SmartConnect Use Case:

D14 – EMS uses online dissolved gas monitoring to detect emerging failures of transformer banks and take corrective action

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Document History

Revision History

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0.1	081124	Kevin Clampitt	Initial draft from workshop on November 3, 2008	N
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Approvals

This document requires following approvals.

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Contents

1. Use Case Description

1.1 Use Case Title

EMS uses online dissolved gas monitoring to detect emerging failures of transformer banks and take corrective action.

1.2 Use Case Summary

This use case describes how the deployment of online Dissolved Gas Analysis (DGA) devices could improve SCE's monitoring, maintenance, and operation of substation transformers. Online DGA allows SCE to monitor transformer conditions as frequently as once per hour. SCE currently performs DGA analyses once per year using a manual process. The increase in monitoring frequency would allow SCE to identify transformers in need of repair or replacement prior to failure. It would also enable SCE to optimize transformer utilization over their life spans. The business value of this enhanced transformer monitoring includes improved system reliability and reduced costs.

1.3 Use Case Detailed Narrative

Transformers represent a significant proportion of an electric utility's capital expenditures, and are the most expensive component of a substation. Replacing an AA-bank transformer can cost several million dollars, while replacement lead times can exceed one year. The loss of a large transformer results in increased operating costs to the utility and increased costs to society at large. Transformer failures can lead to transmission grid congestion, suspension of service to customers and businesses, economic loss, environmental damage, and financial loss to the utility, to name a few. On average, failures of large transformers occur once per year in SCE's service territory. Although rare, these events can impose such enormous costs on SCE and its customers that it is necessary for SCE to address them.

Dissolved Gas Analysis (DGA) is a method of monitoring transformers that entails analyzing various dissolved gases in transformer oil that can predict or indicate particular types of failures. The following is a summary of the various gases analyzed within the DGA process:

Inventory of Gases Analyzed via DGA[1]	
Oxygen	Hydrogen
Methane	Ethane
Ethylene	Acetylene
Carbon monoxide	Carbon dioxide

For more than twenty years SCE has used a manual DGA process that consists of acquiring dissolved gas samples by dispatching crews to retrieve oil samples from the field. These samples are sent to a centralized lab where the results are evaluated manually over a few days. All of SCE's approximately 3,400 transformers are inspected in this manner once per year. More recently, annual sampling has been used to stratify transformers into 4 risk-based tranches. Transformers with high absolute gas levels, and those with negative trends, are now sampled more frequently than once per year. These transformers are tested every 6 months or, in an extreme case of AA banks, every week. However, this is still an infrequent manual process that cannot identify short term trends or sudden changes.

Online DGA represents a vastly improved monitoring process. With online DGA, devices are installed on substation transformers that are capable of sampling and evaluating dissolved gasses, and sending DGA data to SCE back office systems as often as once per hour. This online process provides three improvements over the existing process: (1) online DGA testing is performed on a more frequent basis, (2) test results are obtained more timely, and (3) online DGA data can be integrated into SCE operations and maintenance processes.

Online DGA data would be obtained from each transmission-level substation transformer at least once per day (and in some cases, as often as once per hour). This increased sampling frequency would improve SCE's decision making capabilities since the information would be more current and it would contain more data points (e.g. 1 per day versus 1 per year). A larger number of data points would improve trending analyses, enabling SCE to identify assets in urgent need of repair or replacement prior to failure, and enabling better prediction of the timing of those failures. This would also allow SCE to optimize the retirement and replacement of transformers, extending their use until just before the end of their useful lives. Finally, these capabilities would enhance SCE's ability to perform post mortem analyses.

Online DGA data would be automatically transmitted from the DGA device to SCE's Energy Management System (EMS), allowing the data to be used by operations. EMS would contain a rule engine with preconfigured asset-specific parameters that trigger alarms, alerting operations when transformers are in critical condition. The current maintenance process includes performing weekly trend analyses to identify emergent problems. Online DGA monitoring would automatically trigger alarms when critical DGA levels are identified, increasing SCE's ability to identify and react to emergent transformer problems when they occur. The corrective actions would be similar under both processes, but alerts would be generated more timely with online DGA, providing SCE with time to react to emergent problems prior to asset failure.

