A Recommendation to the Department of Defense to Adopt the S1000D – the International Specification for Technical Documentation

A Discussion of the Merits and Value of S1000D In the Context of Interoperable Data

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Executive Summary

Aerospace Industries Association White Paper:

A Recommendation to the Department of Defense to Adopt the S1000D – the International Specification for Technical Documentation

A Discussion of the Merits and Value of S1000D In the Context of Interoperable Data

February 29, 2008

There is industry consensus that S1000D ought to be the preferred specification for all technical documentation procured by the Department of Defense. S1000D addresses and corrects many problems related to technical data management and concurrency. Included in those problems is the inability to keep training content current with authoritative technical sources. S1000D enables all technical documentation in support of a common system, including training, to be accurate and current throughout a system's life cycle process.

For the first time, program and logistics managers can manage technical data like a configuration item. S1000D's unique naming convention applies the equivalent of a bar code on a chunk of information. That chunk is called a data module, and can be managed like inventory in a warehouse. The metadata describing the data module is contained in the same file as the data it describes. This portable feature allows for interoperability, and it also allows relationships to be established between modules and the systems they document.

The self-contained aspect of data modules consolidates industry and government business processes into a smaller technical footprint across an enterprise. Web services, COTS tools and other applications can be developed in support of a known format, a known set of metadata, and a known file naming convention. S1000D eliminates guess work about programming for unknown electronic formats, promotes reusability and is a centerpiece for a standards-driven data management policy.

The Aerospace Industries Association recommendation to Acquisition, Technology and Logistics within the Office of the Secretary of Defense (OSD/AT&L) is to adopt S1000D as the preferred data format for all technical data in support DoD-acquired systems.

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Aerospace Industries Association
Rosslyn, Virginia

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1. Overview

S1000D is an international specification for producing technical publications. It is co-owned by the European Association of Aerospace Industries (ASD), the Aerospace Industries Association (AIA) and the Air Transport Association (ATA). Although its roots are in the aviation industry, the specification supports any type of air, land or sea system or machinery that requires maintenance, operation and configuration to parts and supplies. The Advanced Distributed Learning (ADL) Initiative, a program of record based in the Office of the Secretary of Defense (OSD) within the Personnel and Readiness Office (P&R), has introduced training support requirements in S1000D.

S1000D is able to handle a wide range of information types such as descriptive, procedural, maintenance schedules, fault isolation, crew/operators, testing, and training. These information types are fundamental elements in designing, developing, and maintaining electronic performance support systems and job aids used once formal instruction is completed.

S1000D uses international standards such as the Standard Generalized Markup Language (SGML), Extensible Markup Language (XML), and Computer Graphics Metafile (CGM) for producing and using documentation that support the maintenance and operation of complex equipment, machinery, and systems. It works as a lifecycle logistics tool that links data to the systems it supports. It is industry-based, it carries metadata structures that reflect in-service engineering business practices, and it provides the opportunity to reuse content across a program.

AIA and the industry groups that build and manage the specification recommend that Acquisition, Technology and Logistics (AT&L) at the Office of the Secretary of Defense (OSD) adopt S1000D as the preferred industry data specification for new DoD system acquisitions.

This White Paper examines and discusses the merits of that recommendation.

2. Industry Management of S1000D

Amongst many S1000D working groups, the U.S.-based U.S. Specification Management Group (USSMG) and the international Technical Publication Specification Maintenance Group (TPSMG) have taken the lead in developing and maintaining the S1000D specification. The USSMG evaluates U.S.-generated change recommendations for S1000D. To assist the USSMG in defining and submitting U.S. interests toward the specification, the U.S. Specification Implementation Group (USSIG) was established under the USSMG to recommend detailed technical solutions, perform feasibility reviews, submit change proposals, and advise USSMG on a course forward. AIA manages the USSMG and the USSIG.

The USSMG and USSIG members represent a mix of DoD representatives and major American companies. Those companies include but are not limited to Boeing, Lockheed Martin, Raytheon, SAIC and Computer Sciences Corporation. Together, members shape

S1000D into a specification that best meets the data management requirements for their DoD customers.

