A Benchmark Study of CAE Sensor Modeling Using LS-DYNA

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Abstract

This paper presents results from a benchmark study of CAE sensor modeling using LS-DYNA. Using the VPG translator, a sensor model was converted from a calibrated RADIOSS model into LS-DYNA input formats for frontal impact simulations carried out in this study. Since two codes have different material laws, element library and functionalities, those deemed to be as closed to RADIOSS were chosen in the translation process. For those that could not be translated directly into LS-DYNA, best engineering judgment was made in selection of appropriate LS-DYNA parameters.

Three different frontal impact modes, namely, rigid barrier, pole, and Thatcham offset are simulated in this study. In frontal rigid barrier mode, both 90^o barrier and 30^o angular impacts are considered. Signals at nine (9) locations were monitored including two sensor signals obtained at the front crash sensor (FCS) and Restraint Control Module (RCM) locations. The quality of CAE data was evaluated using an assessment tool to give objective ratings for comparing results between LS-DYNA and RADIOSS. Sensor signals generated from LS-DYNA were compared with both the RADIOSS and test results. However, only the comparisons with RADIOSS results are presented.

By comparing the ratings, LS-DYNA results were, generally speaking, comparable with RADIOSS' counterparts. Observation of some high frequency response at the onset of acceleration time history obtained at the front crash sensor location at the early stage of this study was improved by LSTC. The study also pointed out areas, i.e. angular and Thatcham impacts, where the LS-DYNA model requires further improvement in the future

Keyword: Airbag Sensor, CAE Sensor

I. Introduction

CAE applications to reduce prototype tests are corporate goal of many automobile manufacturers in reducing development time and cost savings. Efforts in studies [1,2,3] up to this point in time in attempt to develop quality CAE sensor models are directed towards this goal. These studies came to the same conclusion that CAE acceleration signals are too noisy for sensing calibration applications. However, velocity-based algorithm using CAE signals provides a promising application front to preliminary sensor calibration. Steuzler, Chou, Chen, and Le have studied such feasibility using RADIOSS non-linear code [4], and reported their findings in 2003 [5].

II. Background

This study was initiated to investigate LS-DYNA's capability in simulating sensor signals at both the front crash sensor (FCS) and Restraint Control Module (RCM) locations. The Method Group worked jointly with LSTC with the help of ETA to assess the capability of LS-DYNA in generating quality sensor signals.

Since 1998, the Method Group has developed sensor-modeling methodology for frontal impact simulations using the RADIOSS non-linear finite element code. A sensor model was developed, from which CAE generated sensor signals were used to help develop velocity-based sensing algorithm. The Method Group thus provided ETA with a RADIOSS sensor model that was validated for 14 mph frontal barrier impact.

ETA converted the RADIOSS model using their translator into LS-DYNA input data format. Since two codes have different material laws and element library, those deemed to be as close to RADIOSS as possible were chosen in the translation process. For those that cannot be translated directly into LS-DYNA, best engineering judgment was made in the conversion process. LS-DYNA/ETA engineers also made some changes in order to run the model. These changes are given in the Technical Approach in Section III. Detailed conversion of variable/functions is documented in the Appendix.

ETA then run the DYNA analyses and provided simulated results to Ford for further assessment of signal quality using SWA (Sensor Waveform Assessor), that was developed at Ford. In this study, the ratings of

- LS-DYNA vs. RADIOSS results
- LS-DYNA vs. test results
- RADIOSS vs. test results

are compared at the following "strategic" locations:

- Left rocker at "B"-pillar
- Right rocker at "B" pillar
- Left frame at "B" pillar
- Right frame at "B" pillar
- Sensor at RCM
- Sensor at SM
- Frontal Crash Sensor – most critical
- Engine top
- Engine bottom

Frontal impact simulations are performed for the following cases:

i. 14 mph frontal rigid barrier impact
ii. 35 mph frontal rigid barrier impact
iii. 25 mph frontal rigid barrier impact
iv. 22 mph 30^{o} angular frontal barrier impact
v. 9.3 mph Thatcham 40% offset rigid barrier impact

In this paper, technical approaches used are outlined in Section III. Results and discussion are contained in Section IV, where only comparisons of results between LS-DYNA and RADIOSS will be reported. Conclusions drawn in this study are presented in Section V.

III. Technical Approaches

a) Ford provided a base run RADIOSS model, which was used in CAE front impact sensor calibration study [5].

A vehicle model was chosen for this study. The number of parts, elements and nodes are tabulated in Table I. This model was based on a crash analysis model for high-speed impact study where emphasis was placed on energy absorption of major structural components. Use of the high-speed crash model for sensor development revealed the difficulty of this model lies in lack of correlation with low velocity/pole impact test data, particularly in acceleration-time history at an early stage from the onset to 30 milliseconds. This model was further improved for low speed impact simulation with the following enhancements:

- Reducing penetrations
- Adding missing components
- Improving bumper model by using better foam material and modeling technique
- Refining front rails with finer meshes to simulate axial collapse
- Minimizing rigid connections
- Re-defining interfaces
- Incorporating a sensor module at the RCM location

Table I: Total number of parts, elements and nodes

Number of parts	330
Shell (triangular and quads) elements	184,616
Solid elements	272
Nodes	194,513

To make this model a better sensor model, it was calibrated using data obtained from three frontal impact tests, including a 14 mph frontal barrier impact test, a pole impact test and a Thatcham (i.e. 9.3 mph offset crash into a rigid barrier) test. Figures 1-3 show comparisons of results between the model and tests in terms of acceleration-, velocity-displacement-time histories and frequency content for these cases. Good correlation of the model against tests was favorably established. Consequently, this crash/sensor model was used to generate CAE sensor signals at both the FCS and RCM locations for various crash modes including:

- Frontal barrier impacts (8 mph up to 35 mph)
- Center pole impact
- Thatcham (9.3 mph front offset rigid barrier)
- Angular impacts with rigid barrier
- Others (such as car-to-car and offset into deformable barrier)

