

WAMAC Emergency Operations Baseline

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 Monitoring and Control Systems - Emergency Operations Baseline

1.2 Function ID

IECSA identification number of the function

1.3 Brief Description

The purpose of the Wide Area Monitoring and Control Systems - Emergency Operations function is to provide communications services permitting an operator to take the following actions in response to a fault in the power system:

Locate the fault

Verify that protection has operated correctly to clear the fault

Shed load to ensure that the fault does not cause an overload of unaffected lines

Manually re-route power to restore service to subscribers

Dispatch crews and emergency teams to fix the fault

Capture fault recordings so engineers can later analyze the cause of the fault

This function also addresses handling of environmental and security alarms.

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.

Emergency operations are organizational sequences of activities that involve multiple integrated actors exchanging information when a fault is detected on a power system. These activities are integrated through the use of Wide Area Control and Monitoring Systems

(WAMACS) that provide operational control over the distributed network of actors that comprise the SCADA system. Each utility maintains their own WAMACS but in the future these systems must be linked to provide overall control and monitoring across multiple organizations to meet the future demands of the suppliers and users of electrical power.

The remainder of this narrative describes an example scenario illustrating the characteristics and sequence of activities that occur on the power system during Emergency Operations. The example is based on a typical substation with a SCADA system.

1.4.1 Initial State

When a typical substation is operating in the normal state, called initial state for the purposes of this discussion, there are at least two incoming lines connected to two transformers that feed two separate buses that supply the source side of the feeder circuits. In the initial state both lines and transformers would be energized and the main breakers would be closed to allow both buses to be energized. The bus tie breaker between the two buses is closed so both transformers are sharing the load from all four feeders.

The lines, transformers, buses and feeders each are monitored by separate protection relays that can sense abnormalities in the zone of protection that they are responsible for and isolate faults in the zone by opening the appropriate breaker. Adjacent protection relay zones overlap to ensure that there is protection at every point in the system. Incoming line relays are responsible for a zone of protection that extends out of the substation and down the line a certain distance. The other end of the line is usually owned by the power transmitter and there is similar distance protection on that end of the line. If a fault occurs on the line both relays report the distance and direction to the fault. There should be an overlap in the two fault reports and this is the portion of the line that the dispatched maintenance crew will check first for the fault.

In the initial state the SCADA system, shown in Figure 1, would have no outstanding alarms or abnormal readings that would require the operator to take action. The SCADA system, which is made up of these protection IEDs, monitor the critical areas of the substation and report data to the DataConcentrator. The protection IEDs are most often located within a substation, but may also be located at remote sites or on pole-tops.