On the international side, representatives from France, Austria, Holland, Germany, Italy, Spain, Sweden, UK, and USA comprise the TPSMG. The TPSMG has final approval of all changes made to S1000D specification. To help support with decisions and advances within the specification, the TPSMG established a technical development and advisory group, Electronic Publication Working Group (EPWG). The TPSMG and EPWG represent a mix of international companies that include but are not limited to Airbus, Saab, Rolls Royce and Dassault Aviation.

The most important factor in the development and oversight of S1000D is that it is an *industry specification.* Industry is the primary advocate for developing government-procured systems, and it is industry that sees the benefit in developing documentation in S1000D.

Industry and Government benefits of using S1000D are:

- Ensuring system design changes and system documentation are current
- Reducing maintenance costs for technical information
- Allowing a subset of information to be generated to meet specific user needs
- Generating many different output forms from the same base data set, which ensures strong and efficient data configuration at the user interface level
- Allowing neutral delivery and data management, (to stakeholders, e.g. the training community)

S1000D offers the following advantages to its users by.

- Reducing support costs, provides content modularity and reuse
- Enabling data sharing across different computing platforms
- Allowing users to view electronic documentation via a common web browser or text viewer

Hundreds of individual DoD contractors that specialize in life cycle technical documentation have volunteered tens of thousands of hours over seven years to shape S1000D into a specification that can support all services and their equipment.

3. Technical Data Problems in the Life Cycle Environment Addressed by S1000D

The need to enhance technical systems data management in the purview of Acquisition, Technology and Logistics (AT&L) is driven by information growth, the capability of XML-based standards, and the desire to improve operational readiness. These drivers are relevant to AT&L because they address technical data management problems that cannot be solved by vendor solutions alone. Vendors bring product and support data to the DoD marketplace, yet DoD customers do not have an arbitrating device that can ensure compliance to standard data management practices essential to lifecycle maintenance. That arbitrating device must be non-proprietary, industry specific, and extensible.

S1000D addresses the following problems:

- System life cycle content is acquired in proprietary formats and not coordinated together. For example, technical manuals may be bought in PDF, planned maintenance content in Microsoft Word, and training courses in Flash. This is a problem because proprietary data formats do not carry life cycle-specific metadata. S1000D does carry life cycle-specific metadata. Proprietary data formats lead to the following problem:

- Logistical metadata are not applied to life cycle information. Proprietary formats do not reflect business processes in a content management context. Applicability and integrated logistics practices are hampered by a lack of recognizable metadata across related documentation. This is a problem because the absence of logistical metadata across technical documentation prevents relationships to be made between content. S1000D establishes relationships between content by providing logistical metadata tied to assemblies. Lack of logistical metadata on technical content leads to the following problem:

- Inability to automatically track engineering change proposal (ECP) impacts on technical documentation. An ECP will cite which logistical control numbers (LCNs) are associated with a system assembly and effected by a design change. The LCNs are not associated with technical data at the data object level. This is a problem because a data manager cannot manage and assess in real time the potential impact of an ECP across all system documentation. S1000D can provide an immediate assessment of affected life cycle data caused by an ECP through the equal distribution of LCN content across all life cycle documentation. The lack of LCN metadata content leads to the following problem:

- Technical training content developers are notified of system changes after technical manuals have been updated. Training production schedules then lag months, even a year behind the deployment of a redesigned system. This is a problem because training content is not developed prior to the deployment of the system it supports. S1000D can solve the lag time in technical change notification to training developers by building training content in S1000D. Both technical data and its supporting training content would reside and be managed in the same common source database (CSDB). The lag in change notification to training content developers leads to the following problem:

- There is a “lack of readiness” risk for operational and maintenance performance in the fleet. Training is not delivered before or while new and updated systems are deployed to the fleet. Schoolhouses risk teaching concepts and operations that could be one baseline installation version behind in the fleet. This is a problem because time and resources spent teaching and learning new systems in the classroom may be outdated by the time the learner arrives at the workplace. Training must start over again on current systems. S1000D can help solve

concurrency and readiness issues by enabling the distribution of accurate learning data to the classroom and to the workplace. These problems are indicative of the following reality:

- Life cycle logistics teams are not integrating technical content development efforts. The drivers to enhance technical systems data management remain: information growth accelerates, XML improves capability, and operational readiness remains in the national interest. S1000D addresses these issues through a fundamental concept: data interoperability enabled by data standardization.

