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Case Study on Network Model Management Solution Design

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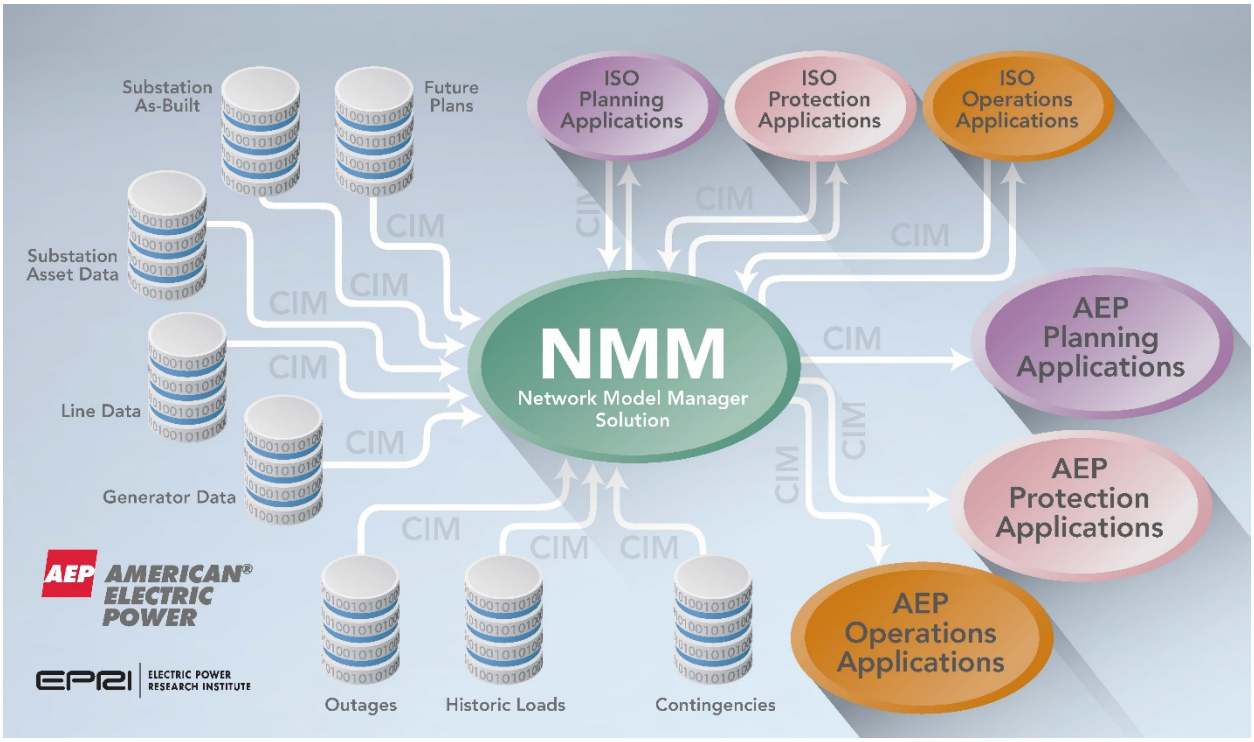

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Technical Update, February 2017

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ABSTRACT

The Network Model Management Improvement (NMMI) program is a major application integration initiative of American Electric Power (AEP) that will improve network model data management across the AEP planning, protection and operations domains. During the initial stages of the initiative, AEP encountered many of the challenges of designing high-level application integration solutions—challenges that are common in enterprise-wide integration projects conducted by the electric utility industry. Arriving at a solid solution design depended on collaborative effort, synthesizing of requirements, exploring alternative solutions, and documentation of an initial design approach.

AEP utilized a number of classic IT design tools and techniques to arrive at its visionary solution strategy. This report provides an overview of AEP's NMMI program and its high-level design activities, focusing on AEP's use of business scenarios for understanding and documenting the organization of AEP's processes for analyzing business networks around a network model management (NMM) tool. Several examples of business scenarios, developed during the final stages of AEP's high-level design effort, are provided.

This report is a deliverable of EPRI's Transmission Modernization Demonstration (TMD). The TMD project is a collaborative multi-year endeavor that provides opportunities to its members to host and share information about demonstrations of cutting-edge transmission applications that advance the use of innovative data analytics to extract benefits from available data sources. One of the key activities of the TMD project is the development of informational materials and demonstrations that enable better understanding of emerging data technologies that can support more effective data insights.

Keywords
Common Information Model
Conceptual solution design
Integration design
Network model management
NMM

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1
INTRODUCTION

Background

Electric utility initiatives to improve information management present a unique and complex set of challenges. Such projects typically involve systems used and maintained by multiple work groups; they are usually undertaken with a goal of improving on the existing state, and they often call for enhancements to both new and existing vendor products. Collectively, these characteristics mean that for a project designed to improve information management to succeed:

- Visionary solution strategies, founded on a deep understanding of requirements, but rising above existing practice, will need to be articulated.
- Business processes will need to change at an enterprise scale.
- Vendor relationships will need to be established that take vendors outside their comfort zone.
- Data management as an intentional, ongoing activity spanning IT and OT will need to be established.

The first item, articulating a visionary solution strategy, is an essential first step on which the other items depend. It is also an activity that is not necessarily straightforward: It requires in-depth exploration, synthesis of information, pattern identification, consideration of solution alternatives, and validation of the selected approach. And the stakes are high: An inappropriate solution strategy can doom an integration project from the outset. It can be difficult, especially for utility personnel who are new to integration projects, to "see" the situation well enough to validate the quality of a solution strategy. However, multiple techniques, tools, and artifacts are widely available and utilized in the IT world for designing and documenting solution strategies. The challenge is using them in a manner that allows a functional, durable, and scalable solution vision to be designed for a specific integration project.

This report provides an overview of the solution design process that was followed at American Electric Power (AEP) in planning its major enterprise-wide integration initiative, which AEP calls the Network Model Management Improvement (NMMI) program. The report describes and provides examples of business scenarios—one of the techniques employed by AEP as part of the design process—and explores the important role that creating business scenarios played in the successful articulation of AEP's solution strategy.

Network Model Management Improvement Program at AEP

A major multi-year, multi-million-dollar network model data management improvement initiative is currently underway at AEP. It will implement an integrated and unified approach to network model data management, which will reduce manual intervention, increase accuracy, improve integration with external partners, and provide a solid core of master data useful for all transmission processes, from daily processing to data analytics. Its scope spans the operations,

planning, and protection domains, involving the deployment of a new network model manager (NMM) tool integrated with seven internal AEP systems and eight systems hosted across three regional transmission operators (RTOs).

Program Timing

The official launch of the project in early 2015 followed several years of pre-work of data gathering, exploring and understanding processes and systems, defining requirements, and visualizing a solution strategy. High-level design work continued into the project's first phase, as the scope of effort was clarified and the design of a high-level solution was articulated. The project is now in its second phase, which is expected to last several years, where an NMM tool is being deployed, detailed data exchange and business processes are being designed, and initial integration is being achieved through a series of incremental steps.

Program Scope

The NMMI project is implementing a comprehensive network model data management solution at AEP, which will ensure that uniform, interrelated, consistent, and timely network model data is available to applications across the planning, protection, and operation domains. The solution will govern the maintenance and use of network model data to provide a single version of truth.

Specific data management functions to be provided by the solution include:

- Maintenance of master network model data derived from engineering detail source data.
- Definition of possible future network modifications (planned projects) and their ultimate incorporation into the as-built model.
- Calculation of facility ratings.
- Validation of network models and cases.
- Simplification of master data into the level of detail required by various consuming systems.
- Assembly of network models and cases, at the appropriate level of detail and for the desired point in time.
- Provision of created models and cases to various consuming systems at AEP and its three RTOs.
- Management of object identifiers across systems.

Program Drivers

Prior to the initiation of the NMMI project, AEP's management of network model data was typical of that found in large transmission utilities around the world. The same network model data, obtained from a variety of potentially overlapping sources, was manually entered and maintained in multiple applications by various transmission business units. Disconnected network model datasets (with unique identifiers in each system) made both cross-application data validation and coordinated analysis difficult. In short, data quality was not assured, data ownership and sourcing were not clear, and the quality of AEP's network models depended more on the diligence of transmission engineers than on any overarching data-management architecture.

The situation was compounded by the fact that AEP has an operating footprint spread across multiple states, as shown in Figure 1-1, and has a business organization that reflects both the geographic spread and AEP's history of mergers. The network-analysis applications, the manner in which they were used, and the business processes that supported data sharing among them varied across the three operating areas.