[1] DGA sensors would also detect and report on the presence of moisture in the transformer oil.

The shorter term objective is for the EMS console to display alarms to the EMS Operator who would then manually clear the transformer bank and notify the Asset Management Engineer (AME). The AME would be responsible for investigating the problem, determining a mitigation process, and communicating this process to the EMS Operator who would then implement it. This is the process described in this use case.

The longer term goal is for the alarm to include a "risk score" that would provide instructions directly to the EMS Operator. This might involve using a "dashboard", or a "transformer odometer" that indicates the transformer condition using multiple sets of sensor data (e.g. DGA data, sensor data for bushing or partial discharge issues, and load and temperature data). A more ambitious and longer term goal is for the "risk score" to automatically initiate the risk mitigation process without involvement of the EMS Operator. This latter goal will not be feasible until substantial research is performed to understand the "art" of interpreting DGA data, other sensor data, and environmental factors, and whether these factors can reliably inform automated risk mitigation strategy decisions.

Business Value

The benefits of monitoring dissolved gas to detect emerging failures of transformer banks include the following:

1. **Improved System Reliability**:
    a. Avoid Catastrophic Failures: DGA devices alert SCE to impending asset failures, allowing the equipment to be repaired or replaced prior to failure. Replacement and remediation costs could amount to millions per event.
    b. Identify Repair & Replacement Needs: Monitoring transformer conditions via DGA increases the likelihood that those in critical condition will be identified, repaired and/or replaced prior to failure. This would result in increased grid reliability.
    c. Improve Corrective Actions: Frequent monitoring of transformers improves the timeliness of SCE's diagnostic capabilities and, thus, the appropriateness of maintenance activities for these assets.
2. **Reduced Costs**:
    a. Lengthen Transformer Life Span: Use of DGA can extend the operating life of transformers, which increases the return on the initial capital investment in those transformers.
    b. Increase Capacity Utilization: Use of DGA allows SCE to increase transformer utilization (e.g. electricity throughput) without causing significant reductions in the useful lives of the equipment.
    c. Avoid Collateral Damage: A reduction in catastrophic failures reduces their associated collateral damage. Collateral damage includes customer interruption and economic loss, declines in customer satisfaction, loss of capital assets, loss of revenue, and loss of productivity during service restoration periods.
    d. Trend Analyses: Online DGA provides a greater number of data points which can be used, in conjunction with other sensor data, to perform trend and causality analyses to identify "bad actors" (by asset types, families, voltage classes, manufacturer, etc.). This information would improve maintenance and procurement practices.

e. Post Mortem Analyses: Online DGA data provides an opportunity to understand, post mortem, the conditions of transformers prior to failure. This knowledge can be used by the Enterprise Asset Management System to improve its ability to identify problems prior to asset failure, improve its ability to predict the timing of asset failures, and optimize its retirement and replacement planning process.

1.4 Business Rules and Assumptions

- The Energy Management System (EMS) has temperature data points and loading data for A-bank and AA-bank transformers (outside of this use case).
- The scenario described in this use case involves the use of Dissolved Gas Analysis (DGA) sensor data. However the process would be similar for other sensor data (e.g. bushing and partial discharge sensors). See use case D19 for a broader discussion of condition-based maintenance.
- SCE has developed a set of rules and configuration settings, by asset, that shall be used by the EMS “rule engine” to generate alarms and notifications, and initiate Equipment Diagnostic Processor functions.
- The current process of manually obtaining DGA samples on an annual basis will continue to run in parallel with the online process described in this use case. This would continue to be performed for regulatory reporting purposes.

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***
Asset Health Rules (AHR)	Rules	Asset Health Rules are used by the Equipment Diagnostic Processor to create a series of metrics about a particular asset using all available inputs including historical and current data. AHR shall be flexible and configurable by asset-type, specific assets, vendor, vintage, etc. They may be modified by the Asset Management Engineer using a relatively simple interface (which does not require a programmer to write code).
Asset Management Engineer (AME)	Person	The Asset Management Engineer is responsible for paying attention to all the assets. SCE might even have a more specialize role for the person who only monitors the transformers (e.g. a Transformer Asset Management Engineer). This person configures Asset Health Rules for submission to the Equipment Diagnostic Processor.
Energy Management System (EMS)	System	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	Person	The EMS Operator monitors the EMS systems, alerts the Asset Management Engineer (AME) to critical EMS alarms, and assists the AME by implementing the AME's mitigation processes.
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.