The logistical advantage in tracking program technical documentation using S1000D is rooted in its standardized naming conventions and metadata structures. S1000D data conventions and structures will drive next generation in-service engineering processes by enabling enterprise lifecycle processes. Web services aimed at locating program logistics content within an S1000D data module will modernize technical data management and production.

4. S1000D Turns Data into Configuration Items

S1000D does for technical data what inventory control mechanisms do for parts management: Data becomes a configuration item that must be created, tracked, modified and distributed. The rigor applied to data management ought to come from some type of neutral source in much the same way Universal Product Codes (UPC) provide standardized barcodes for tracking inventory. S1000D is an industry specification for the life cycle maintenance of air, land, and sea vehicles, but it can also apply to any technical system that requires parts management, operation, and life cycle maintenance.

S1000D's highly specialized information modules (19 in all), collectively provide mechanisms to describe operations and maintenance, troubleshooting, wiring diagrams, procedures, parts lists, and process-oriented content regardless of the system being documented. Each unique information module carries the same metadata inside its own file. When content is updated in S1000D based on a system design change, S1000D provides data filtering mechanisms from within the file's metadata to match the new system configuration. A key driver for using S1000D is its ability to identify the data modules needing to be changed when a design system change is required.

This is the power of data as a configuration item. Information managers need to know exactly what content across all information products must be reviewed and changed if the supported system requires an alteration. If the system is altered, then the data must be altered. Using S1000D, information managers can manage content the way an inventory specialist manages warehoused parts.

5. S1000D Uses Metadata to Track Content Through the Acquisition, Production and Delivery processes.

S1000D uses a Data Module Requirements List (DMRL) to ensure the accurate acquisition of all project content. A DMRL is an XML file that lists every data module code (DMC) used in the project. The DMRL is used to validate that data requirements specified in the statement of work are delivered to the customer. The DMRL supports planning, reporting, production and configuration control. The DMRL does not specify metadata in the data module.

Each S1000D data module carries the same set of metadata structures regardless of topic type. The metadata are divided into two components: identification and status. The identification piece carries the naming convention through the DMC. The status component carries production information such as security and quality assurance. One component of metadata might link an equipment design change to a required change in the technical information. When a particular assembly is either replaced or redesigned, that assembly can be matched to any data module that requires a review. For example, the data module contains learning objectives that must be updated. Or maybe the data module contains procedures that must be revamped. Or maybe a series of test procedures must be reconstructed. Regardless of whether the data module requires a change or not, there is peace of mind knowing that all relevant content has been reviewed against approved system design changes. Sections six and seven discuss two types of metadata: file naming conventions and configuration.

6. S1000D Uses a Unique File Naming Convention That Brings Configuration and Logistics to Technical Data Management.

S1000D files are named according the DMC. Each data module contains a discreet piece of information supporting a discreet aspect of a system. A discreet piece of information is a thematically related set of content mapped to a particular task (e.g. changing oil in an engine, a list of materials associated with an operation, or a test procedure for surface cracks using magnetic materials). The data module name is semantically discreet based on naming conventions in the specification. The data module name retains its integrity even as a system is deployed to multiple platforms. The integrity is ensured by the connection between the model identification code and the corresponding system, subsystem and unit-assembly codes in the DMC that describes the system. Logistically, these modules are managed like any other content in a common source data that tracks applicability and distribution.

Naming conventions in an XML-based specification like S1000D are possible when the information structures are standardized according to industry conventions. The conventions offer data uniformity to multiple industries where life cycle maintenance and configuration are business process requirements. Figure 1 illustrates the standard DMC

breakdown structure that is applicable to any industry where system maintenance and operation is required.

