EPRI

Report on the Common Information Model (CIM) Extensible Markup Language (XML) Interoperability Test #1

The Power of the CIM to Exchange Power System Models

Technical Report

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REPORT SUMMARY

The Control Center Application Program Interface (CCAPI) and Common Information Model (CIM) translated into Extensible Markup Language (XML) provide a very important standard for exchanging power system models. Interoperability tests started in December 2000 have validated the use and acceptance of this standard. This report presents results of these tests.

Background
EPRI spearheaded an industry-wide CCAPI effort to develop open, interoperable applications for Energy Management Systems (EMS) in energy control centers through use of standardized interfaces. Central to the CCAPI concept is CIM, which defines the essential data structure of a power system model. The North American Electric Reliability Council (NERC) had been searching for the best way to exchange power system models electronically, and CIM using the industry standard language XML offered the best solution. The CCAPI project initiated an effort to map CIM into XML, which is supported by all major software platforms. Use of the Resource Description Framework (RDF) schema and syntax to organize XML also was adopted. To validate XML and RDF for model exchange, a series of interoperability tests between products from different suppliers was planned.

Objective
To report results of the first set of interoperability tests performed in Orlando, Florida, on December 18-19, 2000.

Approach
The project team prepared a formal set of test procedures to test the ability of vendor products to correctly import and export sample power system model files. After a period of preparation and preliminary testing, seven vendors gathered in Orlando, Florida, in December 2000 to have an impartial observer test their products.

Results
This report summarizes the test process and its results. The test process is first explained to aid in understanding test results, which are reported in three test matrices. For purposes of testing, tests and results are loosely organized into three categories:

- Basic import/export, which tests an individual product's ability to correctly import and export sample model files based on CIM XML standards. All participants were able to successfully import at least one model file, correctly converting from the CIM XML format to their internal proprietary format. Of six participants able to export a model file, four

correctly exported at least one sample file without modification, one exported an alternate 40-bus model file, and one did not attempt the test.

- Interoperation between a pair of vendor's products, which tests the ability of one vendor's product to correctly import an unmodified sample model previously exported by another vendor's product using CIM XML standards. Twelve pairs of vendors were able to interoperate successfully by exchanging at least one unmodified sample model file.
- The third category added a series of modifications to the sample models that would typically be made as a result of as-built changes within substations before exchanging models. Six pairs of vendors demonstrated interoperability by exchanging at least one modified test file.

A description of tested vendor products is provided. A summary of problems uncovered during testing and their resolution also is included.

EPRI Perspective

CCAPI compliance offers control center managers the flexibility to combine—on one or more integrated platforms—software that best meets their energy company's needs for system economy and reliability. This compatibility allows managers to upgrade, or migrate, their EMS systems incrementally and quickly, while preserving prior utility investments in custom software. Migration reduces upgrade costs by 40 percent or more and enables energy companies to gain strategic advantages by using new applications as they become available.

At the same time, as market forces accelerate the pace of the changing business environment for energy companies, the need for greater business and operating flexibility also has increased. Such responsiveness requires that all members of a business enterprise pool their talents and resources. An energy company's information is one of its most valuable resources, and energy companies are working to improve accessibility of this critical resource, whether it be real-time data on power system operation, energy billing information, or load forecasting data.

CCAPI/CIM-enhanced EMSs foster an interdisciplinary approach to conducting business by enabling interdepartmental teams to access a range of needed information via open systems. Hence, in innovative applications, energy companies are planning to implement CCAPI and CIM outside the control center to reduce costs and improve customer service and staff productivity. EPRI continues to sponsor collaborative efforts to advance CCAPI and CIM capabilities for greater information systems integration solutions—in the control center and beyond.

Keywords

Application program interface	Control centers	Energy management systems
Common information model	Data exchange	Power system model
Power system reliability	XML	Power system security

PREFACE

The reliability of the North American power grid is an increasingly visible topic in the news today. This is due in large part to the need to operate closer to available transmission capacities than at any time in the history of the electric utility industry. Ever-increasing demand in the face of reduced power plant construction is a major factor - evidence the recent rolling blackouts in California.

One way to tackle the reliability issue is to improve the models of the power system used to calculate available transmission capacity, so that calculated capacities more nearly match real world capacities. This permits operation closer to maximum capacity while avoiding unplanned outages. One key to improved models is to have the capability to merge NERC regional models into a combined model. Since these models reside in multiple, proprietary databases in Security Coordination Center EMSs located throughout North America, an information infrastructure that facilitates model exchange is an absolute necessity.

One initiative underway to address this need is based on the Common Information Model (CIM) standards that EPRI helped develop as part of the Control Center Application Program Interface (CCAPI) project. The CIM has been translated into the industry standard Extensible Markup Language (XML), which permits the exchange of models in a standard format that any EMS can understand using standard Internet and/or Microsoft technologies. The North American Electric Reliability Council (NERC) recently mandated the use of this standard by Security Coordination Centers (SCCs) to exchange models by September 2001, adding urgency to the deployment of products that support these standards.

This report presents the results of the first interoperability tests using these standards to exchange power system models between products from seven different vendors. The goal of this report is to raise awareness of the importance and status of this effort to encourage early adoption by additional product suppliers and energy managers.

Dave Becker
EPRI
February 2001

ABSTRACT

On December 18-19, 2000 in Orlando, Florida, seven software vendors serving the electric utility industry met to test the capability of their software products to exchange and correctly interpret power system model data based on the CIM (Common Information Model). The CIM was developed by the EPRI CCAPI project and is now being advanced as an international standard (draft IEC 61970-301 CIM Base). Each vendor present was required to exchange files with the other vendors and to demonstrate that their software correctly converted their proprietary representation of a power system model to/from the CIM XML format.

These interoperability tests address an important industry requirement established by NERC to be able to transfer power system model data between Security Coordinators. NERC has mandated the use of the Resource Description Framework (RDF) as the XML schema/syntax for the CIM, which is defined in another CCAPI standard (draft IEC 61970-501 CIM RDF Schema). These tests demonstrated the use of this draft standard for this purpose and for any other application where a standard way of representing power system models is needed, such as combining multiple, proprietary-formatted power system models into a single merged internal model for an RTO.