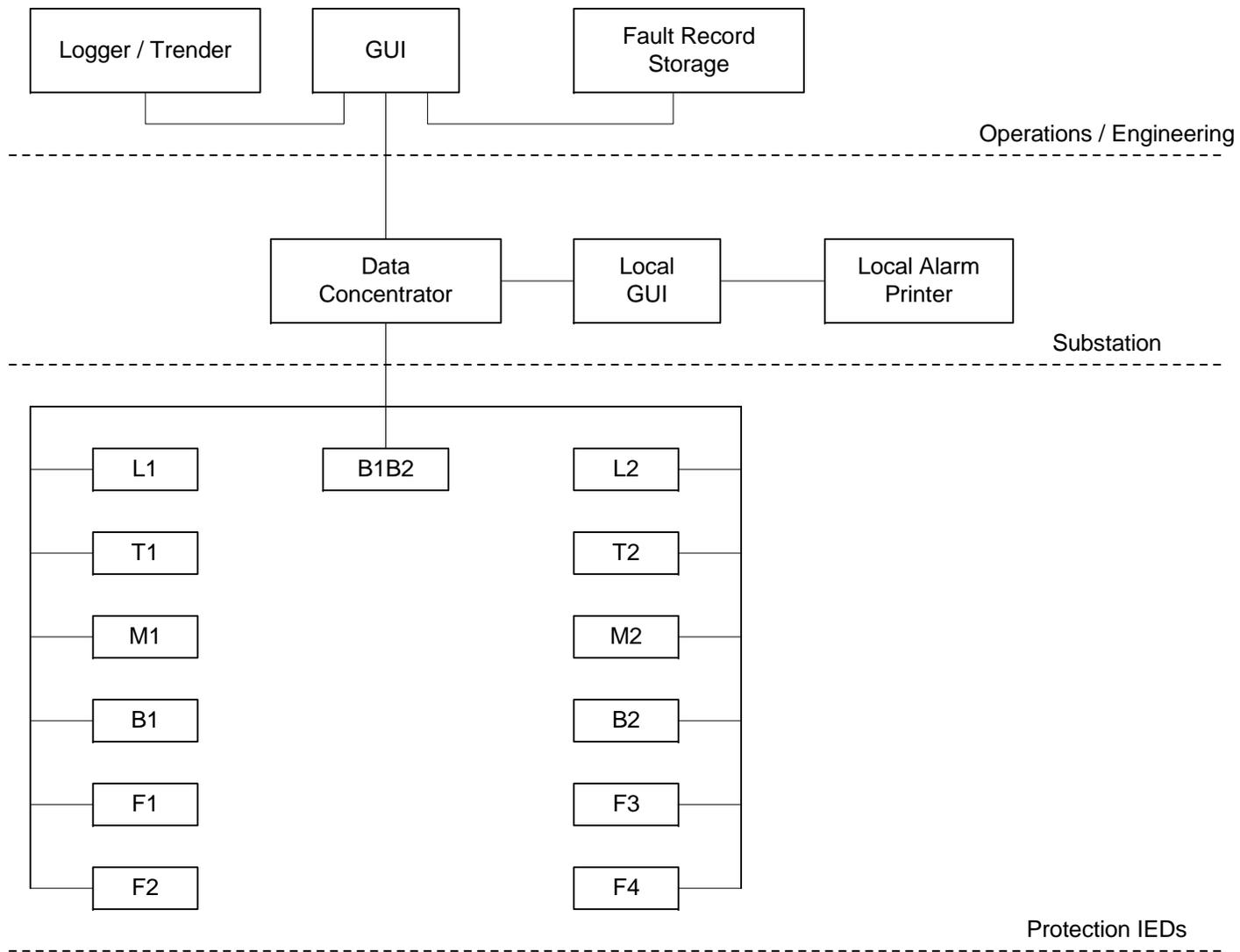


Figure 1: SCADA System

GUI – Graphical User Interface

L1/L2 – Line Distance relays

T1/T2 – Transformer relays

M1/M2 – Main Breaker relays

B1/B2 – Bus relays

F1/F2/F3/F4 – Feeder relays

The DataConcentrator is located in the substation and is connected with a communication link to each IED. The substation is often equipped with a local GUI and an alarm logger. The DataConcentrator is connected through a different communication link to one or more GUIs. GUIs can be local to the substation or in an operations center that monitors several substations.

The operator is located in close proximity to the GUI, which is the operator's window into the substation. The operations center is usually equipped with a logging and trending system to store analog quantities on a regular interval or on a change to display the quantities on a graph. There also must be a method of storing and accessing fault records that are used by engineers to analyze the faults.

DataConcentrators, GUIs, and the communications links between them and the IEDs are usually redundant, and perform switchover if one link fails. Reliability is very important.

1.4.2 Fault Occurrence and Detection

There are several places where a fault can occur on this system and several different ways the equipment can be used to isolate different fault conditions. Some very simple fault scenarios are used in the discussion to help describe Emergency Operations. Each zone of protection is equipped with a protection IED, or relay, that monitors the state of the system and the values of the electrical quantities that are relevant to the zone of protection. If a fault occurs the relay is able to cause a breaker and sometimes also a switch to operate to isolate the fault.

If a fault occurs some distance down the incoming transmission line the line distance relay associated with that zone is responsible for detecting the fault, tripping the main breaker and disconnecting the incoming line disconnect switch. This isolates the substation from the fault so that the excessive current associated with the fault does not damage any equipment in the substation. This operation must occur within one cycle of the power waveform and this precise timing requires accurate time synchronization to be applied to the device so that the time the event occurred and the sequence of events can be determined later. The line distance relay also reports the system changes caused by the fault to the DataConcentrator which in turn passes them to the GUI where the state changes are reported as system alarms to the operator.