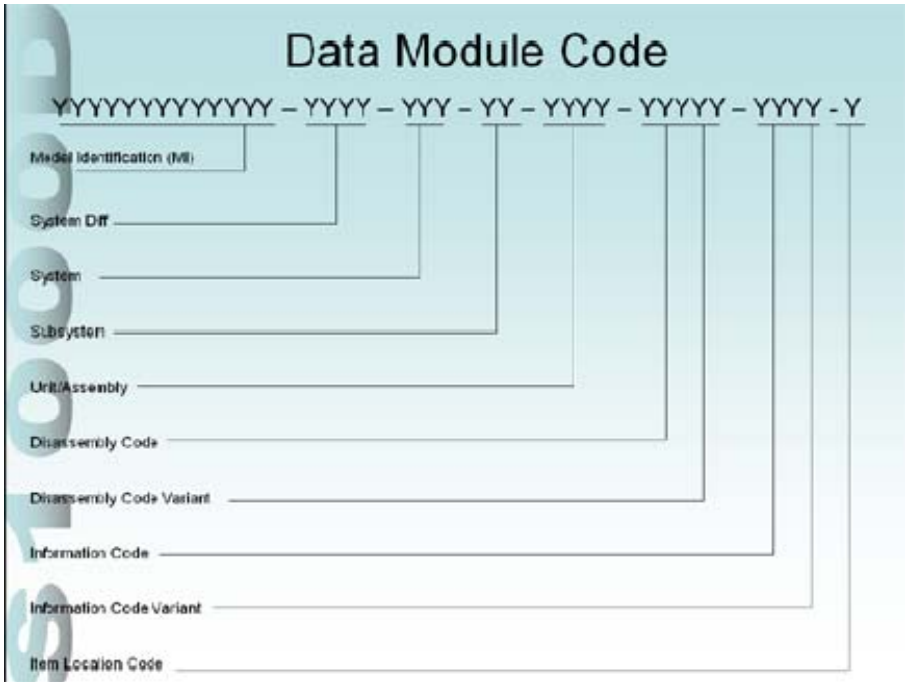

Figure 1 - Standard DMC breakdown structure

There are two other naming conventions specified in S1000D. Those conventions are applied to illustrations and publication modules (PM). PMs are addressed in section eight. Illustration names are referred to as "information control numbers" (ICN). The ICN contains a collection of alpha-numeric metadata that when strung together forms the name of a graphic, schematic, or other visual representation of a system. The <icn> is the link between an illustration, a publication and parts lists.
Figure 2 illustrates the naming convention.

