Developed under NSRP ASE ISE-6

Technology Investment Agreement (TIA) 2007-379

Integrated Shipbuilding Environment Consortium (ISEC)

ISE-6 Final Report

Document Number
ISE-6-TEAM-0002

Version 1.0

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Submitted on:

2009-06-19

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1 INTRODUCTION

1.1 Overall ISE Project Goals

The Integrated Shipbuilding Environment Consortium (ISEC) was formed in 1999 as a consortium of several major shipyards and CAD vendors with the goal of developing an information interoperability capability for U.S. Naval shipbuilding. ISEC has addressed these interoperability issues in a series of NSRP (National Shipbuilding Research Program) Projects known as the Integrated Shipbuilding Environment (ISE). The NSRP Advanced Shipbuilding Enterprise (ASE) was established in 1998 as collaboration of eleven shipyards with Navy and other federal agencies. It has attempted to solve interoperability and data exchange issues by awarding various projects over the past nine years to this consortium of shipyards, CAD vendors, and universities. The projects awarded by NSRP in this area are known informally as: HARVEST, ISPE, ISE-1, ISE-2, ISE-3, ISE-4, ISE-5, and ISE-6 and they have successfully attacked various phases of the interoperability problem.

The HARVEST Project completed the Standard for the Exchange of Product Model Data (STEP) Shipbuilding Structural Application Protocols (AP215, AP216, and AP218) and secured their approval as International Standards (IS). ISPE determined the requirements for exchanging steel processing product model data in a shipyard independent format. ISE-1 outlined the requirements and architecture for an interoperability solution. ISE-2 implemented that solution in the structural and piping disciplines. ISE-3 continued these implementations in the HVAC and Common Parts Catalog (CPC) interface areas. ISE-4 focused on the areas of Ship Arrangements, Steel Processing, Engineering Analysis, and Electrical. ISE-5 continued development and implementation in the electrotechnical area.

The ISE Consortium is continuing its efforts at developing tools for product data interoperability under the current NSRP ASE Project for “Enabling Shipyard Interoperability” (ISE-6). This project has run from March 2007 through June 2009 and extended the ISE work to Product Life Cycle Support issues as well as continuing to support the ISE Team’s participation with the International Organization for Standardization (ISO) and the Navy’s DONXML activities.

1.2 ISE-6 Participants

ISE-6 – Enabling Shipyard Interoperability is an NSRP ASE sponsored, industry led project under the auspices of the ISEC. This program is a collaborative effort that includes several U.S. shipyards, software vendors, and research institutions. The term “shipyard” is used to mean not only the commercial shipyards, but also the “virtual” shipyard represented by the U.S. Navy and the NAVSEA CAD-2 program.

The ISE-6 Team is led by Electric Boat Corporation (EB) with members from the following organizations:

- Northrop Grumman Shipbuilding (NGSB)
- Atlantec Enterprise Solutions (AES)
- Industrial Planning Technology (IPT)
- Intergraph Corporation (INGR)
- Knowledge Systems Solutions, Inc. (KSS)
- Naval Surface Warfare Center – Carderock Division (NSWC-CD)
- Naval Surface Warfare Center – Port Hueneme Division (NSWC-PHD)
- Northrop Grumman Information Systems (NGIS)
- Product Data Services Corp. (PDS)
- ShipConstructor Software, Inc. (SSI)

1.3 ISE-6 Objective

The objective of the ISE-6 Project has been to prototype translators and evaluate the use of international standards and the ISE interoperability architecture in the realm of ship’s life cycle support and post-delivery operations. The project identified and documented the Use Cases and scenarios that apply to data required for post-delivery support and operations, both on shore and on ship. Information requirements derived from the Use Cases were documented in XML format in accordance with the ISE methodology. The project prototyped the ability to manage the identified information elements and demonstrated that life cycle support information can be shared among software applications – using the ISE XML neutral formats. The prototypes demonstrated a Web-based integration architecture that could be applied to systems aboard the ship as well as shore-based repair and maintenance systems. This architecture and consequent prototypes are based upon the international standard for Product Life Cycle Support (PLCS) data (ISO 10303-239) and on the S1000D Standard for XML-based technical documentation.

In previous projects, the ISE Team has utilized a suite of STEP Application Protocols (APs) to transfer product model data in various disciplines. These include:

- ISO 10303-203: AP for Configuration Controlled Design
- ISO 10303-209: AP for Composite and Metallic Structural Analysis and Related Design
- ISO 10303-212: AP for Electrotechnical Design and Installation
- ISO 10303-214: AP for Core Data for Automotive Mechanical Processes
- ISO 10303-215: AP for Ship Arrangement
- ISO 10303-216: AP for Ship Moulded Forms
- ISO 10303-218: AP for Ship Structure
- ISO 10303-227ed2: AP for Plant Spatial Configuration

While these application protocols cover a rich set of product model data, the focus of all of them is on exchanges in the areas of design, analysis, and manufacturing. The operational and maintenance data requirements for product life cycle support necessitate the use of an additional AP developed to meet these requirements, ISO 10303-239: AP for Product Life Cycle Support.

There are several different approaches used in implementing STEP, and as in previous projects, the ISE architecture is flexible and accommodates a variety of implementation techniques. Traditionally when STEP is used for product data exchange, the translators produce a neutral data representation known as a STEP physical file, or a Part 21 file. Some of the ISE-6 prototype translators produce files in this format. However, with the growing use of the Internet and the World Wide Web, a new STEP format has been developed, called Part 28, which utilizes XML structures to encapsulate the STEP data.

Processors were developed during the ISE-6 Project to convert the Part 21 files into XML-based Part 28 files to enable interactive exchanges of PLCS data using the Web. Mediator programs are also available to go in the other direction, converting XML-based Part 28 files into the more traditional Part 21 format. Thus some of the ISE-6 – PLCS translators produce files in Part 21 format while others create Part 28 files. Previously mentioned processors and mediators developed under the ISE Project have been made publicly available and they enable file conversion between Part 28 and Part 21 formats.

The intent of the ISE-6 Project has been to define an information model that encompasses the full range of logistics data and products, with linkage back to the associated engineering data and drawings. This equates to the term Assured Product and Support Information (APSI) in the ANSI Standard EIA-649-A. What is difficult for shipyards, Participating Managers (PARMs), and other entities providing life cycle support is managing the collection of logistics and engineering data in a coherent fashion. Not the least difficulty is that the logistics data and products typically reside in a large number of independent software systems. Nevertheless the ISE-6 Team addressed the definition of an information model and demonstrated prototype digital data exchanges with linkage back to associated engineering data.

The results of the project were highlighted in demonstrations made to a diverse audience of shipyard and Navy personnel. A demonstration held in April 2008 focused on the use of PLCS (ISO 10303-239) to transfer integrated design logistics data from one IDE to another. A final ISE-6 demonstration in April 2009 showed an integrated approach for implementing Ship Change Document (SCD) changes between ISEA and the Shipyard. It featured the automated identification of logistics documentation change impacts, and showed the standards-based exchange of integrated design, logistics, and technical publication data using AP239 and the S1000D Standard for XML-based technical documentation. These demonstrations and other activities of the ISE-6 Project which emphasized Technology Transfer are described in more detail in Section 10 of this report.

1.4 Use of Product Model Data in the Ship Life Cycle

The entire range of product model data for design, engineering, production, logistics, life cycle support, and technical publications is used during the following ship processes:

- ***Ship Operation***. The startup and shutdown of every major piece of equipment and combat system is specified by a government–furnished Operational Sequencing System (OSS). Training requires understanding of the associated Technical Publications.
- ***Damage Control.*** Diagrams are provided for all spaces showing every major piece of equipment and damage control information.
- ***Maintenance.*** Maintenance is performed shipboard or at a depot. The procedure is defined by a Maintenance Repair Card and may require the associated Technical Publication. Preventative maintenance is scheduled based on Planned Maintenance System (PMS) data distributed to all ships. Work candidates with an associated list are parts are created for each maintenance action. Several applications have also been developed to perform continuous condition assessment on key equipment.
- ***Repair.*** Repair is performed shipboard or at a depot, based upon the associated Technical Publication. Work candidates with an associated list of parts are created for each repair action.

The ship processes listed above are facilitated if product model data from several domains may be accessed. This is illustrated in **Figure 1** below.

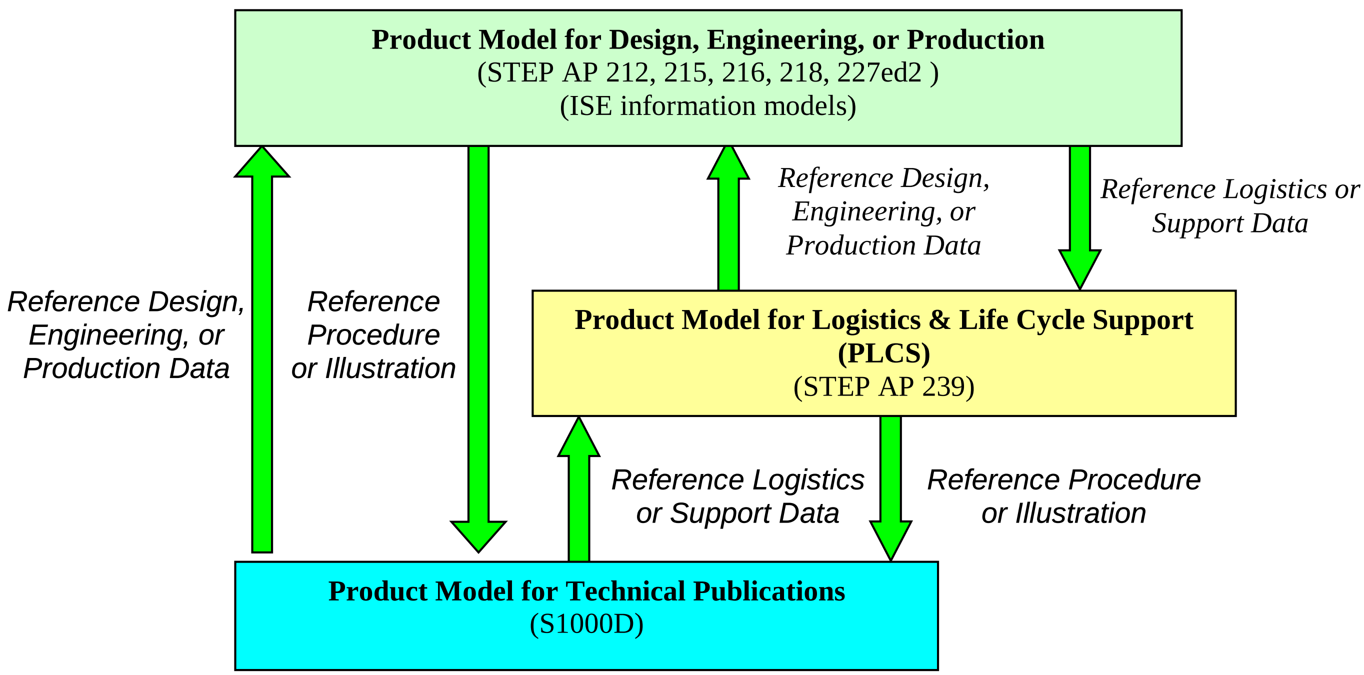

Figure 1 – Interoperability Model

The three data use cases of interest are:

- ***Reference Design, Engineering, or Production Data.*** User is viewing a Technical Publication and needs to reference product model data.

Examples include:
- Detailed part information
- Detailed engineering information
- Specific drawings or visualizations

- ***Reference Logistics or Support Data.*** User is viewing a Technical Publication and needs to reference product model data.

  Examples include:
  - Availability of parts
  - Specific drawings or visualizations
  - Repair history
  - Creation/update of a work candidate authorizing maintenance and parts order
  - View outstanding work candidates filed against this piece of equipment
  - View current tag-out status of system

- ***Reference Technical Publication Information.*** User is in an application which manages product model data and needs to reference Technical Publication information.

  Examples include:
  - Illustrated Parts Breakdown
  - Repair procedure
  - Troubleshooting procedures
  - Illustration

2 NOMENCLATURE

2.1 Acronyms and Abbreviations

AAM: Application Activity Model

AEL: Allowance Equipage list

AES: Atlantec Enterprise Solutions

ANSI: American National Standards Institute

AP: Application Protocol: Documents that specify the format for representing product data within a set of related processes or activities

APL: Allowance Parts List

APSI: Assured Product and Support Information

AP203: ISO 10303-203: AP for Configuration Controlled Design

AP209: ISO 10303-209: AP for Composite and Metallic Structural Analysis and Related Design

AP212: ISO 10303-212: AP for Electrotechnical Design and Installation

AP214: ISO 10303-214: AP for Core Data for Automotive Mechanical Processes

AP215: ISO 10303-215: AP for Ship Arrangement

AP216: ISO 10303-216: AP for Ship Moulded Forms

AP218: ISO 10303-218: AP for Ship Structure

AP227ed2: ISO 10303-227: AP for Plant Spatial Configuration

AP239: ISO 10303-239: AP for Product Life Cycle Support

ASE: Advanced Shipbuilding Enterprise program of the NSRP

ASSET: Advanced Ship and Submarine Evaluation Tool

CAD: Computer-Aided Design

CAM: Computer-Aided Manufacturing

CDMD-OA: Configuration Data Manager Database – Open Architecture

CFF: Class Functional File

CI: Configuration Item

CK: Charlie Kilo

CMRM: Configuration Management Reference Material

COSAL: Coordinated Shipboard Allowance List

CPC: Common Parts Catalog

CPP: Computer Program Packages

CWI: Configuration Worthy Item

DDG: Guided Missile Destroyer ship type

DEX: Data Exchange Set

DM: S1000D Data Module

DoD: Department of Defense

DONXML: Department of Navy XML Repository created to provide guidance for use of Extensible Markup Language in a standardized way

DTD: Document Type Definition

EB: Electric Boat Corporation

ECM: Enterprise Content Management

EFD: Equipment Functional Description

EIA-649-A: ANSI Standard for Configuration Management

ESWBS: Expanded Ship Work Breakdown Structure

EXPRESS: A formal data specification language that specifies the product information to be represented

FMP: Fleet Modernization Process

FSI: Functionally Significant Item

GFI: Government Furnished Information

HARVEST: NSRP Project to complete STEP Shipbuilding Structural Application Protocols

HM&E: Hull, Mechanical, and Electrical

HSC: Hierarchical Structure Code

HVAC: Heating, Ventilation, and Air-Conditioning

IDE: Integrated Data Environment

IETM: Interactive Electronic Technical Manual

ILS: Integrated Logistics Support

INGR: Intergraph Corporation

IPC: Illustrated Parts Catalog

IPDE: Integrated Product Data Environment

IPT: Industrial Planning Technology

IS: International Standard

ISE: Integrated Shipbuilding Environment Project

ISEA: In-Service Engineering Agent

ISEC: Integrated Shipbuilding Environment Consortium

ISO: International Organization for Standardization

ISPE: Integrated Steel Processing Environment Project

IT: Information Technology

KSS: Knowledge Systems Solutions, Inc.

LEAPS: Leading Edge Architecture for Prototyping Systems

LPD: Landing Platform Dock ship type

LSA: Logistics Support Analysis

LSD: Logistics Support Document

MAMS: Maintenance Assistance Modules

MRC: Major Repairable Component

NAVSEA: Naval Sea Systems Command

NGIS: Northrop Grumman Information Systems

NGSB: Northrop Grumman Shipbuilding

NLSC: Naval Sea Logistics Center

NSRP: National Shipbuilding Research Program

NSWC-CD: Naval Surface Warfare Center - Carderock Division

NSWC-PHD: Naval Surface Warfare Center – Port Hueneme Division

OMMS NG: Organizational Maintenance Management System – Next Generation

OSS: Operational Sequencing System

PARM: Participating Manager

PCI: Product Configuration Information

PDI: Product Definition Information

PDM: Product Data Management

PDS: Product Data Services Corporation

PLCS: Product Life Cycle Support

PMS: Planned Maintenance System

POI: Product Operational Information

RDL: Reference Data Library

RIC: Repairable Identification Code

RMA: Reliability Maintenance Analysis

SCLSIS: Ship Configuration and Logistics Support Information System

SCM: Software Controls Manual

SCO: SCORM Sharable Content Object

SCORM: Sharable Content Object Reference Manual

SSI: ShipConstructor Software, Inc.

STEP: STandard for the Exchange of Product Model Data

SWP: Software Programs

S1000D: International Specification for the Procurement and Production of Technical Publications

TIA: Technology Investment Agreement

TDMIS: Technical Data Management Information System

TOC: Total Ownership Cost

UIC: Unit Identification Code (used to identify a ship or shore activity)

URL: Uniform Resource Locator (a web address)

VFI: Vendor Furnished Information

WSF: Weapons System File

XML: Extensible Markup Language

2.2 Definitions

Charlie Kilo (CK)

A record of the ship reporting back as to what work has been done as part of a ship alteration.

Configuration Item (CI)

A collection of objects related to the specific functionality of a larger system. Examples of these objects may be requirements, code, documentation, models, and other files. Configuration Management systems oversee the life of the CIs through a combination of process and tools. The objective of these systems is to avoid the introduction of errors related to lack of testing or incompatibilities with other CIs.