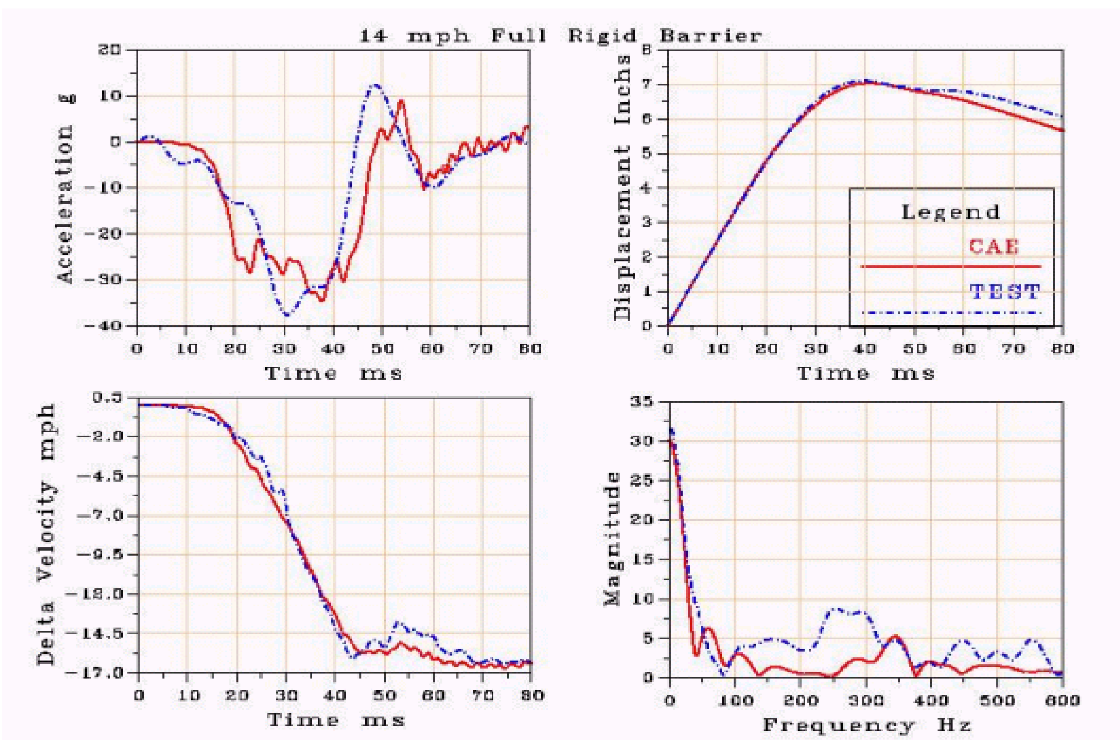

Figure 1 – RADIOSS CAE vs. Test – 14 mph Frontal Barrier Impact

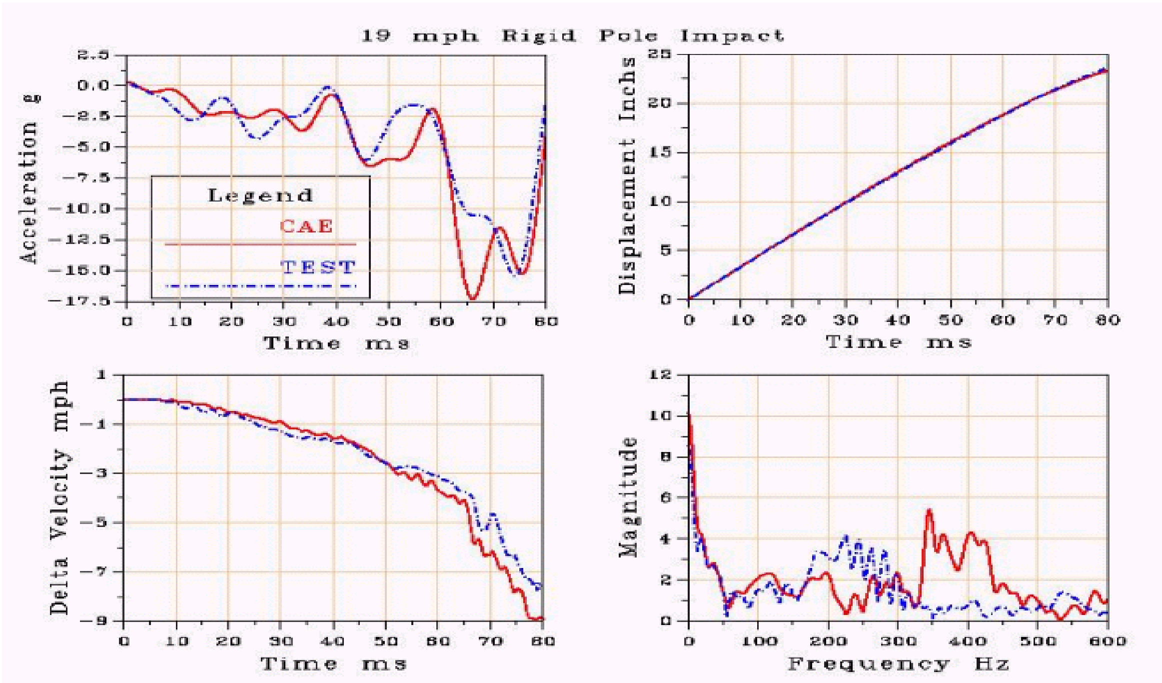

Figure 2 – RADIOSS CAE vs. Test – 19 mph Pole Impact

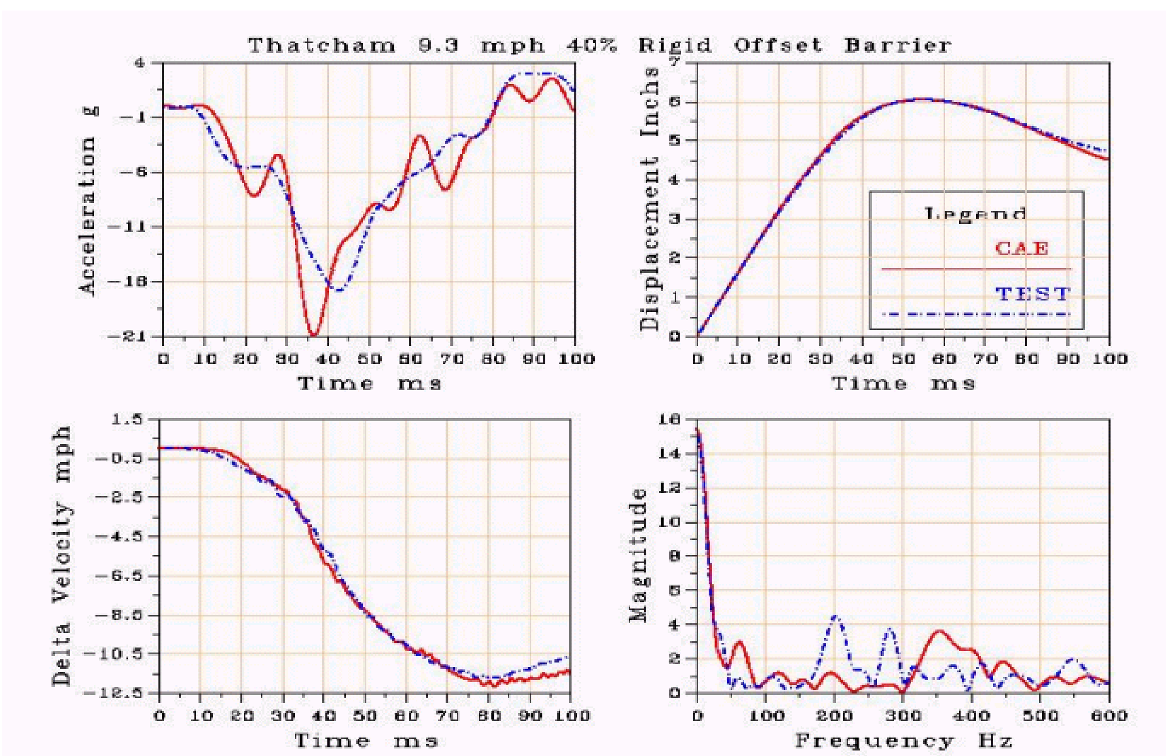

Figure 3 – RADIOSS CAE vs. Test – Thatchem (40% Rigid Offset Barrier Impact)

