Pacific Gas and Electric Company

Pacific Gas and Electric Company

EPIC Final Report

Program	**Electric Program Investment Charge (EPIC)**
Project	**EPIC 1-15 – Demonstrate New Technologies and Strategies That Support Integrated "Customer-to-Market-to-Grid" Operations of the Future**
Project Reference Name	**Grid Operations Situational Intelligence (GOSI)**
Department	Emerging Technologies- Grid Analytics
Project Sponsor	Ferhaan Jawed
Project Business Lead	Tom Martin
Contact	EPIC_Info@pge.com
Date	December 30, 2016
Version Type	Final

Table of Contents

1 Executive Summary 3
2 Introduction 7
3 Project Overview 8
3.1 Issue Addressed 8
3.2 Project Objective 8
3.3 Scope of Work 9
3.3.1 Major Tasks and Deliverables 9
4 Project Results and Key Findings 14
4.1 Successful data integration into vendor's system 14
4.2 Successful Demonstration of the Interactive Map and Use Case Workbenches 14
4.2.1 Use Case 1: Outage Anticipation / Interactive Map 14
4.2.2 Use Case 2: Construction Planning 16
4.2.3 Use Case 3: Tools for Circuit Loading Research 17
4.2.4 Use Case 4: Operations and Emergency Operations 18
4.2.5 Use Case 5: Distributed Generation (DG) Visualization and Research 20
4.3 Agile Development Promoted Frequent Feedback Collection and Iterations 22
4.4 Data Access 22
5 Unique Technology Implementation Issues 23
5.1 Challenges in Maintaining Diverse Data Sources 23
5.2 Challenges in Visualizing Data and Verifying Data Accuracy With Users 24
5.2.1 Automated Testing 24
5.2.2 Visualization Sophistication 24
5.3 Applying the Agile Development Method Without User Analytics 25
6 Key Accomplishments and Future Opportunities 26
6.1 Key Accomplishments 26
6.2 Future Opportunities 26
6.2.1 Potential Features for Future Versions of the GOSI Platform 26
7 Value proposition 27
7.1 EPIC Primary and Secondary Principles 27
7.1.1 Apply Business Logic to Raw Data Visualization 28
7.2 Improving Industry Awareness 28
7.2.1 Adaptability to Other Utilities / Industry 28
7.2.2 Dissemination of Best Practices 29
8 EPIC Specific Metrics 30
9 Conclusion 31
10 Appendix A – Out of Scope Stories 32
11 Appendix B – Introduction Guide to Using GOSI 34
12 Section 1: Interactive Map 34
Navigating to the Interactive Map 34

Map Content Manager 35
Map Layers 35
Clustering 36
Map Use Cases 37
1. Outage and Troubleman Tracking 37
2. Asset Threat Analysis/Outage Cause Assessment 37
3. Grouping Construction Tags 38
13 Section 2: Daily Operations Dashboard 39
Daily Ops Dashboard Uses 39
1. AOR Outages 39
14 Section 3: Emergency Operations Center Video Wall 40
Configuration 40
Closing 40
EOC Video Wall Uses 40
14.1.1 1. Outage Tracking During an Event 40

List of Tables

Table 3-1: Use Cases for the GOSI Platform 10
Table 3-2: Data Sources Incorporated into the GOSI Platform 12
Table 7-1: EPIC Primary and Secondary Guiding Principles 27

List of Figures

Figure 1: Screenshot of Interactive Map 13
Figure 2: Screenshot of Interactive Map with Outages and Troublemen Data Layers 15
Figure 3: Screenshot of Construction Planning Dashboard 17
Figure 4: Screenshot of Circuit Loading Research Workbench Output 18
Figure 5: Screenshot of Daily Operations Dashboard 19
Figure 6: Screenshot of Emergency Operations Center Dashboard 20
Figure 7: Screenshot of DG Visualization Heat Map 21

List of Acronyms

AMI	Advanced Metering Infrastructure
CESO	Customers Experiencing Sustained Outages
DG	Distributed Generation
DER	Distributed Energy Resources
DMS	Distribution Management System
ED	Electric Distribution
EOC	Emergency Operations Center
GOSI	Grid Operations Situational Intelligence

1 Executive Summary

This report summarizes the project objectives, technical results, and lessons learned for EPIC Project 1.15, *Demonstrate New Technologies and Strategies That Support Integrated "Customer-to-Market-to-Grid" Operations of the Future* (in short referred to as *Grid Operations Situational Intelligence* or GOSI in this report), as listed in the EPIC Annual Report.[1]

As Pacific Gas and Electric Company (PG&E) modernizes its grid technology, new sources of potentially valuable operational intelligence are becoming available. SmartMeters, supervisory control and data acquisition (SCADA) devices, and line sensor measurements – in addition to existing environmental and asset data – could provide increased visibility to the state of the grid, but these sources present challenges in their complexity and volume of data. Collating and visualizing this operational data may provide insights into grid operations, and could minimize outages and cost while increasing safety.

Additionally, while there is a wealth of data being generated by new devices, there are growing challenges to organizing and leveraging this data. To operate the next-generation grid safely, affordably, and reliably, electric utilities will need to integrate significantly more data and information into both existing and future operational systems. Data concerning Distributed Energy Resources[2] (DERS) will grow exponentially and be vital for control and planning operations. Data from customers concerning service, outages, and safety issues with existing assets will also need to be tied into analysis tools. System operators will need timely and simple access to this data and resulting analyses in order to manage the system and the resources effectively.

To help address these concerns, EPIC *Project 1.15 - Grid Operations Situational Intelligence* was established with the following objective: to develop and demonstrate a project version of a real-time data visualization software platform for use by PG&E end users.

Key Accomplishments
The following is a summary of the key accomplishments of this project:

- Integrated data streams from over 20 sources, in addition to developing and maintaining a system to provide updated data extracts from each source.
- Developed and demonstrated a visualization tool that enabled users to customize a map with various data layers depending on their specific use case.
- Developed custom data visualization tools for five specific use cases to respond to specific concerns identified through interviews with operations personnel including:
    - UC1: Outage Anticipation. Combines weather, wildfire, lightning, and earthquake feeds onto a single map view along with GIS information to reduce the number of data view windows an operator needs to open during an outage event.

[1] http://www.pge.com/includes/docs/pdfs/about/environment/epic/EPICAnnualReportAttachmentA.pdf.
[2] Including Electric Vehicles (EVs), Photovoltaic solar generation systems (PV), and Battery Energy Storage Systems (BESS).

  - UC 2: Construction Planning. Provides operational and SAP information, including feeder maps, to construction planners to streamline the planning process.
  - UC 3: Circuit Loading Research. Supports operators and engineers finding asset loading information via a map-based search interface.
  - UC 4a: Operations. Provides a real-time graphical dashboard of daily events for control centers providing increased situational and operational awareness.
  - UC 4b: Emergency Operations. Provides a real-time emergency operations center (EOC) dashboard and reporting tool to replace existing Excel-based dashboards. These provide a single-source of truth for data and consistent and timely reporting.
  - UC 5: Distributed Generation (DG) Planning. Provides a geospatial visualization of DG assets, 'as-built', to support improved operational research and planning.
- Demonstrated the overall value and efficiency gains for a tool that allows users to view multiple internal and external data streams on one map.

Key Takeaways

The following are the key takeaways and lessons learned from this project:

- Overall, end users found the GOSI platform and the ability to view multiple layers of data on one map / screen to be highly valuable. For example:
  - In UC1, the GOSI platform demonstrated the value of integrating new external data sources such as Google Streetview into Operations. Previously, users had to spend significant time and energy guiding field personnel to equipment of interest. By providing access to street-level views integrated with PG&E's internal asset data, the GOSI platform acted as a tool for personnel in operations centers to provide improved support to field personnel.
  - In UC2, the Construction Planning Dashboard enabled easier optimization of construction work planning and execution by allowing the user to potentially consolidate work on nearby assets for just one clearance tag, instead of many. It was previously a challenge for construction planners to sort through vast and isolated data sets and understand work optimization opportunities.
  - Prior to the GOSI platform, operators had to manually compare the PG&E asset database displayed via a GIS-enabled map with external weather maps to plan for potential outages. In UC 1, the GOSI platform allowed weather data to be overlaid on top of the asset maps, in addition to providing troublemen locations.
  - In UC 4b, emergency operations user feedback demonstrated the novelty of the GOSI platform in being able to display asset location, field resource locations, and fire boundary data all on one map. The Emergency Operations Dashboard, a specific use case module built into the GOSI platform, was successfully demonstrated during the 2015 Valley and Butte wildfire incidents.
- The agile development method was an effective strategy for this type of technology demonstration project that sought to quickly develop features and functionality that could be regularly tested by end users to drive the end project.
  - A particular testament to this development strategy was the GOSI platform's successful integration and visualization of data from over 20 different internal and external sources,

where updated data extracts were being delivered to the vendor's software using an ad-hoc combination of manual, push, and pull processes.

Unique Challenges

There were some unique challenges addressed in the project:

- This technology demonstration project was unique in both the volume of data being integrated into one platform, but also in the variation among the individual data sources. Not only did each data stream need to be integrated into the vendor's backend system, nearly all of the data sources needed to be updated with some frequency in order for the visualization tool to provide near real-time information. Due to the project nature of this project, varying data integration patterns were used varying from on-going feeds to flat file incorporation.
- Sometimes, a feature would appear to be providing the desired functionality and would pass tests designed to verify that it was behaving as designed. Despite passing these tests, the output of the feature would show incorrect data. Through the frequent user tests and feedback collection mechanisms, it was the end users who would eventually identify the issue of a feature displaying the incorrect data so that it could be corrected. Automated testing suites and sophisticated visualization capabilities might help mitigate this issue, and are important elements for utilities consider in choosing an integrated data platform.
- Due to technical limitations, PG&E was unable to collect and track quantitative user analytics, such as click-rates and data on which features were most widely used. These metrics would have allowed PG&E to compare user provided feedback against how users were actually using the tool's features. The primary challenge preventing data collection was the aforementioned output showing incorrect data. The initial goal of the GOSI project was to collect quantitative feedback based on users' real-life engagement with the technology, but because of the testing challenges, most user engagement occurred in a controlled setting to prevent distribution operations personnel accidentally acting on incorrect information.

Next Steps

Through the experience of this technology demonstration project, PG&E has identified a variety of priorities when pursuing a vendor (or develop the in-house software capabilities) to construct, maintain, and expand an evolving data platform of this type. While the current prototype version of the GOSI platform has reached its end of life, PG&E will continue to explore future situational intelligence platforms using the lessons learned from this demonstration project.

Furthermore, the project offers several recommendations for expanding upon a future version of the GOSI platform:

- Develop a data export functionality to allow users to explore deeper into the data to perform specific analyses.
- Apply an added layer of business logic and other "rules" to the raw data to provide the user with actionable insights. This added layer of synthesis moves the point at which the end user is required to interpret the data enabling increased internal consistency among data end users.
- Seek to combine the GOSI platform approach with other EPIC and new technology initiatives in order to test additional use cases that this situational intelligence platform could serve.

Conclusion

PG&E successfully developed a platform that allowed users to view these complex data sources in ways that were previously impossible, specifically by allowing users to view all relevant data on one map or screen. This project successfully achieved all of its key objectives, and in doing so, has captured key learnings that can be leveraged by other utilities and industry members to leverage new and existing data sources to improve situational intelligence around grid operations. Through the work executed in this technology demonstration project and documented in this report, PG&E gained substantial experience in developing and maintaining the IT infrastructure required to host the data integration and visualization capabilities demonstrated by the GOSI platform.

2 Introduction

This report documents the achievements of EPIC Project 1.15, "Demonstrate New Technologies and Strategies That Support Integrated "Customer-to-Market-to-Grid" Operations of the Future", highlights key learnings from the project that have industry-wide value, and identifies future opportunities for PG&E to leverage this project. In short, the project is referred through the report as "Grid Operations Situational Intelligence (GOSI)".

