SmartConnect Use Case:

D20 – Utility uses “Data Beyond SCADA” to analyze system faults

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Document History

Revision History

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Approvals

This document requires following approvals.

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Contents

1. Use Case Description

1.1 Use Case Title

Utility uses "Data Beyond SCADA" to analyze system faults.

1.2 Use Case Summary

This use case describes how "Data Beyond SCADA" can improve SCE's ability to identify fault locations. SCADA data represents the operations information used by utilities to monitor and control the transmission grid on a real-time and remote basis (generally from a staffed operations center). "Data Beyond SCADA" represents information about the configuration and health of electrical grid and equipment that is not time sensitive or operational in nature. Utilities generally use this information to assess equipment utilization and health, and to develop long-term maintenance plans. It can also be used to analyze events on the electrical grid on post-event basis.

One potential application of "Data Beyond SCADA" is to automate the fault location identification process. Existing fault location identification processes are manual and time consuming. Using "Data Beyond SCADA" to automate these processes would allow SCE to identify fault locations in less time and with greater accuracy. This would enable SCE to complete any necessary repairs and to restore service more quickly.

This use case presents two scenarios, one for transmission and one for distribution. The transmission scenario describes a process whereby a single fault location is identified by a Fault Analysis Application through analysis of the fault currents and voltages, as captured by oscillography. The distribution scenario describes a process in which the Fault Analysis Application identifies a small number of potential fault locations through a similar signature analysis process. The Outage Management System then narrows down the Fault Analysis Application list using additional information from other field devices, such as SmartConnect meters, and customer outage calls. The business value of locating faults through "Data Beyond SCADA" includes improved system reliability and reduced costs.

1.3 Use Case Detailed Narrative

Identifying fault locations is currently a time-consuming manual process. A small number of substation relays provide estimates of fault location. However, since accessing this information is often difficult and time-consuming, it is seldom used. To identify a transmission fault location, a Technician manually downloads event data from field devices, such as substation relays, and sends the data to a Protection Engineer for analysis. Digital Fault Recorders and Remote Fault Indicators may also factor into the analysis. The Protection Engineer correlates the data using a fault simulation model until they find a matching fault signature. A fault signature is the waveform oscillography captured by digital relays. This fault location process can take between 30 and 60 minutes. During non-business hours the process can take longer since on-call personnel must be brought in to the control center.

The process for identifying distribution-level faults is similarly time consuming. Distribution faults are located based on fault information from substation feeder relays, customer calls, a limited number of remote sensor devices (e.g. Remote Fault Indicators), and by physically patrolling a distribution area.

Automating the fault location identification process would reduce the time required to locate faults, while also improving the accuracy of the results. It could also potentially enable SCE to predict pending faults. These capabilities would result in increased grid reliability and other operations improvements.

The data necessary to automate this process is a subset of a broader category of data known as "Data Beyond SCADA" (DBS). DBS represents a large category of data that has not traditionally been used for real-time operation of the electrical grid. DBS systems capture transmission-level information and, to a lesser extent, distribution-level information downstream of substations. DBS consists of information that relates to the configuration and health of electrical equipment, but is not used for real-time operation of the electrical system. The challenges of using DBS for near real-time operations include deploying an adequate number of associated field devices, extracting data from the devices, consolidating it within a centralized monitoring system, and analyzing it in a timely manner. The following represents a partial listing of what is currently considered DBS[1]:

- Oscillography files and fault indications
- Breaker I^2T, bushings, partial discharge, and dissolved gas (*see use case D14*)
- Phasor data (*see use cases D13 & D16*)
- Transformer monitoring data
- Topology and asset tracking
- Power quality and harmonics data
- Relay settings and configuration/firmware
- Field tool (work orders, schematics, status, settings, photos) (*see use cases D10 & D11*)
- Weather data (lightning, wind, solar radiation)
- Video / infrared
- Seismic data
- Fire detection

A number of DBS devices collect information which, if properly collected and analyzed, could be used to automate the fault location identification process. This would facilitate identifying fault locations with greater precision and at faster speeds than current manual processes. This use case presents two scenarios that utilize DBS for the purpose of analyzing disturbance events to identify fault locations on an automated basis. At the transmission level, this use case describes a process of automatically identifying a single fault location which is then communicated to the EMS Operator for resolution. For the distribution-level scenario, this use case describes a process of automatically identifying a small number of potential fault locations, and communicating this to the Distribution Operator who would then dispatch distribution line crews accordingly. This use case does not present a specific scenario for sub-transmission. However, the process and requirements are assumed to be similar to the distribution scenario.

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[1] The distinction between SCADA data and "Data beyond SCADA" varies by utility, and is subject to change over time based on technology development and integration with operations.

Scenario 1

This scenario describes the process of using "Data Beyond SCADA" (DBS) to identify fault locations on transmission lines on an automated basis. The fault location is estimated by a Fault Analysis Application (FAA). The FAA first builds a Short-Circuit Model (SCM), a model of the transmission system that reflects the system topology on a pre-event-basis (e.g. circuit breaker and switch status, and, most importantly, impedance), based on information from the Enterprise Asset Management System (EAMS), the Geographic Information System (GIS), and the Historian. The SCM also includes the predicted fault signature based on information obtained from the relay. When a fault occurs, the communications system forwards the actual fault recording (oscillography) to FAA, which then performs a "signature analysis" of the fault to determine its location. This is similar to the process currently performed manually by Protection Engineers.

The FAA analysis is initiated upon receiving a fault notification from a substation relay. Upon a fault event the relay captures an oscillography file, which is collected by a Substation Data Concentrator and transmitted to the Central Monitoring Database (CMDB). Having received the fault notification, FAA performs a series of queries to obtain information about the fault and build the SCM. It queries the CMDB to obtain additional information related to the fault notification and other faults that occurred at the same approximate time (e.g. other faults that occurred within 1 second of the fault notice). FAA also queries the Lightning Strike Database to obtain information related to any lightning strikes that might have caused the fault. Faults caused by lightning often require a different type of response since lightning can cause significant equipment damage. Thus if FAA determines a fault was likely caused by lightning, it would be able to dispatch a Transmission Line Crew and recommend equipment that may be needed for the repair work. Finally, FAA queries the Enterprise Asset Management System to retrieve impedance data. FAA builds the SCM based on these queries and information from GIS and the Historian. The SCM includes a projected fault signature based on information provided by the relay (e.g. fault type and estimated location).

After building the SCM, FAA performs "signature analysis" to determine the fault location. Signature analysis consists of comparing the relay fault signature (e.g. the actual recorded oscillography from the relay), with the SCM projected fault signature (e.g. SCM's estimate of the oscillography). Since there are likely to be multiple oscillography files that represent the same fault, FAA compares the SCM signature to each oscillography file. FAA performs these comparisons on an iterative basis, adjusting the SCM-estimated fault location until it finds a match.

FAA logs the final computed fault location and other fault information in the Fault Information Database, and then transmits the information to the EMS Operator via EMS. The fault information is overlaid on a map and presented to the EMS Operator via the EMS dashboard. The EMS Operator would have already received a fault alarm via EMS, and switching operations would have automatically begun to address the problem. The Fault Information Database is made available to the Protection Engineer (and others, as needed), for the purpose of validating or improving upon the FAA algorithms, or for other planning purposes.

On a daily basis the CMDB generates a report on excessive pickups and transmission outages. Pickup notifications are logged whenever relays detect fault currents that do not result in a trip. A series of pickups is a leading indictor that something is happening that may eventually trip the line. Creating visibility of these events allows SCE to remedy the cause prior to a fault occurring.

Scenario 2

This scenario describes the process of using "Data Beyond SCADA" (DBS) to identify fault locations on distribution lines. As in Scenario 1, the fault location is estimated by a Fault Analysis Application (FAA) which first builds a Short-Circuit Model (SCM) of the distribution system, and then performs "signature analysis" of the fault. This scenario differs from Scenario 1, however, in that FAA calculates more than one potential fault location. This is necessary due to the relative difficulty in knowing which impedance information FAA should use when constructing the SCM. The substation feeder relay will provide a distance to the fault. However, since there are multiple distribution branches downstream of the substation, there could be half dozen to a dozen potential fault locations, all with the same distance to fault.

The FAA analysis is initiated upon receiving a fault notification from a substation relay. Upon a fault event, a substation feeder relay and Remote Controlled Fault Interrupters (RCI) capture oscillography files which are collected by a Substation Data Concentrator and transmitted to the Central Monitoring Database (CMDB). Having received the fault notification, FAA performs a series of queries to obtain information about the fault and build the SCM. It queries the CMDB to obtain information related to the fault notification and other faults that occurred at the same approximate time (e.g. other faults that occurred within 2 seconds of the fault notice). FAA also queries the Lightning Strike Database to obtain information related to any lightning strikes that might have caused the fault. Faults caused by lightning often require a different type of response since lightning can cause significant damage. Thus, if FAA determines a fault was likely caused by lightning, it would be able to dispatch a Distribution Line Crew and recommend equipment that may be needed for the repair work. Finally, FAA queries the Enterprise Asset Management system to retrieve impedance data. FAA builds the SCM based on these queries and information from GIS and the Historian. The SCM includes a fault signature based on the fault information provided by the substation feeder relays and RCIs (e.g. fault type and estimated location).