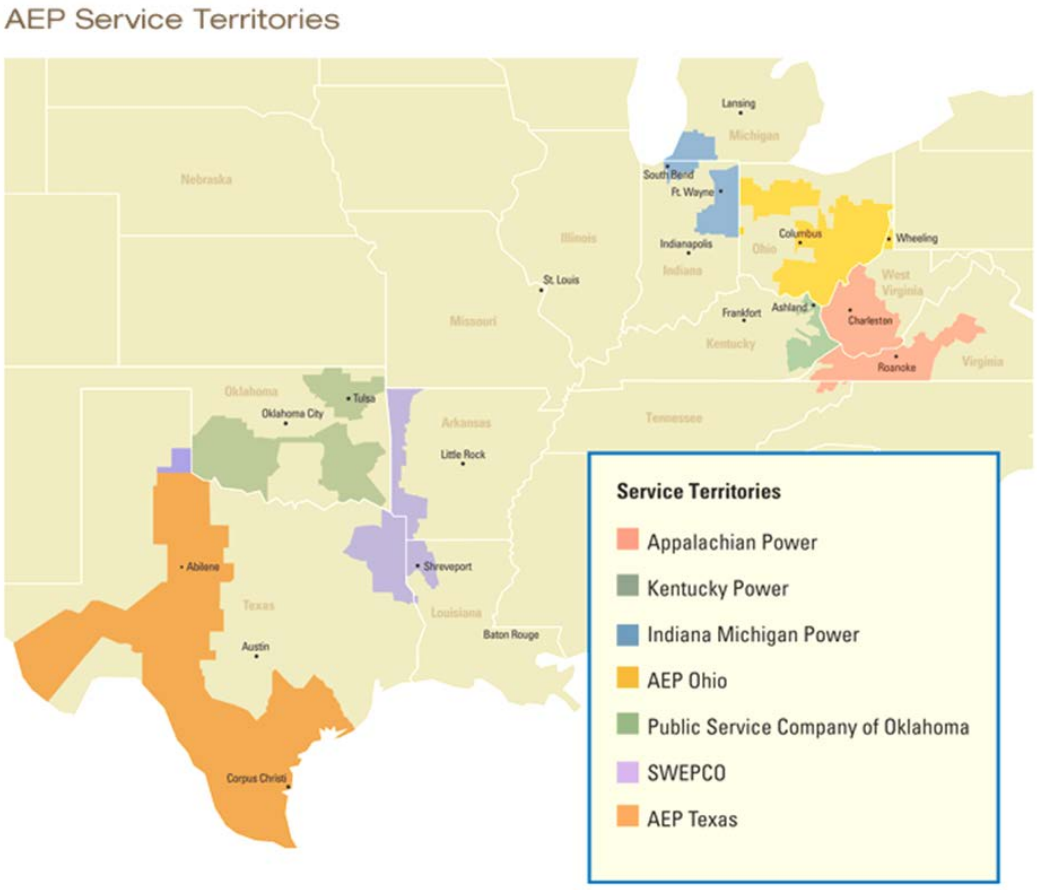

Figure 1-1
AEP service territories

Several factors helped trigger AEP's initial interest in improving its management of network model data:

- The deployment of a new energy management system (EMS) state estimator platform across the three operating areas and a concurrent effort to expand the network model to better support real-time network analysis in line with planning studies.
- Implementation of a major integrated asset health center solution at AEP and the recognition of the relationship between the data managed by the health center and network model data.
- New NERC reliability and compliance mandates, especially NERC MOD 029 ("Available Transfer Capability & Total Transfer Capability" calculations), NERC MOD 030 (Flowgate calculations), NERC MOD 032 (planning model sharing), NERC MOD 033 (validation of planning models based on real-time data), and NERC FAC 008 (facility ratings history).
- Staffing changes and constraints due to retirements and restructuring.

Initial project activity focused in the operations domain, looking primarily at data sharing between the state estimator platform and outage scheduling system. The effort subsequently garnered corporate-level support as the benefits of widening the scope to include the use of network-model data in the planning and protection domains became apparent. With transmission system planning, construction, and operation occupying a key role in AEP's corporate business strategy, AEP's upper management ultimately came to view the creation of a framework to effectively manage transmission network model data across the enterprise as foundational to its future vision for the organization.

Program Benefits

As AEP formally launched the NMMI program, it identified the following areas of anticipated benefits:

- Improved efficiency and reduction in operating cost, through elimination of duplicate processes, facilitation of automation, and decreases in labor.
- Improved overall accuracy of network models and a reduced likelihood of serious operating/ planning errors stemming from bad models.
- Reduced time required to perform or update studies, given accurate tracking of model changes with the ability to recreate cases after changes.

AEP anticipates that coordinated, enterprise-wide management of its network models will allow it to quickly and easily adapt its technology to deal effectively with future regulatory or business changes, putting the company as a whole at a strategic advantage.

2
AEP NMMI SOLUTION DESIGN

Early Design Activities

During the course of AEP's participation in EPRI's "Integrated Network Model Management" supplemental project, AEP laid the groundwork for improving the way that it manages its network model data. The project, in which AEP was one of several participants, envisioned how managing transmission network model data at the participating utilities, and across the industry, might be streamlined. AEP personnel from the operations domain worked together with EPRI over more than 10 months on a series of activities. The flow of information from existing network models was analyzed in detail, an initial design for a consolidated NMM solution was articulated, and the applicability and benefits of the solution to AEP were validated by means of use cases. From the work, a high-level roadmap was developed for AEP providing suggestions on next steps for starting down the path toward implementation.

Documentation of Existing Information Flows

An initial data-gathering activity, kicked off with a two-day workshop onsite at AEP, identified in-scope systems and the AEP work groups that used them and that maintained AEP's data. It also explored and documented existing information flows in a series of Visio diagrams, one set for each of the operating areas. Samples of the information-flow diagrams, for AEP's SPP footprint, are shown in Figure 2-1, Figure 2-2, and Figure 2-3.