The California Public Utilities Commission (CPUC) passed two decisions that established the basis for this project program. The CPUC initially issued D. 11-12-035, *Decision Establishing Interim Research, Development and Demonstrations and Renewables Program Funding Level*[3], which established the Electric Program Investment Charge (EPIC) on December 15, 2011. Subsequently, on May 24, 2012, the CPUC issued D. 12-05-037, *Phase 2 Decision Establishing Purposes and Governance for Electric Program Investment Charge and Establishing Funding Collections for 2013-2020*[4], which authorized funding in the areas of applied research and development, technology demonstration and deployment (TD&D), and market facilitation. In this later decision, CPUC defined TD&D as "the installation and operation of pre-commercial technologies or strategies at a scale sufficiently large and in conditions sufficiently reflective of anticipated actual operating environments to enable appraisal of the operational and performance characteristics and the financial risks associated with a given technology."[5]

The decision also required the EPIC Program Administrators[6] to submit Triennial Investment Plans to cover three-year funding cycles for 2012-2014, 2015-2017, and 2018-2020. On November 1, 2012, in A.12-11-003, PG&E filed its first triennial Electric Program Investment Charge (EPIC) Application at the CPUC, requesting $49,328,000 including funding for 26 Technology Demonstration and Deployment Projects. On November 14, 2013, in D.13-11-025, the CPUC approved PG&E's EPIC plan, including $49,328,000 for this program category. Pursuant to PG&E's approved EPIC triennial plan, PG&E initiated, planned and implemented the following project: 1.15 Grid Operations Situational Intelligence (GOSI). Through the annual reporting process, PG&E kept CPUC staff and stakeholder informed on the progress of the project. The following is PG&E's final report on this project.

[3] http://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/156050.PDF.
[4] http://docs.cpuc.ca.gov/PublishedDocs/WORD_PDF/FINAL_DECISION/167664.PDF.
[5] Decision 12-05-037 p. 37.
[6] Pacific Gas & Electric (PG&E), San Diego Gas & Electric (SDG&E), Southern California Edison (SCE), and the California Energy Commission (CEC).

3 Project Overview

The project ultimately created two key deliverables, including an interactive map that allows users to toggle different data layers on and off, as well as "workbenches" (i.e., customized modules) within the GOSI platform for five specific use cases. These workbenches allow users to view multiple data outputs simultaneously, allowing for more holistic views of the various use case scenarios. This section summarizes the industry gap the project addresses, the project's objectives, the scope of work, and the major tasks, milestones, and their corresponding deliverables.

3.1 Issue Addressed

As Pacific Gas and Electric Company (PG&E) modernizes its grid technology, new sources of potentially valuable operational intelligence data are becoming available. Data from SmartMeters™, supervisory control and data acquisition (SCADA) devices, and line sensor measurements – in addition to existing environmental and asset data – could provide increased visibility to the state of the grid; however ingesting and integrating these sources present challenges due to the complexity and volume of data. Despite these technical challenges, collating and visualizing these new sources of operational data could provide insights into grid operations, and could minimize outages and cost while increasing safety.

Currently, utilities have limited access to easily configurable tools that provide near real-time awareness on circuit loading, weather, fire, crew locations, solar generation, and other key data sources. Additionally, even when these tools do exist, they operate on separate platforms, forcing distribution operations personnel to view data outputs on multiple screens or in different formats in order to access all relevant information about grid operations in a specific scenario. Because these tools are not integrated with each other, this forces the distribution operations personnel to use "swivel chair integration" where the people search between multiple data streams in an ad-hoc fashion.

The ability to integrate and visualize a wide range of data sources on a single platform in near real-time would allow end users to make improved operational decisions, with the benefits of allocating resources more efficiently, improving reliability, and increasing safety. At the time this report was written, other utilities have now begun experimenting with real-time visualization platforms for grid operations, however this is still a new topic in the industry.

3.2 Project Objective

The need for integrating multiple data streams into one platform, especially those from newer sources like SmartMeters™ and SCADA devices, in addition to the lack of a readily available market solution created the foundation for this technology demonstration project. The primary focus of EPIC 1.15 was to demonstrate the integration and visualization of data streams from multiple sources to demonstrate the value of having one integrated system, as opposed to the variety of tools operating across multiple different screens and platforms. The key objective of this project was to develop and demonstrate a project version of a real-time data visualization software platform for use by PG&E end users.

Completion of this objective includes demonstration of:

- A foundation for enhanced tools to increase situational awareness.
- A blueprint to enable PG&E and other utilities to integrate multiple data streams for near real-time visualization of various grid operations.
- The ability to visualize and leverage data in new and more informative ways.
- The ability to streamline data and access, reducing the number of separate windows and screens users must utilize to view data holistically.
- User-based feedback on recommended future enhancements and user experience would provide the most value in a production software platform.
- A qualitative assessment of the degree to which end-users valued the project software platform.

3.3 Scope of Work

This project focused on the application of software technology to develop and demonstrate a situational awareness tool that could visualize data from multiple sources. The tool would integrate near real-time data, and be available on a project basis for a limited set of grid operations personnel to access and provide feedback. The project was not designed to choose a vendor for a production level system, locking PG&E into a choice before any exploratory work had occurred, but to identify the technology, data needs, and change management strategies that would be useful in a future data aggregating platform.

3.3.1 Major Tasks and Deliverables

There are four major tasks associated with this project that correspond to the four work streams:

- **Task 1 - Select a vendor to develop the GOSI platform:** This task issued a RFP for a software vendor to develop and provide the software platform to ingest and visualize the multiple data streams, as well as create a user interface based on PG&E's specifications. As part of the RFP process, 17 vendors were contacted. Four vendors passed the initial scoring criteria, and three of these were selected for finalist interviews (Error! Reference source not found.).
    - **Deliverable:** One vendor was selected as a partner to develop the GOSI demonstration platform.
- **Task 2 - Identify use cases to be built into the GOSI platform:** This task collected input from various internal stakeholders in distribution operations to identify a specific set of use cases to be built into the GOSI platform. Through the engagement with internal stakeholders, PG&E developed an initial framework of what types of functionality the GOSI platform would comprise at an enterprise level and selected the use cases that best balanced the cost of demonstration (i.e., the integration and visualization of data) with the overall benefits to end users.
    - **Deliverable:** Five use cases were selected to have specific workbenches and/or customizable maps built into the GOSI platform. These use cases had the most

available and complete data that spanned a range of complexity, volume, and data update frequencies (e.g., real-time vs. 1-2 day lag).

- Table 3-1 summarizes the five uses cases and their features in GOSI.

Table 3-1: Use Cases for the GOSI Platform

UC	Name	Description
1	Outage anticipation	Combines weather, wildfire, lightning, and earthquake feeds onto a single map view along with GIS information to reduce the number of data view windows an operator needs to open during an outage event.
2	Construction planning	Provides operation and SAP information, including feeder maps, to construction planners to streamline the planning process.
3	Circuit loading research	Supports operators and engineers finding asset loading information via a map-based search interface.
4a	Operations	Provides a real-time graphical dashboard of daily events for control centers providing increased situational and operational awareness.
4b	Emergency operations	Provides a real-time emergency operations center (EOC) dashboard and reporting tool to replace existing Excel-based dashboards. These provide a single-source of truth for data and consistent and timely reporting.
5	Distributed generation (DG) research	Provides a geospatial visualization of DG assets, 'as-built', to support improved operational research and planning.

- **Task 3 - Identify and integrate data for visualization:** This task collected input from various internal stakeholders to identify the various data sources that would need to be integrated into the GOSI platform in order to provide visualizations and dashboards for each use case identified in Task 2.
    - **Deliverable:** A list of over 20 internal and external data sources that were required to support the demonstration of the five use cases and to develop a data integration framework that could support the wide variety of data complexities, volumes, and update frequencies that PG&E would want in a future enterprise situational intelligence platform.

- 2-2 summarizes the data streams included, as well as the frequency with which the data was updated.

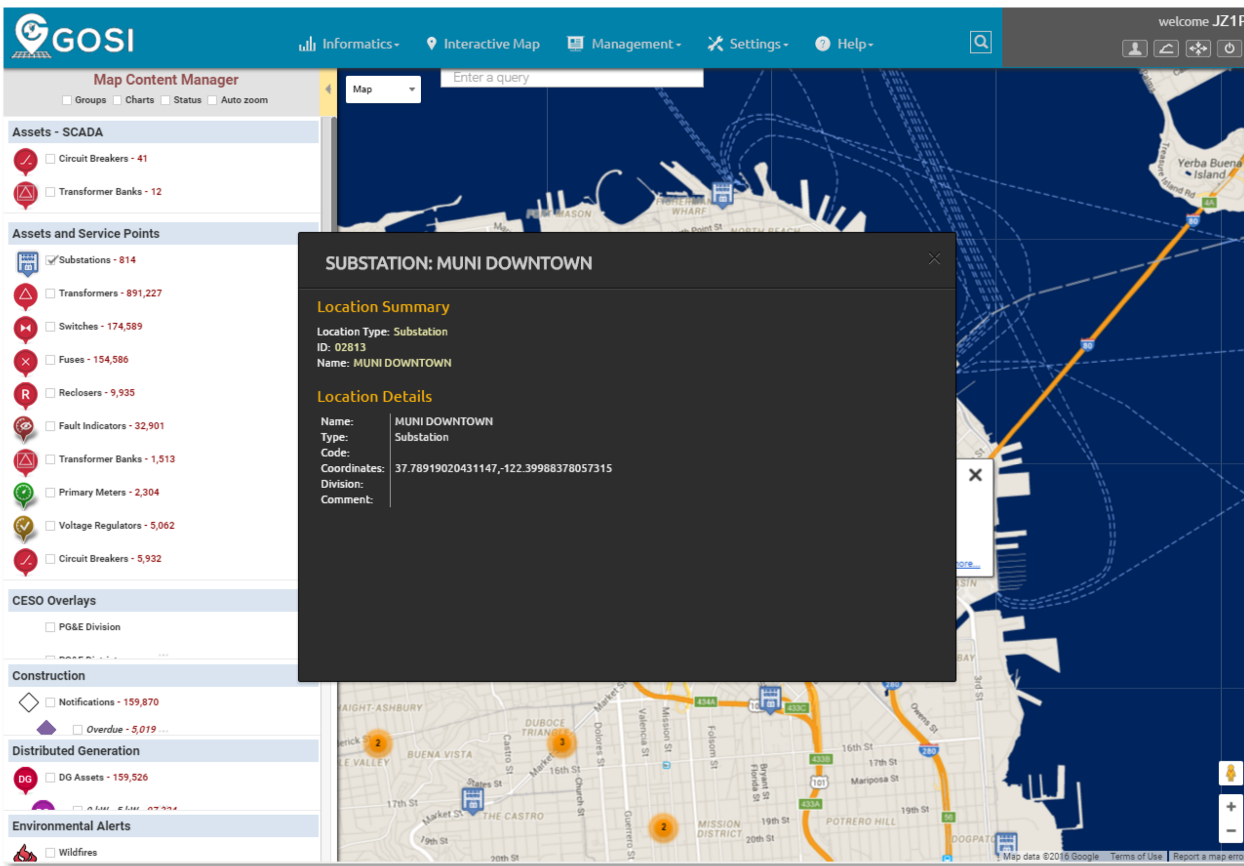
Table 3-2: Data Sources Incorporated into the GOSI Platform