After building the SCM, FAA performs a signature analysis to determine the potential fault locations. Signature analysis consists of comparing the relay and RCI fault signatures (e.g. the actual recorded oscillography from the relay and RCIs), with the SCM projected fault signature (e.g. SCM's estimate of the oscillography). Since there are likely to be multiple oscillography files that represent the same fault, FAA compares the SCM signature to each oscillography file. FAA performs these comparisons on an iterative basis, adjusting the SCM-estimated fault location until it finds a match. Again, FAA shall generate multiple potential fault locations in this distribution scenario.

FAA logs the final computed fault locations and other fault information in the Fault Information Database, and then transmits the information to the Outage Management System (OMS) for further refinement. OMS analyzes the FAA-calculated potential fault locations using additional information from SmartConnect meters, fault notifications from Remote Fault Indicators, and customer outage calls to the Voice Response Unit (VRU). This additional information allows OMS to shorten the FAA list of possible fault locations. SmartConnect meters can indicate which area is out through "last gasp" messaging, while Remote Fault Indicators can reveal which segment of the circuit the fault was on (perhaps within one mile in an urban area). Once complete, OMS logs the fault location information in the Fault Information Database and notifies the Distribution Operator of the potential fault locations. The fault information is overlaid on a map and presented to the Distribution Operator via the OMS dashboard. The Fault Information Database is made available to the Protection Engineer (and others, as needed), for purposes of validating or improving upon the FAA algorithms, or for other planning purposes.

On a daily basis the CMDB generates a report on excessive pickups and distribution outages. The pickup notifications are logged whenever relays detect fault currents that do not result in a trip. A series of pickups represents a leading indictor that something is happening that may eventually trip the line. Creating visibility of these events allows SCE to remedy the cause prior to a fault occurring.

Business Value

The benefits of using "Data Beyond SCADA" to analyze system faults include the following:

1. **Improved System Reliability**:
   a. **Fault Prediction**: The Central Monitoring Database would analyze and report on excessive pickup indications. These reports would alert SCE to conditions on transmission and distribution lines that are likely to result in faults. Crews could be dispatched to

correct those conditions prior to a fault occurring. This could also inform decisions to perform tree trimming near lines with excessive pickups.

b. **Shorten Outage Time**: Fault location identification would allow crews to arrive at the repair site earlier, and to restore service more rapidly during an outage. In Scenario 2 (distribution), this is particularly useful in identifying underground fault locations.

c. **Avoid Recurring Faults**: More detailed fault information would allow SCE to perform post-event analysis to identify recurring problems. This would then inform maintenance decisions to avoid future occurrences (i.e. bird nests next to lines).

d. **Improve Customer Service Metrics**: This benefit relates to the distribution scenario. If SCE can increase its speed in identifying fault locations, crews can be dispatched more rapidly following an outage. This would lead to reduction in restoration times. Transmission-level outages are not normally visible to the customer. Thus, the instances in which SCE would benefit from this in terms of customer satisfaction would be minimal for transmission outages.

e. **Post-Mortem Protection Performance**: Fault event information can be analyzed by Protection Engineers on a post-mortem basis to promote operations and reliability improvements.

2. **Reduced Costs**:

a. **Reduce Repair Times**: Fault location identification would improve crew productivity by directing them directly to the fault location. Patrolmen would avoid having to inspect the entire line to identify the fault location prior to dispatching a crew.

b. **Work Management**: Fault location information could be delivered to field personnel via their Consolidated Mobile Solution (CMS) device, improving the dispatch speed and efficiency.

c. **Avoid Congestion Penalties**: When there are transmission outages and SCE is at fault (typically due to asset failure), SCE must pay a congestion penalty to replace the lost generation with less economic generation. To the extent transmission outage durations are reduced, SCE can avoid these congestion penalties. The ISO would levy these penalties.

d. **Underground Fault Locations**: Improved fault location identification capabilities could reduce the cost associated with locating underground fault locations.

e. **Identify Lighting Strike-Prone Areas**: Enhanced fault location identification capabilities could assist SCE in identifying areas more susceptible to lightning strikes. This could allow SCE to take targeted measures to reduce the cost of maintaining those transmission lines. This could also improve reliability and power quality.

1.4 Business Rules and Assumptions

- Accurate impedance information is available.
- Digital relays are widely deployed throughout the transmission and distribution systems.
- Oscillography devices are widely deployed (e.g. on transmission system and on every distribution feeder).
- Accurate distribution-level topology information is available.
- SCADA and "Beyond SCADA" communications networks are in place at all locations to collect this data for analysis and computation.
- Any speculation regarding the overall value of the transmission versus distribution scenarios assumes there are more challenges associated with the distribution scenario.
- This use case document does not present a specific scenario for sub-transmission. However, the process and requirements for a sub-transmission scenario would be similar to the distribution scenario.

2. Actors

Describe the primary and secondary actors involved in the use case. This might include all the people (their job), systems, databases, organizations, and devices involved in or affected by the Function (e.g. operators, system administrators, customer, end users, service personnel, executives, meter, real-time database, ISO, power system). Actors listed for this use case should be copied from the global actors list to ensure consistency across all use cases.

Actor Name	***Actor Type (person, device, system etc.)***	***Actor Description***
Central Monitoring Database (CMDB)	System	The Central Monitoring Database represents the repository of the pickup and fault notifications, and the oscillography files. This database will likely be the Historian or a sub-component of the Historian.
Enterprise Asset Management System (EAMS)	System	This represents the module of the Enterprise Resource Planning system concerned with storing and updating information regarding utility assets. This keeps track of every asset in the enterprise including all trouble reports, installation information, manufacturer, information gathered by field personnel, etc. This is used to establish baselines on individual assets and classes of assets, and to track these assets to compare against the baselines. This system also contains a suite of analysis tools, decision support functions, dashboard, etc.
Fault Analysis Application (FAA)	System	The Fault Analysis Application (FAA) is a program that performs a series of analyses to identify fault locations. One critical capability of FAA is its ability to maintain an accurate Short Circuit Model that reflects the current network topology. Another critical function is its ability to perform signature analysis to identify fault location.
Fault Information Database	System	The Fault Information Database is the historian for fault events. After the Fault Analysis Application (FAA) calculates a fault location, FAA stores the raw data and the analysis results in the Fault Information Database. The Outage Management System also stores its final list of potential fault locations in the Fault Information Database.
Feeder Relay	Device	Feeder relays represents the relays on primary distribution lines that branch out from substations to serve local distribution areas.
Geographic Information System (GIS)	System	The Geographic Information System (GIS) is an information system that captures, integrates, stores and presents information related to geographic location. The GIS system displays where a specific device is located on the system, both geographically and electrically (where on the grid and where on the communications network).

Actor Name	***Actor Type (person, device, system etc.)***	***Actor Description***
Lightning Strike Database	System	The Lightning Strike Database contains a time-stamped listing of all lightning strikes, by physical location (e.g. longitude and latitude). The Fault Analysis uses this lightning strike location information in conjunction with GIS to determine whether lightning strikes are the cause of any faults.
Outage Management System (OMS)	System	The Outage Management System (OMS) is a distribution management system which uses an analysis engine to identify the location of outages. It correlates end-point outages and infers root causes by identifying common failure points grouped upstream, using information from the GIS, CSS, SCADA and SmartConnect systems. OMS helps in reducing outage duration and assists with restoration plans. Determination of outage locations is based on the system's knowledge of the power system topology.
Protection Engineer	Person	Protection Engineers monitor and maintain the various system protection mechanisms of the utility. In this use case Protection Engineers monitor the fault information stored in the Fault Information Database. After fault events they review the raw data used by Fault Analysis Application (FAA) and Outage Management System to calculate the fault location(s), as well as the results of the FAA analysis. If the FAA algorithm miscalculates the fault location, a Protection Engineer would want to see this data to determine why the FAA answer was incorrect.
Relay	Device	Relays are devices that measure current and, if the current exceeds predefined parameters, send control messages to open or close circuit breakers. Relays in this use case are digital rather than electromechanical.
Remote Controlled Fault Interrupter	Device	Remote Controlled Fault Interrupters (RCI) are circuit breakers located on a distribution line (i.e. not in a substation or at the end of a node). This enables better isolation of fault currents. RCIs record oscillography, and also contain digital relays.
Short-Circuit Model (SCM)	Application	The Short-Circuit Model (SCM) is a model of the electrical system that reflects the system topology on a pre-event basis (e.g. circuit breaker and switch status, and impedance). The SCM also includes the predicted fault signature, based on information obtained from the relay.

Actor Name	Actor Type (person, device, system etc.)	Actor Description
Substation Data Concentrator	System	Substation Data Concentrators capture operations data from Digital Fault Recorders and other field device, and forward the data to the Central Monitoring Database (CMDB). Substation Data Concentrators also capture data from digital relays (pickups, trip/fault information, oscillography capture notice, and oscillography files) and Remote Controlled Fault Interrupters. The Substation Data Concentrator performs a security role for the substation by providing access management. This is necessary for maintaining compliance with NERC standards on Critical Infrastructure Protection (CIP). The Substation Data Concentrator also serves as a collection point, and could be used to perform analysis of the substation data.

3. Step by Step analysis of each Scenario

Describe steps that implement the scenario. The first scenario should be classified as either a "Primary" Scenario or an "Alternate" Scenario by starting the title of the scenario with either the work "Primary" or "Alternate". A scenario that successfully completes without exception or relying heavily on steps from another scenario should be classified as Primary; all other scenarios should be classified as "Alternate". If there is more than one scenario (set of steps) that is relevant, make a copy of the following section (all of 3.1, including 3.1.1 and tables) and fill out the additional scenarios.

