NSRP Systems Technology Panel
Project

Publish ISO Technical Corrigenda for ISO 10303-215, 10303-216 and 10303-227

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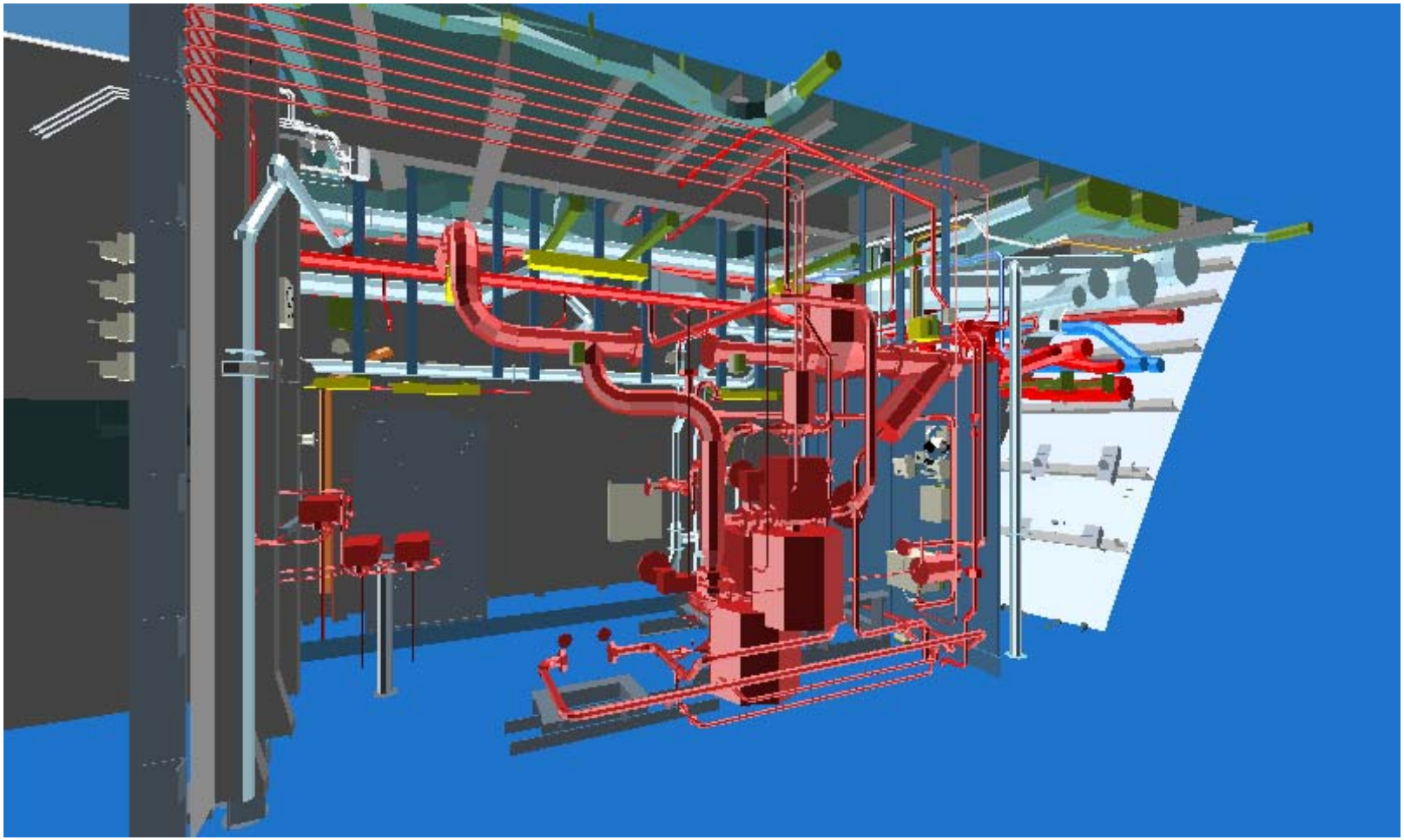
Product
Data
Services
Corporation

What is STEP?

What does it do?

The Navy and Shipbuilders Are Using Product Model Data Technology



Product Model Data = 3-D CAD + object definitions + other documentation

Information Technology ages quickly…

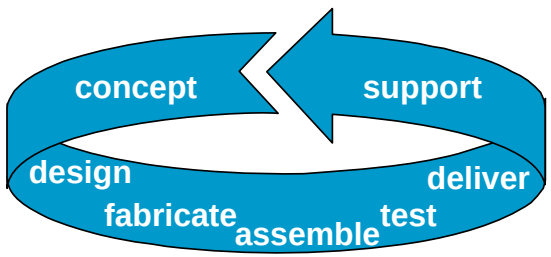
	1987	1997	2006
NAVSEA	CADDS 4x	ISDP	LEAPS
Avondale	CADAM (2-D)	ISDP	ISDP
Bath Iron Works	CADDS 4x	CADDS 5	Catia 5
Electric Boat	CADDS 4	Catia 4Mech	award pends
Ingalls	Calma	Dimension 3	Catia 5
NASSCO	CADAM (2-D)	Tribon	Tribon
Newport News	Vivid	Vivid	Catia 4AEC

… but ships last a long time!

NIDDESC
Navy / Industry Digital Data Exchange Standards Committee

- **NAVSEA / U.S. Shipbuilding Industry cooperative program to improve data exchange (1986-1993).**
- **Started from Seawolf (NNS/EB) and DDG51 (Ingalls/Bath) Data Exchange efforts.**
- **Developed IGES 3D Piping Application Protocol (Mil-D-28000 Class V) and initial U.S. STEP Shipbuilding Application Protocols for:**
  - **Structure**
  - **Piping**
  - **HVAC**
  - **Electrical cabling & wireways**
  - **Outfitting & Furnishings**
- **NIDDESC STEP Application Protocols issued as NSRP "Standards" in 1995.**

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)

STEP Enables Complete and Accurate Data Exchange and Use

STEP Enables Consistent and Timely Data Sharing by Participants

STEP Enables Reuse of Design, Planning and Manufacturing Data

ISO 10303 - STEP
"Standard for the Exchange of Product Model Data"

- **Standardized neutral format for exchanging Product Model data between dissimilar CAD/CAM, Materials management, and PDM systems.**
- **Developed in computer-processible information modeling language (EXPRESS).**
- **Broad international involvement across all major industrial sectors including Aerospace, Automotive, Shipbuilding, Process Plant, Offshore, and Building Construction.**
- **Implemented through CAD system translators to international industry-consensus STEP "Application Protocols".**
- **Provides mechanisms for file transfer or for distributed data sharing.**
- **Related Part Library Standard (ISO 10384) for exchange of vendor and project part catalogs.**

ISO TC184 SC4

STEP on a Page

ISO 10303

APPLICATION PROTOCOLS AND ASSOCIATED ABSTRACT-TEST SUITES

I 201 Explicit draughting [ATS 301 = X]
I 202 Associative draughting [X]
I 203 Configuration-controlled design (c2=I,a1=I)[X]
I 204 Mechanical design using boundary rep [I]
X 205 Mechanical design using surface rep [W]
X 206 Mechanical design using wireframe [X]
I 207 Sheet metal die planning and design [I]
X 208 Life-cycle product change process [X]
I 209 Composite & metal structural anal & related design[X]
I 210 Electronic assy, interconnection & packaging design [X]
X 211 Electronic P-C assy: test, diag, & remanuf[X]
I 212 Electrotechnical design and installation [C]
X 213 Num control (NC) process plans for mach'd parts [X]
I 214 Core data for automotive mech design processes (e2=E)[F]
H 215 Ship arrangement [X]
H 216 Ship moulded forms [X]
X 217 Ship piping [X]
H 218 Ship structures [X]
X 219 Dimension inspection [X]
O 220 Proc. plg, mfg, assy of layered electrical products [X]
C 221 Functional data & their schem rep for process plant [X]
X 222 Design-manuf for composite structures [W]
X 223 Exch of design & mfg product info for cast parts [@]
I 224 Mech pdt def for p. plg using mach'n'g feat (e2=X,e3=A)
I 225 Building elements using explicit shape rep [C] \[X,I]
X 226 Ship mechanical systems [C]
I 227 Plant spatial configuration(e2=C) [X]
X 228 Building services: HVAC [X]
X 229 Design & mfg product info for forged parts[X]
X 230 Building structural frame: steelwork [X]
X 231 Process-engineering data [X]
I 232 Technical data packaging: core info & exch [I]
W 233 Systems engineering data repr (to be PAS 20542)[X]
X 234 Ship operational logs, records, and messages[X]
W 235 Materials info for des and verif of products [X]
W 236 Furniture product and project data[W]
W 237 Computational Fluid Dynamics
A 238 Computer numerical controllers
W 239 Product life-cycle support
W 240 Process plans for machined products

COMMON RESOURCES (with 13584-20 logic, model of expr.(I) and 15531-42 Time (W))

APPLICATION MODULES (Technical specifications)

For status of the modules access the file via the SOAP home page.

