Teaming to achieve a robust LOTAR capability for Engineering Analysis & Simulation data

September 13, 2016
St. Simons Island, GA (USA) and via WebEx
Objectives

- Introduce the LOTAR Engineering Analysis & Simulation (EAS) Working Group
- Team with (Computer Aided Engineering) CAE vendors to implement ISO STEP AP209 edition 2 in commercial tools for Structural Analysis first
- Achieve LOTAR capability for EAS data
Content

- Introduction to LOTAR
- The Engineering Analysis & Simulation (EAS) Working Group
- Technical approach
- Teaming to achieve the goal
- Development and testing of software supporting LOTAR EAS standards based on STEP AP209 ed2
- Resources provided
- Summary & next actions
- Backup
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:

- Facilitated by AFNeT and ProSTEP iViP
- Consists of PDM and STEP Translator vendors
- Supports AP242 BO Model XML

**EN** = European Norm (Standard)

**NAS** = National Aerospace Standard

**CAx** = Computer Aided “x” (Design, Engineering…)

**PDM** = Product Data Management
LOTAR Participants

International consortium of Aerospace manufactures and user companies from around the world.
Seven LOTAR Working Groups at present

**Engineering Analysis and Simulation**
- EN/NAS 9300-6xx series
- ISO STEP AP209 ed2
- 2014 launch

**Wiring Harness**
- EN/NAS 9300-4xx series
- STEP AP242 ed2
- 2012 launch

**Meta Data for Archive Packages**
- EN/NAS 9300-21
- STEP AP239 ed3
- STEP AP 242 ed2
- 2012 launch

**3D Visualization**
- Requirements and Compliance Documents
- 2012 launch

**Composites and Advanced Manufacturing**
- EN/NAS 9300-3xx series
- STEP AP203 ed2
- STEP AP242 ed1
- 2009 launch

**Mechanical 3D CAD with Product and Manufacturing Information (PMI)**
- EN/NAS 9300-1xx series
- STEP AP203 ed2
- STEP AP214 ed3
- STEP AP242 ed1
- 2004 launch

**Product Data Management (PDM)**
- EN/NAS 9300-2xx series
- STEP AP239
- STEP AP242 ed1
- 2004 launch
The Engineering Analysis & Simulation (EAS) Working Group
The LOTAR Engineering Analysis & Simulation Working Group was created in Dec. 2014

Team Members and LOTAR Member companies involved in the activities of this WG:

- Joe Draper
  Americas Co-leader
  Boeing (BCA)
  Everett, WA USA

- Randy Cigel
  Boeing (R&T)
  Seattle, WA USA

- Chris Johnson
  Lockheed Martin
  Aeronautics Company
  Fort Worth, TX USA

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

- Rod Dreisbach
  Boeing (BCA) - retired

- Keith Huntten
  Lockheed Martin - retired

- Gerrit Rollema
  Airbus Operations Ltd
  Filton, UK

- Jochen Boy
  PROSTEP AG
  Darmstadt, DE

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

- Phil Rosche
  ACCR, LCC
  Summerville, SC USA
Goals and Objectives

...to develop, publish and maintain standards-based mechanisms for archiving and retrieval of Engineering Analysis and Simulation information that can be read and reused throughout the product lifecycle, independent of changes in the Information Technology (IT) application environment originally used for creation.
Needs for LOTAR of EAS data

The general requirements include legal and business (engineering) needs:

**Legal needs**
- Certification
- Litigation
- Accident investigation

**Business needs**
- Evaluate changes
- Evaluate damage
- Address customer questions
- Evaluate new conditions and mission requirements
- Engineer modifications
- Engineer derivatives
- Capture knowledge
- Exchange data

An archive information package must be created to support these items, used for 2 main purposes:
- **retrieval**
- **reuse**

LOTAR supports the needs by providing an enduring data archive.
Regulatory requirements for LOTAR aircraft certification and safety

Document & Data Archiving is a legal obligation defined by external requirements and by internal company policies.

The FAA and EASA have promoted efforts to harmonize the regulations, so there are many similarities between them.
A diverse “world” is a business reality and effective data exchange is necessary and important to LOTAR.