3.1 Primary Scenario: Utility uses "Data Beyond SCADA" to determine fault location on transmission grid

This scenario describes the process of using "Data Beyond SCADA" to identify fault locations on transmission lines. The fault location is estimated by the Fault Analysis Application (FAA) which builds a Short-Circuit Model (SCM) of the transmission system, and then performs a "signature analysis" of the fault. The FAA analysis is initiated after receiving a fault notification from a substation relay. FAA performs a series of queries to obtain information about the fault (and other faults that occurred at approximately the same time) and the line impedance, in order to build the SCM. The SCM includes an estimate of the fault signature. FAA next performs a signature analysis to determine the fault location. Once it has calculated the fault location, FAA logs the fault information in the Fault Information Database, and then transmits the information to the EMS Operator via EMS. On a daily basis the Central Monitoring Database generates reports on excessive pickups and transmission outages.

Triggering Event	***Primary Actor***	***Pre-Condition***	***Post-Condition***
(Identify the name of the event that start the scenario)	*(Identify the actor whose point-of-view is primarily used to describe the steps)*	*(Identify any pre-conditions or actor states necessary for the scenario to start)*	*(Identify the post-conditions or significant results required to consider the scenario complete)*
An event occurs on a transmission line.	Fault Analysis Application	Fault current is visible to multiple devices.	EMS Operator receives automatic notification of fault location, verifies recommendation, and takes corrective action (if necessary).

3.1.1 Steps for this scenario

Describe the normal sequence of events that is required to complete the scenario.

Step #	***Actor***	***Description of the Step***	***Additional Notes***
#	*What actor, either primary or secondary is responsible for the activity in this step?*	*Describe the actions that take place in this step. The step should be described in active, present tense.*	*Elaborate on any additional description or value of the step to help support the descriptions. Short notes on architecture challenges, etc. may also be noted in this column.*
1	Relay	Relay detects pickup event.	There are many field devices that have the potential to report on a pickup or fault event (i.e. relays, digital fault recorders, remote fault indicators, etc). In this use case scenario we assume the device is a digital relay. A "pickup" represents a fault current event that does not result in a trip. An example is a tree branch that brushes against an overhead line. This would cause current to rise momentarily, but the fault current would not remain long enough to trip the relay. This tree branch example might last for one half cycle. To establish a fault, the fault current needs to remain for approximately 1 cycle. Events shorter than this would automatically clear themselves. However, a series of these pickup events is a leading indicator that something is happening that may

Step #	*Actor*	*Description of the Step*	*Additional Notes*
			eventually trip the line. Today we do not have centralized access to this information. Generating and monitoring pickup notifications could provide enough information (e.g. what the event was and where it occurred), such that a field worker could be dispatched to correct the issue before it results in a fault. Pickups represent non-operational, non-SCADA data. However, we want to know how many of these events there are, since they may be a precursor to a fault. To resolve these types of emergent issues, in step 25.1, the Central Monitoring Database generates a daily report on excessive pickups.
2	Relay	Relay transmits pickup notice to Substation Data Concentrator.	Relays send data to the Substation Data Concentrator rather than directly to the Central Monitoring Database. This is done primarily for security purposes, since the data must comply with NERC Critical Infrastructure Protection standards. The Substation Data Concentrator acts as a security gateway into the substation. The Substation Data Concentrator also serves as a collection point, and could be used to perform analysis of the substation data.
3	Substation Data Concentrator	Substation Data Concentrator transmits pickup notice to the Central Monitoring Database.	The Central Monitoring Database (CMDB) serves as the historian and operations database. The CMDB

Step #	*Actor*	*Description of the Step*	*Additional Notes*
			receives and stores these notifications, and generates daily reports on excessive pickups (step 25.1).
4	Central Monitoring Database (CMDB)	CMDB stores pickup notice.	The pickup notice simply indicates that there was a pickup. This does not necessarily mean that an oscillography file was created. Faults will always trigger the generation of an oscillography file. Pickups can also result in an oscillography file, but this depends on the settings of the relay that detects the pickup.
5	Relay	Relay detects fault event.	As in step 1, there are many substation devices that have the potential to report on a fault event. In this use case scenario we assume the device is a digital relay. This is similar to step 1 in that the relay detects a fault current. However, in this case the fault current results in a trip. For purposes of this use case, a "fault" shall hereafter refer to a fault current that trips a circuit breaker.
6	Relay	Relay transmits fault notice to Substation Data Concentrator.	This would be reported through SCADA, as it would involve circuit breaker operations. This would show up as a "status change" textual alarm on the EMS console. The digital relay would report the type of fault, date and time, fault status (e.g. whether it reclosed), and estimated fault location. Although the relay will

Step #	*Actor*	*Description of the Step*	*Additional Notes*
			estimate a fault location, the accuracy of this calculation is limited by the quality of the conductor impedance data programmed into the relay. If the impedance information is stale or was entered incorrectly, the distance to fault will be inaccurate. This is generally not as significant a problem for large transmission lines. Sometimes the sub-transmission lines (115kV and 66kV) have tap lines that can impair SCE's ability to maintain accurate impedance information.
7	Substation Data Concentrator	Substation Data Concentrator transmits fault notice to CMDB.	
8	CMDB	CMDB stores fault notice.	This information is used by CMDB in step 25.2 to generate a daily report on transmission outages.
9	Relay	Relay records oscillography file.	Relays are typically used to capture transmission line oscillography data. Digital Fault Recorders are also used for the higher voltage 500kV and 220kV transmission lines.
10	Relay	Relay reports capture of oscillography file to the Substation Data Concentrator.	The Substation Data Concentrator (and ultimately the CMDB), receives an indication from the relay that it has recorded an oscillography file. Most relays are not currently set up to "push" oscillography files because of bandwidth limitations and the large size of oscillography files. Rather, these files are pulled (as performed by CMDB in step 12).

Step #	***Actor***	***Description of the Step***	***Additional Notes***
11	Substation Data Concentrator	Substation Data Concentrator reports capture of oscillography file to the CMDB.	
12	Substation Data Concentrator	Substation Data Concentrator retrieves oscillography file from the relay.	
13	CMDB	CMDB retrieves the oscillography file from the Substation Data Concentrator.	The CMDB retrieves the oscillography files for analysis by the Fault Analysis Application.
14	CMDB	CMDB stores the oscillography file.	
15	CMDB	CMDB sends fault notice to the Fault Analysis Application.	The Fault Analysis Application (FAA) is a program that performs a series of analyses to identify fault location.
16	FAA	FAA performs queries to gather related fault information.	Once FAA receives notice of a fault, it performs a series of queries to locate information related to other faults that occurred at the same approximate time as the reported fault. This information, which must be properly time-stamped, will assist FAA in identifying the instigating fault event. For transmission-level faults, CMDB obtains information pertaining to all reported faults on the transmission grid over the relevant time period. For sub transmission-level faults, CMDB obtains information for all faults that occurred downstream of the associated A substation over the relevant time period.
16.1	FAA	FAA queries the CMDB for related fault notices.	
16.2	FAA	FAA queries the CMDB for related oscillography files.	
16.3	FAA	FAA queries the Lightning Strike Database for related lightning strike information.	

Step #	*Actor*	*Description of the Step*	*Additional Notes*
17	FAA	FAA determines whether the fault was likely caused by lightning.	Faults caused by lightning often require a different type of response. Work crews are usually required due to lightning damage. Thus, when a fault occurs, FAA shall attempt to determine the likelihood it was caused by lightning. The Lightning Strike Database contains a time-stamped listing of all lightning strikes, by physical location (e.g. longitude and latitude). The FAA uses this lightning strike location information in conjunction with GIS to determine whether any lightning strikes match SCE circuit locations. FAA then correlates this lightning strike location information with the fault notifications to determine the likelihood of a fault having been caused by lightning.
17.1	FAA	FAA identifies "reclosed" faults likely caused by lightning.	If a lightning strike resulted in a fault and the line was reclosed, FAA could dispatch a Patrolman (on a lower priority basis), to verify that the line was not damaged.
17.2	FAA	FAA identifies "non-reclosed" faults likely caused by lightning.	If a lightning strike resulted in a fault and the line has not reclosed, FAA could dispatch a Transmission Line Crew. Since lightning strike-induced faults may result in more significant repairs (e.g. lightning strikes can damage the insulators), FAA can instruct the crew to bring insulators and a surge arrestor to the field. The current process entails sending a Patrolman to patrol the line. Once

Step #	*Actor*	*Description of the Step*	*Additional Notes*
			the Patrolman arrives at the fault location, he would dispatch a crew capable of performing the repair work. This process would reduce the duration of these types of line outages. Use cases D10 and D11 address the use of the Consolidated Mobile Solution to dispatch Field Workers for inspection and outage restoration activities. Similar functionalities could be developed for the dispatch of Transmission Line Crews and Patrolmen. The Lightning Strike Database information does not currently inform SCE inspection and maintenance decisions.
18	FAA	FAA reads impedance data from the Enterprise Asset Management System.	The line impedance information consists of the physical characteristics of the conductor (e.g. material, length, diameter and its arrangement on the tower), and is generally assumed to remain constant. This impedance information is stored in the Enterprise Asset Management System (EAMS). However, this impedance information is often stored on an inconsistent basis, or is inaccurate. When equipment is replaced, sometimes the impedance information is not updated. More accurate impedance information could potentially be calculated from phasor data. Having phase angles and voltage (on both ends of a line) would allow a utility to