Legend: TS Status
0-10 =O=prop-->apvl for ballot
10-20=A=NP blt circ-->NP apvl
20-60=D=DTS dev-->reg as TS
>60 =T=TS Published

INTEGRATED-APPLICATION RESOURCES

I 101 Draughting (c1=I)
X 102 Ship structures
X 103 E/E connectivity
I 104 Finite element analysis
I 105 Kinematics (c1=I, c2=I)
X 106 Building core model
C 107 Finite-element analysis definition relationships
C 108 Prmetizat'n&Constraints for expl geom prod mdls
C 109 Assembly model for products
W 110 Mesh-based computational fluid dynamics

INTEGRATED-GENERIC RESOURCES

I 41 Fund of prdct descr & spt (e2=I,c1=I)
I 42 Geom & top rep (c3=I,e2c1=I,e3=F)
I 43 Repres specialization (e2=I,c1=I,c2=I)
I 44 Product struct confg (e2=I,c1=I)
I 45 Materials (c1=I)
I 46 Visual presentation (c1=I, c2=I)
I 47 Tolerances (c1=I)
X 48 Form features
I 49 Process structure & properties
I 50 Mathematical constructs
E 51 Mathematical description
W 52 Mesh-based topology
W 53 Numerical Analysis
C 54 Classification Set theory
A 55 Procedural and hybrid represent.
W 56 State
W 57 Expression extensions
A 58 Risk

APPLICATION-INTERPRETED CONSTRUCTS

I 501 Edge-based wireframe
I 502 Shell-based wireframe
I 503 Geom-bounded 2D wireframe
I 504 Draughting annotation
I 505 Drawing structure & admin.
I 506 Draughting elements
I 507 Geom-bounded surface
I 508 Non-manifold surface
I 509 Manifold surface
I 510 Geom-bounded wireframe
I 511 Topological-bounded surface
I 512 Faceted B-representation
I 513 Elementary B-rep
I 514 Advanced B-rep
I 515 Constructive solid geometry
X 516 Mechanical-design context
I 517 Mech-design geom presentation(c1=I)
I 518 Mech-design shaded presentation
I 519 Geometric tolerances (c1=I)
I 520 Assoc draughting elements
@521 Manifold subsurfaces
E 522 Machining features
A 523 Curve swept solid

IMPLEMENTATION METHODS

I 21 Clear-text encoding exch str (c1=I,e2=I)
I 22 Standard data access interface
I 23 C++ language binding (to #22)
I 24 C language binding (to #22)
C 25 EXPRESS to OMG XMI
X 26 IDL language binding (to #22)
I 27 JAVA language binding (to #22)
@28 XML rep for EXPRESS-schemata & data
X 29 Ltwt Java binding (to #22) \(DTS)

DESCRIPTION METHODS

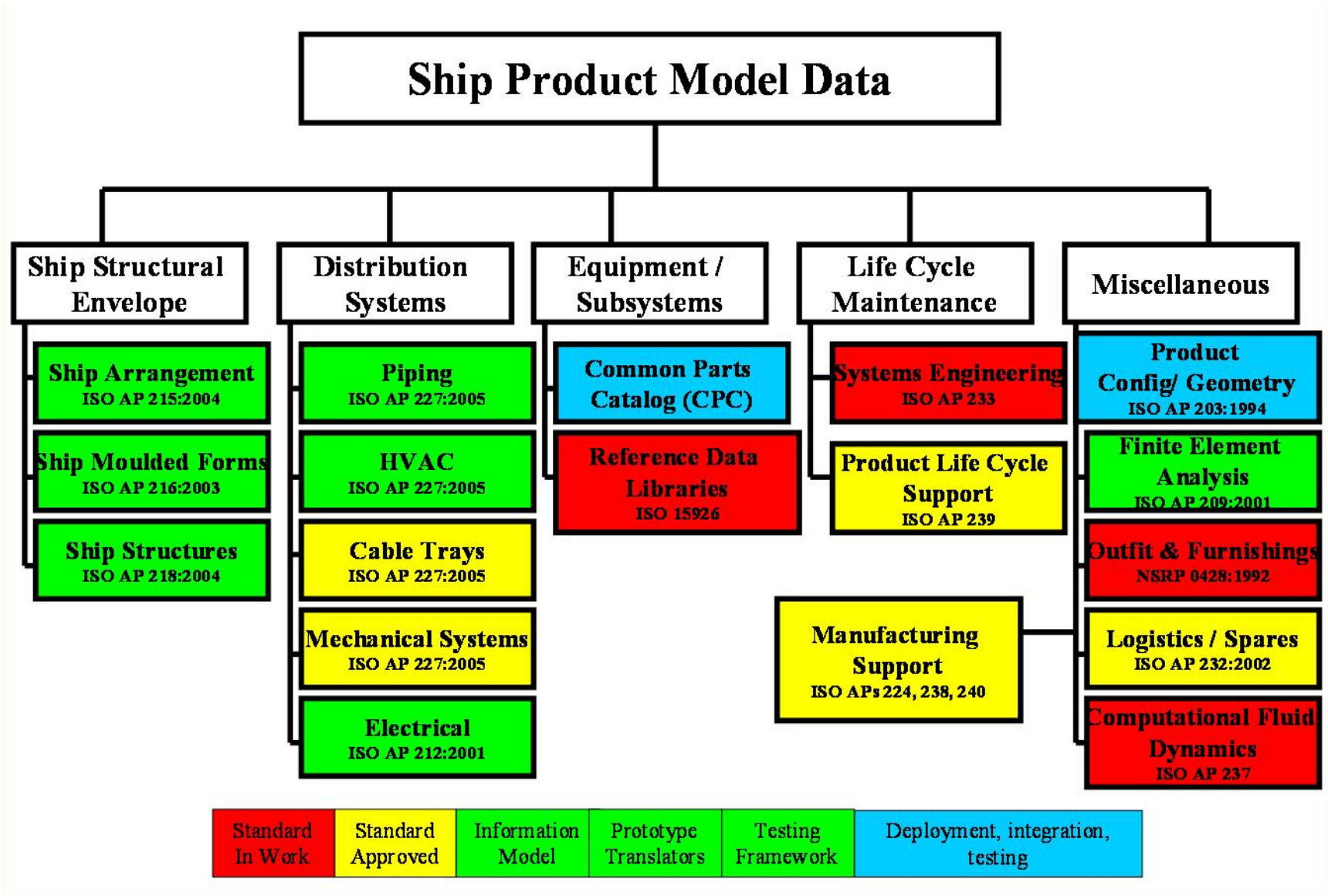
I 11 Overview and fundamental principles
I 11 EXPRESS language ref man. (c1=I,c2=C e2=C e3=X ISO 20303=X a1=X)
I 12 EXPRESS-I language ref man (Type 2 tech report, not a 10303 part)
X 13 Architecture and Methodology reference manual
E 14 EXPRESS X Language reference manual

CONFORMANCE TESTING METHODOLOGY & FRAMEWORK

I 31 General concepts
I 32 Requirements on testing labs and clients
X 33 Structure and use of abstract test suites
I 34 Abstract test methods for Part 21 implementation.
C 35 Abstract test methods for Part 22 implementation.

