Wide Area Control System for the Self-healing Grid (SHG)

1 Descriptions of Function

All prior work (intellectual property of the company or individual) or proprietary (non-publicly available) work should be so noted.

1.1 Function Name

Wide-Area Control System for the Self-healing Grid (SHG)

1.2 Function ID

IECSA identification number of the function

T-4,T-4.1,T-4.2,T-4.3,T-4.12,T-4.14,T-4.15,T-4.17,T-4.18,T-4.19,T-4.20,T-4.21,T-4.22,T-5,T-6,T-6.5,T-6.10,T-6.11,T-6.17,T-6.18,T-6.19,T-6.21

1.3 Brief Description

Describe briefly the scope, objectives, and rationale of the Function.

The objective of the SHG applications is to evaluate power system behavior in real-time, prepare the power system for withstanding credible combinations of contingencies, prevent wide-area blackouts, and accommodate fast recovery from emergency state to normal state.

1.4 Narrative

A complete narrative of the Function from a Domain Expert's point of view, describing what occurs when, why, how, and under what conditions. This will be a separate document, but will act as the basis for identifying the Steps in Section 2.

The SHG function comprises a set of computing applications for information gathering, modeling, decision-making, and controlling actions. These applications reside in central and/or in widely distributed systems, such as relay protection, remedial automation schemes (RAS), local controllers, and other distributed intelligence systems. All these applications and system components operate in a coordinated manner and are adaptive to the actual situations.

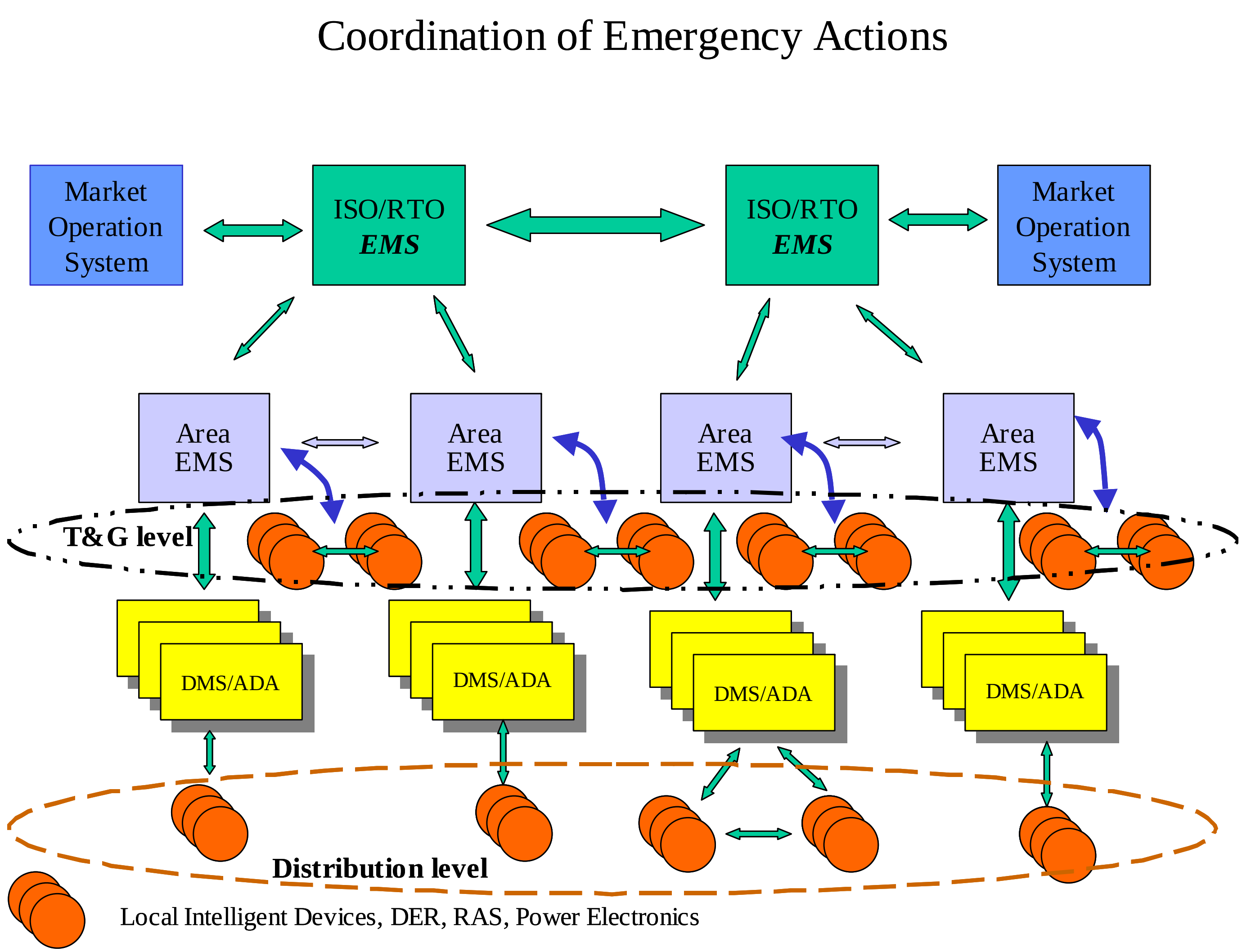
The conventional methodology for emergency control is based on off-line studies for selection of the local emergency automation schemes, their locations, and their settings. Such off-line studies are usually performed for selected operating conditions based on typical cases and on previous emergencies. However, the design of remedial actions and emergency automation schemes based on previous emergencies may be ineffective for the future emergencies. In reality, the emergency situations often occur under conditions that are quite different from the study cases. With the advent of deregulation, the energy schedules are derived from financial considerations rather than strictly power operations considerations. Therefore, the types of possible contingencies increase substantially, and it would be very difficult to study with purely off-line analyses. Not only are there increased pressures from deregulation, there are new challenges imposed by the involvement of distribution systems and customers in preventing and responding to power system emergencies. For instance, with the increased number of distributed energy resource (DER) devices connected to the distribution system, distribution operations have to expand to monitor and manage (if not actually control) these DER devices. The advances of Distribution Management Systems (DMS) and Advanced Distribution Automation (ADA) make these systems available for real-time coordination of transmission and distribution operations in normal, emergency, and restorative states of the power systems.