Actor Name	Actor Type (person, device, system etc.)	Actor Description
Equipment Diagnostic Processor (EDP)	System	The Equipment Diagnostic Processor is an application within EAMS that evaluates current asset condition data with respect to historical baseline data and, based on a series of factors, provides diagnoses and identifies probable “bad actors”. The system is generally used by the Asset Management Engineer to research condition-based monitoring related notifications.

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: EMS receives indication of preemptive failure from AA bank or A bank transformer online-DGA device and transfers load off of bank to prevent failure

This scenario describes how online Dissolved Gas Analysis (DGA) devices are used to identify substation transformers with dissolved gas levels at a "critical" state. DGA data is automatically sent from field devices to the Energy Management System (EMS) at least once per day (and as often as once per hour). If certain rule conditions are met, EMS sends a "critical" alarm to the EMS Operator who would clear the transformer bank and notify the Asset Management Engineer (AME). EMS simultaneously initiates the Equipment Diagnostic Processor (EDP) which runs the DGA data against the transformer's Asset Health Rules. EDP then sends an alert to the AME, who investigates the problem with the use of the EDP information, and the Enterprise Asset Management System. Lastly, the AME determines a mitigation process and communicates it to the EMS Operator, who then implements the mitigation process.

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)*
Energy Management System gathers Dissolved Gas Analysis (DGA) data from a substation transformer DGA device.	Energy Management System	Asset Health Rules have been configured and alarm levels established. (Asset Health Rules are discussed in use case D19)	The Asset Management Engineer implements mitigation strategy for critical condition transformer.

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	EMS	EMS gathers substation transformer DGA data and other sensor data.	DGA data may come from a sensor, aggregator or controller. DGA units at the substations store and forward the data to EMS. Other sensor data could include partial discharge from bushing.
2	EMS	The EMS rule engine performs analysis to determine the transformer condition level.	The EMS rule engine is the application within EMS that analyzes the DGA data and creates alarms based on pre-configured settings. These settings can be based on absolute limits and rates of change. In addition to the DGA data, the rule engine also considers the current transformer loading as well as transformer temperature. There are 4 potential transformer condition levels: normal, caution, warning, and critical. An alarm is generated for the EMS Operator when a transformer is in critical condition. If

Step #	*Actor*	*Description of the Step*	*Additional Notes*
			the transformer is in a “caution” or “warning” state, notifications are sent to the Asset Management Engineer (but an alarm is not generated for the EMS Operator).
2.1	EMS	If the condition level is “normal”, the data is stored and no further action is required.	
2.2	EMS	If the condition level is either “caution” or “warning”, proceed to step 6.	For “caution” or “warning” condition levels, in step 6 data is collected and processed by the Equipment Diagnostic Processor, which then notifies the Asset Management Engineer who takes appropriate action. This data would not be sent the EMS Operator.
2.3	EMS	If the condition level is “critical”, proceed to step 3.	
3	EMS	The EMS console alerts the EMS Operator via a highly visible graphical interface.	A long term goal is for the alarm to include a "risk score” that would provide mitigation process instructions directly to the EMS Operator. The EMS Operator might also be provided with a “Transformer Odometer” or “Transformer Life Meter” that indicates the state of a transformer using multiple sets of sensor data (e.g. DGA data, and sensor data for bushing or partial discharge issues). The “risk score” or transformer odometer information would likely be generated by EDP rather than EMS.

