White Paper

ISO 10303 (STEP) AP 239 edition 3

Application Protocol

For Product Life Cycle Support (PLCS)

Issue 1.0, 23.10.2015

Executive Summary

"Our product information lives for more than 50 years, and we need to understand how to manage that over time".

Enterprises today are more aware that data- and information assets represent significant values, with direct influence on their financial performance and operational capabilities. Poor quality and poor management of data- and information resources are recognized as major cost drivers and a significant obstacle to business performance and improvement.

ISO standard 10303 STEP with its Application Protocols, Methods and Models represents a viable alternative to the current chaos of multiple, fragmented standards and proprietary data formats, and is a proven way to ensure fast, reliable data exchange between partners and suppliers using different systems. STEP supports engineering, manufacturing, electrical/electronics, architecture and product life cycle information.

AP 239 PLCS has proven its capabilities for maintenance and support data exchange across the whole lifecycle of complex products like those in focus by A&D Industry. Nevertheless, complex EXPRESS implementations of edition 1 and edition 2 resulting in big files, the deprecation of OASIS DEXlib and discussions/arguments of OASIS PLCSlib based on edition 2 and the non-standardized Reference Data Library (RDL standardized in OASIS but not at an ISO level) have hampered further potential implementations.

This White Paper gives an overview about the importance, opportunities and challenges of the development of AP 239 PLCS edition 3.

In addition it describes the context, the industry requirements, the targeted business usages, the proposed enhancements compared to AP 239 ed1 and ed2, the interdependencies with other standardization projects, the project risks, and the associated project plan. It takes into account the comments and assessments received from A&D industries, ASD SSG, ASD ILS DMEWG, SAE LOGSA, LOTAR, OASIS PLCS TC and also the requirements from a number of MoDs (US, UK, Swedish, Norwegian and French).

The main objectives of STEP AP 239 edition 3 are:

- Realization of an **efficient Integrated Logistic Support (ILS),** by integration of the different logistic disciplines, covering all aspects of supportability over the entire life cycle of a product. In particular AP 239 edition 3 intends to ensure the full **support of ASD-AIA ILS S-series specifications** based on information needs identified by ASD-AIA ILS DMEWG and also **GEIA-STD-0007**.
- **Minimize the cost and the delay of development of interfaces based on AP 239** :
  - Ease the understanding of the standard.
  - Facilitate the mapping with business specifications (in particular with the AIA/ASD ILS Suite and the GEIA STD 0007) by providing high level business objects (template concept).
  - Propose **simpler and performance implementation methods of AP 239**, based on main stream technologies, taking into account lessons learnt from AP 242, OASIS PLCS PSM/PLCSlib, ASD DMEWG, DoD requirements in GEIA-STD-0007 rev C.

A **normative XML schema** is the priority – **based on the core model** (and related derived XSD) **of the new STEP architecture**, across all STEP APs.

Web based implementation methods (**SOA services** and **linked data/OSLC**) shall be developed in addition to P21 and XML methods.

- Ability for manufacturing Industries and their customers to manage design, product and service information throughout the product lifecycle, including rigorous configuration management and the long term retention of information, where the data is 'created once and used many times', by **ensuring interoperability of AP 239 ed3 with other STEP APs (incl. AP 242)**, and providing unambiguous implementation methods within the common new STEP architecture.
- Contribute to a reliable and harmonized ISO/TC 184/SC 4 information model through the product life cycle and across domains thanks to the **finalization of the harmonization between AP 239 and AP 242**.
- **Preserve legacy investment** (current AP 239 based systems) thanks to upward compatibility (as far as possible) with former standard edition, and a mapping between PLCS PSM and AP 239 ed3.
- Improve **interoperability within domains and across domains** thanks to a mechanism for sharing common information semantics (e.g. classification and reference values defined in common Reference Data Libraries**)** managed at an international level.

The final prioritization will be decided by the stakeholders committed to support the AP 239 ed3 project with the appropriate resources.

The planned actions further to this white paper are:

1. The official confirmation of participation of the associations, manufacturers and stakeholders before the end of 2015,
2. If needed, the update of the project plan according the stakeholders resources and funding,
3. The start of the ISO AP 239 ed3 New Work Item ballot, planned in October 2015,
4. The setting up of the project with the stakeholders, and the detailed WBS,
5. The preparation of the contracts to the STEP experts,

The kick-off of the project is planned 3 months after the distribution of the published white paper, after the acceptance of the NWI ballot, end of December, followed by a 1st project workshop in January 2016, in Europe.

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References

Reference N°	Document Title	Version	Reference
[R1]	ASD SSG Through Life Cycle Interoperability Report	1	ASD_SSG_TLCI_Report_V1.pdf It can be downloaded: http://www.asd-ssg.org/through-life-cycle-interoperability
[R2]	US Army Materiel Command Logistics Support Activity (LOGSA) Utilizing ISO 10303-239 Product Life Cycle Support (PLCS) to Exchange Logistics Product Data	Sep 13	Whitepaper on Utilizing ISO 10303-239 PLCS to Exchange Logistics Product .pdf
[R3]	ASD/AIA ILS S-Series Specifications Exchange Research White Paper	Apr 14	DMEWG-2014-006_001-00_Exchange Research WP.docx
[R4]	STEP Future Architecture 29-30 June 2015 Workshop Draft Report	Draft	STEPFutureArch_Workshop_20150629-30.pptx It can be downloaded: http://ed2.AP242.org/welcome?p_p_id=20&p_p_lifecycle=0&p_p_state=maximized&p_p_mode=view&_20_struts_action=/document_library/view&_20_folderId=258542

Reference N°	Document Title	Version	Reference
[R5]	BUSINESS PLAN ISO/TC 184 Industrial automation systems and integration	2004-09-30	ISO_TC_184__Industrial_automation_systems_and_integration_.pdf

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Document history

Version	Date	Summary of the change
V0.1	2013-10-10	Initial version
V0.2	2015-06-09	Rework of the structure
V0.3	2015-06-12	Deletion of redundant §5.6
V0.4	2015-07-31	Major update of §1
V0.5	2015-09-01	Completion of §1.4 (status on actual web resources) Completion of §2.2.1, §6.3 (US DOD requirements & LOGSA position)
V0.6	2015-10-06	Completion of §2 and §3 following September workshop
V0.7	2015-10-15	Minor changes and move of PLCS history and viewpoints from

		§1.2 to appendix Revision of US DoD text (§2.2.4, §6.3) Completion of §2.2.7, §2.2.9, §4, §5, §6, §7, §8, §9 Rework of the executive summary
V0.8	2015-10-16	Form changes and restructuration of annexes Completion of §8.1.4 (project team) Completion of §8.5 (Scheduling)
V1.0	2015-10-23	Completion of §2.2.8 (NDLO Statement) Risks update (§7) Completion of §8.6 (Total Costs and financial plan)

1. Introduction, context, and rationale

Product lifecycle support (PLCS) is an evolving concept focusing on product support lifecycle (from the design of the product support to product operation support) and data exchange with other parties (e.g. design domains, customer or buyer and supplier or seller, certification authorities) over the lifetime of a product or service. The objective is no less than to ensure the timely delivery and availability of proper data, to the right place, at the right time. Product life cycle support is closely related to the integrated supply chain of physical products and services.

Many see the key challenge of product life cycle support as a software challenge. However it has become clear that the PLCS concept requires developing (internal and external) processes before attempting to exchange data (or information). Only appropriate business processes, in place and effectively operating, assure the right data or information is provided or exchanged between the parties

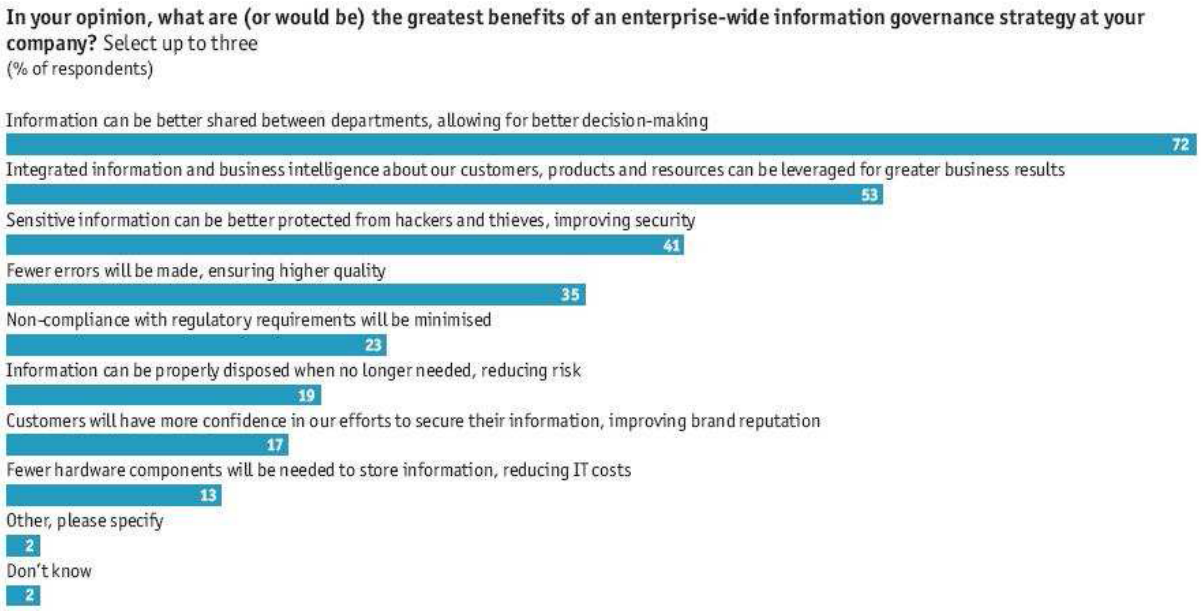

Figure 1: Response from 192 senior executives. The Economist Intelligence Unit, October 2008

The White Paper addresses several opportunities and challenges of exchanging product data in a neutral format compliant with ISO 10303 STEP AP 239 PLCS. STEP standard and its APs are developed and maintained by the ISO technical committee TC 184, *Automation systems and integration*, sub-committee SC 4, *Industrial data*.

AP 239 ed1 (2005) data model has proven very capable but data exchange was affected by STEP legacy issues. Early implementations of PLCS focused on maintenance and repair in the in-service phase.

To be effective, ISO PLCS must be tailored using a Reference Data Library (RDL) and Data Exchange Specifications (DEXs). OASIS PLCS Technical Committee (TC) was formed to promote the advancement of ISO PLCS through the development of DEXs and also to serve as a liaison with the ISO/TC 184/SC 4 who officially manages the development and publication of all STEP application protocols.

The first technology was very specialized and DEX development had been slow and complex (based on ed1 EXPRESS G in DEXlib).

The OASIS PLCS TC created a second edition of DEXlib, called PLCSlib, which is now in production usage in a number of organizations. In PLCSlib, DEXs are based on a Platform Specific Model (OASIS PSM) schema derived from the ISO 10303-239 ed. 2 EXPRESS schema. The OASIS PSM was derived by transforming the ISO PLCS ed2 EXPRESS schema into a Systems Modeling Language (SysML) model. The SysML model was then transformed into an XML schema to facilitate XML implementations.

These developments have been commented by aerospace industries and associations and some issues raised. Summaries and details can be found in this White Paper.

1.1. Objective of the white paper

This paper is a transverse study aimed at developing a "big picture" of all the components required to ensure an optimal update of AP 239 to edition 3 including implementation methods.

- Enhancing the AP 239 ed2 with a Business Object Model (BOM) and associated XML Business Implementation Model based on the OASIS PLCS,
- Ensuring the finalization of PDM harmonization between AP 239 ed3 BOM and AP 242 ed2 BOM
- Ensuring the full mapping of the BOM with the STEP modules.
- Ensuring interoperability between APs
- Ensuring a common Reference Data Library (RDL)

1.2. Reminder of AP 239 ed1, AP 239 ed2 and OASIS PLCS PSM projects

Here after the main milestones of the PLCS history:

1997-99	Work to establish PLCS, Inc. done by the NATO CALS Office
1999	PLCS Inc project started in November
2005	ISO 10303-239 edition1 DEXlib (DEXs, ISO 10303-28 XML Schema)
2010	ISO 10303-239 edition2 PLCSlib developed
2012	PLCSlib adopted by OASIS PLCS TC (DEXS PLCS PSM XML Schema)
2013	Release of Product Life Cycle Support Version 1.0. (OASIS Committee Specification 01 - PLCSlib)

More detailed information on the ISO AP 239 ed1/ed2 standard and the related PLCS development led by the OASIS PLCS TC are available in Annex B: PLCS History.

In addition the viewpoints on last PLCS developments from LOGSA, AIA/ASD DMEWG and LOTAR are provided in Annex C: Viewpoints on last PLCS developments. These viewpoints are delivered under the responsibility of source organizations as they are not necessarily endorsed by the whole PLCS community.

1.3. Lessons learnt

From the experience on previous AP 239 ed1 and ed2 projects and the related framework development (i.e. DEXlib and PLCSlib), a set of general lessons learnt can be pointed out.

Items to be improved:

- Create specific user requirements
    - Business requirements: kept the focus on the support of business processes and use cases, and check the results could be tailored the use to any specific industry or specific project
    - Technical requirements: define efficient implementation methods, based on normative, unambiguous and extensible schemas, using open standards and tools, keeping the backward compatibility when required, and interoperable with other relevant standards
- Decrease harmonization iterations,
- Place dependencies under the control of the project (e.g. harmonization with OASIS PLCS, AIA/ASD DMEWG, LOTAR, AP 242, …)
- Propose concurrent development cycles,
- Create a realistic schedule,
- Create a charter that includes project organization (reporting, minutes, …),
- Remove scope creep,
- Recommend proper resources for the following: - development of PDM recommended practices as part of the PDM Implementer Forum, - Program management,
- Provide funding in a timely manner.
- Remove document development infrastructure deficiencies that caused schedule slippages and higher resource utilization than planned.
- Organize more communication between AP 239 project and ISO/TC 184/SC 4 /WG21,
- Maintain a shared calendar,
- Allocation of a portion of the project budget for the maintenance and enhancement of STEPmod.

Successful items, to be reused:

- Harmonization of implemented standards,
- STEP Modular architecture,
- Regular PSC calls,
- Co-leadership,
- Pilots, to check, when useful, the relevant subset of new AP 242 ed2 information model,
- Reuse of ISO WebEx.

1.4. Use of AP 239 public web site for communications

Communication is a key criterion for the success of the AP 239 ed3 project. The objective of the industries involved in the STEP AP 239 ed3 standardization project is not only to develop a standard, but also includes the following:

- Ease the access to relevant information for different communities (OEM, SME, PLM software suppliers and integrators, R&D centers and universities),
- Provide an easy understanding of the functionalities supported by the AP 239 ed3 standard, by the descriptions of the main use cases supported,
- Identify the STEP recommended practices complementary to the desired standard, via links to the appropriate web sites, such as that of the PDM-IF,
- Create a roadmap of operational solutions supporting interoperability capabilities defined by the AP 239 ed3 standard. It will reference specific web sites dedicated to interoperability testing of PLM vendor solutions, such as the ILS IF or the PDM IF.

Today several public websites are hosting the projects developed by OASIS from the basis of ISO AP 239 ed1 & ed2:

PLCS OASIS Committee:

- *https://www.oasis-open.org/committees/tc_home.php?wg_abbrev=plcs*

DEXlib@ plcs-resources.org

- http://www.plcs-resources.org/plcs/dexlib/dex_index.htm

PLCSlib@ plcs.org

- *http://www.plcs.org/plcslib/*

[PLCS v1.0]Product Life Cycle Support Version 1.0. 15 October 2013. OASIS Committee Specification 01.

- *http://docs.oasis-open.org/plcs/plcslib/v1.0/cs01/plcslib-v1.0-cs01.html*
- *http://docs.oasis-open.org/plcs/plcslib/v1.0/cs01/plcslib-v1.0-cs01.zip*

PLCSlibSourceforgeproject

- *https://sourceforge.net/projects/plcslib/*

PLCSlibWebinars

- *http://robbod.users.sourceforge.net/plcslib_videos/*

In addition to those public websites, the AP 2439 ed3 project shall rely on a dedicated AP 239 public web site: www.AP 239.org (to be put in place) to present the project status and results.

1.5. Overview of the scope of AP 239 ed2

The modelling scope of AP 239 covers

- Histories as well as Design
- Individuals as well as Designs
- Fleets as well as Individuals
- Equipment and Resources as well as Product
- States as well as Faults/Failures
- Schedules and Plans as well as Tasks
- Change process across all
- Allow for Why?
- Enable feedback & traceability

… For fulfilling the business drivers hereafter:

- Exchange and sharing of data across the product life cycle
- Capture of relationships/dependencies between items from different disciplines
    - Which usually reside in different specialist systems
- Capture of information to enable comparison of what was supposed to be and what actually happened
    - Maintenance, failures, usage, configurations
- Enable management of change

The edition 2 of AP 239 (published in 2012 by ISO) is an update of edition 1, with a slightly larger scope than the edition 1, and a greater compatibility with AP 233 (Systems Engineering).

For more details see Annex B: PLCS History**Erreur ! Source du renvoi introuvable.**.

1.6. Overview of the planned scope of AP 239 ed3

The planned evolutions of AP 239 ed3 are of two types, described in the following paragraphs:

Information model changes

In addition to some minor changes on the information model coming from open issues against edition 2, and also other ones coming from ASD/AIA ILS S-Series specifications, the future edition 3 will keep the same information scope related to the management of product support across the product life cycle, including some common generic concepts shared with others STEP APs. The principle of modular APs is kept and no major business extension of AP 239 is planned.

With regards to consistency between APs, the finalization of PDM and requirement management harmonization is planned between AP 239 ed3 and AP 242 ed2.

Implementation performance

Based on the issues and difficulties encountered in the past during pilots and industrial use of AP 239 described in previous chapters, the main expected benefits for the business are linked to the performance of implementation of AP 239 edition in operational context.

Based on the future STEP architecture, AP 239 ed3 shall meet the objectives listed above:

- Build an enhanced data model: the AP 239 model shall be more easily understandable and implementable than previous editions, and some simplification shall be done (was an objective of PSM)
- propose a normative and unambiguous implementation format. The first priority is to propose an XML schema, with a performance objective
- Ensure good and high quality data exchange
- Provide recommended practices: mechanism to ease to implementation (implementation templates – high levels of future STEP architecture), and guidelines are required, in order to minimize the cost of development of data exchanges based on AP 239

2. Industry requirements

Is it sufficient to contract "Data exchange has to be performed by applying ISO 10303 STEP"?

In today's complex and dynamic environment, there is an increasing need to properly share, exchange and archive product information to sustain these systems over their life span. Data sharing, or data exchange, is required in numerous scenarios including first tier design & development, tier to tier contractors for sub-systems and sharing between disparate services, agencies and authorities and finally with customers. When information is shared, it often requires customized solutions resulting in inefficient and costly implementations.

2.1. General requirements

2.1.1. Background

Information drives our decisions

All our decisions are based on information. In most cases good information could be found somewhere. The owner communicates it (or not) to his network in a format which he believes is most suitable and in time for his performance indicators.

Example:

Design decisions and their operational and support related impacts

Designing for future support would benefit from models that provide engineers with quantitative arguments.

These arguments are mainly based on:

- Data collected from in-service fleet;
- Knowledge of the current design and information coming from others skills (safety specialists, system designers…) or organizations (e.g.: equipment suppliers…);
- Knowledge of future operations and support (aircraft mission attributes, types of airlines or customers, …).
- Traced assumptions validated by design team, program management and airlines.

Information drives our products and services through their life

From initiation, concepts, requirements, planning, design and development, manufacturing and integration, in-service to disposal or retirement.

Example Manufacturing Standards:

[as planned, as designed, as prototyped, rejected, concession, in progress, finished]

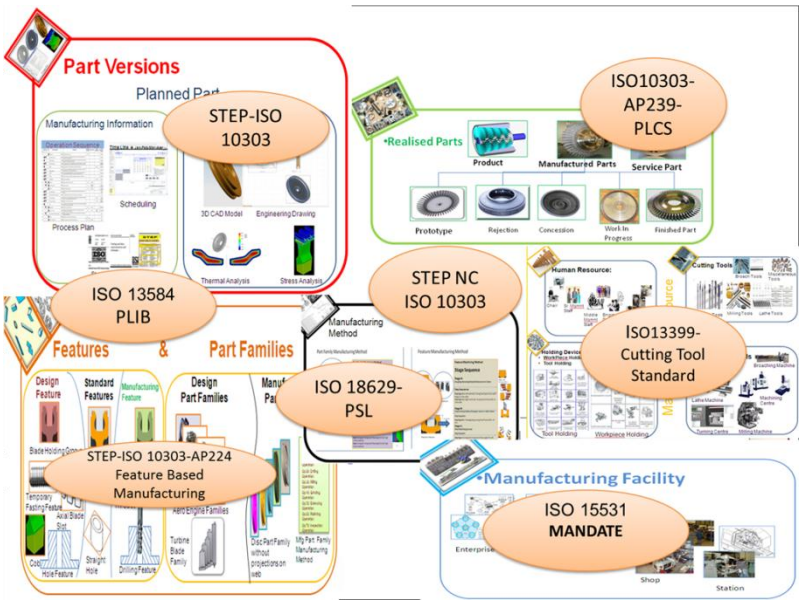

Figure 2: Manufacturing standards landscape

Information drives Quality and Safety of products and services

Optimal quality of products and services is achieved by being compliant to requirements. So requirements have to be or are defined, exchanged and agreed and the “solutions” (design, products, and services) have to be compliant to them.

Airworthiness and Performance requirements are to be fulfilled during the certification and qualification process.Type certification of an aircraft is a well-known example of this process. And Quality is “the means” for Safety.

Need for enhanced collaboration processes

As stated in the above section, a large number of actors and companies are involved to develop and operate different datasets. This includes OEMs (e.g. aircraft architect and integrator) design office(s) and final assembly line(s), engine manufacturers and their supply chain, component/equipment suppliers design offices, simulation centres and testing labs, manufacturing sites, integration sites, flight test site(s), customer support sites, customer offices and operation sites, maintenance sites, etc.

Each of these actors owns a subset of these datasets. This network of actors, or "extended enterprise", is structured by contracts and intellectual property rights apply to the datasets. Each actor manages its own subset in its data management systems, whether a requirement management system, a product definition management (PDM) system, a product manufacturing management system (e.g. ERP), a product operation management system, a product maintenance management system, etc.

The PLM interoperability challenge is to enable these actors to work securely and efficiently on coherent product views.

The move to model-based engineering will significantly reinforce this challenge, as co-simulation for example will require models to be connected seamlessly with short response times.

The current way to ensure consistency between product views and related datasets is through one of the following collaboration processes:

- Data exchange: data is exchanged through digital files or Technical Data Packages (TDP). In case of data modification or complement, only the updated part may be exchanged. This collaboration process being asynchronous could require some reconciliation mechanism to maintain product view consistency.
  This type of exchange generally requires the partners to formally agree exchange principles, process, formats, configuration, traceability and quality rules (e.g. through a data exchange contract).
  To protect its Intellectual Property, the sender could choose to reduce the content to be sent, e.g. by removing some part of the data (design rational, parametrics) or by exchanging using a light visualisation format.
- Data access from a centralised database: one partner centralises product data and grant access rights and modification rights to part of the database to other partners.
- Data sharing through data hubs: hubs provide a neutral space to share information and to synchronise workflows.
- Direct linkage between data repositories: this solution is in general sought when repositories are hosted inside the same company, to avoid replication of data. This is the case for example when connecting a PDM and an ERP through an Enterprise Service Bus. This collaboration process is quite difficult to develop in an extended enterprise context, due to the diversity of the data management rules (the mapping is not obvious), security, export control and IP protection reasons. Nonetheless some new IT technologies, such as OSLC, propose innovative ways to handle the problem.

These collaboration processes require data exchange contracts between involved actors, to ensure effectiveness and quality of the exchanges.

Product support business problem

As reminded in the introduction of DEXlib, companies engaged in managing complex assets through time face several information management challenges:

- Much of the data needed to deliver successful support derives from the product design and manufacturing processes, where support information requirements are rarely a primary focus
- Support activities cross many system and organizational boundaries, making it difficult to impose a "single application" solution for data collection and consolidation
- Obsolescence, upgrades and changes to the operational context can create major problems in maintaining alignment between the configuration of actual assets and that of the technical data which specifies necessary support

- Optimization of support delivery, and the operation of performance management depend crucially on the capture of adequate feedback from the in-service domain
- The significance of such feedback is often dependent on context, yet many of the relationships which provide such context - for example, the nature of the mission just competed, or the precise configuration of the asset in question - are lost when feedback is captured

The goal of PLCS was to create an internationally accepted information model - likely to remain valid for several decades - to enable open information exchanges, and necessary data consolidation to address the issues above. This goal is summarized by the figure hereafter.

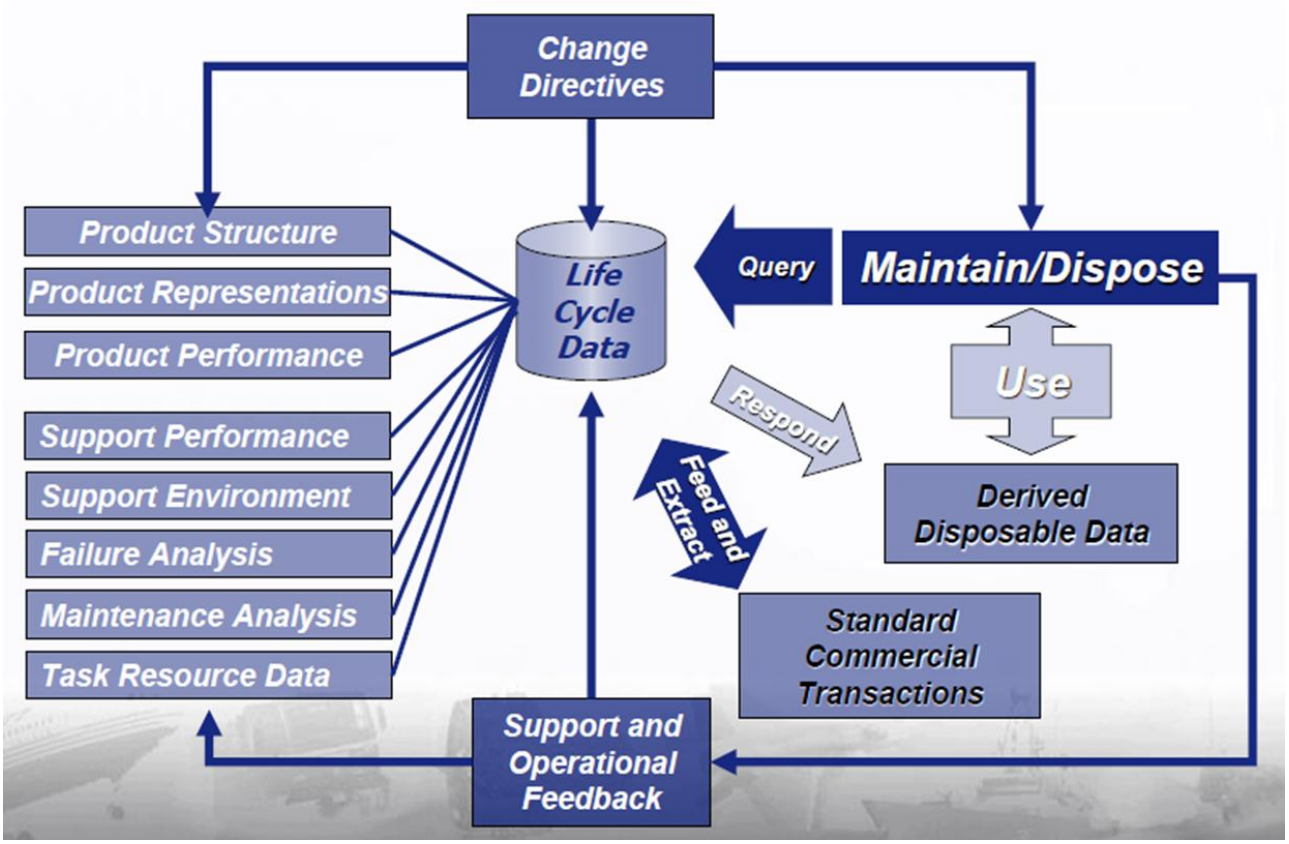

Figure 3: PLCS vision

2.1.2. Business Requirements and Drivers

Business Plan ISO/TC 184 Industrial automation systems and integration

As described in the Business Plan ISO/TC 184 (cf document [R5]), Manufacturing industry as a whole has to face a number of challenges in a competitive global marketplace:

- Reduce drastically costs of design, production and support of its products.
- Improve product quality and reliability.
- Improve customer satisfaction.
- Build alliances to rapidly meet market demands.
- Provide their markets with new and innovative products and services.

The business response to the challenges includes investment in industrial automation and exploitation of electronic business to gain competitive advantage.

Do-it-first-time-right

Avoid rework: do it right the first time in order to reduce expensive curative & corrective actions and potential penalties or business loss.

Principle of 'created once and used many times' for product data

Certification of Products and Services

In particular, for Aerospace and Defense business, industry shall take into account the regulation rules for:

- Compliance to Airworthiness Requirements
- Airworthiness Limitations
- Instructions for Continued Airworthiness (ICA)
- Maintenance Review Board process (MRB)
- Flight Manual

Qualification of Products and Services

Products and related related shall be qualified regarding

- Compliance to Performance Requirements
- Contracts,
- Customer expectations

Life Cycle Support (from cradle to grave) of Products and Services

The whole lifecycle of product shall be prepared, monitored and managed through a set of key indicators: Life Cycle Cost (LCC), Total Ownership Cost (TOC), Direct Maintenance Cost (DMC), Turn around Time (TaT), Downtime…

Interoperability inside domains (eg. Design, Support, Customer, Authorities) and between domains

The need of exchange of "data in context", industrial automation and electronic business through the life of our products and services are main drivers.

Wrt regards to product support,

- Requirements (functional, physical)
- Configuration (as designed, as built, as maintained, as to be maintained)
- Maintenance concept (repair or replace, maintenance procedures, initial provisioning list…)
- In-service feedback from maintenance and operational activities

Integration Issues

Integration is required when information needs to be moved or shared between two or more tools. Problems with data exchange between tools include:

- Tools address different technical or business domains (language of the domain, organization, nation, ontology, taxonomy)
- Tools address different life cycle phases (initiation, architecture, analysis, planning , design, manufacturing, supply chain, …)
- Tools in the same domain utilize different methodologies and notational languages (e.g., relational versus object oriented data, six sigma, UML, SysML, BPMN, IDEF……)
- Tool vendors lack interfaces to all the tools you need in your product development environment for an entire life cycle.

Interoperability Issues

Product/system data has to be exchanged between product/system life cycle process stages – different taxonomy, processes and formats

There is a need to share system knowledge between multiple organizations developing the system

Passing product data from discipline to discipline or one organization to another

Data exchange required between tools being used to support the systems engineering processes feeding multiple engineering disciplines, management, manufacturing, etc.

The Need for Standards in Ground Processing

United Space Alliance, LLC, NASA Kennedy Space Center

Let us look at the need for effective and efficient technical data. According to "The Hidden Costs of Information Work," a 2006 IDC study of information/knowledge workers, it revealed that:

- They spend 48 percent of time searching (9,5 hrs/wk) & analyzing (9.6 hrs/wk) information.
- They waste 3.5 hrs/wk in unproductive searches (information not found).
- They waste 3 hrs/wk recreating content that already exists.
- Not finding the information needed costs an organization employing 1,000 knowledge workers about US$5.3 million per year.

"Knowledge workers" is a term typically for those who use knowledge to analyze, design, make decisions, or do some action based upon knowledge they have or gather. It has been used often for engineers, scientists, researchers, coders, etc, but it is also recognized as applicable to anyone needing to seek or use knowledge for their tasks. That said, the statistics above could apply to the space industry for not only engineers and designers, but also mechanics, inspectors, planners, etc. If space vehicles were so mundane that everything was a routine, mindless task, then a knowledge worker would not be needed. However, a great amount of knowledge and agility is required when working on a space program.

Technical data is everywhere, but it is not always easy to find, or even know that it exists. Information is sometimes recreated or even missed, causing a more costly resulting action. Multiple contractors, sites, vehicle elements, and configurations can complicate the ability to find or interpret data sources. The EELV requirements document stated in 1998 that one of the reasons that the Expendable Launch Vehicle (ELV) launch systems at the time were cost ineffective was due to lack of standardization of facilities, processes, vehicles, procedures, and supporting infrastructure, making each mission a unique event.