Vendors participating in these tests included ABB, ALSTOM ESCA, Siemens, PsyCor, SISCO, CIM-Logic, and Langdale Consultants. Xtensible Solutions prepared the test procedures, witnessed the test results, and will prepare a test report for EPRI. This is an important milestone in the CCAPI project and is the first in a series of planned interoperability tests for 2001 that will demonstrate additional CCAPI capabilities.

ACKNOWLEDGMENTS

EPRI wishes to thank the many people who worked hard to make this first CIM XML interoperability test a success. Not all people who contributed can be named here. However, EPRI would like to give special recognition to the following vendors and contractors:

- Steve Widergren, ALSTOM ESCA, for leadership, assistance with test procedure preparation, and providing the figures used in the test report
- Arnold deVos, Langdale Consultants, for test tools and preparation of the CIM UML and RDF schema files
- Leila Schneberger, CIM-Logic, for test tools and preparation of the CIM UML and RDF schema files.
- Joe Evans, PsyCor, for preparation of the small model
- Rob Fairchild, ALSTOM, for preparation of the 60 bus model
- Lars-Ola Osterlund, ABB, for updates to the CIM model to correct deficiencies
- Hans Joachim Diehl, Siemens, for handling the NERC CPSM Profile generation issue
- The author apologizes if others deserving of special mention were not listed – it was not intentional.

In addition, EPRI acknowledges Terry Saxton, Xtensible Solutions, who prepared the test plan and procedures, witnessed the tests and recorded the results, and wrote this report.

Dave Becker
EPRI

CONTENTS

LIST OF FIGURES

LIST OF TABLES

1
INTRODUCTION

This document reports the results of the first CIM XML interoperability tests, which took place on December 18-19, 2000, in Orlando, Florida. Interoperability testing proves that products from different vendors can exchange information and request services based on the use of the IEC standards that have been developed as an output of the CCAPI project.

The test required that participating products conform to the future IEC 61970-301 CIM Base, which is based on the CIM model file cimu09a.mdl and the future IEC 61970-501 CIM RDF Schema Version 4.

This test was the first in a series of CIM XML interoperability tests planned for the near future (see Section 4 for future test plans).

Objectives of Interoperability Test

The objectives of the interoperability tests and demonstrations were to:

1. Demonstrate interoperability between different vendor products based on the CIM. This includes applications from EMS as well as independently developed applications from third party suppliers.

2. Verify compliance with the CIM for those CIM classes/attributes involved in the information exchanges supported by the tests.

3. Demonstrate the exchange of power system models using the CIM and an RDF Schema and XML representation of the model data.

Secondary objectives included the following:

1. Validate the correctness and completeness of IEC draft standards, resulting in higher quality standards by removing discrepancies and clarifying ambiguities.

2. Provide the basis for a more formal interoperability and compliance test suite development for CCAPI standards. This would eventually become part of set of UCA 2 test procedures and facilities currently being developed by EPRI.

Scope

This first interoperability test involved a CIM XML file exchange, which tested the exchange of power system model data based on an RDF/XML version of the CIM. This test validated that a CIM XML file of power system model data generated by one vendor's application could be used by another vendor's application.

The portion of the CIM that was tested is defined in the NERC Profile for power system model exchange. This profile contains the selected CIM classes, attributes, and relationships defined in the Minimum Data Requirements document produced by the NERC DEWG to model transmission substations, lines, and loads sufficient to run State Estimation and subsequent Power Flow/Contingency Analyses applications (see Reference 1).

Organization of Report

This report presents results of the first CIM XML interoperability tests held in Orlando.

The introductory chapter presents the objectives and scope of these tests. Chapter 2 describes the test plan that was followed and identifies the participating vendors and their products. Chapter 3 presents the test results, beginning with a summary of each test step that was scored. The test scores, which are given as Pass, Pass with Errors, Alternate Pass, Skip, or Not Applicable, are organized in three tables. A summary of the significant results achieved are also provided. The three appendices contain a description of the participant's products used in the tests (Appendix A); the test configuration data, including specific versions of the CIM in UML and XML/RDF, sample model files, and test tools (Appendix B); and issues and resolutions that arose during the tests (Appendix C).

References

1. CPSM Minimum Data Requirements in Terms of the EPRI CIM, version 0.6

2. CIM XML Interoperability Test 1, Test Plan and Procedures, Revision 4, December 17, 2000.

2
THE TEST PLAN

Each application participating in this test was required to (1) generate and export a file that conformed to the standards for the specific model data defined for the test and/or (2) import a file from another vendor's product and correctly interpret the model data contained. A formal set of test procedures were prepared and used to conduct and score the tests (see Reference 2).

Participating Vendors and Their Products

Each participating vendor was required to use an actual product so that testing would demonstrate interoperability of real products. The participating vendors and their products are listed in Table 2-1 below. Table 2-1 also describes the hardware platform and operating system used.

Table 2-1
Participating Vendors and Their Products

Vendor	Product Name	Platform	OS
ABB	DE400 SPIDER Data Engineering and Oracle V. 8.1.6	DEC Alpha station 500	UNIX 4.0F
ALSTOM	eterra-Modeler	IBM-compatible Laptop PC	Windows 2000
CIM-Logic	JCIM	IBM-compatible Laptop PC	Windows NT 4.0, SP5
Langdale	I-Builder	IBM-compatible Laptop PC	Windows NT 4.0, SP5
PsyCor	ODMS Viewer/Editor	IBM-compatible Laptop PC	Windows 2000
Siemens	Spectrum Engineering System	IBM-compatible Laptop PC	Windows 2000, SP1
SISCO	Utility Integration Bus (UIB)	IBM-compatible Laptop PC	Windows NT 4.0, SP6

A description of each product used in the tests is contained in Appendix A. These descriptions also explain how the CIM XML data is used in the product and how successful compliance with the CIM XML format was demonstrated.