Step #	Actor	Description of the Step	Additional Notes
			calculate accurate impedance. As this capability is realized, the utility should update the EAMS to reflect accurate line impedance. This would improve the accuracy of the system topology model described in step 19.
19	FAA	FAA builds a Short-Circuit Model that features a projected fault signature.	The Short-Circuit Model (SCM) is an electrical representation of the current topology of the transmission system. The "base–case" SCM reflects the current circuit breaker and switch status, as reflected in the Historian. It also reflects current impedance information, as reflected in the Enterprise Asset Management System, as well as other location information from GIS. Upon a fault event, the SCM is modified from its pre-event "base-case" to reflect a projected fault signature. It is important to base the SCM on the pre-event topology since the system might have already changed configuration in response to the fault. FAA utilizes information from the fault notices (e.g. the fault type and estimated location), to create a projected oscillographic fault signature.
20	FAA	FAA performs "signature analysis" to identify fault location.	Signature analysis consists of comparing the relay fault signature (e.g. the actual recorded oscillography from the relay), with the SCM projected fault signature (e.g. SCM's estimate of the oscillography). Since there are likely to be multiple

Step #	Actor	Description of the Step	Additional Notes
			oscillography files that represent the same fault, FAA compares the SCM signature to each oscillography file. FAA performs these comparisons on an iterative basis, adjusting the SCM-estimated fault location until it finds a match. FAA also estimates the tower closest to the fault, the fault type, and the distance of the fault from the substation. Signature analysis is currently performed on a manual basis by an engineer who visually compares printouts of the relay oscillography files with projected oscillography signatures from a model. Automating this function within FAA would allow faster identification of fault location. This is particularly helpful during non-business hours when only on-call personnel are available.
21	FAA	FAA compares the estimated location to known environmental problems (fire, lightning strikes, earthquakes, etc.) with nearby towers.	This information can further refine the FAA fault location determination. For example, suppose there is a fault on a line, and FAA narrows the fault location down to 5 possible towers. If the Lightning Strike Database indicates there was a lightning strike with a GPS location signature that matches one of these 5 towers, this would give FAA a reasonable basis for identifying that tower as the fault location. As discussed in step 17, this information could enable FAA to make informed decisions about what resources to dispatch, as well as the

Step #	Actor	Description of the Step	Additional Notes
			tools and materials that may be necessary to complete repair work.
22	FAA	FAA logs the final computed location and other fault information in the Fault Information Database.	Other information would include the fault type, date and time, nearest tower, estimated cause, the line state (e.g. whether the fault reclosed), and action taken (e.g. crew dispatched because of lightning strike). If FAA is not certain about the location, potentially because of discrepancies in the phasor data from opposite ends of the line, FAA would provide an estimated error or range around the location.
23	FAA	FAA notifies the EMS Operator of fault location via EMS.	This is when the "Beyond SCADA" data feeds back into the SCADA system. The EMS Operator would have already received a fault alarm via EMS, and has probably already begun switching operations to address the problem. This step is to provide the EMS Operator with notification of the fault location.
24	Protection Engineer	Protection Engineer views fault information via the web and takes appropriate action.	The Protection Engineer looks at the fault information later via the Fault Information Database. The information would include all the raw data used by FAA to calculate the fault location, as well as the results of the FAA analysis. If the FAA algorithm miscalculates the fault location, the Protection Engineer would want to see this data to determine why the FAA answer was

Step #	*Actor*	*Description of the Step*	*Additional Notes*
			incorrect. The Asset Management group would review the data since it might inform decisions about future maintenance or other planning work.
25	CMDB	CMDB generates daily reports.	
25.1	CMDB	CMDB generates a daily report on excessive pickups.	
25.2	CMDB	CMDB generates a daily report on transmission outages.	This report would be useful in terms of being able to answer performance questions regarding how many minutes certain types of lines (i.e. 500kV) been out of service today, this year, etc. This report is currently performed manually.

3.2 Primary Scenario: Utility uses “Data Beyond SCADA” to determine fault location on distribution grid.

This scenario describes the process of using “Data Beyond SCADA” to identify fault locations on distribution lines. This scenario differs from Scenario 1 in that, rather than identifying one specific fault location, multiple potential fault locations are identified. The Fault Analysis Application (FAA) first determines the potential fault locations through a “signature analysis” of the fault. The FAA analysis is initiated after receiving a fault notification from a substation relay. FAA then performs a series of queries to obtain information about the fault (and other faults that occurred at approximately the same time) and the line impedance, in order to build a Short-Circuit Model (SCM). The SCM includes an estimated fault signature. FAA next performs a signature analysis to determine the potential fault locations. Once it has calculated the potential fault locations, FAA logs the fault information in the Fault Information Database, and then transmits the information to the Outage Management System (OMS) for further refinement. OMS uses information from SmartConnect meters, Remote Fault Indicators, and customer outage calls to the Voice Response Unit (VRU) to narrow down the list of potential fault locations. Once complete, OMS notifies the Distribution Operator of the potential fault locations. On a daily basis the Central Monitoring Database generates reports on excessive pickups and distribution outages.

Triggering Event	***Primary Actor***	***Pre-Condition***	***Post-Condition***
(Identify the name of the event that start the scenario)	*(Identify the actor whose point-of-view is primarily used to describe the steps)*	*(Identify any pre-conditions or actor states necessary for the scenario to start)*	*(Identify the post-conditions or significant results required to consider the scenario complete)*
An event occurs on a distribution line.	Fault Analysis Application and Outage Management System	Fault current is visible to multiple devices.	Distribution Operator receives automatic notification of potential fault locations and a Distribution Line Crew is dispatched to restore service.

3.2.1 Steps for this scenario

Describe the normal sequence of events that is required to complete the scenario.

Step #	***Actor***	***Description of the Step***	***Additional Notes***
#	*What actor, either primary or secondary is responsible for the activity in this step?*	*Describe the actions that take place in this step. The step should be described in active, present tense.*	*Elaborate on any additional description or value of the step to help support the descriptions. Short notes on architecture challenges, etc. may also be noted in this column.*
1	Relay	Relay detects pickup event.	There are many substation devices that have the potential to report on a pickup or fault event (i.e. relays, digital fault recorders, remote fault indicators, power quality monitors, etc). In this use case scenario we assume the device is a digital relay. A “pickup” represents a fault current event that does not result in a trip. An example is a tree branch that brushes against an overhead line. This would cause current to rise momentarily, but the fault current would not remain long enough to trip the relay. This tree branch example might last for 2 cycles. To establish a fault, the fault current needs to remain for 10 to 15 cycles. Events shorter than this would automatically clear themselves. However, a series of these pickup events is a leading indicator that something is happening that may eventually trip the line. Today we do not have centralized access to this information.

Step #	*Actor*	*Description of the Step*	*Additional Notes*
			Generating and monitoring pickup notifications could provide enough information (e.g. what the event was and where it occurred), such that a field worker could be dispatched to correct the issue before it results in a fault. Pickups represent non-operational, non-SCADA data. However, we want to know how many of these events there are, since they may be a precursor to a fault. To resolve these types of emergent issues, in step 28.1, the Central Monitoring Database generates a daily report on excessive pickups.
2	Relay	Relay transmits pickup notice to Substation Data Concentrator.	Relays send data to the Substation Data Concentrator rather than directly to the Central Monitoring Database. This is done for security purposes, since the data must comply with NERC Critical Infrastructure Protection standards. The Substation Data Concentrator acts as a security gateway into the substation. The Substation Data Concentrator also serves as a collection point, and could be used to perform analysis of the substation data.
3	Substation Data Concentrator	Substation Data Concentrator transmits pickup notice to the Central Monitoring Database.	The Central Monitoring Database (CMDB) serves as the historian and operations database. The CMDB receives and stores these notifications, and generates daily reports on excessive pickups (step

Step #	Actor	Description of the Step	Additional Notes
			28.1).
4	Central Monitoring Database (CMDB)	CMDB stores pickup notice.	The pickup notice simply indicates that there was a pickup. This does not necessarily mean that an oscillography file was created. Faults will always trigger the generation of an oscillography file. Pickups can also result in an oscillography file, but this depends on the settings of the relay that detects the pickup.
5	Relay	Relay detects fault event.	As in step 1, there are many substation devices that have the potential to report on a fault event. In this use case scenario we assume the device is a digital relay. This is similar to step 1 in that the relay detects a fault current. However, in this case the fault current results in a trip. For purposes of this use case, a "fault" shall hereafter refer to a fault current that trips a circuit breaker.
6	Relay	Relay transmits fault notice to Substation Data Concentrator.	This would be reported through SCADA, as it would involve circuit breaker operations. This would show up as a "status change" textual alarm in OMS. The digital relay would report the type of fault, date and time, fault status (e.g. whether it reclosed), and estimated fault location. Although the relay will estimate a fault location, the accuracy of this calculation is limited by the quality of the conductor impedance data

