



AIA Position Paper: Engineering Data Interoperability- A Standards Based Approach

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1 Executive Summary

The AIA Engineering Data Interoperability Group (EDIG) was formed by the Engineering Management Committee (EMC) “to establish an Industry wide team to develop plans, strategic and tactical, for the Industry adoption of common standards, and promote approaches to enable interoperability for the engineering domain across the aerospace industry and with its Customers.”

Across the aerospace industry, the need for efficient data exchange has never been greater. Aerospace companies have increasingly focused on the role of systems integrator, relying on partners and suppliers to provide significant portions of their aircraft designs. Meeting the requirement for integration and collaboration, however, has been costly and time-consuming given the disparate set of applications and methods typically employed. Tools and processes range from manual capture in 2D drawings to sophisticated 3D models tightly integrated with other enterprise systems. The challenge is further compounded by the growing need to provide Engineering information for through-life support extending beyond the life span of individual applications.

Maintaining data integrity across the applications and systems that author and consume engineering data is frequently problematic. Integration between systems is often so complex and costly that organizations opt for manual data input when faced with Program budget and schedule constraints. Near-term Program priorities are in conflict with the need for investment in a holistic solution that can be re-used by downstream processes and systems, and that can be leveraged by future Programs.

The Standards community has been at work for decades in an effort to address the issues with data exchange, with varying degrees of success. The EDIG undertook a two-fold effort to determine the readiness of any of these standards to meet aerospace industry requirements for data exchange:

- The EDIG surveyed member companies with respect to their integration efforts, standards-based and otherwise to understand where these companies are challenged, where they have been successful, and where they see potential benefit in implementing a data exchange capability.
- A subset of the EDIG performed a comparative analysis of the leading data exchange Standards from [ISO/STEP](#) and [GEIA](#). The Standards were evaluated for scope and depth of coverage, when mapped against the Product Engineering Lifecycle scenarios.

The survey responses indicated a high level of interest in a standards-based data exchange capability. Nearly all respondents perceived high potential benefit to the business if such a capability could be implemented. Based on the results of the analysis performed, the EDIG believes that certain of these Standards have reached a sufficient level of maturity to be feasibly and cost-effectively implemented. Companies investing

in data exchange capabilities based on interoperability Standards can realize significant technical and business benefits.

The EDIG recommends that AIA Member companies and Suppliers adopt a Standards-based interoperability solution utilizing PLCS, part of the internationally accepted STEP standard (ISO 10303-239). The maturity and scope of coverage of the Standard will provide coverage for the widest cross-section of engineering applications now in use. PLCS also offers the capability to define exchange specifications (DEX) to meet particular data requirements. A number of such DEXs are already being developed, and others may be created as necessary by industry.

In order to minimize the time and cost required to implement, and to maximize the potential benefits, we recommend that aerospace companies implement Best Practices in standards-based interoperability as described in the Engineering Data Interoperability Guide, which are scheduled to be published by this team in 1Q 2008. It is also recommended that PLCS be adopted as part of the overall AIA eBusiness framework.

Details of the EDIG's activities, findings, recommendations, and suggested next steps are described in the Sections following.

2 Background

The EDIG was formed as a result of the growing challenges associated with achieving efficient, accurate and reliable exchange of engineering data across the Aerospace industry. The original Charter statement was "To establish an Industry wide team to develop plans, strategic and tactical, for the Industry adoption of common standards, and promote approaches to enable interoperability for the engineering domain across the aerospace industry and with its Customers."

Inherent in the EDIG charter was the requirement to provide guidance to aerospace companies, their partners and their customers with respect to Data Exchange, in several key areas:

- The adoption of a Standards-based methodology for data exchange
- Identification of those Standards most closely aligned with aerospace industry needs
- Effective implementation of Standards-based data exchange
- Example templates for business case justification for a Standards-based implementation

The Team was subsequently formed with membership from leading aerospace industry companies, tier one suppliers, and Engineering application vendors. As part of its stated charter, the EDIG presents this White Paper, which summarizes the Team's activities, the related findings, and the EDIG's recommendations.

