Integrated Logistics Environment (ILE) Project

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Agenda

- Integrated Logistics Environment Project (ILE)
- Navy Product Data Initiative (NPDI) and Ship Common Information Model (SCIM)
- SCIM Evaluation
  - Migrating VIRGINIA Class IPDE Data
  - Exchanging Structural Design Data with Manufacturing Systems for DDG 1000 and CVN 21
- SCIM Development
  - Completion and Delivery of the Standard
- Adopting the SCIM for Production Use

Integrated Logistics Environment Project

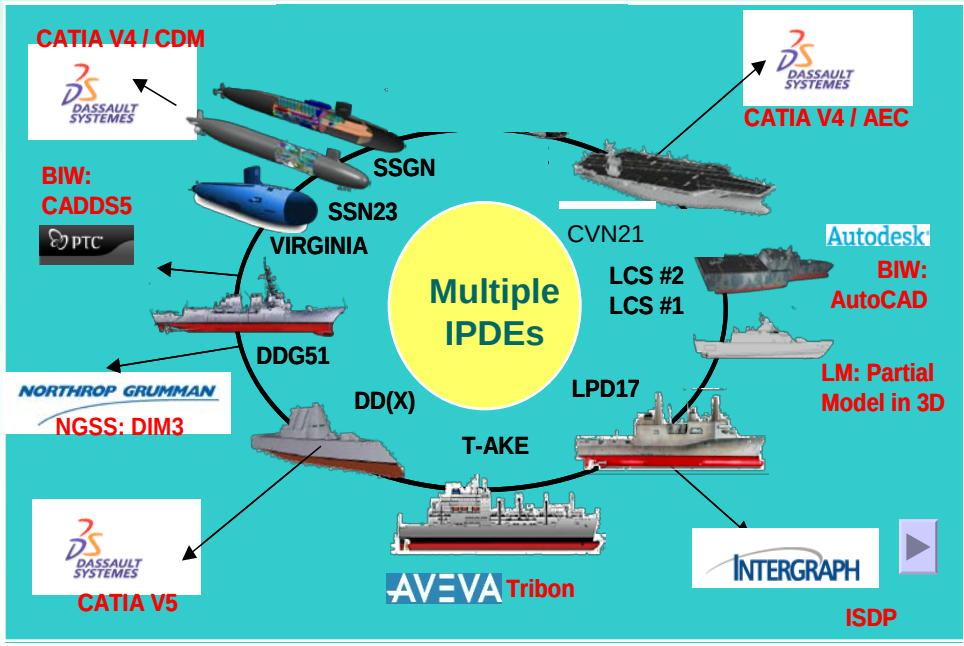
- Over the past several years the ISE Projects under NSRP have been developing and prototyping tools to enable an Integrated Shipbuilding Environment (ISE)
- A current NSRP project is continuing those efforts with a special emphasis on creating an environment to facilitate data exchange and interoperability throughout the entire life cycle of the ship
- This natural transition brings project focus on creating a standards-based Integrated Logistics Environment (ILE)

NPDI and SCIM

- NSRP has led the way in developing standards and prototyping tools to facilitate product model exchange between shipyards and the Navy throughout the life cycle of the ship
- In conjunction with the Navy Product Data Initiative (NPDI) effort, a Ship Common Information Model (SCIM) was defined to specify information exchange requirements within and among IPDE environments throughout the life cycle of the ship
- The current project for an Integrated Logistics Environment (ILE) is evaluating and validating the SCIM models that have been developed, as well as completing the SCIM document for several additional disciplines

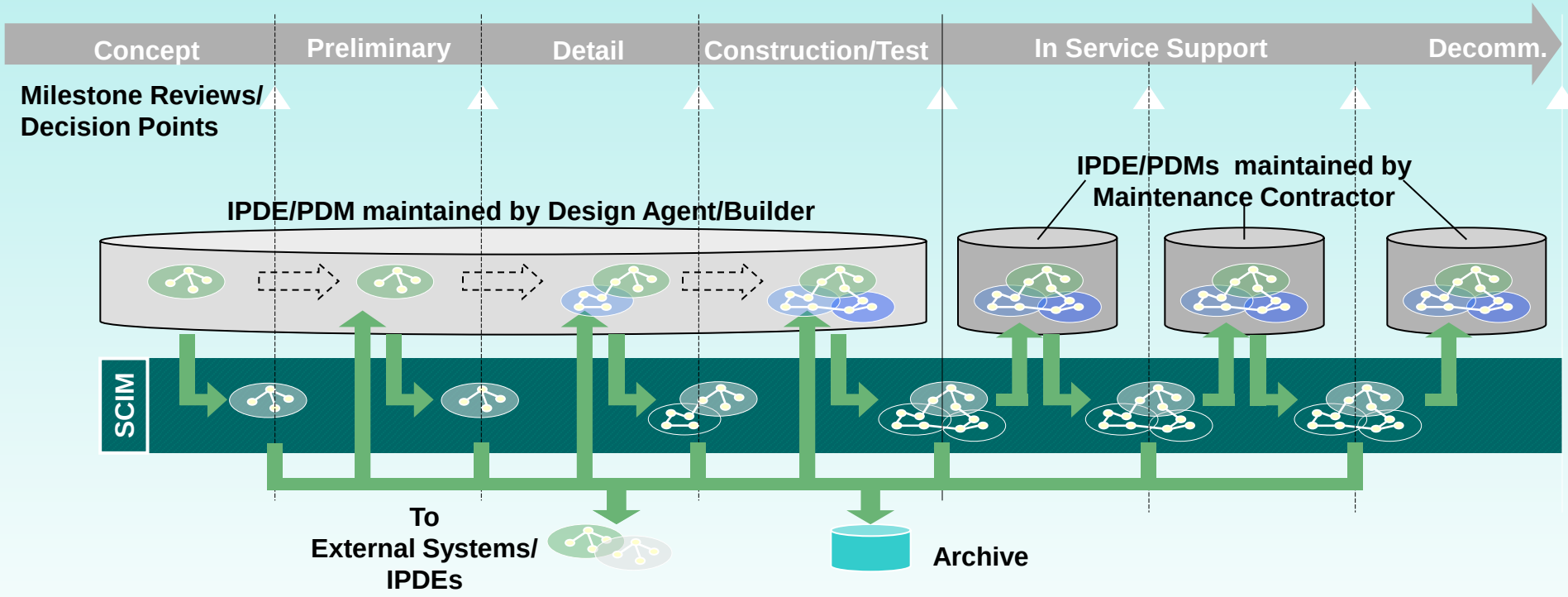
Integrated Product Development Environment (IPDE):

