R66 ANSA & μETA TOOLBOX FOR BUS BODY DEVELOPMENT

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R66 rollover, Buses, ABAQUS, ANSA , TASK MANAGER

ABSTRACT –
SCANIA develops , produces and sells heavy trucks and buses worldwide. The bus program includes city and intercity buses and coaches.
ECE R66 are mandatory for passenger traffic buses in Europe and elsewhere. It demands that a bus to be tipped sideways from a shelf of 0.8 [m] height . The sides of the bus may not intrude into a certain specified volume, the residual/survival space (SUV).
The body design involves both fatigue , stiffness and maximum strength properties. They could be evaluated in fem-model environment. These calculations has been done by explicit code for rollover calculations and implicit code for stiffness and fatigue calculations.

My focus today is on the effort to use initially the same fe model for fatigue as for rollover calculations.
In particular I intend to use an upstanding bus model for the fatigue calculation and the same tipped for the rollover calculation. In the rollover calculation the bus is tipped to a close ground contact position to save computer time , thus differing from the CAD XYZ system.
ANSA Task Manager is a powerful tool which allows the completion of ready-to-run model in a repeatable, controllable and fast manner while it requires the minimum effort from the analyst .The tool exploits ANSA functionality so as to organize the modeling steps in a sequence for the development of R66 template.
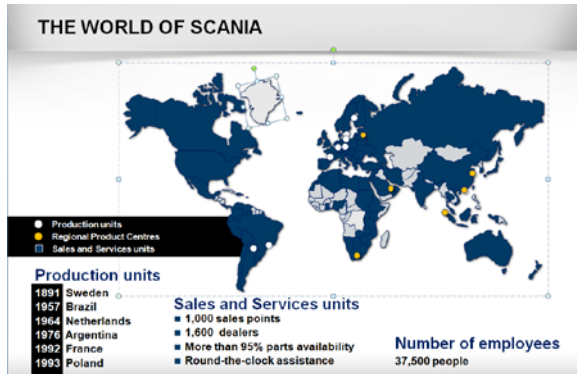The work scheme is to use a newly developed ANSA TASK R66 rollover to create a ABAQUS EXPLICIT input file. The input file created is ready-to run with materials, beam cross sections , initial velocity and post processing demands.
The toolbar Crash-Safety with R66-Rollover task within META POST is used to establish the margins of safety for the SUV intrusion into the bus side members.

TECHNICAL PAPER –

1. SCANIA CV AB TRUCKS , BUSES AND COACHES

Scania develops, produces and markets heavy trucks and buses. Our own produced city buses includes the OmniCity, Omnilink and Citywide brands. (figure below)

2. BUS BODY CALCULATION PROCESSES

ECE R66 are mandatory for passenger traffic buses in Europe and elsewhere. It demands that a bus to be tipped sideways from a shelf of 0.8 [m] height . The sides of the bus may not intrude into a certain specified volume, the survival space (SUV).
The body design involves both fatigue , stiffness and maximum strength properties. The evaluation of these various properties is partly field testing at test tracks and customer traffic. They are also evaluated in fem-model environment. For the fem-calculation the fatigue , stiffness and maximum strength calculations are done by different solver techniques. This puts my focus on the effort to use the same fe model for both fatigue as for rollover calculations.
So far these calculations has been done by LSDYNA for rollover calculations and ABAQUS STANDARD for stiffness and fatigue calculations. There has been a mix of beam and shell element models. The typical time for a complete bus body shell element model is about 4-6 weeks . The making of a bus beam model is about a week. The change of profile dimensions is within hours.
In particular we here intends to use ABAQUS STANDARD for the fatigue calculation and ABAQUS EXPLICIT for the rollover calculation. The intention is to use beam elements for the sides of the bus .
Note that the cad designers o far bus always do their models in some defined X,Y,Z coordinate system.
A useful scheme is X= travelling direction, Y=sideways and Z = vertical of the bus.
The fe-designer then get these models and make their fem-bus body . Most probable in the same coordinate system. This is an acceptable and useful start for a fatigue calculation. But : To save time in the rollover calculation the bus is tipped to a close ground contact position. The ANSA pre processing has shown a valuable and usable tool to create the rollover input file from a fatigue input file. The work scheme is to use a special developed ANSA TASK "rollover" to create a ABAQUS EXPLICIT input file. The input file should be ready-to run with materials, beam cross sections , initial velocity and post processing demands.