A fault occurring in a different zone of protection would be handled in a similar way. For example the transformer relay is responsible for the closed zone of protection around the transformer. If a transformer fault occurs it opens the main breaker and then the disconnect switch.

1.4.3 Fault Record Generated

Often a fault recorder is monitoring the power system quantities at one or more strategic locations around the substation. The protection IEDs or the RTU often have built in fault recorders that can capture data before, during and after a fault. Engineers will use this information to determine the type, magnitude and profile of the fault.

During normal operation the fault recorder is storing several cycles worth of data continuously. If a fault occurs it triggers the recorder to stop overwriting the pre trigger data and continue recording the actual fault data. In this way the engineer is able to observe the stable condition before the fault, (pre trigger), and exactly what happened at the instant the fault occurred and then the post fault profile which is the system reaction to the fault.

The fault data profile usually has separate channels for each of the three phase voltages and currents and can use other signals as well. The fault data is usually stored in a standard format in the IED or in the fault recorder that captured the data. A signal, in the form of an alarm, is sent to the data concentrator and subsequently to the GUI to notify the operator that a fault file is available to be analyzed.

1.4.4 Change of State

Faults cause the system to change state, usually because one of the protection IEDs has tripped a breaker. The state of the breaker is detected by a change in position in the detection device located in close proximity to the breaker. This change of state is generally

detected by the IED and reported to the DataConcentrator or detected directly by the DataConcentrator in other situations. The DataConcentrator determines if it is required to communicate the change of state to the GUI in which case it does. The DataConcentrator's function is to translate the protocol that contains the state change between the IED and the GUI.

Often there is a large number of devices in the substation, slow communication links, legacy protocols that do not have timestamps, sorting requirements or the requirement to send the change of state data to more than one GUI. All these are reasons why a DataConcentrator is required.

1.4.5 Alarm

A fault causes a breaker to trip which causes a change of state in the system which is converted to an Alarm by the GUI to notify the operator of the system change. Usually the alarm shows up as a flashing text message at the bottom of the active screen on the operators GUI and is combined with an audible signal in case the operator is not looking at the screen. The flashing and audible signal stop when the alarm is acknowledged. Characteristics associated with each different alarm are preconfigured such as location, priority and description.

The trip notification is a digital change of state, accompanied by a timestamp indicating when the event occurred. The timestamp is important because it may be later used to reconstruct a "sequence of events" indicating when various devices and personnel within the utility took action to address the fault. For this reason, time between devices within the SCADA system is typically synchronized to within 1 millisecond. Sometimes this takes place over serial links or LANs, but most commonly is performed by connecting satellite time sources to each device.

1.4.6 Retrieve Fault Record

The Fault Record is stored in the IED and a notification that the record exists is provided and can be obtained. There is either a manual or automated process in place for retrieving the Fault Record so that it can be studied. The file is retrieved by the DataConcentrator and passed to the GUI where it is stored and cataloged. The information in the record is analog and digital data that was captured before, during and after the fault.

There are several issues that can limit the systems ability to retrieve faults:

Fault records contain large volumes of data that some devices cannot handle.

Not all DataConcentrators can forward file data.

Legacy protocols may not support file transfer.

Existing communication links may make the transfer of large files too slow.

Some arrangements require personnel to be dispatched to the site to extract the Fault Record directly from the IED.

1.4.7 Change in Line Load

When a breaker trips there is no longer a path for electrical energy to flow from the live side of the breaker through to the other side. The breaker has isolated the downstream equipment by opening the circuit to stop the energy from getting to the equipment. This always causes a change to the entire load that the substation is connected to. Anything downstream of the breaker is not running because the power is removed unless there is a way to feed the load with energy from another line. The IED monitoring the changed load is responsible for detecting and reporting the change in the quantities, such as voltage and current. The IED provides the information necessary to understand how the system has changed.