Test Approach

Pretest Preparation

Prior to the official witnessed interoperability test, sample model files were prepared by PsyCor and ALSTOM to be used during the test. These files contained instances of the CIM classes, attributes, and relationships defined in the NERC profile. The PsyCor model contained two substations connected by a single AC line. The ALSTOM file, termed the 60 bus model, contained 29 substations interconnected by 41 AC lines. Participants applications were only tested for the entities specified in the NERC profile. The models were intentionally kept small to ensure that file size and performance would not be issues in these first tests.

Samples of these files were available before the formal testing began to allow participants to checkout and debug their software as well as to discover any discrepancies or errors in the files themselves.

Basic Export/Import Process

Figure 2-1 shows the process applied by the products under test to export and/or import CIM XML files (also referred to as CIM XML documents). For export, an XML/RDF version of the CIM is used by a product to convert a proprietary representation of one of the sample model files into a standard CIM XML representation of that model. The CIM XML document can then be viewed through a browser using an XSL Style Sheet to format the contents for human readability. Separate XML tools are used to validate the format of the file and the conformance with XML and the RDF Syntax. An XML/RDF Validator tool was prepared and packaged for use during this test.

For import, the product converts from the standard CIM XML representation to the product's proprietary internal representation. Product specific tools are used to validate the import was successful. Since loads and initial generation values were not adequately modeled in the test files, it was not be possible to actually run a Power Flow application. This will be one of the objectives of the next interoperability test.

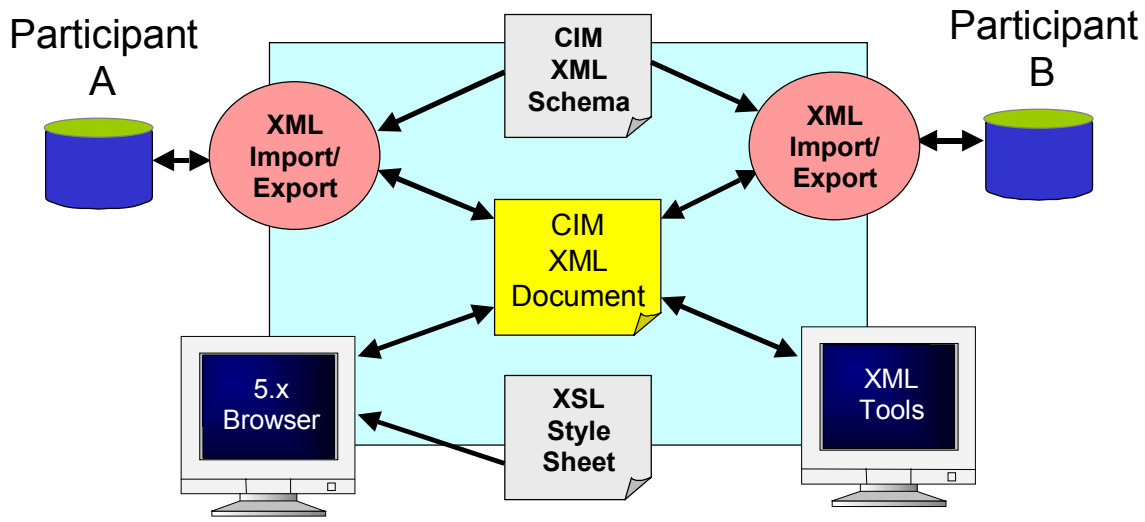

Figure 2-1
Export/Import Process Basics

On-Site Interoperability Test

All seven participants in this test spent two full days at the test site in Orlando, Florida, on December 18-19, 2000. Participants brought their hardware/software and connected to a shared Ethernet LAN set up in the test room. The sample model files used for testing were loaded onto a LAN server. The sample model files and files successfully exported by a participant's product were loaded to the server so that other participant's could access these files for testing their import capability.

Testing was accomplished in two parts. First, each participant's product had to demonstrate correct import/export from/to the standard CIM XML/RDF format. This showed to the extent measurable product compliance with the standard. Second, each participant able to successfully export a file to the CIM XML/RDF format then uploaded that file to the LAN server to make it available for the other participants to import. This tested interoperability of different vendor's products.

The basic steps involved are illustrated in Figure 2-2 below. Each participant (Participant A in Figure 2-2) was first required to import the CIM XML-formatted test files (CIM XML Doc 1) from the server and demonstrate successful conversion to their product's proprietary format (step 1). If the product had an internal validation capability to check for proper connectivity and other power system relationships, that was used to validate the imported file. If the import was successful, the file was then converted back into the CIM XML format (step 2) to produce CIM XML Doc 2, which should be the same as the original. Participant A was required was required to demonstrate compliance by running the XML/RDF validator tool on the exported file (step 3). If successful, the exported file was then be re-imported and compared with the original model to verify that no changes were introduced in the process of converting to the CIM XML format and then back again to the internal product format (Step 4).

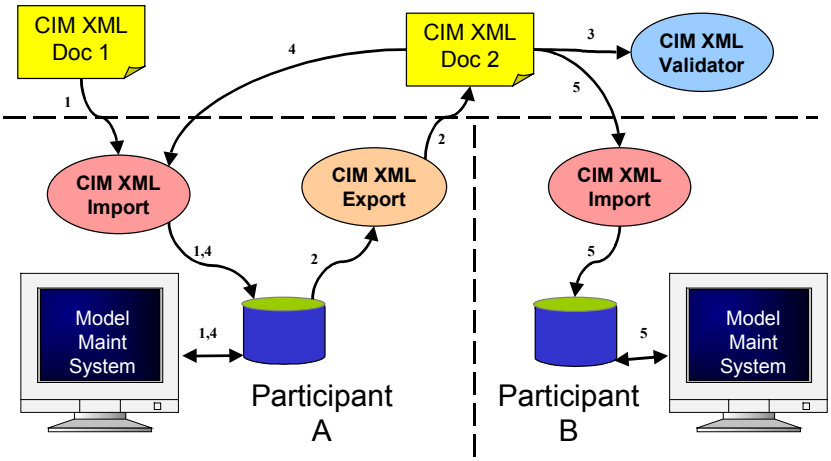

Figure 2-2
CIM XML Interoperability Test Process Steps

At this point the exported file was also loaded onto the LAN server for another participant (Participant B in Figure 2-2) to import and verify that the model imported is in fact the same as the model initially stored in Participant A's application (Step 5). This final step demonstrates interoperability of different vendor's products through use of the CIM XML/RDF standard. (It should be noted that the steps described in this figure are for illustration only and do not correspond directly with the test procedure steps outlined in Table 2-1 below.)