3. R66 CALCULATION WORK FLOW

The calculation process is using META pre-processing :
- Building of fem-model from CAD.
- Adjusting for total mass and centre of gravity.
- Using ANSA R66 task to :
- Tipping of body to initial contact with road plane

- Setting up contacts
- Calculation of initial velocities
- Setting up gravity load
- Exporting an ABAQUS.inp file
- Run an ABAQUS explicit job on job cluster…
- Result evaluation : META R66 toolbar to check : Residual space distance to bus interior side.

4. ABAQUS BEAM ELEMENT FE MODEL

The fe-model initially developed in up-standing position ,fig 1. As this it is used for strength and stiffness calculations. Here the residual space is introduced into the fem-model. Beam elements are used in order to the study of forces and bending moments in the structure.
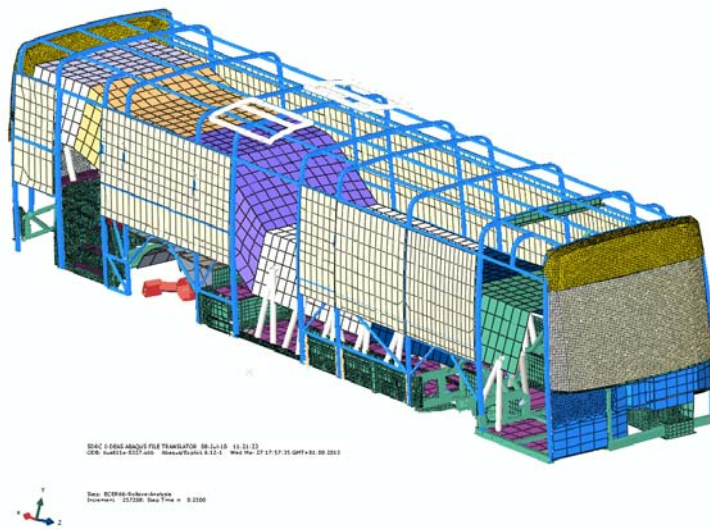

Figure 1 Fem-model in upstanding position.

5. UNITS AND MATERIAL

Units used in the calculation are a commonly chosen SI(mm):

Table 2–1 Consistent units.

Quantity	SI	SI (mm)	US Unit (ft)	US Unit (inch)
Length	m	mm	ft	in
Force	N	N	lbf	lbf
Mass	kg	tonne (10^3 kg)	slug	lbf s^2/in
Time	s	s	s	s
Stress	Pa (N/m^2)	MPa (N/mm^2)	lbf/ft^2	psi (lbf/in^2)
Energy	J	mJ (10^{-3} J)	ft lbf	in lbf
Density	kg/m^3	tonne/mm^3	slug/ft^3	lbf s^2/in^4

Nonlinear as well as linear material are used. A typical ABAQUS material data card will look like this:
*MATERIAL, NAME=A-steel;like-355
*DENSITY
          3.E-8,
*ELASTIC, TYPE=ISOTROPIC
        206800.,   0.3
*PLASTIC, HARDENING=ISOTROPIC
          355.,   0.
          387.3,   0.002124
          388.,   0.00322
          390.1,   0.004107
          390.5,   0.005352
          394.,   0.008873
          396.,   0.01549
          418.8,   0.02194

6. ADJUSTING OF MASS

The mass should be adjusted to have the right mass and position of gravity. The fem-model mass should correspond to the actual bus in unloaded state. The passenger weight should be added according to what is stated within the ECE regulation R-66-01.

7. ANSA TASK R66 ROLOVER

The following items are performed with the assistance of the ANSA R66 task,Fig 2.
<u>Tipping of body</u>
The task finds by calculation the position of the body from upstanding to a initial contact position. The task rotates the body to this initial position.
<u>Calculation of initial velocities</u>
The task makes a calculation of the initial velocity at the time of initial contact to the ground plane.
<u>Setting up contacts</u>
BiW- Body-in-White is the definition of all elements in the bus fem- model. That includes the Windows, Beam pillars, Residual space and the rest of the bus body.
*CONTACT INCLUSIONS
We want to express the contact between the BiW and the road . That is where the major impact is active. At the same time we want to allow for self contact of elements in the BiW.
i.e.   the rear sofa is a big shell-like design. When the rear sofa hits the ground large buckling occurs. The fem- calculus is improved by adding self contact there.
*CONTACT EXCLUSIONS
The Residual space(SUV) is the most important item not to be in contact anywhere. The reason is obvious: it may not improve the performance of the bus body. It shall merely be a passive measuring device inside the bus body.
So we want to have the following exclusions in action:
ROAD to SUV
BiW to SUV
SUV to all other items (just to make sure we doesn't forgot anu SUV contact!)
These items are performed within the ANSA R66 task.
Contacts inclusions and exclusions can be added as needed.
<u>Check the model</u>
A number of checks on the model could be performed. Material , contact.... This is most valuable to assert a high quality fem-model .

