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Introduction

The Reliability Functional Model Technical Document (FMTD) is intended as a companion to Version 6 of the Reliability Functional Model (FM) to help explain the functions, including the functional entities, the respective tasks performed by each functional entity, and the relationships with other functional entities that are necessary to perform the tasks.

Section I – Functional Entity Tasks and Interrelationships provides details regarding the functional entity tasks and interrelationships. A number of the functional entities, such as the Transmission Owner or Purchasing-Selling Entity, are adequately described in the FM, so there is no need to provide further detail in the FMTD. Other entities, such as the Interchange Coordinator and Balancing Authority, are more complex, including their relationships with other functional entities, and the FMTD provides further explanation regarding how these entities work together to ensure reliability.

Section II – Technical Discussion includes technical discussions on related topics such as managing Arranged and Confirmed Interchange, and functional entity areas and boundaries.
SECTION I - FUNCTIONAL ENTITY TASKS AND INTERRELATIONSHIPS
Part 1 - Reliability Coordinator

The Reliability Coordinator purview must be broad enough to enable it to establish Interconnection Reliability Operating Limits, which will involve System and facility operating parameters beyond its own Area as well as within it. This is in contrast to the Transmission Operator, which also maintains reliability, but is directly concerned with system parameters within its own Area.

The Reliability Coordinator is the highest operating authority; the underlying premise is that reliability of a wide-area takes precedence over reliability of any single local area. Only the Reliability Coordinator has the perspective/vision necessary to act in the interest of wide-area reliability.

The Reliability Coordinator also assists the Transmission Operator in monitoring for and relieving equipment or facility overloads through transmission loading relief measures if market-based dispatch procedures are not effective.

Role in Interchange. The Reliability Coordinator does not receive tags, but may curtail Interchange Transactions until they are arranged and ready for implementation as Interchange Schedules. As such, it does not approve or deny tags. However, once the Reliability Coordinator receives the Interchange Schedule information, it will have the necessary information to aid its assessment of the impacts of flowing and impending Transaction Schedules on its area’s reliability. As necessary, the Reliability Coordinator may issue transmission loading relief requests (or similar requests for congestion management) which may result in reducing, removing or halting flowing or impending Interchange Transactions. This is viewed by some as “denying” the Interchange Transactions although in this context, the “denial” is not provided during the collection of approval stage.

Day-ahead analysis. The Reliability Coordinator will receive the dispatch plans from the Balancing Authority(ies) on a day-ahead basis. The Reliability Coordinator will then analyze the dispatch from a transmission reliability perspective. If the Reliability Coordinator determines that the Balancing Authority’s dispatch plans will jeopardize transmission reliability, the Reliability Coordinator will work with the Balancing Authority to determine where the dispatch plans need to be adjusted. The Reliability Coordinator obtains generation and transmission maintenance schedules from Generator Operators and Transmission Operators. The Reliability Coordinator has final authority in coordination and resolution of conflicts regarding transmission and generation outage requests. The Reliability Coordinator can deny a transmission outage request and some elective, generation outage requests if a transmission system reliability constraint would be violated.

The Transmission Operator is responsible for the reliability of its “local” transmission system in accordance with establishing and maintaining System Operating Limits (SOLs). However, in some circumstances, as noted above for reliability analysis associated with generation dispatch instructions, the Reliability Coordinator may become aware of a potential SOL exceedance and issue a dispatch adjustment. Therefore, in this context, the Reliability Coordinator also has a role regarding the Transmission Operator’s management of SOL exceedances.
Emergency actions. The Reliability Coordinator is responsible for Real-time system reliability, which includes calling for the following emergency actions:

- Curtailing Interchange Schedules
- Directing re-dispatch to alleviate congestion or other SOL exceedances
- Mitigating energy and transmission emergencies
- Ensuring energy balance and Interconnection frequency
- Directing load shedding.

The Reliability Coordinator, in collaboration with the Balancing Authority and Transmission Operator, can invoke public appeals, voltage reductions, Demand-Side Management, Energy Emergency alerts, and even load shedding if the Balancing Authority cannot achieve resource-demand balance.

System restoration actions. The Reliability Coordinator directs and coordinates restoration of the Bulk Electric System (BES) for its RC Area, with Transmission Operators, Balancing Authorities and other Reliability Coordinators.

In addition, since the Reliability Coordinator may also have a role regarding the Transmission Operator's management of SOL exceedances, delineation of its authority and that of the Transmission Operator needs to be clearly defined.
Part 2 - Balancing Authority

The Balancing Authority operates within the metered boundaries that establish the Balancing Authority Area. Every generator, Transmission Facility, and end-use customer is in a Balancing Authority Area. The Balancing Authority’s mission is to maintain the balance between Demand and resources in real time within its Balancing Authority Area by keeping its actual Interchange equal to its scheduled Interchange and meeting its Frequency Bias obligation. The demand-resource interchange is measured by the Balancing Authority’s Area Control Error (ACE). In performing its balancing function, the Balancing Authority does not own the resources. The Balancing Authority maintains its ACE within acceptable limits.

Maintaining Demand-resource balance within the Balancing Authority Area requires four types of resource management, all of which are the Balancing Authority’s responsibility. Each of these resource management functions require sufficient resources provided to it by other entities:

- frequency control through tie-line bias
- Regulation Service deployment
- load-following through economic dispatch
- Interchange implementation

**Frequency control through Tie-Line Bias.** To maintain frequency within acceptable limits, the Balancing Authority controls resources within its Balancing Authority Area to meet its Frequency Bias obligation to the Interconnection.

