Report on Interoperability Test #5 of the Generic Interface Definition (GID) Standards and the Common Information Model (CIM) Extensible Markup Language (XML)

Technical Report

Testing of 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 Generic Interface Definition (GID) to Exchange Power System Data

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Final Report, March 2004

EPRI Project Manager
D. Becker

EPRI • 3412 Hillview Avenue, Palo Alto, California 94304 • PO Box 10412, Palo Alto, California 94303 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com

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Xtensible Solutions, Inc.
18125 23rd Avenue North
Plymouth, MN 55447

Principal Investigator
T. Saxton

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REPORT SUMMARY

EPRI's 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 within and between control centers and other systems involved in utility operations. Previous interoperability tests validated the use and acceptance of the CIM standard as translated into Extensible Markup Language (XML). This report describes a fifth set of interoperability tests, which extended this validation by testing new GID standards. Both the Generic Data Access (GDA) and High Speed Data Access (HSDA) draft standards were tested in a controlled environment to validate vendor products that have implemented these interfaces and improve the draft standards before finalization. New participants performed portions of the previous interoperability tests, demonstrating exchange of complete power system models, partial model transfers, and incremental model updates using CIM XML standards.

Background

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

Objective

To report results of the fifth set of CCAPI interoperability tests, performed in Cleveland, Ohio, November 18-20, 2003.

Approach

The project team prepared a formal set of procedures to test the ability of vendor products to conform to the CCAPI-based standards based on the CIM and GID. After a period of preparation and preliminary testing, four vendors (Alstom, Shaw PTI, SISCO, and SNC Lavalin) gathered in Cleveland to have an impartial observer test their products.

Results

The report summarizes the test process and results, organized as follows:

- GID HSDA test – Conformance testing of HSDA servers included 1) connectivity testing, 2) TC57 namespace browsing, 3) data exchange (both single values and groups of values) as well as writing back a data value, and 4) retrieving power system attributes as CIM object attributes.
- Basic import/export of model files – This testing of a product's ability to correctly import and export power system model files based on CIM XML standards 1) validates the correct operation of each participant's system, 2) continues to validate the CIM, and 3) identifies new issues affecting interoperability.
- Interoperability test and transfer of Inter-Control Center Communication Protocol (ICCP) configuration data – This testing evaluates the ability of one vendor's product to correctly import a sample model file previously exported by another vendor's product using CIM XML standards.
- Power flow solution test – This test verifies correct content of model files and exchange and transformation of power system model files, including generation and load through execution of power flow applications.
- Incremental model update – This test confirms correct update of the base Siemens 100 bus model with incremental updates using the XML difference file format.
- Partial model transfer – This test verifies correct import and merge of a new partial model with an existing base model.

EPRI Perspective

CCAPI compliance offers operations center managers the flexibility to combine—on one or more integrated platforms—software that best meets their energy company's needs for system economy and reliability. This compatibility allows managers to upgrade, or migrate, their EMS or other operations systems incrementally and quickly, preserving prior utility investments in custom software and reducing upgrade costs by 40 percent or more. CCAPI-enhanced integration architectures based on the CIM model and GID interfaces also foster an interdisciplinary approach to conducting business by enabling interdepartmental teams to access a range of needed information via open systems. Hence, in innovative applications, energy companies are planning to implement CCAPI/CIM/GID outside the control center to reduce costs and improve customer service and staff productivity. EPRI continues to sponsor collaborative efforts to advance CCAPI-based integration strategies for greater information systems integration solutions – in the control center and beyond.

Keywords

Control Center Application Program Interface (CCAPI)	Control Centers	Energy Management Systems
Common Information Model (CIM)	Extensible Markup Language (XML)	Generic Interface Definition (GID)
Data Exchange	Power System Model, Reliability, and Security	

PREFACE

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

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

One initiative underway to address this need is based on the Common Information Model (CIM) standards that EPRI helped develop as part of the Control Center Application Program Interface (CCAPI) project. The CIM has been translated into the industry standard Extensible Markup Language (XML), which permits the exchange of models in a standard format that any EMS can understand using standard Internet and/or Microsoft technologies. The North American Electric Reliability Council (NERC) 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 both the CIM and the new Generic Interface Definition (GID) standards to facilitate the inclusion of the best-of-breed advanced network applications with existing EMS. This makes it possible to upgrade and improve network operations without complete replacement of existing EMS as well as providing for centralized network model management based on the CIM.

This report presents the results of the fifth interoperability tests 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 to encourage early adoption by additional product suppliers and energy managers.

David L Becker
EPRI
December 2003

ABSTRACT

On November 18-20, 2003 in Cleveland, Ohio, software vendors serving the electric utility industry met for the fifth time to test the capability of their software products to exchange 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 the GID interfaces in vendor products was observed and evaluated. 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 a request/reply type mechanism for a client to access a model 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 Alstom, Shaw PTI, SISCO, and SNC Lavalin. Xtensible Solutions/BearingPoint prepared the test procedures, witnessed the test results, and prepared this test report for EPRI. This is an important milestone in the CCAPI project and is the fifth 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 fifth CIM/GID interoperability test a success. Not all people who contributed can be named here. However, EPRI would like to give special recognition to the following vendors and contractors:

- Herb Falk, SISCO, for his assistance in preparation of the new GID test procedures and for his participation in the test program in Cleveland. Also, thanks to Herb for the LAN hub and FTP server used for management of the test files during testing.
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- Margaret Goodrich, Goodrich Consulting, for assistance in witnessing and recording the test results as well as contributing to the preparation of the test procedures.
- All participants, for bringing enthusiasm and focused energy with a true spirit of cooperation to Cleveland 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 standards and the utility industry’s need for products to exchange power system models in a reliable, consistent fashion. Special thanks to Herb for bringing the coffee pot!

In addition, EPRI acknowledges Terry Saxton, Xtensible Solution, who prepared 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 fifth CIM/GID interoperability tests, which took place on November 18-20, 2003, in Cleveland, Ohio. Interoperability testing proves that products from different vendors can exchange information and request services based on the use of the IEC standards that have been developed as an output of the CCAPI project.

This set of interoperability tests continued the testing of power system model exchanges, including complete model transfers, partial model transfers, and incremental model updates. These tests involve the exchange of files that conform to the CIM XML standards. However, for the first time, products which have implemented the new GID standards were also tested. The GID provides new methods for data exchange, including but not limited to power system models. The data exchange is accomplished through a client/server interface operating over messaging middleware 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.

The tests validate that participating products conform to the relevant draft IEC 61970 standards [see References 7-15]. The complete and partial model imports are based on the Part 301 CIM Base standard, the Part 501 CIM RDF Schema, and Part 503 CIM XML Model Exchange Format [see References 7, 12, and 13, respectively]. For the incremental model update tests, a working draft of the incremental update specification was used [see Reference 14]. The GID testing was based on the Part 401-404 GID standards and the TC57 Namespace Conformance specification (see References [8-11] and [15], respectively). All tests were based on a Siemens 100 bus model.