The SHG will be supported by fast data acquisition systems (WIDE AREA MEASUREMENT SYSTEM(S)/SCADA) and will include fast simulation and decision-making applications observing wide power system areas. These wide-area applications will coordinate the behavior of distributed control systems (regional EMS, DMS, Plant EMS, RAS, and relay protection). These distributed systems and actuators will perform adequately fast under emergency and later under restorative conditions following the rules and settings preset by the upper level simulation and decision-making applications. The coordination of different systems and actuators will be accomplished in a hierarchical manner. Some directive from the upper level, e.g., from the ISO/RTO EMS will be transmitted to the regional EMS, and some commands and settings will be downloaded directly to the actuators. The regional EMS will transmit some directives to the DMS and plant EMS and some commands and settings will be directly downloaded to the actuators, which are in the corresponding areas of responsibility. Some local actuators will be integrated into distributed intelligence schemes and will communicate among themselves in a peer-to-peer manner. The rules of behavior of the distributed intelligence schemes can be preset by the upper control system. (See Fig.1).

The power system operators will be the Persons In Charge (PIC) for the performance of the entire SHG and will participate in the system setup and decision-making processes, which allow sufficient time for the operators to perform an educated action. Under emergency conditions, when fast and complex actions should be performed, the pre-armed and adaptive local and distributed applications and automatic schemes should be the main executors for the protection of equipment and prevention of blackouts.

The future control system for the self-healing grid will differ from the current approaches by implementing significantly more automated controls instead of supervisory controls by the operators and by aiming at preservation of adequate integrity of the generation-transmission-distribution-customer system instead of self-protection of equipment only.

Figure 1 Integration of DMS/ADA with EMS - A real time adaptive decision -making and wide area control system is required to meet the objectives of the self-healing grid.



1.5 Actor (Stakeholder) Roles

Describe all the people (their job), systems, databases, organizations, and devices involved in or affected by the Function (e.g. operators, system administrators, technicians, end users, service personnel, executives, SCADA system, real-time database, RTO, RTU, IED, power system). Typically, these actors are logically grouped by organization or functional boundaries or just for collaboration purpose of this use case. We need to identify these groupings and their relevant roles and understand the constituency. The same actor could play different roles in different Functions, but only one role in one Function. If the same actor (e.g. the same person) does play multiple roles in one Function, list these different actor-roles as separate rows.

Grouping (Community) '		***Group Description***
Top Level Stakeholders		***High-level actors who have significant stake on the SHG function.***
Actor Name	***Actor Type (person, device, system etc.)***	***Actor Description***
Regional System Operator	Organization	Organizations responsible for maintaining transmission system reliability and ensuring open access to the grid for all market participants. Regional System Operator responsibilities include: transmission planning, contingency analysis, real-time system operation, and market monitoring and management.
SCADASyste m	System	Control area supervisory control and data acquisition system
EnergyManage mentSystem	System	Control area energy management system
Wide Area Measurement System(s)	System	Phasor measurement system covers a wide power system area.
PowerMarkete	Entity	Entities who buy and sell electricity in wholesale markets.

Grouping (Community) '		Group Description
Top Level Stakeholders		*High-level actors who have significant stake on the SHG function.*
Actor Name	*Actor Type (person, device, system etc.)*	*Actor Description*
r		
PowerSystem	System	Composition of interconnected transmission, generation, distribution power systems
Reliability/security Coordinator	Entity	Entities that are responsible for the reliability of the power grid and have the authority to fulfill that responsibility within the operating region managed by an Regional System Operator
ControlAreaOperator	Entity	Entities that manually operate and maintain control area facilities and equipment, and execute control orders.
Transmission Level Actuator	System	Power system actuators, which are controlled directly by transmission control area SCADA/EMS
Distribution and PlantControlSystem	System	Distribution management systems, distributed energy resources and generation plant control systems
IED	Device	Intelligent electronic devices including protective relays, RTUs, sensors.

Grouping (Community) '		*Group Description*
Transmission Level Actuator		***Power system actuators, which are controlled directly by transmission control area SCADA/EMS***
Actor Name	***Actor Type (person, device, system etc.)***	***Actor Description***
FACTSDevice	System	A power electronic based system and other static equipment (such as Static Var Compensator, Thyristor Controlled Series Compensator, STATCOM) that provide control of one or more ac transmission system parameters to enhance controllability and increase power transfer capability.
RAS	Systems/devices	Local or distributed intelligence remedial action schemes acting under emergency operating conditions in accordance with either pre-set or adaptive settings to protect equipment, prevent wide-area blackouts, and restore services.

