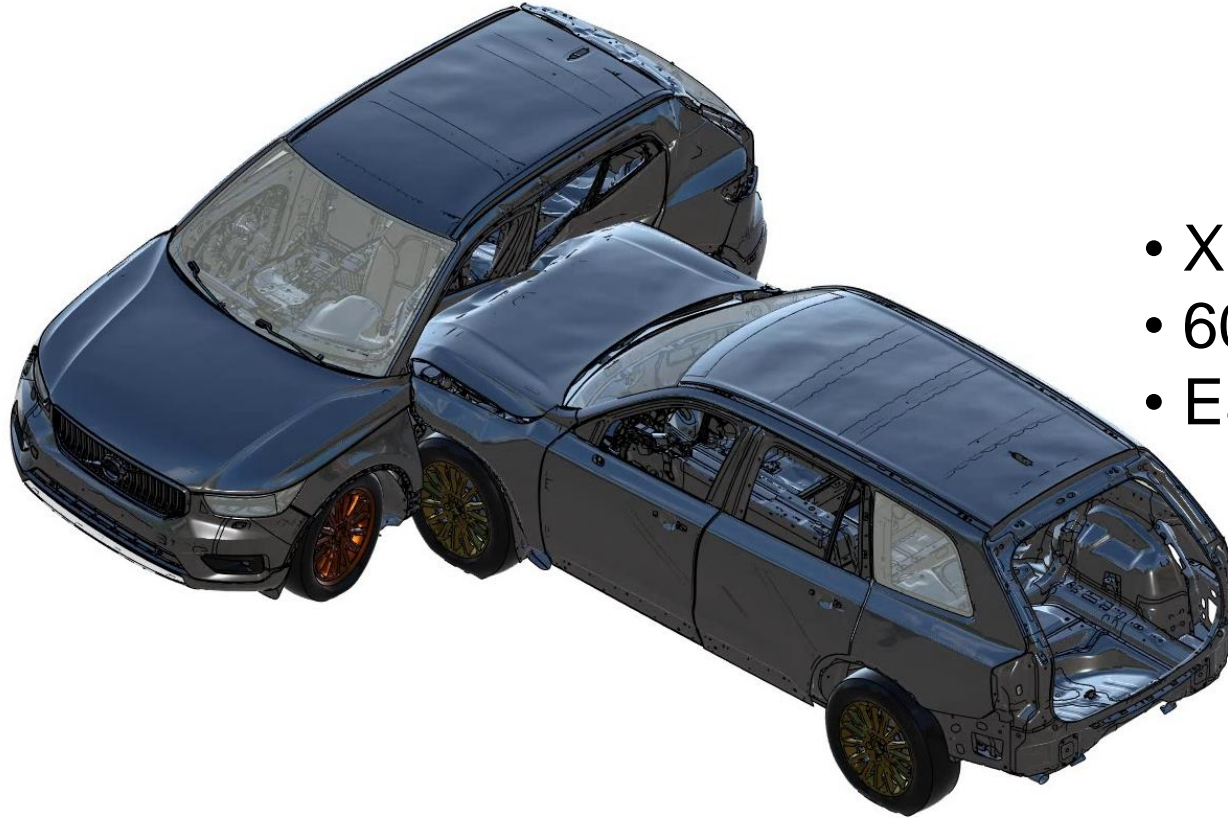


# CAR-TO-CAR FRONTAL IMPACT RECONSTRUCTION



Same accident  
as in slide 8

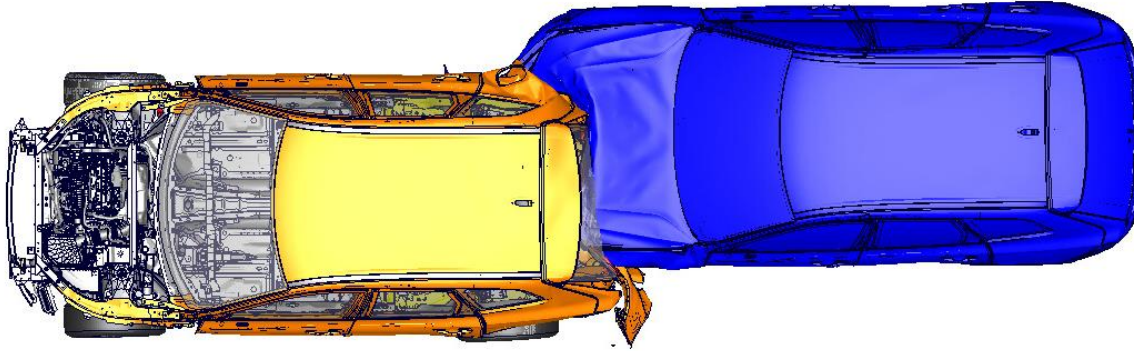
# CAR-TO-CAR SIDE IMPACT



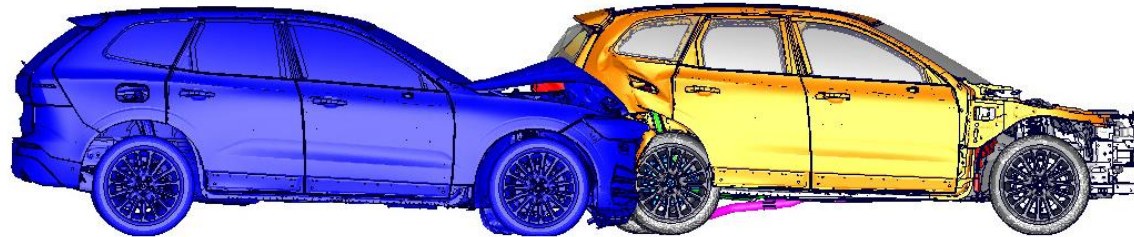
- XC90 vs XC40
- 60 km/h
