North American Transmission FORUM

Community   Confidentiality   Candor   Commitment

EMS External Modeling Reference Document

Versioning

Version History

Date	Version	Notes
4/20/2017	2017-1	Original version
7/03/2018	2018-1	Addition of external model quality topic, update of other topics

Contents

Purpose

The NATF "EMS External Modeling Reference Document" provides guidance to those working to improve performance of their EMS external models. The intended audience for the document is persons with responsibility for development and maintenance of EMS models for real-time state estimator and real-time contingency analysis.

This reference document does not create binding norms, establish mandatory reliability standards, or create parameters by which compliance with Reliability Standards is monitored or enforced. In addition, this reference document is not intended to take precedence over any company or regional procedure. It is recognized that individual companies may use alternative and/or more-specific approaches they deem more appropriate for their EMS external modeling purposes.

10**Open Distribution**

Topic 1: Introduction

Energy management systems (EMS) are used by various entities for monitoring their systems and maintaining a wide-area view for situational awareness. These systems, at the base level, typically consist of the computerized model representation of the electrical grid and a SCADA system that is used to retrieve analog measurements and statuses of equipment that can be studied by operations personnel before actually operating the equipment in field. The EMS also typically functions as the main point of control for devices in the field.

The model of the electrical grid includes the detailed topology of the system along with the appropriate parameters for the equipment within the system. These parameters can include impedances, line and voltage limits, transformer ratios and controls, generator limits, and reactive capabilities, among others. The SCADA measurements (MW, Mvar, kV, and tap positions) along with the statuses of switching devices are added to equipment within the model. Schedules of injections for loads and generators are also included to supplement when measurements are unavailable. These measurement inputs, along with statistical values weighting their confidence, are used in a state estimation mathematical process to calculate the entire state of the power system. This mathematical process calculates the voltage magnitude and angle for every bus along with the tap position for every transformer. This calculation is then further processed to calculate MW, Mvar, MVA, amp, kV, measurements.

The state estimator application is used to supplement the SCADA system by estimating the state of the entire system for which it is monitoring. This solution is then used to provide the following information:

- Calculated values where measurements are missing
- Calculated values where measurements have failed
- Identification of bad measurements
- Identification of bad topology
- Inputs to other applications

This document will focus on the model that is used in the EMS, specifically looking at the external portion of this model. Guidance on how to create and maintain the external model will be included along with typical sources of where to obtain information for these models.

To help with proper modeling of the external area, real-time data also needs to be obtained. This data is typically obtained through Inter-Control Center Communication Protocol (ICCP) links. These links allow companies to send and receive SCADA data with other companies. This data is needed to obtain the real-time state of the system to properly monitor it. Determination needs to be made as to how much of the real-time data needs to be obtained to go along with the extent of the external system that is modeled. Guidance for this determination is included in this paper.

10 EMS External Modeling Reference Document (Version 2018-1)
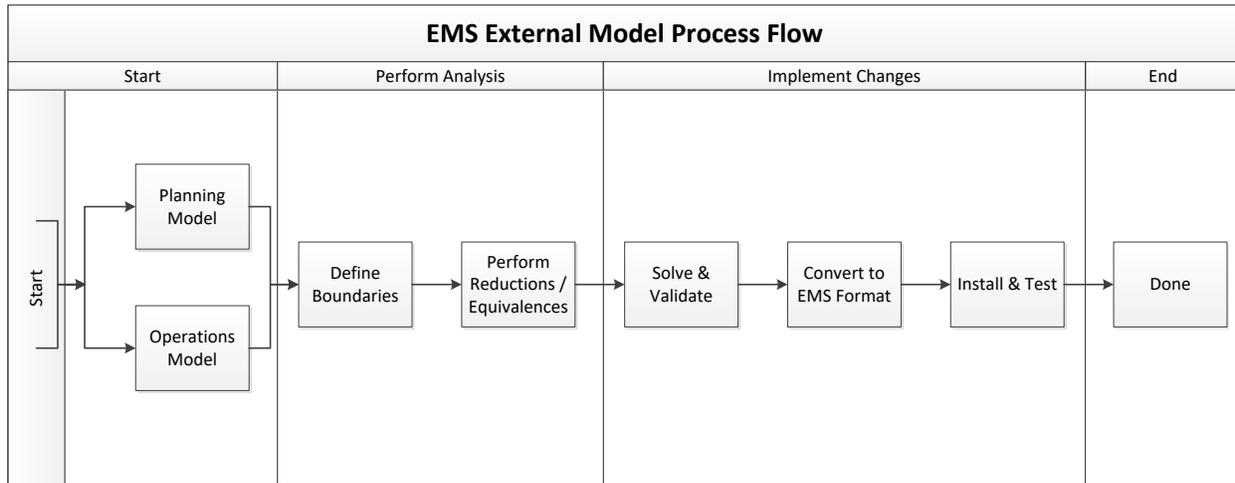
Topic 2: Importance of the External Model