The organization of technical data itself can be inefficient. Each contractor may structure his product breakdown a different way, shown in drawings, specifications, logistics, various databases, or technical publications. Each data set may have a different IT business system to access such data, and these may not be interconnected. The Space Shuttle and the Ares I-X test rocket are examples that used various manufacturers and business systems, making it difficult to find all data efficiently. The now-retired Shuttle had so much old legacy data that it was too difficult to synchronize everything by the time the retirement decision came. Ares I-X began with that experience under its belt, and with modem IT tools, but technical data for each contractor for each major element was still structured differently. United Space Alliance (USA) had the task of integrating all together and developed an IT architecture to make various data sets visible together under standard applications. Had the data been synchronized upfront, it would have been a much easier feat.

Creation, use, and management of technical data are vital-even more so with these challenges.

2.2. Business requirements of the aerospace and defense industries

2.2.1. ASD SSG Requirements

In 2014, the ASD Strategic Standardisation Group (ASD SSG) published a report “Through Life Cycle interoperability” (reference document [R1]) whose objective is to develop a vision of interoperability for Aerospace & Defence and to propose recommendations.

It can be downloaded: http://www.asd-ssg.org/through-life-cycle-interoperability

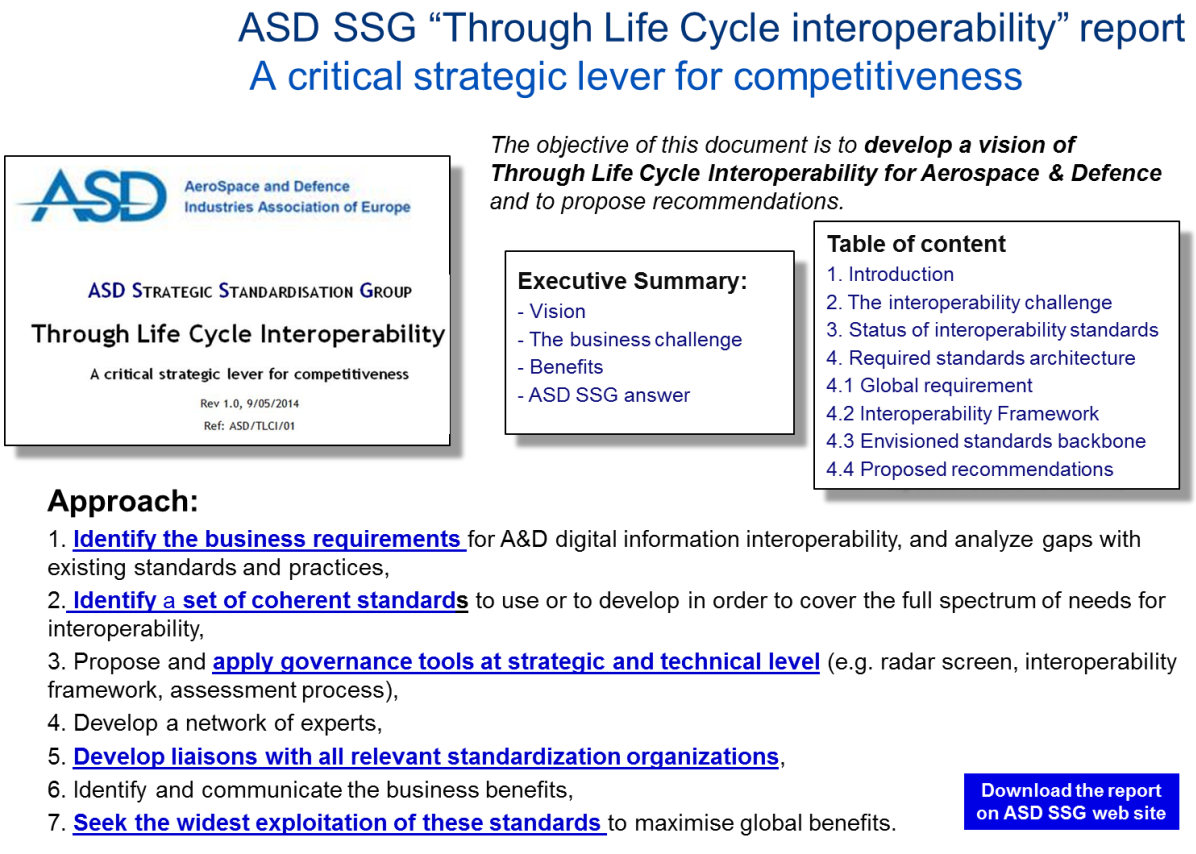

Figure 4: "Through Life Cycle interoperability" report

This analysis results in the following initial set of recommendations that particularly recognizes the value of ISO 10303 STEP Application Protocols, and intends to make these standards the cornerstone of the PLM information interoperability:

1. **Strengthen the STEP architecture approach** to 1) ensure interoperability between STEP standards and 2) provide unambiguous implementation methods (including for new information technologies, e.g. OSLC).
2. Ensure that **3D visualisation format standards** used in the industry are consistent with STEP standards
3. Ensure the **common data model** for **the ILS specifications** is **consistent with STEP AP 239**.
4. Promote the **ASD-AIA ILS suite of specifications** and seek to manage **coherence with ATA specifications** where needed by the industry.
5. Participate in the development, and interoperability testing of the **next generation of PDM/PLM web services**.
6. Facilitate **data interoperability in the Aerospace and Defence Supply Chain** and align business process between Supply Chain stakeholders.
7. Supports the setting-up of **implementer forums** (e.g. PDM implementer forum) to test and validate the implementation of the standards-based solutions.

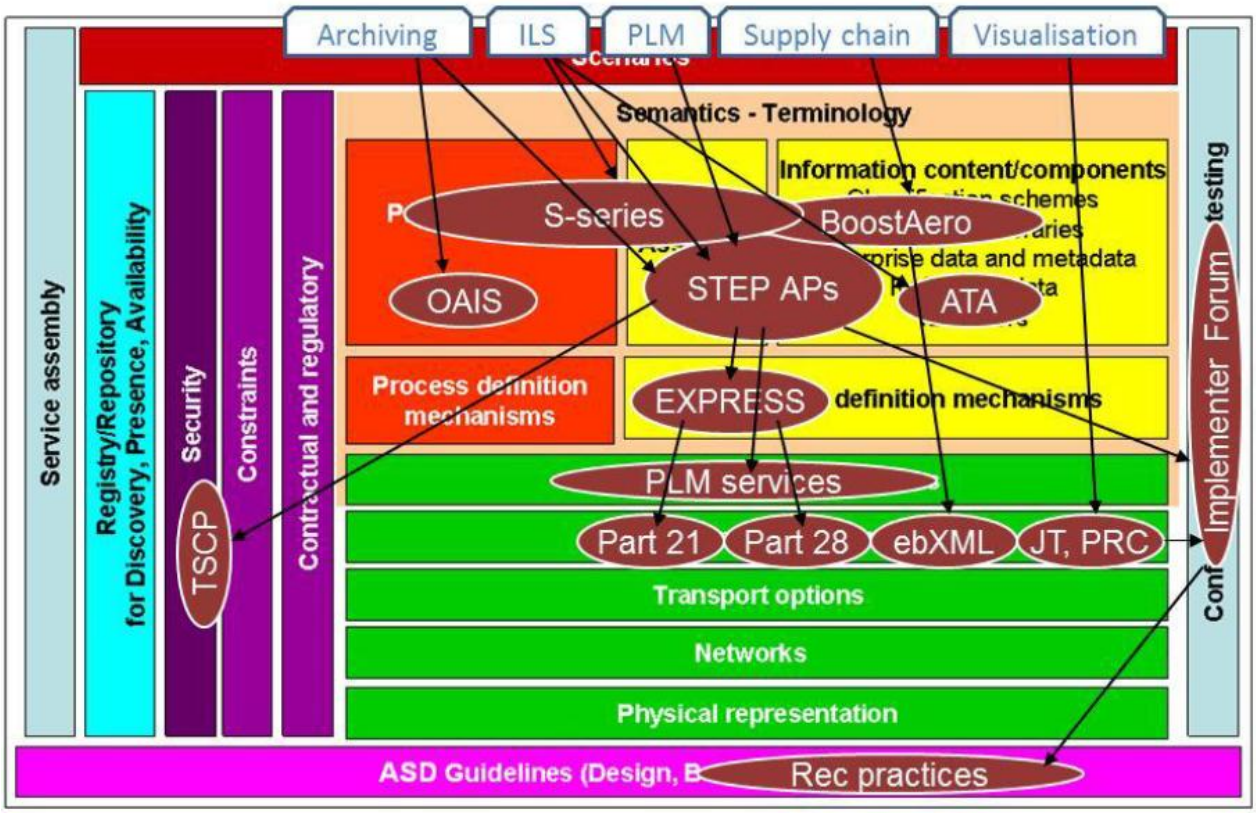

Figure 5: ASD SSG - Envisioned standards backbone

Specifically to the first recommendation of strengthening the STEP architecture approach, the ASD SSG has already engaged some actions to implement this recommendation, including:

- Preparation of a White paper "state of STEP AP modularity -Requirements for the STEP future architecture". This action results from the 6–7 March 2014 workshop organized by the AIA, the ASD SSG and PDES Inc. It will improve the consistency of STEP modular architecture taken into account the BO model and the DEXs templates. This action will be closely associated with the ISO/TC 184/SC 4/WG 12 activities for the new STEP architecture.
- Contribution to STEP AP 242 ed2 White Paper. Planned enhancements, compared to AP 242 ed1 include: PDM (finalization of harmonization with AP 239 ed3 PLCS), 3D PMI (e.g. extension to new entities allowing to support the enhancement of ISO and ASME PMI design standards) , 3D geometry (e.g. extension to 3D curved triangles, voxels) CAD composite design (new entities such as Limited Area Application Indicator), Mechanical design (e.g. extension to design information of manufacturing additive parts).
- Initiation of STEP AP 239 ed3 White Paper (object of this document) whose objective would include:
  - Enhancing the AP 239 ed2 with a Business Object (BO) Model and associated XML Business Implementation model based on the OASIS PLCS PSM,

  - Ensuring the finalization of PDM harmonization between AP 239 ed3 BO model / Business Implementation model and AP 242 ed2 BO model Business Implementation model
  - Ensuring the full mapping of the BO model with the STEP modules.
- More generally, actions have to be taken to implement the initial objective of the STEP modular architecture to manage all APs in a consistent way, including the ability to regenerate APs from a common library to maintain consistency – under careful configuration management. So other STEP APs are concerned, including AP 233.
- Consolidate the coordination with the LOTAR project, for the identification and maintenance of Long Term Archiving payload standards.

For AP 239 ed3, two key business requirements are highlighted by ASD SSG:

1. **Support of ASD-AIA ILS Specifications**

   Business need: Realization of an efficient Integrated Logistic Support, by integration of the different logistic disciplines, covering all aspects of supportability over the entire life cycle of a product.

   Requirement: STEP AP 239 ed3 should support the implementation of each individual ASD-AIA ILS specifications, as well as the data transfer mechanisms between these specifications.

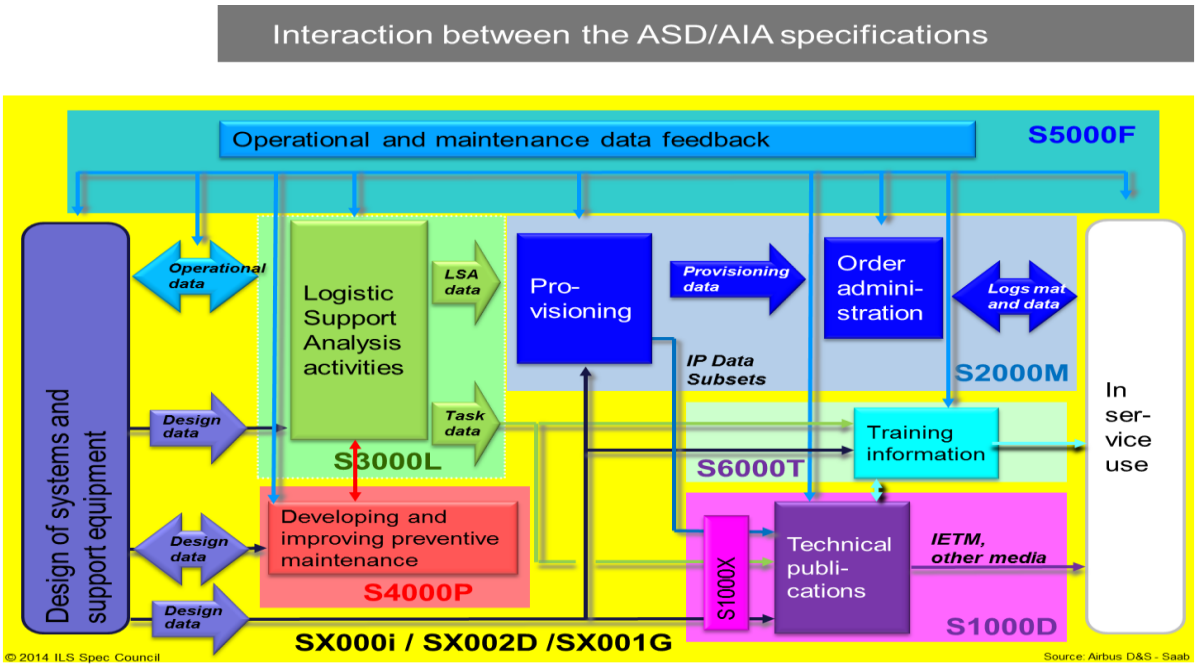

Figure 6: Interaction between the ASD-AIA ILS Suite of specifications

2. **Ensure interoperability of AP 239 ed3 with other STEP APs (incl. AP 242)**

   Business need: Ability for A&D Industries to manage design, product and service information throughout the product lifecycle, including rigorous configuration management and the long term retention of

information, where the data is 'created once and used many times'.

Requirement: STEP AP 239 ed3 should support the Recommendation 1 in ASD SSG TLCI report (reference document [R1]):

> *Recommendation 1:.Strengthen the STEP architecture approach to 1) ensure interoperability between STEP standards and 2) provide unambiguous implementation methods (including for new information technologies, e.g. OSLC).*

2.2.2. ASD DMEWG Statement

The ASD Data Model and Exchange Working Group (DMEWG) is responsible for defining the data exchange framework for the ASD/AIA S-Series ILS specifications.

DMEWGs current position on ISO 10303:239 PLCS ed2/OASIS PSM is that there is not enough benefit in using PLCS to outweigh the complexity and burden that PLCS/PSM imposes. There are too many unknowns and unanswered questions that lead us to believe that PLCS/PSM is not mature enough at this point.

The DMEWG has therefore defined a bespoke XML schema architecture that in the short term will allow users to adopt and implement S-Series ILS specification data exchanges more quickly and with less effort while still providing an avenue to use PLCS/PSM.

However, the long term objective for the DMEWG and the S-Series ILS specifications is to adopt ISO 10303:239 PLCS as the technical backbone to support a future framework for Product Life Cycle data exchange and integration, given that the identified issues with the current PLCS ed2/PSM information model and its associated DEX development platform are resolved in a future PLSC ed3.

DMEWG, on behalf of the ILS Specification Council, will therefore contribute to the development of ISO 10303:239 PLCS ed3 in an effort to support the requirements from the S-Series ILS specifications.

2.2.3. Airbus Group requirements

The Airbus Group is a European multinational aerospace and defence corporation registered in the Netherlands and a defence and military contractor worldwide. It designs, manufactures and markets both civilian and military aerospace products. The group consists of the three business divisions Airbus, Airbus Defence and Space, and Airbus Helicopters.

The Airbus Group requirements related to AP 239 ed3 are as follows:

1. **Support of integration of information models of AIA – ASD ILS specifications**

   4 main use cases are identified as the key business needs related to the challenge of interoperability between ILS disciplines based on the usage of ASD standards, to be supported by future AP 239 ed3.

Use Case #1: Technical Publications

- Scenario: Exchange of Technical Documentation and Data
- Description: This Use Case focuses on the export, from an Industry Technical Publication system, of IETP and Technical Data in order to fill-in automatically the Operators' Maintenance Information System.
- Related ASD standard: S1000D

Use Case #2: Materiel Support

- Scenario: Exchange of Material Data
- Description: This Use Case focuses on the exchange, from an Industry Logistic system, of Technical Data (IPL, IPD and Procurement Planning) and Commercial Data (Order and Invoice), to interact with the Operators' Logistic System.
- Related ASD standard : S2000M

Use Case #3: In-Service Maintenance Optimization

- Scenario: Exploitation of In-Service Data in an ISMO process
- Description: This Use Case focuses on the feedback of In-Service Data from an Operator Maintenance System to an Industry Maintenance Optimization process.
- Related ASD standards : S3000L, S4000P, S5000F

Use Case #4: Maintenance Execution / Resources

- Scenario: Resources on demand of Maintenance execution
- Description: This Use Case focuses on the need, on operator's side, to provide resources, in the frame of the maintenance execution. Therefore, it focuses on the data exchange between Maintenance Information System and Resource Information System
- Related ASD standards : SX000i

The positioning of the previous use cases with the AIA – ASD ILS specifications is illustrated in the next figure.

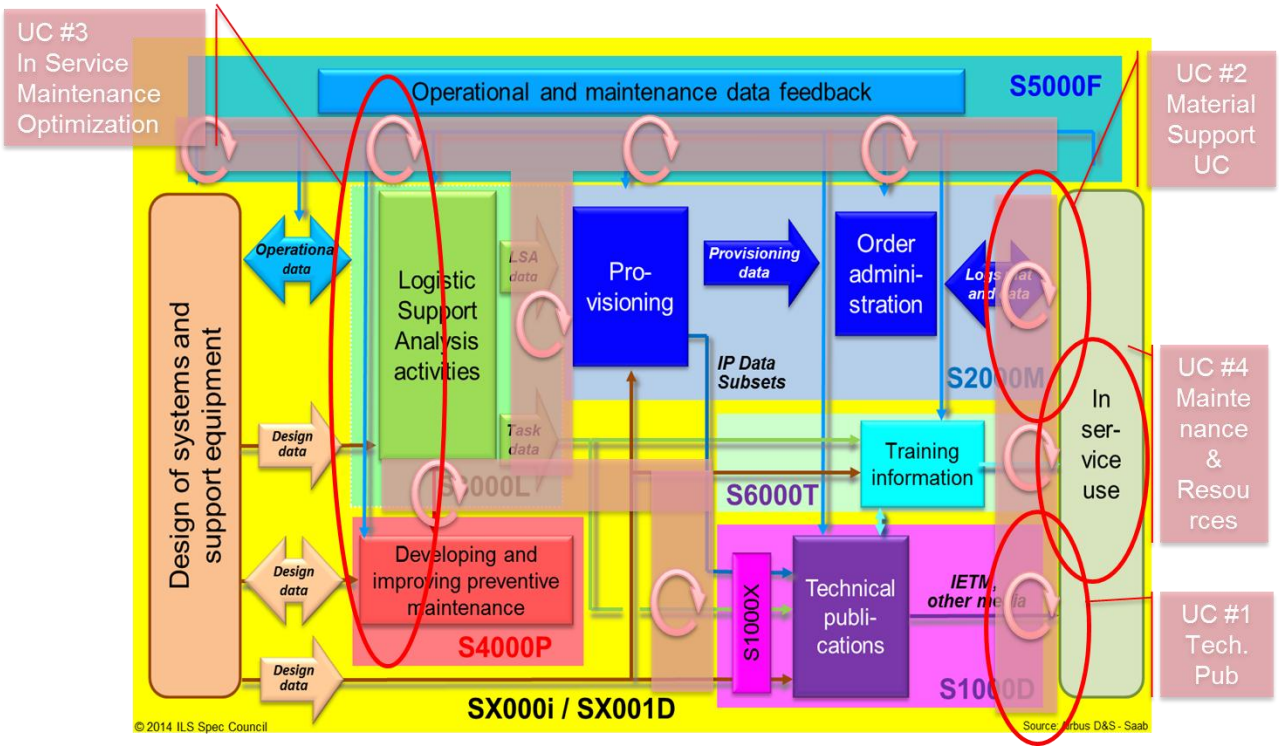

Figure 7: ASD-AIA ILS Suite positioning & Airbus Group selection of Use Cases

To achieve this objective, the selected use cases and the AIA – ASD ILS specifications can be added to the global picture of the expected architecture framework for PLM interoperability for AP 239 edition 3 (see Figure 19: Architecture framework for PLM Interoperability / AP 239) in order to show the top-down approach from ILS needs to implementation.

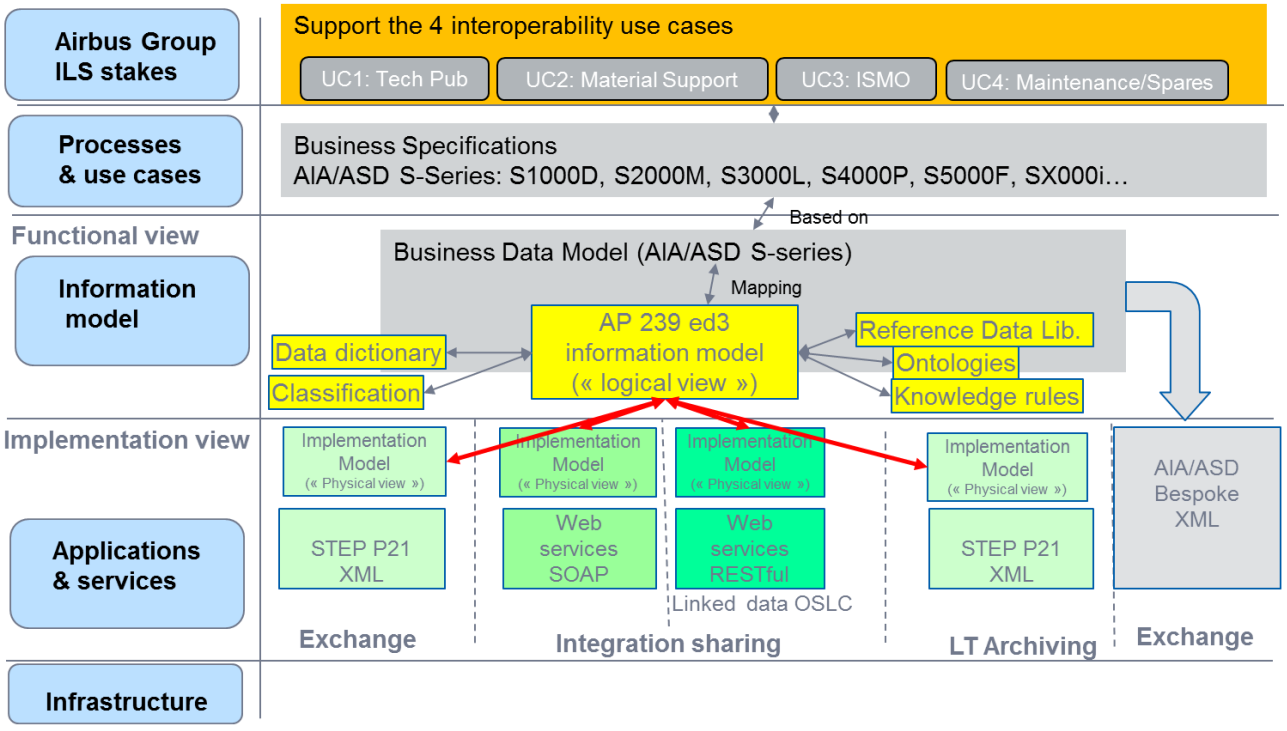

Figure 8: Architecture framework for PLM Interoperability / AP 239 & Airbus Group ILS stakes

2. STEP AP 239 ed3 and AP 242 ed2 as cornerstone information models for PDM and requirement management information interoperability across the full A&D product life cycle

The STEP AP 239 ed3 and AP 242 ed2 projects shall contribute to finalize the harmonization of:

- The ISO STEP "PDM" capability model,

- The ISO STEP "Requirement Management" capability model

used in AP 239 ed3 and AP 242 ed2, and common to the other STEP modular Application Protocols.

It will allow to have a reliable ISO /TC 184 /SC 4 information model for PDM and requirement management interoperability through the product life cycle: exchange, sharing / linked data, LT archiving

3. Need to set up a STEP AP 239 PLCS Implementer Forum

A PLCS implementer forum is required in order to

- To define STEP AP 239 ed3 implementation guidelines, in coordination with other related STEP Implementer forums, in particular, with the PDM Implementer Forum which is based on AP 242 XML, and then on AP 242 ed2 and AP 239 ed3, when available

- To support PLCS interoperability between COTS ILS solutions

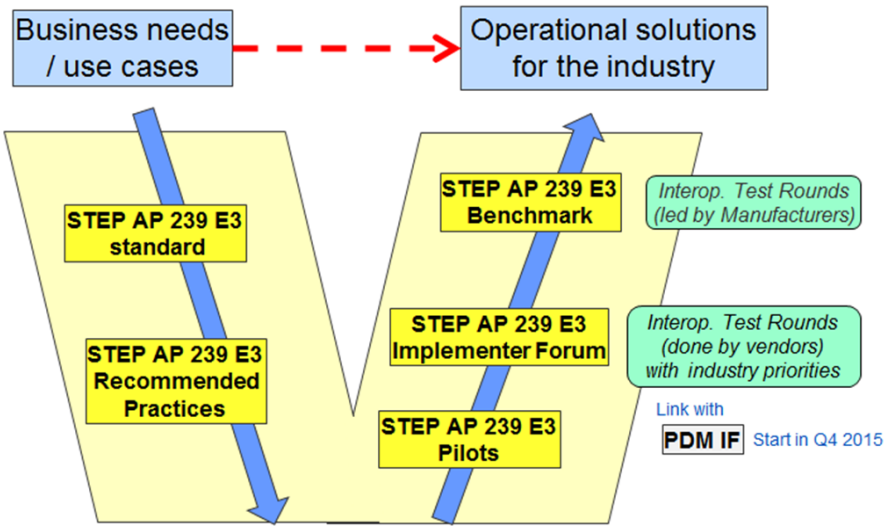

Figure 9: Need for a STEP AP 239 PLCS Implementer Forum

2.2.4. U.S. DoD Requirements

SAE TA-STD-0017, Product Support Analysis (PSA) and SAE GEIA-STD-0007, Logistics Product Data (LPD), along with their companion SAE and U.S. DoD handbooks, meet the U.S. DoD requirements for performing PSA and exchanging LPD.

Due to its generic nature, ISO 10303-239 ed2 currently contains the basic requirements needed to support the U.S. DoD. However, the implementation of those requirements becomes ambiguous without detailed and concise usage guidance (e.g. Data Exchange Specifications (DEXs) and Reference Data Libraries (RDLs)).Annex H (Application protocol implementation and usage guide) of ISO 10303-239 ed2 must be revised or deleted to remove references to the OASIS PLCS TC.

While ISO 10303-239 ed2 currently supports the basic concepts specified by SAE TA-STD-0017 and SAE GEIA-STD-0007, which define the U.S. DoD adopted PSA and LPD requirements, the actual implementation of ISO 10303-239 ed2 is regarded as high risk compared to the basic implementation of SAE TA-STD-0017 and SAE GEIA-STD-0007. ISO 10303-239 ed3 should provide clear and stable informative usage guidance that is the product of the formal ISO decision making process.

2.2.5. Return of experience from PLCS usage in NATO

Even if there is a broad recognition of need, PLCS adoption is slow due to challenging implementation.

As Contracting for Capability (PBL, etc.) increases, standardized life cycle data sharing becomes imperative to mutual success and PLCS is identified as a major enabler for that purpose.

PLCS edition 3 needs to provide:

- An exchange standard implementable by mere mortals (mass adoption vice hiring an expert)
- Starting point DEXs for “routine” exchanges (e.g., usage data, maintenance actions, configuration)
- The ability to exploit DEXs for data sharing regardless of product data model
- Adoption by commercial software products
- A stable standard used across domains

2.2.6. U.K. MoD’s position

Looking back a decade or more, the UK MoD had no small amount of enthusiasm for AP 239 and even in the present, there is a general perception that operating in a coordinated and coherent way is eminently sensible.

In recent years however, there has been a waning of the said enthusiasm and the position of the MoD could best be described as being in a holding pattern, no great desire to move away from AP 239, but no great desire to move forward.

The position is further compromised by the upheaval in support strategy. In essence the MoD is moving from the notion of individual project teams that provide support for specific platforms (and indeed they were given a great deal of autonomy to accomplish this task) to a more centralized regime. This change in philosophy to more central control is underway and the dust has yet to settle.

While this situation is yet to crystallise, there is little pull from the project teams to implement AP 239 and there is little appetite from Industry to push the same. So while some Industry partners such as BAESystems and Rolls Royce have undertaken small scale implementations of the standard, there is no visibility of a path leading to greater deployment as in France and Norway for example.

2.2.7. FMV Requirements

The FMV main rationale for supporting the PLCS ed3 NWI and project is an expectation that the project will improve PLCS in a way which leads to a wider usage of the PLCS standard, and that this in turn results in a wider user community that helps improve the standard even more and drives commercial implementation and standard support. FMV wishes to base information exchange on international standards in order to reduce risk and cost related to development of data formats, to simplify data requirement work during materiel acquisition, and to improve quality. FMV continues to see PLCS a very important standard.

The new edition of the PLCS standard must be accessible. This requires that the content of the standard shall be available for free download over the Internet. But accessibility also requires that the content of the standard is presented in a way that makes it easy to understand and implement. Therefore, in **parallel** to the modelling and RD work, a model usage guide and example data shall be developed. The example data should be consistent throughout PLCS, e.g. in the model usage guide, training material and examples in Templates. Example data development should preferably be made in cooperation with the group working with the ASD/AIA bike data. The model usage guide shall explain the intension of the model constructs, and exemplify them using bike example data. Development of usage guidance in **parallel** to developing/refining/reviewing the model will improve the quality of the model by allowing more people to understand and comment on the model constructs.

The new edition of the PLCS standard should reuse as much as possible from earlier work done. FMV has no larger technical issues with the AP 239ed2 or the PLCSlib/PSM, and has made large investments in developing PLCSlib and DEX:s based on this environment. Therefore the work with AP 239ed3 must reuse as much of the model constructs as possible, as well as the reusing tools and processes for RD-development, guidelines for RD classes, how OWL is used (including reuse of SKOS and DC elements) a.s.o. AP 242 harmonization is not a requirement from FMV, but supported if it is believed to lead to a wider support and implementation of PLCS.

The new edition of the PLCS standard must be supported by a wide community. In order to achieve this, the project must not only focus on technical issues, but also make sure to involve people with good communication skills tasked to work on marketing. This should be an activity starting even before the actual project, in order to involve as many participants as possible.

2.2.8. NDLO Statement

Norwegian Defence has been active in the NATO CALS work from the start, and has this pragmatic view on supporting the CALS vision:

"NDLO's strategy is not for one standard but for a set of compatible standards to address the full scope of Integrated Logistic Support throughout the entire lifecycle of the product."

NDLO has participated on several arenas including AECMA, ASD, PLCS INC, OASIS, NATO and ISO to assist achieving this compatibility between activity and information models.

The proposed scope for ISO 10303-AP239 E3 endeavors to achieve a welcomed harmonization across the STEP family of standards, ASD/ATA specifications, capitalizing on investments already made to enhance the semantic interoperability between models supporting several information domains of the full CALS vison. A broad and strong government and industry base supporting this will be beneficial throughout the value chain of the system of interest, including that of support systems. This is particular true for long term strategic value chains, including concepts such as Contractor Logistics Support and Performance Based Logistics.

2.2.9. Implementation of PLCS by French MoD (DGA) - Return of experience

In January 2010, France ratified STANAG 4661, in which ISO 10303-239 standard (PLCS) is encapsulated.

Then, in the same year, the first implementation of the standard aimed at building a PLCS interface for air systems support to exchange technical data (applicable product configuration, in use product configuration, support data, technical event report) between three LIS (Logistic Information Systems) belonging to French MoD. This interface, named DEX COMP@S, is based on PLCS edition 1 and DEXlib with use of OASIS DEX D003 (Task Set) and ASD business DEXs (DEX1A&D and DEX3A&D).

In 2011, an experimentation of PLCS was realized by DGA, the French procurement agency, in order to:

- Study potential gains in other domains (land systems support and sea systems support),
- Consolidate technical and financial recommendations for future implementations of PLCS with development of DEXs.

