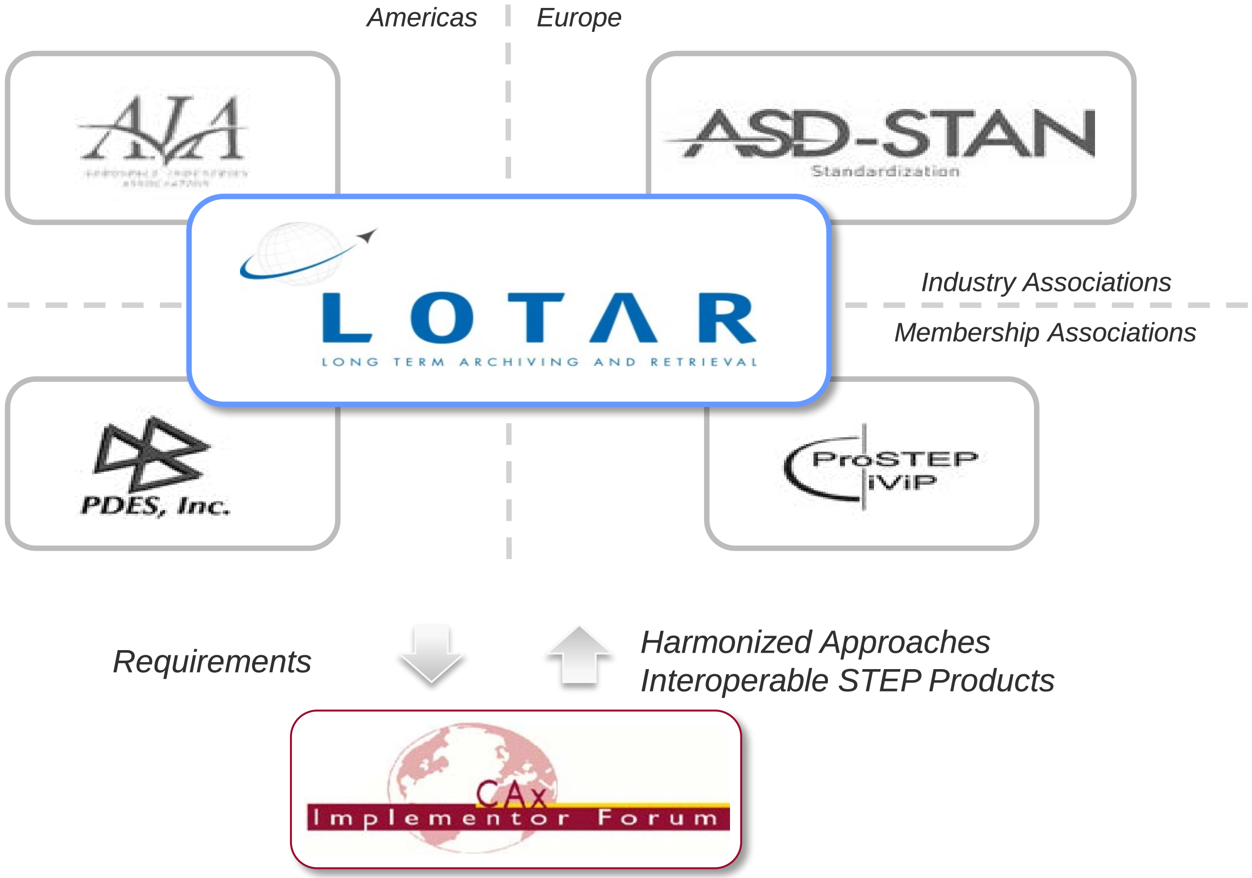
LOTAR EAS 2016-2017
Phase 1 Pilot Studies Description

April 2017

Contents

LOTAR "On A Page"
Details at www.lotar-international.org

- 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



EN = European Norm (Standard)
NAS = National Aerospace Standard
CAx = Computer Aided "x" (Design, Engineering…)
PDM = Product Data Management