- Early development models



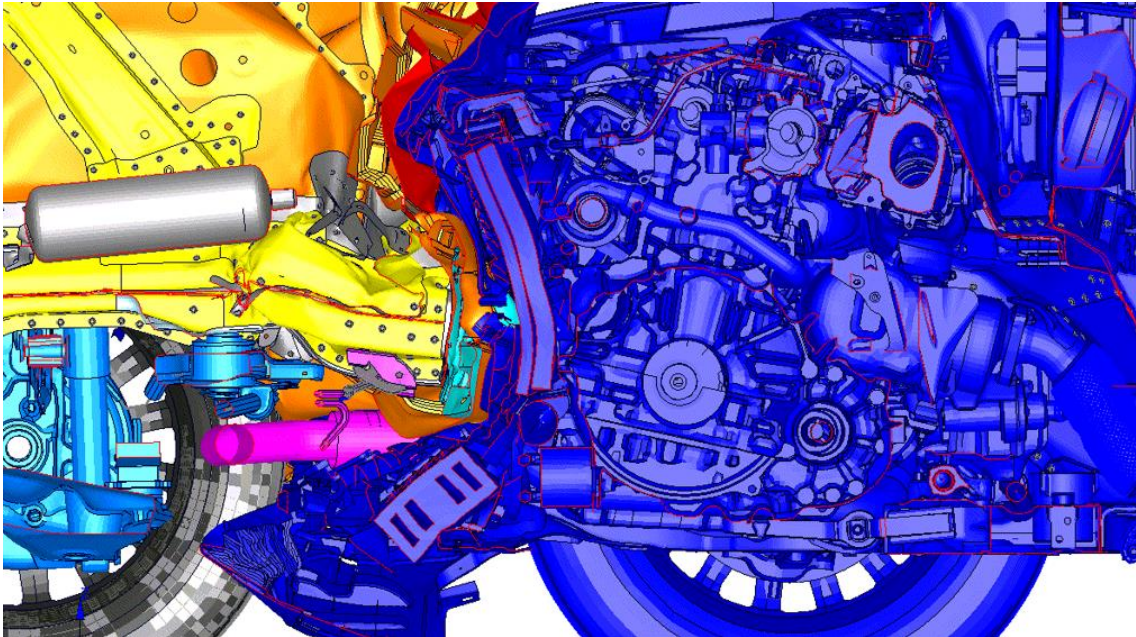
# CAR-TO-CAR REAR IMPACT



- XC60 vs XC60
- 70% offset, 45 mph
- Early development model



# CAR-TO-CAR REAR IMPACT



- XC60 vs XC60
- 70% offset, 45 mph
- Early development model
- Cut at  $y = 410$  mm