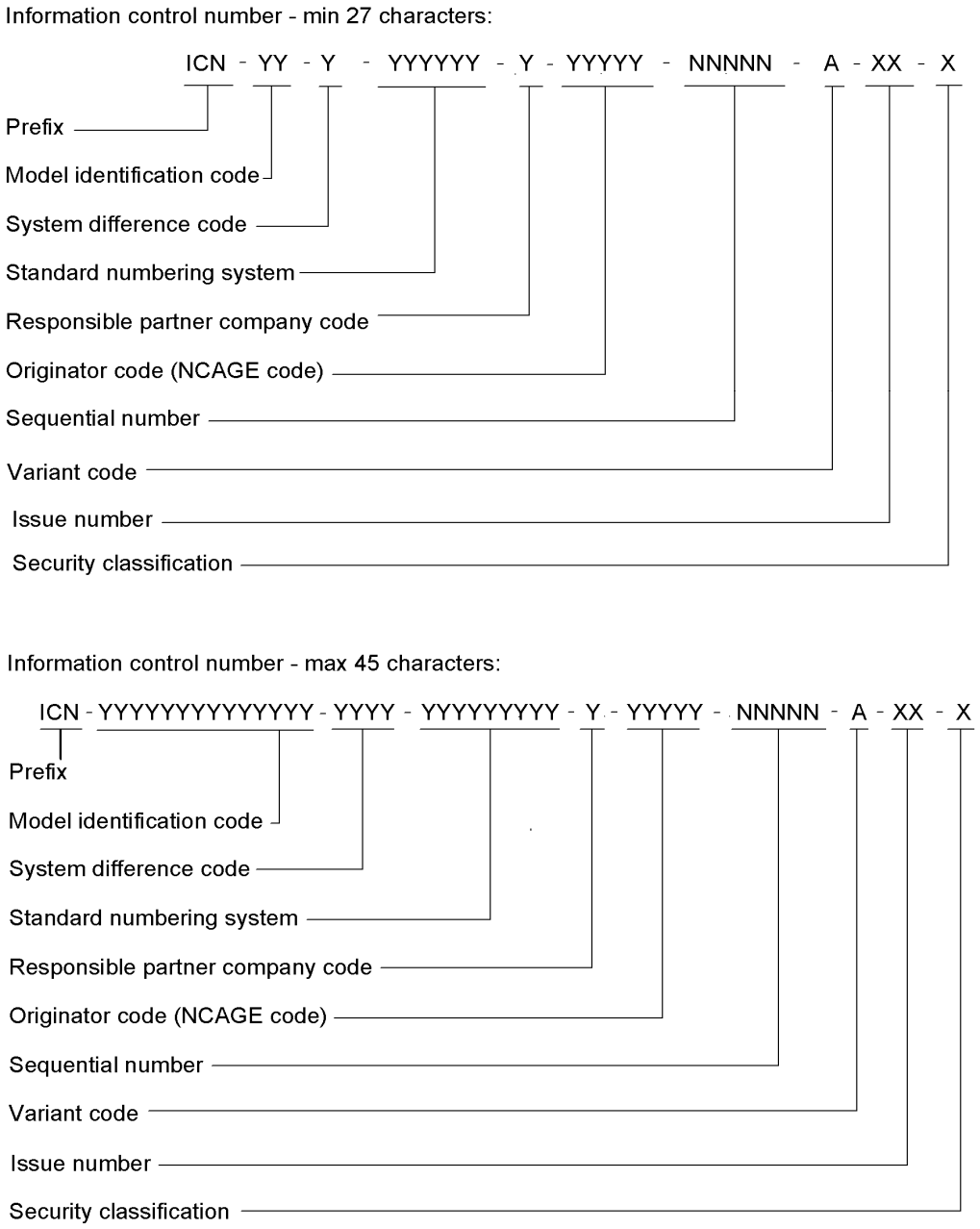

Figure 2 – Standard ICN Breakdown Structure

7. S1000D Configuration Metadata Establishes Relationships Between all Technical Content That Supports a Common System.

S1000D establishes relationships between assemblies and parts to data. This is accomplished by using logistical control numbers in the status component of the data

module metadata. By assigning those numbers to a data module, a data manager can assess exactly what content is affected by system design change. At the same time, a data manager can assess what reused data modules affect various technical publications. This is a powerful tool that ensures all system technical documentation is managed and updated concurrently as the design change is implemented. S1000D metadata contains the following configuration metadata:

- *System Breakdown Code <sbc>*: The SBC contains the logistical control number that numerically defines assemblies and sub-assemblies. Any technical content in a publication that addresses a particular assembly will receive a LCN associated with that assembly. The <sbc> is the link between data and the way it documents how a system is broken down into assemblies and parts.

- *Finctional Item Code <fic>*: The FIC contains the logistical control number that numerically defines where the system fits in the context of a land, air or sea vehicle. The <fic> is the link between data and the way it documents how the system is classified on the air, land or sea vehicle in relation to other systems.

- *Part Number <pnr>*: The PNR contains the number which groups part numbers together as an inventory detail. Any technical content that addresses a particular assembly or sub-assembly will receive a number associated with the parts that comprise the assembly. The <pnr> is one link between data and parts lists.

S1000D contains other types of metadata; however the above list yields the essential relationships to life cycle logistics that can be applied across all technical documentation supporting a common system. That common system can be land-, sea- or air-based. When different system programs use a common digital data format, it is possible for DoD services to use common programs to manage, produce and distribute data. Life cycle metadata standardization will reduce the DoD enterprise technical footprint to the degree that common business rules are followed across the services.

