Interoperability Test #7 of the Generic Interface Definition (GID) Standards and the Common Information Model (CIM)

Technical Report

Interoperability Test No. 7 of the Generic Interface Definition (GID) Standards and the Common Information Model (CIM)

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REPORT SUMMARY

The EPRI Control Center Application Program Interface (CCAPI) project has produced a number of international standards, including the Common Information Model (CIM) and Generic Interface Definition (GID) specifications. These standards provide the basis for model-driven information exchange both within and between control centers and other systems involved in utility operations. Previous interoperability tests validated the use and acceptance of the CIM standard translated into XML. This report describes a seventh set of interoperability tests that expanded GID testing, introduced testing of IEC 61968 Part 13 (CIM-based distribution exchange), and demonstrated exchange of complete, partial, and incremental power system models.

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 (now part of the IEC 61970 series of international standards). 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) sought the best way to exchange power system models electronically. As a result, the CCAPI project initiated an effort to map CIM into XML using Resource Description Framework (RDF) schema and syntax to organize XML. To validate XML and RDF for model exchange, a series of interoperability tests between products from different suppliers was planned and carried out.

Objectives

To report results of the seventh set of interoperability tests performed at CAISO in Folsom, California, on September 27-30, 2005.

Approach

The project team prepared a formal set of test procedures to test the ability of the participants' products to conform to the IEC 61970 (CIM/GID/XML) and the IEC 61968 (distribution exchange) standards. After a period of preparation and preliminary testing, six participants (ABB, Areva, EDF, Siemens PTI, Siemens, and SISCO) gathered in Folsom to have an impartial observer test their products.

Results

Both the High Speed Data Access (HSDA) and the Time Series Data Access (TSDA) draft standards (part of the GID) were tested in a controlled environment. Client and server TSDA products from Siemens PTI and SISCO interoperated successfully for retrieval/exchange of time series data between the client and server. For HSDA interoperability testing, client/server pairs

comprising various combinations provided by ABB, EDF, Siemens PTI (SPTI), Siemens, and SISCO were able to successfully demonstrate connectivity, browsing (using the CIM namespace), reading and writing of data.

Each of the six participants was able to successfully import at least one power system model, correctly converting from the CIM XML format to their internal proprietary format. Eight pairs of vendors also were able to interoperate successfully by exchanging at least one sample model file.

EDF was able to successfully run a power flow solution on an imported transmission model file and then export the file, providing further validation of the content and correct translation between proprietary formats and CIM.

Incremental model update testing verifies correct update of a base model with incremental updates using the XML difference file format. Both EDF and Siemens successfully imported multiple incremental model update files and merged them into an existing base model.

Partial model transfer verifies correct import and merge of a partial model with an existing base model. Areva, SPTI, and Siemens successfully imported at least one partial model, merged it with the base model file, and exported the merged model. EDF imported merged models generated via partial model operations from Areva, Siemens PTI, and Siemens. Partial model pairs were provided by Areva, EDF, and Siemens.

Distribution model exchange testing verifies compliance of a CIM-based XML distribution model as defined in the IEC 61968 Part 13 standard. This test required a participant to import the distribution model provided by EDF. SISCO, the only participant in this test, successfully imported the distribution model.

EPRI Perspective

The changing business environment has increased the need for greater business and operating flexibility in the energy industry. CCAPI compliance offers operations center managers the flexibility to combine one or more integrated platforms and software to best meet their energy company's needs for system economy and reliability. This compatibility allows managers to upgrade, or migrate, their EMS or other operations systems incrementally, thus preserving prior utility investments in custom software and enabling use of new applications as they become available. Migration can reduce upgrade costs by 40 percent or more.

CCAPI-enhanced integration architectures based on the CIM model, GID interfaces, and standard XML messages enable interdepartmental teams to access a range of needed information via open systems. Hence, in innovative applications, energy companies are planning to implement CCAPI/CIM/GID/XML outside the control center to reduce costs and improve customer service and staff productivity. EPRI continues to sponsor collaborative efforts to advance these CCAPI-based integration strategies for greater information systems integration solutions—in the control center and beyond.

Keywords

Application program interface
Common information model (CIM)
Control center
Energy management systems
Generic interface definition (GID)
eXtensible markup language (XML)

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.

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) 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.

Another initiative made possible by the CCAPI project is the establishment of an integration framework based on the CIM, the Generic Interface Definition (GID) standards, and the new CIM-based messaging standards to facilitate the inclusion of the best-of-breed advanced network applications with the existing EMS as well as information exchange between the control center EMS. This makes it possible to upgrade and improve network operations without complete replacement of the existing EMS as well as providing for centralized network model management based on the CIM.

This report presents the results of the seventh interoperability test using these standards to create a model-driven integration architecture. The goal of this report is to raise awareness of the importance and status of this effort and to encourage adoption by additional product suppliers and energy managers.

David L Becker
EPRI
October 2005

ABSTRACT

On September 27-30, 2005 at CAISO in Folsom, California, software vendors serving the electric utility industry met for the seventh time to test the capability of their software products to exchange data and correctly interpret power system data based on the CCAPI interface standards. In the past, the testing focused exclusively on exchanging power system network models using the CIM (Common Information Model). The fifth test, however, introduced both compliance and interoperability testing of the Generic Interface Definition (GID) standards. For the first time, the use of GID interfaces in vendor products was observed and evaluated. This seventh test continued the tests from prior tests and expanded the GID interface tests. This report documents the results of this testing.

Both the CIM and the GID were developed by the EPRI CCAPI project. The part of the CIM used for these tests has been approved as an international standard (IEC 61970-301 CIM Base). The GID is currently being progressed as an IEC standard as well and is available as a series of draft standards. 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. For those that implemented the GID, a series of server conformance and client/server interoperability tests were performed.

These interoperability tests address an important industry requirement established by NERC to be able to transfer power system model data (including ICCP configuration 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. Complete model files as well as partial models and incremental updates to existing base model files were exchanged between participants. The GID was used to provide request/reply and publish/subscribe type mechanisms for a client to access a model or data residing on a server based only on the CIM rather than the internal logical database schema where the model data is stored.

Vendors participating in these tests included ABB, Areva, Siemens PTI (SPTI), Siemens, and SISCO. One utility, EDF, participated as well. Project Consultants prepared the test procedures, witnessed the test results and prepared this test report for EPRI. Loris Arnold of LIPA assisted in witnessing the tests. This is an important milestone in the CCAPI project and is the seventh in a series of planned interoperability tests to demonstrate additional CCAPI capabilities.

ACKNOWLEDGMENTS

EPRI wishes to thank the many people who worked hard to make this seventh CIM/GID/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 utilities, vendors and contractors:

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- Loris Arnold, Long Island Power Authority/KeySpan, for assistance in witnessing and recording the test results.
- All participants, for providing inputs to the outstanding issues, the afternoon sessions and bringing enthusiasm and focused energy with a true spirit of cooperation to Folsom to make these tests a success. Their willingness to participate in these tests at their own expense is a testimony to their commitment to support the CIM/GID/XML standards and the utility industry's need for products to exchange power system models in a reliable, consistent fashion. Special thanks to CAISO for keeping us supplied with coffee and pop!

In addition, EPRI acknowledges Margaret Goodrich, Project Consultants, who prepared and edited the test plan and procedures, witnessed the tests and recorded the results, and wrote this report.

Dave Becker
EPRI

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1
INTRODUCTION

This document reports the results of the seventh CIM/GID/XML interoperability tests, which took place on September 27-30, 2005, at CAISO in Folsom, California. Interoperability testing proves that products from different participants can exchange information, interact with the Generic Interface Definition (GID) components and provide the interfacing requirements based on the use of the IEC standards that have been developed as an output of the CCAPI project. These standards include various parts of IEC 61970 and IEC 61968 standards.

This set of interoperability tests focused on three major types of tests:

- Power system model exchanges via file transfer based on CIM XML standards. These tests included complete model transfers, partial model transfers, and incremental model updates.
- Tests of client/server pairs using interfaces based on the GID service standards. The GID provides methods for accessing data, including power system model transfers as well as complex queries and periodic high-speed data transfers. The data exchange is accomplished through a client/server interface operating over industry-standard middleware, such as Microsoft COM and MSMQ, rather than by file transfer. This provides for a much more dynamic exchange of data, even though the underlying standards for the data format are the same.
- Distribution model exchanges via file transfer based on the CIM XML and 61968 Part 13 standards.

This test was the seventh in a series of CIM XML interoperability tests, which began in December 2000. Goals of future tests are described in Section 4.

Objectives of Interoperability Test

General Test Objectives

The general objectives of the interoperability tests and demonstrations are:

1. Demonstrate interoperability between different products based on the CIM and/or GID. 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.

4. Demonstrate message exchange between different vendor products using the services defined in the interface definition standards. This includes the GID services provided by the Common Services, HSDA and TSDA standards to provide communication interoperability.

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.

Specific Interoperability Test 7 Objectives

Specific objectives for the seventh interoperability test fall into three categories:

1. Model exchange, using the same procedures as portions of test 3, 4, 5 and 6 as defined below:

- Exchange of a full operational power system network model that includes generation and loads. The full model exchange test will verify that a CIM XML file of a power system model generated by one vendor's application can be used by another vendor's application. The CIM XML file will be based on an RDF/XML version of the CIM. The portion of the CIM that will be tested is defined in the updated NERC Profile for Common Power System Model (CPSM) exchange and will contain the set of CIM classes, attributes and relationships defined by the participants prior to the test. The NERC DEWG Minimum Data Requirements specification will be updated and distributed to all participants prior and will be used to validate the exchanged models. This is the **"full operational model exchange"** test.
- Execution of load flow/power flow applications to verify sufficiency of the model files (in terms of having all necessary elements represented) and correctness of the transformations to/from local representations of the models. This is the "**solution**" test.
- Exchange of incremental updates (i.e., send all changes since the last update or since a specific date/time). This is the "**incremental exchange**" test.
- Exchange of partial models. The test focused on the transfer of complete individual substations and companies. This is the "**partial exchange**" test.
- Exchange of ICCP Object ID Configuration data. This is the "**ICCP exchange**" test.

2. GID interface tests, building on testing completed in 5 & 6 and adding a new interface test as defined below:

- HSDA conformance and interoperability tests to validate message exchange via OPC CIM XML Messaging, Message Oriented Middleware (MoM) or OPC DA.
- TSDA interoperability test to validate message exchange via MoM and OPC HDA standards.

3. Distribution model exchange as explained below (IEC 61968-13):

- Exchange of a distribution network model. The full distribution network model exchange test will verify that a CIM XML file generated by one participant's application can be used by another participant's application. The CIM XML file will be based on an RDF/XML version of the CIM. The portion of the CIM that will be tested is defined in the IEC 61968-13 (CDPSM Profile) for distribution model exchange and will contain the set of CIM classes, attributes and relationships defined by the participants prior to the test. The IEC 61968-13 document will be provided and distributed to all participants prior to the test and will be used to validate the exchanged models. This is the **"full distribution model exchange"** test.

This seventh test provided the opportunity for participants to complete any or all of the tests included in the test procedures generated specifically for this test. Both new and returning vendors took part in these tests.

Scope of Interoperability Test 7

Power System Model Exchange Using CIM/XML File Import/Export

To meet the model exchange objectives the same procedures used in prior interoperability tests were used, except that updated draft standards were applied as appropriate. Similar to prior tests, we demonstrated and validated a product's ability to successfully import and/or export a complete model file, partial model files, and incremental updates using standard file operations. This does not require any special interface capabilities for data exchange – just the ability to read and write a CIM/XML-compliant file to memory. This is sufficient for non-real time exchange of power system models (i.e., initial creation of models and periodic updates). The basis for these tests are the IEC 61970 standards dealing with the CIM, CIM RDF Schema, and CIM XML Model Exchange Format (see References [9, 13, and 14], respectively).

However, for this test, many more model files were supplied by the participants (see Appendix B for a full list). In addition to Siemens, Areva and ABB, EDF provided three transmission files, including a French 27 Node network file, a 7 Node file with 3-winding transformers and the European 14 Node file based on the description of the UCTE Data Exchange Format for load flow and three phase short circuit studies (UCTE-DEF, V0.1 - European transmission network exchange).

Full Model Transfer

Each participant in this test was required to (1) import a model file, (2) generate and export a file that conformed to the standards for the model used[1], and (3) import a file from another vendor's product and correctly interpret the model data contained.

[1] Note: Not all participant's products had export capability, in which case this test was not conducted on those products.

The CIM XML model files used included the Siemens 100 Bus model file, the Areva 60 bus model file, the EDF 27 node model file, the EDF 7 node model file and the Union for the Coordination of Transmission of Electricity (UCTE) 14 node model file, each of which contained ICCP configuration data as described in Power System Model Exchange with ICCP Linkage, Revision 2. Appendix B provides a full description of the files. These model files, used for the **full operational exchange** tests, contained at least one instance of the CIM classes, attributes and relationships defined in the NERC profile (see Reference [1]).

Partial Model Transfers

These tests were to validate the transfer of a partial model using the existing CIM XML specifications. This is similar to sending an entire power system model, except that only a portion of the entire model is transferred. However, the portion sent is a complete model in and of itself. The test, then, was primarily to ensure sufficient information is transferred to permit the receiving system to merge this model into the existing model. For this to take place without undue manual intervention, the base addresses of all objects in the partial model must be compatible with the existing model.

The use case titled "Partial Model Transfer" in Appendix C describes this capability.

The scope of this test was limited to the transfer of complete Substation models.

Incremental Model Updates

The incremental model update tests were to validate a product's ability to successfully import and merge incremental changes to an existing power system model. The use case titled "Incremental Model Update" in Appendix C describes this capability.

To test this capability, the incremental update examples provided by Enamul Haq from CAISO contained in Appendix: Incremental Model Update Examples, were translated into equivalent types of changes in the existing sample model test files. The incremental files used for testing included the modification of device attributes and/or the addition and deletion of devices in a substation.

The updated draft IEC 61970 Part 552-4 contains the standard to define the contents of Incremental Model files.

Power Flow Solution Test

The Power Flow Solution test is intended to verify the correct exchange and transformation of power system model files including generation and load through the execution of power flow applications. The following instance data is provided in the model files used in this test:

- Generation values
- Load values

- Measurements
- Transformer settings
- Generator voltage control values
- Device states
- MVAr values for shunt Compensators

To meet the load flow application execution, either the Areva 60 Bus model file, the Siemens 100 Bus model file, the EDF 27 node model file or the UCTE 14 node model files were used.

Power Flow Applications produce MW and MVAr flows for each line in the model. The MW & Mvar (MVA) flows are a direct function of the voltage difference between the two ends of a line and the resistance of the line. They serve as a check on the transfer of the characteristics of a line (topological connectivity and impedance), but are direct derivatives of the voltage.

As part of the solution, each Power Flow Application produced a table of bus voltage and voltage angle readings for each bus in the model. To evaluate power flow solutions, the tables produced by two different executions of a Participant's Power Flow Application were compared.

If the models used for both executions are identical, then the solutions should be very close, although identical solutions are not expected due to the small effects of conversions between participants. If the models are identical, but different Participant's applications are used, again the table values are not expected to be identical, but should be consistent and within a reasonable range of each other.

It should be kept in mind that the purpose of the test is not to evaluate different Participant's Power Flow Applications, but rather to ensure that the contents and format of the CIM XML documents exchanged are sufficient to permit each Participant's product to converge on a solution.

GID Testing

The GID standards specify a group of CIM-compliant client/server interfaces for data access and exchange over messaging middleware. This provides a data exchange mechanism more suitable to a near-real time operating environment. For an overview of the GID, see Appendix E. For this Interoperability Test #7, the parts of the GID draft standard that were tested were the common services and the HSDA and TSDA interfaces as contained in References [9-12, 16, and 17].
It should be noted that although the Test Procedure contained tests for the GDA interface, these tests were not executed by any of the participants during this test; therefore, this interface in not included in this test report. GDA tests were executed at IOP 6 by several participants.

To meet the GID test objectives, the models used in the exchange tests were preloaded into the HSDA and TSDA servers. A variety of messaging technologies were used for the HSDA tests and the MoM technology was used for the TSDA tests.

HSDA Testing

Based upon the definitions and philosophy of the GID, HSDA conformance testing applies primarily to the server side. That is, it should be possible to use off-the-shelf OPC clients without modification in actual implementations of the HSDA standard. As a result, testing was divided into two parts:

1. Conformance testing – dealing with the ability of the HSDA server to correctly conform to the standard and the TC57 Namespace[2]
2. Interoperability testing – dealing with the ability of one participant's client ability to interoperate with another participant's server

HSDA products were tested by requesting data and initiating/terminating data transfers of sample SCADA data.

TSDA Testing

The TSDA testing comprised interoperability tests between two test participant's products – one acting as a TSDA client and one as a TSDA server. Since the scope of the testing is determined by the TSDA services supported by the product under test, each participant was required to declare the TSDA services that it supports.

The TSDA interface is designed for accessing time series data and for this seventh Interoperability test, the test scenario focused on requesting and receiving data from a TSDA client/server pair. The assumption for this test is that the base models accessed by the client/server pair were already synchronized. That is, the models that were preloaded and accessed by the TSDA Server and TSDA client were exact duplicates.

IEC 61968 Part 13: Distribution Model Exchange Testing

The **full distribution model exchange** test used two model files provided by EDF. These files contained the classes, attributes, and associations defined for the Common Distribution Power System Model (CDPSM, a superset of the NERC profile - see Reference [15]).

Scope of the CIM Tested

The portions of the CIM that were tested are defined in the following:

- Reference [1] – 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. This profile is mostly a subset of the IEC 61970-301 Base CIM standard (see Reference [9]).

[2] Note: It is not sufficient to use OPC Data Acquisition (DA) and claim conformance to the HSDA. The recommended TC57 Namespace must also be exposed by the OPC/HSDA server.

- Reference [15] – CDPSM standard for exchanging distribution models. This profile is a superset of the NERC profile and contains the selected CIM classes, attributes and relationships defined by EDF to model a distribution network.

Organization of Report

The introductory chapter presents the objectives and scope of these tests. Chapter 2 describes the test plan that was followed and identifies the participants 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, or Not Applicable, are organized in a series of tables. A summary of the significant results achieved is also provided. The first two appendices contain a description of the participant's products used in the tests (Appendix A) and the test configuration data, including specific versions of the CIM in UML and XML/RDF, sample model files, and test tools (Appendix B). Appendix C contains the use cases that define the capabilities being tested, while Appendix D contains examples of incremental model updates. Appendix E provides an overview of the GID functionality and the relevant IEC standards for each service.