1.4.8 Analog Data Change

When Analog Data changes in the IED it is reported to the DataConcentrator first. If the DataConcentrator identifies the data as being of interest to one or more of the GUIs that are connected to it and the change in value is significant in that it exceeds a preconfigured deadband it translates the data from the IED to the GUI through the communications protocols.

1.4.9 Change in System Load

When the System Load changes and the GUI is notified of the change by the DataConcentrator it must perform several activities for the operators to be able to investigate:

Maps the point number of the protocol to the appropriate location in the database.

Scales the data appropriately for accurate display in the correct units.

Updates any values currently being displayed.

Raises appropriate alarms associated with the quantities.

Logs and trends data if required.

1.4.10 Shed Load or Restore Power

The SystemOperator addresses the alarm by viewing the system state displayed on the GUI. IEDs pass load and switch state change information to the GUI through the DataConcentrator, permitting the SystemOperator to:

Determine the location of the fault

Verify that the protection equipment has operated properly to clear the fault (isolate the faulted section).

See the impact of the fault isolation on the rest of the power system.

The SystemOperator takes action to address the alarm. This action may include any of the following items:

Reset any breakers that should not have tripped.

Disconnect the faulted section of line from the remainder of the power system, if protection equipment has not already done so.

Re-route power so the loss of the faulted line does not cause other portions of the system to be overloaded.

Re-route and restore power so the affected area is minimized.

Disconnect (shed) load from the power system if there is no other way to prevent an overload.

From the point of view of the communications network, the effect of all these actions is the same: the SystemOperator sends control requests to various IEDs within the substation and elsewhere in the network, to either open or close switches or breakers. The SystemOperator enters these controls at the GUI. They are forwarded through the DataConcentrator to the correct IED. At any point in this path, the SCADA System may reject the controls if they violate safety rules, e.g. closing a switch to run power back onto the faulted line. This is called Interlocking and is discussed further in the Automated Controls use case.

1.4.11 Control

If the operator has sent a control the GUI must format the control into an appropriate request, usually a Select-Before-Operate service is used, for the DataConcentrator or IED and sent through the protocol. The control can be digital such as changing the state of a breaker or an analog setpoint such as changing the position of a valve. The information contained in the control request includes: Point number, operation, duration and setpoint value.

1.4.12 Forward Control

If the operator has sent a control that is destined for a protection IED the DataConcentrator must forward the request to the IED. The IED acknowledgement to the request is received by the DataConcentrator first and then forwarded to the GUI. This is a protocol translation function performed by the DataConcentrator. The indication of the correct state of the control being achieved or the alarm to indicate that the control failed is also received first by the DataConcentrator and then forwarded to the GUI for display on the

screens the operator is looking at. When forwarding the control the DataConcentrator uses the Select-Before-Operate service similar to the GUI. The DataConcentrator can support multiple GUIs issuing controls if required.

1.4.13 Locate Fault

The protection IEDs that monitor the lines, L1 and L2, and the feeders, F1, F2, F3 and F4, usually have the capability of locating the fault by measuring the impedance of the line, and then comparing it to known impedances that exist when the fault is not present and preconfigured characteristics of the line. Usually the direction and distance to the fault are outputs of the IEDs calculations. This information is used to make operational and maintenance decisions by the DataConcentrator, the GUI and the operator.

1.4.14 Display Fault Location

The GUI is capable of interpreting the fault data and providing a meaningful display of the fault location in terms of the location and distance values that include the overlap provided by two different relays reporting the same fault from different locations. It also logs the distance and direction for future reference by engineers that need to study the characteristics of the fault.

1.4.15 Dispatch

The operator dispatches a maintenance crew to an area where it is believed that the fault exists based on the distance and direction that was logged and displayed by the GUI. This dispatching may take place through many types of media, including radio, telephone, a separate dispatcher, or a computerized system. Whatever mechanism the operator uses must be wireless at some point because the crews are mobile. The crew does not utilize the SCADA network on their own but receives orders directly from the operator.