8. **S1000D Data Modules Aggregate into Publication Modules.**

A data module in and of itself is not an information product, just like a single part is not a complete system. Data modules, like engine parts, must be assembled into a publication. S1000D has a data assembly mechanism to collect data module names into an XML file called a publication module. The publication module does not *produce* output. It's a staging area that creates an inventory of data modules intended for a particular information product. Then, an application, or a style sheet, or a processing file, identifies the data modules required for a particular output instance. That instance could be a manual, or a set of procedures, each intended for the right data for the right time.

A Publication Module contains a naming convention called a Publication Module Code (PMC). The PMC contains a collection of alpha-numeric metadata that when strung together forms the name of a collection of data modules intended for distribution. A

PMC may identify an entire manual, or may define a discreet set of tasks that entail a collection of modules intended for distribution. The PMC represents the aggregation of content used for a unique purpose. **Table 1** describes the naming convention.

PMC breakdown	Length
Model identification code	2 thru 14 alphanumeric characters
Issuing authority (eg NCAGE)	5 alphanumeric characters
Number of the publication	5 alphanumeric characters
Volume number	2 numeric characters

Table 1 – Publication Module Naming Convention

The publication module works as a data module gathering point structured in XML. It is a flexible aggregation tool that allows a publication to be any size and used for any purpose. The publication module will not know or care whether the collection is for training, or for on-demand data, or for a 5000 page catalog. It is also unaware if the output product will be linear or non-linear. Furthermore, the publication module contains *its own naming convention*. But there's an additional benefit in S1000D: Publication module names reflect the information product as well as being a tool for aggregating data modules in support of a product version. **Figure 3** illustrates how select data modules are aggregated into publication modules, while reusing a specific data module in two outputs.

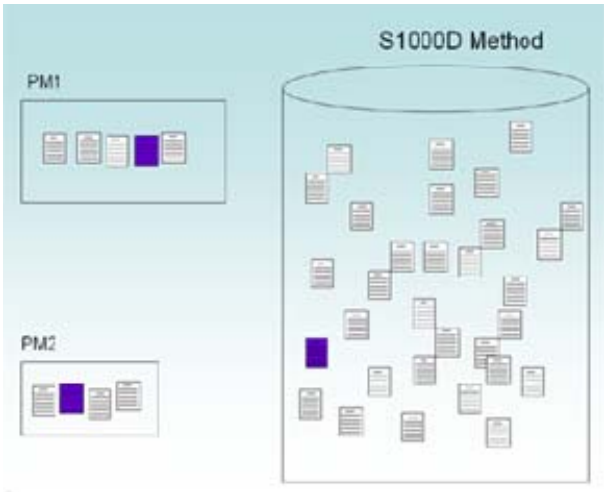

Figure 3 - Select data modules aggregated into publication modules

9. S1000D Promotes Data Reusability

The data module information architecture in S1000D enables technical data to be chunked into small files. These files can be aggregated by the publication module for the creation of unique output products. Therefore, one data module can be referenced by one

or more publication modules. This is the reuse mechanism in S1000D, a mechanism that allows for technical data content to be inserted into supporting courseware without the expense of data transformation from one format to another.

Data reuse does not happen on its own. Technical data managers and authors must be aware of and plan for content to be used in multiple outputs. Whether the reused content is in support of multiple configurations, the reuse of technical information in training products, or the reuse of unique graphics and multimedia across a suite of products, coordinating the reuse must be implemented in the publication module.

Inherent in the reuse objective is cost savings. The reuse can achieve the objective of "buy once, use many times." The ability to track common content across information products relieves the acquisition manager of repurchasing the same data if it is deployed to multiple outputs. At the same time, a data manager can assess what reused data modules affect various technical publications.