References

1. CPSM (Common Power System Model) Minimum Data Requirements in Terms of the EPRI CIM, version 1.9, April 2004.
2. CIM XML Interoperability Test 7, Test Plan and Procedures, Revision 2, September 23, 2005.
3. *Report on the First Common Information Model (CIM) Extensible Markup Language (XML) Interoperability Test: The Power of the CIM to Exchange Power System Models.* EPRI, Palo Alto, CA: 2001. 1006161.
4. *Report on the Common Information Model (CIM) Extensible Markup Language (XML) Interoperability Test #2: The Power of the CIM to Exchange Power System Models.* EPRI, Palo Alto, CA: 2001. 1006216.
5. *Report on the Common Information Model (CIM) Extensible Markup Language (XML) Interoperability Test #3: The Power of the CIM to Exchange Power System Models.* EPRI, Palo Alto, CA: 2001. 1006217.
6. *Report on the Common Information Model (CIM) Extensible Markup Language (XML) Interoperability Test #4: The Power of the CIM to Exchange Power System Models.* EPRI, Palo Alto, CA: 2002. 1007351.
7. *Testing of the Generic Interface Definition (GID Standards and the Common Information Model (CIM) Extensible Markup Language (XML) Interoperability Test #5: The Power of the Common Information Model (CIM) and the Generic Interface Definition (GID) to Exchange Power System Data.* EPRI, Palo Alto, CA: 2004. 1009404.
8. *Report on the Sixth Control Center Application Program Interface (CCAPI) Interoperability Test.* EPRI, Palo Alto, CA: 2004. 1010117.

9. IEC 61970 Energy Management System Application Program Interface (EMS-API) – Part 301: Common Information Model (CIM) Base, Edition 1, based on cim10_030501.mdl.
10. Draft IEC 61970: Energy Management System Application Program Interface (EMS-API) – Part 402: Common Services, Draft Revision 8, 1 July 2005.
11. Draft IEC 61970: Energy Management System Application Program Interface (EMS-API) – Part 407: Time Series Data Access (TSDA), Revision 2, 16 June 2005.
12. Draft IEC 61970: Energy Management System Application Program Interface (EMS-API) – Part 404: High Speed Data Access, Revision 2, 16 June 2005.
13. Draft IEC 61970: Energy Management System Application Program Interface (EMS-API) – Part 501: CIM RDF Schema, Revision 4, 2004-02-25.
14. Draft IEC 61970-554-4: Energy Management System Application Program Interface (EMS-API) – Part 554-4: CIM XML Model Exchange Format, Revision 6, 2005-05-05.
15. Draft IEC 61968: System Interfaces for Distribution Management – Part 13: CIM RDF Model Exchange Format for Distribution, Revision 01, January 2005.
16. OPC DA 2.05a Specification, Revision 2.056.1.01, 28 June 2002.
17. OPC HDA 1.20 Specification, Revision 1.20.1.00, 10 December 2003.
18. UCTE Data Exchange Format for load flow and three phase short circuit studies (UCTE-DEF) v0.1 – 2003-09-01.

2
THE TEST PLAN

A formal set of test procedures were prepared and used to conduct and score the tests (see Reference [2]). These procedures were made available ahead of time, and all participants were encouraged to execute as many of these tests as possible prior to coming to Folsom. The goal was to have each participant successfully complete as many tests as possible while in Folsom.

The specific criteria used for evaluation of successful completion of each test was not revealed ahead of time, although the nature of the criteria was discussed.

This section provides an overview of the test plan used for this seventh interoperability test.

Participants and their Products

The six participants in this test were given the opportunity to spend four full days at the CAISO test site in Folsom, California. Participants brought their hardware/software and connected to a shared Ethernet LAN set up in the test room. The model files used for testing were loaded onto a JumpDrive USB mass storage device for use by each participant. The sample model files and files successfully exported by a participant's product were loaded onto the JumpDrive and each participant could access these files for testing their import capability.

Participants were allowed to correct deficiencies or errors found during testing and then, as time permitted, retest. All official testing took place only on-site in Folsom. The final test results achieved at that time are recorded in the test matrices provided in Section 3, Test Results.

Each participant was required to use an actual product(s) so that testing would demonstrate interoperability of real products. The participants and their products are listed in Table 2-1 below.

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

Table 2-1
Participants and their Products

Vendor	Product Name	Tests
ABB	PCU400	HSDA Interoperability Test
ABB	DAIS2OPC	HSDA Interoperability Test
Areva	e-Terra-Platform	Transmission Power System Model CIM/XML file transfer
EDF	CIM C++ Framework	1.) Transmission/Distribution Power System Model CIM/XML file transfer 2.) Incremental file transfer
EDF	GEDEON	Transmission/Distribution power system model CIM/XML file transfer
EDF	OPC Matrikon Server/Client + Micro-Turbine Simulator	HSDA Interoperability test
EDF	CIM-EUROSTAG Adapter	Transmission Power Solution Test
Siemens PTI	HSDA Server	HSDA Interoperability
Siemens PTI	TSDA Client	TSDA Interoperability
Siemens PTI	ODMS (Operational Database Maintenance System)	1) Transmission power system model CIM/XML file transfer 2) TSDA Interoperability 3) HSDA Interoperability
Siemens	Spectrum PowerCC IMM	Transmission power system model CIM/XML file transfer
Siemens	Spectrum PowerCC SCADA	HSDA Interoperability
SISCO	UIB Adapter for OPC	1) HSDA Interoperability 2) TSDA Interoperability
SISCO	UIB PI Adapter	1) TSDA Interoperability 2) HSDA Interoperability
SISCO	UIB Core	1) Transmission power system model CIM/XML file transfer 2) Distribution Power System Model CIM/XML file transfer

Test Approach

As stated in the Introduction, there were three major categories of tests:

1. GID interface tests conducted as both conformance tests and interoperability tests
2. Power system model and data exchange tests based on CIM XML using file transfers
3. Distribution model and data exchange test based on IEC 61968 Part 13

Participants were able to perform one, two, or all three sets of tests.

GID HSDA Interface Testing

Based upon the definitions and philosophy of the GID, testing applies primarily to the HSDA Servers and to HSDA Clients that are not required to meet the full OPC client specifications. That is, it should be possible to use off-the-shelf OPC clients without modification in actual implementations of the HSDA standard. In addition, this test document recognizes the need to test the conformance of HSDA servers to the relevant standards in addition to the interoperability of HSDA clients and servers.

As a result, testing is divided into two parts:

1. Conformance testing – dealing with the ability of the HSDA server to correctly conform to the standard. This test applies only to HSDA servers.
2. Interoperability testing – dealing with the ability of one participant's client ability to interoperate with another participant's server.

Since the HSDA interface standard does not specify a specific architecture or technology to use in an implementation, it is necessary to define this as part of the test to ensure all components can exchange data without any barriers. Figure 2-1 provides three sample architectures using the OPC and OMG DAIS components. The exact architectures used during this test are defined in the Conformance and Interoperability sections below.

The data that will be exchanged in these tests will vary depending on which pair is being tested. If the EDF server is one of the pairs, the data to be exchanged are GeneratingUnit measurement data attached to the Siemens 100 bus model. The set of possible data to be exchanged is shown below.

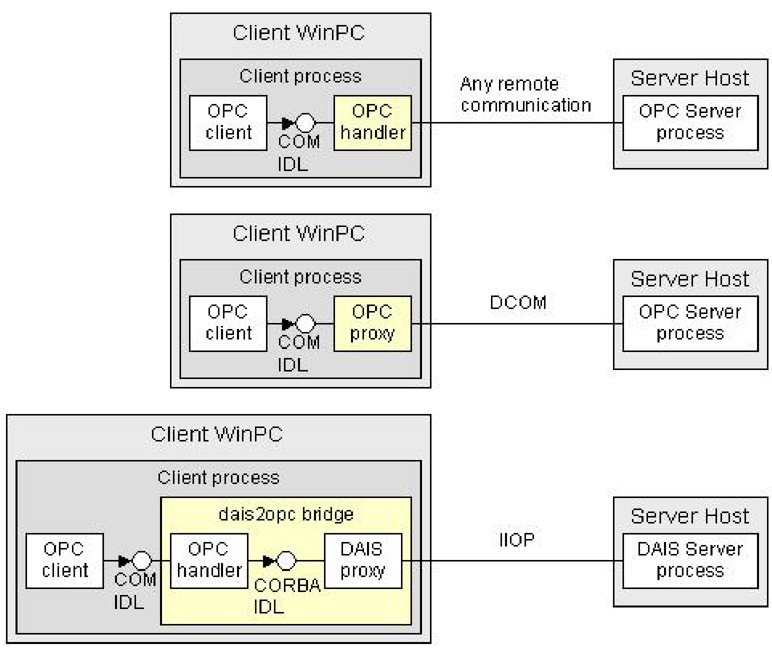


Figure 2-1
HSDA Architectures with OPC and DAIS

Modbus Address	CIM Naming.Name	Description
	Global Variables	
2	Hydrométrie	Atmospheric Hydrometry
904	Jour	Day
12	OnOff_Compresseur	M/A Compressor
902	Minute	Minute
905	Mois	Month
4	Pression_atmospherique	Atmospheric Pressure
901	Seconde	Second
3	Temp_atmospherique	Atmospheric Temperature
14	Temp_circuit_biogaz	biogaz commun circuit temperature
52	Temp_eau	water circuit temperature
	μTac Specific Variables	
1043	CO	CO
1044	CO_2	CO_2
1008	OnOff_de_la_TAC	Command M/A of μTAC
1052	OnOff_du_circuit_eau	Command M/A of water/cogeneration circuit
1012	Commande_vanne_biogaz	Command valve biogaz
1005	Compteur_OnOff	Meter M/A
1004	Compteur_de_fonctionnement	Gear Meter
1006	Consigne_de_puisance	Nominal power
1013	Diffe_de_presion_filtre_biogaz	Diff. biogaz pressure
1022	Diff_de_pression_filtre_a_air	Diff. air pressure
1015	Debit_biogas	biogaz flow before combustion
1054	Debit_de_cogeneration	Cogeneration flow
1002	Etat_de_la_machine	Machine state
1084	Frequence_en_sortie	Output Frequency
1083	Intensite_du_courant	Current
1014	Pression_biogaz	biogaz Pressure before combustion
1082	Puissance_electrique_produite	Power generated
1007	Selection_AutoManuelle	mode Auto/Manual
1023	Temp_air_entree_compresseur	Input Air Temperature of compressor
1053	Temp_sortie_de_cogeneration	Output Temperature of cogeneration
1042	Temp_fumees_de_turbine	Output Steam Temperature of turbine
1085	Tension_en_sortie	Output voltage
1062	Vitesse_de_rotation_turbine	Rotation Velocity of turbine

The data to be exchanged between the remaining pairs in the test may include some or all of the measurement data listed below. This data is contained in the ABB 40 Bus model.

1. ‘AMHEG1 BUS GEN_P’@<H-ACTUAL VALUE>
2. ‘AMHEG1 BUS GEN_Q’@<H-ACTUAL VALUE>
3. ‘AMHEG2 BUS GEN_P’@<H-ACTUAL VALUE>
4. ‘AMHEG2 BUS GEN_Q’@<H-ACTUAL VALUE>
5. ‘AMHEG3 BUS GEN_P’@<H-ACTUAL VALUE>
6. ‘AMHEG3 BUS GEN_Q’@<H-ACTUAL VALUE>

HSDA Conformance Testing

Conformance testing is a server issue. While some tests unavoidably duplicate similar OPC tests (e.g., client establishes a connection to a server), the main focus of the GID conformance testing was to validate the new requirements imposed on HSDA due to the CIM NameSpace and related standards (see References [10, 12, 16]). The areas tested and demonstrated in the server product were:

- Establishment of a connection with a client.
- TC57namespace browsing of data on the server (i.e., the ability to view the data in a CIM-compliant fashion without knowledge of the underlying database logical schema).
- Data exchange (e.g. read/write) where individual values as well as groups of values are read and written to the server using CIM classes and namespace.
- Obtaining TC57Namespace Custom Properties.

Figure 2-2 illustrates the test set-up used for conformance testing. A well recognized, general, OPC Client (e.g., from FactorySoft[3] or Matrikon) was used to validate the conformance of the HSDA Servers. The participant’s server under test imported the sample power system model file to populate the server database. A test data generator was used to simulate the collection of telemetered SCADA data. This provided the ability to see data changing over the HSDA interface and to compare the values received at client with those sent by the receiver. The server under test provided the technology for connectivity between the OPC Client and the HSDA Server.

[3] The FactorySoft OPC client was modified to allow queries of custom properties.

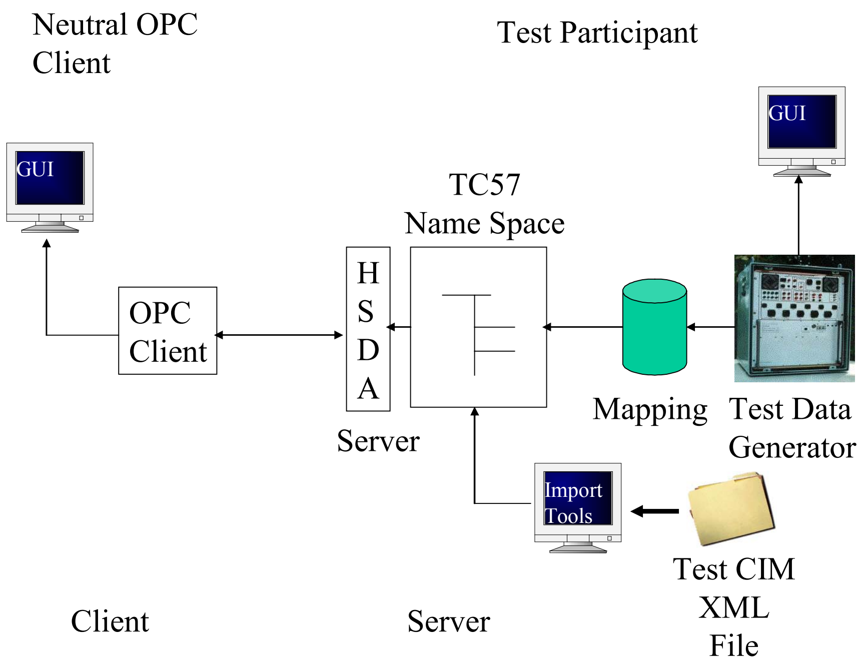


Figure 2-2
Conceptual Test Set-Up for HSDA Conformance Testing

HSDA Interoperability Testing

Figure 2-1 depicts the possible general test setups for interoperability testing between an HSDA Server and an HSDA Client. The participants in the HSDA interoperability tests included ABB, EDF, Siemens PTI, Siemens, and SISCO. A total of nine participant pairs were tested as shown in the table below. The SPTI Client and the Siemens Server was tested using 2 different communication technologies. Figures 2-3 through 2-7 show the actual test configurations used for the HSDA interoperability tests.

In each case the test scenario included three tests; connectivity, data exchange and disconnect.

HSDA Server Participant	HSDA Client Participant				
	ABB	**SISCO**	**SPTI**	**Siemens**	**EDF OPC Client**
SISCO			X		X
Siemens	X		X		X
EDF OPC Server		X	X		
ABB			X		

All tests involving the SISCO HSDA Server or Client will use the MoM technology provided in the SISCO UIB message bus. All tests not using MoM technology will use the OPC XML DA or DCOM directly, or will use a third party bridge (Kassl dOPC Xgate/XCOM products) for the communication platform. For the HSDA pairs that use the MoM technology and have an EDF Server or EDF Client as one of the pairs the architecture shown in Figure 2-3 may be used.

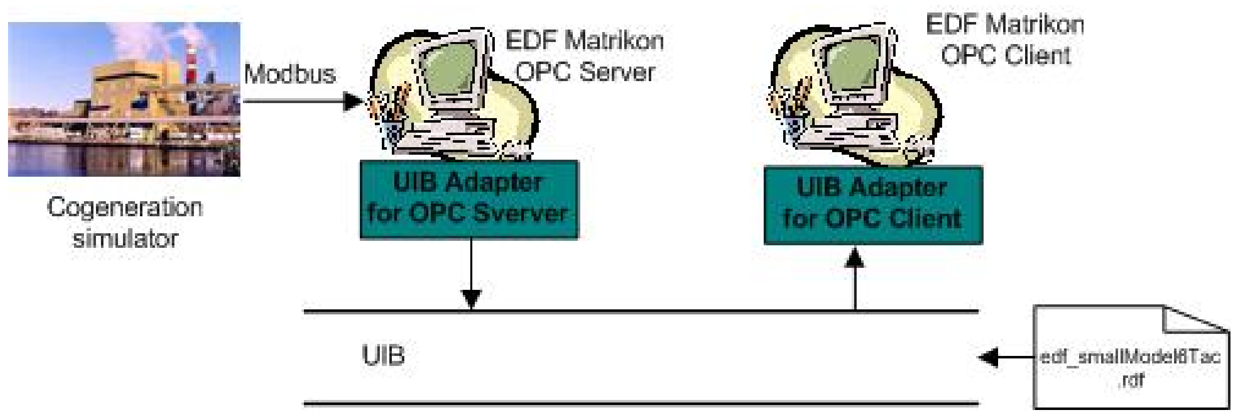


Figure 2-3
HSDA Interoperability Test Using EDF Matrikon Client/Server

The diagrams shown in Figure 2-4, 2-5, 2-6 and 2-7 provide graphical representations of architectures that were used for one or more of the HSDA Client/Server pairs defined in the participant pairs table above. Each diagram uses a specific Server and defines the architecture that would be deployed for the HSDA Clients to establish a connection and provide communications.

In Figure 2-4, the HSDA client is provided by Siemens PTI (SPTI). The connection to the ABB HSDA Server is completed using a dais2opc bridge. The actual communications are accomplished using OPC XML-DA. The SPTI Client subscribed for measurements by getting MeasurementValue identifiers from the CIM-XML file.

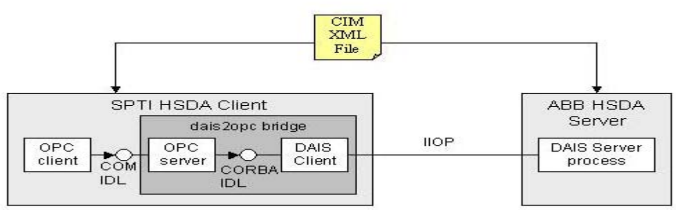


Figure 2-4
HSDA Interoperability Test Using an ABB HSDA Server

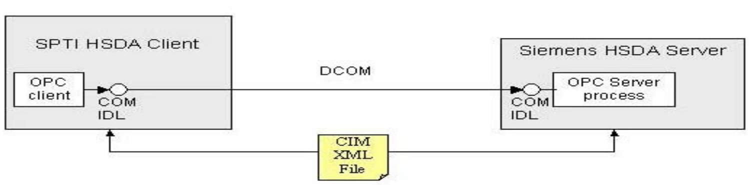


Figure 2-5
HSDA Interoperability Test Using a Siemens HSDA Server with DCOM

The HSDA Client shown in Figure 2-5 was provided by SPTI. The connection to the Siemens HSDA Server is completed using DCOM and the Client subscribed for measurements by getting MeasurementValue identifiers from the CIM-XML file.

