Ship Product Model Data Exchange

Ben Kassel

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Who wants product data…
What data do they want …
When do they want it?

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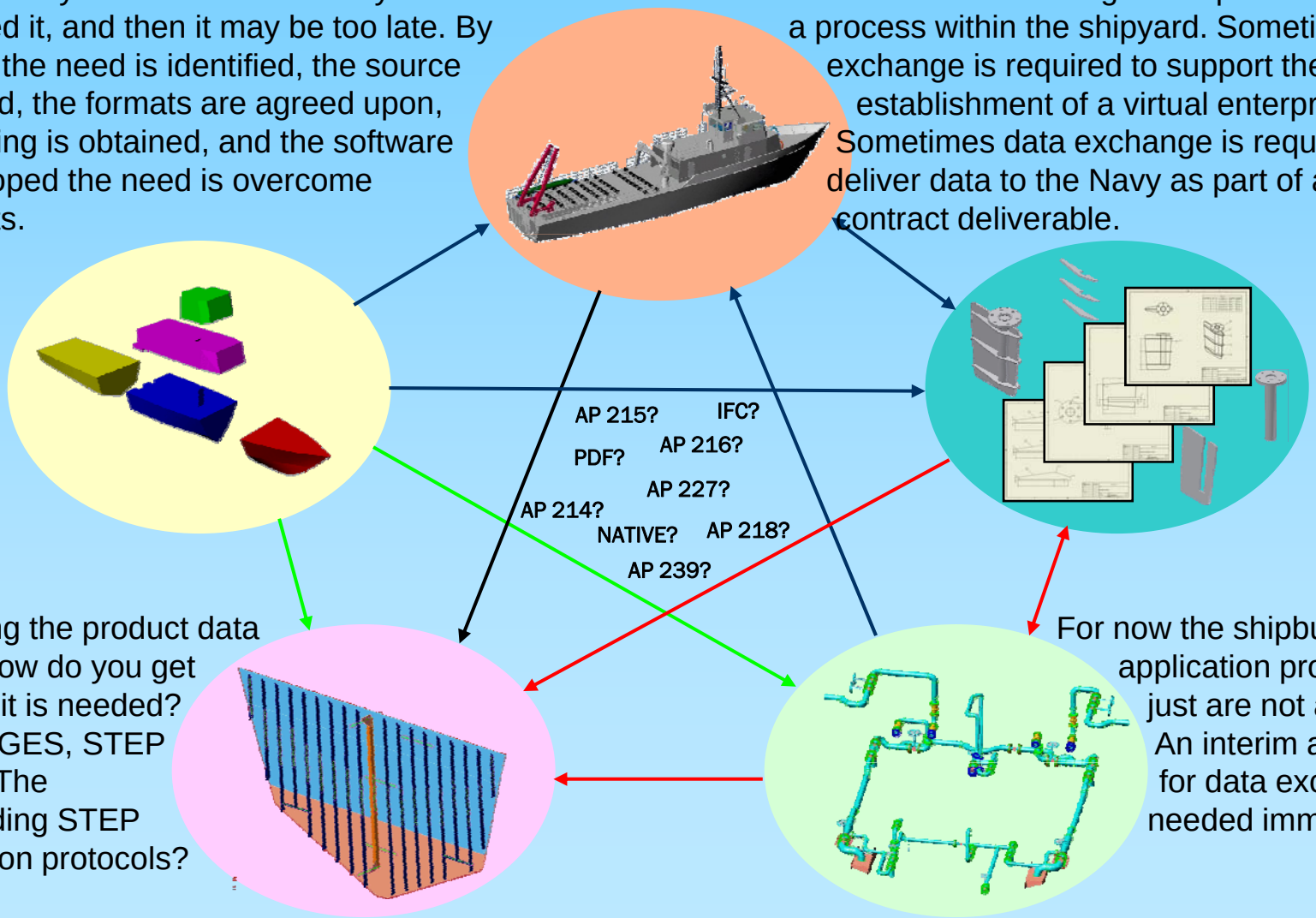
Nobody really knows what data they want until they need it, and then it may be too late. By the time the need is identified, the source is located, the formats are agreed upon, the funding is obtained, and the software is developed the need is overcome by events.

Sometimes data exchange is required to support a process within the shipyard. Sometimes data exchange is required to support the establishment of a virtual enterprise. Sometimes data exchange is required to deliver data to the Navy as part of a contract deliverable.



Assuming the product data exists, how do you get it where it is needed? Native, IGES, STEP AP203, The shipbuilding STEP application protocols?

For now the shipbuilding application protocols just are not available. An interim approach for data exchange is needed immediately!

Product Model Data

A brief review

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Product Model data is the combination of 3D geometry and non-graphic attributes to define ship objects such as a piece of equipment, deck, bulkhead, etc. Product Model data can be organized to define interim products and ultimately the entire ship.

Part & System Definition (Caterpillar 3512, Starboard Main Engine, Propulsion System)

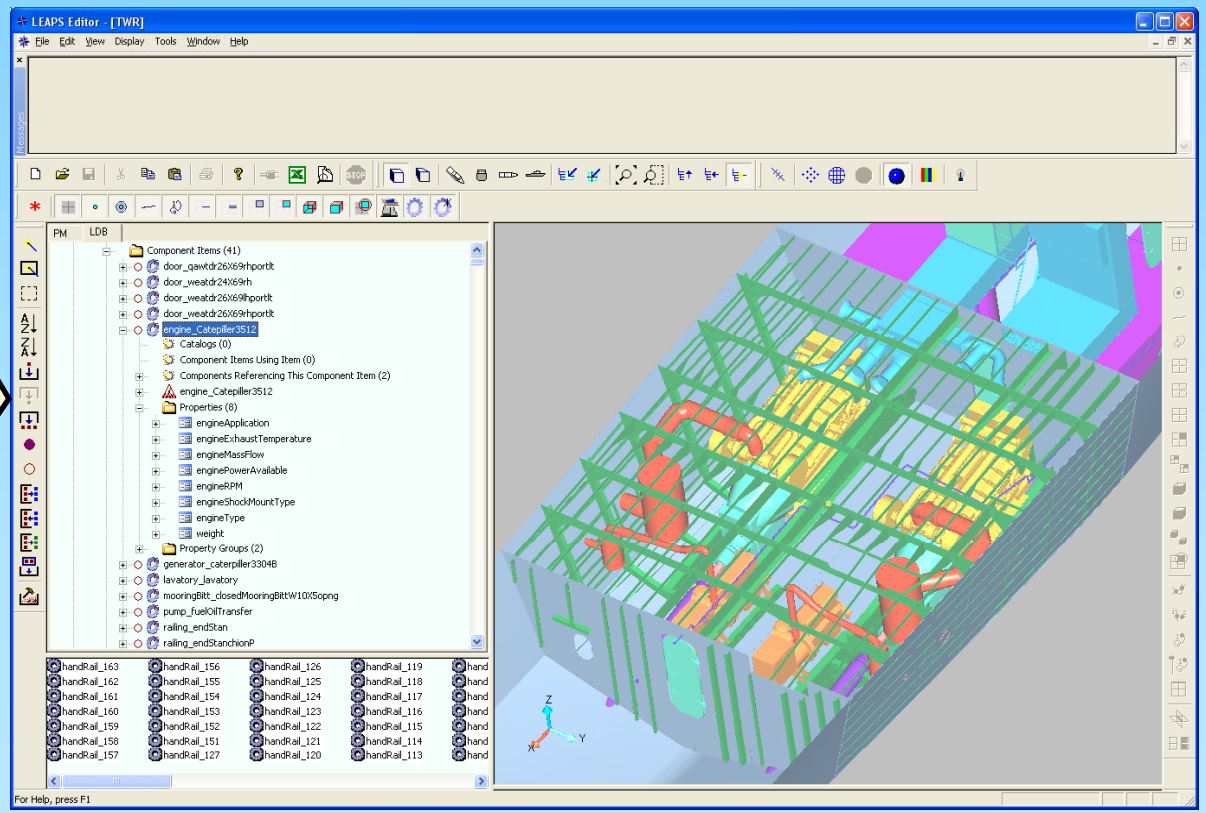
Design Definition (12 cylinder 4 stroke diesel engine)

Physical (Geometry, material connections, etc.)

Engineering Definition (1175 HP, 6464kg, 170mm bore, 190mm stroke)

Process Definition (Starting instructions, shaft alignment)

Logistics Support (FGC, SCLSIS, etc.)



Advocates anticipate substantial economies from Product-Model-based design, construction, and service-life support activities due to better integration and reduction of engineering effort to locate, verify, and transform information.

Product Model Data and Exchange

Current Policy

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DON Policy stipulating that product model data should be delivered in STEP format

NAVSEA instruction for the development, maintenance, and acquisition of product model data

THE ASSISTANT SECRETARY OF THE NAVY
Research Development and Acquisition
1000 Navy Pentagon
Washington DC 20350-1000

OCT 23 2004

MEMORANDUM FOR DISTRIBUTION

Subj: DON POLICY ON DIGITAL PRODUCT/TECHNICAL DATA

Ref:
(a) DEPSECDEF Memorandum, "Policy for the Transition to a Digital Environment for Acquisition Programs", 2 July 1999
(b) USD (A&T) Management Reform Memorandum #2, "Moving to a Paper-free Contracting Process by January 1, 2000", 21 May 97 w/Addendum, 29 July 1997
(c) USD (A&T) Memorandum, "Guidance for the Transition to a Digital Environment for Acquisition Programs", 15 July 1997
(d) USD A&T Memorandum, "Transition to a Digital Environment for Acquisition Programs (Paperless Program Office)", 15 April 1999
(e) SECNAVINST 5000.36, Department of the Navy Data Management and Interoperability, 1 November 2001
(f) GENADMIN/CNO Washington DC/032300ZAPR2001, "Implementing the Web Enabled Navy"
(g) Web-Enabled Navy Logistics Integration (WEN-L) Plan, June 2001
(h) NAVAIR ltr Ser AIR-3.3/005, "Digital File Formats Required for Technical Data Repository and Distribution Management", 1 May 2003
(i) DoD Directive 5230.24, Distribution Statements on Technical Documents, 18 March 1987
(j) SECNAVINST 5000.2B, "Implementation of Mandatory Procedures for Major and Non-major Defense Acquisition Programs and Major and Non-major Information Technology Acquisition Programs", 6 December 1996
(k) DOD Directive 5000.1, "The Defense Acquisition System", 12 May 2003
(l) DoD Memorandum on the DoD Information Technology Standards Registry (DISR), 15 July 2004; DoD CIO, USD AT&L, and JS
(m) Joint Aeronautical Commanders Group, Strategy for Product Data Throughout the Life Cycle, 8 May 2002
(n) DISA DIICOE, Version 3.1, Baseline Specifications, 29 April 1997
(o) Global Information Grid, Overarching Policy, DoD Directive 8100.1, 19 Sept 2002
(p) ASN RDA Memorandum on Summary of FORCEnet EXCOM, 19 February 2004, ASN RDA
(q) SECNAVINST 4105.1A, Independent Logistics Assessment (ILA) and Certification Requirements
(r) DON Independent Logistic Assessment Handbook, NAVSO P-3692, December 2003