	Data Source	Description	Update Frequency	Update Process
Internal	Electric Distribution (ED) GIS – bulk	Bulk data for asset and connectivity.	One time load	Manual
	ED GIS – updates	Daily updates to assets and connectivity	Daily	Automatic (Push)
	Distribution Management System (DMS) – temp. states	List of DMS devices in temporary states	Every 5-minutes	Automatic (Informatica[7])
	DMS - Outages	List of active power outages		
	DMS - Outage transformers	List of service transformers affected by power outages		
	DMS – CESO time series	Customers Experiencing Sustained Outages (CESO) statistics; time series		
	DMS – CESO 12 hour summary	(CESO) statistics; 12 hour summary		
	DMS – CESO current status	(CESO) statistics; current status		
	DMS - Damaged Equipment	List of equipment damaged in outage		
	AFW – Switch plans / Distribution operations	"Application for Work". Planned clearances, clearance open points, clearance times		
	ILIS - Scheduled Work Report	Short-term scheduled work plan		
	AMI - Smart Meter, MDMS	SmartMeter loading	Daily (with 1-2 day lag)	Automatic (Push)
	AMI - Smart Meter, UIQ	SmartMeter outages	Real-time (event driven)	
	PI - SCADA Time series	Field device measurements	Near real-time	Automatic (Pull)
	PI - SCADA Alarms	Field device alarms and alerts		
	Land Base (LB) GIS - Lightning	Lightning strike data	Every 5 minutes	
	FAS - Truck Location	Truck GPS location, truck id and employee name	Every 5 minutes	Automatic (Informatica)
	SAP - EC notifications	Outstanding electric compliance tag list	Daily (incremental)	Automatic (Push)
	ENOS	Distributed Generation (DG) installation report	Daily snapshot	Automatic (Informatica)
External	inciweb.nwcg.gov	Wildfire alerts	Every 5 minutes	Automatic (Pull)
	activefiremaps.fs.fed.us	Wildfire boundaries		
	usgs.gov	Earthquake alerts		
	Wunderground.com	Public weather station observations	Near real-time	

[7] Informatica is a tool that supports data extraction, transformation, and loading across multiple databases.

- **Task 4 - Develop and demonstrate the GOSI platform:** This task used agile development cycles to enable PG&E to collaborate iteratively with the vendor. The GOSI platform was developed with support from contracted developers and the vendor. Development was iterative, working in sprints to develop increasing levels of functionality. The development cycle often took the form of rectifying smaller, configuration-based product needs with the help of the vendor delivery team, while working with the vendor's core engineering team to achieve more significant feature enhancements. The core engineering development cycle often spanned across multiple sprints.
    - **Deliverable:** The Interactive Map, shown in Figure 1, that enabled users to toggle on and off different data layers depending on need. These data layers represent the 20+ data sources that were integrated on the back-end of the GOSI platform. Additionally, this task developed the use case specific workbenches that are discussed further in Section 4.

Figure 1: Screenshot of Interactive Map



4 Project Results and Key Findings

The project's objective was to develop a platform on which features could be built to enable valuable analytics and situational awareness use cases. The core success of the project was demonstrating the capability to ingest and visualize data to improve operational decision-making. This section summarizes the project's technical results and key findings.

4.1 Successful data integration into vendor's system

An integral step to the success of this technology demonstration project was the ability to extract and integrate data streams from over 20 internal and external sources into the vendor's proprietary backend software system. Additionally, the data being ingested had to be updated with some frequency in order for the visualization tool to provide near real-time information. Due to the project nature of this project, varying data integration patterns were used. Some data sources required manual extracts to then be pushed to the vendor's system, while others were automatically pulled from or pushed to the system. Table 3-2 summarizes the types of processes used to update different data source extract.

PG&E also learned a variety of lessons regarding important qualities of a data aggregation and visualization system, which will benefit the company when exploring production

4.2 Successful Demonstration of the Interactive Map and Use Case Workbenches

After data were integrated into the software's backend system, the vendor developed the various visualization capabilities, based on PG&E's specifications. The data visualizations and other functionality of the GOSI platform were iteratively developed based on end user testing and feedback.

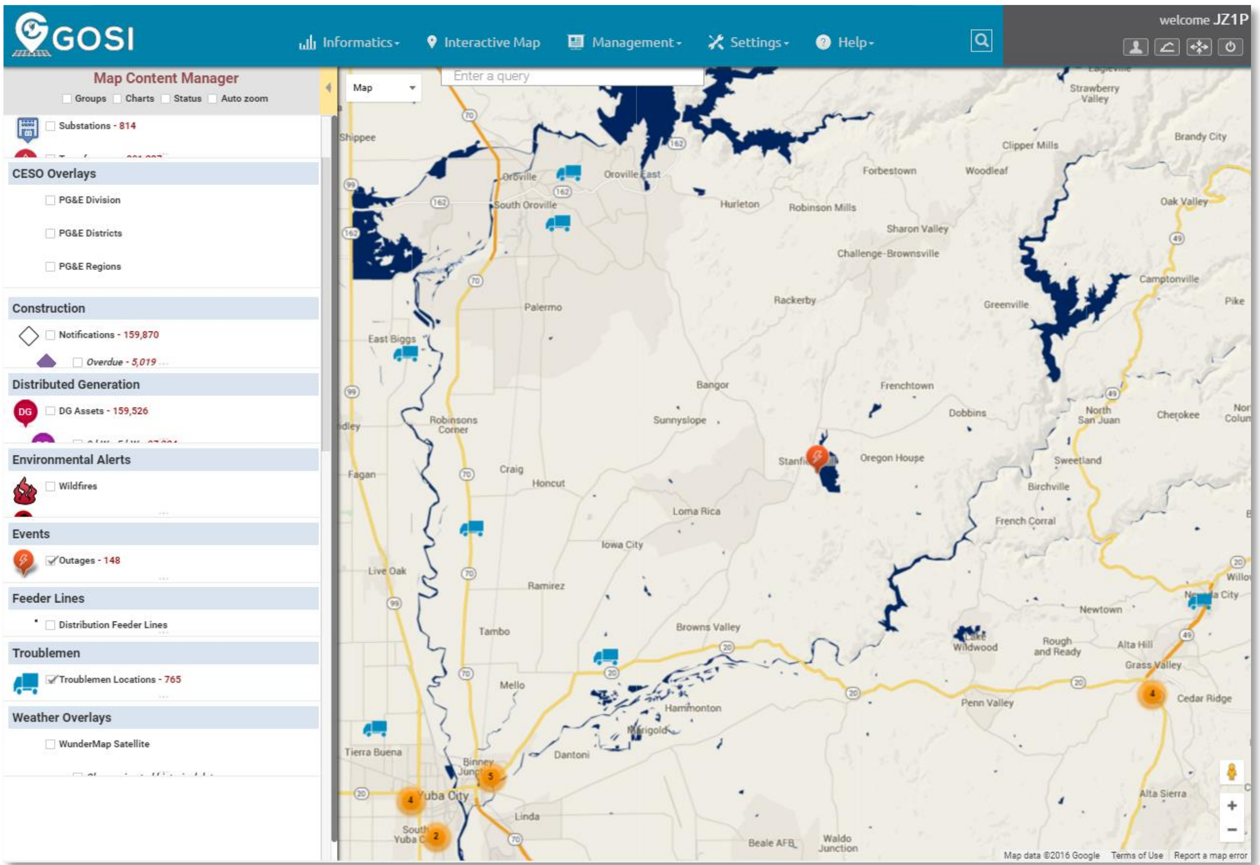
4.2.1 Use Case 1: Outage Anticipation / Interactive Map

The demonstration of use case one required the integration of all of the data sources listed in Table 3-2 and created the Interactive Map, the primary tool for data visualization and a core functionality component on the GOSI platform.

The Interactive Map was designed to solve a key problem for grid operators: data necessary to understand a complex situation required multiple windows to be open on an operators' screen, and sometimes was not available at all. The operator would, for example, need to compare side by side a map of utilities assets with information about a developing wildfire, to determine if assets were endangered.

The Interactive Map addressed this gap by visualizing the data in a set of layers, allowing for improved analysis as users generated custom data views. Distribution operators could select data sources to be toggled on and off, allowing for a highly configurable situational awareness during outage scenarios. This approach allowed users to visualize the data sources that were specifically relevant to their current situation, while hiding non-pertinent data streams. For example, an operator could toggle the data layers showing active outages and troubleman locations, as shown in Figure 2. If the operator sees a critical customer (e.g., a hospital) has experienced an outage, the operator can use the Interactive Map to see the location of the nearest troubleman working on a lower priority item and divert resources to the critical customer instead. Prior to the GOSI platform, operators had to manually compare the PG&E asset database displayed via a GIS-enabled map with external weather maps to plan for potential outages.

Figure 2: Screenshot of Interactive Map with Outages and Troublemen Data Layers



Additionally, the Interactive Map demonstrated the value of integrating new external data sources such as Google Streetview. Previously, users had to spend time and energy guiding field personnel to equipment of interest. By providing personnel in operations centers with access to street-level views, the GOSI platform enabled operators to offer improved support to field personnel.

A sample of additional scenarios where users could benefit from a customized map includes:

- By displaying weather, lightning strikes, and map views from SmartMeter outage alerts, a user could quickly infer if a recent outage was likely caused by a lightning strike. The responding field crews could then be notified to take appropriate action, reducing the duration and severity of the outage.
- By displaying wildfire boundary data, asset information (GIS), and troubleman locations during a wildfire emergency event, a user could ensure that all crews were safely out of the fire boundary area. Then the user could begin making switching decisions based on which assets where already likely consumed by the fire and which assets were likely to be destroyed based on the projected growth of the wildfire boundary.

- By viewing the GIS asset layer combined with Google StreetView, a user could electronically trace a circuit and then zoom in to see the StreetView image of a specific device. This could be used to field-verify a device in GIS for a Troubleman in the field attempting to locate a device by providing specific visual identifiers.

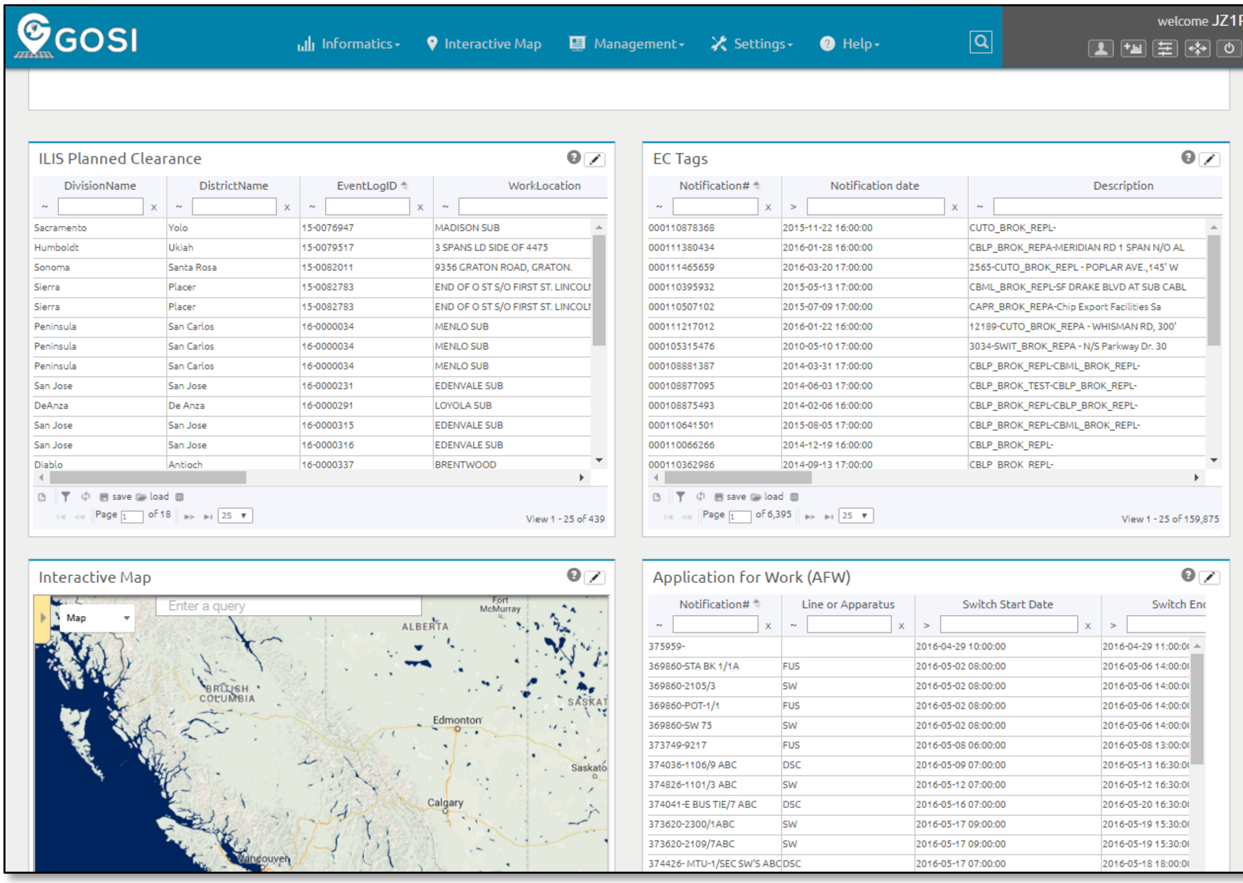
Additional information about the functionality and features of the GOSI platform can be found in Appendix B – Introduction Guide to Using GOSI, a guide which was creating for operational personnel testing the system.