The technical conclusions of the experimentation were:

- As PLCS edition 2 provides the scope to cover all the French MoD requirements, choice of this edition 2 for implementations.
- Realization of DEXs by using PLCS PSM and PLCSlib which have several advantages compared to DEXLlib approach :
  - ✓ improved information model : increased scope derived from AP 239 edition 2, more efficient information model, less complex XML schema, easier to implement ;
  - ✓ SysML based : usage of mainstream software technology and practices.
- Architecture components for implementations :

- ✓ PLCS database, named PENCIL, to consolidate exchanged information ;
- ✓ secure ENX connection, named Partners Area, to interface Administration LIS and manufacturers LIS because French MoD network is separated from the Internet network ;
- ✓ WebDav server, ESB (Enterprise Service Bus), transactions handler.

In September 2012, French MoD organization for land systems support (SIMMT) decides to firstly apply these recommendations in CAESAR program, built by NEXTER manufacturer for French Army, for exchanging and sharing data between NEXTER LIS and SIM@T (LIS for land systems support). Then, six SIMMT business DEXs were created to cover in-service support data. These PLCS interfaces for CAESAR program will be operational in the middle of 2015.

In 2015, SIMMT launched the MAPS project which is :

- the extension of *"PLCS for CAESAR"* to all the functionalities of SIM@T,
- the generalization of PLCS data exchange with all the land vehicles manufacturers.

MAPS will take into account initial support data, and in particular LSA (Logistics Support Analysis) data by implementing ASD/AIA specification S3000L with usage of :

- PLCS PSM,
- 2 ASD business DEXs (DEX1A&D and DEX3&D),
- OASIS and SIMMT templates.

From 2012 to 2015, much advertisement has been done to promote French MoD policy : during PDT Europe conferences (2012 and 2014), during NATO Life Cycle Management conferences (2013 and 2015, presentations available on the ASD SSG web site – Publications section) and during Steering Committee S3000L in April 2015.

As a conclusion, French MoD supports the development of PLCS edition 3 and the updating of PLCS to reflect the industrial requirements that were met by PLCSlib.

2.2.10. "Type Certification"-process and "Continued Airworthiness"-activities

In A&D business the "Type Certification"-process and "Continued Airworthiness"-activities are specific for this industry sector. The applicant has to demonstrate compliance with legal certification regulations (requirements) of ICAO, EASA or FAA.

Airworthiness Limitations and Maintenance Instructions for Continued Airworthiness (ICA) are part of the Type Design and the Maintenance Review Board (MRB) process is an Acceptable Means of Compliance (AMC) to develop maintenance instructions ensuring the objectives of an efficient aircraft maintenance program.

AP 239 implementations have focused in the past on maintenance in the in-service phase. However the MRB-process starts at the very beginning of the concept and design of an aircraft. Data exchanged with the different design domains (structure, electronics/avionics, electrics, engine, flight test, …), the configuration and performance to be certified are the basis of an aircraft maintenance program and the starting basis of the Operators Maintenance Program (OMP).

It's a living process till retirement of the last aircraft and years beyond. Continuing Airworthiness involves operators, manufacturers and airworthiness authorities. "Feedback from the fleet" on operators experience and reliability of aircraft and systems is an essential part of this process.

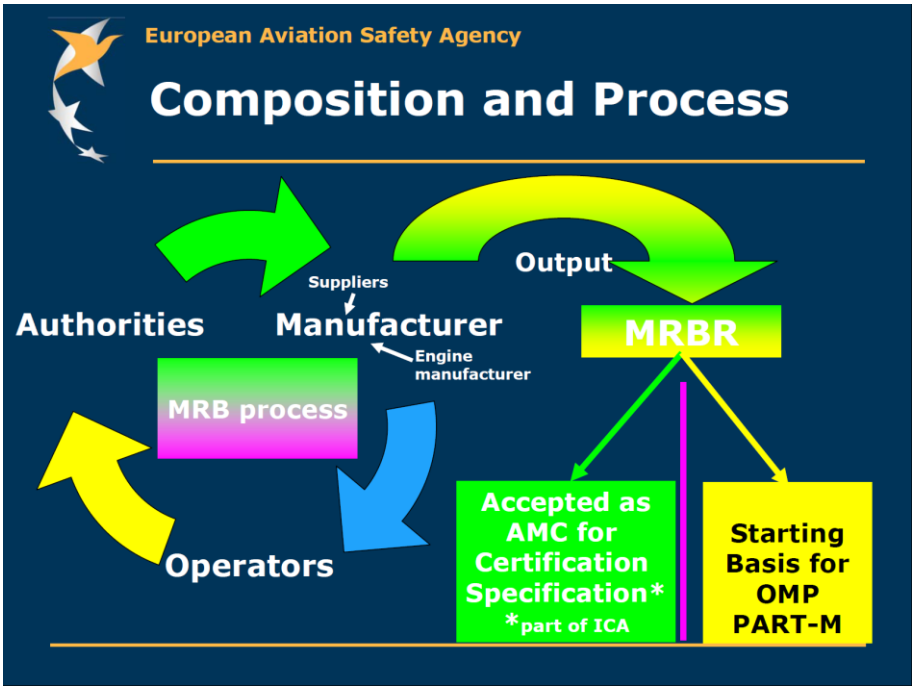

Figure 10: Maintenance Program Development (MRB process)

The challenge:

- An heterogeneous application ecosystem
- An heterogeneous standard system
- An heterogeneous implementation system
- A multi-domain approach with distributed data
- A highly organization dependent data management

The requirements:

- A unified framework for full "data exchange" process execution and management
- A single persistent data management system
- A unified user interface to data/information

There are on-going activities between the aerospace industries and the certification authorities to define new rules and applicable means of compliances compatible with digital model-based processes. In most cases, the new regulations will result in new AMCs, referencing open interoperability standards, such as NAS/EN 9300 or the ISO 10303 STEP AP 242 and AP 239 PLCS.

2.3. Business requirements of other industries

No requirements identified.

2.4. Requirements for simpler implementation of STEP AP 239 ed3

Even if AP 239 PLCS standard has proven its pertinence for modelling the ILS business thanks to a common, generic and extensible information model, the expected benefits for the business are closely linked to the performance of implementation in an operational context.

Such implementation projects shall be driven by a method which:

- Is clearly specified and includes **usage guidance** to avoid discrepancies between implementation projects and actors involved in the targeted data exchange. Unambiguous implementation method is a must.
- Is based on an **international standard**, commonly shared, in order to preserve investment at mid and long term
- Is **stable** to avoid rework and heavy maintenance costs
- Preserves legacy investment thanks to upward compatibility (as far as possible) with former standard edition
- Is able to interoperate with other STEP APs, and existing heterogeneous systems based on standards or not
- Is **simpler** as far as possible
- Requires technical skills widely available
- Relies on **open standards** and **mainstream information standards**, in particular UML/sysML for modelling and XML for formatting information data
- Is vendor **independent**, including the required toolset

  Note: open issue about XMI harmonization between sysML editors for supporting new STEP architecture – today dependence from MagicDraw

- Covers the technical business requirements if any. In particular, the standard shall rely on a stable core information model, whose implementation may support several technologies as current ones (P21 and XML) as well new ones (Web services, Linked data – OSLC technologies…)
- a mechanism for sharing common semantic between actors across technical or business domains, like reference data libraries, shall be considered

2.5. Requirements for consistency with other interoperability standards

2.5.1. Consistency of STEP standards

As illustrated in the next figure, the STEP series of standards has been designed to cover the entire life cycle of product data across all functions throughout the supply network.

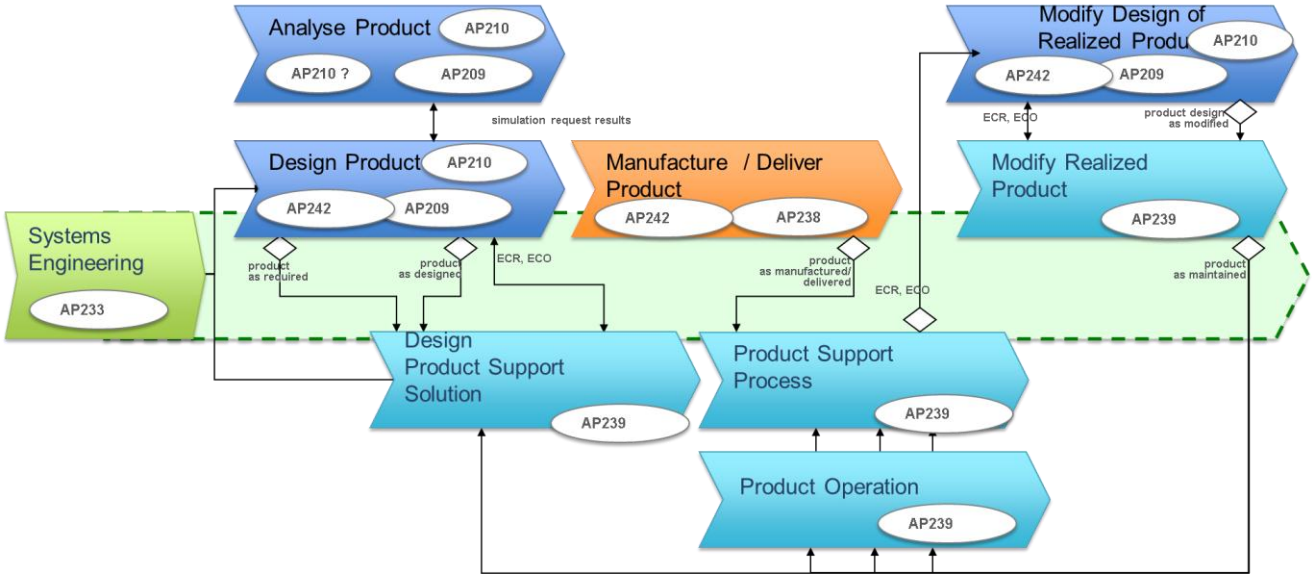

Figure 11: Overall information flow covered by the STEP Application Protocols

The next figure summarises the current analysis of STEP Application Protocols coverage and overlaps.

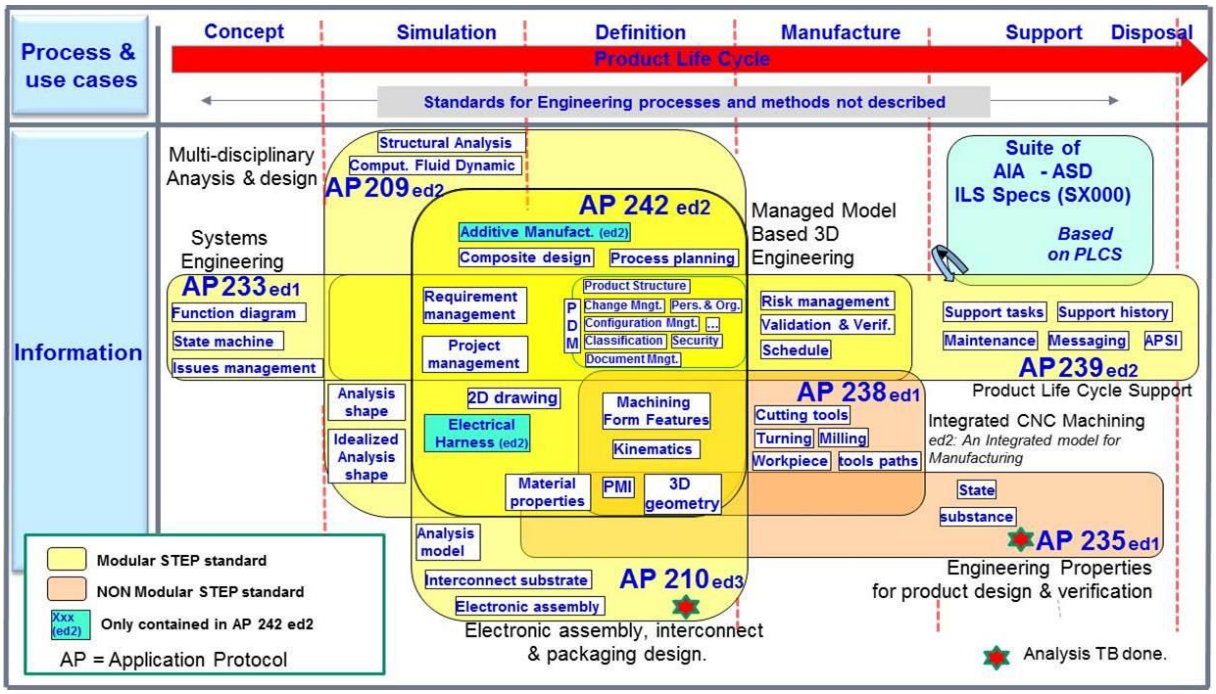

Figure 12: Suite of STEP core standards for PLM interoperability

As recommended by the ASD Strategic Standardisation Group (ASD SSG), ISO 10303 STEP Application Protocols can be seen as the cornerstone for PLM information interoperability. However, as described hereafter, some risks of divergence or incompatibility are identified, that require clear recommendations and actions to be mitigated.

The Business Object Model (BO Model) was introduced recently in AP 242 and AP 209, in response to a need to have information definitions at a level which was easily understood by business in their own terminology. Introducing the BO Model allows an information model in the language of the business discipline experts. In addition, the BO Model is on a high level of granularity and thus more suited for the communication with and understandable by domains expert (e.g. Aerospace and Defence and Automotive for AP 242). An XML schema may be derived from the BO Model, formalised with EXPRESS, in order to support the implementation of data exchange and sharing.

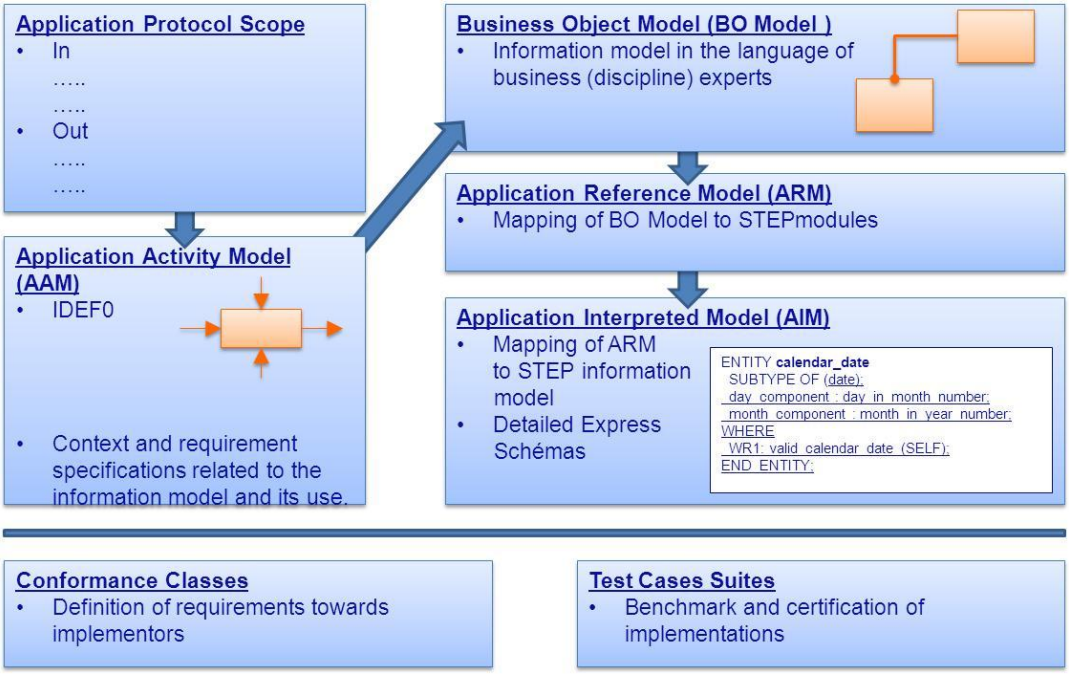

Figure 13: STEP architecture with BOM included

A number of challenges to interoperability arise from the architecture.

- The original concept of monolithic STEP APs led to incompatible information models which did not interoperate, leading to a demand for "Recommended Practices" which facilitated common use. This was largely addressed by the introduction of the modular approach, but not all STEP APs have yet been converted to modular form. For example AP 238 for STEP-NC and AP 235 for material properties remain as monolithic documents, although the modules for the latter already exist within the SMRL in order to support the new AP 242. AP 214 for the automotive industry remains monolithic, as it will only have legacy interest after the publication of AP 242.
- For modular APs, interoperability issues can arise when the SMRL containing all the component parts is updated to reflect new APs. Changes to modules and their architecture through subdivision and aggregation can demand the regeneration of the AP based on the updated SMRL. If an AP is not updated due to lack of resources, then there is a risk that it will be rendered non-interoperable with those generated from the new SMRL version.

- Interoperability can also be destroyed by selecting different implementation methods with the same application protocol, unless the translators are capable of accommodating all implementation methods.

The AP 242 BO Model and the PLCS PSM both provide improved accessibility for domain experts, and a basis for implementing XML-based PDM exchange. While considerable efforts have been made to ensure the harmonization of the new Business Object Model for AP 242 and the PLCS PSM based on AP 239e2 there are still some inconsistencies that have not been resolved in the latest documents, for reasons of schedule and complexity.

This leads to coexistence and simultaneous usage of inconsistent implementation frameworks, making it difficult to harmonize the practices and the tests for the different communities relying on STEP.

The following figure describes differences between the AP 239/PLCSlib and AP 242 ed1 for which a way for defining recommended practices is to be decided, if possible taking the best of model based approach as defined by OASIS PLCS, but having to ensure consistency and full control within ISO.

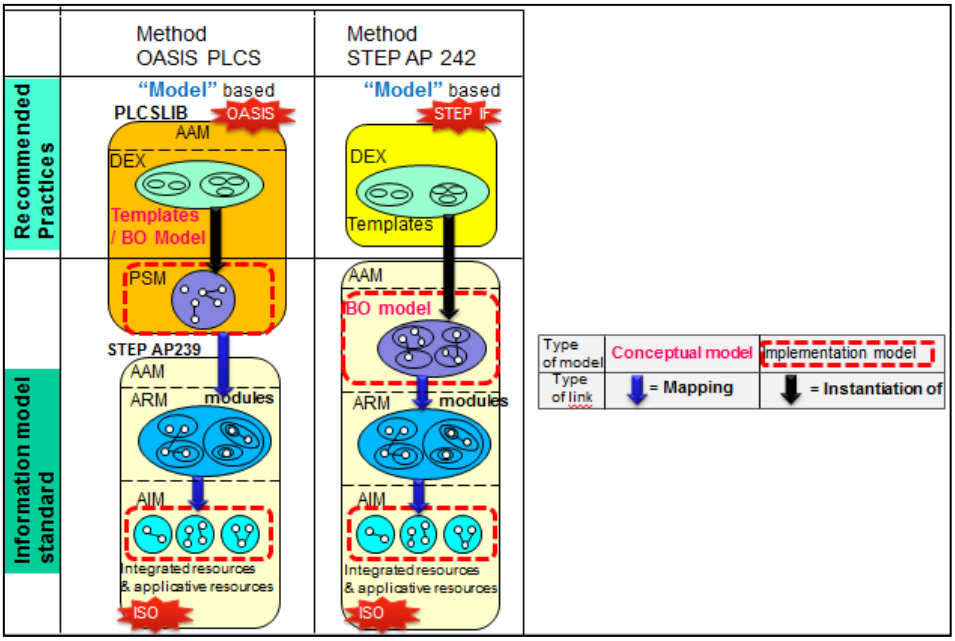

Figure 14: Comparison between OASIS PLCSlib and AP 242 ed1 approaches

In order to support the availability of a consistent and configured set of interoperable Application Protocols for supporting the Aerospace & Defence community, there is a clear requirement for a consistent approach to the generation of Business Object Models from the underlying STEP architecture, and to work in a harmonised way on testing and recommended practices.

A further missing component is a consistent definition of Web services based on the Business Object Models.

To ensure interoperability between AP 239 ed3 and other related STEP APs, the new edition of AP 239 shall ensure the compliance with existing ISO STEP modular standards and the future modular STEP architecture (new framework, new SMRL…) initiated by AP 242 ed2.

Aligning the requirements and implementation forms of AP 242 and AP 239 will ensure that these standards can be used together to support the entire product lifecycle. The ISO 10303 standard is critical for small business participation in manufacturing. The standard allows small business to use low-end CAD systems that are in some cases one tenth the cost of high-end CAD systems used by large manufacturers. Using STEP, small manufacturers need only maintain a single design system rather than multiple systems when working with multiple original equipment manufacturers.

2.5.2. Coordination with STEP AP 242 ed2 for common modules

As represented in Figure 12: Suite of STEP core standards for PLM interoperability, AP 239 and AP 242 are sharing common information requirements.

Indeed, the following common modules (identified to date) shall be harmonized between AP 242 ed2 and AP 239 ed3:

- PDM module including:
    - Product Structure
    - Change Management
    - Person & Organization
    - Configuration Management
    - Classification
    - Security
    - Document Management
- Requirement Management
- Project Management

Based on the partial harmonization work performed between OASIS PLCS PSM and AP 242 ed1, this work shall be finalized in the frame of the future AP 239 ed3 in coordination with the on-going AP 242 ed2 project.

2.5.3. Consistency with linked data standards, such as OSLC

Open Services for Lifecycle Collaboration (OSLC) standard is an emerging approach to lifecycle integration based on Web and Linked Data technologies, with the objective to simplify the key integration scenarios across heterogeneous tools.

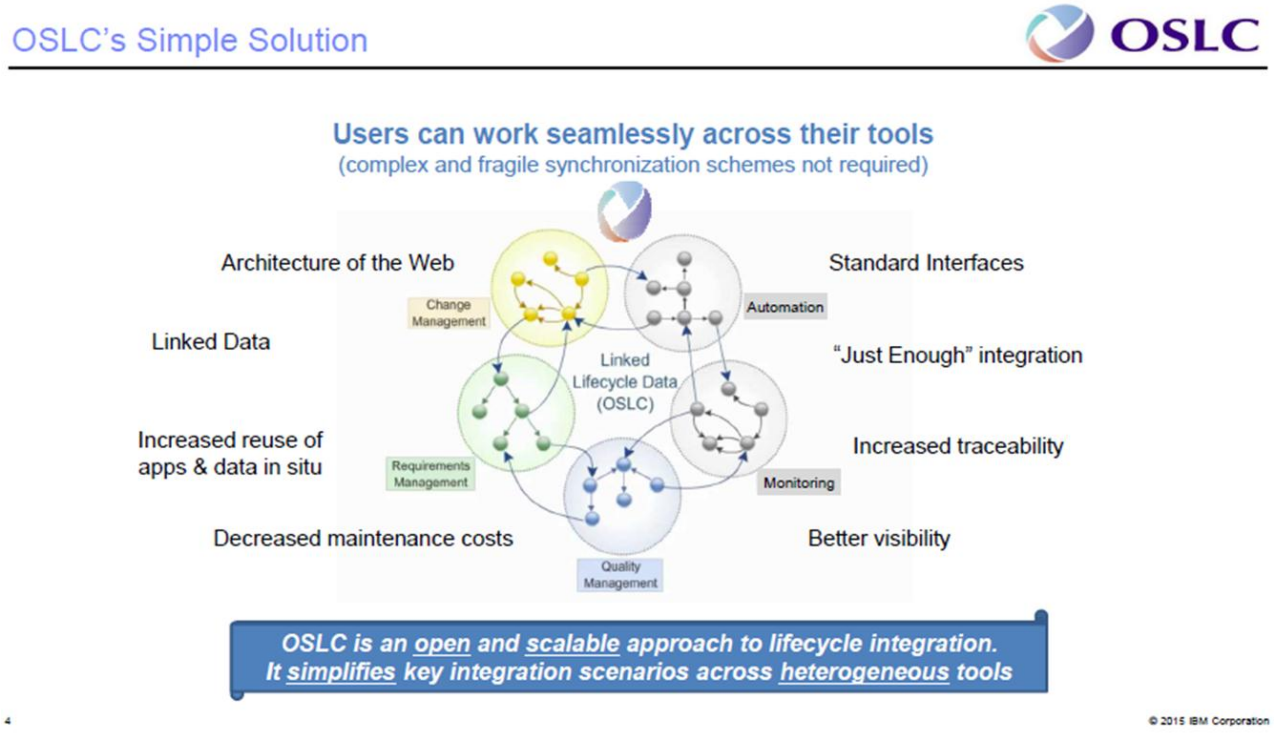

Figure 15: OSLC Principles

Even if OSLC comes from Software Engineering, OSLC intends to cover other domains (like PLM) to ensure cross-disciplinary relationships.

The OSLC core specification is published and available (issue 2.0 at open-services.net), and domain specific specifications are on the way. For PLM interoperability, a specific working group has just been launched ("ALM-PLM Interoperability") and the related OSLC specification does not exist yet.

In the Aerospace & Defence community, OSLC is identified as a new implementation technology to be supported by STEP standards (cf requirements from ASD Strategic Standardisation Group), so AP 239 edition 3 and the underlying new STEP architecture shall provide a way to propose an OSLC implementation method of STEP.

3. Benefits and business drivers for AP 239 ed3

3.1. Summary of main business drivers

The creation of the AP 239 PLCS was based on the business drivers related to STEP use, and these drivers are still fully relevant for AP 239 ed3.

The report, "Economic Impact Assessment of the International Standard for the Exchange of Product Model Data (STEP) in Transportation Equipment Industries" offers great examples of the benefits from implementing international standards. The objective of this economic study was to conduct an economic impact assessment of STEP's use by transportation equipment industries, namely the automotive, aerospace, shipbuilding, and specialty tool and die industries. Both the full potential and current realized benefits are quantified.

Data collected from industry surveys and case studies were used to estimate the potential benefits of existing STEP capabilities. We estimate that STEP has the potential of save $928 million (2001) per year by reducing interoperability problems in the automotive, aerospace, and shipbuilding industries. Currently approximately 17 percent ($156 million) of the potential benefits of STEP quantified within the scope of this study are being realized. Benefits and costs were projected through 2010 assuming a 75 percent penetration rate for STEP in 2010. STEP development costs include expenditures by government agencies, software vendors, and industry users, and were estimated to be approximately $17 million per year in the late 1990s.

Benefits accrue to users through increased interoperability of computer-aided design, engineering, and manufacturing and product data management systems (collectively referred to as Cax in this study) used in the product design supply chain. These benefits can be generally categorized as:

- decreased avoidance costs
- decreased mitigation costs
- decreased delay costs (RTI, 1999)

With regards to AP 239, the key concept is the creation, of a single source of truth for assured product and support information, for use across the enterprise. This information will necessarily be created in many different IT systems CAD, MRP, ERP, FMECA, LSAR and authoring tools etc. but, to realize the vision in full, the information needs consolidation to create the necessary explicit links between related items.

This business vision is important because it enables a major improvement in quality and efficiency over typical practice. Currently, some point-to-point exchange capabilities have been established, but the information required to deliver efficient support typically exists in many different IT systems, used by many organizations for different business functions across different life cycle phases.

Particular difficulties are often found in the gap between the OEM and end-user communities, neither of whom have appropriate access to information created by the other. As a result, information which already exists either has to be re-generated, re-formatted or re-entered manually with a proliferation of errors over time, or managers are forced to make decisions based on incomplete or inaccurate information. The impact of information errors and omissions is rarely measured by accountants, but such errors add heavy costs and time delays to many business processes.

In addition, from the experience on previous edition of AP 239 and feedback from product support projects, specific business drivers have been identified for AP 239 ed3:

Business needs	Business requirements for AP 239 ed3
Realization of an efficient Integrated Logistic Support, by integration of the different logistic disciplines, covering all aspects of supportability over the entire life cycle of a product.	**Support of ASD-AIA ILS Specifications and also GEIA-STD-0007** STEP AP 239 ed3 should support the implementation of each individual ASD-AIA ILS specifications, as well as the data transfer mechanisms between these specifications.
Use cases are identified as the key business needs related to the challenge of interoperability between ILS disciplines based on the usage of ASD standards, to be supported by future AP 239 ed3.	STEP AP 239 ed3 should be applicable as contractual baseline when implementing ASD-AIA ILS specifications in procurement programmes. Long term objective for the DMEWG and the S-Series ILS specifications is to adopt ISO 10303:239 PLCS ➔ future mapping of the DMEWG bespoke XML schema to AP 239 ed3 Note: ISO 10303-239 ed2 currently contains the basic requirements needed to support the U.S. DoD. However, implementation issues are encountered and shall be addressed (see other requirements).

Business needs	Business requirements for AP 239 ed3
Minimize the cost and the delay of development of interfaces based on AP 239.	**Ease the understanding** of the standard. Facilitate the **mapping with business specifications** (in particular with the AIA/ASD ILS Suite and the GEIA STD 0007) by providing high level business objects. **Propose a simpler and performance implementation method of AP 239** taking into account lessons learnt from AP 242, PSM/PLCSlib, DMEWG, DoD requirements in GEIA-STD-0007 rev C. A normative XML schema is the priority – based on the core model (and related derived XSD) of the new STEP archi, across all STEP APs. **Web based implementation methods** (SOA services and linked data/OSLC) shall be developed in addition to P21 and XML methods.
Ability for A&D Industries to manage design, product and service information throughout the product lifecycle, including rigorous configuration management and the long term retention of information, where the data is 'created once and used many times'.	**Strengthen the STEP architecture approach to ensure interoperability of AP 239 ed3 with other STEP APs (incl. AP 242), and provide unambiguous implementation methods** (including for new information technologies, e.g. OSLC). AP 239 ed3 shall be based on the new STEP architecture initiated by AP 242 ed2 project.
A reliable and harmonized ISO /TC 184 /SC 4 information model through the product life cycle is considered as a key enabler for product data interoperability across domains. **Note: no clear business case identified to date for harmonizing the information model of ILS domain with the information models of other domains.**	**STEP AP 239 ed3 and AP 242 ed2 as cornerstone information models for PDM and requirement management information interoperability across the full A&D product life cycle** (exchange, sharing / linked data, LT archiving) - Finalization of PDM and requirement management harmonization between AP 239 ed3 and AP 242 ed2
Preserve legacy investment (current AP 239 based systems) thanks to upward compatibility (as far as possible) with former standard edition.	**Provide way forward** for existing AP 239 ed2 and PLCS PSM / PLCS lib implementation projects
Ensuring efficient interoperability within domains and across domains requires a mechanism for sharing common information semantics (e.g. classification and reference values) managed at an	Provide common **Reference Data**, managed at ISO level. Provide Reference Data infrastructure.

Business needs	Business requirements for AP 239 ed3
international level.	

3.2. Related business processes supported by of AP 239 ed3

As originally defined in the first edition of AP 239, the PLCS Activity Model illustrates the processes and information flows in the PLCS scope (see Annex B: PLCS History). This provides context for potential data exchanges through life, and can be used to identify information interfaces across any chosen functional boundary. Both the PLCS vision (see Figure 3: PLCS vision) and the PLCS Activity Model have “informative” status in ISO.

PLCS root activity “Provide through life support for product” is defined as the action to achieve and sustain efficient support of a product in focus throughout its life cycle.

NOTE: This activity covers the support and disposal of products, the definition, commissioning, use and upkeep of the support system, and the management of support information. The product is designed, tested, manufacture and operated outside the scope of this model.