This memorandum updates existing DoN Policy for Digital Product/Technical Data. New business practices relying on the use of digital methodologies and products have generated significant cost savings, reduced process cycle times and expanded capability for

DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
2531 JEFFERSON DAVIS HWY
ARLINGTON VA 22242-5160

IN REPLY REFER TO

NAVSEAINST 9040.3
Ser 043/056
4 Mar 98

NAVSEA INSTRUCTION 9040.3

From: Commander, Naval Sea Systems Command

Subj: DEVELOPMENT, MAINTENANCE, AND EXCHANGE OF PRODUCT MODEL DATA BY SHIP AND SYSTEM PROGRAMS

Ref:
(a) NAVSEAINST 4120.7
(b) NSRP Document No. 0424, NIDDESC Piping Application Protocol
(c) NSRP Document No. 0425, NIDDESC Electrical/Cableway Application Protocol
(d) NSRP Document No. 0426, NIDDESC Heating, Ventilation, and Air Conditioning (HVAC) Application Protocol
(e) NSRP Document No. 0428, NIDDESC Outfit and Furnishings Application Protocol
(f) NSRP Document No. 0429, NIDDESC Ship Structure Application Protocol
(g) NAVSEA Technical Manual T0750-AH-PRO-010/CAD 2, 3D Product Modeling Practices Manual
(h) MIL-PRF-28000
(i) MIL-STD-1840

1. Purpose

a. To provide policy for developing, maintaining, and using three dimensional (3D) computer generated product models and associated data files in support of Navy ships and ship systems during all phases of design, acquisition, construction, conversion, repair, maintenance, modernization, and in-service life cycle support.

b. To insure data transfer mechanisms and standards are implemented to effectively provide for the exchange of 3D Computer Aided Design (CAD) product model data, including digital design and engineering information between Department of the Navy (DON) activities, commercial shipbuilders, suppliers, and other marine industry organizations.

2. Applicability and Scope

a. This instruction applies to all ship and ship system design, acquisition, construction, conversion, repair, maintenance, modernization, and life cycle support programs under the cognizance of NAVSEA and/or supporting shore activities.

0693-LD-014-8740

STEP Shipbuilding Application Protocols

NAVSEA commitment to standards

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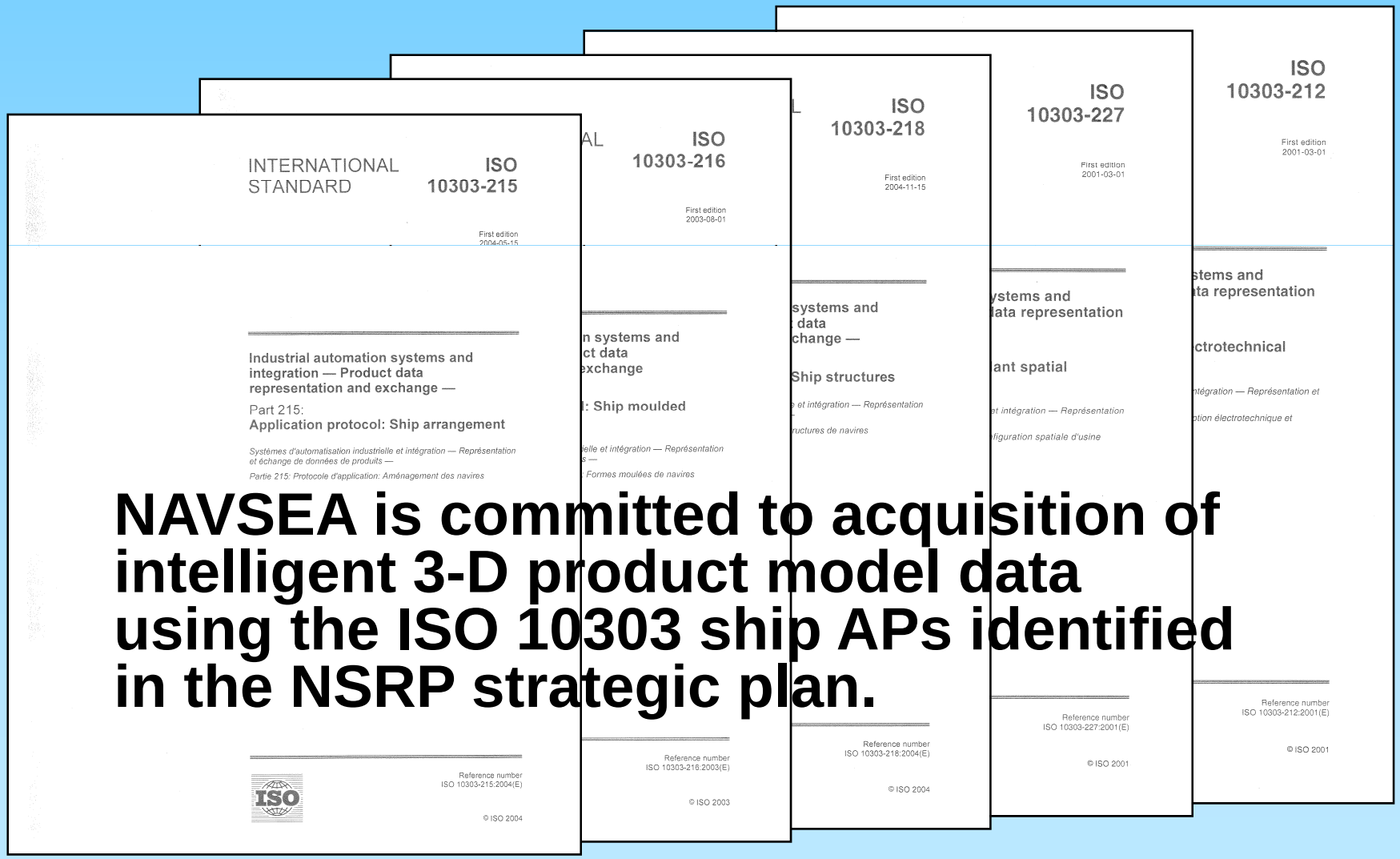

NAVSEA is committed to acquisition of intelligent 3-D product model data using the ISO 10303 ship APs identified in the NSRP strategic plan.

STEP Application Protocols

applicable to ships and ship systems

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Ship Product Model Data Exchange
ISO TC 184/SC 4/WG 3

AP 233 Systems Engineering Data Representation
AP 239 Product Life-cycle Support

Ship Structural Envelope

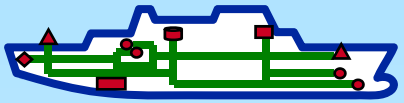
- Ship Arrangement ISO AP 215:2004
- Ship Moulded Forms ISO AP 216:2003
- Ship Structures ISO AP 218:2004

Distribution Systems

- Piping (Plant Spatial Configuration) ISO AP 227 E2:2005
- HVAC (Plant Spatial Configuration) ISO AP 227 E2:2005
- Cable Trays (Plant Spatial Configuration) ISO AP 227 E2:2005
- Mechanical Systems (Plant Spatial Configuration) ISO AP 227 E2:2005
- Electrical (Electrotechnical Design & Install) ISO AP 212:2001

Equipment/Subsystems

- Parts Library ISO 13584
- Reference Data Libraries ISO 15926



- Ship Structural Envelope (hull form, arrangements, structure)
- Distributed Systems (piping, electrical, HVAC, cable trays, mechanical)
- Equipment/Subsystems

Miscellaneous

- Finite Element Analysis ISO AP 209:2001
- Computational Fluid Dynamics ISO AP 237
- Logistics/Spares ISO AP 232:2002
- Automotive ISO AP 214:2001

Business as Usual

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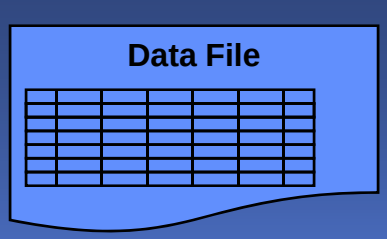

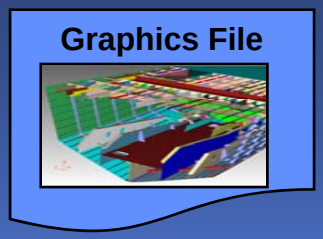

- Proprietary format graphics
- Proprietary format data
- No linkage between data and graphics
- EXPENSIVE, SLOW, UNTENABLE

Full Shipbuilding Exchange

the long term solution

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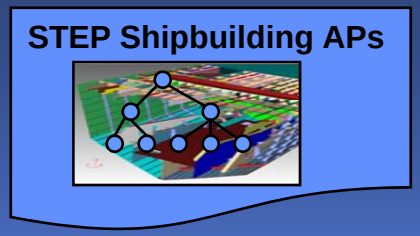

- Single STEP standard file
- Integrated product structure, graphics, and data
- Parameterized components
- Logical and geometric relationships

New Ship Programs Today

current implemented state of the art

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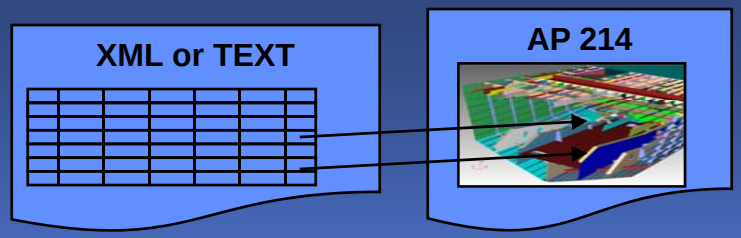

- STEP standard graphics
- Attribute data, no product structure
- Minimal linkage between data and graphics
- The beginning of the path

Interim Approach

the compromise is achievable today

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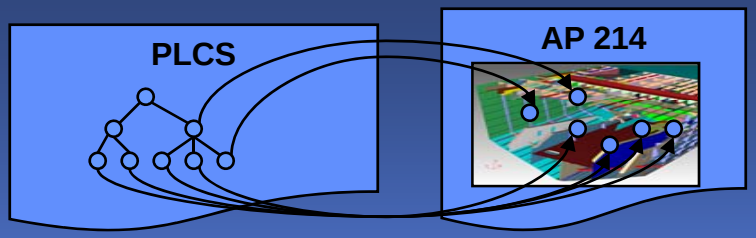

- STEP standard graphics
- STEP standard product structure
- STEP standard properties
- Linkage between product structure and graphics
- Potential state of the art achievable today

Interim Approach

Remind me, why aren't we using the Ship STEP AP's?