4.2.2 Use Case 2: Construction Planning

When construction planners are scheduling assignments, there is a prioritized list of necessary jobs. However, a piece of work at the top of the priority list might be in the same location as several pieces of work that are farther down the list. For example, construction planners used the Distribution Asset Reconciliation Tool (DART), which is a software tool use to modify electric distribution facility information, to give them visibility into assets, however the system only showed asset locations and planners had to access another database to determine where construction tags were on the system. Additionally, DART only showed assets “as built” with no information about “as switched” assets. It was a challenge for construction planners to sort through vast and isolated data sets and understand work optimization opportunities. The lack of knowledge on switching operations made clearance for construction more difficult for operators.

The workbench developed for this use case allowed construction planners to view relevant data in one window (see Fig. 3: Screenshot of Construction Planning Dashboard). This dashboard enabled easier optimization of construction work planning and execution by allowing the user to potentially consolidate work on nearby assets for one clearance tag. By providing situational awareness via the construction planning dashboard, work could be grouped and optimized. Grouping tickets and bundling work in this way helps reduce the number of planned, construction-related electricity outages experienced by customers.

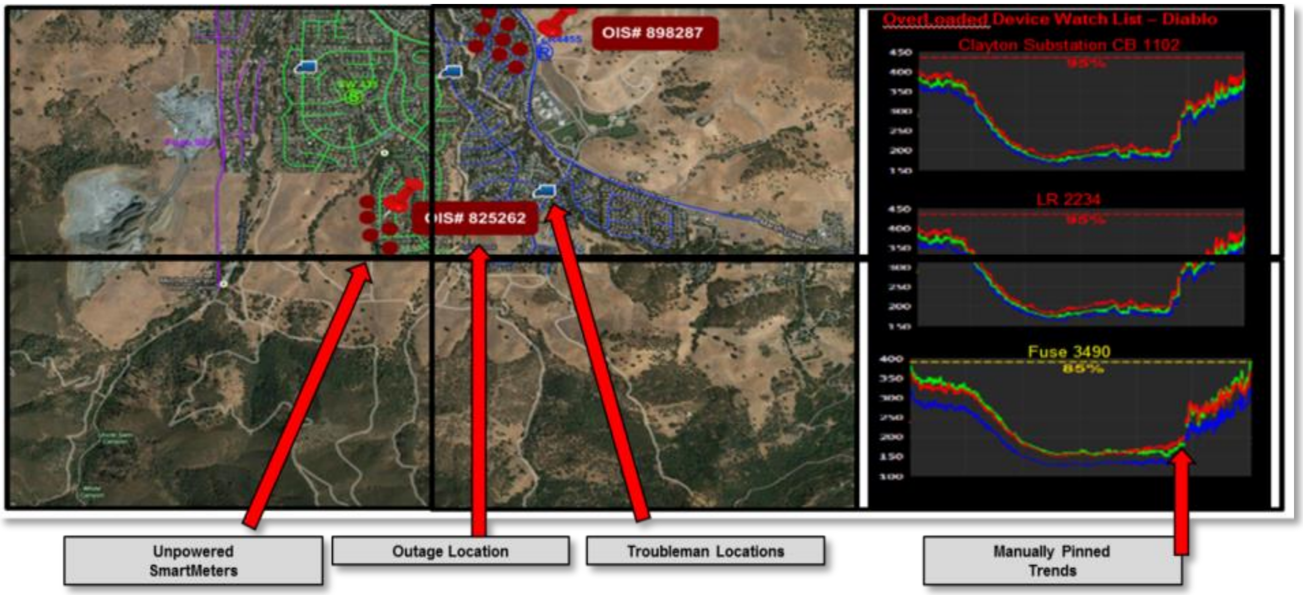
Figure 3: Screenshot of Construction Planning Dashboard



4.2.3 *Use Case 3: Tools for Circuit Loading Research*

This workbench included a set of features and functionalities to assist circuit-loading research across the service territory. This included the experimental SmartMeter™ Aggregation function, which provided an estimate of asset loading based on downstream SmartMeter™ loading data. An example output of this workbench is shown in Figure 4. Prior to GOSI, PG&E did not have an easy way to view load for a particular area of a circuit when conducting a switching operation. Traditionally, a distribution operator would use a system of seasonal estimates that provided conservative estimates of load. These estimates were designed to leave a large margin of safety to ensure operators did not overload a switch or a part of a circuit. The SmartMeter™ aggregation functionality demonstrated in the GOSI platform provides more precise information, which could lead to efficiencies in grid capacity by allowing operators to safely conduct switching operations with smaller margins. While this loading estimate relied on non-real-time SmartMeter™ data (latency of one to two days) and had other known deficiencies, this ability to estimate load based on SmartMeter™ aggregation represented a significant improvement from the previously available seasonal loading predictions.

Figure 4: Screenshot of Circuit Loading Research Workbench Output



The primary deficiency identified by end users for this workbench was the search functionality. Although users could search for a specific device, the search function returned all possible matches across all asset types. This forced users to comb through multiple results to find the device of interest.

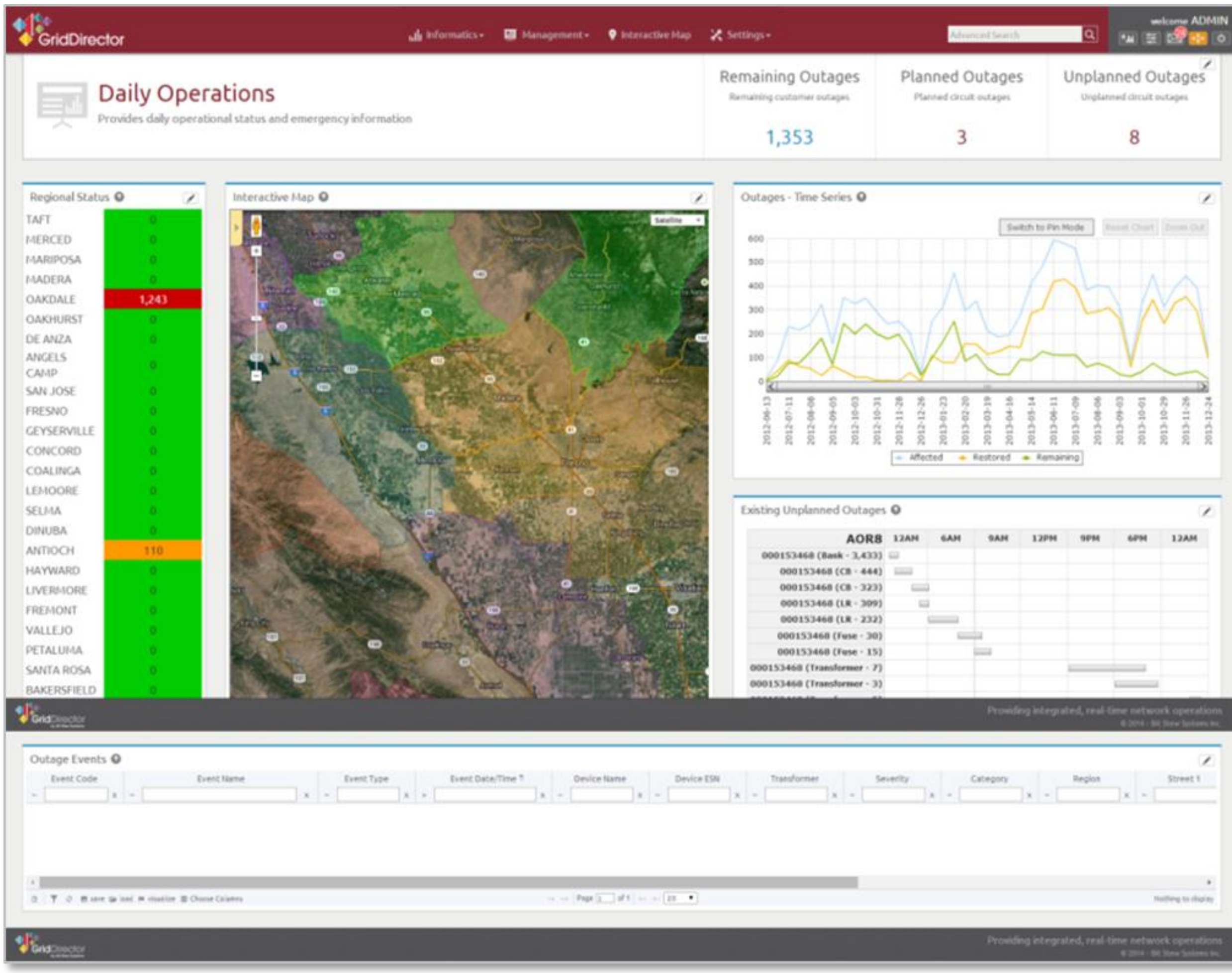
This use case has demonstrated the value of such functionality, and specific potential deficiencies, such as the missing data coming from non-communicating meters, the variation caused by changes in loading patterns between days or changes due to weather and solar output. PG&E will explore how to resolve these deficiencies and the potential of implementing the SmartMeter™ aggregation functionality into its core DMS product. This opportunity is being further explored through *EPIC Project 2.07 – Real Time Loading Aggregation*, which focuses on refining the algorithm for upstream SmartMeter™ aggregation and leverages the learnings of the GOSI project.

4.2.4 Use Case 4: Operations and Emergency Operations

This workbench had two primary components: a daily operations dashboard and an emergency operations dashboard, both of which were optimized to be displayed on large video monitors.

The GOSI Daily Operations Dashboard, shown in Figure 5 leveraged summary-level views of real-time outages and planned clearance data. The goal of this use case was to allow users to optimize operator workload by better understanding the peaks and troughs of both planned and unplanned work throughout the day. Prior to the GOSI platform, operators had to access multiple databases to find information on planned operations, unplanned outages, and current and future switching reports for their respective areas of responsibility.