Steps 2 – 5 were first performed on an unmodified test file. They were then repeated after a number of predefined changes were made with Participant A's model editing facilities to demonstrate that changes were correctly exported and reimported. Examples of changes included the following:

- change the value of some attributes on existing classes
- add a new instance of a class and enter attribute values for that class
- delete a single leaf instance of a class
- delete an entire equipment class instance requiring a cascade delete
- change connectivity.

Participants were allowed to correct deficiencies or errors found during testing and then, as time permitted, be retested. All testing was stopped at 5:00 PM on the second day. The final test results achieved at that time are recorded in the test matrices provided below.

Test Configuration

The details of the specific files used at the beginning of the testing period are specified in Appendix B. This appendix contains file names for the CIM ROSE model, the RDF schema, RDF syntax definition, and sample model files. As testing progressed and problems were discovered and resolved, updates were generated to some of these files.

3
TEST RESULTS

This section presents the results of the interoperability tests. First, the individual tests that were performed and scored are summarized below. This is followed by the test matrices with scores shown for each test. For details on each test step, including setup required and step-by-step procedures, see the Test Procedures document (Reference 2).

Description of Tests Performed

1	**Basic Import by Participant A**
1.1	Import small model and demonstrate import was done correctly
1.2	Run internal validation against small model to check for proper connectivity and other power system relationships
1.3	Import 60 bus model and demonstrate import was done correctly
1.4	Run internal validation against 60 bus model to check for proper connectivity and other power system relationships
2	**Basic Export by Participant A**
2.1	Export small model and run validator
2.2	Re-import small model and demonstrate import was done correctly
2.3	Export 60 bus model and run validator
2.4	Re-import 60 bus model and demonstrate import was done correctly
3	**Export with Modification by Participant A**
3.1	Modify small model, export, and run validator against model
3.2	Re-import small model with modification and demonstrate import was done correctly
3.3	Modify 60 bus model, export, and run validator against model
3.4	Re-import 60 bus model with modification and demonstrate import was done correctly
4	**Interoperation without modification** – Participant B import of Participant A exported CIM XML file without modification.
5	**Interoperation with modification** – Participant B import of Participant A exported CIM XML file after it has been modified to include changes accomplished with the Participant A product internal editing capabilities

Summary of Test Results

Individual Product Tests for Compliance

Table 3-1 shows the results of the tests on the individual products to determine compliance with the CIM XML/RDF standards. All participants were able to pass some of the tests, but only one passed all tests. Highlights of the tests are as follows:

- All participants were able to successfully import at least one model file correctly converting from the CIM XML format to their internal proprietary format.
- Of the six participants able to export a model file, four correctly exported at least one sample file without modification, one exported an alternate 40-bus model file, and one did not attempt the test.
- Two participants correctly exported at least one file with modifications, two exported with some errors noted.

Table 3-1
Test Results on Individual Product

Test Procedure	1. Basic Import				2. Basic Export				3. Export with Modifications			
	Small Model		60 Bus Model		Small Model		60 Bus Model		Small Model		60 Bus Model	
Test Number	1	2	3	4	1	2	3	4	1	2	3	4
ABB	P		P				AP					
Alstom			P	P			P	P			P	P
CIM-Logic	P	N/A	P	N/A								
Langdale	P	N/A	P	N/A	P	P	P	P	PE			
PsyCor	P[1]	P[1]			P	P			PE[3]	P		
Siemens	P	P	P	P	P	P	P	P	P	P	P	P
SISCO	P[2]	N/A	P[2]	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Notes:
P (Passed) – all aspects of the test were performed successfully
PE (Passed with Errors) – most aspects of the test were performed successfully
AP (Alternate Pass) – an alternate 40 bus model from ABB was exported successfully
Blank entry – indicates test was skipped
N/A (Not Applicable) - product does not support the functionality to perform this test
1. Could not verify instances of all classes
2. Could not verify instances of load classes within substation view
3. Type assigned to certain resources was incorrect due to NERC profile omitting a base class of BusSection.

Interoperation without Modification

This section documents the pairs of vendors that were able to demonstrate interoperation via the CIM XML formatted-model file. Though the CIM XML documents are from different parties, the test verification for import and export followed the same pattern as done on the tests of individual products above.

Table 3-2 is a matrix of results for the interoperability testing with unmodified files. The rows show the source of an exported file. Each column represents an importer for an exported file. For example, the cell (row ALSTOM, column CIM-Logic) indicates the result of the interoperability test of CIM-Logic importing CIM XML documents exported by ALSTOM ESCA.

The entries in each cell should be interpreted as follows:

- P – Pass. Indicates a successful import of another participant's exported file. The specific sample model file imported is indicated.
- AP – Alternate Pass. Indicates a successful import of ABB's alternative 40 bus model exported file. This was not part of the structured testing and was not a required test for participants.
- Not Available – Indicates an exported file from a participant was not available for import.
- X - Product does not have export functionality
- Blank (no entry) – The column participant did not demonstrate an import of the file exported by the row participant.

All but one participant with functionality to export a file did so successfully and then made that file available on the LAN server for other participants to import. Therefore, a blank entry in a column indicates that the participant whose name is at the heading for that column did not demonstrate an import of that file.

These tests demonstrate true interoperability by exchanging CIM XML documents produced by different participants. A Pass indicates that a pair of vendors successfully demonstrated the exchange of a power system model file using the CIM XML format. The specific model file exchanged is also identified.