1.4.16 Notify

The operator is also responsible for notifying engineers that study the fault characteristics to determine why the faults occurred where they did. The priority of this step is increased if the fault also affected service in a region. The information that these personnel use is obtained from the ProtectiveRelay, the DataConcentrator, the GUI and the operator. The personnel interested in the data are emergency personnel, protection engineers, system stability analysts and management. The process of notifying additional personnel may or may not be automated but typically does not use the SCADA network.

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
Actor Name	Actor Type (person, device, system etc.)	Actor Description
SystemOperator	Person	Prime actor in this function. Responds to emergencies by operating the control system and dispatching personnel.
Graphical User Interface (GUI)	Device	Displays status of system for the SystemOperator and permits the SystemOperator to control the system. Often mistakenly called the SCADA system.
DataConcentrator	Device	Collects, stores, and filters data between the GUI and multiple IEDs. Often converts from one communications media to another. Often converts from one protocol suite to another. May or may not exist within the SCADA system.
IED	Device	End device monitoring and controlling primary equipment. May also be called a Remote Terminal Unit (RTU). Detects and reports faults and system state. May incorporate Protection and FaultRecorderDevice functions.
ProtectiveRelay	Device	Class of IED 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 ProtectiveRelays.
FaultRecorderDevice	Device	Class of IED that collects, stores, and reports waveform samples and other state information associated with a fault.
SCADASystem	System	Supervisory Control and Data Acquisition System. Consists of GUI, DataConcentrator and IEDs, interconnected to provide monitoring and control of the power system.
FieldPersonnel	Person	Dispatched by SystemOperator to fix a fault.
Protection Engineer	Person	Notified by SystemOperator to analyze a fault.
EmergencyPersonnel	Person	Security, medical, maintenance, or other personnel called by the SystemOperator in response to a fault or other emergency.
Subscriber	Person	End user of the power system
ManagementPersonnel	Person	Notified by SystemOperator in case of service-affecting outages.

1.6 Information exchanged

Describe any information exchanged in this template.

Information Object Name	Information Object Description
Point Number	The unique index of the point that is associated with the state or value that is currently of interest and is one of the points being monitored in the system. This number is a certain point in the IED, which becomes a different point in the DataConcentrator database and in turn becomes a different point number in the protocol that communicates with the GUI. There could be several mapping stages at each device the point goes through.
Timestamp	A data event such as a change of state is associated with a timestamp that indicates when the change of state occurred relative to the system clock. There is often a 1 ms accuracy requirement that specifies that the timestamp must be within 1 millisecond of the actual event. The time stamp is applied at the device that is responsible for processing the field point for which the event occurred. The timestamp is then associated with the change of state event that is reported to the other devices in the system. These time stamped events can occur on the IED or the DataConcentrator if it is equipped with equipment to monitor field devices.
State	Digital Input with value Open or Closed, 0 or 1, Trip or Closed, Off or On, Normal or Alarm, etc. The change of state of a field input such as a switch. Includes: a point number, the quality of the point (online/offline or valid/invalid), the new state, and the time the state changed which is typically accurate to millisecond resolution. If the state of the input is Trip it represents a particular type of state change that indicates through its point number that a certain breaker has tripped and is now open. Includes all the same data as any state change but state is unique to the application.
Fault Indication	Point Number + Timestamp + State
Location	The location of a point that has undergone a state change is represented on the GUI oneline graphic and in any number of other graphics. On the oneline the states of breakers are represented by filling in a box and the location of the breaker is provided by the labeling and location on the oneline graphic.
Priority	Varies; typically H,M,L, colored. Priorities are usually represented by different coloured objects or different locations in a graphic that show it's ranking. Priorities can be established on groups of data by assignment in the protocol between two devices.
Description	Text description of the condition that is represented by a certain digital input point in a certain state. These are used as the alarm descriptions for indicating when an alarm is established or cleared.
Notification of Alarm	Location + Priority + Description + State + Timestamp
Analog and digital sample file	Usually COMTRADE or PQDIF. Sometimes IEC 60870-5-103. Typically around 1Mb.
Voltage, Current	Analog values used in the system are often a twelve-bit or sixteen-bit integer that must be scaled for display in

