# **LS-DYNA<sup>®</sup>** "Model Compare" in Visual-Environment

Shivakumara H. Shetty, Velayudham Ganesan, Milind Parab\*, Sreedhar Kandagatla\*\*

> ESI Group 32605, W 12 Mile Road, Suite 350 Farmington Hills, MI 48334 USA Ph: (248) 381-8040

> \*Mindware 32605, W 12 Mile Road, Suite 350 Farmington Hills, MI 48334 USA Ph: (248) 381-8040

\*\* ESI Software (India) Pvt Ltd #24-25, 27<sup>th</sup> Cross, Banashankari 2<sup>nd</sup> stage Bangalore, 560070 India Ph: +91 80 41818400

> Email: <u>info@esi-group-na.com</u> URL: www.esi-group.com

#### Abstract

A downturn in the industry drives companies to execute projects with fewer resources. The demand for product innovation and productivity improvements has increased exponentially. In order to meet the customers' demand, ESI's Visual-Environment provides new features and improvements to achieve productivity, better usability and workflow. One such new feature is "Model Compare". Using "Model Compare", a user can compare models to identify the changes in geometry and LS-DYNA entities such as material, section, contact and, constraints. These differences can be copied from one model to another. This feature improves productivity by eliminating manual bookkeeping.

In this paper, the key features of Visual-Environment for LS-DYNA and usefulness of these features in FEA simulation are discussed with examples of productivity improvements and process automation.

Keywords: LS-DYNA, Model Compare, Visual-Environment, Productivity, Process Automation, FEA.

### Introduction

Visual-Environment (VE) is an advanced pre-post processing solution platform for LS-DYNA solver. It is a context based environment based on different FE Simulation<sup>1</sup> needs such as Visual-Crash Dyna (VCD) for LS-DYNA, Visual-Mesh (VME) for meshing and model assembling, Visual-Viewer (VVI) for post processing, Visual-Safe (VSA) for advanced safety applications, Visual-Process (VPR) for CAE process automation and so on. All the contexts of Visual-Environment<sup>4</sup> are integrated seamlessly, facilitating the user to navigate within one environment to access multiple solvers. All the dialogs are easily scriptable through Python language for quick customization.

#### **Visual-Environment Contexts**

As mentioned above, VE provides several contexts out of which a few are explained below from the LS-DYNA user's point of view.

#### Visual-Mesh

Visual-Mesh(VME) is the complete meshing tool, which supports CAD Import, 1D, 2D and 3D Meshing and editing features. It also provides batch-meshing utility based on topology meshing with user guidance as well as automatic approach.

# Visual-Crash Dyna

Visual-Crash Dyna (VCD) is the most competitive environment for LS-DYNA solver. It helps engineers perform crash and safety simulations in the smoothest and fastest possible by providing lot of productive features. This environment provides quick model browsing and advanced model setup capabilities. VCD allows graphical creation, modification and deletion of all LS-DYNA entities like contacts, materials, constraints, control cards and all crash entities. In VCD there are lot of features which helps to improve the productivity<sup>2</sup>, thus saving time and resources.

### Visual-Viewer

Visual-Viewer (VVI) is the advanced Post-Processing tool with state-of-the-art Plotting/Viewing utility. Viewer works with multi page/multi plot concept, which enables the user to group data into pages and plots. Users can create presentation ready high quality reports. Complete plotting session is captured and it can be re-executed without losing any data. It is also fully command-driven that enables the user to execute at command-line.

### **Visual-Process**

Visual-Process(VPR) is an advanced CAE environment for process customization and automation. The process templates establish high productivity and standardization by customizing any regulatory CAE procedure such as FMVSS, ECE etc and corporate best practices. The environment's state of the art process execution methodology allows carrying out the jobs automatically and semi automatically for consistent results. The Visual-Process Executive has more than 30 standard process templates such as Occupant Safety, Pedestrian Safety, Impact Tests and Model Checks,

# **Model Compare**

The detailed modeling enabled by improvements in hardware and software technology is increasing the size of the input file. Also users are doing a lot of iterations to improve the quality of products. Finding the difference between two models is an essential process to control the changes and evolution of models. These differences could be geometry changes, weld changes, materials changes, section changes, curves changes, contact changes or any LS-DYNA entity changes.

Visual-Crash DYNA, which has already achieved a remarkable success in providing the users with a complete end-to-end environment for LS-DYNA solver, takes one more step to facilitate the LS-DYNA user with a tool named "Model Compare". With this tool, the user is empowered to compare two models with a click of a button. The comparison is done based on LS-DYNA entities. This helps the user to understand what and where the difference lies in the two models. It also helps user to copy the difference from one model to another.

