IT Labs Proof-of-Concept Project: Technical Data Interoperability (TDI) Pathfinder Via Emerging Standards

Project Co-Leads Mike Conroy/KSC and Paul Gill/MSFC
Technical Lead John Ingalls/KSC-ESC

2014-12-16
Overview

Problem definition
- No known system is in place to allow NASA technical data interoperability throughout the whole life cycle. Life Cycle Cost (LCC) will be higher on many developing programs if action isn’t taken soon to join disparate systems efficiently. Disparate technical data also increases safety risks from poorly integrated elements. NASA requires interoperability and industry standards, but breaking legacy ways is a challenge.

Background
- Past efforts have been made to evaluate and use industry standards for technical data. Emerging standards are promising.

Expected Project Outcome:
- The TDI project testing and evaluation expected to validate industry concepts of interoperability using a certain suite of integrated industry standards.
Alignment with 2011 NASA IRM Strategic Goals and Objectives

- **Strategic Goal 1: Objective 1.5** – Enhance mission success by providing efficient and effective access to enterprise information and collaborative functionality.
  » Validate industry standards designed to be interoperable across life cycle.
- **Strategic Goal 2: Objective 3.1** – Develop architectural roadmaps that reflect future mission requirements and guide selection of new IT.
  » Test a proposed industry architecture of interoperable suite of standards.
- **Strategic Goal 3: Objective 3.2** – Partnership of best practices with other government agencies and commercial partners.
  » Align with practices emerging in global government and commercial world.
- **Strategic Goal 4: Objective 4.2** – Utilize innovative methods to attract a productive IT workforce.
  » TDI standards use modern technology. New connections are developing.
Test import/export of part of PLCS-centered interoperability concept:
» PLCS AP239, PDM, LSA (S3000L & GEIA-STD-0007), and S1000D
Project Activity

- **Testing Scenarios Performed**
  - CAD Product Structure Export, Import BOM to LSA
  - CAD Data Export from PDM Using AP239 PLCS Adapter
  - JSC ISS EAGLE LSA MIL-STD-1388-2B Data Export as GEIA-STD-0007 Format
    - Import to TDI EAGLE LSA GEIA-STD-0007 Rev A Client (as GEIA format)
    - Import to PowerLOG-J as GEIA-STD-0007 Rev A
    - Import to TDI EAGLE LSA GEIA-STD-0007 Rev A
    - Import to PowerLOG-J as MIL-STD-1388-2B
  - TDI LSA EAGLE Bike Data GEIA-STD-0007 Export
    - Import to PowerLOG-J as GEIA-STD-0007

- **TDI Conversion Map of EAGLE LSAR to PLCS Format**
  - No adapter for this has been attempted in industry.
    - Only rare tests of other LSA tools with PLCS.
  - The TDI team has partially developed a translator tool for this.
    - Utilizing U.S. Army’s LOGSA LSA DEX mapping and EDMtruePLM test exports
Issues/Challenges

- Time and resource limitations and typical software installation and configuration issues hindered progress, which was expected.
- Obtaining test data progressed slowly.
- One expected obstacle was the lack of existing adapters in the industry to join the technical data entities.
- The AP239 PLCS adapter was not ready out-of-the-box to use for CAD data exchanges. Development is required.
- The PLCS repository client performs DEX1 exchanges out-of-the-box, but requires development for DEX3 functionality.
- ISS LSA data exchanges from JSC’s EAGLE LSAR were not clean. This was somewhat expected, since that system is customized, though based on the older standard MIL-STD-1388-2B.
Findings/Observations

- **TDI Project Accomplished Rare Testing**
  - PLCS-centered industry concept has not been attempted much in the industry.
  - Industry vision has only been implemented in a limited number of efforts.

- **Much Research Accomplished**
  - Discovered positive new developments in TDI standards.
  - Found potential NASA requirements paths.

- **PLCS Repository Populated with Several Test Data Sets**
  - Data was entered by DEX1 import and manual entry.
    - No adapters were available for EAGLE LSAR or EPS S1000D.
    - Adapter for Windchill PDM required development.

