LOTAR EAS 2016-2017
Phase 1 Pilot Studies Description

April 2017
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- Summary
LOTAR is an international consortium of Aerospace manufacturers.

Prime objective is creation and deployment of the EN/NAS 9300 series standard for long-term archiving and retrieval of digital data, based on standardized approaches and solutions.

Integration of LOTAR requirements in software tools ensured by close cooperation with the CAx Implementor Forum (CAx-IF):

- Facilitated by PDES, Inc. and ProSTEP iViP
- Consists of CAD, STEP Translator, and Validation Tool vendors
- Supports AP203, AP209, AP214, AP242

Similar PDM-IF currently in operation.
The LOTAR Engineering Analysis & Simulation Working Group was created in Dec. 2014

Team Members and LOTAR Member companies involved in the activities of the Engineering Analysis and Simulation Working Group:

- **Joe Draper**
  - Americas Co-leader
  - Boeing
  - Everett, US-WA

- **Rod Dreisbach**
  - Boeing - retired

- **Rodrigo Britto**
  - Embraer S/A
  - São José dos Campos, BR-SP

- **Chris Johnson**
  - Lockheed Martin
  - Fort Worth, US-TX

- **Phil Rosche**
  - ACCR, LLC
  - Summerville, US-SC

- **Albert Lévy**
  - EU Co-leader
  - CIMPA S.A.S. (on behalf of Airbus)
  - Blagnac, FR-N

- **Gerrit Rollema**
  - Airbus
  - Filton, GB-GLS

- **Torben Lindemann**
  - Airbus
  - Manching, DE-BY

- **Randy Cigel**
  - Boeing
  - Seattle, US-WA

- **Jochen Boy**
  - PROSTEP AG
  - Darmstadt, DE-HE

- **Jean-Marc Crepel**
  - AFNet
  - Paris, FR-J

- **Keith Hunten**
  - Lockheed Martin - retired

- **Chris Johnson**
  - Lockheed Martin - retired

Legend:
- Leaders
- Members
- Facilitators
The primary technical approach is based on using a vendor-neutral ISO STEP AP209 ed2 data model.

The complete archive of analysis and simulation data will be based on fulfilling the requirements of the member companies. ISO STEP AP209 ed2 is an enabling technology for preserving engineering analysis input and results for the long-term.

The scope of Phase 1 of the LOTAR EAS WG is currently limited to linear quasi-static structures FEA.
Testing follows a building block approach synchronized with the development of the standard and the supporting software.

EAS Workgroup is developing a suite of finite element models test problems to support the development and testing of AP 209 ed2 enabled software.

The pilot study test problems are not inclusive of all FEA requirements (additional models will be added in future test rounds).
LOTAR EAS Test Problems

- Pilot study test suite
  - Basic finite element model components
  - Simple test problem solutions for simple load cases using FEA
    *(the collection is known as the “Abstract Test Suite”)*
  - Approximates classical solutions for linear quasi-static problems

- Ultra-light glider model (ULG) test suite
  - Representative load cases and results for a total vehicle quasi-static linear internal loads finite element model
  - Additional load cases available
  - Coarse mesh FEM representative of semi-monocoque construction
  - SDM elements such as metadata to establish pedigree
  - Publically available
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<sup>1</sup> FEA Input = nodes, elements with associated physical and material properties, applied loads (forces and pressure) and boundary conditions (single point constraints)

<sup>2</sup> Test suite includes a “beam” idealized as discrete collections of rod, beam, plate, or solid finite elements (each test model focusing on a single type of element)
Pilot Study #1 – Using Beam Tests – Translate native FEA input data to ISO STEP AP 209 ed2 Files