In an EMS, the main focus area for modeling is the electric system area internal to the company. This area is easy to model, as all of the information should be readily available. Additionally, an external model of neighboring entities' systems is needed to support the EMS (state estimator/contingency analysis) solutions and operations of the internal area. The external model is needed for the following reasons:

- To obtain an accurate solution, a state estimator or power flow solution needs to appropriately represent the system that is being modeled to obtain an accurate solution. In the power system, there are no defined limitations to where power is flowing at company boundaries. The paths where power can flow need to be modeled to be able to simulate the true power flow.

- To ensure any maintenance or emergent outages on external equipment are visible and that the contingent internal impacts can be studied and confirmed with a very high degree of confidence.

- To be able to see what is happening in neighboring areas to coordinate and communicate more effectively.

The amount of external modeling that needs to be included in an EMS differs widely by system and company preference. This reference document includes guidance to help with properly determining the amount of the external system that needs to be modeled. To retain accurate monitoring of the external system, the model will periodically need to be updated to reflect any changes that have been made to the power system. (This can be an extensive and time-consuming task.)

Topic 3: How to Update an EMS External Model

EMS External Model Process Flow

Start	Perform Analysis	Implement Changes	End
Planning Model / Operations Model	Define Boundaries → Perform Reductions / Equivalences	Solve & Validate → Convert to EMS Format → Install & Test	Done

Starting

The starting point for updating the external model is determining if an evaluation of the external system is needed. It is necessary to update and maintain a current and accurate EMS external world model. It is recommended to review and update the external world model at least every two years. More-frequent reviews are necessary when large-scale construction projects will alter regional transmission flows impactful to the local system. Sometimes, an outside world model evaluation reveals that portions of external areas are no longer impactful to the internal model. In those situations, it would be desirable to reduce or remove those areas of the external model.

The next step is to determine the type of model that will be used to conduct the analysis. The starting point for developing a new external model to incorporate into an operating EMS is determining what kind(s) of viable models can be used. This is partly determined by what a particular EMS can accept and partly by what tools a user has available. In general, there are two distinct starting points for building an external model: "Planning Model" or "Operations (EMS) Model."

A Planning Model is a bus-branch, steady-state power flow model that can be run using positive sequence power flow software. The data requirements and structure are consistent and well understood. All of the commercially available power flow programs have the ability to import/export data files of various formats. As such, portability among the platforms is not an issue. It should be noted that power flow programs used for transmission planning are starting to include the capability to provide more detailed breaker-node models.

Typically, the planning models used to perform external model reviews are the cases that were provided by the Reliability Coordinator (RC). Those cases, at a minimum, include detailed models from all the Transmission Owners (TOs) that are under the jurisdiction of the RC. Reliability Coordinators develop those planning load flow models to perform studies on the future system topology. These cases are beneficial for determining external model needs since they include a large representation of the bulk electric system. These cases are typically generated for studying peak summer or winter load periods.

EMS External Modeling Reference Document (Version 2018-1)

To ensure that the Planning Model case represents the worst-case scenarios needed to identify the necessary external model, the following should be taken into consideration for best results:

- Is the case based on my peak load season (summer or winter)?

- Is the case based on light load topology (stability)?

- What interchange is being represented (high/low imports/exports)?

- Are future large-scale construction projects included?

- Are the generators dispatched appropriately?

