TEST CASE DOCUMENTATION AND TESTING RESULTS

ANSYS-QA-LS-DYNA-AWG-ERIF-8-19

TEST CASE ID AWG-ERIF-8

Orion Water Landing Model

Tested with LS-DYNA® R14.1.1 Revision 4-gaf1eb871e8

Friday 5th July, 2024

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1 Introduction

1.1 Purpose of this Document

This document specifies the test case AWG-ERIF-8. It provides general test case information like name and ID as well as information to the confidentiality, status, and classification of the test case.
A detailed description of the test case is given, the purpose of the test case is defined, and the tested features are named. The test case specifications also state the target measures for testing and the expected results, as well as their pass and fail criteria.
Testing results are provided in section 5 for the therein mentioned LS-DYNA® version and platforms.

2 Test Case Information

Test Case Summary	
Confidentiality	external use
Test Case Name	Orion Water Landing Model
Test Case ID	AWG-ERIF-8
Test Case Status	active
Test Case Classification	Example
Test Case Source	NASA
Tested Keyword	*CONSTRAINED_LAGRANGE_IN_SOLID
Member of Test Suite	AWG ERIF SUITE
Metadata	AWG ERIF

Table 1: Test Case Summary

3 Test Case Specification

3.1 Test Case Purpose

The purpose of Test Case ID AWG-ERIF-8 is the comparison of results from different cpu architectures on the basis of a water impact of the Orion crew module.
The reliability and consistency of LS-DYNA® as a finite element solver for this water impact simulation is evaluated by performing analyses on different cpu architecture platforms.

3.2 Test Case Description

This Test Case contains a water impact analysis (see figure 1) using an Orion crew module impacting a water surface.