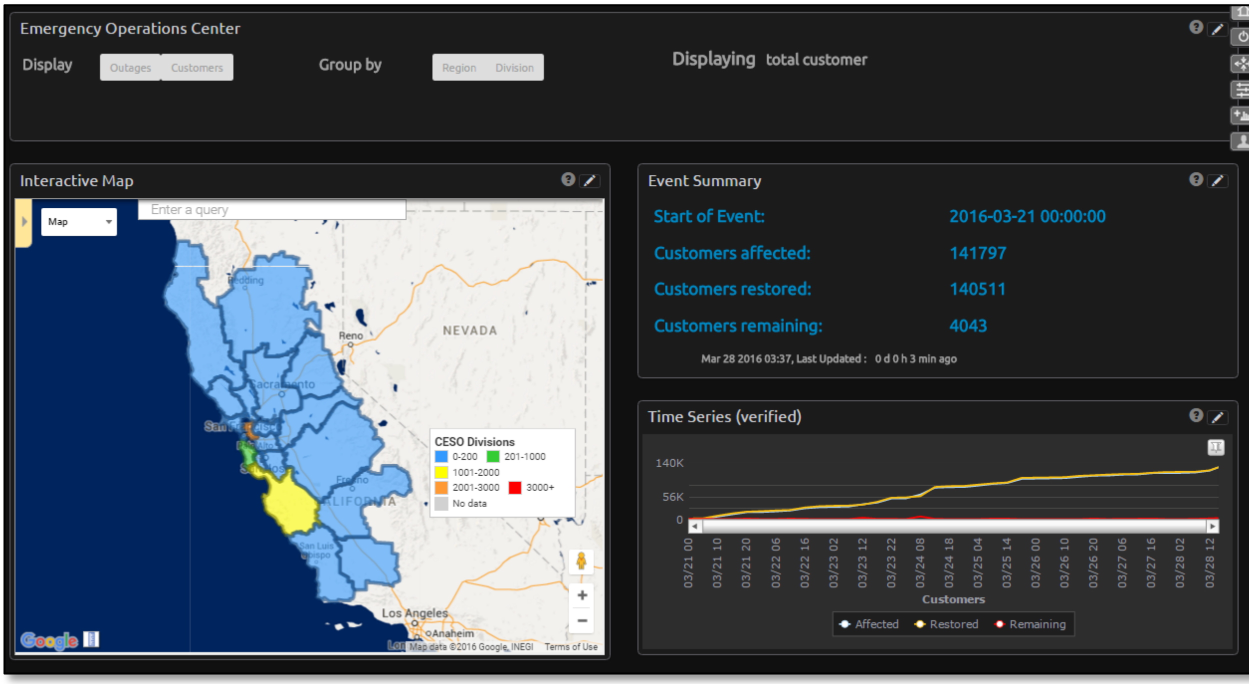
Figure 5: Screenshot of Daily Operations Dashboard



The GOSI Emergency Operations Center (EOC) Dashboard, shown in Figure 6 leveraged summary-level views of the GOSI data to provide real-time awareness during storms and other major events. This use case aggregated data pertinent to an outage situation, including tracking the number of customers without power, the number of outages over time, Customers Experiencing Sustained Outage (CESO) data throughout PG&E's regions and divisions, and weather system data. The goal of this use case was to allow information to be automatically summarized for EOC planning teams during an emergency activation. This reduces the time that emergency operations personnel spend compiling data summaries, and delivers that data to EOC planners more quickly.

The value of this functionality was demonstrated during the 2015 Valley and Butte wildfire incidents, in which valuable time was saved by providing Emergency Operations Center (EOC) teams with key situational intelligence. By providing a visual overlay of the real-time wildfire location merged with PG&E asset. Emergency operations user feedback demonstrated the novelty of the GOSI platform in being able to display asset location, field resource locations, and fire boundary data all on one map.

Figure 6: Screenshot of Emergency Operations Center Dashboard



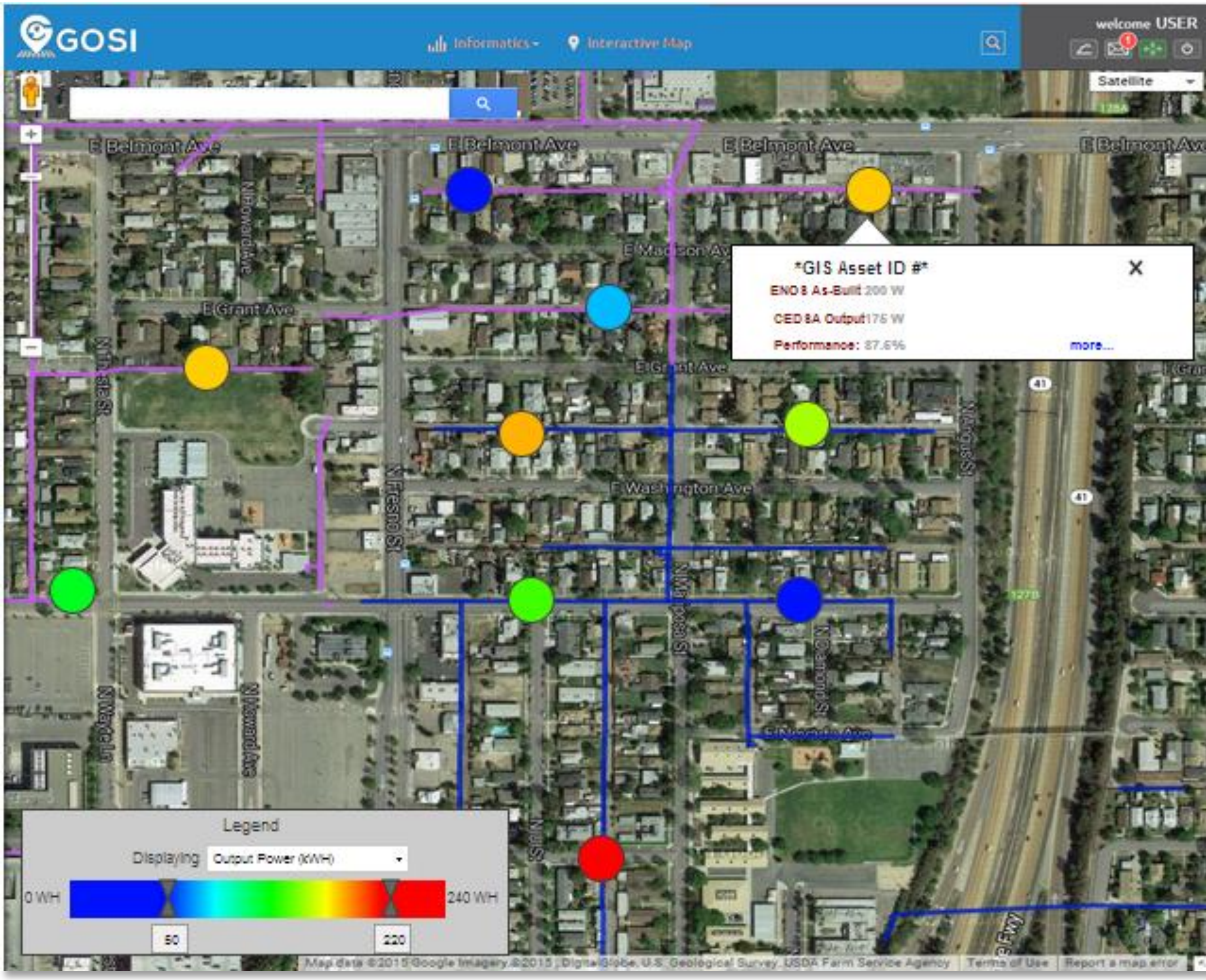
4.2.5 *Use Case 5: Distributed Generation (DG) Visualization and Research*

The workbench developed for this use case allowed users to create geospatial visualizations of DG assets as-built to support distribution operations and planning. Prior to the GOSI platform, planning engineers would have to use a largely manual, Excel-based process to find and aggregate DG assets by the jurisdiction of interest. The DG Visualization workbench removes many of the manual steps by automatically integrating the necessary data to provide high-level aggregations and is an example of cost-effectively leveraging existing data to improve efficiency in planning operations.

An example of the output from this use case is shown in Figure 7. The tool was primarily designed to support planning engineers and allow them to view solar penetration levels across PG&E's service territory at various jurisdictional levels. Within this use case, there were two main features:

- High-level aggregation of residential solar installations by Region and Division, which were visualized as a heat map of DG penetration levels.
- Detailed view allowing filtering and identification of individual solar installations based on size and location.

Figure 7: Screenshot of DG Visualization Heat Map



If this use case were developed further to include actual generation and further aggregations down to the feeder and specific asset level, the resulting tool could reduce or remove the need for manual report generation, and streamline distribution planning activities.

The development of this use case also served as a test of the vendor's capabilities to absorb additional use cases into its system, and PG&E's ability to pursue development with other vendors while still leveraging the same platform. PG&E collaborated with a second vendor to develop the DG data visualization tool using the initial vendor's technology and system framework. Although the second vendor was eventually able to build the DG functionality into the Interactive Map, the experiment ultimately proved that initial vendor's system would be unable to efficiently support potential long term expansion of the GOSI platform due to the complex and proprietary nature of the project vendor's platform code.

4.3 Agile Development Promoted Frequent Feedback Collection and Iterations

The GOSI platform was developed using an iterative, agile approach. This agile approach allowed PG&E to test the GOSI technology in a lean and efficient way, leveraging minimum viable products to collect regular, real end-user feedback and improve future iterations. This feedback collection took many forms, including informal on-site sessions, training sessions, and "lunch and learns". These interactions helped to solidify an understanding of the features and functions that users valued most. For example, in one feedback session, users identified the need to have a search functionality that could help them quickly view a particular asset. This capability was built into a later iteration of the GOSI platform.

In another example, feedback from GOSI users yielded the potential value of including brand new data sets, such as California Highway Patrol (CHP) car-pole[8] data into the GOSI platform, with operators suggesting that this data might allow them to shave valuable minutes off of the outage diagnosis and restoration process. When a car hits a power pole and causes an outage, typically a call is first made to 911 and the incident is flagged in the CHP database. When an operator sees an unexpected outage on the system, typically the first check is to cross-reference the location with the CHP database to see if there was a car-pole. When end users were shown the lightning strike data layer in the Interactive Map during the feedback sessions, they noted that a similar data layer could be created to overlay car-pole data from CHP onto outage data. While this ultimately was not implemented into the project GOSI platform due to prioritization during the limited time length of the project demonstration, this example demonstrates the value of agile development. By quickly developing minimal, but functional parts of the overall platform that users could actually test, users' perspectives shifted regarding the potential of the tool. This allowed users to identify additional data streams and use cases that were not initially identified through user input sessions or through interaction with only screenshots of the platform's functionality.

Overall, user feedback was positive for the GOSI platform, especially the ability to view multiple data streams at once using the Interactive Map. The feedback collection process also identified a number of opportunities for improvement, such as the car-pole example discussed above, that could make future versions of GOSI more user-friendly and effective. The project tracked and prioritized these ideas through its product backlog. This also yielded a set of potential features and enhancements that did not fit within the direct scope of this EPIC project, but may be used to inform future analytics and situational awareness product requirements (Appendix A – Out of Scope Stories).

4.4 Data Access

Upon request, PG&E will provide access to data collected that is consistent with the CPUC's data access requirements for EPIC data and results.

[8] When a car hits a power pole and causes an outage.

5 Unique Technology Implementation Issues

5.1 Challenges in Maintaining Diverse Data Sources

This technology demonstration project is unique in both the volume of data being integrated into one platform, but also in the variation among the individual data sources. Not only did each data stream need to be integrated into the vendor's backend system, nearly all of the data sources needed to be updated with some frequency in order for the visualization tool to provide fresh and accurate information. Due to the nature of this project, varying data integration patterns were used. Some data sources required manual extracts to then be pushed to the vendor's system, while others were automatically pulled from or pushed to the system. These data extract processes are summarized in **Error! Reference source not found.**.

Platform Architecture was critical to GOSI's data processing performance. In the pilot, a single data router within the vendor system architecture proved to be one of the main contributing bottlenecks for the system performance. This design degraded the performance of the data throughput.