Grouping (Community) '		*Group Description*
Distribution and PlantControlSystem		***Distribution management systems, distributed energy resources and generation plant control systems.***
Actor Name	***Actor Type (person, device, system etc.)***	***Actor Description***
DistributionManagementSystem	System	A distribution management system is a suite of application software that supports distribution system operations.
ADA	System	Advanced distribution automation is a multifunctional system that supports remote monitoring, coordination and operation of distribution components by taking full advantage of new capabilities in power electronics, information technology and system simulation.

Grouping (Community) ’		*Group Description*
Distribution and PlantControlSystem		***Distribution management systems, distributed energy resources and generation plant control systems.***
Actor Name	***Actor Type (person, device, system etc.)***	***Actor Description***
DERDevice	Device/System	Distributed energy resource refers to distributed generation, storage, load management, combined heat and power and other sources involved in electricity supply, both in stand-alone and interconnection applications.
PlantControlSystem	System	A DCS (distributed control system) that operates a generation plant

Grouping (Community) ’		*Group Description*
IED		***Intelligent electronic devices including protective relays, RTUs, sensors.***
Actor Name	***Actor Type (person, device, system etc.)***	***Actor Description***
ProtectiveRelay	Device	A device that responds to faults by tripping a breaker according to control logic, based on the monitoring of current and voltage values, and on communications with other protective relays.
PhasorMeasurementUnit	Device	Phasor Measurement Unit – a generic device which produces synchronized phasors from voltage and/or current inputs and synchronizing signals.
RemoteTerminalUnit	Device	Remote Terminal Unit – A device used to control/monitor/record sensor results in SCADA applications

Replicate this table for each logic group.

1.6 Information exchanged

Describe any information exchanged in this template.

Information Object Name	*Information Object Description*
Real Time Data	Information needed to be updated or exchanged in real time. These data include voltage, current phasor measurements, and frequency, rate of change of frequency, rate of change of voltage calculations. The system flow (both MW and MVAR) can be derived by the voltage and current phasors.
Control Area Network Model	One could partition the power system network model used by a control area into four subnetworks as follows: [1] Subnetwork 1. Internal transmission network is modeled in detail and it is monitored. Subnetwork 2. Unmonitored internal transmission network is modeled in detail as well. It is expected that the unmonitored internal network will be minimized in time given the growth in the utility communication infrastructure. Subnetwork 3. Adjacent external network is modeled in detail because it has significant impact on the security of the internal system. This model will be updated based on the input from adjacent control center. Subnetwork 4: Distant external network is modeled by reduced equivalents because it has less impact on the internal system.
Control Area Network Model Parameters	The parameters in the control area network model include facility status (such as generation shifts due to changes in transaction schedules, redispatch and unit outages, and the status of power plant auxiliary equipments), transmission element impedances, control device set points (such as generator and LTC settings), generation response capabilities (MW/min), breaker/switch states (these states are critical to update the topology of the control area network), and bus load.
Controller Settings	These settings include relay protection and load shedding schemes, other remedial action schemes (RAS), and set points for FACTSDevice devices, voltage controller, phase-shifters and other controllers.

Information Object Name	*Information Object Description*
Control Actions	The control actions involve real and reactive power generators, controllable shunts in transmission, FACTSDevice devices, phase shifters, Load Tap Changers (LTCs), transmission sectionalizing, and distribution automation functions like Volt/Var control, feeder reconfiguration, and load management functions.
Transmission System Limits	The transmission system limits include the determination of the thermal limits, available capacity, economic constraints, interface limits, steady state, transient and small signal voltage stability limits.
PowerSystem Vulnerability Data	The power system vulnerability data include fault information, environmental data, and other sources of power system vulnerability data
Boundary Conditions	Refer to the power system conditions such as voltage, current, and phase angles at the boundary of the network model that is used to simulate internal system behavior.

1.7 Activities/Services

Describe or list the activities and services involved in this Function (in the context of this Function). An activity or service can be provided by a computer system, a set of applications, or manual procedures. These activities/services should be described at an appropriate level, with the understanding that sub-activities and services should be described if they are important for operational issues, automation needs, and implementation reasons. Other sub-activities/services could be left for later analysis.

Activity/Service Name	*Activities/Services Provided*
Dynamic Model Update	EMS system performs dynamic model update, state estimation, bus load forecast. Dynamic Model Update sub-function updates the system model to reflect the status of the transmission and generation equipment and critical operational parameters in real-time, based on gathering the wide-area synchronized phasor measurements and estimating the missing and inaccurate data; The bus-load model update and forecast is supported by the distribution operation model and analysis; In a multi-area interconnected system, each control area updates its model and exchanges the full or reduced model with neighbor areas.
Optimal Power Flow (OPF)	EMS system performs optimal power flow analysis, recommends optimization actions: Optimal Power

Activity/Service Name	*Activities/Services Provided*
	flow provides operations personnel with recommended system changes to correct limit violations while optimizing the system for pre-defined objectives including minimizing losses, maximizing MW capacity via optimal Mvar control, minimizing the number of controls moved, or minimizing the movement in all available controls. OPF uses bus load models supported by DistributionManagementSystem applications and includes the bus dispatchable load in its variables. OPF issues sets of actions for multiple local controllers, distributed intelligence schemes, and DistributionManagementSystem applications.
Stability Analyses	EMS system performs stability study of network to: Determine the dynamic stability limits and Determine whether network is operating close to limits of stability
Real Time Contingency Analysis	EMS system performs contingency analysis (CA), recommends preventive and corrective actions: Contingency Analysis and post-contingency analysis of remedial action provides the ability to correct problems caused by harmful disturbances Result from contingency analysis is analyzed by post contingency optimal power flow The post contingency optimal power flow simulates the behavior of relay protection, load shedding schemes, other remedial action schemes (RAS), FACTS devices, voltage controllers, phase-shifters, and other local controllers. Status and set points are obtained from the dynamic model update, and are applied to probabilistic models of power system operations. CA sub- function considers multiple sets of independent and dependent contingencies and provides risk assessment and severity evaluation of the sets CA sub-function develops and implements preventive actions to reduce the risk and severity of anticipated contingencies, including generation-constrained optimal power flow implemented in closed-loop mode, blocking of some controls, and pre-arming of RAS and other distributed intelligence schemes. CA checks the success of execution of the preventive actions and changes the input criteria in case of failure.