Export a run file
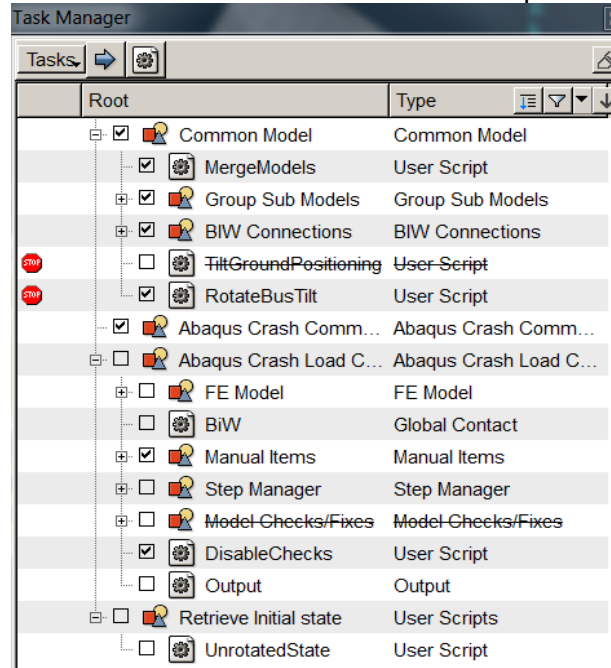As the last item within the ANSA TASKR66 rolover is the export of an ABAQUS run file.

Figure 2 Ansa task R66 rollover.

8. EXPORT THE ABAQUS.INP FILE FROM ANSA R66 ROLOVER TASK, SUBMIT JOB, GET RESULTS BACK.

Last item inside the ANSA Rolover task is to export an ABAQUS.inp file. This file is used to run a calculation, i.e My-Bus-job . After the calculation is ready the resulting My-Bus-job.odb file is transferred to a suitable disk where the postprocessing will be performed.

9. POSTPROCESSING – META CRASH AND SAFETY R66 TOOLBAR , ABAQUS VIEWER

By inspection of the contact general domain we see that the residual space is not part of it. This is the correct situation. **Fig 3**
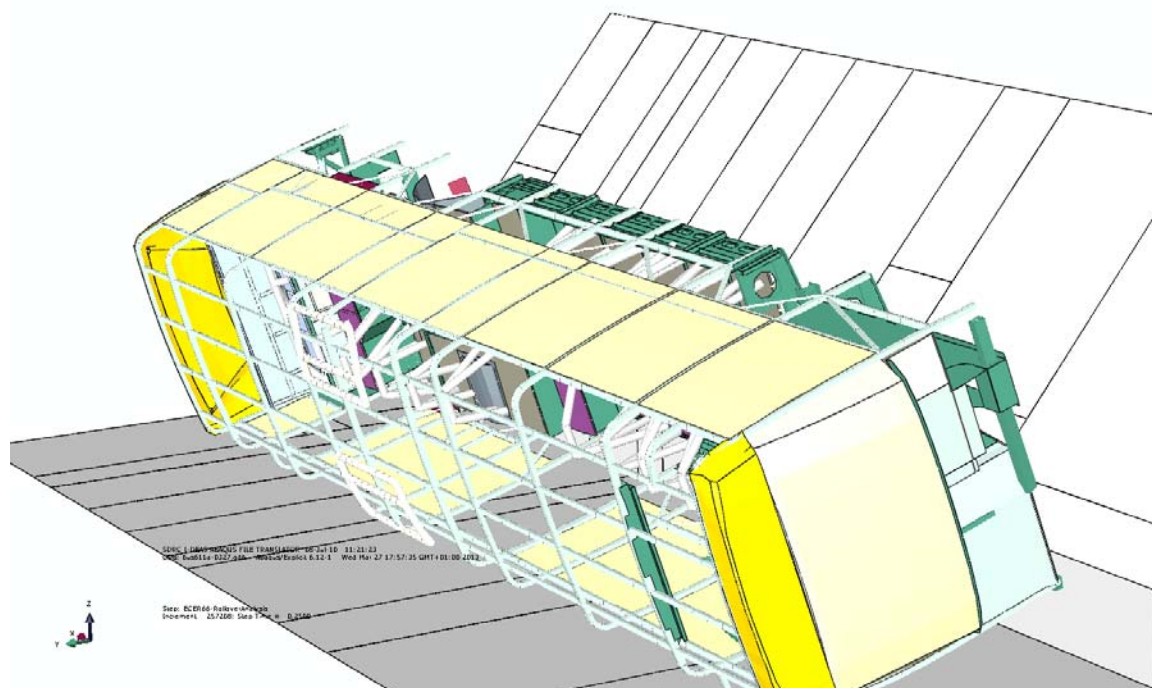
Figure 3 ABAQUS viewer - visualization of contact domain