CAE generated signals at the sensor locations for the aforementioned test modes were evaluated using a waveform assessor to check their qualities with a quantifiable metric. This is to ensure that CAE generated crash pulses with such FEA sensor model lies within the deviations of the timing for crash test data, which in the real world arise due to vehicle build tolerances, slight differences in the test setup conditions e.g. weight, impact angle, etc. Consequently, the accuracy of the CAE generated sensor pulses as such is sufficient for determining deployment times of an airbag restraint system. All CAE signals used in this study passed this check for assurance of their accuracy and quality not only in the velocity change, but also in the desired frequency range [3]. These signals were used in the determination of deployment times of the first and second stages of an airbag restraint system using both the acceleration- and the velocity-based algorithms [5]. The 14mph frontal impact simulation was then chosen as the base run for this study.

b) LS-DYNA/ETA engineers then converted the RADIOSS file into LS-DYNA version, conducted simulation, identified discrepancies in the results, and resolved issues. Sensor Waveform Assessor (SWA) was used to evaluate generated pulses and their rating with respect to RADIOSS simulations.

The study from the initial conversion of the RADIOSS model to an acceptable LS-DYNA run can be divided into three phases. In each phase the displacement-, velocity- and acceleration-time histories at all 9 locations were obtained and compared with any available RADIOSS and/or test data. As mentioned previously, only comparisons of simulated results between LS-DYNA and RADIOSS will be reported below. It should be mentioned that, due to use of different executable LS-DYNA codes, the most current executable one available was used at the point in time when the input was modified. It is further mentioned that changes in input files were not made one at a time.

It should point out that the Type 16 shell element was used in the LS-DYNA model when conversion was made in Phase 3. Results of simulations during Phases 1 and 2 of the study are shown in Table II.

Table II: LS-DYNA Benchmark
CAE Sensor Study (Results based on SWA Rating)

Case 14 mph rigid barrier impact	LS-DYNA vs. RADIOSS		LS-DYNA vs. Test		Remarks
	FCS	Tunnel	FCS	Tunnel	
Phase 1	3	0	0	1	This is an initial run (See Figure 1)
Phase 2	3	4	0	2	Refined simulation with improvement over the signal (See Figure 2)

Comments on results shown in Table II are given below.

Phase 1:

Simulations were made in this phase with the following changes while converting RADIOSS model to LS-DYNA counterpart:

1. LS-DYNA version 960/rev. 1643/double precision/SMP was used.
2. All contact definitions given in RADIOSS model were basically lumped into one single contact definition in LS-DYNA. This approach was different from those defined by RADIOSS.
3. The gas tank inadvertently was not tied to the supporting straps.

Referring to Figure 4, LS-DYNA result at FCS location when compared with the RADIOSS counterpart is rated "3", indicating a good correlation between two codes. A higher rating can be achieved if the high oscillation in the first 5 in LS-DYNA simulation can be reduced. However, at the RCM location, a “0” rating indicates that there are differences between the LS-DYNA and RADIOSS results. Some differences can be seen in (1) comparing the velocity curve where simulated LS-DYNA result deviates from that of RADIOSS from 25 onward, (2) comparing the frequency content that LA-DYNA signal has a higher frequency content than the RADIOSS signal, and (3) in LS-DYNA result, showing a stiffer structure response.

When compared to test data, LS-DYNA result at the FCS location shows a larger variation with test data than its RADIOSS counterpart. While at the RCM location, it also shows larger peaks at about 26-27 from the onset of impact.

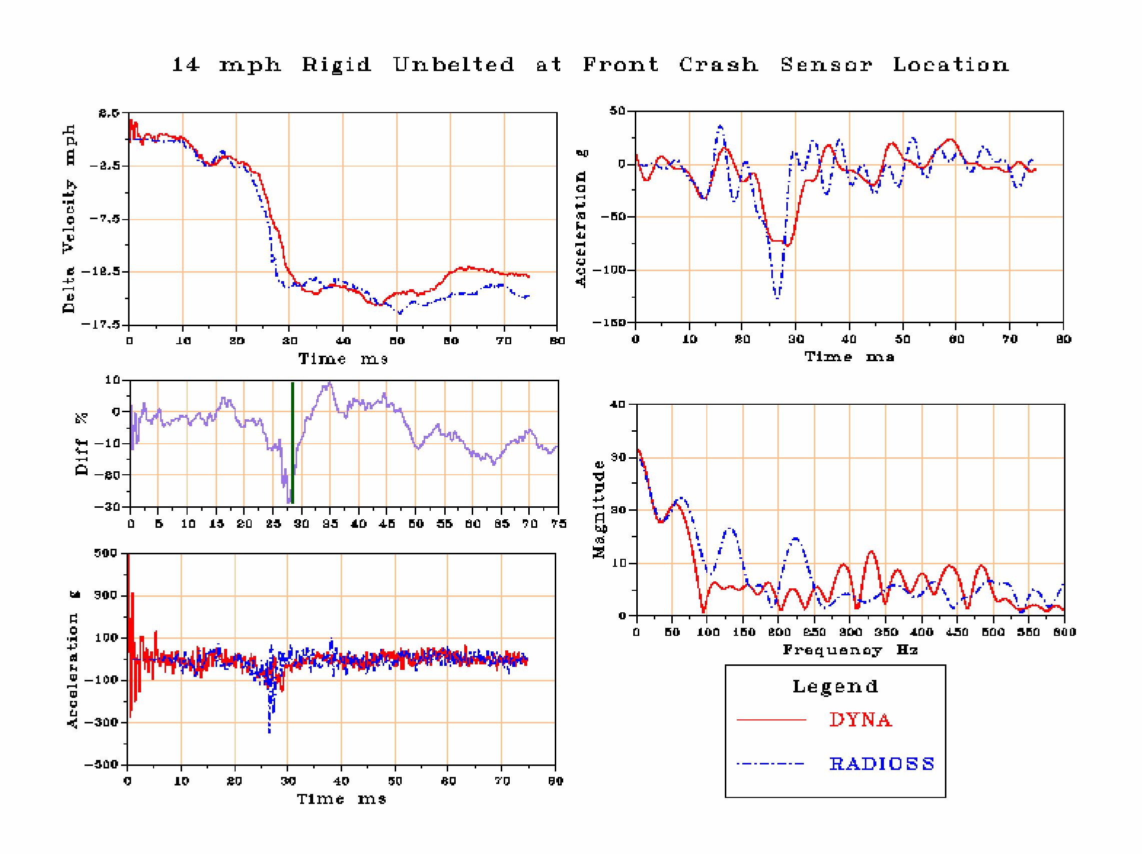

Figure 4 – LS-DYNA CAE vs. RADIOSS CAE – 14 mph Frontal Barrier Impact (Run 1)