An Operations (EMS) Model is a far more detailed breaker-node model with substantially increased data. This model option is more directly interlinked to available ICCP data for status and analog data. Generally, obtaining EMS models from other entities is the most direct method for creating an external model. This option can be desirable when companies are using the same EMS vendor to easily transfer modeling data between the two entities. However, due to numerous EMS vendors using their own proprietary format for their models, that may not make this option as desirable.

When using an Operations (EMS) Model, manual efforts towards piecing together different models or creating an equivalent area to create the desired model will be required. Another concern, similar to the Planning Model, is that these models may also contain more information than is needed. EMS models will require careful coordination and considerable efforts to effectively maintain the external model in the future.

Boundary Definition

A crucial portion of model building is the determination of how large an external model needs to be. The size of the external model will vary depending on considerations such as companies' (TO) needs, level of accuracy required, and the impact of the local bulk electric transmission system with respect to other TOs. Some companies may have external models that are larger than the internal model. This reference document outlines several methods (in no particular order) to consider:

1. Number of buses away from the system boundary

2. All first-tier external entity detail

3. Distribution factors taken from analyzing planning model contingencies

4. Combination of distribution factor and MW impact

Number of Buses Away from the System Boundary

"Number of buses away from the system boundary" is used as a "rule of thumb" to explicitly model a pre-determined number of buses away from the internal system boundary. This method ensures that accurate topology is in place at any internal system borders. The rest of the system will be equivalentized utilizing a bus/branch model representation. This method may be useful in instances with large companies with large model needs and reduces the need for complex analysis (such as distribution factor) to determine external model boundaries, as the criteria methods are clear and discrete. Another benefit is minimal analysis time compared to other methods. However, depending on number of buses away selected, this method could result

EMS External Modeling Reference Document (Version 2018-1)

- All tie lines to internal area meeting internal criteria (100 kV or above/BES).

- Single Contingency (TPL-001-4 P1 through P2) of any element within the external area that results in a DF to internal equipment greater than a specific threshold.

- Lower-voltage contingent elements as required by system boundary connections.

Distribution-factor threshold levels on determining whether a device is impactful or not to the internal model can vary by company. In general, a suggested threshold is modeling anything that creates a change to the model greater than 5% change in power flow. Distribution-factor threshold values can vary with respect to the equipment voltage classes if desired. Also, depending on the desired criteria and results, modeling facilities based on multiple-contingency disturbance impacts or other extreme contingencies could lead to a much larger external model and should be used on an as-needed basis.

In general, distribution-factor studies can be time-consuming to perform but provide the most-detailed information on the external equipment considered impactful to the internal model.

Power flow software programs such as TARA, PSS/E, PSLF, and MODELEX can be used to automate the large amount of contingency result compilations needed to perform the "distribution factor" and the "combination of distribution factor with MW impact" analysis options. Refer to Appendix 2 for an example use of "Distribution Factor and MW Impact" methodology by one utility.

Combination of Distribution Factor and MW Impact

Similar to the concept of performing a distribution-factor study, some companies determine outside world model based on their desired threshold levels from a MW-impacts-to-the-internal-area or tie-lines-change instead of a percent-change perspective. The complexities of these studies are similar to the distribution factor option.

Build the External Model Boundary Cuts and Solve

A complex Ward-Hale reduction will create an equivalent line from every boundary bus to every other boundary bus. While such an equivalence is technically accurate and probably useful for detailed power flow and transient stability studies, it may be too detailed for implementation in an EMS system. A generator/load pair at the boundary buses is a simple solution to establish some stability of voltages and allow for variability of boundary flows that are otherwise unobservable. It is critical that as a model is reduced that it retains a valid solution.

In buses that are close to the "internal" model, there should not be widely divergent flows and voltages in either normal or contingent conditions. To maintain the ability to study transfers between different areas, appropriate generation should be retained if it affects the entity's internal model. Such benchmarking of the external is critical. Load power factor in the equivalentized portions of the model should be consistent or similar to the internal model.

For confirmation that a reduced model is able to solve comparatively close with respect to a full model, an N-1 contingency analysis (TPL-001-4 P1) should be performed on both the reduced and full model. The results should be compared and the accuracy of the equivalent model should be within an approved deviation tolerance.

EMS External Modeling Reference Document (Version 2018-1)

Convert the External Model and Install

For most EMS models, there is a distinction from an operator's perspective between "internal" and "external" largely determined by whether the data points are "real" telemetered values or brought in via ICCP from some other entity.