Legend: Part Status (E, F, I safe to implement)
0=O=Preliminary Stage (Proposal-->appr for NP ballot)
10=A =Proposal Stage (NP ballot circ-->NP approval)
20=W=Preparatory Stage (Wkg Draft devel.-->CD regis)
30=C =Committee Stage (CD circulation-->DIS regis)
40=E =Enquiry Stage (DIS circ.-->FDIS registration)
50=F =Approval Stage (FDIS circ-->Int'l Std regis)
@=At ISO, approved for publication (ISO status 40.95 or 50.99)
60=I =Publication Stage (Int'l Std published)
98=X=Project withdrawn

jgnell, 89-Oct.-23, **rev. 03-04-07**. Origin: ISO 10303 Editing Committee. On-line: http://www.nist.gov/sc5/soap/

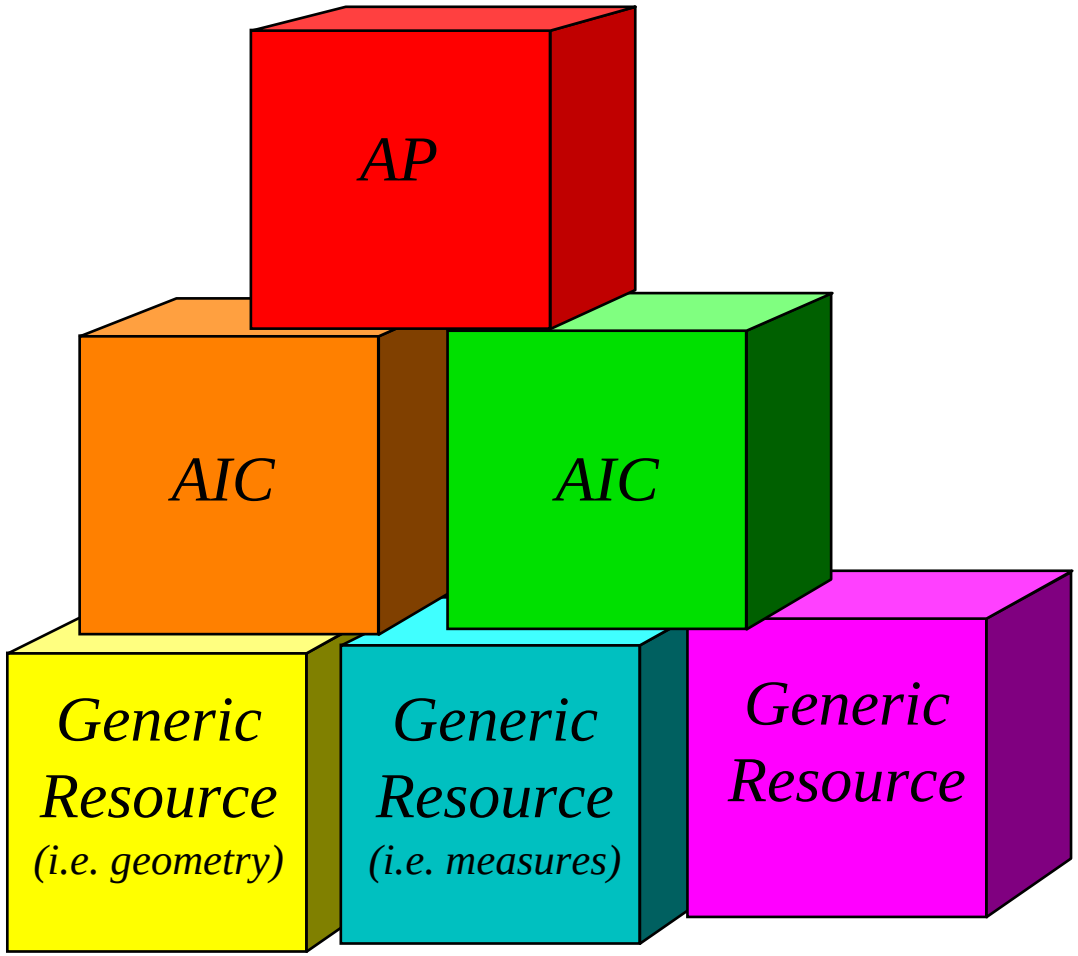

Ship Product Model Data
Ship Structural Envelope
Ship Arrangement
ISO AP 215:2004
Ship Moulded Forms
ISO AP 216:2003
Ship Structures
ISO AP 218:2004
Distribution Systems
Piping
ISO AP 227:2005
HVAC
ISO AP 227:2005
Cable Trays
ISO AP 227:2005
Mechanical Systems
ISO AP 227:2005
Electrical
ISO AP 212:2001
Equipment / Subsystems
Common Parts Catalog (CPC)
Reference Data Libraries
ISO 15926
Life Cycle Maintenance
Systems Engineering
ISO AP 233
Product Life Cycle Support
ISO AP 239
Manufacturing Support
ISO APs 224, 238, 240
Miscellaneous
Product Config/ Geometry
ISO AP 203:1994
Finite Element Analysis
ISO AP 209:2001
Outfit & Furnishings
NSRP 0428:1992
Logistics / Spares
ISO AP 232:2002
Computational Fluid Dynamics
ISO AP 237
Standard In Work
Standard Approved
Information Model
Prototype Translators
Testing Framework
Deployment, integration, testing