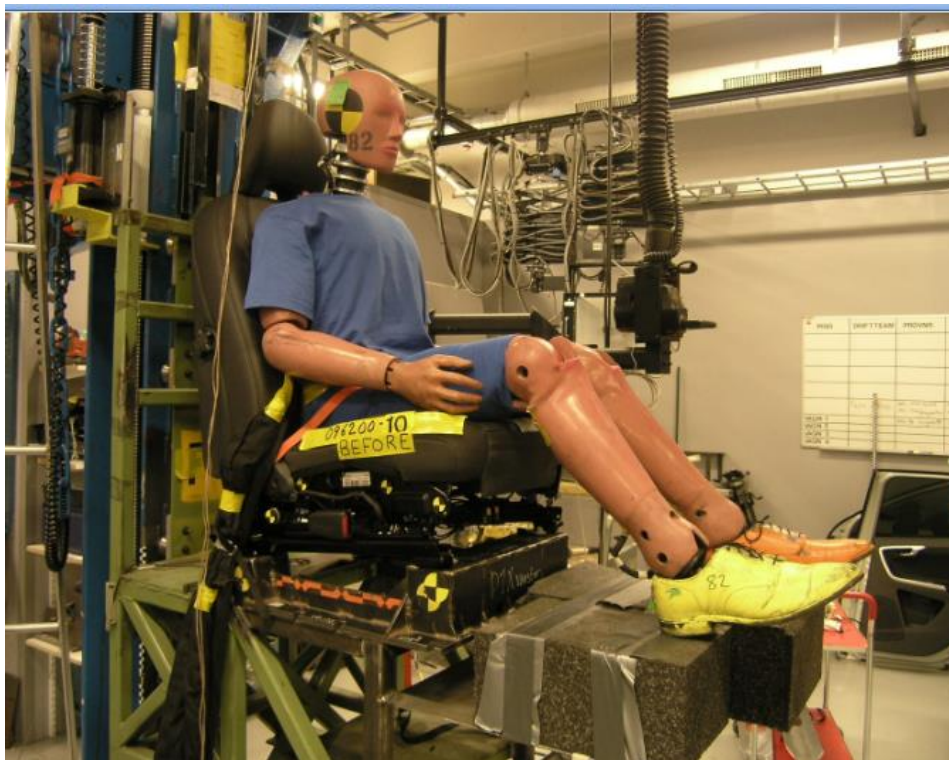
# RUN-OFF-ROAD CRASHES

- Complex and common scenario
- High speeds, serious consequences
- Occupants move in many directions
- Spine injuries over represented

