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Final Report

2008 Systems Technology Panel Project:

Interim SCIM and STEP Implementation

Version 1.0

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1. Introduction

This project examined the use of the Navy Product Data Initiative (NPDI) Ship Common Information Model (SCIM) XML schemas and the STEP application protocol for Core Data for Automotive Mechanical Design Processes (AP 214) to represent ship specific information during the interim period before NPDI-based translators for the shipbuilding application protocols[1] become commercially available.

AP 214 and AP 203[2] translators are commercially available with most current CAD systems and have been used successfully across many industries for the representation of shape data and assembly structure. The shipbuilding industry has been a major user of AP 214 to exchange shape data as well. For example, the DDG 1000 program is providing detail ship design shape data in AP 214 format as a Navy deliverable. However, in addition to this shape data, realization of useful shipbuilding data exchange requires additional system product structure information and some property data for these systems and component parts that are not available within the AP 214 standard. This includes component properties, material properties, relationships, system structure functional description, physical description, connections, and joints. In contrast, the DDG 1000 program is currently using an auxiliary XML file to communicate additional attributes in addition to the AP 214 shape information.

The NPDI SCIM [4], currently under development within NSRP, has the capability to define this logical shipbuilding product structure, including identifiers, component properties, material properties, relationships, connections, and joints. In the long term, this data will be supported by development of NPDI-compliant IDEs at the shipyards [3], and commercial implementation of translators from those IDEs. Data exchange from and between NPDI-compliant IDEs is expected to be implemented at some point in the future, but will not be available for those ship classes that are already under design

1.1. Purpose

This document is the final report of 2008 System Technology Panel Project: Interim SCIM and STEP Implementation. This report, with the briefing given Dec. 8, 2009 at the New Orleans NSRP Joint Panel Meeting [1], summarizes the results of this project.

1.2. Project Scope

This project will investigate the technical solution necessary to utilize NPDI SCIM XML and AP 214 geometric data during the interim period before NPDI-based translators for the shipbuilding application protocols[1] become commercially available. The project will examine the feasibility of utilizing existing commercial AP 214 translators for shape data, in conjunction with NPDI SCIM XML for PDM and ship system and component information, for ships currently under contract, such as the DDG 1000 program. The project will analyze the SCIM XML schemas to ensure that it is a correct and complete specification of the data needed for delivery to the Navy's systems, and propose any modifications needed in the SCIM to externally reference existing commercial STEP CAD translators' shape geometry files. It will document the proposed DDG 1000 data transfer solution, making it more understandable and repeatable by other Ship programs that may require interim data exchanges prior to the availability of full implementations of NPDI-compliant IDEs.

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[1] (AP 215, AP 216, AP 218, and AP 227 ed2)

[2] AP 203 is the application protocol for Configuration Controlled Design (AP 203). AP 214 is used synonymously with AP 203 throughout the remainder of the report and briefing.

1.3. Project Objective

The goal of this project was to determine the feasibility of using AP 214 and the NPDI SCIM data model to:

1) improve the exchange of early design data from the shipbuilder to the Navy for analysis and class approval;
2) improve the exchange of detail design data within an enterprise during the design and construction process;
3) perform an initial validation of the adequacy and completeness of the SCIM for communicating PDM, system product structure, and component part product information

The specific benefits include:

- Development of an effective interim solution to support the near term data exchange requirements of the US shipbuilding industry and Navy ship programs.
  - Develop recommendations for use in existing ship programs
  - Demonstrate feasibility of using NPDI SCIM to exchange design data for DDG-1000 program and Navy LEAPS repository.
- Initial validation of NPDI SCIM data model
  - Initial population of the SCIM XML schema
  - Provide feedback to SCIM Technical Working Group

1.4. Project Participants

The project team was led by Intergraph with members from the following organizations:

- Northrop Grumman Shipbuilding (NG SB)
- Northrop Grumman Technical Services (NG TS)
- Product Data Services Corp. (PDS)
- Naval Surface Warfare Center – Carderock Division (NSWC-CD)

1.5. Acronyms and Abbreviations

AP:	Application Protocol: Documents that specify the format for representing product data within a set of related processes or activities
AP203:	ISO 10303-203: AP for Configuration Controlled Design
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
CAD:	Computer-Aided Design
DDG:	Guided Missile Destroyer ship type