**Regulation service deployment.** To maintain its ACE within these acceptable limits, the Balancing Authority controls a set of generators within its Balancing Authority Area that are capable of providing Regulation Service.

**Load-following through economic dispatch.** The organization that serves as the Balancing Authority will in general also perform unit commitment and economic dispatch; however, in some markets, Generator Operators may be permitted to perform unit commitment and economic dispatch among the fleet of generators under their control and within the requirements accepted by the Market Operator.

**Interchange implementation.** The Balancing Authority receives Confirmed Interchange from one or more Interchange Coordinators, and enters those Interchange Schedules into its energy management system.

**Unit commitment and schedules from Load-Serving Entities.** The Balancing Authority receives resource dispatch plans from the Market Operator and/or unit commitment and dispatch Schedules from the Load-Serving Entities that have bilateral arrangements for generation within the market or the Balancing Authority Area. The Balancing Authority provides this commitment and dispatch Schedule to the Reliability Coordinator.

**Role in approving Interchange.** The Balancing Authority approves an Arranged Interchange with respect to the ramping requirements of the generation that must increase or decrease to implement the Interchange. The Balancing Authority provides its approval or denial to the Interchange Coordinator.

**Energy Emergencies.** In the event of an Energy Emergency, the Balancing Authority can implement public appeals, Demand-Side Management programs, and, ultimately load shedding. Obviously, it must do this in concert with the Reliability Coordinator.

**Failure to balance.** The Balancing Authority must take action, either under its own initiative or direction by the Reliability Coordinator, if the Balancing Authority cannot comply with NERC’s Reliability Standards regarding frequency control and Area Control Error.
**Reserve Sharing Groups:** In the past, only reserve sharing groups that have been associated with Contingency Reserve. However, as the industry has evolved, additional commercial relationships between Balancing Authorities are occurring and thus creating new responsible groups. These responsible groups now include Regulation Reserve Sharing Groups, Frequency Response Sharing Groups, Frequency Response Sharing Groups and Contingency Reserve Sharing Groups. These groups are the responsible entities, but the Balancing Authorities remain responsible for performance within each respective group. The Balancing Authorities enter into commercial arrangements among themselves to form the respective sharing groups.
Part 3 - Planning Coordinator

The Planning Coordinator coordinates and integrates Transmission facility and service plans, resource plans, and protection system plans among the Transmission Planner(s) within its area of purview. These activities range from review and assessing expansion and corrective action plans developed by the Transmission Planner(s) within the Planning Coordinator’s area. The assessment should consider the interaction of system changes under a range of selected scenarios across the entire Planning Coordinator area. The PC assessment includes the collection of Transmission assets over which the Planning Coordinator is responsible for coordinating planning (“PC Area”). The PC Area is normally comprised of more than one Transmission Planner. However, the area under the purview of a Planning Coordinator may include as few as one Transmission Planner. The Planning Coordinator’s scope of activities is intended to span a broader area that may include BES assets of multiple Transmission Planners. All BES Facilities should be assigned to a Transmission Planner and to a Planning Coordinator, so that there are no gaps in the assessment of the BES.

Planning Coordinators work through a variety of processes to conduct facilitated, coordinated, joint, centralized, or regional planning activities to the extent that all portions of the interconnected BES are completely coordinated for planning activities. While much of what the Planning Coordinator performs could be actually performed by a Transmission Planner, such as developing methodologies in conjunction with surrounding Transmission Planners, recognition of resource plans, assessing system performance consistent with reliability needs by itself, and collaborating with other Transmission Planners to assess impacts on the interconnected area, the Planning Coordinator by its very nature will generally take responsibility over a wider perspective than the Transmission Planners for which its coordinates. The Planning Coordinator generally conducts system performance assessments, in collaboration with other Planning Coordinators to consider transfer/flows across multiple Transmission Planner areas or intra- and inter-state areas such as generation dispatch scenarios caused by temperature or fuel extremes. Geographic size is not necessarily a critical consideration, it is the extent and impact of the electrical network that the planners have taken responsibility for assessing that determines whether an area is large enough for analysis and planning.

The boundaries for the Planning Coordinator area are basically defined by the location of the BES facilities under the purview of the Planning Coordinator, i.e. those facilities for which the Planning Coordinator coordinates and evaluates and recommends reinforcement and corrective plans resulting from studies and analysis of system performance and interconnection of facilities. The BES facilities under its purview, are generally contiguous and cover in aggregate the same areas as the Transmission Planners its coordinates. Traditionally transmission planning has been associated with one or more Transmission Owners, i.e. reinforcement and corrective action plans must be associated with certain Transmission Owner facilities. Since transmission ownership may cross state or provincial or regional boundaries, the BES Facilities on one side of the Transmission Owner boundary may be in one Planning Coordinator area whereas the remaining facilities may be in another. As such the Planning Coordinator area is not constrained to fit within a Reliability Coordinator or Transmission Operator Area. However, the Planning Coordinator area must cover at least one Transmission Planner Area.