Step #	*Actor*	*Description of the Step*	*Additional Notes*
			programmed into the relay. If the impedance information is stale or was entered incorrectly, the distance to fault will be inaccurate.
7	Substation Data Concentrator	Substation Data Concentrator transmits fault notice to CMDB.	
8	CMDB	CMDB stores fault notice.	
9	Field Devices	Field devices record oscillography file.	
9.1	Relay	Relay records oscillography file.	In this use case scenario, the substation feeder relay is the device that captures the oscillography file.
9.2	Remote Controlled Fault Interrupter	Remote Controlled Fault Interrupters (RCI) record oscillography files.	
10	Field Devices	Field devices report capture of oscillography files to the Substation Data Concentrator.	The Substation Data Concentrator (and ultimately the CMDB), receives an indication from the field devices that they have recorded oscillography files. These devices are not currently set up to "push" oscillography files because of bandwidth limitations and the large size of oscillography files. Rather, these files are pulled (as performed by CMDB in step 12).
10.1	Relay	Relay reports capture of oscillography file to the Substation Data Concentrator.	
10.2	RCI	RCIs reports capture of oscillography files to the Substation Data Concentrator.	Following a fault, if communications is unavailable to the RCIs on the circuit, the RCIs would not be able to transmit capture notices (nor the oscillography files) to the Substation Data Concentrator. Thus, CMDB and the Fault Analysis Application (FAA) would also not receive this

Step #	*Actor*	*Description of the Step*	*Additional Notes*
			information. FAA needs to know the communications status of these devices in order to decide whether wait for the RCI data or to proceed with its analysis without the RCI data. This use case includes a requirement that FAA shall have access to the communication status of these sensors, but does not recommend a specific communications architecture.
11	Substation Data Concentrator	Substation Data Concentrator reports capture of oscillography files to the CMDB.	
12	Substation Data Concentrator	Substation Data Concentrator retrieves oscillography files from the field devices.	
12.1	Substation Data Concentrator	Substation Data Concentrator retrieves oscillography file from the relay.	
12.2	Substation Data Concentrator	Substation Data Concentrator retrieves oscillography files from the RCIs.	
13	CMDB	CMDB retrieves the oscillography files from the Substation Data Concentrator.	The CMDB retrieves the oscillography files for analysis by the Fault Analysis Application.
14	CMDB	CMDB stores the oscillography files.	
15	CMDB	CMDB sends fault notice to the Fault Analysis Application.	The Fault Analysis Application (FAA) is a program that performs a series of analyses to identify fault location.
16	FAA	FAA performs queries to gather related fault information.	Once FAA receives notice of a fault, it performs a series of queries to locate information related to other faults that occurred at the same approximate time as the reported fault. This information, which must be properly time-stamped, will assist FAA in identifying the instigating fault event. CMDB obtains information for

Step #	*Actor*	*Description of the Step*	*Additional Notes*
			all faults that occurred downstream of the associated substation over the relevant time period.
16.1	FAA	FAA queries the CMDB for related fault notices.	
16.2	FAA	FAA queries the CMDB for related oscillography files.	
16.3	FAA	FAA queries the Lightning Strike Database for related lightning strike information.	
17	FAA	FAA determines whether the fault was likely caused by lightning.	Faults caused by lightning often require a different type of response. Work crews are usually required due to lightning damage. Thus, when a fault occurs, FAA shall attempt to determine the likelihood it was caused by lightning. The Lightning Strike Database contains a time-stamped listing of all lightning strikes, by physical location (e.g. longitude and latitude). The FAA uses this lightning strike location information in conjunction with GIS to determine whether any lightning strikes match SCE circuit locations. FAA then correlates this lightning strike location information with the fault notifications to determine the likelihood of a fault having been caused by lightning.
17.1	FAA	FAA identifies “reclosed” faults likely caused by lightning.	If a lightning strike resulted in a fault and the line was reclosed, FAA could dispatch a Patrolman (on a lower priority basis), to verify that the line was not damaged.
17.2	FAA	FAA identifies “non-reclosed” faults likely caused by lightning.	If a lightning strike resulted in a fault and the line has not reclosed, FAA could dispatch a Distribution Line

Step #	*Actor*	*Description of the Step*	*Additional Notes*
			Crew. Since lightning strike-induced faults may result in more significant repairs (e.g. lightning strikes can damage the insulators), FAA can instruct the crew to bring insulators and a surge arrestor to the field. The current process entails sending a Patrolman to patrol the line. Once the Patrolman arrives at the fault location, he would dispatch a crew capable of performing the repair work. This process would reduce the duration of these types of line outages. Use cases D10 and D11 address the use of the Consolidated Mobile Solution to dispatch Field Workers for inspection and outage restoration activities. Similar functionalities could be developed for the dispatch of Distribution Line Crews and Patrolmen. The Lightning Strike Database information does not currently inform SCE inspection and maintenance decisions.
18	FAA	FAA reads impedance data from the Enterprise Asset Management System.	The line impedance information consists of the physical characteristics of the conductor (e.g. material, length, diameter, and its arrangement on the pole or in the conduit), and is generally assumed to remain constant. This impedance information is stored in the Enterprise Asset Management System (EAMS).

Step #	*Actor*	*Description of the Step*	*Additional Notes*
19	FAA	FAA builds a Short-Circuit Model that features a projected fault signature.	The Short-Circuit Model (SCM) is an electrical representation of the current topology of the distribution system. This step is more challenging for distribution than transmission due to the large number of devices in the distribution network. The challenge is to obtain accurate and current topology and impedance information for these devices. The "base–case" SCM reflects the current circuit breaker and switch status, as reflected in the Historian. It also reflects current impedance information, as reflected in the Enterprise Asset Management System, as well as other location information from GIS. Upon a fault event, the SCM is modified from its pre-event "base-case" to reflect a projected fault signature. It is important to base the SCM on the pre-event topology since the system might have already changed configuration in response to the fault. FAA utilizes information from the fault notices (e.g. the fault type and estimated location), to create a projected oscillographic fault signature.
20	FAA	FAA performs "signature analysis" to identify potential fault locations.	Signature analysis consists of comparing the feeder relay and Remote Controlled Fault Interrupter (RCI) fault signature (e.g. the actual recorded oscillography from the relay and RCIs), with the SCM projected

Step #	*Actor*	*Description of the Step*	*Additional Notes*
			fault signature (e.g. SCM's estimate of the oscillography). Since there are likely to be multiple oscillography files that represent the same fault, FAA compares the SCM signature to each oscillography file. FAA performs these comparisons on an iterative basis, adjusting the SCM-estimated fault location until it finds a location that matches the signature. In this distribution-level scenario, FAA will generate a number of potential fault locations. FAA also estimates the structure closest to the fault, the fault type, and the distance of the fault from the substation for each potential fault location.
21	FAA	FAA compares the estimated locations to known environmental problems (fire, lightning strikes, earthquakes, etc.) with nearby structures.	This information can further refine the FAA fault location determination. For example, suppose there is a fault on a line, and FAA narrows the fault location down to 5 possible structures. If the Lightning Strike Database indicates there was a lightning strike with a GPS location signature that matches one of these 5 structures, this would give FAA a reasonable basis for identifying that structure as the fault location. As discussed in step 17, this information could enable FAA to make informed decisions about what resources to dispatch, as well as the tools and materials that may be necessary to complete repair work.

Step #	*Actor*	*Description of the Step*	*Additional Notes*
22	FAA	FAA logs the final computed locations and other fault information in the Fault Information Database.	Other information would include the fault type, date and time, nearest structure, estimated cause, the line state (e.g. whether the fault reclosed), and action taken (e.g. crew dispatched because of lightning strike). If FAA is not certain about the location, FAA would provide an estimated error or range around the location.
23	FAA	FAA transmits the potential fault locations to the Outage Management System (OMS).	Up to this point, this Scenario 2 has resembled Scenario 1. At this point in Scenario 1 FAA transmits a single calculated fault location to EMS. However, in this scenario FAA calculates a series of potential fault locations and transmits them to the Outage Management System (OMS) for further refinement. In subsequent steps OMS uses data from AMI (e.g. meter "last gasps"), Remote Fault Indicators, and customer outage calls to further narrow the list of potential fault locations.
24	OMS	OMS analyzes the FAA-calculated potential fault locations with additional data to narrow the list of potential fault locations.	OMS analyzes the potential fault locations provided by FAA using other data. This other data includes "last gasp" messages from SmartConnect meters, fault notifications from Remote Fault Indicators, and customer calls to the VRU. This additional information enables OMS to shorten the FAA list of possible fault locations.

Step #	***Actor***	***Description of the Step***	***Additional Notes***
24.1	OMS	OMS compares the FAA fault locations to SmartConnect meter "last gasp" messages.	The receipt (or lack thereof) of a "last gasp" message from a specific meter (or from several in a neighborhood) would provide additional information for the FAA analysis. See use case D4 for further information.
24.2	OMS	OMS compares the FAA fault locations to VRU outage calls.	Similar to step 24.1, the occurrence or absence of customer calls to the VRU can assist OMS in eliminating or corroborating FAA-calculated fault locations.
24.3	OMS	OMS compares the FAA fault locations to Remote Fault Indicator fault notifications.	Remote Fault Indicators will provide the circuit segment on which a fault occurred. This could potentially narrow the fault location to within one mile. The existence or absence of fault indications can assist OMS in eliminating or corroborating FAA-calculated fault locations.
25	OMS	OMS logs the final computed fault locations in the Fault Information Database.	
26	OMS	OMS notifies the Distribution Operator of potential fault locations.	The Distribution Operator would have already received a fault alarm via OMS. This step is to provide the operator notification of the potential outage locations so that a Distribution Line Crew can be dispatched to restore service.