Phase 2:

In this phase, LS-DYNA 970 beta version was used with no record of revision number. The following changes were noted:

1. Each of the contact definitions used in RADIOSS model was translated individually with slight modification to appropriate parameters in LS-DYNA to ensure accurate conversion of RADIOSS contact definitions. The parameters such as “nfail1” and “nfail4” in *CONTROL_SHELL were turned on for shell elements. This is the flag to check for highly distorted elements under integrated shell elements.
2. The Gas Tank was tied to straps. The tied contact for the gas-tank-to-straps was modified to *CONTACT_TIED_SHELL_EDGE_TO_SURFACE_BEAM_OFFSET type contact definitions, which was found to be more appropriate.
3. Sensors are attached to small nodal rigid bodies. This was mainly to reduce the numerical noise generated in Phase 1.
4. Shell formulation Type #16 used instead of B-T shell. The shell formulation “ELFORM” was set to Type #16 – Fully integrated shell elements.

It is remarked here that when using contact that follows RADIOSS approach, animation of LS-DYNA model shows parts penetration occurs in the aft end of the vehicle because no contact is defined in that region.

Referring to Figure 5, LSTC attempted to reduce the high frequency noise as observed in Run 1. At the FCS location, the rating has improved, but relatively high frequency noises are still observed in the early response of acceleration. This portion of the signal affects this rating. Similarly, the rating of simulated LS-DYNA results at the tunnel location has been improved after contact changes. LS-DYNA pulse of a rating of "4" can be considered as a test variation of RADIOSS. Similar comments are applicable to LS-DYNA results when compared to test data. Signals at the FCS location are somehow degraded. Therefore, the early response of FCS still needs to be improved.

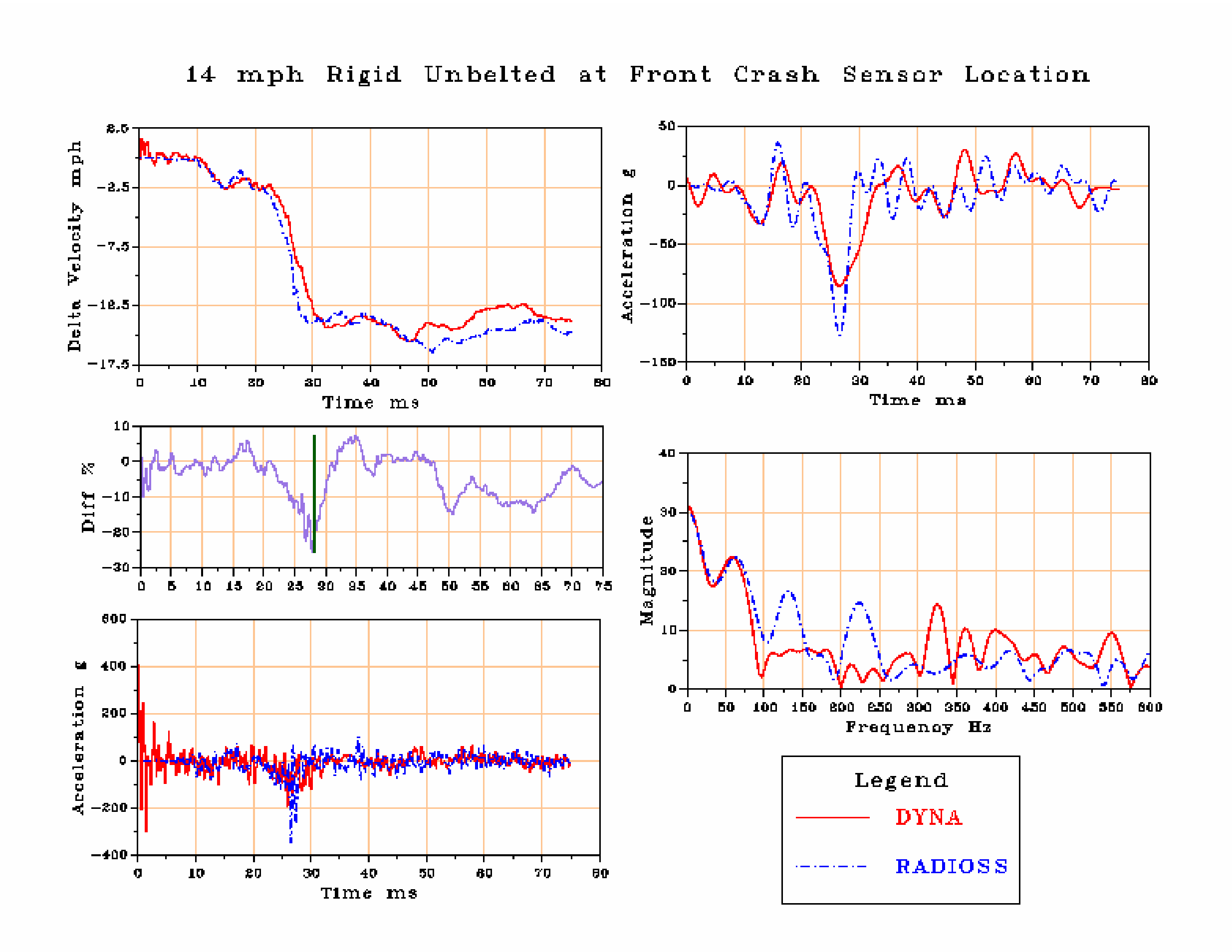

Figure 5 – LS-DYNA CAE vs. RADIOSS CAE – 14 mph Frontal Barrier Impact (Run 2)

Phase 3:

LS-DYNA version 970/3518/double precision/SMP was used in Phase 3. The integrated shell Type #16 was replaced with shell formulation Type #2 for *MAT_SIMPLIFIED_JOHNSON_COOK. In general, a Type #2, a fast under-integrated shell formulation, is somewhat softer than a shell Type #16 and is more similar to the shell formulation used in RADIOSS. Examination of the Type #2 shell run results indicates that it yields a softer response than that from the Type #16, but is still stiffer than the test data.