3 Business and Technical Drivers

The variety of engineering tools used to support design, procurement, manufacturing, and support of aerospace products has never been greater. From company to company, tools and processes range from manual capture in 2D drawings to sophisticated 3D models tightly integrated with other enterprise systems. The challenge is further compounded by the growing need to provide Engineering Information for through-life support extending beyond the life span of individual applications.

This heterogeneity has created both technical and business challenges. Data integrity across the applications and systems that author and consume engineering data is problematic. Integration between systems is often so complex and costly that organizations opt for manual data input when faced with Program budget and schedule constraints. This decision has a lasting impact to Supplier Management, Manufacturing Integration, and in-service support.

From a business perspective, budget and schedule constraints often dictate a concise solution for the tool and process subset in use for the Program duration. Near-term Program priorities are in conflict with the need for investment in a holistic solution that can be re-used by downstream processes and systems, and that can be leveraged by future Programs. Again, the long-term impact is significant from a cost and risk perspective.

Leading software vendors currently have little incentive to develop and support a generic interoperability capability that is comprehensive with respect to all engineering data exchange requirements. The use of proprietary data models and exchange tools foster vendor “lock-in”, assuring vendors of a long-term relationship with consumers of their products.

The Standards community has been at work for decades in an effort to address the issues with data exchange, with varying degrees of success. Based on our research and analysis, the EDIG believes that certain of these Standards have reached a sufficient level of maturity to be feasibly and cost-effectively implemented. Companies investing in data exchange capabilities based on interoperability Standards will realize both technical and business benefits.

From a business perspective, companies will benefit from reduced investment in piecemeal integration projects. The corresponding increase in data quality, based on data transfer versus data re-creation, will lower the cost resulting from re-work. Ultimately, companies should see a significant reduction in application integration costs, as downstream processes and successive Programs re-use the existing interoperability framework.

From a technical perspective, the Standards-based approach can greatly simplify integration complexity, by largely eliminating the need to develop and maintain point-to-point integration solutions. The simpler integration model will make it feasible to add new applications as demands arise for new capabilities. The time required to deploy new

applications and processes that are integrated with existing capabilities will be greatly reduced.

These benefits are predicated on several factors. The Standards used must be comprehensive enough to support a complete business scenario, such as Engineering Design. They must be robust enough that they can support exchange between a wide variety of data models and applications. They must be feasible to implement, and the implementation itself should follow certain established patterns to derive maximum benefit. Perhaps most importantly, the implementation must be sponsored and supported at the Executive level. This is critical to obtain the significant up-front investment and commitment that is required, and to ensure that the implementation will be prioritized and sustained beyond the scope of a single Project or Program.

A primary concern for all aerospace companies is the management of Type Design data, especially as they migrate to 3D Model-Based Design (3D MBD). While 3D MBD offers tremendous potential benefit for design cost reduction, the elimination of 2D drawings introduces new technical challenges for meeting Type Design data consistency and longevity requirements. Proprietary vendor-specific software and data is inherently life-limited. Long-term storage is no guarantee that the tools will exist to access the data, 20-50 years down the road.

The requirement for long-term retention of Type Design data as called out in AIR 101 and [8110.4C](#) can be supported by the use of a neutral, open, human-readable format such as that provided by a standards-based data exchange tool. The format addresses the limited-life issues incurred through use of proprietary tools, by providing a way to persist core design information independent of the vendor-specific authoring tool. Data can be extracted and persisted in the standards format, ready to be imported and consumed by any supporting application as needed. Extraction to the neutral format also provides the means for validation of data consistency independently from the authoring application, over time and across application versions.

The factors cited above formed the basis for the research and analysis activities undertaken by the EDIG. These activities are summarized in the Sections following.

4 Scope of Activity

The full scope of the activities and analysis to be performed by the EDIG would ideally have included the entire lifecycle of the product or system, from requirements formulation to product retirement. This, however, was not practical given the constraints on the EDIG's schedule.