STEP Architecture Overview

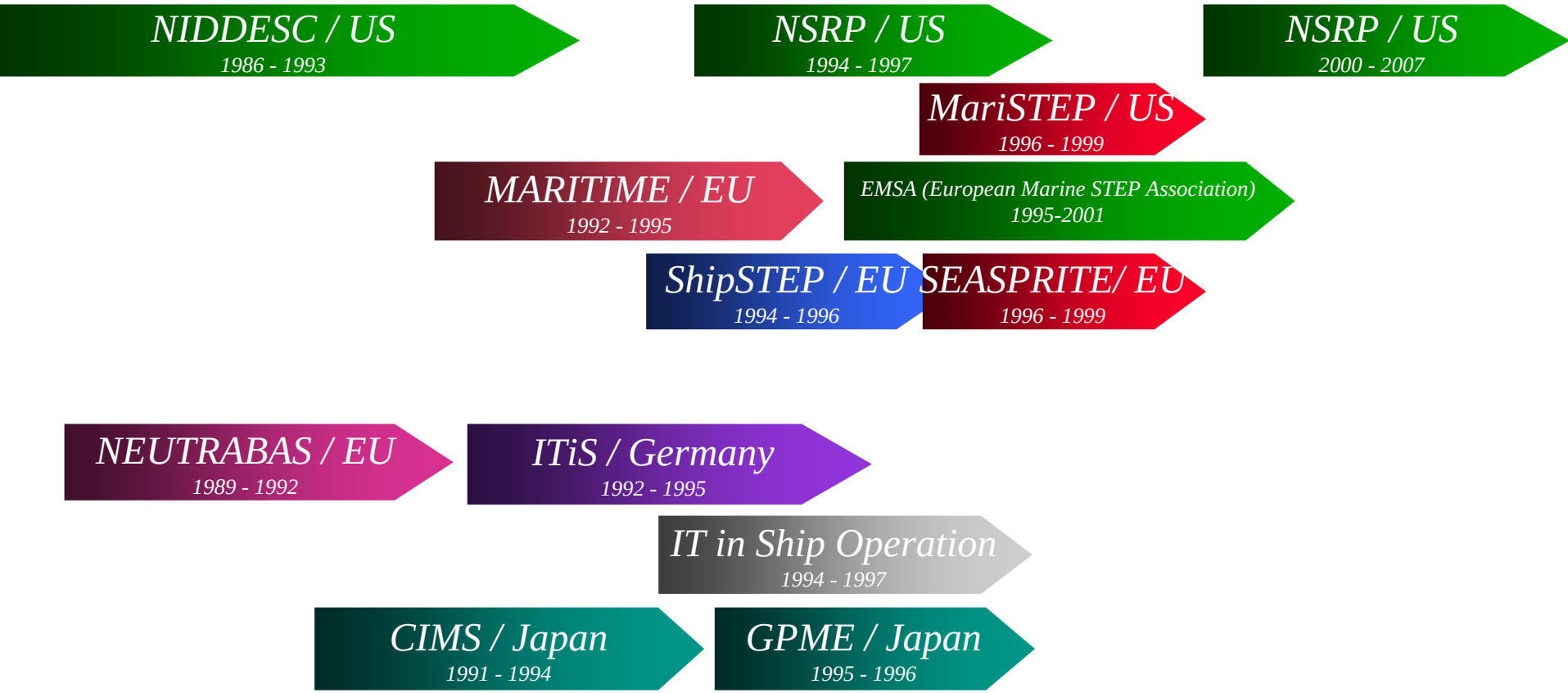
200 Series Parts

500 Series Parts

40 & 100 Series Parts



AP Development / Implementation Timeline



EXPRESS ARM

```
SCHEMA structural_part_manufacturing_definitions_model;

TYPE Manufacturing_process = SELECT (Hole_production_process, Part_production_process);
        (* a reference by a structural part manufacturing definition to either a hole production process or part production
process to be used in the fabrication of a structural part.
        *)
END_TYPE;

TYPE Hole_production_process = ENUMERATION OF (burn, drill, punch, other);
        (* an indicator used to denote the method by which the structural opening, as represented by the associated inner contour, is to
be produced in the part during manufacturing. Several commonly used processes supported are burning, drilling, and punching. All
others are generically supported. This indicator may be used by production engineers to develop shop routings for the structural parts.
        *)
END_TYPE;

ENTITY Structural_part_manufacturing_definition
  SUPERTYPE OF (ONEOF(Non_numerically_controlled_structural_part_manufacturing_definition,
        Numerically_controlled_structural_part_manufacturing_definition))
  SUBTYPE OF (Manufacturing_definition);
        (* a production lifecycle stage view of a structural part that represents characteristics and attributes directly related to the
manufacturing of the part. An earlier detailed design part stage view may or may not exist for the part. At this stage, structural part
features are identified that affect aspects of the part that have to do with processes that will be used to cut and form the part. Some
examples of the kinds of features identified during this stage are edge grinds, layout marks, and part stock. Information relating
the structural part to the raw material stock it will be manufactured from is also added during this stage. A 2D flat pattern
representation may be defined for the part, enabling it to be nested and cut from flat raw material stock.
        *)
  for_structural_part_design_definition        : SET OF Structural_part_design_definition;
        (* a reference to a specific version of the detailed design definition of the structural part that is to be manufactured.
        *)
  with_manufacturing_processes                 : OPTIONAL SET [1:?] OF Manufacturing_process;
        (* an indication of the manufacturing processes that will be used in the manufacturing of the part.
        *)
  manufactured from_raw_material_stock_occurrence  : OPTIONAL Raw_material_stock_occurrence;
        (* the purchased plate or rolled shape stock from which the finished part is to be cut.
        *)
  having_part_stock_feature                    : OPTIONAL SET [1:?] OF Part_stock_feature;
        (* a part edge feature that extends the detailed design geometry of an edge to account for the need to add material to allow
for variance in fitup clearances. All or part of the additional material is manually removed at the time of assembly to achieve an
acceptable fit.
        *)
  having_edge_grind_feature                    : OPTIONAL SET [1:?] OF Edge_grind_feature;
        (* a part edge feature that specifies the angle or angles to which the part edge is to be burned or ground to assure correct
part fitup or to fulfill the requirements of the welding specification for the particular edge.
        *)
  having_flat_pattern_shape_representation  : OPTIONAL Flat_pattern_shape_representation;
        (* a 2D shape representation generated for a structural part. In the case of a curved, knuckled, or twisted structural part,
this flat pattern is the developed shape to allow fabrication of the part from flat plate or shape raw material stock.
        *)
  having_layout_mark_feature                   : OPTIONAL SET [1:?] OF Layout_mark_feature;
        (* a reference to marking features that will be manually or automatically applied to the part during manufacturing to
provide part identification or indications of reference locations or attachments to other structural parts.
        *)
  containing_inner_contour                     : OPTIONAL SET [1:?] OF Edge_curve;
        (* a reference to a structural opening that is to be burned from or drilled into the part face.
        *)
  associated_production_template                          : OPTIONAL SET [1:?] OF Production_template;
        (* identification of a manufacturing template that is to be used to aid in production of the part.
        *)
WHERE
WR1:  (EXISTS(with_hole_production_process) AND EXISTS(containing_inner_contour)) XOR  (NOT
EXISTS(with_hole_production_process) AND NOT EXISTS(containing_inner_contour));
END_ENTITY;
```

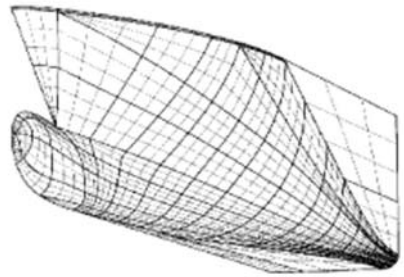
ARM to AIM Mapping Table

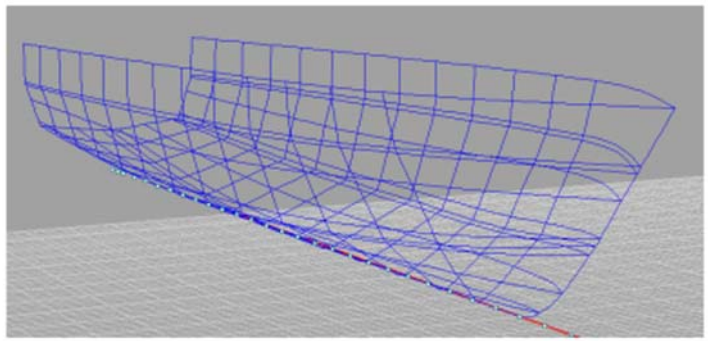
## PLATE_DESIGN_DEFINITION	extended_product_definition_shape	218		{[CLASS<extended_product_definition_shape 'plate design definition', 'structural part design definition'>] [CLASS<extended_product_definition_shape, 'structural part design definition', 'design defin [CLASS<extended_product_definition_shape, 'design definition', 'definition'>] [CLASS<extended_product_definition_shape, 'definition', 'versionable object'>] [ROOT_CLASS<extended_product_definition , 'versionable object'>]}
# plate_design_definition to plate_boundary (as border) (L[1:?]) #1: border is a bounded_curve #2: border is a panel_system_boundary #3: border is a plate_boundary_relationship	#1: PATH #2: PATH #3: PATH			#1: extended_product_definition_shape <= product_definition_shape <- shape_aspect.of_shape shape_aspect {[ROOT_CLASS<shape_aspect, 'border'>] [shape_aspect = represented_definition <- PDR<'border representation'> ->representation representation.items[i] ->GEO_REP_ITEM<'.UNUSED.', bounded_curv #2: extended_ product_definition_shape <= product_definition_shape <- shape_aspect.of_shape shape_aspect {[ROOT_CLASS<shape_aspect, 'border'>] [shape_aspect <- shape_aspect_relationship.relating_shape_as shape_aspect_relationship shape_aspect_relationship.related_shape_as shape_aspect {CLASS_ID<shape_aspect, 'border'>} shape_aspect.of_shape ->extended_product_definition_shape {CLASS_ID<extended_product_definition_sha 'panel system design definition'>}]} #3: extended_product_definition_shape <= product_definition_shape <- shape_aspect.of_shape shape_aspect {[ROOT_CLASS<shape_aspect, 'border'>] [shape_aspect <- shape_aspect_relationship.relating_shape_as shape_aspect_relationship {CLASS_ID<shape_aspect_relationship, 'plate boundary relationship'>}]}