Creation of a LOTAR WG for engineering analysis and simulation data

- 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

Randy Cigel
Boeing
Seattle, US-WA

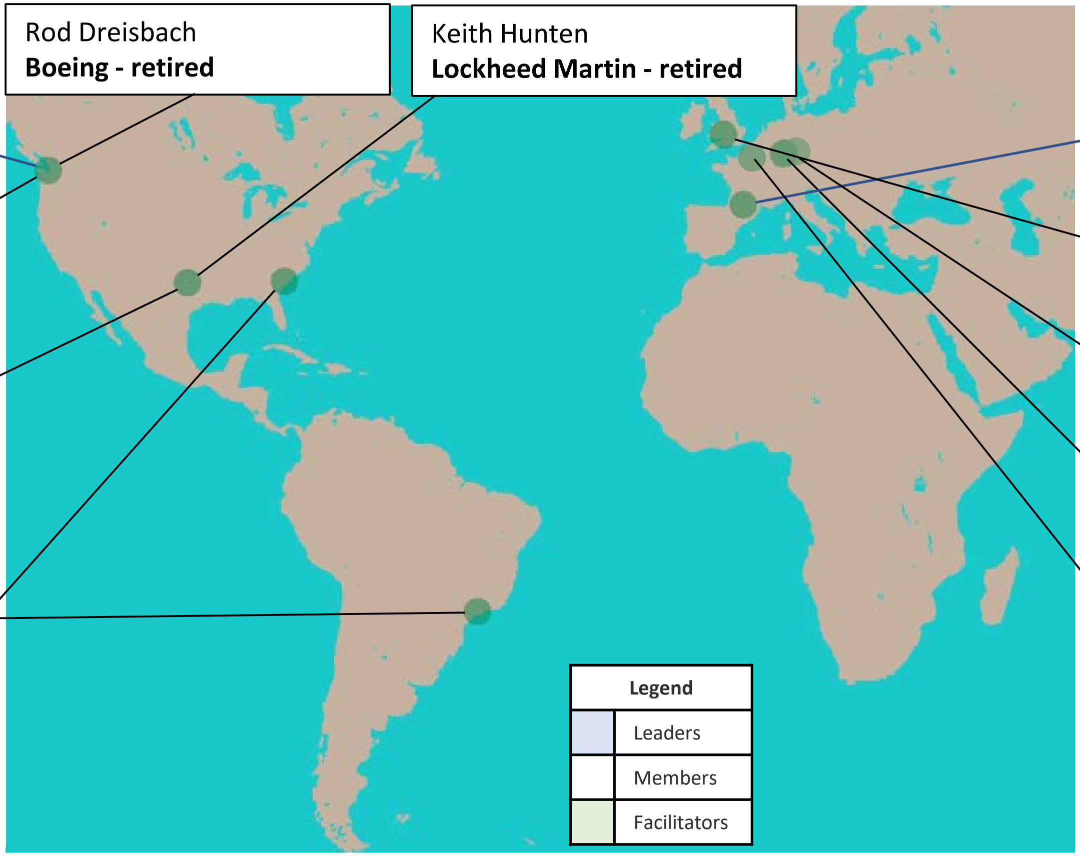
Chris Johnson
Lockheed Martin
Fort Worth, US-TX