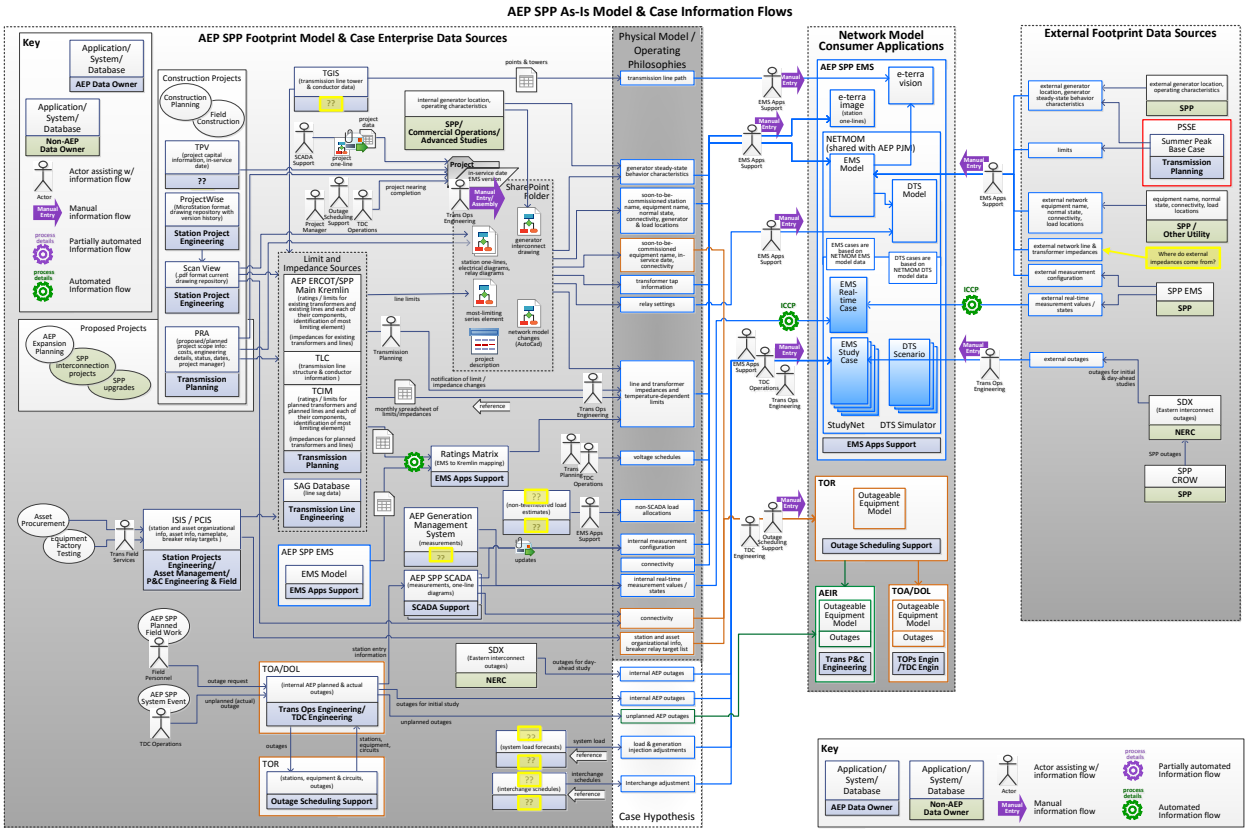

Figure 2-1
Network model data flows to AEP network analysis applications

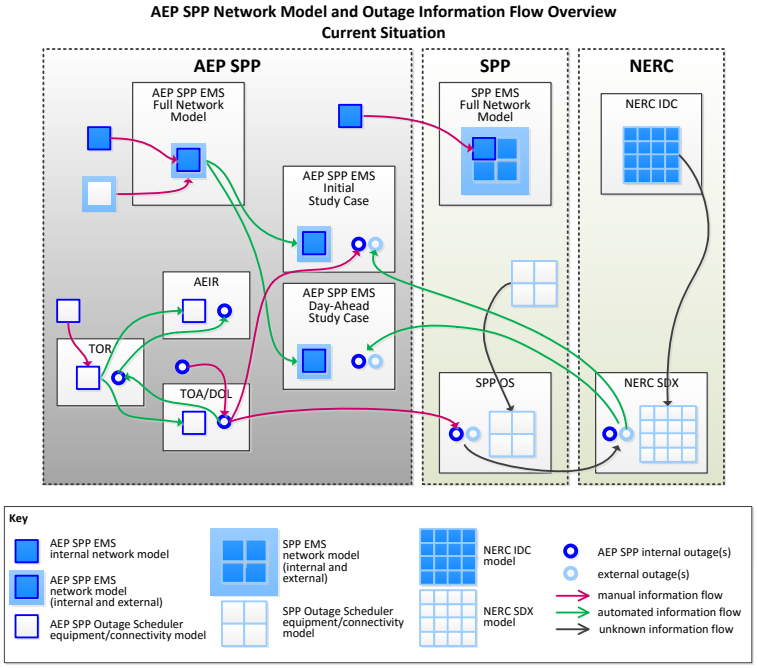

Figure 2-2
Network model data flows related to outage scheduling

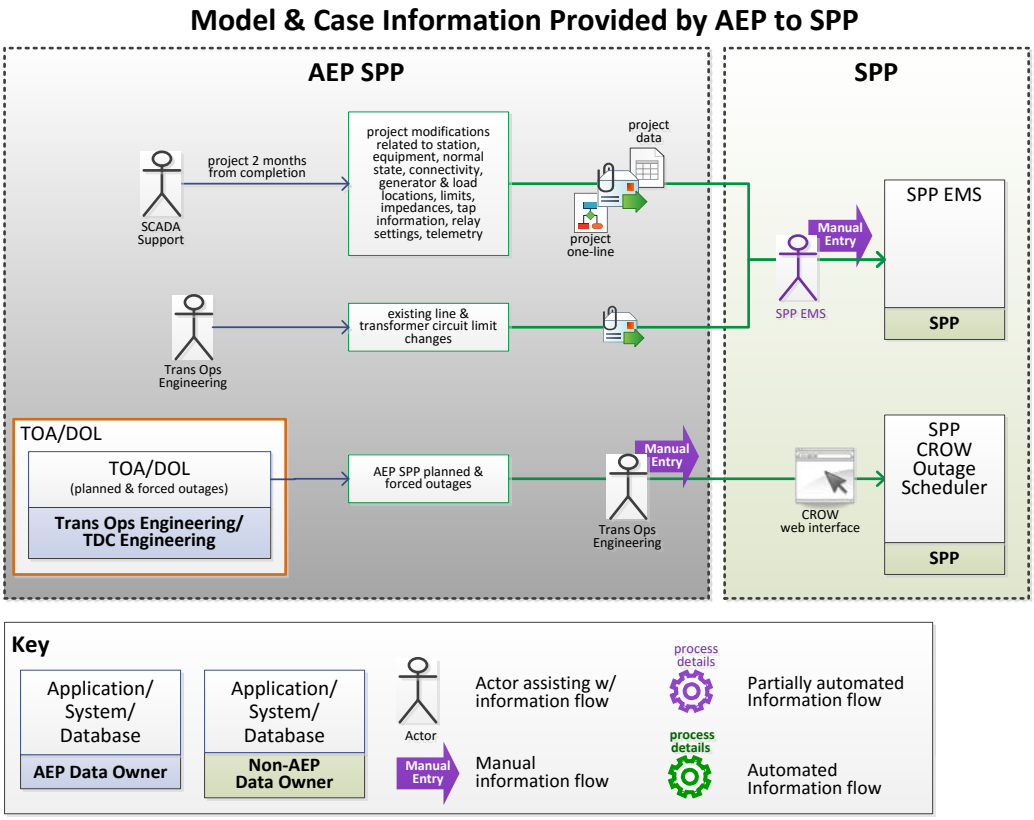

Figure 2-3
Network model data supplied to ISO by AEP

Validation of Initial Proposed Architecture by Means of Use Cases

An NMM architectural approach for consolidated management of network model data was proposed, where a network model manager function would:

- Accept detailed equipment and connectivity input from a variety of data sources.
- Maintain detailed master data as “model parts” and “projects” (projects being changes to model parts).
- Support the assembly of model parts and projects into cases, expressed at the appropriate level of detail and for the desired moment in time.
- Export those cases to interested consumer applications.

The proposed NMM architectural approach was explored and validated by AEP using a collection of approximately 20 use cases, which envisioned how the network model manager function might facilitate managing network-model data at AEP. The use cases accomplished a number of purposes:

- They helped AEP personnel “become believers” as they envisioned how an NMM approach might help them in their work.
- They validated the EPRI and AEP team’s understanding of data-exchange requirements.
- They allowed a preliminary set of NMM tool requirements to be developed.

A high-level diagram of the grouping of those use cases into process groups, which interact with an NMM to effectively manage network-model data, is shown in Figure 2-4.

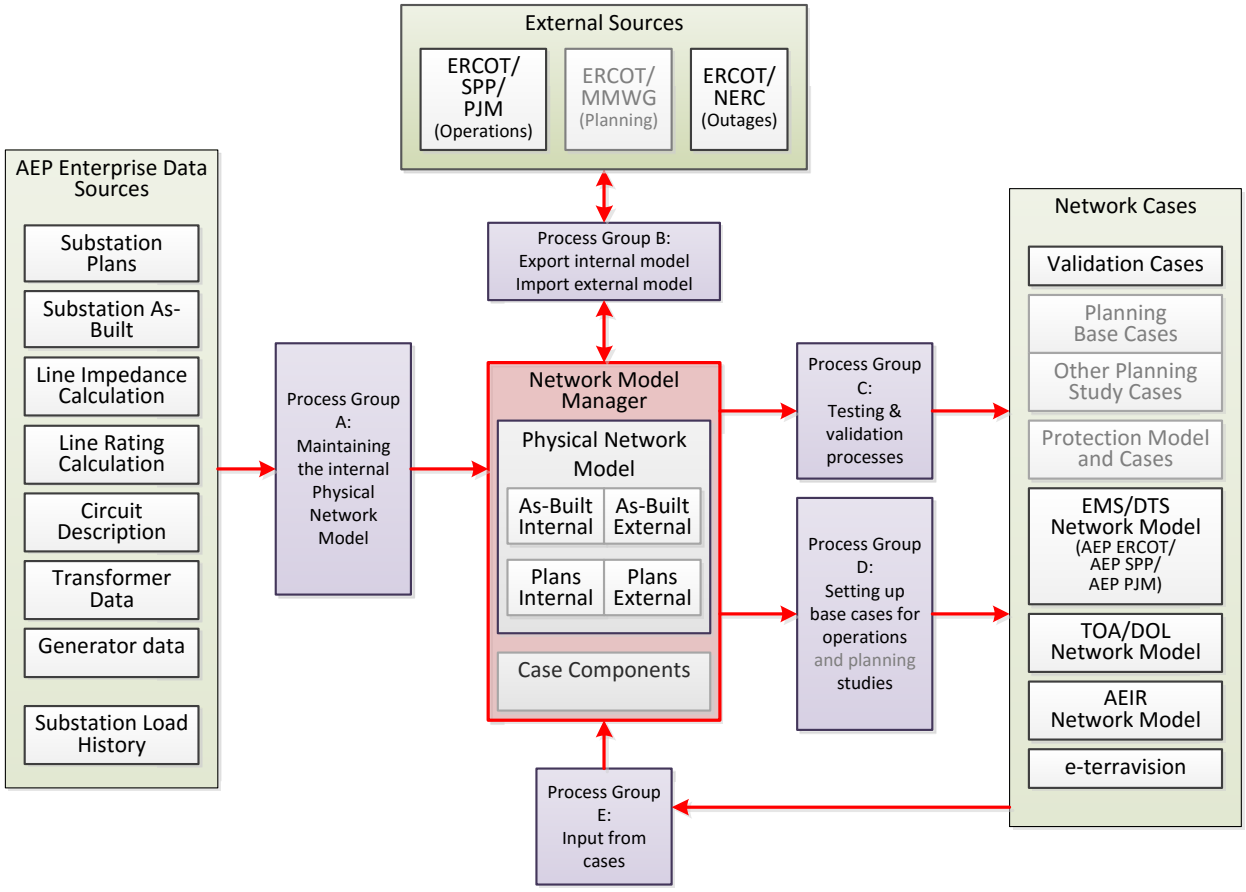

Figure 2-4
Use case process groups used to explore NMM requirements and NMM role within AEP network model management

Next Steps Definition

Next steps suggested for AEP as a result of the "Integrated Network Model Management" project included:

- First phase – EMS network model sourcing from NMM
- Second phase – Sourcing of outage scheduling system equipment definitions from NMM

Additional subsequent activities were also suggested that addressed import of external EMS models from ISOs, inclusion of e-terravision (mapboard visualization software) into the scope of work, and leveraging asset information more directly.

A final recommendation focused on the possibility and benefit of increasing the scope of consideration to include the network model management activities of the AEP planning and protection domains. Specifically, it was suggested that there appeared to be significant potential benefit afforded by merging the functions of the proposed NMM solution with the functions of an existing AEP homegrown application to manage impedance and ratings called Kremlin.

Sample of Initial Design Methodology

The methodology followed in the "Integrated Network Model Management" project at AEP was documented in a publicly available EPRI report, *Network Model Manager and Repository: A Guide to Exploring the Potential of Centralized Network Model Management* [1]. The report provides step-by-step guidance on data gathering, architecture validation, benefits definition, and processes for planning "next steps" activities. In addition, it illustrates the use of the methodology at a hypothetical transmission utility.

Early Design Process Observations

Many of the challenges common to integration design were encountered during the initial work in the AEP operations domain.