Highlights of the tests are as follows:

- Ten pairs of vendors were able to interoperate successfully by exchanging at least one unmodified sample model file.
- Two additional pairs successfully exchanged the 40-bus ABB model.

Table 3-2
Interoperation without Modification

	4. Import without Modification							
Export without Modification		**ABB**	**ALSTOM**	**CIM-Logic**	**Langdale**	**PsyCor**	**Siemens**	**SISCO**
	ABB						AP - 40 bus	AP - 40 bus
	ALSTOM	P – 60 bus		P – 60 bus	P – 60 bus		P – 60 bus	P – 60 bus
	CIM-Logic	Not available	Not available		Not available	Not available	Not available	Not available
	Langdale		P - 60 bus				P – 60 bus	
	PsyCor							P – small
	Siemens				P - small P – 60 bus			P – small P – 60 bus
	SISCO	X	X	X	X	X	X	

Notes:
X – product does not have export functionality
Not Available – indicates an exported file from a participant was not available for import

Interoperation with Modification

In this series of tests, the small model and 60 bus model CIM XML documents created with modifications in the earlier tests by one vendor are imported by another participant after first being checked with the validator tool.

Table 3-3 is a matrix of results for the interoperability testing with modified files. These tests also demonstrate interoperability by exchanging CIM XML documents produced by different participants, only this time the original files have been modified in small ways that are typical of actual power system changes in the field. A Pass indicates that a pair of vendors successfully demonstrated the exchange of a modified power system model file using the CIM XML format. The specific model file exchanged is also identified.

Highlights of these tests are as follows:

- Six pairs of vendors demonstrated interoperability by exchanging at least one of the modified test files.

Table 3-3
Interoperation with Modification of Sample Model File

	5. Import with Modifications							
Export with Modifications		**ABB**	**ALSTOM**	**CIM-Logic**	**Langdale**	**PsyCor**	**Siemens**	**SISCO**
	ABB							
	ALSTOM				**P – 60 bus**		**P – 60 bus**	**P – 60 bus**
	CIM-Logic							
	Langdale							
	PsyCor							
	Siemens		**P-60 bus**		**P - small**			**P – small** **P – 60 bus**
	SISCO	**X**	**X**	**X**	**X**	**X**	**X**	

Notes:
X – product does not have export functionality

Summary of Issues Identified

Another output of the testing effort was the identification of issues that affect interoperability, either in the CIM documents themselves, in the sample model files, or in the test procedures. Every attempt was made to resolve issues during testing so that a common resolution could be adopted and implemented by each participant, followed by a retest.

The following is a summary of the issues that were identified organized by category. The detailed problem reports with resolutions and status are contained in Appendix B:

General

- CIM UML and XML file versions need to be frozen several days before testing begins

CIM UML and ROSE

- Duplicate associations found for TransformerWinding
- Profiles need to be able to specify a format for exchange of date and timestamp information

CIM XML/RDF Validator Tool

- Need to add capability to check that only the simplified RDF syntax specified for this test is used
- Need to add capability to check for proper use of cardinality
- Need to add capability to restrict RDF vs. Schema to give warnings or error if a property is not associated with the correct CIM Class, for example

NERC CPSM Profile

- Duplicate profile entry in ROSE model under associations called NERCAssocProfile and NERCProfile
- Profile does not specify rules regarding model usage. For example, it does not state that an ACLineSegment must be a member of a Line. It also does not provide a way to indicate whether items are mandatory or optional, or what combinations of attributes are required for uniqueness

Sample Model File

- In the sample model files cardinality 1 references have the inverse generated as well. This results in unnecessarily large data files and transfer of redundant data
- The ALSTOM 60 bus model file has a duplicate association for TransformerWinding.TapChangers. This was encountered during import.
- In the PsyCor small model, ACLineSegment has only 1 terminal, #35
- In the PsyCor small model file SmallModel_001218b implements exclusively TransWinding – BaseVoltage

- In the PsyCor small model TransformerWinding has character data for windingId:HS,LS, whereas the CIM RDF file specifies that windingId is Integer

Product in Test

- ALSTOM 60 bus export has the same name for all transformer windings within a transformer. These need to be unique. However, it points out a larger issue where required names need to be specified with agreed "scope" of uniqueness.
- Siemens determined the original ALSTOM 60 bus model file contained "&rdf " and "&cim". This could not be imported with the current version of the XML parser used.
- ALSTOM - Modeler importer created a new base voltage object rather than strictly adopting the CIMBaseVoltage. Specifically a new 346 kV BaseVoltage was created in addition to the 345KV BaseVoltage
- Siemens – When importing 60 bus model exported by Siemens, no GeneratingUnit information is in the CIM XML. The GeneratingOpSpec is there but without reference to any GeneratingUnit

The status of resolutions to these issues is documented in Appendix C. A summary follows:

- CIM issues for the most part require resolution by the IEC WG13 responsible for the CIM standard, so resolutions were not reached and these are open issues.
- Tool issues are suggestions for future enhancements that did not affect testing directly.
- NERC CPSM profile issues again are suggestions to the DEWG for changes to improve interoperability.
- Sample model file problems for the most part were corrected and revised on the spot, uploaded to the LAN server, and used for retest.
- Test procedure issues were also resolved on the spot and will be reflected in a revised set of test procedures as one of the outputs of this test effort.

4
FUTURE INTEROPERABILITY TESTS

Plans for future interoperability tests need to be defined. However, it is expected that they will include the following:

1. Opportunities for more participants to complete the tests used for this first interoperability test

2. WAPA model with Powerflow Applications: Use the WAPA planning model after conversion to an operational model. Participants can run their Power Flow applications and demonstrate other applications (e.g., OPF and State Estimator), as available. This will test larger models with loads.

3. NERC Model Exchange: Expand the CIM classes and attributes as specified for the NERC model exchange. Participants can run their Power Flow applications and demonstrate other applications (e.g., OPF and state estimator), as available.

