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## **Research Project**

**Research Question:** Has implementation of GIS software at PG&E been an effective tool in enhancing pipeline safety and safety of the company as a whole?

### **Introduction:**

Safety of natural gas pipelines in the country is a very controversial topic and requires a lot of attention. Risks associated with gas lines integrity are very high; therefore, companies are required to comply with specific Integrity Management Rules set by the National Transportation Safety Board. Whether those instructions are being properly implemented is an arguable question and may vary from one utility company to another.

PG&E is one of the major utility corporations in the United States. It has a large network of pipelines that spreads through a vast area of over seventy thousand square miles of service territory in northern and central California (Singh 2012). The pipeline system is divided into two components: transmission pipelines that comprise six thousand seven hundred and fifty miles of pipes and distribution pipelines comprising forty-two thousand miles of pipes. Of those totals, two thousand eighty eight miles of transmission lines cross high consequence areas that include some of the most seismically active topography. Furthermore, many of the transmission lines run through urban areas, and those pipes represent a much higher percentage when compared to the rest of the industry (Singh 2014, Telephone Interview). In addition, the pipelines in PG&E's transmission system are, on average, approximately forty years old, with most miles installed prior to 1970 (Pipeline Records Integration Program. Chapter 5, 5-7). Considering these facts, it

is clear that it is not an easy task to have effective quality assurance in such a corporation.

The Integrity Management Program is a very important component of a safety perspective at PG&E or any other utility organization. Its effectiveness is highly dependent on accurate, complete, and verifiable data. Furthermore, this program is reliant on an efficient tool – GIS software - for recording, analysis, and result reporting using that data. GIS is a computer-based system to aid in the collection, maintenance, storage, analysis, output, and distribution of spatial data and information (Hines 2014). It has been a key instrument at PG&E since the first day of its implementation in 1993. One of the main purposes of the ArcGIS software in the company is the capability to effectively and efficiently digitize the network of pipelines with added various descriptive information. That information allows enhancing PG&E's capabilities to track and address issues pertained to the pipelines' integrity.

### **Literature Review:**

Several literature sources question the effectiveness of GIS in improving safety policies employed by the company. The majority of those works rely on the tragic event that took place in San Bruno in 2010, when one of the PG&E's pipes exploded and took eight lives, injured many others, and destroyed and/or damaged homes. The authors argue that the company's GIS datasets were not reliable and contained inconsistencies, which did not allow for proper realization of quality control. To be more specific, they claim that in many instances PG&E used assumed values for various data such as key pipeline parameters, where depth of cover, seam type, and SMYS attribute information was implicit (Hayes 2014, 2-3). Furthermore, it has been mentioned that during the incident, the pipeline location and description data were not promptly shared with the first response agencies - PG&E followed its security and right protection policies. Most of these statements about effectiveness of GIS in disaster mitigation at the

company were based on analysis of the incident report released by the National Transportation Safety Board, which, in this instance, may be considered as a primary source of information.

Throughout the analysis of literature for this research project, there were several instances of a debate about the effectiveness of ArcGIS at PG&E in particular during the San Bruno incident. However, all of the authors of those few research works and journal articles agree that implementation of GIS is particularly important in our time. Besides seeing the drawbacks, they can see its benefits, and consider one of the main tasks to be the continuation of evolving the software by updating and incorporating it with other data that is collected through utilization of different modern software and equipment. That is what PG&E has been pursuing since the tragic event in San Bruno, as it has been stated in several journal articles (Energy Weekly News 2012).

The software that is being incorporated into ArcGIS at PG&E and has been mentioned in a few journal articles and the company's news releases is called Maximum Allowable Operating Pressure (MAOP) validation calculator. Partnering with Coler & Colantonio, Inc., a privately owned consulting and engineering firm, helps to enhance management of critical asset information and PG&E's pipeline safety in general (Namec 2013). The software performs calculations validating the MAOP for each pipeline component, providing information for a traceable and verifiable asset management system.