Step #	*Actor*	*Description of the Step*	*Additional Notes*
27	Protection Engineer	Protection Engineer views fault information via the web and takes appropriate action.	The Protection Engineer looks at the fault information later via the Fault Information Database. The information would include all the raw data used by FAA to calculate the fault locations, as well as the results of the FAA and OMS analyses. If the FAA algorithm miscalculates the fault locations, the Protection Engineer would want to see this data to determine why the FAA answers were incorrect. Likewise, if the OMS algorithms failed to locate the correct fault location, the Protection Engineer would want to see the data to determine why OMS did not isolate the correct fault location. The Asset Management group would review the data since it might inform decisions about future maintenance or other planning work.
28	CMDB	CMDB generates daily reports.	
28.1	CMDB	CMDB generates daily report on excessive pickups.	

4. Requirements

Detail the Functional, Non-functional and Business Requirements generated from the workshop in the tables below. If applicable list the associated use case scenario and step.

4.1 Functional Requirements

Req. ID	***Functional Requirements***	***Associated Scenario #*** ***(if applicable)***	***Associated Step #*** ***(if applicable)***
1	Relays shall detect pickup events (a fault current that does not result in a circuit breaker trip).	1 & 2	1
2	Relays shall estimate the location of pickups. This would be necessary for the daily pickup report from step 24.1 since a worker would need to know where to go investigate any excessive pickups.	1 & 2	1
3	All data required by the Fault Analysis Application (FAA) shall be time-stamped.	1 & 2	1, 5, 9 & 16.3
4	Relays shall generate pickup notifications.	1 & 2	2
5	Relays shall be able to differentiate between high-impedance faults and pickups.	1 & 2	2
6	Relays shall transmit pickup notifications to the Substation Data Concentrator.	1 & 2	2
7	The Substation Data Concentrators shall be able to store relay data. This would be necessary in the event communication is lost between the Substation Data Concentrator and the Central Monitoring Database (CMDB). This could potentially happen during a storm.	1 & 2	2, 6, 10 & 12
8	Substation Data Concentrators shall transmit pickup notifications to the CMDB.	1 & 2	3
9	CMDB shall store pickup notifications.	1 & 2	4
10	CMDB shall store timestamp information for each pickup notification.	1 & 2	4
11	Relays shall detect fault events.	1 & 2	5
12	Relays shall generate fault notifications.	1 & 2	6

Req. ID	*Functional Requirements*	*Associated Scenario #* *(if applicable)*	*Associated Step #* *(if applicable)*
13	Fault notifications shall include the type of fault.	1 & 2	6
14	Fault notifications shall include the date and time of fault.	1 & 2	6
15	Fault notifications shall include the fault status (e.g. whether the fault reclosed).	1 & 2	6
16	Fault notifications shall include the estimated fault location.	1 & 2	6
17	Relays shall transmit fault notifications to the Substation Data Concentrator through SCADA.	1 & 2	6
18	Substation Data Concentrators shall transmit fault notifications to CMDB.	1 & 2	7
19	CMDB shall store fault notifications.	1 & 2	8
20	CMDB shall store timestamp information for each fault notification.	1 & 2	8
21	Relays shall record oscillography files.	1 & 2	9 & 9.1
22	Remote Controlled Fault Interrupters shall record oscillography files.	2	9.2
23	Relays shall report the capture of oscillography files to the Substation Data Concentrator.	1 & 2	10 & 10.1
24	Remote Controlled Fault Interrupters shall report the capture of oscillography files to the Substation Data Concentrator.	2	10.2
25	Substation Data Concentrators shall report the capture of oscillography files to CMDB.	1	11
26	Substation Data Concentrators shall retrieve oscillography files from relays.	1 & 2	12 & 12.1
27	Substation Data Concentrators shall retrieve oscillography files from Remote Controlled Fault Interrupters.	2	12.2
28	Data Concentrators shall comply with NERC Critical Infrastructure Protection (CIP) requirements.	1 & 2	2
29	CMDB shall retrieve oscillography files from Substation Data Concentrators.	1 & 2	13
30	CMDB shall store oscillography files.	1 & 2	14
31	CMDB shall store timestamp information for each oscillography file.	1 & 2	14
32	CMDB shall send fault notifications to the Fault Analysis Application (FAA).	1 & 2	15

Req. ID	*Functional Requirements*	*Associated Scenario # (if applicable)*	*Associated Step # (if applicable)*
33	FAA shall perform time-based queries of CMDB for related fault notifications.	1 & 2	16.1
34	FAA shall perform system-wide queries of CMDB for related fault notifications.	1 & 2	16.1
35	FAA shall perform substation-based queries of CMDB for related fault notifications.	1 & 2	16.1
36	CMDB shall permit time-based queries of fault notifications.	1 & 2	16.1
37	CMDB shall permit system-wide queries of fault notifications.	1 & 2	16.1
38	CMDB shall permit substation-based queries of fault notifications.	1 & 2	16.1
39	FAA shall perform time-based queries of CMDB for related oscillography files.	1 & 2	16.2
40	FAA shall perform system-wide queries of CMDB for related oscillography files.	1	16.2
41	FAA shall perform substation-based queries of CMDB for related oscillography files.	1 & 2	16.2
42	CMDB shall permit time-based queries of oscillography files.	1 & 2	16.2
43	CMDB shall permit system-wide queries of oscillography files.	1	16.2
44	CMDB shall permit substation-based queries of oscillography files.	1 & 2	16.2
45	FAA shall perform time-based queries of the Lightning Strike Database for related lightning strike information.	1 & 2	16.3
46	FAA shall perform queries of GIS. This is necessary to correlate Lightning Strike Database information with locations on the network.	1 & 2	16.3
47	The Lightning Strike Database shall permit time-based queries for lightning strike information.	1 & 2	16.3
48	FAA shall correlate Lightning Strike Database information with fault notifications to determine whether a fault was likely caused by lightning.	1 & 2	17
49	FAA shall identify lightning strike-induced faults that have reclosed.	1 & 2	17.1
50	FAA shall initiate investigation of lightning strike-induced faults that have reclosed.	1 & 2	17.1
51	FAA shall identify lightning-induced faults that have not-reclosed.	1 & 2	17.2
52	FAA shall initiate dispatch of work crews for lightning strike-induced faults that have not reclosed.	1 & 2	17.2

Req. ID	***Functional Requirements***	***Associated Scenario #*** ***(if applicable)***	***Associated Step #*** ***(if applicable)***
53	FAA shall read impedance information in the Enterprise Asset Management System (EAMS).	1 & 2	18
54	FAA shall read sensor location information in (EAMS). This is necessary for FAA to build the Short Circuit Model topology.	1 & 2	18
55	Phasor Data Concentrator shall calculate and update transmission impedances in EAMS.	1	18
56	The Phasor Data Concentrator shall report exceptions whenever impedances change significantly.	1	18
57	FAA shall build a Short-Circuit Model (SCM).	1 & 2	19
58	The SCM shall represent the network topology on a pre-event basis.	1 & 2	19
59	The SCM shall obtain asset location information from GIS.	1 & 2	19
60	The SCM shall include a projected fault signature.	1 & 2	19
61	FAA shall perform signature analysis.	1 & 2	20
62	FAA shall indicate the tower (or structure) closest to the fault, by tower (or structure) number.	1 & 2	20
63	FAA shall indicate the type of fault.	1 & 2	20
64	FAA shall indicate the distance from the substation (e.g. relay location) to the fault.	1 & 2	20
65	FAA shall indicate the date and time of the fault.	1 & 2	20
66	FAA shall calculate multiple potential fault locations on the distribution circuit.	2	20
67	FAA shall have access to local environmental information (such as earthquakes, lightning strikes, and fires).	1 & 2	21
68	FAA shall compare the estimated fault location to local environmental problems.	1 & 2	21
69	FAA shall refine the estimated fault location(s) based on known environmental problems.	1 & 2	21
70	FAA shall log the computed fault location(s) in the Fault Information Database.	1 & 2	22
71	FAA shall log the fault type in the Fault Information Database.	1 & 2	22

Req. ID	*Functional Requirements*	*Associated Scenario #* *(if applicable)*	*Associated Step #* *(if applicable)*
72	FAA shall log the fault date and time in the Fault Information Database.	1 & 2	22
73	FAA shall log the tower (or structure) nearest to the fault in the Fault Information Database.	1 & 2	22
74	FAA shall log the substation nearest to the fault in the Fault Information Database.	1 & 2	22
75	FAA shall log the estimated cause of the fault in the Fault Information Database.	1 & 2	22
76	FAA shall log the line state (e.g. whether it reclosed) in the Fault Information Database.	1 & 2	22
77	FAA shall log the estimated fault location error in the Fault Information Database.	1 & 2	22
78	FAA shall log the action taken (e.g. crew dispatched) in the Fault Information Database.	1 & 2	22
79	The Fault Information Database shall provide a cross-reference to raw oscillography in the CMDB.	1 & 2	22
80	FAA shall notify the Energy Management System (EMS) of the fault location.	1	23
81	EMS shall present the fault location information overlaid on a map via the EMS dashboard.	1	23
82	FAA shall notify the Outage Management System (OMS) of the potential fault locations.	2	23
83	OMS shall present the fault location information overlaid on a map via the OMS dashboard.	2	23
84	FAA shall notify EMS of the fault type.	1	23
85	FAA shall notify OMS of the fault type.	2	23
86	FAA shall notify EMS of the fault time.	1	23
87	FAA shall notify OMS of the fault time.	2	23
88	FAA shall notify EMS of the tower nearest to the fault.	1	23
89	FAA shall notify OMS of the structure nearest to the potential fault locations.	2	23
90	FAA shall notify EMS of the substations nearest to the fault.	1	23