Activity/Service Name	*Activities/Services Provided*
	This activity is further elaborated in the “Contingency Analysis” use cases.
Real-time Emergency Operations (system protection level)	Protects power system facilities from damage Automatically sheds load under conditions of low frequency, based on pre-defined or real-time computed settings, modes of operations, and priorities of connected groups of customers. Should be made adaptive to the conditions of the interconnected self-healing grid and non-intentional and intentional islanding. Automatically sheds or reduces generation to preserve load balance over the transmission lines and power system stability Automatically sheds load under conditions of low voltage, based on pre-defined or real-time computed settings, modes of operations, and priorities of connected groups of customers. Should be made adaptive to the conditions of the interconnected self-healing grid and non-intentional and intentional islanding. Automatically sheds load under specific conditions, based on pre-defined or real-time computed settings, modes of operations, and priorities of connected groups of customers. Should be made adaptive to the conditions of the interconnected self-healing grid and non-intentional and intentional islanding. Restores load based on real-time power system restoration capabilities. Should be made adaptive to the changing conditions. Fast control of LTC to prevent voltage instability (Fast = 10 to 100ms – depending on the size of the control area) Fast control of shunts to prevent voltage instability Fast control of series compensation devices to prevent system instability and critical overloads Balanced separation of the power system into near balanced islands to prevent cascading development

Activity/Service Name	*Activities/Services Provided*
	of severe contingencies into wide-area blackout. Filters and summarizes multiple alarms into a conclusive message about the core cause of the contingency. Uses centralized alarm reduction based on events from multiple substations Automatically locates faults based on high-speed synchronized measurements Provides field crews with real-time information by using mobile computing Provides pre-fault, fault, and post-fault data for fault location, alarm processing, and analyses of the emergency operating conditions. Provides other EMS applications and the operators with near-real time stability limits Changes the modes of operation, the settings, and the priorities of RAS, based on evaluation of the developing or expected emergency conditions. Issues summary requirements to DISCOs for changing distribution operations, based on evaluation of the developing or expected emergency conditions. Changes the modes of operation, the objectives, constraints, and the priorities of DistributionManagementSystem Volt/var control application, based on evaluation of the developing or expected emergency conditions Changes the modes of operation, the objectives, constraints, and the priorities of DistributionManagementSystem feeder reconfiguration application, based on evaluation of the developing or expected emergency conditions Issues summary requirements (amount and timing) to DISCOs for activating the interruptible/curtailable load systems. DISCO defines the specifics of implementation. Issues summary requirements (amount and timing) to DISCOs for activating the direct load control systems. DISCO defines the specifics of implementation.

Activity/Service Name	Activities/Services Provided
	Issues summary requirements (amount and timing) to DISCOs for activating the DERDevice reserves. DISCO defines the specifics of implementation. Issues summary requirements (amount and timing) to DISCOs for activating the load managements systems. DISCO defines the specifics of implementation. This activity is further elaborated in the "Emergency Operation" use cases.
System Restoration	Operators perform system restorations based on system restoration plans prepared (authorized) by operation management. System restoration to normal state, in addition to automatic restoration, if needed. Unit starts, auto-synchronization, load energization, based on the power system recovery capability monitored and coordinated by EMS This activity is further elaborated in the "Advanced Auto Restoration" use case.

1.8 Contracts/Regulations

Identify any overall (human-initiated) contracts, regulations, policies, financial considerations, engineering constraints, pollution constraints, and other environmental quality issues that affect the design and requirements of the Function.

Contract/Regulation	Impact of Contract/Regulation on Function
Data Exchange Contract	

Policy	From Actor	May	Shall Not	Shall	Description (verb)	To Actor
Data Exchange Policy	EnergyManagementSystem			X	Provides data to other control area EMS based upon bilateral agreements, which define the types and amounts of data and the data exchange frequencies. [1]	EnergyManagementSystem

Constraint	Type	Description	Applies to
Economics Constraints		Optimal Power Flow function is subject to the market constraints.	Optimal Power Flow (Activity)

2 Step by Step Analysis of Function

Describe steps that implement the function. If there is more than one set of steps that are relevant, make a copy of the following section grouping (Preconditions and Assumptions, Steps normal sequence, and Steps alternate or exceptional sequence, Post conditions)

2.1 Steps to implement function

Name of this sequence.

SHG

2.1.1 Preconditions and Assumptions

Describe conditions that must exist prior to the initiation of the Function, such as prior state of the actors and activities

Identify any assumptions, such as what systems already exist, what contractual relations exist, and what configurations of systems are probably in place

Identify any initial states of information exchanged in the steps in the next section. For example, if a purchase order is exchanged in an activity, its precondition to the activity might be 'filled in but unapproved'.

Actor/System/Information/Contract	***Preconditions or Assumptions***
PowerSystem	PowerSystem is under normal operation state.