This test was the fifth 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

The objectives of the interoperability tests and demonstrations were to:

1. Demonstrate interoperability between different vendor products based on the CIM and 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. Verify compliance with the GID standards.

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 objectives for the fifth interoperability test can be grouped into two major categories:

1. GID compliance and interoperability testing
   – Validate compliance of GID High Speed Data Access (HSDA) server products.
   – Validate interoperability of GID Generic Data Access (GDA) client and server products.

2. CIM XML interoperability testing
   – Validate the import and export of complete power system models by spot checks and execution of load flow applications on the imported model files.
   – Validate the transfer of partial models (i.e., new complete additions to an existing model). The tests focused on the transfer and merging of complete individual substations.
   – Validate the transfer of incremental model updates (i.e., send all changes since the last update or since a specific date/time).
   – Exchange of ICCP Object ID Configuration data.

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

Scope of Interoperability Test 5

This fifth interoperability test involved a CIM XML power system model file similar to those used in the previous tests. Similar to those 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).

However, for the first time we also demonstrated and validated the exchange of power system model data via the GID interface. 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, as explained in the next section.

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 [see Bibliography, Reference 1]. 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 8-11]. 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. A draft recommendation of the "TC57Physical Namespace" [see Reference 15] was used as the premise of this testing. Therefore, compliance to the standardized interfaces and namespace definitions were both required in order to claim conformance for these tests.

GID Testing

For this Interoperability Test #5, the parts of the GID draft standard that were tested were the common services and the HSDA and GDA interfaces as contained in References [9], [10], and [11], respectively.

HSDA Testing

Based upon the definitions and philosophy of the GID, 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[1]
2. Interoperability testing – dealing with the ability of one participant's client ability to interoperate with another participant's server

GDA Testing

The GDA testing comprised interoperability tests between two test participant's products – one acting as a GDA client and one as a GDA server. Since the scope of the testing is determined by the GDA services supported by the product under test, each participant was required to declare the GDA services that it supports. A GDA application may function as both a client and a server. If so, then both a client and server declaration table were required.

While the GDA interface is designed for accessing a wide range of data (i.e., anything represented in the CIM), for this fifth Interoperability test, the test scenarios were focused on the use of GDA to access a power system model using the GDA services indicated for the application under test. In order to populate and modify the CIM model, different types of files were used:

- Complete power system model file
- Partial model files
- Incremental model files

Power System Model Exchange Using CIM XML File Import/Export

These tests were similar to those performed in the Interoperability Test 4, 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.

[1] 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.

Full Model Transfer

Each participant in this test was required to (1) import a sample model file, (2) generate and export a file that conformed to the standards for the model used[2], and (3) import a file from another vendor's product and correctly interpret the model data contained. The model file used was a Siemens 100 bus model prepared by Shaw PTI. This was the only model used for this test.

The Siemens 100 bus model file used for these tests contained at least one instance of the CIM classes, attributes and relationships defined in the NERC profile [see Reference 1]. This part of the interoperability test was the same as that done on previous tests but with new participants and more emphasis on the partial model transfers and incremental model updates.

Power Flow Solution Test

The Power Flow Solution test was 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 was provided in the Siemens 100 bus model used in this test:

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

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.

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

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.

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 by SNC Lavalin.

The basis for this testing is the specification developed by Arnold deVos, Langdale Consulting, for transferring changes to existing power system models. The specification is titled "RDF Difference Models – Representing the Difference Between Two RDF Models" [see Reference 14].

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.

ICCP Configuration Data Transfer

This test was to validate the proposed approach for transferring ICCP configuration data. This approach is described in the use case contained in Appendix C titled "Power System Model Exchange with ICCP/TASE.2 Linkage."

The purpose of this capability is to send the information needed to be able to correlate the real-time SCADA point values transferred via ICCP with the proper measurements in the power system model.

Existing CIM attributes were used for the configuration data, so no changes to the CIM were required.

Scope of the CIM Tested

The portion of the CIM that was tested is defined in the NERC Profile for power system model exchange. This profile contains the selected CIM classes, attributes, and relationships defined in the Minimum Data Requirements document produced by the NERC DEWG to model transmission substations, lines, and loads sufficient to run State Estimation and subsequent Power Flow/Contingency Analyses applications [see Reference 1]. This profile is mostly a subset of the IEC 61970-301 Base CIM standard [see Reference 7].

Organization of Report

This report presents results of the fifth CIM XML interoperability tests held in Cleveland, Ohio.

The introductory chapter presents the objectives and scope of these tests. Chapter 2 describes the test plan that was followed and identifies the participating vendors and their products. Chapter 3 presents the test results, beginning with a summary of each test step that was scored. The test scores, which are given as Pass, Pass with Errors, or Not Applicable, are organized in a series of tables. A summary of the significant results achieved are 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). The remaining appendices contain the use cases that define the capabilities being tested (Appendix C) and examples of incremental model updates (Appendix D).

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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 Cleveland. The goal was to have each participant successfully complete as many tests as possible while in Cleveland.

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 fifth interoperability test.

Participating Vendors and their Products

The four participants in this test were given the opportunity to spend three full days at the test site in Cleveland, Ohio. 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 LAN server. The sample model files and files successfully exported by a participant's product were loaded to the server so that other participant's could access these files for testing their import capability.

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

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

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
Participating Vendors and their Products

Vendor	Product Name	Platform	OS
Alstom	GENESYS - eterra-Modeler and Study Powerflow	PC	Windows 2000
Shaw PTI	ODMS (Operational Database Maintenance System) and PSS/O (Power System Simulator for Operations)	PC	Windows 2000
SISCO (1)	Utility Integration Bus and UIB Core GDA Provider	PC	Windows XP
SISCO (2)	OSIsoft PI Adapter for the UIB	PC	Windows XP
SISCO (3)	UIB Model Adapter for OPC	PC	Windows 2000
SNC Lavalin	GEN4 EMS	Compaq Alpha DS10	True64Unit

Test Approach

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

1. GID interface tests conducted as both conformance tests and interoperability tests, and
2. Power system model and data exchange tests based on CIM XML using file transfers

Participants were able to perform either one or both of these sets of tests.

GID Interface Testing

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 Reference 9]. 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 2-1 illustrates the test set-up used for conformance testing. A well recognized, general, OPC Client from FactorySoft[3] was used to validate the conformance of the HSDA Servers. The test 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.