The decision was made to focus on the Product Engineering Lifecycle. This decision was made due to the fact that the majority of engineering data is created in this period, so that a variety of data exchange scenarios would be in-scope for the Standards analysis. It is recommended that follow-on EDIG activities continue the analysis process for the

remainder of the engineering lifecycle, such as Requirements Analysis and In-Service Support.

The scope of the Product Engineering Lifecycle scenarios included information flows typical within and across businesses participating in the Product Engineering Lifecycle:

- Within business organizations
- Across business organizations (primes, subcontractors, partners) throughout the supply chain
- Between business organizations and customers

The EDIG compiled and prioritized a list of business scenarios. The scenarios included in the research and analysis focused on the integration of engineering data, in support of specific lifecycle requirements. Critical design information relative to a constituent step in the product development process, such as Engineering Bill-of-Material (EBOM) data elements needed for creation of the Manufacturing Bill-of-Material (MBOM) or design information needed for Work Instructions, were identified and listed as analysis criteria. The selected scenarios were then extended to support the additional business and architectural requirements listed below.

Specific use cases included:

- Computer Aided Design (CAD) to Product Data Management (PDM)
 - BOM properties transfer support
 - Mass Properties metadata transfer support
 - Material Properties metadata transfer support
- Computer Application to Computer Application
 - PDM to Enterprise Resource Planning (ERP) – transfer of product structure and associated documentation
 - ERP to Logistics System – support for product instance as-built data
 - Logistics System to PDM – maintenance-driven configuration changes
 - PDM to (Manufacturing Execution System) MES (internal) - part identity and manufacturing instructions
 - MES to ERP/PDM (internal)
 - Content Management (tech pubs)
 - Transfer of Ownership
 - PDM to Parts Catalog
- Configuration and Change Management
 - As Designed to Document/CAD Artifacts
 - BOM Effectivity Across Multiple Systems
 - Part Nomenclature Assignment
 - Change Control Authority – Ownership and control of design authority
 - Change Flowdown – Notification and transaction support
 - As Built to Document/CAD Artifacts (MBOM)
 - Model
 - Drawing

- Referenced Documents (Specifications)
- Part Nomenclature Assignment
- Change Flowdown
- Change Control Authority
- As Maintained to Document/CAD Artifacts (EBOM)
 - Model
 - Drawing
 - Referenced Documents (Specifications)
 - Part Nomenclature Assignment
 - Change Control Authority
- Bill of Material Audit Traceability
 - Part Nomenclature Assignment
 - Change Control Authority

Additional architectural and business criteria including those used by the AIA Electronic Enterprise Integration Committee (EEIC) list were also identified for the comparative analysis. The additional criteria under which the standards were evaluated were:

- The existence of an active current support body for the Standard
- Support for an XML (eXtensible Markup Language) format of the standard's data model with XSD (XML Schema Definition) validation
- Existence of a built-in mechanism to extend model in business specific ways
- Existence of adequate implementation documentation
- Support for conformance testing
- Whether the standard is the basis for one or more AIA Framework Components
- Support for Web / Internet-based standards
- Global acceptance in industry
- Whether the data model is captured in open and/or vendor neutral format
- Supported by an open standards organization committed to collaboration with other standards groups to ensure interoperability
- Industry proven approaches
- Software and Hardware vendor participation in the process and commitment to use the results in their products
- Critical mass of usage and support for adoption
- Interoperability with the standards already used by customers and suppliers
- Data protection support
- Based on the results of science, technology and experience
- Promoting optimum community benefits (win-win)
- Providing clear business value & supports the industry business strategy and requirements
- Alignment with overall architecture strategy that is driven by the business
- Leveraging available standards and technologies, first within aerospace, then in the broader market
- Partnership with aero-related groups to increase adoption and lower workload
- Support Global Design and Supply Chain
- Labor Costs for Implementation and Maintenance

- Hardware Costs for Implementation and Maintenance
- Software Costs for Implementation and Maintenance

More detailed information on the scenarios used is available on request.