2.1.2 Steps – Normal Sequence

Describe the normal sequence of events, focusing on steps that identify new types of information or new information exchanges or new interface issues to address. Should the sequence require detailed steps that are also used by other functions, consider creating a new "sub" function, then referring to that "subroutine" in this function. Remember that the focus should be less on the algorithms of the applications and more on the interactions and information flows between "entities", e.g. people, systems, applications, data bases, etc. There should be a direct link between the narrative and these steps.

The numbering of the sequence steps conveys the order and concurrency and iteration of the steps that occur. Using a Dewey Decimal scheme, each level of nested procedure call is separated by a dot '.'. Within a level, the sequence number comprises an optional letter and an integer number. The letter specifies a concurrent sequence within the next higher level; all letter sequences are concurrent with other letter sequences. The number specifies the sequencing of messages in a given letter sequence. The absence of a letter is treated as a default 'main sequence' in parallel with the lettered sequences.

Sequence 1:

```
1.1 - Do step 1
1.2A.1 - In parallel to activity 2 B do step 1
1.2A.2 - In parallel to activity 2 B do step 2
1.2B.1 - In parallel to activity 2 A do step 1
1.2B.2 - In parallel to activity 2 A do step 2
1.3 - Do step 3
1.3.1 - nested step 3.1
1.3.2 - nested step 3.2
```

Sequence 2:

```
2.1 - Do step 1
2.2 – Do step 2
```

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
#	*Triggering event? Identify the name of the event.*[1]	*What other actors are primarily responsible for the Process/Activity? Actors are defined in section1.5.*	*Label that would appear in a process diagram. Use action verbs when naming activity.*	*Describe the actions that take place in active and present tense. The step should be a descriptive noun/verb phrase that portrays an outline summary of the step. "If …Then…Else" scenarios can be captured as multiple Actions or as separate steps.*	*What other actors are primarily responsible for Producing the information? Actors are defined in section1.5.*	*What other actors are primarily responsible for Receiving the information? Actors are defined in section1.5.* *(Note – May leave blank if same as Primary Actor)*	*Name of the information object. Information objects are defined in section 1.6*	*Elaborate architectural issues using attached spreadsheet. Use this column to elaborate details that aren't captured in the spreadsheet.*	*Reference the applicable IECSA Environment containing this data exchange. Only one environment per step.*
1.1A		EnergyManagementSystem	Gather model data	Gather the network model parameters in real time, including actual data about the mode of operation and settings of the automated systems and devices.	SCADASystem	EnergyManagementSystem	Control Area Network Model Parameters	High amount of data need to be handled. Common data format is an issue. Missing data is another issue. The data exchange could be report- by-change. Synchronization of data is an issue	Intra-Control Center
1.1B		Regional System Operator	Receive phasor measurements	Receive the wide-area synchronized phasor measurements	WIDE AREA MEASUREMENT SYSTEM(S)	Regional System Operator	Real Time Data	Time synchronization is required. C37.118 specifies synchronization in 1ms for some applications, 5ms for others. [2] Real time constraints: Phasor Measurement Unit delivers up to 60/50 measurements within one second in a 60/50 Hz system.	Inter-Control Center

[1] Note – A triggering event is not necessary if the completion of the prior step transitions to the next step.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
1.2		Regional System Operator	Synchronize data	Synchronizes and estimates the data obtained from SCADA and WIDE AREA MEASUREMENT SYSTEM(S), identifies and corrects inaccurate data, replaces bad and missing data. Incorporates updates of parameters of controllers and control systems and outputs from other automated systems (DistributionManagementSystem, ADA, plant EMS, neighbor area, ISO/ RTO EMS, MOS).	Regional System Operator	Regional System Operator		Regional System Operator through State estimation/Dynamic Model Update Appliction. The calculation and updates should be complete within 1 second in some cases	Inter-Control Center
2.1		EnergyManagementSystem Real Time Security Analysis Applications	Collect vulnerability data	Collect fault information, environmental data, and other sources of power system vulnerability data.	SCADASystem	EnergyManagementSystem	PowerSystem Vulnerability Data	Time-step for real-time security assessment is 1-10sec [3]	Intra-Control Center
2.2		EnergyManagementSystem Real Time Security Analysis Applications	Simulate system behavior	Simulates the reactions of relevant automated systems based on the updated system model.	EnergyManagementSystem	EnergyManagementSystem	Boundary Conditions	In order to achieve timely results, the system configuration should be considered. Whether to conduct the simulation in centralized or distributed fashion will have significant impact on the architecture.	Inter-Control Center

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
2.3A		EnergyManagementSystem Real Time Security Analysis Applications	Conduct steady state analyses	Conduct steady state analyses by applying probabilistic models of power system components.	EnergyManagementSystem	EnergyManagementSystem			Inter-Control Center
2.3B		EnergyManagementSystem Real Time Security Analysis Applications	Conduct dynamic analyses	Conduct dynamic analyses considering multiple sets of independent and dependent contingencies.	EnergyManagementSystem	EnergyManagementSystem			Inter-Control Center
2.4		EnergyManagementSystem Real Time Security Analysis Applications	Update system limits	Define the distances to system limits that will determine the severity of the contingencies.	EnergyManagementSystem	EnergyManagementSystem	Transmission System Limits		Inter-Control Center
2.5A		EnergyManagementSystem Real Time Security Analysis Applications	Assess security risk	Assess the risk associated with each contingency.	EnergyManagementSystem	EnergyManagementSystem			Inter-Control Center
2.5B		Control Area EM Real Time Security Analysis Applications S	Assess intentional islands	Assess the feasibility of automatically created islands and determine the root cause of insecurity.	EnergyManagementSystem	EnergyManagementSystem			Inter-Control Center
3.1	Perceived power system condition change based on Sequence 2 assessment results	EnergyManagementSystem with its Real Time Security Analysis Application preemptive control function	Implement preventive actions	Activate the OPF and implements preventive actions	EnergyManagementSystem	Transmission Level Actuator, Distribution and PlantControlSystem, IED	Controller Settings	A huge amount of data needs to be exchanged in real time.	Intra-Control Center