DEX:	Data Exchange Set
DoD:	Department of Defense
HM&E:	Hull, Mechanical, and Electrical
HVAC:	Heating, Ventilation, and Air-Conditioning
IDE:	Integrated Data Environment
IETM:	Interactive Electronic Technical Manual
ILS:	Integrated Logistics Support
IPDE:	Integrated Product Data Environment
IS:	International Standard
ISE:	Integrated Shipbuilding Environment Project
ISEA:	In-Service Engineering Agent
ISEC:	Integrated Shipbuilding Environment Consortium
ISO:	International Organization for Standardization
LEAPS:	Leading Edge Architecture for Prototyping Systems
LPD:	Landing Platform Dock ship type
NSWC-CD:	Naval Surface Warfare Center - Carderock Division
PDM:	Product Data Management
PLM	Product Lifecycle Manager
STEP:	STandard for the Exchange of Product Model Data
TIA:	Technology Investment Agreement
URL:	Uniform Resource Locator (a web address)
XML:	Extensible Markup Language

2. Background

The problems with shipbuilding data exchange are illustrated in Figure 1 below. Shipyard data from multiple sources is required for use by analysis programs, the Navy, and class societies. The use of standards permits an open architecture approach. However, this does not ensure that the 3D geometry is linked with ship design data or that the 3D geometry is defined parametrically. The SCIM data model [4] was developed to address these issues. Commercial SCIM compliant translators will probably not be available for the foreseeable future. At this time only AP 203 and AP 214 translators are commercially available, which generate explicit 3D shapes, not parameterized geometry.

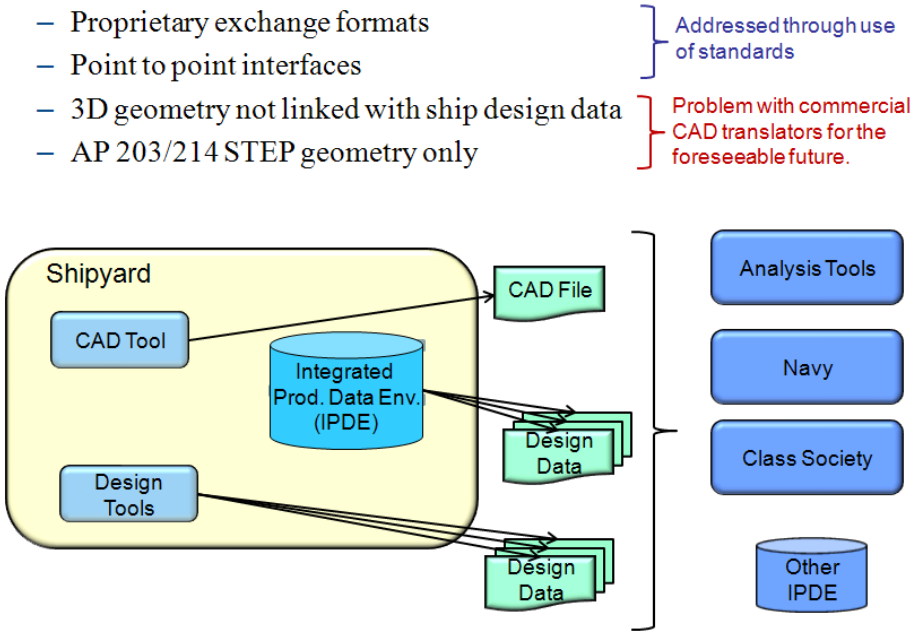

Figure 1 Shipbuilding Data Exchange Problems

Currently, each ship program uses an IPDE based on different CAD and PDM tools, as shown in Figure 2 below. The intent of NPDI is to define a standard IPDE specification (see [3]) and SCIM data exchange. In the interim, a data exchange approach is needed can addresses different CAD and PDM tools, using commercially available translators and a SCIM compatible approach.