In many areas, there may exist more than one Transmission Planner each performing a different role demarcated primarily by their particular function and scale (area-wise) of assessments performed. In order to ensure all BES Facilities are associated with a Planning Coordinator, clear delineation of the “PC Area” should establish the BES Facilities and associated connections to its adjacent Planning Coordinators.

The Planning Coordinator is not responsible for implementing the Transmission and resource plans. However, it helps to facilitate the process whereby adequate resources and Transmission Facilities are placed into service in a timely and efficient manner through coordinated planning with the Transmission Planners.
Part 4 - Transmission Planner

The Transmission Planner develops a long-term (generally one year and beyond) plan for the reliability (adequacy) of the interconnected bulk electric transmission systems within its portion of the Planning Authority area.¹

The Transmission Planning function is typically associated with the Transmission Ownership function. The Transmission Planner performs the tasks of modeling, simulating and assessing the performance of the Transmission system under a range of future scenarios on a recurring basis. As Transmission system performance deficiencies are identified through this process, the Transmission Planner studies alternative solutions for correcting the deficiencies. Through interactions with various stakeholders, the Transmission Planner ultimately arrives at a recommended Corrective Action Plan that will resolve the identified deficiencies. For solutions that involve Transmission system capacity expansion, the associated Transmission Owner(s) is responsible for implementing the solution.

Both the Transmission Planner and Planning Coordinator perform assessments to evaluate whether future Transmission system performance will meet the minimum acceptable system performance requirements. The Transmission Planner and Planning Coordinator may consider different system conditions (and BES Facilities) in performing their assessments. This flexibility allows the Transmission Planner and Planning Coordinator to study a wider range of system conditions, which leads to a more complete and comprehensive assessment of the BES. For example, a Transmission Planner may set higher System performance criteria for a particular area under assessment.

The Transmission Planner assessment includes the collection of Transmission assets over which the Transmission Planner is responsible for planning (“TP Area”). The Planning Coordinator assessment includes the collection of Transmission assets over which the Planning Coordinator is responsible for coordinating planning (“PC Area”). The PC Area is normally comprised of more than one TP. Every Facility must have one associated Transmission Planner and at least one Planning Coordinator. This means that every Facility in the TP Area should be included in the assessment conducted by the TP.

As noted above, this typically aligns with the Transmission system facilities owned by an associated Transmission Owner(s). Because of the interconnected nature of the BES, the Transmission Planner works with other Transmission Planners to periodically update power system models used to perform simulations. Information needed to update these models is collected from various functional entities within a particular Transmission Planner’s area of purview. Power system modeling data is also “rolled up” by the Transmission Planner(s) to the Planning Coordinator to support development of Interconnection level models.²

The Transmission Planner evaluates the impact of long-term Transmission Service requests, and the integration of new generation, Transmission, and end-use customers, on the planned Transmission system performance. In evaluating requests for long-term Transmission Service or new interconnections, the Transmission Planner is expected to coordinate with other Transmission Planners, as appropriate, to ensure new service/facilities do not adversely affect the reliability of neighboring Transmission systems.

The Transmission Planner provides its assessment results to the appropriate Planning Coordinator for review to ensure that the impacts on the interconnected systems are duly addressed. In reporting its assessment results to the Planning Coordinator, the Transmission Planner is expected to assess whether its plans for new

¹ Definition of Transmission Planner (effective July 1, 2016) from the NERC Glossary of Terms. In the Glossary, Planning Coordinator and Planning Authority are defined interchangeably.
² In some instances, the same entity may serve as both a Transmission Planner and Planning Coordinator.
or reinforced facilities meet reliability needs or whether corrective plans are necessary. The Transmission Planners work with the Planning Coordinator to identify potential alternative solutions, including solutions proposed by stakeholders, to meet interconnected BES requirements.
Part 5 - Resource Planner

The Resource Planner develops a long-term (generally one year and beyond) plan for the resource adequacy of specific loads (customer demand and energy requirements) within a Resource Planner area. Note: The term "resource" is to be understood to include supply resources and demand-side resources (such as dispatchable loads).

The boundaries for the Resource Planner area are basically defined by the location of the specific loads being considered for resource adequacy. The loads under considerations are generally contiguous and form the fundamental input for analysis of resources such as loss of load studies. The Resource Planning function may be performed by one or more Resource Planners within a Planning Coordinator area, Transmission Planner or Reliability Coordinator Area; however, the Resource Planning Function could be performed by one Resource Planner that covers one, or more than one, Planning Coordinator area, Transmission Planner Area or Reliability Coordinator Area. As such the Resource Planner area is not constrained to fit within the footprint of any other functional entity. The analysis and development of resource plans by their very nature will need to consider generation capacity and other resources outside the area defined by the specific loads as well as the transmission capability to access those resources.

In some markets, market rules may require the same organization to assume the role of both the Planning Coordinator and the Resource Planner. For example, in those markets where there are no entities responsible for or obligated to serve load, the Planning Coordinator will generally assume the Resource Planner’s role. In these cases, the Planning Coordinator identifies the need for additional resources to be provided by the market and performs the Resource Planning Function.

Types of Resource Planning

Resource planning, in a generic sense, may be divided into two types:

- Planning conducted by an organization under the authority of legislation, regulation order, tariff or market rule. Such planning will typically be conducted in an open process and subject to industry, public and stakeholder review. It will have as one objective, ensuring resource adequacy.

- Planning directed to identifying and realizing commercial opportunities. Such plans will typically be commercially sensitive, may not be made public before required for the plan to be implemented, and will not be directed to ensuring resource adequacy.