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
3.2A		EnergyManagementSystem with its Real Time Security Analysis Application preemptive control function	Pre-arm actuators	Pre-arm the appropriate actuators with the corrective actions for emergency events.	EnergyManagementSystem	Transmission Level Actuator, Distribution and PlantControlSystem, IED	Controller Settings	A huge amount of data needs to be exchanged in real time.	Intra-Control Center
3.2B		EnergyManagementSystem with its Real Time Security Analysis Application preemptive control function	Impose inhibition of control	Impose the inhibition of control, if the analysis of hypothetical controller failure would yield much more severe consequences than the denial of the control action itself.	EnergyManagementSystem	Transmission Level Actuator	Controller Settings		Intra-Control Center
3.2C		Regional System Operator	Coordinate corrective actions	Coordinate the corrective actions based on acceptable supply-demand balance in prospective islands, weak links between control areas, within control areas, and within islands, contractual agreements and market rules for implementation.	Regional System Operator	PowerMarketer, EnergyManagementSystem	Control Actions	Bi-directional communications among PowerMarketer, Regional System Operator and control area EMS.	RTOs / Market Participants, Inter-Control Center
4.1		EnergyManagementSystem EnergyManagementSystem through Optimal Power Flow application	Power flow optimization actions	Take power flow optimization actions.	EnergyManagementSystem	PowerMarketer, Regional System Operator, EnergyManagementSystem, Transmission Level Actuator, Distribution and PlantControlSystem	Control Actions		Intra-Control Center, RTOs / Market Participants, Inter-Control Center

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
4.2A		EnergyManagementSystem through Preemptive Control function	Verify system status	Verify the execution results in closed-loop control mode	EnergyManagementSystem	Regional System Operator, EnergyManagementSystem, Transmission Level Actuators, Distribution and PlantControlSystem	Real Time Data		Inter-Control Center, Intra-Control Center
4.2B		EnergyManagementSystem through Real-time emergency operations	Detect imbalance	Detect the generation and load imbalance.	EnergyManagementSystem	Regional System Operator, EnergyManagementSystem	Real Time Data	This function should be executed with 10-100sec. [3]	Inter-Control Center
5.1	Power system under emergency state	Regional System Operator	System decomposition	Decompose the power system into approximately self-sufficient islands.	Regional System Operator	EnergyManagementSystem			Inter-Control Center
5.2		Regional System Operator	Control reconfiguration	Coordinate the interrelated control actions and resolve the conflicting control signals by the higher-level controllers.	Regional System Operator,	EnergyManagementSystem			Inter-Control Center
6.1	Power system under emergency state	Regional System Operator	System correction	Implement emergency control actions such as reducing generation or shedding load or both to restore the generation/load balance.	Regional System Operator	Regional System Operator, EnergyManagementSystem, Transmission Level Actuator, Distribution and PlantControlSystem	Control Actions	The control action must be accomplished within 0.1-1.3 seconds. [4]	Inter-Control Center
7.1	Post emergency state	Regional System Operator	Prepare for restoration	Re-synchronize the separated transmission lines (reconnect islands).	EnergyManagementSystem	Regional System Operator	Real Time Data	System restorations based on system restoration plans prepared (authorized) by operation management	Inter-Control Center

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
7.2		Regional System Operator	Restoration	Start reserve/tripped generation, control shunts and analyze the conditions for load restoration, based on generation reserves, reactive power support, and transmission transfer capacity.	Regional System Operator	EnergyManagementSystem		System restorations based on system restoration plans prepared (authorized) by operation management	Inter-Control Center

2.1.3 Steps – Alternative / Exception Sequences

Describe any alternative or exception sequences that may be required that deviate from the normal course of activities. Note instructions are found in previous table.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments

2.1.4 Post-conditions and Significant Results

Describe conditions that must exist at the conclusion of the Function. Identify significant items similar to that in the preconditions section.

Describe any significant results from the Function

Actor/Activity	*Post-conditions Description and Results*
PowerSystem	Power system is back to normal operation state.

2.2 Architectural Issues in Interactions

Elaborate on all architectural issues in each of the steps outlined in each of the sequences above. Reference the Step by number.

Microsoft Excel
Worksheet

2.3 Diagram

For clarification, draw (by hand, by Power Point, by UML diagram) the interactions, identifying the Steps where possible.