Some of the literature for this research project consists of PG&E's news releases. Although this type of information is at times accepted with skepticism, I found it to be beneficial for my project. In my understanding, the most accurate answer to a question could only be obtained through listening to both sides of the barricade. Taking this into account, the research question would have to be supported by both: not only the data and analysis based on the San

Bruno events, but also new data acquired through questionnaire/interview with the GIS department at PG&E and its analysis. Furthermore, an assessment of effectiveness of recently implemented techniques utilized alongside ArcGIS would have to be performed and incorporated into the structure of the main analysis. This approach will differentiate the current research work from the ones that have been done in the past. Also, it will provide additional and updated results related to the effectiveness of GIS at the corporation.

### **Methodology:**

Objective: To obtain first hand current information and data regarding effectiveness of GIS as a safety tool for the company's pipeline network.

In order to obtain the necessary information and data to answer the research question, a contact has been established with the PG&E's GIS department through their executive staff. An email containing questions pertained to the project was sent to the executive, who forwarded it to the appropriate party - a Vice President of Gas Operations. Through direct email and phone correspondence the following information has been acquired: description of current GIS database representing the pipeline system of PG&E with details on how the gas transmission maps and records are different compared to just a few years ago; specifics of the hydrostatic testing program and its correlation with ArcGIS; details of the data transfer process from MAOP validation calculator and automatically controlled valves to GIS; connection of faster responses to leaks and records updates with GIS software; other pipeline safety steps taken after the San Bruno event related to GIS software. Attained information and data were analyzed and compared to the ones from previous research works.

**Analysis:**

Every year PG&E has to file a safety plan with the California Public Utilities Commission (CPUC). The CPUC ensures that the natural gas systems in the state of California are designed, constructed, maintained, and operated according to safety standards set by the organization and the federal government ([cpuc.ca.gov](http://cpuc.ca.gov)). The post San Bruno PG&E's reports to the CPUC primarily include safety improvements on the company's transmission pipelines, due to their generally larger size and higher operating pressures than distribution pipes. Therefore, transmission lines are of higher safety concern and have to be prioritized.

Many of the PG&E's transmission pipelines run through areas with dense populations. That is why it is critical for the company to have an understanding of their assets and to know their condition and location. This has been further proved by the 2010 event in San Bruno. Therefore, an effective implementation of GIS software could be a right tool in enhancing safety of the company's pipelines, improving understanding of the types of risks associated with natural gas transmission lines, and recognizing mitigation steps that PG&E needs to take.

Through the analysis of the information gathered for this project, two primary distinctions could be made in relation to PG&E's GIS: the pre-San Bruno and post-Sun Bruno GIS databases. The significant difference between the two is that after the San Bruno incident, PG&E took an approach of understanding the underlined quality of the information that was in their pre-San Bruno ArcGIS database. The company launched nearly a quarter billion dollars effort to improve the quality of data in their GIS database.

In order to comply with the Pipeline Records Integration Program, PG&E took the following steps: "entered critical information into its GIS system from source documentation, validated the piping systems information, and upgraded the system to allow users to drill-down

and view original source documentation (Pipeline Records Integration Program. Chapter 5, 5-7).” More specifically, nearly four million paper records have been collected from PG&E’s ninety field offices and scanned into a centralized database (Singh 2014, Telephone Interview). All of the records were reviewed in detail and all of the six thousand seven hundred and fifty miles of pipelines have been translated into approximately six hundred thousand individual pipeline components. The other information that was being reviewed from the records was the type, size, material properties, wall thickness, and strength of the component, as well as MAOP data and the date that the test was performed on. All of that information was transposed into Excel files and then uploaded into the new post-San Bruno GIS Pipeline Open Data Standard (PODS) based system. In combination, all the uploaded information was transformed into approximately eight million data attributes (Singh 2014, Telephone Interview). Where pre-San Bruno GIS database only contained about seven hundred and fifty thousand data attributes (Singh 2014, Telephone Interview). With the main reason being the fact that the old ArcGIS database contained only the pipeline components information and did not include their descriptive attribute data. Furthermore, PG&E linked all about four million scanned documents to each pipeline component in the new GIS system. This has allowed for almost instant access to any original records of pipes. Before, it could take two weeks or more to get most of those documents.