The ABAQUS VIEWER used to judge the quality of the solution by plotting of Energy levels for the solution. **Fig2**
ALLIE = ALLPD + ALLSE+ALLAE.(=>Internal energy=plastic energy+elastic+hourglass+..)
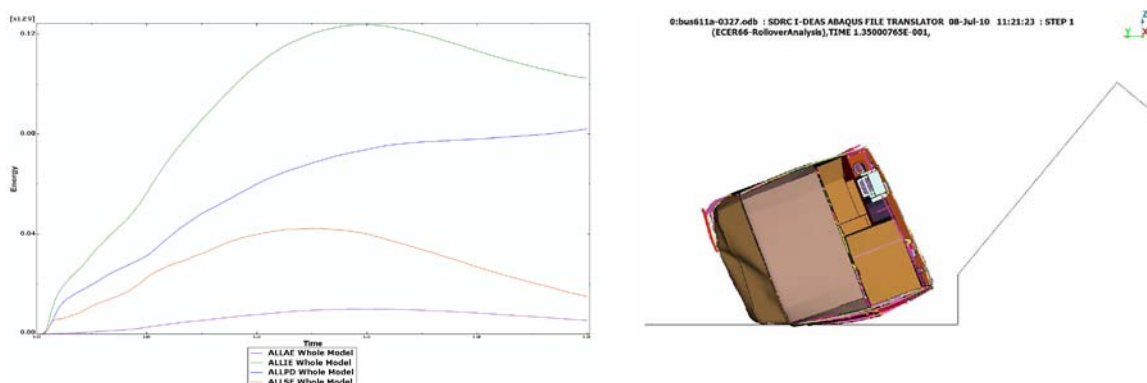

Figure 4 ABAQUS Viewer Bus body energy levels. Body deflection at t=0.135 [s]
In **fig 4** we also see the deformed shape of the bus body.
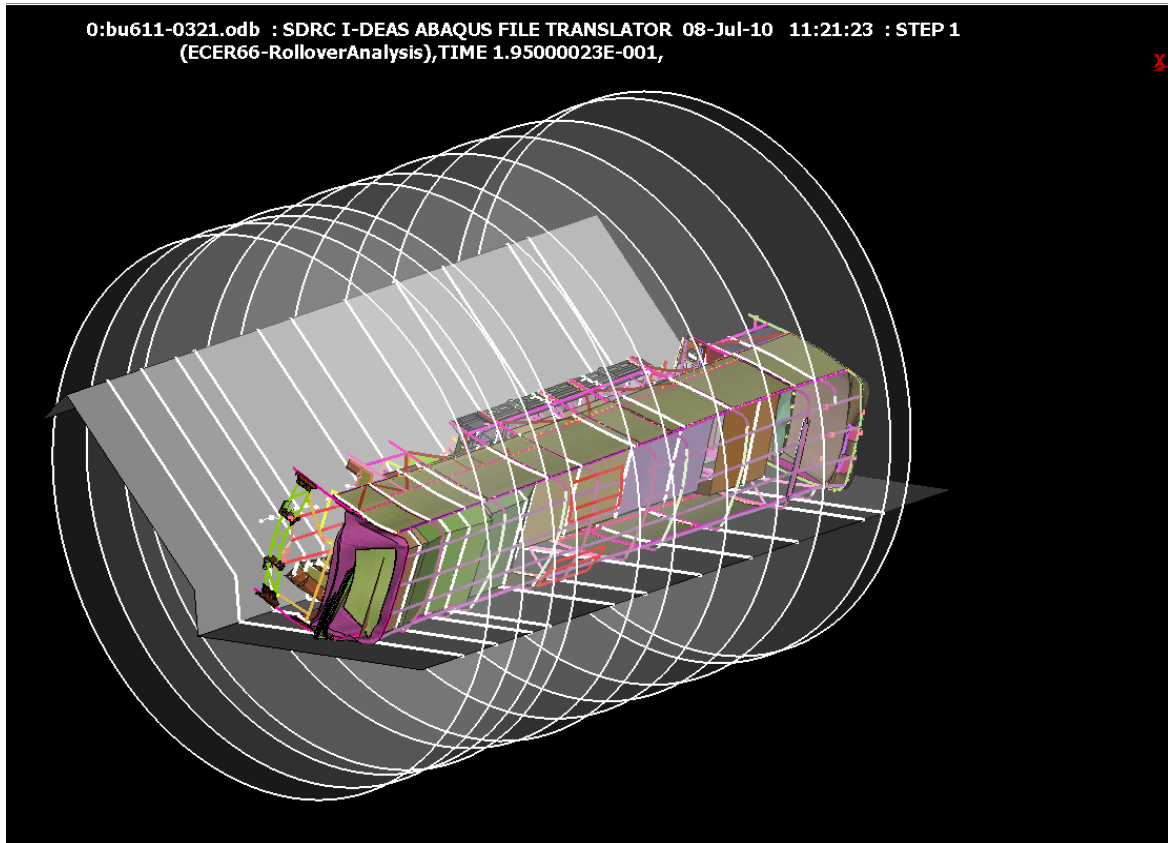
Figure 5 Meta R66 toolbar . Residual space intrusion calculation.