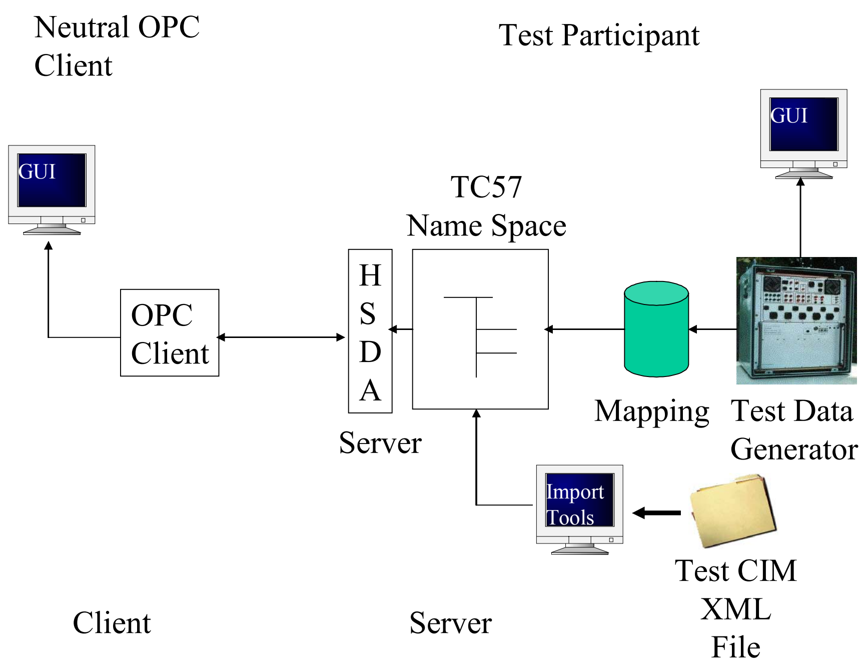


Figure 2-1
Test Set-up for HSDA Conformance Testing

Interoperability Testing

Figure 2-2 depicts the test setup for interoperability testing between two participants (e.g., Test Participant 1 supplies a Client and Participant 2 supplies a server). The same test cases used for Conformance Testing are performed; however, in this case both the HSDA client provided by Participant 1 and the HSDA server provided by Participant 2 are evaluated.

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

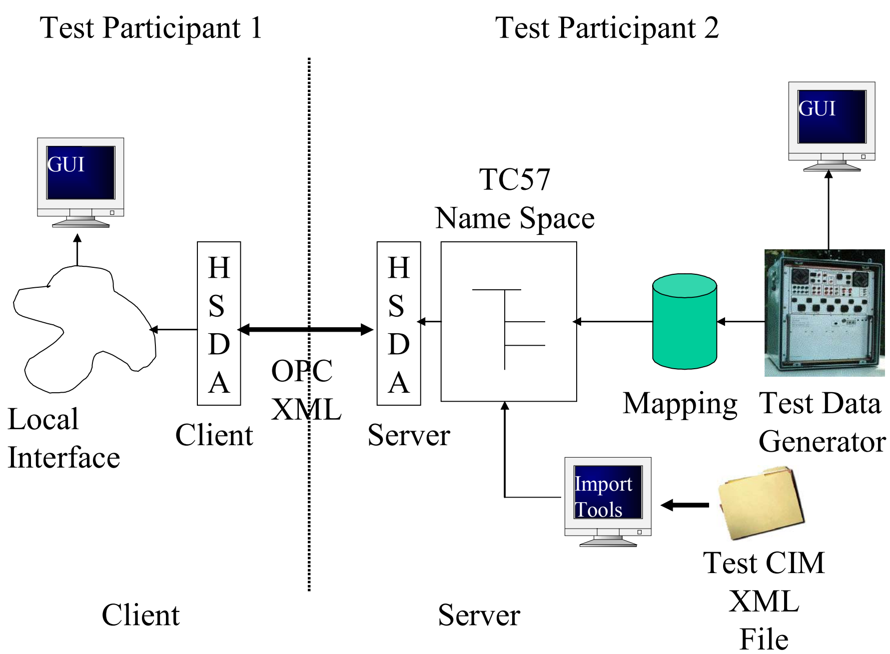


Figure 2-2
Test Set-up for HSDA Interoperability Testing

GDA Testing

The GDA testing comprised interoperability tests between two test participant's products – one acting as a GDA client and one as a GDA server. Since the scope of the testing is determined by the GDA services supported by the product under test, each participant was required to declare the GDA services that it supports. A GDA application may function as both a client and a server. If so, then both a client and server declaration table were required.

Table 2-2 is the table used for both client and server declaration. The only difference between client and server declarations is that the method/event declaration column has a different meaning.

Table 2-2
GDA Provider Declaration Table

Participant		
Application		
GDA Client Methods/Event Declarations		
GDA Method	**Client: Used/Optional/Not Used (U, O, NU)** **Provider: Supported/Not Supported (S, NS)**	**Comment**
Requests		
create_resource_Ids		
get_resourceIDs		
get_uris		
get_values		
get_extent_values		
get_related_values		
get_descendent_values		
get_filtered_extent_values		
get_filtered_related_values		
get_filtered_descendent_values		
apply_updates		
Events		
on_event		
ResourceChangeEvent		

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.
- NS – 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.

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.

While the GDA interface is designed for accessing a wide range of data (i.e., anything represented in the CIM), for this fifth Interoperability test, the test scenarios were focused on the use of GDA to access a power system model file using the GDA services indicated for the application under test. The types of files to be accessed with GDA include the following:

- Complete power system model file
- Partial model files
- Incremental model files

Model and Data Exchange Tests

These tests were similar to those performed in the Interoperability Test 4, 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

Full Model Transfer

Figure 2-3 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.

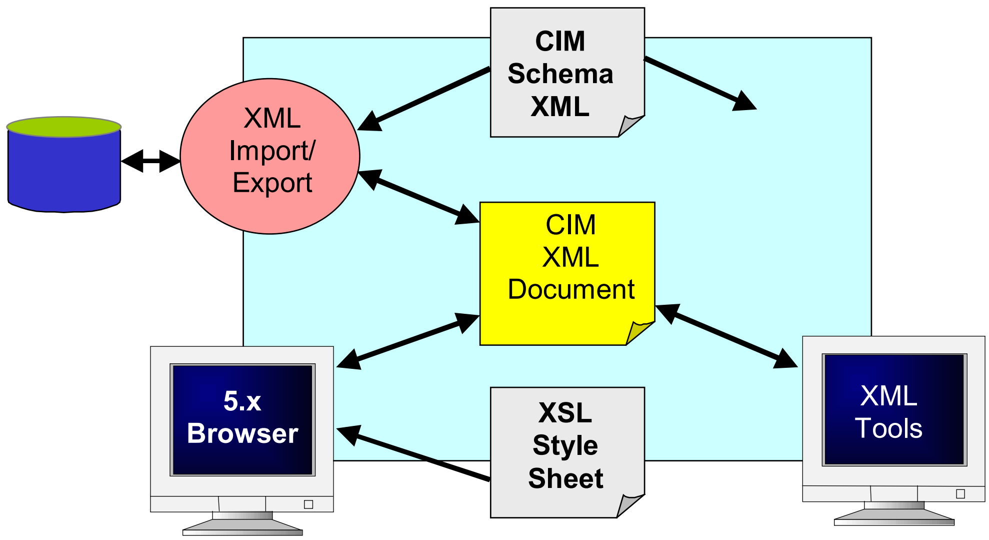


Figure 2-3
Export/Import Process Basics

Interoperability 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 LAN server to make it available for the other participants to import. This tested *interoperability* of different vendor's products.