A Configuration Item (CI) can be differentiated from a Configuration Worthy Item (CWI) in that:

- a CWI is terminology to translate what is in the design and requires support (initial determination of a CI)
- the CI typically means the actualization of the item onto the ship with its support

Configuration Worthy Item (CWI)

A Configuration Worthy Item (CWI) is defined as any item that requires maintenance or logistic support during its life cycle.

An item is considered configuration worthy if it meets one or more of the following criteria:

a. Any item that requires any one of the following elements of logistics: Planned Maintenance System (PMS), Software Programs (SWP), Software Controls Manual (SCM), Computer Program Packages (CPP), Maintenance Assistance Modules (MAMS), or intermediate/depot level maintenance plans or drawings.
b. Any hardware, software or firmware item required to describe a ship's functional hierarchy.
c. Any clearly identifiable functional assemblies such as pump/motor combinations.
d. Any electronic functional groups.
e. Any system or equipment requiring maintenance.
f. Any Computer Aided Design (CAD) item used in digital data exchange that is identified separately from the associated software. These CAD items are the components that are in the drawings or models which need to be supported logistically.

Coordinated Shipboard Allowance List (COSAL)

The allowance list of spare parts carried onboard the ship.

Data Exchange Set (DEX)

A subset of the overall PLCS information model that is suited for a particular business process. It also includes usage guidance.

Expanded Ship Work Breakdown Structure (ESWBS)

A five character work breakdown structure, defined by the Navy, which establishes system boundaries, system descriptions and functional nomenclature for an entire ship class. ESWBS has many functions, one of them being to serve as a framework for categorizing each and every item on a ship. The ESWBS is the basis for the development of Hierarchical Structure Codes (HSC), used by the shipyard to identify all configuration worthy items on the ship.

Functionally Significant Item (FSI)

A Functionally Significant Item (FSI) is defined as an item whose failure would have a significant impact on the availability of a required function or on life cycle costs. An FSI can be a system, subsystem, equipment, or component, or a summary level of two or more FSIs. For life cycle management purposes, an FSI is any item that requires any element of logistic support for which configuration information is needed to operate or maintain the ship that is needed to fully describe the functional hierarchy of the ship itself down to the lowest level subassembly.

A Functionally Significant Item (FSI) can be considered as an equivalent term to Configuration Worthy Item (CWI).

Part 21:

ISO 10303-21: STEP Implementation Method - Clear Text Encoding of Exchange Structure

Part 28:

ISO 10303-28: STEP Implementation Method - XML representation for EXPRESS-driven data

Postprocessor

A software unit that translates product information from an independent public domain product data format to the internal format of a particular computer system.

Preprocessor

A software unit that translates product information from the internal format of a particular computer system to an independent public domain product data format.

Product Configuration Information (PCI)

The term used in the current configuration standards. It is synonymous with the older term Configuration Status Record and the PLCS term Assured Product and Support Information (APSI). PCI is produced and managed by the process of Configuration Status Accounting. It lists all product and configuration information for each approved baseline. PCI includes both Product Definition Information (PDI) and Product Operational Information (POI).

Product Definition Information (PDI)

A synonym for product attributes, configuration documentation, design basis, design information, design output, engineering drawing, interface control document, interface document, requirements document, software requirements specification, software design document, software product specification, or specification.

Product Life Cycle Support (PLCS)

The methodology to handle the life cycle concerns of a component. The methodology handles hazard (environmental) issues, configuration management, logistics issues, ship specifications, maintenance engineering, and supply support.

A STEP Application Protocol (ISO 10303-239:2004) has been adopted as an International Standard to be used for PLCS product model exchanges.

Product Operational Information (POI)

A synonym for product operation and maintenance instructions and other derived information, operational information, technical manual, or technical order.

Ship Configuration and Logistics Support Information System (SCLSIS)

The Navy Standard for logistics systems.

STandard for the Exchange of Product Model Data (STEP)

It is the familiar name given for the international standard ISO 10303 Industrial Automation Systems and Integration - Product Model Representation and Exchange. The objective is to provide a mechanism that is capable of describing product model data throughout the life cycle of a product. The standard is a collection of parts, each published separately.

Use Case

A description of a set of sequence of actions performed by a system and initiated by an actor. It is used to capture the functional requirements of a system.

3 BACKGROUND

Shipyards are becoming increasingly responsible for the life cycle support of ships, including maintenance and logistics data over the life of the ship. Hence, it has become important for shipyards to efficiently integrate acquisition product model data with the lifecycle support product model data. The use of Integrated Data Environments (IDE) for Navy ship programs has fostered the integration of design, logistics, and production information for the ship. However, it has not been possible to exchange this information between different IDEs as an integrated data set; rather, different data sets are typically transferred at different times, often leading to inconsistencies. Further, the investment in IDE data has not yet been leveraged for life cycle support.

The majority of the total ownership cost of a Navy ship accrues after the ship has been delivered. Life cycle support, repair, maintenance and overhaul, ships' operations, testing and training are all information intensive processes. The Navy has steadily moved toward more modern systems and technologies to cope with the burgeoning information needs, but technology has evolved faster than the deployed solutions.

The business drivers for both the Navy and shipyards are to reduce the cost of ownership and exploit the investment in product data created during acquisition and maintained throughout the life cycle. Therefore, data management systems must:

- Ensure that ships have improved availability, reliability, maintainability, and lower cost of ownership.
- Be implemented as open platforms that reduce Information Technology (IT) costs and ensure longevity in use of information.
- Ensure digital product data is treated as a valuable business asset.

The Product Life Cycle Support (PLCS) STEP Standard (ISO 10303-239) for logistics data and life cycle support provides the capability to exchange logistics data linked back to design data. The standard was developed and has been implemented by the aerospace and defense industry. The ISE-6 project has demonstrated the feasibility of using the PLCS Standard for naval shipbuilding. The benefits of using PLCS include:

- PLCS provides an integrated data model with a scope that is a holistic view encompassing the entire product life cycle.
- Life cycle community benefits from use of PLCS to define and exchange life cycle support data.
- Life cycle community can also benefit from use of PLCS to access information defined during acquisition.
- Acquisition community can also benefit from the use of PLCS to exchange integrated design and logistics information.
- PLCS provides a neutral format and open architecture which eliminates point-to-point interfaces and fosters the exchange of data across the marine enterprise.
- PLCS enables interoperability of life cycle data with vendors and other defense programs.

The PLCS Standard enables data exchange across the marine enterprise as illustrated in **Figure 2**. This includes the exchange of consistent design and logistics data. It also enables the exchange of integrated data between IDE systems, legacy systems, maintenance centers, and the ship. This technology is applicable to a wide-range of scenarios, including: reuse of design and logistics information within the Navy, life cycle support, modernization & repair, co-design, and co-production.

This integrated exchange of design and logistics data supports:

- Distance Support
- Regional Waterfront Integration
- 'One Shipyard' concept
- Efficient logistics product development
- Life Cycle Maintenance
- Operations

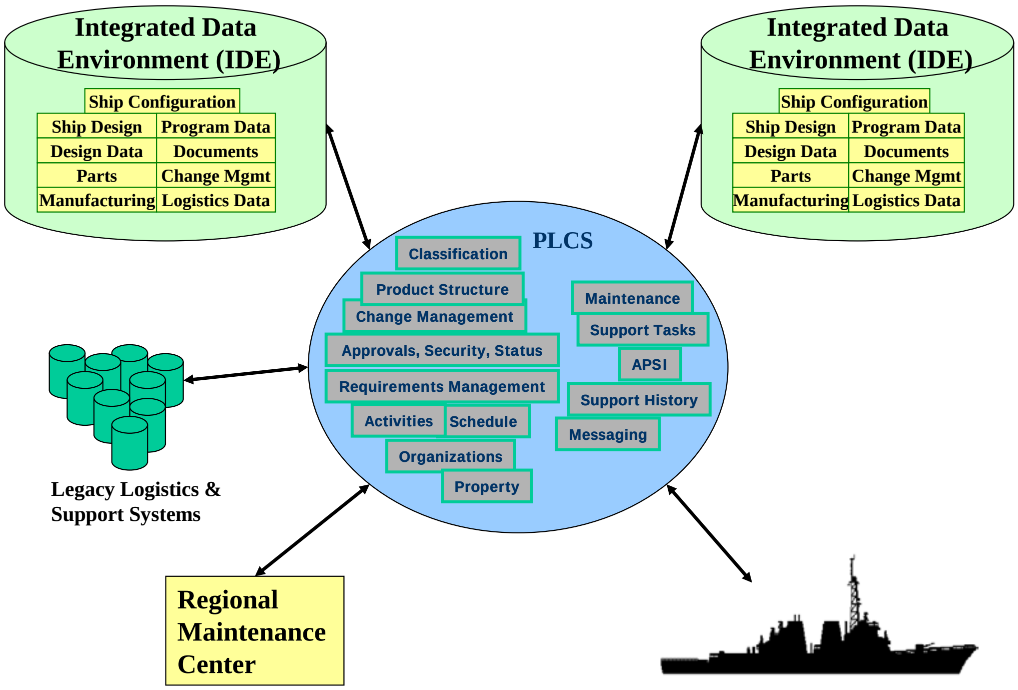

Figure 2 – Potential PLCS data exchange across the ship life cycle

It should be noted that although the blue circle in **Figure 2** represents the entire scope for PLCS, the ISE-6 Project only implemented a portion of this standard. The ISE-6 Project developed and implemented a Business DEX for AP239 to represent the Navy logistics data requirements as captured in the Ship Configuration and Logistics Support Information System (SCLSIS). This implementation focused on the AP239 modules for classification, product structure, and change management as diagramed in **Figure 3** below.

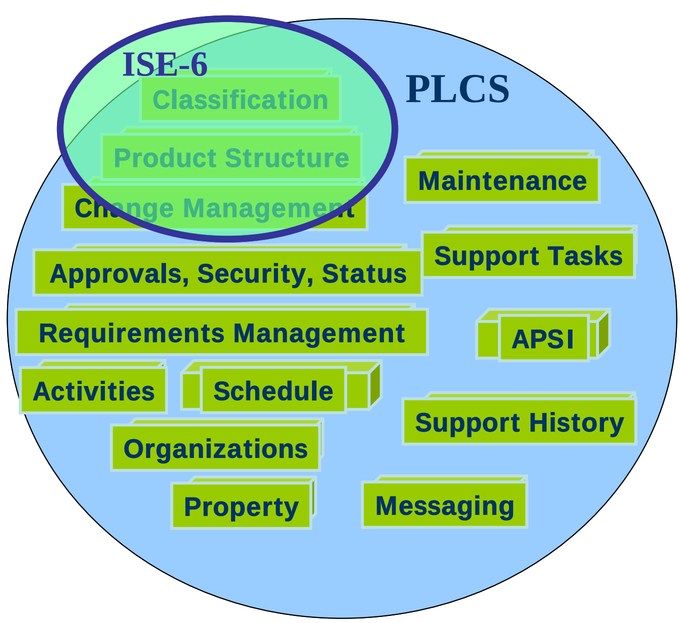

Figure 3 – Scope of PLCS Implementation for ISE-6

The SCLSIS System is described in more detail in Section 4.2 while the creation of the ISE-6 Context Schemas and Business DEX are described in Section 7.

In recent years shipyards have established sophisticated Integrated Data Environments (IDE) to enable them to capture product model data describing the ship and use that data for various applications such as: design, analysis, visualization, and construction. Unfortunately, the wide choices available for CAD systems, PDM systems, CAM systems, and numerous software applications have led to a situation where each shipyard has established a unique environment; in fact, one shipyard may have several different IDEs to support different ship classes. This has led to a wide variety of IDE environments in the U.S. shipbuilding industry, with little interoperability among them.

Specialized tools have been developed to exchange portions or subsets of a product model to feed various analysis packages or to permit visualization of the model on a different system. However, techniques to effectively and accurately transfer the entire product model to a different IDE environment have not been generally available. Under the auspices of the International Organization for Standardization (ISO), the STEP Standard (ISO 10303) was developed to meet this need. STEP (STandard for the Exchange of Product model data) consists of a series of parts, each designed to support a particular application area.

4 OVERVIEWS

4.1 PLCS

AP239, Product Life Cycle Support (PLCS), known officially as ISO10303-239, is an international STEP Standard for the definition and exchange of product data needed for the long-term support of very complex products, such as ships. The development of this standard was led by a joint industry and government initiative dedicated to the goal of accelerating new standards for product support information. Work on the standard commenced in November 1999 and it was approved as an international standard in 2005.

The AP239 Product Life Cycle Support Standard is intended for use with complex products having numerous parts and configurations, a long service life, and demanding in-service support requirements. Not surprisingly, for such products and support scenarios, in-service costs comprise a significant proportion of the total cost of ownership. Clearly, the scenario applies to ships, and even more emphatically to U.S. Navy warships.

The scope of the information domain for PLCS is quite broad encompassing static characteristics, such as states of the environment, of people, and of the product, as well as dynamic characteristics, such as activities performed by the product (operational behavior, diagnostic data) and activities performed by people (e.g., test, repair, move). The AP239 information model has been assembled from a number of STEP modules, each focused on a specific functionality.

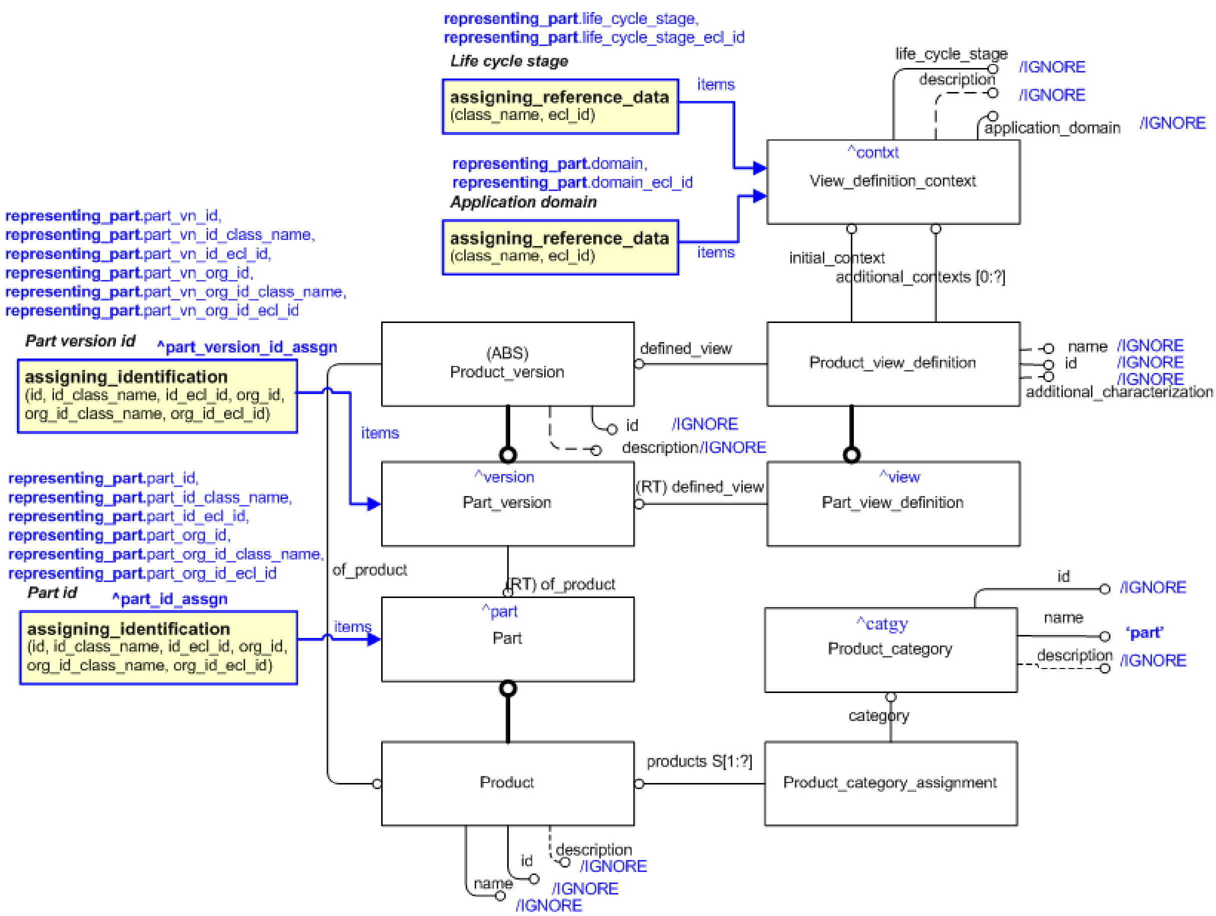

Figure 4 – PLCS Template for Part

The AP239 information model is notable for its use of generic product structure, similar to the STEP Integrated Resource information models. In comparison, most STEP application protocols, including the shipbuilding application protocols, contain domain specific entities. The AP239 relationships are structured to point to the affected entity, allowing additional attributes and properties to be added as required. Further, only a minimal set of attributes is explicitly defined. Additional attributes may optionally be specified through the use of a set of entities and relationships.