- Multiple work groups were involved across AEP's three operating areas, including those supporting the state estimator platforms, the supervisory control and data acquisition (SCADA) systems, and the multiple components of AEP's outage scheduling system. This meant that in addition to the technical work, effort needed to be expended in developing solid working relationships, in understanding and acknowledging different perspectives and priorities, and in identifying terminology that could be commonly understood.
- Participation from both information technology (IT) staff and business unit staff was necessary. IT resources included both those who maintained transmission applications/infrastructure and those who provided enterprise-integration expertise for the utility. Because it is not uncommon for transmission organizations to have their own in-house IT resources supporting the EMS or home-grown rating- and impedance-management tools, forming the required partnerships between transmission business units and corporate IT was a new undertaking with many areas of uncertainty.
- Existing information flows and business processes that were explored and documented were localized solutions that only indirectly reflected the true requirements for managing and exchanging AEP's network model data. This is a normal situation in enterprise-wide integration and requires an approach that teases out the underlying organization of data and its required patterns of management and exchange. Luckily, the International Electrotechnical Commission (IEC) Common Information Model (CIM), specifically the 61970 set of standards, provided a solid starting point for understanding the nature and logical organization of network model data.
- Existing NMM vendor products lacked either the required functionality, the required data-exchange interfaces, or both. While this situation is not atypical in integration efforts, it was particularly obvious when AEP considered NMM product integration. No potential vendor had an NMM product that provided the full range of functions actually required to manage network model data at an enterprise-wide level. However, five or six vendors had products that had basic network model configuration functionality as well as the potential to be developed into a fully-fledged NMM tool. To address the lack of maturity in the NMM tool market, AEP joined a multi-member EPRI "NMM Functional Requirements Definition" collaborative project to publicly define industry requirements for an NMM tool. Eight utilities and two software vendors contributed the work that resulted in a publicly available EPRI document, *Network Model Manager Technical Market Requirements: The Transmission Perspective* [2].

Design Activities After Official Program Launch

The formal launch of the NMMI program included an expansion in scope to include the applications that utilize network models in the AEP planning and protection domains, as well as the systems providing source engineering detail information. As a result, the design work of the first phase was updated.

The information flow documentation created during the initial phase was augmented to reflect:

- Data going *to* two planning tools (the PSEE network analysis tool, the MOD data management tool) and *to* the Aspen protection tool (as well as data going *to* the corresponding systems at the three ISOs).
- Data coming *from* the IPS system (station engineering detail), *from* the TGIS system (transmission line engineering detail), and *from* two Kremlin instances (circuit ratings, circuit impedances, and project definitions).

By this point in time (about two years after the operations domain work), the initially proposed NMM solution architecture had been well-vetted by not only by AEP but also by the IEC CIM Standards Working Group, by other utilities, and by the vendor community. Using the NMM architecture as a basis, AEP set about a comprehensive exploration of how to organize AEP's business processes around an NMM tool in order to avoid duplication of effort and ensure high-quality network models. The exploration was done by means of a collection of business scenarios, which described functionally how the NMM solution architecture would be used by AEP to accomplish the full range of maintenance of its network-model data and case assembly tasks. The output of the business scenario work provided a design foundation that was essential to subsequent detailed designs of the data exchanges and adapters; it helped the AEP team sequence the incremental integration steps of the project; it refined and clarified NMM functionality requirements, which were used in crafting AEP's NMM request for proposal (RFP) to vendors; and it gave AEP insight on approaches to populate an NMM, which could effectively support intended usage.

At the time of this report, AEP is in the final stages of its vendor- and product-selection process and is beginning the next (more detailed) level of design in a number of areas. Work is being done in fleshing out the specific data-management functions performed by each system, in finalizing what data is sourced from which system and how it is shared with other systems, and in how AEP business processes and work groups will be redefined to appropriately support the new data-management strategy. The business scenarios, which are overviewed in the next section, have provided the basis on which these current activities can be successfully undertaken.

3
AEP NMM BUSINESS SCENARIOS

This section provides an overview of the business scenario approach utilized by AEP in its Network Model Management Improvement program for exploring and articulating its high-level solution design. The content of a lengthy and detailed AEP "NMM Business Scenarios" document is summarized here to provide the reader with a sense of the nature and usefulness of business scenarios and the breadth of the scope that they documented in AEP's high-level design. Background information on the organization of business scenarios into business scenario groups is provided, along with information about model parts, a fundamental concept in managing network-model data. Then each business scenario group is explored. Finally, two complete business scenarios are presented as samples of scenario content.

Background

The AEP vision for network model data management is to organize all of its network analysis business processes around an NMM system in order to avoid duplication of effort and ensure high-quality models as network analysis becomes more and more central to utility operations and planning. The purpose of business scenarios is to describe functionally how NMM will accomplish its goal by articulating how key business processes will utilize NMM.

AEP business scenarios are categorized into four groups, three of which are illustrated in Figure 3-1:

- The business scenarios that maintain the master elements of the network-model data, including integration with engineering data sources to collect data automatically. This is the New Construction Projects business scenario group.
- The business scenarios used to create network studies (both planning and protection) from the elements of the master-model data. This is the EMS business scenario group.
- The business scenarios used to configure the real-time operations of the control center based on the elements of the master-model data.
- The re-usable general functions and services associated with NMM.

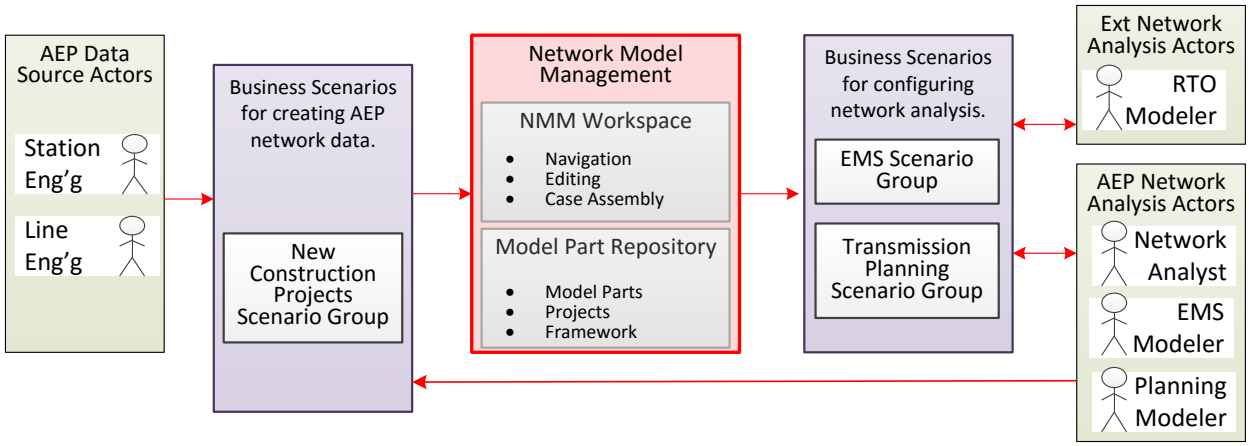

Figure 3-1
Business scenario groups

NMM is designed to collect master network modeling data from AEP sources (at the far left in Figure 3-1) and make that data available to network analysts (at the far right). NMM (in the middle) allows all network analysts to share the common pool of master data. NMM itself has two main parts:

- The Model Part Repository maintains the master datasets required to produce network analysis cases representing all required situations and time frames.
- The NMM Workspace allows NMM users to browse and edit model parts and to execute case-assembly procedures as required.

Network Model Parts

A primary goal for NMM is to unify all network modeling around a set of non-overlapping master model parts building blocks that can be used to create all required kinds of network models and cases. The point of "non-overlapping" is that data is entered once in a fashion that makes it available for all purposes. Most of the business scenarios describe either creating model parts or using the building blocks of these model parts in assembling complete models and cases. Several key ideas govern the model parts as they are used by NMM:

- A model part framework defines how the overall grid is subdivided into non-overlapping extents for assembling network models.
- Each model part occupies a specific "frame" in the framework, is maintained by one modeling authority, and contains data of one type. Types of data include:
  - Equipment (EQ) – the existence, characteristics, and connectivity of grid equipment
  - Short Circuit (SC) – characteristics required for short-circuit studies
  - Dynamics (DY) – dynamic (sub-cycle) behavior characteristics of generators and loads
  - Normal Operating Plan (NOP) – normal states and nominal control strategies
  - Diagram Layout (DL) – one-line diagram layout
  - Steady-State Hypothesis (SSH) – power flow inputs for a particular case (generator and load injections, breaker/switch states, voltage-control strategies)

  - Topology Processor (TP) – result of topology analysis that computes power flow buses from nodes and switches
  - State Variables (SV) – power flow solution
- A base set of as-built model parts represents the complete current state of all AEP territory and all external territory that is of importance in any AEP network analysis context.
- A timeline that models the evolution of the grid is created with projects that describe planned changes to the grid.
- Appropriate model parts, plus specific selected projects, are used to create network models and cases for a given point in time. These are exported by the NMM for use by various network-analysis applications.

In NMM, all network models are built from master model parts, and all processes for assembling network models begin by loading a subset of as-built model parts. Each as-built model part describes the current state of one type of data for some part of the grid (usually for one frame).

Adjustments in NMM are managed as projects. Most projects represent a planned or hypothetical change to the grid and have an associated schedule for implementation, so that models can be automatically built for a requested future time. As-built model parts need to be updated from time to time as the grid changes. This creates a series of versions for each instance of a model part.

AEP's Business Scenario Groups

NCP: AEP New Construction Projects (NCP) Business Scenario Group

This business scenario group covers the data-maintenance activities associated with new construction projects as they proceed from initial proposals through to engineering design, construction, and commissioning. Because as-built model parts are updated only by adding new projects to the previous as-built version, these scenarios cover maintenance of all of the AEP master source data in NMM.