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

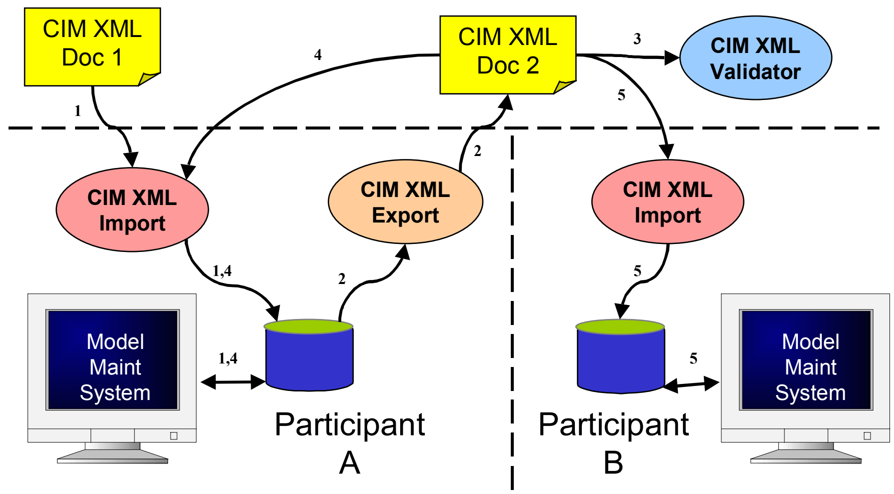


Figure 2-4
CIM XML Interoperability Test Process Steps

At this point the exported file was also loaded onto the LAN server for another participant (Participant B in Figure 2-4) 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 in Chapter 2, 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 2-5.

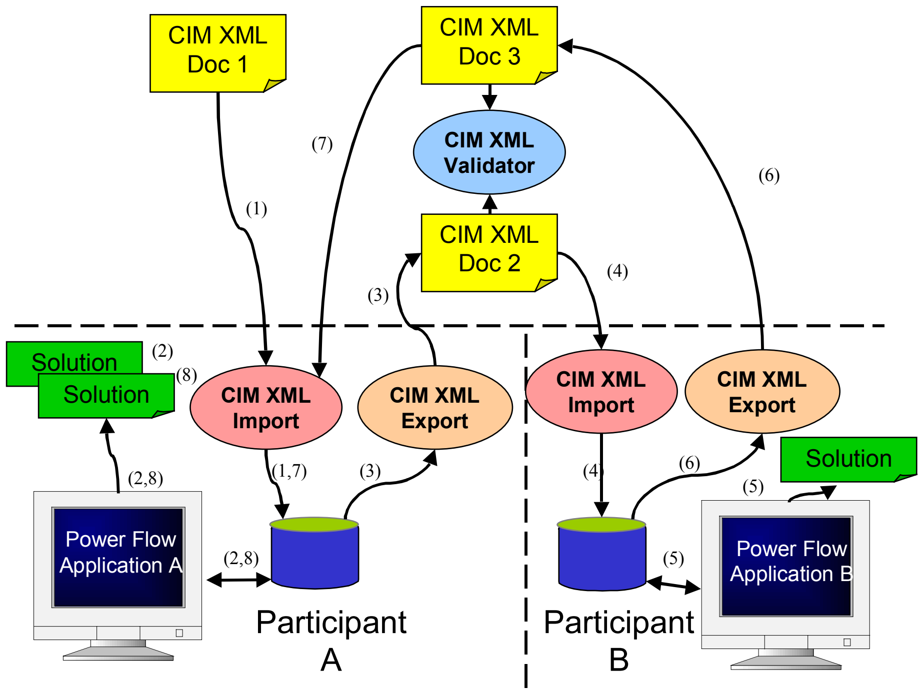


Figure 2-5
Solution Test Process

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].

[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.

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 the specification is titled "RDF Difference Models – Representing the Difference Between Two RDF Models" [see Reference 14].

Test Process

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 system participating in the incremental model update test followed these steps:

1. import the base small 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 the sample model from Siemens that had a substation removed. Then a substation partial model file was exported and imported, the partial model merged with the base file, and the merged model 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 A imported the "Siemens100 Less Port" base model file that did not contain Substation Port.
2. Participant A 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 A compared this new model "Siemens100 Plus Port" with previously imported sample model file "Siemens100" that already contained Substation Port.
4. Participant A exported the merged model file "Siemens100 Plus Port" and validated it.
5. Participant B imported the merged model file "Siemens100 Plus Port" and validated correctness using display tools.
6. Participant B imported original base model file "Siemens100" and compared with newly imported merged file "Siemens100 Plus Port" from Participant A.
7. 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.

ICCP Configuration Data Transfer

The ICCP configuration data transfer test demonstrated that ICCP configuration data prepared by one participant was imported and correctly interpreted by another participant.

The test used the same Siemens 100 bus model file with instance data for 20 ICCP points included.

Test Process

The steps for this test were as follows:

1. Participant A added ICCP configuration instance data and exported sample model file.
2. Participant B imported the file exported by Participant A and validated the contents of the ICCP configuration data.

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 [2].

Table 3-1
Description of Tests Performed

Step from Test Plan	Test Description
3.2.1	***Basic Import/Export***
3.2.1.1	Basic Import - Participant A import 100 bus model and demonstrate import was done correctly
3.2.1.2	Basic Export - Participant A export 100 bus model and run validator
3.2.1.3	Interoperation - Participant B import of Participant A exported CIM XML file.
3.2.2	***Solution Test***
3.2.2.1	Initial Import Document 1, Run Solution, and Export Document 2
3.2.2.2	Interoperability Test Using CIM XML Document 2 from Another Participant, Export Document 3
3.2.2.3	Final Import and Power Flow Execution on CIM XML Document 3
3.3	***Incremental Model Update***
3.3.4	Export Incremental Update File
3.3.5	Import Incremental Update File and Merge
3.4	***Partial Model Transfer***
3.4.1	Import Partial Models and Merge
3.4.1.1	Import sample model with substation removed
3.4.1.2	Import sample model for single substation
3.4.1.3	Merge model files

Table 3-1
Description of Tests Performed (Continued)

3.4.2	**Export Merged Model Files**
3.4.2.1	Export merged model - Participant A exports merged model file
3.4.2.2	Re-import merged model - Participant A re-imports exported merged model file
3.4.2.3	Participant B import merged model file from Participant A and validate
3.4.3	**Export Partial Model File**
3.4.4	***ICCP Configuration Data Transfer***
	Import of previously exported model file with ICCP data
3.5	***HSDA GID Testing***
3.5.1	**Connectivity testing**
3.5.2	**TC57 Namespace browsing**
3.5.3	**Data exchange**
3.5.4	**TC57 Namespace custom property exposure**
3.6	***GDA GID Testing***
3.6.1	**Import model file**

Summary of Test Results

The following sections report the highlights of the testing.