Information Object Name	Information Object Description
	engineering units. The information includes: a point number, the quality of the point, and the value. It may or may not include a millisecond timestamp if the value is associated with a change event. A voltage would be scaled to engineering units of V or kV and a current in A. This is usually converted in the GUI which is a PC platform that supports floating point easily. This preserves the resolution in the raw data coming through the protocol.
Change in Line Load	Point Number + Voltage, Current
Operation	A control request is used to initiate a digital field operation such as close a breaker or switch. A setpoint request is used to initiate an analog field operation such as close the valve position by a certain amount. The operation required is defined in the protocol and can be a Trip or Close, Raise or Lower for a digital control or Open or Close or Raise or Lower for an analog event. The operation type is selected by the operator when the request is setup.
Duration	The time in milliseconds that the coil of a relay will be energized in the device that is required to perform the requested operation. The time is usually determined by how long it takes to pick up the field operation which seals itself in for the full duration of the operation. Most digital controls are short pulses between 500 and 1000 ms. Sometimes the operator enters the desired duration and sometimes it is pre configured in the device.
Setpoint Value	The setpoint value is the absolute engineering value that the field device is supposed to reach when the operation is complete. This value is entered by the operator and represents the desired outcome of the operation. The result of the operation is usually fed back to the operator using a separate sensor so the error between the setpoint and actual can be observed.
Send Control	Point Number + Operation + Duration + Setpoint Value
Direction	In a Fault Location Algorithm the direction to the fault is indicated as part of the information required to locate the fault.
Distance	In a Fault Location Algorithm a calculation is performed where the impedance of the conductor normally is compared to the impedance of the fault. The result is in an estimate of how far from the relay the fault is located in miles or kms. The value must be scaled from integer to engineering units and displayed on a GUI graphic in a meaningful way for the operator.
Locate Fault	Direction + Distance
Display Location	Location + Distance
Directions	When the operator dispatches a maintenance crew to correct a fault on a line part of the information includes the expected location of the fault and directions on how to find and access the location.
Request to contact operator	This is a voice, telephone, pager or email message to an operator, requesting that a particular action be taken, e.g. opening a particular switch. Includes: the operation to be taken (e.g. trip, close), and the location (e.g. the device name or feeder location). This may be graphical, text, or voice message that is sent to the operator and requires an acknowledgement and an action for the operator to perform. The procedures for opening breakers and switches and isolating parts of circuits are operationally critical because equipment damage and personal injury are risks if the operation is incorrect. Utility organizations have strict procedures which are followed to execute these operations.

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
Display and Manage Alarms	Identifies that a fault or other emergency has occurred and the priority of the alarm. May suppress some alarms in favor of concentrating the operator's attention on critical information.
Display System State	Permits the SystemOperator to verify that protection has operated properly to clear the fault, and to view the current state of load on various components of the system
Manually Shed Load	Permits the SystemOperator to disconnect load from the power system so the fault will not cause cascading failures. Load shedding may also be done automatically, but that is discussed in another function.
Manually Restore Power	Permits the SystemOperator to restore power to Subscriber by re-routing through the operation of switches and breakers.
Locate Fault	Permits the SystemOperator to determine where the fault has occurred
Record Fault and Collect Fault Records	Collects and stores waveform data and other fault information for later analysis
Alert Additional Personnel	Alerts managers, engineers, troubleshooters to the fault via telephone, email, pagers, etc.
Dispatch Crews	Directs FieldPersonnels to the site of the fault
Dispatch EmergencyPersonnel	Directs Emergency personnel to the site of a problem

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

Policy	From Actor	May	Shall Not	Shall	Description (verb)	To Actor
Fault notification	SCADASystem			X	Report faults within 1 second	SystemOperator
Load monitoring	SCADASystem			X	Report load values within 2 seconds	SystemOperator
Control	SCADASystem			X	Change switch states within 2 seconds	SystemOperator

Constraint	Type	Description	Applies to

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.