The next figure sums up the main business processes through the product life cycle, which will take benefits from STEP AP 239 ed3 project:

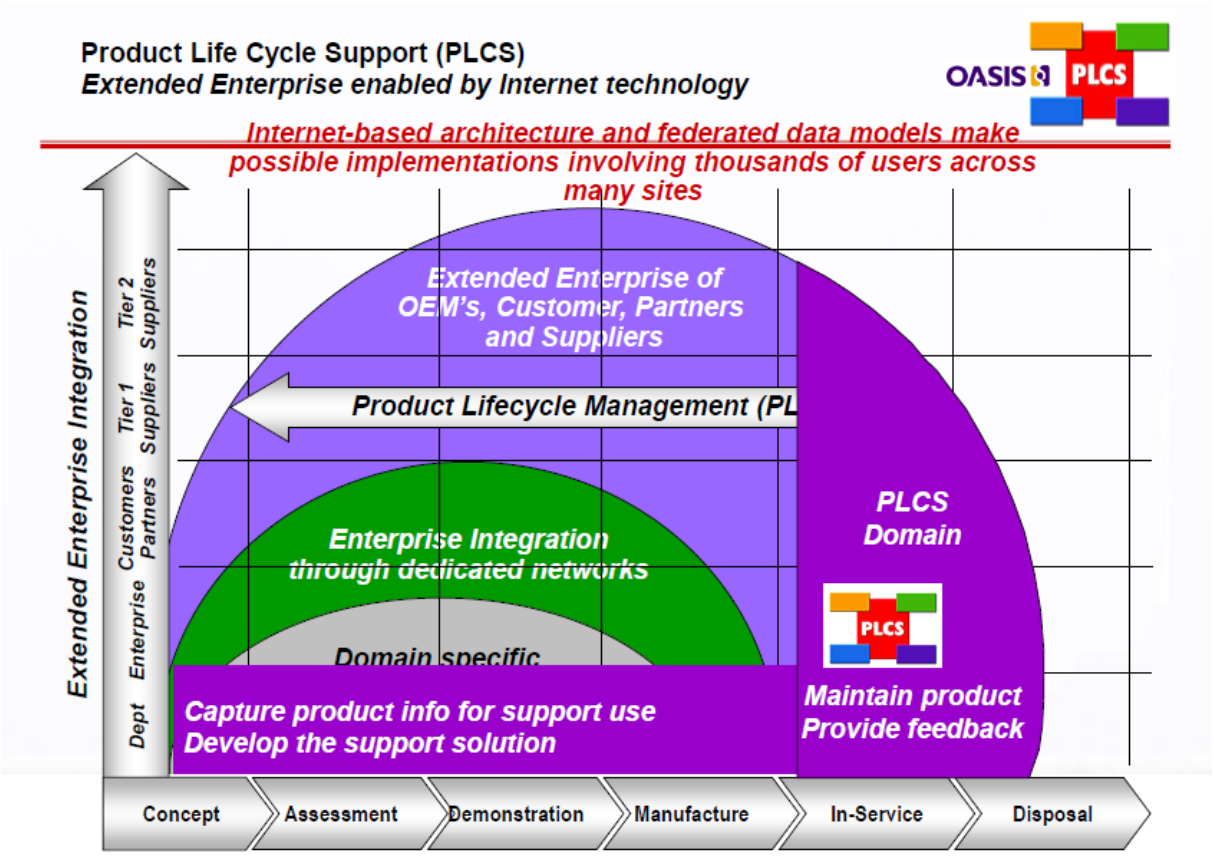

Figure 16: PLCS Business scope

3.3. Extended usage scenarios and use cases

No major extension identified yet.

4. Proposed AP 239 ed3 technical content

4.1. Information model changes request

In order to support the ASD/AIA ILS S-Series specification, a set of changes of the AP 239 ed2 information model are required.

Hereafter the list of change requests to date.

Business requirement	**Change request on STEP AP 239 ed2**
S5000F: need to establish relationships with persons, organizations and in some cases a combination of both.	Extend the People-Organization module in order to allow relationships with a person that does not belong to an organization. It is proposed to create a "Party" entity, that retains all relationships, and subclass it to "Person and "Organization".
S5000F: Need to be able to assign an address directly to a Person and other entities (not only organizations).	• Convert Address into a Location subclass.
S5000F: need to be able to provide cost data	• Include cost data
S5000F: Need to be consistent with locations for multiple uses.	• Need to differentiate between geographical locations and functional/ relative locations. • A geographical (physical) location will never move and is permanent • A functional/relative location might move or be only valid during a certain period of time • A functional/relative location (e.g., within a product, a warehouse, an organization, etc) will ultimately be located at a geographical/physical location, though it might move to a different one. • A geographic location will never be part of a functional/ relative location.
S5000F: Redefine Person	• Current Person definition ignores the fact that a Person might have several family names, as occurs in many countries. On the other side, Middle names and prefix and suffix titles are far less important.
S5000F: Redefine Address	• Current Address definition is prone to misspellings and duplicate entries because of the usage of string fields. • Some of the String fields are actually geographical locations (e.g., Country, or City).
S5000F: Ensure consistency within model	• Example: Language has a Country Code, but Address has a String to indicate the full country name
S5000F: Redefine Language	• Language has a CountryCode as an optional string, but a same language can be spoken in multiple countries. • Similarly, a country might have multiple official languages, or even a region could have multiple languages. We need a

	relationship between Language and geographical locations.
S5000F: Include movement data	• Need to incorporate movement information in case the Product is able to move, as well as transport information (e.g., for spares)
S5000F: Include operational environmental data	• Allow the inclusion of environmental data in the product operation (type of environment, operational conditions, weather)
S5000F: Need operational information	• Include operational periods of the product, including function times, start, end, relationship with operational environment, movement data and operational status during the operation.
S5000F: Redefine Contract as Document	• Contract is a special type of document, and should be a subclass of Document, as it is managed like any other document.
S5000F: Need to define Product as individual relationships with Persons and Organizations	• The Product_as_individual needs timed relationships (as these can change) to Persons and Organizations (suggested to use a "Party" class), for example who is the owner, the operator, maintainer, etc.
S5000F: Need to have timed Product as individual breakdown	• Product_as_individual needs a product breakdown with individualized items (e.g., serial numbers) that is valid at a specific moment in time.
S5000F: Need to define infrastructure	• There needs to be the possibility to define an infrastructure (e.g., computer network). This is a resource_item that has multiple geographical locations.
S5000F: Need to define facilities	• There needs to be the possibility to define an facility (e.g., landing strip, warehouse, workshop) that is not necessarily an organization. This is a resource_item that has a single geographical location. (could be a subclass of infrastructure)
SX002D/S5000F: Product breakdown	• Product breakdown in SX002D/S5000F is slightly different from AP 239. Assess reason for deviation.

Furthermore, the following issues shall be taken into account:

- A set of open issues on AP 239 ed2 are today raised according standard ISO SC 4 procedure and managed in http://www.wikistep.org/bugzilla/.

  On 18/09/2015, 20 open issues are recorded (see Annex A: AP 239 open issues)

- The outstanding issues against the PLCS PSM collected by OASIS PLCS
- Other issues arising from experience of deploying AP 239 ed1,ed2, DEXlib and PLCSlib

4.2. New core model

In order to tackle implementation issues against existing ARM/AIM approach, AP 239 ed3 intends to contribute to the definition of the new core model within the new STEP architecture.

The key expected features of the core model are:

- Using sysML language,
- Mapped with ARM,
- Optimized compared to ARM,
- The basis for building upper level business objects thanks to the sysML parametric diagram mechanism (support of templates)
- Ease the support of multiple implementation methods including the support of new implementation technologies

Such core model, common to all STEP APs based on the STEP architecture, can be decomposed (partitioned) into a set of “Core Technical Capabilities” (CTC), also called “Capability models” as shown hereafter.

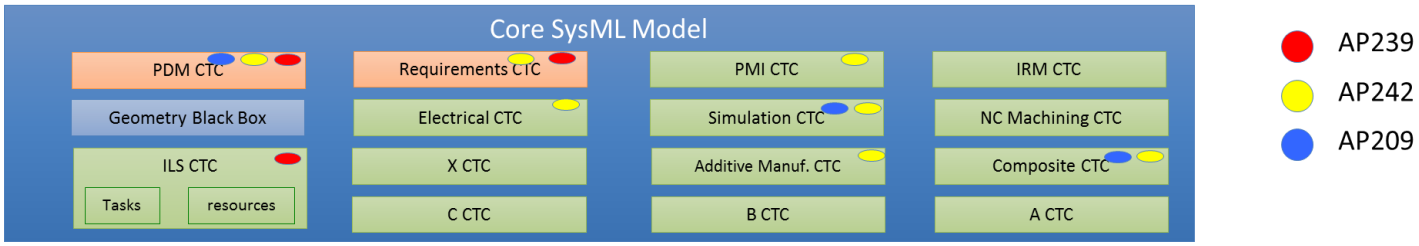

Figure 17: Core model and Core Technical Capabilities (CTC)

The definition rules of a CTC are:

- A CTC shall be a consistent group of Application Object
- One object is defined in a single CTC, the CTC do not overlap
- A CTC is a set of SysML blocks or objects which are fully defined (all attributes), documented and implementable
- CTC shall be as large as possible, to reduce the links between capabilities. the bigger the better.
- A CTC shall be meaningful to the user community
- A CTC can be decomposed into domains and subdomains using in sysML Packages ie: multidisciplinary simulation decomposed into Thermal analysis, finite element analysis or PMI decomposed into G&T, D&T, Weld, …
- CTC shall provide interfaces and auxiliary information

AP 239 ed3 will define the CTC in its scope, in consistency with AP 242 ed2 for common ones.

4.3. Mapping with other implementation technologies standards

In the frame of the new STEP architecture, AP 239 edition 3 intends to improve and extend the existing implementation technologies:

- P21 implementation method is kept for preserving legacy P21 data exchanges
- P28 (XML) is deeply enhanced in order to propose a new unambiguous and performant way to exchange data thanks to XML files. A normative XML schema will be build.
- A new method for building Web services
- A new method for building Linked Data Services/ OSLC

Note 1: AP 239 ed3 project shall support P21 implementation method if the need is confirmed by interested companies and organizations at the beginning of the project.

Note 2: As required in section 3.1, the support of XML data exchange is the priority; other methods shall be seen as additional ones under the condition of enough appropriate resources committed by the stakeholders of AP 239 ed3 project.

4.4. High level business objects

Based on the experience from PLCS framework development (mainly DEXlib and PLCSlib) and implementation projects, AP 239 edition 3 will support the development of high level business objects based on the template mechanism to ease the understanding, and the mapping between business specifications and the generic concepts part of the STEP standard.

For that, the target new STEP architecture will support a multi-layered information model, with at the lowest level (the core model), the existing generic concepts of the standard coming from ARM/AIM modules, and above the possibility to define specific business objects within business layers addressing the right level of consensus between the stakeholders.

The next figure illustrates how this multi-layered information is planned with the positioning of AP 209, AP 242 and AP 239.

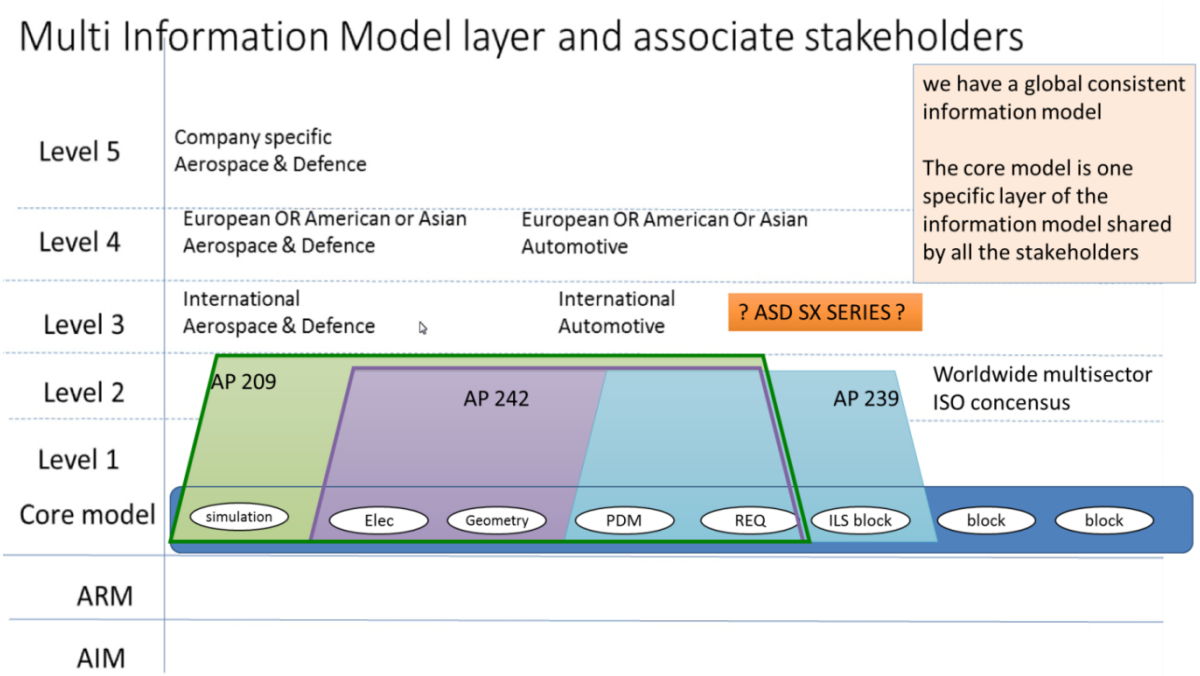

Figure 18 : Multi-layered model and positioning of STEP APs

Note 1: in order to capitalize the work done in past, AP 239 ed3 will include the definition of a set of AP 239 templates. Those templates will be selected among the used templates available in the scope of DEXlib (DEX1 prod structure & DEX3 maintenance task) and PLCSlib.

Note 2: as proposed in the figure, the business objects defined in the ASD S-Series data model could be seen as potential business objects of the 3rd level, which would be represented by Aerospace & Defence specific templates built on AP 239 templates defined in lower levels. Aerospace & Defence specific templates are out of the scope of AP 239 ed3.

4.5. Use of Reference Data Libraries

A common mechanism for using reference data shall be defined for being used by all STEP APs based on new STEP architecture (e.g. AP 242 ed2 and future AP 239 ed3 in a first step).

Furthermore, common Reference Data Libraries (RDL) shall be built and managed at an international level (ISO in that case) for offering the possibility to share a common international set of reference data definitions, potentially harmonized or mapped with other international standards using reference data, for example the ISO 15926 standard.

Considering the targeted multi-layered information model, reference data will be defined at two levels within the AP 239 ed3 standard

- Reference data related to the core information model
- Reference data related to upper levels of information level, specific the AP templates (for instance the AP 239)

Note: reference data mechanism shall provide the way to specialize common reference data for defining specialized reference data applicable to a specific context of implementation.

5. Principles for the development of AP 239 ed3

5.1. Architecture framework for PLM interoperability

The targeted architecture framework shall ensure the PLM Interoperability by addressing the different business needs and the different implementation technologies, but based on a unique and consistent information model (highlighted in yellow colour in the following figure):

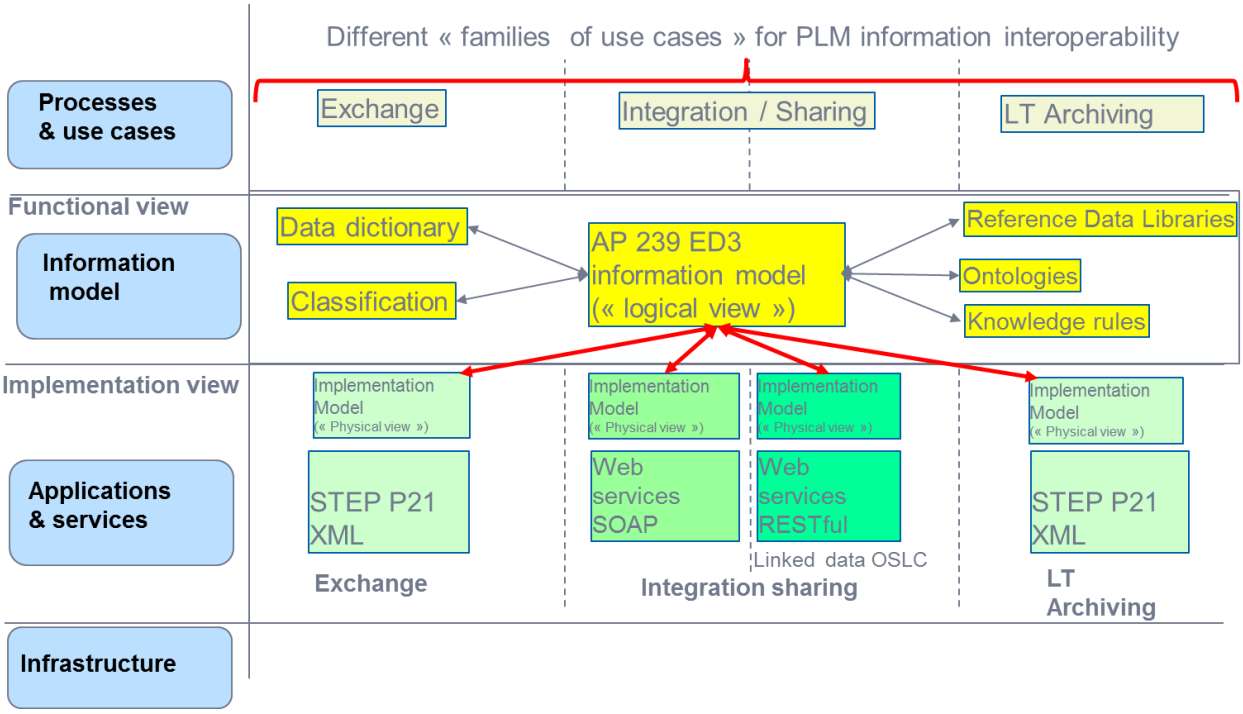

Figure 19: Architecture framework for PLM Interoperability / AP 239

Thanks to a clear division between the functional view and the implementation view, the information model stays the same whatever the implementation technologies are (e.g. STEP files P21, XML, web services, or linked data services).

5.2. Use of the New STEP architecture

In coordination with AP 242 ed2, the future AP 239 ed3 shall rely on the basis of the new STEP architecture.

Managed by ISO/TC 184/SC 4, The goal of the new STEP architecture project is to answer to the increasing needs of the industries, governmental agencies and PLM vendors / integrators to use a set of efficient and consistent international standards for product and process information interoperability.

The New STEP architecture project aims at enhancing the existing module-based STEP standard architecture, in order to deliver more benefits and easier implementation and usage by the international community.

Business benefits:

- Ensure consistent product information models through the different product life cycles and technical disciplines (ref.: results of the ASD SSG "Through life cycle interoperability" WG).
- Ensure the smooth evolution and the longevity / upward compatibility of the STEP modular standards.
- Speed up the adoption of the STEP based standards, by the proper management of a set of consistent standards, sharing the same principles and common subsets (modules).

Technical benefits:

- Update and refine the STEP standards development framework,
- Promote a consistent, modular and flexible interoperability architecture framework to support new specific implementation technologies:
  - Data exchange and long term archiving based on files
  - Data sharing and integration based on web services
  - Data visualisation and consultation,
  - Linked data based on web services,
- Define the principles of interdependencies between the ISO standards and the other standardisation projects completing the standards, such as the Implementer Forums.

Hereafter an overview of the multi-layered information model of the new STEP architecture and the key principles.

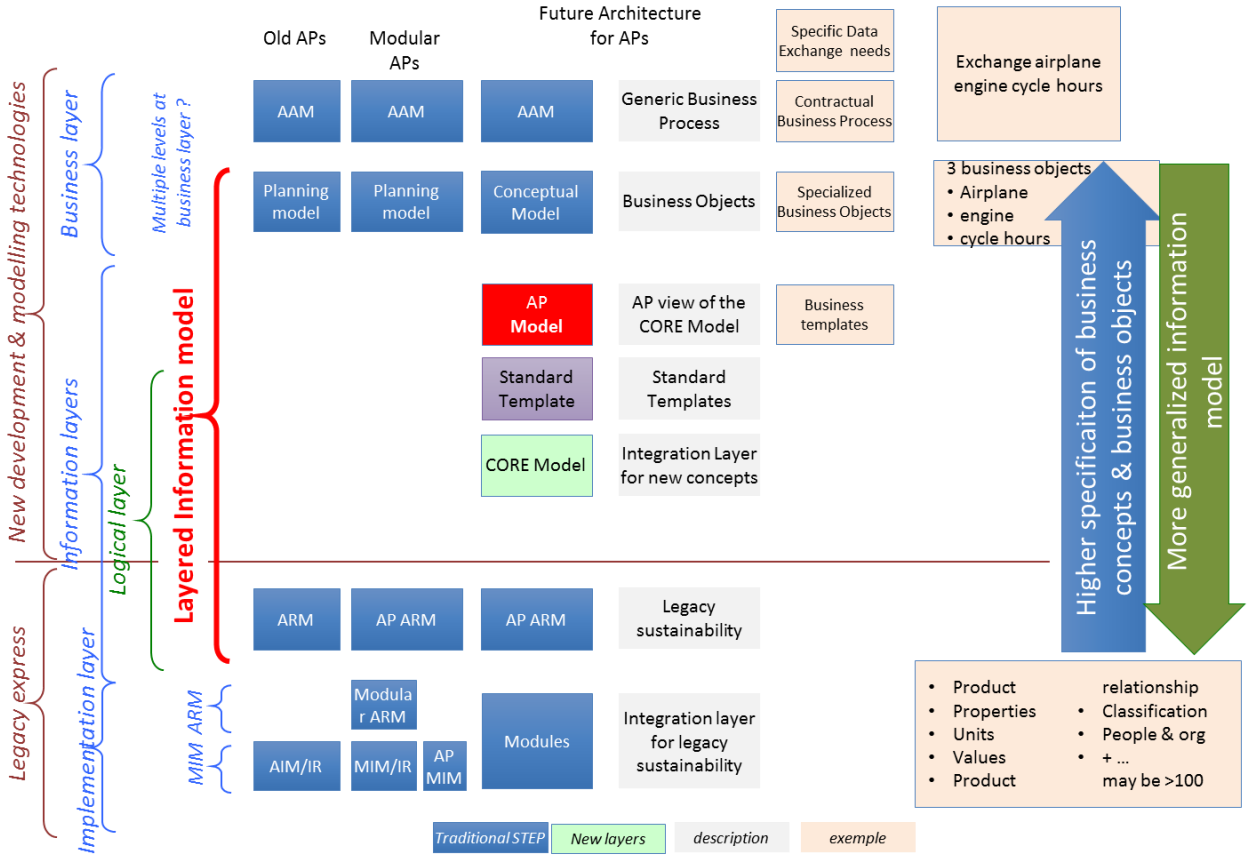

Figure 20: Multi-layered information model within new STEP architecture

A layer is a level of consensus from a group of stakeholders[1] on a specific « architecture layer »

The higher the level the narrower the group of stakeholders and the more specialized is the information model.

The lower the level the wider the group of stakeholders and the more generic is the information model

Two of the layers are integration layers:

- the Core model and
- the AIM for sustaining legacy implementation based on it

The integration layer spans multiple APs, and integration has to be consistent across layers

A layer can only reference components from layers below under it.

Technical implementation relies on several methods based on the core information model as illustrated in the next figure:

- P21 (for legacy sustainability)
- XML (based on XML schema XSD, unambiguous and enhanced method compared to P28)
- Other implementation technologies: SOA web services or linked data integration

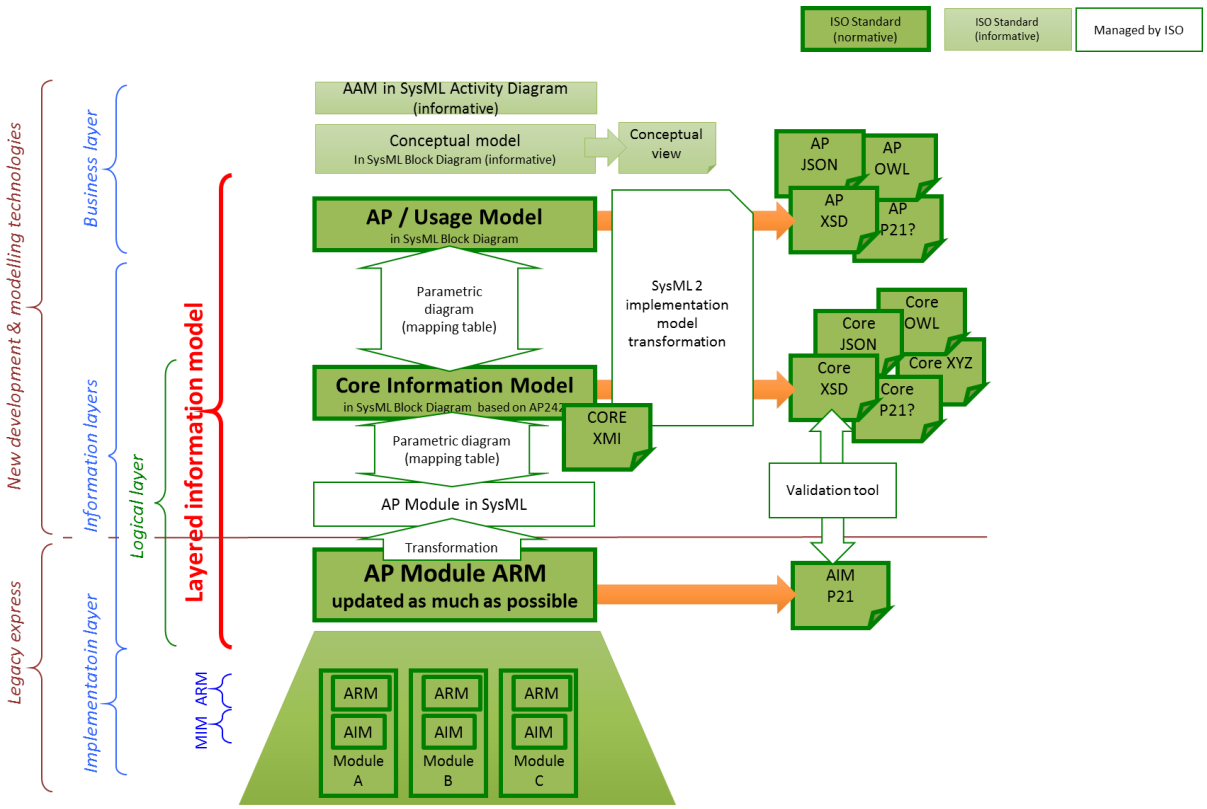

Figure 21: Common framework of the new STEP architecture

[1] a stakeholder group is a specific industry, or a business domain, or a lifecyle stage operators, or …

The legacy STEP architecture produces the AIM P21 files for implementation

Direct output of the legacy express in XML have proven to be not efficient and PLCS and AP 242 have introduced the concept of XML implementation based on a new specific model (PSM or BO Model)

In order to provide multiple implementations we need to take advantage of the evolution of the IT technologies and Model based enterprise and Model driven architecture.

The Core Information model and the Usage Model (both in SysML) will be able to produce implementation shemas like XML/XSD, JSON, OWL, RDF…

5.3. Modeling principles of AP 239 ed3

5.3.1. Architecture framework for AP 239 ed3

The AP 239 as other STEP APs will address a subset of the core model and the upper levels as long as these levels are resulting from a worldwide multi sector ISO consensus.

In details, the work to be done for AP 239 ed3 is highlighted in yellow color below:

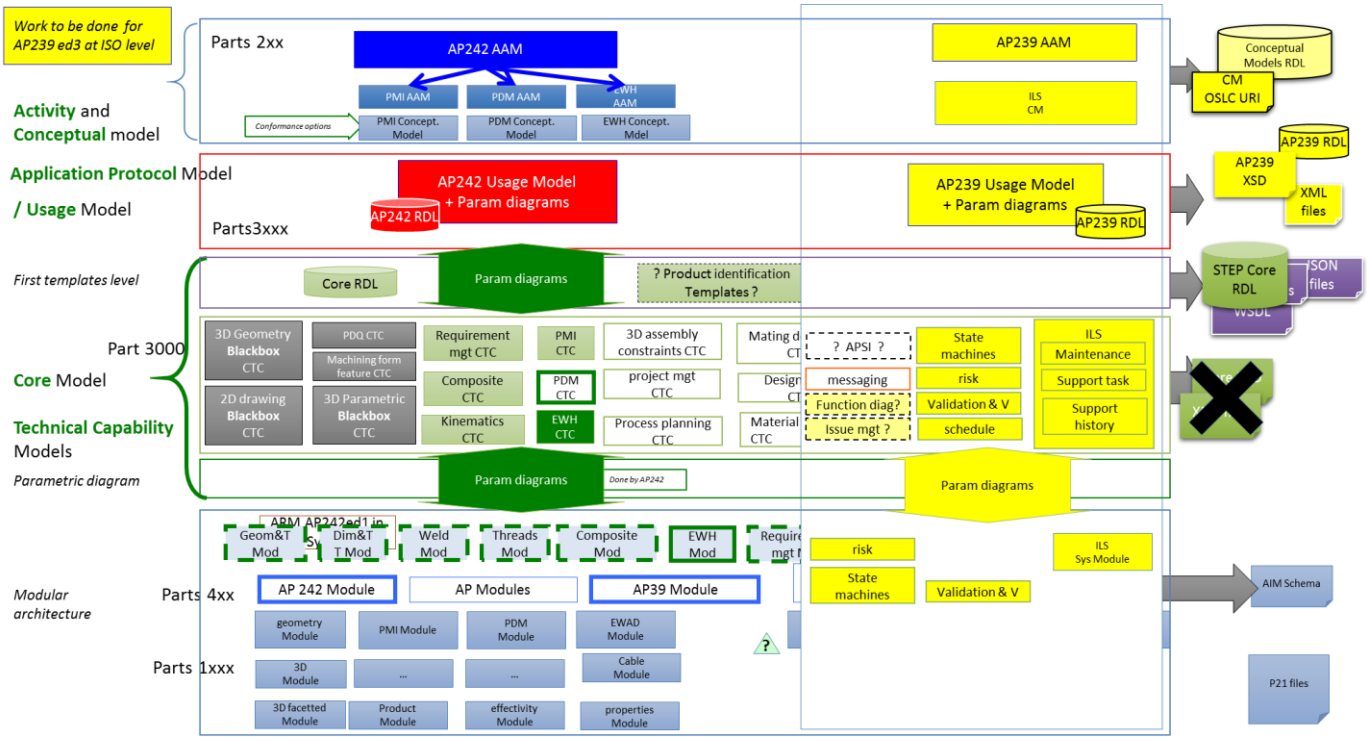

Figure 22: AP 239 ed3 within the new STEP architecture

5.3.2. Common approach to XML Schema

By the use of the new STEP architecture, an implementation method based on XML shall be developed in common with the on-going AP 242 ed2 project.

This harmonized method shall fullfill the requirements previous listed for a simpler implementation of STEP AP 239 ed3. In particular,

- Accessible and useable by programmers :
  - direct mapping to sysML (sysML 2 implementation model transformation)
  - based on a normative[2] XSD as XML programmers expect
- Ensure performance:
  - Reduce the size of the XML files: lessons learnt for AP 242, OASIS PLCSlib and also from DMEWG as well as from SAE GEAI-STD-0007, shall be taken into account
  - Usage of reference data libraries
- Openness of the method
  - Based on tools of the markets
  - XSD constructs commonly supported by tools shall be preferred

5.3.3. Other Implementation methods

The new STEP architecture proposes additional implementation methods to be used by AP 239 ed3:

- P21 : this existing method, based on AP 239 ARM, shall be kept in order to ensure sustainability of existing P21 implementation in production.
- SOA (WSDL) Web services: even if this method has been experimented in the frame of MoSSEC project (definition of a set of MoSSEC BDA services), some questions are still open, for instance about the granularity of services and underlying templates. The collaboration with MoSSEC and potential other web services projects shall go on in order to define an agreed approach and method.
- Linked Data: the support of emerging RESTful/linked data technologies is a major market trend to be taken into account. In order to avoid duplicated work between ISO SC 4 and OASIS OSLC, the Future STEP architecture team recommends that the OSLC specifications for PLM domain should be based on the Product data information models defined by STEP ISO 10303 and complementary SC 4 standards. A close collaboration with OASIS OSLC ALM-PLM working group will be required to carry out a linked data method in compliance with OSLC core specification.

5.3.4. Usage of Reference data

The reference data capabilities of the new STEP architecture shall support:

- The definition of a core RDL containing the whole semantics of the core model, including the core technical capabilities used by AP 239
- The definition of an AP 239 RDL containing the semantics coming from the AP 239 usage model (e.g. AP 239 templates)

Those RDLs shall be managed at ISO level to provide an international referential to be used by PLCS implementation projects. These RDLs can also be extended in the frame of development of specific RDLs required for a particular industry or use case. For example,

[2] Part of the standard

such RDLs may be extended by AIA/ASD to address the specific Aerospace & Defence industry.

5.3.5. Activity model and Conceptual model

In order to cover the need of a global view (all APs) and to ensure cross domain interfaces match (identification of common conceptual objects to be exchanged), the actual Application Activity Model (AAM) of AP 239 shall evolve:

- Transformation from IDEF0 to sysML modeling language
- Harmonization of highest levels:
    - Development of a cross AP high level activity model, supporting the global view shown in Figure 11: Overall information flow covered by the STEP Application Protocols, be managed at SC 4 level
    - Detailed levels specific to each AP , below cross AP high level, are under the responsibility of each AP

The new harmonized AP 239 AAM will be provided as informative part of standard. The AAM will ease the identification of data exchange/web services needs as the identification of conceptual objects to be exchanged.