10. S1000D Data Structures Promote the Development and Use of Standardized COTS Toolsets

Common business rules and a common digital format are the foundations for standardizing toolsets and applications, while still encouraging choice and competition in the data management market place. In the legacy specification environment, the variations of compliance are varied in that proprietary solutions are the norm. DoD programs should not be trapped by proprietary life cycle solutions. DoD programs should dictate how its technical content is instantiated by XML-based specifications and encourage the market to support specifications through thoughtful implementation. A cross-service specification obviates proprietary solutions and encourages a fidelity to life cycle processes.

A variety of vendor products support S1000D data structures and data processes that originate from the very industry that produced the specification. The key here is that S1000D data modules produced in one vendor's S1000D product will import into another vendor's S1000D product. Standardized COTS toolsets support the development of the following S1000D data types:

- Business rules
- Illustrated parts
- System description
- Fault isolation
- Maintenance schedules
- Wiring Diagrams
- Crew requirements
- Database processing

The above constructs support air, land, and sea content across all of the Services. The neutrality is evident by the application of common logistics metadata in each data module

construct. S1000D accommodates DoD content that requires configuration management without anticipating which vendor will implement the specification. Each construct is an information model that represents actual content that DoD programs are required to produce to support highly technical systems. Interoperability starts with an XML-based information model that mirrors the very content it intends to support and is then enabled through standardized toolsets that support S1000D's intentions. These intentions include support for page- and screened-based output using XML and web technologies. As S1000D is a reflection of industry that supports DoD, DoD policies must reflect S1000D as a governing specification in the maintenance of program content.

11. **Integrating Technical Data with Training Content**

There is a growing recognition that technical data development and its supporting technical training development ought to be created together. This holistic perspective has never been possible under current organizational practices. For example, the training community often receives technical manuals via distribution lists … the same lists used to distribute manuals to regular end users. This practice lumps training production organizations with end users that ought to receive updated training content in sync with updated technical manuals. The distribution list mechanism puts training readiness at risk because instructional content is developed well after the system technical documentation is deployed.

Solving the data problems that naturally occur between organizations that depend on each other will require attention to infrastructure and net-centric communication. Knowing what the problems are will suggest solutions. For instance, the training community does not have direct access to technical data assets in a database. The training community does not have the opportunity to pair task analysis with learning objectives development during the technical design phase. Those are the moments when true content reuse can be planned across the program enterprise.

Coordinating the technical data and learning communities must start with a common denominator. Certainly, each has a common system to support; each has a common interest in using specifications. These elements have not been enough to motivate and shape a collaboration strategy. Collaboration cannot begin with a networked infrastructure or common source databases, because these elements do not exist in a mold that unifies the communities. The approach to a collaborative strategy for content development ought to start with basic requirements: *what are the technical data requirements for training, and how can those requirements be met?*

The natural commonality between the technical data and the supporting learning content is the subject matter. Whether content is fashioned as technical data procedures about a system or fashioned as instructionally designed content meant to instruct the procedures, the subject is still the procedures themselves. Common topics can lead to common file naming and identification. It can also lead to common configuration and life cycle management metadata. The collaboration is enabled through the appropriate choice of a data specification to support the collaborative and management needs of the content. The

Advanced Distributed Learning's (ADL) position on which specification to use is to drive the choice based on data life cycle requirements: the right spec for the right data environment. By endorsing S1000D, AT&L encourages collaboration between technical data and related technical training communities.

The primary reason for using S1000D for training content is not because of reuse. Reuse is a bonus if and when it can be achieved. The primary reason for using S1000D is to name, identify and structure technical training and technical data content during *life cycle configuration management.* It is crucial for a data manager to know at a given point how an engineering change proposal effects the entire data support environment. There must be a common thread that is strung throughout the data. S1000D provides common threads which enable data agility. Managers can track changes in near real time.

The next step for collaborative content development is to assume a larger role for S1000D beyond technical data and training. Those data products are only two elements within the entire system life cycle environment. All information products that document planned maintenance, operations and maintenance, troubleshooting, wiring diagrams, procedures, parts lists, testing and process-oriented content join with technical manuals and training to form a more complete picture of all content written to support a system. Using S1000D to integrate this content would transform technical content into configuration items, for the content is written expressly to support configurable systems. Only then will standards-based data interoperability be truly viable.