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

Phil Rosche
ACCR, LCC
Summerville, US-SC

Rod Dreisbach
Boeing - retired

Keith Hunten
Lockheed Martin - retired



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

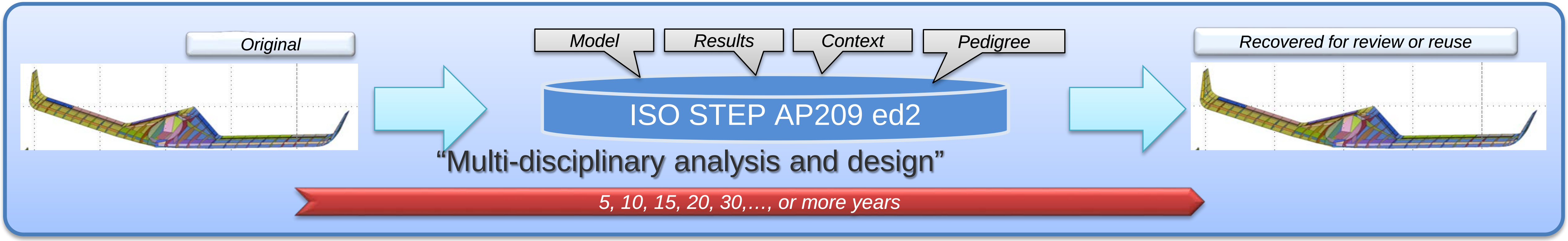
Gerrit Rollema
Airbus
Filton, GB-GLS

Torben Lindemann
Airbus
Manching, DE-BY

Jochen Boy
PROSTEP AG
Darmstadt, DE-HE

Jean-Marc Crepel
AFNeT
Paris, FR-J

Primary Technical Approach

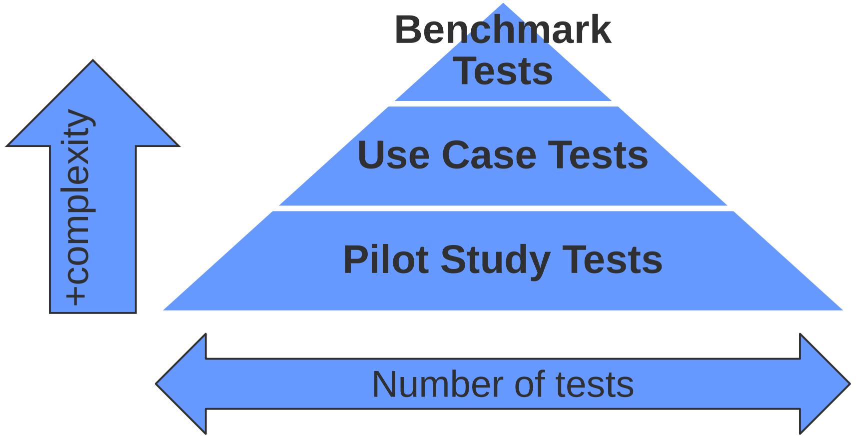


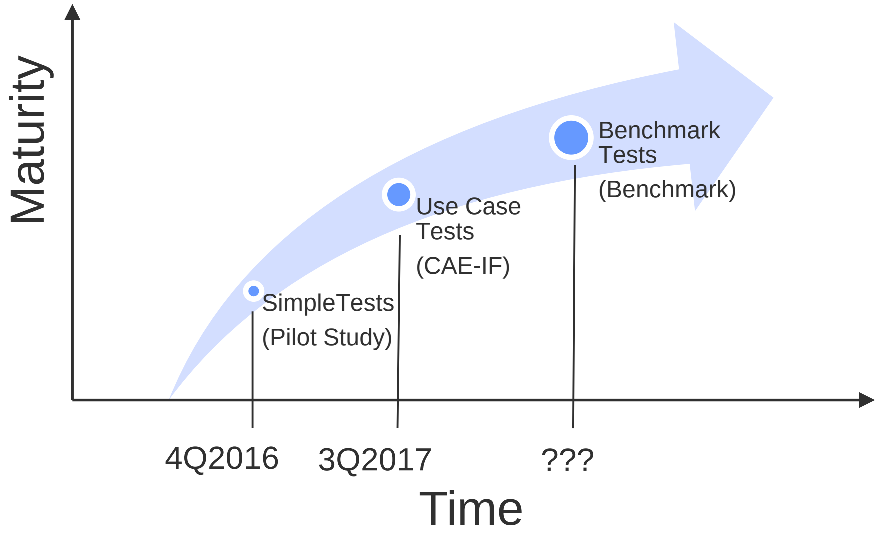
The primary technical approach is based on using a **vendor-neutral ISO STEP AP209 ed2 data model**.