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
SCADASystem	No outstanding alarms

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 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 section 0.	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 section 0.	What other actors are primarily responsible for Receiving the information? Actors are defined in section 0. (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.
1.1	Fault	ProtectiveRelay	Report Fault	Detects fault and trips appropriate breaker.	ProtectiveRelay	DataConcentrator (sometimes GUI)	Fault Indication	Must be detected within a cycle. Timestamp requires accurate synchronization	Inter-Field Equipment
1.2		FaultRecorderDevice	Generate Report	Send indication that a fault record is available.	FaultRecorderDevice	DataConcentrator or GUI	Fault Indication		Inter-Field Equipment

¹ Note – A triggering event is not necessary if the completion of the prior step – leads to the transition of the following step.

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
1.3		DataConcentrator	Report COS	Identifies data as being of interest to the GUI. Translates protocol from IED to GUI.	DataConcentrator	GUI	Fault Indication	Concentrator required due to slow links, large numbers of devices. Legacy protocols may not support timestamp. May sort events by timestamp before transmission May distribute to multiple GUIs.	Lower Security DAC
1.4		GUI	Notification of Alarm	Identifies the trip as an alarm condition and displays notification on screen. Maps point number and state to human-readable information. Logs the alarm / change of state.	GUI	SystemOperator	Notification of Alarm	Location, priority, description must all be pre-configured.	Intra-Control Center
2.1	Retrieve Fault	DataConcentrator or GUI	Retrieve Fault	Retrieves the fault record from the fault recorder.	IED	DataConcentrator or GUI	Analog and digital sample file	Large volumes of data. Many data concentrators cannot forward files. Legacy protocols may not support file transfer. Existing links may make transfer slow. Sometimes may need to send operator to site.	Lower Security DAC

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
3.1	Change in line load	ProtectiveRelay	Change in line load	Detect change in load due to protection activity.	IEDs	DataConcentrator or GUI	Change in Line Load		Inter-Field Equipment
3.2		DataConcentrator	Change in Analog Data	Identifies data as being of interest to the GUI. Identifies the change as being significant (deadband). Converts communications protocol from IED to GUI.	DataConcentrator	GUI	Change in Line Load	May distribute to multiple GUIs.	Lower Security DAC
3.3		GUI	Load Change	Maps point number to database. Updates values if currently on display. Raises alarm if threshold exceeded. Logs data if it is being trended.	GUI	SystemOperator	Voltage, Current	Scaling is usually pre-configured	Intra-Control Center
4.1	Shed Load, or Restore Power	SystemOperator	Shed Load / Restore Power	Operates control	SystemOperator	GUI			Intra-Control Center
4.2		GUI	Send Control	Sends control or setpoint	GUI	DataConcentrator or IED	Send Control	Normally uses Select-Before-Operate service. Occasionally broadcast.	Lower Security DAC
4.3		DataConcentrator	Forward Control	Translates control or setpoint and sends to IED.	DataConcentrator	IED	Send Control	Uses Select-Before-Operate service. Often supports multiple GUIs.	Inter-Field Equipment

#	Event	Primary Actor	Name of Process/Activity	Description of Process/Activity	Information Producer	Information Receiver	Name of Info Exchanged	Additional Notes	IECSA Environments
5.1	Locate Fault	ProtectiveRelay	Locate Fault	Measures impedance of line and calculates distance based on pre-configured characteristics of the line.	ProtectiveRelay	DataConcentrator or GUI	Locate Fault		Inter-Field Equipment
5.2		GUI	Display Location	Displays location and distance on GUI in a manner that shows overlap. Logs distance and direction.	GUI	SystemOperator	Display Location		Intra-Control Center
6.1	Dispatch	SystemOperator	Dispatch FieldPersonnel	Dispatches crew based on fault location log and display.	SystemOperator	FieldPersonnel	Directions	Currently does not use SCADA network	User Interface
7.1	Notify	SystemOperator	Notify Personnel	Notifies personnel that a service-affecting fault has occurred based on an alarm condition.	GUI, DataConcentrator, SystemOperator	Protection Engineer, ManagementPersonnel	Request to contact operator	May or may not be automated. Typically does not use SCADA network	User Interface

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
FieldPersonnel / Protection Engineers	Identify fault, fix problem. Check system is ready to have power restored.
SystemOperator	Uses SCADA system to restore power system to original state.