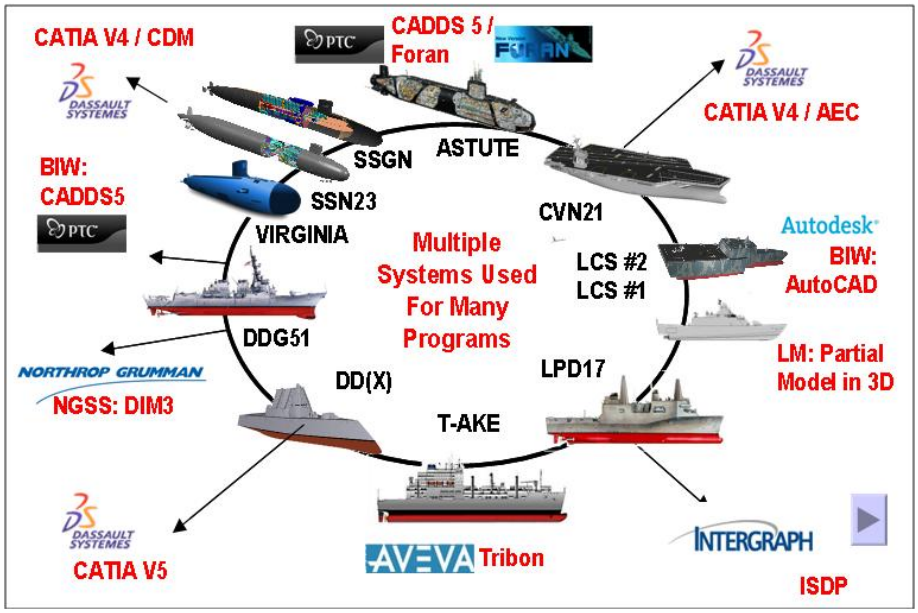

Figure 2 CAD and PDM Tools used by Current Ship Programs

3. Technical Approach

Several commercial CAD translators generate an AP 214 file and a related XML attribute file as illustrated in Figure 3 below. This enables the geometry to be referenced externally by other applications.

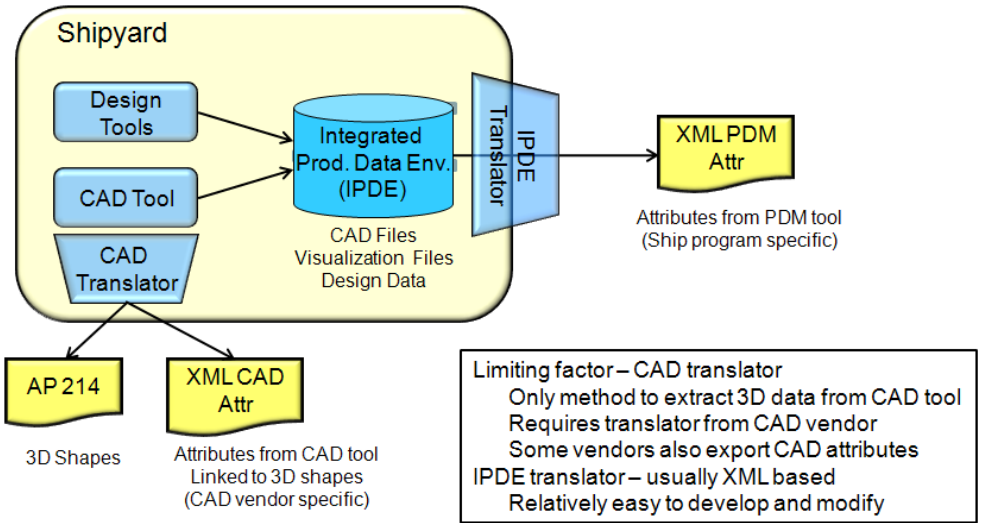

Figure 3 Current IPDE Data Exchange Situation

1.1. Linking Geometry and SCIM Design Data

The technical approach assumes that the AP 214 file has identifiers on CAD components, which can be related to design information (either directly or through association in an auxillery attribute file).

An example of LPD 17 ISDP translator output is shown below in Figure 4. In this case, the CAD components are labeled with identifiers within the CAD environment, which are cross-referenced to design data identifiers in the XML attribute file.