AP239 also utilizes the concept of a Reference Data Library (RDL), which is standardized, computer-interpretable data that can be used to extend or tailor an information model: specializations that can be applied for a particular industry or usage scenario. Reference data is used within AP239 primarily to define classifications of items, such as classes of documents, tasks, or for enumerated code lists, such as fault codes. Reference data is intended to allow adoption of the standard within a specific domain, such as shipbuilding.

The PLCS working group has developed a methodology to apply AP239 to specific business cases. Parameterized *templates* are used to define patterns of AP239 entities and relationships. An example template is shown above in **Figure 4**. Specific *capabilities* are defined for each major entity type to describe the templates used to instantiate the entities and relationships, as well as describe the required and optional data usage. A *Data Exchange Set (DEX)* is a subset of the overall AP239 schema. Each DEX supports a specific business process or purpose. It is defined by a set of capabilities. There are currently eight generic DEXs, which apply to all industries and business cases, e.g. product_as_individual or product_breakdown_for_support. A *business DEX* defines a specific business process, e.g. Navy configuration management.

4.2 SCLSIS and CDMD-OA

The Ship Configuration and Logistics Support Information System (SCLSIS) was developed in the 1960's to track shipboard and shore-based equipment configuration. However, due to high infrastructure costs and poor process throughput, SCLSIS was migrated to the Configuration Data Manager's Database – Open Architecture (CDMD-OA) environment that is managed by Naval Sea Logistics Center (NLSC) Pacific. The ship configuration data of every class of ships is maintained in CDMD-OA. Typically, local CDMD-OA servers are located on-site at shipyards and planning yards. This data is replicated at periodic intervals to a Navy-wide central repository. The CDMD-OA server also coordinates communication between shipboard configuration systems such as Organization Maintenance Management System – Next Generation (OMMS-NG), shore-based systems such as the Weapons System File (WSF), and remote users such as in-service engineering agents (ISEA).

CDMD-OA tables, shown below in **Figure 5** store either reference data or a specific type of SCLCIS record as defined in the SCLSIS Technical Specification Rev C. Key fields are denoted with a "+". Only the key fields are mandatory, i.e. records can be created with all other fields null. Note that all data is hull-specific, i.e. relates to a specific UIC. Type 1 records denote a ship. Type 2 records denote a configuration item on the ship. Type 3 records define documentation about the item. Type 4 records define an alteration to items.

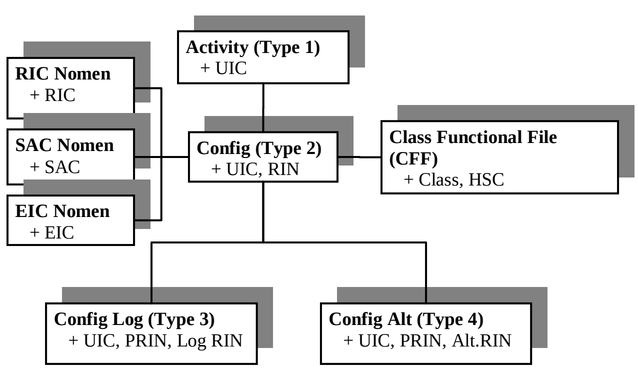

Figure 5 – CDMD-OA SCLSIS Tables

4.3 S1000D Specification

The S1000D Specification is an international standard that was developed to establish standards for authored content used in creating documentation for vehicles or equipment of any type. It offers benefits to both producers and consumers of such content. For producers, these benefits include greater data re-use stemming from its modular nature, better streamlining of publishing since material is authored in one format and then published in multiple ways, and the cost benefits associated with following a common standard that will ideally provide better low-cost off-the-shelf tools for authoring, managing and processing of such data. With regards to consumers, the benefits stem mainly from having an international standard embraced by data suppliers, resulting in such data becoming more interoperable with improvements in data communications and data mining. In addition, the cost benefits associated with using standardized software such as off-the-shelf viewers and the improved quality and maintenance of documentation is also envisioned.

S1000D originated in Europe in the 1980s. U.S. interest has increased in recent years as the specification evolved to include requirements addressing military needs. U.S. military projects, such as the Air Force's Global Hawk and F117A programs have elected to utilize the specification. Various Navy programs are also expecting to make use of S1000D, such as the CVN21 for its reactor plant documentation. The S1000D Specification today is managed by a consortium consisting of representatives from government and industries from the United States and eight European countries.

4.3.1 Why the progression to S1000D?

- S1000D is winning converts. Previous attempts to establish a standard have failed, resulting in a hodge-podge of information models for documentation. Some military standards, such as MIL-PRF-87269, have been developed, but have been customized for specific projects or interpreted differently – compromising their effectiveness as standards. S1000D on the other hand is now becoming a true standard amongst document producers with wide interest in the U.S. and Europe.

- The growing need for a single unifying information model for the document development process to allow content producers to benefit from commonality amongst the document producing communities is apparent. Currently most document producing organizations use a homegrown approach to creating documents. This approach typically consists of some customized information model(s) and collection of custom tools for authoring and producing documents that is highly proprietary. As one would expect this homegrown approach results in the dependency on costly and perhaps cumbersome tools which are developed in-house or customized extensively. Such tools are typically inflexible, unlikely to be interoperable, and costly to maintain and replace. The producer's document development processing environment (content authoring, content management through delivery) often stagnates, making adaptation for new work or tools difficult.

- The perceived benefits from content re-use that can be achieved with S1000D warrant consideration of the standard for many documentation producers. S1000D by design allows content authors to construct reusable chunks of content. The granularity of the chunks is flexible and in the hands of the author and his organization. This flexibility allows documents to be constructed and managed as virtual documents, where modules of the document are linked together to produce the final document. The modules can be used and re-used in numerous documents simply through the module linking mechanisms built into S1000D. This allows document producers a better way to create and manage specific documents constructed from shared content. The modules themselves can also be configuration managed in a more straightforward manner as independent entities. S1000D also allows for the insertion of "where used" applicability information associated with the module itself, so that the module can identify the products with which it is associated. For instance, an authored module can include information about what variant or version of equipment it is specifically for. Modules can be re-used by other document producers as well. For instance, a part's supplier module can be re-used within the documentation of the part's buyer documentation, greatly simplifying the construction of documents using content from different organizations.

4.3.2 Data Modules

S1000D is organized around the concept of Data Modules. Each data module type has its own DTD (Document Type Definition) to describe how content in the module is structured. The available modules are:

- ***Descriptive Data Module*** – This module is used to contain the descriptive text (e.g. introductory material, purpose, planning, etc.) found in the front section of most technical publications. In addition to traditional document content (i.e. paragraphs of text, titles, tables, etc.), this module can also capture applicability information associated with the module.

- ***Procedural Data Module*** – This module is used to contain the content associated with the steps of maintenance or operations procedure; content areas include preliminary requirements, maintenance function, and close-up procedures. The preliminary requirements section is used to capture any conditions and resource requirements that must be in place before the procedure can be executed. The maintenance section is to be used to contain the actual procedure's steps that a user must follow to complete the maintenance activity. The close-up procedure section contains the steps that a user must follow to return the item to an operational state.

- ***Illustrated Parts Data Module*** – This module is used to contain information that may have previously been contained within an Illustrated Parts Catalog (IPC) or a Complete Equipment Schedules (CES) document. Table and graphic information can be attached as well.

- ***Fault Isolation and Reporting Data Module*** – This module is used to contain Fault Diagnostic information. The isolation section describes the known faults and the associated isolation procedures. Fault localization is handled through a series of questions. Graphics can be attached to aid in the fault location process.

- ***Maintenance Planning Data Module*** – This module is used to contain planning information. This information consists of timeline data, data associated with the task to be performed for maintenance, and data about routine checks (scheduled checks, unscheduled checks, etc).

- ***Aircrew Operator Data Module*** – This module is specifically for use for flight information data.

4.3.3 Storage Model

Today's businesses increasingly compete on their ability to collectively create, process, share and distribute content. Most businesses that generate documents must rely on an integrated Enterprise Content Management (ECM) system to store and manage their documents and their associated content. ECM helps an organization manage all of the unstructured information - or content - in its enterprise. This information exists in many digital forms: text documents, engineering drawings, XML, still images, audio and video files, and many other file types and formats. ECMs help organizations create content with common desktop applications that are seamlessly integrated with the ECM. ECMs can also aid in capturing and incorporating existing content from a variety of sources.

ECMs that are particularly effective for S1000D-based documents provide operator aids specifically for the management of S1000D modules and the construction of S1000D-based document deliverables. These deliverables can be paper documents, standalone electronic documents (i.e. PDF files), or content delivered by electronic presentation systems (e.g. web servers, database driven Interactive Electronic Technical Manuals (IETMs), etc.). Seamless integration of the ECM with desktop authoring tools such as XML editors that understand S1000D content, are also integral to efficient authoring of content and creation of S1000D-based documents.

S1000D specific processing aids that may be provided by the ECM include:

- The tracking of references to other modules by a module;

- The validation of module references, assuring that the modules referenced exist and are contained within the ECM;
- Searching and locating modules based on metadata or on module identifiers allowing for re-use of module content by the same or different authors;
- The automated extraction of module information as modules are added to the ECM;
- The identification of dependencies of a module on other modules to facilitate change management.

Authoring documents under S1000D using an ECM and a desktop XML editor mainly consists of authoring individual S1000D modules and then using S1000D's module referencing to essentially stitch together the authored content into a single document. Under this model, the lowest level of reusable content is the module. Modules are authored and validated as individual chunks of content and may be re-used repeatedly in one document or in many documents. An ECM can be used to manage modules as individual objects, with versioning and access control of the objects maintained by the ECM. ECMs may also be used in conjunction with a workflow engine to route the authored content and associated documents for approvals. Finally the ECM is often used to perform the necessary extractions of modules, bringing together the set of modules needed to produce the deliverable document.

4.3.4 Presentation Model

S1000D can also be viewed as a presentation content standard, not just as a standard for content authoring. The international recognition of S1000D will enable a new market for technical data viewers. Previously tools developed for presentation of content had to be extensively customized to handle in-house information models, and were limited by the degree of customization often needed and the lack of integration. Now with the use of S1000D modules these vendors can instead develop tools that focus on being interoperable at the module level, requiring little customization for the customer. The document development community can now capitalize on the commonality of S1000D to save these customization costs, improve content sharing and re-use, and reduce time for document presentation development through better and more integrated tools. Different presentation engines, for instance to handle different presentation formats, can now readily be applied to S1000D Standard captured content without the need for customization of content.

5 LIFE CYCLE SUPPORT OF BUSINESS PROCESSES

The overall Business Process for Life Cycle Support during Ship Acquisition is shown below in **Figure 6**. The diagram notionally illustrates the overall process, major participants, and major data flows. This diagram represents the viewpoint of an ILS organization and does not show all the relationships between the entities. (For example, supplier VFI is not shown as input to detailed design.) However, the relationship between design data and ILS is explicitly detailed. Use Cases are explicitly identified where appropriate, otherwise major ILS activities are further decomposed into specific Use Cases in **Figures 8-11** as indicated.

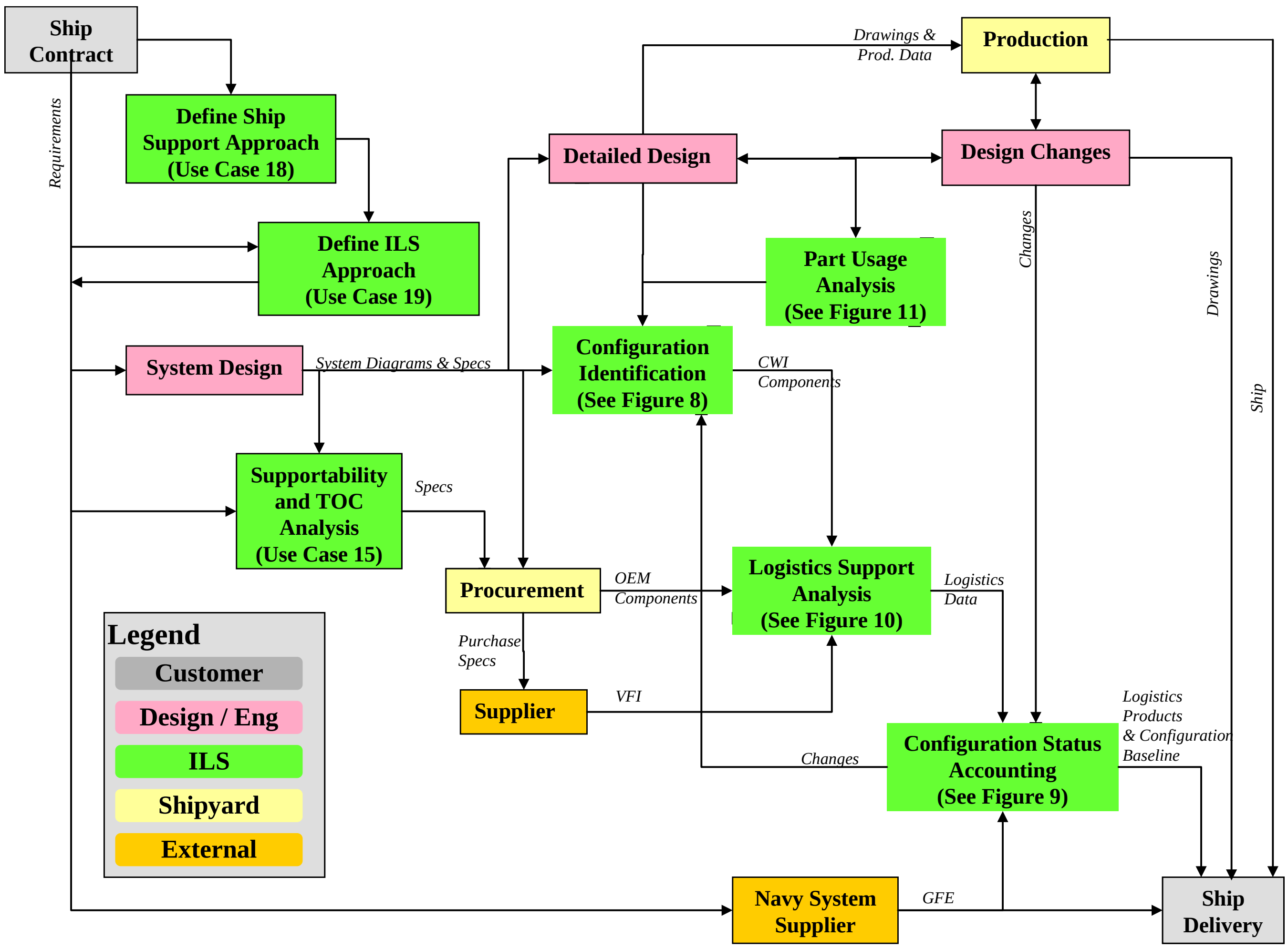

Figure 6 – Overall Life Cycle Support Business Process for Ship Acquisition

This overall process can be summarized as follows:

- The contract is awarded, which provides the base requirements for the ship design and logistics data and products.
- The Navy refines their expectations and requirements for the life cycle support of the ship.
- The shipyard and Navy ILS organizations define the specific approach and tools that will be used for this ship contract within the bounds of the contract and the customer life cycle support approach.
- The ship design starts with a system design that defines the system components and their functional properties. This information is specified in system diagrams and functional specifications for components.
- The supportability and Total Ownership Cost (TOC) of the components are analyzed and additional specifications are generated.
- Procurement utilizes the functional and support specifications to select a supplier.

- Vendor Furnished Information (VFI) is provided by the supplier to define the specific engineering, maintenance, and support properties of the component.
- Detailed design develops the full ship design, drawings, and production data. Changes to the design result from analysis results, design changes, production problems, or design problems.
- Configuration worthy items are identified, based initially upon the system design and later upon the detailed design and design changes. The details are shown in **Figure 8**.
- Once a component has been identified as a Configuration Worthy Item (CWI) and a specific supplier selected, a Logistics Support Analysis (LSA) is performed to develop the associated logistics data and products. The details are shown in **Figure 10**.
- The configuration of logistics data and products is maintained by Configuration Status Accounting (CSA) processes. Newly developed data is added to the baseline. Design changes are assessed and incorporated. The details are shown in **Figure 9**.
- Government Furnished Information (GFI) is provided by the supplier of Navy systems, either to the contractor or directly to the Navy. These suppliers are typically PARMs, under contract to the program office.
- The contractor delivers the drawings, configuration baseline, and set of logistic products to the Navy.

Note that each Navy system supplier follows the same process as the prime contractor, usually with the exception of the last step (unless they are integrating other Navy systems or components).