The main conceptual objects of AP 239 ed3 will be formalized in an AP 239 Conceptual Model (CM). This model will improve the current conceptual model published in OASIS PLCSlib:

- Transformation to sysML modeling language
- Completion with key attributes
- Review of business definition and scope according to changes integrated in the AP 239 information model
- Provide the relationships between conceptual objects and the AP 239 templates and core model objects (mapping for information)

5.4. AP 239 ED3 recommended practices

AP 239 ed3 gives the opportunity to capitalize the best practices and the lessons learnt from past implementations and OASIS PLCS framework development (e.g. OASIS DEXlib and PLCS lib), as such, the concept of templates for representing high level objects is a key enabler for the mapping between business concepts and their STEP representation, and it also a way to formalize an agreement on a common representation of concepts within a Data Exchange specification (DEX).

Thanks to the adoption of sysML modelling language, the templates are represented by block diagrams and the transformation to low level objects (mapping) is supported by parametric diagrams.

To avoid duplication between APs, a set of generic templates, shared by AP 239 ed3 and others APs (e.g. with AP 242 ed2 in the frame of AP 239 ed3 project) will be defined to support common generic capabilities, for example, templates for managing identification, properties…

AP 239 templates will be built from generic templates and objects of the core model.

In the frame of the AP 239 ed3 project, the used templates coming from past DEX1 and DEX 3 of DEXlib (and their evolution in PLCSlib) will be embedded.

Out of the standard, project specific business templates can be built based on standardized templates in order to represent the specific concepts in the frame of a given project.

Nevertheless, in addition to definition of templates, an usage guidance shall help future users to use the standard in an efficient and formal way.

This guidance, planned as an ISO SC 4 document out of the AP standard, shall describe the way to use the specification, making the link between the expected components of AP 239 ed3:

- Activity model and conceptual model
- Core model, generic templates and AP 239 templates
- Reference data
- Implementation methods

The complete PLCS implementation approach shall be covered, from the mapping between business concepts and the AP 239 objects, to the usage of implementation methods.

The main entry point for the usage guidance is the conceptual model: the guidance shall answer to the question “How each concept can be represented thanks to AP 239 ed3 ?”.

To ease the understanding and foster adoption, ad hoc and representative examples shall be provided. In particular the “Bike” example (used in the development of S1000D) could be re-used to illustrate the approach.

Note: templates will be mentioned in the guidance, but their definitions are not part of the usage guidance as they are part of the AP standard.

5.5. Development of pilots to validate the AP 239 ed3 capabilities

The development of the AP 239 ed3 project will include pilots allowing validation, when requested, of the new capabilities or extensions. The goal is to provide a proof of concept to demonstrate the efficiency and the adequacy of the new edition of AP 239. The pilots will involve a limited number of PLM vendors or integrators; the objective being not to organize an Implementer Forum.

Proposed rules to define and manage the pilots

The technical domain determines the need for pilots, e.g. new multi-layered information model and new implementation methods:

- To test sensitive, complex or unclear functionalities, on a significant subset of the information scope
- To give feedback to the usage guidance
- The companies involved in the project will prepare the related test cases, of increasing complexity,
- The preparation of a pilot shall determine and secure the funding sources and the associated resources / expertise,

- A part of the pilots are fully funded by the AP 239 ed3 project. Other projects may contribute to fund another part of the pilots (E.g., funding by the AIA – ASD-Stan LOTAR projects, …),
- The AP 239 ed3 project will define the management rules for the funding of pilots: date of the planned funding availability per year, etc.

Planning of the pilots

The pilots for the AP 239 ed3 project will be organized according to the following schedule:

- Pilot #1: Start once the AP 239 ed3 CD version available, during CD ballot, with first results of the pilot before the DIS development. This Pilots aims to check the adequacy of AP 239 ed3 CD
- Pilot #2: during the DIS development for final results as input for comments during DIS ballot.

Input for the review of the AP 242 ed2 documentation by the ISO/TC 184/SC 4 convener

The results of the pilots will be documented and provided as part of the technical documentation accompanying the AP 239 ed3 CD and DIS.

The successful organization of pilots, in time and quality, is one condition of success of the AP 239 ed3 project.

6. Interdependencies with related standardization projects

The full benefit to use PLM interoperability capabilities based on open standards requests to overcome silos between technical disciplines and product life cycle stages. To overcome this risk, the development of the AP 239 ed3 standard will have to take into account close coordination with other related standardization projects, which can be classified in 4 main categories:

- Project focused on development of PLM interoperability processes and use cases, such as EN / NAS 9300 LOTAR standards and MoSSEC.
- Project focused on development of product information model standards for a specific discipline or lifecycle stage (e.g. AP 209, AP 233, AP 238, AP 242)
- Project focused on specific implementation technologies (e.g. OASIS OSLC),
- Projects focused on the development of recommended practices and interoperability test rounds, generally covered by Implementer Forums.

The description of these coordination actions are described in the following paragraphs.

6.1. With other ISO STEP standards

Being a STEP Application Protocol, the AP 239 ed3 project rely on the STEP technology and is linked with the other STEP APs with which it shares Application Modules.

In regards to the STEP technology, the current efforts made at ISO/TC 184/SC 4 to develop the “new STEP architecture” will strongly influence the methods and languages that will be used for AP 239 ed3 development. The AP 239 ed3 project is also a contributor to this new STEP architecture, as some activities planned in the project will contribute to refine and strengthen this architecture.

In regards to other STEP APs, links will have to be established with other running AP projects, with the objective to organize common work on shared Application Modules. This will be typically the case with the STEP AP 242 ed2 project, with which a common work will be necessary on the PDM-related Application Modules.

6.2. With LOTAR international standards

The objective of LOTAR International is to develop, test, publish and maintain standards for long-term archiving (LTA) of digital data, such as 3D CAD and PDM data. These standards will define auditable archiving and retrieval processes. Use of the standard series by other branches of industry such as the automotive or shipbuilding industry is possible.

In order to develop the domain-specific part of the LOTAR Standard, the project group has divided itself into Workgroups, each dealing with a particular domain. Archiving of support data is a potential subject for LOTAR, and STEP AP 239 ed3 will be a natural candidate to support long term archiving of supportability/support information.

6.3. With US ILS standards for DoD

SAE TA-STD-0017 defines a process that establishes a set of product support analysis activities that result in the creation of life cycle product data. These processes are the equivalent to the Application Activity Model (AAM) in ISO 10303-239 ed2 for the U.S. DoD. Its counterpart, SAE GEIA-STD-0007, defines the information requirements (e.g. Data Exchange Specification (DEX) and Reference Data Library (RDL)) needed to capture and deliver the data generated from the PSA process. SAE GEIA-STD-0007 is equivalent to the Application Reference Model (ARM), Module Interpreted Model (MIM), and Part 28 implementation method described in ISO 10303-239. These areas are described in following table and graphically represented in Figure 23 below.

ISO 10303-239 ed2	**SAE PSA and LPD Standards**
Application Activity Model (AAM)	SAE TA-STD-0017 Activities
Application Reference Model (ARM)	SAE GEIA-STD-0007 LPD Data Entities and Elements (with accompanying entity relationship models and XML schemas)
Module Interpreted Model (MIM)	SAE GEIA-STD-0007 LPD Data Entities and Elements (with accompanying entity relationship models and XML schemas). Note: SAE GEIA-STD-0007 information model/schema is not formally derived from or mapped to other information models (e.g. like the ARM to MIM mapping). The SAE GEIA-STD-0007 information model can be viewed as serving the purposes of both an ARM and MIM when interpreting the definitions contained of ISO 10303-239 ed2.
ISO 10303-28 Implementation Method	SAE GEIA-STD-0007 XML based data exchange

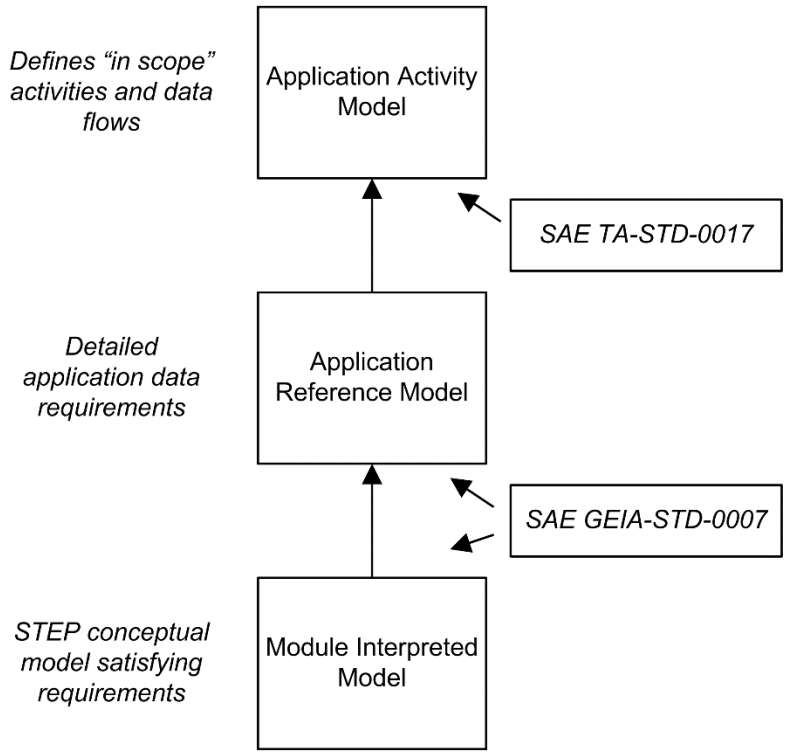

Figure 23: Standards Relationships STEP – SAE PSA and LPD Standards.

(Adapted from "STEP for Data Management, Exchange, and Sharing" by J. Fowler, 1995, p.60)

LOGSA Position

The LOGSA position is noted in the referenced LOGSA PLCS whitepaper and is consistent with the SAE Life Cycle Logistics Supportability (LCLS) committee position. The SAE LCLS committee reviewed LOGSA's PLCS whitepaper in 2013 and concurred with the recommendations.

In addition, Annex H of ISO 10303-239 ed2 must be deleted or revised to remove references to the OASIS PLCS TC. Usage guidance can be derived from a variety of sources such as SAE TA-STD-0017, SAE GEIA-STD-0007, and their associated handbooks.

Also, LOGSA worked with the ASD/AIA Data Model and Exchange Working Group (DMEWG) to help develop their position which is consistent with that of LOGSA and the SAE LCLS committee. LOGSA is currently working with the SAE LCLS committee on Revision C of SAE GEIA-STD-0007. Revision C meets the U.S. DoD requirements for LPD and has been enhanced in several areas to be more compatible with ISO 10303-239 ed2:

- A set of analysis activities for generating product data (SAE TA-STD-0017/MIL-HDBK-502 Activities are equivalent to ISO 10303-239 ed2 Application Activity Model (AAM))
- An information model/schema (SAE GEIA-STD-0007) for defining business information requirements and their relationships (e.g. data entities, elements, attributes and relationships)
- A common data dictionary (SAE GEIA-STD-0007) equivalent to the Reference Data Library concept in ISO 10303-239 ed2 usage guidance
- An extension mechanism for accommodating evolving data requirements (equivalent to the "classification" mechanism in ISO 10303-239 ed2 that utilizes external class libraries)

- "Short Names" for data exchange (ISO 10303-239 ed2 Annex B – MIM Short Names)
- An XML implementation method (ISO 10303-28)
- Product breakdown structure that includes products, models, and breakdown elements (equivalent to parent/child and relating/related relationships for product breakdown structures in ISO 10303-239 ed2)

SAE GEIA-STD-0007 contains the U.S. DoD approved reference data for LPD. The reference data is specified in Chapter 2 and defined in Appendix A.

Note: It is U.S. DoD policy to participate in the development of non-Government standards (NGSs) and to adopt and use them to the extent feasible, practical, and economical. In accordance with this policy, the U.S. DoD participates in various non-Government standards bodies (NGSBs), including SAE and ISO. To this extent, the U.S. DoD supports ISO 10303-239 ed3 effort. However, U.S. DoD participation does not connote DoD agreement with, or endorsement of, decisions reached by such bodies or of the standards approved and published by the NGSBs.

Standards Background:

SAE TA-STD-0017

SAE TA-STD-0017 establishes general principles and descriptions of activities which, when performed in a logical and iterative nature, comprise the Product Support Analysis (PSA) process. The activities are directly relatable to the tasks contained in the cancelled MIL-STD-1388-1A, but also include additional activities such as Diminishing Manufacturing Sources and Materiel Shortages/Obsolescence System Support Analysis and Disposal Analysis.

MIL-HDBK-502A

MIL-HDBK-502A offers guidance to the U.S. DoD for the implementation of SAE TA-STD-0017, Product Support Analysis (PSA). It defines the Product Support Analysis (PSA) framework and activities as an integral part of the Systems Engineering process, and includes the selection and tailoring of those activities to meet U.S. DoD program supportability objectives. Since SAE TA-STD-0017 establishes the normative requirements for performing PSA and is structured in an easily contractible format, it does not contain informative implementation guidance. Instead, this guidance is found in MIL-HDBK-502.

SAE GEIA-STD-0007

SAE GEIA-STD-0007 represents a new approach for defining acquisition logistics data captured during the product support analysis process. It defines the data elements, structure, and business rules for Logistics Product Data (LPD), but does not prescribe how the data must be managed (e.g. relational tables). Instead, it specifies the requirements for the exchange/delivery of the data in an Extensible Markup Language (XML) format as prescribed by an XML Schema Definition (XSD). SAE GEIA-STD-0007 has two companion handbooks called SAE GEIA-HB-0007, Logistics Product Data Handbook and SAE TA-HB-0007-1, Logistics Product Data Reports Handbook.

6.4. With "linked data" standards (OSLC)

There is a common interest between OSLC and PLCS, and more generally with STEP APs, for supporting product data exchange/collaboration through the whole lifecycle (PLM domain).

An OSLC working group "ALM-PLM Interoperability" has been set up in June 2015 in order to provide business scenarios and recommendations. PLCS experts and industry representatives are welcome.

OSLC community recommends to work together with other standardization organizations to eliminate redundancies between OSLC specifications.

To date, the way of collaboration between OSLC and STEP / PLCS community (within ISO/TC 184) remains to be defined: no MOU for defining responsibilities, governance, common initiatives (implementer forum for example)…

6.5. With AIA – ASD ILS

The international aerospace and defense community have, over the past 20 years, invested considerable effort to develop specifications in the field of Integrated Logistic Support (ILS). The vision of the S-Series ILS specifications is that all stakeholders will be able to apply common logistics processes, so as to enable the sharing and exchange of data securely through the life of products and services.

The work was initially accomplished by integrated Working Groups (WG) composed of Industry (initially members of the AeroSpace and Defence Industries Association of Europe (ASD)) and customer organizations (MOD, etc) in a collaborative environment. The structure and functional coverage of these specifications was largely determined by NATO requirements specified during an international workshop (HAW Acquisition Logistics) in Paris in 1993.

In July 2010 an MoU was signed between ASD and AIA (Aerospace Industries Association of America, Inc.) in order to promote a common, interoperable, international suite of integrated logistics support specifications in the aerospace and defense industries of Europe and the United States and to make optimal use of the resources available, ASD and AIA agreed to work in concert on the joint development of the S-Series of ILS specifications.

The following specifications are currently available or in the process of development:

- SX000i - International guide for the use of the S-Series of Integrated Logistics Support (ILS) specifications
- S1000D - International specification for technical publications using a common source database
- S2000M - International specification for material management - Integrated data processing
- S3000L - International specification for Logistics Support Analysis - LSA
- S4000P - International specification for developing and continuously improving preventive maintenance

- S5000F - International specification for operational and maintenance data feedback
- S6000T - International specification for training analysis and design
- SX001G - Glossary for the S-Series ILS specifications
- SX002D - Common data model for the S-Series ILS specifications
- SX003X - Interoperability matrix for the S-Series ILS Specifications
- S1000X, S2000X, S3000X, S4000X, S6000X - Input data specifications
- ASD-STE-100 - International specification for the preparation of maintenance documentation in a controlled language (Simplified Technical English)

One objective of the AP 239 ed3 project is to provide the base technology and data model to support the ASD-AIA ILS specifications, the interoperability between these specifications and the capability to interface the ILS world with other engineering domains like product design. The AIA and ASD organisations are strong stakeholders of the project, and the link with AIA-ASD ILS Suite of Specifications will be ensured by direct participation in AP 239 ed3 project of people involved in the development of theses specifications. A formal link will be set-up with the AIA-ASD DMEWG to report progress and ensure consistency.

6.6. With related implementer Forums

The objective of the PDM Implementer Forum (PDM-IF) is to accelerate the development and general availability of PDM interoperability solutions based on ISO open standards.

These interoperability solutions rely on converters, services or transaction hubs answering to PDM interoperability industry business cases.

The goals of the PDM Implementer Forum are to:

- Develop international PDM interoperability recommended practices, completing the international PDM interoperability standards,
- Establish shared test activities in the PDM area, based on agreed and reliable methods

The first meetings of the PDM-IF User Group and Implementer Group took place the 29th of September 2015 in Paris, with a significant participation of IT vendors and industry representatives, from both Aerospace and Automotive industry.

The AP 239 ed3 project intends to prepare the validation of future implementations and the development of associated recommended practices. For this purpose, a link will be established with the PDM-IF, to share use cases/test cases and validation procedures. Through the proposed PDM-IF activities the objective is also to push IT vendors to propose early implementations as soon as the AP 239 ed3 concepts and data model are stabilized.

7. Risk management

According to the size and complexity of the AP 239 ed3 project, risks are possible in various areas. The following risks, the probability of them occurring, their severity, and the mitigation strategy are detailed below. For the probability and severity, the following abbreviations apply:

Notation: Prob. = probability, Sev. = severity, L = Low, M = Medium, H = High..

Risk	Prob	Sev.	Mitigation
Cost			
Lack of funding for development of the AP 239 ed3	H	H	1. AP 239 ed3 development will not start until a minimum amount of funding is secured. 2. Committed organizations will pursue funding aggressively
Organization			
Unbalanced sharing of responsibilities and/or resources between the project partners (e.g. America, Europe, and Asia regions)	M	H	1) Committed joint ownership between the relevant international associations 2) Memorandum of Agreement between all committed organizations 3) Regular communication at the management, PSC, and technical levels
Lack of procedures for the project management of the project	L	M	1) Committed joint ownership between the relevant international associations 2) Creation of a STEP AP 239 ed3 Project Charter and Quality plan with written procedures
Interdependencies			
Lack of coordination with the AP 242 ed2 project	M	H	1) Define a resource to be responsible for the liaison with the AP 242 ed2 project. 2) Coordination in the context of ISO /TC 184 /SC 4 new STEP architecture activities.
Lack of coordination with PDM-IF	M	M	Appropriate involvement and supports from stakeholders in the PDM Implementers Forum
Lack of AP 239 ed3 interface implementation by main PLM vendors	M	H	1) Timely involvement of IT vendors 2) Timely availability of recommended practices and sample files
No PDM-IF available in a timely fashion to assure coordination of activities for common topics	L	M	Support to the setting up of the PDM Implementer Forum by the AP 239 ed3 PSC

Risk	Prob	Sev.	Mitigation
Scope			
Scope unclear or evolving during the project, leading to additional costs and delays.	M	H	Keep the focus on ILS and interfaces between ILS and other domains (e.g. product design).
Additional/new implementation methods proposed.	L	M	Confirm the precise list of implementation methods during the 1st AP 239 ed3 workshop
Management			
Lack of availability of AP 239 ed3 project leader and co project leader	L	M	Identify, and assure the availability & time commitment of the project leader and co project leader
Shift of project plan during the project	L	M	1) Alignment on agreed project plan and ensure appropriate consensus between all committed organizations 2) Memorandum of Agreement between all committed organizations 3) Regular Project Steering Boards.
Stakeholders change their priorities during the project	L	H	1) Alignment on agreed scope and ensure appropriate consensus between all committed organizations 2) Memorandum of Agreement between all committed organizations
AP 239 ed3 not available in the time requested by stakeholders (timely availability of funding)	H	H	1) The stakeholders will provide resources as required, due to their commitment to STEP AP 239 ed3 Project 2) Careful preparation of the project plan, with precise milestones 3) Project management resources will be made available by committed organizations
Lack of STEP experts to develop the AP 239 ed3	H	H	1) Identify, secure necessary funding for, and assure the availability of key STEP experts 2) Recruit new STEP experts 3) Train new STEP experts
Communication			
Lack of internal communication in the STEP AP 239 ed3 Project	L	M	1) Regular communication at the management and technical levels. 2) Organization of regular project team teleconferences 3) Organization of at least 1 workshop / year
Lack communication of STEP	L	M	1) Define a communication plan in the STEP AP 239 ed3 Project

Risk	Prob	Sev.	Mitigation
AP 239 ed3 Project to external stakeholders			2) Organization of at least 1 teleconf. / year
Quality			
Lack of quality of the AP 239 ed3 documentation	M	H	Organization of document reviews, to make sure a sufficient quality is achieved and documents are understandable/usable by the appropriate communities.
Lack of pilots to validate AP 239 ed3 standard	H	H	Identity the key areas that should have pilots, and assure availability of resources and funding to their execution
Technical			
Lack of upward compatibility between AP 239 ed2 and ed3	H	L	Trace changes against AP 239 ed2 ARM
The STEPmod infrastructure is not available anymore during the development of AP 239 ed3	L	H	1) Ensure the support of PDES Inc and NIST to maintain STEPmod during the development of AP 239 ed3 2) Specific funding of the AP 239 ed3 project to contribute to the maintenance of STEPmod infrastructure
Lack of maturity of the STEP new architecture (languages, tooling, methods)	H	H	Share lessons learnt from OASIS PLCS team, and strengthen the collaboration with other STEP APs based on the new architecture
Difficulty to converge on shared APs	M	M	Clearly identify modules shared with other projets (e.g. product structure module shared with AP 242 ed2) and organize collaboration with these projects to deliver a shared definition of the module.

Table 1: AP 239 ed3 project risk synthesis

8. Project management

The project management activities of AP 239 ed3 include the following:

- Project organization,
- Deliverables,
- Financial principles,
- Management of liaisons with other standardization projects
- Scheduling, Planning of international workshops and associated topics,
- Total Costs, Financial plan,
- Preparation of yearly project plan to secure resource availability,
- Communication

8.1. Project principles

The AP 239 ed3 project organization is summed up on the next figure, detailed in the following paragraphs.

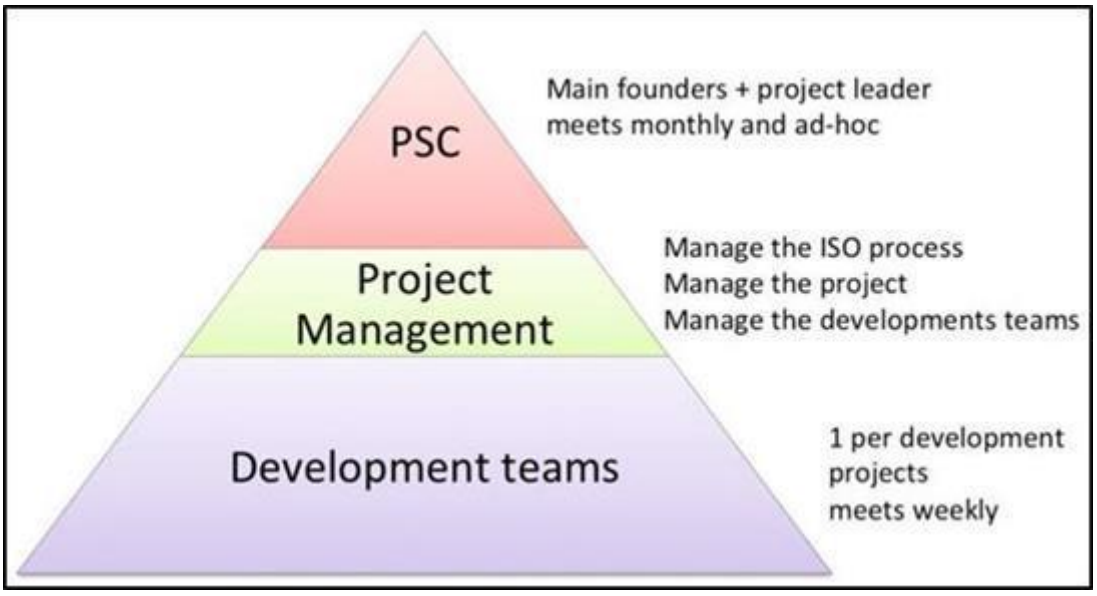

Figure 24: Overview of the AP 239 ed3 project organization

8.1.1. Project contributors

The project contributors will provide contributions monetarily and/or in man-days. The cash contributions will be used to fund the STEP experts needed to develop the standard in cooperation with the industry man-days contributions. The project contributors which are providing monies to found the sub projects are called founding members.

8.1.2. Project Steering Committee

The project will be under the management of a project steering committee (PSC). The PSC is composed of one representative of the founders and of the project management team. All project contributors are invited to the PSC.

The PSC meets by web-conference every month. The meeting schedule will be defined in order to have PSC meetings 2 weeks before the ISO milestones and ISO meetings, and to review the ISO AP 239 ed3 ballots within a week.

The PSC is in charge of:

- Validating the development budget allocation on the work packages,
- Controlling the progress of the project,
- Validation of the communication actions.

8.1.3. Hosting associations

In addition to contributions to the projects, like the other sponsoring associations (fees or expertise), the hosting associations appoints the Project Team and the needed external expert resources accordingly to the agreed project plan.

8.1.4. Project Team

Project Leader

The Project leader will be appointed by the PSC. The project leader is responsible for the following:

- Manage the ISO process,
- Report the project status to the PSC,
- Schedule, manage and report to all the PSC meetings ,
- Schedule and manage a monthly meeting with the development teams in order to identify synergies or divergences,
- Provide the agenda and the minutes of the meetings.

If needed a co-leader will be appointed to assist the project leader in his tasks.

Project editor

The project editor is in charge of assembling the ISO documentation from the elements published in STEPmod by the development teams. He/she provides, when requested, the status of edition of the different sections (target status, achieved status, potential risk, …).

Development teams

Work will be distributed in work-packages, corresponding to sub projects agreed for the final scope and work plan of the AP 239 ed3 project. The development work will be distributed among the contributors and the STEP experts based on priorities and effort needed. Each development team will have a responsible, nominated for the duration of the project. Each development team will have weekly web-conference meeting during the development phases, and will meet all together by web conferencing once a month to review the work progress and the dependencies between the work packages.

The number of work-packages and perimeter of each work-package is still in discussion, and will be adapted depending on the final scope and size of the project.

There are 3 main work packages identified so far:

- WP1: Information model
  - Mapping ARM / Core model
  - Core model and Core Technical Capabilities
  - Templates (generic and AP239 specific)
  - AP239 RDL
  - Mapping PSM > AP239 Ed3
- WP2: Implementation methods
  - P21 generation
  - XML schema
  - Web services
  - Linked Data
- WP3: Business layer
  - Activity model & Conceptual model
  - Usage Guidance

Note: the work package 3 “Business layer” will run in parallel to the development of the model (work package 1) and the development of implementation methods (workpackage 2)

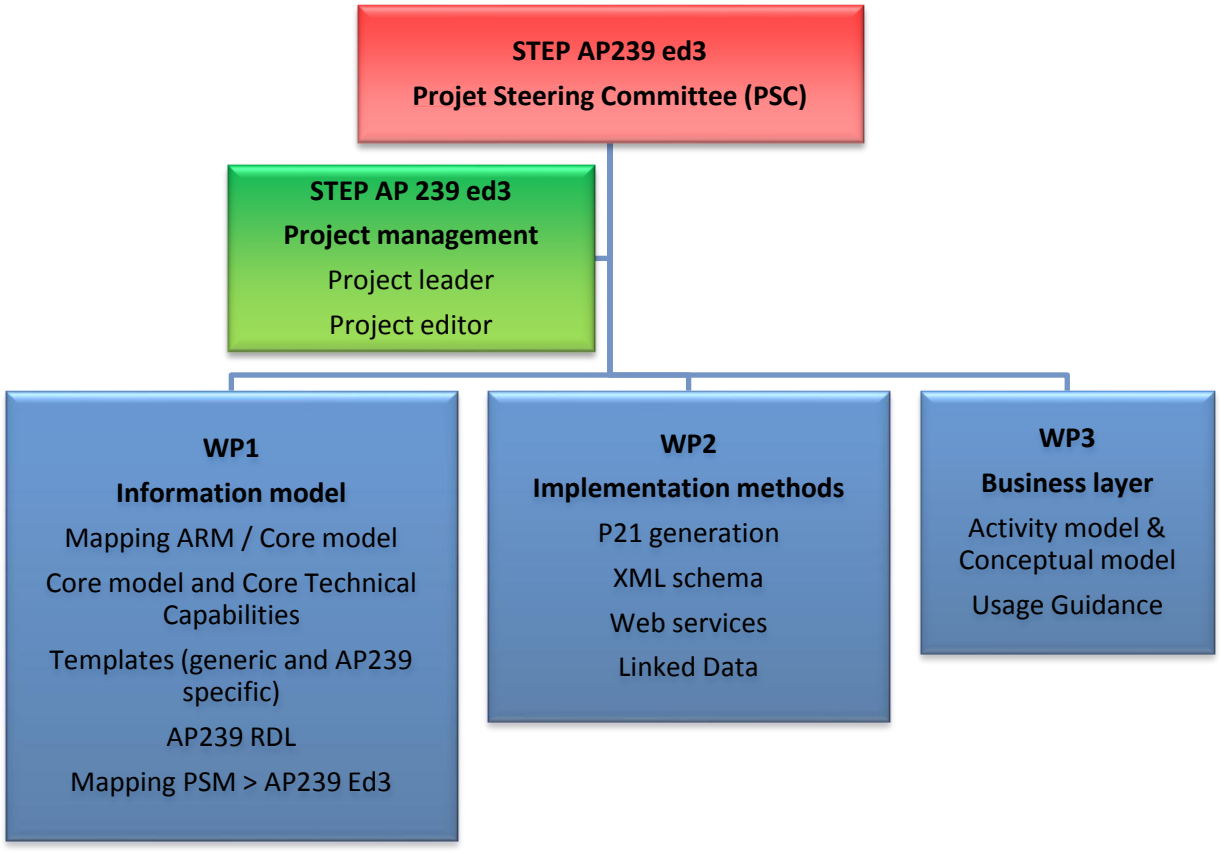

Figure 25: AP 239 ed3 project organization breakdown structure

8.1.5. Face to face workshops of all the project team

Face to face workshop will be held in order to bootstrap or speed up the critical phases of the project: at kickoff, after the first pilots round, for the CD comments resolution, and before the finalization of the DIS document. The workshop will be held at alternate location between Europe and the US.

8.1.6. Participation to the ISO /TC 184 / SC 4/ WG 12 & WG 21

The project leader or co-leader will contribute to the WG12 "STEP product modeling and resources" and WG21 "SMRL Validation Team" weekly teleconferences to report any issue related to the project. The Project will use the standards WG12 management tools: ISO web-conferencing, ISO Livelink repositories and forums, STEPMOD, and Bugzilla. The project deliverables: data models, documentation, etc..., will be delivered directly in the STEPMOD environment.

8.2. Deliverables

The main deliverable is a new edition of the modular application protocol AP 239 ed3, and any associated new components of the ISO /TC 184/SC 4 standards (modules, core model, reference data, xsd, etc). The project plan includes the delivery of NWI/CD document, its submission for CD and DIS ballot, and the resolution of comments received.

The feasibility of the development of critical functionalities will be checked through 2 rounds of pilots, one during the CD ballot and one before the DIS ballot (see chapter 5.5 for more details).

Besides the ISO document itself, two documents are expected:

- STEP AP 239 ed3 usage guidance, document gathering the recommended practices, will have to be created/updated and delivered to ISO /TC 184/SC 4.
- Mapping between existing OASIS PLCS PSM and AP 239 ed3, in order to provide way forward for existing PLCS PSM / PLCS lib projects and preserve the legacy investment of the PLCS PSM adopters

AP 239 interfaces will have to be tested (check the support of legacy P21 ones and the support of new ones based on new implementation methods). This task is not part of the AP 239 ed3 development project, but liaisons with the related projects (for example, the PDM implementer forum, MoSSEC, OASIS OSLC…) will be set up to .

In addition, the project team will carry out the appropriate communication actions (see section 8.8).

Set of updated/new application modules

For AP 239 ed3, several modules used by AP 239 ed2 have to be modified and new versions submitted to the Part 1000 maintenance process.

New modules could be created to support new units of functionality not covered by existing APs, however this is unlikely as the intent is to build as much as possible on existing application modules.