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- Name 2 commercial CAD systems that can process AP215, or AP216, or AP218, or AP227, or, …?
- The Ship STEP application protocols are relatively unstable; between AIM implementations, ARM implementations, varying degrees of interpreting the schema, each prototype has basically been developed to a different schema.
- NAVSEA has not really been adamant enough about the delivery of digital data, let alone the format of the digital data.
- The shipbuilders have never embraced Ship STEP application protocols to support interprocess communications within the enterprise.
- The shipbuilders have never demanded a Ship STEP translation capability from their product model vendors.

Interim Approach

Why do we need it?

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NAVSEA intends to use AP 214 as a migration strategy to overcome technical, contractual, and cultural resistance

- CAD vendors can deliver AP 214 software now.
- Shipyards can deliver 3-D AP 214 data to NAVSEA now
- JEDMICS is preparing to accept AP 214 3-D data for long-term DoD support
- AP 214 initiates a technical migration to more complex fully attributed 3-D ship geometry that will drive analysis, manufacturing, and support
- AP 214 defuses the shipyards comments that STEP data is too expensive to deliver
- AP 214 can provide needed 3-D information for part library/catalog items.

Interim Approach

What is it?

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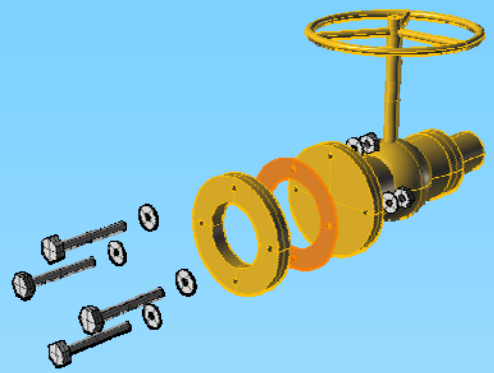
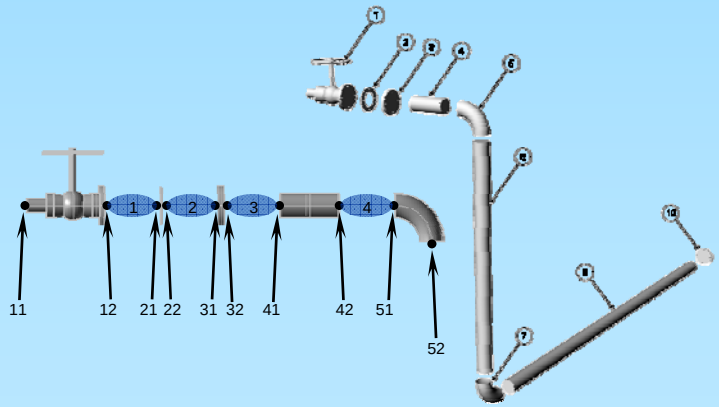


AP203 or AP214 to define shape.

AP239 to define product structure and the relationships between objects.



Product Structure

AP239 System Breakdown

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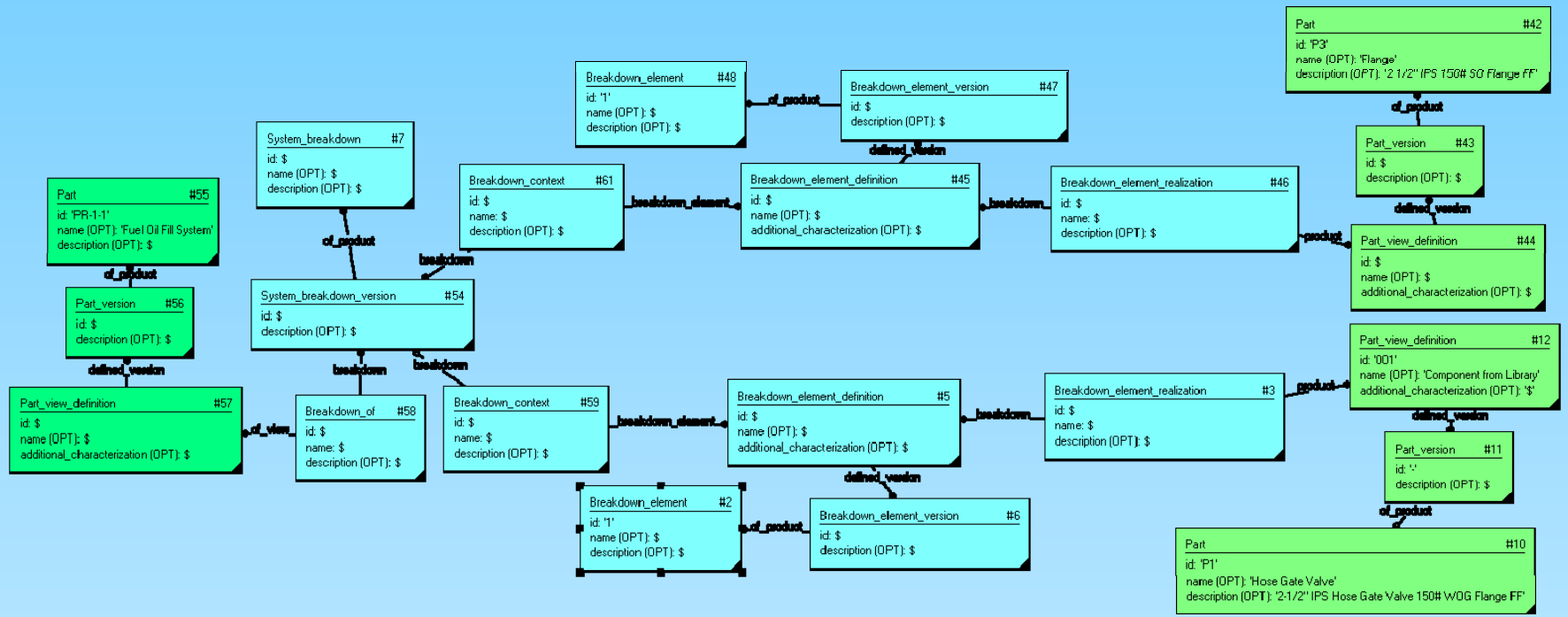

- The Fuel Oil System is treated in AP239 as a PART.
- Each component in the system is treated in AP239 as a PART.
- Basically a system can be a part and a part can be a system.
- Systems and assemblies are fundamentally similar. They are an aggregation of parts.

System Connectivity

AP239 Interface Connection

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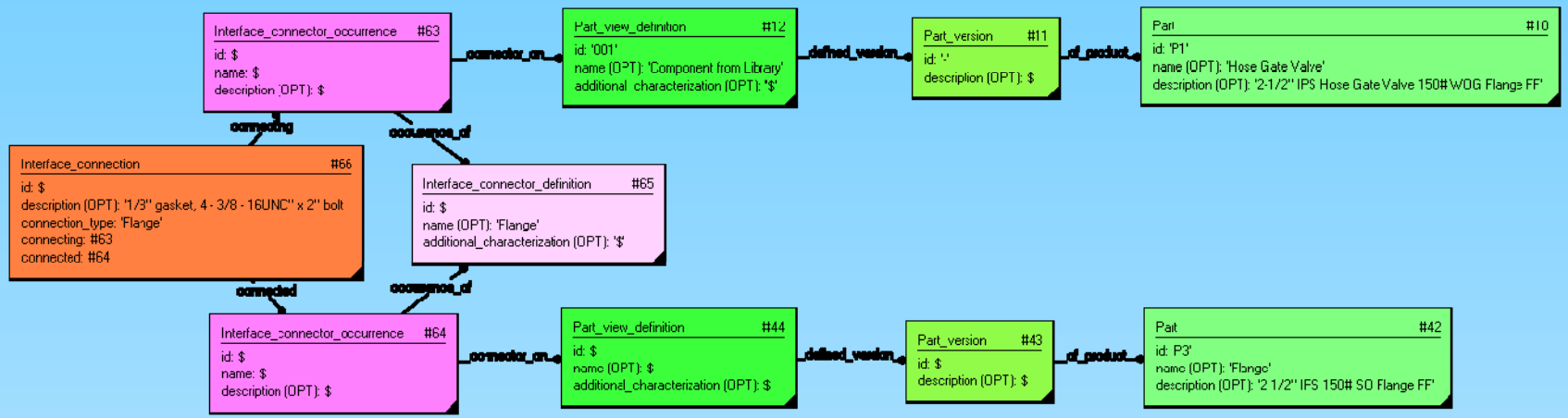

- A connector is associated to a PART.
- A connection is made by associating two connectors.