Analysis data is shared between many different systems and authors during each phase of aerospace and defense product development. The benefit of ISO STEP standards for effective LOTAR is obvious.

Diverse Geography (sites extend across multiple time zones & cultures)

Diverse Computing (from multiple vendors)

Diverse CAD (systems from multiple vendors)

Diverse CAE (systems from multiple vendors)

Vendors and products listed for illustration only

STEP AP209 ed2 translators permit CAE diversity while mitigating the risk of losing valuable investments in analysis.
Business value of ISO STEP AP209 ed2 translators for LOTAR at Aerospace & Defense companies

- **Situation**
  - Aerospace & Defense companies and their suppliers buy software from multiple CAE vendors
  - Analysis, substantiated by test, is the evidence that aerospace products conform to customer and regulatory requirements
  - For many reasons, LOTAR of analysis data is a business requirement
  - Loss of analysis data results in costly rework to reproduce it

- **Target** – ISO STEP AP209 ed2 translators enable the preservation of value in the analysis models and results without dependence on a single CAE tool

- **Business Proposition**
  - Buy CAE software that supports ISO STEP AP209 ed2 translators and phase out CAE software that doesn’t
Business value of ISO STEP AP209 ed2 translators for CAE vendors

**Situation**
- Most of your customers already use CAE products from your competitors
- You must evolve or you will not sell new products
- Customers tend to use a version of your product for long periods of time due to the cost of migration (upgrade, validate, verify, educate, etc.)

**Target** – satisfied customers who see the value in your newest software will buy it and migrate to it

**Business Proposition**
- Seek to understand your customers needs for LOTAR of engineering analysis data
- Offer solutions that ease the process of migration to new software
- Offer solutions that preserve the value of their existing analysis models and results for the long term by supporting ISO STEP AP209 ed2 translators
Technical Approach
Driving questions for designing LOTAR EAS use cases

- Why do we archive?
- What is the content for an archive?
- Why do we retrieve and reuse?
- What is a round trip of an archive?
- Criteria for successful roundtrip?
- What is the lifespan of Aerospace products?
Vehicle Level Finite Element Analysis (VLFEA) is at the tip of the structural analysis “iceberg.”

VLFEA, substantiated by test, is the basis for analysis that serves as evidence that our products conform to the requirements of our customers and regulatory authorities. It is the culmination of a large volume of analytical data that supports it and represents a significant investment.

The importance of VLFEA is common to all A&D companies in the EAS WG.
Phase 1 Scope

- Structural Analysis
- Linear, Static, Deterministic
- Finite element method (h-formulation)
- Metallic and composite materials

Phase 1 Focus

- Internal loads
- Total vehicle
- Retrieve and reuse previous analysis
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 FEA input and results for the long-term.
**STEP AP209 edition 2: Multidisciplinary analysis and design**

**Development History**
- AP209 ed1 published in 2001
- Builds upon the full capabilities of [STEP AP242 ed1](#) (Managed Model Based 3D Engineering)
- Edition 2 scope now includes:
  - Product definition (product structure and 3D shapes)
  - Configuration control information
  - Finite element data (linear statics and modes)
  - Material specifications & properties
  - Computational Fluid Dynamics (based on CGNS Std.)
  - Generic structured and unstructured analysis mesh
  - Meshless numerical analysis
  - Discrete/continuous field representation
  - Kinematics analysis

**STEP AP209 ed2** is the target data model for simulation data long term archiving (LOTAR)
- STEP AP209 public web site: [www.ap209.org](#)
- Governance by ISO Technical Committee 184 for Industrial Automation Systems and Integration, Subcommittee 4 for Industrial Data

**AP209 Integrates 4 domains:**
- **CAD, CAE, SDM and PDM**
  - SDM : Simulation Data Management
  - CAD : Computer Aided Design
  - CAE : Computer Aided Engineering
  - PDM : Product Data Management

**Computer Aided Design**
- 3D Solids
- Surface Lofts
- Structural Layouts

**Analysis Geometry**
- Idealized for Loads
- Idealized for Structures
- Idealized for Aero

**Product Data and Metadata**
- Product Structure
- Analysis Structure
- Configuration Data
- Material Specification

**Finite Element Models and Analysis**
- Linear Statics
- Panel Aero
- CFD

**Simulation Data Management**
- Long Term Archival and Retrieval (LOTAR)

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Examples of essential information to preserve for LOTAR of FEA data

**Metadata**
- Descriptive text
- Pedigree
- Software used to produce original FEA and results
- Finite element analysis plan (purpose, assumptions, etc.)