- A collection of business processes, computer systems, and associated services, which house the product model data, and enable people to work in concert towards common business goals throughout the life cycle of the product
- Each shipyard approaches IPDE development differently leading to the following challenges
  - Systems are complex and expensive to build and integrate
  - Common problems are addressed independently
  - Product information for service life support is inconsistent and expensive
  - Cost of change is impacting shipboard technology insertion and modernization



- Industry does not have an agreement on resolving these challenges

Product Model Data Needs to Transition Throughout the Life Cycle



- During design and construction phases a set of PDM and application tools capture and maintain product model data in native format
- However at any time during those phases, product model data may need to be transferred to external systems or archived
- These transfers should comply with the Ship Common Information Model (SCIM)

ISE Project and Interoperability

The ISE Project is Finding a Solution!

- **Interoperability between IPDEs or between systems within an IPDE is a major concern**
- **Interoperability Problem**
  - **Communication between diverse computer systems is a big challenge in today's environment:**
    - **As CAD/CAE/CAM systems have proliferated in the U.S. shipyards, interoperability among these systems has become a major issue**
    - **Interoperability is an issue within a shipyard as well as between partnering yards and with the Customer**
  - **This situation is further aggravated because:**
    - **Most recent and future ship contracts involve multiple shipyards**
    - **Length of time to design and build a ship often exceeds the life span of current computer systems, driving the need to move existing data to new computer systems**
    - **Requirements for life cycle support of the ship will far exceed the life span of current computer systems, again driving the need to move existing data to new computer systems**

ISE Interoperability Solution

- The Integrated Shipbuilding Environment Project (ISE) has attacked the interoperability problem on a broad front involving numerous standards, tools, and organizations including:
  - XML (Extensible Markup Language)
  - STEP (Standard for Exchange of Product Model Data)
  - isetools.org Website
- Drive development of shipbuilding product data standards
  - Construct a single shipbuilding information model
  - Demonstrate and educate U.S. shipbuilding community
- Develop and demonstrate tools that are low cost
  - Can be selectively used by shipyards to support interoperability
  - Capitalize on XML and related Internet technologies
- Accessible to large and small shipyards
  - Only system dependency is Web infrastructure
  - Utilizes open standards
- Permissive (mediation) architecture
  - Lets each enterprise choose its own tool set
- Amenable with CAD platforms used by U.S. shipbuilders

Adoption of ISE Information Models

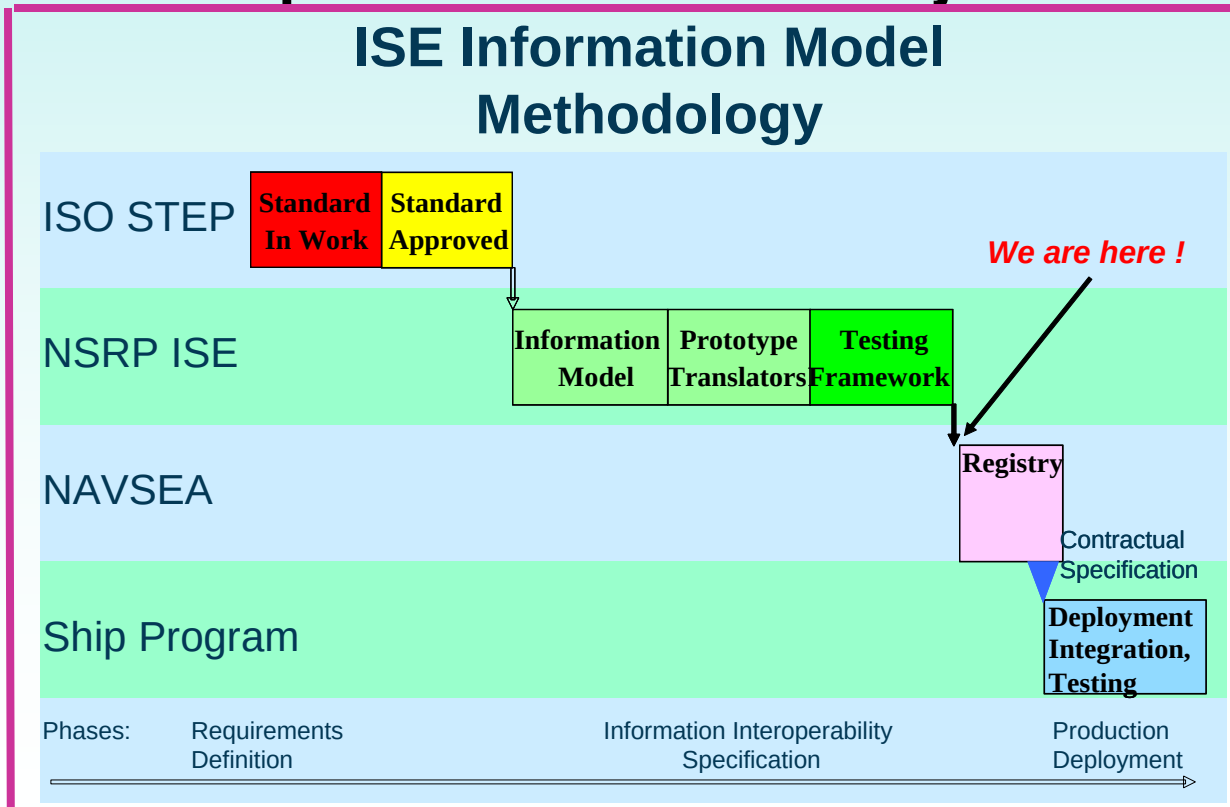
Diagram below of "ISE Information Model Methodology" was developed years ago to show plan for adoption of ISE information models