The Resource Planner described in the Model is associated with the former type of planning, i.e., planning having a mandate to ensure resource adequacy.

The latter type of planning, which is driven primarily by commercial opportunity, may be viewed as an activity associated with generation ownership. However, resource planning that is purely commercially-driven clearly will have an impact on resource adequacy. The Resource Planner, with its mandate for resource adequacy, must reflect to the extent possible commercially-directed planning affecting its Resource Planner area.
Part 6 - Transmission Operator

The Transmission Operator acts or authorizes action to connect to, disconnect from or reconfigure (switching operations) Facilities classified as Transmission assets, as described by the following:

a. Actions may include direct or indirect control of Transmission assets from a Control Center to conduct operations during Normal and Emergency conditions.

b. Authorizations to act may include orders directing designated field personnel with Transmission System switching responsibilities to perform switching operations on Facilities classified as Transmission assets during Normal and Emergency conditions.

The Transmission Operator maintains local-area reliability, that is, the reliability of the system and area for which the Transmission Operator has responsibility. The Transmission Operator achieves this by operating the Transmission system within its purview in a manner that maintains proper voltage profiles and System Operating Limits, and honors Transmission equipment limits established by the Transmission Owner. The Transmission Operator is under the Reliability Coordinator’s direction respecting wide-area reliability considerations, that is, considerations beyond those of the system and area for which the Transmission Operator has responsibility and that include the systems and areas of neighboring Reliability Coordinators. The Transmission Operator, in coordination with the Reliability Coordinator, can take action, such as implementing voltage reductions, to help mitigate an Energy Emergency, and can take action in System restoration.
Part 7 - Interchange Coordinator

The e-tagging process exists for scheduling Transmission usage by entities who have contracted for Transmission access. NAESB maintains the e-tagging specification. The Interchange Coordinator is equivalent to the tag authority described in the specification. (NAESB states this service has been assigned to the Sink Balancing Authority. The functional model envisions that the Sink Balancing Authority may serve as its own Interchange Coordinator or have this service provided by a separate organization.)

The “authority service”\(^3\) is the focal point for all interactions with an e-Tag and maintains the single authoritative “copy of record” for each e-Tag received. Every Sink Balancing Authority is responsible for registering the URL of an “authority service.” The authority service forwards all valid received RFI to each entity identified in the transaction as having “approval” or “viewing” rights over that RFI, and collects approvals/denials issued by these approval services. Based on time and the message(s) received from the approval services, the authority service arbitrates and sends the final disposition of the request to each entity in the distribution list. The authority service also provides the capability for both the agent (requestors of service) and approval services to interrogate the current approval state of any transaction RFI on demand.

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\(^3\) Definitions from NAESB:

**e-Tag Agent Service**: Software component used to generate and submit new e-Tags, corrections, and profile changes to an e-Tag Authority Service and to receive state information for these requests.

**e-Tag Authority Service**: Software component that receives e-Tag Agent Service and e-Tag Approval Service requests and responses and forwards to the appropriate approval service. Also maintains master copy of e-Tag (all associated requests), the composite state of the e-Tag, etc. and responds to queries regarding the e-Tags in its possession.

**e-Tag Approval Service**: Software component used to indicate individual approval entity responses when requested by the e-Tag Authority Service, as well as submit profile changes.
Part 8 - Transmission Service Provider

The Transmission Service Provider authorizes the use of the transmission system under its authority. In some cases, the organization serving as Transmission Service Provider is also the Market Operator.

**Role in approving Interchange.** The Transmission Service Provider approves Arranged Interchange by comparing the Transmission Service previously arranged by the Transmission Customer (Purchasing-Selling Entity, Generator Owner, Load-Serving Entity) with the Transmission information supplied by the Interchange Coordinator. The Transmission Service Provider also ensures that there is a contiguous Transmission path and that adjacent Transmission Service Providers are on the Scheduling Path. The Transmission Service Provider then provides its approval or denial to the Interchange Coordinator.

**Providing Transmission and Ancillary Service.** As its name implies, the Transmission Service Provider provides transmission service and Ancillary Service to transmission customers, such as Generator Owners, Load-Serving Entities, and Purchasing-Selling Entities. The Transmission Service Provider determines Available Transfer Capability based on the established Total Transfer Capabilities, System Operating Limits and Interconnection Reliability Operating Limits (by various entities including the Planning Coordinator, Transmission Planner, Transmission Operator and Reliability Coordinator), and coordinates ATC with other Transmission Service Providers. The Transmission Service Provider manages the requests for transmission service according to the Transmission Owner’s tariff, and within the operating reliability limits determined by the Reliability Coordinator. The Transmission Service Provider ensures necessary Ancillary Services are provided to the Transmission Operator and Balancing Authority. The Transmission Service Provider does not itself have a role in maintaining system reliability in Real time — that is done by the Reliability Coordinator and Transmission Operator and Balancing Authority.

The Transmission Service Provider arranges for transmission loss compensation and Ancillary Service requirements with the Balancing Authority.
Part 9 - Transmission Owner

The Transmission Owner owns its transmission facilities and provides for the maintenance of those facilities. It also specifies equipment operating limits, and supplies this information to the Transmission Operator, Reliability Coordinator, and Transmission Planner and Planning Coordinator.