**Input data**
- Units
- Nodes
- Elements
- Properties
- Loads and Boundary Conditions

**Results**
- Solution diagnostics (element and solution quality metrics)
- Displacements
- Reactions
- Internal Forces
- Node/Element Corner Forces
The “round-trip” of an EAS archive to/from long-term storage

**Archive**

- **Original FEA**
- **Metadata, input data & results**
- **AP209 ed2 translator**
- **AP209 ed2 file**
- **Ingest**
- **Access**

**Retrieve and validate**

- **Is the recovered FEA functionally equivalent to the original?**
- **AP209 ed2 translator**
- **Metadata, input data & results**
- **AP209 ed2 file**
- **Translated input data**
- **Translated results from original FEA**
- **New results from translated input data**
- **FEA Solver**
- **Equivalent outcome?**
- **Yes** → **Pass**
- **No** → **Fail**

**Source system**

- **Storage Vault**

**Target system**

- **Recovered FEA for review or reuse**

Long Term Archival and Retrieval (LOTAR)

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Teaming to achieve the goal
LOTAR engineering analysis and simulation (EAS) working group (WG) and related entities

End Users
Producers of requirements for archiving and recovering engineering analysis and simulation data, and consumers of the associated methods, tools, and standards.

Users
Requirements & Use Cases

LOTAR EAS WG
Develop, publish and maintain standards for archiving and retrieval of Engineering Analysis and Simulation information.

Providers

NAFEMS
International non-profit organization for advancing and promoting engineering analysis and simulation methods, data management, standards and education.

LOTAR EAS WG

National Institute of Standards and Technology (NIST)
Promote the use of standards.

PDES, Inc., ProSTEP iViP and AFNeT
Develop data models, standard data representations, including AP209 ed2, and common approaches through standards.

International Organization for Standardization (ISO)
Develop and publish international standards, in particular
- ISO 10303 STEP
- ISO 14721 OAIS (Open Archival Information System )

Modeling and Simulation information in a collaborative Systems Engineering Context (MoSSEC)
Develop methods for organizing and sharing Modeling and Simulation metadata and information in a collaborative system, and for capturing context to enable traceability.

CAx-Implementers Forum (CAx-IF) & CAE vendors
Develop software capabilities and recommended practices by implementing standards and validating them through testing the associated codes.

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Modeling and Simulation information in a collaborative Systems Engineering Context (MoSSEC)
Develop methods for organizing and sharing Modeling and Simulation metadata and information in a collaborative system, and for capturing context to enable traceability.
Memoranda of Understanding (MoU) have enabled collaboration

MoU between LOTAR EAS WG and NAFEMS

1. Purpose
   The purpose of the Memorandum of Understanding (MoU) is to define the desired level of cooperation between the principal in existing EAS vendors to accelerate the development and implementation of the standard for the exchange of Product Model Data (ISO 10303), usually referred to as STEP, and to capture engineering analysis for long-term archiving and retrieval. Initial efforts will focus on fostering the development of interfaces for the ISO 10303 STEP standard.

2. Background
   The LOTAR International Engineering Analysis and Simulation Working Group (EAS WG) was formed in December 2008 to create and promote standards for long-term archiving and retrieval (LOTAR), digital product and analysis models and standards, and 3D STEP standards. During the 4th quarter of 2014, the domain of Engineering Analysis and Simulation (EAS) was added to the scope of this activity and the LOTAR/STEP Working Group (LOTAR WG), was created in December 2014.

Although the scope of the LOTAR EAS WG is quite large, all of the technical disciplines associated with engineering analysis and simulation, it is critical that an international standard (generic) be developed for the exchange of product data (including the STEP standard). The LOTAR EAS WG shall develop, and will be published as: "EN ISO 10303, STEP, part 21, "A multidisciplinary analysis and design" standard."