Distribution System Definition

Simplified physical file

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```
ISO-10303-21;
HEADER;
FILE DESCRIPTION(('Description'),'2;1');
FILE_NAME('connectionExample2.p21','2007-07-22T22:48:56',
('someone'),(''),'', 'GraphicalInstance 1.0 Beta 5
[1.0.5.18]','');
FILE_SCHEMA(('AP239_PRODUCT_LIFE_CYCLE_SUPPORT_ARM_LF'));
ENDSEC;
/* - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - */
/* * * * * * * * EUROSTEP SOFTWARE PREVIEW * * * * * * * */
/*    THE DATA (OR ITS SYNTAX) CONTAINED IN THIS FILE  */
/*    MAY NOT BE VALID - BETA RELEASE                  */
/* - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - */
DATA;
/* Part that defines the system */
#55=PART('PR-1-1','Fuel Oil Fill System',$);
#56=PART_VERSION($,$,#55);
#57=PART_VIEW_DEFINITION($,$,$,$,(),#56);

/* Hose Gate Valve */
#10=PART('P1','Hose Gate Valve','2-1/2" IPS Hose Gate
    Valve 150# WOG Flange FF');
#11=PART_VERSION('-',$,#10);
#12=PART_VIEW_DEFINITION('001','Component from
    Library','$',$,(),#11);

/* Flange */
#42=PART('P3','Flange','2 1/2" IPS 150# SO Flange FF');
#43=PART_VERSION($,$,#42);
#44=PART_VIEW_DEFINITION($,$,$,$,(),#43);
```

```
/* Fuel Oil Fill System Definition */
#58=BREAKDOWN_OF($,$,$,#54,#57);
#54=SYSTEM BREAKDOWN VERSION($,$,#7);
#7=SYSTEM_BREAKDOWN($,$,$);

/* Hose Gate Valve as member of Fuel Oil Fill System */
#59=BREAKDOWN_CONTEXT($,$,$,#54,#5);
#5=BREAKDOWN_ELEMENT_DEFINITION($,$,$,$,(),#6);
#6=BREAKDOWN ELEMENT VERSION($,$,#2);
#2=BREAKDOWN_ELEMENT('1',$,$);
#3=BREAKDOWN_ELEMENT_REALIZATION($,$,$,#5,#12);

/* Flange as member of Fuel Oil Fill System */
#61=BREAKDOWN_CONTEXT($,$,$,#54,#45);
#45=BREAKDOWN ELEMENT DEFINITION($,$,$,$,(),#47);
#47=BREAKDOWN_ELEMENT_VERSION($,$,#48);
#48=BREAKDOWN_ELEMENT('1',$,$);
#46=BREAKDOWN_ELEMENT_REALIZATION($,$,$,#45,#44);