Step #	Actor	Description of the Step	Additional Notes
			A more ambitious longer term goal is for the "risk score" to automatically initiate the risk mitigation process without involvement of the EMS Operator.
4	EMS Operator	The EMS Operator notifies the Asset Management Engineer (AME).	The EMS Operator notifies the AME (probably by phone) that there was an EMS alarm, and discusses remedial action steps. The remedial action would most likely involve clearing the transformer. Automated information about the transformer will be provided to the AME following EDP processing.
5	EMS Operator	The EMS Operator clears the transformer.	The EMS Operator sees the alarm and clears the transformer based on predefined operations and exception practices. An exception could be an instance in which the EMS Operator intentionally does not shed load because it could cause high customer dissatisfaction (e.g. during the 4th quarter of the Superbowl or other).
6	EDP	The Equipment Diagnostic Processor (EDP) analyzes data from EMS.	EDP performs analysis based on parameters and algorithms that have been pre-configured at an asset-specific level (see discussion of Asset Health Rules in use case D19). EDP utilizes the following EMS data for this analysis: recent DGA metrics and trends, temperature data, loading data, through fault

Step #	*Actor*	*Description of the Step*	*Additional Notes*
			activity, and any other system events. Over the longer term, algorithmic and analytical capabilities are expected to increase such that EDP would be able to generate a "risk score", incorporating the accumulated knowledge and experience of Asset Management Engineers into a specific and actionable diagnosis. Another possibility is to provide the EMS Operator with a "Transformer Odometer" or "Transformer Life Meter" that would indicate the state of a transformer using multiple sets of sensor data (e.g. DGA data, and sensor data for bushing or partial discharge issues). The "risk score" or transformer odometer information would be communicated directly to the EMS Operator and Asset Management Engineer (step 7).
6.1	EDP	EDP may issue instructions to change the DGA sampling rate.	If appropriate, EDP could reprogram the DGA device with a more frequent data capture rate. This would involve a modification to the relevant Asset Health Rule. For example, this might occur if EDP detects a fault or something else that warrants more frequent monitoring.

Step #	*Actor*	*Description of the Step*	*Additional Notes*
7	EDP	EDP notifies the AME of the abnormal transformer condition.	EDP notifies the AME whenever the transformer condition is not normal (i.e. whenever the condition is “caution”, “warning” or “critical”). EDP shall provide the AME with the condition level, current reading and trend of DGA metrics and ratios, current and trending temperature, loading, and information about any through fault events.
8	AME	The AME uses EAMS to investigate the problem and determine mitigation strategies.	The AME uses EAMS to investigate what happened to the transformer, and to determine what steps should be taken to address the problem. EAMS consists of a dashboard (a screen that displays key equipment parameters), a decision support module (e.g. EDP), rules to calculate key metrics, the ability to query and extract information about the equipment’s pedigree, maintenance history, previous test data, etc. In the event the AME receives “caution” or “warning” notifications (from step 2.2), he would receive the notification from EMS immediately after EMS receives the data from the online DGA device. At a minimum the AME would perform a manual DGA sample to confirm the results of the online DGA monitor. The sample would likely be taken the day following receipt of the data, and it would be analyzed at an in-house

Step #	***Actor***	***Description of the Step***	***Additional Notes***
			lab. A secondary objective of this manual sampling is to identify any false positives from the online DGA monitor.
9	AME	If necessary, the AME issues updated instructions to the EMS Operator, who implements the mitigation process.	This involves the AME calling or e-mailing the EMS Operator with mitigation process instructions. Mitigation processes could include minimizing the loading level, taking the transformer off-line, using a spare transformer, etc. One strategy could be to instruct the EMS Operator to update the EMS rule engine.

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	Dissolved Gas Analysis (DGA) devices shall be able to measure absolute values of dissolved gas levels.	1	1
2	DGA devices shall be able to measure the rates of change in dissolved gas levels.	1	1
3	DGA devices shall be able to send DGA data to EMS once per hour.	1	1
4	DGA devices shall be able to store dissolved gas measurement data.	1	1
5	DGA devices shall be able to measure oxygen levels.	1	1
6	DGA devices shall be able to measure hydrogen levels.	1	1
7	DGA devices shall be able to measure methane levels.	1	1
8	DGA devices shall be able to measure ethane levels.	1	1
9	DGA devices shall be able to measure ethylene levels.	1	1
10	DGA devices shall be able to measure acetylene levels.	1	1
11	DGA devices shall be able to measure carbon monoxide levels.	1	1
12	DGA devices shall be able to measure carbon dioxide levels.	1	1
13	DGA devices shall be able to measure moisture levels.	1	1