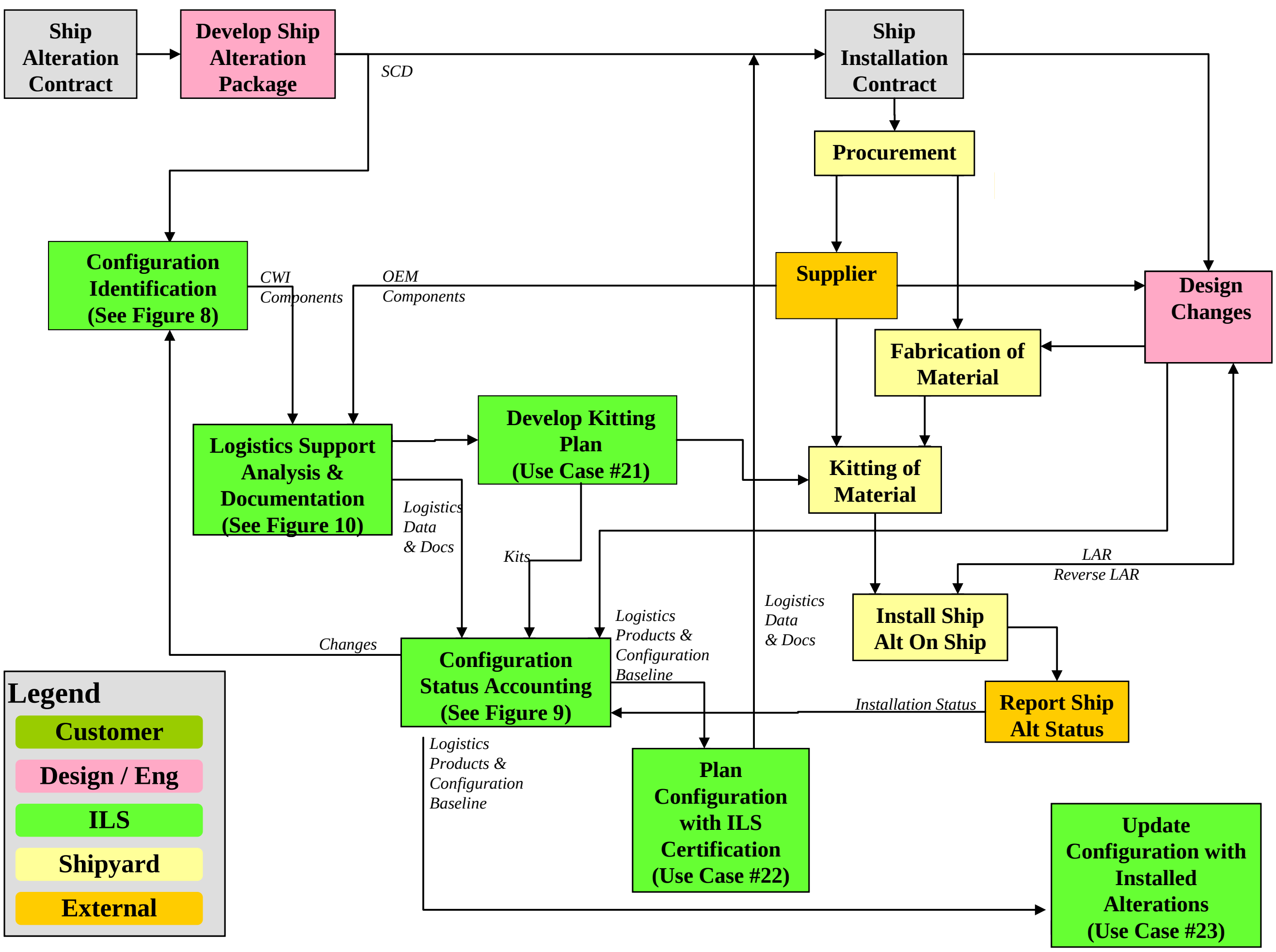

Figure 7 – Overall Life Cycle Support Business Process for Ship Alteration

The overall Business Process for Life Cycle Support during Ship Alteration is shown above in **Figure 7**. As in the case of **Figure 6**, the diagram notionally illustrates the overall process, major participants, and major data flows. This diagram represents the viewpoint of an ILS organization and does not show all the relationships between the entities. Use Cases are explicitly identified where appropriate, otherwise major ILS activities are further decomposed into specific Use Cases in **Figures 8-11** as indicated.

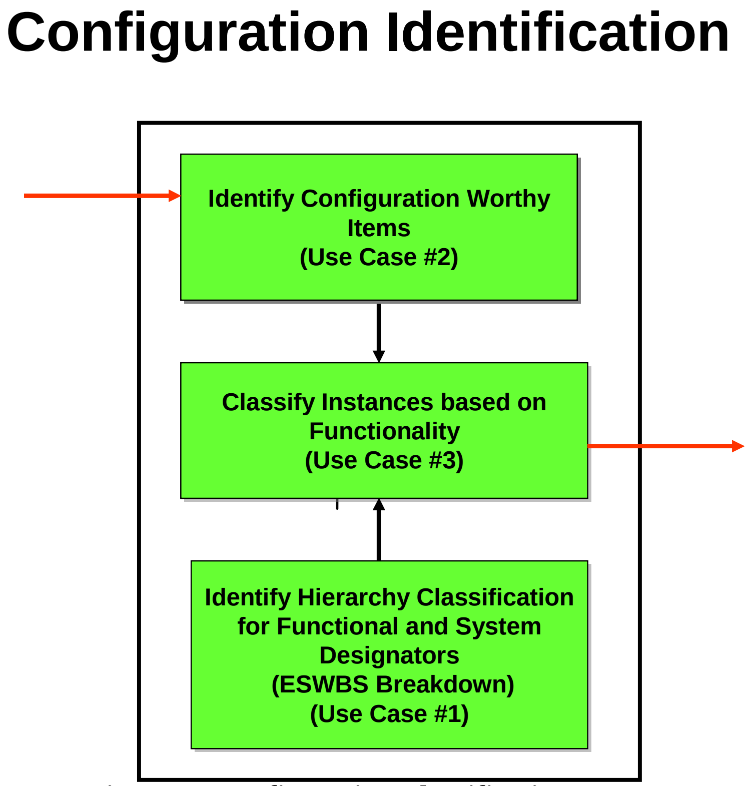

Figure 8 –Configuration Identification Use Cases

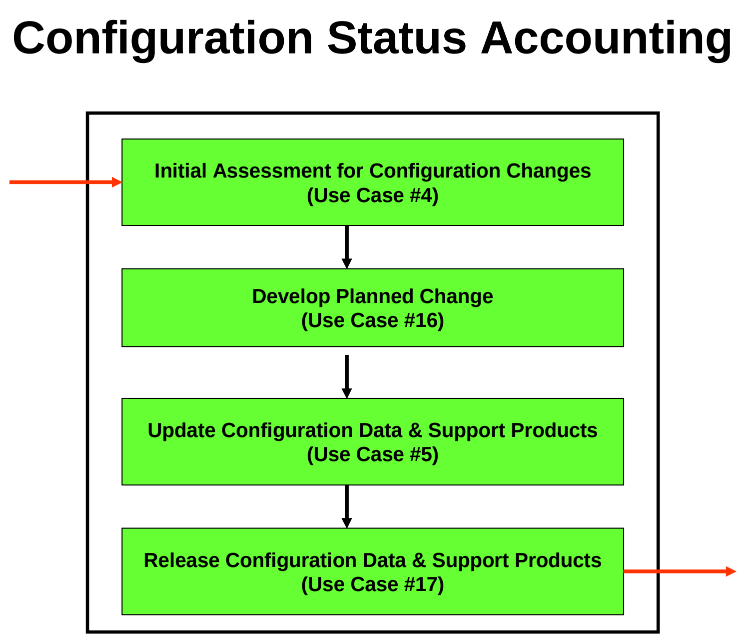

Figure 9 –Configuration Status Accounting Use Cases

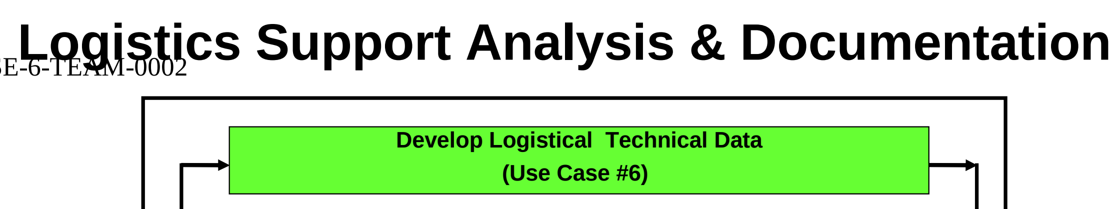

Figure 10 –Logistics Support Analysis & Documentation Use Cases

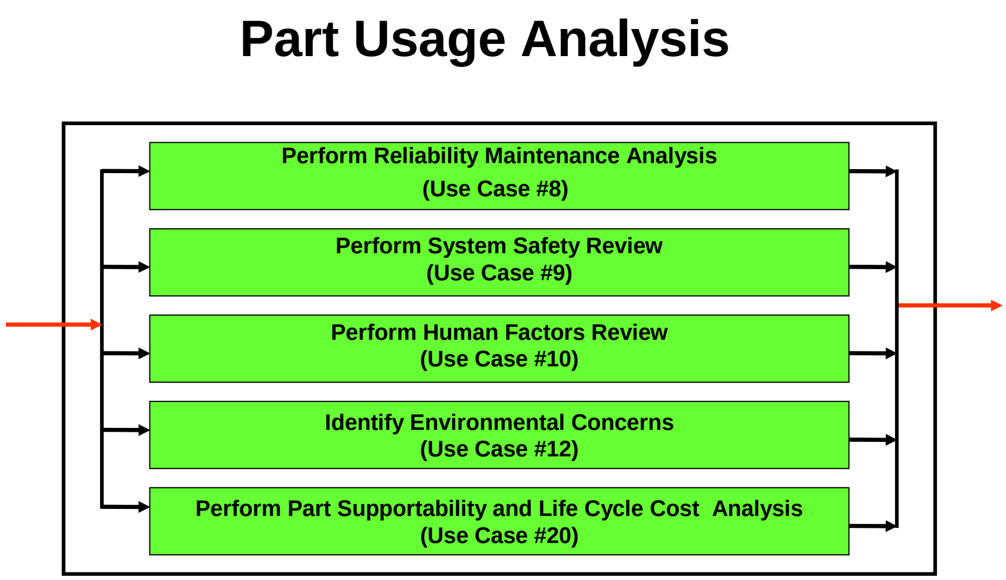

Figure 11 – Part Usage Analysis Use Cases

5.1 Business Process for Supporting Technical Documentation

Both the acquisition and life cycle support phases of a ship program require authoring/updating of technical documentation:

- **Acquisition** – The ship is under construction. The Construction Yard designs the hull, mechanical, and electrical (HM&E) ship systems. The associated ILS department authors/updates the technical documentation for the ship and HM&E systems. The Navy Participating Manager (PARM) furnishes design information and technical documentation for government furnished systems, including combat systems.
- **Ship Alteration (Modernization)** – Plans are developed to modernize a portion of the ship. The Planning Yard (and associated ILS department) designs the alteration (HM&E) and authors/updates technical documentation for the ship and systems under contract. Navy In-Service Engineering Agent (ISEA) furnishes design information and technical documentation for government furnished systems,

including combat systems. In some cases, the ship alteration may result from a change to the government furnished system.

Both acquisition and life cycle maintenance follow the same business process for authoring/updating of technical documentation. The change may be initiated by either the Navy or the shipbuilder, as illustrated in **Figure 16** below.

The S1000D Use Cases (24-26) were demonstrated in the ISE-6 Project by simulating a scenario in which Technical Publications and Training Modules must be modified based on a design change initiated at the shipbuilder. The S1000D Data Modules were modified based on changes to the shipbuilders HM&E system which are reflected in the data modules used to support the documentation of the Radar system throughout the life cycle.

Figure 12 illustrates the Data Exchange Business Process that was shown by the ISE-6 Project in its final demonstration held in April 2009. The scenario was initiated by a new radar modification which required additional HVAC or a Ship Alt that changed Radar HVAC requirements.

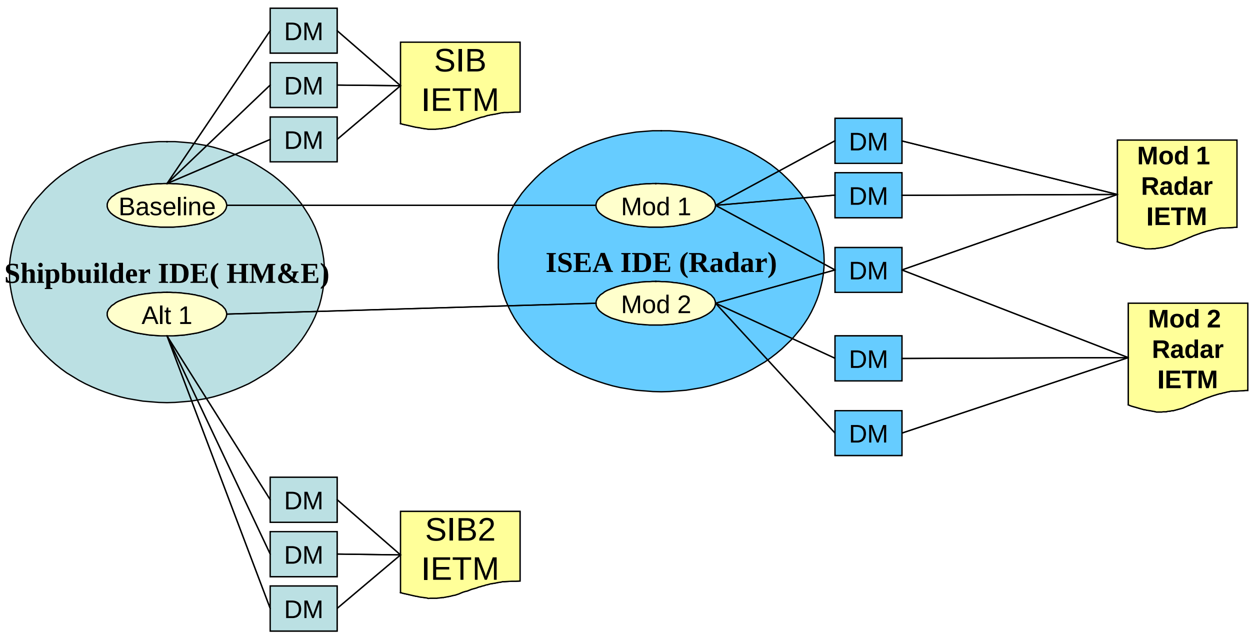

Figure 12 – Data Exchange Business Process including Technical Publications

The Shipbuilder business process includes the following actions:

- Engineering updates the baseline design in the Shipbuilder IDE to create the Alt 1 design
- Data Modules (DM) affected by design updates are identified and updated
- Alt 1 version of Tech Manual and Training is published

The ISEA (In-Service Engineering Agent) business process includes the following actions:

- Engineering updates the design in the ISEA IDE for the new mod (Mod 2)
- Data Modules affected by design updates are identified and updated
- Mod 2 version of Tech Manual and Training is published

5.2 Life Cycle Support Business Process for IPDE Data Exchange

The Use Cases described above have focused on the business processes of life cycle support during ship acquisition as well as for ship alterations.

Although these two scenarios provide the basis for the ISE-6 context schemas and have led to the Use Cases defined in this project, it was felt that these were not ideal scenarios for the first project demonstration held in April 2008. That demonstration focused on life cycle support business processes that represent exchange between multiple Integrated Product Data Environments (IPDEs). This scenario is illustrated in **Figure 13** and was executed in the first ISE-6 demo.

The Use Cases described in **Figure 13** are a subset of those from the previous two scenarios, so the demonstration did not require any new schema development.