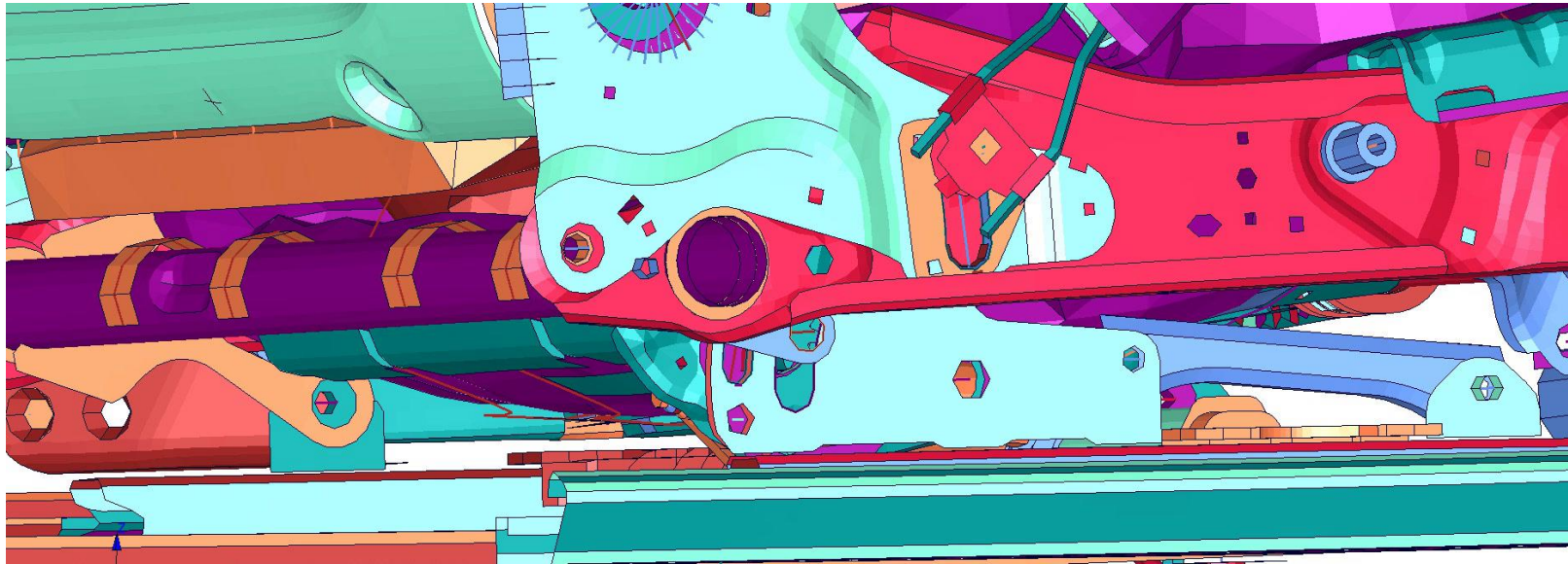
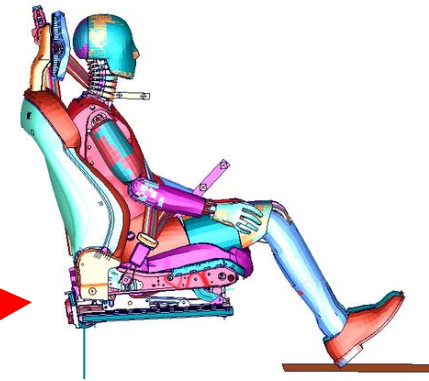




# VEHICLE SEAT DROP TEST



# VEHICLE SEAT DROP TEST SIMULATION



# FRONTAL IMPACT TO LARGE ANIMALS



- Sweden 2014: 46,000 animal crashes whereof more than 5,000 involved moose.
- Typical characteristic is a **high centre of gravity** due to long and slim legs, which will have **limited interaction with a passenger vehicle front**.