Req. ID	***Functional Requirements***	***Associated Scenario #*** ***(if applicable)***	***Associated Step #*** ***(if applicable)***
14	DGA devices shall provide dissolved gas data to the Energy Management System (EMS).	1	1
15	Bushing sensors shall measure, store and provide partial discharge data to EMS.	1	1
16	EMS shall have transformer temperature data available for analysis. This data is not provided by DGA devices.	1	2
17	EMS shall have transformer loading data available for analysis. This data is not provided by DGA devices.	1	2
18	The EMS rule engine shall be configurable at the asset-specific level.	1	2
19	The EMS rule engine shall evaluate transformer conditions based on absolute limits.	1	2
20	The EMS rule engine shall evaluate transformer conditions based on rates of change.	1	2
21	The EMS rule engine shall consider the DGA data when determining the transformer condition level.	1	2
22	The EMS rule engine shall consider the transformer temperature when determining the transformer condition level.	1	2
23	The EMS rule engine shall consider the transformer loading level when determining the transformer condition level.	1	2
24	The EMS rule engine shall contain parameters for key dissolved gas concentration levels, as defined by SCE operators and maintenance standards.	1	2
25	The EMS rule engine shall contain parameters for key dissolved gas concentration rates of change, as defined by SCE operators and maintenance standards.	1	2
26	The EMS rule engine shall contain parameters for key dissolved gas ratios and metrics, as defined by SCE operations and maintenance standards.	1	2
27	EMS shall initiate the Equipment Diagnostic Processor for transformers in either "caution", "warning" or "critical" conditions.	1	2.2 & 2.3
28	EMS shall generate "critical" alarms for the EMS Operator.	1	2.3

Req. ID	*Functional Requirements*	*Associated Scenario #* *(if applicable)*	*Associated Step #* *(if applicable)*
29	The EMS console shall provide simple and highly visible on-screen “critical” alarm indications to the EMS Operator.	1	3
30	The EMS alarm shall include a “risk score” with mitigation process instructions.	1	3
31	The EMS display shall include a “Transformer Life Meter” that presents the projected remaining life of the transformer.	1	3
32	SCE shall have operations and exception processes for clearing transformers. For example, the operator has an alarm indication, but it’s during the Super Bowl and he makes a decision to wait 30 minutes to drop load.	1	5
33	EMS shall notify EDP of any transformer conditions other than “normal” (i.e. “caution”, “warning” and “critical” conditions).	1	6
34	EDP shall have access to through fault magnitude and duration data. This data could come from a digital fault recorder, a power quality monitor, a built in monitor in a transformer, or a relay.	1	6
35	EDP shall obtain the most recent DGA data from EMS.	1	6
36	EDP shall analyze the most recent DGA data.	1	6
37	EDP shall obtain temperature data from EMS.	1	6
38	EDP shall analyze temperature data.	1	6
39	EDP shall obtain loading data from EMS.	1	6
40	EDP shall analyze loading data.	1	6
41	EDP shall obtain through fault metrics from EMS.	1	6
42	EDP shall analyze through fault metrics.	1	6
43	EDP shall be able to query the Enterprise Asset Management System (EAMS) for historical transformer data.	1	6
44	EDP shall be able to query EAMS for transformer baseline information.	1	6

Req. ID	Functional Requirements	Associated Scenario # (if applicable)	Associated Step # (if applicable)
45	EDP shall be able to query EAMS for transformer nameplate information.	1	6
46	EDP shall be able to query EAMS for transformer rating levels.	1	6
47	EDP shall calculate a “risk score” with mitigation process instructions.	1	6
48	EDP shall calculate mitigation process instructions for each “risk score”.	1	6
49	EDP shall calculate a “Transformer Life Meter” that presents the projected remaining life of the transformer.	1	6
50	The “risk score” and “Transformer Life Meter” shall utilize multiple sets of sensor data (including all data provided by DGA devices, historical and asset nameplate data contained in EAMS, and other device data).	1	6
51	EDP shall be able to recommend a change in the DGA sampling rate.	1	6.1
52	EDP shall recommend changes in the DGA sampling rate based on SCE operations and maintenance standards.	1	6.1
53	EDP shall be able to effect a change in the DGA sampling rate for a specific DGA device.	1	6.1
54	DGA devices shall be remotely reconfigurable (i.e. to change the sampling rate).	1	6.1
55	EDP shall notify the Asset Management Engineer (AME) with DGA information (current and recent data).	1	7
56	EDP shall notify the AME with temperature information.	1	7
57	EDP shall notify the AME with loading information.	1	7
58	EDP shall notify the AME with key metrics and ratios.	1	7
59	EDP shall notify the AME with recent fault event information.	1	7
60	EDP shall notify the AME with a risk score (long term goal).	1	7
61	EDP shall be able to generate an e-mail notification to the AME that contains the information contained in functional requirements 23 through 28.	1	7