Figure 6 displays the result from the final run, showing that the previously observed high noise in the FCS response diminished. Therefore, the LS-DYNA results are rendered to be acceptable. This completes the initial phase. The spurious noise in the first 5 of Fontal Crash Sensor (FCS) response was considerable in initial phase. However, this level of noise was reduced or eliminated by attaching small patch of rigid elements at the sensor location. This technique is considered to be a common modelling practice.

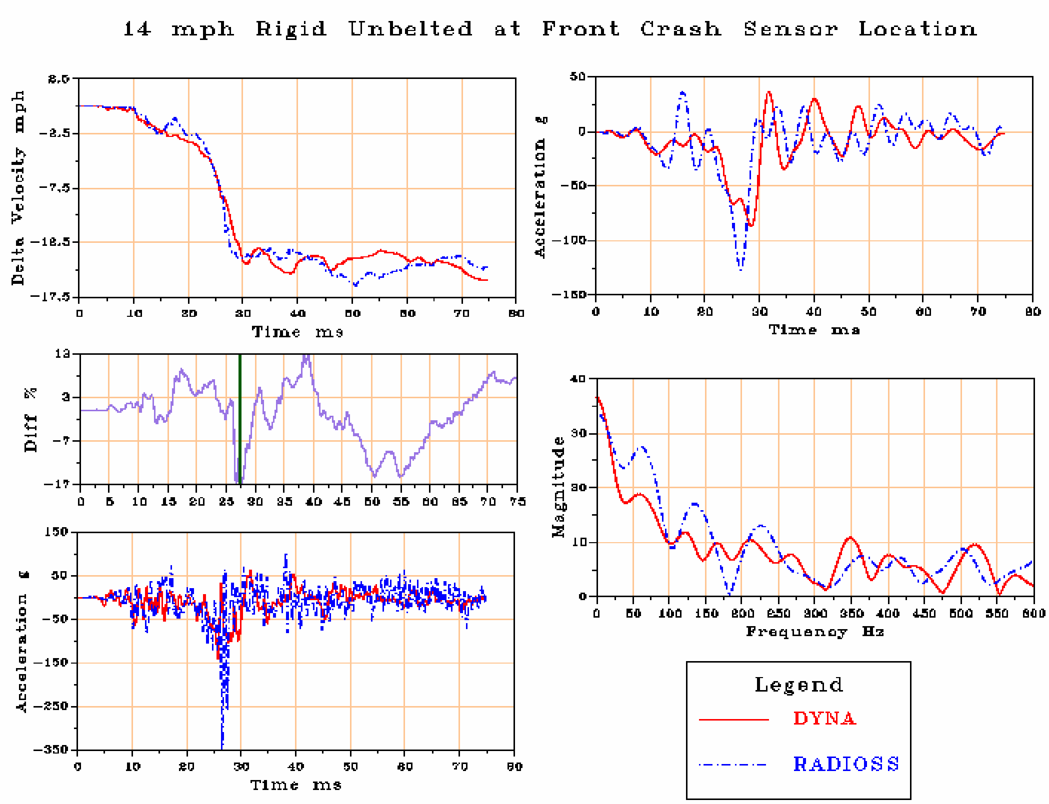

Figure 6 – LS-DYNA CAE vs. RADIOSS CAE – 14 mph Frontal Barrier Impact (Run 3)

c) Using the model developed in (b), ETA/LSTC continues simulations of additional cases in different test configurations and speeds, by varying the test vehicle weight and initial impact velocity only, while keeping the model same for all cases. It should be pointed out here that the test data for the 25 mph frontal barrier impact is not available, the test vehicle weight for this simulation is assumed to be the same as the 35 mph test vehicle. LS-DYNA results for the above cases are shown in Figures 7 to 10.

IV. Results / Discussion

Prior to discussion of results, it should be pointed out again, the two types of shell elements, i.e. Type #16 (4 integration points) and Type #2 (single point integration) are used in LS-DYNA simulations. Since the RADIOSS does not have a 4-integration-point shell element, therefore, in RADIOSS simulations, the single point integration shell element is used.

Again, ratings are obtained using SWA by comparing LS-DYNA results with test data, LS-DYNA results with RADIOSS results, and LS-DYNA results between Type #16 and Type #2. Table III is a compilation of comparisons of the results along with RADIOSS vs. LS-DYNA results for discussion.

Frontal rigid barrier impact Modes:

Using LS-DYNA's shell element Type #2 provides results that are closer to those obtained by RADIOSS. This can be seen from data marked in "green" as shown in Table III. Referring to Figures 4 to 6, data also indicates that using shell element Type #16, LS-DYNA produces a stiffer response to which the same v is achieved within a shorter time period when compared with using element Type #2. It is further noted that element Type #16 seems to provide better results than element Type #2 at RCM and FCS (marked in "purple") when compared to test data (except angular).

Figure 7 shows the results from both LS-DYNA and RADIOSS for a 35 mph frontal rigid barrier impact. Referring to the frequency plot, the signal generated from LS-DYNA has higher frequency content than that from RADIOSS over the entire frequency ranges.