STEP AP 214 File

```
#1012=PRODUCT(':1440232005.m:1412:170347:40:',':1440232005.m:usr:avlpd609005_00','equipment',(#
1002));
#1013=PRODUCT_RELATED_PRODUCT_CATEGORY('item','',(#1012));
#1014=PRODUCT_DEFINITION_FORMATION_WITH_SPECIFIED_SOURCE(':1440232005.m:1412:1703
47:40:','equipment',#1012,.NOT_KNOWN.);
#1015=PRODUCT_DEFINITION('','equipment',#1014,#1003);
#1016=PRODUCT_DEFINITION_SHAPE(':1440232005.m:usr:avlpd609005_00','equipment',#1015);
```

XML Attribute File

```
<ss_om_eqp comp_path=":1440232005.m:usr:avlpd609005_00"
    comp_tagx=":1440232005.m:1412:170347:40:" symbology="300:2:1:0:"
    class_name="VDequipment" rep="4" macro_name="avlpd609005" macro_lib="avlpdmech03">
 <ss_om_collector eqp_family="avtank01" eqp_partno="1CC97-LP-V-51401-18" eqp_partrev="000"
    p_macro="avlpd609005" nomenclature="Receiver,Storage" mac_name="avlpd609005" />
 <ss_om_collector eqp_number="RAC-TK1" eqp_descr="AC_UNIT_REFRIG_TANK" unit_number="1440"
    compt_number="5-33-0-Q" sirobid="NULL" mark_user="double 0" sirid="81290-0001-1"
    system_name="RAC" zone_number="1440" />
 <ss_om_cs matrix="doubles 16 0 -1 0 -39750 1 0 0 42000 0 1 7964.4 0 0 0 1" />
</ss_om_eqp>
```

Figure 4 Example LPD 17 ISDP Translator Output

An example of DDG 1000 CATIA translator output is shown below in Figure 5. In this case, the CAD components are labeled with part numbers, which can be directly cross-referenced to design data. The XML attribute file is not required if the PDM system can be accessed directly. (In fact, the XML attribute file is generated within the DDG 1000 IPDE environment after the AP 214 file is generated.)

STEP AP 214 File

```
#13=PRODUCT_DEFINITION('BR549501XXXDG00000','
',#6,#3) ;
#6=PRODUCT_DEFINITION_FORMATION_WITH_SPECIFIE
D_SOURCE('',',#5,.NOT_KNOWN.) ;
#3=PRODUCT_DEFINITION_CONTEXT('part definition',#1,' ')
;
#1=APPLICATION_CONTEXT('automotive design') ;
#5=PRODUCT('BR549501XXXDG00000','','',(#2)) ;
#2=PRODUCT_CONTEXT(' ',#1,'mechanical') ;
#8=PRODUCT_RELATED_PRODUCT_CATEGORY('part',$,(#
25,#39482)) ;
#39465=NEXT_ASSEMBLY_USAGE_OCCURRENCE('B0000
27','B000027','',#13,#27,' ') ;
#27=PRODUCT_DEFINITION('PLANT_AC_500_TON','
',#26,#3) ;
#26=PRODUCT_DEFINITION_FORMATION_WITH_SPECIFI
ED_SOURCE('Added maint space for condenser and chiller
tubes removal',' ',#25,.NOT_KNOWN.) ;
#25=PRODUCT('PLANT_AC_500_TON','','ENGINEERING
DIAGRAM FOR AC PLANT, RAFT AND HARD MOUNTED
EQUIPMENT',(#2)) ;
#44957=NEXT_ASSEMBLY_USAGE_OCCURRENCE('B0000
94','B000094','',#13,#39484,' ') ;
#39484=PRODUCT_DEFINITION('EVAC_ASSY_500T_
AC_PLANT',' ',#39483,#3) ;
#39483=PRODUCT_DEFINITION_FORMATION_WITH_SPEC
IFIED_SOURCE('',' ',#39482,.NOT_KNOWN.) ;
#39482=PRODUCT('EVAC_ASSY_500T_
AC_PLANT','','DEVELOPED FROM: YORK INTERNATIONAL;
DWG NO. 376-92108-000, REV
C.\X2\0009\X0\CONNECTIONS PER ANSI B16.22 AND MIL-
V-24578 ',(#2)) ;
```