ISE Project has achieved the top two lines for the major product disciplines

- **Development**
- **Approval**
- **Prototype Testing of ISO Standards**

Models must now be:

- **Published**
- **Managed**
- **Invoked on Navy Contracts**
- **Implemented by Shipyards and Vendors**



What remains to be done…

- The information exchange requirements assembled by ISE have been published in a formal, XML-based notation
- Remaining work:
  Package the ISE work in a manner that is:
  - Fully documented and user-friendly
  - Usable by shipyard personnel, including non-IT specialists
  - Capable of validation
  - Suitable for contractual specification
  - Of practical use for agreements between shipbuilder and CAD/system vendors
- ILE Project is completing this remaining work – SCIM will be available for production use by 2012

ISE Developed the Basis for the Ship Common Information Model

- **Shipbuilding information requirements are a prerequisite both for IPDE implementation and for interoperability**
- **Over the past ten years ISE has formulated the U.S. Navy shipbuilding requirements:**
  - **Identifying from the comprehensive ISO standards, those requirements that apply to U.S. Navy shipbuilding**
  - **Formulating the technical approaches for implementation including:**
    - **Simplification of information models**
    - **Definition of an implementation-independent means of specifying information requirements**

SCIM is codifying the information models developed and prototyped under ISE

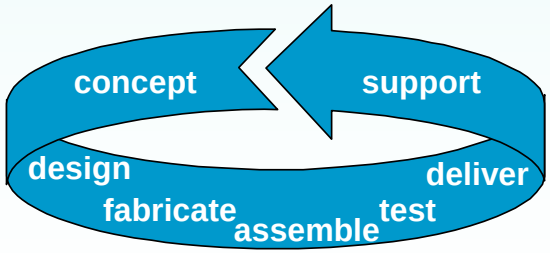
SCIM Background

The SCIM provides an information model that defines the data exchange requirements to enable interoperability among Shipyard and Navy systems

- **Background**
  - **Information models developed, prototyped, and tested under the NSRP Integrated Shipbuilding Environment (ISE) Project**
  - **SCIM is codifying the information models developed under ISE**
- **Association with NPDI IPDE Specification**
  - **Separate document referenced by IPDE Specification**
  - **SCIM will be placed on Web and made available to the Shipbuilding community**

SCIM is Based on (ISO 10303) - Standard for the Exchange of Product Model Data (STEP)

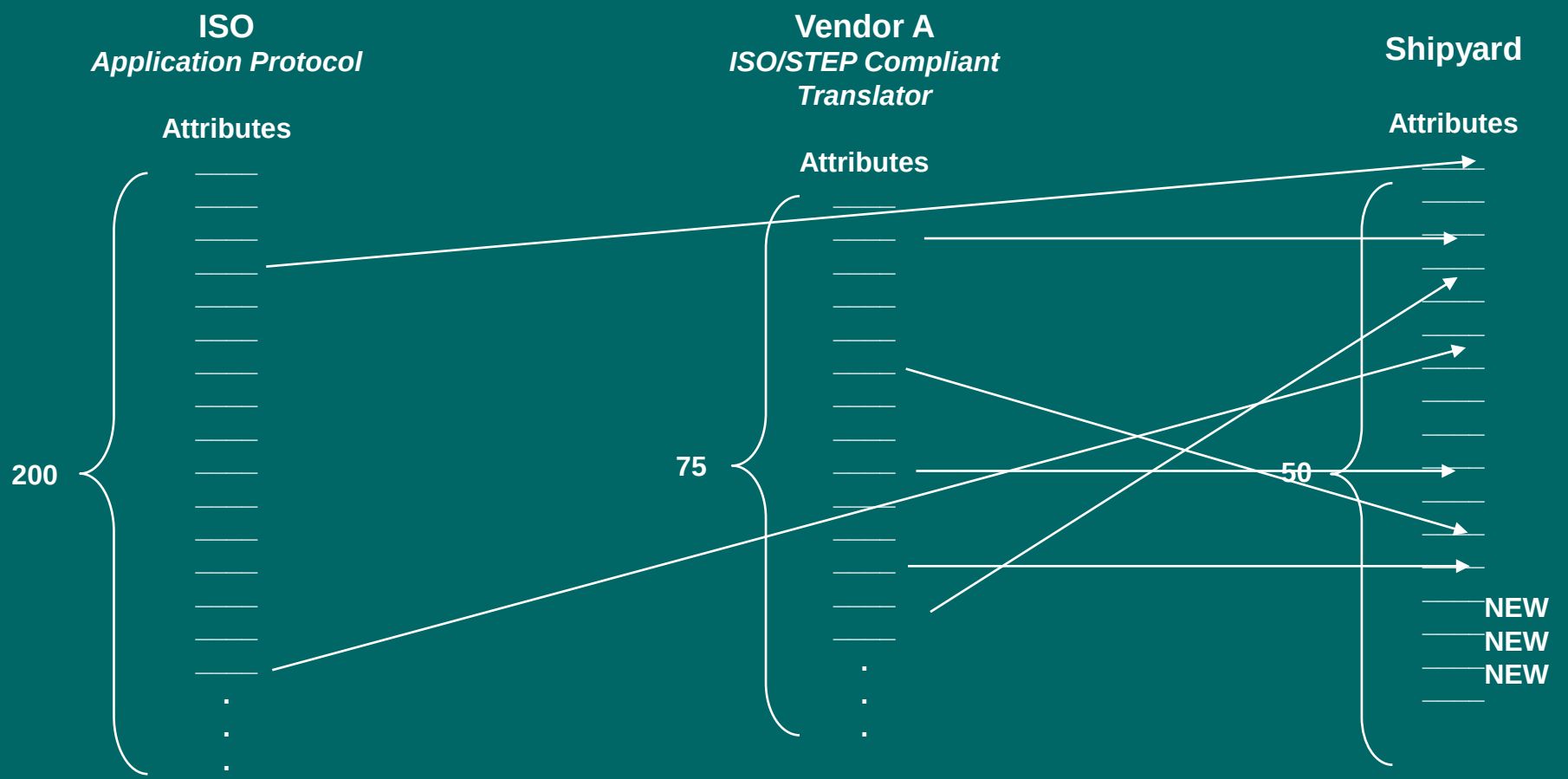
What is STEP?