5 Project Methodology and Decision Tools

Member and Supplier Surveys

A survey was prepared and disseminated to AIA Member companies and to aerospace Suppliers part of the AIA Supplier Management Council (SMC). The survey was designed to identify the full range of issues that currently are being experienced by companies required to share data both internally and externally. To support the EDIG's objective, the survey collected information in several areas:

- To gauge current standards-based practices used to exchange various types of engineering data on development programs, e.g.
 - Specifying application independent data exchange standards, such as [STEP](#) (STandard for the Exchange of Product model data), or [EIA](#) (Electronic Industries Association)-[836](#)
 - Using visualization specifications, such as [JTOPEN](#) or [U3D](#)
 - Leveraging commercially available integration tools, such as Theorem Solutions or STEP Tools, vs. relying on internally developed point-to-point integrations
 - Using methods for ensuring the integrity of data that is exchanged via standards
- To gauge current non-standards based information exchange methods currently in practice
 - Specifying common applications, such as particular versions of commercial products
 - Performing manual translations, interpretations, and/or verifications
- To determine how standards are actually used in facilitating data exchange, including
 - Identifying which standards are currently used as the basis for data exchange between applications and/or data repositories
 - Determining the degree that standards are tailored or extended as needed to support required data exchanges on programs, and why
 - Determining if adequate methods exist to guarantee the quality of standards based data exchange
- To determine the degree to which the capabilities and limitations of existing interoperability standards are understood
 - Identifying enhancements needed to existing standards to enhance their understandability or effectiveness.
- To identify standards that should be developed to support outstanding data exchange requirements.
- To identify reasons why existing standards are not being leveraged

The responses were compiled and analyzed. Survey results are available via a link provided in the appendix.

3-7-2008

Comparative Analysis of Leading Standards

A comparative analysis of the leading data exchange Standards from ISO and GEIA was performed by a subset of the EDIG. The analysis was captured in Pugh Matrix format, using commercial tools as a capability baseline. The Standards were evaluated for scope and depth of coverage, when mapped against the Product Engineering Lifecycle scenarios.

The comparative analysis (PUGH Matrix) is available via a link provided in the appendix. ([See Appendix 9.2](#))

6 Summary Findings

Survey Summary

Responses were received from both the supplier community and the Prime Contractors. Survey results showed a significant interest on the part of AIA Member companies and Suppliers in an implementable Standard. All responses rated data interoperability as very high priority, with significant potential benefit to the business. Suppliers in particular cited data interoperability as a significant cost factor when dealing with Tier-ones and Primes. Aggregate results were consistent from both the Suppliers and the Prime Contractors.

Most respondents have struggled or failed to implement a Standards-based data exchange solution thus far. Little more than half of the respondents believe that information flows seamlessly to and from their internal systems. In areas where more mature Standards are available (e.g. 3D Design), companies tended to have a balanced approach between the use of common tools and Data exchange standards for interoperability. In areas where standards were regarded to have less maturity, such as requirements management and systems design, the predominant approach was to use common tools.

There appeared to be less concern for Interoperability internally than externally. Very little in-house development of data exchange tools or translators were indicated except in support of BOM data exchange. This was consistent with the team's expectations, since BOM data tends to be legacy systems dependent from a format and computing platform perspective.

Identity Management did not seem to be well-understood or was not listed as an immediate concern to the respondents, except when dealing with customer and supplier data. Potential liability issues appeared to be the primary concern in this area.

The biggest cited challenge was change management. The complexity of the systems in use has a significant impact on the ability to integrate. Large variability in data was a cited obstacle.

It was noted that in all cases, the scope of usage of Standards-based integration appeared to directly correlate to the maturity of the Standard.

Comparative Analysis Summary

The comparative analysis of the leading data exchange included Standards from ISO (STEP AP 203, AP233, AP239, and AP214) and GEIA (GEIA-STD-007 and EIA-836). The weighted criteria from the Product Engineering Lifecycle scenarios included process-based, design data, data management, and architectural criteria, in five major areas.