XML Atribute File

```
<RootProduct SP="4" CATIA="B18" CATSync="3.3.2"
RevItem="-1" Version="---"
PartNumber="BR549501XXXDG00000"
Effectivity="[Engineering Effectivity] (R( 1 - oo))"
InstanceName="BR549501XXXDG00000"
XMLCreationDate="Thursday 30 October 2008 11:32:16">
- <Product PartNumber="PLANT_AC_500_TON"
InstanceName="B000027">
- <AttributeList>
  <Attribute Name="MelID" Value="001" />
  <Attribute Name="NCN" Value="4120-DA0-760895" />
  <Attribute Name="BIWCatalogNumber" Value="000001" />
  <Attribute Name="System" Value="NULL" />
  <Attribute Name="CompartmentNumber" Value="x-xx-x-x" />
  <Attribute Name="CompartmentFunctionNumber"
Value="5016" />
  <Attribute Name="DamageControlClassification"
Value="NULL" />
  <Attribute Name="NavyComponentNumber" Value="NULL" />
  <Attribute Name="Service" Value="NA" />
  <Attribute Name="DiagramNumber" Value="001" />
  <Attribute Name="DrawingNumber" Value="001" />
  <Attribute Name="PieceNumber" Value="C0002" />
  <Attribute Name="FindNumber" Value="AC PLANT NO. 4" />
  <Attribute Name="ARFC" Value="RFS-BW-000" />
  <Attribute Name="Remarks" Value="NULL" />
  <Attribute Name="NormalValvePosition" Value="NA" />
  <Attribute Name="MountingMethod" Value="NA" />
  <Attribute Name="Tightness" Value="NA" />
  .....
  </AttributeList>
  </Product>
```

Figure 5 Example DDG 1000 CATIA Translator Output

The project incoporated external references based upon STEPMod External_model module 10303-1033:2004 into the SCIM schema.

1.2. Translator Approach

Given the linkage between geometry in the AP 214 file and the design data, a SCIM XML file can be generated as shown in Figure 6 below. This approach builds upon commerical CAD translators and transforms vendor proprietary XML data into SCIM compliant XML, adding additional PDM data as required. The SCIM translator requires only minimal development effort to transform XML from one format to another (supported by XSLT and other techniques) and possibly access to PDM and CAD data sources.

The test cases generated in this project were hand populated. The project did not develop a SCIM translator.

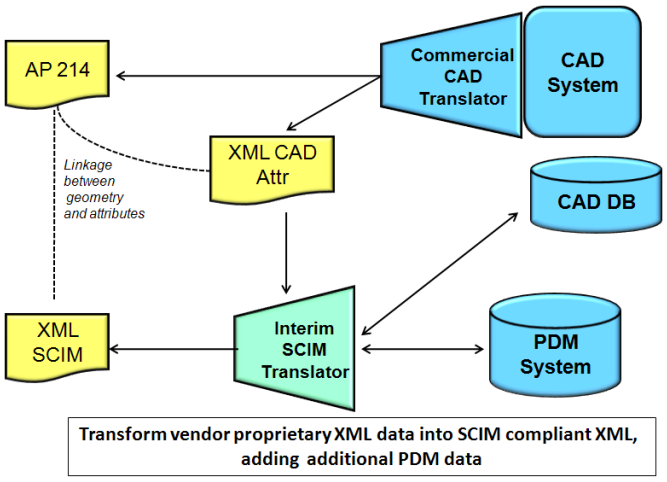

Figure 6 Interim SCIM and STEP Data Exchange Approach

1.3. Seperation of Geometry and Design Data

An AP 214 file may contain assembly structures and the SCIM data may contain geometry. However, the AP 214 assembly structure is usually CAD file specific and usually does not represent an assembly in the general sense of design.This information is better represented as SCIM data. Similarily, geometry is better represented in the AP 214 file.

Hence, the project adopted the following conventions as recommended practice

- All geometry is contained in AP 214 file, which is eternally referenced from SCIM file
- All product structure is contained in SCIM file.