For a future enterprise platform, data velocity, volume and other performance characteristics should be evaluated in detail. Any future state of the GOSI platform should streamline and automate the data extract process and develop a backend system that could pull in updated data, rather than depending on manual updates or new data extracts being pushed to the system.

In addition to the challenge of keeping a variety of data sources updated, another significant challenge was the initial integration of this wide variety of data. Each set of data has its own unique properties, and responds to changes in a unique way, which, if not correctly interpreted at the beginning of a project, can lead to significant data errors later on. One example of this scenario was that a few external data sets containing event data did not indicate the termination of those events. So while internal outage data sends an ending message signifying that power has been restored, and GOSI can remove the outage from the visualization, some data sets simply stopped transmitting, leaving a decision that had to be made whether to keep displaying the data. During the GOSI project, the imported wildfire data set would share the location of large wildfires, but once that fire was extinguished, there was no "fire out" message. The vendor solution did not recognize this challenge at first, which inadvertently led to a number of old fires being displayed in the visualization screen. The final solution for this was to create a timer that leveraged business rules to determine when "stale" data could be closed out and removed from the visualization display.

The project identified many metadata gaps in source data, such as discrepancies in entity naming across various source systems. These discrepancies impacted aggregated data across multiple use cases in the pilot. Some of these issues had never manifested themselves before as this was the first time that these data sources had been combined in this way.

Any future state of the GOSI platform should leverage a data quality assurance system to ensure the consistency of source data and metadata. In addition, deep engagement with data-owners and subject matter experts can help explain the unique behaviors of each data set, ensuring that differing data behaviors do not manifest themselves in displaying inaccurate information.

5.2 Challenges in Visualizing Data and Verifying Data Accuracy With Users

Given the volume and complexity of data streams being integrated and updated into the vendor's proprietary backend software, as well as the iterative nature of the GOSI platform's development, it was difficult to compare the data visualizations with their source data. Using the agile development method, PG&E, in collaboration with the vendor, would develop a feature that was minimally operational to be tested and assessed by end users. Sometimes, a feature would appear to be providing the desired functionality and would pass tests designed to verify that it was behaving as designed. Testing was typically manual in nature therefore took a long time to execute.

Despite passing these tests, the output of the feature would show incorrect data. Through the frequent user tests and feedback collection mechanisms, it was the end users who would eventually identify the issue of a feature displaying the incorrect data.

Any future state of the GOSI platform, or other projects integrating and visualizing large volumes of data from different sources, should develop a process to verify the accuracy of the data being displayed to end users at each stage the data are manipulated. These stages include, but are not limited to: when the data are transferred from PG&E's systems to the vendor's software system, after the data are cleaned, and after any formatting or other manipulations that are required to visualize the data for end use.

Potential tactics to assist with user engagement, testing, and data verification, include automated testing and sophisticated visualization capabilities.

5.2.1 Automated Testing

In support of delivering a clearer user experience and verifiable data, future development of the GOSI platform should employ automated testing as a cornerstone to a robust Quality Assurance program. Test automation could allow for individual software components to be repeatedly and reliably tested, at scale, at every point in the development process. As well as identifying software issues that might lead to inconsistencies in data being displayed to end-users, this could reduce the burden of manual testing while also identifying bugs introduced through incremental development of new and existing features under an agile process.

5.2.2 Visualization Sophistication

A related priority to data verification is the sophistication of the visualization software. Without appropriate display of data for users, it cannot be verified effectively. Utilities manage and interact with a large number and variety of assets, and standard visualization packages may be inadequate to support visualization capability requirements. Examples of this issue include:

- *Rendering Circuits at Scale:* distribution circuit topology is the backbone of any distribution operations application, illustrating connectivity of assets from the substation to each individual customer. Viewing this information in an appropriate fashion is paramount for operations personnel. Modeling and visualizing this density of lines caused performance issues that impacted user experience, resulting in both client and server issues.
- *Obstructing Clusters:* If a number of assets in a given data layer were located close to each other, they obscured the view of the area. The project's solution was to develop grouped

clusters, showing the total number of assets in the cluster. However, not being able to differentiate between types of assets in the cluster (e.g. reporting 9 assets, instead of indicating 3 service transformers, 5 meters, and a troubleman) led to a suboptimal level of visual detail.

Utilities considering visualization platforms should be expansive in their requirements for visualization sophistication because of the uniquely complex and voluminous nature of the data sets. This is particularly important for engaging users whose expectations have been set by intuitive products like GoogleMaps and Uber. These UIs represent complex geospatial information at scale in an intuitive fashion, and utilities should benchmark themselves against such products.

5.3 Applying the Agile Development Method Without User Analytics

Due to challenges ensuring that all data shown was correct and could be acted on, PG&E was unable to collect quantitative user analytics, such as click-rates and data on which features were most widely used. In order to iteratively test and develop the GOSI platform, the product team had to rely on qualitative feedback provided by end users. Measurable data on tool use is an important aspect of agile development, as it allows developers to compare and benchmark actual use to user-provided feedback.

Any future state of the GOSI platform, or other projects using agile development, should enable the collection of quantitative user analytics.

6 Key Accomplishments and Future Opportunities

6.1 Key Accomplishments

The following is a summary of the key accomplishments of the project:

- Integrated data streams from over 20 sources, in addition to developing and maintaining a system to provide updated data extracts from each source.
- Developed and demonstrated a visualization tool that enabled users to customize a map with various data layers depending on their specific use case.
- Developed custom data visualization tools for five specific use cases to respond to specific concerns identified by PG&E.
- Demonstrated the effectiveness of using an agile development method for this type of technology demonstration project.

6.2 Future Opportunities

6.2.1 Potential Features for Future Versions of the GOSI Platform

A repeated theme during the feedback collection sessions was that some users require the ability to explore deeper into the data to perform specific analyses. Future versions of the GOSI platform or other situational awareness tools would benefit from leveraging the wide variety of data sources by creating an export functionality for data to be further analyzed and distributed.

In addition to the use cases and features that were developed as part of the project, information collected before, during, and after the GOSI project was captured and documented as part of an extensive backlog of product requirements that reflects learnings from throughout the GOSI project. The backlog can be used to inform future requirements for data analytics and situational awareness projects.

This backlog is a valuable resource for electric utility teams designing a scalable, enterprise-wide advanced operational data analytics and visualization platform, and includes additional use cases beyond the five tested during the GOSI Project. Details from this backlog can be found in Appendix A – Out of Scope Stories.

In addition to developing more use cases and features, a key consideration for future versions of the GOSI platform is who will lead the development. PG&E will continue to conduct an analysis of the marketplace to assess whether there are vendors that could deliver a tool to its full specifications. Additionally, there is the potential to build out the platform in-house, although this would require significant investment in software development assets.

7 Value proposition

7.1 EPIC Primary and Secondary Principles

This project advances several EPIC primary and secondary principles by providing a single platform for user to holistically visualize over 20 data sources that are integral to distribution operations and planning. The information presented in the Interactive Map and through the use case modules enables grid operators to collect and visualize many disparate data sources to deliver more actionable situational awareness. Table 7-1 summarizes the specific primary and secondary EPIC Guiding Principles advanced by this technology demonstration project.

Table 7-1: EPIC Primary and Secondary Guiding Principles

Primary EPIC Guiding Principles			Secondary EPIC Guiding Principles					
Safety	Reliability	Affordability	Societal Benefits	GHG Emissions Mitigation	Loading Order	Low-Emission Vehicles	Economic Development	Efficient Use of Ratepayer Monies
✓	✓	✓						✓

The GOSI technology demonstration project advances the following primary EPIC principles:

- *Safety:* the DG Research, Circuit Loading Research, and Outage Anticipation use cases could allow operators to identify potentially-dangerous reverse power flow from distributed generation assets during circuit outages. The EOC Dashboard can get key information to emergency planners faster.
- *Reliability:* The information displayed on the Interactive Map and the Outage Anticipation use case could enable grid operators to dispatch resources more effectively. Access to better and fresher data could support more effective early warnings, reduce power quality complaints, and accelerate power restoration activities.
- *Affordability:* The information displayed in the Interactive Map and the Outage Anticipation, Construction Planning, and Circuit Loading Research use cases improves root cause analysis and detection of outages, reduces circuit planning efforts from customer reassignments, and provides planned outage support. These capabilities could enable more efficient resource allocation.

The GOSI technology demonstration project advances the following secondary EPIC principle:

- *Efficient Use of Ratepayer Monies:* The information displayed on the GOSI platform will enable more efficient actions and resource allocation by operators and engineers during planned work and unplanned outages.

7.1.1 *Apply Business Logic to Raw Data Visualization*

The GOSI platform provides visualization of raw data, but the end user still has to synthesize the data in order to develop actionable insights. This tool can further be expanded by applying business logic and other "rules" to provide initial insights from the raw data. This added layer of synthesis could lead to improved decision making by extending the point at which the end user is required to interpret the data.

An example of this would be a future dashboard for critical operating equipment (COE). When a piece of equipment fails, but does not cause an outage because the system is able to reconfigure and backfeed customers, the system is said to be in an abnormal operating condition. Because this does not need to be fixed immediately (as compared to an equipment failure that causes an outage) the equipment is flagged as a COE. At the time the equipment is flagged, PG&E assigns a priority level, which informs the timing for repair; however the grid is very dynamic and the static priority tag for a COE is not sufficient to reflect how changes to the grid would change the priority level of a given COE tag. An example of business logic that could be applied to the raw data of COE tags is a basic algorithm that can build a risk score by feeder (i.e., leveraging risk factors such as: number of customers downstream of the COE, other COE tags on that feeder, safety for Critical and Essential customers such as schools or hospitals, etc.) that is updated daily and displayed on a map. This would allow PG&E to work on COE tags that would remove the most risk from the system on a given day.

7.2 Improving Industry Awareness

7.2.1 *Adaptability to Other Utilities / Industry*

The following findings of this project are relevant and adaptable to other utilities and the industry:

- **Agile Development:** The GOSI project demonstrated the potential value of agile development as a software development practice. By focusing on customer feedback and iterative development, agile software development allows for teams to optimize their development process in a way that delivers the most value to customers. PG&E plans to consider using this methodology, where appropriate, for other advanced software development efforts. PG&E and other utilities should consider what practices they can enact in order to make themselves more agile, and what "traditional" enterprise project management practices hinder their ability to ultimately produce product that is useful to end users.
- **Consideration for Open Environment Stack[9] Components:** As PG&E and other utilities move towards more advanced systems for situational intelligence; the development architecture is an important choice when building products using an agile methodology. Given the potential complexity posed by a large scale analytics platform, the adoption of

[9] A "stack" is the term used in PG&E's reference architecture and refers to a group of functional components.

open environment stack components that promote a scalable and flexible architecture should be considered and assessed during the project's early planning and development phase. An open environment architecture is a combination of vendor software, open source software, and custom built software. Software from any of these three categories can fulfill specific functional requirements within the overall IT environment, with the key assumption that as the environment evolves, these components also evolve and are either further developed or replaced completely as better and/or cheaper technology becomes available. Orchestrating these synergies on an enterprise scale requires an open environment to enable the use of different technologies and the streamlined integration between each stack component.

7.2.2 Dissemination of Best Practices

A key element of the EPIC program is the technology and knowledge sharing that occurs both internally within PG&E, and across the other IOUs, the CEC and the industry. In order to facilitate this knowledge sharing, PG&E has and will continue share the results of this project in industry workshops and through public reports published on the PG&E website. Specifically, information-sharing forums where the results and lessons learned from this EPIC project were presented or plan to be presented are:

Information Sharing Forums Held	**Potential Upcoming Information Sharing Forums**
• EPIC Winter Symposium Folsom, CA| 12/3/15 • Electric Utility Consultants Inc. (EUCI) ADMS Conference San Jose, CA | 4/14/16 • Utility Analytics Week Atlanta, GA | 11/1/16 • The Internet of Things and Big Data for Utility Conference San Jose, CA | 12/7/16	• DistribuTECH Conference & Exposition San Diego, CA | 2/2/17

8 EPIC Specific Metrics

This project successfully demonstrated integrated features that were capable of driving improvements in data accessibility and utilization. This represents the potential for a foundational improvement to support improved decision making in a dynamic grid environment with increased penetration of distributed energy resources (DERs).