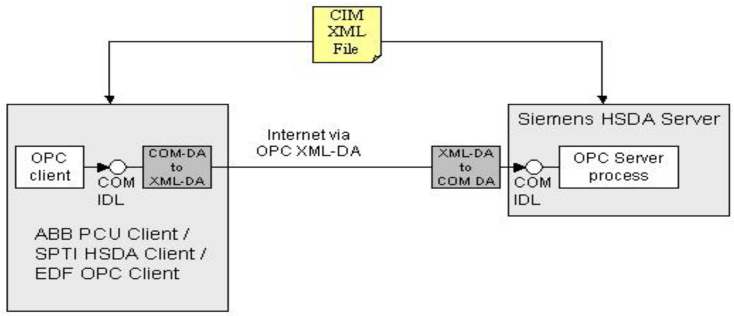


Figure 2-6
HSDA Interoperability Test Using a Siemens HSDA Server

The HSDA Client shown in Figure 2-6 was supplied by SPTI, ABB and EDF. The connection to the Siemens HSDA Server is completed using a combination of COM-DA and XML-DA. Clients subscribed for measurements either by browsing an IECTC57PhysicalView or by getting MeasurementValue identifiers from the CIM-XML file.

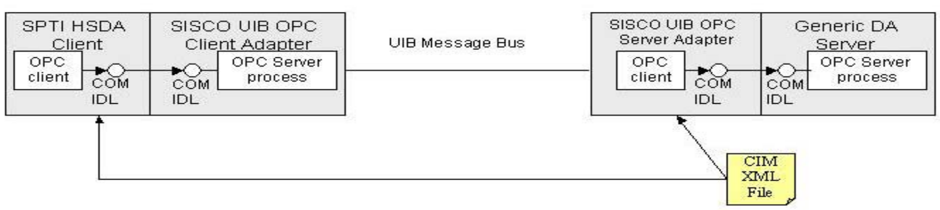


Figure 2-7
HSDA Interoperability Test Using a SISCO HSDA Server

The HSDA client in Figure 2-7 was provided by SPTI and the connection to the SISCO server uses the UIB Message Bus (MoM technology) as the communication layer. The HSDA client subscribes for measurements by getting MeasurementValue identifiers from the CIM-XML file.

The table below provides a simple cross-reference between the Client/Server pairs and the middleware technology/architecture used in the tests.

Table 2-2
HSDA Client/Server Combinations for Testing

Client	Server	Architectural Representation	Middleware Technology
Siemens PTI	SISCO OPC DA	Figure 2-7	UIB
Siemens PTI	ABB	Figure 2-4	ABB DAIS2OPC Bridge
Siemens PTI	EDF OPC DA	Figure 2-3	UIB
Siemens PTI	Siemens	Figure 2-5	DCOM
Siemens PTI	Siemens	Figure 2-6	OPC XML DA
EDF OPC DA	Siemens	Figure 2-6	OPC XML DA
EDF OPC DA	SISCO OPC DA	Figure 2-3	UIB
SISCO OPC DA	EDF OPC DA	Figure 2-3	UIB
ABB	Siemens	Figure 2-6	OPC XML DA

To complete each of these test scenarios, the client and server had to be connected and data exchanged according to the test procedures.

GID TSDA Interface Testing

The TSDA testing comprised interoperability tests between the test participant's products – one acting as a TSDA client and one as a TSDA server. Since the OPC HDA specification defines several services with internal methods, the participant must declare the TSDA services/methods/events that are supported or used in the client or server application under test.

The tables are supplied for each IOP Test. Each participant shall provide a TSDA Client Declaration and/or a Server Declaration Table as required. Table 2-3 below is used for both client and server declaration. The only difference between client and server declarations is the Title row and the method/event declaration column has a different meaning. The methods and events listed in the table are defined in References [10, 11, and 17].

The meaning of the terms used for the Client Declaration is described below:

U – If a Client application declares a service as being "Used", then a server must support this function for the two applications to interoperate.

O – If a Client application declares a service as being "Optional", then a server may or may not need to support this service for the two applications to interoperate. Presumably, it the server supports this service, the Client will operate in an enhanced fashion.

NU – If a Client application declares a service as being "NotUsed", then a server does not need to support this function for the two applications to interoperate.

Table 2-3
TSDA Provider Declaration Table

Participant		
Application		
TSDA Methods/Event Declarations		
TSDA Method	Client: Used/Optional/Not Used (U, O, NU) Server: Supported/Not Supported (S, NS)	Comment
Requests		
IOPCHA_Server::GetHistorianStatus		
IOPCHA_Server::GetItemHandles		
IOPCHA_Server::GetItemAttributes		
IOPCHA_Server::GetAggregates		
IOPCHA_Server::ReleaseItemHandles		
IOPCHA_Server::ValidateItemIDs		
IOPCHA_Server::CreateBrowser		
IOPCHA_A_SyncRead::ReadAtTime		
IOPCHA_A_SyncRead::ReadRaw		
IOPCHA_A_SyncRead::ReadProcessed		
IOPCHA_A_SyncRead::ReadModified		
IOPCHA_A_SyncRead::ReadAttribute		
IOPCHDA_Browser::GetEnum		
IOPCHDA_Browser::ChangeBrowserPosition		
IOPCHDA_Browser::GetItemID		
IOPCHDA_Browser::GetBranchPosition		

The meaning of the terms used for the Server Declaration is described below:

S – If a Server application declares a service as being "Supported", then it must support this function.

NS – If a Server application declares a service as being "NotSupported", then it may not support this function.

The test scenarios consisted of using the TSDA services to transfer historical data/messages for the applications under test. The test cases completed for each test scenario include Connectivity, Data Exchange (e.g. read/write), and disconnect. The interoperability testing included the above scenario for a SISCO TSDA Server and an SPTI TSDA Client. The historical model used was loaded into the TSDA Server and Client prior to the exchange of data and the model was synchronized with the data; that is, the data requested and exchanged had the corresponding device contained within the model.

At a minimum, the TSDA applications had to comply with the following requirements:

1. OPC HDA Version 1.20 or later must be used
2. The TSDA Server must support IOPCHDA_Server and IOPCHDA_Syncread. The Server may optionally support IOPCHDA_Asyncread
3. If the TSDA Client supports IOPCHDA_AsyncRead it must also support IOPCHDA_Datacallback
4. The TSDA Server must allow the historical point to be subscribed to using the full CIM path and it must be able to map that point to the tag name within the historian. The client may be implemented to provide a subscription using the tag associated to the historical value but this is not required for compliance to the standard. If the Client provides this capability, it should be noted in the declarations.

The TSDA tests employed the MoM technology shown in Figure 2-8 to accomplish access and exchange of time series data.

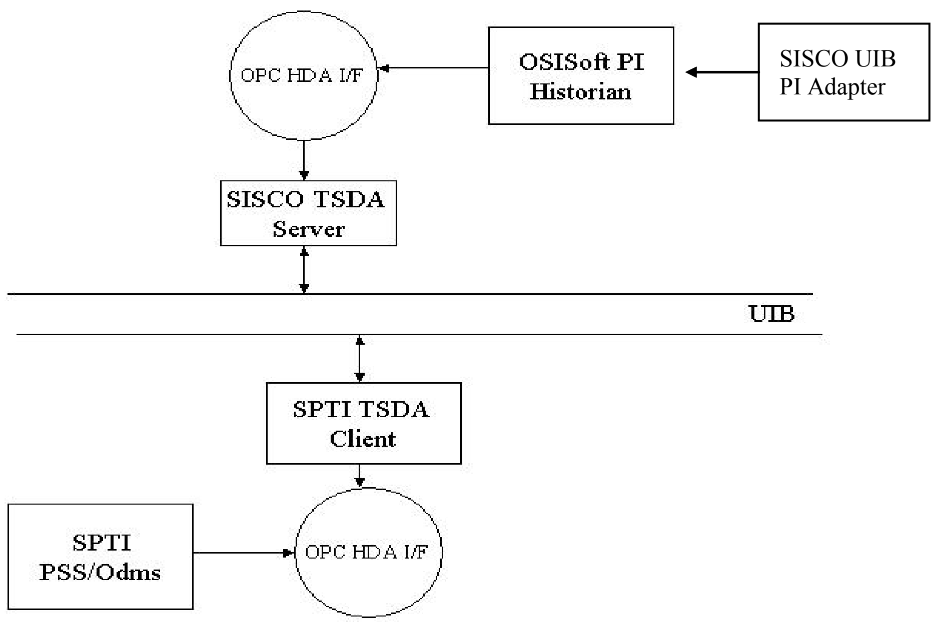


Figure 2-8
TSDA Interoperability Architecture Using MoM Technology

As shown in Figure 2-8, the SPTI Client interoperability with the SISCO Server was accomplished using OPC HDA interfaces connected to the SISCO message bus.

Model, Data Exchange and Solution Tests

These tests were similar to those performed in previous interoperability tests, where three types of data transfers involving power system models were tested:

1. Full (complete) model transfers.
2. Partial model transfers.
3. Incremental model updates.

This set of tests also included the Solution test results.

Full Model Transfer

Figure 2-9 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 developed for earlier tests was used during this test to confirm that the CIM XML documents created on export were both well-formed and valid. This tool also provides a count of the number of instances of each CIM class specified in the NERC CPSM Minimum Data Requirements document (see Reference [1]).

For import, the application under test 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.

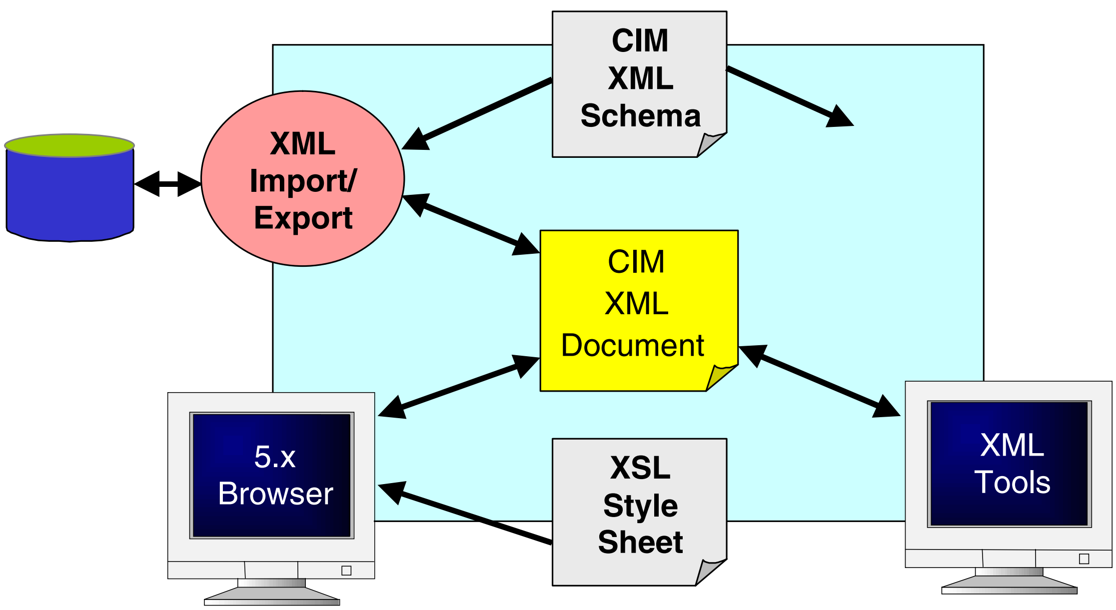


Figure 2-9
Export/Import Process Basics

Interoperablity Testing with Complete Power System Models

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 JumpDrive to make it available for the other participants to import. When other participants were able to import these files, the *interoperability* of different vendor's products was verified and demonstrated.

The basic steps involved are illustrated in Figure 2-10 below. Each participant (Participant A in the figure 2-10) was first required to import the CIM XML-formatted test files (CIM XML Doc 1) 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 to demonstrate compliance by running the XML/RDF validator tool on the exported file (step 3). If successful, the exported file was then re-imported 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).

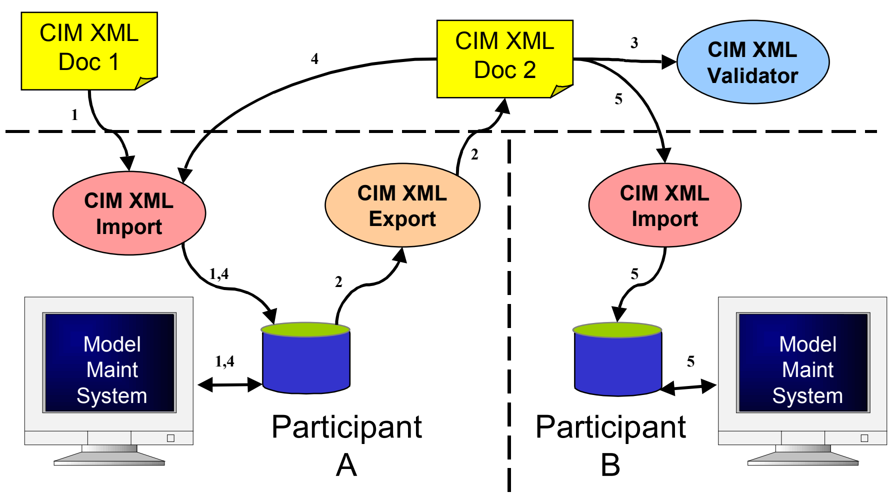


Figure 2-10
CIM XML Interoperability Test Process Steps

At this point the exported file was also loaded onto the JumpDrive for another participant (Participant B in Figure 2-10) 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.

One of the key issues evaluated with these tests is that while all vendors must export and recognize on import the CIM classes specified in the NERC CPSM profile, additional classes exported by one vendor may not be used by the vendor importing the model file, and vice-versa (i.e., one vendor may not export certain classes outside the NERC profile that the importing vendor does use in its internal applications).

Power Flow Solution Test

As stated earlier, the objective of the Power Flow Solution testing was to verify the correct exchange and transformation of power system model files including generation and load through the execution of power flow applications, not the exchange of power flow solutions. Therefore, the test approach involved a round trip exchange of power system model files, with an execution of a power flow initially on Participant A's EMS, then after sending the model file at the Participant B's EMS, and finally after being transferred back to Participant A, executed once more on Participant A's EMS.

Verification was accomplished by a comparison of solutions before and after transformation and model exchange, as illustrated in Figure 2-11.

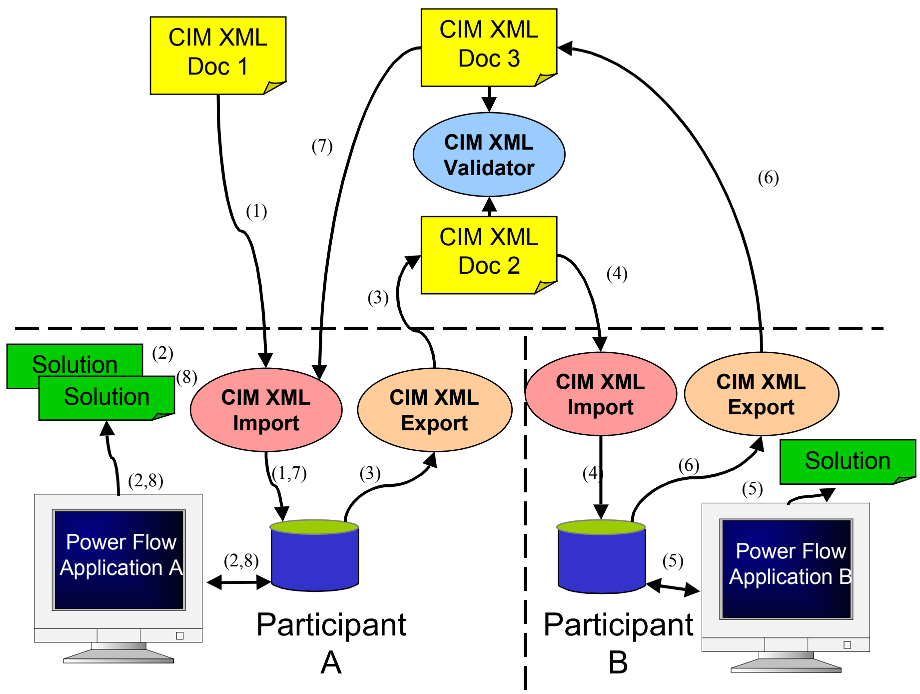


Figure 2-11
Solution Test Process

The steps for this process were as follows:

1. Participant A imported a standard power system model file (CIM XML doc 1) and converted to local representation. The imported model in local representation was then validated using participant's display tools.
2. Participant A then ran a power flow and saved the solution.
3. Participant A exported a file, creating CIM XML Doc 2.
4. Participant B imported CIM XML Doc 2 and converted to local representation. The imported model in local representation was then validated using participant's display tools.

5. Participant B then ran a power flow and checked to verify correct operation. Comparison with Participant A's results from step (2) was the first measure of success for this test.
6. Participant B then exported a file, creating CIM XML Doc 3.
7. Participant A imported CIM XML doc 3 and converted to local representation. The imported model in local representation was then validated using participant's display tools.
8. Participant A then ran a power flow and compared results with the solution obtained in step (2) to determine if the solutions matched within a reasonable margin, which was the second measure of a successful test[4].

The reason for a complete round trip is recognition that solutions generated by Power Flow applications from different suppliers may be different and not readily comparable.

Incremental Model Update

This test used the Siemens 100 bus model file developed for this test as a starting point. Then the types of changes described in Appendix D were used to create difference files containing these types of changes. The format and syntax for this file is described in Reference [14].

Test Process

Once the Siemens 100 bus model was imported by all participants, a difference file produced by one participant was imported by another. This tested the ability of the first participant to produce a correctly formed file with correct resource IDs, and tested the second participant to interpret this file correctly and apply it to the internally stored base model file.

Each participant in the incremental model update test followed these steps:

1. import the base model file and validate, then
2. import the difference file, apply the updates to the base model file, and demonstrate correct interpretation of the difference file changes.

Partial Model Transfer

The partial model transfer test demonstrates the ability of products to export and import a subset of a complete model, then stitch this partial model into a base model file.

This test used, either the Siemens 100 bus model, the Areva 60 bus model or the EDF 27 bus model. A base file with one or more substations removed was created. Then a partial model file with the removed substations was created. Each participant executed the following steps:

[4] The solutions of multiple runs of a power flow after exporting and re-importing from another participant were expected to result in consistent solutions with reasonable differences that result from model translation to local representation.