Basic Import/Export and Interoperation and ICCP Configuration Data Transfer

Basic Import and Export

Table 3-2 shows 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 to show compliance. All of the participants were able to pass this test. Highlights of the tests are as follows:

- All participants were able to successfully import the Siemens 100 bus model file correctly converting from the CIM XML format to their internal proprietary format.
- All participants successfully passed the export test, except that some errors regarding Measurement classes were noted for Shaw PTI and SNC Lavalin.

Table 3-2
Basic Import/Export Test of Individual Products

Test Procedure	**3.2.1.1 Basic Import**				**3.2.1.2 Basic Export**			
Test Number	100 Bus Model				100 Bus Model			
Alstom	**P**				**P**			
Shaw PTI	**P**				**PE**[1]			
SISCO PI Adapter	**P**				**N/A**			
SISCO UIB GDA	**P**				**N/A**			
SNC Lavalin	**P**				**PE**[2]			

Notes:
P (Passed) – all aspects of the test were performed successfully
PE (Passed with Errors) – most aspects of the test were performed successfully
O – Originator of model (Model originators did not import or export their own models in this test step.)
Blank entry – indicates test was either skipped or not witnessed
N/A (Not Applicable) – product does not support the functionality to perform this test

1. MeasurementValues dropped, but added new Measurements to handle line ratings, added one new Measurement Type
2. MeasurementValue and MeasurementValueSource classes associated with ICCP configuration data were not exported.

Interoperation

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

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

The entries in each cell should be interpreted as follows:

- P – Pass. Indicates a successful import of another participant’s exported file. The specific sample model file imported is indicated
- 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, or an exported model file was not available for import.

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 on the LAN server for other participants to import. Therefore, a blank entry in a column indicates that the participant whose name is at the heading for that column did not demonstrate an import of that file. A “VR” indicates that an import was attempted but errors in the file caused a product’s internal validator to reject the file although the XML document validator tool did accept it.

Highlights of the tests are as follows:

- Six pairs of vendors were able to interoperate successfully by exchanging at least one sample model file.
- SISCO successfully imported into two products all files exported by other vendors.
- All other participants successfully imported SNC Lavalin’s exported model.

Table 3-3
Interoperation with Sample Models

		3. Import				
		Alstom	Shaw PTI	SISCO UIB	SISCO PI Adapter	SNC Lavalin
Export	Alstom			P	P	P
	Shaw PTI			P	P	VR
	SISCO	N/A	N/A			N/A
	SNC Lavalin	P	P	P	P	

Power Flow Solution Testing

This testing used the Siemens 100 bus model. Table 3-4 shows the results of each of the steps as defined in Chapter 2, Figure 2-5, Solution Test Process. Highlights of the Solution test are as follows:

- Shaw PTI and SNC Lavalin were able to successfully complete all steps of the test on the Siemens 100 bus model.
- 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 3-4
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
Alstom										
Shaw PTI	P	P	P	P	P	P	P	P	P	P
SISCO	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
SNC Lavalin	P	P	P	P	P	P	P	P	P	P

Incremental Model Update

This section shows the results of the incremental model update tests. SISCO and SNC Lavalin participated in these tests.

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). Since SISCO does not export models, only SNC Lavalin exported incremental updates to an existing model. SNC Lavalin prepared and exported the following types of incremental updates:

- Changed an AC line’s resistance and reactance values
- Added an AC line segment between substations
- Added a power transformer and all associated equipment, including transformer windings and tap changers, to an existing substation
- Added a load to existing substation
- Deleted an existing load from a substation
- Moved a load form one voltage level to another voltage level within substation
- Changed MW value of load

The second test required a participant to import an incremental model update file exported by another participant, 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:

- Both SISCO and SNC Lavalin successfully imported the incremental model update files exported by SNC Lavalin and merged them into the existing Siemens 100 bus model stored internally in their products under test.

Table 3-5 shows the results of the tests. SNC Lavalin did not have the opportunity to import incremental updates from other participants, since there were no other exported incremented model files. This is, of course, no reflection on SNC Lavalin.

Table 3-5
Incremental Update Testing

		Import			
Export		Alstom	Shaw PTI	SISCO	SNC Lavalin
	Alstom				
	Shaw PTI				
	SISCO	N/A	N/A	N/A	N/A
	SNC Lavalin			6 update files	6 update files

Partial Model Transfer

This section shows the results of the partial model testing. All four participants (Alstom, Shaw PTI, SISCO, and SNC Lavalin) took part in these tests. Table 3-6 shows the results of these tests.

The first test required a participant to import a partial model and merge with a pre-existing model from the same vendor. Highlights of this test are as follows:

- All participants successfully imported and merged the Siemens Port substation model with the Siemens 100 bus model (without the Port substation).

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:

- All participants with export capability were able to export the merged model file successfully. SNC Lavalin had no errors, while both Alstom and Shaw PTI passed with errors.
- Both SISCO and SNC Lavalin successfully imported merged model files exported by Alstom. This is a further check on the Alstom file, as well as the ability of SISCO and SNC Lavalin 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:

- SNC Lavalin successfully exported partial model files for three substations – PORT, CRYSTAL, and BRADFRD.
- SISCO successfully imported the above three substation partial model files.

Table 3-6
Partial Model Testing

Test Procedure	3.4.1 Partial Model Import			3.4.2 Merged File Export and Import from Another Participant		3.4.3 Export New Partial Model Files		
Test Number	Import 100 Bus Model w/o PORT SS	Import PORT SS	Merge PORT Partial Model with Base	Export Merged Model	Import Merged Model from Another Vendor	PORT SS	CRYSTAL SS	BRADFRD SS
Alstom	P	P	P	PE[1]				
Shaw PTI	P	P	P	PE[2]				
SISCO PI Adapter	P	P	P	N/A		N/A	N/A	N/A
SISCO UIB GDA	P	P-PORT P-Bradfrd P-Crystal	P	N/A	P Alstom	N/A	N/A	N/A
SNC Lavalin	P	P	P	P	P Alstom	P	P	P

1. SynchronousMachine.MVARCapabilityCurve association is missing in exported merged model file. Also, LoadArea is missing an association to Company, which is an optional association in the NERC profile.
2. Exported merger model file validates OK, but there are additional instances for Limit, Measurement, MeasurementType, and Terminals that are not in original Siemens 100 bus model file.