NCP business scenarios have two key objectives:

1. Define one method of maintaining network models for all of AEP (the same processes shall apply whether it is ERCOT, SPP, or PJM territory).
2. Eliminate duplication of data (planning, operations, protection, and all other users of network analysis operate from the same source of information in the NMM system).

In these processes, the main division of responsibility is as follows:

- Operations (EMS modeling) is the source of the initial as-built state of the network in NMM.
- Planning has the primary responsibility for maintaining future projects in NMM, including versions that reflect engineering detail imported from IPS and TGIS.
- Other specialized groups will add information that is specific to their specialty (such as dynamic models).
- Operations and planning are jointly responsible for updating as-built model parts for AEP internal.

Figure 3-2 provides a map of the business scenarios comprising the NCP group. In it:

- Green rectangles with single-line boundaries represent business scenarios that are part of this NCP group.
- Yellow rectangles represent individual NMM services documented by the NMM Services business scenario group.
- Rectangles with double-line boundaries represent business scenario groups other than NCP.

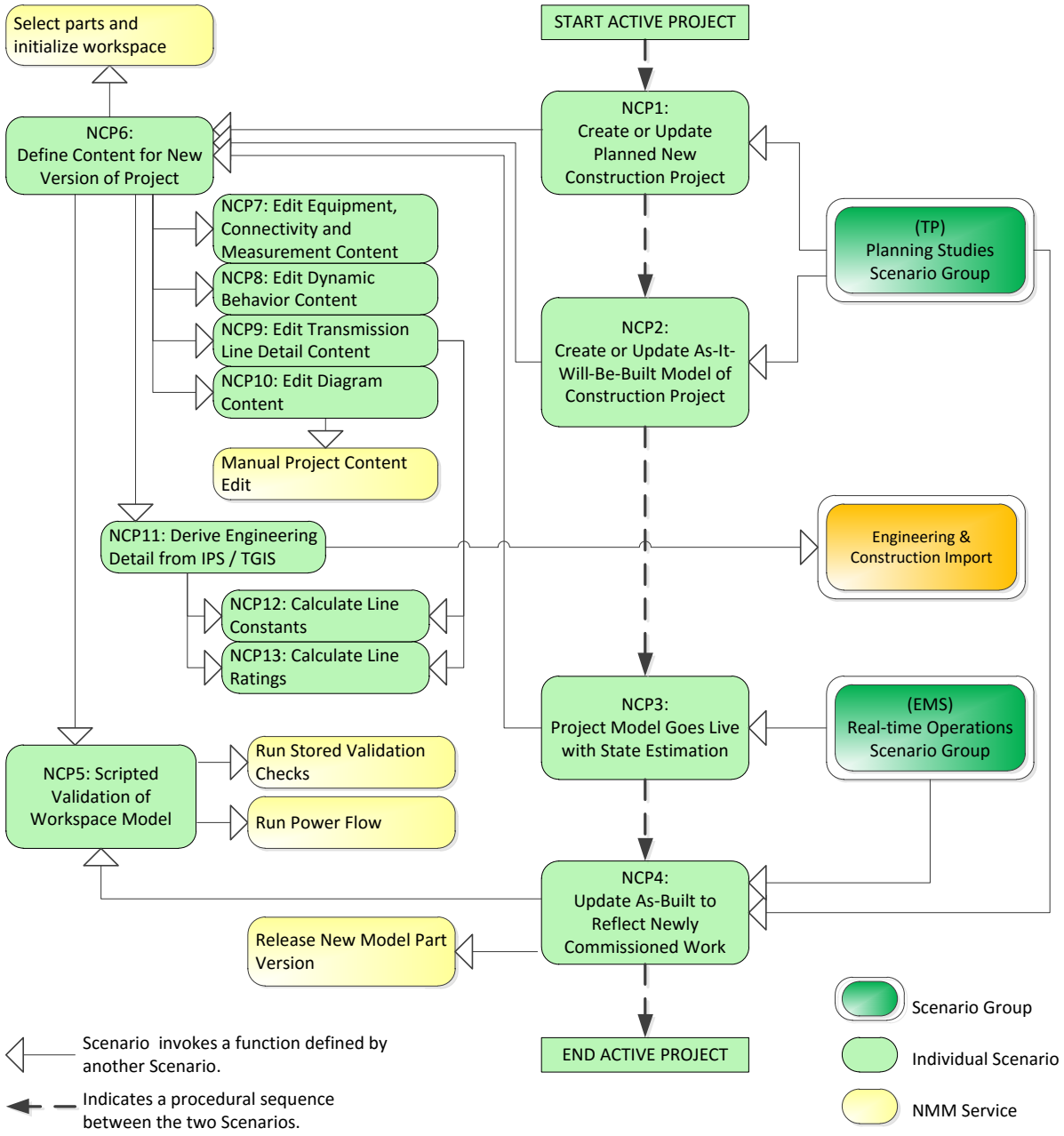

Figure 3-2
Business scenario map for AEP NCP business scenario group

New construction projects typically move through a logical sequence of activities, and there are certain points at which the nature of both the activity and the data changes. These are the primary basis for the breakdown into business scenarios.

The typical starting point is a rough “conceptual” proposal that must be examined for its impact on the grid as a whole. The origin of the proposal may be any number of different sources, but in all cases, the proposal must be expressed in a form that can be analyzed by planning engineers, and this initial expression usually just captures the minimal amount of information required to support that analysis. Scenario NCP1 covers the initial specification of the proposal and any subsequent revisions that occur while planners are evaluating the proposal.

Proposals that survive analysis and are approved at some point are passed from planning into the hands of engineering and construction organizations for a detailed design. At a further point in the engineering and design activity, an initial engineering design is completed that in general has much more detail than the original plan and more detail than is desired for network analysis. Because this design may be different in some respects from the original plan, studies being run for the time period where this proposal would be commissioned should now use an updated view of the plan derived from the engineering modeling. This significant new revision of the plan and any subsequent design revisions are covered in NCP2.

Eventually, a project goes live in the field. At this point, the latest model of the project is incorporated into EMS models and is being used by state estimation, which provides quantitative evaluation of the accuracy of the modeling for network analysis. While engineering and construction is still the responsible party for source data, responsibility for the network model representation has really passed to operations. This activity is covered in NCP3.

The last phase of project data occurs when operations has been successfully using the modeling and is ready to stop treating the model as a stand-alone change and declare it as part of a new version of the as-built model part. This final stage is covered in NCP4.

Other scenarios in this group define sub-processes that are used in one or more of the primary scenarios. Table 3-1 lists the summary statements of the scope of each business scenario.

Table 3-1
Summary statements of the scope of each business scenario

NCP	Scope
NCP1: Create or Update Planned New Construction Project	Create or update a project representing the plan for a proposed new construction project.
NCP2: Create or Update As-It-Will-Be-Built Model of Construction Project	Update a project with results of detailed engineering design to reflect more accurate “as-it-will-be-built” version of the plan.
NCP3: Project Model Goes Live with State Estimation	Project construction is complete and is energized. Control center state-estimation software begins using the latest model of the project, providing direct validation of the accuracy of project models.
NCP4: Update As-Built to Reflect Newly Commissioned Work	When project modeling is verified as accurate, the project is ready for incorporation into a new release of an as-built model part.
NCP5: Scripted Validation of Workspace Model	User executes a validation procedure (such as set up and run power flow).
NCP6: Define Content for New Version of Project	User defines the changes to the network model that are expected for a particular project stage.
NCP7: Edit Equipment, Connectivity, and Measurement Content	User manually enters the data associated with project modification of EQ model parts.
NCP8: Edit Dynamic Behavior Content	User manually enters the data associated with project modification of DY model parts.
NCP9: Edit Transmission Line Detail Content	User manually enters the detail description of line construction associate with project, leading to calculation of line constants and ratings.
NCP10: Edit Diagram Content	User manually enters the data associated with project modification of DL model parts.
NCP11: Derive Engineering Detail from IPS/TGIS	Integration with IPS/TGIS to acquire detail of line construction associated with project.
NCP12: Calculate Line Constants	Computes line constants from line construction detail.
NCP13: Calculate Line Ratings	Computes line ratings from evaluation of most-limited series element.

TP: Building Study Cases (TP) Scenario Group

The TP business scenario group describes how NMM supports AEP business processes for creating base cases for planning and protection studies (study base cases). It covers all activities that use NMM as a data source for creating study base cases. This includes studies for all analytical purposes: interconnection planning, dynamic analysis, short-circuit analysis, electromagnetic transient analysis, and so on.

An overview of the group is given in Figure 3-3. At the left, scenario TP1 covers the basic process of creating any kind of case, whether a simple power flow or a study that requires additional specialized modeling, such as dynamic behavior. All types of cases are covered by this single scenario because mechanically, the only difference between, say, a short-circuit case and a dynamic case, is the particular model parts that are selected by the script that defines the case.