- **PLCS Repository Exported Data as DEX1**
  - This was used to evaluate for development of a conversion map with EAGLE LSAR.
Findings/Observations

- Developing Conversion Map of EAGLE LSA Data to PLCS Format
  - About 20% complete, mapping GEIA-STD-0007 LSA data to PLCS (DEX 1).
  - Effort took equivalent of about 2 weeks of full-time hours.
Findings/Observations

- An Industry Project Found with PDM, PLCS Adapter & Repository
  - UTRS developed a system for Boeing and the U.S. Army to exchange data.
  - They required development to enable the adapter and PTC to fix issues.
  - The project took 6 months.
  - Evidence that PLCS-centered system works with Windchill, adapter, and TruePLM.
Recommendations

- Results so far point to a positive direction for the TDI standards
  - The interoperability between PDM, LSA, and Tech Pubs data appears to be available or developing within a year or two.
  - Further testing could validate this.

- Short-Term Recommendation
  - Continue with the unfinished testing that is able to be accomplished.
    - JSC ISS EAGLE LSAR export as XML, import to EAGLE GEIA client as XML.
    - JSC ISS EAGLE LSAR export as 2B, import to PowerLOG-J, then export as GEIA, then import to EAGLE GEIA client as GEIA.
    - JSC ISS EAGLE LSAR export as 2B, import to EAGLE S3000L client as 2B.
    - Export TruePLM PLCS data as DEX1, attempt import to PowerLOG-J.
    - Use JSC ISS data imported into EAGLE LSAR (both GEIA & S3000L versions) to produce EAGLE EPS S1000D data and publish as an IETP. Compare with NASA’s IPV.
    - Evaluate what it would take for NASA IPV’s XML version of SODF/PODF procedures to convert/import into EAGLE EPS S1000D.
  - More time is needed for thorough evaluation of data exchange integrity.
  - Incorporate into revision 1.1 of white paper.
Continue Developing the LSA-PLCS Conversion Map

» Develop until at least DEX1A&D (product breakdown) functionality works.
» Estimate approximately 2 months of full-time work.
» Vendor software arrangements may be needed.
» Once DEX 1 is achieved, the translator would be about 90% complete for all DEXs.
  • Recommend to get DEX 1 working, then evaluate future efforts.
Recommendations

- Long-Term Recommendation
  » Carry results forward to the next level.
    • Testing a networked integration
    • Testing additional functionality
    • Adding data sets from more space products/systems
  » If test results still have positive potential, propose a full integration pilot.
  » Collaborate with other space agencies for possible joint efforts.
    • Possibly begin with the annual NASA-ESA PDE Workshop.
    • The TDI standards are used by many industries and governments in Europe.
    • Russia is known to have S1000D use cases.
# Required Project Deliverables

<table>
<thead>
<tr>
<th>Required Deliverable</th>
<th>Deliverable Description</th>
<th>Was it produced and submitted?</th>
<th>If no, why not?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final presentation</td>
<td>TDI project</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>White paper</td>
<td>TDI project</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>
## Additional Project Deliverables

<table>
<thead>
<tr>
<th>Additional Deliverable</th>
<th>Deliverable Description</th>
<th>Was it produced and submitted?</th>
<th>If no, why not?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publish results</td>
<td>To conferences for space &amp; standards communities</td>
<td>No</td>
<td>Not finished testing. Need release permission &amp; conference acceptance &amp; funding.</td>
</tr>
<tr>
<td>Possible prototype</td>
<td>Interoperability model setup</td>
<td>No, but a partial LSA-PLCS adapter was developed</td>
<td>Not enough time or funding. This was not expected, but a long-term goal.</td>
</tr>
</tbody>
</table>
Project Team

- Project Manager: Mike Conroy/KSC and Paul Gill/MSFC
- Project Team (Civil Servant and Contractors):
  - Anthony Zucco/Raytheon
  - Bradley Hill/KSC
  - Brandon Ibach/KSC
  - Corey Jones/KSC
  - David Ungar/KSC
  - Jeffrey Barch/KSC
  - John Ingalls/KSC, Technical Lead
  - Joseph Jacoby/KSC
  - Josh Manning/KSC
  - Kjell Bengtsson/Jotne
  - Mark Falls/JSC
  - Peter Kent/KSC
  - Shaun Heath/KSC
  - Steven Kennedy/KSC
Backup
Standards Adoption & Development
AIA 2013 Status