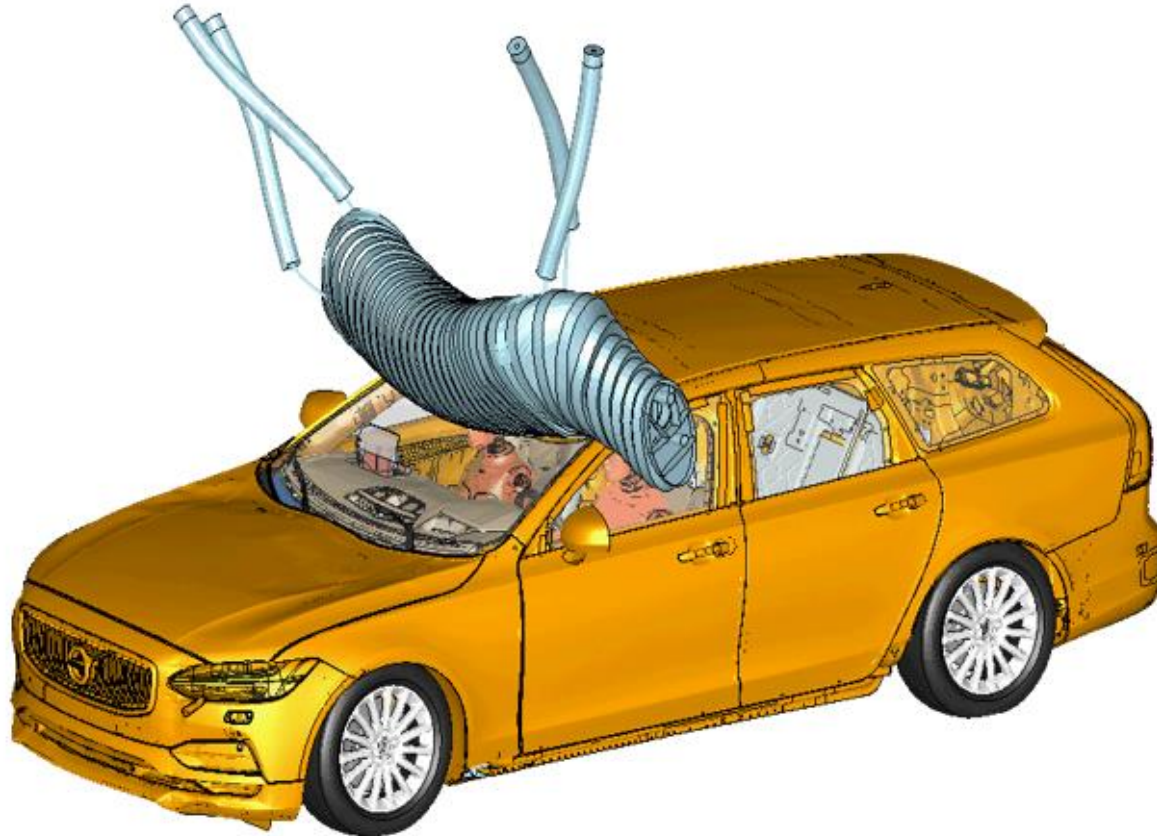




# LARGE ANIMAL IMPACT



# LARGE ANIMAL IMPACT SIMULATION



# INTEGRATED SAFETY



Protective Safety

Preventive Safety

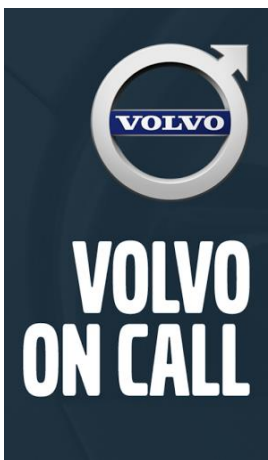
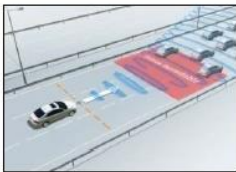
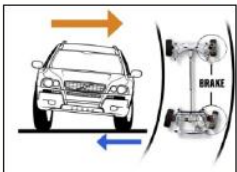
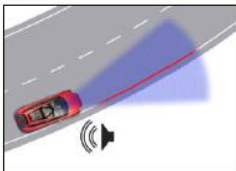
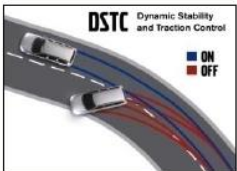
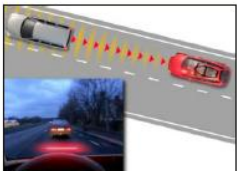
Normal driving