HSDA Conformance Testing

This section shows the results of the HSDA conformance testing. SISCO was the only participant for these tests. Therefore, interoperability testing was not possible.

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 UIB Model Adapter for OPC. The series of tests conducted are summarized in Table 3-7.

Table 3-7
HSDA Conformance Test Results

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

The first set of tests (3.5.1) 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 (3.5.2) tests the Server support for Client browsing if 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.

The third group of tests (3.5.3) 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.

The fourth group of tests (3.5.4) validates that a Client can obtain the correct values of the custom properties of a node in the Server namespace. SISCO passed this test.

In summary, SISCO, the only participant for this test, passed all tests concerning the HSDA interface.

GDA Testing

This section shows the results of the GDA interoperability testing. SISCO and Shaw PTI participated in these tests. Three test setups were involved, each involving a different set of clients and servers. Table 3-8 shows these three client/server pairs that were tested for conformance to the GDA specification.

Table 3-8
GDA Conformance Test Results
(3.6.1. Basic Model Import and Incremental Model Read/Write)

Client	Score	Server	Score
SISCO GDA PI Adapter	P	SISCO GDA Provider	P
SISCO GDA PI Adapter	P	PTI GDA Provider	P
Standard OPC Client		SISCO GDA Model Adapter for OPC	P – Complete model P – Incremental model read P – Incremental model write

This test validated that a GDA Client was able to access a GDA server/provider and correctly read/import the complete Siemens 100 bus model using the GDA services which are checked off in Table 3-9. In other words, the complete model read/import exercised and validated correct operation of the methods identified in the table below. The other methods shown, while part of the GDA specification, were not exercised nor validated as part of this interoperability test.

In addition to the complete model import demonstrated by both Shaw PTI and SISCO, SISCO also demonstrated and validated (with their OPC GDA Model Adapter product and a modified off-the-shelf OPC client) the capability to make incremental updates to the Siemens 100 bus model.

To summarize, both Shaw PTI and SISCO correctly read/imported the complete Siemens 100 bus model using the GDA interface. In addition, SISCO also read in incremental updates to the model and wrote back a changed value to one of the leaf nodes.

Table 3-9
GDA Methods Tested

GDA Method	Tested/Optional (T, O)	Comment
Requests		
create_resource_Ids		
get_resourceIDs	T	
get_uris	T	
get_values	T	
get_extent_values	T	
get_related_values	T	
Get_descendent_values		
Get_filtered_extent_values		
Get_filtered_related_values		
get_filtered_descendent_values		
Apply_updates		
Events		
on_event	O	
ResourceChangeEvent	O (demonstrated but not part of official test)	

Summary of Issues Identified

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

The following issues were identified and documented during or prior to the test:

- ***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 that needs an association to this existing curve, that association has to be recognized and added as part of the substation partial model. It was resolved that for these tests at lease, it is the responsibility of the sending application to included all needed curves with the partial model file, and leave it to the application performing the merge to recognize and eliminate redundancy.
- ***Xpetal RDF Tool***: Xpetal does not include all Domain information needed in a model file. Specifically, the cim10_030501.rdf file does not define value or unit for primitive data types.
- ***Siemens 100 Bus_pti.rdf***: Measurements are not associated with equipment. The containment hierarchy is incomplete.

- ***GDA Specification***: The specification is not clear on what to return when asking for the rdf:type of an instance that is a base class of a derived class type (e.g., asking for instances of EquipmentContainers. If it is actually a Substation or VoltageLevel, returning an rdf:type of any of the base classes is valid, but not specific enough). A suggested resolution is to require the rdf:type to be the ID of the “leaf” class, i.e., the outer-most derived type (e.g., Substation, not EquipmentContainer or Naming).
- ***Incremental Update***: Rules are needed for what is included in the Reverse section of file for deletions. Suggested resolution is that a Reverse file for a deletion contains only the object name. The receiving application is responsible for finding and deleting all related attributes and associations. However, the scope does not include cascading deletes (i.e., each downstream object to be deleted needs to be identified by name). Header content also needs to be defined.
- ***XML Document Validator Tool***: Enhancements are needed to include validation that the NERC Profile is being followed (i.e., all mandatory attributes as well as classes are checked and errors noted if mandatory attributes are not present in the file).

4

FUTURE INTEROPERABILITY TESTS

Plans for future interoperability tests will shift the focus even more the testing of the GID interfaces operating over middleware. This will include the following:

- GDA – in addition to power system model access, add new data access scenarios to retrive/write other types of data.
- HSDA – conduct interoperability testing (only conformance testing was possible for the fifth test).
- GES – test the use of publish/subscribe services provided by the GES specification.
- TSDA – test historical data access.

A more complex demonstration and interoperability tests involving multiple GID interfaces on multiple vendor products should be staged. One possibility is to demonstrate a virtual data warehouse concept.

Another new emphasis will be on conformance and interoperability testing of the IEC 61968 XML standard messages being defined by IEC TV57 WG14, System Interfaces for DMS. This would entail testing of other parts of the CIM.

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 fifth 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.

ALSTOM ESCA eTerra-Modeler and Study Powerflow

The test procedures related to CIM XML model exchange are to be performed against the ALSTOM eTerra-Modeler product (also referred to as the Modeler) and the Study Powerflow application.

eTerra Modeler

The Modeler is a power systems operations modeling tool for initializing EMS applications with the information they need for real-time operations. The tool is used to generate the power system models and maintain them. Import and export facilities are provided for bulk data import and export while a tailored user interface is used for manual additions, edits, and deletions of information as well as model browsing.

The tool runs in a Windows 2000 environment. Though the design supports a distributed configuration, all components will be located on a single NT platform for the purposes of this interoperability test. Model validation software is included which verifies the integrity of the model and prepares information for use by operational applications such as the Study Powerflow.

Study Powerflow

The Study Powerflow (aka Powerflow) is one of a suite of transmission network analysis applications that also includes State Estimation, Contingency Analysis, OPF, etc. These applications are designed for use by operators in an EMS environment. The Powerflow is initialized with information from the real-time system, other network analysis applications, or the Modeler. The last initialization option is what is used in this interoperability test.

The Powerflow is configurable to use several solution techniques and has many options with respect to how slack generation and other solution variables are handled. A distributed slack scheme is used for these tests.

Shaw 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 Shaw 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.