Adopt existing standard

AIA development

Monitor external development

Participate in external development

Track  Candidate  Adopted

AIA Guidelines

Update 2014-12-16
Standards Contributing to PLCS
1999-2004

EXPRESS based

ISO 15288
OMG
STEP
ISO 10303
MIL STD 2549
AP208
MIL STD 1388
FMV CTG2
AP203
STEP ISO 10303
NCDM
AECMA 1000D 2000M
ATA Effectivity
PDM Schema
POSC/ Caesar
Def Stan 00-60 Logical
RCM IT
PLCS AP239
TC184/SC4 WG3/T8 PWI
PWI
AP233
ISO 15288
PLIB
Logical SGML EDIFACT

Updated 2014-12-16
Page 19
International Space Station (ISS) Has an International LSAR
- Built on MIL-STD-1388-2B, uses COTS “EAGLE LSAR”
- Potential link to an international S1000D for technical procedures & IPB’s

ISS LCN Product Breakdown Structure Sample:

1st Indenture Level:
S – Core Space Station
P – Payload
F – Ground Facilities
O – Orbital Supt. Equip.
G – Ground Supt. Equip.
T – Training Equipment

2nd (S) Indenture Level:
0 – Truss Segment S0
1 – Truss Segment S1
… etc.
A – U.S. Laboratory
B – European APM
C – Japanese JEM
D – Russian Service Mod.
E – FGM
F – Pressurized Mating Adaptor (PMA)
G – Press. Doc. Mod. ADP
H – Canadian MSS
… etc.

Total LCN Structure:
• 9 Indenture levels avail.
• 18 Digits max.
S1000D SNS: Product Structure in Tech Pubs Breakdown

- Data Module Code (DMC) = Unique, Structured Identifier of a Data Module
- Variable Character Length: min. 17 to max. 41 (gray X is optional)

Hardware / System Identification

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Product/project</td>
<td>Id. alt. versions of sys’s in SNS</td>
<td>Sys-Subsy-Unit • Initial XX-X is set by MICC</td>
<td>Further breakdown for maintenance</td>
</tr>
</tbody>
</table>

(SOpt.) MICC: Materiel Item Category Code

<table>
<thead>
<tr>
<th>SNS code set:</th>
</tr>
</thead>
<tbody>
<tr>
<td>A – Generic</td>
</tr>
<tr>
<td>B – Supt/train eqpt.</td>
</tr>
<tr>
<td>C – Ordnance</td>
</tr>
<tr>
<td>D – General comm.</td>
</tr>
<tr>
<td>E – Air vehicle</td>
</tr>
<tr>
<td>F – Missile</td>
</tr>
<tr>
<td>G – Surface vehicle</td>
</tr>
<tr>
<td>H – Sea vehicle</td>
</tr>
</tbody>
</table>

IC/ICV: Information Code/Variant

<table>
<thead>
<tr>
<th>Type of Info:</th>
</tr>
</thead>
<tbody>
<tr>
<td>IC=3 char.</td>
</tr>
<tr>
<td>0xx–Function, data, descrip.</td>
</tr>
<tr>
<td>1xx–Operation</td>
</tr>
<tr>
<td>2xx–Servicing</td>
</tr>
<tr>
<td>3xx–Exam / test</td>
</tr>
<tr>
<td>4xx–Fault isolate</td>
</tr>
<tr>
<td>5xx–Disconnect / remove</td>
</tr>
<tr>
<td>6xx–Repair / make</td>
</tr>
<tr>
<td>7xx–Assy / instl</td>
</tr>
<tr>
<td>8xx–Storage</td>
</tr>
<tr>
<td>9xx–Misc</td>
</tr>
<tr>
<td>ICV =1 char.</td>
</tr>
</tbody>
</table>