...a computer interpretable definition of the physical and functional characteristics of a product throughout its life cycle

...an international standard (ISO 10303) for exchanging data between different systems (CAD, CAM, CAE and PDM)

Relationship of ISO Standards to SCIM Models



- Attributes and properties in SCIM models will be a subset of the attributes and properties in the associated STEP Standard
- They will be the subset required for U.S. shipbuilding product model exchanges

Justification for SCIM Philosophy

- Neutral file exchange requires translators from vendors
  - Minimal interest from CAD or PDM vendors has been shown in supporting the STEP Shipbuilding APs
  - Product data may reside in multiple systems of an IPDE, so (even when it is developed) a given vendor's translator may not be sufficient
  - SCIM allows for neutral file exchanges using ISO 10303-28 (STEP XML)
  - However, it also permits the use of other XML translators which may be available on the sending or receiving systems
    - Such a transfer would involve the use of a "Mediator"
- STEP APs contain more product data than is available in current IPDEs or at points in the design process where data must be exchanged
  - Even Conformance Classes in the STEP APs do not resolve this problem
  - SCIM attempts to define a subset of each STEP AP that contains a minimum information model and can be supported in today's IPDE environments
- It is recognized that this minimum subset may have to be modified to meet the needs of a particular program or ship class, but in general it should be very close to the desired solution

Layout of Each SCIM Section

- **Front Matter for Each Discipline**
  - Overview
  - Data Definitions of Terms
  - Usage Guides and Implementation Agreements
- **Content for Each Entity**
  - Entity Name
  - Definition
  - Intent
  - Motivation
  - Structure
  - Information Requirements
  - Properties
  - Implementation Consequences
  - XML

STEP APs to be Invoked by SCIM

- SCIM will define requirements for data transfer with entities and properties based on STEP APs
  - AP203 – Configuration Controlled Design
  - AP209 – Engineering Analysis
  - AP212 – Electrotechnical
  - AP215 – Ship Arrangements
  - AP216 – Ship Moulded Forms
  - AP218 – Ship Structures
  - AP227 – Plant Spatial Configuration for Ship Piping and HVAC
  - AP239 – Product Life Cycle Support

SCIM Application Areas

SCIM Chapters Completed

- PDM and Change Management Fundamentals
- Structural Moulded Forms
- Ship Arrangements
- Structural Detailed Design
- Piping Functional Design
- Piping Physical Design
- Common Parts: Procurement
- Product Life Cycle Support

To be Validated under Task 1

SCIM Chapters Required

- HVAC Functional Design
- HVAC Physical Design
- Electrotechnical Functional Design
- Electrotechnical Physical Design
- Engineering Analysis
- Pipe Stress Analysis
- Structural CAM

To be Developed under Task 2

Status of NPDI and SCIM Efforts

- IPDE Specification from NPDI Project has been completed and delivered to the Navy
- SCIM document development is underway
  - First eight sections are complete
  - Work on remaining seven sections will be completed as part of the current ILE Project
- SCIM is separate document from IPDE Spec
  - Will be referenced by IPDE Specification
    - Could be updated or revised independently of IPDE Spec
  - Is vital to enabling interoperability among various IPDEs

Relevant Definitions to Describe the SCIM

- **Data Model is an abstract model that describes how data is represented and used**
- **Schema is defined as a data model that represents the relationships of a set of concepts within a domain**
  - **XML Schema is a way to define the structure, content and, to some extent, the semantics of XML documents**
- **Data File Format is a particular way to encode information for storage in a computer file**

SCIM *provides a* ***Data Model*** *and associated* ***Schema***

STEP Part 28 *or* ***other XML*** *are possible* ***Data File Formats*** *that can be used to transfer the* ***SCIM Data Models***

Integrated Logistics Environment (ILE) Project Tasks

- **Task 1 – Tools and Methods for Supporting the Next Generation Shipbuilding IPDE** ***(SCIM Evaluation)***
  - **Subtask 1.1 – Migrating VIRGINIA Class IPDE Data**
  - **Subtask 1.2 - Exchanging Structural Design Data with Manufacturing Systems**
- **Task 2 – Completion of the Ship Common Information Model** ***(SCIM Development)***

ILE Project Objectives

- **Apply the tools and methods developed by the ISE team to two current shipbuilding requirements**
  - **VIRGINIA Class IPDE data migration**
  - **Sharing of structural design data with manufacturing systems across shipyards**
- **Demonstrate the use of the NPDI SCIM as a means for supporting Shipyard and Navy interoperability**
- **Validate that the SCIM chapters meet Navy and Shipyard requirements for specific data exchange scenarios**
- **Complete the development of the SCIM**

Subtask 1.1

- Migrating VIRGINIA Class IPDE Data
- VIRGINIA has been designed in an IPDE environment featuring CATIA and CDM
- Migration is currently underway to a new IPDE featuring NX and TeamCenter
- VIRGINIA design and construction efforts will continue for several more years, so the VIRGINIA product models must be successfully moved to the new IPDE
- Task is led by Electric Boat Corporation