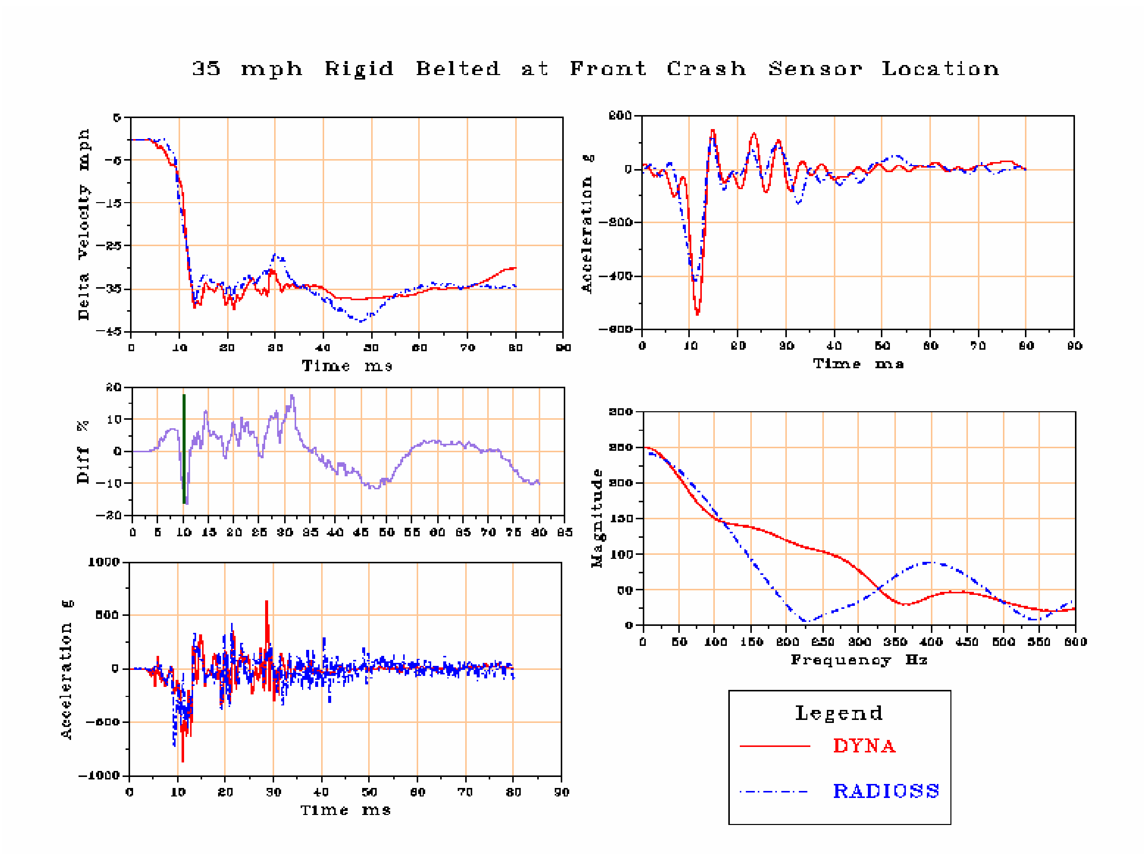

Figure 7 – LS-DYNA CAE vs. RADIOSS CAE – 35 mph Frontal Barrier Impact

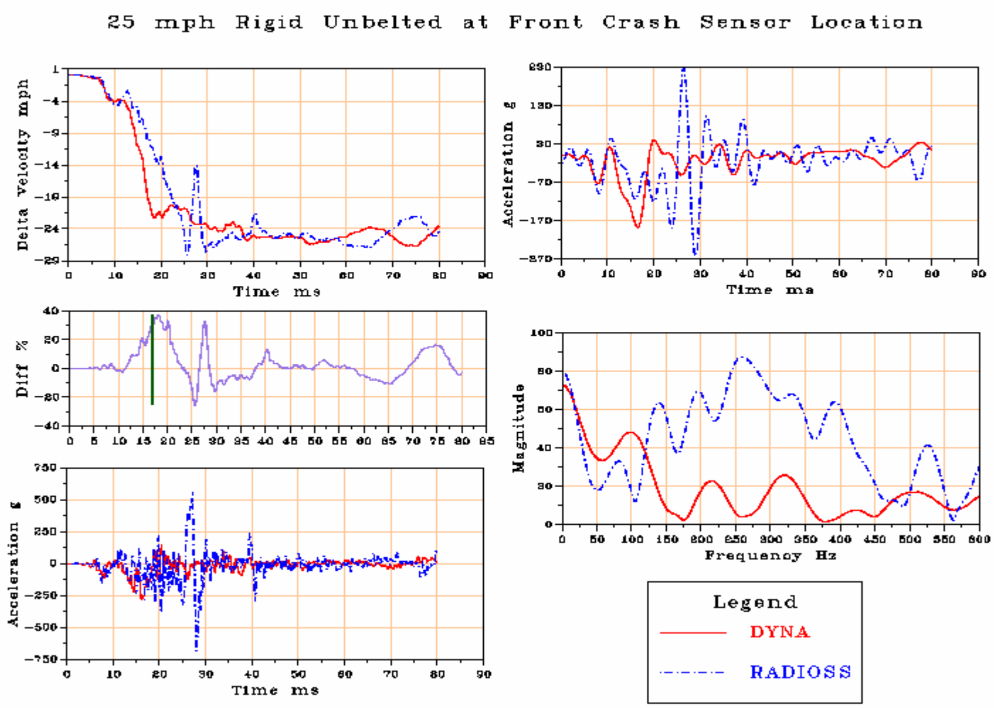

Figure 8 – LS-DYNA CAE vs. RADIOSS CAE – 25 mph Frontal Barrier Impact

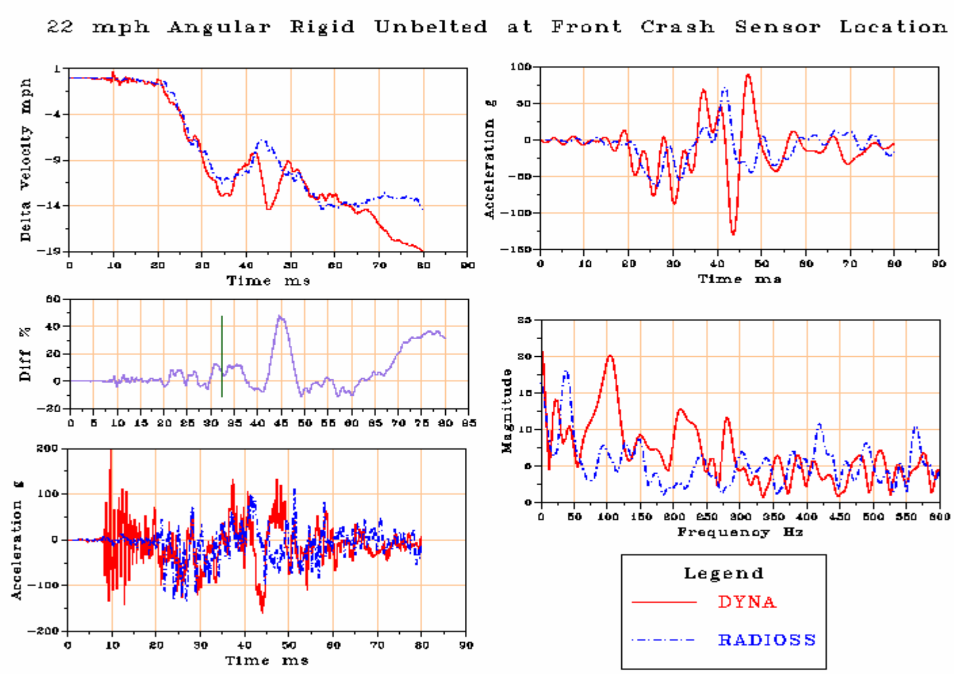

Figure 9 – LS-DYNA CAE vs. RADIOSS CAE – 22 mph Angular Frontal Barrier Impact

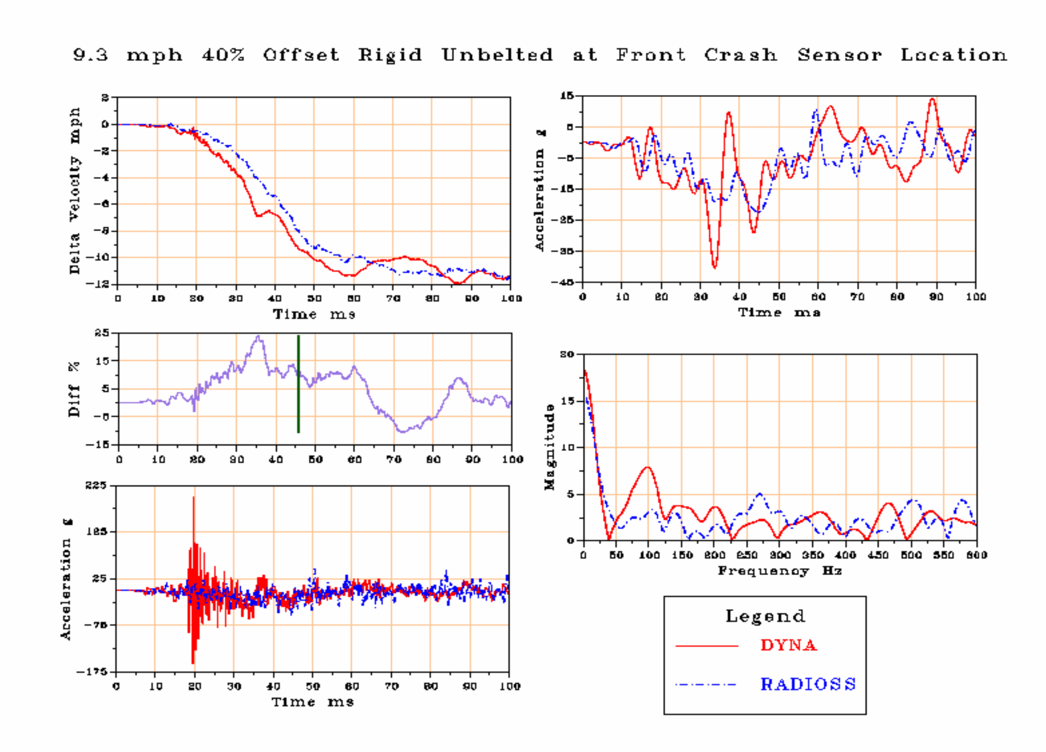

Figure 10 – LS-DYNA CAE vs. RADIOSS CAE – 9.3 mph 40% Offset Frontal Barrier Impact

An intermediate impact velocity at 25 mph in frontal barrier impact was carried out using the LS-DYNA model. The results are compared with those from RADIOSS as shown in Figure 8. This comparison reveals that the RADIOSS result has a peak-and-valley exhibited from 25 to 30 milliseconds. This is peculiar, because it is not shown in both the 14 mph and 35 mph simulations. This is resulted from the high peaks in the acceleration-time history. Again, high frequency content ranging from 100 to 400 Hz are primarily caused by the high peaks occurring from 25 milliseconds to 30 milliseconds in acceleration.

Angular impact Mode:

Now, we are in position to evaluate the LS-DYNA sensor model in angular frontal barrier impact. A simulation was carried out for a 30^o left angular impact at 22 mph. The results are shown and compared with the RADIOSS results in Figure 9. The delta velocity and acceleration are in fair agreement with each other from the onset of impact up to 40 milliseconds, thus providing the same firing time at 32.5 as indicated by a vertical bar in the "Diff %" plot. LS-DYNA again seems to yield a higher frequency content signal. In this mode, simulations need to be improved at the FCS and RCM locations in both codes

Thatcham mode:

A 9.3 mph 40% offset frontal barrier impact was also simulated in order to complete cases needed for calibrating a sensor model as previously stated. Both the LS-DYNA and RADIOSS results are compared in Figure 10. LS-DYNA result shows a faster velocity change after 20 milliseconds, indicating a stiffer structural response. A phase shift in delta velocity time history will affect its rating when evaluated using SWA. In addition, simulated results indicate that use of shell element types (#2 or #16) does not appear to affect results in angular impact and Thatcham modes.