NAFEMS is the international association for the engineering analysis community and seeks to create awareness of current and evolving techniques in numerical simulation of physical processes, to deliver appropriate education and training for them, and to encourage standards in their use. Its membership is drawn from industry, software suppliers, government, and academia from around the world and continues to grow at an encouraging rate. Much of its technical work is conducted through a number of specialist working groups and so an MoU, the simulation data management working group, has worked to establish best practices for capturing simulation context and pedigree along with the analysis – which is essential to LOTAR.

Signed 23 June 2016

MoU between AFNet, PDES and ProSTEP iViP

1. Parties to the Memorandum of Understanding
   This Memorandum of Understanding (MoU) is entered into by and between the three organizations: L’Association Française des utilisateurs du Norme ISO 10303 (AFNet), ProSTEP iViP (hereinafter referred to as "PDES") and ProSTEP iViP (hereinafter referred to as "ProSTEP iViP").

   1.1. AFNet
   AFNet is a non-profit association in operation for more than 30 years. It is a multi-sectoral Think Tank articulated with a Do Tank (i.e. with digital transformation projects in standardisation projects in many industries). These activities have led to the emergence of a network of recognized and highly skilled participants from the manufacturing industry, IT business and research companies. Its members cover a wide range of activities (SMEs, French governmental agencies, software vendors, universities, and research organizations)

   1.2. PDES
   PDES is an industrial/governmental consortium committed to accelerating the development and implementation of standards that enable enterprise integration and Product Lifecycle Management (PLM). Members support standards that define data formats and semantics, digital content, information models, and reference models.

   1.3. ProSTEP iViP
   ProSTEP iViP is an independent international association for the digital transformation in selected industries, such as aerospace and automotive, among others. Its mission is to define solutions for the challenges facing the manufacturing industry as a result of networked collaboration in a worldwide development network. A concept based on a

Signed 7 September 2016
Collaborative development space for LOTAR EAS

User requirement from member companies, NAFEMS, MoSSEC, and other sources

LOTAR EAS WG
(NAS / EN 9300-6xx)

Coordinates overall project, communicates user requirements, develops use cases and test models, aids in testing capabilities, develops standards for long term archiving and retrieval of EAS data

Requirements, use cases, test models

Software capabilities & recommended practices

PDES, Inc., ProSTEP iViP, AFNeT (AP209 development)

Develops STEP capabilities & standards

CAx-IF & CAE vendors

Develops and tests software capabilities, develops recommended practices, identifies STEP enhancements needed

Enhancement requests

Translator functionality

Test compliance with standards

NIST

Checks compliance with standards and promotes them to a wider audience

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CAx-IF participation requirements

Formal:

- Either be a PDES, Inc. member, AFNeT member OR be a ProSTEP iViP member

- Sign a NDA (non-disclosure agreement)
  - Basis for the trusted atmosphere and unprecedented cooperation among the vendors in the forum

- Have at least a prototype STEP processor
  - Export and/or Import
  - Based on AP242 or AP209

Active:

- Attend CAx-IF meetings
  - Four per year; alternating between Europe (Jun/Dec) and the US (Mar/Sep)
  - Discuss results, identify issues, develop solutions

- Participate in conference calls
  - Track test round progress and action items

- Actively collaborate in STEP interoperability testing
  - Provide STEP files
  - Upload results to online database
Development and Testing of Software supporting LOTAR EAS Standards
Testing follows a building block approach synchronized with STEP and LOTAR standards.
■ **Unit test models**
  - To test single functionalities

■ **Ultra-light glider model (ULG)**
  - Representative of model, 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
  - Simulation Data Management (SDM) elements such as metadata to establish pedigree
  - Publically available

*Symmetric pull-up manoeuvre*
Pilot study – using unit tests – bi-directionally generate and consume ISO STEP AP 209 ed2 files and native FEA

1. Test Models in native FEM format for input/results

2. Processes (including standalone translators) to consume native FEM input/results 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 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
CAx-IF testing methodology

Translation based on:
• Current EXPRESS / XML Schemas (AP209 ed2 / AP242)
• Latest (draft) Recommended Practices
• Test Case definitions