1. The base file with the substations removed was imported
2. The partial model file containing the removed substations was imported
3. The partial model file was merged with the base file
4. The merged model was exported for validation.

Test Process

The steps for this process were as follows (the same process applies to the other substation partial model files):

1. Participant imported the "Siemens100 Less Port" base model file that did not contain Substation Port.
2. Participant imported a partial model file containing a new substation Port and merged it with the base model file, to create a new model "Siemens100 Plus Port". The imported model in local representation was then validated using participant's display tools.
3. Participant compared this new model "Siemens100 Plus Port" with previously imported sample model file "Siemens100" that already contained Substation Port.
4. Extra credit was offered for creating and exporting a new partial model file that is demonstrated to be correct by validation and import by another participant.

IEC 61968 Part 13: Full Distribution Model Exchange Test

For the first time at one of these interoperability tests, an IEC 61968 distribution model exchange test was conducted using the Common Distribution Power System Model (CDPSM) Profile defined in Reference [15]. This test demonstrated the ability of a product to correctly import a CIM XML model file generated using the specifications defined in IEC 61968-Part 13.

The test used a full CIM XML distribution model provided by EDF exchange to demonstrate the ability of participants to import a distribution model. Each participant in this test was required to import the EDF CIM XML model file and correctly interpret the model data contained. This model contains at least one instance of the CIM classes, attributes and relationships defined in Reference [15]. Product specific tools were used to validate the import was successful.

This test was performed by SISCO using their UIB Core product.

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]).

Note: the GDA sections of the Test Procedure are not presented in the table since these tests were not executed by any participant during this test.

Table 3-1
Description of Tests Performed

Step from Test Procedure	Test Description
4.2	***Basic Import/Export***
4.2.1	Basic Import - Participant A import sample model file and demonstrate import was done correctly
4.2.2	Basic Export - Participant A export 100 bus model and run validator
4.2.3	Interoperation - Participant B import of Participant A exported CIM XML file.
4.2.4	***Solution Test***
4.2.4.1	Initial Import Document 1, Run Solution, and Export Document 2
4.2.4.2	Interoperability Test Using CIM XML Document 2 from Another Participant, Export Document 3
4.2.4.3	Final Import and Power Flow Execution on CIM XML Document 3
4.3	***Incremental Model Update***
4.3.3	Export Incremental Update File
4.3.4	Import Incremental Update File and Merge
4.4	***Partial Model Transfer***
4.4.1	**Import Partial Models and Merge**
4.4.1.1	Import sample model with substation(s) missing
4.4.1.3	Import & Merge sample model containing only substation(s)

Table 3-1
Description of Tests Performed (Continued)

Step from Test Procedure	Test Description
4.4.2	**Export Merged Model Files**
4.4.2.1	Export merged model - Participant A exports merged model file
4.4.2.2	Re-import merged model - Participant A re-imports exported merged model file
4.4.2.3	Participant B import merged model file from Participant A and validate
4.4.3	**Export Partial Model Pair and Re-Import with Merge**
4.4.3.1	Export Partial Model Pair
4.4.3.2	Re-Import Partial Model Pair and Merge
4.5	***ICCP Configuration Data Transfer***
4.6	***HSDA GID Testing***
4.6.1	**Conformance testing**
4.6.2	**Interoperability testing**
4.8	***TSDA GID Testing***
4.8.1	**Connectivity test**
4.8.2	**Exchange historical data test**
4.8.3	**Disconnect test**
4.9	***61968 Part 13 Distribution Model Exchange Test***
4.9.2	**Import Interoperation**

Summary of Test Results

The following sections report the highlights of the testing. The final results are presented in tables within each section. The entries in each cell of the tables 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
- PE (Passed with Errors) – most aspects of the test were performed successfully
- VR (Validator Reject) – import file rejected due to errors detected by product internal validator
- X – No files were exported by this participant, so none available for import
- N/A – Product does not have export functionality

- Blank (no entry) – indicates test was skipped, not witnessed, an exported model file was not available for import, or an exported file was available but had errors that prevented a successful import.

Basic Import/Export, ICCP and Interoperation

Basic Import and Export

Tables 3-2 and 3-3 show the results of the tests on the individual products to determine compliance with the final CIM version 10 XML/RDF standards, which have been approved as an International Standard IEC 61970-301 CIM Base. The primary objective of this test was to successfully import and export a sample model file based on the NERC CPSM transmission model profile to show compliance. It should be noted that to pass the export test successfully, the exported model file had to be re-imported correctly. So all participants that passed the export test also demonstrated a successful re-import of the exported file.

All of the participants were able to pass this test. Highlights of the tests are presented in the following tables.

Table 3-2
Basic Import Test of Individual Products

Test Procedure	4.2.1 Basic Import					
Test Model Used	100 Bus Model	60 Bus Model	40 Bus Model	27 Node Model	UCTE 14 Node	EDF7 3TW Model
Areva	P		P	P	P	
EDF CIM Framework	P		P	P	P	
EDF GEDEON	P		P	P	P	P
Siemens PTI	P	P	P	P	P	P
Siemens	P	P	P	P	P	P
SISCO UIB Store	P		P	P	P	

Table 3-3
Basic Export Test of Individual Products

Test Procedure	4.2.2 Basic Export					
Test Model Used	100 Bus Model	60 Bus Model	40 Bus Model	27 Node Model	UCTE 14 Node	EDF7 3TW Model
Areva	P		P	P	P	
EDF CIM Framework	P		P	P	P	
EDF GEDEON	P		P	P	P	P
Siemens PTI	P	P	P	P	P	P
Siemens	P	P	P	P	P	P

ICCP Test

The ICCP test uses the Basic Import Procedure and then directs the participant and the witness to verify the existence of the ICCP point within the model after it has been imported (using the product tools) or after it has been exported using XML inspection tools. EDF completed this test using the Siemens 100 Bus model. This model has 20 ICCP points. EDF completed the following steps:

1. Imported the Siemens 100 Bus model
2. Exported the Siemens 100 Bus model
3. Verified all 20 ICCP points were contained in the exported model.

EDF executed this test using the CIM Framework and GEDEON products. In each case the test passed.

Interoperation

This section documents the pairs of vendors that were able to demonstrate interoperation via the CIM XML formatted-model file.

Table 3-4 shows the results for the interoperability testing. The primary objective of this test was for a participant to successfully import a power system model exported by another participant. The rows show the results of the interoperability test for each participant. Each column represents a file available for testing. These files were previously exported as part of the Basic Export test above (See Table 3-3).

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.

All participants with functionality to export a file did so and then made that file available for other participants to import.

Highlights of the tests are as follows:

- Nine pairs of vendors were able to interoperate successfully by exchanging at least one sample model file.

Table 3-4
Interoperation with Sample Models

Test Procedure	**4.2.3 Import of 4.2.2 CIM XML Exported file**				
Participant Importing File	**File Exported by Areva**	**File Exported by EDF CIM Framework**	**File Exported by Siemens PTI**	**File Exported by Siemens**	**File Exported by EDF GEDEON**
Areva	X				
EDF CIM Framework	P – 100 Bus P – EDF 27 P – UCTE14 P – 40 Bus	X			X
EDF GEDEON	P – 100 Bus P – EDF 27 P – UCTE14 P – 40 Bus	X		P – 60 Bus P – EDF 27 P – UCTE14 P – 40 Bus	X
Siemens PTI		P – 100 Bus	X	P – 60 Bus P – 40 Bus P – EDF 27	
Siemens	P – EDF 27	P – 100 Bus P – 40 Bus	P – EDF 27	X	P – UCTE14
SISCO					

Power Flow Solution Testing

EDF participated in these tests using the Siemens 100 bus model, the EDF 27 Node model and the UCTE 14 Node model. Table 3-5 shows the results of each of the steps as defined in Chapter 2, Figure 2-11, Solution Test Process. Highlights of the Solution test are as follows:

- EDF was able to successfully run a power flow solution on an imported model file and then export the file. They were also able to import and run a load flow on a model file that had been previously imported and exported by another participant.
- Bottom line: The contents and format of the power system model files exchanged with the CIM XML file representation are adequate for running power flow applications. But more importantly, the running and comparison of power flow solutions is the ultimate validation of the CIM version 10 content and the adequacy of the CIM XML standards for exchanging power system model files.

Table 3-5
Solution Test Results

Test Number	1 Import Doc-1	2 Run PF Sol-1	3 Export Doc-2	4 Import Doc-2	5a Run PF Sol-2	5b Compare Sol-1, Sol-2	6 Export Doc-3	7 Import Doc-3	8a Run PF Sol-3	8b Compare Sol-1, Sol-3
EDF w/100 Bus Model	P	P	P	P w/SPTI export	P	P	P			
EDF w/EDF27 Node Model	P	P	P	P w/Siemens export	P	P	P	P w/SPTI export	P	P
EDF w/UCTE14 Node Model	P	P	P	P w/Siemens export	P	P	P	P w/SPTI export	P	P

Incremental Model Update

This section shows the results of the incremental model update tests. EDF and Siemens participated in these tests. Table 3-6 shows the results of the incremental model update testing. The results are grouped according to the type of incremental model update tested: Add, Modify, Delete, or a Combination of adds, modifies, and deletes as would most likely be found in a real-world application of this standard. The entries show the number of incremental update files of each type that were tested.

Table 3-6
Incremental Model Update Testing

Test Procedure	4.3.3 Export Incremental Update				4.3.4 Import Incremental Update			
Incremental Update Type	**Add**	**Modify**	**Delete**	**Combination**	**Add**	**Modify**	**Delete**	**Combination**
EDF CIM FRamework					P – 1	P – 2	P – 1	
Siemens	P – 1	P – 1	P – 1	P –1	P – 2	P – 2	P – 2	P – 1

Siemens prepared the following files for IOP6 and these files were used by EDF as import files for this IOP:

- Add Company with one Substation and two Bays of equipment (Siemens_inc_add.xml)
- Delete 11 objects (e.g., bus with transformer, transformer with related objects, and one measurement. (Siemens_inc_del.xml)

Export Incremental Updates

The first test required a participant to make incremental changes to the Siemens 100 bus model and export those changes as an incremental update (i.e., a difference file). Siemens successfully exported the following incremental update files:

- Siemens_inc_add_siemens.xml
- Siemens_inc_del_siemens.xml
- Siemens_inc_mod_del_siemens.xml
- Siemens_inc_mod_siemens.xml
- Siemens_inc_modRev1.xml (this was modified from the original siemens_inc_mod_siemens.xml file listed above)

Import Incremental Model Updates and Merge with Existing Base Model

The second test required a participant to import an incremental model update file, correctly parse the file for model changes, and apply the changes to a previously stored sample model file. The revised model was reviewed in the importing product to validate the change was correctly interpreted and applied to the existing model. This test validates interoperability using the difference file specification for incremental model updates.

Highlights of this test are as follows:

- Siemens successfully exported 4 incremental model update files. They also imported 7 incremental model update files and merged them into the existing Siemens 100 bus model stored internally in their product under test. This included files with a combination of several types of changes in a single file.
- EDF successfully imported 4 incremental model update files and merged them into the existing Siemens 100 bus model stored internally in their product under test. This included files with a combination of several types of changes in a single file.

This test validated that additions, deletions, and modifications to base models can be handled with the incremental update approach, as long a logical sequence of actions are followed. The test also validated the draft specification that defines the approach to creating the difference files used for this test (see Reference [14]).

Partial Model Transfer

This section shows the results of the partial model testing. Four participants (Areva, Siemens PTI, Siemens, and EDF) took part in these tests. Table 3-7 and Table 3-8 show the results of these tests.

Table 3-7
Partial Model Testing (Section 4.4.1)

Test Procedure	4.4.1 Partial Model Import								
Test Model Used	**Import 100 Bus Model w/o SS**	**Import 100 Bus SS Model**	**Merge 100 Bus Partial Model Pairs**	**Import 27 Node Model w/o SS**	**Import 27 Node SS Model**	**Merge 27 Node Partial Model Pairs**	**Import 60 Bus Model w/o SS**	**Import 60 Bus SS Model**	**Merge 60 Bus Partial Model Pairs**
Areva				P – No N33	P N33	P			
Siemens PTI				P – No N33	P N33	P	P – No Brighton	P – Brighton	P
Siemens	P – No Oak Derby Gannon	P Oak P Derby P Gannon	P				P – No Brighton	P Brighton	P

Table 3-8
Partial Model Testing (Section 4.4.2 & 4.4.3)

Test Procedure	4.4.2 Merged File Export & Import from Another Participant			4.4.3 Export New Partial Model Files	
Test Model Used	**Export Merged Model**	**Re-Import Merge Model**	**Import Merged Model from Another Vendor**	**Export Partial Model Pair**	**Re-Import Partial Model Pair & Merge**
Areva	P – 27 Node	P – 27 Node	P – 27 Node from Siemens	P – 60 Bus with SS Brighton & 60 Bus w/o Brighton	P – 60 Bus with SS Brighton & 60 Bus w/o Brighton
EDF CIM Framework			P – 27 Node from Areva P – 60 Bus from Areva P – 60 Bus from SPTI		
EDF GEDEON			P – 60 Bus from Areva P – 60 Bus from Siemens P – 60 Bus from SPTI P – 27 Node from Areva		
Siemens PTI	P – 27 Node P - 60 Bus				
Siemens	P - 100 Bus P - 60 Bus	P - 100 Bus P - 60 Bus	P - 27 Bus from SPTI P – 60 Bus from Areva P – 60 Bus from SPTI	P – 27 Bus with SS N33 & 27 Bus w/o N33	P – 27 Bus with SS N33 & 27 Bus w/o N33

The first test required a participant to import a partial model and merge with a pre-existing base model. The base model had a certain substation removed as shown by the notation (e.g., "No Kincaid", which indicates the Kincaid substation was removed from the Siemens 100 bus model before importing). Some base model files had three substations removed (e.g., "No Gannon, Oak, Derby", which indicates the Gannon, Oak and Derby substations were removed). Highlights of this test are as follows:

- Areva, Siemens PTI and Siemens successfully imported and merged at least one substation model with the base model file.
- Siemens successfully imported and merged 3 substations.

The second test required a participant to export a merged model file and to also import a merged model file from another participant, as a way to validate the contents and format of the merged files. Highlights of this test are as follows:

- Areva, Siemens PTI and Siemens were able to export the merged model file successfully.
- Areva and EDF successfully imported merged model files exported by Siemens. Siemens and EDF successfully imported merged model files exported by Areva and Siemens PTI. These are further checks on the Areva, Siemens PTI and Siemens merged files, as well as the ability of Areva, EDF, and Siemens to interoperate with another vendor.

The third test was an opportunity for participants to further demonstrate their product's capability to export partial model files. For this test:

- Areva successfully exported a partial model file comprising one substation (ESCA60_nobrighton_20050929.xml and ESCA60_brighton_20050929.xml).

Siemens successfully exported a partial model file comprising one substation (edf27_non33.xml and edf27_n33.xml).

HSDA Conformance Testing

This section shows the results of the HSDA conformance testing. SISCO was the only participant for these tests.

As described in Section 2, conformance testing only involves the server side of a product. For this test, a FactorySoft OPC Client was used to test the SISCO HSDA Server. The results of these tests are summarized in Table 3-9.

The first set of tests (4.6.1.1) validate that a Client is able to establish a connection to the Server, terminate that connection, and then when the Server is terminated, check that the connection is terminated. SISCO passed all these tests.

The next group of tests (4.6.1.2) tests the Server support for Client browsing of its namespace. These and the following tests assume the Client has established a connection to the Server, and the Server has previously loaded/configured the Siemens 100 bus model file. First, the Client browses the Server's namespace and locates the TC57Physical as a node. Then, the Client expands the NameSpace presented by the Server, and the NameSpace hierarchy presented by the Server is checked to ensure it matches the hierarchy in the Siemens 100 bus model file. SISCO passed all these tests.

Table 3-9
HSDA Conformance Test Results

Test Step	SISCO
4.6.1.1 Connectivity Testing	
1. Establish connection	P
2. Client disconnect	P
3. Server terminate and disconnect	P
4.6.1.2 TC57 NameSpace Browsing	
1. Browse server root NameSpace	P
2. Change NameSpace location	P
4.6.1.3 Data Exchange	
1. Read a single data element	P
2. Read Time Stamp	P
3. Write a single data element	
4. Create and monitor a Group of data elements	P
4.6.1.4 TC57 NameSpace custom property exposure	
1. Obtain TC57 custom properties	

The third group of tests (4.6.1.3) validates the Server's capability to support data exchange with the Client. First a single data element (leaf node on the browseable hierarchy tree) is read by the Client and checked against the Server value. Then the timestamp value is checked each time the value is changed by the data generator (see section 2 description of test setup) to ensure the Client value matches the Server value. The next two tests validated that a leaf node value in the Server could be written by the Client. The last test validated the ability of the Client to create a data group in the Server and then validate that the Server sends updated values for each element in the group at the requested update interval. SISCO passed all these tests as noted above.

The fourth group of tests (4.6.1.4) validates that a Client can obtain the correct values of the custom properties of a node in the Server namespace. SISCO did not attempt this test.

The highlights of these tests are as follows:

- SISCO, the only participant for this conformance test, passed all tests concerning the HSDA interface except demonstrating the Write Interface capability or the ability to obtain TC57 NameSpace Custom Properties.

HSDA Interoperability Testing

There are four major tests involved in proving interoperability:

1. Connect an HSDA server and client
2. Exchange message data – client Read server
3. Exchange message data – client Write server
4. Disconnect the server from the client.

At least one of the data exchange tests must be completed to prove interoperability. The exchange portion of these tests are all basically the same – browse the server CIM namespace and select a measurement to read/write - except the messaging technology for each test may be different. For example, one set of tests uses DCOM and the other set of tests uses the SISCO message bus to demonstrate the MoM technology. All tests used the Siemens 100 bus, the ABB 40 bus or the EDF Small model and the measurements contained therein. The exact model used is presented in the results table below.

There were five participants for this test (ABB, EDF, Siemens PTI, Siemens, and SISCO). The results of the tests are shown in Table 3-10 below, where the numbers in parenthesis correspond to the following tests:

1. Connectivity between HSDA Client/Server
2. Exchange Message data via a Client Read operation
3. Disconnect the HSDA Client/Server pair

The highlights of these tests are as follows:

- Eight client/server pairs successfully demonstrated the capability to connect, read data, and disconnect:

Client	Server
ABB	Siemens
EDF OPC DA (Matrikon Client)	Siemens
EDF OPC DA (Matrikon Client)	SISCO OPC DA
Siemens PTI	SISCO OPC DA
Siemens PTI	ABB
Siemens PTI	EDF OPC DA (Matrikon Server)
Siemens PTI	Siemens
SISCO OPC DA	EDF OPC DA (Matrikon Server)

- Four different messaging technologies were used to complete the tests. The specific technology used for each HSDA pair tested is shown on the server side of the results table below. A full description (with block diagrams) of the technologies used is provided in Chapter 2 of this document.