Others:

Based on results shown in Table III, areas where LS-DYNA needs improvement are angular (as marked in "red") and Thatcham (as marked in "blue") impact modes.

Table III - Comparison of Simulated Results from LS-DYNA and RADIOSS - Sensor Model

Mode	RADIOSS/test		LS-DYNA/test				LS-DYNA/RADIOSS				#16shell/#2shell	
	FCS	RCM	FCS		RCM		FCS		RCM		FCS	RCM
			#16*	#2*	#16	#2	#16	#2	#16	#2		
14 mph rigid barrier	0	2	2	0	2	1	1	1	2	5	3	2
35 mph rigid barrier	1	2	0	1	4	2	1	3	2	4	0	3
25 mph rigid barrier	N/A	N/A	N/A	N/A	N/A	N/A	1	1	3	5	4	3
22 mph angular	0	2	0	0	0	0	2	1	0	0	3	3
9.3 mph Thatcham	3	4	2	2	0	1	2	3	1	2	1	1

Note: No test data for “25 mph rigid barrier

V. Conclusions

A benchmark study of using LS-DYNA for sensor modelling was conducted jointly between Ford Motor Company and ETA/LSTC. A validated RADIOSS sensor model was converted into a LS-DYNA model using a translator developed by ETA with minor adjustment in establishing equivalency if functions used in RADIOSS are not available in LS-DYNA.

Three different frontal impact modes, namely, rigid barrier, pole, and Thatcham offset are simulated in this study. In frontal rigid barrier mode, both 90^o barrier and 30^o angular impacts are considered. In LS-DYNA's study, both #2 and #16 type shell elements are used to study their respective effect on signals. Simulated LS-DYNA results are compared with both the test data and the RADIOSS results using an assessment tool to provide an objective evaluation with ratings ranging from 0 to 5, with 5 being the best correlation.

By comparing the ratings, LS-DYNA results are, generally speaking, comparable with RADIOSS' counterparts. Some high frequency noise of the response at the onset of acceleration time history obtained at the front crash sensor location at the early stage of this study is improved by LSTC. The study also points out areas, i.e. angular and Thatcham impacts, where the LS-DYNA model requires further improvement in the future.