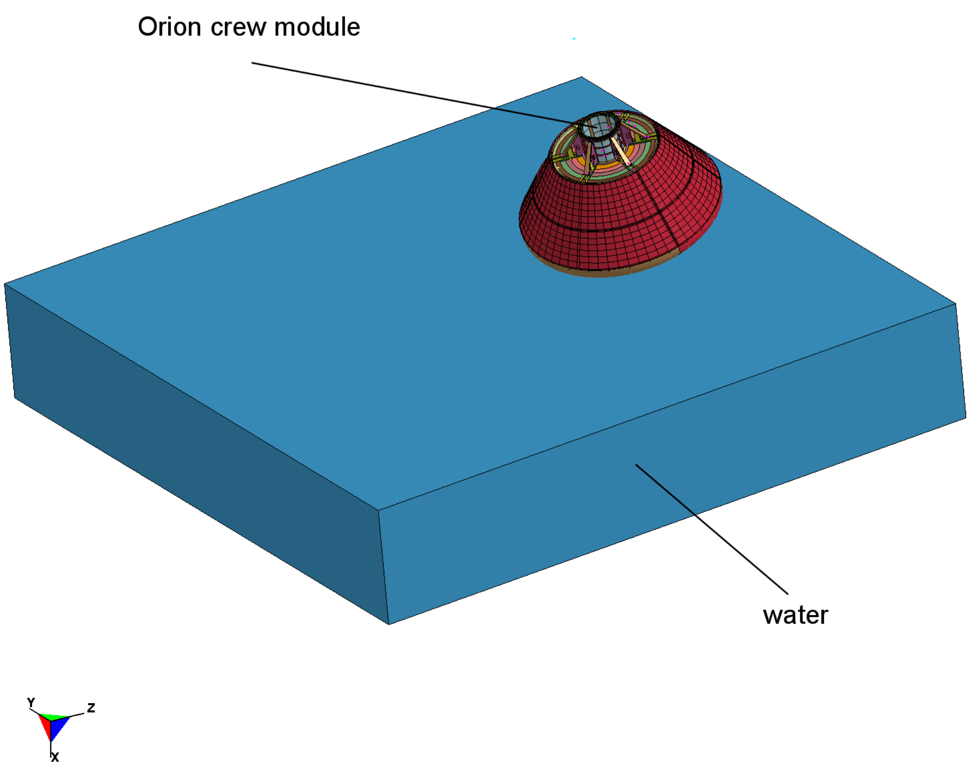

Figure 1: Model sketch: Orion crew module impacting a water surface

3.3 Model Description

The model geometry is discretized with solid, shell, beam and discrete elements for the Orion crew module. The water and the air are modelled by a volume fraction distribution in an ALE computational domain discretized by solid elements (see figure 2).
The model specifications can be found in table 2, and table 3 reflects the sub test case specification.
The material definitions and their parameters can be found in the input decks.

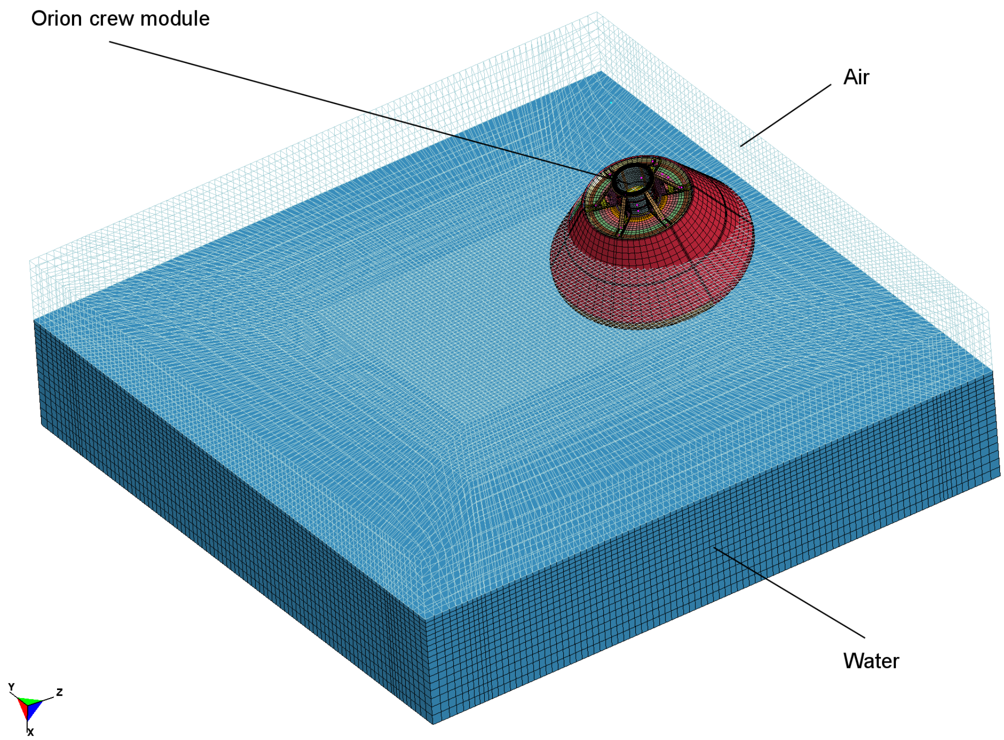

Figure 2: FEA model: Orion crew module water landing

FEA Model information	
Nodes	287147
Shell elements	24167
Shell materials	112
Beam elements	1730
Beam materials	26
Solid elements	242355
Solid materials	12
Discrete elements	9
Discrete materials	9
Mass elements	39
Inertia elements	86
Nodal rigid bodies	191
Rigid elements	4213
Parts	167

Table 2: FEA Model Information

Sub Test Case ID	Input Deck Name
1	c52281.k

Table 3: Specification of sub test cases

4 Test Specifications

4.1 Test Case Targets

Table 4 displays the test case targets. The test case targets specify values or a series of values taken from the finite element analysis solution of the test case and they are used in a comparison of analysis results on different cpu architectures. They are chosen in a way that they are representative of the numerical model.

