SIMULATION FOR AIRBAG SENSOR CALIBRATION

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2nd European HyperWorks Technology Conference
Volvo 3P
AB VOLVO GROUP – Business Area

Volvo Trucks
Renault Trucks
Mack Trucks
Nissan Diesel
Construction Equipment

Buses
Volvo Penta
Volvo Aero
Financial Services
QUALITY

SAFETY

ENVIRONMENT
Volvo 3P
AB VOLVO GROUP – Corporate Values

QUALITY

“Safety is – and must always be – the fundamental principle of our design work-”

Assar Gabrielsson and Gustaf Larson, founders of Volvo

SAFETY

ENVIRONMENT
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AIRBAG TEST

FM
30 km/h
0° TRAILER BACK
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AIRBAG CONTROL

ECU
Electronic Control Unit

CRASH SITUATION

ECU

accelerations

algorithm

NON FIRE

FIRE
HOW TO CALIBRATE AN AIRBAG ECU?

TODAY = TESTS

FUTURE = SIMULATION

ECU

algorithm

accelerations

accelerations

NON FIRE

FIRE
An airbag sensor has to be calibrated based on acceleration signals.
A two years research and development project has been done to define the simulation methodology:

- **MESH GUIDELINES**: recommendations for the mesh quality, mesh size (mesh class) and element formulation
- **TEST SENSOR ACCELERATION**: frequency analysis to find the frequency spectrum that needs to be caught
- **FILTERING**: cut off frequency and sampling rate have been set up to filter numerical noise and catch physical accelerations
- **SENSOR MODELING**: recommendations to represent the sensors
A new airbag sensor will be introduced in **FH trucks** and in the mean time, some parts will be modified:

2007-2008: 1st application of airbag sensor calibration with simulation help in the VOLVO Group
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PROJECT APPLICATION: FH trucks

**Airbag sensor** calibration matrix

DEVELOPMENT TESTS
- HIGH SPEED TEST 1
- HIGH SPEED TEST 2
- HIGH SPEED TEST 3
- LOW SPEED TEST 1
- LOW SPEED TEST 2
- LOW SPEED TEST 3

VERIFICATION TESTS
- HIGH SPEED TEST 1
- HIGH SPEED TEST 3
- LOW SPEED TEST 2
- LOW SPEED TEST 3

Sensor CALIBRATION

Algorithm

Sensor SUPPLIER

Acceleration signals
Volvo 3P
PROJECT APPLICATION: FH trucks

Finite Element model
1.5 million elements
RADIOSS 5.1 solver

Complete chassis +
Engine + FUPS +
Power train

Complete BIW + DIW + Dummies +
Dashboard + Seats +
Steering column + …
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PROJECT APPLICATION: FH trucks

Test versus simulation correlation: Simulation / Physical test

![Graphs showing comparisons between simulation and physical test results for barrier force, airbag sensor acceleration, and airbag sensor velocity.]
PROJECT APPLICATION: FH trucks

Test versus simulation **correlation**: validation of the model with the airbag sensor supplier

**PHYSICAL TEST**
(from the development test phase)

- **Same Time To Fire**
  - Model is validated

- **Different Time To Fire**
  - Model is not validated

**SIMULATION**

- Accelerations
- Sensor Algorithm
- Accelerations
Sensitivity analysis: done if the model is validated to improve the robustness of the algorithm.

- influence of new or modified parts
- influence of cab variants
- influence of chassis variants
- influence of truck mass
- influence of test speed
- influence of barrier position (height, angle…)

Influence on the airbag *Time To Fire* ⇒ Algorithm adjustments
Airbag sensor calibration matrix

DEVELOPMENT TESTS

HIGH SPEED TEST 1
HIGH SPEED TEST 2
HIGH SPEED TEST 3
LOW SPEED TEST 2
LOW SPEED TEST 3

SAVING: ~ 200 k€
CONCLUSIONS: DIFFICULTIES ENCOUNTERED

- Level of details needed in the models (pipes, tanks, brackets…)
- Material characteristics for crash application
- Rupture, tearing (welds, glue, bolts, sheet metal…)
- Model size: 64 bits workstations and software needed
- Model size: CPU time
- Test robustness
CONCLUSIONS: CAE BENEFITS

- Many variants can be simulated (cab size, engine...)
- Details can be seen in simulation and not in test (transparent vehicle)
- The worst case scenario can be found by computation and influence the verification test configuration
- New test conditions can be tested (speed, angle...)
- Simulations will bring higher robustness to the algorithm
- Simulations can show how new introduced parts (eg Front lid in steel instead of plastic) will effect the sensor signal and the algorithm
THANK YOU FOR YOUR ATTENTION
If we need 10 sampling points per period and if we want to catch accelerations up to 1500 Hz we need a sampling frequency:

\[ T_{samp} = \frac{1}{10\nu} = \frac{1}{15/\text{ms}} = 0.06\text{ms} \]
We need 10 elements \((10.1c)\) per wavelength \((c.T = c/\nu)\) for the highest frequency and the slowest (plastic) stress wave:

\[
l_c \leq \frac{c}{10\nu} = \frac{50\text{mm/ms}}{15/\text{ms}} = 3.333\text{mm}
\]

For thicknesses of 2.mm or less this is close to the mesh convergence requirement.