Acknowledgement

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References

1. C. Lin, M. Neal, and J. T. Wang, "Can Finite Element Model be Used to Aid in Calibrating a Crash Sensing System?", 2000 ASME Design Engineering Technical Conference & Computers and Information in Engineering Conference, Sept. 10-13, 2000, Baltimore, Maryland.
2. Chin-Hsu Lin, Mark O. Neal and J. T. Wang, "A Case Study of FEA-based Crash Sensing System calibration", Int. J. of Vehicle Design, Vol. 29, No. 3, 2002.
3. C. C. Chou, J. Le, P. Chen and D. Bauch, "Development of CAE Simulated Crash Pulses for Airbag Sensor Algorithm/Calibration in Frontal Impacts", 17th ESV, Paper No. 301, June 4-7, 2001, Amsterdam, Netherlands.
4. RADIOSS User's Manual, Version 4.1, Mecalog, 2000.
5. Frank-Juergen Steuzler, C. C. Chou, P. Chen and J. Le, "Development of CAE-based Crash Sensing Algorithm and System Calibration", SAE Paper No. 2003-01-0509.
6. LS-DYNA User's Manual, Version 970, Livermore Software Technology Corporation, 2002

APPENDIX

CONVERTING FROM RADIOSS TO DYNA

A. ELEMENT:

RADIOSS (V4.1)	===>	LS-DYNA (V960)
BEAM		BEAM
TRUSS		BEAM
SOLID		SOLID
SHELL		SHELL
SPRING		BEAM
MASS		MASS
JOINT		2 CONSTRINED_NODAL_RIGID_BODY, 1 CONSTRAINED_JOINT_CYLINDRICAL (with 4 nodes) . Otherwise, CONSTRAINED_NODAL_RIGID_BODY
RIGID BODY		CONSTRAINED_NODAL_RIGID_BODY (Does not have mass and inertia) CONSTRAINED_NODAL_RIGID_BODY_INERTIA (Including mass and inertia)
SPOTWELD		CONSTRAINED_SPOTWELD

B. ELEMENT PROPERTY:

General Comments: Delete VOID, RIVET property. Convert spring stiffness into DYNA material.

RADIOSS (V4.1)	===>	LS-DYNA (V960)
9 -ORTHOTROPIC SHELL		SECTION_SHELL
10-COMP. SHELL		SECTION_SHELL
11-COMP. SHELL		SECTION_SHELL
12-3-NODES SPRING		SECTION_BEAM (discrete)
13-BEAM TYPE SPRING		SECTION_BEAM (discrete)
14-GENERAL SOLID		SECTION_SOLID

C. MATERIAL PROPERTY:

RADIOSS(V4.1)	===>	LS-DYNA(V960)
0 -VOID		1 -MAT_ELASTIC
1 -ELASTIC		1 -MAT_ELASTIC
2 -ELASTIC_PLASTIC		98-MAT_SIMPLIFIED_JOHNSON_COOK
3 -ELASTIC_PLASTIC_HYDRODYNAMIC		10-MAT_ELASTIC_PLASTIC_HYDRO
4 -JOHNSON_COOK		15-MAT_JOHNSON_COOK
6 -HYDRODYNAMIC_VISCOUS		9 -MAT_NULL
10-ELASTIC_PLASTIC_DP		63-MAT_CRUSHABLE_FOAM
14-ELASTIC_PLASTIC_ORTHOTROPIC		2 -MAT_ORTHOTROPIC_ELASTIC
19-ELASTIC_ORTHOTROPIC		130 MAT_SPECIAL_ORTHOTROPIC
21-ELASTIC_PLASTIC_DP		57-MAT_LOW_DENSITY_FOAM
22-ELASTIC_PLASTIC		81-MAT_PLASTICITY_WITH_DAMAGE
23-ELASTIC_PLASTIC		81-MAT_PLASTICITY_WITH_DAMAGE
24-ELASTIC_PLASTIC_BRITTLE		16-MAT_PSEUDO_TENSOR

25-ELASTIC_PLASTIC_ORTHOTROPIC	2 -MAT_ORTHOTROPIC_ELASTIC
27-ELASTIC_PLASTIC_BRITTLE	81-MAT_PLASTICITY_WITH_DAMAGE
28-ORTHOTROPIC	26-MAT_HONEYCOMB
32-ELASTIC_PLASTIC_ORTHOTROPIC	3 -MAT_PLASTIC_KINEMATIC
33-VISCOPLASTIC	53-MAT_CLOSED_CELL_FOAM
34-VISCOELASTIC	61-MAT_KELVIN-MAXWELL_VISCOELASTIC
35-VISCOELASTIC	76-MAT_GENERAL_VISCOELASTIC
36-ELASTIC_PLASTIC	24-MAT_PIECEWISE_LINEAR_ PLASTICITY
38-VISCOELASTIC	76-MAT_GENERAL_VISCOELASTIC
40-VISCOELASTIC	76-MAT_GENERAL_VISCOELASTIC
42-HYPERELASTIC	77-MAT_OGDEN_RUBBER
43-ELASTIC_PLASTIC_ORTHO	

D. BOUNDARY AND LOAD CONDITION:

RADIOSS (V4.1)	===>	LS-DYNA (V960)
SPC		BOUNDARY_SPC_SET
CONCENTRATED LOAD		LOAD_NODE_SET
PRESSURE LOAD		LOAD_SEGMENT_SET
INITIAL VELOCITY		INITIAL_VELOCITY
IMPOSED VELOCITY		BOUNDARY_PRESCRIBED_MOTION_SET

E. CONTACT AND RIGIDWALL:

General Comments: Delete RIGIDWALL which not include node. Convert slave/master shell material/property set into segment set.

File name: CAE S

RADIOSS(V4.1)	===>	LS-DYNA(V960)
2 -TIED		CONTACT_AUTOMATIC_SINGLE_SURFACE
3 -SLIDE/VOID		CONTACT_AUTOMATIC_SINGLE_SURFACE
5 -SLIDE/VOID		CONTACT_AUTOMATIC_SINGLE_SURFACE
6 -SLIDE/VOID		CONTACT_AUTOMATIC_SINGLE_SURFACE
7 -SLIDE/VOID		CONTACT_AUTOMATIC_SINGLE_SURFACE
8 -SLIDE		CONTACT_DRAWBEAD
10-TIED/VOID		CONTACT_AUTOMATIC_SINGLE_SURFACE
11-SLIDE/VOID		CONTACT_AUTOMATIC_SINGLE_SURFACE

Create a new one CONTACT_AUTOMATIC_SINGLE_SURFACE.
Set all CONTACT_AUTOMATIC_SINGLE_SURFACE's SofT=1, IGNORE=1.

RIGIDWALL	RIGIDWALL_GEOMETRIC

F. AIRBAG (MONITORED VOLUMES):

MONITORED VOLUMES AIRBAG_SIMPLE_AIRBAG_MODEL
REPLACE THE ORIGINAL MATERIAL WITH *MAT_FABRIC.

G. SEATBELT:

General comment: Convert RADIOSS' material type 1 with very small Young's modulus into

LS-DYNA *MAT_FABRIC

H. OTHERS:

General Comments: Delete TRUSS SET, MAT SET, PROP SET. Delete ACCELEROMETER, MONITORED VOLUME, SECTIONS, SENSOR, CONTROL CARDS.

RADIOSS (V4.1)	===>	LS-DYNA (V960)
FUNCTION		DEFINE_CURVE
SKEW (moving)		DEFINE_COORDINATE_NODES
SKEW (fixed)		DEFINE_COORDINATE_VECTOR