Req. ID	*Functional Requirements*	*Associated Scenario #* *(if applicable)*	*Associated Step #* *(if applicable)*
91	FAA shall notify OMS of the substation nearest to the potential fault locations.	2	23
92	FAA shall notify EMS of the estimated cause of the fault.	1	23
93	FAA shall notify OMS of the estimated cause of the fault.	2	23
94	FAA shall notify EMS of the line state.	1	23
95	FAA shall notify OMS of the line state.	2	23
96	FAA shall notify EMS of estimated fault location error.	1	23
97	FAA shall notify OMS of the estimated fault location error.	2	23
98	EMS shall prioritize information from FAA based on whether the fault reclosed. For example, if the fault reclosed, the EMS Operator would want to know about it, but it would be a lower priority concern.	1	23
99	OMS shall prioritize information from FAA based on whether the fault reclosed. For example, if the fault reclosed, the Distribution Operator would want to know about it, but it would be a lower priority concern.	2	24
100	The Fault Information Database shall be viewable to authorized users via the web.	1 & 2	24 & 27
101	The Central Monitoring Database (CMDB) shall generate a daily report of excessive pickups.	1 & 2	25.1 & 28.1
102	CMDB shall generate a daily report of transmission outages.	1	25.2
103	OMS shall have access to "last gasp" messages from SmartConnect meters.	2	24.1
104	OMS shall compare FAA fault locations to SmartConnect meter last gasp messages to refine potential fault locations.	2	24.1
105	OMS shall have access to VRU outage call information.	2	24.2
106	OMS shall compare FAA fault locations to the outage locations identified by VRU outage calls.	2	24.2
107	OMS shall have access to Remote Fault Indicator (RFI) fault notifications.	2	24.3
108	OMS shall compare FAA fault locations to the circuit segments identified by RFIs as having a fault event.	2	24.3

Req. ID	*Functional Requirements*	*Associated Scenario # (if applicable)*	*Associated Step # (if applicable)*
109	FAA shall have access to communication status for all fault sensors, including Remote Fault Indicators.	2	24.3
110	OMS shall log the final computed fault locations in the Fault Information Database.	2	25
111	OMS shall notify the Distribution Operator of the potential fault locations.	2	26

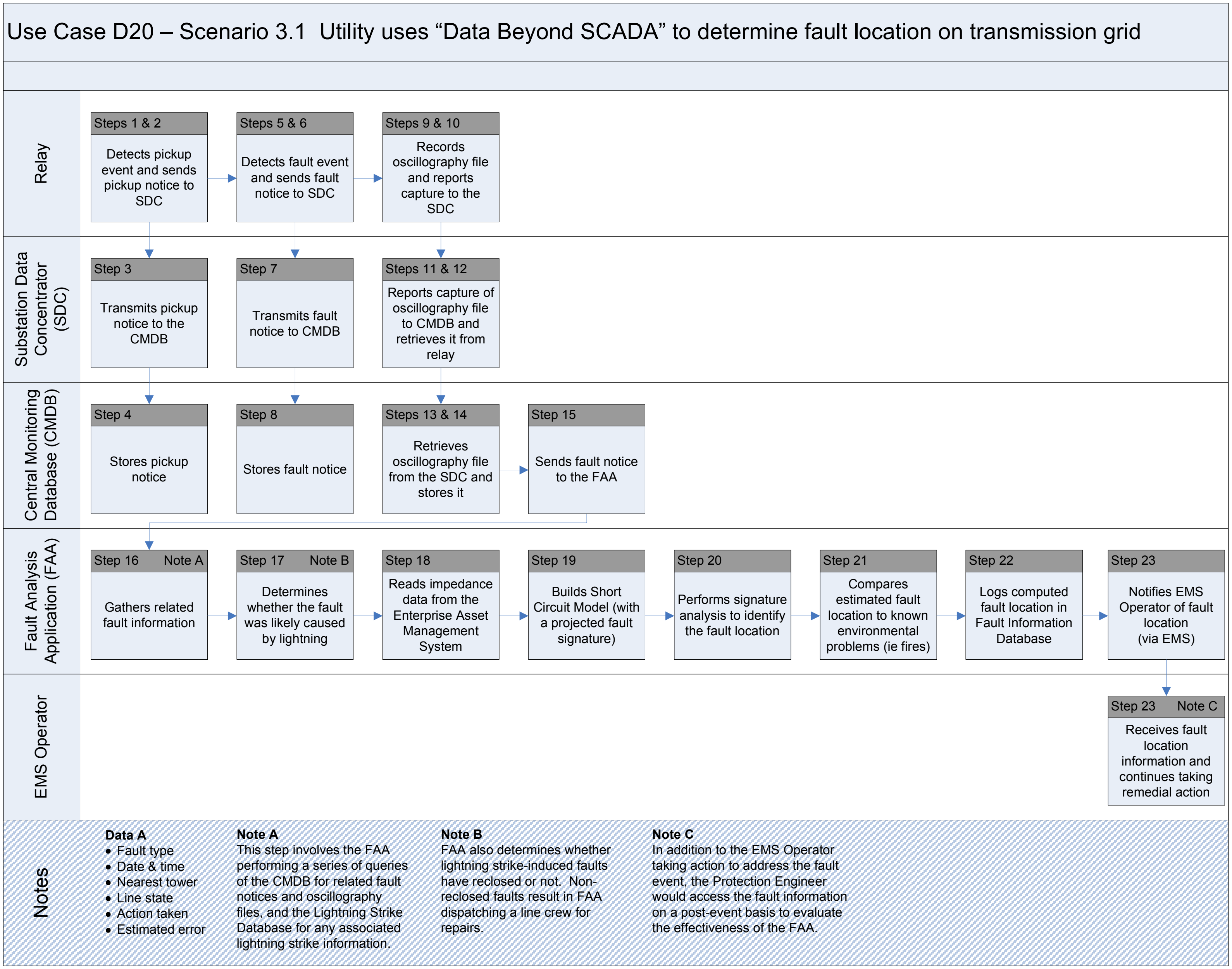
4.2 Non-functional Requirements

Req. ID	*Non-Functional Requirements*	*Associated Scenario #* *(if applicable)*	*Associated Step #* *(if applicable)*
1	Relay time-stamping of data shall comply with IEEE time-stamping standards.	1 & 2	1, 5 & 9
2	Pickup notices shall be stored in the Central Monitoring Database (CMDB) within 2 minutes of occurrence.	1 & 2	4
3	Fault indications shall be stored in the CMDB within 2 minutes of occurrence.	1 & 2	8
4	CMDB shall acquire oscillography files within one minute of the notification.	1 & 2	13
5	Timestamps on pickup, fault, and capture notices shall be synchronized to less than 1 millisecond.	1 & 2	4, 8 & 13
6	The Fault Analysis Application (FAA) shall query CMDB for other fault notices that occur within 1 second of the primary fault notice.	1 & 2	16.1
7	FAA shall query CMDB for other oscillography files that captured within 1 second of the primary file capture.	1 & 2	16.2
8	The Lightning Strike Database data shall comply with IEEE time-stamping standards.	1 & 2	16.3
9	FAA shall query the Lightning Strike Database for lightning strikes that occurred within 5 seconds of the fault notice.	1 & 2	16.3
10	The Phasor Data Concentrator (PDC) shall update transmission impedances in the Enterprise Asset Management System (EAMS) once per week.	1	18
11	The Energy Management System shall receive the calculated fault information within 5 minutes of the fault occurrence.	1	23
12	The Outage Management System shall receive the calculated fault location within 10 minutes of the fault occurrence.	2	23
13	CMDB shall generate a report on excessive pickups once per day.	1 & 2	25.1 & 28.1
14	CMDB shall generate a report on transmission outages once per day.	1	25.2

5. Use Case Models (optional)

This section is used by the architecture team to detail information exchange, actor interactions and sequence diagrams

