ESRI International User Conference
July 11-15, 2011 – San Diego, CA

GIS Technology Supports Pipeline Construction Management System

Sidney Pereira dos Santos
Alessandro Ferreira Monteiro
Ubirajara Mendes Nunes Junior
Roselaine Cristina Barbosa da Silva
Paulo Marcelo de Figueiredo Montes
PETROBRAS
Av. Almirante Barroso, 81 – 12th floor, 20031-004, Rio de Janeiro, RJ, Brazil.
Ronicarlos Pereira
GTEQ
Rua Benito Campoi, 298 – 1 st floor, 09570-010, São Caetano do Sul, SP, Brazil.

ABSTRACT

Pipeline projects are capital intensive and their construction and assembly involve many activities and risks that need to be handled in an effective and productive way to guarantee (a) project quality, (b) staying under budget and (c) managing construction schedule as planned. Pipeline Construction Management System is an integrated, GIS based, platform using ArcGIS technology as a user friendly graphical interface. All planning, management, basic and executive design, material acquisition and storage, construction activities as well as field data collection are handled by PCMS. PCMS development strategy is to integrate well proved applications that are used for this kind of project and to access selected information that is important to high-level management.

INTRODUCTION

Petrobras is a Brazilian state controlled company that has been founded in October 3rd, 1953. It is ranked the 3rd biggest company in market value in the world, has total proved reserves of 15.986 billions of barrel of oil equivalent in 2010, average oil production in February 2011 of 2,603.9 million barrel oil equivalent per day (www.petrobras.com.br, 2011). Petrobras has a total pipeline length of around 16,000 kilometers in operation.

Petrobras corporate engineering division, among other projects, is responsible for pipeline design and construction management.

The implementation of a GIS solution to support pipeline design started in 2003. GIS technology selection was part of a survey to identify which technology would better support pipeline and other industrial projects while providing data reliability and integrity and system scalability (Santos 2004).

PIPELINE CONSTRUCTION

Characteristics

Transmission pipelines are built for transportation of fluids like oil, oil products, ethanol, ammonia, natural gas, water, etc. over distances ranging from a few kilometers to over a thousand

kilometers. Pipeline nominal diameters range from around ten inches (254 mm) to more than 56 inches (1422 mm). Pipeline operating pressures range from ten bar (150 psi) or less to a hundred fifty bar (2200 psi) or even more. Pipelines are known to be the safest and most economic way for transporting fluids.

The decision to construct a pipeline begins with an evaluation study carried out by the Transportation Company to assess the pipeline technical-economical feasibility. Commodities and volumes to transport, pipeline routes, transportation distances, market, facilities, construction and operating costs, etc. are all considered. Once project construction is approved, more steps are taken.

The design phase begins and yields plans, drawings, specifications and documents for procurement and services bidding.

A license process is filed in the Brazilian Environment Institute (IBAMA). An aerial land survey is carried out to yield the plants of the pipeline route. A survey of social and environmental characterization is done to support the elaboration of environmental studies and reports required for the acquisition of licenses. The right-of-way is warranted by government decree and cleared by court settlements or decisions. Areas required for permanent facilities like compressor or pump stations and tank farms are purchased and areas for provisional facilities like field camps and storage yards are rented.

Pipes are ordered to the pipe mills, manufactured and shipped to the storage yards, 84 pieces per kilometer, each piece 12 meter long. Pipes come by ship, barge, train, truck, or a combination of any. Pipes may be supplied by a nearby or a distant manufacturer.

The pipeline project may be split into two or more sections for construction strategy. One or more contractors are hired after the conclusion of the bidding process. A contractor may be awarded one or more sections. A pipeline section is to be constructed by one pipeline construction spread. A spread is a set of all resources (work force, equipment, etc.) necessary to construct a section of pipeline from mobilization to commissioning. A pipeline spread may be composed of around 700-1000 workers at the peak of the construction activity. A span of around 100 kilometer of pipeline may be built by one spread in a typical construction window.

After construction a pipeline shall be tested for resistance and tightness, cleaned, dried and then commissioned. On commissioning, the operator takes charge of the facility.

Planning and Logistic

Planning, procurement and logistics are key subjects in pipeline projects. Pipeline projects requires a lot of material, equipment and services provided by local and distant providers and are sensitive to weather conditions, terrain geography and environmental. An effective project management must rely on accurate, contextualized and readily available information that is supported by a GIS based management system as PCMS. For instance, in wet regions the construction window spreads from the end of the rain season up to the beginning of the next rain season. In contrast, in regions like the low Amazon basin, in Brazil, pipes can be shipped to the storage yards only during the high flood season and construction work can be performed only in the dry season.