1.4. Test Case Methodology

Test Cases were generated using the following methodology:

- Define instance diagram which defines key objects and relationships
- Generate AP 214 file and CAD XML file based on selected data source
- Hand populate spreadsheetbased on instance diagram with SCIM attributes and external references.
- Generate XML SCIM Test Case File from spreadsheet using atomated tool.

An example of the Molded Form Test Case instance diagram is shown below in Figure 7. Each box denotes an entity type. Arrows denote relationsips between enities.

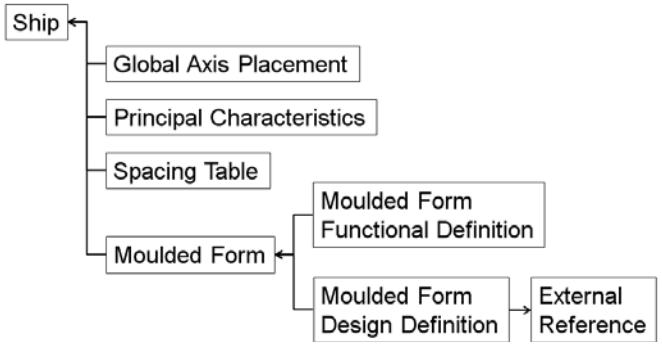

Figure 7 SCIM Molded Form Test Case Instance Diagram

An example of the Molded Form Test Case spreadsheet is shown below in Figure 8. Columns represent different instances of the same entity type, e.g. molded form instances bleow. Each tab defines a separate entity type. Relationships are also included as attributes.

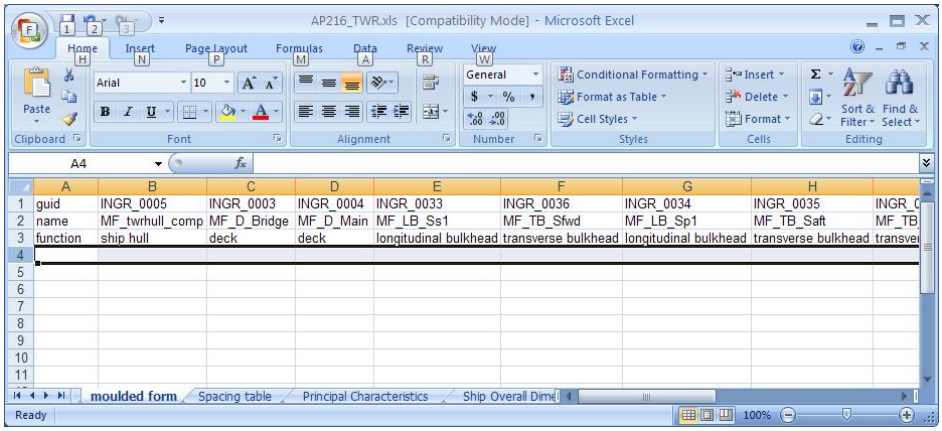

Figure 8 SCIM Molded Form Test Case Spreadsheet

4. Summary of Project Results

The project addressed the three test cases. However, this required more assistance than anticpated from the SCIM Technical Working Group, which was not fully active and funded until early summer. The SCIM documentation defines entities, relationships, and their supertypes. Implementation and test case population requires a fully expanded schema in which supertype attribuites are included for each entity. The project required the addition of external references. The project also identified several missing realtionships that were required to generate test cases. Finding and recommendations are discussed in subsequent sections.

The results of the project are summarized below for each test case:

- Molded Forms Test Case
  - Test Case defined based on pubically released TWR data
  - SCIM AP 216 expanded schema with external references generated
  - Molded Form Test Case defined
  - ISDP Molded Form translator modified to generate correctly generated separate STEP product entity for each molded form
  - Test Case available on isetools web site

- Structural Test Case
  - Structural Test Case defined based on DDG 1000 data
  - SCIM AP 218 expanded schema generated
  - Missing relationship and attributes identified in SCIM schema
  - SCIM schema updated to include missing attributes and relationships in addition to external references
  - Test Case Spreadsheet available on isetools web site
  - Full Test Case available on NSWC CD web site

- Piping Test Case
  - SCIM AP 227 expanded schema generated
  - Missing relationship and attributes identified in SCIM schema
  - SCIM schema updated to include missing attributes and relationships in addition to external references

5. Technology Transfer

The project emphasized technology transfer by participating in seminars, symposia, and standards activities. Panel Project presentations were given at several meetings and symposia:

- NSRP Joint Panel Meeting in San Diego on May 6, 2009
- Ship Production Symposium in Providence, RI on October 23, 2009
- NSRP Joint Panel Meeting in New Orleans on December 8, 2009

The Panel Project also worked closely with the SCIM Technical Working Group to discuss and resolve SCIM schema issues.