In 2013, PG&E has undertaken another effort to enhance their GIS database and, therefore, improve the pipeline integrity system and company’s operations. To better delineate the accuracy of geospatial location of the transmission pipelines, they have sent “locators” out in the field to physically mark natural gas lines. Afterwards, the company sent out crews to capture GPS points of those locations (Singh 2014, Telephone Interview). The benefit of this effort is

that PG&E has now enhanced the knowledge of the geospatial alignment of their pipelines in the field. Besides, the location information is now appropriately shown in the GIS system. Pre-San Bruno GIS database had many inconsistencies in representing spatial locations of PG&E's pipeline. Only sixty percent of lines were somewhat correctly shown geospatially - within ten feet of a pipeline. Another forty percent of lines had significant errors (Singh 2014, Telephone Interview).

The effort that has been undertaken in the last several years was to develop an understanding of the quality of underlining GIS information: the location and asset data. Having that data, PG&E can start to use the information to perform analysis. Today, the company is implementing new applications that work in correlation with the GIS system. One of those applications is the Classification Calculator. By the Federal Code that governs the safety of pipeline infrastructure in the United States, there are four classifications that exist, which are driven by the population density. Depending on how dense the population is within six hundred and fifty feet on either side of the sliding mile of a pipeline, the classifications are divided into first class being the lowest density through the fourth class – the highest density of the population (Singh 2014, Telephone Interview). The ability to identify the classification is important for utility companies, because it derives what should be the safety factors that are used to operate the pipelines in those areas. The pipeline that runs along class one could operate at a higher pressure, where the pipeline in class four has to be operated with lower pressure.

The other type of analysis that PG&E has recently started performing is the Maximum Allowable Operating Pressure (MAOP) calculations. It is dependent upon class, material properties, and stress test information, where the class location calculator uses the geospatial alignment of the pipeline to determine a class (Singh 2012). Therefore, all the data that was

captured as a part of the record validation effort is what is being used to help validate safety-operating pressure of the pipelines. Moreover, in GIS, calculating algorithms could be applied to the entire dataset or any selected part of it, such as a section of the pipeline (Singh 2014, Telephone Interview).

### **Conclusion:**

PG&E has taken large steps towards improving safety of their assets and the company as a whole and setting an example to other utility corporations. It is clear that application of the GIS software at the company significantly enhances the safety of their natural gas operations. From the application standpoint, GIS gives the ability to store large amounts of information, as well as perform analysis on much quicker bases, as the information from field and other works gets updated into the system in real time. Therefore, the software reduces the amount of time that it takes PG&E to make better decisions related to the safety of the system. Besides, GIS allows for a controlled environment – there is only one database. This factor enables high quality and consistency in updating the GIS system with new information. The third important safety factor of implementation of GIS at PG&E is the ability to push the information out to the operating employees. With mobile devices that people have in the field, they are able to view geospatial locations of the pipelines. In case of a leak, employees on site have the understanding of what the assets are and they can use the information to quickly stop the flow of gas and make the area safe. The fourth safety element, derived from the operation standpoint, is the improved emergency response.

PG&E continues to try and improve the quality of the information. A lot of the records that the company has are associated with the assets that are ninety to a hundred years old (Singh 2014, Telephone Interview). As operational personnel works in the field and/or construction,



they are able to see the actual pipelines and update the GIS database to represent the current state of the asset. This process is known as field-testing – comparison of information to the one that is already in the database. GIS enables an efficient platform for such operations.

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