/* Connection between hose gate valve and flange */
#66=INTERFACE CONNECTION($,$,'bolted',#63,#64);
#65=INTERFACE_CONNECTOR_DEFINITION($,$,'1/8" gasket,4 - 3/8
    16UNC" x 2" bolt ',$,(),$,$);
#64=INTERFACE_CONNECTOR_OCCURRENCE($,$,$,#65,#44);
#63=INTERFACE_CONNECTOR_OCCURRENCE($,$,$,#65,#12);
ENDSEC;
END-ISO-10303-21;
```

Product Model Data and Exchange

Design and Analysis Environment

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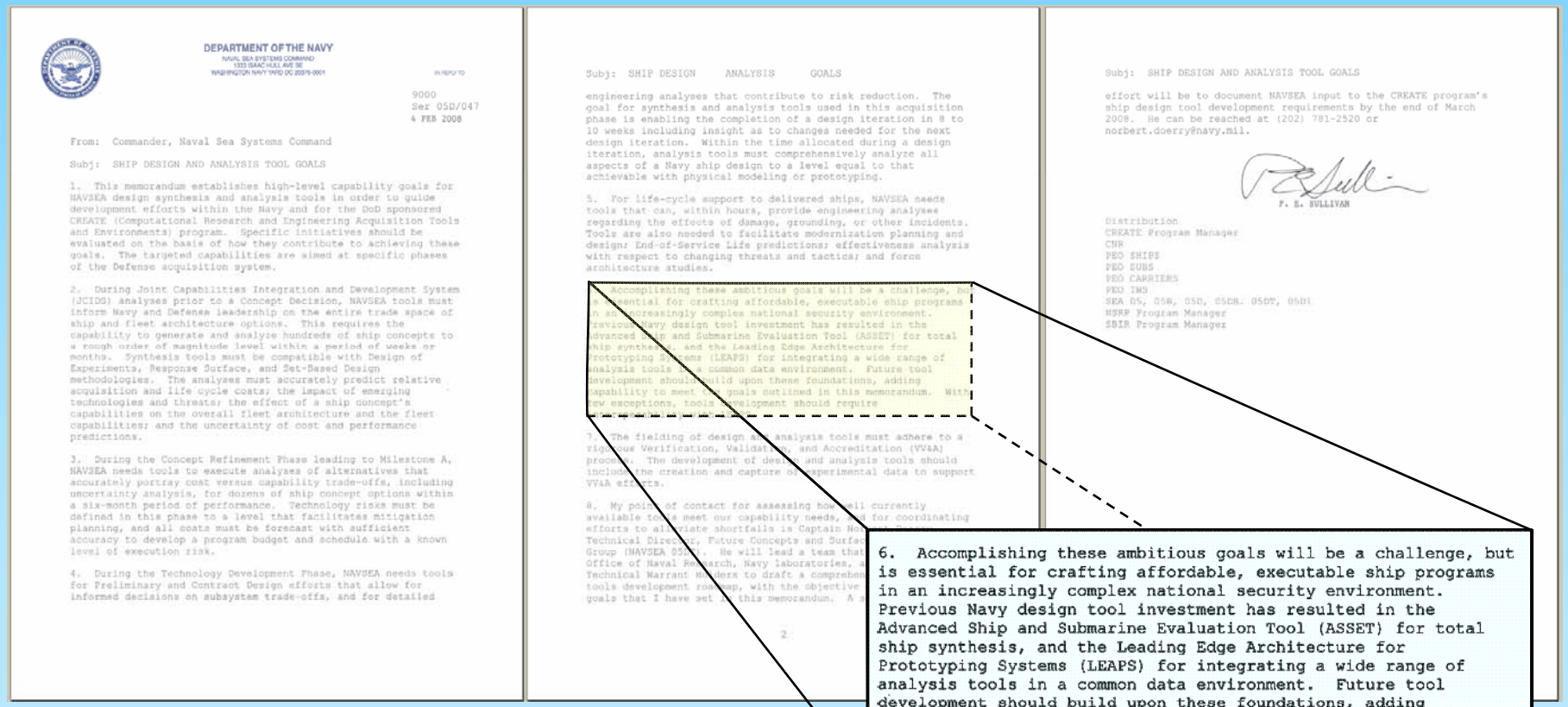
Vice Admiral Sullivan's design synthesis and analysis environment vision



DEPARTMENT OF THE NAVY
NAVAL SEA SYSTEMS COMMAND
1333 ISAAC HULL AVE SE
WASHINGTON NAVY YARD DC 20376-0001

IN REPLY TO

9000
Ser 05D/047
4 FEB 2008

From: Commander, Naval Sea Systems Command

Subj: SHIP DESIGN AND ANALYSIS TOOL GOALS

1. This memorandum establishes high-level capability goals for NAVSEA design synthesis and analysis tools in order to guide development efforts within the Navy and for the DoD sponsored CREATE (Computational Research and Engineering Acquisition Tools and Environments) program. Specific initiatives should be evaluated on the basis of how they contribute to achieving these goals. The targeted capabilities are aimed at specific phases of the Defense acquisition system.

2. During Joint Capabilities Integration and Development System (JCIDS) analyses prior to a Concept Decision, NAVSEA tools must inform Navy and Defense leadership on the entire trade space of ship and fleet architecture options. This requires the capability to generate and analyze hundreds of ship concepts to a rough order of magnitude level within a period of weeks or months. Synthesis tools must be compatible with Design of Experiments, Response Surface, and Set-Based Design methodologies. The analyses must accurately predict relative acquisition and life cycle costs; the impact of emerging technologies and threats; the effect of a ship concept's capabilities on the overall fleet architecture and the fleet capabilities; and the uncertainty of cost and performance predictions.

3. During the Concept Refinement Phase leading to Milestone A, NAVSEA needs tools to execute analyses of alternatives that accurately portray cost versus capability trade-offs, including uncertainty analysis, for dozens of ship concept options within a six-month period of performance. Technology risks must be defined in this phase to a level that facilitates mitigation planning, and all costs must be forecast with sufficient accuracy to develop a program budget and schedule with a known level of execution risk.

4. During the Technology Development Phase, NAVSEA needs tools for Preliminary and Contract Design efforts that allow for informed decisions on subsystem trade-offs, and for detailed

Subj: SHIP DESIGN ANALYSIS GOALS

engineering analyses that contribute to risk reduction. The goal for synthesis and analysis tools used in this acquisition phase is enabling the completion of a design iteration in 8 to 10 weeks including insight as to changes needed for the next design iteration. Within the time allocated during a design iteration, analysis tools must comprehensively analyze all aspects of a Navy ship design to a level equal to that achievable with physical modeling or prototyping.

5. For life-cycle support to delivered ships, NAVSEA needs tools that can, within hours, provide engineering analyses regarding the effects of damage, grounding, or other incidents. Tools are also needed to facilitate modernization planning and design; End-of-Service Life predictions; effectiveness analysis with respect to changing threats and tactics; and force architecture studies.

6. Accomplishing these ambitious goals will be a challenge, but is essential for crafting affordable, executable ship programs in an increasingly complex national security environment. Previous Navy design tool investment has resulted in the Advanced Ship and Submarine Evaluation Tool (ASSET) for total ship synthesis, and the Leading Edge Architecture for Prototyping Systems (LEAPS) for integrating a wide range of analysis tools in a common data environment. Future tool development should build upon these foundations, adding capability to meet the goals outlined in this memorandum. With few exceptions, tools development should require