2.2 Architectural Issues in Interactions

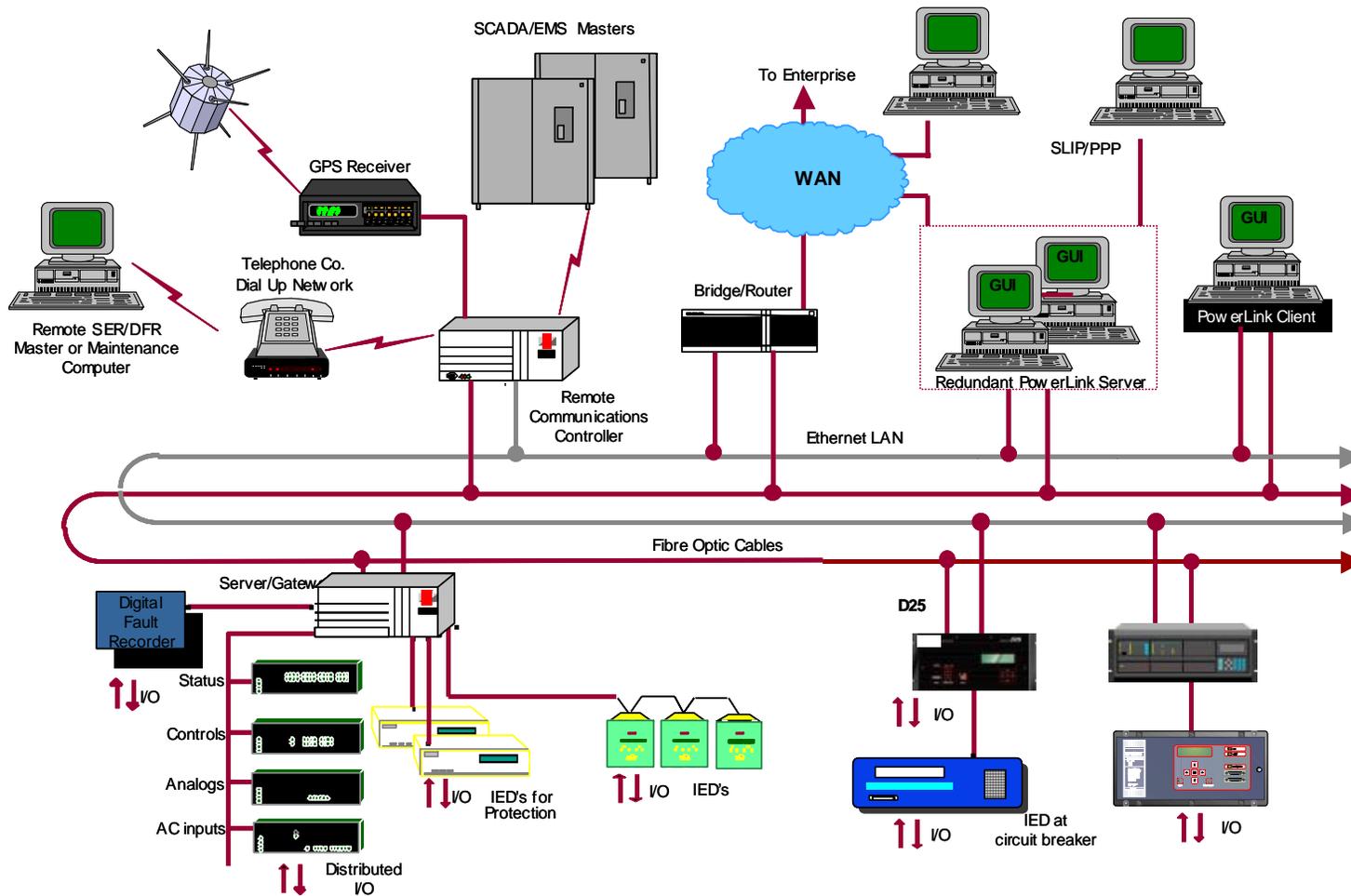
Elaborate on all architectural issues in each of the steps outlined in each of the sequences above. Reference the Step by number.



Microsoft Excel
Worksheet

2.3 Diagram

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



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

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

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.			

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