Table 3-10
HSDA Interoperability Test Results

		Client			
Server w/Middelware Technology		**ABB**	**EDF OPC DA**	**Siemens PTI**	**SISCO OPC DA**
	ABB (DAIS2OPC Bridge)			P - (1,2,3) ABB 40	
	EDF OPC DA (UIB Message Bus)			P - (1,2,3) EDF_smallModel6 Ta_2005-09-02.xml	P - (1,2,3) EDF_smallModel6 Ta_2005-09-02.xml
	Siemens (DCOM)			P - (1,2,3) Siemens 100 and ABB 40	
	Siemens (OPC XML DA)	P - (1,2,3) ABB 40	P - (1,2,3) ABB 40	P - (1,2,3) Siemens 100 and ABB 40	
	SISCO OPC DA (UIB Message Bus)		P - (1,2,3) EDF_smallModel6 Ta_2005-09-02.xml	P - (1,2,3) Siemens 100	

TSDA Testing

This section shows the results of the TSDA interoperability testing. All tests used the Siemens 100 bus and the measurements contained therein. SISCO and Siemens PTI participated in these tests and used the UIB Message Bus as the middleware technology. The results of the tests are shown in Table 3-11 below.

The highlights of these tests were as follows:

- The SPTI TSDA client and the SISCO TSDA server were able to connect and the SPTI TSDA client was able to request historical data from the SISCO TSDA server
- The TSDA client and server utilized 3 of the TSDA services (ReadAtTime, GetItemHandles & GetHistorianStatus) to effect the transfer
- The TSDA client subscribed to the requested data using the full CIM pathname

Table 3-11
TSDA Test Results (4.8 Connect, Read Data and Disconnect)

Siemens PTI TSDA Client			
Test Procedure	**Connect**	**Obtain Historical Data**	**Disconnect**
SISCO TSDA Server	P	P	P

This test validated that a TSDA Client was able to subscribe to a TSDA server and correctly read the historical data using the TSDA services, which are checked off in Table 3-12. In other words, the test exercised and validated correct operation of the methods identified in the table below. The other methods shown, while part of the TSDA specification, were not exercised nor validated as part of this interoperability test.

Table 3-12
TSDA Methods Tested – SISCO TSDA Server/SPTI TSDA Client

TSDA Method	SISCO TSDA Server	SPTI TSDA Client
Requests		
IOPCHA_Server::GetHistorianStatus	P	P
IOPCHA_Server::GetItemHandles	P	P
IOPCHA_Server::GetItemAttributes		
IOPCHA_Server::GetAggregates		
IOPCHA_Server::ReleaseItemHandles		
IOPCHA_Server::ValidateItemIDs		
IOPCHA_Server::CreateBrowser		
IOPCHA_A_SyncRead::ReadAtTime	P	P
IOPCHA_A_SyncRead::ReadRaw		
IOPCHA_A_SyncRead::ReadProcessed		
IOPCHA_A_SyncRead::ReadModified		
IOPCHA_A_SyncRead::ReadAttribute		
IOPCHDA_Browser::GetEnum		
IOPCHDA_Browser::ChangeBrowserPosition		
IOPCHDA_Browser::GetItemID		
IOPCHDA_Browser::GetBranchPosition		

61968-13 Distribution Model Exchange Test

EDF prepared two sample model files based on the IEC 61968 Part 13 Distribution Model Exchange standard (the CDPSM Profile): *edf_cdpsm_aigueV2_2005.rdf* and *edf_cdpsm_simpleV3.xml*.

EDF & SISCO demonstrated a successful import of the AigueV2 model and interoperation as shown in table 3-13.

Table 3-13
Distribution Model Import, Export and Interoperation Test

Test Procedure	Basic Import	4.9.1 Basic Export	4.9.2 Basic Import - Interoperation
Test Model Used	**Edf_cdpsm_aigue V2_2005**	**Edf_cdpsm_aigue V2_2005**	**Edf_cdpsm_aigueV2_ 2005_edf_gedeon**
EDF GEDEON	P	P	
SISCO UIB Store			P (from 4.9.1)

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. For this test, a working session was held on Tuesday and Wednesday afternoon. This was initiated to provide a more formal review of issues followed by a discussion and a recommended solution if possible. The identified issues were entered into a spreadsheet and will be forwarded to the appropriate industry group or standards committee. The first page of the issues list has been reproduced in Appendix F. For a copy of the complete Spreadsheet, contact Dave Becker at EPRI.

In the future, we will create an IOP/CPSM/CDPSM issue list, which will allow us to specifically identify instance file issues, CPSM profile issues and CDPSM profile issues. This document will be maintained and referred to for future interoperability tests.

4

FUTURE INTEROPERABILITY TESTS

Good progress was made during Interop #7 on several fronts. However, additional testing is needed to validate the many resolutions reached as a result of testing and vendor consultations to reach agreement. Future interop tests should concentrate on the following areas:

- Power Flow Solutions – Have more participants and test files in order to improve CPSM and CDPSM profiles.
- Create a European profile based on the CPSM profile and validate it during the interoperability tests.
- Partial model transfers – validate resolutions on contents of partial model files.
- Incremental model updates – validate resolutions on how to do deletions and pre-condition statements
- GDA – in addition to complete power system model access, need to test more vendors for partial model access, incremental model update, event notification, and add new data access scenarios to retrieve/write other types of data as a formal part of the test. Much of this testing was begun during IOP 6 but this time no GDA tests were perform. Also need to include more vendors.
- HSDA – the HSDA testing was quite inclusive and comprehensive during this IOP. All that is needed for this area of testing is to include more participants and exercise the various communication technologies to ensure all areas are included.
- GES – test the use of publish/subscribe services provided by the GES specification.
- TSDA – include more vendors, test more services and possibly add more communication technologies.
- A more complex demonstration and interoperability tests involving multiple GID interfaces on multiple vendor products operating simultaneously should be staged. One possibility is to demonstrate a virtual data warehouse concept.
- Continue the compliance testing of the IEC 61968 XML message standards defined by IEC TC57 WG14. More participants testing additional message types are needed.
- Start true interoperability testing of the IEC 61968 XML standard messages involving pairs of participants.
- Continue the testing of distribution model exchange (IEC 61968-Part 13) begun this time by EDF and SISCO.

Hopefully, future testing will also be possible off-line using a conformance test suite (yet to be developed) with official observation, evaluation, and documentation of results.

Future interoperability tests will, of course, still include opportunities for new participants to complete the tests used for this interoperability test or previous tests.

A
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

The following software will be used by ABB. The platforms mentioned below are the ones used during the interoperability tests. The below mentioned software is also available on other platforms.

Network Manager SCADA/EMS/DMS

This is a SCADA/EMS/DMS including advanced network applications for both Energy Management System (EMS) and Distribution Management System (DMS) including full graphics GUI WS500. The server system is running on Linux and the WS500 GUI on Microsoft Windows.

Utility Data Warehouse (UDW)

UDW is an Oracle based historian running on Linux.

DE400

DE400 is an Oracle based Data Engineering environment used to configure the SCADA/EMS/DMS server with data and is running on Microsoft Windows.

PCU400

PCU400 is a process communication unit running on Microsoft Windows. The PCU400 has an OPC DA client that is used to connect with external OPC servers.

DAIS2OPC

DAIS2OPC is an OPC DA bridge to the to the SCADA/EMS/DMS server.

Areva e-Terra Platform(TM)

The interop tests were executed for e-terraplatform(TM). This is AREVA T&D Automation's solution for Energy Management Systems.

AREVA's data modeling component, called e-terramodeler(TM), is responsible for import/export of CIM compliant files.

For more information, contact a local Areva T&D representative or log onto www.areva-td.com.

EDF Tools

EDF provided a series of tools for this test.

CIM C++ Framework

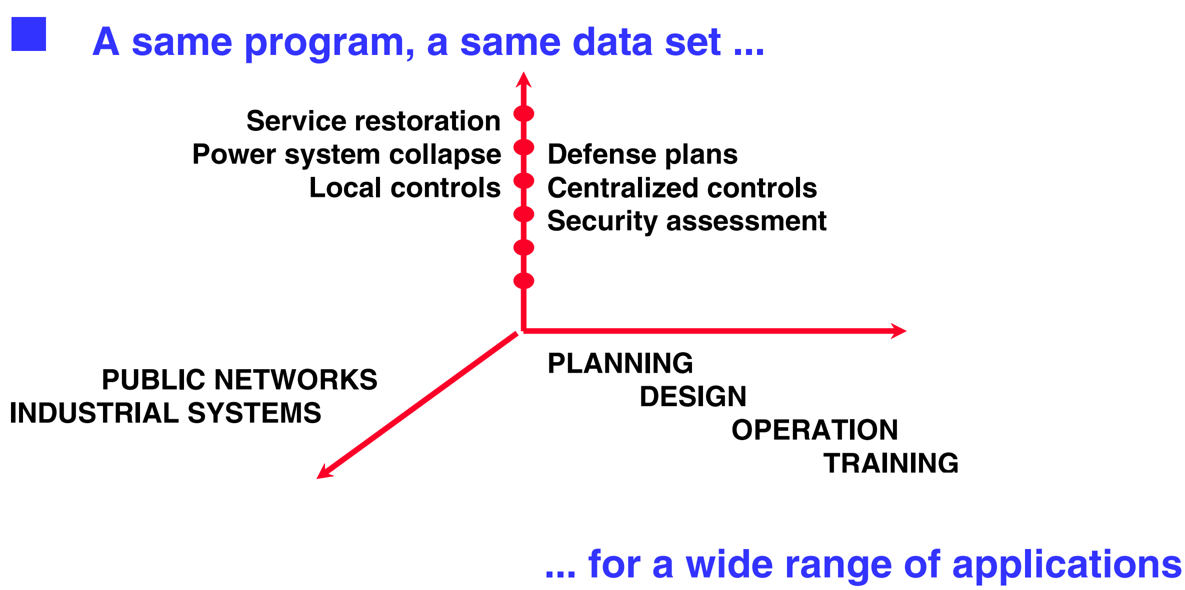
A C++ API library allows read and write of a CIM-RDF file. It is used in this test on complete model and incremental model tests.

Microturbine Simulator and Matrikon OPC Server/Client

The OPC server is based on a commercially available OPC server plus an EDF Microturbine simulator on a separate computer via a ModBus connection.

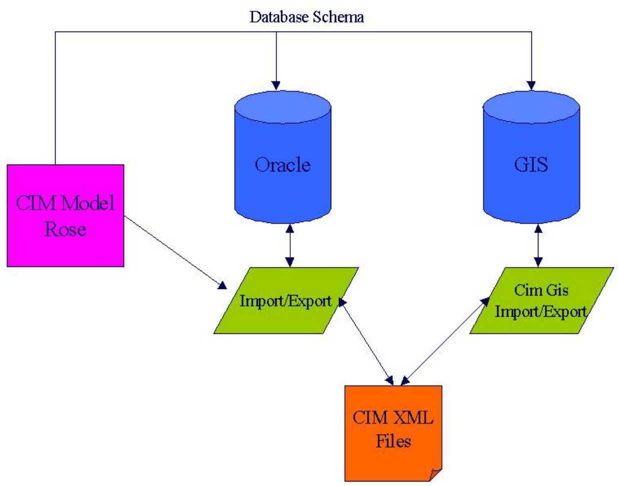
Cim Eurostag Adaptor

Eurostag is a Power system dynamic simulator for transient, mid and long term stability. The adaptor transforms proprietary Eurostag file format into CIM RDF format. It is based on CIM C++ Framework.



GEDEON

GEDEON is an EMS/DMS Database application prototype. It is built on Oracle and GIS. GEDEON uses Java, XML, XSLT techniques. For IOP7 purpose, only the Oracle part is tested for complete Transmission and Distribution model. In the future GEDEON will support CIM incremental test and interoperability could be demonstrated between GEDEON and GIS, or between GEDEON or other Electricity Network Software having a CIM compliant interface.



Siemens PTI® Operational Database Maintenance System (ODMS) and Power System Simulator for Operations (PSS/ODMS©)

The test procedures related to the CIM XML model exchange will be performed against the Siemens PTI® Operational Database Maintenance System (ODMS) and their Power System Simulator for Operations (PSS/ODMS). As configured for the interoperability tests, the ODMS Data Repository and the ODMS Viewer/Editor products will be used for CIM XML model exchange and data representation, and the PSS/ODMS© load flow application will be used to verify CIM XML load flow model transfers. Model and CIM XML construct are verified through a rich data checking provided in ODMS, while the reasonableness of the model is validated using the PSS/ODMS© application. How these two were interfaced for the interoperation tests is depicted in Figure A-1.

The ODMS is an established product that is designed to import model data from diverse EMS systems and to merge or replace these models in the ODMS client's native EMS model. An overview of the ODMS data management facilities is presented in Figure A-1.

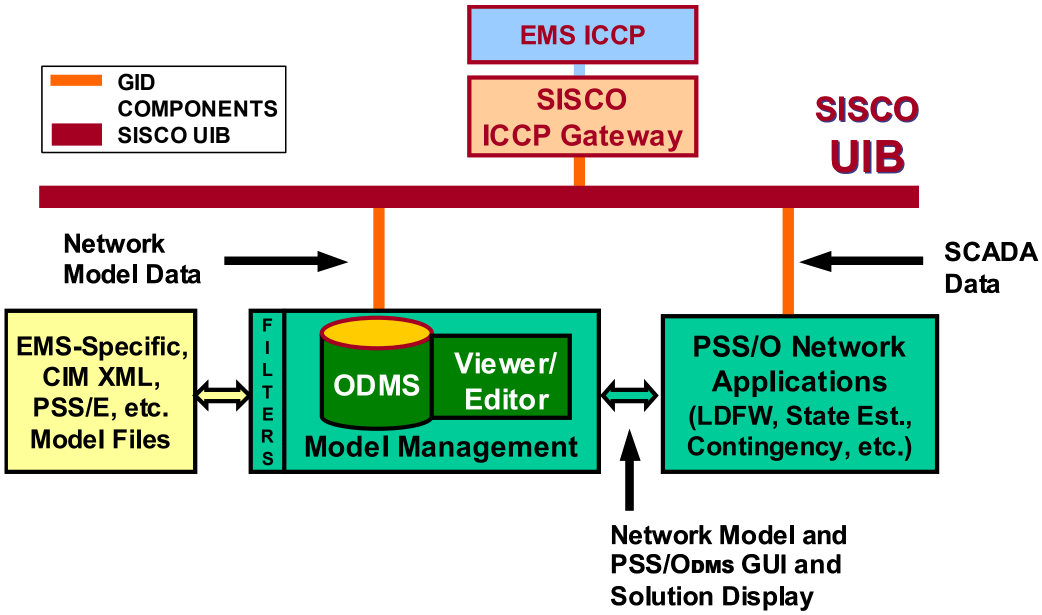


Figure A-1
Siemens PTI®'s ODMS and PSS/ODMS© Interfaced to SISCO's UIB for GID Testing

Until the CIM XML process became available, Siemens PTI® developed import "filters" that operated on vendor-specific data formats and converted the data from the various EMS systems into the CIM – which Siemens PTI® calls the ODMS Data Repository. The ODMS Data Repository is based on the CIM and is provided on an Oracle (8i+) database platform. Having translated and expressed all EMS models in the CIM, submodels can be extracted from the various sources and then merged together and otherwise manipulated in this common CIM environment. Siemens PTI® also developed export "filters" that allow the contents of the ODMS Data Repository to be exported into vendor-specific, CIM XML, PSS/E, and other formats.

The ODMS Viewer/Editor provides a full-graphics interface to the underlying ODMS Data Repository for merging model data and adding, deleting, and/or editing specific model data. The ODMS Viewer/Editor automatically generates station one-lines and worldviews based on only the data contained in the ODMS Data Repository. As changes are made to the data using the one-line diagram, a rich set of data validation constraints is applied. These validations not only guarantee that the change will maintain CIM integrity, but that reasonable power systems data entries have been made.

The ODMS has extensive data validation processes it uses during data import. For the Interoperability Tests, the ODMS was configured to perform full validation on each incoming CIM XML file to assure that the file was first CIM XML compliant, and second, that the file represented a valid CIM model. The intention of the NERC data exchange is to exchange only working network load flow models. Therefore, imports of invalid models - either due to CIM, CIM XML, or network model violations, while imported into the ODMS Data Repository, are carefully logged as to the cause of the violations. The user may elect to correct the violations using ODMS's rich editing environment, or to request another CIM XML import file.

Siemens PTI's ODMS model management and PSS/ODMS© network applications package are integrated to the Systems Integration Specialists Company's Utility Integration Bus (UIB). In the configuration used in these interoperation tests, the network model data is made available to the UIB from the ODMS model management application through a GID Generic Data Access adapter. This model is also made available to the PSS/ODMS© network applications package. PSS/ODMS© provides load flow, contingency, optimum power flow, economic dispatch, and short circuit analyses in both an on-line and study mode. Real time SCADA data is obtained from the host SCADA system via an ICCP connection using the SISCO ICCP to UIB Gateway. The results from both the study mode and on-line analyses are presented on the ODMS Viewer/Editor screens as well as in tabular results.

In the interoperation tests, the PSS/ODMS© package was used both as an additional data validation for the CIM XML files transferred in the tests, as well as verify that a reasonable load flow solution was possible based on the data.

Siemens Information Model Manager

The test procedures related to CIM XML model exchange are proposed to be performed against the Siemens Information Model Manager. The Siemens Information Model Manager (IMM) is a component of the PowerCC 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 IMM 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 IMM uses a repository driven by a schema compliant with the NERC CPSM profile of the CIM 10.

The user interface provides a hierarchical view of the instances imported or manually edited. It allows creation of 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 IMM records errors in a log for further analysis while running an import. Import translates the RDF/XML document into the internal structure of the IMM 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.