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

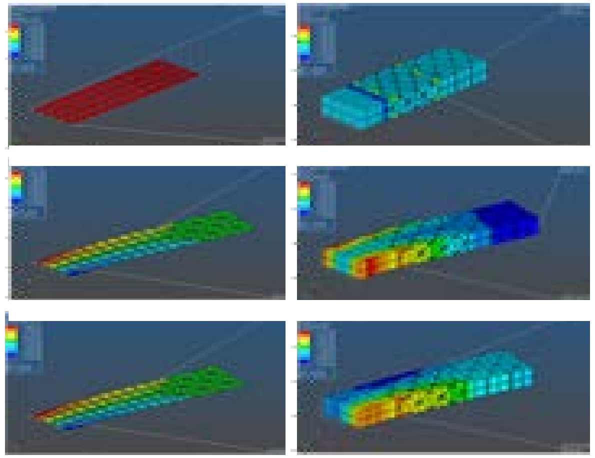




- EAS Workgroup is developing a suite of finite element model~~s~~ test problems to support the development and testing of AP 209 ed2 enabled software
- The pilot study test problems are not inclusive of all FEA requirements *(additional models will be added in future test rounds)*

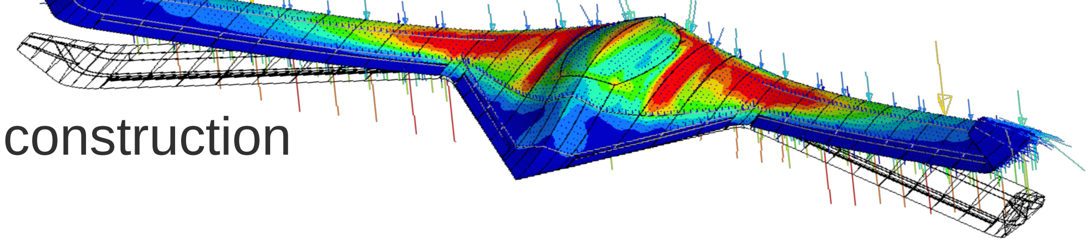
LOTAR EAS Test Problems

- 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

Symmetric pull-up manoeuver



Pilot Study #1, #2 and #3

Pilot Study	Test Suite Problem Scope[2]	Description of LOTAR Activity
1	Beam FEA input	Translate Native FEA input[1] (MSC Nastran) to ISO STEP AP209 ed2 Part 21 file
2	Beam FEA input / results	Translate Native FEA input[1]/results (MSC Nastran) to ISO STEP AP209 ed2 Part 21 file
3	Beam FEA input / results round trip	Translate Native FEA input[1]/results (MSC Nastran) to ISO STEP AP209 ed2 Part 21 file and translate ISO STEP AP209 ed2 Part 21 file to Native FEA input/results (MSC Nastran)

[1] FEA Input = nodes, elements with associated physical and material properties, applied loads (forces and pressure) and boundary conditions (single point constraints)