Typically, updated external model information is obtained by reaching out to neighboring TOs or to the RCs and requesting model parameters, latest substation or transmission system one-line diagrams, ICCP analog information, etc. This is typically coordinated through the RCs to ensure that the information transferred to those entities who have signed data confidentiality agreements.

It is also possible to convert and/or receive external models between TOs and RCs if the information is "converted" into a consistent format that a particular EMS can read and use. This topic will become more important with the increased use of CIM. (For more information on this topic, refer to Appendix 1). The breadth of such systems and the tools for the conversion of a reduced external model into the compatible format is beyond the scope of this reference document.

In addition to receiving updated model parameters, the external model conversion effort includes the following tasks:

- Creating foreign substation one-line diagrams to internal display standards for operator situational awareness.

- Reviewing and ensuring accurate impedances, ratings, topology, and contingencies for equipment already included as part of the external model.

- Creating new contingencies for equipment that will need to be added to the model. (Review the list of remedial action schemes (RAS) in neighboring companies and implement RAS which are on equipment determined to be impactful to the internal system.)

- Obtaining object IDs (ICCP) for all new facilities that are to be added to the EMS.

- Testing and installing the new external model. (It is critical that the real-time system is not compromised by the addition of the new external model. A good practice is that time should be allocated to load external model changes into a test system that retrieves real time data to ensure that the updated model will not adversely impact the EMS's real-time performance.)

Topic 4: Adding Measurements to Substation Details

Substation Details – Real-Time Measurements

Real-time measurements are transferred between entities utilizing ICCP. There are three main options to receive external real-time measurements: a direct ICCP link with another entity; request for information to the Regional Transmission Organization (RTO) or Reliability Coordinator (RC); and a connection through the Eastern Interconnect Data Sharing Network (EIDSN).

Analog Telemetry Measurements

State estimator accuracy is dependent on the availability of real-time measurements that are mapped to specific model objects with a unique location within the system topology. It is recommended that anywhere node-breaker modeling is represented, real-time analog measurements be in place. A focus should be placed on measurements within the desired observability area and the higher kV system equipment, including transmission lines, transformers, and generating units. Placement of an analog measurement, such as for a transmission line, at the incorrect terminal end may cause a measurement with good accuracy to be de-weighted or ignored during the iterative state estimation calculation. It is imperative when mapping measurements to model objects that the proper location of instrument transformers is ensured for the purpose of determining proper analog representation. Likewise, in cases of ring-bus designs, accurate mapping of breaker current transformer telemetry is key to ensuring accurate flow when the system experiences abnormal ring configuration. In many cases, if a transmission line does not terminate with a breaker, the line may not have analog measurements. When transformers or shunt devices are coupled at the same topological nodal location as a transmission line or breaker string, the associated measurement should be closely scrutinized to determine whether analog telemetry includes or omits devices connected to the node. The flow direction attribute must be correct on the measurements. Most companies have a standard that positive flow is out of the bus on measurement installations.

Typically, the following analog telemetry measurements are used in the external model:

- Active and reactive power for transmission line

- Voltage measurement for buses

- Active and reactive power, voltage, and tap position for transformer

- Active and reactive power, and kV for generating unit

Status Telemetry Measurements

An EMS model enabled by state estimation depends upon accurate topology in order to produce accurate load-flow results. It is recommended that anywhere node-breaker modeling is represented, real-time switching status measurements be in place. A focus should be placed on measurements within the desired observability area and the higher kV system switching equipment. Stations in the area of interest without node-breaker switching detail, including the absence of status measurements, require the state of these transmission facilities to be maintained manually. As with all modeled topology, unmeasured facilities in parallel with measured facilities are more critical to solution integrity. Radial circuits can be accommodated such that the error created by the incorrect topology is adjusted by flow quantities.

EMS External Modeling Reference Document (Version 2018-1)

ICCP Connection Considerations

Communication of real-time measurements is accomplished utilizing the ICCP application and the TASE 2 standard. There are currently three main options to receive external real-time measurements: a direct ICCP link with another entity; request for information to the Regional Transmission Organization (RTO) or Reliability Coordinator (RC); and a connection through the EIDSN.