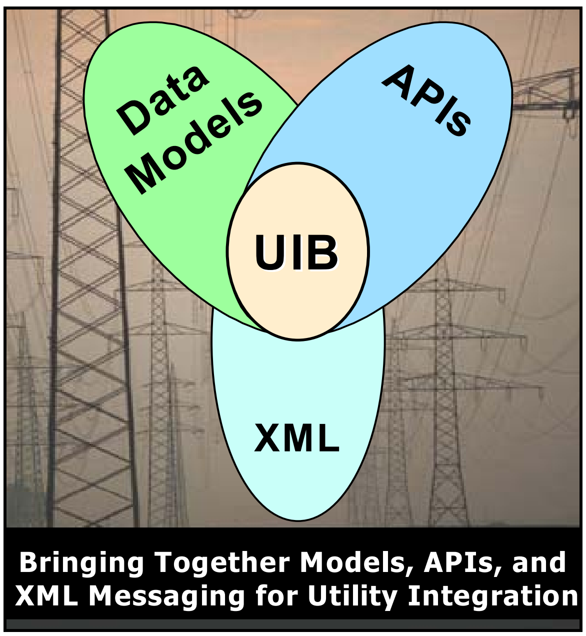
The IMM uses a Window 2000 platform. Although it can be configured for a multiple server environment, the complete systems runs on a laptop for the interoperability test.

SISCO Product Descriptions

Utility Integration Bus and UIB GDA Provider

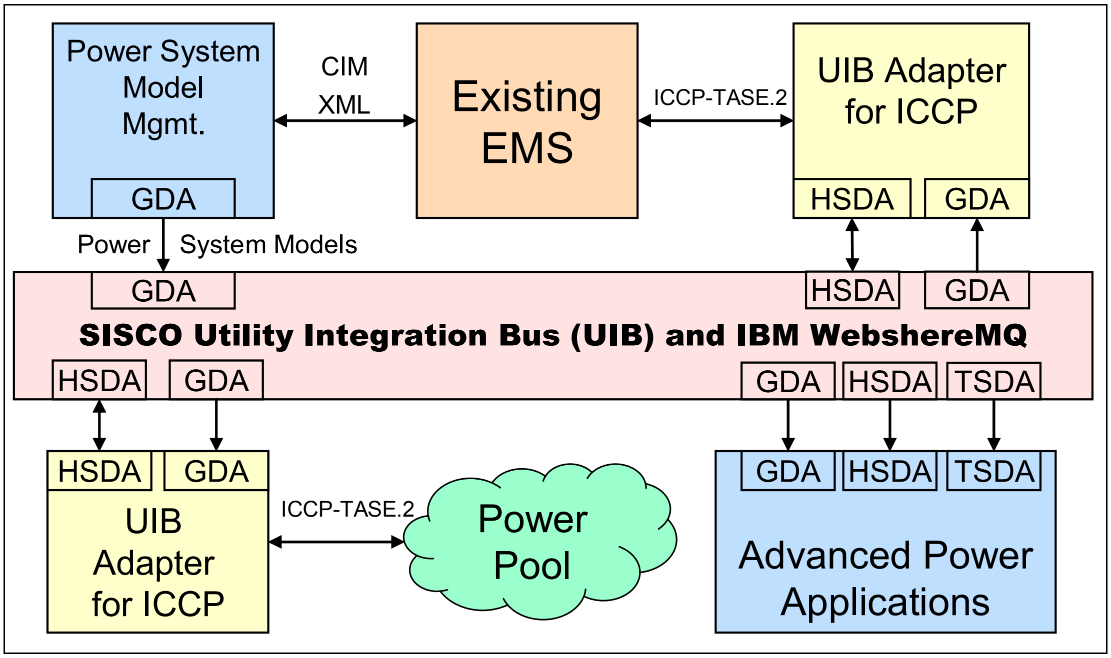
The Utility Integration Bus (UIB) is a standards-based integration platform designed to significantly reduce the engineering effort required to integrate data in the utility environment. The UIB extends off-the-shelf Enterprise Application Integration (EAI) middleware with utility specific extensions for support of distributed power system models, and standards-based application programming interfaces (API) using XML messaging. The UIB enables you to build a flexible model-driven architecture for application integration and data warehousing to leverage existing power system related application investments.

SISCO's UIB products include off-the-shelf adapters as well as toolkits for building custom adapters for your own applications. SISCO UIB adapters are currently available for the OSIsoft PI System, ICCP-TASE.2, and any communications protocol or application using an OLE for Process Control (OPC) interface. Our OEM partners have developed adapters for power system model management and advanced power applications like power flow, contingency analysis, state estimators, etc.



An Example Application

The system shown to the right is taken from an actual implementation for a southern U.S. utility. They had several proprietary applications that they needed to integrate with their existing EMS and wanted to integrate new advanced power applications with their system. Their current system was difficult for them to maintain because each revision of the EMS required them to change their own applications in order to maintain interoperability. Moreover, because the power system modeling function was buried in the EMS, they could not share the power system models with other applications. With the UIB model-driven approach and an off-the-shelf model management system, they are able to maintain the power system models outside of the EMS and share the models with other applications. When changes are made to the power system model, all applications are notified via model change messages distributed by the UIB. With all the modeling information exposed, the ICCP interfaces are able to configure all the ICCP data values automatically and to maintain their configuration over time greatly reducing the maintenance effort by the system engineers.



The UIB utilizes standards based APIs that are widely supported. This enables the adaptation of many existing off-the-shelf application products from hundreds of suppliers for use in a UIB based system. But, the UIB goes beyond simply supporting the standardized APIs. The UIB also enables these existing products to present their data to other applications on the UIB in the context of the common data exchange model, *even if they haven't been designed to support a model-driven approach*. SISCO's UIB adds object mapping and location services to these standard APIs. Object mapping wraps the existing non-model aware data source with a model aware view of the data so that UIB applications do not have to understand how other applications represent data. SISCO's UIB then adds location services to hide the details of where applications are on the bus. The result is an application integration architecture that provides all data in the context of the model that is independent of how the data source stores data or where it is located. You can then change or move data sources across the bus without affecting all the previous integration work.

API Name	Acronym	Description
Generic Data Access	**GDA**	Based on the Object Management Group (OMG) Data Access Facility (DAF) specification, GDA is used to access and modify model data in a model server and supports model change notifications. The UIB provides a GDA Provider and CIM XML Import capability to allow applications to be created using a unified model.
High Speed Data Access	**HSDA**	Based on the OMG Data Access for Industrial Systems (DAIS) and the OLE for Process Control (OPC) Data Access (DA) specifications, HSDA is used for the exchange of real-time data in the context of a unified model.
Time Series Data Access	**TSDA**	Based on the OMG Historical Data Access from Industrial Systems (HDAIS) and the OLE for Process Control (OPC) Historical Data Access (HDA) specifications, TSDA is used for the exchange of Historic data in the context of a unified model.

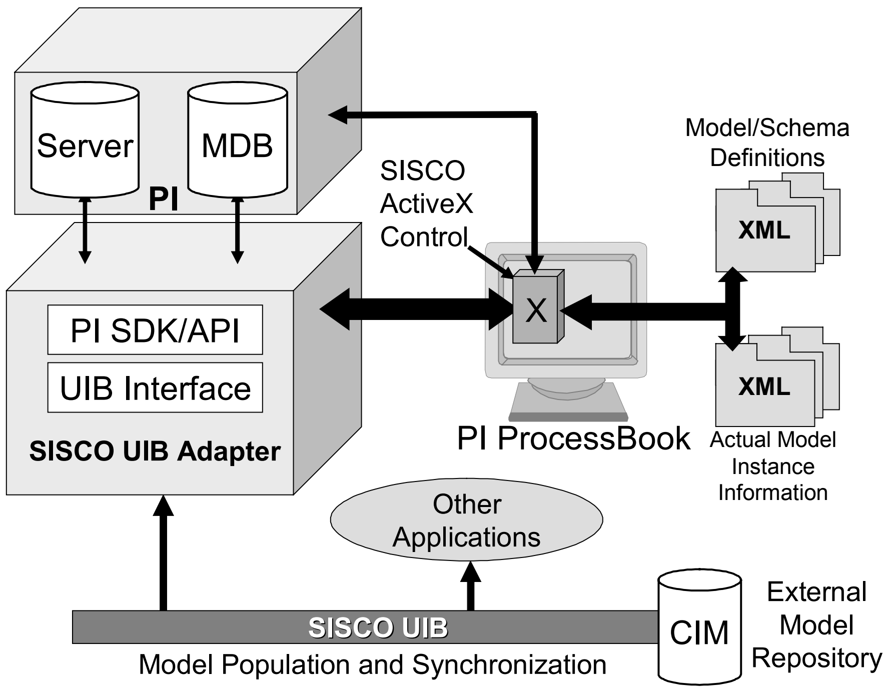
SISCO UIB Adapter for OSIsoft's PI System

SISCO's Utility Integration Bus (UIB) adapter for the PI System (PI) from OSIsoft combines the power of the OSIsoft world-leading platform for real-time performance management with the application integration and common information exchange model capabilities of SISCO's UIB. The UIB PI adapter receives modeling information, such as a network connectivity model typically maintained by a network modeling tool, EMS, DMS, or GIS system; and automatically configures the PI Module Database (PI MDB) for those points that are being historized by the PI Server. The UIB Adapter organizes the PI tags within the context of models familiar to the user such as EPRI's Common Information Model (CIM), existing models from other applications like GIS or EMS, or a user-defined power system model. Changes made to the connectivity model are delivered via the UIB to the UIB PI adapter, which automatically creates the PI MDB entries, and PI configuration needed. The UIB and PI System provide a unique cost saving solution for electric utility users that minimizes manual reconfiguration and data handling.

SISCO's UIB PI Server Adapter consists of: the adapter itself and a Process Book compatible ActiveX™ Control. The software allows for model creation and maintenance in the PI MDB either manually or automatically. Both of these mechanisms allow for standardized or customer defined models to be used.

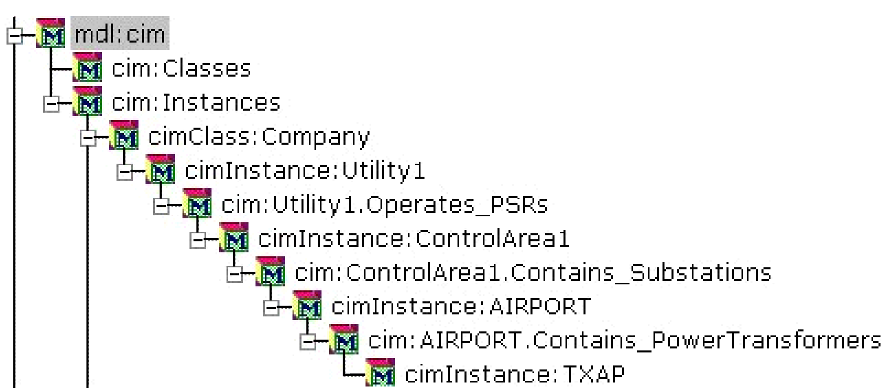
Manual model creation and maintenance is performed through the import of XML Resource Description Format (RDF) files whose format has been standardized within the IEC. The two formats that have been standardized allow for schema/model definitions and actual object instance information to be conveyed using XML RDF.

Automatic model creation and maintenance is enabled through the use of SISCO's Utility Integration Bus (UIB) and GDA. Using the UIB and GDA with the PI Server Adapter allows changes made in an external model to be automatically delivered to SISCO's PI Server Adapter and to other non-PI applications as well (e.g. network applications, GIS, EMS, and others). The model repository can contain model information relating to standard models (e.g. CIM, IEC, ISA, …), customer defined models or models residing in other applications such as GIS, EMS, ODMS, and other network modeling applications and tools. SISCO UIB Model Adapter for OPC.



The Result

Users of the PI MDB, and other PI MDB related tools, will have the ability to view the relationship between measurements and equipment. The SISCO UIB Adapter creates and maintains the various relationships specified by the model definition. As a result, it is now possible for a PI MDB user to locate a transformer (e.g. TXAP) that is contained within a substation whose name is AIRPORT without having to know the PI tag in advance.



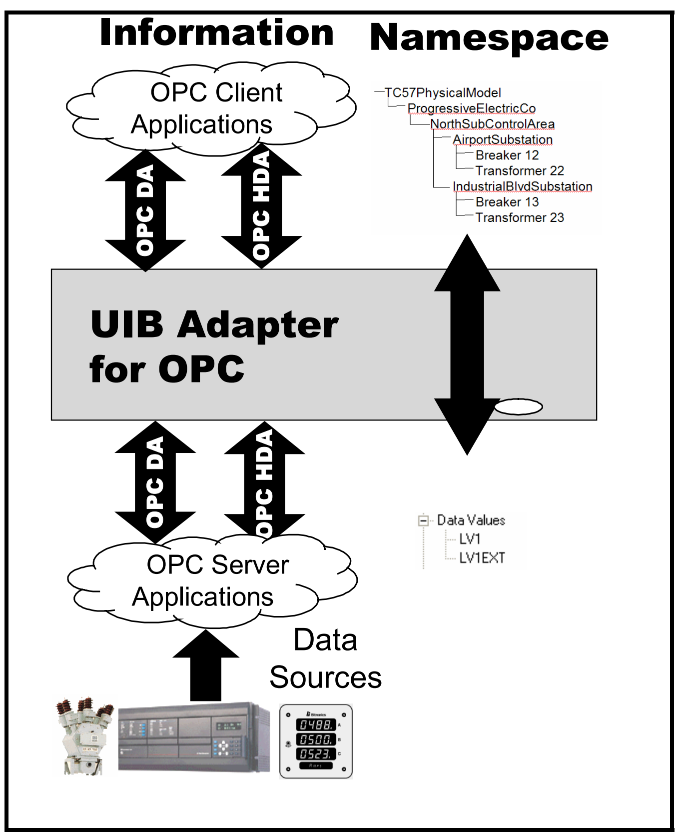
UIB Adapter(s) for OPC

Users of SISCO UIB Adapter(s) for OPC now have the capability to take data from OPC Data Acquisition (DA) and OPC Historical Data Acquisition (HDA) and present OPC Item names based upon a unified model that is based upon the IEC TC57Physical Namespace specification. The OPC Adapters allow for the non-intuitive OPC item names to be converted into a topology power system model centric set of names and to be exchange over the UIB in the common model context.

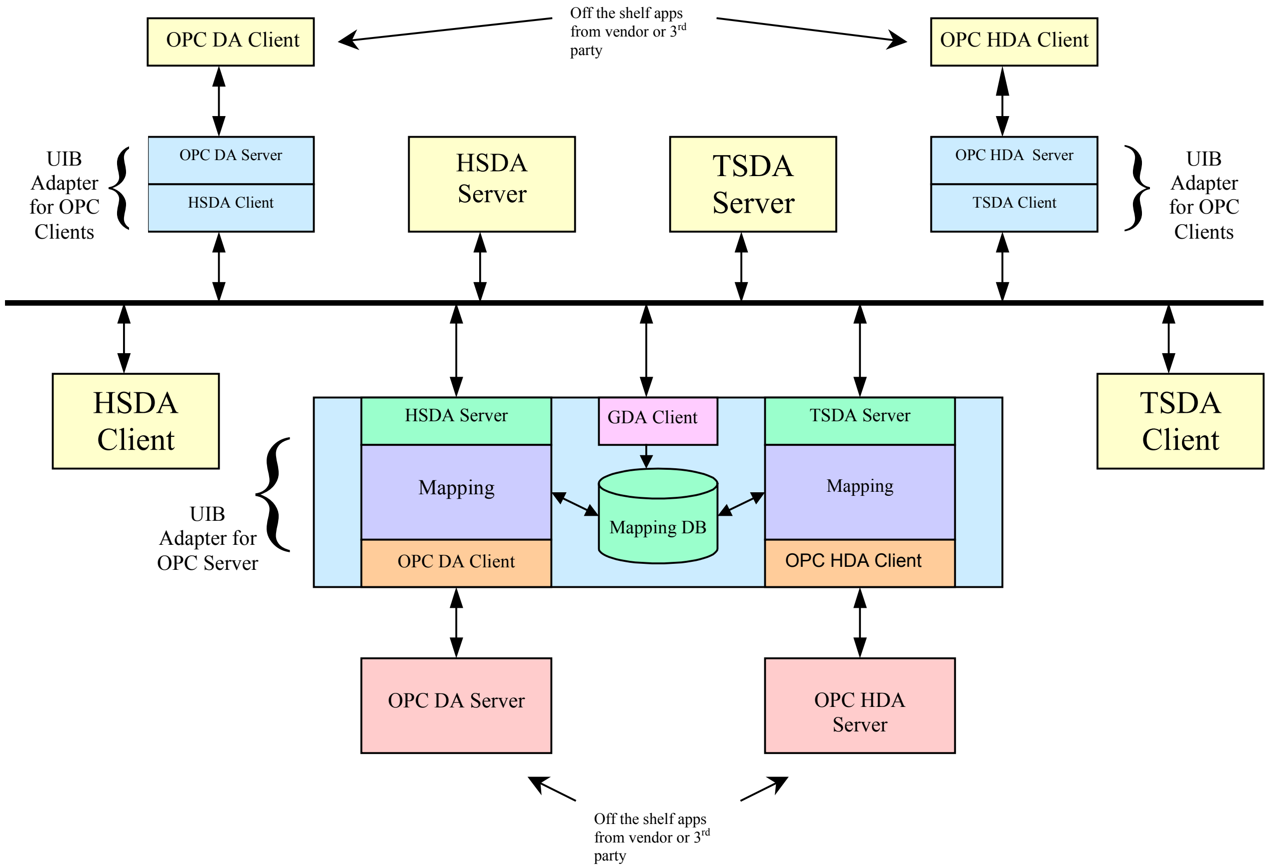
The UIB Adapter for OPC Servers is an off-the-shelf HSDA and TSDA client that uses an embedded OPC client to discover the OPC item information from OPC Servers can expose information from DNP, Modbus, IEC 61850, ICCP/TASE.2, and other sources. The Adapter then allows the user to map the non-model items into a standardized and unified namespace and the common model resourceIDs.

The UIB Adapter for OPC Clients is an off-the-shelf OPC server that uses embedded HSDA and TSDA clients to discover/browse the common model. The Adapter then allows the OPC Clients to use the standardized and unified namespace and the common model.

The UIB Adapters for OPC allow off-the-shelf OPC Clients/Servers to exchange information with HSDA and TSDA client/servers in a transparent manner while achieving the benefits of exchanging the information within the common model context.



UIB Adapter for OPC Architecture



Intended Test Scenarios

It is the intent of SISCO to make use of IOP 7 to provide an observed test environment for key GID components. Therefore, it is SISCO's intent to concentrate on those components and interoperability. Other tests will be performed as time/resources permits. The tests that SISCO considers important are labeled as Primary.

The tests to be executed are:

- UIB Adapters for OPC Conformance Testing
- UIB Adapters for OPC Interoperability Testing
- PI Adapter XML Imports
- UIB XML Imports
- PI Adapter GDA Interoperability with PTI
- PI Adapter GDA Interoperability with SISCO UIB Store

CIM XML Testing

SISCO is supplying two (2) products that can be tested for CIM XML import: UIB and PI Adapter.