[2] 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

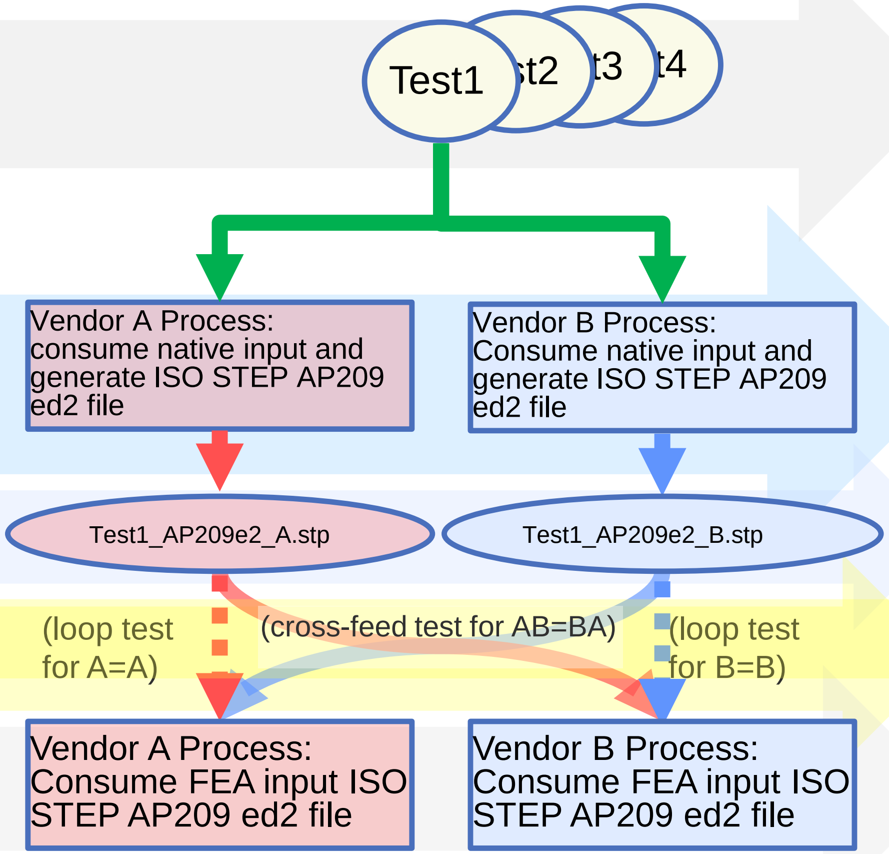
1 Test Models in native FEA format for input