Req. ID	*Functional Requirements*	*Associated Scenario # (if applicable)*	*Associated Step # (if applicable)*
62	EAMS shall store the DGA data points.	1	8
63	EAMS shall have a dashboard screen that displays key equipment parameters.	1	8
64	EAMS shall include a decision support module (EDP). This would be used by the AME to determine appropriate next steps.	1	8
65	EAMS shall store lifecycle parameters and attributes. This could include transformer design type (shell form versus core form), voltage level, installation date, descriptions and dates of previous trouble, nameplate data, manufacturer, year manufactured, and other basic asset attributes. This information would be used by the Asset Management Engineer (AME) to investigate the problem and develop a mitigation process. It would also be used over the longer term to generate trend and causality analyses to identify “bad actors” (by asset types, families, voltage classes, manufacturer, etc.).	1	8
66	EAMS shall support to ability to query and extract information about asset histories.	1	8
67	The AME shall be able to provide instructions to the EMS Operator to update the EMS rule engine. Rules are different for each asset and for each gas.	1	9

4.2 Non-functional Requirements

Req. ID	*Non-Functional Requirements*	*Associated Scenario #* *(if applicable)*	*Associated Step #* *(if applicable)*
1	DGA devices shall support the Modbus TCP communications protocol.	1	1
2	DGA devices shall support the DNP3 protocol.	1	1
3	DGA devices shall support the IEC 61850 standard.	1	1
4	A-bank and AA-bank transformers shall provide Dissolved Gas Analysis (DGA) data.	1	1
5	DGA devices shall send approximately 30 points per data sample to EMS.	1	1
6	EMS shall receive transformer temperature and loading data in 4 second intervals via SCADA systems. The ability to see step load changes at SCADA-level frequency would improve the accuracy of the Asset Management Engineer's (AME) analysis.	1	1
7	DGA devices shall send data to EMS at least once per day. This may be increased depending on the condition of the asset. For example, transformers with a "warning" condition level would be monitored more frequently.	1	1
8	There shall be no intentional delay between the time EMS sends an alarm to the EMS Operator and when the EMS Operator clears the transformer bank (unless one is prescribed by operations and exception procedures).	1	5