New Core Data Model and associated implementation methods

- Publication of the core model as a set of Core Technical Capabilities
- Delivery of core RDL
- Delivery of mapping (parametric diagrams)
- Delivery of standard templates
- Delivery of AP 239 templates
- Delivery of AP 239 RDL
- Delivery of ad hoc schema and rules for the specification of new implementation methods

Additional documents (out of AP standard)

- STEP AP 239 ed3 usage guidance
- Mapping between existing OASIS PLCS PSM and AP 239 ed3

8.3. Financial principles

The financial principles of the AP 239 ed3 project are the following:

- A minimum fee is paid equally by all members of the project
    - This fee will be used to fund the project management activities and the maintenance of the STEP development infrastructure
    - It provides a provision of the budget, available to manage the risks along the project life.
    - it is estimated at around 30% of overall costs
- The rest of the funding (e.g. 70%) is shared by the funding partners with the following rules:
    - The funding partners control the use of their funding through their participation to the PSC.
    - The transparency of all subprojects is ensured to all the funding members.

“Funding” here should be understood here either as cash or as Man-Days (MDs). In the second case, human (expert) resources are provided.

The financial principles are illustrated by the following figure:

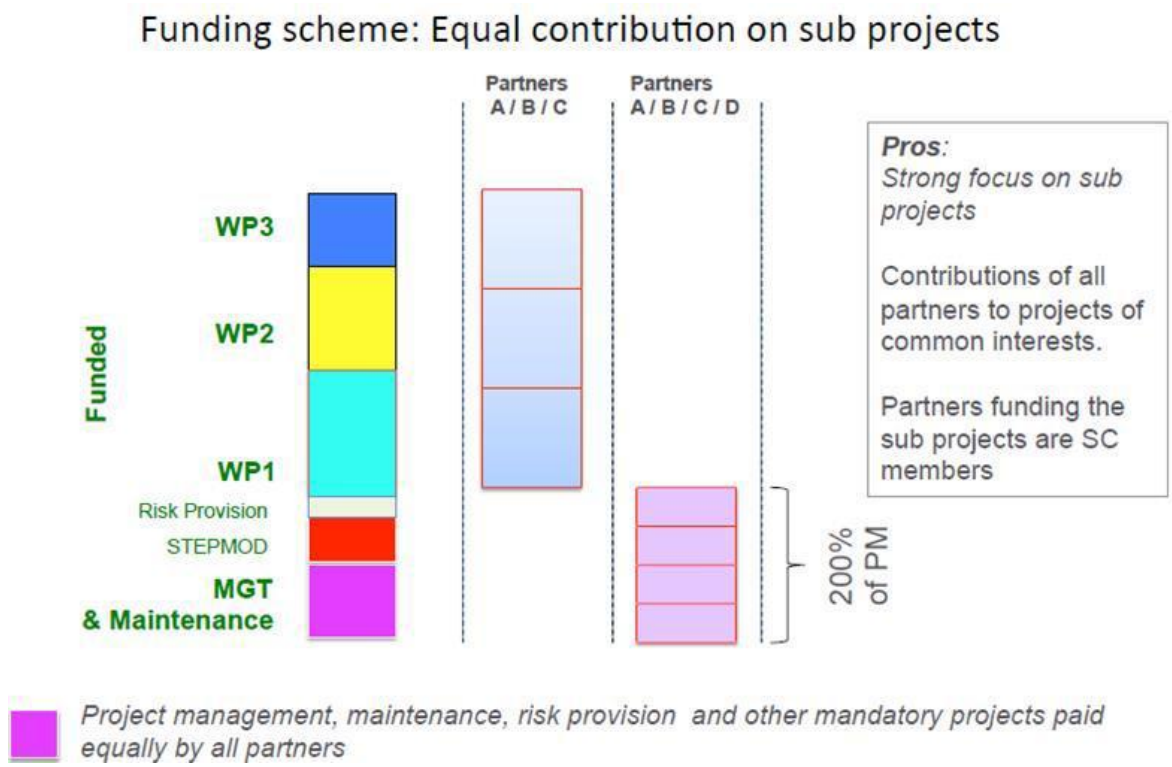

Figure 26: Financial principles of the AP 239 ed3 project

8.4. Management of liaisons with other standardization projects

As presented in the introduction and in the section 6, the full benefits of the AP 239 ed3 standard will be reached if efficient liaisons are established and maintained with related standardization organization/projects.

This includes:

- Liaison with ISO/TC 184/SC 4: will be ensured through participation to the weekly teleconferences of the ISO/TC 184/SC 4/WG 12 "STEP product modeling and resources" and WG 21 "SMRL Validation Team"
- Liaison with STEP AP 242 ed2 project: regular meetings will be set-up with the objective to organize common work on shared Application Modules, including PDM-related modules.
- Liaison with U.S. ILS standards for DoD (e.g. SAE GEIA STD 0007): meetings to be planned for taking into account the US standard requirements.
- Liaison with AIA-ASD ILS Spec council: meetings to be planned for ensuring AP 239 ed3 will be able to support S-Series specifications; in particular, common work with the DMEWG about the definition of information layers and the implementation methods
- Liaison with STEP AP 242 ed2 project: regular meetings will be set-up with the objective to organize common work on shared Application Modules, including PDM-related modules.
- Liaison with OASIS PLCS working group: regular meetings for ensuring AP 239 ed3 will benefit from the experience of OASIS in framework development

- Liaison with INCOSE & AP 233 team: to be invited to international workshops as there is an information overlap between AP 239 and AP 233
- Liaison with PDM-IF project: : meetings to be planned for collecting recommended practices and organizing interface tests

8.5. Scheduling

The figure hereafter gives an overview of the global planning for the White Paper and the AP 239 ed3 project with the link with AP 242 ed2 project. The synchronization between AP 239 ed3 and AP 242 ed2 is important as both projects are based on the new STEP architecture, and furthermore they will share common harmonized modules (PDM and Requirement Management).

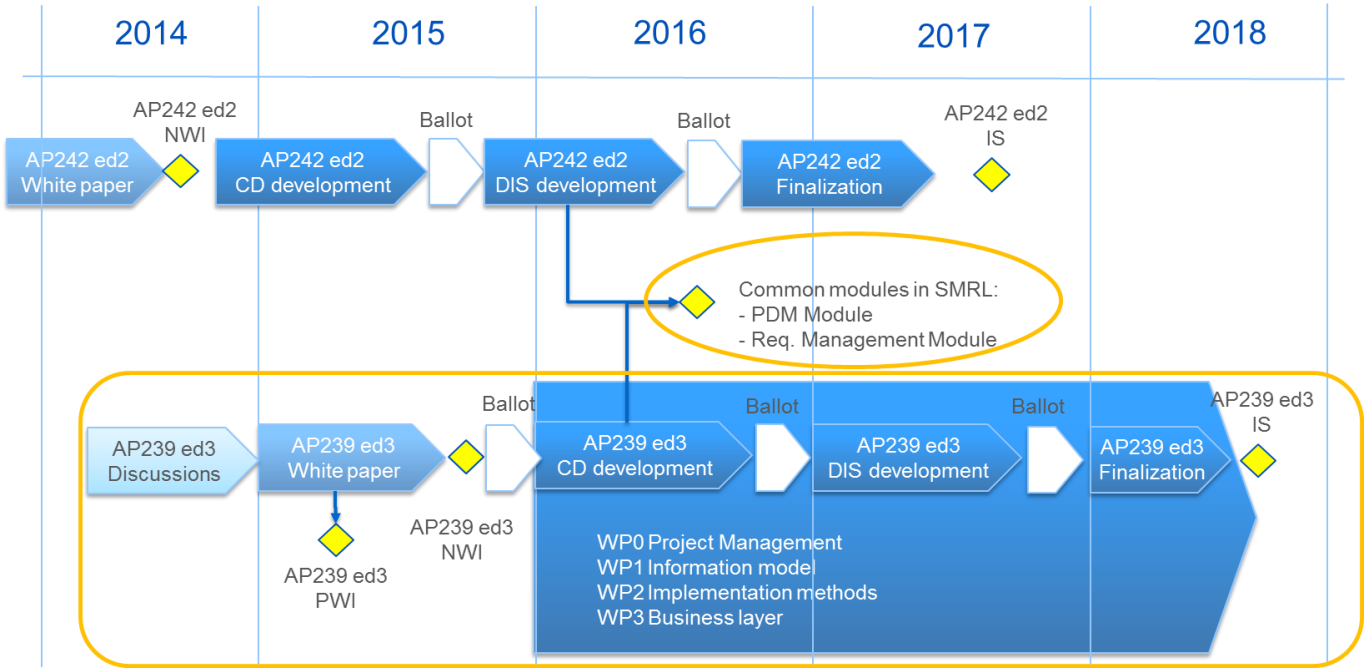

Figure 27: Target planning for STEP AP 239 ed3

Detailed Schedule

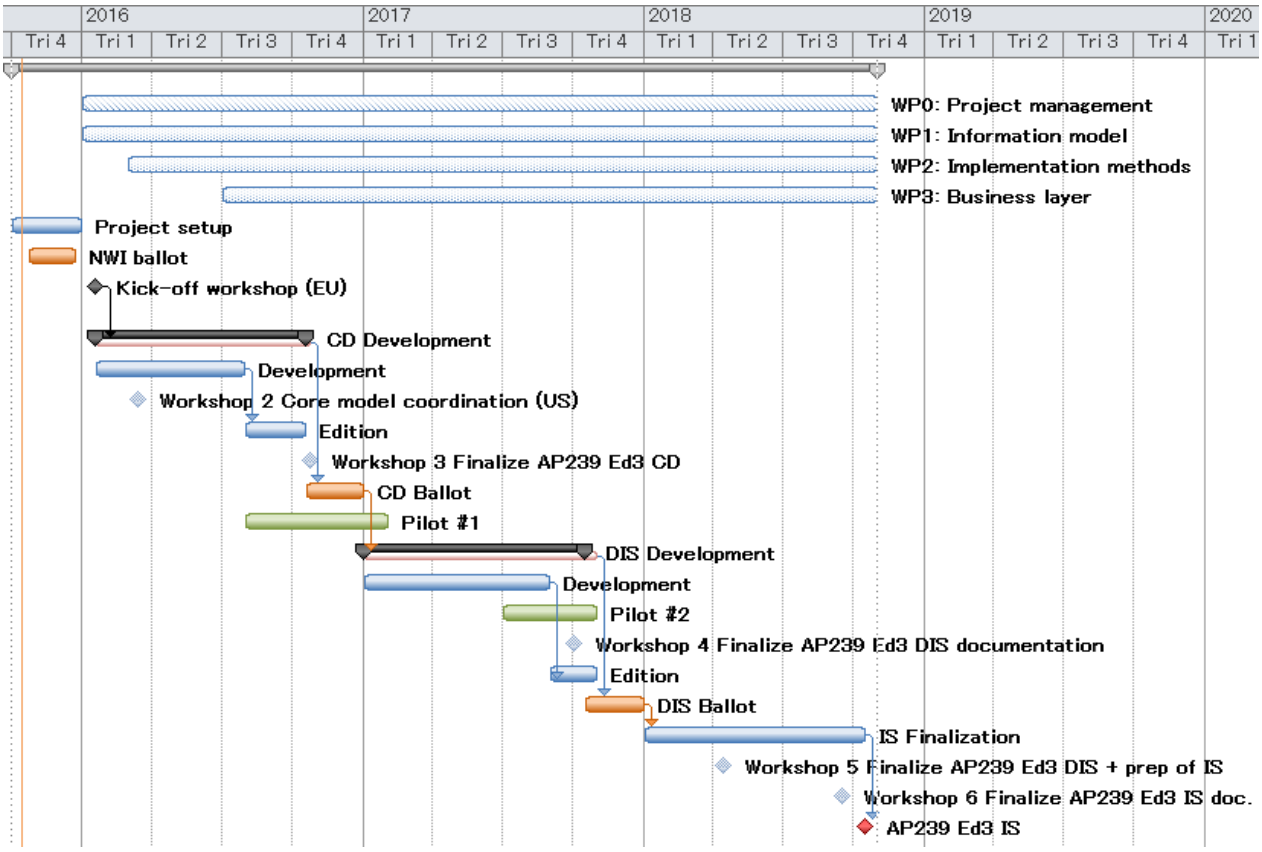

Figure 28: Detailed schedule of STEP AP 239 ed3 project

Planning of international workshops and associated topics

The development of the AP 239 ed3 project will be based on the organization of 6 international workshops

	Date	Location	Main topics
Workshop 1	2016 January	Europe	Kick- off workshop
Workshop 2	2016 Mars	US	Coordination of AP 239 ed3 Core Model and shared modules with other APs (AP 242, AP 233) (before LOTAR / PDES Inc workshop ?)
Workshop 3	2016 Q4	TBD	Finalize AP 239 ed3 CD
Workshop 4	2017 Q4	TBD	Finalize AP 239 ed3 DIS documentation
Workshop 5	2018 Q2	TBD	Finalize AP 239 ed3 DIS comments resolution + prep of IS tech. document

Workshop 6 (TBC)	2018 Q3	TBD	Finalize AP 239 ed3 IS documentation

Table 2: Planned dates of AP 239 ed3 international workshops

8.6. Total Costs and financial plan

The total cost of the AP 239 ed3 project is summed up in the following table:

	2016				2017				2018				TOTAL		TOTAL		TOTAL value in USD with a 1K USD = MD
	H1		H2		H1		H2		H1		H2						
	externs K USD	Intern MD	externs K USD	Intern MD	externs K USD	Intern MD	externs K USD	Intern MD	externs K USD	Intern MD	externs K USD	Intern MD	externs K USD		Intern MD		Externs + Intern K USD
NWI																	
Edition 2 maintenance																	
Edition 3 Development of information model		100		220		215		140		30		20			725	44%	725
Edition 3 Development of Implementation methods	10	5	40	10	80	15	70	10	60	10	40	10	300	24%	60	4%	360
Edition 3 Development of business layer			10	80	30	108	20	79		47			60	5%	314	19%	374
Pilots			80	40	90	40	30	20					200	16%	100	6%	300
Edition 3 Validation	40	60	30	40	10	10	80	40	20	10	20	10	200	16%	170	10%	370
Publishing			70	5			70	5			20	5	160	13%	15	1%	175
Communication		2	5	5	5	5	5	5	5	5		5	20	2%	27	2%	47
Project Management (computed)	10	16,5	46	39,5	42	38,8	54	29,4	16	9,7	32	9	200	16%	143	9%	342,9
Risk Provisioning (computed)	2,5	4,13	11,5	9,88	10,5	9,7	13,5	7,35	4	2,43	4	1,13	46	4%	34,6	2%	80,6
STEPmod infrastructure (computed)	2,5	8,25	11,5	19,8	10,5	19,4	13,5	14,7	4	4,85	4	2,25	46	4%	69,2	4%	115,2
														96%		96%	2889,7
Total externs K USD	65		304		278		356		109		120		1232				
Total internal Man Days		196		469		461		350		119		62,4			1658		
Annual need in K USD:			369				634				229		43%		57%		
Annual need in Man Days:				665				811,35				181,35					

Table 3: Planned Total costs of the AP 239 ed3 project

The internal resource cost is assessed in Man.Days (M.D)

The project represents a total cost of 1 232 K$ + 1 658 Man.Days.

The funding of the project is based on the following:

1) Fees paid by project member organizations (associations or companies),

2) Internal Man.Days provided by experts of the organizations participating in the project.

The budget (fees and internal Man.Days) shall be considered as a whole: if the internal resources cannot be provided by project member organizations, these resources will be bought externally thank to project fees.

During the preparation of the white paper, several companies and associations have confirmed their interest in participating to the project, and have started to plan the funding for the duration of the project. The detailed sharing of funding by organizations will be known once the confirmation of interest received. According to the official confirmation of participation, the project members will have to review the project scope and schedule activities accordingly (e.g. pilots, functionalities).

With regards to AP 239 ed3 priorities, as mentioned in the chapter 4, the support of XML data exchange is the priority, the support of P21 data exchange shall be confirmed by interested companies and organizations at the beginning of the project, and additional ones (Web services, linked Data / OSLC) are in the project scope under the condition of confirmed resources (external and/or internal ones) for their development.

8.7. Preparation of yearly project plan to secure resource availability

In order to avoid any shift in the planning by lack of funding of the subcontracted STEP experts, the AP 239 ed3 project will prepare a yearly project plan and send the request for payment of the project fees, a minimum of 3 months before the date of payment. See the following figure.

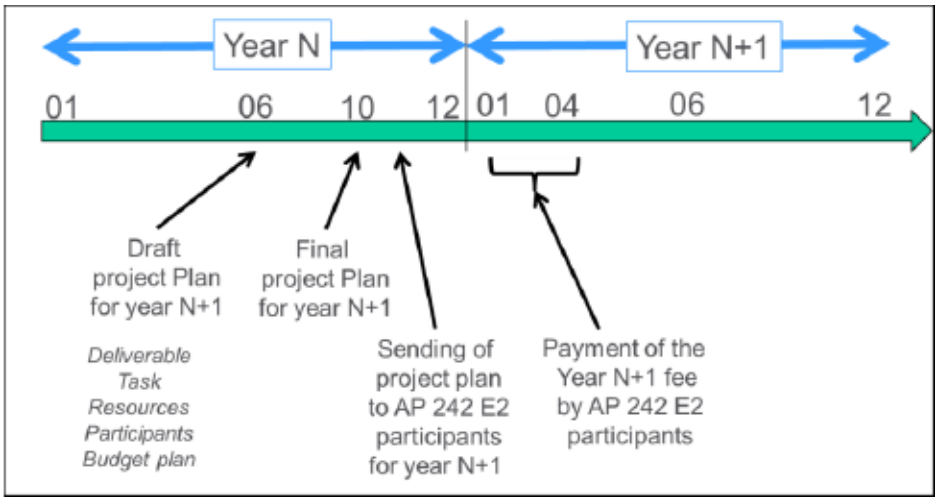

Figure 29: Preparation of yearly project plan

8.8. Communication

A set of communication material will be assembled by the project to promote the AP 239 ed3 to the Industry: Slides, Website, Poster, Logo, status of progress of the different tasks to the related involved parties. It includes more specially:

Type of communication	Frequency
Reporting to the stakeholder associations	Quarterly
Status of progress to the PLM editors and integrators	At least one time per year
AP 239 ed3 project annual report,	Yearly
Update of the AP 239 ed3 web site	Every 6 months, or according to ISO ballot stages
Contributions to international conferences, directly or via the stakeholders representatives	Case by case; for example: Europe: PDT Days, ProSTEP Symposium, NASA/ESA conference, Afnor, GIFAS , STEP Industry days, PDES Inc., LOTAR …

Table 4: AP 239 ed3 project communication actions

9. Summary – next actions

This standard will be consistent with other STEP APs, in particular with:

- AP 209 “Multi-Disciplinary Analysis and design”,
- AP 210 “Electronic assembly, interconnect, and packaging design”,
- AP 233 “Systems Engineering”
- AP 238 “Application interpreted model for computer numeric controllers”
- And AP 242 “Managed Model Based 3D Engineering”

Together they will be the foundation for specifications, engineering simulation, 3D model based design and product support information interoperability of aerospace, automotive and other transportation industries. It will strengthen the acceptance and support of STEP by the main manufacturing industries.

The present white paper describes the context, the business usages, the enhancements of AP 239 ed3, interdependencies with other standardization project, project risks, and the associated project plan.

The final prioritization will be decided by the stakeholders committed to support the AP 239 ed3 project with the appropriate resources, once the white paper is published.

The main next actions are as follows:

1. The official confirmation of participation of the associations, manufacturers and stakeholders before the end of 2015,
2. If needed, the update of the project plan according the stakeholders resources and funding,
3. The start of the ISO AP 239 ed3 New Work Item ballot, planned in October 2015,
4. The setting up of the project with the stakeholders, and the detailed WBS,
5. The preparation of the contracts to the STEP experts,

The kick-off of the project is planned 3 months after the distribution of the published white paper, after the acceptance of the NWI ballot, end of December, followed by a 1st project workshop in January 2016, in Europe.

If there are any questions about this whitepaper, they should be directed to one of the following persons:

Jay GANGULI
Boeing

Didier CHARPY
CIMPA on behalf of Airbus

List of acronyms / abbreviations used in this document

Acronym / abbreviation	Definition
A&D	Aerospace and Defence
AD	Airworthiness Directive
AIA	Aerospace Industries Association (USA), see www.aia-aerospace.org
AIM	Application-Interpreted Model
AMC	Applicable Means of Compliance
AP 203	Standard for the Exchange of Product model data (STEP – ISO 10303) – Application Protocol 203 "Configuration controlled 3D design of mechanical parts and assemblies"
AP 214	Standard for the Exchange of Product model data (STEP – ISO 10303) – Application Protocol 214 "Core data for automotive mechanical design processes"
AP 239	Standard for the Exchange of Product model data (STEP – ISO 10303) – Application Protocol 239 – Product Life Cycle Support (PLCS)
AP 242	Standard for the Exchange of Product model data (STEP – ISO 10303) – Application Protocol 242 – Managed Model Based 3D Engineering
ARM	Application Reference Model
ASC X.12	Accredited Standards Committee X.12 (ANSI Committee)
ASD	AeroSpace and Defence Industries Association of Europe, see www.asd-europe.org
ATA, A4A	Air Transport Association of America, Inc. (ATA), now named Airlines for America (A4A). ATA remains as name of standards.
BOM	Bill of Material
BO Model	Business Object Model
CAD	Computer Aided Design
DEX	Data Exchange Specification (PLCS terminology)
EDI	Electronic Data Interchange
EASA	European Aviation Safety Agency
ERP	Enterprise Resource Planning
FMI	Functional Mock-up Interface
ILS	Integrated Logistics Support
IPR	Intellectual Property Rights
ISS	In Service Support
LSA	Logistic Support Analysis
LT	Long Term
MoSSEC	Modelling and Simulation in a Systems Engineering Context
MRO	Maintenance, Repair and Overhaul

Acronym / abbreviation	Definition
MRP	Manufacturing Resource Planning
MSN	Manufacturer Serial Number
OASIS	Organization for the Advancement of Structured Information Standards. See www.oasis-open.org
OEM	Original Equipment Manufacturer
OSLC	Open Services for Lifecycle Collaboration
PBS	Product Breakdown Structure
PDM Schema	STEP PDM (Product Data Management) Schema
PLCS	Product Life Cycle Support
PLM	Product Life-cycle Management
RAMT	Reliability, Availability, Maintainability and Testability
SB	Service Bulletin
SDAI	Standard Data Access Interface
SMRL	STEP Module and Resource Library
SSG	ASD Strategic Standardisation Group, see www.asd-ssg.org
STC	Supplemental Type Certificate
TDP	Technical Data Package
XML	Extensible Markup Language

Annexes

Annex A: AP 239 open issues

Source : http ://www.wikistep.org/bugzilla/

Fri Sep 18 2015 09:05:36 UTC

Status: UNCONFIRMED, CONFIRMED, IN_PROGRESS, NEW, ASSIGNED, REOPENED

Component: 0239 Product life cycle support, 0439 AP 239_product_life_cycle_support, AP 239 general

20 bugs found.

ID▲	Sev	Pri▲	OS	Assignee▲	Status▲	Resolution	Summary
4193	enh	P4	SEDS	lothar.klein@lksoft.com	CONF	---	Enable assignment of security classification to Envelope
4412	enh	P4	SEDS	lothar.klein@lksoft.com	CONF	---	Requirement_source should contain Person/Organization/Activity/Project/Contract
4415	enh	P4	SEDS	lothar.klein@lksoft.com	CONF	---	Add Activity to Affected_items_assignment SELECT affected_item_select;
4512	enh	P4	SEDS	rob.bodington@eurostep.com	CONF	---	CollectionAssignment.assignedTo
4513	enh	P4	SEDS	rob.bodington@eurostep.com	CONF	---	Extend Select: JustificationAssignmentSelect
4597	enh	P4	Inte	rob.bodington@eurostep.com	CONF	---	Add Product_configuration_relationship to Effectivity select
4610	enh	P4	Inte	rob.bodington@eurostep.com	CONF	---	Extend Select : WorkRequestAssignmentSelect
4611	enh	P4	Inte	rob.bodington@eurostep.com	CONF	---	Extend Select: PropertyAssignmentSelect

4612	enh	P4	Inte	rob.bodington@eurostep.com	CONF	---	Extend Select : StateDefinitionAssignmentSelect
4613	enh	P4	Inte	rob.bodington@eurostep.com	CONF	---	Extend Select: LocationAssignmentSelect
4646	enh	P4	Inte	rob.bodington@eurostep.com	CONF	---	Missing characterization of Environment Assignments
4677	enh	P4	Inte	rob.bodington@eurostep.com	CONF	---	Extend Select: ObservedEnvironmentAssignmentSelect
4678	enh	P4	Inte	rob.bodington@eurostep.com	CONF	---	Extend Select: DocumentAssignmentSelect
2757	nor	P2	SEDS	rob.bodington@eurostep.com	NEW	---	SEDS PBM-09 Assignment of a project to a contract
2759	nor	P2	SEDS	rob.bodington@eurostep.com	NEW	---	SEDS PBM-11 Property assigned to several products
3455	enh	P5	Inte	mike.ward@eurostep.com	NEW	---	Part28 xsd has missing attributes and no header
3782	enh	P5	Ball	rob.bodington@eurostep.com	NEW	---	Ballot ISO4: Citing of definitions from other standards
3783	enh	P5	Ball	rob.bodington@eurostep.com	NEW	---	Ballot ISO3: Normative references
3844	enh	P5	Inte	rob.bodington@eurostep.com	NEW	---	Invalid select extension of property_assignment_select
5572	enh	P4	Inte	didier.charpy@cimpa.com	NEW	---	harmonization of interface connector models among AP 233, AP 239, AP 242, AP 210

Annex B: PLCS History

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B.9 OASIS PLCS PSM / PLCSlib 101

B.1 AP 239 edition 1

Issued from a joint industry and government initiative to accelerate development of new standards for product support information, PLCS, Inc. was an international project to produce an approved ISO standard within 4 years; ran from November 1999 – September 2003.

PLCS is designed to ensure support information is aligned to the evolving product definition over the entire life cycle.

PLCS extends ISO 10303 STEP - the STandard for Exchange of Product model data, under the control of ISO.

Prepared by Technical Committee ISO/TC 184, Industrial automation systems and integration, Subcommittee SC 4, Industrial data, PLCS was normalized and published in 2005 as the ISO 10303 Part 239, Application Protocol (AP) “Product life cycle support” (PLCS).

PLCS has been designed in order to address the key business problem “How to keep the information needed to operate and maintain a product aligned with the changing product over its life cycle in a heterogeneous organization, process and system environment?”

For instance, the information scope includes product definition, Maintenance schedules, Tools, test equipment, support facilities, storage requirements, training, spares, softwares, consumables and transportation.

An abstract of the scope is available in next section B.2 ISO 10303-239:2005 (Edition 1) Scope Abstract.

The modelling approach is:

- Through-life, not snapshot
- Extensible –using reference data
- Independent of process
- Deal with legacy approaches and enable more/better
- Model must be process neutral

As a consequence, instead of using entity attributes (used throughout STEP), the mechanism of assignment is extensively used in PLCS in order to give more flexibility. This choice allows the possibility to "characterize" attributes: Effective from when? Who assigned attribute? Why...

The modelling scope covers

- Histories as well as Design
- Individuals as well as Designs
- Fleets as well as Individuals
- Equipment and Resources as well as Product
- States as well as Faults/Failures
- Schedules and Plans as well as Tasks
- Change process across all
- Allow for Why?
- Enable feedback & traceability

… For fulfilling the business drivers hereafter:

- Exchange and sharing of data across the product life cycle
- Capture of relationships/dependencies between items from different disciplines
    - Which usually reside in different specialist systems
- Capture of information to enable comparison of what was supposed to be and what actually happened
    - Maintenance, failures, usage, configurations
- Enable management of change

Within the STEP architecture, AP 239e1 was the early modular AP (Much of the infrastructure (STEPmod) was effectively established by PLCS Inc.).

AP 239 used the AP 203 / PDM Schema style of Product Structure, in contrast with AP 214, by decision of the PLCS Inc. board.

PLCS Inc. accepted that most implementations would be against the ARM (unlike other STEP APs)

- Which was the level most easily tied back to legacy requirements
- Which was defined in EXPRESS
    - There was no significant AIM level legacy and PLCS was not directly using the STEP geometry defined at the AIM level

Nevertheless, PLCS followed the AP approach (ARM-mapping-AIM) and provided the mappings down to the STEP resources even if this incurred significant additional effort.

A part-28e2 XML Schema was defined as part of OASIS DEXlib.

PLCS Inc. lived up to its starting position of closing down in 2004 after the standard was (nearly) done.

The members decided to pass the responsibility on to OASIS (Organisation for the Advancement of Structured Information Standards), a standards body with the policy of making standards

- Open and freely available
- Having invested a lot of time and money in PLCS there was no appetite for paying ISO for a copy
- It was "expected" that OASIS would enable more rapid publication of DEXs
- OASIS was more implementation focused
- Membership by organization rather than National Body

Then the investment continued in defining DEXs in the frame of the PLCS Technical Committee within OASIS.

B.2 ISO 10303-239:2005 (Edition 1) Scope Abstract

Industrial automation systems and integration – Product data representation and exchange – Part 239: Application protocol: Product life cycle support

This part of ISO 10303 specifies the use of the integrated resources necessary for the scope and information requirements for product life cycle support.

The following are within the scope of this part of ISO 10303 :2005:

- information for defining a complex product and its support solution;
- information required to maintain a complex product;
- information required for through life configuration change management of a product and its support solution;
- the representation of product assemblies including:
    - the identification and representation of parts, their versions, definitions, and documentation and management information, such as dates and approvals assigned to parts;
    - the representation of multiple product structure views and product breakdowns;
    - the representation of the shape of an assembly as the composition of the shape representation of its components;
    - the identification of positions within an assembly of parts to which component parts may be attached;
    - the association of valued properties to a part or to an assembly;
    - the representation of interfaces between products;
    - the classification of parts, documents and assemblies.
- the representation of a product through life including:
    - the representation of product requirements and their fulfilment;
    - the representation of existing or potential future products;
    - the identification of the configuration of a product for a given role;
    - the specification of effectivity constraints applied to configuration of a product;

    - the representation of predicted and observed states of products.
- the specification and planning of activities for a product including:
    - the specification of tasks to be performed on a product;
    - the representation of conditions for performing the tasks, including the resources required and the location of the resources and product;
    - the representation of the type of person and skills required for performing a task;
    - the representation of planning and scheduling of the tasks and the management and authorization of the subsequent work.
- the representation of the activity history of a product including:
    - the recording of the usage of a product and the resource usage;
    - the recording of the activities performed on a product and the resource usage.
- the representation of the product history including:
    - a historical record of the states of a product;
    - a historical record of the configuration status of the product;
    - the location of product data;
    - the observation of product data.

The following are outside the scope of this part of ISO 10303:

- the representation of business transactions for ordering, supplying or returning products and other resources needed for product support;
- the representation of business transactions concerning the transportation, shipment and receipt of products and other resources needed for product support.

The scope of this part of ISO 10303 is refined in the Application Activity Model in Annex F of the standard, illustrated in the following figures.