In many cases, the Transmission Owner has contracts or interconnection agreements with generators or other transmission customers that would detail the terms of the interconnection between the owner and customer.

**Maintenance.** The Transmission Owner provides the overall maintenance plans and requirements for its equipment, specifying, for example, maintenance periods for its transformers, breakers, and the like. The Transmission Owner then develops or arranges for the development of the detailed maintenance schedules (dates and times) based on the Transmission Owner’s maintenance plans and requirements, and provides those schedules to the Reliability Coordinator and others as needed.

The organization serving as Transmission Operator may also physically provide or arrange for transmission maintenance, but it does this under the direction of the Transmission Owner, which is ultimately responsible for maintaining its owned transmission facilities.
Part 10 - Distribution Provider

The Distribution Provider provides the physical connection between the end-use customers, distribution-connected energy resources, and the BES, including customers served at Transmission level voltages. The Distribution Provider is not defined by a specific voltage, but rather as performing the Distribution function at any voltage. One Distribution Provider may be directly connected to another Distribution Provider, such connections must be reported to the Balancing Authority even though not directly connected to the BES.

The Distribution Provider maintains “local” safety and reliability and is responsible for the distribution facilities to serve end-use customers and distribution-connected energy resources. The Distribution Provider provides the switches and re-closers necessary for emergency action and information necessary for the Transmission Operator and Transmission Planner. The Distribution Provider may need to demonstrate manual Load-shedding capability to the Balancing Authority and Transmission Operator. Design and maintain protective relaying systems, under-frequency load-shedding systems, under-voltage Load-shedding systems, and Remedial Action Schemes that interface with the Transmission system.

Unlike the Load-Serving Entity, the Distribution Provider has the facilities or assets (“wires”) and does not take title to any energy. However, while these functions are distinct, in many cases an organization, such as a vertically integrated utility, bundles these functions together.
Part 11 - Load-Serving Entity

The Load-Serving Entity (LSE) arranges for the provision of energy Resources and Ancillary Services to its Balancing Authority and Resource Planner in order to supply its end-use customers, but does not provide distribution services (“wires”).

Organizations serving as Load-Serving Entities may also be Generation Owners and can self-provide, or have contracts with other Generator Owners for capacity, energy and Ancillary Services to serve the Load-Serving Entity customers, or purchase capacity, energy, and Ancillary Services from non-affiliated Generator Owners through a Purchasing-Selling Entity (or Market Operator), or employ a combination of these three options.

The Load-Serving Entity reports its resource (affiliated and non-affiliated) arrangements to serve load to the Balancing Authority, which forwards this information to the Reliability Coordinator, for day-ahead analysis.

The LSE may contract for Ancillary Services through the Transmission Service Provider or the Market Operator (if the Load-Serving Entity is part of a market or pool) or directly from Generator Owners or loads.

Unlike the Distribution Provider, the Load-Serving Entity, does not have BES assets (“wires”) but does take title to energy. However, while these functions are distinct, in many cases an organization, such as a vertically integrated utility, bundles these functions together.

The Load-Serving Entity is responsible for the identification of loads for Curtailment and those critical customer loads that are to be excluded from the load-shedding systems, and the development of load profiles and load forecasts.

The Load-Serving Entity communicates requests for Curtailment to the appropriate end-use customer loads.
The Reliability Assurer is subject to oversight by the Federal Energy Regulatory Commission and governmental authorities in Canada. The Reliability Assurer assures the reliability of the Bulk Power System (BPS) in North America by developing and enforcing Reliability Standards; annually assessing seasonal and long-term reliability; monitoring the BPS through system awareness; and, educating, training, and certifying industry personnel.
SECTION II - TECHNICAL DISCUSSION

The below diagram provides an illustration of how the various functional entities can be categorized.
Part 1 - Market Operations (Resource Integration)

Market Operations is not a reliability function. Nevertheless, market operations, a commercial or market function, is included in the FM, in order to provide an interface point between reliability and commercial functions.

The role of the Market Operator\(^4\) also varies in design and responsibilities depending on whether resources are dispatched within a full-service market or where there is not a full-service market. However, all Market Operators perform a resource integration task of one form or another under a resource integration protocol that is recognized by a state, federal, or provincial regulator. A resource integration protocol is the method used to determine the merit order of the generation to be dispatched. Generally, resource integration protocols are either cost-based or bid-based, depending on the market rules established by the regulatory authority. The basis and results for the resource integration algorithms are generally the same for cost-based and bid-based dispatch, which is why the Functional Model accommodates either type of protocol.

**Multiple Balancing Authorities Within a Market Area.** If the market area includes more than one Balancing Authority Area, then the Market Operator will also provide each Balancing Authority with the Net Interchange Schedule that results from the resource plan (“Resource Dispatch Interchange Schedule”, or RDIS). Each Balancing Authority’s RDIS will be an import or export to the Balancing Authority Area, and the sum of all RDISs within the market area must add to zero at each dispatch cycle.

Resource integration is discussed below for the cases of a full-service market and where there is no full-service market.

1. **The Market Operator in a Full-Service Market**

   A full-service market is one which offers both the commercial services such as integrating resources ahead of Real-time and settlement after the completion of Implemented Interchange and dispatch cycles, and implement the resource plan in Real-time, making adjustment as necessary to meet other reliability requirements not envisaged during the resource integration process (for example, reliability constraints).