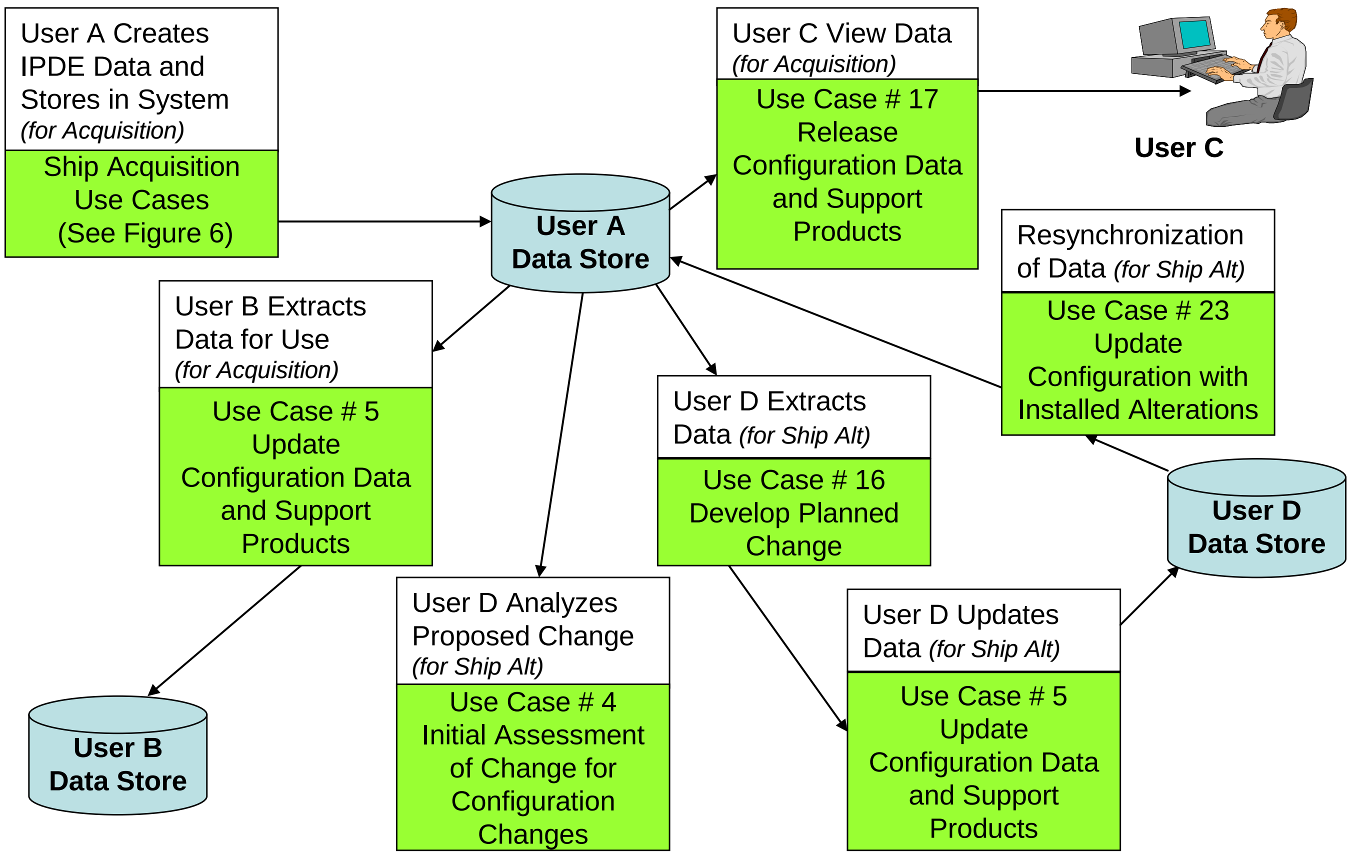

Figure 13 – Overall Life Cycle Support Business Process for IPDE Data Exchange

5.3 *Technical Documentation Support Business Processes*

The overall Business Process for Technical Documentation Support during Ship Acquisition is shown below in **Figure 14**. The diagram repeats the illustrations of the overall process, major participants, and major data flows as previously shown in **Figure 6**, but has an additional activity for the Development of Technical Data which includes the development and update of technical manuals and training materials. The technical manuals should be created in accordance with the S1000D Specification, while the training materials should be developed as specified in the Sharable Content Object Reference Model (SCORM) Specification.

Technical documentation and training are currently treated as two distinct types of acquisitions; a contract for one does not reference the other except possibly as source material. It has been demonstrated that training data can be captured in an S1000D Data Module (DM) and that technical and training DMs can be rendered as a SCORM conformant learning object without affecting learning efficacy—provided the workflow allows for content analysis and application of sound instructional design principles.

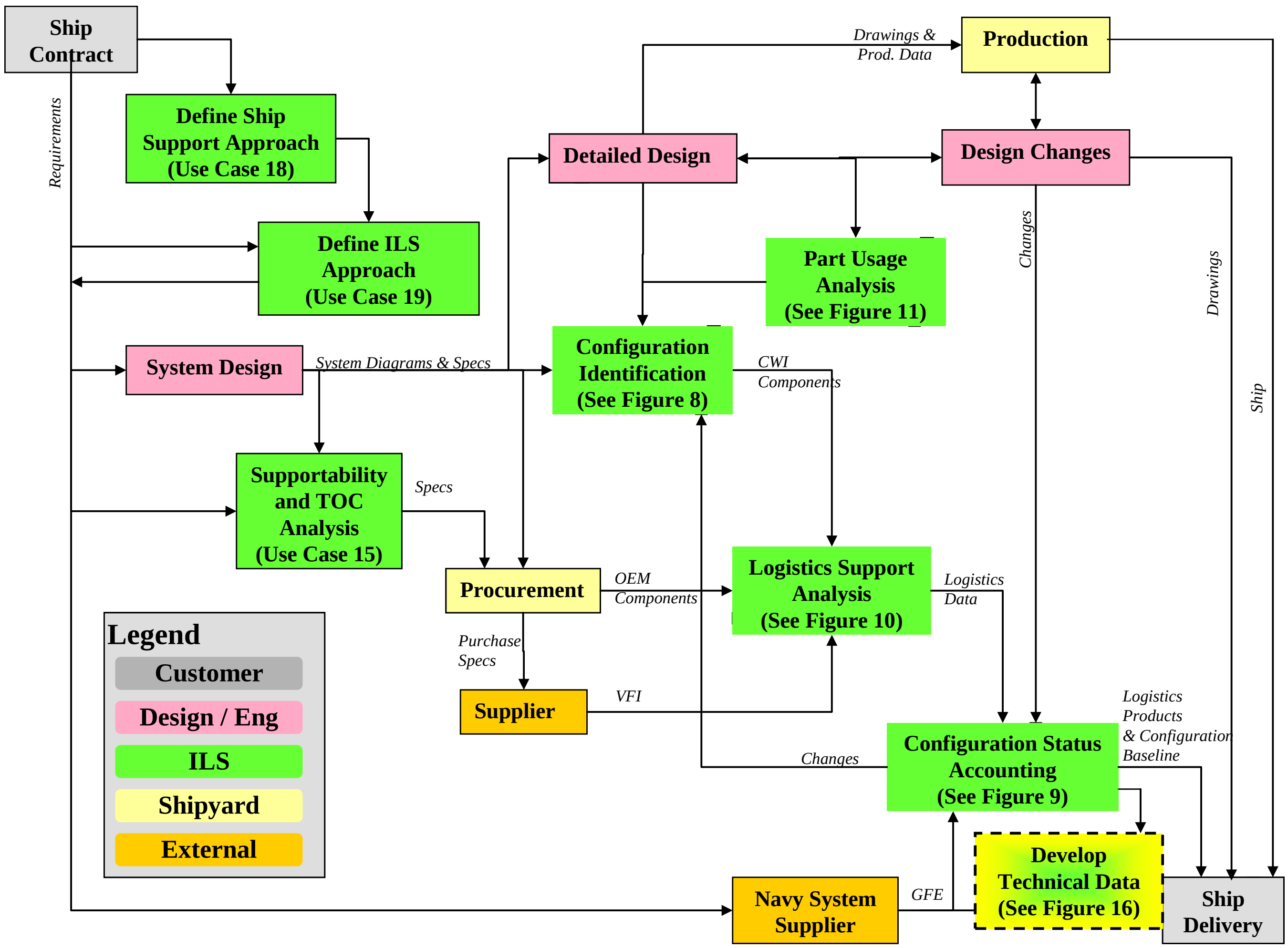

Figure 14 – Business Process for Ship Acquisition including Development of Technical Data

While the S1000D Standard has been adopted for technical documentation, including technical manuals, the training community has adopted an analogous standard for e-learning, SCORM. Both standards are modular, allowing the reuse of content. An S1000D Data Module (DM) packages content within an XML file. A SCORM Sharable Content Object (SCO) packages learning content. SCORM is a reference model used to aggregate and sequence SCOs, but does not address how learning content is arranged within an SCO.

In the realm of military training, SCORM and S1000D are closely related standards. SCORM is a model that references other standards. It is not concerned with file content, file format, or file reuse. S1000D is an XML markup specification. It structures source data, is concerned about specific content, and has file naming conventions. Thus one can use S1000D to name, identify, and structure technical training content in a manner consistent with the SCORM Specification.

These standards provide the framework for a powerful single-source, multi-channel publishing solution. S1000D provides a framework for a common source database that enables content reuse across different publication types and modalities. SCORM provides the delivery channel, enabling one to provide a means to consistently deliver and track content that is served, whether it is a technical document or a Web course.

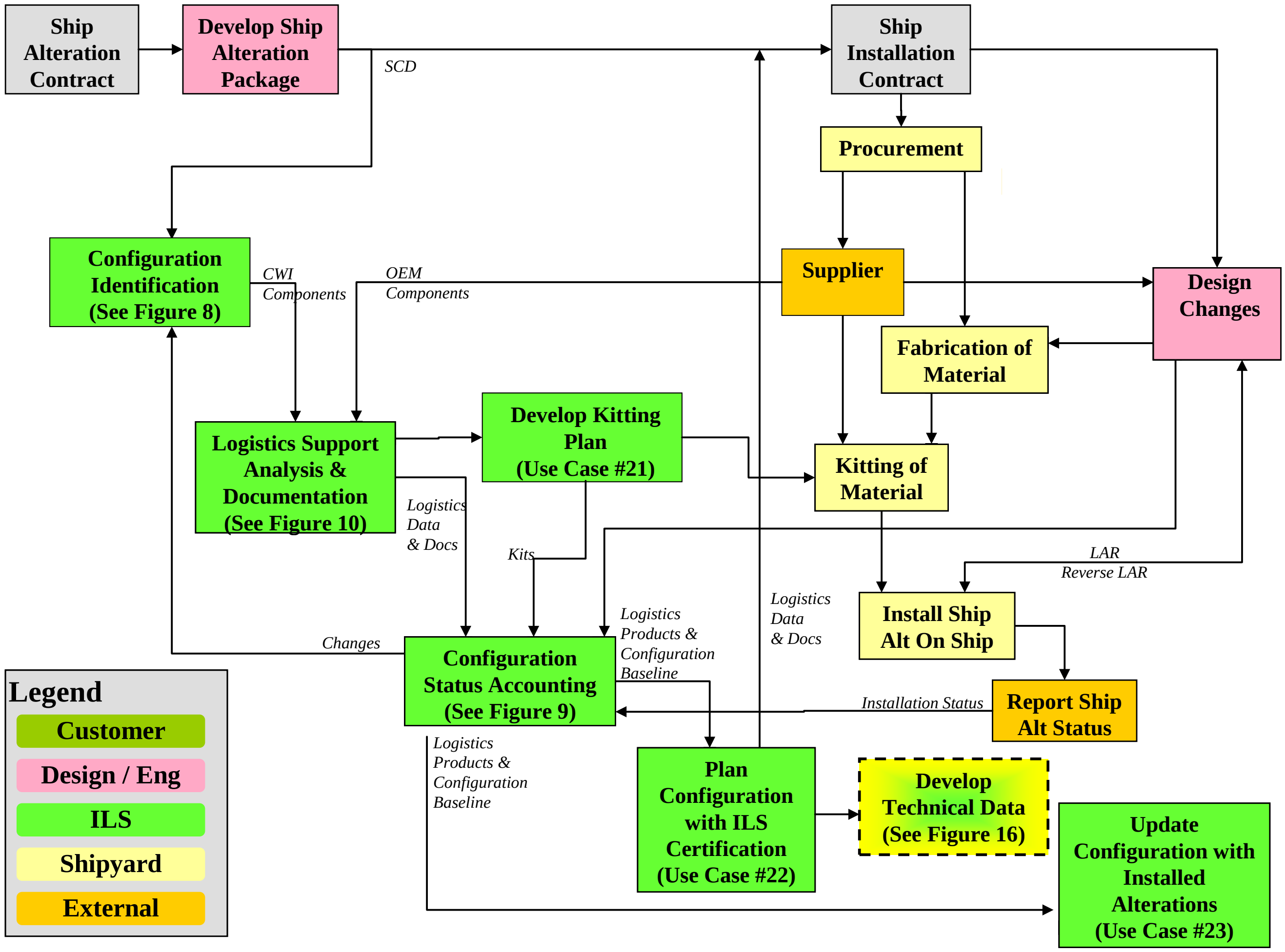

Figure 15 – Business Process for Ship Alteration including Development of Technical Data

Hence "dual-use" S1000D Data Modules can be used to package both technical documentation and learning content. In this case, the technical documentation (training) consists of some dual-use modules as well as data modules which are specific to technical documentation or training. Dual-use data modules must be authored specifically for this purpose. (See for example: Katz, MacDonald, Worsham, and Haslam, *"S1000D/SCORM Redundancy Analysis and Conversion Guidelines Final Report"*, NSWC-PHD, Aug. 2006).

In a similar manner, the overall Business Process for Technical Documentation Support during Ship Alteration is shown above in **Figure 15**. The diagram repeats the illustrations of the overall process, major participants, and major data flows as previously shown in **Figure 7**, but has an additional activity for the Development of Technical Data which includes the development and/or update of technical manuals and training materials.

6 USE CASES

During the first phase of the project, the ISE-6 team developed twenty three Use Cases to describe the life cycle support business processes during ship acquisition as well as for ship alterations. These were compared to the STEP AP239 Application Activity Model (AAM). There was only a partial correlation because the AAM focuses on providing support throughout the life cycle, while the ISE-6 Use Cases focus on managing the support information during ship acquisition or ship alterations.

In particular, the AP239 Application Activity Model (AAM) is a general model for logistics support which may include the development of logistics support systems and procedures. Many activities relate to planning and development of requirements for support. In contrast, the ISE-6 Use Cases assume that the Navy infrastructure will be used for logistics support. Hence, logistics support systems have been implemented and most logistics support procedures are defined. Further, the overall support requirements are established by the Navy and a contractor typically negotiates specific support requirements with the Navy for given ship class contract.

In the second phase of the ISE-6 Project, additional Use Cases were developed to support the generation and modification of technical documentation. Three additional Use Cases were developed to represent the generation, modification, and distribution of S1000D modules for technical documentation.

6.1 Summary of PLCS Use Cases

The set of Use Cases for Life Cycle Support during Ship Acquisition and Ship Alterations, illustrated in **Figures 6-11** above, are summarized below. These two sets of Use Cases were the basis of the context schemas and exchanges developed during the ISE-6 Project.

In the table below, Use Cases that apply only to Ship Acquisition are indicated by Type = "Acquisition", while those Use Cases that apply only to Ship Alterations are indicated by Type = "Ship Alt". Use Cases that are applicable to both Ship Acquisition and Ship Alterations are indicated by Type = "Both".

Life Cycle Support Use Cases for Ship Acquisition and/or Ship Alterations:	**Type**
1. Identify Hierarchy Classification for Functional and System Designators	Both
2. Identify Configuration Worthy Items	Both
3. Classify Instances Based on Functionality	Both
4. Initial Assessment of Change for Configuration Changes	Both
5. Update Configuration Data & Support Products	Both
6. Develop Logistical Technical Data	Both
7. Develop Provisioning Technical Documentation Packages and Assign Repairable Identification Code	Both
8. Perform Reliability Maintenance Analysis	Both
9. Perform System Safety Review	Acquisition
10. Perform Human Factors Review	Acquisition
11. Perform Maintenance Planning Development	Both
12. Identify Environmental Concerns	Acquisition
13. Establish Stowage Requirements and Identify Locations	Both
14. Develop Training Tools and Documentation	Both

15. Part Usage Requirements	Acquisition
16. Develop Planned Change	Both
17. Release Configuration Data and Support Products	Both
18. Define Ship Support Policy	Acquisition
19. Define ILS Approach	Acquisition
20. Perform Part Supportability and Life Cycle Cost Analysis	Acquisition
21. Develop Kitting Plan	Ship Alt
22. Plan Configuration with ILS Certification	Ship Alt
23. Update Configuration with Installed Alterations	Ship Alt

6.2 Definition and Description of Each PLCS Use Case

Use Case #1 - Identify Hierarchy Classification for Functional and System Designators

Develop the hierarchy classification for functional and system designators. This is done by selecting the appropriate Expanded Ship Work Breakdown Structure (ESWBS) code from the *Users Guide for Expanded Ship Work Breakdown Structure (ESWBS) for All Ships and Ship/Combat Systems*. The ESWBS is a work breakdown structure, utilizing a five character numbering system, to identify functional areas, systems, and major components. Systems to be included on the ship should be specified by the Navy (not all ESWBS groups are used on all ships). The ESWBS is the basis for the Hierarchical Structure Code (HSC), developed later to classify all Configuration Worthy Items (CWI).

The top level ESWBS is shown below in Table 1. An example ESWBS breakdown structure is shown in Table 2.

Table 1 – Top Level ESWBS Breakdown

ESWBS	Equipment Functional Description (EFD)
10000	HULL STRUCTURE, GENERAL
20000	PROPULSION PLANT, GENERAL
30000	ELECTRIC PLANT, GENERAL
40000	COMMAND AND SURVEILLANCE, GENERAL
50000	AUXILIARY SYSTEMS, GENERAL
60000	OUTFIT AND FURNISHINGS, GENERAL
70000	ARMAMENT, GENERAL

Table 2 – Example of a Specific ESWBS Breakdown Structure

ESWBS	Equipment Functional Description (EFD)
51500	AIR REVITALIZATION SYSTEMS
51510	CO/H2 BURNERS
51511	CO/H2 BURNER - NO. 1
51512	CO/H2 BURNER - NO. 2

Use Case #2 - Identify Configuration Worthy Items

Based on design models and system diagrams, identify component instances that are configuration worthy. A Configuration Worthy Item (CWI) is defined as any item that requires maintenance or logistic support during its life cycle. (see Section 2.2 for a detailed definition of CWI).