12. Using S1000D as Basis for Life Cycle Logistics Process Development

Integrated Logistics Support (ILS) is the accumulated processes that support a product to its final destination: the user. Logistics include acquisition, storage, delivery, change management, customer support, redesign processes, sustainability, installation and disposal … any activity that supports a product or system, other than actually using the product by the intended audience. Each logistical activity requires documentation. Some goes to the customer, some remains in-house. Regardless, if a product design change or customer feedback results in a logistical change, then the documentation needs to change. For that reason, S1000D ought to be applied to all technical documentation supporting a common system. S1000D will link product design changes to supporting data. The link enables timely content updates and results in product readiness.

Technical documentation includes planned maintenance, training content, operations and maintenance, troubleshooting, wiring diagrams, procedures, parts lists, testing and process-oriented content …any content that represents one aspect of life cycle support. Life cycle technical documentation ought to be coordinated into an industry-specific common digital data format. When all content is named, identified and structured into a common digital data format like S1000D, common life cycle metadata structures will be carried in each data module regardless of content type.

There are many ways to implement a standards-based solution for interoperable data. Ironically, standards do not restrict implementation, but optimize options based on a common set of rules. HTML is the common markup for all websites, which has not impeded the diversity of styles and implementations. In fact, HTML's success and popularity lead to a demand for more web-based capabilities. That demand gave way to XML. XML can be used as a common digital data standard upon which interoperability can be based. Current S1000D prototyping is showing that a common markup language can support a variety of processing and output.

It is particularly useful to start with a common digital data format for all related technical data. It helps reduce the number of web-based applications required to process enterprise content. For example, if a Navy base in California uses S1000D to document a ship system, and a submarine base in Connecticut uses S1000D to document a submarine, then either organization could use a common web service that identifies any data module that is subject to change, with the ability to update it on the fly thereby assuring both organizations distribute correct information.

The variety of technical documentation supported by S1000D is scoped down to content that support a complex array of machinery, weaponry, vehicles and other systems that have long and expensive lifecycle requirements. In this regard, the power of S1000D is that it is *an information specification and not simply an XML architecture.* A specification that does not feature an information component will not serve the complex configuration and life cycle requirements demanded by program managers. S1000D does much of the data life cycle heavy lifting *because it supports a complex process.*

13. Recommendation and Summary

The desire for net-centric warfare will require data interoperability and agile distribution systems. That desire can only be achieved in an environment grounded by specifications. Perpetuating proprietary data formats and vendor-driven life cycle management solutions does not reflect the international will that embraces the value of S1000D and data reuse. The unifying effect of S1000D on integrated logistics sharpens and reduces the technical footprint for data management because common source databases and web services will serve as technical interfaces to business processes. Common metadata across S1000D-based information products enables automated business processes to be accessible across the enterprise. Accessibility is the key to delivering the right data to the right person at the right time. The precision required to deliver the right data at the right time can only be derived from a refined information naming system that turns data into configuration items. For the first time, training content and other logistics content can be configured together so the global impact on system documentation can be determined from a single ECP, a capability previously unrealized using varied data formats. S1000D is the only industry-based, internationally recognized, technical data specification that is designed to support the lifecycle management of documentation supporting all the systems DoD endeavors to acquire. AIA recommends that AT&L adopt S1000D as the preferred industry data specification for new DoD system acquisitions.

14. For Further Reference

- S1000D, Version 3, International Specification for Technical Publications utilizing a common source database. http://www.s1000d.org

- S1000D/SCORM Redundancy Analysis and Conversion Guidelines, August 16, 2006, http://www.s1000dscorm.org/resources/_S1000D_SCORM_RA_Final.asp.com

- European Technical Data Conference Presentations. Oslo, Norway. October 1-4, '07 http://www.s1000d.org/?sector=events/OSLO/&page=index

- ADL Job Performance Technology Center S1000D-SCORM Testbed: www.s1000dscorm.org

- S1000D Sea Working Group Business Rules (Access requires membership to USSMG web site). https://ussmg.btas.com/swg/Library.aspx