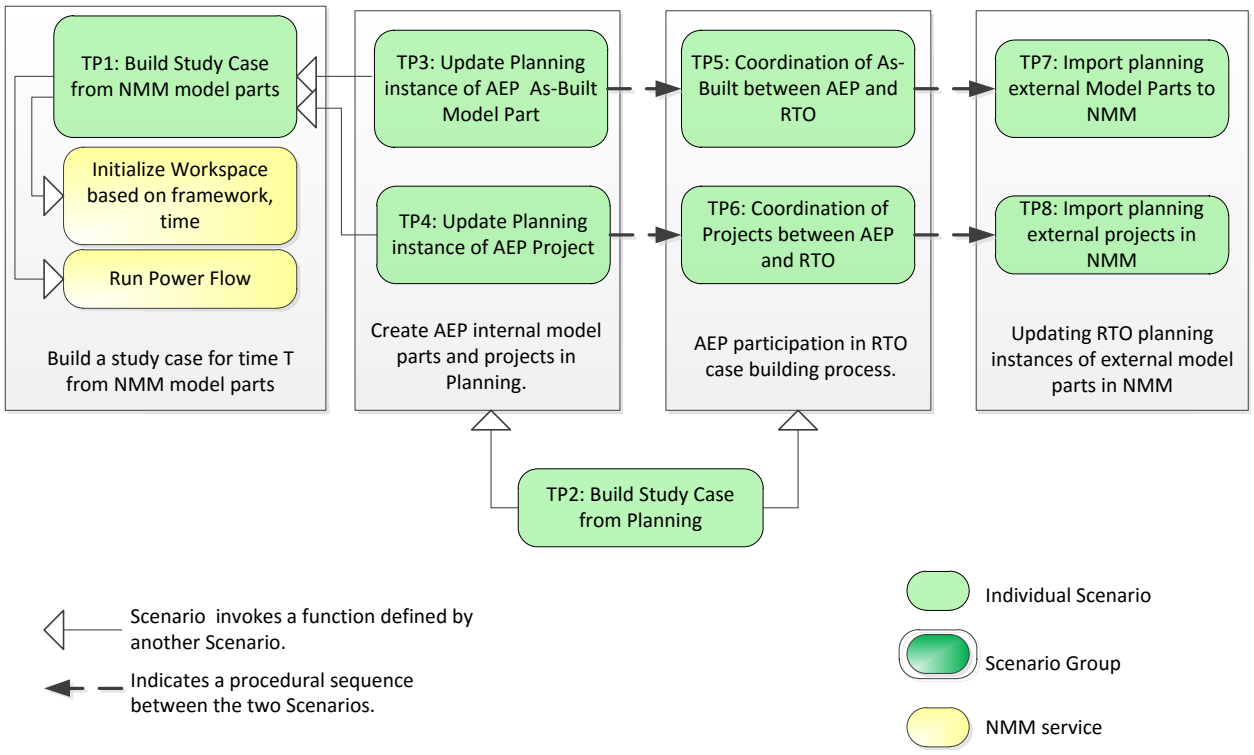

Figure 3-3
Business scenario map for TP business scenario group

If AEP was an island by itself, no other business scenarios would really be required. However, AEP operates within interconnected grids governed by three different RTOs, each of which has multiple transmission owner members, which are the source of record for modeling in their territories. These RTOs are responsible for grid planning and determine a set of processes in which AEP must participate. These processes are typically orchestrated around traditional “bus-

branch" planning tools and modeling approaches that are separate from the modeling processes used in operations. As a result, our scenario group includes integration of NMM with a planning environment at AEP and a planning environment at the RTO:

- TP2 defines an alternative process for building study cases from the planning environment.
- TP3 and TP4 update the AEP planning data from NMM, so that planning is synchronized with NMM.
- TP5 and TP6 coordinate between AEP planning and RTO planning.
- TP7 and TP8 bring external models obtained from RTOs back into NMM.

Table 3-2 lists the summary statements of the scope of each scenario.

Table 3-2
Summary statements of the scope of each scenario

Scenario	Scope
TP1: Build Study Case from NMM Model Parts	Generic procedure that creates a solved case in an NMM workspace from NMM model parts and projects—usually for specified time and scope—which is defined in a script.
TP2: Build Study Case from Planning	Alternative to TP1 that constructs a study case from artifacts in a planning system that has been populated from NMM.
TP3: Update Planning Instance of AEP As-Built Model Part	Describes the process for updating the planning system AEP as-built models from NMM.
TP4: Update Planning Instance of AEP Project	Describes the process for updating the planning system view of AEP projects from NMM.
TP5: Coordination of As-Built between AEP and RTO	Describes how AEP updates as-built representation at an RTO and how AEP receives updates of the external as-built from an RTO.
TP6: Coordination of Projects Between AEP and RTO	Describes how AEP updates its projects at an RTO and how AEP receives updates of external projects from an RTO.
TP7: Import Planning External Model Parts to NMM	This scenario updates NMM instances of planning external model parts. (Note that planning externals are different from operations externals, but both share the same internal model parts.)
TP8: Import Planning External Projects in NMM	Describes how an external project in planning (imported from an RTO) is converted into a project in NMM.

EMS: Real-Time Operations (RTO) Business Scenario Group

AEP has three active EMS sites. Each of them require network models for the territory in which they operate plus any external areas that are significant to the analysis carried out in the EMS. Two of the EMSs are part of the eastern interconnection. The other is in the ERCOT interconnection. The external models for the two eastern EMSs overlap. There are DC connections and open AC ties between ERCOT and the eastern interconnect.

This group of business scenarios describes how NMM supports the supply of network models required for AEP operations. This includes:

- Network models for configuring AEP's three EMS.
- Network models that fulfill AEP's modeling obligations with PJM, SPP, and ERCOT RTOs.

Major objectives:

- Build EMS configuration from the same source material as is used in AEP planning scenarios.
- Make EMS modeling identical to RTO modeling, wherever both represent the same objects.
- To the maximum extent possible, align modeling practices for the PJM, SPP, and ERCOT domains.
- Include the asynchronous ties between ERCOT and the east in the modeling to achieve a single continuous model.

EMS state estimation requires that EMS network models must contain measurement objects associated to measurement sources. SCADA is sometimes installed only to support network analysis. (For example, where SCADA at an RTO imports network measurements only via ICCP.) In these cases, the required SCADA configuration files may be completely derivable from the network model. If, however, the purpose of a SCADA is the more traditional operations role that includes alarming, logging, supervisory control, and the like, then a "complete" SCADA modeling activity is required, and many of the measurements will have no network-modeling purpose.

At this point, it is an open possibility that there could be a new NMM model part that provides complete SCADA configuration, but this is unresolved. The process descriptions listed in Table 3-3 and Table 3-4 show SCADA configuration as coming from NMM, but the functionality of the processes would not change significantly if SCADA files are built independently using existing maintenance tools.

Table 3-3
Process descriptions of ERCOT business scenarios

ERCOT Business Scenario	Process Description
EMS1: Network Model Assembly at AEP Texas EMS	The network model assembly procedure will produce the following configuration files for the Alstom EMS: • AEP Alstom EMS Network Configuration • AEP Alstom Fake SCADA Configuration • AEP Alstom ISD Configuration
EMS2: ERCOT Network Model Import to AEP NMM	This scenario acquires the latest ERCOT network model from ERCOT. The external ERCOT model is then available in NMM for both informational purposes and for construction of models for AEP Texas EMS. The internal is available as a cross-check for consistency with modeling at the AEP Texas EMS.
EMS3: ERCOT Project Import to AEP NMM	This scenario acquires a selected ERCOT project from ERCOT NMMS. Such projects are then available to be used in constructing EMS configuration or future cases.
EMS4: Real SCADA Assembly at AEP Texas EMS	The real SCADA system is the operator's SCADA. It is defined from a SCADA model part that defines required SCADA data, including the behavioral configuration and RTU scanning configuration.
EMS5: Send Configuration Information to ERCOT EMS	AEP is solely responsible for maintaining the ERCOT modeling of AEP territory, and there is a set of procedures that ERCOT has defined that dictate what information must be supplied and when. The normal situation involves AEP submitting its future planned construction, but it may at times also be necessary for AEP to send a correction to ERCOT of the present AEP model.

Table 3-4
Process descriptions of PJM business scenarios

PJM Business Scenario	Process Descriptions
EMS6: Update Network Model Configuration at AEP PJM EMS	This scenario describes how the network model configuration is supplied to the New Albany EMS, which covers AEP's PJM operation.
EMS7: Update AEP Model at PJM	This scenario updates the AEP modeling used by the PJM EMS.
EMS8: Import PJM Model	This scenario acquires the latest PJM EMS model from PJM.
EMS9: Update AEP External Model Parts and Projects in NMM	This scenario describes update of AEP external node-breaker model parts from the model acquired from PJM.
SPP Business Scenarios	*<These business scenarios should be identical to PJM for configuration of the AEP EMS except that real SCADA configuration at SPP uses Alstom SCADA. SPP model management may have some differences from PJM. This needs review.>*

NMM: Network Model Management Functions

NMM functions describe re-usable procedures or services within the NMM implementation. These scenarios are written separately from the business scenarios, usually for one of the following main reasons:

- A generic parameterized service is required in order to achieve flexibility to cover business uses beyond what is explicitly described in business scenarios.
- The case-specific steps that are detailed in the business scenario, which uses the function should inherit a consistency of design and/or user look and feel from the generic steps outlined here.

The first situation expresses functionality that is probably used in a call and return pattern, while the second simply expresses a generic pattern of steps. In both of these situations, the business scenario using the function will describe characteristics specific to the particular usage, while the functions shown in Table 3-5 describe the activity generically.