Checks performed:
• Syntax and Structure (conformance to schema)
• Semantics (conformance to Rec. Practices)

Translate to STEP

Perform STEP file checks and report findings

Participants access and process STEP files; report results

Participants resolve issues during the test rounds

Detailed review at meeting

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Resources provided
Resources Provided
(see backup slides for additional information)

- Test models
  - Unit test models
  - Ultra-light glider realistic model

- Training
  - Information model
  - Recommended practices overview

- Recommended Practices updates
  - In response to inputs from vendor testing

- Support
  - Regular meetings, workshops, test rounds
  - Conference calls
  - Access to STEP and domain experts
Summary & Next actions
**Summary: LOTAR EAS “On a Page”**

**Why:**
In an environment of rapidly changing software and hardware, a general requirement exists for access to and viability of digitally formatted engineering assets over the life of the product.

- Legal drivers
  - Cover certification needs
  - Support litigation
  - Support accident investigations
- Engineering, design & customer support drivers
  - Evaluate changes/improvements
  - Engineer derivatives/conversions
  - Extend payload/range/performance
  - Address customer questions
- Evaluate damage
- Capture knowledge
- Increase business capability

**Business Need**
**When & What***:

**Phase 1 Schedule:** 2015-2018
**Phase 1 Scope:** Vehicle-level model & loads employing linear static FEA

<table>
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<tr>
<th>Year</th>
<th>2015</th>
<th>2016</th>
<th>2017</th>
<th>2018</th>
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<td>Identify Business reqts &amp; Use cases</td>
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<td>Prepare test cases</td>
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<td>Dev. AP209 rec. practices</td>
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<tr>
<td>Conduct Pilot Study</td>
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<td>Launch CAE IF</td>
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<td>Create LOTAR Parts</td>
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**How:**

**Primary Technical Approach**

ISO STEP AP209
“Multi-disciplinary analysis and design”

Model Results Context Pedigree

Recovered for review or reuse

5, 10, 15, 20, 30,…, or more years

**Who:**

**Players & Roles**

- **LOTAR International EAS Working Group**
  - Overall project orchestration; User requirements; Test models; LOTAR EAS standard development (NAS/EN 9300-6xx)

- **Users & Member companies**
  - Requirements

- **PDES, Inc., ProSTEP iViP, AFNeT**
  - AP209 ed2 development

- **CAX-IF & CAE vendors**
  - Translator development & testing

- **NAFEMS, NIST, more**
  - Additional collaboration

*EAS scope is broad. Other analysis types and disciplines to be addressed in subsequent phases*
LOTAR EAS WG planning for Phase 1

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<td>Identify business reqts &amp; use cases</td>
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<td>Identify essential info to preserve</td>
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<td>Prepare test cases</td>
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<tr>
<td>AP209 Rec. Pract. update</td>
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<tr>
<td>Liaise with NAFEMS</td>
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<tr>
<td>Create and maintain LOTAR EAS webpage</td>
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<td><strong>2016</strong></td>
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<td>Create LOTAR parts</td>
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<td>Pilot study</td>
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<td>Creation of the CAE IF</td>
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<td>First CAE IF test rounds</td>
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<td>AP209 training</td>
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<td>Dev. of AP209 translators</td>
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Next actions

- **Vendors**
  - Review the current presentation and the back-up slides for more information
  - Ask questions if needed
  - Respond to a questionnaire
  - Brief the LOTAR EAS WG & CAx-IF about the capabilities you currently have and lessons learned
  - Inform LOTAR EAS WG of your desire to engage in the development and deployment of software solutions that enable use of ISO STEP AP209 ed2 files

- **LOTAR EAS WG**
  - Respond to questions from vendors
  - Collect feedback from questionnaires
  - Select pilot study participants following a process using feedback from questionnaires and analysis of readiness
  - Provide support for implementation development: AP209 ed2 up to date recommended practices, training, STEP expertise, etc.