Use Case #3 - Classify Instances Based on Functionality

Assign each instance of a CWI a unique HSC classified by system within the functional area. The HSC is an indenturing code of up to 12 characters, which identifies the functional/hierarchical relationship of the ship, ship systems, and equipment configuration records. HSC is typically defined for the entire ship class.

Associated with each HSC is an Equipment Functional Description (EFD) which provides a unique functional description of the component.

Further breakdown of the component is possible, to support subcomponents identified as configuration worthy.

HSC Guidelines:

- The first five characters: Positions 1-5 must be in the accordance with the Master Default ESWBS file (available in the reference section of the CDMD-OA Database and the Configuration Management Reference Material (CMRM) websites).
- The sixth through the twelfth characters: The seven digit character sequence, which follows the ESWBS, breaks the equipment into subsystems, components, assemblies and subassemblies. Valid values for each of the last seven characters include combinations of digits “0-9” and characters “A-Z”, excluding the characters “O” and “I”. Typically, two alpha characters in the sixth and seventh position denote the functional group of the component (i.e. “DH” is a valve).
- Usage note:
    - For equipment, the structure starts with the highest-level equipment followed by lower components in functionally related groups.
    - For piping systems, the structure starts with the source to the demand consistent with the system diagrams, indenturing at major components and services.
    - Components may also be split into different groupings according to component types, e.g. globe valves, butterfly valves, etc.

The ESWBS breakdown example given in Table 2 is extended to illustrate an HSC breakdown structure in Table 3 below.

Table 3 – Example of a Specific HSC Breakdown Structure

ESWBS	Equipment Functional Description (EFD)
51500	AIR REVITALIZATION SYSTEMS
51510	CO/H2 BURNERS
51511	CO/H2 BURNER - NO. 1
51511SG1	CO/H2, BURNER #1
51511SG1A	CO/H2, BURNER #1, ELECTRIC MOTOR
51511SG1D	CO/H2, BURNER #1, ELECTRICAL ASSY
51511SG1D1	CO/H2, BURNER #1, CONTACTOR
51512	CO/H2 BURNER - NO. 2

Use Case #4 - Initial Assessment of Change for Configuration Changes

This assessment reviews a design or logistics proposed change to determine the logistical impact. It identifies the items which are planned for removal, modification, or addition to the baseline with the impact to its technical documentation, maintenance, and provisioning.

Use Case #5 - Update Configuration Data & Support Products

Incorporate the updated configuration data and support products resulting from a design or logistics change. This will update the configuration baseline.

Use Case #6 - Develop Logistical Technical Data

For each instance of a CWI, develop the appropriate technical data and documentation required to effectively operate and maintain each class of ship throughout its life cycle. This may be developed at the system level and/or the equipment level. This documentation will be used to effectively operate and maintain each class of ship throughout its life cycle.

Damage Control Plates are included as a part of the Logistics Technical Data.

Use Case #7 - Develop Provisioning Technical Documentation Packages and Assign Repairable Identification Code

This process, occurring after procurement, involves the decomposition of a Configuration Worthy Item (CWI) into components which themselves are CWIs. Each CWI is assigned a Repairable Identification Code (RIC) to the component so that the item will have full logistical support. The RIC provides the interface key to the supply support of components and to the components technical documentation such as identifying technical manuals in the Technical Data Management Information System (TDMIS) and identification in the supply system.

A RIC uniquely identifies a particular commodity. When the code is related to an Allowance Parts List or an Allowance Equipage List, it is known as an APL or AEL, respectively. Although the Hierarchical Structure Code (HSC) identifies a function on a ship, the Repairable Identification Code (RIC) identifies the commodity that is performing that function. The RIC relates to a set of characteristics which identify a particular system, equipment, or component.

Please note that another term which may be used for a Configuration Worthy Item (CWI) is Functionally Significant Item (FSI).

Use Case #8 - Perform Reliability Maintenance Analysis

Ensure that the ship and its systems are designed in a way that the top level Reliability Maintenance Analysis (RMA) requirements imposed by the customer are met. The requirements ensure that the ship meets its operational requirements with minimal down time for equipment. There is also an evaluation of proposed procurement items, which happens before procurement and provisioning.

Use Case #9 - Perform System Safety Review

Support the timely identification of hazards and the initiation of actions necessary to eliminate hazards or reduce the associated risks to an acceptable level within the system.

Use Case #10 - Perform Human Factors Review

Perform Human Engineering review of arrangement drawings, digital and physical mockups or operational consoles designed for areas involving human interface.

Use Case #11 - Perform Maintenance Planning Development

Determine and set up the conditions required to perform specific repairs and preventive maintenance. This includes developing maintenance plans, maintenance standards, and maintenance requirement cards. Maintenance plans and maintenance requirement cards are developed for each Major Repairable Component (MRC).

The Maintenance Planning and Development Phase provides a cost effective life cycle approach which is consistent with the Class Maintenance Program Procedure.

Use Case #12 - Identify Environmental Concerns

This is the process of identifying and documenting the chemical material properties that make up a component, structure, or piping. This provides documentation (an 'Environmental Map') of where hazardous compounds are used onboard the ship.

Use Case #13 - Establish Stowage Requirements and Identify Locations

Identify and track items identified on the Coordinated Shipboard Allowance List (COSAL) for stowage requirements. The COSAL is made up of equipment/components required for the ship to perform its operational requirements, and repair parts, special tools and miscellaneous portable equipment required to repair those items. This provides the basis for development of the stowage requirements. The stowage items identified in this process produce the stowage requirements for the locations to stow those items.

Use Case #14 - Develop Training Tools and Documentation

Develop training materials and trainers that support personnel procedures for operation, maintenance and repair of ship systems.

Use Case #15 – Part Usage Requirements

Identify part usage requirements relating to logistics and support, and incorporate them into procurement specifications.

Use Case #16 – Develop Planned Change

Develop updates for configuration data and support products to address a proposed design or logistics change.

Use Case #17 – Release Configuration Data and Support Products

Release configuration data and support products to the ship owner.

Use Case #18 – Define Ship Support Policy

This is the process by which the ship owner defines the policies that will be employed to support the ship. This may include: the contractual arrangements for support (such as organic support, contractor logistic support, contract for availability); the maintenance philosophy to be applied (such as reliability centered maintenance or calendar based maintenance); inventory management policy; the stock management philosophy policy to be applied (such as just in time supply or managed inventory); training philosophy to be used (such as on-the-job training). These policy choices will be influenced by many factors including: ship capabilities, intended missions, contractor capabilities, available technology, the program office, expected budget, DoD and Navy policy, as well as experience from the other ship programs.

Use Case #19 – Define ILS Approach

This is the process of specifying and implementing the processes, procedures, and tools that an ILS organization will use to develop logistics data and products for a specific ship or ship class. Different ship contracts have different requirements which may be satisfied by various combinations of processes, procedures, and tools. This is a collaborative process between the ILS organization and the Navy customer and will be influenced by the specifics of the ship support approach adopted.

The resulting ILS Support Plan is utilized throughout the ILS organization in all activities relating to this ship contract. (This is not shown in **Figure 6**.)

Use Case #20 – Perform Part Supportability and Life Cycle Cost Analysis

Ensure that the part is designed in a way that the top level supportability and life cycle cost requirements imposed by the customer are met. Supportability and life cycle cost analysis includes the whole life cycle of system and support elements. The analysis ensures that the ship will achieve optimum system performance at minimum life cycle cost.

Use Case #21 - Develop Kitting Plan

Specify and define kits required by the AIT to install the Ship Alteration. Kitted material is supplied to the AIT by the planning yard.

Use Case #22 - Plan Configuration with ILS Certification

Plan the finalizing of the Ship Alteration, including incorporating all planned configuration changes in the configuration baseline and approval of the ILS Certification, indicating all required support products are complete.

Use Case #23 - Update Configuration with Installed Alterations

Update the configuration baseline to incorporate all configuration changes reported from the installation of the Ship Alteration.

6.3 Summary of Technical Documentation Use Cases

The set of Use Cases for the Development of Technical Data is illustrated in **Figure 16**, and is discussed below. Although one can go to many different levels of detail, and can easily divide these Use Cases into several discrete operations, it was felt that these three Use Cases provide a consistent and discrete level of consideration for the ISE-6 efforts. These Use Cases were the basis of the context schemas and exchanges developed during Phase 2 of the ISE-6 Project.

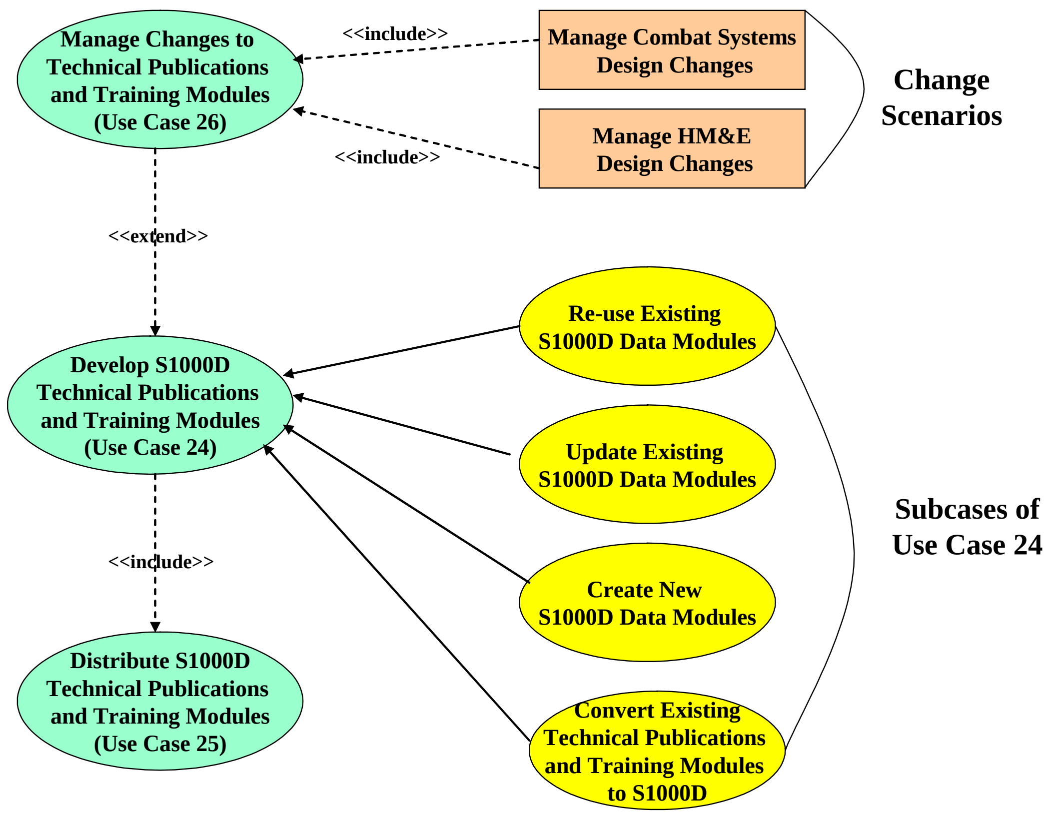

Figure 16 – Use Cases for Development of Technical Data

The ISE-6 Use Cases focus on the usage and aggregation of data modules. The data module content is assumed to be authored correctly for the purposes intended and is not addressed by the Use Cases.

<u>#</u>	<u>Use Case Title</u>
24	Develop S1000D Technical Publications and Training Modules
25	Distribute S1000D Technical Publications and Training Modules
26	Manage Changes to Technical Publications and Training Modules

While the S1000D Standard has been adopted for technical documentation, including technical manuals, the training community has adopted an analogous standard for e-learning, the Sharable Content Object Reference Model (SCORM). Both standards are modular, allowing the reuse of content. An S1000D Data Module (DM) packages content within an XML file. A SCORM Sharable Content Object (SCO) packages learning content. SCORM is a reference model used to aggregate and sequence SCOs, but does not address how learning content is arranged within an SCO. Hence "dual-use" S1000D Data Modules can be used to package both technical documentation and learning content. In this case, the technical documentation (training) consists of some dual-use modules as well as data modules which are specific to technical documentation or training. Dual-use data modules must be authored specifically for this purpose.

6.4 Definition and Description of Each Technical Documentation Use Case

Use Case #24 - Develop S1000D Technical Publications and Training Modules

The Use Case for Developing S1000D Technical Publications and Training Modules can be broken down into at least four sub cases which guide the development of these publications and modules. This Use Case will depend on whether the change permits re-use of existing S1000D Data Modules, whether it requires an update of existing S1000D Data Modules, whether it necessitates the creation of new S1000D Data Modules, or whether it requires the conversion of existing Technical Publications and Training Modules into S1000D. All are valid scenarios that are possible responses to design changes.

Traditionally, different formats have been used for technical publications and training. Often even different technical publications require different formats. However, with the use of S1000D Data Modules, it is possible to use a common format to develop both Technical Publications and Training.

Use Case #25 - Distribute S1000D Technical Publications and Training Modules

This Use Case describes the procedures used to distribute the S1000D Technical Publications and Training Modules after their development has been completed in response to the two previous Use Cases.

Traditionally, technical publications and training utilize different formats and use different distribution channels. Often even different technical publications have different distribution channels. However, with the use of S1000D Data Modules, it is possible that a common distribution format and channel might be developed which utilize the data models directly.

Use Case #26 - Manage Changes to Technical Publications and Training Modules

The Use Case for Managing Changes to Technical Publications and Training Modules includes defining how these changes are handled in several different change scenarios. Among the scenarios to be considered in the ISE-6 Project are the management of design changes to Combat Systems or to Hull, Mechanical, and Electrical (HM&E) Systems.

7 CONTEXT SCHEMA AND PLCS BUSINESS DEX

7.1 Context Schema

The scope of PLCS, as shown in **Figure 2**, is extremely broad. The ISE-6 project focused on the core ship configuration data, which is necessary for all life cycle support activities. The ship configuration data requirements were formalized as a context schema generated from the SAS database schema. The SAS system, used at Electric Boat for the Virginia class, predates the development of SCLSIS and reflects shipyard requirements to incrementally assemble configuration data.

The core of the resulting context schema is illustrated schematically below in **Figure 17**. Entities are shown as rectangles with rounded corners. Green is used to denote logistics entities, orange for design entities, and blue for other entity types. Key fields are shown in parenthesis. Solid lines represent relationships. Dashed lines are used to indicate subtypes. Yellow boxes are used to provide minimal explanation and usage example. Both the design and HSC breakdown are assumed to be defined for the ship class.

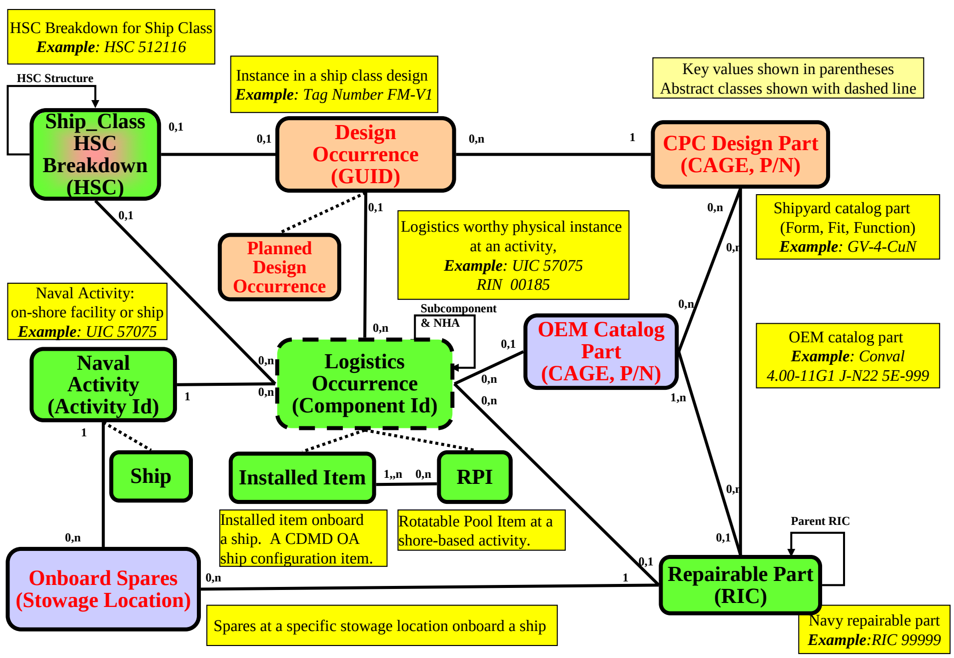

Figure 17 – Core ISE Life Cycle Support Context Schema

The resulting context schema corresponds roughly to the SCLSIS configuration data (ignoring Record Type 4 and changes to the configuration). However, one SCLSIS record may be represented in the ISE context schema by several distinct entities. The SCLSIS Record Type 1 maps to a Naval Activity entity. The CDMD Class Functional File (CFF) maps to a Ship Class HSC Breakdown entity. The SCLSIS Record Type 2 maps to Logistics Occurrence, Repairable Part, and Org Unit (not shown in **Figure 17**) entities. The SCLSIS Record Type 3 maps to Logistics Support Document (LSD) and LSD RIN entities.