   **Bid-Based Resource Integration.** In those areas of North America having a full-service market, market protocols provide Generator Owners the ability to bid into the market. In those cases, Generator Owners will direct the submission of bids via the Generator Operators to the Market Operator. The Market Operator, in turn, provides the Balancing Authority with the generator dispatch plan, so that the generators within the market footprint would be instructed to operate at the same incremental bid. Transmission constraints may cause the actual dispatch to deviate from the dispatch plan. Re-dispatch methods used to relieve the congestion may use: direct resource assignments, area / zonal dispatch signals, or bus-signals. The zonal and bus methodologies are often referred to as “Locational Marginal Pricing,” or LMP.

   **Relationship between the Market Operator and Balancing Authority.** In a full-service market, there is a close relationship between the Market Operator and the Balancing Authority. A full-service Market Operator performs resource integration tasks and is assigned the tasks of:

   - Determining the generation dispatch plan (unit commitment) ahead of time
   - Integrating scheduled interchange into that generation plan
   - Designating which generators are available for regulation service
   - Providing the generation dispatch plan to the Balancing Authority ahead of Real-time.

\(^4\) For simplicity, only the term “Market Operator” is used; this is intended to apply even where there is not a full-service market.
The Balancing Authority receives the plan, and implements it in real time.

2. The Market Operator Where There is not a Full-Service Market

**Cost-based Resource Integration.** Where there is not a full-service market, the Market Operator will often be a traditional, vertically-integrated utility that acts also as Balancing Authority. The utility will dispatch its resources based on its incremental costs (fuel and operations and maintenance) and losses. The regulatory authority might specify the accounting rules for calculating these costs.

In addition, there are jurisdictions that use a model other than full-service market and vertically-integrated utility, in particular bilateral Interchange Transactions. In this case, the organization serving as Balancing Authority will also be the Market Operator, operating on the basis of Net Interchange.

3. Summary: The Market Operator Using Different Structures

The table below describes how the current operating tasks may be performed by both the vertically-integrated utility and the unbundled, full-service Market Operator.

<table>
<thead>
<tr>
<th>Task</th>
<th>No Full-Service Market: Vertically Integrated Structure</th>
<th>Full-Service Market: Unbundled Structure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Commitment</td>
<td>Utility (performing as the Generator Owner) decides which units to run.</td>
<td>Generator Owners decides which units to make available.</td>
</tr>
<tr>
<td>Economic Dispatch</td>
<td>Utility (as Market Operator or Resource Integrator) performs economic dispatch calculation based on incremental costs or other requirements. Utility must consider generator operating limits, which units are providing regulation service, and any commitments for bilateral arrangements.</td>
<td>Market Operator collects bids from Generator Owners and develops integrated resource plans based on market rules (e.g., bids). Market Operator must consider generator operating limits, which units are providing regulation service, and any commitments for bilateral arrangements.</td>
</tr>
<tr>
<td>Congestion Management</td>
<td>Results in different incremental costs (&quot;lambdas&quot;).</td>
<td>Depending on the market structure, results in Different LMP, or Different marginal costs</td>
</tr>
<tr>
<td>Regulation Service</td>
<td>Utility (serving as the Balancing Authority, Load-Serving Entity, and Generator Owner) in concert with the Reliability Coordinator, determines the amount of regulation service required, and designates those units that provide the regulation service. Utility (as Balancing Authority) uses this information in its economic dispatch.</td>
<td>Balancing Authority, along with Reliability Coordinator, determines the amount of regulation service required. Generator Owners decide which units to bid in for regulation service. Market Operator runs bid pool for regulation service. Load-Serving Entity arranges for regulation services.</td>
</tr>
<tr>
<td>Generator Control</td>
<td>Utility (as Balancing Authority) pulses units that are designated by the Market Operator for regulation service. As regulating ability declines, the part of the utility that acts as Balancing Authority directs the part of the utility that acts as Market Operator to develop a new dispatch plan.</td>
<td>Balancing Authority pulses units that are designated by the Market Operator for meeting energy and regulation service requirements. As regulating ability declines, the Balancing Authority asks the Market Operator for a new dispatch plan.</td>
</tr>
</tbody>
</table>
Part 2 - Providing and Deploying Ancillary and Interconnected Operations Services

The North American electric power system is transforming to a resource mix that relies less on coal and nuclear while integrating more natural gas, wind, solar, distributed generation, and demand response resources. Additionally, the power system will change further as micro-grids, smart networks, and other advancing technologies continue to be deployed. Recognizing that these changes represent a fundamental shift in the operational characteristics of the power system with potential reliability implications, the policies that govern Ancillary Services and the characteristics of Interconnected Operations Services may evolve to address these newer resources. Proper planning and providing system operators with the ability to manage resources in real time will be required to ensure that the appropriate levels of Interconnected Operations Services are available so that reliability is maintained as the resource mix evolves.

The Building Blocks of Reliability
Based on the analysis of geographic areas that are experiencing the greatest level of change in their types of resources, a number of measures and industry practices are recommended to identify trends and prepare for the transition in resource mix. These recommendations consider both real-time operations and future planning to support frequency, ramping and voltage of the system.