Subtask 1.1 Objectives

- **Tools and Methods for Supporting Next Generation Shipbuilding IPDE (SCIM Evaluation)**
  - **Demonstrate the capabilities of the NPDI SCIM as the means for supporting the next generation IPDE**
- **Subtask 1.1 - Migrating VIRGINIA Class IPDE Data**
  - **This subtask will apply the tools and methods developed by the ISE team to the VIRGINIA Class IPDE data migration**
  - **Moreover, this subtask will use the NPDI Ship Common Information Model (SCIM) as the basis for this pilot**
  - **As a result, this subtask will potentially benefit the VIRGINIA program, but its primary objective will be to validate and demonstrate the capabilities of the SCIM**

VIRGINIA Class IPDE Data Migration

- VIRGINIA Class submarine is in the midst of its production cycle with several more hulls pending
- VIRGINIA Class IPDE
  - Platform is approaching its end of life and EB is in the process of implementing a new next generation IPDE
  - Highly customized solution that evolved and grew as the VIRGINIA Class design progressed and as new requirements and issues revealed themselves
- Exact entities, attributes, properties, and relationships that must be migrated to the new IPDE are not obvious
- Several difficult technical questions must be resolved before a successful data migration can be completed

Extraction of Piping & Structural Models

- SCIM is intended to provide the information requirements to guide the extraction of product data and specifies the entities, attributes, and properties required
- SCIM was not available in time to support early efforts of VIRGINIA data migration
- Thus this task will be primarily focused on validating the SCIM, rather than on assisting VIRGINIA Class data migration
- Focus will be on piping and structural models
  - These represent a major portion of the VIRGINIA product model
  - SCIM chapters relating to these disciplines have already been completed
  - Some piping and structural models have been translated to the NX/TeamCenter environment
  - These will be extracted from NX/TeamCenter in XML and transformed to SCIM representation
  - SCIM models will be analyzed manually to identify errors or discrepancies

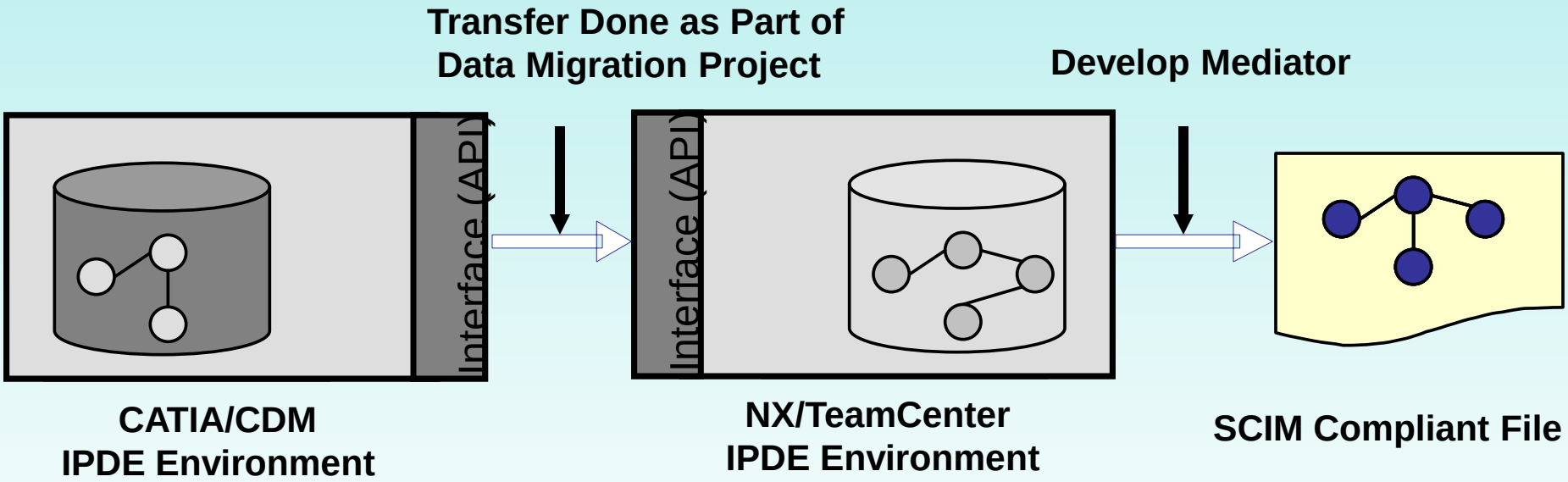
Load CATIA/CDM Models into NX/TeamCenter Environment

- Translators and/or mediators will be developed as required to load the CATIA/CDM models into the new IPDE environment using NX and TeamCenter
- These models can be evaluated in the new IPDE as far as completeness and accuracy
- Models will be processed on the new system to verify their validity and completeness

Translate Models from NX/TeamCenter into SCIM Format

- As part of the Data Migration Project, some piping and structural models have been extracted from CATIA/CDM and loaded into the NX/TeamCenter environment
- Models are reviewed for completeness and accuracy to validate the data migration model
- Piping and structural models are extracted from NX/TeamCenter (using PLMXML) and translated into SCIM format using an XML mediator
- Validation will then be done on the resulting SCIM files
- This approach enables validation of the SCIM format and will reveal any errors or discrepancies in that format, while it takes advantage of the work already done in the VIRGINIA Data Migration Task

Diagram of SCIM Validation Effort



- Requires development of only one mediator
- Can evaluate if model is well represented by current SCIM or by proposed modifications to SCIM
- Builds upon results of VIRGINIA Data Migration Project

Validate SCIM Models - Note Any Deficiencies

- Any deficiencies revealed in the SCIM chapters relating to piping or structures will be noted and corrected as part of Task 2 under the ILE Project
- Also, if difficulties are encountered in using the SCIM because of incompleteness or lack of clarity in the SCIM descriptions, an attempt will be made during Task 2 to improve the format of all the SCIM chapters to resolve these problems