7. The fielding of design and analysis tools must adhere to a rigorous Verification, Validation, and Accreditation (VV&A) process. The development of design and analysis tools should include the creation and capture of experimental data to support VV&A efforts.

8. My point of contact for assessing how well currently available tools meet our capability needs, and for coordinating efforts to alleviate shortfalls is Captain N[illegible] Technical Director, Future Concepts and Surfac[illegible] Group (NAVSEA 05[illegible]). He will lead a team that [illegible] Office of Naval Research, Navy laboratories, a[illegible] Technical Warrant Holders to draft a comprehen[illegible] tools development roadmap, with the objective [illegible] goals that I have set in this memorandum. A s[illegible]

2

Subj: SHIP DESIGN AND ANALYSIS TOOL GOALS

effort will be to document NAVSEA input to the CREATE program's ship design tool development requirements by the end of March 2008. He can be reached at (202) 781-2520 or norbert.doerry@navy.mil.

P. E. SULLIVAN

Distribution
CREATE Program Manager
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NSRP Program Manager
SBIR Program Manager

6. Accomplishing these ambitious goals will be a challenge, but is essential for crafting affordable, executable ship programs in an increasingly complex national security environment. Previous Navy design tool investment has resulted in the Advanced Ship and Submarine Evaluation Tool (ASSET) for total ship synthesis, and the Leading Edge Architecture for Prototyping Systems (LEAPS) for integrating a wide range of analysis tools in a common data environment. Future tool development should build upon these foundations, adding capability to meet the goals outlined in this memorandum. With few exceptions, tools development should require interoperability with LEAPS.

Leading Edge Architecture for Prototyping Systems

NAVSEA Product Modeling Environment

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What is LEAPS?

The NAVSEA Product Modeling Environment

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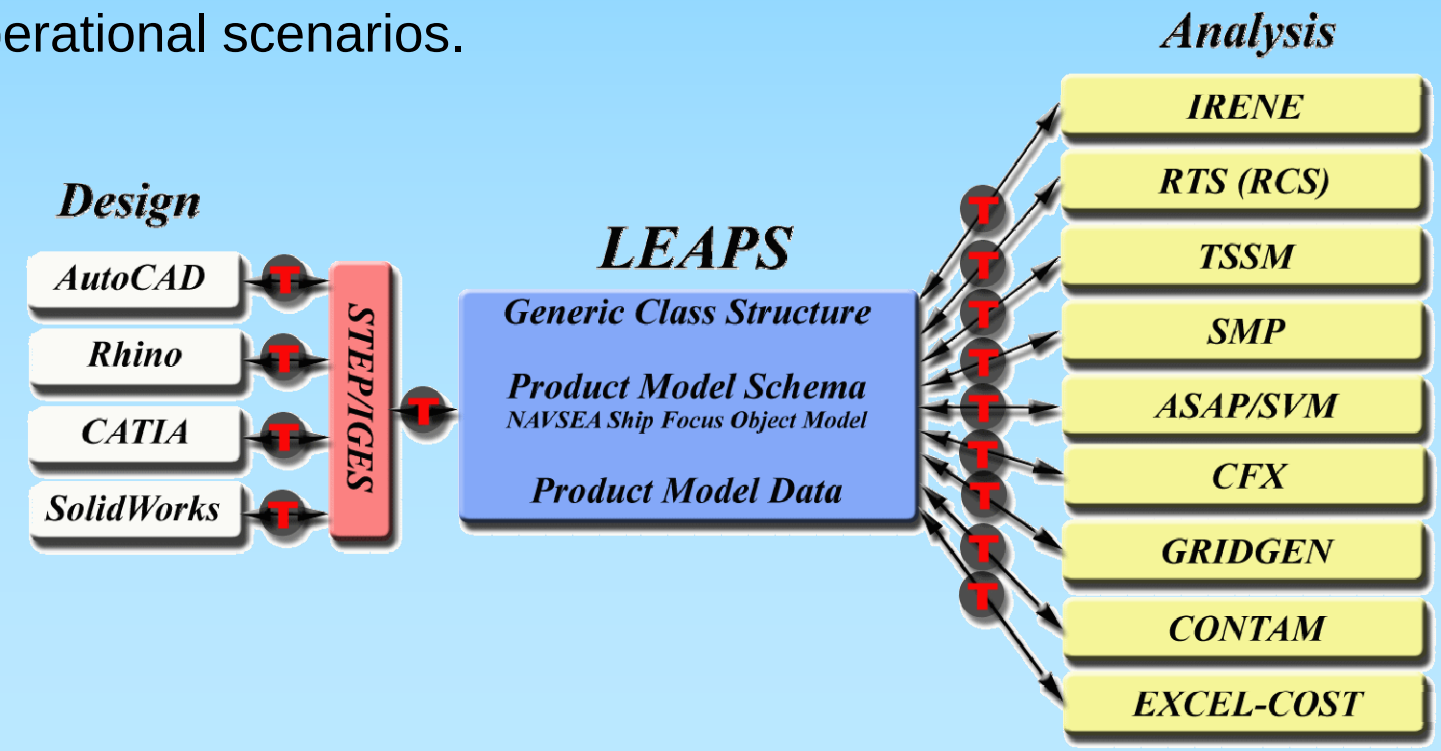
Leading ***E***dge ***A***rchitecture for ***P***rototyping ***S***ystems, is the product model repository used by the Naval Sea Systems Command. LEAPS is based on an extensible information meta-model. It is designed to provide product model data to support modeling and simulation tools used by Navy Ship Designers. The current focus is concept studies, analysis of alternatives, and operational scenarios.



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Carderock Division

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LEAPS

Where it all started

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In 1996, an innovation team was formed at the Carderock Division, Naval Surface Warfare Center (NSWCCD) to investigate the issues of virtual prototyping and modeling and simulation. This team became known as the LEAPS (Leading Edge Architecture for Prototyping Systems) team. The efforts of this team led to the development of an architecture that facilitated an integrated virtual prototyping process. This architecture was targeted to meet the requirements for naval ship design and analysis, but was designed to support virtual prototyping for any complex system.

What is LEAPS?

The meta model

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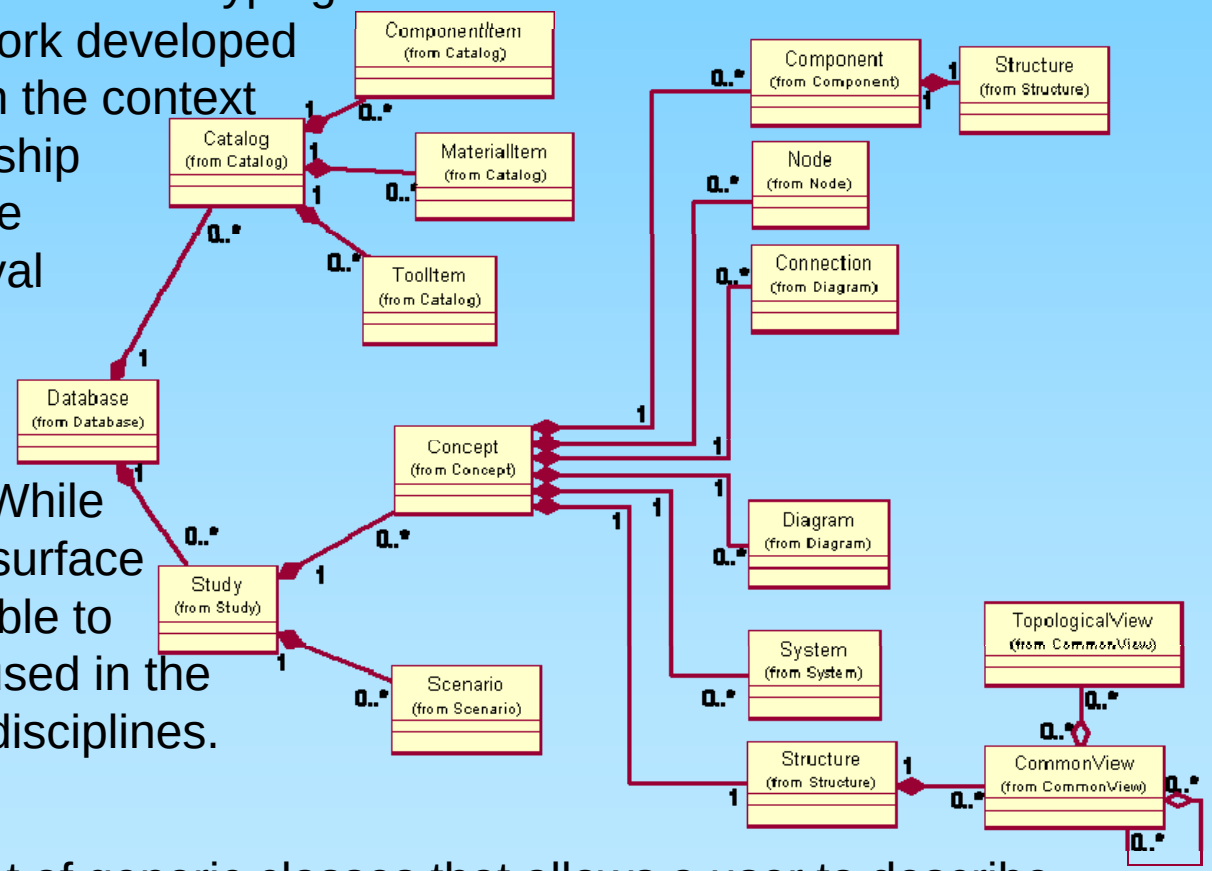
The Leading Edge Architecture for Prototyping Systems (LEAPS) is a framework developed to support virtual prototyping in the context of conceptual and preliminary ship design and analysis. Due to the complexity and diversity of naval ship design and analysis, the LEAPS architecture takes a "meta model" approach to product model development. While originally developed for naval surface combatants, LEAPS is applicable to other products and has been used in the aviation and urban structures disciplines.



The LEAPS MetaModel is a set of generic classes that allows a user to describe physical and/or functional representations of objects and methods that can be applied to the development of the NAVSEA Ship product model.