1. Direct ICCP link

    A direct ICCP link with a neighboring entity allows direct access to the information requested at the source. Any modifications to data would likely cause issues with the neighbor's system and thus be communicated almost immediately to other parties. Establishing a new ICCP link for each neighbor with whom you would request data could incur significant connection costs, and thus prove financially prohibitive.

2. RTO or RC link

    The ICCP connection to the RTO or RC is already established. It allows the customer to request information from several neighbors, both within and without the RTO/RC footprint, through the same path at no additional setup cost. However, the information is flowing via one link so any time there is an issue all external data is compromised. Additionally, there may be a notification lag on any modifications coming to the RTO/RC via the neighboring entity.

3. EIDSN link (Eastern Interconnect Only)

    The Eastern Interconnect Data Sharing Network (EIDSN) mission is to develop an "effective network for the sharing of operating reliability data, including both SCADA and synchrophasor data, among appropriate entities to promote the reliable and efficient operation of the Eastern and Quebec Interconnections." The EInet was created to accomplish the transfer of data between members. Entities with a NERC designation of Reliability Coordinator, Transmission Owner, Transmission Operator, or Balancing Authority may establish a link through this network. Currently, 12 members transfer data through EInet. This may limit the amount of data that can be accessed by an individual entity. Additionally, this will require a new ICCP connection to be set up. Information on the EInet can be found at https://eidsn.org.

Topic 5: External Model and Data Maintenance

Regardless of the method utilized to transfer model data and information between entities, a protocol for updates should be established. The protocol should clearly outline the timing and format of information exchanged and establish regular communication checkpoints. The information exchanged should include any modifications to system topology, existing equipment parameters, existing ICCP object ID, and addition of new measurements within a substation or removal of physical or monitoring equipment. Without this protocol, entities risk utilizing out-of-date information within their state estimator programs.

Some available options for exchanging data include sharing models, Common Information Model (CIM) exchange, or SERC format model exchange. Should neighboring entities utilize the same vendor, sharing the node-breaker-level models becomes a feasible option. CIM format is becoming more widely utilized in the industry for model exchange. (Refer to Appendix 1 for more information on CIM.) Entities within the SERC reliability region have developed a .csv standard for model exchange. Techniques to automate any model comparisons will provide for more efficient use of engineering study time.

If an entity's model has not been maintained in quite some time, consideration should be given to replacing the "full" model. This is a time-consuming process because one needs to verify the accuracy and perform some equivalizing. Note that making large changes like this can cause reliability issues to the internal system model that will need to be addressed.

From a model-validation standpoint, a good practice is to load changes in a test environment before placing into production. The test environment allows proper vetting of changes in a real-time type atmosphere while not compromising the reliability of the production system should an error be discovered. Another good practice to reduce the risk of modeling error is to perform changes in a piece-meal fashion rather than load bulk changes all at once. This piece-meal fashion also encourages detailed model review and education from an employee level that may be missed from loading a bulk file.

For the actual modeling and maintenance of this data, a good practice is to utilize internal company resources as they are more likely to have refined knowledge on the modeling environment and its various intricacies. External contractors can be utilized provided they receive proper training on modeling processes.

EMS External Modeling Reference Document (Version 2018-1)

Topic 6: External Model Quality (External Model and EMS network Applications)

Background

The EMS network model must accurately represent the electrical power system for the state estimator to provide system operators situational awareness to outages. Equipment status changes to the power system are dynamic and the EMS model should be designed to provide visibility to all necessary internal and external system equipment.

The lack of an accurate external system model can negatively impact the results of network applications (state estimation, contingency analysis, study applications, stability applications). Quality state estimator results are paramount to the success of operating the electric power system. For stability purposes, it is important to a have large, detailed external model for accurate results. Therefore, the inputs (SCADA measurements and network model) to the state estimator need to be constantly reviewed for accuracy.

The state estimator uses SCADA measurements and the power system model to provide the best estimate of power-system status. The state estimator is the base function for all real-time network applications. If the state estimator does not converge or is provided with insufficient or incorrect measurements that dramatically skew results, those negative results will carry over to other affected applications.