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

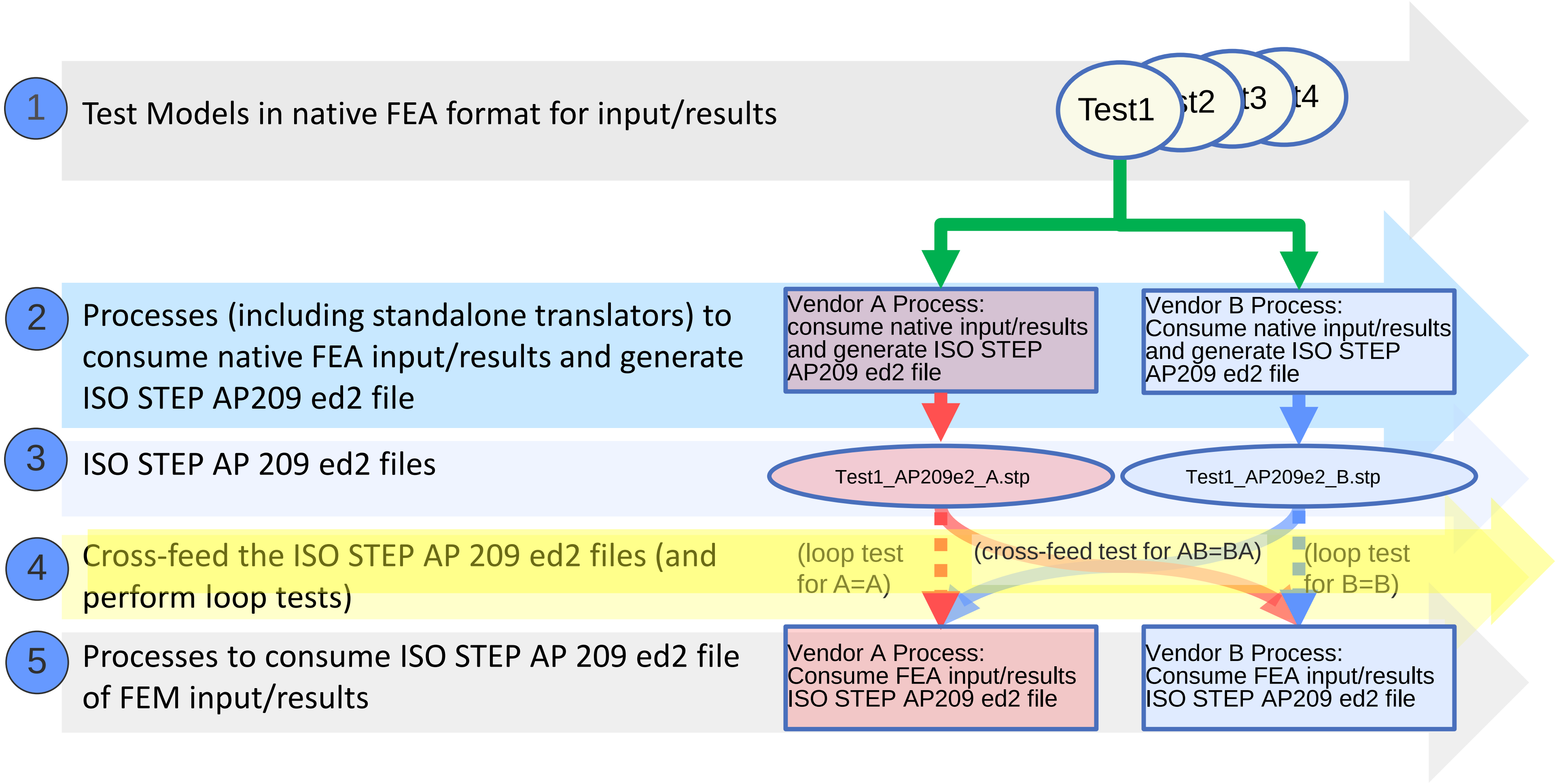
3 ISO STEP AP 209 ed2 files

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

5 Processes to consume ISO STEP AP 209 ed2 file



Pilot Study #2 – Using Beam Tests –Generate ISO STEP AP 209 ed2 Files from native FEA input/results data



Pilot Study #3 – Using Beam Tests – Bi-directionally generate ISO STEP AP 209 ed2 Files from native FEA input and results data