Test Case Targets				
Target number	output	component type	component id	retrieved from
1	kinetic energy	glstat	-	binout/glstat file
2	internal energy	glstat	-	binout/glstat file

Table 4: Test Case targets for Test Case ID AWG-ERIF-8

Test case targets are used to evaluate the cross cpu architecture consistency (see section 4.2).

4.2 Pass/Fail Criteria

These are the Pass/Fail criteria used for the cross cpu architecture consistency test of the Test Case ID AWG-ERIF-8.

The sub test case passes if the test case target data falls within the corridor bounds. Otherwise the test fails.

The test case corridors are upper and lower bounds for the test case targets. They were defined based on the test target data obtained with LS-DYNA® R9.0 Revision 108899 binaries by the following process:

- For a specific test case target, interpolate the data from different platform and executable (R9.0 Revision 108899) combinations, so that the time domain is the same.
- Calculate the upper and lower bounds by:

$$bound_{up}(i) = max(i) + 0.2 \times [max(i) - min(i)] + 0.05 \times peak$$
$$bound_{low}(i) = min(i) - 0.2 \times [max(i) - min(i)] - 0.05 \times peak$$

  where $max(i)$, $min(i)$ are the maximum and minimum values at the i_{th} time step across all platforms and executable (R9.0 Revision 108899) combinations the test case was calculated with, $peak$ is the maximum absolute y value across the whole time domain, $bound_{up}(i)$ and $bound_{low}(i)$ are the upper and lower bounds for the i_{th} time step.

5 Test Case Results

5.1 Software and Hardware Specifications

In order to ensure cross-platform consistency, the herein mentioned sub test cases are run on platforms specified in table 5 and the results are calculated with software versions defined in table 6.

Platform Name	Operating system	CPU type	MPI-Protocol	Number of cpu's [1]	Memory Option
cdcvdce7mbu01	CentOS 7.9	Intel® Xeon® Gold 6238R @ 2.20GHz	Platform MPI 08.3.0.2	4	

[1] Number of cpu's used for calculation of the test case

Table 5: Used Platforms and CPU Type's

Product	Version	Release	Revision	Parallel type [1]	Precision [2]	executable
LS-DYNA®	971	R14.1.1	4-gaf1eb871e8	SMP	SP	ls971.4-gaf1eb871e8.R14.1.1
LS-DYNA®	971	R14.1.1	4-gaf1eb871e8	SMP	DP	ld971.4-gaf1eb871e8.R14.1.1
LS-DYNA®	971	R14.1.1	4-gaf1eb871e8	MPP	SP	mpp971.4-gaf1eb871e8.R14.1.1
LS-DYNA®	971	R14.1.1	4-gaf1eb871e8	MPP	DP	mpd971.4-gaf1eb871e8.R14.1.1

[1] MPP = Massively Parallel Processing, SMP = Symmetric Multiprocessing

[2] SP = single precision, DP = double precision

Table 6: Tested LS-DYNA® version

5.2 Results Summary

Table 7 contains the results of the Test Case ID AWG-ERIF-8 completed with all combinations of software and hardware defined in section 5.1 (1 * 2 * 4 total calculation runs).
Details on the test results can be found in the section 5.3.

The table 7 cross cpu architecture consistency and validation summary is:

- **PASS** - Pass criteria in section 4.2 is attained.
- **FAILED** - Pass criteria in section 4.2 is not attained.
- **ERROR** - sub test case terminates due to error.
- **N/A** - sub test case was not calculated.

Sub Test Case ID	PASS/FAILED
1	**PASS**

Table 7: Results summary for Test Case ID AWG-ERIF-8

5.3 Result Details

The following subsections contain detailed results for the Test Case ID AWG-ERIF-8 for LS-DYNA® R14.1.1 Revision 4-gaf1eb871e8.

For each sub test case defined in section 3.3 there is a graph displaying the time history of the result target defined in section 4.1 for the platform and software version combinations defined in section 5.1.

The title of the graph states the test case ID and the name of input deck. The legend contains the type, branch and the revision of the executable.