7.2 PLCS Ship Configuration Business DEX

The ISE context schema was then mapped into PLCS which defines (at least conceptually) a ship configuration business DEX. The methodology used to map the context schema entities into PLCS and define the DEX is outlined below. Note that due to the limited time for Phase 1, only steps 1 and 2 were completed.

1. Identify PLCS entity for each major context schema entity (completed)
2. Define a template for each major context schema entity (completed)
3. Define corresponding capabilities for the templates. These are based primarily on existing capabilities and templates. However, some new shipbuilding specific templates will need to be defined as well as new lower level capabilities and templates
4. Define RDL data for new entity types, based on proposed mapping
5. Define RDL data for attributes and data values, based on context schema and SCLSIS Tech Spec
6. Define ISE ship configuration Business DEX which clearly defines shipbuilding business process, based on capabilities defined above. This extends/specializes two existing PLCS generic DEX:
   - 001 Product_breakdown_for_support
   - 008 Product_as_individual.

The key constraints for mapping the ISE context schema into PLCS include:

- Build on existing PLCS capabilities and DEXs
- Use these capabilities and DEXs consistent with other implementation areas – aerospace, DoD, etc.
- Extend existing capabilities and DEXs for shipbuilding
- Avoid adopting shipbuilding-specific interpretations unless necessary

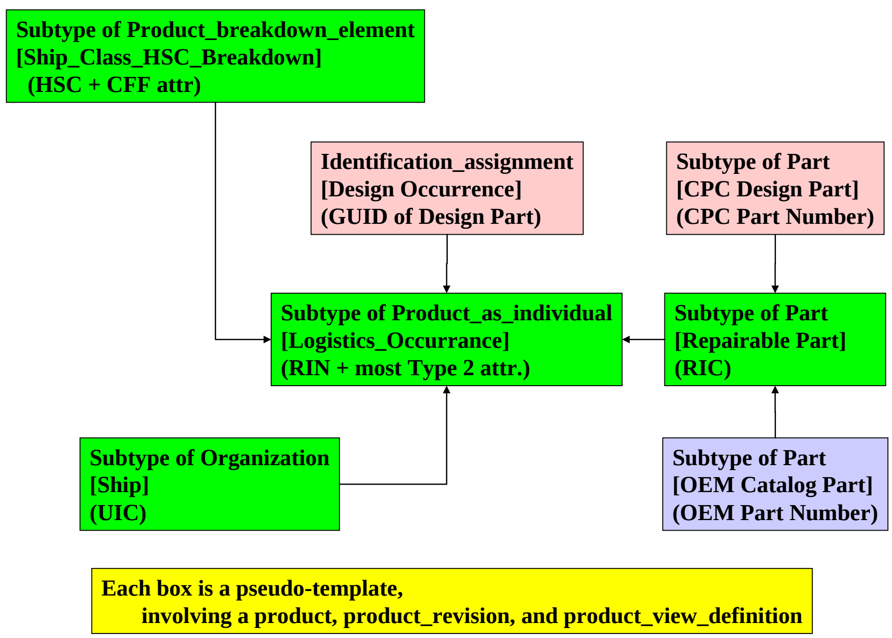

Figure 18 – Instance of ISE Life Cycle Support Context Schema

The key problem encountered was that PLCS concepts do not map neatly into Navy life cycle concepts. PLCS design structure is based on a part/assembly structure, not distinct instances used for design and configuration management. Also, PLCS includes a number of breakdown structures, but the HSC breakdown requires a new structure.

An example of a SCLSIS Record Type 2 with a reference to an associated design entity and design part is shown in **Figure 18.** The PLCS entity types are shown with the context schema entity denoted in square braces. Each entity as drawn is a template representing a product, product_revision, and product_view_definition, and several other related entities.

7.3 Implementation of PLCS Translators

A two-level translation strategy was adopted to minimize the work required to implement translators for applications. This is illustrated in **Figure 19** below. Each application needs only a simple translator to generate and/or read ISE context schema XML. Typically application data is organized in manner similar to the ISE context schema. A common bi-directional mediator can be used by all applications to generate all the entities and relationships required for a valid PLCS XML file. The mediator was implemented based on the template expansion of ISE context schema entities.

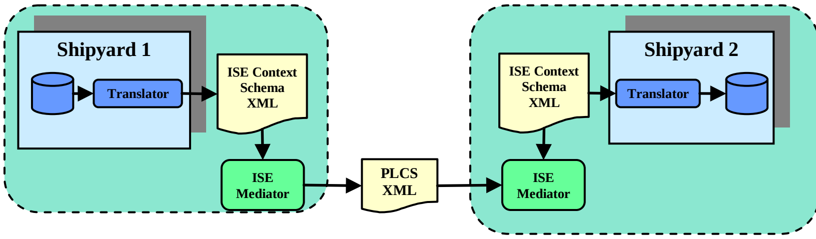

Figure 19 – ISE Life Cycle Support Data Exchange Approach

8 EXCHANGE WITH NAVY

LEAPS (Leading Edge Architecture for Prototyping Systems) is an integration environment developed and supported by Naval Surface Warfare Center Carderock Division (NSWC-CD) for use by NAVSEA and its contractors. LEAPS serves both as a central repository for ship design and operational analysis data and as the link to numerous software programs used by NAVSEA to perform specific performance analysis tasks for a new ship design project (see **Figure 20**). Since its inception, LEAPS has primarily been used as a repository of early-stage design data to support ship performance analysis in the associated legacy analysis tools for conceptual studies of potential new ship classes.

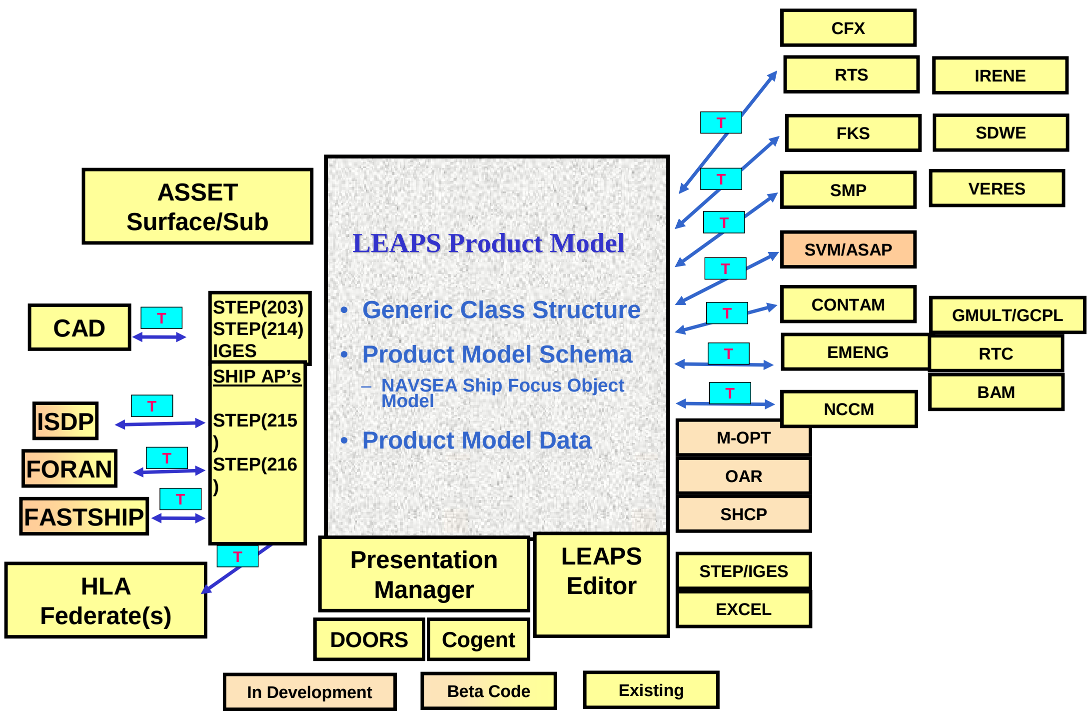

Figure 20 – The Navy Leading Edge Architecture for Prototyping Systems (LEAPS)

Over the last few years, NSWC-CD has invested considerable development effort in the improvement and expansion of the LEAPS environment. A major release in early 2008 better integrated NSWC-CD's ASSET (Advanced Ship and Submarine Evaluation Tool) software with LEAPS by storing ASSET's parametric ship class hullform geometry within a LEAPS database. This geometry and the associated performance properties may now be used more directly by the LEAPS-related analysis and visualization tools. Various projects over the last few years have also expanded the options for importing ship design data from sources outside of ASSET, such as from design agents and shipbuilders. STEP translation capabilities have been added which support the import of ship hull and major surface geometry using STEP AP216, the import of compartment definitions using STEP AP215, and the import of components using STEP AP203 or AP214. These components may represent any type of ship part, such as structural plates and stiffeners, piping parts, HVAC ducts, electrical cableways, mechanical components, mission systems components or weaponry. STEP AP203 and AP214 will be used for some of these categories of components until such time as translation capabilities are added between the shipbuilders' IDEs and LEAPS for a few additional STEP Ship-specific APs such as structural systems (AP218) and distributed systems (AP227ed2).

LEAPS has reached a level of maturity such that NAVSEA has determined that it will be the central Navy integration environment and product model data repository for the vast majority of data associated with ship acquisition. The "Ship Design Tools Roadmap", currently under development within NAVSEA 05D, will delineate these development plans for LEAPS and other design tools, with near-term emphasis on the Preliminary, Contract, and Detail Design Phases of new ship programs.

In the near term:

- LEAPS will be the single source of authoritative data for all pre milestone B activities;
- LEAPS will be used by NAVSEA to support validation of the design as required to provide oversight during the detail design / Ship Production phase;
- LEAPS will be the authoritative source of data in support of the Situation Incident Room upon delivery of the ship.

It is expected that later ship lifecycle phases, such as service life and logistics support, will eventually also be integrated with the LEAPS environment. At present, Integrated Logistics Support (ILS) products developed in parallel with the design for a ship class are delivered directly by the design organizations into the Navy's purpose-built Logistics Support software environments such as CDMD-OA. This process is not expected to change soon, but with the expansion of LEAPS as the principal Navy product model data repository at ship delivery, it will be possible to better link the design and logistics information systems to make both more accessible and visible to the LEAPS user community.

During the first phase of the ISE-6 project, Product Data Services developed the initial prototype of a capability to link the detailed design product model data in LEAPS with the documentation required for its service life support, using STEP AP239. An important product management "key" included in all of the STEP Shipbuilding APs is a globally unique identifier attribute, which uniquely identifies each part in a ship's product model data.

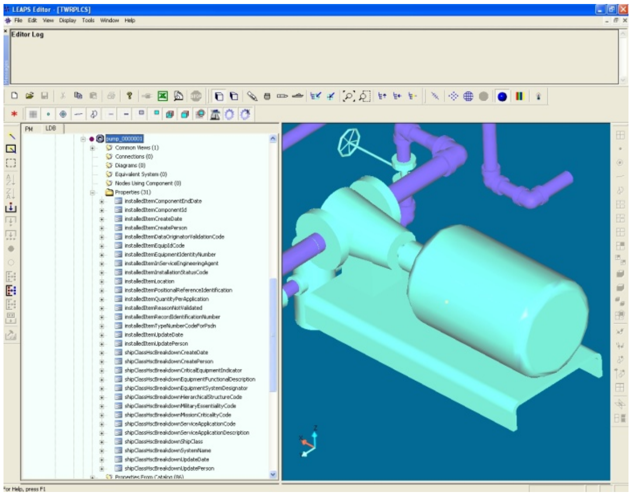

Figure 21 – SCLSIS attributes stored as LEAPS Properties on repairable parts

A similar key in logistics systems is the Hierarchical Structure Code (HSC) which uniquely identifies the logistics-worthy parts of a ship for in-service support, and associates the digital documentation needed to maintain the part. These key relationships were used in the AP239 prototype developed for LEAPS. For each repairable part in the LEAPS product model, identified in the detailed design data by a specific globally unique identifier, the corresponding HSC code was read from the AP239 exchange file and stored in LEAPS. This HSC Code could be used as a digital link to the related information stored in a separate logistics system, or the logistics data itself, such as the SCLSIS attributes, can be stored directly within the LEAPS database (see **Figure 21**). The prototype also made use of LEAPS' capability to store URL associations as property data on any product model object. In this way, a hyperlink reference can be stored to any engineering or logistics digital document information desired. The document files themselves are stored outside of the LEAPS environment in a separate document repository, but can be viewed by selecting this stored URL from within the LEAPS environment (see **Figure 22**).

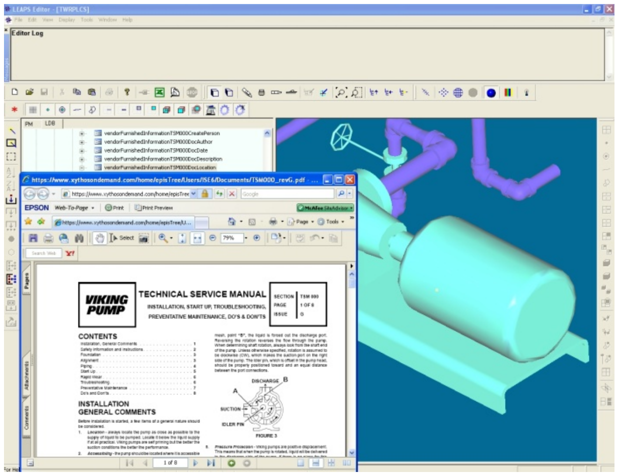

Figure 22 – LEAPS Hyperlinking to Engineering or Logistics Documentation

During the second phase of the ISE-6 project, Product Data Services developed the capability to link the detailed design product model data in LEAPS with S1000D technical manual and training document authoring tools. While it is expected that the document authoring process will remain outside of the LEAPS repository, the capability was added to better link LEAPS with the Navy's tool of choice for document authoring through hyperlinks to the S1000D Publication Modules, and storage of document version and configuration management information for S1000D documents that are applicable to any particular component in the LEAPS product model (see **Figure 23**).

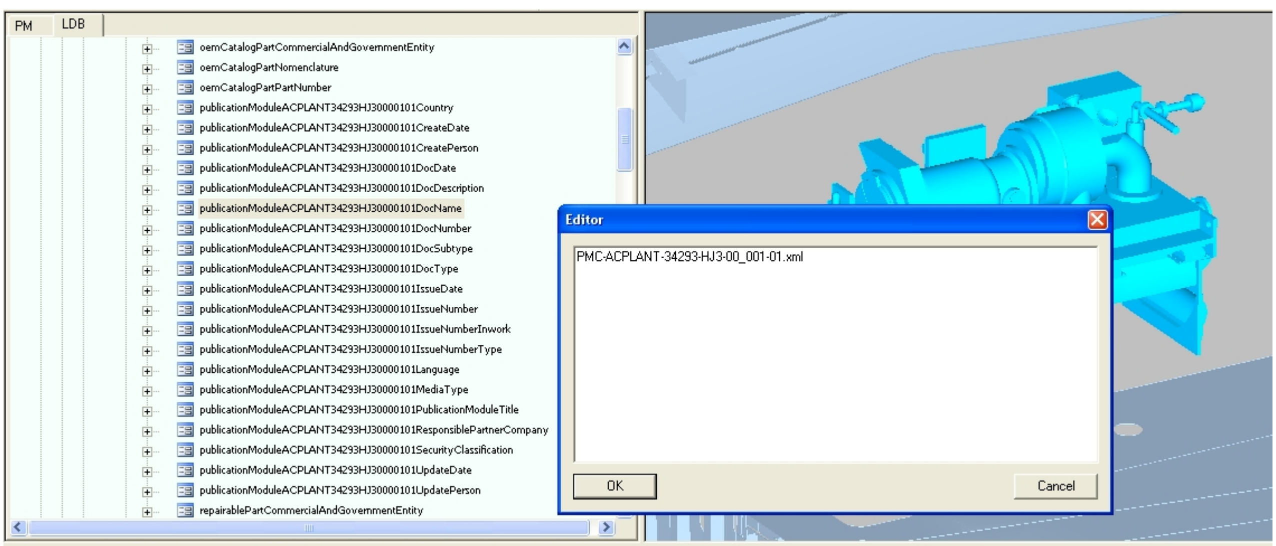

Figure 23 – LEAPS S1000D Publication Module Referencing

This project demonstrated that LEAPS could facilitate better shipboard or shore visualization of both logistics information and ship documentation from within the product model data integration environment if LEAPS is potentially more widely used in both the acquisition and the service-life support communities outside of the Navy labs. In addition, LEAPS could be used as either a portal or storage mechanism for the related SCLSIS data delivered from Design Agents to the Navy in parallel with the engineering product model data.