	Full Import	Partial Import	Incremental Import
PI Adapter	x	x	
UIB	x	x	x

Order of Testing

- Initial files first (ABB, Areva, EDF and Siemens).
- Exported files as available.

The intent is to execute the CIM import testing in parallel with GDA and HSDA testing.

GDA GID Testing

SISCO intends to concentrate on GDA testing with PTI. GDA testing is a low priority since this was completed during IOP 6 and should be marked as such in the IOP 7 test results.

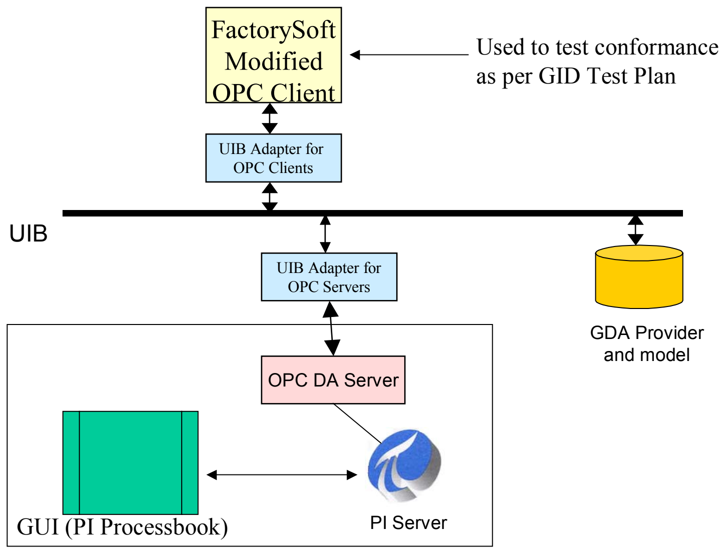
HSDA GID Testing

This involves the testing of the UIB Adapters for OPC (both client and server adapters). In order to perform this test, the common model must be provided from a GDA Provider. The selected GDA provider for this test will be the Siemens PTI GDA provider.

Conformance Testing (Primary Test)

The combination of the UIB Adapters for OPC will perform the Conformance testing as specified by the GID test plan. For the purposes of this test, the set-up will be as shown below.

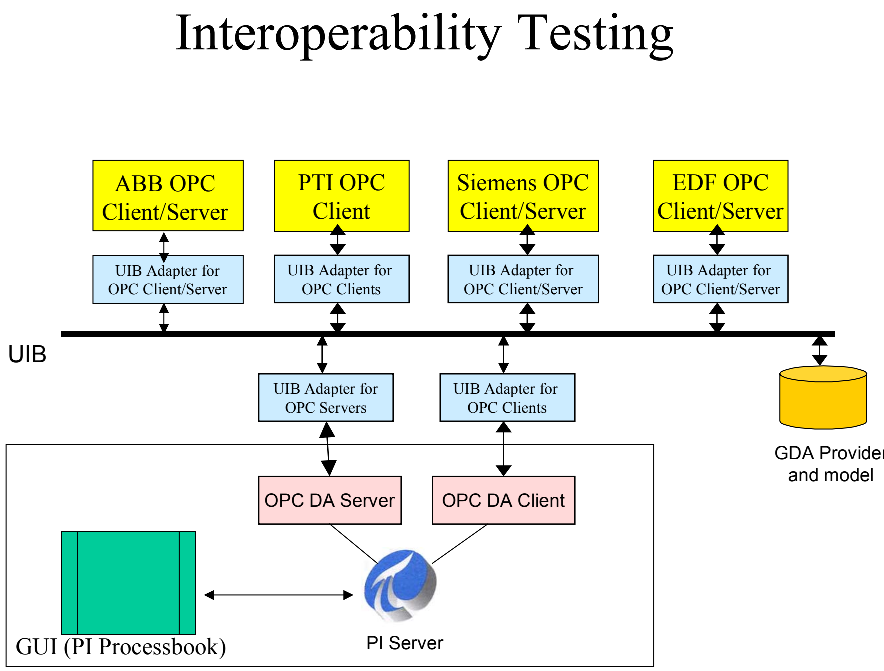
Conformance Testing



There will be two (2) PI Tags mapped through the UIB Adapter for OPC Servers (e.g. one that is Read Only and one that is read/write). A PI ProcessBook display will be created to display the actual values of the two tags. The OPC Adapters will be co-located on the same machine as the PI Software.

The GDA provider that will be used to provide the model will be a pre-loaded Siemens PTI GDA Provider that SISCO has set-up. All Adapters/store will be pre-configured prior to arrival.

Interoperability Testing (Primary)



The interoperability architecture should allow the testing of the following interoperability:

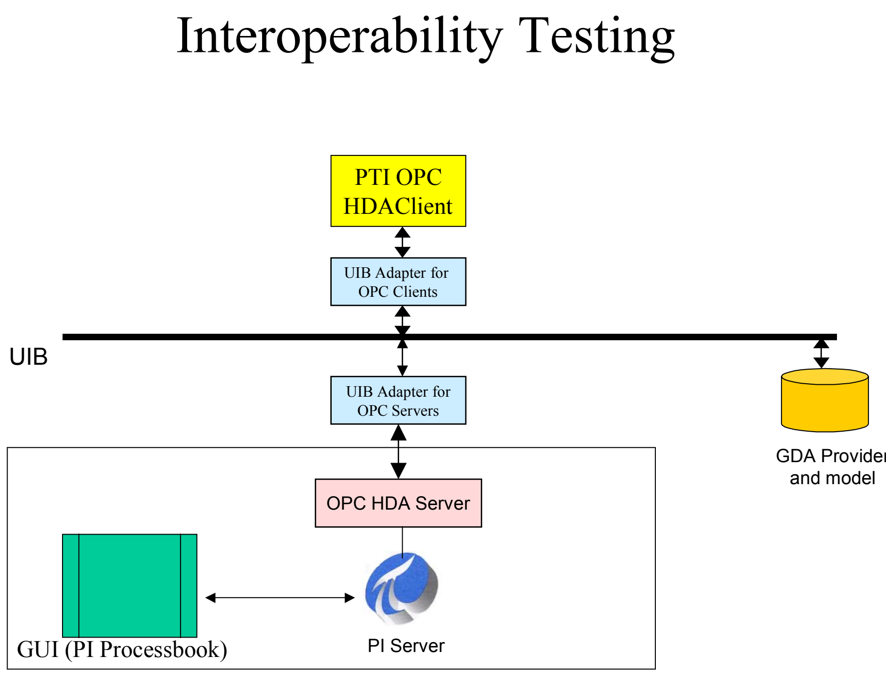
	PTI	Siemens	EDF	ABB
SISCO UIB Adapter for OPC Servers		x	x	x
SISCO UIB Adapter for OPC Clients	x	x	x	x

The GDA provider used as the common model will be the pre-configured Siemens PTI GDA provider.

TSDA GID Testing

This involves the testing of the UIB Adapters for OPC (both client and server adapters). In order to perform this test, the common model must be provided from a GDA Provider. The selected GDA provider for this test will be the Siemens PTI GDA provider.

Interoperability Testing (Primary)



The interoperability architecture should allow the testing of the following interoperability:

	Siemens PTI
SISCO UIB Adapter for OPC Servers	
SISCO UIB Adapter for OPC Clients	x

The GDA provider used as the common model will be the pre-configured PTI GDA provider.

B
TEST CONFIGURATION DATA

Test Procedures

The test procedure for this series of tests was *CIM XML Interoperability Test 7 Test Plan and Procedures*, Revision 2, September 23, 2005 contained in the following file:

- Test procedures: cim_gid interop test 7 plan r2 092305.DOC

CIM Baseline Version for Testing

The version of the CIM used for these tests was 10. Specifically, the CIM RDF Schema version of this file was used. Any file generated or imported was required to conform to this RDF Schema, although only the classes, attributes, and relations defined in the NERC CPSM profile needed to be included.

The files used for the CIM UML and RDF schema were as follows:

- CIM ROSE UML file: cim10_030501.mdl
- CIM RDF Schema file: cim10_030501.rdf

The namespace for properties and classes used in the model files was:

- http://iec.ch/TC57/2003/CIM-schema-cim10#

RDF Syntax

The RDF syntax approved for these tests is the Reduced RDF (RRDF) Syntax defined in the draft IEC 61970-552-4 CIM XML Model Exchange Format document [14]. 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 specification to be used for the RDF syntax definition at the time of this revision is Reference [14].

Test Files

Each participant was given the opportunity to post a sample model file that they produced using the Reduced RDF Syntax approved for these tests. The test file for the CIM 10 Validation, Full Model Import/Export and Solution tests is one of the following files (selected by the participant):

1. Siemens 100 Bus Model: *Siemens100_pti_2005-08-29.rdf*
2. Areva 60 Bus Model: *ESCA60_20050914rev5.xml*
3. ABB 40 Bus Model: *ABB40_20050914rev3.rdf*
4. EDF 27 Node file: *EDF27_caplim.xml (file generated from Eurostag)*
5. EDF 7 node file: *edf7_Transfo3TW_teststatstop.xml (contains 3 winding transformers and was generated from Eurostag)*
6. EDF UCTE 14 Node file: *ucte14_i3e.xml (file generated from UCTE-DEF format which is used in continental Europe by transmission system operators)*

The GID tests will use one or more of the following files:

1. Siemens 100 Bus Model: *Siemens100_pti_2005-08-29.rdf*
2. ABB 40 Bus Model: *ABB40_20050914rev5.rdf*
3. EDF Model: *EDF_smallModel6Ta_2005-09-02.xml*

The partial model transfer test will use one or more of the following files:

- Siemens100_pti_PORT_11-10-03.rdf
- Siemens100_pti_NO_PORT_11-10-03.rdf
- Siemens100_pti_NORTHSDE_6-11-04.xml
- Siemens100_pti_KINCAID_6-11-04.xml
- Siemens100_pti_NO_DEL_NO_KIN_NO_NS_6-11-04.xml
- Siemens100_pti_NO_DELANDW_6-11-04.xml
- Siemens100_pti_NO_KINCAID_6-11-04.xml
- Siemens100_pti_NO_NORTHSDE_6-11-04.xml
- Siemens100_pti_DELANDW_6-11-04.xml
- Siemens100_pti_DERBY.xml
- Siemens100_pti_GANNON.xml
- Siemens100_pti_OAK.xml
- Siemens100_pti_NO_OAK_NO_DERBY_NO_GANNON.xml
- ESCA60_nobrighton_20050913rev1.xml
- ESCA60_brighton_20050913.xml
- EDF_N33rev1.xml
- EDF_NoN33rev1.xml

The incremental model update test will use one or more of the following files:

- Difference-AddACLine.rdf
- Difference-AddLoad.rdf
- Difference-AddTransformer.rdf
- Difference-DelTransformer.rdf
- Difference-ModACLine.rdf
- Difference-ModLoad.rdf
- Difference-ModTransformer.rdf
- Difference-MovLoad.rdf
- Co_acline_add.rdf
- Co_acline_mod.rdf
- Co_brad_load_mod.rdf
- Co_load_add.rdf
- Co_load_del.rdf
- Co_load_delete_restore.rdf
- Co_load_move.rdf
- Co_pt_add.rdf
- Co_pt_add.rdf
- Siemens_inc_add.xml: Add Company A
- Siemens_inc_mod.xml: Change attribute values of ACLineSegment and swap parent connections
- Siemens_inc_del.xml: Delete 11 objects
- Siemens_inc_add_del_mod.xml: Delete, add, and modify
- Siemens_inc_add_mod2.xml: Delete, add, and modify

In addition, Siemens created the following incremental files during the test to be used by other participants:

- Siemens_inc_add_siemens.xml
- Siemens_inc_del_siemens.xml
- Siemens_inc_mod_del_siemens.xml
- Siemens_inc_modRev1.xml

EDF created the following two files to be used in the Full import test for the distribution model based on IEC 61968-13:

- Edf_cdpsm_aigueV2_2005.rdf
- Edf_cdpsm_simpleV3.xml

Tools

The tools used for the interoperability testing are:

- CIM XML Document Validator and documentation for both a GUI and command line interface is available at the cimxml egroup site and on the SourceForge web site. The latest version can be obtained from http://www.langdale.com.au/validate.
- RDF Generator (Xpetal) (to convert UML to RDF) and documentation is available at the cimxml egroup site and on the SourceForge web site. The latest version can be obtained from http://www.langdale.com.au/styler/xpetal.

C
USE CASES

This appendix contains three of the use cases describing some of the major objectives for the seventh interoperability tests:

1. Incremental Model Update
2. Partial Model Transfer
3. Power System Model Exchange with ICCP/TASE.2 Linkage

Use Case

Name: Incremental Model Update

Summary

Periodically or on demand, transfer all changes to a power system model since some point in time or since the last update.

Actor(s)

Name	Role Description
Security Coordinator (SC)/Advanced Applications Engineer at WAPA	Needs current updates from other SCs in the Western Region to run advanced apps (e.g., contingency analysis, state estimation, power flow, etc.) on boundary security coordination area. This requires any changes made to substation models in California, for instance, since the original model or any previous update was received.
SCADA Manager in California, Bonneville	Receive and approve request, then initiate export of changes to requestor.

Probable Participating Systems

System	Services or Information Provided
Security Coordination system in California (ABB) and Bonneville (ESCA)	Receive request for incremental model update, interpret, prepare model changes for transfer, and initiate the model update transfer. Also responsible for notification of updates when changes are made.
ODMS from PTI	Receive model and perform model merge with existing model, export to GE SCADA system
Loveland SCADA with advanced apps	Import merged model, run advanced apps to evaluate contingencies, calculate available capacity, ensure reliable operation, etc.

Pre-conditions

There is an existing power system model at both Loveland and California based on CIM.

Assumptions/Design Considerations

- These same systems will also be involved in partial model transfers and network snapshot use cases.
- Unique identifiers are required, as well as consistent naming between partial model received and existing models, and subsequent updates.
- Sufficient model data is needed to unequivocally identify where model has changed.
- Real time network data (e.g., status, generation, load) needed for running advanced apps (e.g., contingency analysis, power flow) will be obtained via the Network Snapshot Transfer use case or via ICCP.

Examples of partial model updates:

- Add new substation
- Replace existing transformer with a new transformer with different ratings
- Add new line or delete existing line
- Change rating or setting

State any known assumptions, limitations, constraints, or variations that may affect this use case. Consider:

- Timing requirements – no real-time. Want changes immediately if already energized. Otherwise, for a new substation, want substation model transferred approximately 2 weeks before energized, and then notification when energized. However, NERC should probably specify the timing requirements for the ISN case.
- Frequency of use – whenever there is a change.
- Sizing characteristics.

Normal Sequence

Use Case Step	Description	From - To	Information Content
Step 1	Security Coordinator makes request for incremental update. This becomes a standing request (or persistent query) for any updates	(from) SC (to) Calif. System SC	Qualifiers for that portion of network of interest
Step 2	California system accepts input parameters, prepare incremental update, prepare XML document, and export to WAPA ODMS.	(from) Calif. SC system (to) ODMS	CIM/XML model file containing incremental model updates. Need sufficient info to uniquely identify where updates fit in overall model.
Step 3	Verify scope and merge. After merging, ODMS exports updated network model to WAPA SCADA system	(from) ODMS (to) WAPA SCADA system	Complete merged model file
Step 4	Test update in offline EMS.	SCADA system	
Step 5	Notify the update is now in service	(from) Calif. SC system (to) WAPA SCADA system	Update notification, timestamp, time of activation, reference to specific update file
Step 6	Apply the update to online system	SDADA system	

Exceptions/Alternate Sequences

Describe any alternative actions that may be required that deviate from the normal course of activities. Should the alternate sequence require detailed descriptions, consider creating a new Use Case.

Since updates are supplied in advance of commissioning, several may be outstanding at one time. Furthermore, updates could be issued in one order and notified in another, i.e., for two updates X and Y, the steps could be: issue X; issue Y; notify Y in service; notify X in service.

Post-conditions

Complete and error-free transfer. A model merge is required before model will used. Any unnecessary (e.g., duplicate data or data outside scope of merged model) model data received will be discarded.

Integration Scenario

Insert Visio diagram showing interactions between systems/business function/databases with each interaction labeled with use case step and short descriptive title.

References

Use Cases referenced by this use case, or other documentation that clarifies the requirements or activities described.

- Incremental Model Update Use Case
- Network Snapshot Use Case

Issues

ID	Description	Status
1.		

Revision History

No	Date	Author	Description
0.	3/18/2002	T. Saxton	Initial version

Use Case Diagram

Use Case

Name: Partial Model Transfer

Summary

Transfer a portion of a power system model network using "where is" type reasoning to define the portion of the network of interest (for example, all substation equipment with VoltageLevel greater than or equal to 200KV). Assumption is that this is for coordination between NERC Security Coordinators. Complete models are not needed.

Actor(s)

Name	Role description
Security Coordinator (SC)/Advanced Applications Engineer at WAPA	Needs data from other SCs in the Western Region to run advanced apps (e.g., contingency analysis, state estimation, power flow, etc.) on boundary security coordination area. This requires substation model data from California. Need partial model transfer, merge models, and then get real time data from Calif. for those substations. Need sufficient data to permit model merge.
SCADA Manager in California, Bonneville	Receive request, input data to SCADA EMS system.

Probable Participating Systems

System	Services or information provided
Security Coordination system in California (ABB) and Bonneville (ESCA)	Receive manual request for partial model transfer, interpret, prepare partial model for transfer, and initiate the model transfer. Also responsible for notification of updates when changes are made.
ODMS from PTI	Receive model and perform model merge with existing model, export to GE SCADA system
Loveland SCADA EMS with advanced apps	Import merged model, run advanced apps to evaluate contingencies, calculate available capacity, ensure reliable operation, etc.

Pre-conditions

There is an existing power system model at both Loveland and California based on CIM.

Assumptions/Design Considerations

- These same systems will also be involved in incremental model update and network snapshot use cases.
- Unique identifiers are required, as well as consistent naming between partial model received and existing models, and subsequent updates.

- Sufficient model data is needed to permit a model merge. For example, if we decide to go for partial model exchange based on voltage level, then it may be best to do that on area basis. For example - give all the equipments of SDGE where the voltage is above 230KV. We need to specify whether we want to represent the network components below the cut voltage by an equivalent component (may be by an injection) or simply don't include them in the partial model.
- Real time network data (e.g., status, generation, load) needed for running advanced apps (e.g., contingency analysis, power flow) will be obtained via the Network Snapshot Transfer use case or via ICCP.

Examples of partial model updates:

- Voltage cut plane (i.e., all equipment in substations including step down/up transformer and above a set voltage, such as 345 KV)
- Enumerated substation list (i.e., all equipment in substation including connecting lines with identification of destination substation for each line)
- Geographic cut plane (i.e., all power system model North of Path 15).