OVERALL SYSTEM ARCHITECTURE

The overall system architecture consists basically of two fully integrated systems, in real time: (i) pipeline Construction Company System – *CCS* and (ii) Pipeline Construction Management System – *PCMS*. Such integration has to guarantee unrestricted reading access, in real time, by

PCMS to all data and documents produced by Construction Company and its subcontractors. All documents are replicated into *PCMS*. The integration is performed by a Web Service as shown in figure 1.

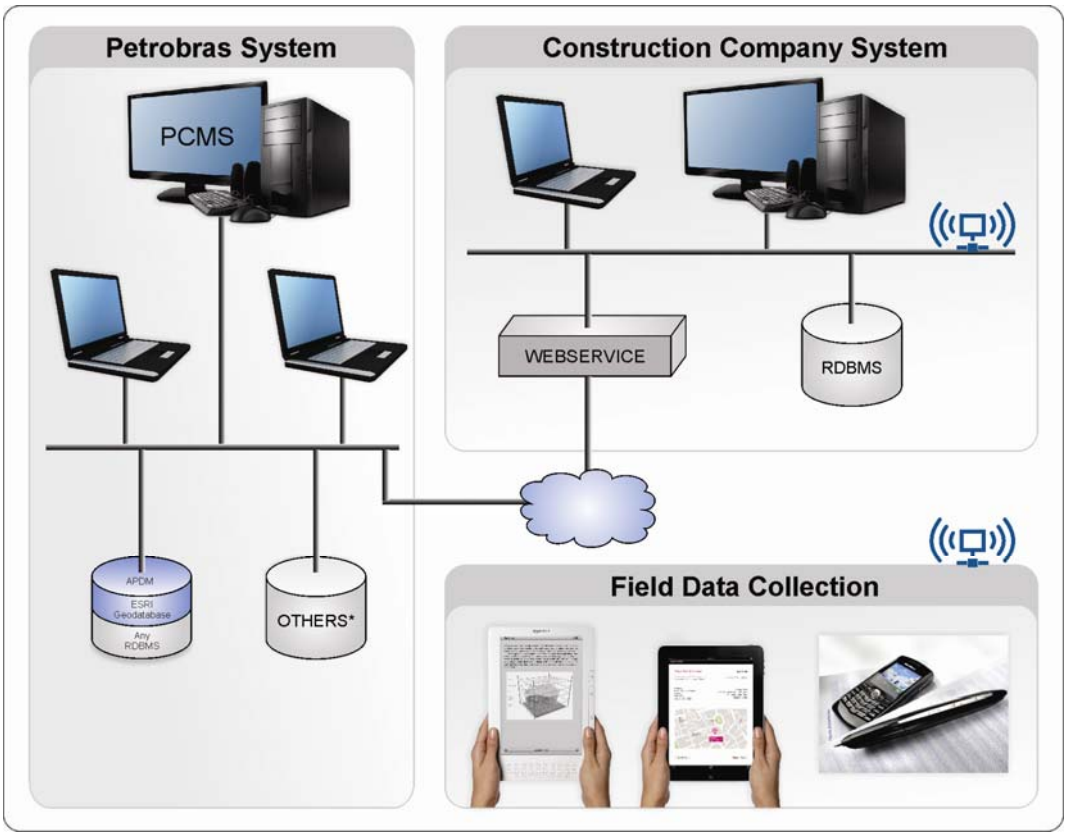

Figure 1 – Overall System Architecture

CONSTRUCTION COMPANY SYSTEM – CCS

CCS must be designed to manage all construction and assembling phases from start up mobilization until the effective delivery of the project to customer or project sponsor. *CCS* must integrate, in real time, the activities of design, management, planning and control, IHS, execution of services, field data collection, inspections tracking and any activity which requires queries, in real time, to the project data base and documents related to execution of the project. *CCS* must also issue comprehensive reports with all necessary information to each related process such as the progress of services, material supply, welding, commissioning, and so on.

PIPELINE CONSTRUCTION MANAGEMENT SYSTEM – PCMS

Driving concept

PCMS driving concept is to support all project phases that include conceptual design, basic design, executive design, construction and assembling activities and project operation by adopting GIS technology while providing a reliable management and an environment that contains all documents and data produced to the Project.

GIS technology

Figure 2 shows the application architecture supported by GIS Server.