Conflict

Avoidance

Crash  
Damage  
reduction

Post  
crash



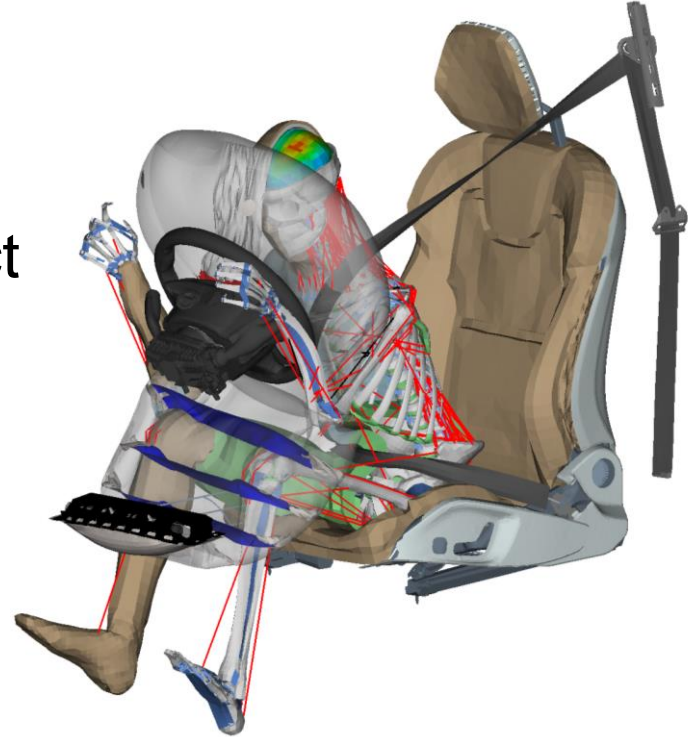


# HUMAN BODY MODELS

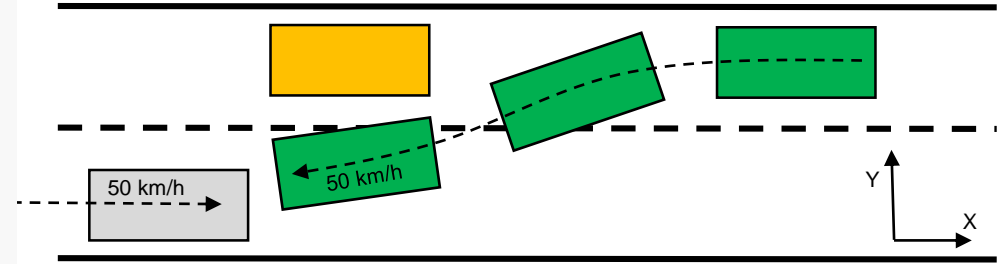
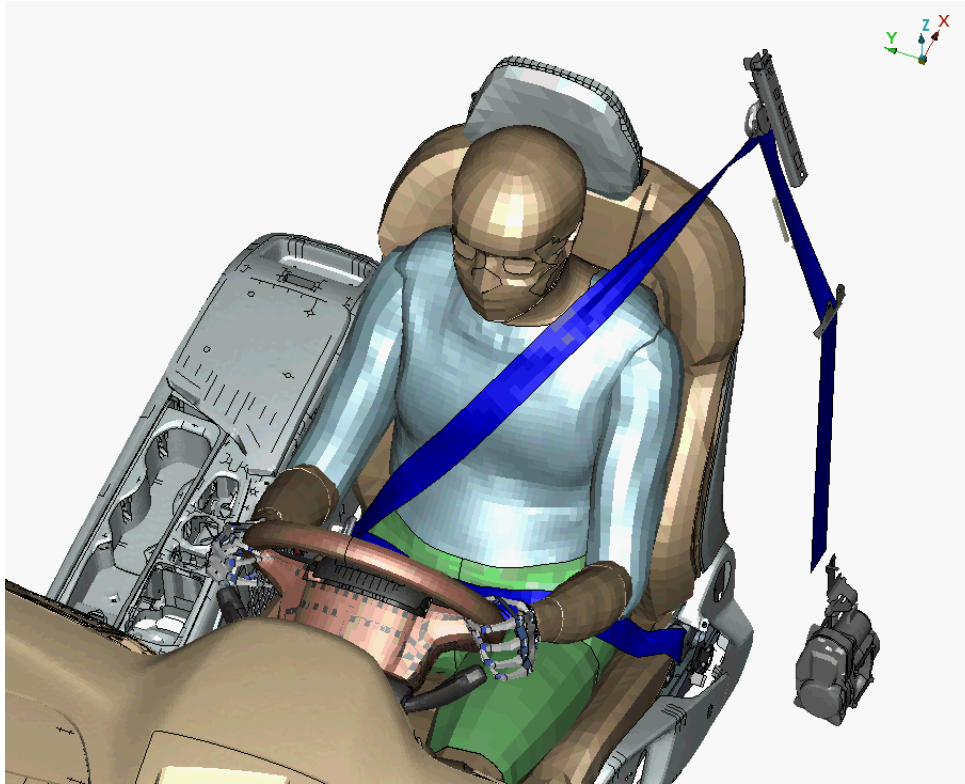


Why?