State any known assumptions, limitations, constraints, or variations that may affect this use case. Consider:

- Timing requirements – no real-time. Want changes immediately if already energized. Otherwise, for a new substation, want substation model transferred approximately 2 weeks before energized, and then notification when energized. However, NERC should probably specify the timing requirements for the ISN case.
- Frequency of use – Once initially, then whenever there is a change.
- Sizing characteristics, etc. – Initial large (thousand buses at 345kv for all California), to single substations when adding a new one.
- Some requests for partial models may not be supported by the system receiving the request. For example, a request for a geographic cut plane cannot be supported by CAISO, since they do not maintain geographic information with the network model. Therefore it seems likely that the request would have to be done manually between the Security Coordinator (SC)/Advanced Applications Engineer making the request and the SCADA Manager receiving the request. The standard for partial model transfer would apply only to the sending of the partial model, not the request.

Normal Sequence

Use Case Step	Description	From - To	Information Content
Step 1	Security Coordinator makes request for partial model transfer. Initially will be done off-line. This becomes a standing request (or persistent query) for any updates to that portion of the model that has changed.	(from) SC (to) Calif. System SC	Qualifiers for that portion of network requested
Step 2	California system accepts input parameters, prepare partial model, prepare XML document, and export to WAPA ODMS.	(from) Calif. SC system (to) ODMS	Complete CIM/XML model file for requested portion of network model. Need sufficient info to uniquely identify where partial model fits in overall model. For substation list, want connecting lines and identification of connected substation. Also need ICCP Conf data for all measured points.
Step 3	After merging models, ODMS exports updated network model to WAPA SCADA EMS system	(from) ODMS (to) WAPA SCADA EMS system	Complete merged model file
Step 4	Populate EMS database tables and generate the updated database. Run application in test environment off-line. If the results are ok, the transfer the new database into the production system	EMS system	
Step 4	California system initiate transfer of any changes to the partial models previously asked. This would be done with Incremental Model Update use case on partial model.		All changes to the partial model previously defined.
Step N	Step N details		

Exceptions/Alternate Sequences

Describe any alternative actions that may be required that deviate from the normal course of activities. Should the alternate sequence require detailed descriptions, consider creating a new Use Case.

An alternate approach would automate the request as well as reply, but this would require a protocol to identify the request. One approach would be to use DAF concepts to serialize partial model queries. An XML version of DAF that uses CIM XML as its payload could minimize the amount of development effort.

Given growing acceptance of web services and SOAP, it might also make sense to see how this technology could be leveraged.

Post-conditions

Complete and error-free transfer. A model merge is required before model will be used. Any unnecessary (e.g., duplicate data or data outside scope of merged model) model data received will be discarded.

Integration Scenario

Insert Visio diagram showing interactions between systems/business function/databases with each interaction labeled with use case step and short descriptive title.

References

Use Cases referenced by this use case, or other documentation that clarifies the requirements or activities described.

- Incremental Model Update Use Case
- Network Snapshot Use Case

Issues

ID	Description	Status
2.		

Revision History

No	Date	Author	Description
0.	2/27/2002	T. Saxton/D. Ambrose	Initial version
1	3/18/2002	T. Saxton	Incorporated suggestions by Enamul, John, Arnold

Use Case Diagram

Use Case

Name: Power System Model Exchange with ICCP/TASE.2 Linkage

Summary

Exchange of power system models with linkage to ICCPTASE.2 measurements.

Actor(s)

Name	Role Description
EMS A Data Engineer	Maintains EMS A power system model. Adds ICCPTASE.2 linkage data to power system model
EMS B Data Engineer	Maintains EMS B power system model. Makes mapping between ICCPTASE.2 Object ID in received model and measurements received via ICCPTASE.2 link

Probable Participating Systems

System	Services or Information Provided
EMS A	Converts an internal representation of a power system model to CIM XML format and sends to EMS B. Also sends real-time ICCPTASE.2 SCADA points via an ICCPTASE.2 link to EMS B.
EMS B	Receives power system model from EMS A as a CIM XML formatted file and converts to internal model representation of EMS B. Also receives real-time measurement data from EMS A via an ICCPTASE.2 link.

Pre-conditions

1. A unique local SCADA Reference ID has been locally assigned to each measurement value by EMS A data engineer to be included in the power system model transferred from EMS A to EMS B.
2. An ICCPTASE.2 link is already established and an ICCPTASE.2 Object ID has been assigned to at least some of the measurement values available for transfer to intended receiver.
3. A CIM-compatible representation of the power system model at both EMS A and B exists.
4. A bilateral table is already established for SCADA points available at EMS A for EMS B to receive.

Assumptions/Design Considerations

[State any known assumptions, limitations, constraints, or variations that may affect this use case. Consider:

- *Timing requirements*
- *Frequency of use*
- *Sizing characteristics, etc.]*

Normal Sequence

Use Case Step	Description
Step 1	EMS A data engineer adds ICCPTASE.2 Object ID to each measurement value in the power system model that is available for transfer to EMS B. The ICCPTASE.2 Object ID must be exactly the same as the ICCPTASE.2 Object ID that is used with the real-time data transfers via ICCPTASE.2 link. In CIM MeasurementValue class: a. store SCADA ID in MeasurementValue.name attribute b. store ICCPTASE.2 Object ID in MeasurementValue.aliasName attribute. In CIM MeasurementValueSource class: a. store “ICCPCC Link” in MeasurementValueSource.name to indicate data is supplied by an ICCPTASE.2 link b. store “EMS A” in MeasurementValueSource.pathName to give specific instance of control center providing the ICCPTASE.2 data
Step 2	EMS A converts power system model to CIM XML format and transfers file to EMS B.
Step 3	EMS B receives EMS A power system model in CIM XML format and converts to internal model format.
Step 4	EMS B Data Engineer merges the power system model from EMS A into the EMS B power system model. This requires configuring EMS B software to correlate each measurement value in the EMS A power system model and the real-time SCADA points received via the ICCPTASE.2 link. Recommendation: Using the CIM SCADA package, the MeasurementValue and MeasurementValueSource instances received from EMS A should be stored at EMS B as remote measurements. This should be done by modeling the EMS A control center as a RemoteUnit and all the MeasurementValues as RemotePoints. This requires the following mapping: a. MeasurementValueSource.name to RemoteUnit.name b. MeasurementValueSource.pathName to RemoteUnit.pathName c. MeasurementValue.name to RemotePoint.name d. MeasurementValue.aliasName to RemotePoint.aliasName

Exceptions/Alternate Sequences

1. An ICCPTASE.2 SCADA point is available via ICCPTASE.2 link and there is no corresponding measurement value in the CIM power system model. This will require manual intervention to update the power system model ICCPTASE.2 linkage data for that point and perhaps a resend of the model (or an incremental update if available).
2. The converse: There is a measurement value in the CIM model with an ICCPTASE.2 source and ICCPTASE.2 Object ID, but there is no real-time data received from the EMS A over the ICCPTASE.2 link for that point. This is not necessarily a problem. It is up to the EMS B, as an ICCPTASE.2 client, to request all ICCPTASE.2 SCADA points available to it from EMS A. It may require a revision to the bilateral table as well.

Post-conditions

A mapping is established at EMS B between each ICCPTASE.2 Object ID received and a measurement value in its power system model. This is needed, for example, to run power flow and state estimator applications and for displaying real-time measurement data on one-line displays.

Note that it is possible to have a complete round-trip transfer of the model from EMS A through EMS B and then back to EMS A with the RemoteUnit and RemotePoint model information added at EMS B so that EMS A can verify completeness/correctness of the transfer.

References

Issues

ID	Description	Status
1.		

Revision History

No	Date	Author	Description
0.	6/6/2001	T. Saxton	Initial
1	7/16/01	T. Saxton	Added SCADA reference ID as well as ICCPTASE.2 Object ID as part of power system model transfer, and also added specific recommended use of CIM to transfer this information
2	7/24/01	T. Saxton	Changed attributes in MeasurementValueSource used to indicate ICCPTASE.2 data and name of control center supplying ICCPTASE.2 data, changed “ICCPTASE.2 ID” to “ICCPTASE.2 Object ID” to match NERC’s terminology, clarified text in Step 4, minor editing improvements
3	4/5/02	T. Saxton	Changed “ICCP” to “TASE.2”. Changed MeasurementValueSource from “ICCP” to “CC Link” to be inclusive of other CC protocols that may be used for other applications of this use case.

Use Case Diagram

D
INCREMENTAL MODEL UPDATE EXAMPLES

This appendix contains examples of the types of incremental model updates that frequently occur in transmission power system models. Exchanging entire power system models to communicate these changes is not feasible. Transferring them as incremental changes in a difference file was the subject of one set of tests.

These examples were provided complements of Enamul Haq, CAISO.

Changes Related to Lines

Difference in Line Impedance

Line Name	:	KESWICK_OBANION			
From Substation	:	KESWICK	From KV	:	230
To Substation	:	OBANION	To KV	:	230

Old Values	**New Values**
Rpu = 0.0282	Rpu = 0.0646
Xpu = 0.1972	Xpu = 0.5961
Bpu = 0.4062	Bpu = 0.4066

Difference in Line Ratings

Line Name	:	PITSBURG_SANMATEO			
From Substation	:	PITSBURG	From KV	:	230
To Substation	:	SANMATEO	To KV	:	230

Old MVA Ratings	**New MVA Ratings**
1st Rating = 295.6	1st Rating = 398
2nd Rating = 388.6	2nd Rating = 463
3rd Rating = 398.4	3rd Rating = 488
	4th Rating = 518

Difference in Line Status

//This line was in service in the previous update

//This line is out of service in the new update

Line Name	:	EL PECO_BIOLA			
From Substation	:	EL PECO	From KV	:	70
To Substation	:	BIOLA	To KV	:	70

Old Status	**New Status**
In Service	Out of Service

//This line was out of service in the previous update

//This line is in service in the new update

Line Name	:	DRHM JCB_ESQUON			
From Substation	:	DRHM JCB	From KV	:	60
To Substation	:	ESQUON	To KV	:	60

Old Status	**New Status**
Out of Service	In Service

Addition of a new Line

A new line has been added between Substation “AAAA” and Substation “BBBB”.

Increased the # of Series Capacitor Sections from 2 to 3 of the Line “AAA_BBB” at a Substation

Added a new section of series capacitor section with line “AAA_BBB” at the substation “AAA”.

Changes Related to Transformers

Difference in Transformer Impedance

Transformer Name: GOLDHILL 115/230KV

	Old Value	New Value
Rpu	0.0021	0.0024
Xpu	0.0584	0.064
Bmag	-0.006	-0.0028

Difference in Transformer Ratings

Transformer Name: TESLA 500/230 KV

	Old MVA Ratings	New MVA Ratings
1st Rating	940	981
2nd Rating	1073	1092

Missing Transformer

Transformer DIAB 25/500 KV is no longer in service.

Addition of a New Transformer

Added a new 2-winding transformer at Substation AAA

Added a new 3-winding transformer at Substation BBB

Transformer Regulating Schedule has Changed

The regulating schedule of transformer “TTTT” at Substation “HHHH” has been changed.

Changes Related to Loads (Energy Consumer)

Load value has Changed

Load value has changed from the previous update.

Location of the Load has Changed

The location of the load “AAAA” at Substation “CCCC” has changed from 230KV bus to 69KV bus.

Load has been Removed

The load “DDDD” from substation “TTTT” has been removed.

A new Load has been Added

The load “PPPP” is added at 69KV bus at Substation “RRRR”

Change in Load Status

The nonconforming load “LLLL5” at Substation “YYYY”:

Old status – Out of Service New Status – In Service

The nonconforming load “LLLL6” at Substation “YYYY”:

Old status – In Service New Status – Out of Service

Changes Related to Generators

Addition of a new Generator

A new generator “GGG1” is added at Substation “SSSS”

Removal of a Generator

The generator “GGG2” from Substation “SSSS” has been removed.

Changes in Generator Status

The generator “GGG5” at Substation “YYYY”:

Old status – Out of Service New Status – In Service

The generator “GGG6” at Substation “YYYY”:

Old status – In Service New Status – Out of Service

Changes Related to Reactive Devices

Added New Reactive Devices

Added a new capacitor bank at Substation “LLLL”

Added a new reactor bank at Substation “LLLL”

Changes in status of Reactive Devices

The Status of the Reactive Device “RRRR1” at Substation “HHHH”

Old Status – In Service New Status – Out of Service

The Status of the Reactive Device “RRRR2” at Substation “HHHH”

Old Status – Out of Service New Status – In Service

Other Examples

1. A new capacitor bank was added to a previously unused transformer tertiary.
2. A new substation was built near the middle of an existing transmission line.
3. A large industrial company purchased all (or part) of a substation from a transmission provider and renamed it.
4. A load (or generator) was previously modeled as an aggregate and was split up into component parts to more accurately model the physical situation.
5. A bus was sectionalized and a new bus name was created. Existing equipment was divided between the two buses.
6. A second (or third) parallel conductor was added with the same from and to buses of an existing line.

Types of Changes

The changes can be categorized as follows:

1. Changes in topology of the network model (addition/deletion/reconfiguration of the physical devices).
2. Changes in values (ratings, parameters etc).
3. Status changes (in service/out of service).

Note:

1. WECC model does not contain any information on station switches and as such no change information is mentioned in the examples. When utilities will exchange detailed station models, there will be changes in CBs, Switches and Bus Bars.

E
GID FUNDAMENTALS

The GID (Generic Interface Definition) provides a set of APIs to be used by software applications for accessing data and for exchanging information with other applications. It builds on existing industry interface standards in common use to provide additional functionality and tailoring to meet the needs of applications dealing with utility operations. Because these APIs are application-independent, they are considered to be generic and common across applications (hence the name GID). By using the GID, the system integrator or software developer is able to create a variety of software components but avoid having to develop software conforming to multiple and potentially conflicting programming models.

The GID development was sponsored by the EPRI CCAPI project. The EPRI GID defines interfaces in the following categories:

- Generic Data Access (GDA): This interface provides a Request/Reply capability which allows data access (read/write) with change notification and browsing (i.e., navigation) based on the CIM without knowledge of logical schema. This interface is based on the OMG Data Access Facility (DAF).
- High Speed Data Access (HSDA): This interface provides both a Request/Reply and Publish/Subscribe capability designed primarily for high volume, efficient, periodic SCADA data transfers. This interface is based on the OPC Foundation Data Access specification.
- Generic Eventing and Subscription (GES): This interface provides a Publish/Subscribe capability which allows a message to be published once with multiple subscribers receiving the message based on topic (i.e., content) filtering. This interface is based upon the OPC Foundation Simple Eventing.
- Time Series Data Access (TSDA): This interface provides both a Request/Reply and Publish/Subscribe capability designed primarily for exchanging time series values. The intended use is for retrieval of historical/archival data.

The GID is being progressed as a part of the IEC 61970 series of standards (see References [10-12]). In addition to Parts 403, 404, 405, and 407 which apply to the four sets of services above, respectively, Part 401 provides an overview and roadmap to the GID and Part 402 defines a set of common services used by all interfaces, including a naming service for browsing GID server databases.

Compliance with the GID standard requires implementation of the Common Services, Part 402 plus one or more APIs (Parts 403, 404, 405, or 407), although which parts are used for any particular component is a design choice.

Additionally, there are constraints placed upon the GID standards when used in conjunction with the CIM model. These constraints can best be summarized as a definition of a standardized namespace hierarchy as described in Reference [10]. Therefore, compliance to the standardized interfaces and namespace definitions were both required in order to claim conformance for these tests.

F
IDENTIFIED ISSUES

The spreadsheet below contains the results of the afternoon work sessions. In addition to the identification of issues, we have provided possible resolutions for review and discussion by the appropriate industry or standards groups. To obtain a full copy of the Issues Excel spreadsheet, contact Dave Becker at EPRI.

Issue No.	Source	Date	Clause/ Subclause/Paragraph /Figure/Table	Comments	Proposed Change	Decision	Person Assigned	Due Date	Status
141	Interop. Test #5	11/18/2003	Partial Model Transfers	An issue arises with associations that have a many:many multiplicity regarding how to handle deletions or additions. For example, a single MVARCapabilityCurve class can apply to synchronous machines in multiple substations. So when a substation is added	It was resolved that for these tests at least, it is the responsibility of the sending application to include all needed curves with the partial model file, and leave it to the application performing the merge to recognize and eliminate redundancy.	6/22/2004: Issue for Part 503. No change.2/1/2005 W G13: Need new approach that Kurt will articulate regarding how references are handled in general for partial model exchange	Kurt/Hans	2/1/2005	Resolve in Part 503 - Kurt to provide text to Hans - IOP 7 comment: since 503 has moved to 552-4, will this be documented in the new standard?
147	Jan. '04 Meeting	1/13/2004	CIM	SI units need to be addressed.	The IOP group would like to have this ready and release from WG-13 by the Summer of 2006 and be able to test this in the Fall of 2006.	CIM2 issue			
IOP7-1	Fei W u	9/16/2005	Areva 60 bus Model	the EquivalentLoad (LD-160KV-345ST-Holdendv-ECARCO-ECAR) is connected to the Terminal (TERM-LD53). This terminal is connected to a ConnectivityNode (ND-160KV-345ST-Holdendv-ECARCO-ECAR) which has no other terminal. This means the Equivalent Load is isola	Correct the model		S. Vargas		Model Corrected -Need to validate correction

Issue No.	Source	Date	Clause/ Subclause/Paragraph /Figure/Table	Comments	Proposed Change	Decision	Person Assigned	Due Date	Status
IOP7-2	Enamul Haq	9/14/2005	05 Areva 60 bus Model	No Measurement and RegulationSchedule association exists for the VoltageControl transformer	Correct the model	Model Corrected -Need to validate correction	S. Vargas		Resolved -need follow-up
IOP7-3	Enamul Haq	9/15/2005	Areva 60 bus Model	Should ZBR be part of PowerFlow. Some uses (Utilities) want this and others may not - need clarification.	Correct the model	Model Corrected - Need to validate correction	S. Vargas		Resolved -need follow-up
IOP7-4	M. Goodrich	9/16/2005	Part 552-4	How should the Precondition area in an Incremental file be used.	Preconditions contains values, associations, etc. that should be in the current model. If these values are not in the current model, the change should be rejected.	Would like the standard (61970-552-4) updated to include the proposed change.			Submit proposed change to WG13
IOP7-5	M. Goodrich	9/16/2005	All Models	What should containment hierarchy be - this was on the IEC WG13 list but I didn't see it here - so, I added it. Containment Hierarchy Resolution - this is already under discussion in WG13 - report on status from WG13 members is requested.	Deferred to WG13 for resolution.				Open - Deferred to WG13

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