LOTAR EAS is available for follow-up meetings if you have questions: LOTAR-EAS-Contact@lists.purdue.edu
Backup slides
LOTAR parts
EN/NAS 9300 standards to be developed

- Scope

- Structure

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Title</th>
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<tr>
<td>Part 600</td>
<td>Fundamentals and Concepts for LOTAR of Engineering Analysis &amp; Simulation information</td>
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<td>Part 610</td>
<td>LOTAR of Simulation Process and Data Management</td>
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<td>Part 620</td>
<td>LOTAR of Structural Analysis information</td>
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<td>Part 630</td>
<td>LOTAR of additional analysis domain</td>
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Business needs for LOTAR of EAS data

The need for LOTAR revolves around retrieval and reuse of previous analysis and simulation input data and results for a variety of purposes, such as:

- Evaluate changes to products (new materials, processes, etc.)
- Evaluate damage (design repairs, improve design, accident investigation, etc.)
- Address customer questions (fleet support, inspection, etc.)
- Evaluate new conditions and mission requirements (extend the range, increased payload, etc.)
- Engineer modifications (convert from passenger to freighter, add winglets, respond to changes in regulations, etc.)
- Engineer derivatives (“stretch” the fuselage, re-engine, freighter, military, etc.)
- Capture/recover knowledge (analysis assumptions, analytical basis, etc.)
CAx-IF Testing Methodology
Criteria for successful roundtrip – What is an “equivalent outcome”?
Comparison of Pilot Study, CAE-IF and Benchmark Testing
Pilot Study – algorithm for loop and cross-feed testing
Test Models used for Phase 1

SOFTWARE TESTING FOR PHASE 1
CAx-IF Testing Methodology

1. First inputs are test models to be translated into STEP, based on:
   - Current EXPRESS / XML Schemas (AP209 ed2 / AP242)
   - Latest (draft) Recommended Practices
   - Test Case definitions

2. STEP files are checked for:
   - Syntax and Structure (conformance to schema)
   - Semantics (conformance to Rec. Practices)

3. STEP files and corresponding statistics are provided in the member area of the CAx-IF homepage

4. Participants download all provided files, process them, and report on their results.

5. If issues are found, they are resolved during the test round as far as possible.

6. Detailed review at meeting.
Criteria for successful roundtrip – what is an “equivalent outcome”

- SDM/SPDM information (Metadata, pedigree, etc.) matches the validation properties of the original
- Input data conforms to the original FEA (units, node locations, etc.) and matches the validation properties of the original
- Results match original FEA within a specified tolerance and match the validation properties of the original and meets the test criteria
## Comparison of Pilot Study, CAE-IF and Benchmark testing

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<tr>
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<th>Pilot Study</th>
<th>CAE-IF</th>
<th>Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Who?</strong></td>
<td>2~3 vendors with a prototype ISO STEP AP 209 ed2 product</td>
<td>Any member of PDES, Inc or ProSTEP iViP with a functional ISO STEP AP 209 ed2 product</td>
<td>Independent third party testing COTS ISO STEP AP 209 ed2 products</td>
</tr>
<tr>
<td><strong>What?</strong></td>
<td>Unit tests with limited scope, but enough to exercise the ISO STEP data model</td>
<td>Use cases based on requirements used to define LOTAR standards</td>
<td>A collection of tests that conform to best practices in the industry</td>
</tr>
<tr>
<td><strong>Why?</strong></td>
<td>Proof of concept, allowing for further refinement of recommended practices and requirements.</td>
<td>Develop and mature product in a controlled forum for collaboration</td>
<td>To independently verify and validate the COTS products with analysis representative of intended usage in the industry</td>
</tr>
<tr>
<td><strong>When?</strong></td>
<td>After pilot study test plan is ready and pilot study candidates have been selected</td>
<td>After use case tests are defined and initial recommended practices are complete</td>
<td>After planning, funding, resources and COTS products become available.</td>
</tr>
<tr>
<td><strong>Where?</strong></td>
<td>At vendor sites with regular coordination</td>
<td>At vendor sites, with regular coordination and test files shared through sandbox, quarterly face-to-face meetings</td>
<td>At an independent test facility with up-to-date production versions of COTS software</td>
</tr>
<tr>
<td><strong>How?</strong></td>
<td>PDES, Inc. and ProSTEP iViP coordinate testing, EAS WG provides test models and criteria</td>
<td>PDES, Inc. and ProSTEP iViP coordinate testing, EAS WG provides test models and criteria</td>
<td>Third party defines a plan, funds and monitors the work</td>
</tr>
</tbody>
</table>
Pilot Study – Loop and Cross-feed tests are repeated for each test model with the goal being an equivalent outcome