Table 3-5
NMM functions

NMM Function	Description
NMM1: Manual Project Create/Update	Outlines the procedure by which a user of NMM can manually create a project (that is, a set of changes) by capturing a series of edits against a model.
NMM2: Register Identity of Public Object	Generates an MRID (master resource identifier) for a new object and stores the new object in the AEP object registry with additional metadata.
NMM3: Apply Change Set to a Dataset	Applies a ChangeSet, such as would describe the changes associated with a project stage, to a Dataset representing the state of some business system.
NMM4: Initialize Workspace to Specified Criteria	Selects and adds one model part to a workspace.
NMM5: Execute Power Flow	Executes a power flow on the workspace content, generating a steady-state solution.
NMM6: Release New Model Part Version	Stores an updated version of a model part.
NMM7: Run Stored Validation Checks	Executes selected stored validation checks.
NMM8: Diff Datasets	Compares two models and generates a project representing the difference.
NMM9: Dataset Merge	Merges a dataset into a workspace, resolving external references.
NMM10: Report Generation	Provides user access to report generation facilities that can document NMM content.

Example Business Scenarios

Two selected business scenarios are presented in their entirety below and illustrate the type and level of detail of information that AEP typically included in its scenarios. The first business scenario is NCP2: Create or Update As-It-Will-Be-Built Model of Construction Project, which describes the process of creating a detailed description of the changes to the network model that will occur as the result of construction activity. Its role in the AEP New Construction Project (NCP) business scenario group is illustrated in Figure 3-4.

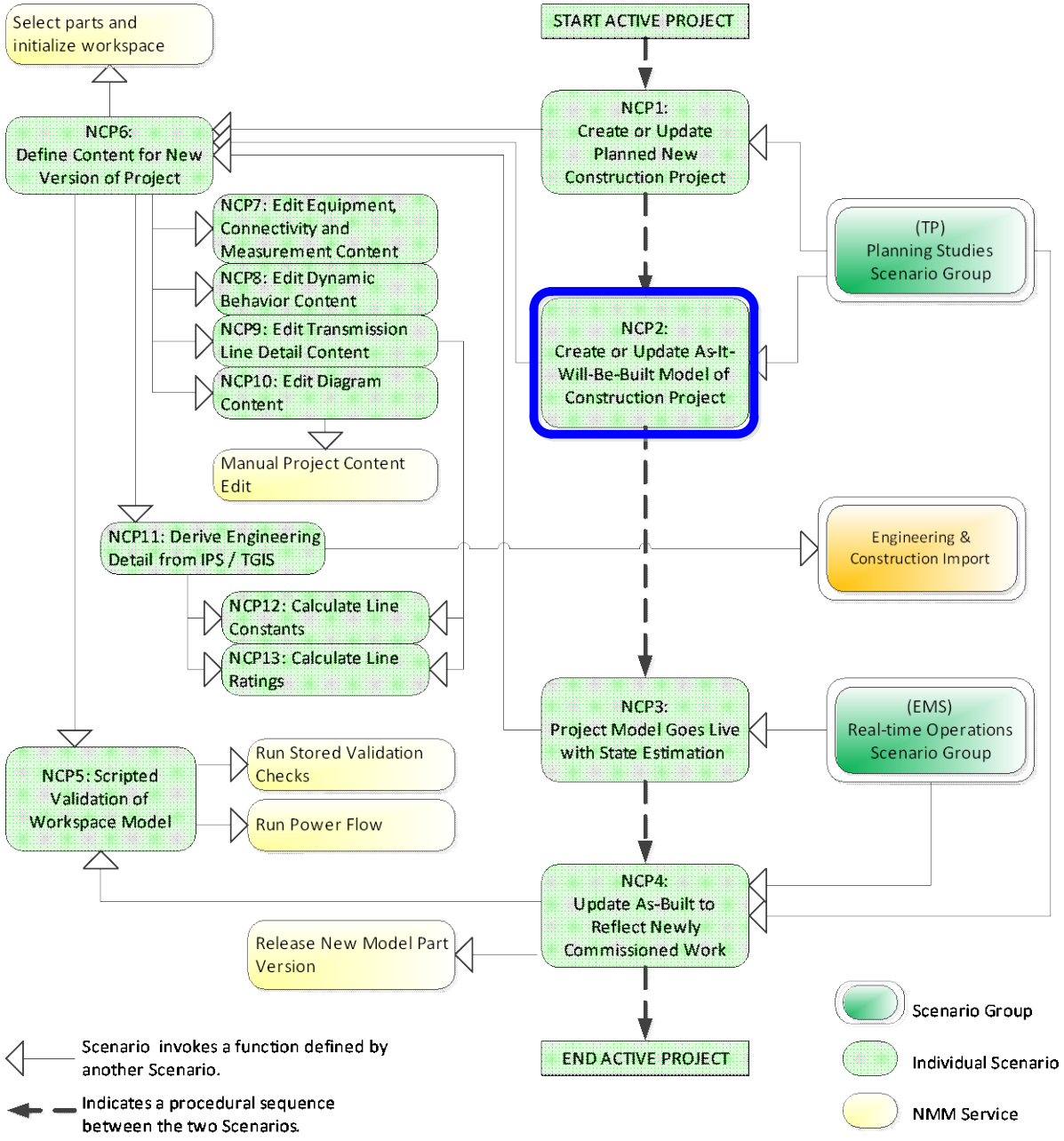

Figure 3-4
NCP2 business scenario in the NCP business scenario group

The other business scenario is TP4: Update Planning Instance of AEP Projects, another scenario that relates to the definition of projects (changes to the network model). In this scenario, detailed project information, of the sort created by scenario NCP2, is transformed into a simplified project description in bus/breaker form appropriate for use by a planning network analysis tool. Its role in the Building Study Cases (TP) business scenario group is illustrated in Figure 3-5.

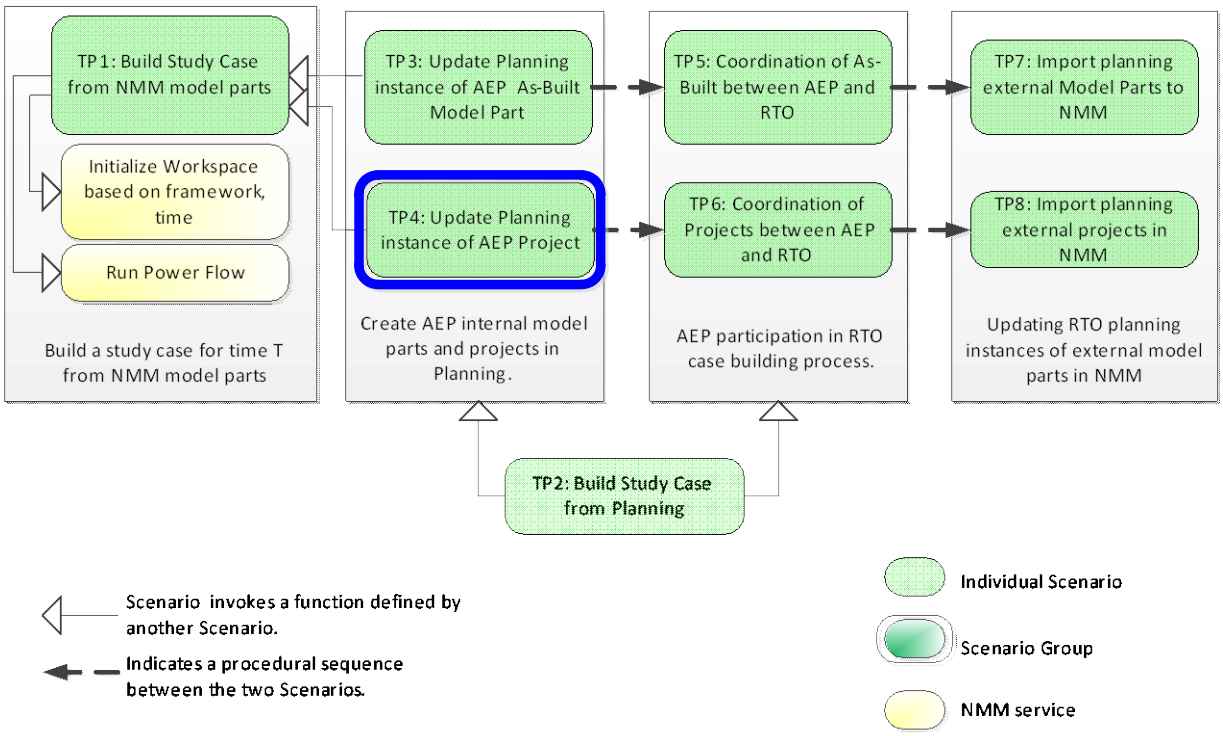

Figure 3-5
TP4 business scenario in the TP business scenario group

NCP2: Create or Update As-It-Will-Be-Built Model of Construction Project

Purpose

When a planned project is turned over to engineering and construction, the first step is to create a detailed design and schedule of work activity. As soon as the detailed design and schedule are available, network models—particularly those used in operating studies—need to reflect this more accurate "as-it-will-be-built" version of the plan, so an update of the project needs to be created within NMM. As the design proceeds, these models need to be updated appropriately until ultimately an as-built version is produced.

Assumptions/Design Considerations

- The main technical assumption in this scenario that is different from NCP1 is that the user is creating a new version of a project based on available engineering design detail.
- Projects may be defined with multiple stages of work.

Pre-Conditions

- Project design has reached the stage where project detail is known.
- Source data exists in IPS/TGIS.

Triggers

- This business scenario begins when detailed construction data is available and a new as-it-will-be-built version of the project needs to be reflected accurately in network analysis cases.
- Also triggered when detailed construction data changes.