5.1 Diagrams

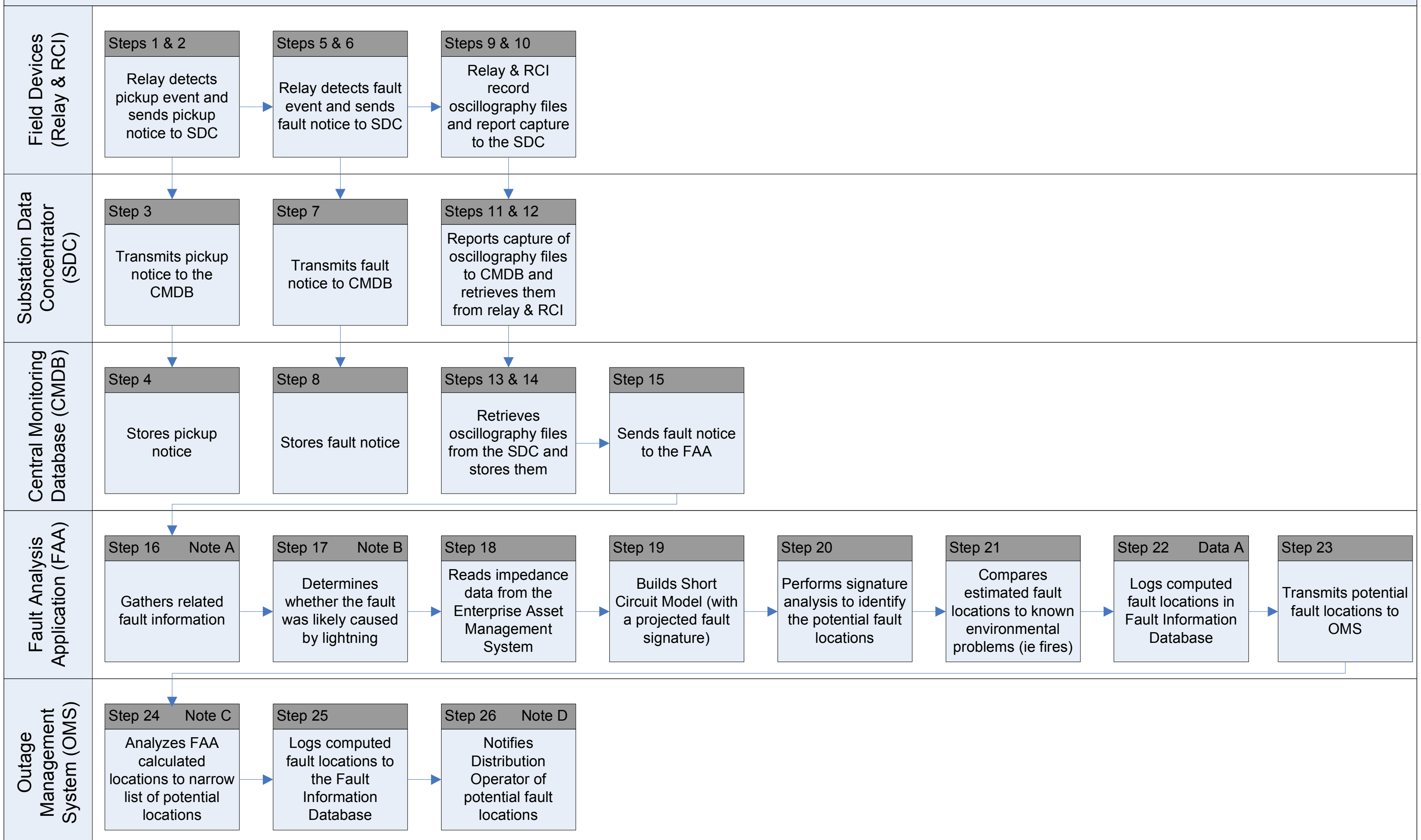


Use Case D20 – Scenario 3.1 Utility uses “Data Beyond SCADA” to determine fault location on transmission grid
Relay
Substation Data Concentrator (SDC)
Central Monitoring Database (CMDB)
Fault Analysis Application (FAA)
EMS Operator
Notes
Steps 1 & 2
Detects pickup event and sends pickup notice to SDC
Steps 5 & 6
Detects fault event and sends fault notice to SDC
Steps 9 & 10
Records oscillography file and reports capture to the SDC
Step 3
Transmits pickup notice to the CMDB
Step 7
Transmits fault notice to CMDB
Steps 11 & 12
Reports capture of oscillography file to CMDB and retrieves it from relay
Step 4
Stores pickup notice
Step 8
Stores fault notice
Steps 13 & 14
Retrieves oscillography file from the SDC and stores it
Step 15
Sends fault notice to the FAA
Step 16 Note A
Gathers related fault information
Step 17 Note B
Determines whether the fault was likely caused by lightning
Step 18
Reads impedance data from the Enterprise Asset Management System
Step 19
Builds Short Circuit Model (with a projected fault signature)
Step 20
Performs signature analysis to identify the fault location
Step 21
Compares estimated fault location to known environmental problems (ie fires)
Step 22
Logs computed fault location in Fault Information Database
Step 23
Notifies EMS Operator of fault location (via EMS)
Step 23 Note C
Receives fault location information and continues taking remedial action
Data A
• Fault type
• Date & time
• Nearest tower
• Line state
• Action taken
• Estimated error
Note A
This step involves the FAA performing a series of queries of the CMDB for related fault notices and oscillography files, and the Lightning Strike Database for any associated lightning strike information.
Note B
FAA also determines whether lightning strike-induced faults have reclosed or not. Non-reclosed faults result in FAA dispatching a line crew for repairs.
Note C
In addition to the EMS Operator taking action to address the fault event, the Protection Engineer would access the fault information on a post-event basis to evaluate the effectiveness of the FAA.

SmartConnect Program *DRAFT*

D20 – Utility uses "Data Beyond SCADA" to analyze system faults

Use Case D20 – Scenario 3.2 Utility uses "Data Beyond SCADA" to determine fault location on distribution grid



Data & Notes

Data A
- Fault type
- Date & time
- Nearest structure
- Estimated cause
- Line state
- Action taken
- Estimated error

Note A
This step involves the FAA performing a series of queries of the CMDB for related fault notices and oscillography files, and the Lightning Strike Database for any associated lightning strike information.

Note B
FAA also determines whether lightning strike-induced faults have reclosed or not. Non-reclosed faults result in FAA dispatching a line crew for repairs.

Note C
OMS analyses the FAA-calculated locations using other data, including "last gasp" messages from SmartConnect meters, fault notifications from Remote Fault Indicators, and customer calls to the VRU.

Note D
Upon receiving the potential fault locations, the Distribution Operator would dispatch a Distribution Line Crew to restore service. Additionally, a Protection Engineer would access the fault information on a post-event basis to evaluate the effectiveness of the FAA.

6. Use Case Issues

Capture any issues with the use case. Specifically, these are issues that are not resolved and help the use case reader understand the constraints or unresolved factors that have an impact of the use case scenarios and their realization.

Issue
Describe the issue as well as any potential impacts to the use case.
1. Is there a single Fault Analysis Application (FAA), or a separate FAA for transmission and distribution?
2. Does FAA have knowledge of meter outage events (or only the Outage Management System)?
3. Can FAA accuracy be improved using fault direction indications from multiple sources?

7. Glossary

Insert the terms and definitions relevant to this use case. Please ensure that any glossary item added to this list should be included in the global glossary to ensure consistency between use cases.

Glossary	
Term	**Definition**
Consolidated Mobile Solution (CMS)	A collection of remote field tools, mobile software, and the associated communications network infrastructure used by field workers. CMS shall be configured to be role-based, providing varying functionalities depending on the user.
Digital Fault Recorders	Digital Fault Recorders (DFRs) are substation-based protection devices that record and capture power data, such as voltage and current information, in very high-resolution sine wave form. DFRs monitor the behavior of the power system during disturbance events. In use case D20, DFRs report recorded data to the relevant Substation Data Concentrator, which then forwards it to the Operations Database.
Energy Management System (EMS)	The Energy Management System is a system of tools used by system operators to monitor, control, and optimize the performance of the transmission system. The monitor and control functions are performed through the SCADA network. Optimization is performed through various EMS applications.
EMS Operator	The EMS Operator monitors the EMS systems, including the DLRS Visualization Screen. They would receive the alarms from DLRS and would be responsible for initiating resolution of the alarm (e.g. by reconfiguring the grid, moving load, etc.)
Historian	The Historian is a common data repository for all operational and non-operational data. Operational data is fed to this system via SCADA, while non-operational data is transmitted via the Non-Operational Data Downloader. The historian function is currently performed by eDNA at SCE.
Independent System Operator (ISO)	The Independent System Operator (ISO or Regional Transmission Organization) is responsible for the economic and reliable operation of the transmission grid. The ISO creates a functioning market for Energy, Capacity, and Ancillary Services. The ISO is responsible for compliance with federal and state rules and regulations. The Independent System Operator, or California Independent System Operator, is the regional transmission system operator. The regional transmission system, regional grid, is operated independently of the suppliers and load aggregators by the ISO. The ISO is sort of like the "traffic cop" charged with balancing the electricity and the flow on the grid.
Phasor Data Concentrator (PDC)	This is a device that collects and aggregates phasor data from multiple Phasor Measurement Units. There would be multiple PDCs throughout SCE's service territory. In this use case, phasor data is used to calculate

	impedances. This impedance information is updated in the Enterprise Asset Management System for later use by the Fault Analysis Application (FAA) for purposes of building Short-Circuit Models.
Remote Fault Indicator (RFI)	Remote Fault Indicators (RFI) are devices that indicate whether a fault has occurred on a circuit. If a fault occurs, they have a light that will blink to alert Troublemen. In the future they could also potentially communicate this information remotely via the AMI communications infrastructure.
Supervisory Control and Data Acquisition (SCADA)	SCADA refers a group of centralized systems that monitor and control the assets within SCE's transmission and distribution system. SCADA data is relayed in 4 second intervals.
Voice Response Unit (VRU)	The Voice Response Unit (VRU) is an automated telephone answering system responsible for first tier of response to customer outage calls.

8. References

Reference any prior work (intellectual property of companies or individuals) used in the preparation of this use case

9. Bibliography (optional)

Provide a list of related reading, standards, etc. that the use case reader may find helpful.