Display options like Overlay, Highlight, Window Coupling and Locate add even more comfort and support to this process of model comparison. Model Compare eliminates the manual bookkeeping. Without this feature user had to maintain a note of all the IDS and Entities to track the changes while handling the huge input files. Model Compare is bound to improve the productivity of today's user by eliminating the time and error involved in tracking and controlling the changes. Basically it helps in the evolution of better CAE models.

Model Compare can be accessed via Tools Menu in Visual-Crash DYNA context of ESI's Visual Environment.

Model Compare	₽ ? 🗙
Select Models Entity Wise Model A	
C:\Model_Compare\Base_Model.dyn 🗸 🖆 Updat	e Submodels
C:\Model_Compare\Iteration_Model_1.dyn	e Submodels
Advanced >> Reset Compare	Close

Fig. 1: GUI of Model Compare

Users have option to select complete model or some include files for comparison. If more than two models are loaded, the current model will be taken as Model A and then the reference model can be selected graphically and updated as Model B using the "Update" button. On selecting the

"Advanced  $\gg$ " button, the user interface (GUI) extends to show all the LS-DYNA entities

available in the data file, which are selected for comparison. User is required to check the entities of interest. By default, all entities are selected. Refer Fig. 2

elect Models Entity Wise								
C:\Mode	Compare	\Base Model dvr	Undate	Submodels				
Model B	Model B							
C: (Model_Compare Literation_Model_1.dyn V Update Submodels								
Advanced e.e.								
Auvanceu <<								
Entity Name	Check	How To Co	What To Compare	(%)Toler				
D All				0				
Parts		ld	Card Data and Geo.	0.1				
Nodes	<b>V</b>	ld	Card Data	0.1				
Elements				0.1				
Mesh Independ	<b>~</b>			0.1				
Beam/Beam		ld	Card Data	0.1				
Airbag	<b>V</b>	Index	Card Data	0.1				
Constrained				0.1				
Extra Node		Index	Card Data	0.1				
Joint		Index	Card Data	0.1				
Rigid Bodies	<b>V</b>	PID	Card Data	0.1				
Nodal Rigid		NSID	Card Data	0.1				
Spot Weld	<b>V</b>	Index	Card Data	0.1				
Contacts				0.1				
Contact	<b>V</b>	Index	Card Data	0.1				
Contact Inter		Index	Card Data	0.1				
Control	<b>V</b>	Name	Card Data	0.1				
Define				0.1				
Box	<b>V</b>	ld	Card Data	0.1				
Curve	<b>V</b>	ld	Card Data	0.1				
Hourglass		ld	Card Data	0.1				
				0.1				
Velocity Gen		Index	Card Data	0.1				
Material		ld	Card Data	0.1				
Rigidwall		Index	Card Data	0.1				
Section		ld	Card Data	0.1				
				0.1				
Set Node	<b>V</b>	ld	Card Data	0.1				
Set Part	<b>V</b>	Id	Card Data	0.1				
Note: For Meshindependent considered as Exact Value. F	Welds in Po or remainir	sition wise com ng entities Tolera	parison Tolerance Valu ance is considered as °	ue is % value.				

Fig. 2: GUI of Model Compare with ADVANCED features.

Comparison is based on the users selection of LS-DYNA keywords<sup>3</sup>, "How to Compare", "What to Compare " and "% Tolerance" options.

"How to Compare" is done on the basis of either by ID or by Name. For those entities, which do not have ID field, then Index criteria is default option. For example in case of Mesh Independent welds users have option to perform position based comparison, connected parts IDs and different weld types. Similarly, for Constrained Nodal Rigid Bodies, NSID based comparison criteria is provided. For Materials, comparisons by MID, Material Title, Part Id or Part Name criteria are provided.

"What to Compare" is a comparison criterion to find the difference between the selected models. Base on entity type, any one or more of the following options are available.

- 1. Card Data ( LS-DYNA keyword)
- 2. Card Data and Geometry
- 3. Card Data and Others.

First option is used to compare only keyword differences. The second option is used to compare keywords along with geometry data (mass, area, volume, number of nodes and number of elements). The third option is used to compare the keywords and their references.

"% Tolerance" is applicable for position-based comparison of geometry and connection entities, to track position/location changes between models. The default tolerance is 0.1 %.