- No crash dummies in real-life
- Dummies are for one-directional impact
- Dummies have limited injury prediction
- Dummies have no posture control

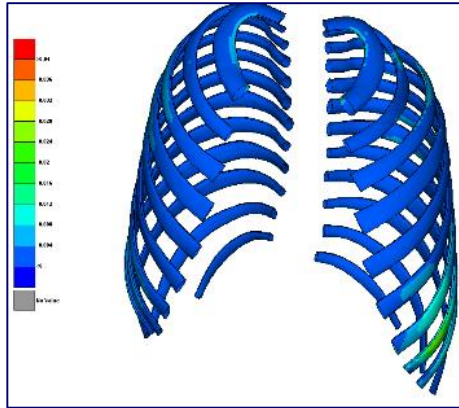


# ACTIVE-HUMAN BODY MODEL

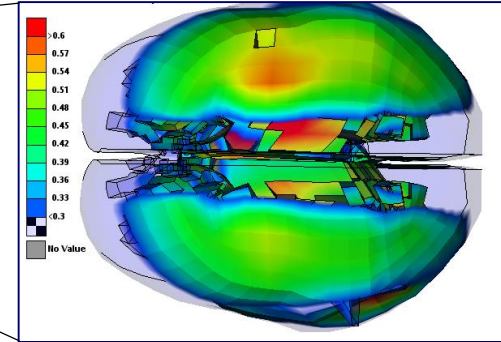
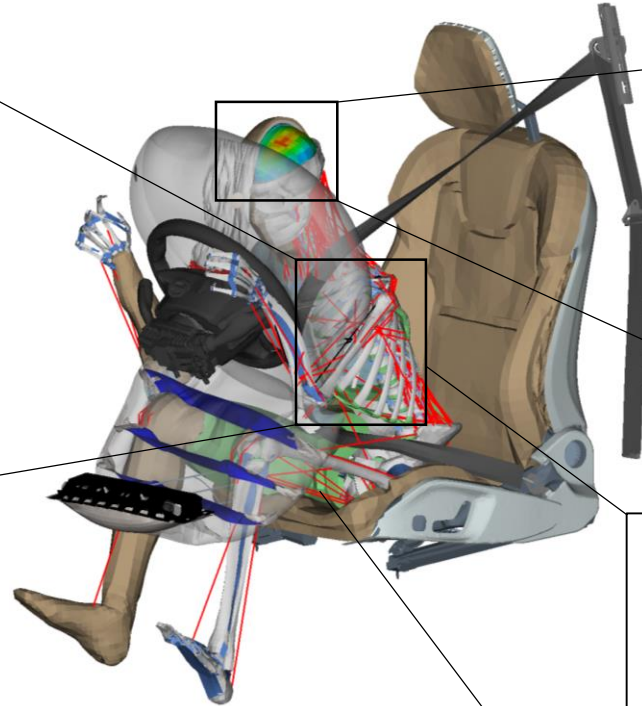


- Evasive action followed by crash
- 2000 + 150 ms simulation time
- Double precision needed
- 115 h on 240 CPU cores

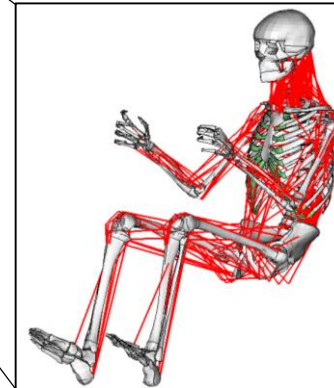
# SAFER HBM



Strain based rib fracture criteria



Tissue level / Strain based brain injury criteria developed at KTH



Active muscles in the neck and trunk, arms and legs based on AHBM development at Chalmers

The SAFER HBM is based on THUMS v3, but have been substantially revised by the SAFER partners



# SOME FUTURE CHALLENGES

- Run-off-road simulations
- Roll-over simulations
- CFRP and other advanced materials







Thank you for your attention!