The outcome showed the PLCS (Product Life Cycle Support) Standard, ISO 10303-239, as having the greatest scope and depth of coverage, when mapped against the Engineering lifecycle. It also scored highest based on architectural criteria.

7 Recommendations

Based on the outcome of our research and analysis, the EDIG recommends that AIA Member companies and Suppliers transition to a Standards-based interoperability solution utilizing PLCS (ISO 10303-239) and its associated DEXs. The maturity and scope of coverage of the Standard will provide coverage for the widest cross-section of engineering applications now in use.

In order that AIA Member companies and their Customers maximize the benefits of the Standards-based interoperability tools, Software Vendors must provide comprehensive support for the selected Standards. Accordingly, we recommend that AIA Companies make complete support of the relevant parts of the PLCS model and associated DEXs a primary selection criterion for software acquisitions, and that they communicate this criterion to the Vendors. Additionally, we recommend that AIA Members and their customers make the same level of support among parties as selection criterion for all commercial and DoD acquisition programs, to fully realize the expected business benefits.

In order to minimize the time and cost required to implement, and to maximize the potential benefits, we recommend that aerospace companies implement Best Practices in standards-based interoperability as described in the Engineering Data Interoperability Guide, which will be published by this team in 1Q 2008. It is also recommended that PLCS be adopted as part of the overall AIA eBusiness framework, seeking endorsement from all the affected stakeholders (e.g. SMC, EMC/TOC, and eBSG).

There are several benefits, from a cost and cycle time reduction perspective, to be realized through the implementation of Standards-based data interoperability. The quantification of such benefits will be unique to each company, as this analysis is dependent on factors such as the operating business model, the capability and maturity of their existing tools and processes. The EDIG has developed an example template that can be used as a tool to support quantifying the benefits of a standards-based interoperability approach, from an implementation, change and maintenance perspective (see [Appendix 9.2](#)).

NIST Reports

The National Institute of Standards and Technology (NIST) undertook a major research effort in 2002 on the Economic impact of STEP on the transportation equipment industry in the US. The report "[Economic Impact Assessment of the International Standard for the Exchange of Product Model Data \(STEP\) in Transportation Equipment Industries](#)", concluded that the aerospace industry had the potential to save over \$250M per annum through using STEP, divided between reduced costs of operating legacy software, and eliminating data re-entry/file transfer costs. This the scope of this savings related to the design and development phases only. In 2001, only about \$30M of this was being realized.

NIST also released a study, [NISTIR 7339](#), in August 2006 - "Analysis of Standards for Lifecycle Management of Systems for US Army --- a preliminary investigation". The study highlights the importance of ISO 10303, the Standard for Exchange of Product model data (STEP), noting that it appears to offer the greatest savings potential for lifecycle support management in comparison to a number of other standards.

8 Topics for future consideration

While the efforts of the EDIG to date provide a good baseline with regard to the ability of a standards-based data exchange solution to meet aerospace industry requirements for data exchange within the Product Engineering lifecycle, considerable additional effort is needed to expand the scope of recommendations and support to the entire product lifecycle. More effort is also required to provide implementation guidelines and best practices for adopters. Recommended additional efforts are summarized below.

8.1 Engineering Data Interoperability Guide

A critical key to the success of Standards-based data exchange lies in its implementation. History and experience show that even good tools can fail as the result of poor implementation or architecture. It is therefore the intent of the EDIG to author guidelines for the implementation of Standards-based data exchange, based on industry best practices, successful implementations, and the associated lessons learned. This guidance will be structured in alignment with the EIC product lifecycle development business scenarios, and is intended to include coverage of data modeling, architecture, application integration, and system deployment.

8.2 Development of guidance for priority scenarios.

It is recommended that the Engineering Data Interoperability Group develop business guidance for supporting each individual data exchange scenario using PLCS DEXs, in a format consistent with the emerging EEIC eBusiness Interoperability Guidebook.