Display options like "List All Entities", "Window Coupling", "Overlay", "Locate" and "Highlight" are provided at the top of the GUI. These options help users to visualize the changes and differences. On clicking the "List All Entities", all the entities that have difference will be displayed. Window coupling feature helps the display operations (like Rotate, Pan, Zoom options) of both the model windows simultaneously. Overlay option allows the overlaying of selected entities to show the geometric difference. Locate option helps to locate the selected entity in the model window. Differences are marked in red color for easy identification. On clicking the red colored entity the difference of its data is shown in the bottom list. Using copy option, user can copy specific data from one model to another. Similarly, not only the difference but also the unique items from one model can be viewed and copied to another model.

Following examples shows some of the differences between selected models.

- 1. Actual difference of keywords (Fig 3)
- 2. Geometry changes (Fig4)
- 3. Thickness Changes( Fig5)
- 4. Set Changes(Fig 6)

del A <u>Compare\Base_V</u> 12 / 593 68 / 68 1 / 30 3 / 521 1 / 6720 2 / 2 0 0 4 / 12 0 1 / 593 1 / 1 8 / 593 4 / 703 2 / 16	Aodel.dyn _(	odel B Compare\terati 12 / 67 , 1 / 3 / 1 / 6 3 , 1 / 4 / 1 , 1 / 4 / 1 , 8 /	ion_Model_1.dyn 593 (67 530 5521 5720 (3 (1 12 (1 593 (1
Compare\Base_N 12 / 5933 68 / 68 1 / 30 3 / 521 1 / 6720 0 4 / 12 0 1 / 593 1 / 1 8 / 593 4 / 703 2 / 16	Aodel.dyn _(	Compare\lterati 12 / 67, 1 / 3 / 1 / 6 3, 1 , 4 / 1, 1 / 8 /	ion_Model_1.dyn 593 / 67 / 30 5521 5720 / 3 / 1 12 / 1 593 / 1
12 / 593 68 / 68 1 / 30 3 / 521 1 / 6720 2 / 2 0 4 / 12 0 1 / 593 1 / 1 8 / 593 4 / 703 2 / 16		12/ 67, 1/ 3/ 1/6 3, 1, 4/ 1, 1, 1/ 8/	<pre>/67 /67 /30 /521 /520 //3 //1 /1 /1 //1 //1 //1 //1 //1 //1 /</pre>
68 / 68 1 / 30 3 / 521 1 / 6720 2 / 2 0 4 / 12 0 1 / 593 1 / 1 8 / 593 4 / 703 2 / 16		67, 1/ 3/- 1/6 3, 1, 4/ 1, 1, 1/ 1, 8/	/ 67 '30 521 5720 / 3 / 1 '12 / 1 593 / 1
1 / 30 3 / 521 1 / 6720 2 / 2 0 4 / 12 0 1 / 593 1 / 1 8 / 593 4 / 703 2 / 16		1/ 3/ 1/6 3, 1, 4/ 1, 1, 1/ 1/ 8/	30 521 5720 / 3 / 1 12 / 1 593 / 1
3 / 521 1 / 6720 2 / 2 0 4 / 12 0 1 / 593 1 / 1 8 / 593 4 / 703 2 / 16		3/ 1/6 3, 1, 4/ 1, 1, 1/ 1, 8/	521 5720 / 3 / 1 12 / 1 593 / 1
1 / 6720 2 / 2 0 4 / 12 0 1 / 593 1 / 1 8 / 593 4 / 703 2 / 16		1/6 3, 1, 4/ 1, 1/ 1, 8/	/3 /1 /12 /1 593 /1
2 / 2 0 4 / 12 0 1 / 593 1 / 1 8 / 593 4 / 703 2 / 16		3, 1, 4/ 1, 1/ 1, 8/	/3 /1 /12 /1 593 /1
0 4 / 12 0 1 / 593 1 / 1 8 / 593 4 / 703 2 / 16		1, 4/ 1, 1/ 1/ 8/	/ 1 / 12 / 1 593 / 1
4 / 12 0 1 / 593 1 / 1 8 / 593 4 / 703 2 / 16		4/ 1, 1/- 1, 8/	/ 1 593 / 1
0 1 / 593 1 / 1 8 / 593 4 / 703 2 / 16		1, 1/: 1, 8/:	/ 1 593 / 1
1 / 593 1 / 1 8 / 593 4 / 703 2 / 16		1/	/ 1
8 / 593 4 / 703 2 / 16		8/	/ 1
4 / 703 2 / 16		6/	603
2 / 16		4.1	555 702
2 / 10		1/	15
0		2	13
	Ą	Δ <u></u> Μ	A Model B