ILC: Item Location Code

<table>
<thead>
<tr>
<th>Situation/place applicable to the info</th>
</tr>
</thead>
<tbody>
<tr>
<td>A – Installed</td>
</tr>
<tr>
<td>B – Installed on a removed major assy</td>
</tr>
<tr>
<td>C – On bench</td>
</tr>
<tr>
<td>D – Combo of A, B, &amp; C</td>
</tr>
<tr>
<td>T – Training info only if no LC</td>
</tr>
<tr>
<td>Z – Generic</td>
</tr>
</tbody>
</table>

(Opt.) LC/LEC: Learn / Learn Event Code

<table>
<thead>
<tr>
<th>LC=3 char.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hxx – Human performance technology</td>
</tr>
<tr>
<td>Txx – Training</td>
</tr>
</tbody>
</table>

LEC=1 char.

| A – Learn plan |
| B – Learn overview |
| C – Learn content |
| D – Learn summary |
| E – Learn assessment |

Updated 2014-12-16
### Product Breakdown Structure Is a Key Link for S-series & PLCS

### Potential Space Application – Example S1000D Structure:

- **MI: Model Identification**
  - **Product/project**
  - **Potential Examples:**
    - **AtlasV5** = Atlas V 500 Series
    - **X37B** = X-37B Orbital Test Vehicle (OTV)
    - **CST100** = CST-100 Capsule
    - **RD180** = RD-180 Engine
    - **SLS** = SpaceLaunchSys
    - **ISS** = Int’l Space Station

- **SDC: System Difference Code**
  - *Id. alt. versions of sys’s in SNS*

- **(Opt.) MICC: Materiel Item Category Code**
  - *Sys-Subsy-Unit*
  - *Initial XX-X is set by MICC*
  - **24** Vehicle Elec. Power
  - **30** DC Generation
  - **74** Engine Ignition
  - **10** Elec. Power Supply

- **SNS: Standard Numbering System**
  - **SNS code set:**
    - **A** – Generic
    - **B** – Supt/train eqpt.
    - **E** – AeroSp* vehicle
    - **F** – Missile/rocket*
    - **H** – Sea vehicle
    - **S** – Space station*

- **DC/DCV: Disassembly Code/Variant**
  - *Further breakdown for maintenance*

### Product Examples:

- **ATLASV500** `XXXXX` `-501X` `-F24-30-00XX` `-000XX` `-………..`
  - **X37B** `XXXXXXXXX` `-OTV1-E24-30-00XX` `-000XX` `-………..`
  - **RD180** `XXXXXXXXX` `-0XXX-F74-10-00XX` `-000XX` `-………..`
  - **SLS** `XXXXXXXXXX` `-001X-E24-30-00XX` `-000XX` `-………..`
  - **ISS** `XXXXXXXXXXX` `-SCXX-S24-30-00XX` `-000XX` `-………..`

*Potential adaptation of S1000D (red)*

---

**Updated 2014-12-16**

**Page 22**
- **ODF (Operations Data File)**
  - Procedures to operate/maintain/train for ISS systems, payloads, ATV/HTV’s
  - Used by ground controllers, on-board crew, & on-orbit executor software

- **IPV (International Procedure Viewer)**
  - IETM (Interactive Electronic Technical Manual) system of data & ODF files
  - Used by NASA, ESA, CSA, and JAXA
  - NASA JSC authors in Word, converts to XML
  - ESA authors direct in XML
  - All use XML authoring software XMetaL
    - ODF customizations
    - Compatibilities with S1000D

- **IPB (Illustrated Parts Breakdowns)**
  - A deliverable from the ISS LSAR
  - NASA JSC L&M creates in Word
  - S1000D could produce from LSAR
Flight Software Command & Control

» Read commands in IPV, execute on separate flight software display

» European Space Agency (ESA) developed an integration of IPV / ODFs with flight software
  • Flight software station has 2 windows in one display
    – ODF step activates a flight display on same screen
    – Execution is a separate click

» IPV could directly execute, but does not due to safety concerns
  • S1000D potential capability

» ESA is evaluating voice-activated commands