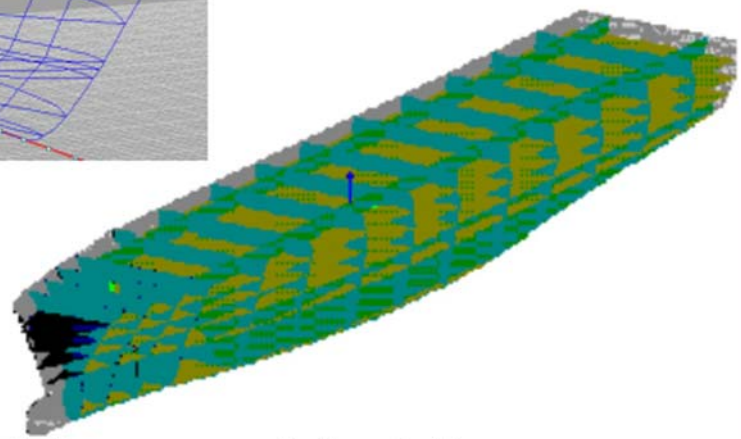
EXPRESS AIM

```
ISO-10303-21;
HEADER;
/* Generated by software containing ST-Developer
 * from STEP Tools, Inc. (www.steptools.com)
 */

FILE_DESCRIPTION(
/* description */ ('LEAPSExport Demo Testcase1 EngineRoom 20060312 '),
/* implementation_level */ '2;1');

FILE_NAME(
/* name */ 'LEAPSExport_Demo_Testcase1_EngineRoom_20060312',
/* time_stamp */ '2006-03-12T23:22:30-05:00',
/* author */ ('Leaps User'),
/* organization */ ('NSWCCD Code 2230'),
/* preprocessor_version */ 'ST-DEVELOPER v10',
/* originating_system */ 'NSWCCD Leaps 3.3',
/* authorisation */ 'N00167-04-M-0544');

FILE_SCHEMA (('SHIP_ARRANGEMENT_SCHEMA'));
ENDSEC;

DATA;
#10=REPRESENTATION_CONTEXT('used for','compartment function parameters');
#11=SHAPE_DEFINITION_REPRESENTATION(#93,#350);
#12=PROPERTY_DEFINITION_RELATIONSHIP('coating material',
'rel between coating and corrosion_protection',#154,#156);
#13=REPRESENTATION_RELATIONSHIP('corrosion protection',
'corrosion protection',#135,#136);
#14=REPRESENTATION_RELATIONSHIP('coating height',$,#136,#137);
#15=COMPOUND_REPRESENTATION_ITEM('centre of volume',LIST_REPRESENTATION_ITEM((#96,
#97,#98)));
#16=PRODUCT_DEFINITION_RELATIONSHIP('Compartment 0013',
'compartment boundary','compartment boundary',#161,#162);
#17=PRODUCT_DEFINITION_RELATIONSHIP('Compartment 0013',
'compartment boundary','compartment boundary',#161,#163);
#18=PRODUCT_DEFINITION_RELATIONSHIP('Compartment 0013',
'compartment boundary','compartment boundary',#161,#164);
```

Surface, wireframe and offset point representations
Design, Production and Operations lifecycles
General characteristics
Main dimensions
Hull form geometry
Major internal surfaces
Hydrostatics
Intact Stability tables



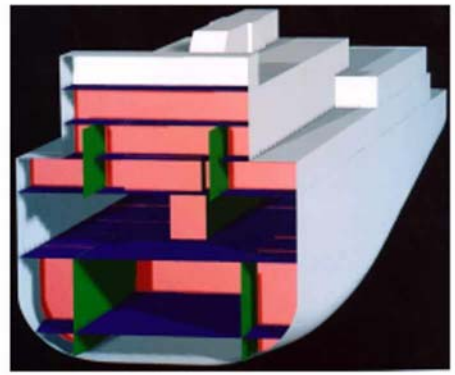


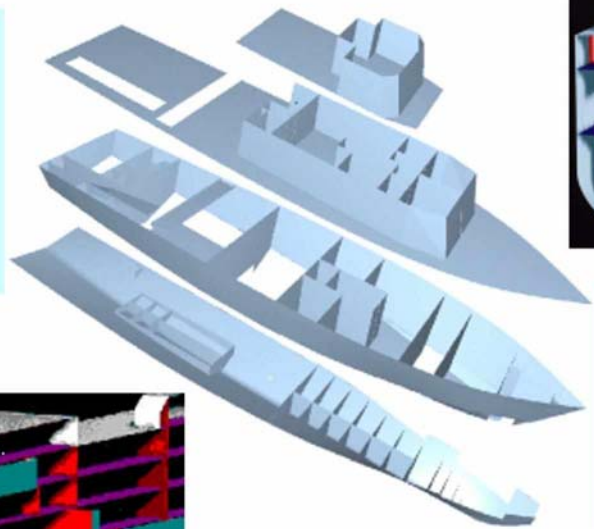


AP216:2003, Ship moulded forms

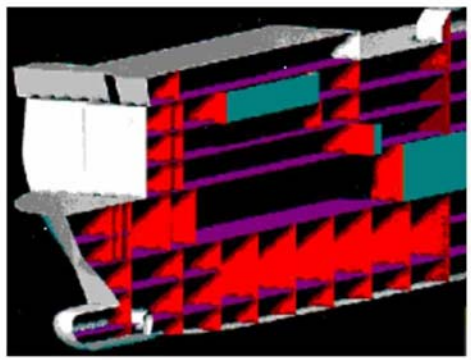
Loading conditions

Compartments
- types
- properties
  (shape,
  coatings,
  adjacency,
  access….)





Zone Boundaries
- Controlling Access
- Design Authority
- Cargo Stowage
- Machinery Compartments
- Crew Occupancy
- Common Purpose Spaces



Stability
- intact
- damaged

General Subdivision of a Ship into Spatially Bounded Regions

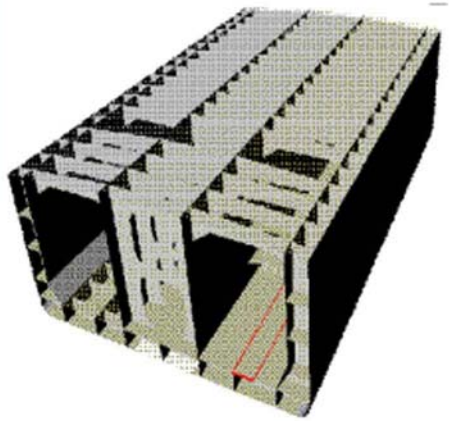
Cargoes
- assignment to compartments
- weight,
- centre of gravity

AP 215:2004 Ship arrangement

Production Design Data

General Characteristics

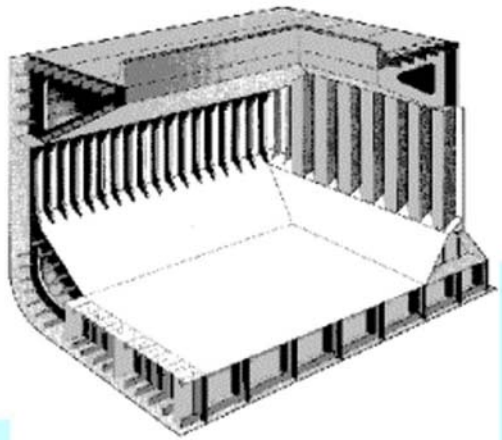
Configuration Management
- Class Approval
- Approval Relationship
- Change Administration
- Promotion Status



Production Engineering Data

Product Structure
- Generic Product Structure
- System
- Space
- Connectivity
- Assembly

Weight Description



Structural Parts
- Feature
- Plate
- Edge Content
- Opening
- Profile
- Profile Endcut