Errors in the external model (missing equipment, incorrect topology, or incorrect measurement mapping) can cause an invalid solution of the state estimator or cause a large estimated mismatch on external or tie-line buses. Even if estimation results for the internal system are valid, errors in the external model can invalidate solution results and reduce the accuracy of the state estimator solution.

Contingency analysis is an EMS network application used to analyze the impact on power system security of a specific set of simulated events, such as unplanned outages of transmission lines, generators, or other transmission system elements. For each individual event (contingency) in the set of simulated events, contingency analysis will identify any problems, such as branch overloads or voltage limit violations, that will occur if that event takes place.

Foreign System Analog Telemetry

With respect to the external model, it is recommended to receive and model all analog and status measurements from any external substations that have been identified as impactful to the internal system to provide the state estimator with enough information for the model to properly match SCADA-telemetered values.

There may be times when the telemetry provided for foreign utility equipment is incorrect or modeled incorrectly. The state estimator can determine and declare if some measurements are suspect or anomalous if the estimated values are not matching with other telemetered measurements.

State Estimator Mismatches

EMS network application results provide information about the quality of the model. Those results can indicate errors in both the internal and external model and direct the operator to a node, bus, or area where that error

or mismatch occurs. State estimator results can show convergence issues or where large busbar mismatches (deviation between SCADA and state estimator) occur.

Several methods exist to identify if there are errors in the external model, such as comparing the model with single-line diagrams from the "foreign utility" (Transmission Owner) and/or comparing state estimator results with results from the Reliability Coordinator or the foreign utility.

A state estimator is able to calculate residuals for all external measurements, which are part of a cost calculation for a completed modeled system (internal and external). The "cost index" is the sum of residuals for all measurements (MW and MVAR) in the system. Residuals represent the difference between estimated and measured values. Therefore, the cost is a good indicator to show how close the state estimator is from actual SCADA telemetered measurements. An increase in "cost" can be caused by measurement or model errors.

Typically, differences between SCADA measurements and the state estimator calculations in the external model are the largest contributors to cost. Large contributors to the cost should be investigated as soon as possible to ensure there are no modeling issues.

To ensure the state estimator is solving accurately, a recommendation is to frequently monitor and review all modeled foreign areas that contain large mismatches. In lieu of a full detailed review, however, some companies simply track state estimator results on tie lines or from the first foreign utility substations and compare those values with SCADA measurements.

Contingency Analysis Mismatches

In the case of contingency violations, results can be compared with those from neighbor companies (TOs) and/or RCs. If mismatches exist, operators and reliability engineers should reach out to the relevant external parties and discuss the differences. Many times, equipment changes or modeling issues can be identified from these discussions.

To ensure good situational awareness to an operator, it is recommended that all necessary contingencies determined to be impactful to the internal model are accurate within +/- 3% with neighboring utilities and/or the RC. A higher difference in contingency analysis results could be caused by some error in the external model.

Some companies are importing foreign company outages to use as part of their outage studies through the use of the NERC System Data Exchange (SDX). Implementation of this tool can be used to proactively identify mismatches in foreign company areas that could be impactful to the internal area.

EMS External Modeling Reference Document (Version 2018-1)

Appendix 1: Planning-Produced CIM External

CIM Overview

Common Information Model (CIM) cases are platform-independent cases that can be used to translate EMS model data between entities without needing to convert between their respective EMSs. The CIM uses a standardized extensible markup language (XML) format. This standard is set and maintained by IEC 61970.

CIM models from planning models can also be produced, but there may be little relation to any existing EMS models.

Potential Uses of a Planning-Produced External CIM

There are instances where conversion from a planning case to CIM for inclusion in an EMS can be useful. The case would have to be modeled out to an appropriate number of buses beyond the internal model and equivalized and trimmed beyond that.

1. Initial startup of an EMS model. The ideal time to bring in a model with no node-breaker information or SCADA links is when none exist elsewhere in the model.

2. Insufficient external modeling exists within the EMS model for a desired study purpose, such as transfer analysis. Adding any external model detail is an improvement at this point, even if no node-breaker information or SCADA links are included.

3. The existing EMS model is very old and there are many changes to be made. The effort to update the external system using CIM should be weighed against the effort to update it manually, especially if there are existing SCADA links or node-breaker data that could be lost. Getting a planning model from a relatively small area and importing that may be an option if other areas have SCADA links or node-breaker data.