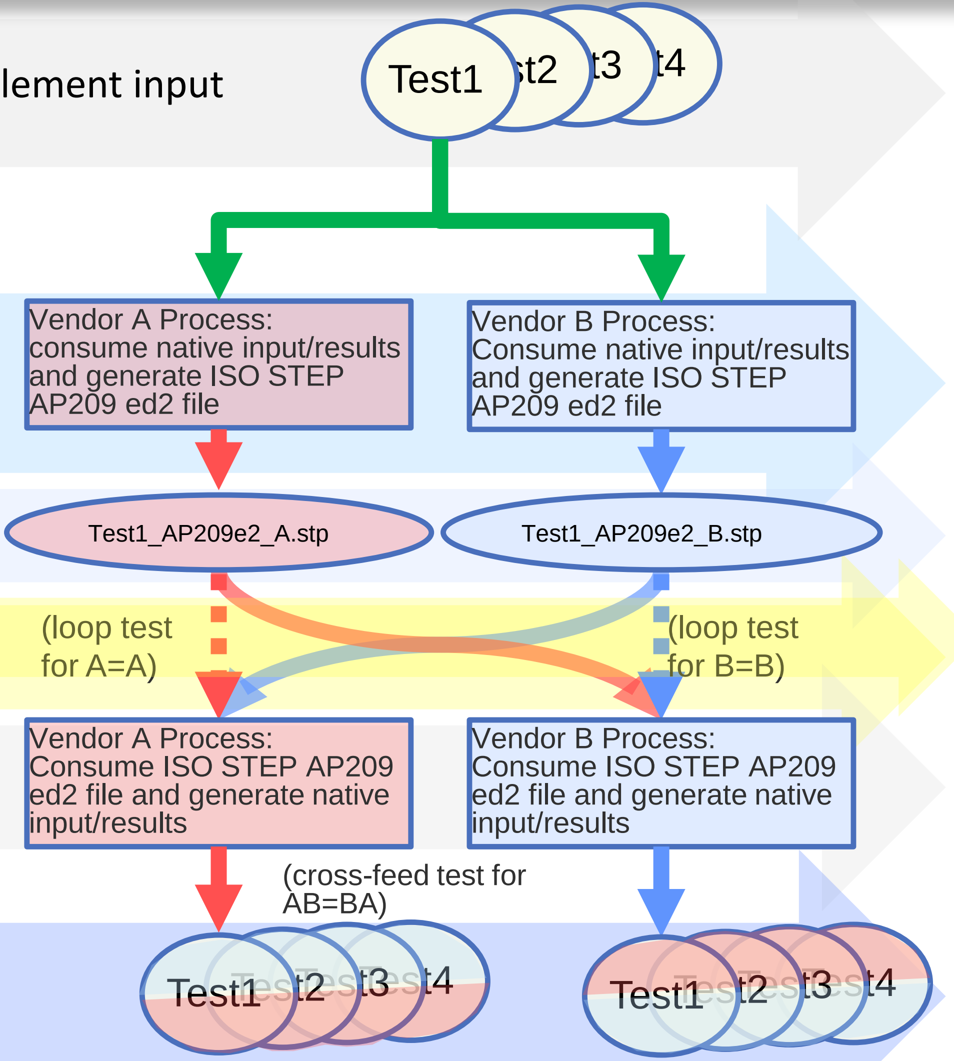
LOTAR
LONG TERM ARCHIVING AND RETRIEVAL

Conformance testing

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

Interop. testing

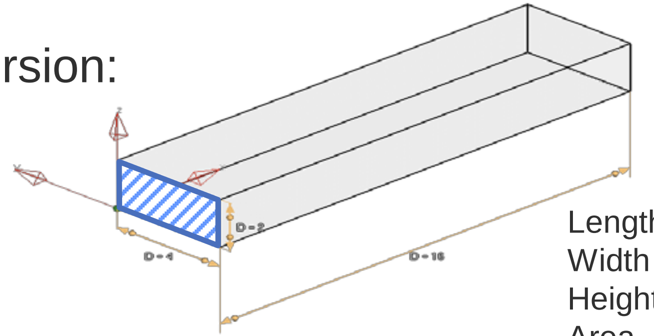
4. Cross-feed the ISO STEP AP 209 ed2 files (and perform loop tests)
5. Processes to consume ISO STEP AP 209 ed2 file and generate native FEM input/results
6. Test Models in native FEM format for input/results should result in "equivalent outcome" relative to the original input/results



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:

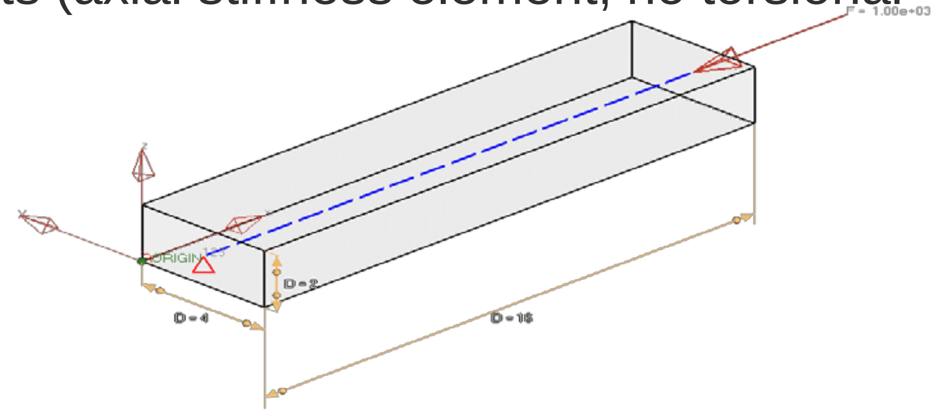
Beam (rectangular prism) models:
ATS1m4 : idealized using "rod" elements
ATS2m4 : idealized using "bar" elements
ATS3m4 : idealized using "shell" elements
ATS4m4 : idealized using "solid" elements



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)



Axial stress: 1000 / 8 = 125 psi
Axial strain: 125 / 10e+6 = 1.25e-5 in/in
Axial defl: 1.25e-5 x 16 = 0.0002 in