Hull Cross Section

Geometric Representations
- Wireframe
- Complex Wireframe
- Surfaces
- Solids

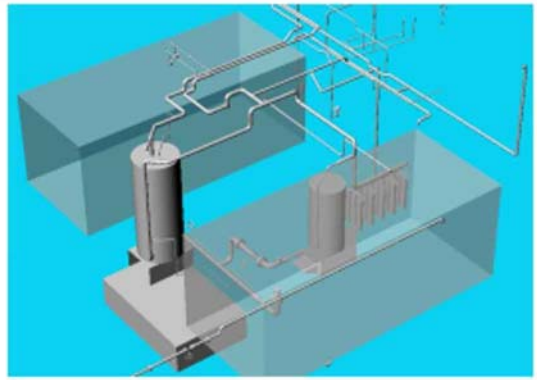
Technical Description

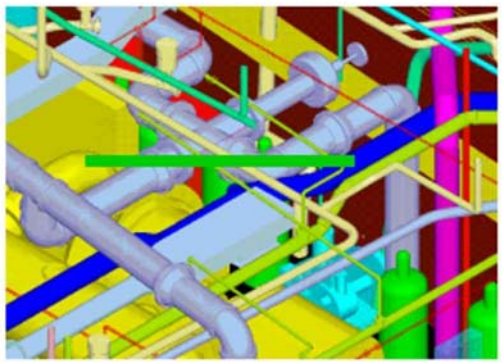
AP218:2004, Ship structures

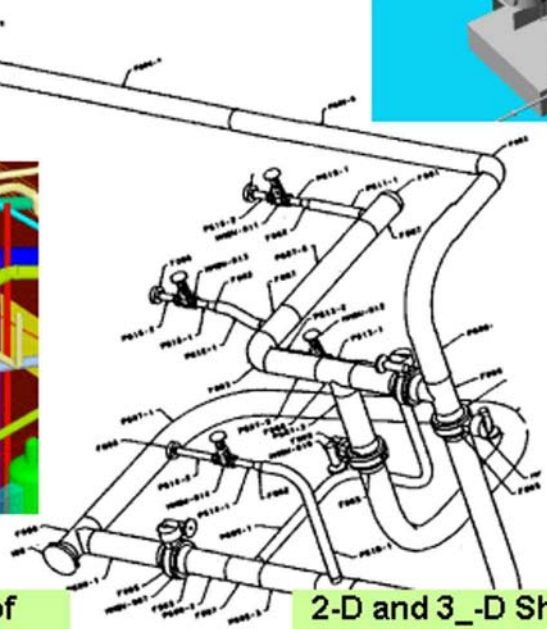
Connectivity
- assembly
- penetrations
- ports

Pipe Flow Analysis and Sizing

Pipe Stress Analysis







Configuration Management of Product Structure

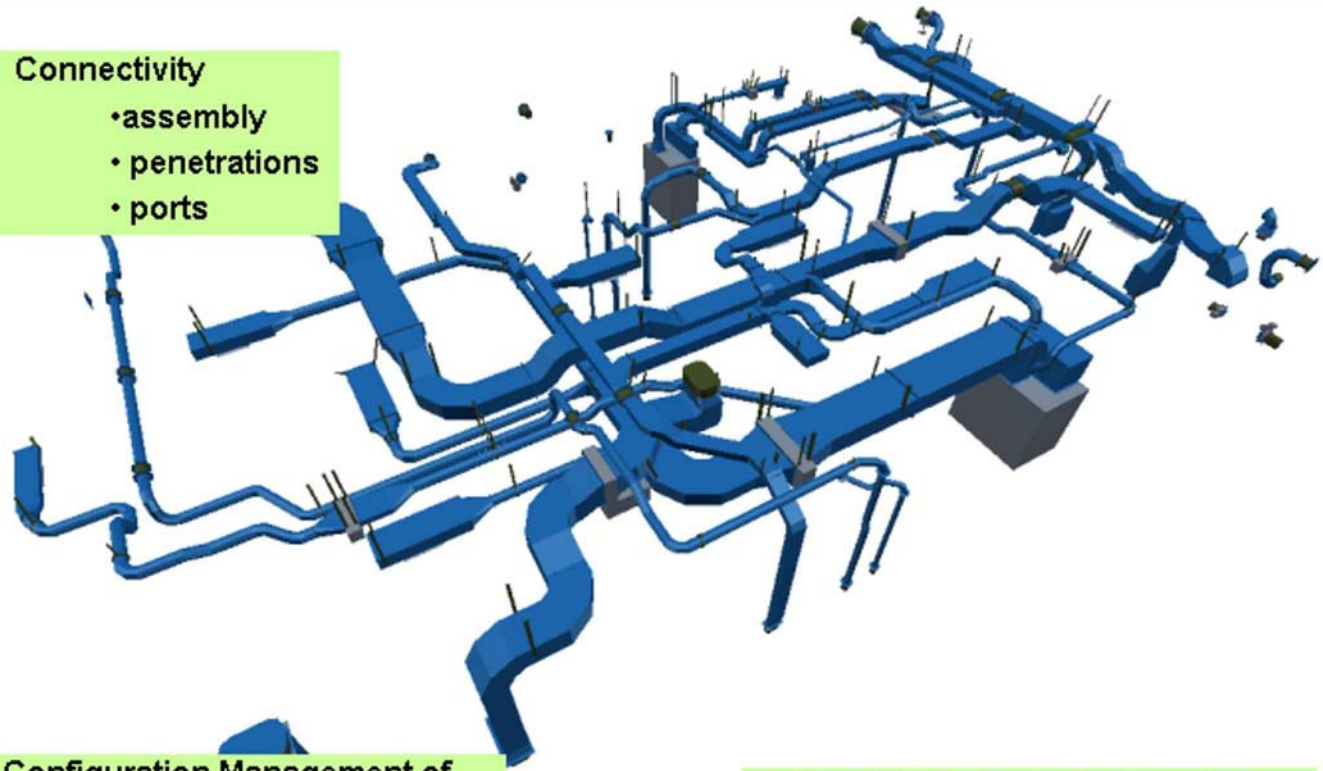
Versioning and Change Tracking

Bill of Materials

2-D and 3_-D Shape Representation
- Diagrammatic Presentation
- Solid Model Presentation
- Interference Analysis

AP227:2005, Plant spatial configuration – piping systems

Connectivity
- assembly
- penetrations
- ports



Configuration Management of Product Structure

Versioning and Change Tracking

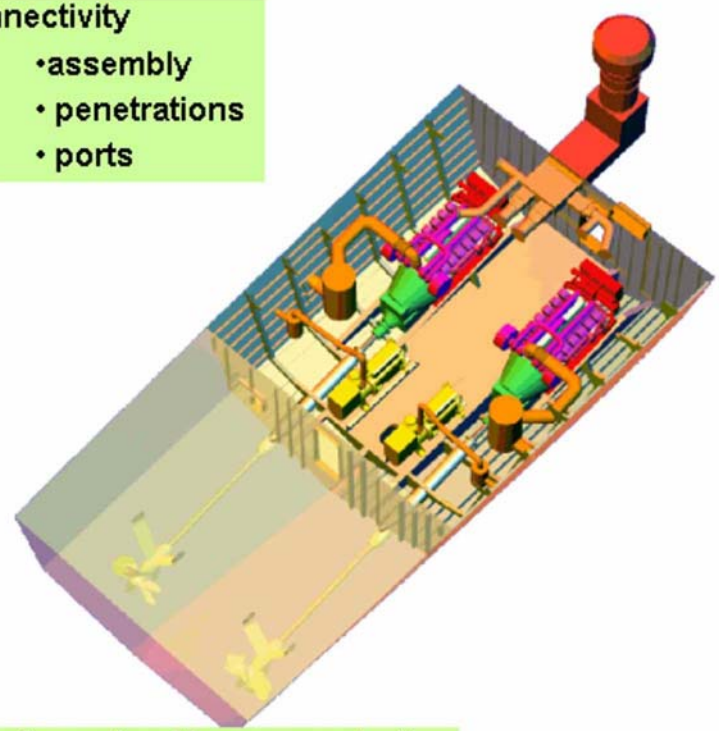
Bill of Materials

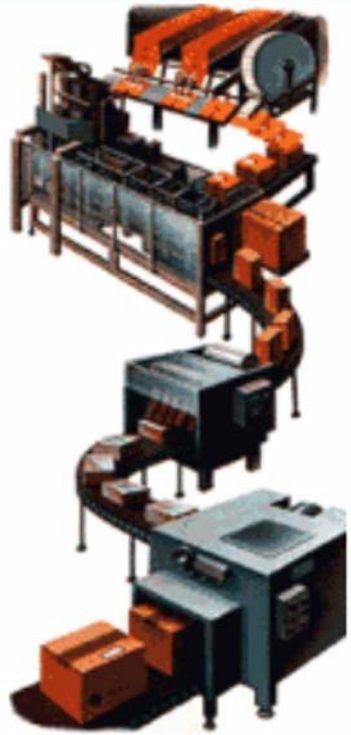
2-D and 3_-D Shape Representation
- Diagrammatic Presentation
- Solid Model Presentation
- Interference Analysis