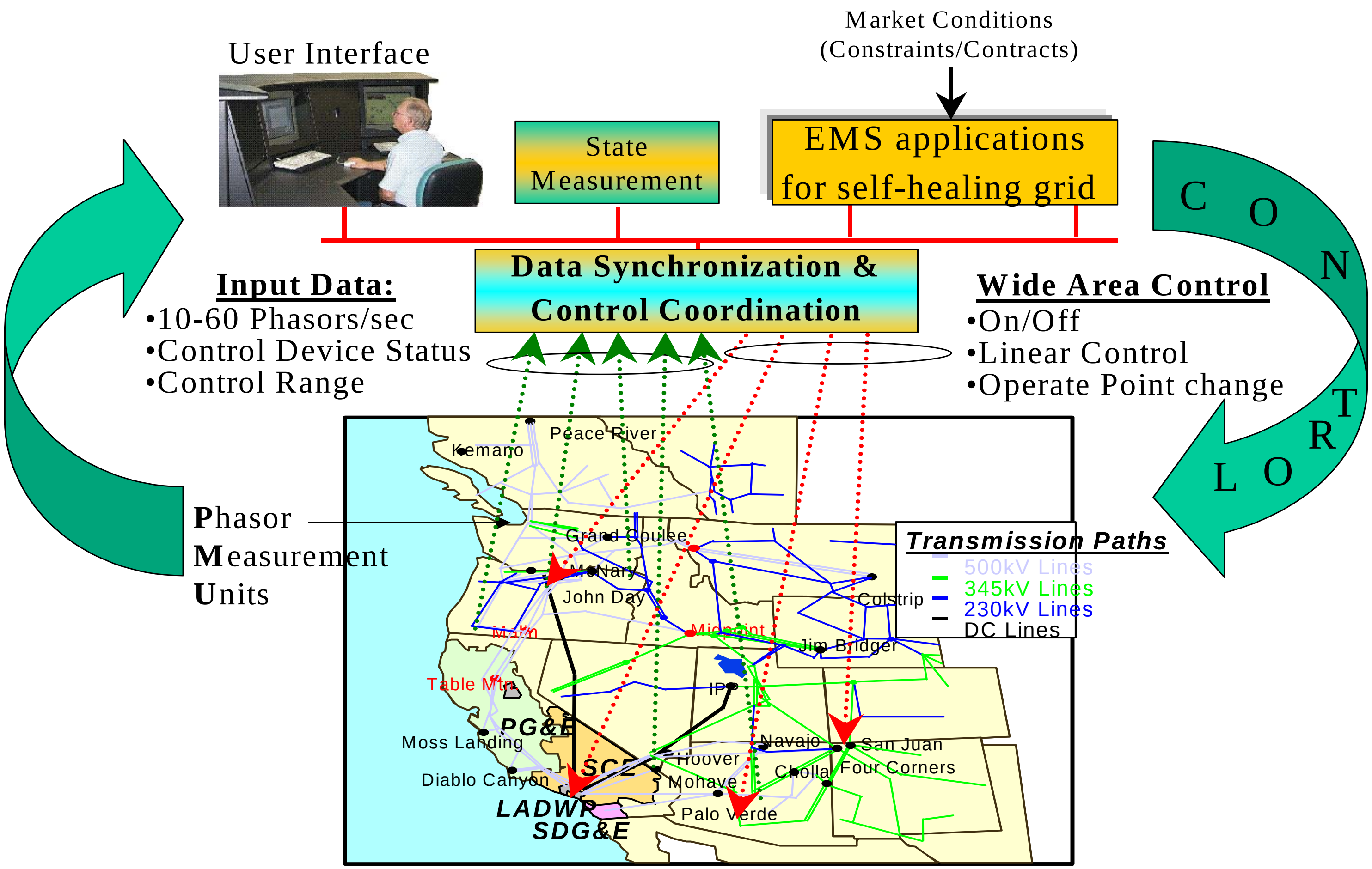


Figure 2 Overview of SHG Application

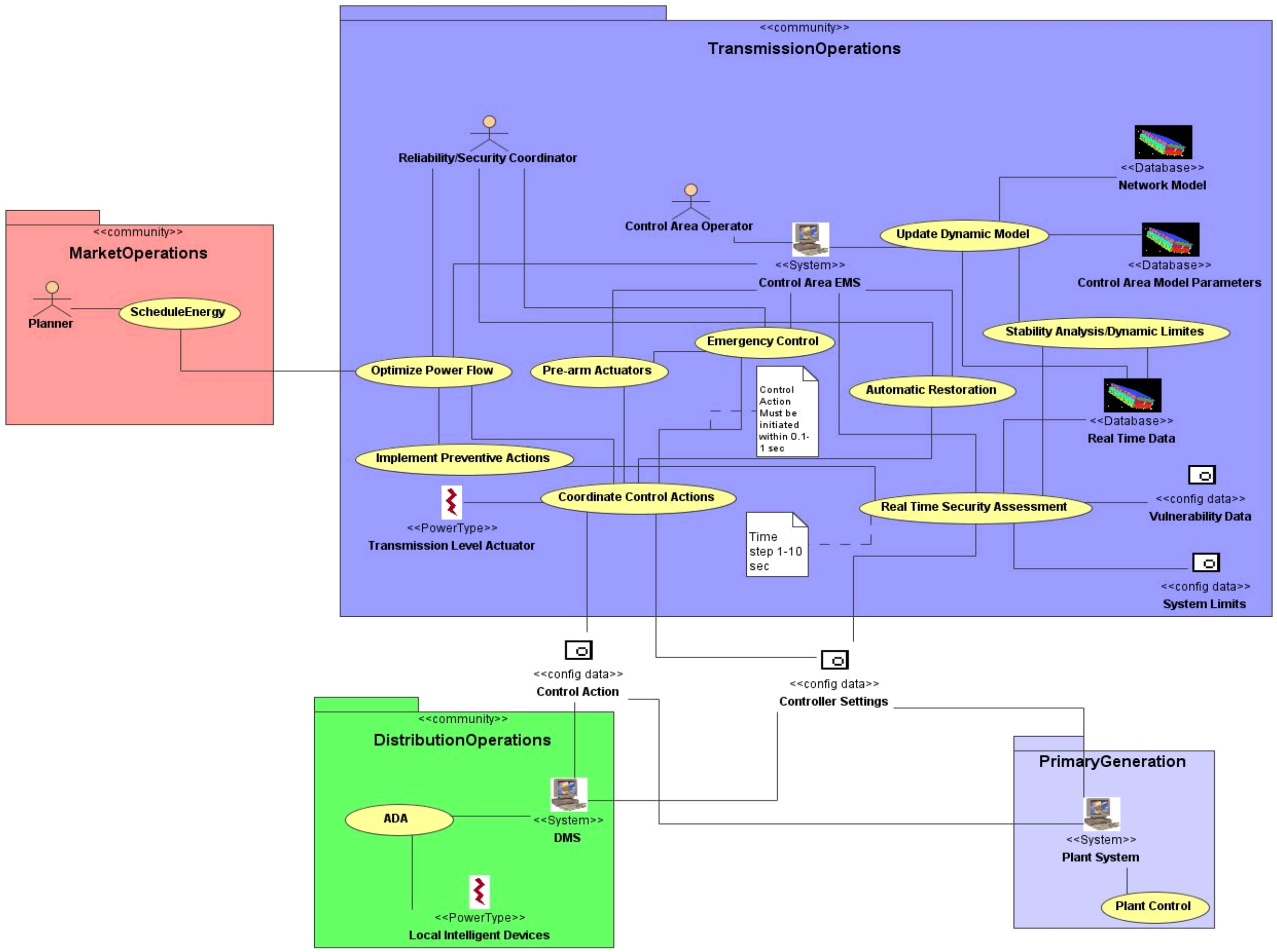


Figure 3 Information Flow Diagram

3 Auxiliary Issues

3.1 References and contacts

Documents and individuals or organizations used as background to the function described; other functions referenced by this function, or acting as “sub” functions; or other documentation that clarifies the requirements or activities described. All prior work (intellectual property of the company or individual) or proprietary (non-publicly available) work must be so noted.

ID	Title or contact	Reference or contact information
[1]	Real-time data exchange for on-line security assessment	K, Kato et.al, Power Industry Computer Application Conference, May 1991, pp30-36
[2]	Syncro Phasor Domain Template	William Premerlani
[3]	Fast Simulation and Modeling System RFP	E2I/CEIDS, Sept 2003
[4]	Adaptive Protection as Preventive and Emergency Control	M.J.Damborg et.al. Power Engineering Society Summer Meeting, 2000. IEEE , Volume: 2 , 16-20 July 2000 Page(s): 1208 -1212 vol. 2
[5]	Specification of integrated SCADA/EMS/DMS for Florida Power and Light (FP&L and UCI proprietary) Experience of System - Wide Distribution Automation At JEA, Don C. Gilbert, Nokhum Markushevich and Alex Fratkin, Distributech 2004 conference The Specifics Of Coordinated Real-Time Voltage And Var Control In Distribution, Nokhum S. Markushevich, Utility Consulting International (UCI), Distributech 2002 Conference	Nokhum Markushevich, (UCI), nokhum@uci-usa.com

	Implementation Of Advanced Distribution Automation In Us Utilities, Nokhum S. Markushevich and Aleksandr P. Berman (Utility Consulting International), Charles J. Jensen (JEA), James C. Clemmer (OG&E), USA, CIRED Conference, Amsterdam, 2001 Integration Of Distribution Automation into Power System Operation, Edward H.P. Chan, Nokhum S. Markushevich; DA/DSM Conference, January 