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

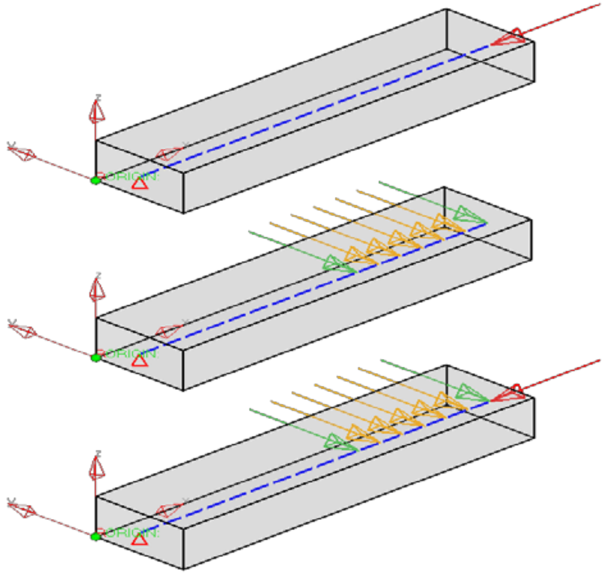
  **See listing for output parameters*

- 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*

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

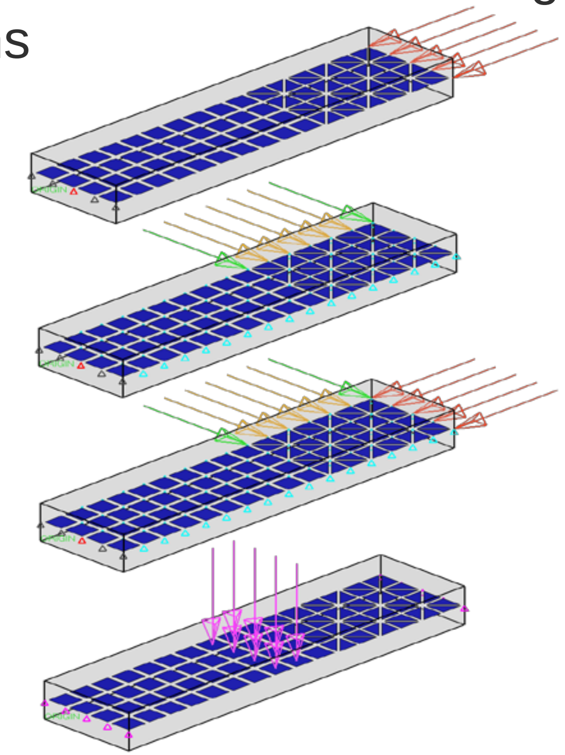
See listing for output parameters

- 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
	48	CTRIA3
Nodes:	86	GRID
Loads:	12	FORCE
	8	PLOAD2 (normal pressure)
	3	LOAD
Boundary:	104	SPC1
	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)
		DISPLACEMENT
		SPCFORCES
		STRESS

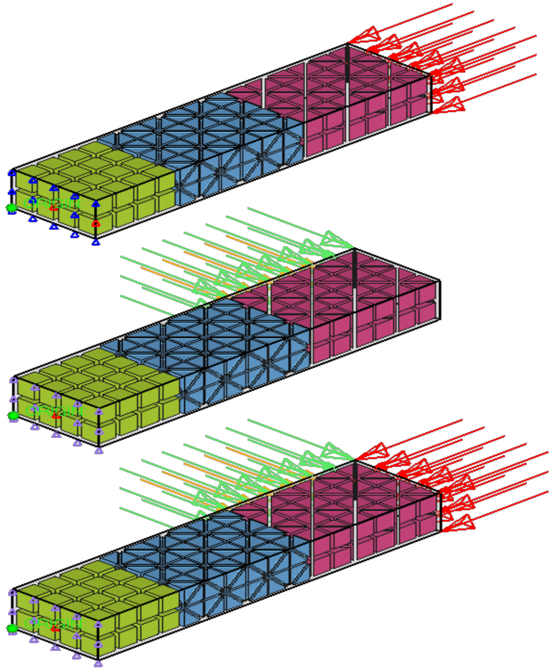
**See listing for output parameters*

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

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)*

Summary

- 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