AP227 Edition 2:2005, Plant spatial configuration - adds HVAC systems

Connectivity

- assembly
- penetrations
- ports





Configuration Management of Product Structure

Versioning and Change Tracking

Bill of Materials

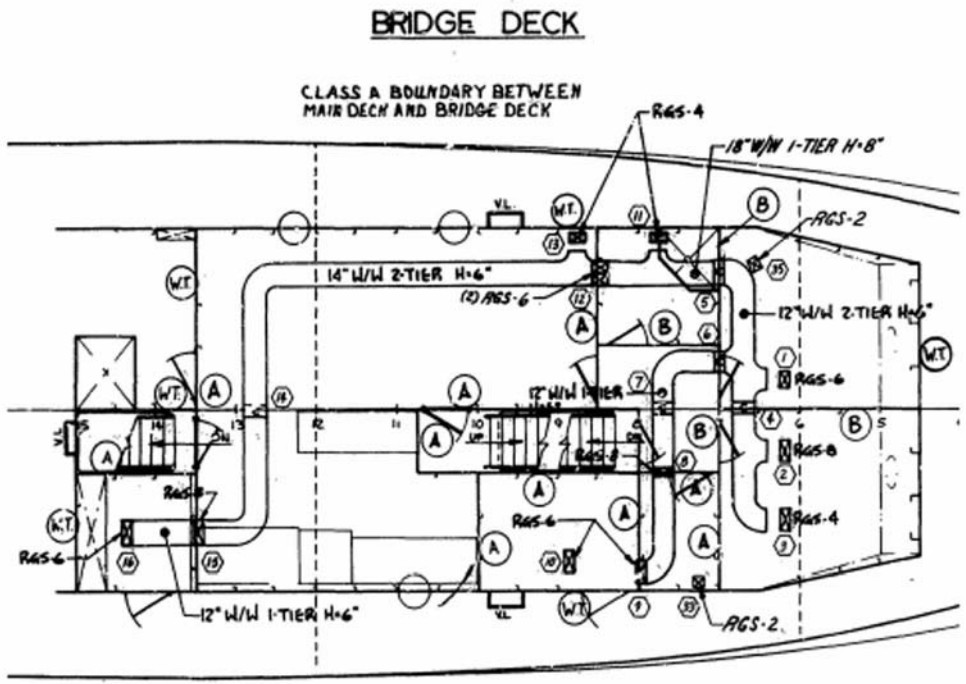
2-D and 3_-D Shape Representation

- Diagrammatic Presentation
- Solid Model Presentation
- Interference Analysis

AP227 Edition 2:2005, Plant spatial configuration - adds mechanical systems

Connectivity

- assembly
- penetrations
- ports



Configuration Management of Product Structure

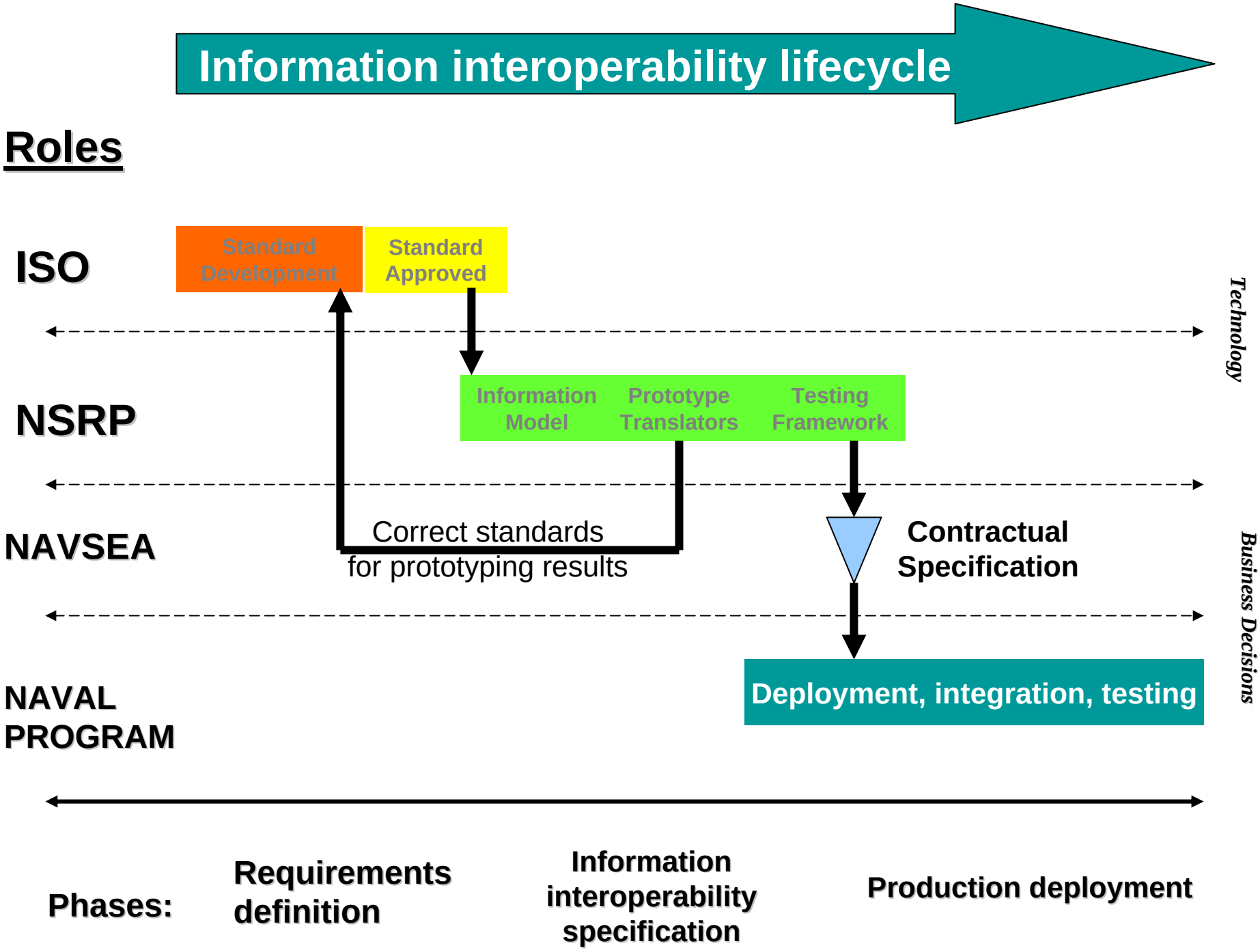
Versioning and Change Tracking

Bill of Materials

2-D and 3_-D Shape Representation

- Diagrammatic Presentation
- Solid Model Presentation
- Interference Analysis

AP227 Edition 2:2005, Plant spatial configuration - adds cable trays


Information interoperability lifecycle
Roles
ISO
Standard Development
Standard Approved
NSRP
Information Model
Prototype Translators
Testing Framework
NAVSEA
Correct standards for prototyping results
Contractual Specification
NAVAL PROGRAM
Deployment, integration, testing
Technology
Business Decisions
Phases:
Requirements definition
Information interoperability specification
Production deployment

Integrated Shipbuilding Environment (ISE)

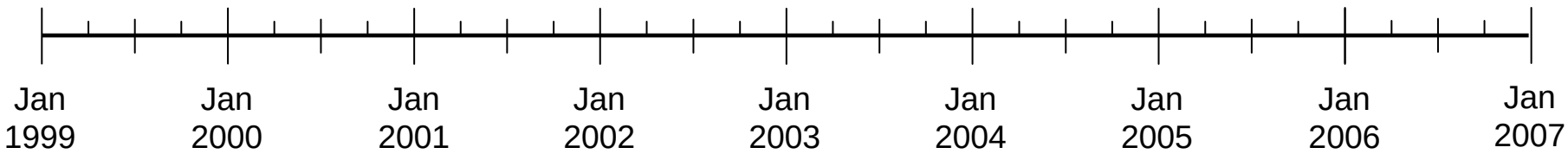
Multi-year U.S. Project to Implement STEP APs for Shipbuilding

Phase 1- Requirements definition & architecture for shipbuilding systems interoperability

Phase 2 – Deployment for Structure & Piping

Phase 3 – Deployment for HVAC & CPC Interfaces

Phase 4 – Deployment for Arrangements, Steel Processing, Engineering Analysis, & Electrical