SCIM Chapters Needed for VIRGINIA Migration

- This task will be attempting to validate the SCIM approach and will be looking in detail at the information models in four different SCIM chapters
  - Product Data Management (PDM)
  - Piping Physical
  - Piping Functional
  - Structural Detailed Design

Current Status of Subtask 1.1

- Information models for data migration were developed at Electric Boat and have been compared with SCIM piping and structural models
- This analysis is leading to improvements in the data migration models, as well as recommended enhancements to the SCIM
- Mediators are being developed to map the migrated data models into SCIM format for piping and structural data
- When completed this mapping will enable evaluation of how the SCIM formats support the VIRGINIA data migration effort

Subtask 1.2

- Exchanging Structural Design Data with Manufacturing Systems
- Focus on applicability of the SCIM for exchange of structural product models on two current design and manufacturing projects
  - DDG 1000
  - CVN 21

Subtask 1.2 Objectives

- **Demonstrate use of the NPDI SCIM as means for supporting Shipyard and Navy interoperability**
- **Address data sharing challenge in multiple shipyard development environments**
  - **Exchange of structural design between prime designer and manufacturing, either in same shipyard or second shipyard**
- **Validate and demonstrate capabilities of the SCIM on current programs**
- **Recommend improvements to SCIM**

Participants

- Huntington Ingalls Industries – Ingalls
- Huntington Ingalls Industries – Newport News
- Northrop Grumman Technical Services
- Product Data Services Corporation

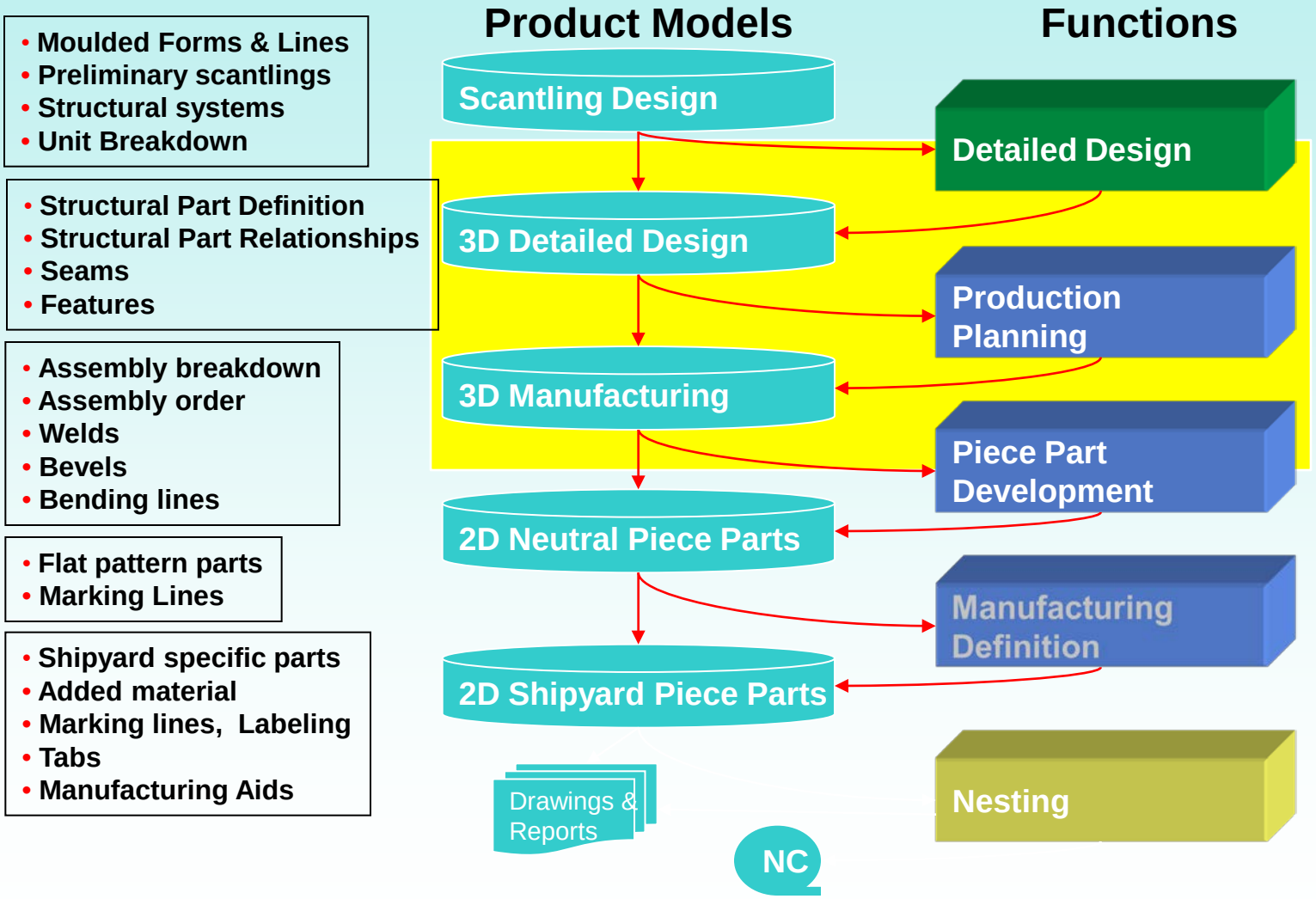
Approach

- Define the data model for the exchange of structural design data with manufacturing using existing programs as examples
- Compare the data model to the SCIM data model
- Identify gaps in the SCIM data model
- Make recommendations for improving the SCIM

Business Context

- **Used NSRP Integrated Steel Processing Environment (ISPE) Common Process Model to define the Business Context for the task**
  - **Reviewed by HII-Ingalls and HII-NNS to confirm applicability**
- **Focus on exchange of Design Product Model with manufacturing in order to perform production planning function and develop Manufacturing Product Model**