1994, Florida Intelligent Alarm Processing, Electric Power Research Institute (EPRI) TR-101576, Research Project #2944-04, E.H.P. Chan, Nokhum Markushevich, and J. Birchfield. December 1992 Automated Dispatcher Control System, Nokhum S. Markushevich Moscow, 1986. Under-frequency Load Shedding in Power Systems, Nokhum S. Markushevich, Moscow, 1975.	

3.2 Action Item List

As the function is developed, identify issues that still need clarification, resolution, or other notice taken of them. This can act as an Action Item list.

ID	Description	Status
[1]		
[2]		

3.3 Revision History

For reference and tracking purposes, indicate who worked on describing this function, and what aspect they undertook.

No	Date	Author	Description
0.	10/14/2003	Rui Zhou	Draft the narrative section based on Nokhum's original write-up
1.	10/14/2003	Rui Zhou	Start to fill in the tables and draw the block diagrams
2.	10/15/2003	Nokhum Markushevich	Revised section 1.3 and 1.4
3.	10/16/2003	Rui Zhou	Filled in Section 1.5 and 2.2
4.	10/16/03	Nokhum Markushevich	Rewrote section 1.6 and revised section 2.2
5.	10/16/03	Nokhum Markushevich	Changed 1.6 to a higher level, edited 1.5, changed 2.2, and marked up the use-case diagram
6.	10/27/03	Rui Zhou	Updated based on the domain template ver 1.19
7.	12/16/03	Ellen Liu	Updated based on the latest domain template ver 1.27. Revised section 2.1.2; start working on section 2.2.
8.	12/22/03	Rui Zhou	First cut done for section 2.2; updated 1.6. The document now conforms to the latest version of the domain template.
9	1/30/04	Rui Zhou	Addressed the comments received from the team.
10	1/31/04	Nokhum Markushevich	Added text to 1.4 and an illustration for coordinated emergency operations. Edited and commented on text in other sections.
11	2/26/04	Rui Zhou	Clean up the use case considering the automated importing process.

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