4. Incremental updates: Once a protocol has been specified to permit methods to be included in message exchanges and a process to handle incremental model updates is defined, then testing of this incremental update capability will be needed.

5. Exchange of solved power flow solutions: This an existing need that will be tested once a solution is defined.

A
APPENDIX: PARTICIPANT PRODUCT DESCRIPTIONS

This appendix contains descriptions of the different products used for the interoperability tests. The product descriptions were provided by the individual participants.

ABB Data Engineering Tool (RDE)

The test procedures related to CIM XML model exchange will be performed against the ABB data engineering tool (RDE).

The CIM schema has been implemented in an Oracle database. This CIM Oracle database will be used for both import and export processes.

We will be using ABB's data engineering tool (RDE). This is also an Oracle database tool that allows view of the data as well as changing of the data. The runtime database system is populated by the RDE either as a full population or as an incremental population.

During the import process, data from the CIM database will be imported to the RDE. During the export process, data from RDE will be exported to the CIM database.

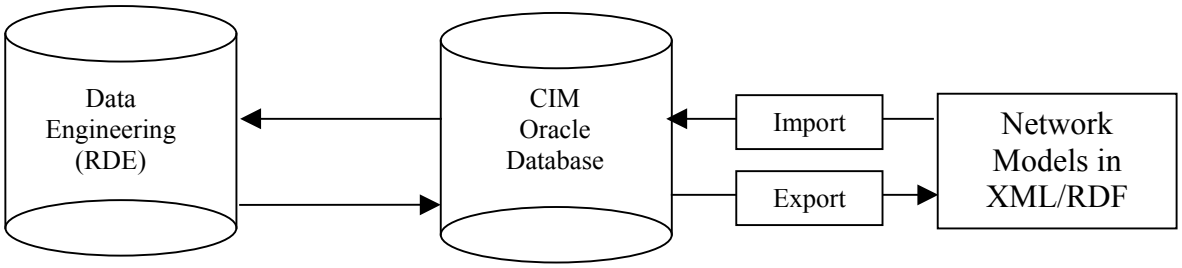

Figure A-1
ABB's Data Engineering Tool (RDE)

ALSTOM ESCA eterra-Modeler

The test procedures related to CIM XML model exchange are to be performed against the ALSTOM **eterra**-Modeler product (also referred to as the Modeler).

The Modeler is a power system operations modeling tool for initializing EMS applications with the information they need for real-time operations. The tool is used to generate the power system models and maintain them. Import and export facilities are provided for bulk data import

and export while a tailored user interface is used for manual additions, edits, and deletions of information as well as model browsing. After import, an internal validation tool is run that checks for proper connectivity, naming, and cardinality of relationships, among other things. Error messages are sent back for user review and to assist with proper verification of interpreting the imported model.

The tool runs in a Windows NT environment. Though the design supports a distributed configuration, all components will be located on a single NT platform for the purposes of this interoperability test.

For this first interoperability test, the following conversions between the Modeler information representation and the CIM XML representation are required:

- CIM Bays and VoltageLevels are represented as Equipment Groups in the Modeler.
- CIM BusSections are represented as nodes.
- CIM Condensers are a type of synchronous machine.
- All CIM switch types are modeled as switches.
- Grounds are not modeled as separate objects.
- Single terminal devices are interpreted as shunts.

CIM-Logic JCIM

The test procedures related to CIM XML model exchange are proposed to be performed against the CIM-Logic JCIM product.

JCIM is a stand alone data maintenance tool and also an integrated J2EE development environment. JCIM provides a flexible set of software tools based on a stable set of classes driven by a model specified in UML. These classes can access data from multiple data sources and make the data available to users with standard desktop browsers. Data can be imported to or exported from an Oracle8i relational database from CIM RDF format.

Langdale I-Builder

The test procedures related to CIM XML model exchange will be performed against the Langdale I-Builder product.

I-Builder is a Knowledge Representation tool for power system modeling and control system configuration. Knowledge Representation techniques allow it to manage model-evolution and parallel model development.

I-Builder imports full models, partial models and incremental changes to models. It displays the integrated model in an easily edited form. I-Builder exports incremental model differences or the complete model. The native import and export format for I-Builder is RDF.

PsyCor ODMS

The test procedures related to CIM XML model exchange are proposed to be performed against the PsyCor ODMS product.

The ODMS XML Import / Export facilities will be demonstrated as standalone utilities for the first interoperability test. Future implementations of these features will be integrated into the ODMS product suite.

The ODMS Viewer/Editor accesses the ODMS database of system operations data. The ODMS database, in the Common Information Model (CIM) data schema, is presented to the user of the ODMS Viewer/Editor in a full graphics environment. This environment provides CAD-like operations in a substation one-line view, or in the world-map view. By highlighting object icons in the drawing, the user may perform editing operations on the CIM data through an engineering environment, instead of the database environment available in the ODMS.

This feature will be utilized to verify successful import of system operations data via the XML Import Utility and to allow modification of these data prior to export.

Siemens Engineering System

The test procedures related to CIM XML model exchange are proposed to be performed against the Siemens Engineering System product.

The Siemens Engineering System is a component of the Spectrum product line. It provides the means to maintain power system model data for the configuration of EMS/DMS applications, SCADA and the communication to RTU's, and ICCP. For the interoperability test only a subset of the data model is used.

The Engineering System provides import/export of bulk model data as well as a user interface to manually view and edit model data. The import/export format is compliant to the CIM/XML information exchange format.

The Engineering System uses a repository driven by a schema compliant with the NERC CPSM profile of the CIM u09a.

The user interface provides a hierarchical view of the instances imported or manually edited. It allows creating new instances, as well as modification of exiting ones. Instance data can be deleted selectively. Child instances in the hierarchy are recursively deleted in the same operation.

The import/export function of the Engineering System records errors in a log for further analysis while running an import. Import translates the RDF/XML document into the internal structure of the Engineering System repository. Export retrieves all data for a selected instance and exports it according to the defined profile.