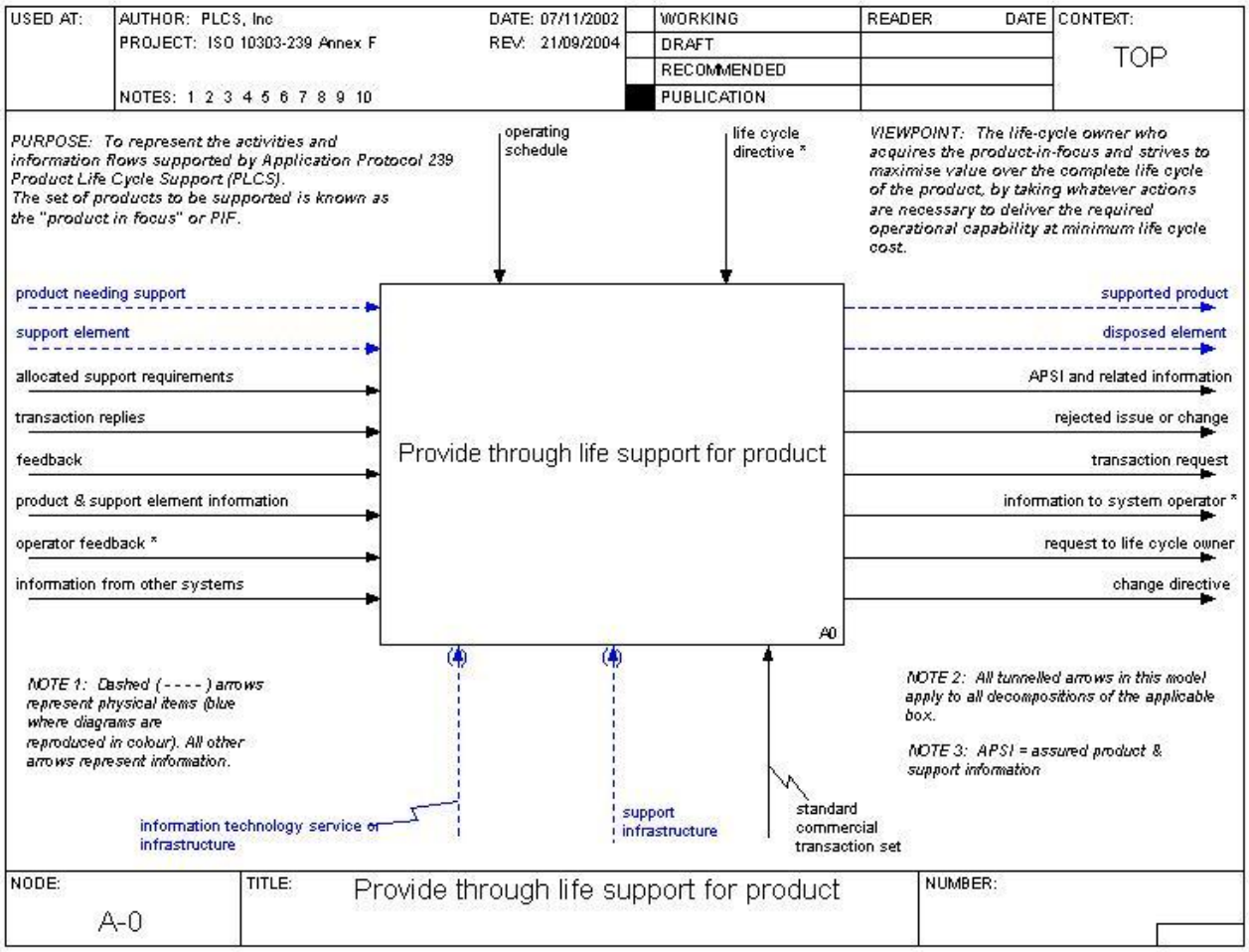

Figure 30: PLCS Application Activity Model A-0

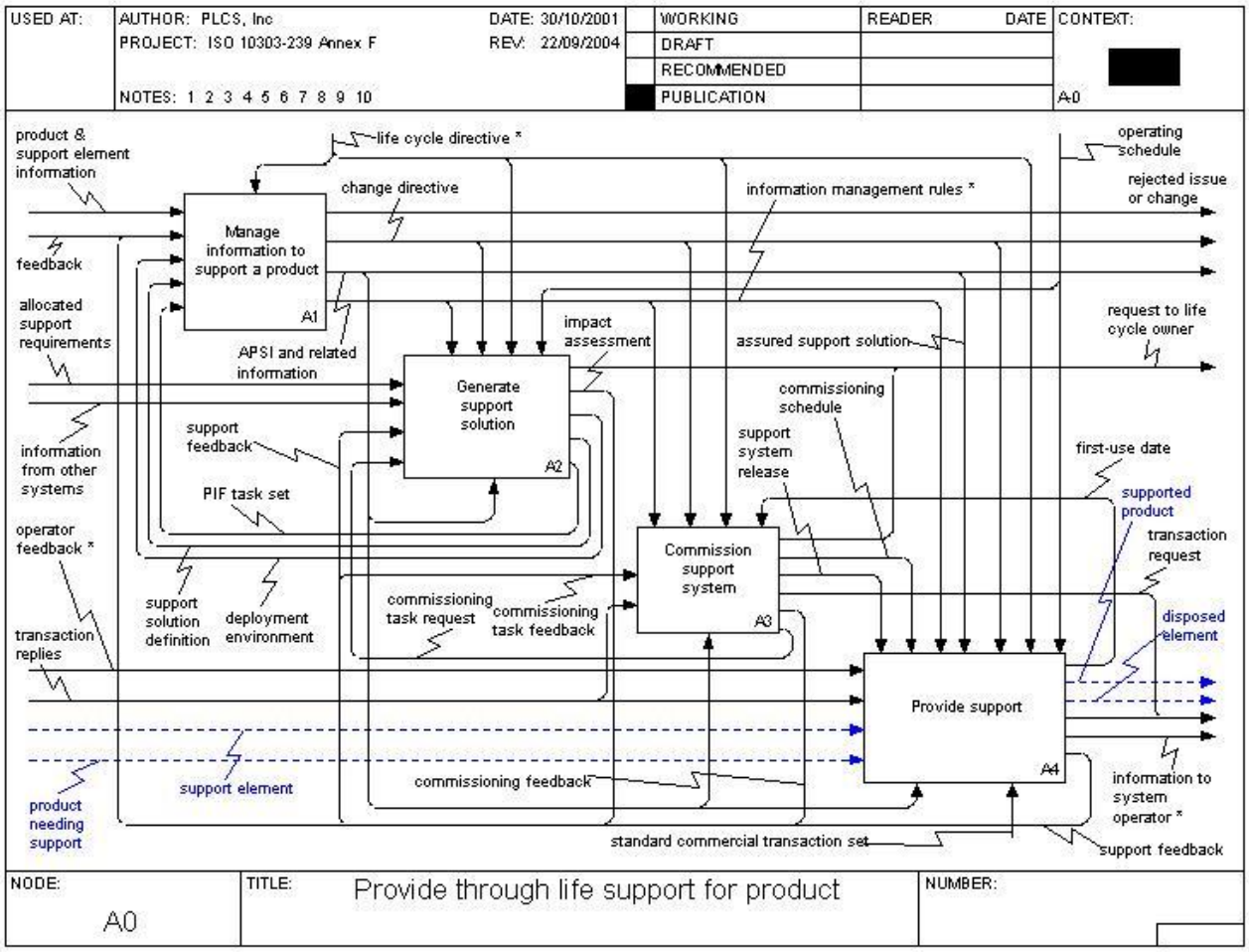

Figure 31: PLCS Application Activity Model A-0 (details – First level breakdown)

The ISO 10303-239 PLCS Application Activity Model (AAM) is provided as an aid to understanding the scope and information requirements. AAM is an IDEF0 representation of the business activities that set the scope and information requirements for the PLCS standard. The model is composed of a set of figures and a set of definitions of these business activities and their associated information flows.

IDEF0 provides a graphical notation for function modeling of an organization or system. Activities can be described by their inputs, outputs, controls and mechanisms (ICOMs).

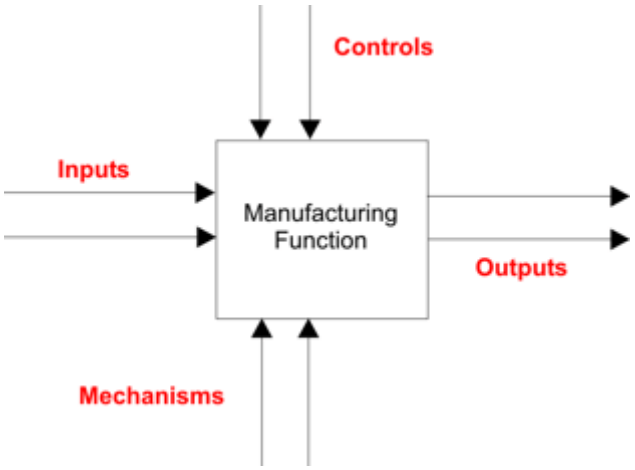

Figure 32: IDEF0 Box and Arrow Graphics

Note: the information flows marked with an asterisk are not explicitly represented within PLCS. This information is instead transferred by other means, e.g., handled by a document.

B.3 AP 239 edition 2

The project of edition 2 of 10303 AP 239 was launched in 2009 according the following rationales:

- Addressed areas that were in original scope of PLCS project but were not covered
- Bring in more of AP 233 (Systems Engineering)
- Address some deficiencies shown up in deployments / DEX development
    - ASD S3000 mapping
    - UK Defence DEXs

The changes integrated in edition 2 are:

- Used latest editions of modules
    - Significant work required to update the modules AND the AP to reflect the changes
- Extended Selects
- Added from AP 233:
    - System / non abstract Product
    - Analysis
    - Validation & verification
    - Risk
- Created:
    - Configuration management
        - Collection
        - Conditional effectivity (now in AP 242)
    - Product Environment
    - Same-as
    - Identification relations
- Modified:

- Message
- Observation
- Resources
- Product category –removed from modules
- Justification –added assumption

The next figure shows the communalities between AP 239 ed2 and AP 233.

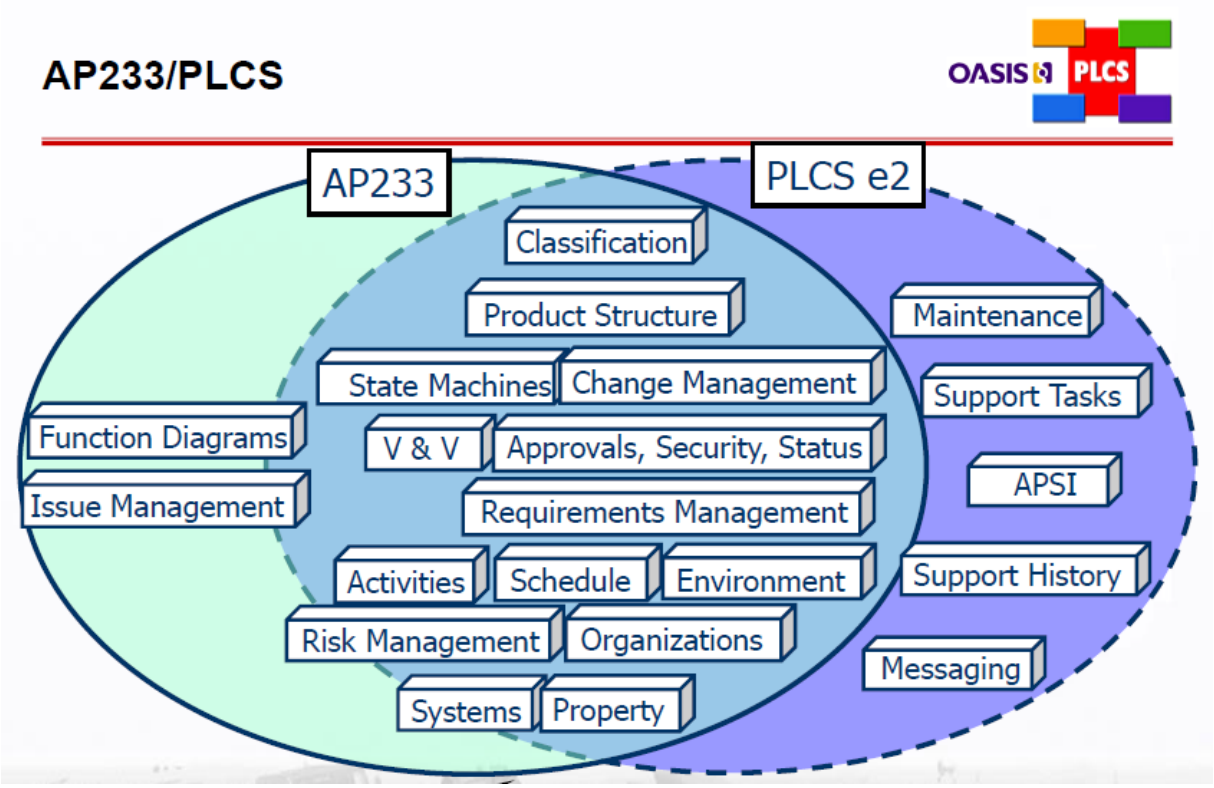

Figure 33: AP 239 ed2 / AP 233 common core

Even if a harmonization on common modules was done between AP 233 and AP 239e2, PLCS deliberately did not aim to absorb data from two related standard areas:

- MIMOSA (dealing with Health and Usage Monitoring)
  - Large data volumes need specific techniques
  - Potential good fit between the CBM/HUMS and PLCS
- Trade messaging standards such as OAGIS
  - Moving target during the PLCS, Inc. project
  - Some overlap in content
  - Transactions vs. history

To sum-up, the edition 2 is an update of edition 1, with a slightly larger scope than the edition 1, and a greater compatibility with AP 233 (Systems Engineering).

An abstract of the scope is available in section B.4 ISO 10303-239:2012 (Edition 2) Scope Abstract.

B.4 ISO 10303-239:2012 (Edition 2) Scope Abstract

Industrial automation systems and integration – Product data representation and exchange – Part 239: Application protocol: Product life cycle support

ISO 10303-239:2012 specifies the application protocol for Product life cycle support edition 1.

The following are within the scope of ISO 10303-239:2012:

- information for defining a complex product and its support solution;
- information required to maintain a complex product;
- information required for through life configuration change management of a product and its support solution;
- the representation of product structures, assemblies and breakdowns including:
    - the identification and representation of parts, their versions, definitions, and documentation and management information, such as dates and approvals assigned to parts;
    - the representation of multiple product structure views;
    - the representation of functional, physical, system and zonal breakdown of the product structure, from system via subsystems or components to end items;
    - the representation of the shape of an assembly as the composition of the shape representation of its components;
    - the identification of positions within an assembly of parts to which component parts may be attached;
    - the association of valued properties to a part or to an assembly;
    - the representation of interfaces between products;
    - the classification of parts, documents and assemblies.
- the representation of a product through life including:
    - the representation of product requirements and their fulfilment;
    - the representation of existing or potential future products;
    - the identification of the configuration of a product for a given role;
    - the specification of effectivity constraints applied to configuration of a product;
    - the representation of predicted and observed states of products.
- the specification and planning of activities for a product including:
    - the specification of tasks to be performed on a product;
    - the representation of conditions for performing the tasks, including the resources required and the location of the resources and product;
    - the representation of the type of person and skills required for performing a task;
    - the representation of planning and scheduling of the tasks and the management and authorization of the subsequent work.
- the representation of the activity history of a product including:
    - the recording of the usage of a product and the resource usage;
    - the recording of the activities performed on a product and the resource usage.

- the representation of the product history including:
    - a historical record of the states of a product;
    - a historical record of the configuration status of the product;
    - the location of product data;
    - the observation of product data.

The following are outside the scope of this part of ISO 10303:

- the representation of business transactions for ordering, supplying or returning products and other resources needed for product support;
- the representation of business transactions concerning the transportation, shipment and receipt of products and other resources needed for product support;
- schematic representation and diagrams of the product or system such as piping and instrumentation diagrams (P&ID) and electro-technical schematics.

As the edition 1, the scope of this part of ISO 10303 is refined in the Application Activity Model in Annex F of the standard (no changes on AAM in edition 2 compared to edition 1).

The technical modifications to the first edition of ISO 10303-2391are documented in Annex J of the standard.

B.5 Reference Data

A STEP AP cannot be too specific since it is supposed to be applicable for all cases within its purpose and scope. Too specific information types would likely make it unsuitable for some applications. Moreover, it would become sensitive to changed circumstances, such as the introduction of new resource types and tool types.

The generic character of a STEP standard entails that each organization can choose to instantiate information in a slightly different way. Both (Johansson, 2001) and Nielsen (2003) concludes the importance of a consistent way of naming and classifying entities when using the standard AP 214. Since it is very unlikely that each modeler chooses an identical modeling approach, the communication between organizations, or even within organizations, cannot be fully automatic without agreements on the instantiation.

In order to make information standards more specific without losing their generic qualities, the newer APs such as AP 239 (PLCS – Product Life Cycle Support) and ISO 13399 (Cutting tool data representation and exchange) use further definitions of concepts outside of the core model in so called reference data libraries (RDL) (Larsson and Kjellberg, 2006), (Nyqvist and Kjellberg, 2004). Reference data classes are referenced from the core model to classify entities into more specific information types.

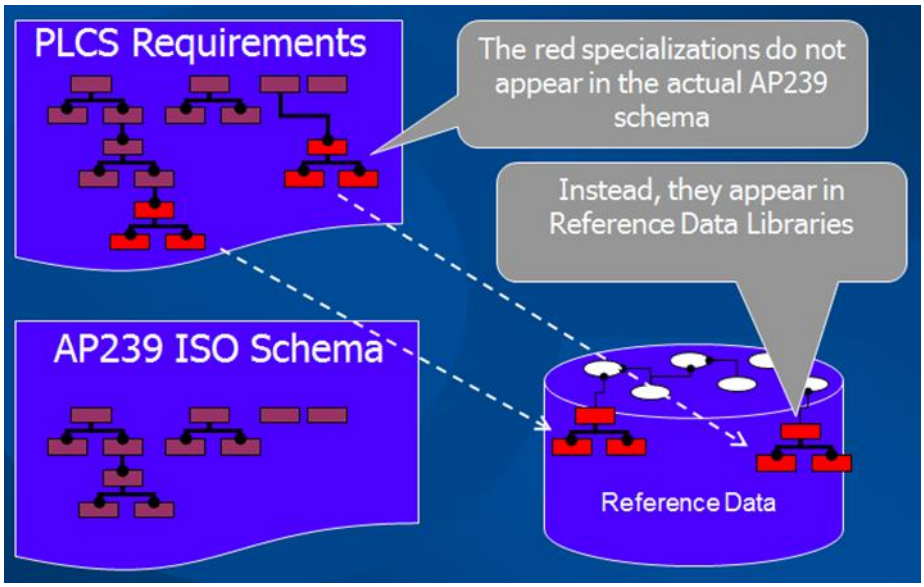

Figure 34: Reference Data

Reference data can have different levels of complexity (Eurostep, 2005), (Larsson, 2006). The simplest form could be a list of definitions. A complex form of reference data is to define an ontology model that specializes the generic model.

The standard ISO 15926 (Integration of life-cycle data for process plants including oil and gas production facilities) (ISO/FDIS 15296-2, 2003) includes an initial set of reference data defined as an ontology model.

The RDL defined for PLCS lies in the middle. It allows further specialization of generic information into more specific reference data classes, but do not define relationships between them. The standard RDL for PLCS is represented in OWL format. OWL (Ontology Web Language) is an XML-based format for publishing and sharing ontologies on the web (W3C, 2004).

The use of RDL together with the core model PLCS is exemplified in **Erreur ! Source du renvoi introuvable.** (a part of Capability C001 (OASIS PLCS TC C001, 2007)): There is a *Part* with an identifier "ZXS10345" which is used (or owned) by an *Organization* with an identifier "Big Planes Inc". The *Identification_assignment* instances are further specialized into the reference data classes *Part_identification_code* and *Organization_name*. *Organization_ or_person_in_organization_assignment* is classified as the reference data class called *Owner_of*. These reference data classes are defined in an external class library *urn:plcs:rdl:std*.

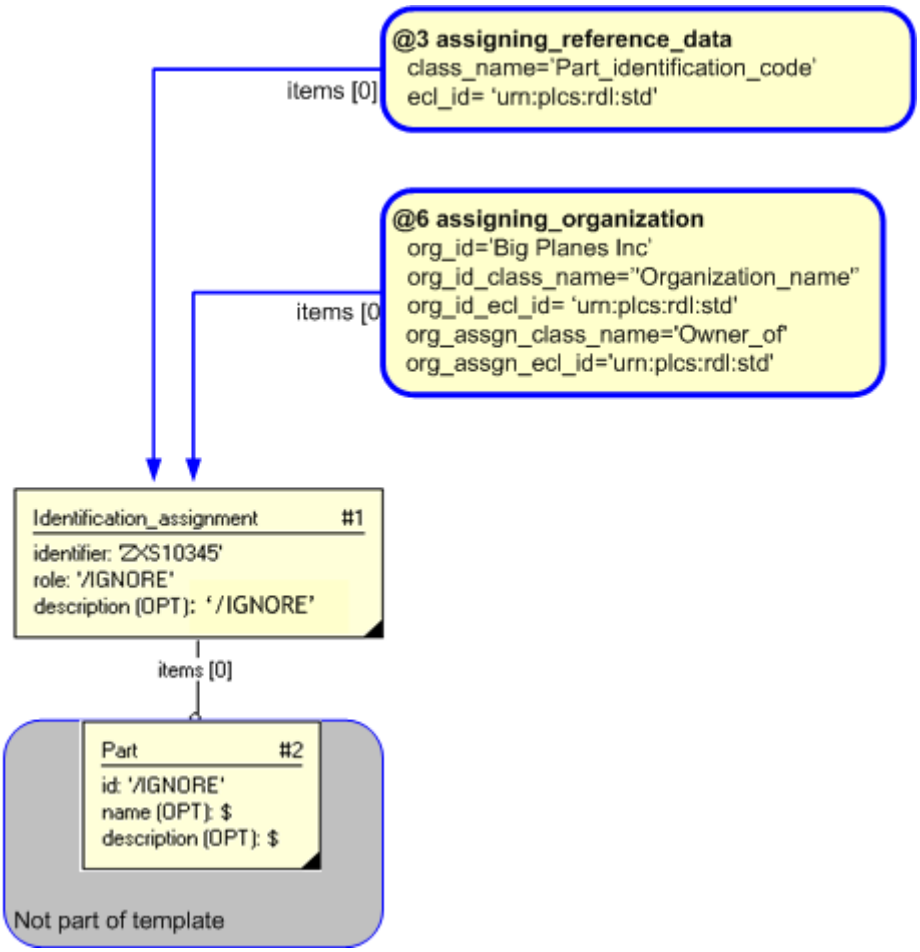

Figure 35: OASIS PLCS DEXlib Capability C001- Instantiation of Template Components

B.6 Domain –specific concept models and ontologies

Example:

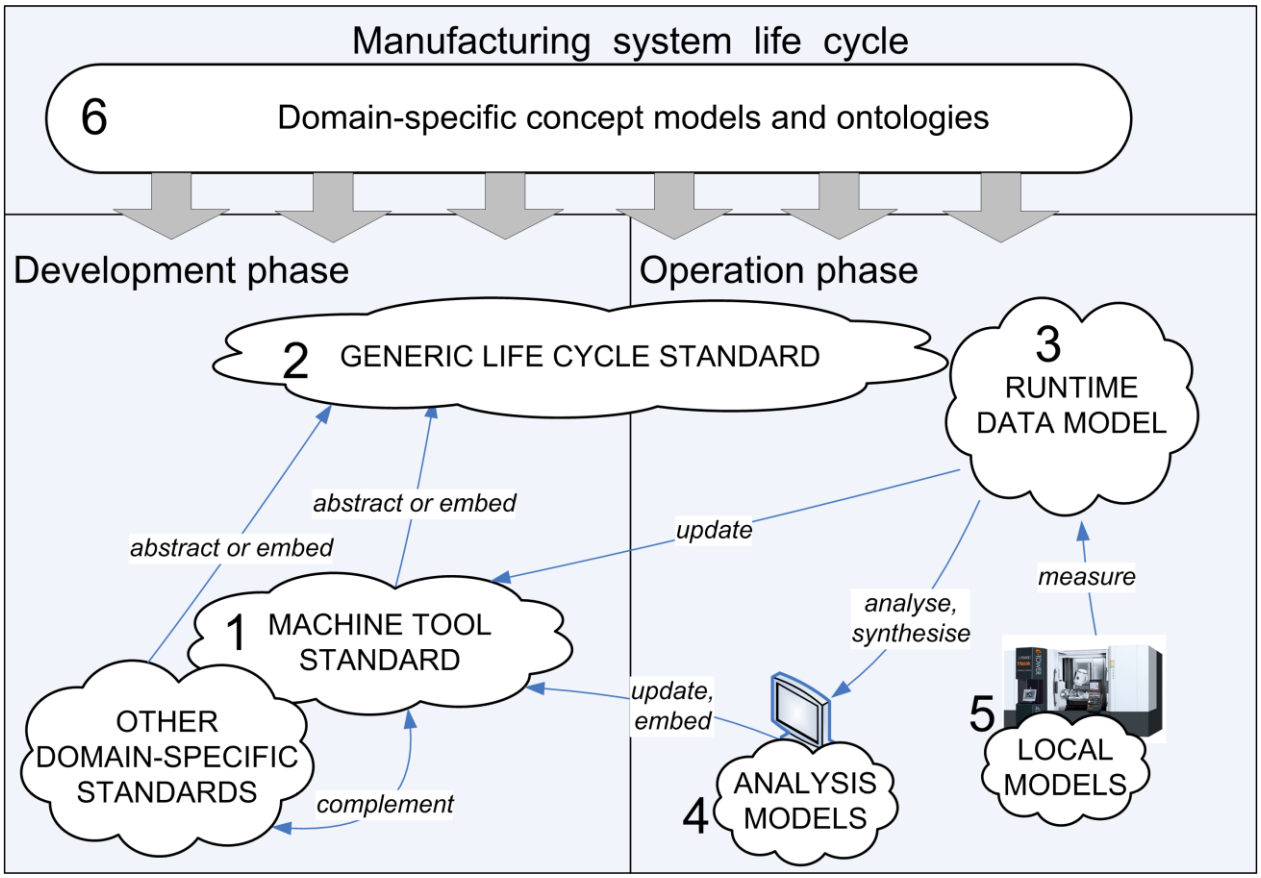

Figure 36: Manufacturing system life cycle

Since AP 239 PLCS does not contain business specific entities, DEXs utilize reference data as a classification mechanism for adding business semantics. Reference data offers the ability to specialize the meaning of PLCS entities to support specific contexts while still utilizing a neutral file format. Reference data simply extends the scope of PLCS to meet organizational and project specific needs and is often adapted from existing government and industry standards.

B.7 Data Exchange specifications (DEX) and Capabilities - communication using AP 239 (OASIS)

In order to use generic STEP standards such as PLCS for system-to-system communications, further guidance is needed in addition to the core model and reference data libraries.

In order to know what modules of the PLCS standard should be used, so called Capabilities are defined to describe typical instantiations, e.g. “representing product as individual”. Capabilities are used to ensure a common interpretation of PLCS, to avoid multiple dialects of PLCS, and to simplify instantiation of the PLCS data model (OASIS PLCS TC, 2007). Within a capability, so called Templates are defined, specifying exactly what entities need to be represented.

Based on these Capabilities, Data Exchange specifications (DEX) are defined. A DEX specifies a set of information that is to be exchanged to support a particular business process, e.g. managing “product as individual” (OASIS PLCS TC, 2007). Entities in Capabilities and DEXs can refer to reference data for defining and classifying the entities.

The work of defining Capabilities, DEXs and RDL is a standardization work by the PLCS Technical Committee within OASIS (Organisation for the Advancement of Structured Information Standards) (OASIS, 2008). Ever since the core model of PLCS reached the international standard status in 2004, the work of developing DEXs and RDLs has continued within OASIS.

The communication scenario can be pictured as in **Erreur ! Source du renvoi introuvable.**, adapted from (Eurostep, 2005). In order to set up a communication scenario based on PLCS and DEX, there also need to be project-specific business agreements on the Capabilities, reference data, as well as exchange agreements regarding DEXs between the communicating organisations (Eurostep, 2005). The exchange agreements concern what parts of a DEX is needed, which RDL to use, adaptations of Capabilities to what is communicated (business concepts), and the file format to be used for the exchange (e.g. Part 21 or Part 28).

Since the setup of this type of communication scenario requires a relatively high initial effort, this kind of communication will likely be used only for long-term exchange scenarios with a high degree of reusability.

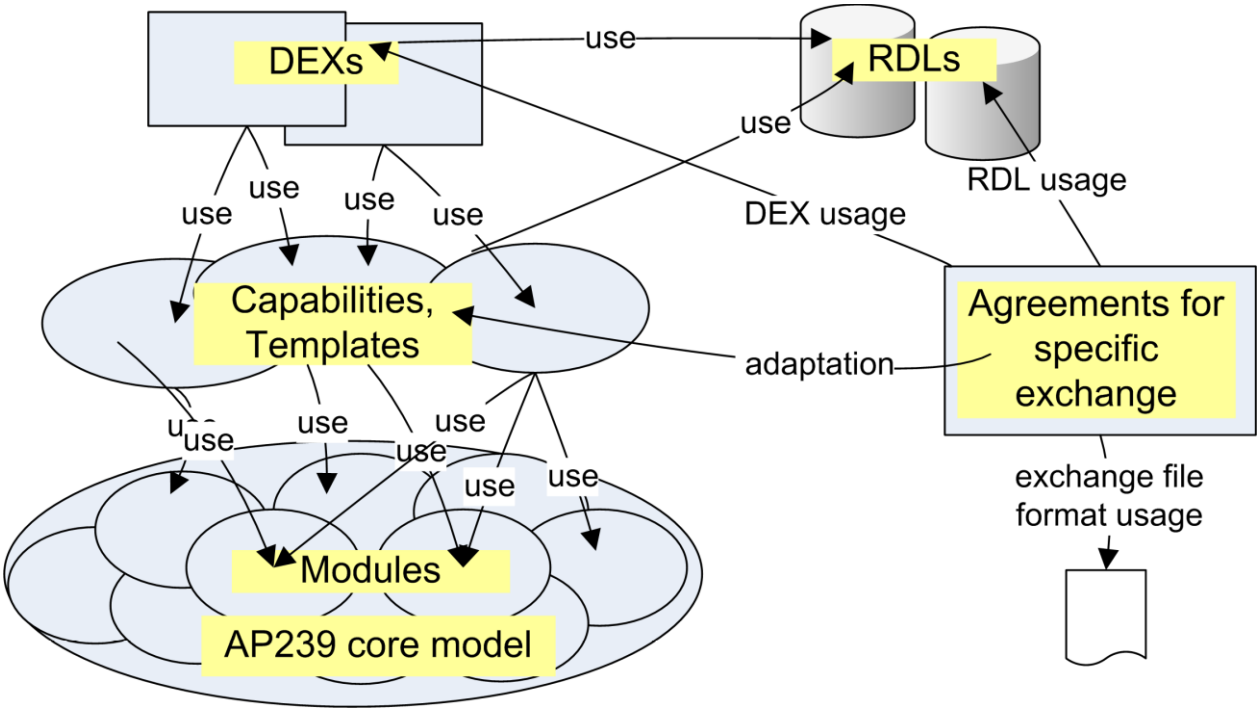

Figure 37: DEX landscape

B.8 OASIS PLCS DEXlib

The purpose of the OASIS Product Life Cycle Support (PLCS) DEXlib standard was to establish structured data exchange and sharing capabilities for use by industry to support complex engineered assets throughout their total life cycle. The Data Exchange Specifications (DEXs) are based upon ISO 10303 (STEP) Application Protocol 239 Product Life Cycle Support (PLCS) edition 1.

A DEX is a division of the PLCS information model into data exchange specifications (DEXs) suited for a particular business process.

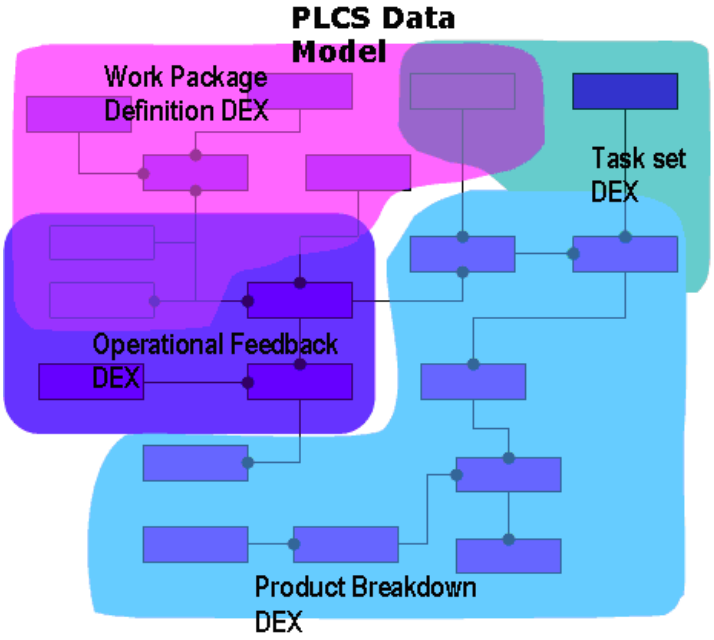

Figure 38: DEXs as subsets of PLCS Data Model

For example, DEX: (D001) —Product Breakdown for support, aims to cover the exchange of the relationship of the parts assembly structure, derived from a PDM system, to an LSA structure used to manage support, and the links to relevant documents.

Each DEX comprises the following:

- Introduction
- Scope
- ISO 10303-239 Activity model
- Business overview
- Business information overview
- Business information requirements
- ISO 10303-239 representation
- Template
- Capabilities
- Schemas
    - The EXPRESS model for the DEX;

- The XML Schema for the DEX derived from the EXPRESS according to ISO 10303-28 edition 2.