Frequency – The electric grid is designed to operate at a frequency of 60 hertz (Hz). Deviations from 60 Hz can have destructive effects on generators, motors, and equipment of all sizes and types. It is critical to maintain and restore frequency after a disturbance such as the loss of generation. Frequency will immediately fall given such an event. This requires an instantaneous (inertial) response from some resources and a fast response from other resources to slow the rate of fall during the arresting period, a fast increase in power output during the rebound period to stabilize the frequency, and a more prolonged contribution of additional power to compensate for lost resources and bring system frequency back to the normal level.

Ramping – Adequate ramping capability (the ability to match load and generation at all times) is necessary to maintain system frequency. Changes to the generation mix or the system operator’s ability to adjust resource output can impact the ability of the operator to keep the system in balance.

Voltage – Voltage must be controlled to protect system reliability and move power where it is needed in both normal operations and following a disturbance. Voltage issues tend to be local in nature, such as in sub-areas of the Transmission and distribution systems. Reactive power is needed to keep electricity flowing and maintain necessary voltage levels.

Excerpt from North American Electric Reliability Corporation (NERC) ERS Framework Report, December 2015
Tariff Domain — Requirement for Ancillary Services. The FERC pro-forma tariff requires that the Transmission Provider offer to provide Ancillary Services, as a provider of last resort, to customers serving loads within the Transmission Provider’s own area which do not purchase or self-provide:

1. Scheduling, system control, and dispatch
2. Reactive supply and voltage control from generation.
3. Energy imbalance
4. Regulation and frequency response
5. Operating reserve — spinning
6. Operating reserve — supplemental.
7. Generator Imbalance

Functional Model Domain — Interconnected Operations Services. A service (exclusive of basic energy and Transmission Services) that is required to support the Reliable Operation of interconnected BESs. These Interconnected Operations Services are physically provided by generators, transmitters and loads in order to maintain reliability.

Certain Transmission facilities can provide reactive support, but are not considered an Ancillary Service in the open access tariff, rather, they are considered part of basic Transmission service. In addition, loads may provide reserves through load-shedding or Demand-Side Management, and may also provide frequency response.

Ancillary Services in the “tariff domain” could be served by Interconnected Operations Services in the “reliability domain.” The Functional Model explains that the Balancing Authority, alone or in coordination with the Reliability Coordinator, determines the amount required and arranges for Interconnected Operations Services to ensure balance:

- The Balancing Authority determines regulation, load following, frequency response, ramping capability and contingency reserves, and deploys these as Interconnected Operations Services.
- The Transmission Operator determines the reactive resources necessary to meet its Reactive Power requirements to maintain Transmission voltage within operating limits, and deploys these as its set of Interconnected Operations Services.
- The Reliability Coordinator, working with the Transmission Operator, determines the need for black start capacity. The Transmission Operator cannot do this alone, because it may not have a wide enough picture of the Transmission system.

The quantity of and processes used to deploy those Interconnected Operations Services depend on the regional and local system characteristics and regulatory requirements. The responsible organizations establish the quality and quantity of their own Interconnected Operations Services, using these processes and procedures in a manner that ensures reliable operation of the BES.

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6 Definition of Interconnected Operations Services from the NERC Glossary of Terms (as of May 15, 2016).
Part 3 – Implementing Interchange Coordination

Requests for Interchange (RFI) are initiated by entities (Purchasing-Selling Entities, Load-Serving Entities, or Generator Owners) who have arranged for Interchange and contracted for Transmission Service from a Transmission Service Provider. The RFIs are submitted to a (Tag) agent service who confirms all information needed and electronically sends Tags to the authority service, or the Interchange Coordinator. The Interchange Coordinator tasks are performed by the functional entities registered as Balancing Authorities (BAs), specifically the Sink Balancing Authority for a particular interchange transaction. A Sink Balancing Authority is defined as, “[the Balancing Authority in which the load (sink) is located for an Interchange Transaction and any resulting Interchange Schedule.”

The remainder of this section clarifies the context and need for an Interchange Coordinator by describing the associated reliability tasks and their implications.

INTERCHANGE PRACTICE
Background
To help ensure reliability, “requests” for Interchange Transactions (Arranged Interchange) must be approved before that request is allowed to become an Implemented Interchange (or Confirmed Interchange). Without approvals, it is possible that the sum of all Interchange Schedules in an interconnection will not sum to zero. That, in turn, would lead to the condition that even if every Balancing Authority were controlling to zero Area Control Error, there could still be off-generation occurring because of the Net Interchange Schedule being in error.

Historically, approvals were handled on a control area to control area basis. Net Interchange Schedules between neighbors were checked and approved prior to implementation. Only if there were disagreements did individual requests get checked. This pragmatic practice served the industry well — but not perfectly. When given control areas did not take the time to compute their own Net Schedule interchange (and instead merely accepted the numbers from its individual neighbors) — what can and did happen was that individual schedules were active on one side of the control area, but not on the other side. Not until serious operational symptoms arose (e.g., unexplained parallel flows, or unusual number of time error corrections) was there an investigation.

Current Practice
The inclusion of an Interchange Coordinator in the FM recognizes a reliability concern regarding responsibility for approving a Request for Interchange, and the distribution of the information for the approved request for Interchange. Each and every Interchange Transaction that a Purchasing-Selling Entity desires to implement must have approvals from all parties involved, and must have approval by each of them regarding the characteristics of each of those Interchange Transactions.