1. Test Models in native FEA format for input

2. Processes (including standalone translators) to consume native FEA input and generate ISO STEP AP209 ed2 file

3. ISO STEP AP 209 ed2 files

4. Cross-feed the ISO STEP AP 209 ed2 files (and perform loop tests)

5. Processes to consume ISO STEP AP 209 ed2 file

Vendor A Process:
- Consume native input and generate ISO STEP AP209 ed2 file

Vendor B Process:
- Consume native input and generate ISO STEP AP209 ed2 file

Test1_AP209e2_A.stp

Test1_AP209e2_B.stp

(loop test for A=A)

(cross-feed test for AB=BA)

(loop test for B=B)

(cross-feed test for AB=BA)
1. Test Models in native FEA format for input/results

2. Processes (including standalone translators) to consume native FEA input/results and generate ISO STEP AP209 ed2 file

   - Vendor A Process: Consume native input/results and generate ISO STEP AP209 ed2 file
   - Vendor B Process: Consume native input/results and generate ISO STEP AP209 ed2 file

3. ISO STEP AP 209 ed2 files

   - Test1_AP209e2_A.stp
   - Test1_AP209e2_B.stp

4. Cross-feed the ISO STEP AP 209 ed2 files (and perform loop tests)

   - (loop test for A=A)
   - (cross-feed test for AB=BA)
   - (loop test for B=B)

5. Processes to consume ISO STEP AP 209 ed2 file of FEM input/results

   - Vendor A Process: Consume FEA input/results ISO STEP AP209 ed2 file
   - Vendor B Process: Consume FEA input/results ISO STEP AP209 ed2 file
Pilot Study #3 – Using Beam Tests – Bi-directionally generate ISO STEP AP 209 ed2 Files from native FEA input and results data

1. Test Models in native FEM format for node and element input

2. Processes (including standalone translators) to consume native FEA input/results and generate ISO STEP AP209 ed2 file

3. ISO STEP AP 209 ed2 Part 21 files

4. Cross-feed the ISO STEP AP 209 ed2 files (and perform loop tests)

5. Processes to consume ISO STEP AP 209 ed2 file and generate native FEM input/results

6. Test Models in native FEM format for input/results should result in “equivalent outcome” relative to the original input/results

Vendor A Process:
- Consume native input/results and generate ISO STEP AP209 ed2 file
Vendor B Process:
- Consume native input/results and generate ISO STEP AP209 ed2 file

Vendor A Process:
- Consume ISO STEP AP209 ed2 file and generate native input/results
Vendor B Process:
- Consume ISO STEP AP209 ed2 file and generate native input/results
Overview of Pilot Study Test Problems

- EAS WG provides simple standardized models to test vendor implementations of ISO 10303 AP 209 ed2 (STEP) interfaces
- Initial focus is on linear quasi-static analysis FEA data structures and generating the required STEP data model content (along with testing methodology development)
- Model definition uses NASTRAN card descriptions but could be represented by any vendor data model capable of generating a compliant AP 209 ed2 STEP file (*Documentation of NASTRAN input syntax is readily available on-line using any search engine: Search string = “NASTRAN quick reference guide”*)
- Pilot study considers first 4 ATS models that will require implementation of basic AP 209 ed2 data model elements
- Models represent 1D, 2D and 3D finite element abstractions of a constant section beam with various boundary conditions and loads for which the theory and practice of engineering mechanics are well understood
- ATS models are identified with ‘ATS’ + model number + ‘m’ + version:
  - Beam (rectangular prism) models:
    - ATS1m4 : idealized using “rod” elements
    - ATS2m4 : idealized using “bar” elements
    - ATS3m4 : idealized using “shell” elements
    - ATS4m4 : idealized using “solid” elements
  - Length : 16.0 inch
  - Width : 4.0 inch
  - Height : 2.0 inch
  - Area : 8.0 square inch
ATS1m4 Model Details

- Beam (rectangular prism) idealized using “rod” elements (axial stiffness element, no torsional stiffness)
- FE model composition
  - Elements: 16 CROD
  - Nodes: 17 GRID
  - Loads: 1 FORCE
  - Boundary: 1 SPC1
  - Property: 1 PROD
  - Material: 1 MAT1 (aluminum)
  - System: 1 CORD2R (at origin)