4. Few ties exist between the internal and external models. This can limit the effort needed to tie the model together.

5. Little or no SCADA data is used in the external model, or little or no node-breaker modeling is used in the external model. This can limit the effort needed to tie the model together.

Challenges

When considering whether to use a planning model to add or upgrade the EMS model, there are challenges to overcome.

1. Planning models are often bus-number dependent, but EMS models are usually bus-substation-name dependent.

2. CIM version 13 does not accept six-digit bus numbers, so buses from planning models using longer bus numbers may have to be renumbered to five digits. The existing external EMS model generally includes equivalent lines, generators, loads, or a combination of them. The boundaries of the EMS may need to be redefined in order to apply a new external CIM.

EMS External Modeling Reference Document (Version 2018-1)

3. Existing external topology may also have associated telemetry, such as data via ICCP, that may need to be preserved or even reworked to fit the expansion of the external model.

4. The new external CIM-generated external model still has to be manually tied to all of existing portions of the internal model.

5. If there is an existing model, it may be necessary to handle the planning model-derived CIM data and conversion efforts outside of the production system to avoid conflicts.

6. Master Resource Identifiers (MRIDs) in CIM, sometimes called object identifiers or OIDs, are used to link one model update to existing items in the existing model. New MRIDs indicate new equipment has been added or changes to existing equipment have occurred. If the MRIDs stay the same, nothing for that piece of equipment has changed. Presently, many planning model cases do not carry MRIDs, so any conversion of such a planning model to CIM will produce all new MRIDs. This will result in a loss of integrity of the external model from one planning case upload to the next upload.

Appendix 2: Utility Experiences in Updating the External Model

Company A's Experience in Updating an External Model

The purpose of building an external model is to improve state estimator solution quality around tie-lines and to allow for contingency analysis to generate more accurate results. This provides better situational awareness on external equipment outages that can impact one's internal footprint. Below is the methodology used to update the external model.

1. Methodology used to determine how many bus tiers into the neighboring system that will be modeled. This methodology is a guideline and is adjusted on an as-needed basis to improve state estimator solution quality.

    a. 1-4 buses – model with virtually full detail, with all status, and all telemetered analog data available

    b. 5-6 buses – model with virtually full detail, with all status, and no telemetered analog data available

    c. 7-9 buses – model stations in an equivalized manner, with no status, and no telemetered analog data available

    d. 10 bus – model lines with one unit and one load, with no status, and no telemetered analog data available

2. Methodology used to determine when contingencies should be modeled in the neighboring system. The purpose of defining external model contingencies is to determine if the loss of equipment outside of the internal model can cause voltage or thermal violations within the internal model. This methodology is a guideline and is adjusted on an as needed basis.

    a. 1-2 buses – define line, transformer, and generator contingencies that have a voltage level from 100 kV to 230 kV

    b. 3 bus – define line, transformer, and generator contingencies that have a voltage level above 230 kV

3. Methodology used to determine the effectiveness of the external model.

    a. State estimation should closely track metering at the tie lines. Areas that do not closely track metering are evaluated and a mitigation plan is created to resolve the issue.

    b. When switching by an external company occurs, the state estimation solution quality should not be impacted. This assumes the following:

        i. Metering and status are appropriately mapped within the external model

        ii. All metering and status points are communicating accurately

        iii. All topology is accurate

        iv. All physical model data is accurate

EMS External Modeling Reference Document (Version 2018-1)

Company B's Criteria for Outside World Model Changes

Company B models facilities that impact any internal transmission line based on the criteria as listed in the table below.

Example: For foreign 500 kV lines, a contingency loss of that facility must impact a Company B 500 kV line more than 5% of the line loading to be included.

Foreign company voltage line (kV)	Typical max powerflow (MW)	Company B facility voltage (kV)	DFAX cutoff on Company B Facility	Load Cutoff on Company B Facility (MW)
500	1500	500	5%	75
500	1500	230	2%	30
345	1000	500	8%	75
345	1000	230	3%	30
230	500	500	15%	75
230	500	230	6%	30
138 / 115	150	230	20%	30
138 / 115	150	138	10%	15

EMS External Modeling Reference Document (Version 2018-1)