Today, the approval and communication are implemented in a two-step process — each step focusing on different quantities. One step focuses on the individual Interchange Transactions and their respective characteristics. This step is carried out by a tagging authority, which is the Interchange Coordinator. In order to obtain approval or denial, the Interchange Coordinator sends the Request for Interchange electronically, as Arranged Interchange, to the (tag) approval service provider for the Balancing Authorities, Transmission Service Providers, Load-Serving Entities, Purchasing-Selling Entities, and Generator Owners. After obtaining approval or

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7 Definition of Sink Balancing Authority from the NERC Glossary of Terms (as of Mary 15, 2016).
denial, the approval service then sends the decision to the Interchange Coordinator. If all parties approve the Interchange Transaction, the Arranged Interchange becomes Confirmed Interchange. The Interchange Coordinator then informs all parties of this status.

The other step focuses on implementing Net Interchange Schedules (i.e., the net of the Transactions that were approved). This step is carried out by neighboring Balancing Authorities. The Sink Balancing Authority is responsible for ensuring the process is properly carried out.

Today the NAESB Tagging Specification is in place. Under the NAESB Tagging Specification, each Sink Balancing Authority is responsible for providing tagging services, either directly or by arranging with a third party to provide this service as its agent.⁸

Part 4 - Risk-Based Registration

In support of its mission to assure the reliability of the BPS, NERC has transformed its approach to compliance and enforcement to be forward-looking with a focus on high reliability risk areas. The purpose of the NERC Risk-Based Registration (RBR) initiative was to ensure that the right entities are subject to the right set of applicable Reliability Standards, using a consistent approach to risk assessment and registration. In December 2014, NERC submitted a petition for approval of proposed revisions to the NERC Rules of Procedure (ROP), seeking to implement the changes sought as a result of the RBR initiative. Specifically, NERC requested major reforms to the registration process, including the elimination of the Purchasing-Selling Entity (PSE), Interchange Authority (IA), and Load-Serving Entity (LSE) functional registration categories; modifications to the thresholds for registering entities as Distribution Providers (DP); and procedural improvements to the registration process. The procedural improvements to the registration process included: (1) the establishment of a materiality test for registration, with clear procedures and criteria for evaluation of whether an entity has a material impact on reliability with respect to above-the-line and below-the-line Registry Criteria determinations; (2) an enhanced process for review by a NERC-led, multi-regional panel of certain registration, deactivation and deregistration decisions, as well as certain requests for sub-set lists of Reliability Standards; (3) development of a common registration form to facilitate uniformity in Regional Entity collection of the information from registration candidates; and (4) one-time attestations that allow entities to record that a specific Reliability Standard requirement is “Not Applicable.” On March 19, 2015, the Commission issued an order largely approving proposed revisions to the NERC ROP.

As outlined in the RBR petition, the ERO compliance program and stakeholders benefit from the proposed revisions as they appropriately focus resources on entities with the greater potential impact on reliability. The RBR reforms were based on the February 2011 Commission technical conference in Docket No. AD11-6-000 on Priorities for Addressing Risks to the Reliability of the Bulk-Power System, where there was a recognition that “if everything is a priority, then nothing is a priority.” Priorities must be driven by a clear understanding of risks and consequences, and the costs and benefits associated with addressing them. With a shift toward risk-based approaches and a learning industry, NERC introduced quantitative measures of reliability performance. The revisions were a result of NERC taking a risk-based approach to reliability and to incorporating lessons-learned through continuously improving and adapting operations.

Even though the three entities (PSE, IA, and LSE) were removed from the NERC Registry Criteria, these entities—as users, owners and operators of the BPS—remain within in the statutory scope of both FERC and NERC pursuant to Section 215 of the Federal Power Act. Functionally, Load-Serving Entities, Purchasing-Selling Entities and Interchange Authorities continue to exist and continue to perform in the markets or operate under open access transmission tariffs, as applicable. The revisions did not alter the NERC registered ballot body (codified in Appendix 3D of the NERC Rules of Procedure).

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Part 5 - Areas and Boundaries

The building block for defining boundaries and areas for the functional entities that operate and plan the BES is electrical, namely the individual BES asset. That is, the building blocks are the individual Transmission, generation and customer equipment assets that collectively constitute the BES. This enables any given BES asset to be associated with at least one functional entity. This will provide the basis for clear assignment of responsibility for managing the potential reliability impacts of the asset.

A geographic definition is not appropriate in a situation where there are, for example, two Transmission Operators in a given geographic footprint, differentiated by the voltage level of the assets under their respective control. In such a situation, the use of the specific BES assets provides an adequate basis for defining Areas/boundaries.

The following areas and boundaries are essential for understanding how to reliably operate and plan for a particular BES asset:

1. **Reliability Coordinator Area**: The collection of generation, transmission, and loads within the boundaries of the Reliability Coordinator. Its boundary coincides with one or more Balancing Authority Areas.
2. **Balancing Authority Area**: The collection of generation, transmission, and loads within the metered boundaries of the Balancing Authority. The Balancing Authority maintains load-resource balance within this area.
3. **Transmission Operator Area**: The collection of Transmission assets over which the Transmission Operator is responsible for operating.
4. **Transmission Planner area**: The collection of Transmission assets over which the Transmission Planner is responsible for planning.
5. **Planning Coordinator area**: The collection of Transmission assets over which the Planning Coordinator is responsible for coordinating planning. Its area includes one or more Transmission Planner Areas.