Loop test (for=1 to N):

\[ Test_i^{\text{native}} \xrightarrow{\text{Vendor } A} Test_i^{\text{AP } 209 \text{ ed2}} \xrightarrow{\text{Vendor } A} Test_i^{\text{native}} \]

\[ Test_i^{\text{native}} \xrightarrow{\text{Vendor } B} Test_i^{\text{AP } 209 \text{ ed2}} \xrightarrow{\text{Vendor } B} Test_i^{\text{native}} \]

\[ Test_i^{\text{native}} \xrightarrow{\text{Vendor } B} Test_i^{\text{AP } 209 \text{ ed2}} \xrightarrow{\text{Vendor } A} Test_i^{\text{native}} \]

Cross-feed tests (for=1 to N):

\[ Test_i^{\text{native}} \xrightarrow{\text{Vendor } A} Test_i^{\text{AP } 209 \text{ ed2}} \xrightarrow{\text{Vendor } B} Test_i^{\text{native}} \]

\[ Test_i^{\text{native}} \xrightarrow{\text{Vendor } A} Test_i^{\text{AP } 209 \text{ ed2}} \xrightarrow{\text{Vendor } A} Test_i^{\text{native}} \]

\[ Test_i^{\text{native}} \xrightarrow{\text{Vendor } B} Test_i^{\text{AP } 209 \text{ ed2}} \xrightarrow{\text{Vendor } B} Test_i^{\text{native}} \]

\[ Test_i^{\text{native}} \xrightarrow{\text{Vendor } B} Test_i^{\text{AP } 209 \text{ ed2}} \xrightarrow{\text{Vendor } A} Test_i^{\text{native}} \]

\[ Test_i^{\text{native}} \xrightarrow{\text{Vendor } B} Test_i^{\text{AP } 209 \text{ ed2}} \xrightarrow{\text{Vendor } A} Test_i^{\text{native}} \]

The LOTAR EAS WG (in collaboration with participating vendors) will define the criteria used to determine what substantiates an equivalent outcome. The concept of validation properties in ISO STEP will be used as much as possible to achieve this goal.
EAS Working Group is developing a suite of Finite Element Models (FEM) for use by LOTAR members and the CAx-IF:

- Unit test models for specific FEM constructs and element types
- Models for testing ISO 10303 AP 209 ed2 geometric founding and transformation implementation
- A publically available ultra-light glider FEM that contains analysis product structure and associativity to idealized surface geometries
AP209 ed2 Training
Recommended Practices for implementing STEP AP209 ed2
STEP AP209 ed2 Testing Support

ISO STEP AP209 BACKGROUND
Objective: Explain AP209 ed2 to the implementers to a level needed so that they can successfully implement the protocol in their simulation analysis software and create solutions that satisfy the LOTAR EAS use cases and requirements. Training materials shall expand on information contained in the Recommended Practices document to provide instances typical of common solver data structures.

- Training sessions for implementers
  - 1 day high level review (ARM) to introduce scope of the information model
  - 3 day implementation model review (AIM) to provide details on using the Recommended Practices and Part 104 documents to implement compliant translators

- Training materials shall be accessible on-line
Recommended Practices for implementing STEP AP209 ed2

- Documents available so far are based on the first edition of STEP AP209:
  - Recommended Practices – April 23, 2002
  - Geometric Founding and Associativity – Feb. 15, 2001

- Available on the internet:
  - https://www.cax-if.org/joint_testing_info.html#recpracs

- Documentation updates are under way, in order to cover:
  - New and extended approaches of the second edition of AP209
  - Alignment with AP242
  - LOTAR EAS requirements
Testing support will be given through the well-established CAx-IF Infrastructure:

- Public and private web site at www.cax-if.org
- Regular meetings, in conjunction with LOTAR workshops
- Additional conference calls
- Two test rounds per year
- Intense technical discussions with STEP and domain experts
- Syntax and structure, and semantic checking of STEP files