The results of the panel project, including test files based on publically released data, are available on the isetools website [2]. Test files based on DDG 1000 files are available on a restricted access NSWC CD web site.

6. SCIM Findings

The findings of the project with respect to implementation and hand population of SCIM include:

- The technical approach is viable for translators which generate AP 214 files with CAD identifiers on that can be related to design information
- The SCIM data model was sufficiently defined for NPDI specification, but additional work was required for translator usage.
  - The SCIM documentation was originally intended to be only a data model. However, previous ISE work provided XML context schemas and tools, which were used as a starting point for the definition of SCIM schemas. Implementation and test case population require use of a specific schema.
  - The SCIM schemas were not fully expanded to include supertype attributes in each entity.
  - Missing attributes were discovered. These were added to the SCIM Issue Log and corrected.
- The SCIM attributes and relationships require further validation
- The SCIM needs to define which attributes are mandatory
- The SCIM model is missing geometry definitions from STEP
- The use of SCIM still requires access to ISO STEP documentation
- STEP expertise is required to implement or populate the SCIM schema
- A STEP geometry viewer is required to hand populate SCIM files
- The SCIM is inconsistent about inclusion of supertype attributes
- The SCIM doesn't clearly defiune how to populate supertype attributes
- The SCIM is missing XML schema (XSL) files to validate XML files.

7. SCIM Recommendations

The recommendations to the SCIM Techncial Working Group include:

- Incorporate the external reference mechanism into SCIM. This will allow geometry to be fully defined in an AP 214 file.
  - Clarify usage rules for External Geometric Model. One instance may be sufficient, but in general, one instance is required per CAD component.
- Include documentation for STEP geometry model in the SCIM documentation.
- Define mandatory attributes in the SCIM documentation.
- Provide a SCIM User's Guide containing examples with the SCIM documents.
- Reference required ISO STEP documentation where required.
- Define how supertype attributes are to be populates in the SCIM documentation.
- Review SCIM documentation and treat inclusion of supertype attributes consistently.
- Include example SCIM XML schemas with the SCIM documents.
- Validate the SCIM documents and schema against STEP schema to identify any missing attributes or relationships.
- Include fully expanded XML schemas with the SCIM documents.
- Include XSL files to validate XML data files with the SCIM documents.

8. Summary

This project investigated an interim approach to utilize SCIM XML and AP 214 geometric data during the interim period before SCIM-based translators for the shipbuilding application protocols become commercially available. The approach was found to be viable for the test cases considered. Use of this

approach in current ship programs would require development of at least two SCIM XML translators. This is expected to require minimal development effort; however, the project did not investigate the specification or implementation of such a translator.

A number of SCIM issues were identified and recommendations were made to the SCIM Technical Working Group. Specific issues were added to the SCIM Issue Log.

Potential next steps could include:

- Validate fully expanded SCIM schemas
- Validate SCIM schema against STEP schema to identify any missing attributes or relationships.
- Utilize project Test Case for SCIM User's Guide

9. References

1. T. Briggs, M. Olson, R. Wood, P. Lazo, B. Kassel "*Interim SCIM and STEP Implementation: 2008 NSRP System Technology Panel Project*", NSRP Joint Panel Meeting, New Orleans, Dec. 8, 2009, http://www.isetools.org/eb-cgi-bin/yabb2_ISE/YaBB.pl?num=1260134519.
2. http://www.isetools.org/eb-cgi-bin/yabb2_ISE/YaBB.pl?board=scim_panel_project
3. NPDI web site, http://npdi.nsrp.org/
4. SCIM, http://www.isetools.org/eb-cgi-bin/yabb2_ISE/YaBB.pl?catselect=scimCategory.