- Subcase and output requests
  - Subcases: 1 SUBCASE
  - Boundary: 1 SPC
  - Loads: 1 LOAD
  - Output: 4 GPFORCE (global) DISPLACEMENT SPCFORCES STRESS

  *See listing for output parameters

- Isotropic aluminum material property at room temperature (see listing)
- 1000 lb axial load in compressive (-x) direction
- Rectangular coordinate system at origin with model at [0, -2, 1] *basic

Axial stress: $\frac{1000}{8} = 125$ psi
Axial strain: $\frac{125}{10^6} = 1.25e-5$ in/in
Axial def: $1.25e-5 \times 16 = 0.0002$ in
ATS2m4 Model Details

- Beam (rectangular prism) idealized using “bar” elements (axial and bending stiffness element, no torsional stiffness)

- FE model composition
  - Elements: 16 CBAR
  - Nodes: 17 GRID
  - Loads: 8 FORCE, 2 LOAD
  - Boundary: 1 SPC1, 1 SPCADD
  - Property: 1 PBAR
  - Material: 1 MAT1 (aluminum)
  - System: 1 CORD2R (at origin)

- Subcase and output requests
  - Subcases: 3 SUBCASE
  - Boundary: 3 SPC
  - Loads: 3 LOAD
  - Output: 12 GPFORCE (global), DISPLACEMENT, SPCFORCES, STRESS

  *See listing for output parameters

- Introduces boundary condition combinations, adds lateral bending and combined axial and lateral (-y) load cases

- Uses double field card format for element definition
ATS3m4 Model Details

- Beam (rectangular prism) idealized using “shell” elements (membrane and bending stiffness element) with additional load cases and boundary conditions

- FE model composition
  - Elements: 40 CQUAD4
  - Nodes: 86 GRID
  - Loads: 12 FORCE
  - Loads: 8 PLOAD2 (normal pressure)
  - Loads: 3 LOAD
  - Boundary: 104 SPC1
  - Boundary: 2 SPCADD
  - Property: 1 PSHELL
  - Material: 1 MAT1 (aluminum)

- Subcase and output requests
  - Subcases: 4 SUBCASE
  - Boundary: 4 SPC
  - Loads: 4 LOAD
  - Output: 16 GPFORCE (global)
  - Output: 16 DISPLACEMENT
  - Output: 16 SPCFORCES
  - Output: 16 STRESS

- Adds shell element normal pressure case (-z direction) definition
- Boundary conditions definition adds node range specification

*See listing for output parameters
ATS4m4 Model Details

- Beam (rectangular prism) idealized using “solid” elements (mix of 4-noded tetrahedral, 6-noded pentahedral and 8-noded hexahedral elements)

- FE model composition
  - Elements: 32 CHEXA, 240 CTETRA, 96 CPENTA
  - Nodes: 256 GRID
  - Loads: 36 FORCE, 3 LOAD
  - Boundary: 30 SPC1, 2 SPCADD
  - Property: 1 PSOLID
  - Material: 1 MAT1 (aluminum)

- Subcase and output requests
  - Subcases: 3 SUBCASE
  - Boundary: 3 SPC
  - Loads: 3 LOAD
  - Output: 12 GPFORCE (global), DISPLACEMENT, SPCFORCES, STRESS

*See listing for output parameters

- Rich combination of constraints at cantilever planar face (x=0)
- Interfaces between element types are recognized as inconsistent (i.e. quad faces and triangular faces share nodes at planar interface)
The pilot test problems are not inclusive of all FEA requirements (additional models that include more element types, materials, composites, solutions and results will be added in future test rounds)

Testing additional metadata such as analysis product structure and idealized geometry association is also planned

Vendor feedback on both test problem definitions and testing methodology is welcomed