COMPREHENSIVE SAFETY CAE FOR THE ALL-NEW VOLVO S90/V90/V90CC

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Frontal impact:
- Frontal impact structural analysis
- Frontal impact interior analysis

Side impact:
- Side impact
- Roof crush / rollover
- Pedestrian and low speed impact
- Interior head impact (FMH)

Rear impact:
- Rear impact
- Rear seat and child safety
- External testing liaison team

One section – three groups – several teams

Management team – SM + 3 GM + 1 TS + 1 VML
FRONTAL IMPACT

- Full-scale loadcases
  - Legal loadcases
  - Rating loadcases
  - Field/overload loadcases

- Structural performance
  - Structural integrity
  - Intrusion level
  - Material failure

- Interior performance
  - Occupant safety
  - Restraint systems
  - Sensor calibration
  - Many different dummies in a number of different positions

- Increased complexity
  - 2 body variants (sedan and station wagon)
  - 3 roof variant (steel roof, sunroof and panoramic roof)
  - 2 chassis variant (standard and cross country)
  - 2 engine variant (Drive-E 4Cyl petrol and diesel)
  - 2 gearbox variant (manual and automatic)
  - 2 drivetrain variant (FWD and AWD)
  - T8 twin engine + 400V tunnel battery + EAWD
FRONTAL IMPACT

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CHALLENGE – SAME PERFORMANCE FOR ALL VARIANTS

The IIHS Small Overlap loadcase is a challenge in itself.
CHALLENGE – SAME PERFORMANCE FOR ALL VARIANTS

Y-displacement

Time

- v90 PHEV A/T Y Displacement
- v90 Petrol A/T Y Displacement
- s90 Diesel M/T Y Displacement
SIDE IMPACT

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  - Legal loadcases
  - Rating loadcases
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- Structural performance
  - Structural integrity
  - Intrusion level
  - Material failure
- Interior performance
  - Occupant safety
  - Restraint systems
  - Many different dummies in a number of different positions

- Other loadcases
  - Sensor calibration
  - Side airbag break through
  - Roof crush / rollover

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SIDE IMPACT LOADCASES

USNCAP

EuroNCAP

AE-MDB high

ChinaNCAP

IIHS

EuroNCAP pole

FMVSS214 50%ile

FMVSS214 5%ile
SIDE IMPACT LOADCASES

USNCAP

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FMVSS214 50%ile

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SIDE IMPACT – GENERAL CHALLENGES

Balance the pole and barrier loadcases

• Pole need high airbag pressure to avoid bottoming through effects
• High airbag pressure drives occupant injury criteria in barrier load cases
SIDE IMPACT - NEW CHALLENGES S90/V90

Update of EuroNCAP rating test

• Introducing two new dummies (Q6 and Q10) on 2nd row
• Dummy on far side 2nd row ➔ Need to secure CAE method
REAR IMPACT

- Full-scale loadcases
  - Legal loadcases
  - Rating loadcases
  - Field/overload loadcases
- Structural performance
  - Fuel integrity
  - Structural integrity
  - Material failure
- Interior performance
  - Occupant safety
  - Restraint systems
  - Many different dummies in a number of different positions
- Other loadcases
  - Interior rear seat safety
  - Whiplash
  - Head impact on seats
  - Luggage impact
REAR IMPACT LOADCASES

Low rigid barrier

High rigid barrier

FMVSS301 LHS/RHS

Rear side impact
OTHER LOADCASES

Interior rear seat safety

Whiplash

Head impact on seats

Luggage impact
FMH INTERIOR HEAD IMPACT

- Infinite number of loadcases
  - Possible impact on all trim panels and 70% of headliner area
  - Robustness variations
  - Any angle combination

- Difficult materials etc.
  - Plastic trim panels
  - Headliner foam
  - Rubber door seal
  - Contacts with thick and thin parts
PEDESTRIAN SAFETY

• Main loadcases
  • Legal loadcases
  • Rating loadcases
  • Sensor calibration
  • Humanoid dummies

• Options
  • Base car
  • R-design / accessories
  • With or w/o fog light
  • Xenon or LED head light

• Active systems
Pedestrian accident  ➞  Sub tests with separate impactors

Pedestrian safety

Head impact

Hip impact

Leg impact
PEDESTRIAN SAFETY

WAD Wrap Around Distance

6-yo 5%-female 50%-male

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PEDESTRIAN SAFETY – MAJOR CHALLENGE

Soft ...

... but strong enough

... and then we have the windscreen ...
METHOD DEVELOPMENT

• External research programs
  • Windscreen modelling (Vinnova, SE-DE)
  • Boron steel model verification (FFI, Optus 3)
  • Carbon Fibre Reinforced Polymers (FFI, Phase 1 => 2)

• Internal method development projects
  • Building comprehensive material database
  • New joint testing method
  • Pedestrian safety in early phases
  • Digimat for short fibre composites
  • Correlation studies

• “Skunk work”
  • Performed within car programme work ... 
  • ... out of necessity
  • A lot of good stuff ...
  • ... but not always well documented
Method Development – Windscreen Modelling

• Swedish / German project
  • Financing from Vinnova
  • Academic partners
  • Industrial partners

• Extensive test program
  • Glass
  • PVB
  • Complete laminate
  • PUR Adhesive
  • Complete windscreen

• New modeling techniques
  • TSHELLs and SOLIDs
  • Smeared crack material model for glass
  • Non-linear hyper-viscoelastic material model for PVB and adhesive
Methods - New Joining Verification Test

- Purpose
  - Verify new joining methods
  - Validating CAE modeling methods

- Prerequisites
  - Use available drop tower
  - Concentrate load to joint flanges
  - Minimize influence of material behavior and friction
  - Simple joint performance measurement

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METHODS - NEW JOINING VERIFICATION TEST

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Methods - Pedestrian Safety in Early Phases

Simplified model with spring elements. Modifying the proportions of the car.

- Hood force
- Bumper force
- Spoiler force

Grille thickness

Spoiler offset from facia
• New V90 in car-to-car crash with S60L as bullet car
• Full Interior with two HIII Dummies in New V90
• Original models: 15 000 000 + 5 000 000 = 20 000 000 elements
• Reduced model: 12 500 000 + 2 500 000 = 15 000 000 elements
• Simulation time: 100 ms
• Run time: 127h @ 480 CPU cores
**COMPUTER CAPACITY**

- Large models and a lot of simulations
  - 10-15 million elements per simulation
  - Normally 4 x 5 = 20 integration points per element
  - 200 000-300 000 timesteps per simulation
  - 100-200 simulations per day
  - > 7000 000 000 000 000 \(\approx\) 10\(^{16}\) int.pt. calculations per day or
  - > 80 000 000 000 \(\approx\) 10\(^{11}\) int.pt. calculations per second

- Volvo Cars Crash CAE server system:
  - 1200 Xeon Octa Core CPUs = 9600 CPU cores
  - 1949 Xeon Deca Core CPUs = 19400 CPU cores
    total CPU capacity = 29000 CPU cores

- Theoretical max capacity = 783 TFLOPS
Total staff: 82
CAE Engineers: 67%
Test Engineers: 33%
Females: 20%
Nationalities: 15

63 in picture
THANK YOU FOR YOUR ATTENTION!

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