8.3 Phased Extension of recommendations over remaining Scope of Product Lifecycle.

It is recommended that the Engineering Data Interoperability Group proceeds to identify and prioritize engineering information exchange scenarios to be supported by exchange standards, and to develop business guidance for applying standardized solutions to those scenarios. Additional scenarios are to be considered, beyond the scope of the initial project.

8.4 Adoption of PLCS as a component in AIA eBusiness Interoperability framework.

It is recommended that ISO 10303-239 (PLCS) be adopted as a component of the AIA eBusiness Interoperability Framework, with an appropriate adoption statement agreed by EMC and EEIC, and additional guidance for using and extending the information models.

- **Guidance for using DEX.** It is recommended that industry guidance for the development and use of PLCS Data Exchange Specifications (DEX) be generated in cooperation with the EEIC, and made available through the AIA website. The guidance material can be based on the generic material under development in OASIS.
- **Guidance for extending APs.** It is recommended that industry guidance for extending existing PLCS models to include additional information types in a manner consistent with the underlying standard should be generated in conjunction with the EEIC and the standards developers, and made available via the AIA website.

8.5 Work with Standards Bodies to Address Gaps.

The analysis of PLCS against the full range of Bill of Material business scenarios indicated that there could be some shortfalls against the scope of information required to transfer product information from the PDM environment to manufacturing execution systems, and for the feedback of actual product configurations from MES to ERP environments. It is recommended that the Engineering Data Interoperability Group identify the specific information requirements for these scenarios and propose appropriate enhancement requests to the PLCS standard. The group should also identify any new DEXs that may be required to support its needs. The requests should be submitted and executed through active participation of AIA members in the US TAG to ISO TC184/SC4, the PDES, Inc consortium and the OASIS PLCS TC.

9 Appendices

9.1 AIA Interoperability EDIG Organization:

9.1.1 Authority

The EDIG is a working group chartered by the AIA Engineering Management Committee (EMC). The EMC is authorized by the AIA Technical Operations Council (TOC) and is responsible to the Executive Committee of the TOC.

9.1.2 Objective

The EMC objective is to develop and promote the consensus decisions or conclusions of AIA member companies on common, non-competitive engineering management issues and initiatives.

9.1.3 Resources

The EDIG has been staffed by Subject Matter Experts from many AIA Original Equipment Manufacturers on the EMC, Electronic Business Integration Committee. Several Suppliers also participated, representing the AIA Supplier Management Council (SMC).

9.2 Referenced Working Documents

The following documents are referenced in this Position Paper. As stated, all documents are available upon request.

- **Example business Case Template**

The EDIG developed an example business case template that demonstrates how it is possible to quantify the business value of implementing Standards-Based data exchange. This is not intended to be a one-size-fits-all solution for all businesses, in recognition of the fact that each business has unique requirements and criteria for establishing business value. It does, however, demonstrate one way in which benefits can be characterized and communicated to company leadership.

http://www.aia-aerospace.org/pdf/temp/use_case_qfd_presentation_v2.pdf

- **Interoperability Group Member Survey**

This is a copy of the survey provided to AIA member companies, regarding the priority, value and state of their data interoperability implementations.

http://www.aia-aerospace.org/pdf/temp/stds_based_interop1.3.xls

- **Interoperability Group Supplier Survey**

This is a copy of the survey provided to AIA Supplier Management Council (SMC) member companies, regarding the priority, value and state of their data interoperability implementations.

http://www.aia-aerospace.org/pdf/temp/data_interoperability_survey_7-10-07.pdf

- **Interoperability Group Comparative Analysis Pugh Matrix**

This is a copy of the working spreadsheet-based Pugh matrix that served as the basis for analysis of leading data exchange standards.

http://www.aia-aerospace.org/pdf/temp/interoperability_oem_survey.pdf

- **Interoperability Group Implementation Guide**

A Guidebook form for implementation of a data exchange capability is currently under development.