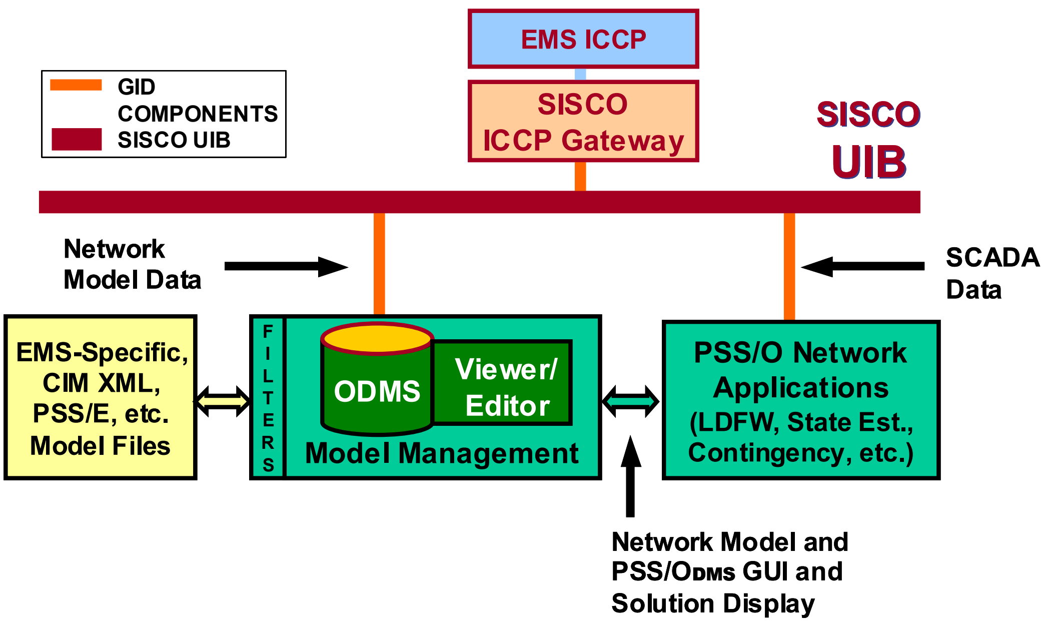


Figure A-1
Shaw PTI®'s ODMS and PSS/ODMS© Interfaced to SISCO's UIB for GID Testing

Until the CIM XML process became available, Shaw PTI® developed import "filters" that operated on vendor-specific data formats and converted the data from the various EMS systems into the CIM – which Shaw 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. Shaw 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.

Shaw 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 which implements the Generic Data Access (GDA) server services. 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.

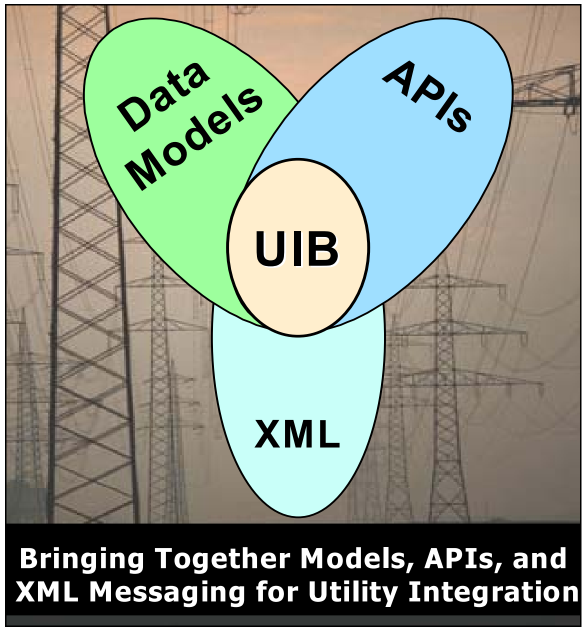
In the interoperation tests, the PSS/ODMS© package was used both as an additional data validation for the CIM XML files transferred in the tests, as well as verify that a reasonable load flow solution was possible based on the data.

SISCO (Systems Integration Specialists Company)

SISCO tested three different products during the interop.

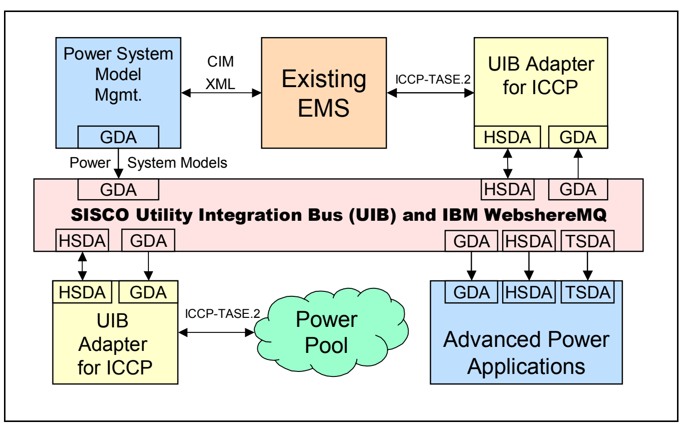
Utility Integration Bus and UIB GDA Provider

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.

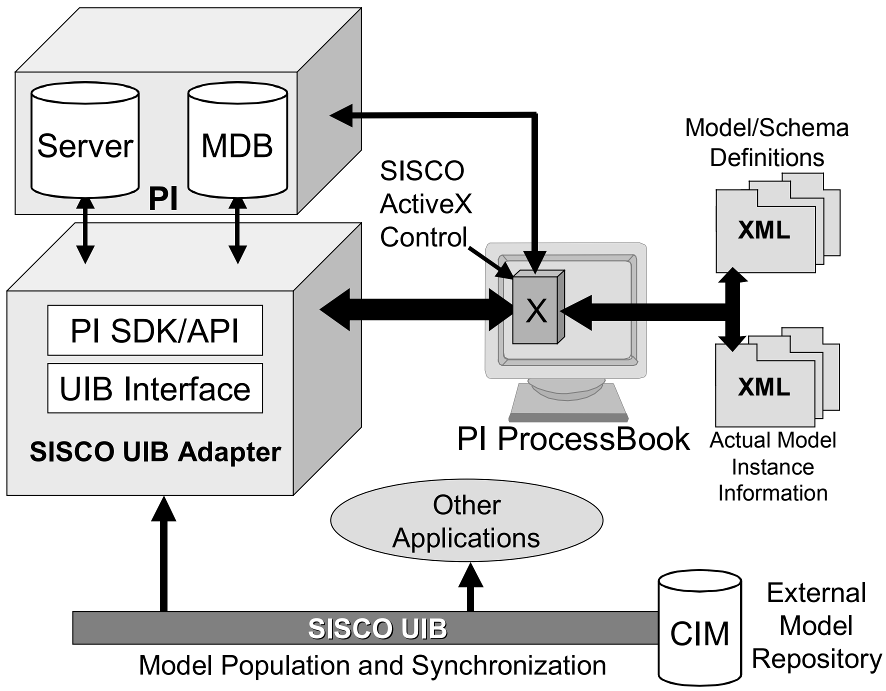
API Name	Acronym	Description
Generic Data Access	**GDA**	Based on the Object Management Group (OMG) Data Access Facility (DAF) specification, GDA is used to access and modify model data in a model server and supports model change notifications. The UIB provides a GDA Provider and CIM XML Import capability 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.