Fig. 3: Model Compare showing the actual keyword differences between two models

📽 Visual-Crash DYN	IA 6.0.0 - Base_Mo	del.dyn	
Model Compare	in hide the an an		Safe Tools _Checks _Lime Savers _Lools _Macro _ Window _Help
Select Models Entity Wise			和名中一種語語。1999年1月1日(1999年)月1日(1999年) 1999年(1999年)月1日(1999年) 1999年(1999年)
List All Entities Vindow Co	upling 🗹 Overlay 🗹 Locate	Highlight	
Entities(# Diff.)	Model A	Model B	
Entities	del_Compare\Base_Model.dy	n _Compare(Iteration_Model_1.d	
- Parts (12)	12 / 593	12 / 593	Model A Model B
	2000000+>63-bpillarroofsppor	2000000=>63-bpillarroofspport2	
	2000043+>21-bw-floorfront	2000043+>21-bw-floorfront	
	2000044=>21-bas floorrear	2000044->21-bwfoomear	
	2000179a36-framiumidde.cut	2000179ab6-frail-middle-outer	Querte Channel
	2000209-sh rai middle outer	2000209-of-rol-middle-outer	Geometry Changes
	2000215->50 km kumper	2000215->E0 km kumper	
	2000215-2000W-0411per	2000213=>50-00-0011per	
	2000304=2FART_55	2000304=2PART_05	
	2000320+>mc-leafspringconn.	2000320=>mc-leatspringconnec	
	2000324=>mc-leatspringrubb	2000324=>mc-teatspringrubben	
	2000344=>mc-driveshaft	2000344=>mc·driveshaft	
	2000353=>115-ob-hoodouter	2000353=>115-ob-hoodouter	
	2000436+>bd-bedsideR	2000436+>bd-bedsideR	
Extra Node (68)	68 / 68	67/67	
Doint (2)	1 / 30	1/30 -	
4		>	
Field Name	Model A	Model B	
No.of Elements (45)	20273	20228	
No.of Nodes (64)	20280	20216	
Mass	0.0154439458	0.0154004384	
Area	2206112.31	2199909.56	
PostCG	2165 73909 -0.010060605 6	-3156 97437 0.949113576 6	
ParthertiaDX	3472 53335	3465 4272	
ParthertialYY	1915.59881	1913.37721	
PartinertialZZ	5253.86948	5247.47515	
ParthertiaDCY	-5.03978754	-7.62669995	
Parthertia/YZ	12.9701445	12.8538431	
<ul> <li>☑ List Different Berns</li> <li>☑ List Model A Unique Berns</li> <li>☑ List Model 8 Unique Berns</li> </ul>	Copy Kri ->>		Elements found in Model A are grouped into a collector : Model/Linduat-hingDuardElements Elements found in Model & are grouped into a collector : Model/Linduat-hingDuardElements elements found in Model A are grouped into a collector : Model/Linduat-hingDuardElements
		Compare Close	Pements found in Model B are grouped into a collector : ModelBUnMatchingTriaElements
Ready			(804 x 930) -> (804 x 930) so (0, 0)

Fig. 4: Model Compare showing the geometry differences between two models



Fig. 5: Model Compare showing the thickness differences between two models.



Fig. 6: Model Compare showing the SET PART differences between two models.

# **Comparison of Results files ( d3plot)**

Visual-Environment not only supports data file comparison, but it also supports results files comparison. Visual-Viewer context of Visual-Environment helps to identify the differences between two d3pot models. The changes in the results file could happen because of the changes

in pre-processor file. Users can display only the differences in contours and animate to visualize the impact of these changes in the simulation.

User can find the differences in nodal and elemental results between two models. Comparison is based on ID. During comparison, Visual-Viewer checks geometry changes and prompt users about these changes.



Fig. 7: Model Difference showing the differences in displacement between two d3plot models.

### **Summary and Conclusion**

LS-DYNA user needs a tool, which can quickly find the difference between two models to control the changes and evolution of CAE models at various stages in the product life cycle. This paper has presented ESI's Model Compare tool to satisfy the same need of the user. It comes with many additional features to track the model changes and remove book keeping.

#### References

- 1. Velayudham Ganesan et all, "Fast New Methodology for Regulatory test simulation" Proceedings from The 8th International LS-DYNA Users Conference, 2004.
- Shivakumara Shetty, Petter Sahlin, "Productivity Gain in Crashworthiness Simulation EASi-CRASH for Complete Safety and Crash Modeling for LS-DYNA", Proceedings from the 5th European LS-DYNA Users Conference, 2005.
- 3. LS-DYNA<sup>®</sup> 971 Keyword User's Manual, LSTC, USA.
- 4. Visual-Environment Users Manual