The following metrics, as identified in Decision 13-11-025, Attachment 4 have been pursued in the project and described in the associated sections noted in the report.

D.13-11-025, Attachment 4. List of Proposed Metrics and Potential Areas of Measurement (as applicable to a specific project or investment area in applied research, technology demonstration, and market facilitation)	See Section
3. Economic benefits	
a. Maintain / Reduce operations and maintenance costs	4.2.1 – 4.2.5
5. Safety, Power Quality, and Reliability (Equipment, Electricity System)	
a. Outage number, frequency and duration reductions	4.2.1 – 4.2.5
7. Identification of barriers or issues resolved that prevented widespread deployment of technology or strategy	
b. Increased use of cost-effective digital information and control technology to improve reliability, security, and efficiency of the electric grid (PU Code § 8360)	4.2.1 – 4.2.5

9 Conclusion

This project successfully achieved all of its key objectives, and in doing so, has captured key learnings for use by other utilities and industry members to leverage new and existing data sources in improving situational intelligence around grid operations. Through the work executed in this technology demonstration project and documented in this report, PG&E gained substantial experience in using the agile development method and in developing and maintaining the IT infrastructure required to host the data integration and visualization capabilities demonstrated by the GOSI platform. Specifically, the project achieved the following:

- Integrated data streams from over 20 sources, in addition to developing and maintaining a system to provide updated data extracts from each source.
- Developed and demonstrated a visualization tool that enabled users to customize a map with various data layers depending on their specific use case.
- Developed custom data visualization modes for five specific use cases to respond to specific concerns identified by PG&E personnel.
- Demonstrated the effectiveness of using an agile development method for this type of technology demonstration project.
- Demonstrated the overall value and efficiency gains for a tool that allows users to view multiple internal and external data streams on one map.

While the current version of the GOSI platform developed through this technology demonstration project is at its end of life due to the closeout of EPIC funding and the decision that the EPIC-selected vendor is not the right long-term partner for a production GOSI, the successful execution of this project has laid the foundation for the several potential future opportunities that include, but are not limited to:

- Building out a new GOSI platform that expands upon the key learnings from this demonstration project to include more use cases and user interface features.
- Further building out the future GOSI platform to apply layers of business logic and other rules to synthesize the raw data to provide users with actionable insights.
- Further exploring potential market and in-house solutions for continued GOSI software development and maintenance.

The GOSI project has allowed PG&E to validate the potential to better identify and leverage insights from an increasingly complex ecosystem of operational data. The successful demonstration of the GOSI technology demonstration has proven the value of combining and visualizing disparate data sources, and has helped inform of the needs of a future visualization and analytics platforms.

10 Appendix A – Out of Scope Stories

A "story" is an action a user would like to take in terms of adding or modifying a function or capability of the GOSI platform. These tickets (stories) were deemed to not be within the scope of the GOSI EPIC project, but could be part of future situational awareness and situational intelligence use cases and may provide valuable ideas for other utilities seeking to build their own situational intelligence platform.

Summary	Issue Key	Issue Type	Status
User can export EOC Video Wall time series graph data • This allows a super-user to do deeper data exploration.	GOSI-1137	Story	Open
Mouse-over of planned clearances shows count of affected customers • This allows a user to quickly understand the scope of a planned clearance.	GOSI-874	Story	Open
Display CHP car pole incidents that are in close proximity to an outage • This provides an early signal whether a third-party car accident caused an outage.	GOSI-771	Story	Open
Display lightning strikes near troubleman assigned outage • This provides troublemen notification whether it may be unsafe for them to elevate the bucket on their truck.	GOSI-770	Story	Open
Substation weather observations and forecast • This allows users to understand possible temperature impacts aggregated by substation.	GOSI-751	Story	Open
Trucks are colored according to function • This allows users to quickly understand whether a truck belongs to a Troubleman, Gas Crew or other.	GOSI-749	Story	Open
User can select an area on the map and generate a summary of assets, trucks, outages etc. • This provides users with data outputs beyond just visualization to make data even more impactful.	GOSI-743	Story	Open
User can select a wildfire and generate a summary of assets, trucks, outages etc. • This provides users with a more specific, wildfire version of the output feature GOSI-743.	GOSI-742	Story	Open
Top 10 feeder list columns initially include feeder, region, division, and total DG • This allows DG users to get quick summaries of the most impactful solar information.	GOSI-694	Story	Open
User can view transmission lines (ETGIS) on a map view • Would add additional data set to product.	GOSI-439	Story	Open
Capability to show weather map layer data at mouse cursor • Provides quick access to weather visualization.	GOSI-372	Story	Open
Default to show Downstream DG installation entries in descending order of Total kW Out • Allows users to quickly gather the most impactful DG installation information.	GOSI-355	Story	Open
All Downstream DG table should have defined columns • Allows users to quickly gather the most impactful DG installation information.	GOSI-353	Story	Open

Summary	Issue Key	Issue Type	Status
Default Columns for DG Manufacturer Count Table to include Manufacturer Name, Count, and Aggregated Capacity • Allows users to quickly gather the most impactful DG installation information.	GOSI-352	Story	Open
Default Column Labels for DG Summary Chart to include Downstream DG Count, Largest Single Asset, and Total Downstream DG • Allows users to quickly gather the most impactful DG installation information.	GOSI-351	Story	Open
Update asset popup wireframe to include ILIS, AFW and SAP links • Links GOSI to the system of record for a user to jump between the two if desired.	GOSI-332	Story	Open
Link EC tag entries to SAP • Links GOSI to the system of record for a user to jump between the two if desired.	GOSI-323	Story	Open
User can control displayed DG data by adjusting legend slider bounds • Allows users to quickly gather the most impactful DG installation information.	GOSI-311	Story	Open
DG choropleth should color points / jurisdictions based on value relative to the chart legend • Allows users to quickly gather the most impactful DG installation information.	GOSI-308	Story	Open
DG legend min and max represent data visible on the current data visualization layer • Allows users to quickly gather the most impactful DG installation information.	GOSI-306	Story	Open
DG choropleth display range can be adjusted either through sliders or through text entry • Allows users to quickly gather the most impactful DG installation information.	GOSI-305	Story	Open
DG choropleth legend min and max determined by the range of data represented in the map area • Allows users to quickly gather the most impactful DG installation information.	GOSI-304	Story	Open
DG choropleth legend settings to persist through layer switching • Allows users to quickly gather the most impactful DG installation information.	GOSI-303	Story	Open
Display flood inundation information in GOSI • Provides an additional data set for the GOSI platform.	GOSI-4	Story	Open

11 Appendix B – Introduction Guide to Using GOSI

While GOSI engaged a number of distribution operations personnel in a variety of hands-on training and user-engagement, because of the limited scope of the technology demonstration, not all personnel were trained in an effort to conserve EPIC funds. The following *Introduction Guide to Using GOSI* document was provided to any additional PG&E personnel who were interested in exploring some of the highlights of GOSI, but without being regularly engaged in the project. This "additional user" list included distribution operators and engineers outside of the scope of the technology demonstration, EPIC program management personnel, and Electric T&D leadership.

Getting Started With GOSI

Overview

GOSI, or 'Grid Operations Situational Intelligence', is a project system which helps to visualize and make sense of a wide array of PG&E operational data. GOSI aggregates data from over 30 different data sources, both internally to PG&E (e.g. DMS, OMT, SAP), and from external sources (e.g. weatherunderground.com, US geological survey).

The goal of GOSI is not to replace any existing systems, but rather GOSI has some interesting use cases which we think makes it an interesting supplemental tool for cases which you currently do not have easily accessible data, or cases where you might look towards a number of outside data sources to solve a problem.

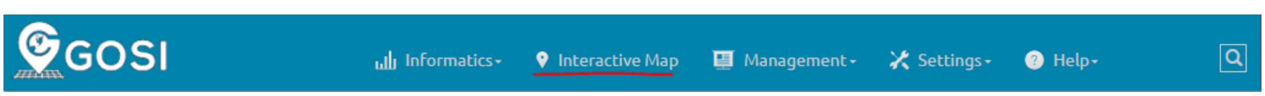
This guide provides an introductory look at some of the features of GOSI, as well as providing a job aid for driving the main components of the application.

12 Section 1: Interactive Map

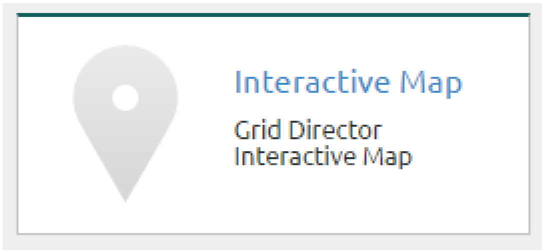
This section's examples all demonstrate GOSI's Interactive Map, which serves as the primary means of data visualization for GOSI.

Navigating to the Interactive Map

In order to navigate to the interactive map, click on the "Interactive Map" item in the top menu (available across the entire GOSI system)

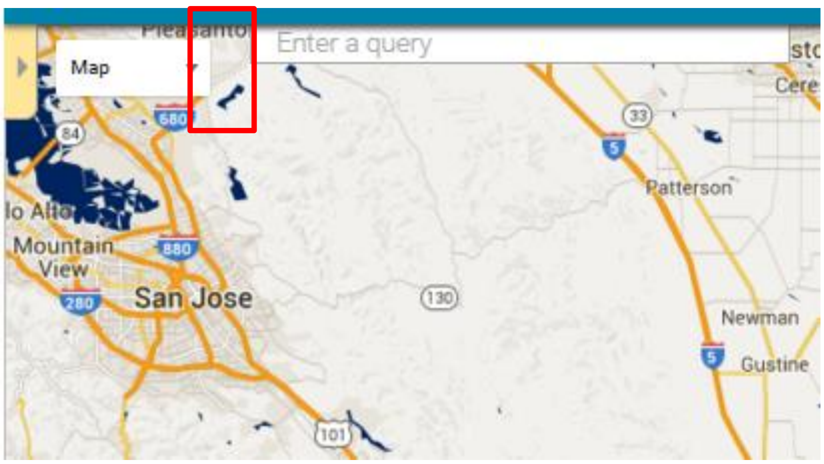


Alternatively, you can access the interactive map from the GOSI home page by clicking on the following box:



Map Content Manager

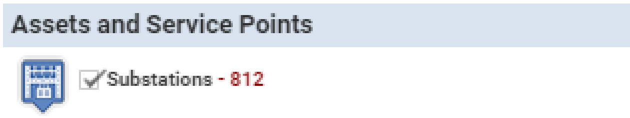
The "Map Content Manager" contains all available data layers for the Interactive Map. To access the Map Content Manager, click on the yellow arrow in the top-left corner of the Interactive Map. This button can also be used to hide the Map Content Manager when it is visible.



Map Layers

The Interactive Map is divided up into expandable sections containing map layers. In order to see all of the layers in a section, click on the name of that section. Clicking a second time on the section header will collapse the section.

Click the layer tick-box to toggle it on and off.