What is LEAPS?

Geometry is just a small part

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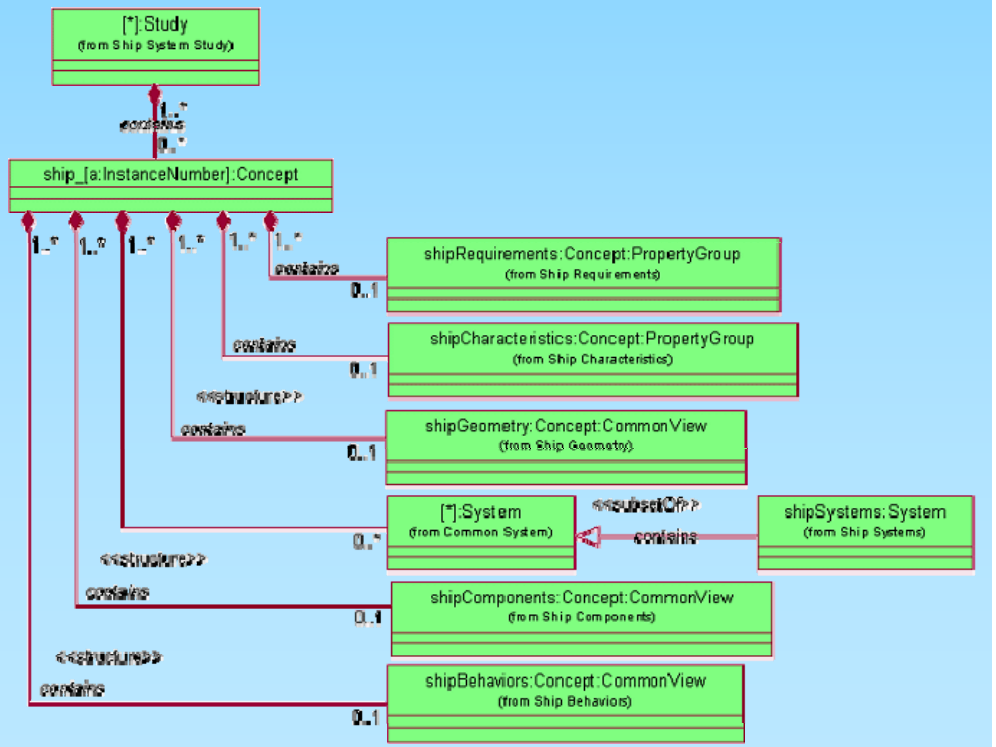
Geometry is important as it provides the spatial definition and is critical in supporting visualization. However it is important to realize geometry is no more relavent to the Product Model Definition of a ship than any other non graphical attribute.

- Requirements are a property group that capture information that can be obtained from an AoA, ICD, and other high level program document.
- Characteristics are a property group that capture conditions related to the total ship. Examples of characteristics are curves of form, hydromechanics, mission profile, and stability.
- Systems are a combination of components, connections, subsystems, and functional relationships.
- Components are a collection of geometry and characteristics. Components can have multiple representations, and may have a system equivalent.
- Behaviors are a collection of geometry, conditions, environmental definition, and results.



Geometry Object Structure

Idealized Geometry

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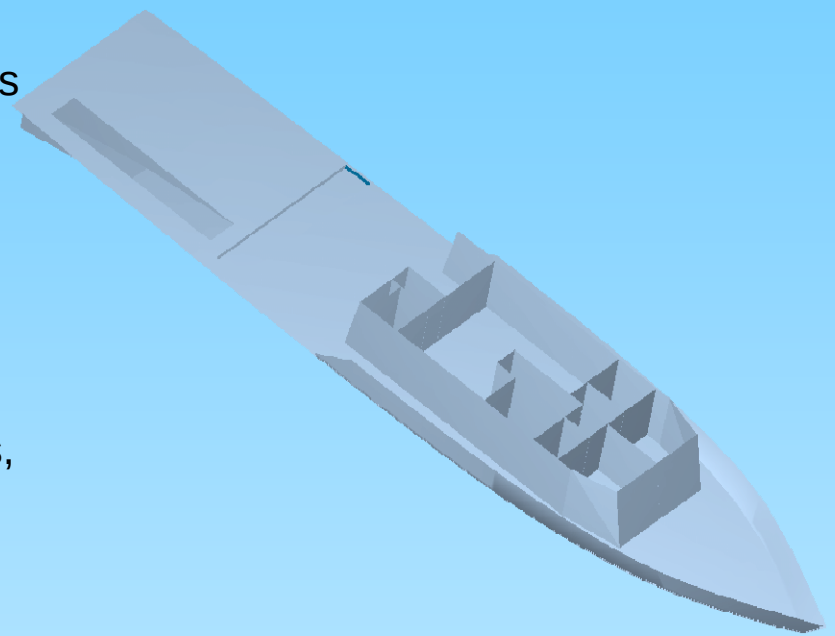
- The LEAPS Geometry OBject Structure (GOBS) classes allow geometry to be presented to various engineering designers and analysts in a context which allows for convenient discretization or manipulation with respect to their domain requirements.
- The GOBS modeling concept develops a geometric product model that is defined and represented as logical views of geometric objects, unlike most CAD representations where the geometry defines the view and the object simultaneously.



- GOBS creates associations between related geometry objects to define connectivity along common boundaries, such as the intersection at a deck edge and the hull.
- The GOBS process imparts “knowledge” to the various geometric entities such that they each know they are connected and where that connection occurs.
- The need for idealized geometry is driven primarily from analysis requirements where surfaces are discretized into meshes or grids. Similarly, spatial domains such as compartments or tanks, and other zones of space are best modeled as a collection of surface regions with shared and known boundaries.

Geometry Object Structure

Explained

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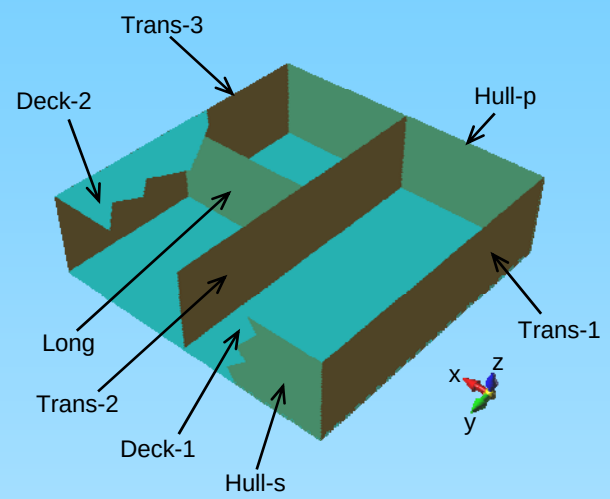

This three-compartment example, while simplistic in appearance, actually poses a number of challenges to product modeling, primarily related to the associations and connectivities of the various geometric entities comprising the model, such as transverse bulkhead 2 (Trans-2) and the port and starboard hulls (Hull-p and Hull-s, respectively). While not particularly complicated, note the several connections of the middle transverse bulkhead (Trans-2) to the longitudinal bulkhead (Long) and the port and starboard hulls (Hull-p and Hull-s). The transverse bulkhead spans the deck height between the upper deck (Deck-2) and the lower deck (Deck-1). Additionally, there is inherent information that the transverse bulkhead (Trans-2) can provide to the smart product model, and thus to the engineer interrogating it, such as connectivity locations on the bulkhead at corner points and along lines of intersection with other surfaces (longitudinal, hull, deck, etc.), and boundaries of spaces or volumes, for example, compartments. The GOBS process defines these relationships as “views” of the bulkhead, and these views contain the knowledge implicit in the connectivity of the bulkhead to the rest of the structure and its role in spatial discretization. In this fashion, the geometric objects (surfaces, trimmed surfaces, intersections, etc.) representing the transverse bulkhead, Trans-2, can have relationships in views that describe the walls of several adjacent compartments, or it may be a piece of a larger bulkhead bounding a watertight zone on the ship.

Geometry Object Structure

Entities and Topology

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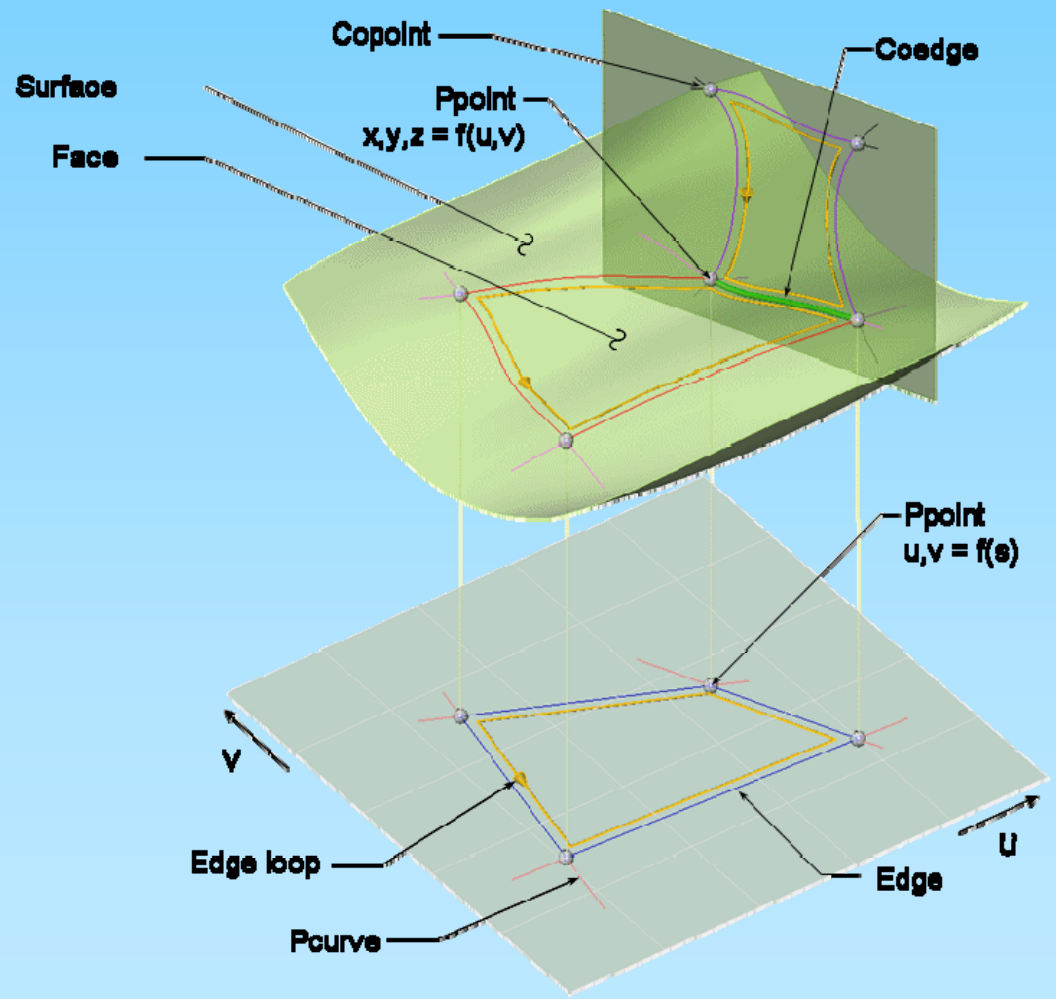