9 USE OF AP227 FOR PIPING & HVAC EXCHANGE

Although the primary thrust of the ISE-6 Project dealt with digital data exchanges throughout the life cycle using PLCS (AP239) and the S1000D Standard for technical documentation, there was one task under ISE-6 (Subtask 7) which addressed using STEP AP227ed2 for piping and HVAC exchanges. The ISE-6 revised proposal that was funded by NSRP describes this effort as: "This task will update the interoperability data set to include piping and HVAC for the ShipConstructor Product Model. This will open up the benefits of ISE to the Navy LSC project, the Coast Guard deep water project, and to the 65 US shipyards and design agents using the ShipConstructor design and production software. The task will develop and test STEP AP227 translators for piping and HVAC. The translators will be tested against data sets developed under ISE-2 and ISE-3. An incremental software development will be applied. An early, limited, capability for importing STEP AP227 data will be developed. Additional functionality will be added and tested each quarter. This task will bring the ShipConstructor data models into the interoperability environment."

The end result of this effort was the development and demonstration of prototype AP227 preprocessors and postprocessors for the transfer of piping and HVAC product models both into and out of ShipConstructor. Prototype AP227 translators had been developed for other CAD systems during previous projects (ISE-2 and ISE-3), so this task enabled the ShipConstructor software (that is widely used at mid tier U.S. shipyards) to use test data from previous ISE projects to validate its new exchange capability. These tools were shown at a very successful ISE-6 demo held in Biloxi, MS in March 2009. That demo is described below in Section 10 of this report.

An important development is that ShipConstructor Software, Inc. (SSI) intends to turn this prototype software into a production product and to offer it as part of the ShipConstructor package by the end of 2009. This could be a significant milestone in the goal of the ISE Team to see its tools and translators used in production at U.S. shipyards.

10 TECHNOLOGY TRANSFER

The ISE-6 Project has emphasized technology transfer by participating in seminars, symposia, and standards activities.

10.1 ISE-6 Project Demonstrations

The most important activities were the three Project Demonstrations which were presented to diverse audiences of shipyard and Navy personnel.

- The first demonstration occurred in Washington, D.C. in April 2008 and emphasized the exchange of information using PLCS (AP239).

  The ISE-6 Phase 1 Demonstration, illustrated below in **Figure 24**, focused on the potential reuse of logistic products between two IDE environments. Significant work is required to research and provision equipment. Often the equipment is common across ship programs, but there is currently no method to transfer an integrated package of logistics data. This scenario was intended to demonstrate:

  1. Use of PLCS to transfer integrated design logistics data from one IDE to another
  2. Ability to maintain data relationships during the PLCS transfer
  3. Ability to successfully link to the design data in the receiving IDE

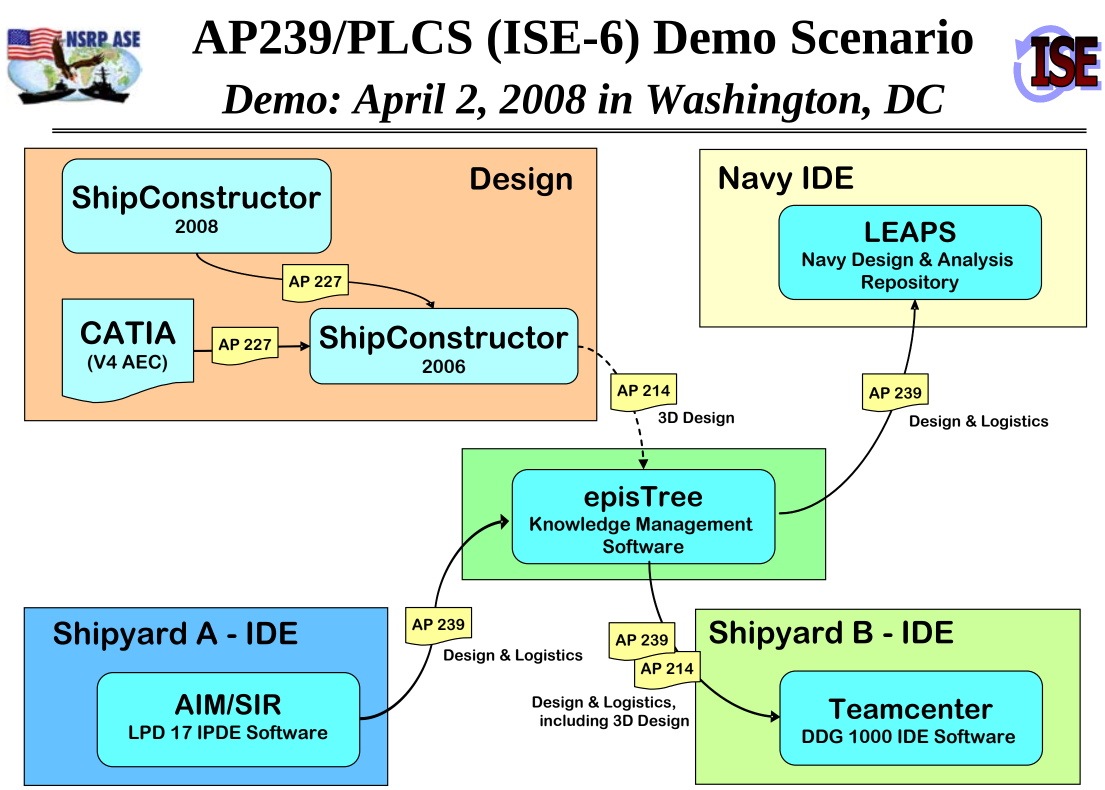

Figure 24 – ISE-6 Phase 1 Data Exchange Demonstration

During the ISE-6 Phase 1 Demonstration project, previously developed design and logistics systems were used as sources of knowledge and information. The ShipConstructor design system created an early stage 3D design of the Fuel Oil System. Related design and logistics information was previously created in the Shipyard A IDE, implemented by the Intergraph AIM/SIR system, which is in use on the LPD 17 Program. The episTree© Knowledge Management tool was used to combine the 3D design with related logistics data as well as modify part numbers and compartment numbers to reflect the receiving environment. The combined data was imported into the Shipyard B IDE, implemented with Teamcenter, which is in use on the DDG 1000 Program. The design and logistics data was imported into the Navy LEAPS system, used as a repository for design and analysis information.

- The second demonstration focused on using AP227 to transfer ship piping and HVAC product models into and out of ShipConstructor. This demo was held immediately after ShipTech 2009 in Biloxi, MS in March 2009. It was very well received and showed how STEP AP227 could be used to transfer distributed system product models for either piping or HVAC between multiple CAD systems including CATIA, FORAN, a STEP Viewer, a Pipe Shop Simulator, and of course ShipConstructor which was the primary CAD system involved in the demo. The transfers demonstrated are illustrated in **Figure 25** below.

  ShipConstructor hopes to make the AP227 translators developed for the ISE-6 Project available as production tools by the end of 2009.

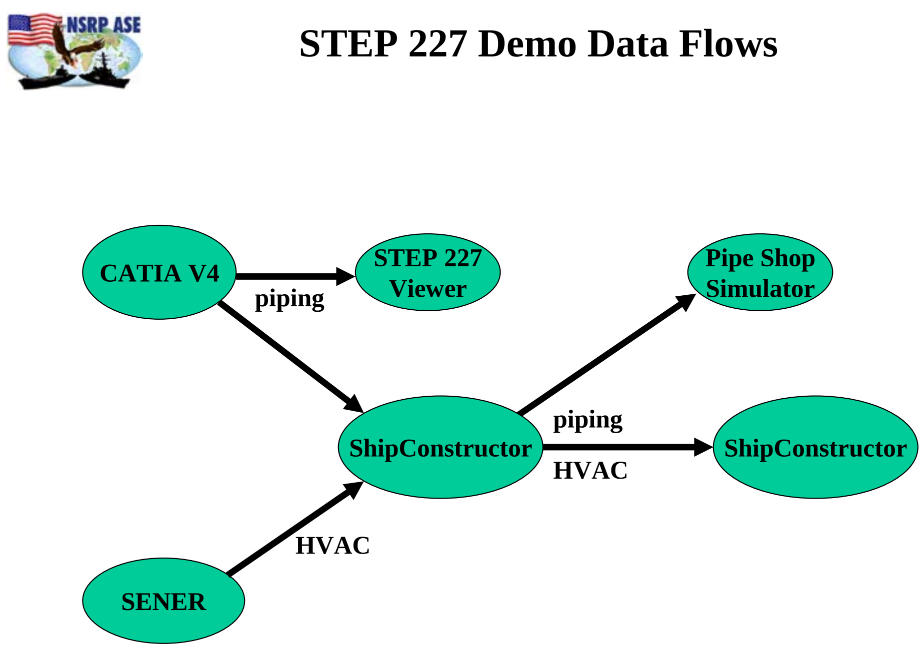

Figure 25 – Exchanges During ISE-6 AP227/ShipConstructor Demo

- The final ISE-6 demonstration took place in Washington, D.C. in April 2009 and focused on the use of PLCS and S1000D to transfer life cycle information and data relating to technical documentation between shipyards and the Navy.

  A major goal of the ISE-6 Project was to coordinate the use of the PLCS (STEP AP239), S1000D, and ISE Standards to integrate more closely with the shipyard's product model to enable product life cycle interoperability. The project's objective was to prototype and evaluate the use of international standards and the ISE interoperability architecture in the realm of ship's life cycle support and in-service operations both on shore and on ship. The final demonstration showed an integrated approach for implementing Ship Change Document (SCD) changes between ISEA and the Shipyard. It featured the automated identification of logistics documentation change impacts, and showed the standards-based exchange of integrated design, logistics, and technical publication data using PLCS (ISO 10303-239) and the S1000D Standard for XML-based technical documentation. The exchanges were based on the Navy Common Source Database (Contenta) and the IDE in use on the DDG-1000 Class Destroyer program. **Figure 26** below illustrates some of the Navy systems that were linked in this process.

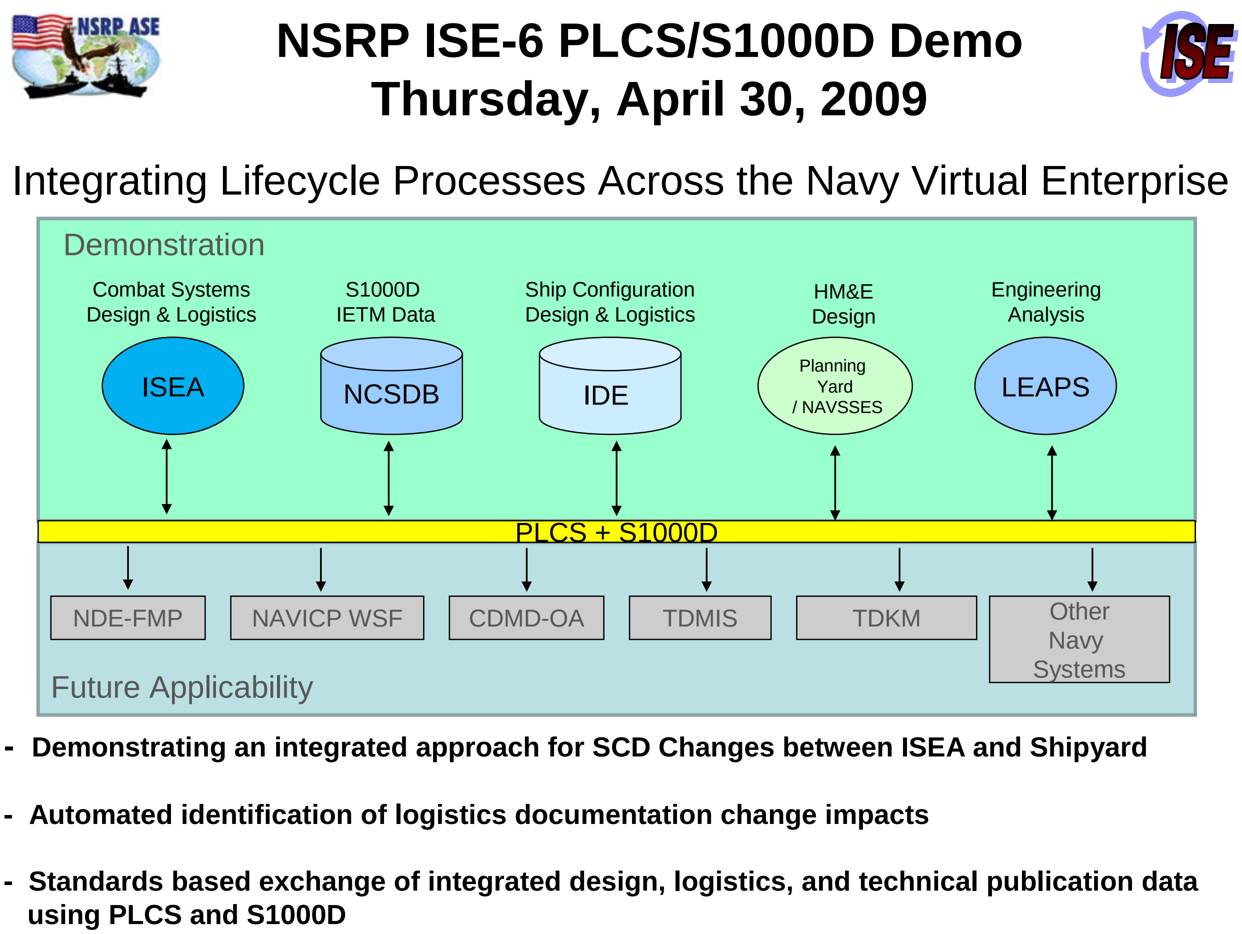

Figure 26 – ISE-6 Final Demo

10.2 Presentations to Outside Organizations

In addition to these demos, ISE-6 Project presentations were given at several major international events. These included:

- Two major ISE presentations were given at ShipTech 2008 in Biloxi, MS in March 2008 and at the Ship Production Symposium in Houston, TX in October 2008.
- Presentations were made to groups from other industries including the Army's TARDEC Program in Warren, MI in May 2008; the Aerospace Industries Association (AIA) in Cincinnati, OH in July 2008; and a Conference on Digital Preservation of Complex Engineering Data held in Morgantown, WV in April 2009.
- The ISE-6 project actively participated in the ISO TC184/SC4 Committee that is developing the STEP Standard. Discussions of ISE activities took place at ISO TC184/SC4 Meetings in Funchal, Portugal in March 2007; Dallas, TX in October 2007; Louisville, KY in March 2008; and Parksville, BC, Canada in May 2009.
- Updates were provided to Navy groups working on implementations of S1000D in Panama City, FL in August 2008; Ft. Belvoir, VA in October 2008; and Carderock, MD in February 2009.

- Reports were also given at several NSRP Joint Panel Meetings including New Orleans, LA in December 2007; Seattle, WA in April 2008; and Warwick, RI in August 2008.

Tools, implementers agreements and other documentation are publicly available on the ISE Tools Website (www.isetools.org).

The schemas developed under ISE-6 will be submitted to the DONXML Registry.

11 SUMMARY

The majority of the Total Ownership Cost (TOC) of a Navy ship accrues after the ship has been delivered by the shipbuilder to the Navy. The processes of life cycle support, repair, maintenance and overhaul, ships' operations, testing, and training are all information intensive processes. The Navy has steadily moved toward more modern systems and technologies to cope with the burgeoning information needs, but technology has evolved faster than the deployed solutions. As a result there are a number of incompatibilities or opportunities for significant process improvement as a result of systems technologies advances.

The configuration of a ship changes during its lifecycle as a result of maintenance, repair, and modernization activities. The SHIPMAIN process defines this overall process. Modernization activities are planned and scheduled as Ship Alterations. This is defined by the Fleet Modernization Process (FMP). The SHIPMAIN and FMP processes are available at: www.fmp.navy.mil.

At the same time the business environment for post-delivery support is changing. Shipyards have become responsible for the life cycle support of ships, including managing maintenance and logistics data over the life of the ship. This is the so-called full service contract. The shipyards have, in the meantime, deployed sophisticated digital Integrated Product Data Environments (IPDEs). This presents a new opportunity for a shipyard to efficiently integrate its acquisition product model data with life cycle support product model data. This information is also required to develop the logistics data for the ship. After ship delivery, the acquisition data is required to initialize life cycle support systems for the ship. Technical publications, required to operate and maintain the ship, also require similar ship product model information. All of the systems and processes are highly interrelated through the information that they share. System, technological, and process boundaries inhibit information interoperability in today's environment. The shipyard's cost and performance on these new Navy contracts can be improved significantly through the efficient transfer and incorporation of ship product model data.

The ISE-6 Team has prototyped a system architecture to enable the information required for Product Life Cycle Support (PLCS) and for Technical Documentation to be captured in a manner that is interoperable and portable across the various ship platforms. The Use Cases defined by the project capture the functional requirements of the system and can be mapped to various DEX's (Data Exchange Sets) in AP239 as well as to DMs (Data Modules) from S1000D. This enables the derivation of a consistent and extensible information model to capture a set of information requirements that span application domains.

Using standards to transfer and maintain product model and technical documentation information is a major challenge and the ISE-6 Project has only scratched the surface. It is hoped that by prototyping the translators and demonstrating the use of these technologies that ISE-6 has contributed toward the goal of defining product model and technical documentation data once, but having it available when needed throughout the lifecycle of the ship.