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.

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.

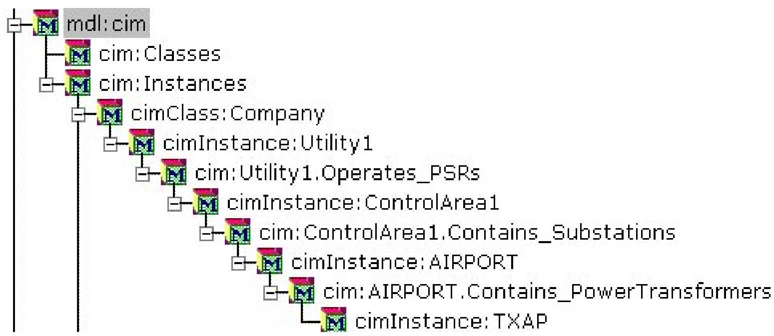


SISCO's UIB PI Server Adapter consists of: the adapter itself and a Process Book compatible ActiveX™ Control. The software allows for model creation and maintenance in the PI MDB either manually or automatically. Both of these mechanisms allow for standardized or customer defined models to be used.

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.

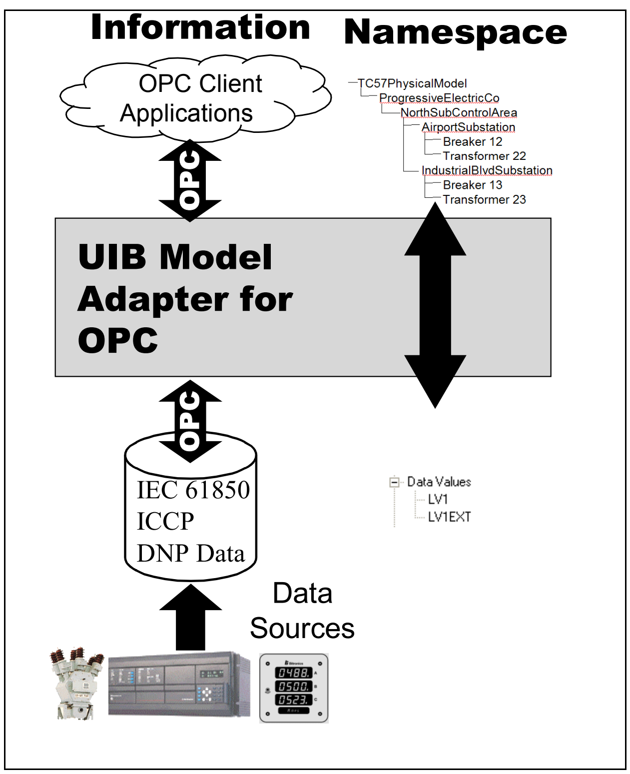
Automatic model creation and maintenance is enabled through the use of SISCO's Utility Integration Bus (UIB) and GDA. Using the UIB and GDA with the PI Server Adapter allows changes made in an external model to be automatically delivered to SISCO's PI Server Adapter and to other non-PI applications as 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 Model Adapter for OPC



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

The UIB Model Adapter for OPC is an off-the-shelf OPC server 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 Model Adapter then allows the user to map the non-model items into a standardized and unified namespace.

The end OPC client application (e.g. Wonderware, OSIsoft PI, etc…) can then obtain the data using model centric items.

The Model Adapter imports its unified model information through the use of GDA.

SNC-Lavalin GEN4 EMS

SNC Lavalin's GEN4 EMS product includes a full suite of transmission network security analysis and generation management applications using state-of-the-art algorithms. The EMS applications are fully integrated with the GEN4 SCADA and DMS products and use a common real-time database. As a result, the displays used for real-time SCADA operations can also be used to display network security analysis results.

The GEN4 EMS uses the SNC Distributed Application Environment (DAE) middleware which allows implementation of both small and large systems on an arbitrary number of distributed computing nodes using Unix, Windows and Linux operating systems. The Oracle RDBMS is used for storage of persistent system and historical data.

The GEN4 CIM Converter function can both import and export static EMS models as defined by the NERC CPSM profile. The importer produces equivalent models in native format, which is then processed by the GEN4 network validation and generation tools. The exporter extracts a GEN4 EMS model to produce an equivalent in CIM XML format suitable for model exchange.

B
TEST CONFIGURATION DATA

Test Procedures

The test procedure for this series of tests was *CIM XML Interoperability Test 5 Test Plan and Procedures*, Revision 3, November 14, 2003 contained in the following file:

- Test procedures: cim_gid interop test 5 plan r3 111403.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 61970-503 CIM XML Model Exchange Format document. Files produced may contain syntax definitions beyond the RRDF Syntax, but only the RRDF Syntax will be used to completely express the power system model in the file produced for testing. Participants reading files will be expected to properly interpret the RRDF Syntax definitions contained therein but are not required to interpret and use any definitions beyond the RRDF Syntax.

The file used for the RDF syntax definition was as follows:

- CIM XML syntax definition: draft IEC 61970-503 CIM XML Model Exchange Format, Revision 0.

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. Shaw PTI provided the test file based on the Siemens 100 bus model file.

The test file for the complete power system model transfer and GID testing was the Siemens 100 Bus Model, Siemens100_pti_11-10-03.rdf.

The partial model transfer test used the following files:

- Siemens100_pti_PORT_11-10-03.rdf
- Siemens100_pti_NO_PORT_11-10-03.rdf

The incremental model update tests used one or more of the following files:

- co_acline_mod.rdf
- co_acline_add.rdf
- co_load_add.rdf
- co_pt_add.rdfdf
- co_load_move.rdf
- co_load_del.rdf

A difference file exported by one participant was also available for import by another participant.

There was an overview diagram and one-line schematic diagrams for 4-5 substations that were the subject of the validation tests. These diagrams illustrate the power system model defined in the files.

Tools

The tools used for the interoperability testing are described in the draft IEC 61970-503 CIM XML Format document as follows:

- 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/download/CIMValidate-20010909a.jar.
- 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. File Transfer.

Sharing and transferring files between participant's systems was accomplished using a shared file server and connected to by all participants through a LAN switch.

C
USE CASES

This appendix contains the three use cases describing the major objectives for the fourth 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, etc. ???.

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

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). Assmption 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 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

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.

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.

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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**
1^{st} Rating = 295.6	1^{st} Rating = 398
2^{nd} Rating = 388.6	2^{nd} Rating = 463
3^{rd} Rating = 398.4	3^{rd} Rating = 488
	4^{th} 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. WSCC 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.

Program:
Grid Operations and Planning

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EPRI • 3412 Hillview Avenue, Palo Alto, California 94304 • PO Box 10412, Palo Alto, California 94303 • USA
800.313.3774 • 650.855.2121 • askepri@epri.com • www.epri.com