5. Use Case Models (optional)

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

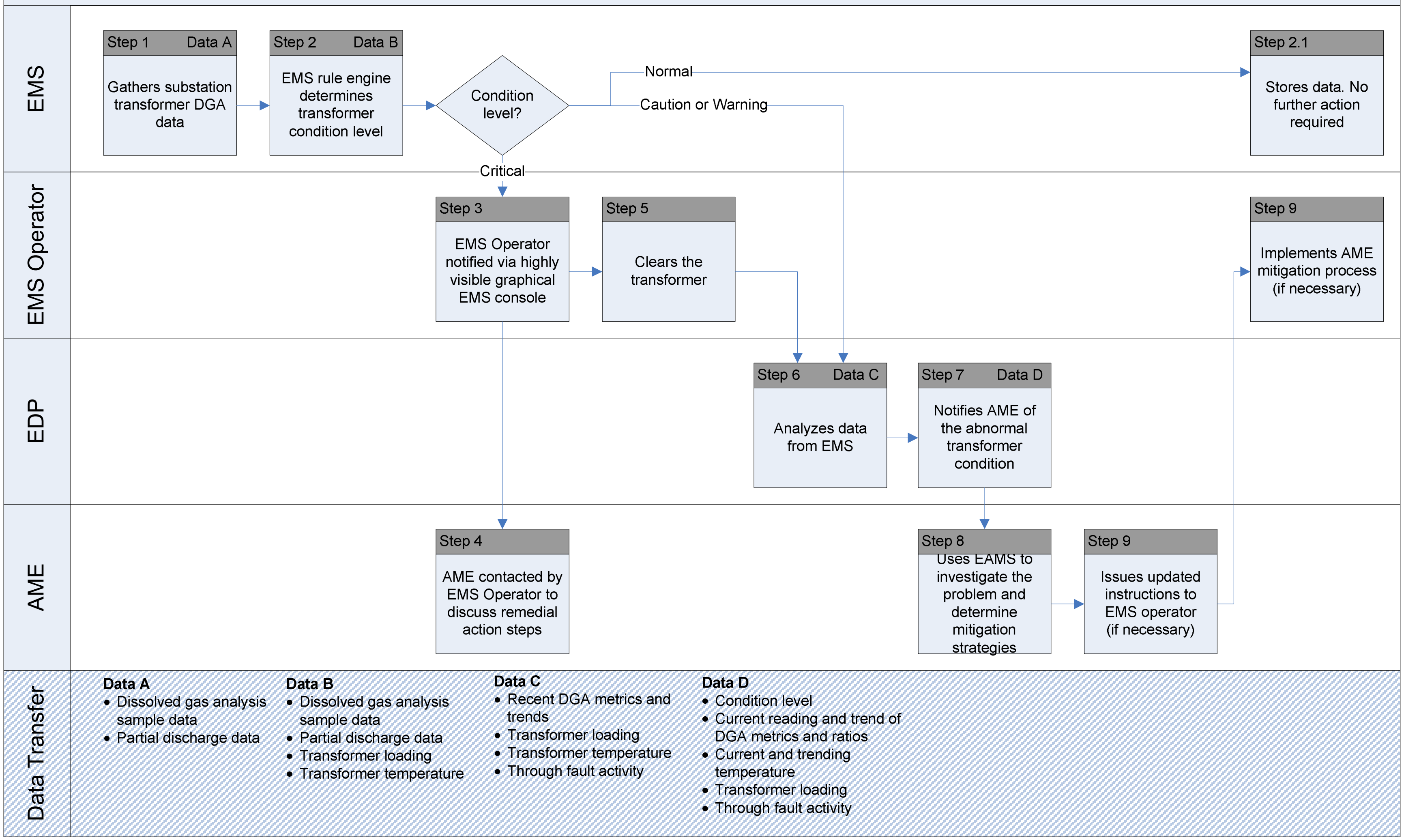
5.1 Information Exchange

For each scenario detail the information exchanged in each step

Scenario #	***Step #, Step Name***	***Information Producer***	***Information Receiver***	***Name of information exchanged***
#	*Name of the step for this scenario.*	*What actors are primarily responsible for Producing the information?*	*What actors are primarily responsible for Receiving the information?*	*Describe the information being exchanged*

5.2 Diagrams

Use Case D14 – Scenario 3.1 EMS receives indication of preemptive failure from AA bank or A bank transformer online-DGA device and transfers load off of bank to prevent failure



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. This use case focuses only on transmission substation level transformers (A & AA) due to cost / benefit considerations. As prices of DGA monitoring equipment decline, the use of these sensors for distribution level assets should be reconsidered.

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**
Dissolved Gas Analysis Device (DGA Device)	A Dissolved Gas Analysis device monitors the condition of power transformers. The presence of dissolved gas can be an indication of imminent asset failure, or as an early warning for assets in need of repair.
EMS Rule Engine	The EMS rule engine enables EMS to determine when to generate alarms, send notifications to the EMS Operator, and initiate the Equipment Diagnostic Processor (EDP). The rule engine is configurable at the asset-specific level. This rule engine is discussed further in use case D19.
Transformer	A transformer is a device that transfers energy electricity from one circuit to another (or one set of circuits to another set of circuits) through electromagnetic induction, while maintaining the same frequency. Usually the voltage and current change when energy passes through a transformer. Voltage is typically stepped down at substation transformers, where energy moves from transmission lines to distribution-level circuits.

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.

1. Application of On-Line DGA to SCE's AA and A Transformer Banks