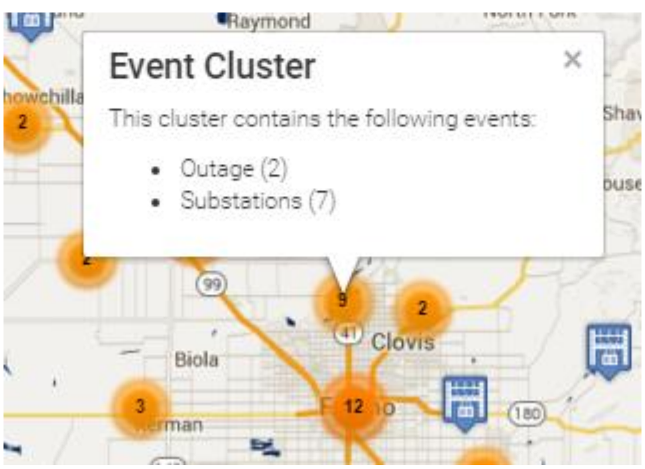


NOTE: there is a known issue with map layers with a large number of items (e.g. EC notifications and Service Transformers). Rapidly clicking map layers on and off may cause the layer to get 'stuck' in a half loaded state. The workaround for this issue is to reload the page.

Clustering

If the map layer or layers that you have selected show 2 or more data points that are very close together, markers are clustered as shown below. The cluster icon is an orange circle containing a count of the number of items that are included in the cluster.

Clicking on a cluster will tell you what sort of items it contains



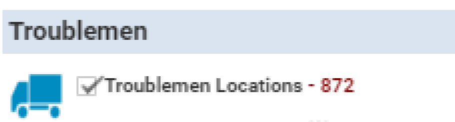
To show the contents of a cluster, either:

- zoom in on the cluster icon until the individual pins are shown, or
- CTRL+Click on the cluster to automatically zoom in and show the cluster contents.

Map Use Cases

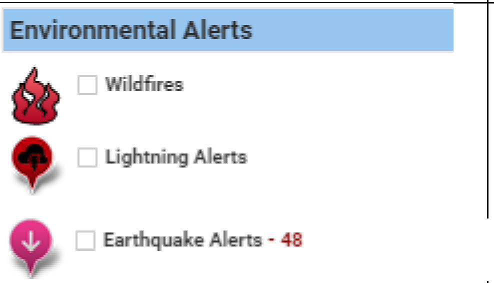
This section features some ways that you can utilize the interactive map to accomplish particular goals. We'd encourage you to flip through these and try them out as situations arise. Furthermore, if you find a novel and interesting way to use GOSI to accomplish a problem, we'd like to hear about it at PGEGOSI@pge.com

1. *Outage and Troubleman Tracking*

Setup	Overview
In the interactive map's map content manager, activate the following layers: Events > Outages  Troublemen > Troublemen Locations 	This combination of layers is useful for figuring out the general relationship between an outage and its assigned troublemen, or simply the troublemen closest to a particular outage. The more information popup for a particular outage (accessible by clicking on a particular outage, then clicking "more info") features basic info about an outage, including the currently assigned troubleman, if there is one. You can use this information to find and track the troubleman as they approach the outage in question. Note: We are aware of a bug wherein the Truck layer is named "Troublemen Location". This layer contains data for all FAS-enabled crews, not just Troublemen. You can check to see if a crew is a Tman crew by looking at their "more info" popup.

2. *Asset Threat Analysis/Outage Cause Assessment*

Setup	Overview
In the interactive map's map content manager, activate the following layers: Events > Outages  Environmental Alerts > Wildfires, Lightning Alerts, and Earthquake Alerts	This combination of layers is useful for determining potential environmental causes of a particular outage, or to assess potential future impact of an occurring environmental event. GOSI allows you to view recent earthquake and lightning strike occurrences (cloud to ground only) as well as the boundaries for any current wildfires. Clicking on these events will allow you to see more information about them, and their location in proximity to outages and assets will allow you to more readily assess an environmental event's potential future impact on the grid. Optionally, you can augment this analysis by looking at the

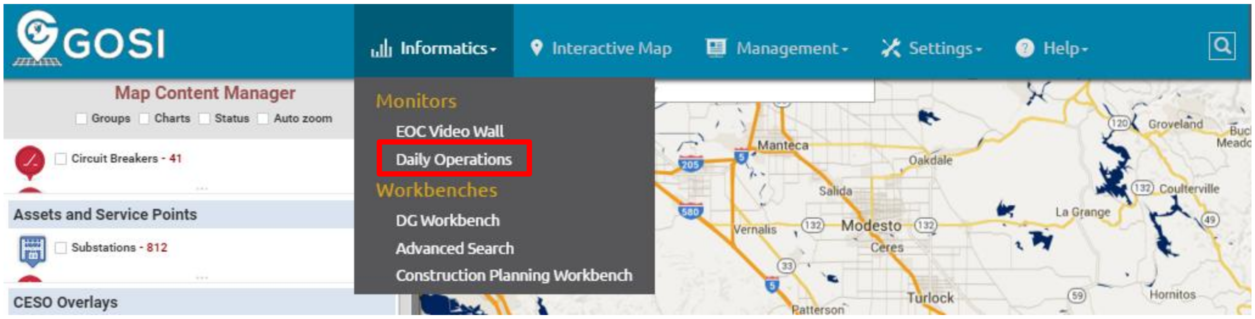
Setup	Overview
 (Optional) Assets and Service Points > All Layers  (Optional) Feeder Lines > Distribution Feeder Lines  	locations of PG&E assets in relation to environmental events which have the potential to affect electric infrastructure.

3. Grouping Construction Tags

Setup	Overview
In the interactive map's map content manager, activate the following layers: Construction > Notifications  Feeder Lines > Distribution Feeder Lines  	This combination of map layers will allow you to gain a notion of where pending EC tags are located, both on the map and on a particular circuit, and should allow for the grouping of work tags into fewer clearances. EC tags are colored according to how far out the tag's Required End Date is.

13 Section 2: Daily Operations Dashboard

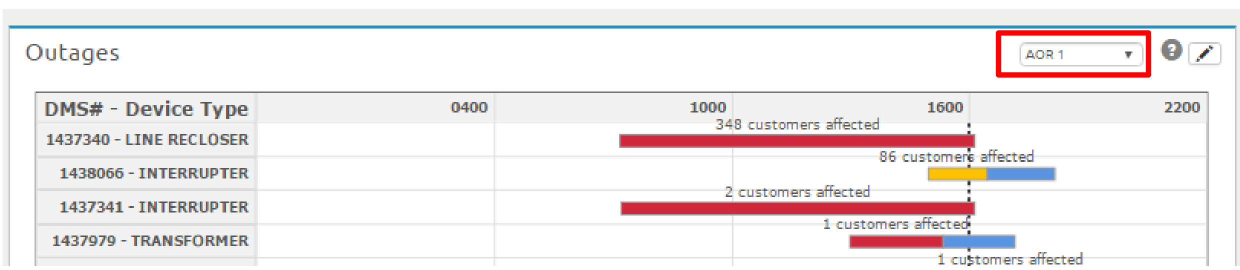
The daily operations dashboard is useful for assessing outages, both planned and unplanned, by AOR. You can access the Daily Operations Dashboard from the Informatics dropdown menu in the top bar.



Daily Ops Dashboard Uses

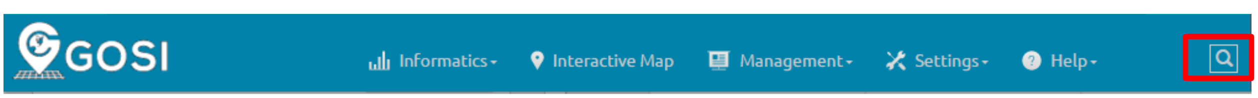
1. *AOR Outages*

In the **Outages** window of the Daily Ops Dashboard, select a particular AOR of interest in the dropdown menu in the top-right corner



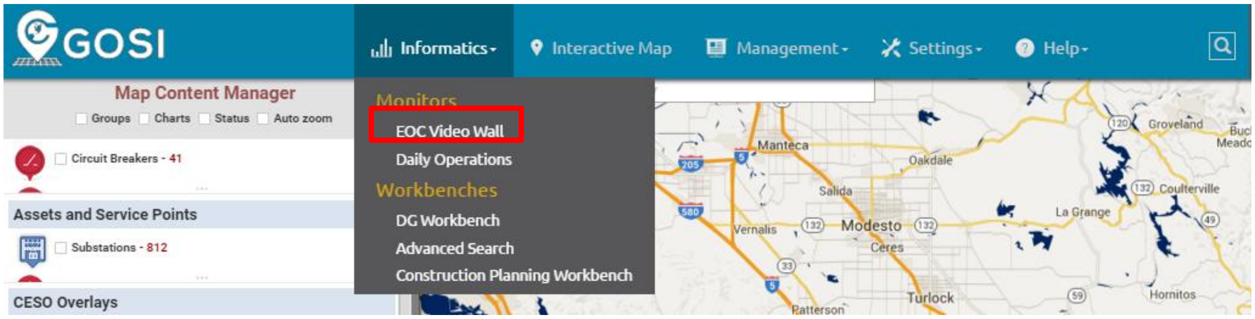
Each row of the outages table represents an unplanned outage within the selected AOR. Each row also includes the DMS# of each outage, as well as the device type. The bar in the timeline is colored according to outage duration, and ends at an outage's ETOR. If an outage has been assigned to a troubleman, then you'll see the amount of time between the ETA of the Tman and that outage's ETOR in blue.

If you're interested in locating a particular outage, you can find it using the advanced search feature, available by clicking on the magnifying glass icon in the top bar.



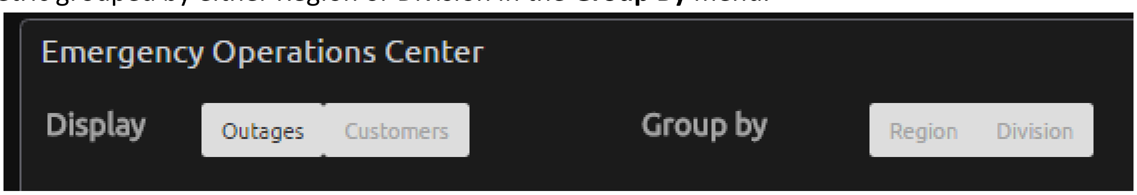
14 Section 3: Emergency Operations Center Video Wall

The EOC Video wall is useful for tracking the ongoing impact of an emergency event. It is accessible through the **EOC Video Wall** menu selection of the informatics dropdown menu.



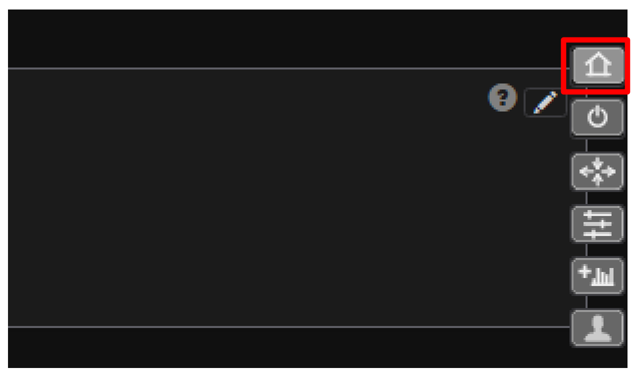
Configuration

To configure the EOC video wall, select whether you'd like to see Outages – Probably, Verified, or Total, or Customers – Probable, Verified, or Total from the **Display** menu. Then select whether you'd like to see that metric grouped by either Region or Division in the **Group By** menu.



Closing

To exit the EOC Video Wall, click the **Home** icon in the top-right corner of the screen



EOC Video Wall Uses

14.1.1 1. Outage Tracking During an Event

During a large-scale outage event, the EOC Video wall is particularly useful for staying up to date on the current outage status. Simply select **Outages > Total** from the **Display** menu and **Division** from the **Group By** menu to bring up a map which shows the current CESO values for each of PG&E's districts.

In addition, the **Event Summary** panel will keep a real-time count of the number of total outages that have occurred since the start of the event, the number of outages restored in that time, and the number of outages that are remaining/ have not yet been restored. This information is also available in the form of a Time Series Graph, which shows, over time, how many total outages have occurred, been restored, and how many current active outages there are.