ISE Project Approach

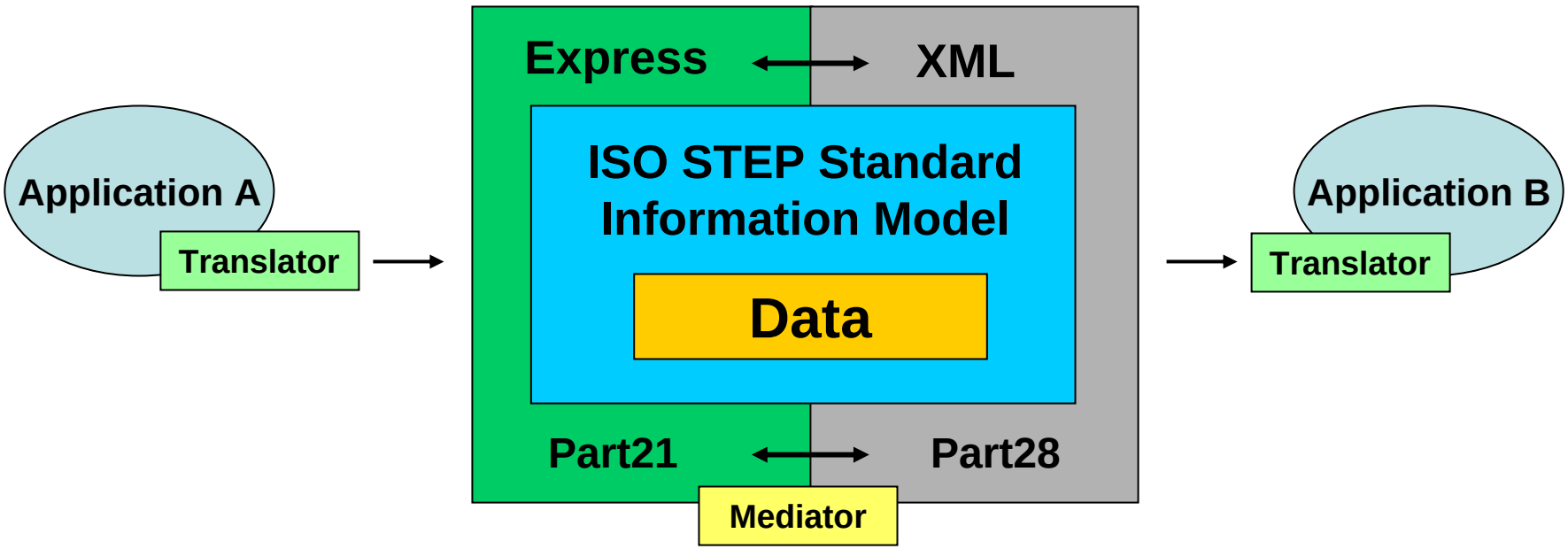
- Develop and demonstrate tools that are low cost
  - can be selectively used by shipyards to support interoperability
  - capitalize on XML and related Internet technologies

- Flexibility is critical
  - allow shipyards to transform their data to/from common information model

- Drive development of international shipbuilding product data standards (e.g. STEP, PLIB)

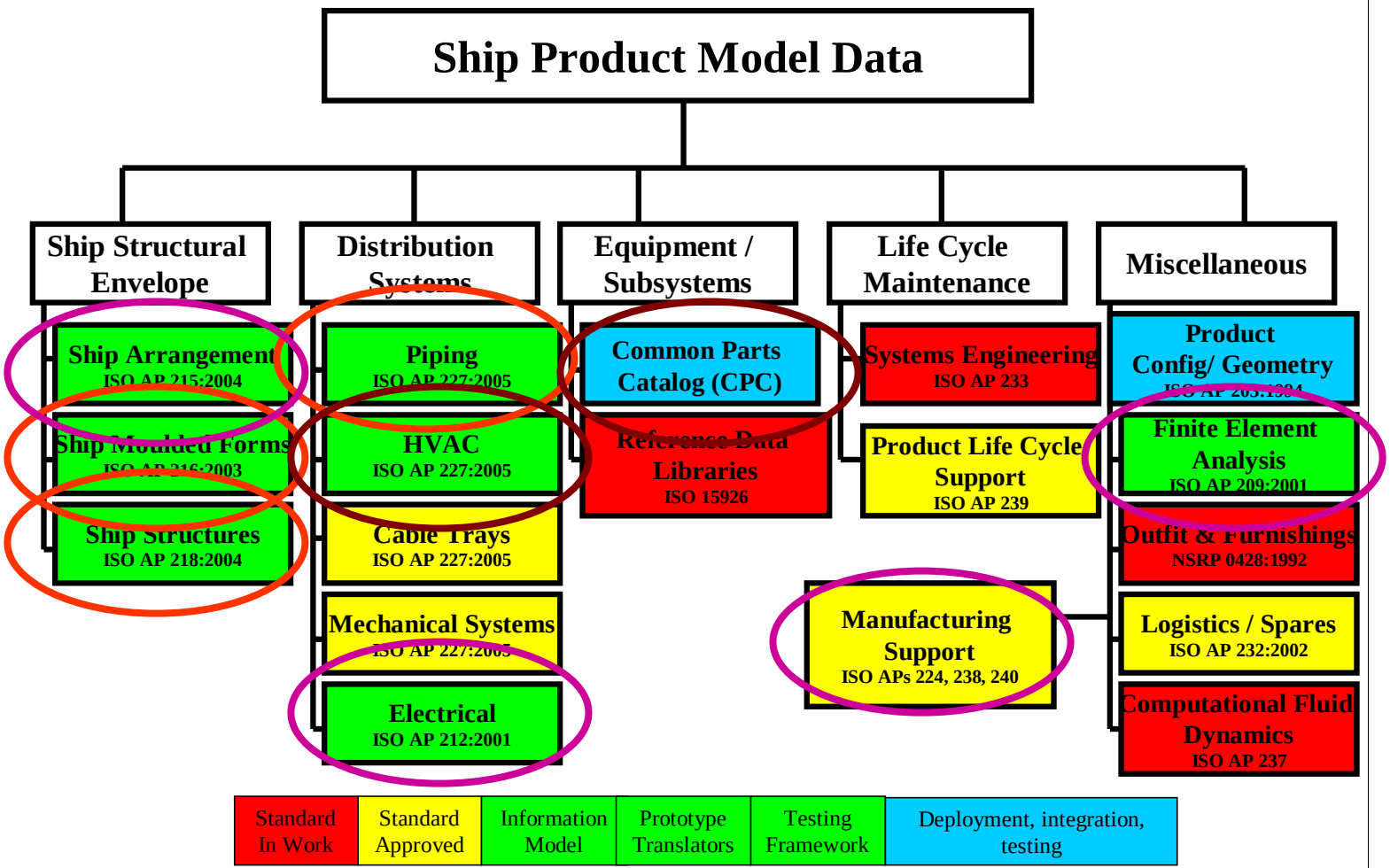
  - Construct a single Shipbuilding Information Model
  - Demonstrate and educate U.S. shipbuilding community
  - Validate the international product data standards

NSRP ISE Model for Information Interoperability



Translator = Modify Data between CAD System Proprietary Format and STEP
Mediator = Change Data Format between various STEP Representations

ISE Product Model Prototyping



Publish ISO Technical Corrigenda for ISO 10303-215, 10303-216 and 10303-227

Purpose

NSRP ISE Prototyping efforts identified editorial and minor technical corrections needed to the STEP Ship standards.

Publish ISO Technical Corrigenda for ISO 10303-215, 10303-216 and 10303-227

Tasks

Resolve Ship AP SEDS (STEP Standard Enhancement and Discrepancy System)

Produce ISO Technical Corrigendum (TC) documents to fix issues

Submit TC documents to ISO for publication

Publish ISO Technical Corrigenda for ISO 10303-215, 10303-216 and 10303-227

Progress

16 AP216 SEDS have been resolved

Initial Draft of AP216 TC1 completed 1 April

Completed AP216 TC1 submitted to ISO Convener 10 May

Publish ISO Technical Corrigenda for ISO 10303-215, 10303-216 and 10303-227

Remaining Work

21 AP215 SEDS have been resolved.

Draft of ISO 10303-215 TC1 under development

AP215 TC1 to be complete by 1 July for submission to ISO.

AP227 Ed2 TC1 to be complete by 1 October for submission to ISO.

Publish ISO Technical Corrigenda for ISO 10303-215, 10303-216 and 10303-227

Questions?