The aim of the calculations is to calculate the distance between the Residual space and the bus inside wall. This is most easily done with the special developed R66 rollover toolbar within META postprocessor. The cutting planes defined are shown in **fig 5**. The result is plotted in **fig 6**.
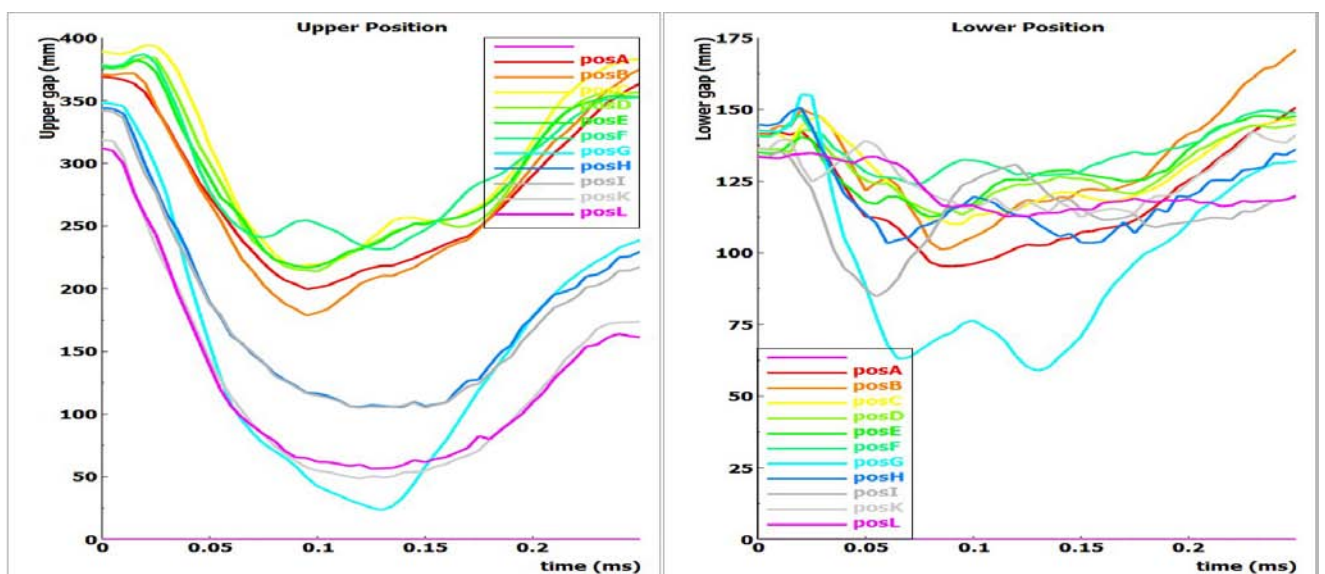

Figure 6 META R66 toolbar . Intrusion calculation

10. CONCLUSIONS

In this example they have been used to study an ABAQUS EXPLICIT bus beam element model . A design change was introduced and the result was examined. The difference in behaviour is clearly visible within the META POST R66 toolbar produced residual space intrusion curves .
The ANSA R66 task has shown to be a most competent way to setup the ABAQUS run file for a R66 rollover calculation.
The META POST R66 toolbar has shown to be an fast way to analyze the result from a R66 rollover calculation.
The R66 task&tool together creates a fast and efficient way to make R66 rollover calculations .

11. REFERENCES

(1)   ANSA version 14.0.2 User's Guide, BETA CAE Systems S.A..
(2)   μETA PostProcessor version 14.0.2. User's Guide, BETA CAE Systems S.A.
(3)   ABAQUS 6.12.1 manuals .
(4)   SCANIA CV AB short company presentations 2012/2013.