Solid	A manifold BREP (boundary representation) solid defined by a single OrientedClosedShell
Surface	An untrimmed 3D NURBS surface used to define any shape.
Oriented ClosedShell	A set of Face objects that form a closed shell that is oriented.
Face	A region of a surface represented as a trimmed NURBS surface.
EdgeLoop	A set of connected Edge objects that form a closed loop that is not self intersecting. This loop is also oriented.
Edge	A region or segment of a Pcurve. The collection of contiguous Edges is used for composing paths, loops, or topological boundaries.
Pcurve	A parametric curve defined by means of a 2D curve in the parameter space of a surface.
Ppoint	A parametric point lying on a Pcurve object.
Coedge	The relationship between two or more Edges. The CoEdge is used to allow traversal across Surfaces or Faces and defines explicitly an association between two or more Surfaces or Faces.
CoPoint	The Cartesian Location equivalent for a list of Ppoint objects.



Explicit Geometry

Components

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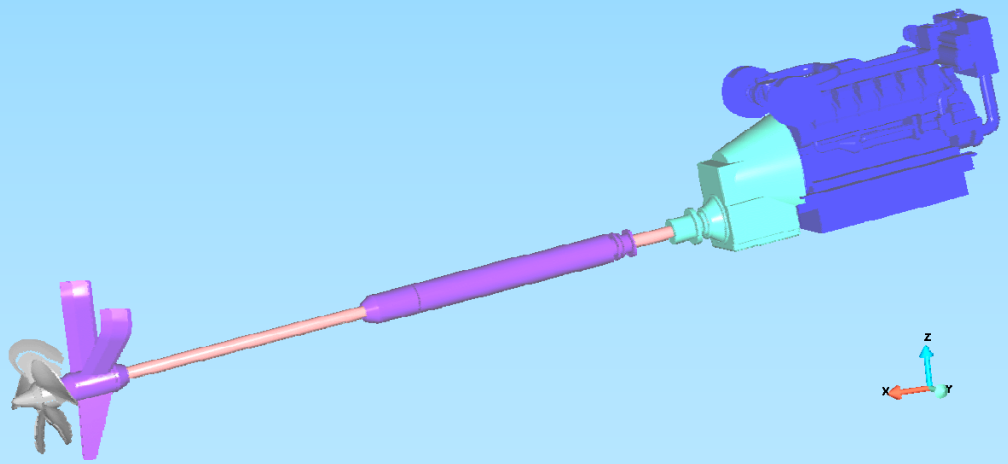
Explicit geometry can be thought of as assembly geometry or a close approximation. In essence, explicit geometry is treated exactly as it is modeled. It presumes that this geometry is a manufactured part, that it is dimensionally “explicit”, and that is contains volume (i.e. not an idealized surface). In LEAPS, a fully populated product would contain systems of components where the sum of every component describes the entire ship.



Explicit geometry is intended to model a part or assembly exactly as it would be built. Most solid modeling done within CAD systems today falls into the category of explicit geometry.

LEAPS

… its more than just early stage design

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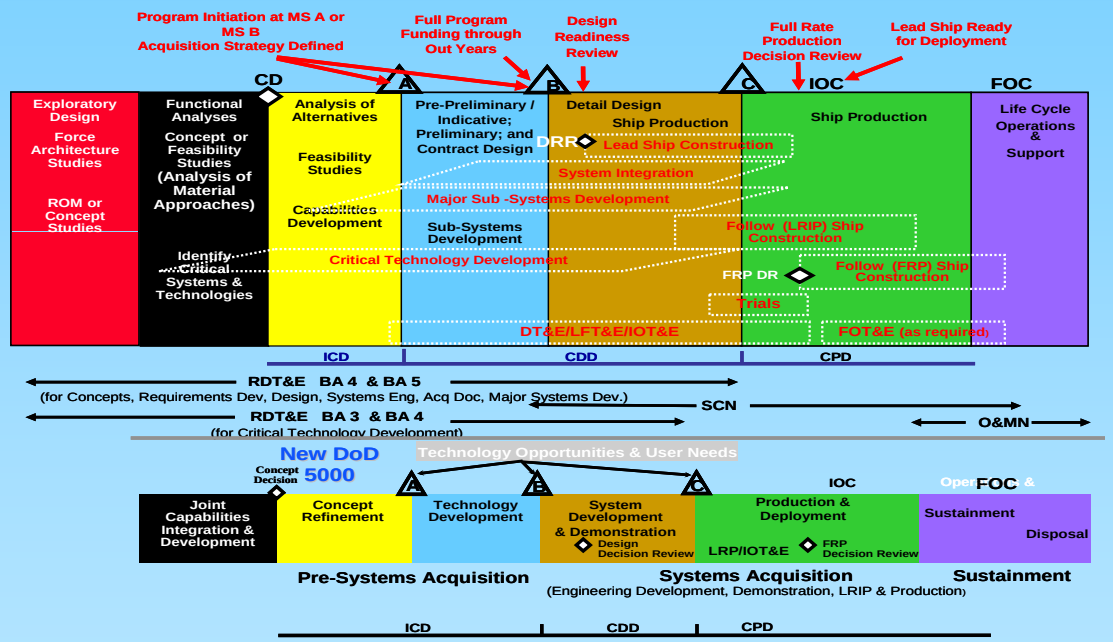
The LEAPS model can support the entire ship's lifecycle.



- LEAPS will be the primary source of data for all pre milestone B activities.
- LEAPS will be used by NAVSEA to validate the design during the Detail Design and Ship Production phases.
- LEAPS will be the authoritative source of data in support of the Situation Incident Room upon delivery of the ship.

Applications migrating to LEAPS

ASSET

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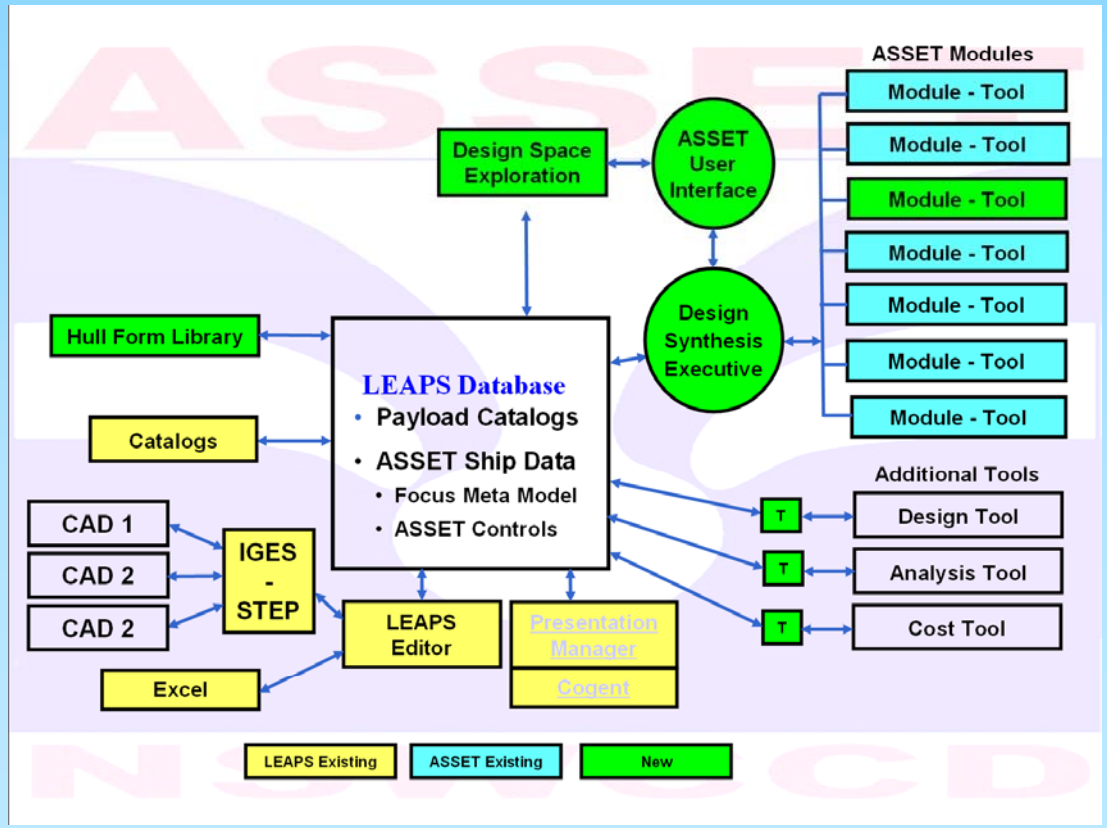
The primary purpose of the LEAPS Product Model database is to enable engineering analysis and M&S activities during the early phases of the ships lifecycle. The LEAPS Product Model database will interact with other M&S/Tools/Life Cycle Applications but will be external to the SPM itself.

LEAPS Enables

- **Synthesis modules to work directly from a surface model.**
- **Hull surfaces can be rescaled during synthesis.**
- **Surface geometry kernel enables modeling of complex geometries.**
- **Geometry is the most important factor for accurate synthesis models.**
- **Product meta-model facilitates efficient modeling of multi-hulls.**



Applications migrating to LEAPS

Ship Hull Characteristics Program

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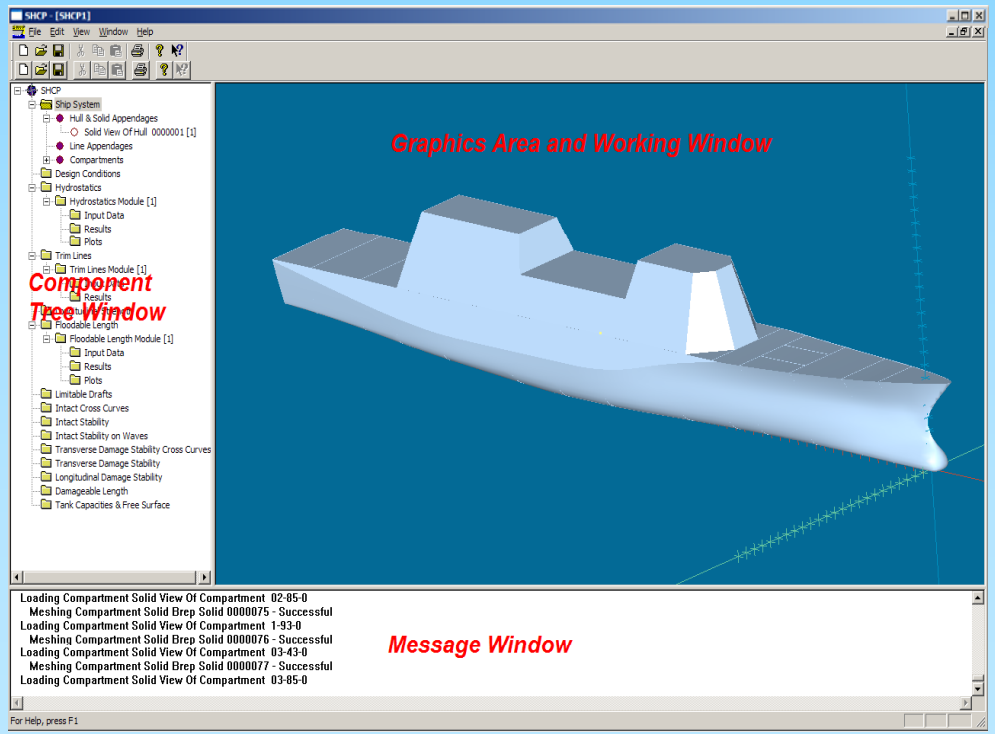
The primary purpose of the LEAPS Product Model database is to enable engineering analysis and M&S activities during the early phases of the ships lifecycle. The LEAPS Product Model database will interact with other M&S/Tools/Life Cycle Applications but will be external to the SPM itself.

LEAPS Enables

- **An integrated development environment.**
- **No pre-processing required for geometry generation.**
- **Built in graphing and geometry viewing.**
- **FOCUS[1] compliant database.**
- **Can model any shape compartment or hull.**
- **Multiple solids can be aggregated into larger objects.**
- **Tunnel sterns and multi-hull vessels can be modeled**



[1] FOCUS is the name of the schema that describes naval combatants.

Applications interfaced to LEAPS

FKS

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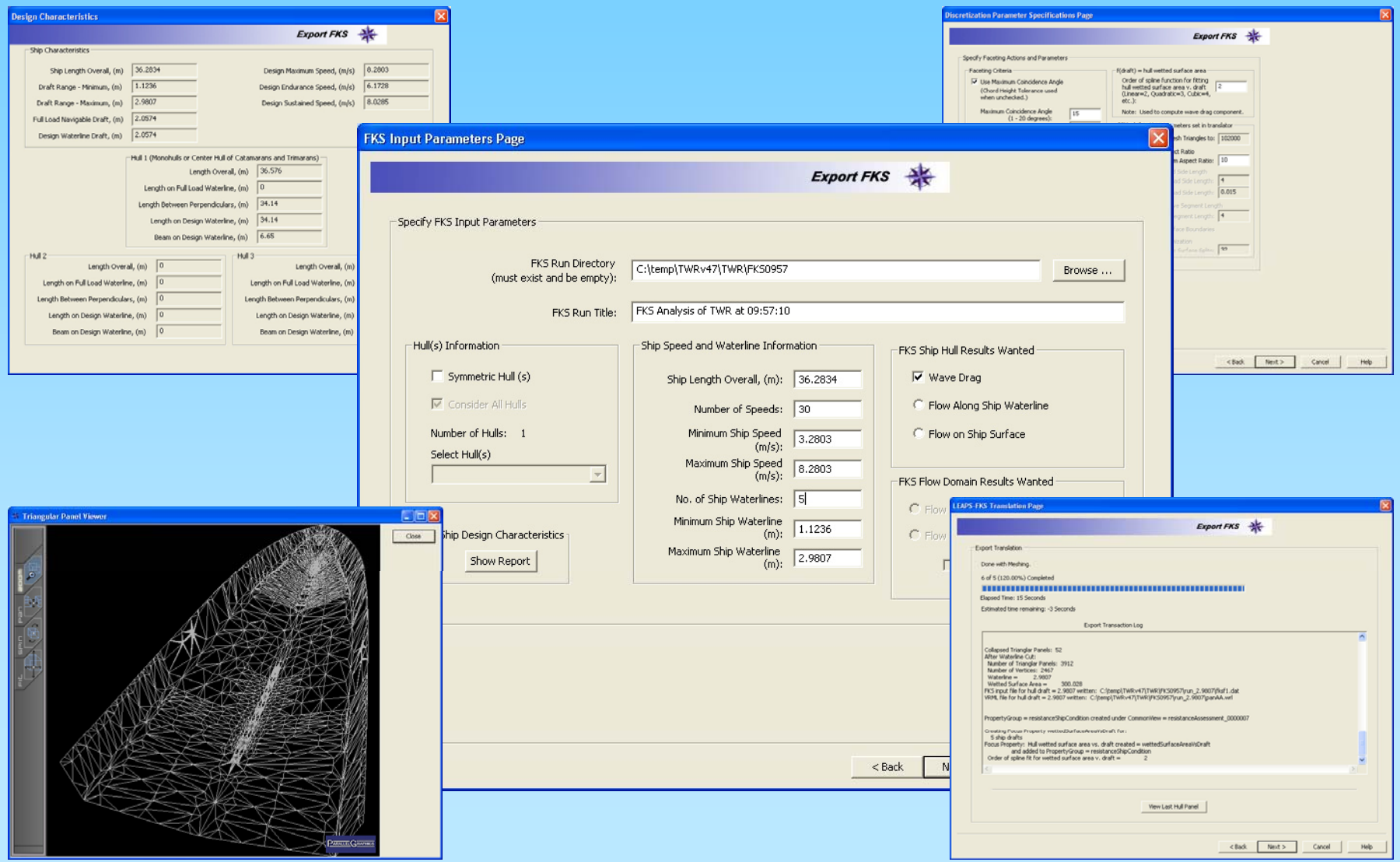
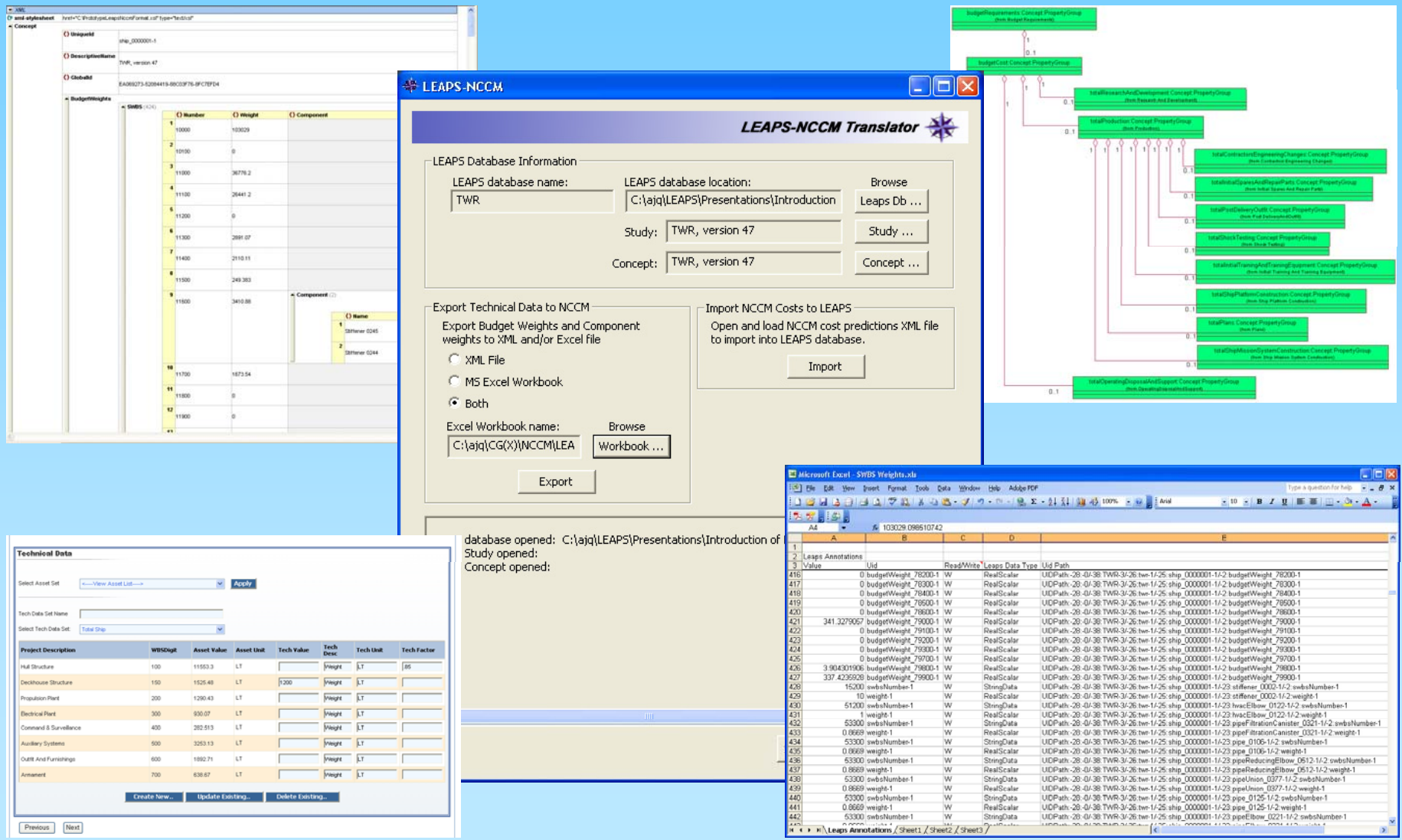


Applications interfaced to LEAPS

Navy Common Cost Model

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