Changes and extension of the current model data can be prepared independent of the current active model data in a session. An activation process applies the changes to the current model data and applications get notified about those changes. This part of the functionality is not used in the test environment.

The Engineering System uses a Window 2000 platform. Although it can be configured for a multiple server environment, the complete systems runs on a laptop for the interoperability test.

SISCO Utility Integration Bus

The test procedures related to CIM XML model exchange are to be performed against the CIM RDF import utility provided by SISCO as part of the Utility Integration Bus (UIB) product.

The UIB is a message broker based enterprise application integration product created to meet the unique needs of utilities. The UIB allows users to publish and subscribe to messages by selecting all or parts of the CIM schema/operational model as well as determine what parts of the schema/operational model are currently being published on the bus by UIB components.

The CIM test files are imported through the CIM RDF import utility provided by SISCO as part of the UIB product, as shown in the diagram below. The import utility stores the CIM RDF information in a meta-data repository supplied with the UIB product. Once the CIM schema definition and operational information files have been imported, UIB applications can browse this information via a Data Access Facility (DAF) interface.

An XML IOP application developed for these interoperability tests will be used to validate the CIM import capability of the UIB only, as shown below. There is no export capability for the model data, so those portions of the test procedure dealing with exporting of files will be skipped.

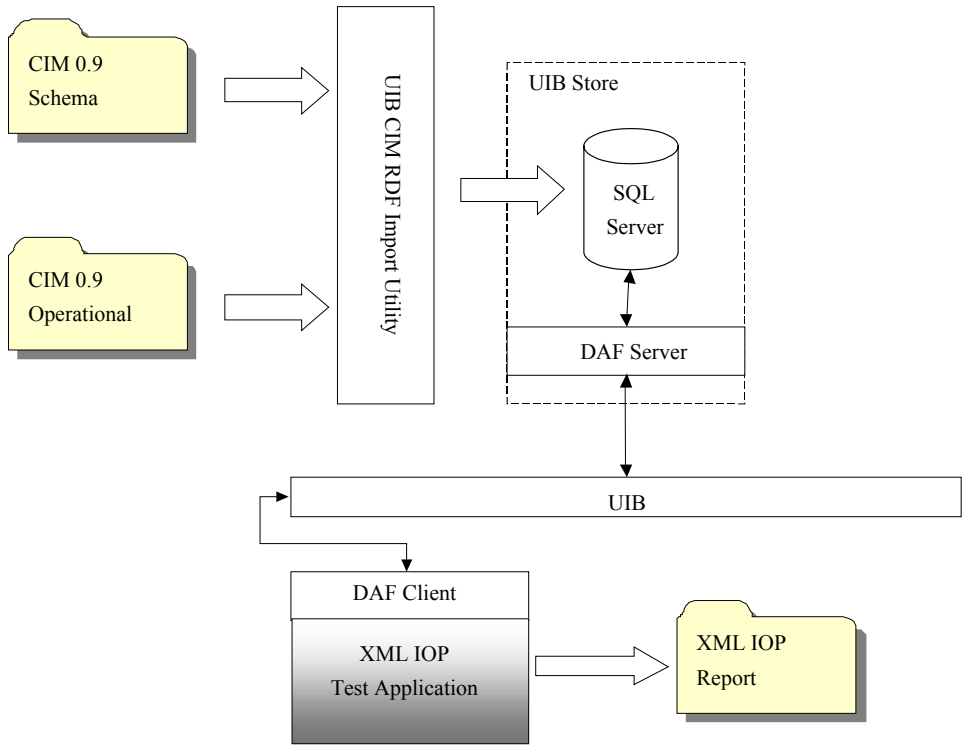

Figure A-2
SISCO Utility Integration Bus

This import capability will be demonstrated through the importing of two (2) CIM files (the 0.9b schema definition and the vendor supplied operational information CIM file). These files are imported through the CIM RDF import utility, provided by SISCO as part of the UIB product. The import utility will translate the CIM RDF information into a SISCO proprietary meta-data repository supplied with the UIB product. The repository is known as the UIB Store and shall use SQL Server as the database that stores the repository information. The UIB Store contains both schema and operational information.

SISCO supplies the UIB Store is with a UIB based Data Access Facility (DAF) wrapper that allows standardized access to the schema and operational information over the UIB via messages. A test application has been written to produce a text report, via DAF, that reflects the operational data imported stored within the UIB Store.

The UIB components being tested do not validate nor export the CIM information in regards to power system network information. Nor do the components make this information available except through the DAF interfaces provided by the SISCO UIB product.

The software to be tested by SISCO consists of the following:

Table A-1
UIB Toolkit Version 1.0

Message Broker	IBM MQSeries V5.1
UIB Store Repository	SQL Server 7.0
DAF Client Interface	SISCO Version 1.0
Operating System	Windows NT 4.0/ Service Pack 6

All software components are installed and located on a single Toshiba Satellite Laptop. The laptop resources are: 4G hard drive, 128MB of RAM, 366 MHz Intel Celeron.

XML Authority will be used to validate XML files.

B
APPENDIX: TEST CONFIGURATION DATA

CIM Baseline Version for Testing

The version of the CIM to be used for these tests is u09a. Specifically, the CIM RDF Schema version of this file will be used. Any file generated or imported will conform to this RDF Schema, although not all classes, attributes, or relations defined need to be included.

The files to be used for the CIM UML and RDF schema at the time of this revision were as follows:

- CIM UML file: cimu09a_Rose_001215a.zip
- CIM RDF Schema file: cimu09a_RDF_001215a_1.zip

RDF Syntax

The RDF syntax approved for these tests is the Reduced RDF (RRDF) Syntax defined by Arnold deVos. Files produced may contain syntax definitions beyond the RRDF Syntax, but only the RRDF Syntax will be used to completely express the power system model in the file produced for testing. Participants reading files will be expected to properly interpret the RRDF Syntax definitions contained therein but are not required to interpret and use any definitions beyond the RRDF Syntax.