Diagram of Business Context



Business Functional Requirements

- Describes high level business functional requirements for the shipyard common process
- Functional requirements described as a set of use cases and provide the basis for deriving the data requirements
- ISPE common process areas serve as three high level use cases within the shipyard environment:
  - Create Detailed Design Product Model
  - Create Manufacturing Product Model and Parts
  - Manufacture Ship

Diagram of Business Functional Requirements

Planning

- Scheduling
- BOM maintenance
- Unit arrangements
- Assembly sequences

Material Mgmt

- Material Requirements
- Procurement
- Material tracking

Preliminary Design

- Hull Form Development
- Fairing
- Naval Architecture
- Scantlings

Detailed Design

- Interference Checking
- Penetrations
- Detailed Design Product Model

Create Detailed Design Product Model

Mfg Product Model

- Bevels, Welds, End cuts
- Construction Drawings
- Mfg Product Model

Lofting

- Shell Plate Development
- Nesting
- Part Generation
- Work Packages
- Mfg Aids

Create Manufacturing Product Model and Parts

Production Control

- Work Orders
- Production oversight

Production

- Fabrication
- Assembly
- Plate/Profile cutting

Manufacture Ship

Structural Model Requirements

- Analyze data exchange between design and manufacturing for current programs
  - DDG 1000
  - CVN 21
- Focus on structural design data required for manufacturing
  - Detailed design product model used to perform production planning activities

Use of SCIM

- Use SCIM chapter based on STEP AP 218 (Ship Structures) as starting point
- Include additional SCIM chapters as necessary, such as Product Data Management (PDM)
- Augment SCIM chapters as necessary to include required manufacturing data

Validate SCIM

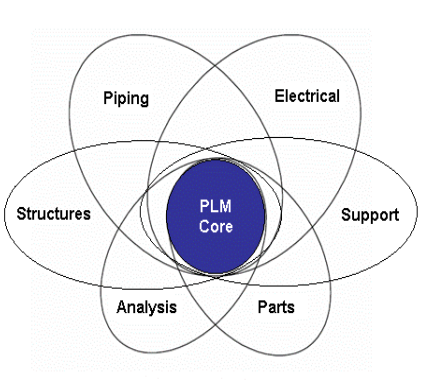
- **Validate that the SCIM chapters meet Navy and Shipyard requirements for specified data exchange scenarios**
- **Correct SCIM Structural Design Data deficiencies in future releases of SCIM**
- **Make recommendations for improving SCIM usability, including completeness and clarity of SCIM descriptions, format and content**
  - **Consider eliminating the planned SCIM Chapter on "Structural CAM" and instead including the required entities in the Structural Detailed Design Chapter with an indication of which apply only for a manufacturing exchange**

Current Status of Subtask 1.2

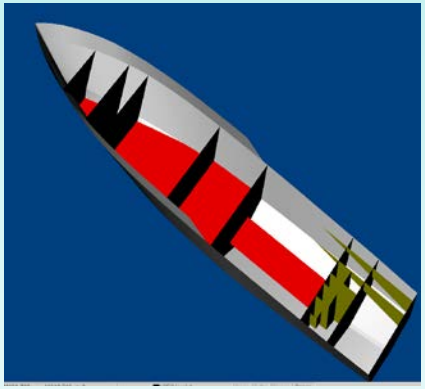
- Analyzed current SCIM structural design chapter against STEP AP 218 to understand data and scope of SCIM
  - Noted potential issues that need to be addressed
- Coordinated with HII-Ingalls DDG 1000 IDE team
  - Analyzed CATIA to Teamcenter Enterprise (TcE) interface
  - Analyzed TcE to Teamcenter Manufacturing (TcM) interface
  - Documented Design to Manufacturing data exchange requirements
- Coordinated with HII-NNS CVN 21 Team
  - Analyzed CVN 21 design to manufacturing data exchange
  - Documented Design to Manufacturing data exchange requirements
- Developed Structural Model Import Requirements Report
  - Leveraged analysis and data produced for ISPE Project as a framework for organizing and analyzing data
- Developed Structural Model Gap Analysis Report
  - Analyzed gaps between shipyard data and SCIM structural design chapter