– Reference data

– Conformance

Each DEX can be used to contract against or to claim conformance to.

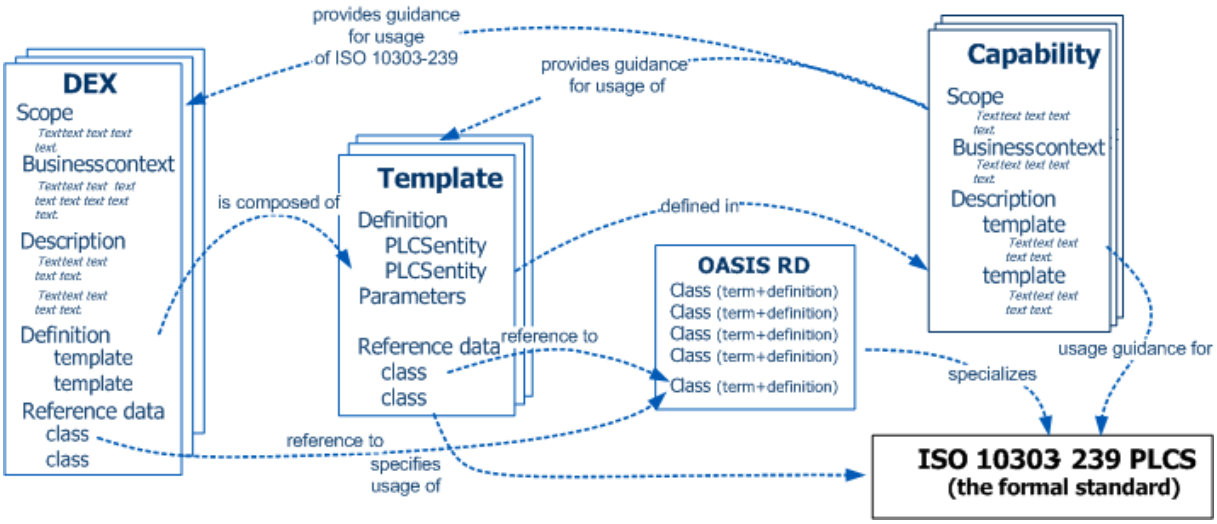

Figure 39: DEXlib - Relationships between the different DEX components, Reference Data and PLCS

DEXlib introduces the mechanism of “template” in order to:

- Model business objects
- Formally map to AP 239 (generic and low level) entities
- Formally define repeatable patterns
- Allow code to generated from the templates

OASIS template intend be re-usable to build business object templates specific to the context of each business DEX, and by the way ease the mapping between business high level information objects and their PLCS representation and provide a more efficient implementation compared to a direct mapping against the PLCS standard (ISO 10303-239).

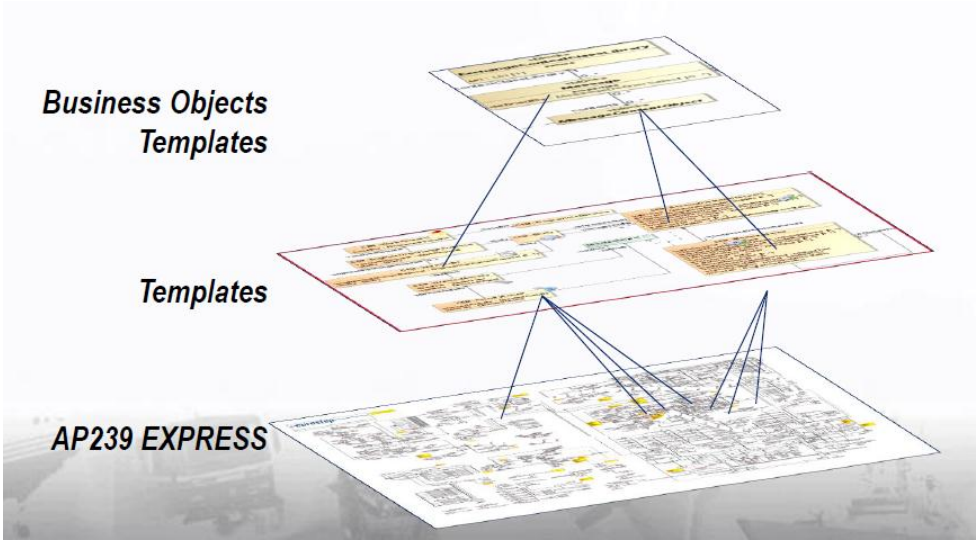

Figure 40: DEXlib – Templates and mapping to the standard

In accordance with DEXlib, the following DEX development projects were launched by the following actors:

- OASIS
  - Task set
  - Aviation Maintenance
  - Item identification
- UK Defence
  - 52 DEXs
- Swedish Defence
- US Navy
  - Ship building
  - Archiving
- LOGSA
- AIA/ASD
  - Aerospace and Defense DEXs for S3000L support
- French MoD
- LOTAR
- NATO – STANAG 4661

OASIS DEXlib summary

- Based on AP 239 ed1 ARM EXPRESS model
- DEXs developed by mapping source data to OASIS templates (with use of reference data)

- DEXs implemented via ISO methods (P21 or P28e2)
- DEX development environment maintained by OASIS and associated software vendors
- DEXlib Published as OASIS Committee Specification:
    - Task Set DEX D003
    - http://docs.oasis-open.org/plcs/dexlib/cs01/oasis_cover.htm
- Required knowledge includes PLCS, PLCS implementation methods, and OASIS templates (with instantiation path)

To date, DEXlib has been deprecated (but still available on http://www.plcs-resources.org/plcs/dexlib/dex_index.htm), superseded by PLCSlib.

B.9 OASIS PLCS PSM / PLCSlib

A number of pilot projects and deployments based on ISO 10303-239 ed1 / DEXlib were conducted and successfully demonstrated the business value of PLCS and confirmed that the DEX based approach is key to successful specification and implementation. However, the adoption of PLCS was not wide spread. Experience of deployments of PLCS lead the OASIS PLCS TC to identify a number areas that could be improved to increase the take up of the standard. Namely:

- Modular STEP APs
    - Model + documentation scattered across large number of small ISO 10303 modules hence hard to understand
    - Lack of clarity of definitions –often generic
    - STEP imposes a two (three?) level model ARM –MIM / Integrated Resource
        - In many cases ARM is very close to MIM
        - The ARM model is complex –the MIM even more so
        - Mapping the ARM to the MIM costs significant time and effort, especially if the required Integrated Resources need updating / creating
        - Most PLCS implementations did not use the MIM, only use the ARM
    - Foundation on legacy STEP leading to unused attributes / entities
        - Attribute versus Assignment modelling
        - Data files large with low signal to noise ratio (/IGNORE) –this was a show stopper
    - Modules get changed –this impacts the APs –the APs don't get updated
        - Different APs have different requirements
    - Use of EXPRESS powerful, but not mainstream modeling language
- Part 28
    - P28 extremely complex
        - XML data structure was OK ... but AP 239ed1 XSD extremely difficult to generate and too difficult to use

- DEXs
    - DEXs proved a good way of segmenting model
        - But … one size does not fit all .. Hence lots of "Business" DEXs
        - Must be Business process driven
        - Challenging to get support for generic DEXs
    - Model Usage guidance is not enough
        - You need accurate specification of how a business object maps/represented in the standard
        - Templates enable this
    - Templates
        - Specify ARM implementations –in fact specify business objects
        - Define consistent patterns by use of "templates"
        - Improve documentation
        - Templates "hide" model quirkiness (use of /IGNORE)
        - Add higher level classes –business objects
    - Reference data needs:
        - Enables accurate semantic extensions to the generic model
        - Is a modelling exercise
        - Needs managing
        - Accurate / understandable definitions
- But critically ….
    - DEXlib does not use mainstream technology…
        - uses derivation of SC 4 mapping tables. SC 4/DExlib bespoke
        - uses bespoke, sole vendor tools to document EXPRESS and EXPRESS based Templates
        - uses Part 21 and Part 28

Consequently the OASIS PLCS TC agreed to initiate a project to develop a second iteration of DEXlib that took account the lessons learned.

The technical drivers of the PLCSlib project were:

- Rely on a Core information model (e.g. PLCS Platform Specific Model PSM) that is:
    - Founded in AP 239 ed2 ARM
    - Easier to understand,
    - Easier to access
    - Easier to implement
- Explicit mechanism for semantic extension of core information model via reference data
- Explicit reusable approach to mapping business objects/concepts to the Core information model
- Using COTS tools / Mainstream standard technologies
    - Avoid bespoke where possible
    - Keep EXPRESS but derive UML (SysML) + XSD
        - Mainstream
        - extensive COTS tools
- Align with AP 242 BOM as far as timescales / resources permit

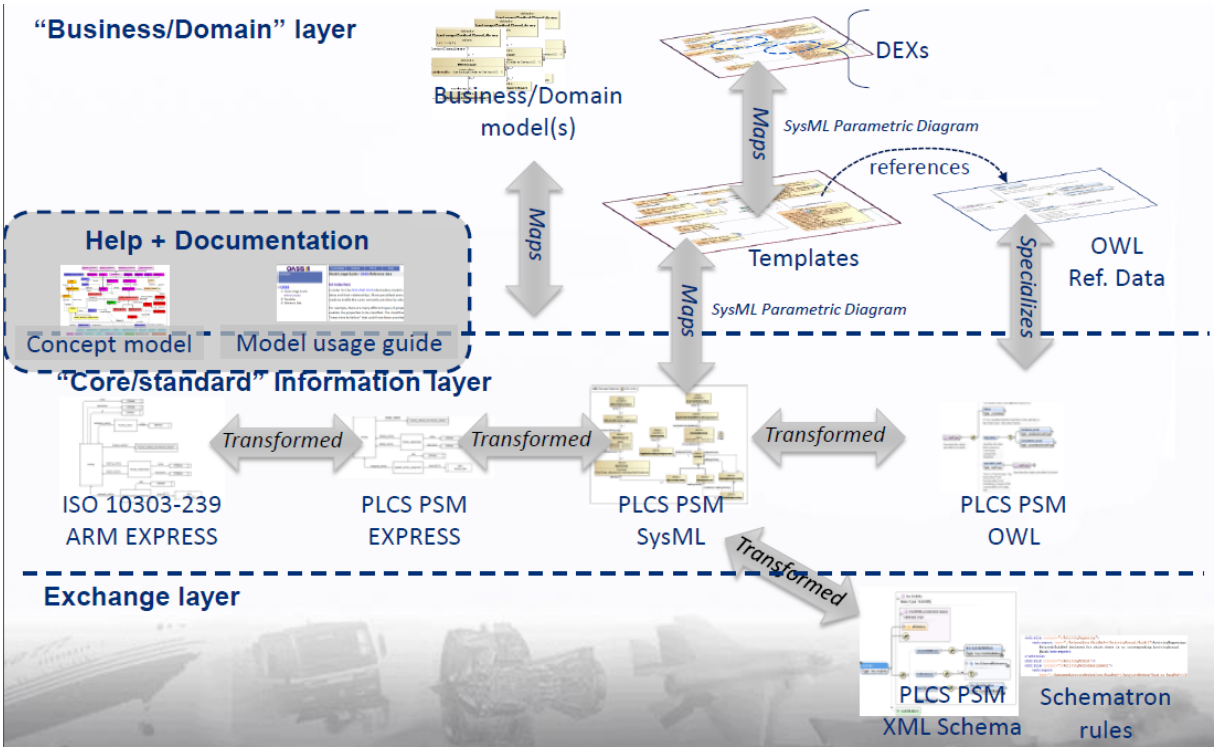

Figure 41: PLCSlib - Information architecture

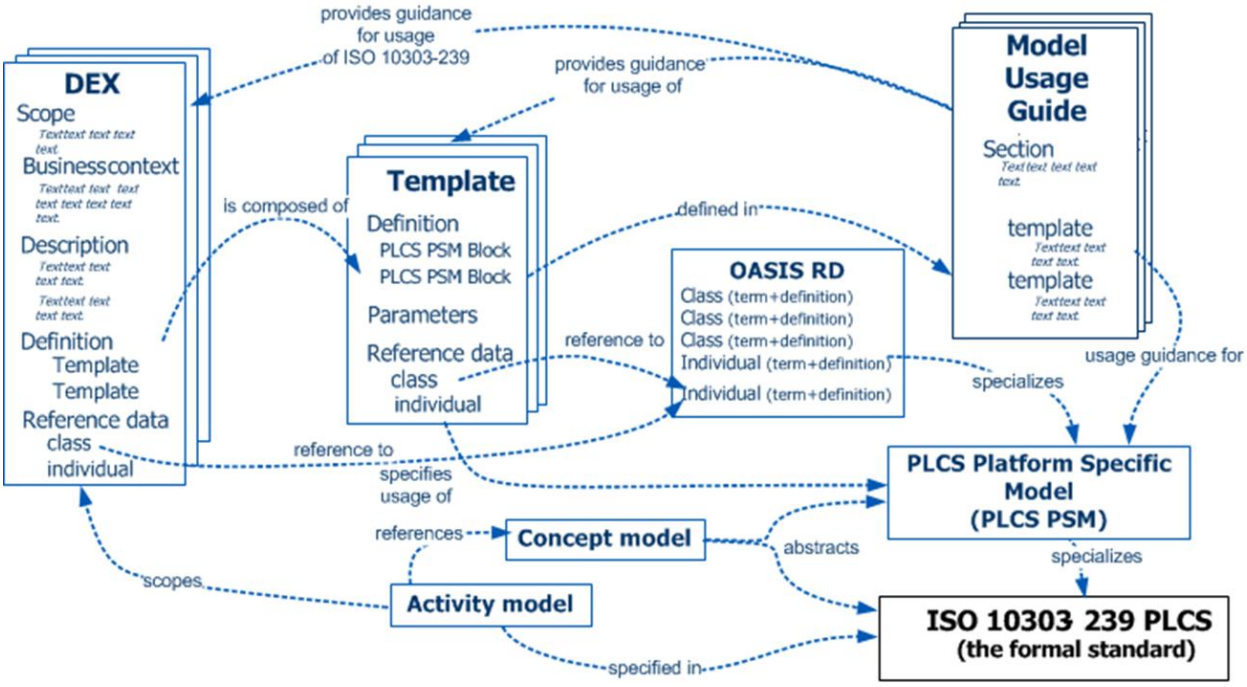

Figure 42: PLCSlib - Relationships between the different DEX components, Reference Data and PLCS

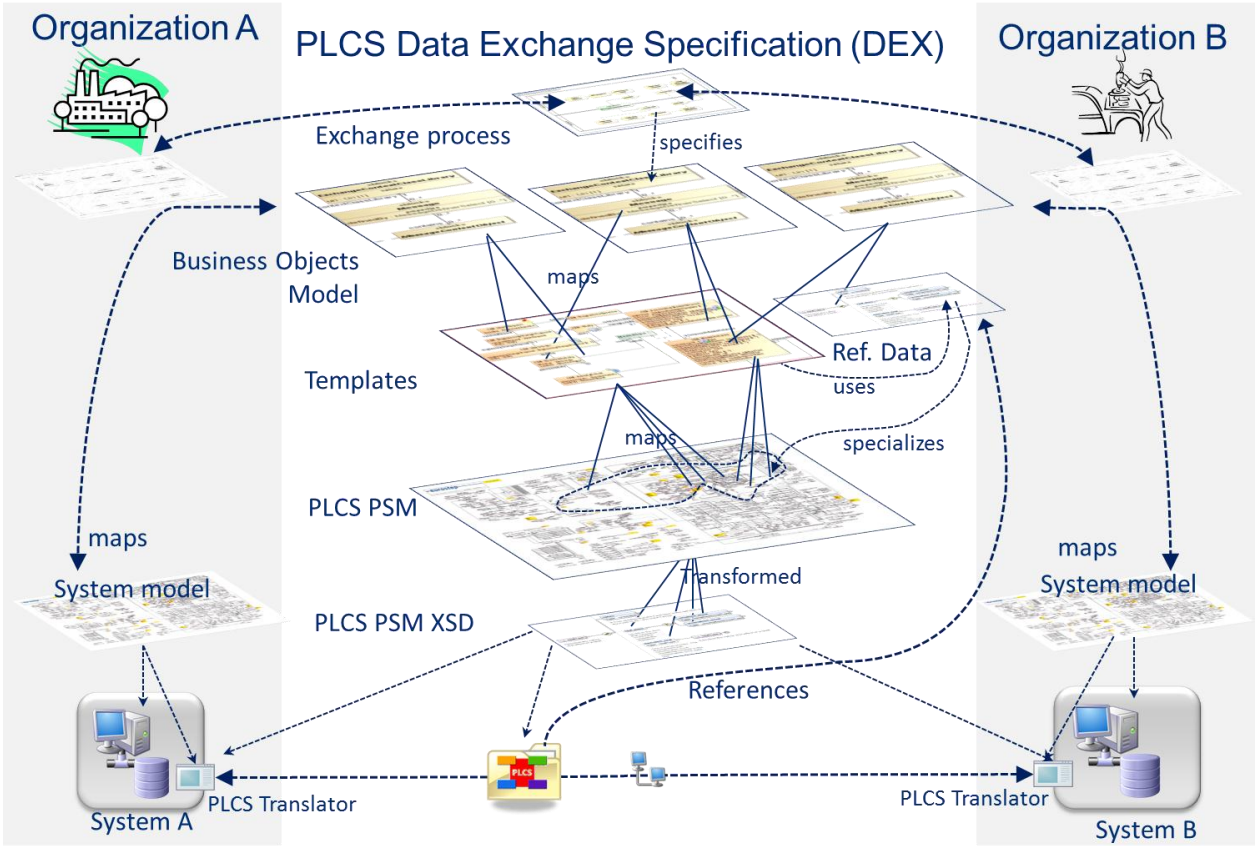

Figure 43: PLCS PSM/PLCSlib based data exchange

OASIS PSM/PLCSlib summary

- Environment for developing / publishing DEXs: http://www.plcs.org/plcslib/plcslib/
- SysML based Model Driven Architecture:
  - From Business Objects modelized in SysML to XML schema (XSD) + schematron rules
- Libraries of DEXs, Templates and reference data in one place
  - Concept Model: Conceptual overview of PLCS model, based on UML, non exhaustive, provided for information
  - Activity Model (coming for AP 239 ed2)
  - Core PLCS PSM data model derived from AP 239 ed2 EXPRESS model and harmonized with ISO 10303-242 BOM, in:
    - SysML
    - EXPRESS
    - XSD
    - OWL
  - DEXs
  - Templates
  - Reference Data
  - Model usage guidance

- Documentation + help
- Published as OASIS Committee Specification in 2013: http://docs.oasis-open.org/plcs/plcslib/v1.0/cs01/plcslib-v1.0-cs01.html
- DEXs developed by mapping source data to OASIS templates (with use of reference data)
- DEXs implemented via OASIS methods (PSM XML schema)
- DEX development environment maintained by OASIS and associated software vendors
- OASIS PLCS is in production usage in a number of organizations and is supported by several vendors.

Annex C: Viewpoints on last PLCS developments

Note: The following viewpoints are delivered under the responsibility of source organizations as they are not necessarily endorsed by the whole PLCS community.

C.1. LOGSA: Challenges and Risks.....106
C.2. AIA/ASD DMEWG: OASIS PSM/PLCSlib versus ISO PLCS ed2 107
C.3. LOTAR AP 242 BOM / AP 239 PLCS PSM.....110

C.1. LOGSA: Challenges and Risks

The hereafter LOGSA analysis for the use of PLCS for supporting exchange of logistics product data, is coming from the reference document [R2].

Although ISO 10303-239 PLCS accommodates the data content of GEIA-STD-0007, the following risks and challenges must be carefully considered prior to a migration to PLCS:

- ISO 10303-239 lacks supporting evidence such as public business case analyses or public pilot projects to prove its expected return on investment for its stakeholders
- ISO 10303-239 continues to see a lack of widespread support and adoption in DoD
- Current DoD systems must be changed to accept ISO 10303-239 data, a major challenge due to the weak value proposition of ISO 10303-239
- ISO 10303-239 lacks a common/harmonized set of robust reference data so DEXs are essentially customized with organizational specific reference data
- PLCSlib deviates from the ISO 10303-239 EXPRESS information model resulting in an OASIS unique data exchange format (PSM XML) that is different than any of the formal ISO STEP implementation methods (e.g. Part 21 and Part 28)
- PLCSlib implementation requires a proprietary SysML application
- Only one vendor has claimed success in implementing the PLCSlib architecture which suggests significant immaturity
- PLCSlib will eventually supersede DEXlib and the support of DEXlib remains unclear leading to the potential loss of previously standardized templates and DEXs
- DEXlib is based on the ISO 10303-239 edition 1 schema while PLCSlib is derived from ISO 10303-239 edition 2 schema (does not directly support the schema of ISO 10303-239 edition 2)
- There is no direct compatibility between DEXlib and PLCSlib so DEXs developed using DEXlib must undergo extensive re-work to be migrated to PLCSlib.
- There is no official publication medium for business DEXs developed in either DEXlib and PLCSlib

- LOGSA's DEX development alternative is conceptual and requires a proof of concept prior to any further development
- Migrating to any version of ISO 10303-239 will result in larger file sizes than the native GEIA-STD-0007 XML format, presenting a major challenge for software vendors and data exchange partners
- ISO 10303-239 does not adequately address the issue of change files or incremental updates, a key Logistics Product Data (LPD) transaction

LOGSA Alternative

In addition to OASIS developed methodologies such as DEXlib and PLCSlib, LOGSA proposes its own approach for utilizing STEP AP 239 to deliver Logistics Product Data (LPD).
The key principles of the LOGSA alternative approach are:

- Based on AP 239 ed2 EXPRESS model
- DEXs developed by mapping source data to AP 239 entities (with use of reference data)
- DEXs implemented via formal ISO methods (P21 or P28)
- DEX published via GEIA-STD-0007
- DEX development environment maintained by TechAmerica via GEIA-STD-0007 appendix
- Required knowledge is limited to PLCS and PLCS implementation methods

LOGSA: Recommendations and Conclusion

Due to the many challenges and uncertainties surrounding PLCS in the near term, LOGSA's short term efforts should be focused on enhancing GEIA-STD-0007 as an intermediate step in migrating to an ISO 10303 solution in the future. This can be done by improving areas of the XML schema to help reduce its relational database similarities and to improve the efficiency of the data exchange. In the long term, efforts should be focused on closing the gap between the design engineering and logistics domains to ensure a proper interface exists for streamlining the arduous product breakdown to logistics/provisioning processes.

C.2. AIA/ASD DMEWG: OASIS PSM/PLCSlib versus ISO PLCS ed2

The Aerospace and Defense Industries of Europe (ASD) and the Aerospace Industries Associate (AIA) Integrated Logistic Support (ILS) Specification Council (ASD/AIA ILS Spec Council) has governance over the S-Series of specifications including S2000M thru S6000T, S9000D, and SX000i. S1000D is not currently included. The ASD/AIA ILS Spec Council authorized formation of the Data Modeling and Exchange Working Group (DMEWG) with the responsibility to create a harmonized underlying data model and a standard exchange mechanism for information exchanged between the S-Series Specifications. The DMEWG charter includes the following statement: "The DMEWG shall also be responsible for the governance, review and publication of Aerospace and Defense Data Exchange Specifications (AD DEXs), using ISO 10303:239 Product Life Cycle Support (PLCS)".

The white paper "ASD/AIA ILS S-Series Specifications Exchange Research

White Paper" published in April 14 (reference document [R3]) addresses the DMEWG research and recommendation for a standard exchange mechanism between the S-Series Specifications based on ISO PLCS.

The DMEWG drew upon existing knowledge and experience with ISO PLCS and OASIS PSM/PLCSlib within the group, additional research, and collaboration with the OASIS PLCSlib Technical Committee.

AIA/ASD summary on ISO PLCS and OASIS PLCS DEXlib

ISO 10303-239 PLCS was published in 2005 to satisfy an industrial need to exchange and integrate product support information. ISO PLCS accommodates the entire spectrum of life cycle data, including product definition, activity management, support solution, and operational feedback information.

ISO PLCS ed2 was published in 2012 and contains a slightly larger scope with a greater compatibility with systems engineering.

The Organization for the Advancement of Structured Information Standards (OASIS) PLCS Technical Committee (TC) was formed to promote the advancement of ISO PLCS through the development of DEXs and also to serve as a liaison with the ISO/TC 184/SC 4 who officially manages the development and publication of all STEP application protocols. To aid organizations in DEX development and to promote the uptake of ISO PLCS, the OASIS PLCS TC created an open source development environment called DEXlib. The TC also developed a set of templates, or predefined business objects, that specify collections of ISO 10303-239 ed1 entities required to exchange a specific concept.

OASIS Platform Specific Model (OASIS PSM)

The OASIS PLCS TC recently created a second edition of DEXlib, called PLCSlib. In PLCSlib, DEXs are based on a Platform Specific Model (OASIS PSM) schema derived from the ISO 10303-239 ed2 EXPRESS schema. The OASIS PSM was derived by transforming the ISO PLCS ed2 EXPRESS schema into a Systems Modeling Language (SysML) model. The SysML model was then transformed into an XML schema to facilitate XML implementations.

Figure 44: ISO STEP AP 239 to OASIS PSM information model transformation

During the transformation process, several changes were made to the ISO PLCS ed2 information model. According to OASIS, these changes were made in order to improve the efficiency of resulting implementations. The OASIS PSM is distinct from ISO PLCS ed2 in 16 major areas:

Classification efficiency	ViewDefinitionContext	Identification efficiency	Description Attribute

Attribute redundancy	Role entity redundancy	Composition	Assignment / Relationship objects
Event	Properties	Risk properties	Units
Message	Shape	Multiple inheritance	single_property_is_definition

Each area represents a set of deletions, additions, or modifications to the ISO PLCS ed2 schema during the transformation process.

DMEWG: Comparison of the two alternatives and recommendation

The OASIS PSM and PLCSlib work is currently published as an OASIS committee specification titled "Product Life Cycle Support Version 1.0". It is unclear if this work will remain an OASIS committee specification, or serve as a baseline for an ISO 10303 ed3 effort. While the OASIS PSM results in a more streamlined schema, it also departs from core structural requirements found in the ISO PLCS ed2 schema. Many of entities and attributes currently required by ISO PLCS were modified or completely removed when creating the OASIS PSM, leaving a gap between the OASIS PSM and other STEP APs. It also introduces a new implementation format, the OASIS PSM XML, which is OASIS unique and not a formal ISO 10303 implementation method.

DMEWG Recommendation

It is recommended that the ILS Spec Council approved strategy is published by the ILS Spec Council (for example, on the different AIA/ASD specification websites) so that users can see the roadmap, are aware of this strategy, and therefore can establish long-term IT plans.

Short Term Recommendation

Based upon the outcome of the research and the ideas on how XML can be used to implement optimized data exchanges for S-Series Specifications, the short term recommendation from the DMEWG is to implement S-Series specifications data exchange using the bespoke schema approach with a direct mapping to ISO PLCS ed2.

Long Term Recommendation

As a long term objective, the DMEWG recommends that the ASD/AIA ILS Spec Council supports development of ISO PLCS ed3 and supports the eventual migration of the S-Series specification data exchange to ISO PLCS ed3.

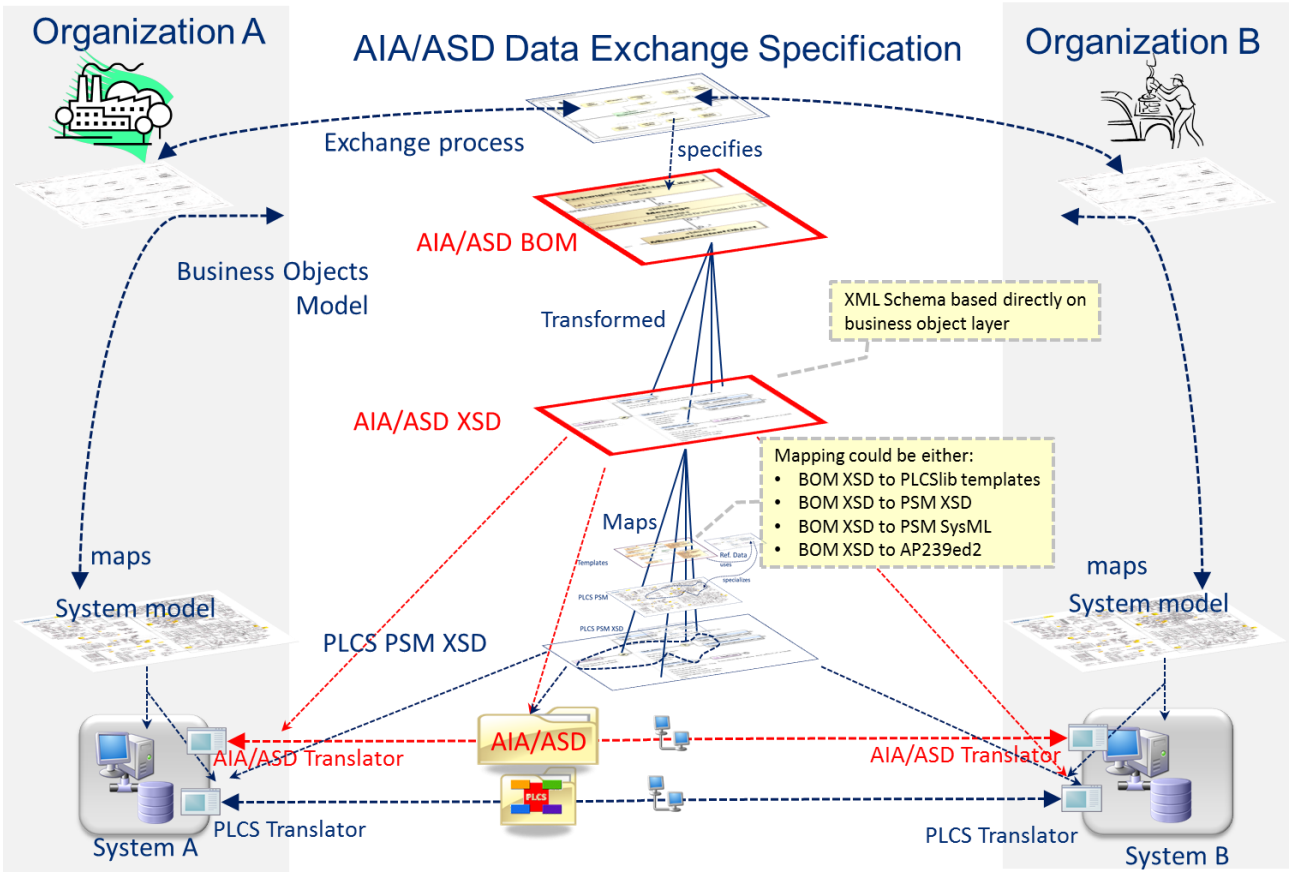

Figure 45: AIA/ASD Data Exchange Specification

C.3. LOTAR AP 242 BOM / AP 239 PLCS PSM

Background

- Since PLCS PSM was first published 1st quarter 2011, we have had experience of developing DEXs/templates and implementing the PSM
- AP 242 Business Object Model (BOM) developed
- On-going project sponsored by LOTAR to investigate potential for harmonization between AP 242 Business Object Model (BOM) and PLCS PSM
- Challenge:
  - PLCS a generic though life information model by design.
  - AP 242 BOM a more explicit design / manufacture information model
- Deliverable (Phase 1):
  - A set of recommendations for harmonization in the following areas:
    - Identification, Classification
    - Properties
    - Physical Instance / Product As Realized
    - Part
    - Common XSD Approach
  - Propose changes to AP 242 BOM and PLCS PSM to the PLCS and AP 242 communities for consideration.
  - Deliverable (Phase 2) – not yet started:
  - A set of recommendations for harmonization in the following areas:

        - Common XSD Approach Part 2
        - Requirements
        - Assemblies
        - Breakdown
        - Specification Control
        - Activity/Work Order/Work Request
- Hence a number of changes are proposed outlined here that will improve the model

Positioning of AP 239 – AP 242

- AP 242 for 3D model based mechanical design
    - Information model focussed on 3D mechanical design
    - More a “Snapshot” of product’s 3D design rather than a through life view
    - aimed at understandability by domain experts
    - Hence information model is explicit and complete
- AP 239 for product life cycle support
    - Information model designed to represent product evolving through life
    - Model is Multi-discipline / Multi industry
    - Hence information model
        - is generic and extensible
        - represents explicit histories of the evolving product, activities to design, support and operate product