The file to be used for the RDF syntax definition at the time of this revision was as follows:

- CIM XML syntax definition: Simplified RDF Syntax 6.pdf

Test Files

Each participant is requested to post a sample model file that they have produced using the RRDF Syntax approved for these tests. Each such sample file should be accompanied by a one-line schematic diagram illustrating the power system model defined in the file.

The test files to be used for the small models at the time of this revision were as follows

- PsyCor small model: SmallModel_001214c.zip
- ALSTOM ESCA small model: CIM_60_esca.zip

Tools

The tools to be used for the interoperability testing at the time of this revision were as follows:

- Validation tools: cimrdf-2000-11-16.zip
- UML to RDF Converter tool: Xpetal-2000-12-16.zip

File Transfer

For sharing or transferring files between participant's systems was accomplished using a shared file server (provided by PsyCor) and connected to by all participants through a LAN switch (provided by ALSTOM ESCA).

C
APPENDIX: TEST ISSUES AND RESOLUTIONS

This appendix contains a list of the issues identified during the CIM XML interoperability testing organized by category. The status of the resolutions reached during the testing period are also reported. The open issues will be addressed within the CCAPI Task Force and IEC Working Group 13.

The issue categories include the following:

- General – issues dealing with the high level testing processes
- CIM UML – issues with the UML model of the CIM
- CIM XML Validator – issues with the CIM XML validator tool
- NERC CPSM Profile – issues with the format or content of the NERC CPSM profile definition of classes, attributes, and associations to be included in the sample model files, or the way the profile definitions are handled in UML or XML/RDF
- Product in Test – issues concerned with the specific product under test
- Sample Model File – issues with any of the sample model files exchanged, such as incorrect XML or missing/incorrect classes, attributes, or associations

No.	Category	Problem Statement	Suggested Resolution	Final Resolution and Status
16	General	Requirements for interoperability tests, including ROSE model and RDF Schema, were changing even after close of business Friday before tests.	Impose a freeze date for future tests after which requirements that affect testing may not change	
8	CIM UML	TransformerWinding has duplicate association to both VoltageLevel and BaseVoltage. The same problem also exists for ACLineSegment and DCLine Segment.	Remove one or the other association. Prefer removing association to BaseVoltage.	
12	CIM UML/Product in Test	ALSTOM 60 bus export has the same name for transformer windings within a transformer. These need to be unique. However, it points out a larger issue where required names need to be specified with agreed “scope” of uniqueness.	Provide unique names for transformer windings in a transformer. CCAPI/WG13 should specify required naming and scope of uniqueness	
13	CIM UML	The profiles need to be able to specify a format for exchange of date/timestamp information. The DAF specifies using a Gregorian date offset from 1582, but this is not practical for interchange	Use ISO formats for date and time, e.g., 2000-12-19.	
2	CIM XML Validator	Open source validator tool does not check that only simplified RDF is used nor does it check for proper use of cardinality	Enhance validator tool to make these checks	
6	CIM XML Validator	The Validator does not restrict RDF vs. Schema. Specifically, the Validator passed cim:xAxisData for CurveSchedData. It should have generated a warning or error since property should be in cim: CurveSchedData.xAxisData	Enhance Validator to include these checks	
1	NERC CPSM profile	In the current ROSE model there is a duplicated profile entry under associations called NERCAssocProfile and NERC Profile.	Remove first entry (NERCAssocProfile)	

No.	Category	Problem Statement	Suggested Resolution	Final Resolution and Status
7	NERC CPSM Profile	Profile does not specify rules regarding model usage. For example, it does not state that an ACLineSegment must be a member of a Line. It also does not provide a way to indicate whether items are mandatory or optional, or what combinations of attributes are required for uniqueness.	Create common usage guidelines document. Investigate UML options for modeling these types of rules.	
3	Product in test	Siemens found the that the original cim_60_esca_???.xml generated by Alstom contained “&rdf “ and “&cim”. This cannot be imported with the current version of the parser used.	Immediate fix to replace the “&” by hand.	Fixed during tests and subsequent imports were successful
5	Product in test	ALSTOM - Modeler importer created a new base voltage object rather than strictly adopting the CIMBaseVoltage. Specifically a new 346 kV BaseVoltage was created in addition to the 345KV BaseVoltage	Fix Modeler import to restrict BaseVoltage	Fixed and demonstrated with import of Langdale generated 60 bus model
15	Product in Test	Siemens – When importing 60 bus model from Siemens, no GeneratingUnit information is in the CIM XML. The GeneratingOpSpec is there but without reference to any GeneratingUnit.	Add GeneratingUnit with references	The reason the instances of GeneratingUnit were dropped is related to the profile definition. The imported file had ThermalGeneratingUnits as well as Lines. As both are not included in the profile, the export did not export those instances.
10	Sample model file	In the sample model files cardinality 1 references has its inverse generated as well. This results in unnecessarily large data files and transfer of redundant data.	Do not generate the 0..* cardinality references into the data files (e.g., there are a number of references from substation to its child that does not need to be generated.	

No.	Category	Problem Statement	Suggested Resolution	Final Resolution and Status
4	Sample model file – 60 bus model	The ALSTOM 60 bus model file has a duplicate association for TransformerWinding.TapChangers. This was encountered during import.		ALSTOM fixed exported file and SISCO verified the fix on re-import.
9	Sample model file – small model	In the PsyCor small model, ACLineSegment has only 1 terminal, #35, in SmallModel_001218a.xml		Added terminal which had been inadvertently deleted. New model is SmallModel_001218b.xml
11	Sample model files – Small model	In the PsyCor small model file SmallModel_oo1218b implements exclusively TransWinding – BaseVoltage.	Include TransWinding – VoltageLevel also to accommodate vendors dependent on VoltageLevel	
14	Sample model files – Small model	In the PsyCor small model TransformerWinding has character data for windingId:HS,LS. The cimu09a_0012151_1.rdf file specifies that windingId is Integer.		Corrected in SmallModel_001218d.xml to be number

Target:
Grid Operations and Management

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