Example for title:

Title:
'AWG_ERIF_TEST_CASE_8: orion.k' states the test case ID 8 and name of the input deck for sub test case 1.

5.3.1 Sub Test Case ID 1 - Test Target 1

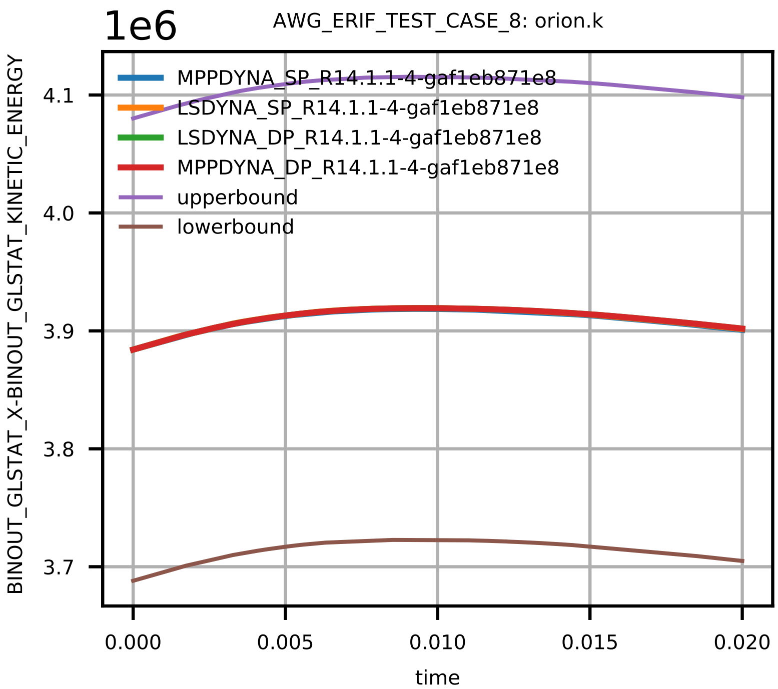

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Figure 3: Cross platform results, global kinetic energy, sub test case ID 1

5.3.2 Sub Test Case ID 1 - Test Target 2

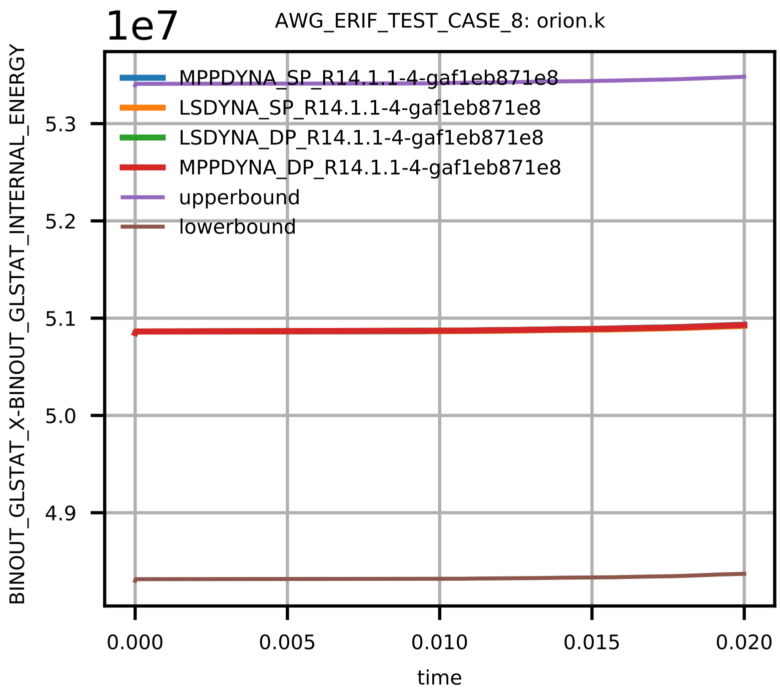

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Figure 4: Cross platform results, global internal energy, sub test case ID 1