Normal Sequence

Table 3-6
Normal sequence of NCP2

Step	Functional Actor	Action	Comment
1	NMM Modeler	If the project is new, engineering plan is reviewed to establish the project scope and number of stages. Also the content of data import from IPS/TGIS is checked.	Project is broken into stages depending either on periods of time where the electrical grid is impacted differently or because different parties are responsible for different parts of the work (e.g. if tie lines are involved).
2	NMM Modeler	Project envelope information is revised.	If new, project is created and new project envelope data is entered. If old, project to update is selected.
3	AEP Modeler	Change content for the project is defined.	Uses NCP6. Note here that this differs from editing in NCP1 primarily in that the engineering detail objects are in view.

Post-Conditions

- Operations and planning versions of project are usable for case assembly activities.
- Project dependencies (on other projects) are noted.

TP4: Update Planning Instance of AEP Projects

Purpose

This scenario describes the process by which AEP creates a bus-branch representation of an AEP internal project from a node-breaker representation, for use in building planning base cases.

Assumptions/Design Considerations

- For this scenario, it is assumed that the master description of a new construction project is maintained in NMM, as described in the New Construction Project business scenario group documentation.
- It is also possible, for future plans that are only of interest to planners working in bus-branch environments, that some projects might be mastered in the planning environment, at least for some period of time before being moved into NMM. A requirement for such projects, however, is as follows: No project shall be mastered in planning if it is a pre-requisite to any project that is maintained in NMM.

- Projects mastered in NMM are maintained in node-breaker format, even if switching detail is not included. NMM projects will typically include only the amount of detail that makes sense given the design stage of the project.
- Bus-branch projects must be generated by creating “before” and “after” cases and then DIFFing the two cases. The DIFF operation may be performed in either the NMM or the planning environment (if supported by the planning tool). Both methods are shown here, and indeed both could be done and compared as a validation check.

Pre-conditions

- The node-breaker project to be converted is stored in NMM.
- The AEP internal as-built model part to which the project applies is stored in NMM.
- Representation of AEP external parts for planning in NMM have been imported from RTO planning coordinators using TP7: Update NMM External Planning Node-Breaker As-Built from RTO.

Triggers

- An AEP new construction project is created or revised in NMM.

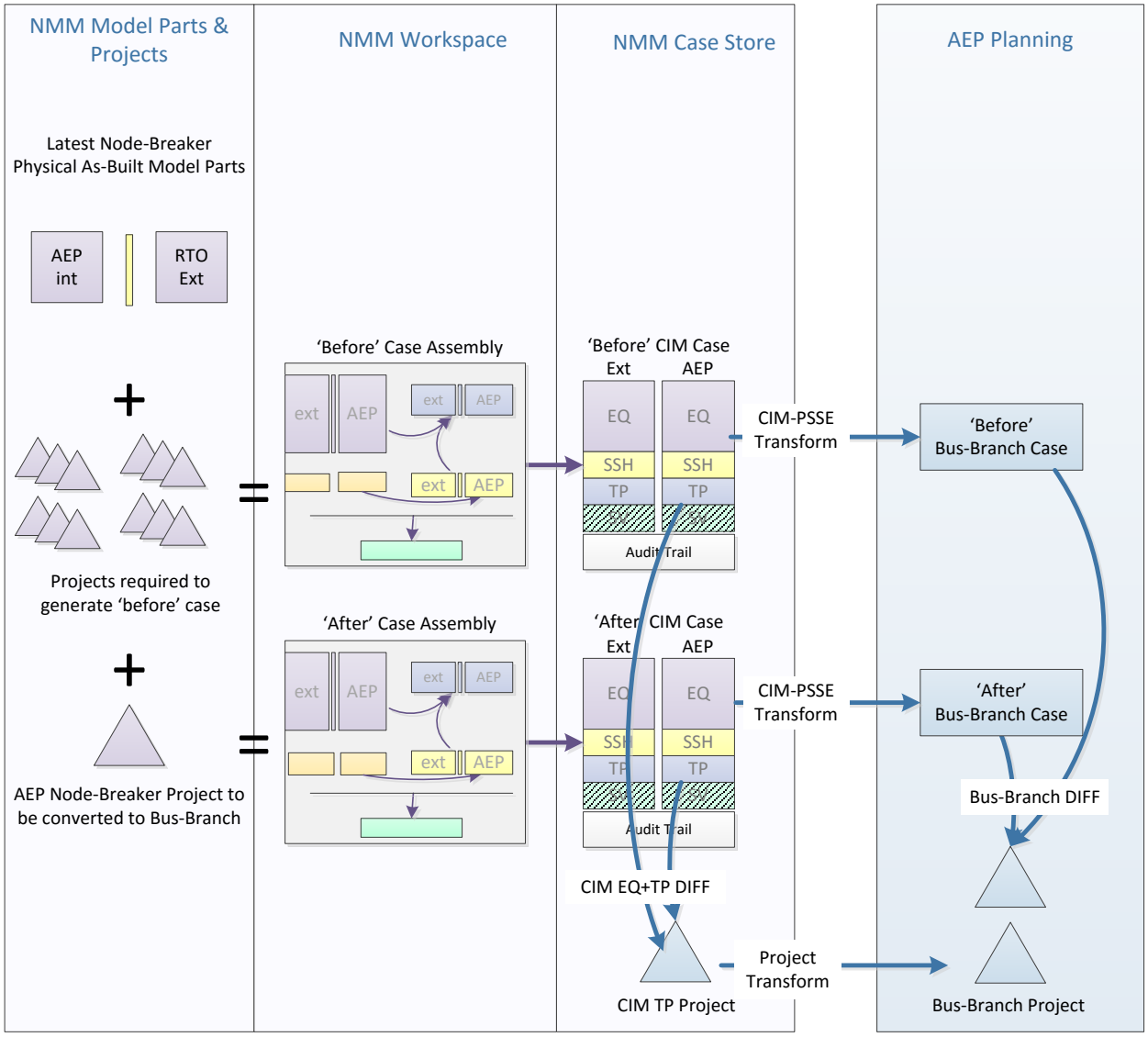

Figure 3-6
Information flow diagram

Table 3-7
Normal sequence of TP4

Step	Functional Actor	Action	Comment
1	NMM Procedure	A power flow case is created in an NMM workspace representing the state of the grid before the project is to be added. AEP territory is the latest NMM as-built for the relevant RTO + all relevant projects. Latest external RTO territory model part is used. Total load, gen, and interchange set to nominal specs. Normal status, taps. Select a time that generates a nominal regulation pattern.	Uses TP1: Build Power Flow Case Only the project is of interest, so external modeling and steady-state hypothesis are only an expedient to get a well behaved power flow. The NMM power flow generates a “TP” model part, which is a bus-branch model. The TopologyNodes in TP are buses and will have been assigned planning names and numbers according to the instructions in the node-breaker EQ model. This is the key information that allows a straightforward conversion to a bus-branch format.
2	NMM Procedure	An ‘after’ power flow case is created as in the preceding step but with the addition of the project that is to be converted to bus-branch.	Uses TP1: Build Power Flow Case
3	NMM Procedure	The before and after cases are DIFFed in NMM to produce a CIM TP Project.	
4	NMM Procedure	The resulting CIM TP project is transformed to a bus-branch project and transferred to planning.	The transform includes the CIM envelope description of the project. If new, a new planning project is established.
5	NMM Procedure	Before and after cases are exported to planning, along with Project identification.	This step converts the two cases to bus-branch form.
6	AEP Planning User	If available, a planning service is used to DIFF the bus-branch cases and generate a bus-branch project.	This creates an alternative version of the project as a cross-check.
7	AEP Planning User	The two instances of the project are compared to verify that they contain equivalent information.	

Post-Conditions

- The planning representation of the project is updated.

4
CONCLUSION

AEP's Network Model Management Improvement program is a major integration initiative, spanning its planning, protection, and operations domains, whose high-level solution design has encountered many of the challenges common in enterprise-wide integration projects in the electric utility industry. Arriving at a solid solution design depended on the collaborative efforts of multiple work groups (both OT and IT) across AEP; it required synthesis of requirements uncovered via in-depth exploration of existing practice; it necessitated combining those requirements with an understanding of the functionality of systems and the nature of the data being shared; it called for the creation of alternative solution proposals and their vetting by means of use cases; and it demanded major modifications to vendor product.

AEP has utilized a number of classic IT design tools and techniques to arrive at a visionary solution strategy, including:

- Information flow diagrams illustrating the path of data across the organization among system and human actors.
- Data exchange standards to inform understanding of the nature of shared data and mechanisms by which it could be exchanged.
- Use cases for the validation of solution design, the communication of project vision to various stakeholders and the development of system functionality requirements.
- Business scenarios to comprehensively explore and document high-level design of the selected solution approach.

This report has focused on AEP's use of business scenarios for understanding and documenting the organization of AEP's network analysis business processes around an NMM tool. AEP's business scenarios, developed during the final stages of its high-level design effort, describe functionally how the NMM solution architecture is to be used by AEP to accomplish the full range of its maintenance of network model data and case assembly tasks. Individual business scenarios are categorized into four business scenario groups:

- NCP: AEP New Construction Project
- TP: Building Study Cases
- EMS: Real-Time Operations
- NMM: Network Model Management Functions

Grouping allowed AEP to develop a "big picture" understanding of how its integration solution would ultimately function, enabled comprehensive consideration of the various facets of data management and the identification of areas where additional design was required, and helped refine the NMM product requirements that were used in the creation of AEP's NMM RFP.

5
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