Completed Sections of the SCIM

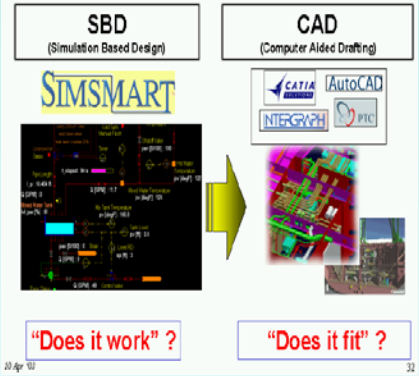
PDM and Change Management Fundamentals



Ship Arrangements

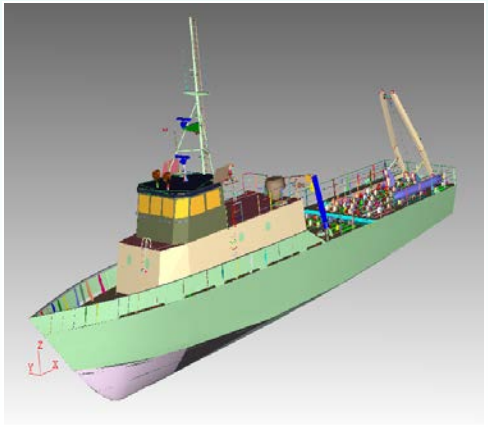


Piping Functional Design

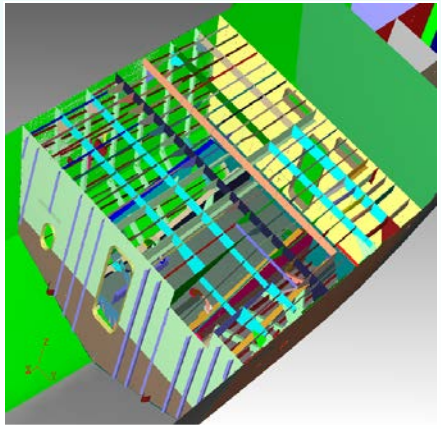


Common Parts: Procurement

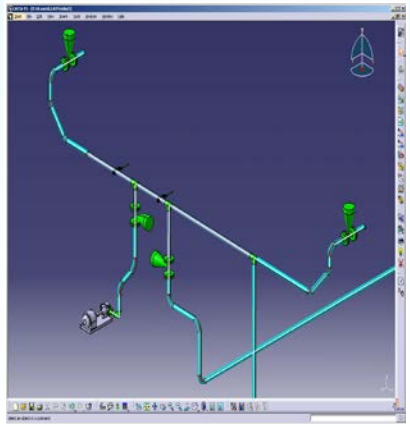
Structural Moulded Forms



Structural Detailed Design



Piping Physical Design

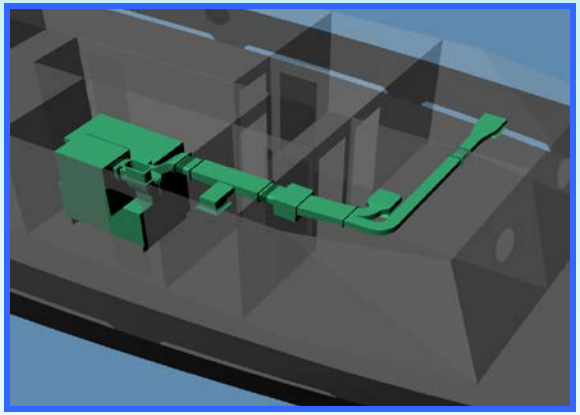


Product Life Cycle Support

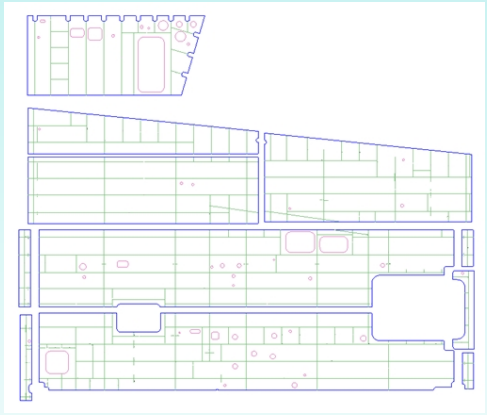
- SCLSIS/CDMD-OA for Navy Logistics
- S1000D Electronic Document Authoring

Sections of SCIM to be Completed in ILE Phase 2

HVAC Functional & Physical Design

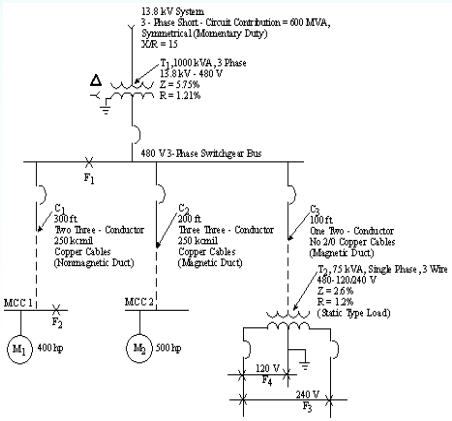


Structural CAM

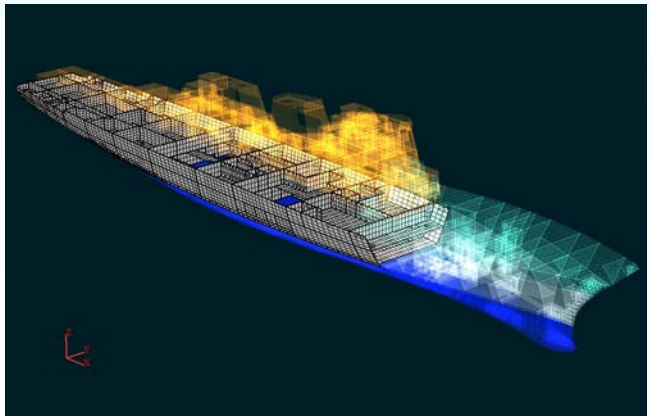


Pipe Stress Analysis

Electrotechnical Functional & Physical Design



Engineering Analysis



Relationship of the SCIM to other Ship Product Model Data Exchange Standards

- The ISO STEP Ship Application Protocols define the requirements for sharing data between and among Shipyards, the Navy, Commercial ship owners, and Classification Societies
- CAD Vendors have not implemented the ISO Ship APs as Shipbuilding is a small part of their customer base
- The U.S. Yards and Navy need a version of the ISO Ship APs that are implementable in-house and fulfill just the requirements for Navy shipbuilding
- The SCIM subsets the ISO STEP Ship AP Object definitions to what is needed just for Navy ships, in a data format (XML) that can be extracted from commercial CAD/PDM systems, and that can be cost-effectively supported by Shipyard IT developers

Adopting the SCIM for Production Use

- The Shipyards need to share data among pieces of their IPDE Design and Manufacturing solutions
- The Shipyards need to share data with their co-design and manufacturing partners
- The Shipyards need to deliver data to the Navy, and the Navy to the Shipyards
- Data in SCIM format can feed later lifecycle uses such as AP239 Ship Logistics support, simplified product model visualization, and part information within the Navy's systems
- The SCIM will be completed and available for production use by 2012

Conclusion

- There has been significant investment in interoperability and data exchange standards by the Shipyards and Navy through NSRP
- ILE Project is validating and publishing the results of this investment
- Next step is to implement the SCIM for specific high priority data exchange scenarios within the Shipyards and Navy
- Need feedback from Shipyards, Navy, and NSRP on candidate scenarios for implementation