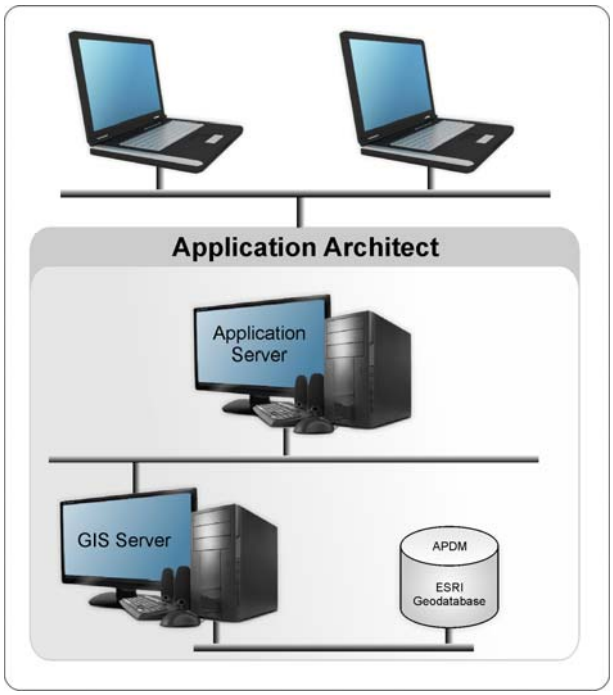

Figure 2 – Application Architecture

PCMS interface

Figures 3 and 4 show PCMS main interface. Left column shows pipeline projects and theirs respective layers. At the top we have GIS tools.

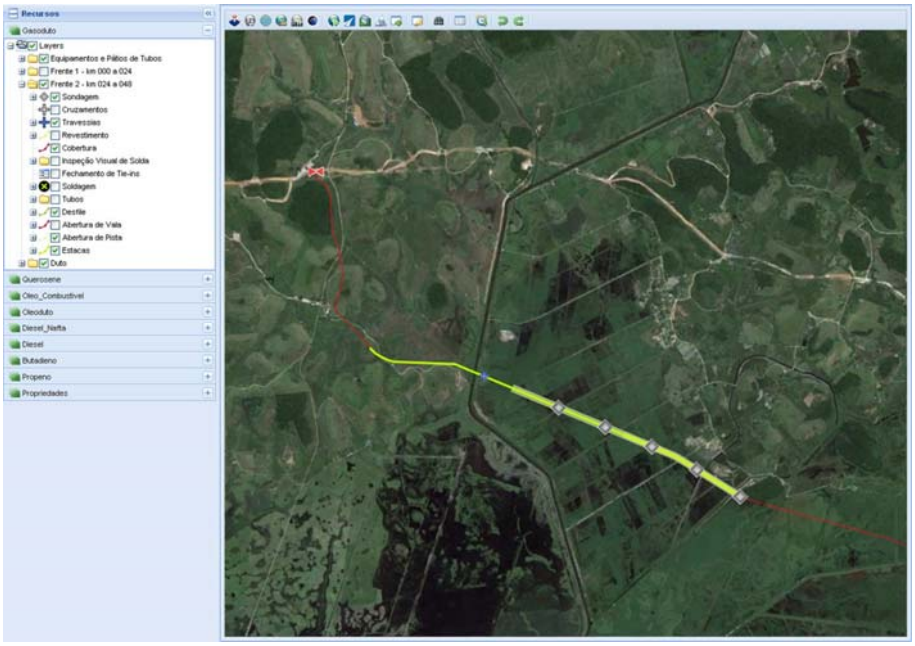

Figure 3 – PCMS Main Interface

Figure 4 – PCMS Project Physical Progress Management

FIELD DATA COLLECTION

Field data collection, as shown in figure 5, is based in mobile devices capable to digitalize data into forms as well as to recognize hand written inputs by Intelligent Character Recognition – *ICR* and Optical Character Recognition – *OCR* and transform it into digital data inserted in pre-defined fields of the forms to be sent to the *CCS* server.

Figure 5 – Digital Pen and ICR Procedure

USE OF RADIO FREQUENCY IDENTIFICATION – RFID

RFID tags are attached at both ends of the pipes transported from pipe manufacturers to pipe storages close to pipeline construction sites. Pipes deliveries are then tracked and feeds a data base that provides information to PCMS supporting the decision made process during project construction phase. Figure 6 shows a truck loaded with pipes, RFID tag and data collector. Whenever a loaded truck arrives at the pipe storage facility all pipes are altomatically identified by sensors located at the entrance gate and immediately feeds the project data base.

RFID TAG

RFID Data Collector

Figure 6 – RFID Pipeline Logistics Usability

DEVELOPMENT TEAM

Petrobras development team:

1 – Coordinator and Pipeline Engineer
1 – GIS specialist and System Analyst
1 – GIS specialist and cartographer
2 – System Analyst and Programmer
1 – Web Designer and Programmer

GTEQ development team:

1 – System Analyst and Mechanical Engineer
1 – System Analyst and Application Developer

LESSONS LEARNED

Along the development of the PCMS some important lessons were learned by the development team such as:

- Development team should have at least one member who knows the pipeline business;
- Application development should address the users requirements and they must be involved in the process;
- Process workflow must be identified right from the beginning;
- System must be kept as simple and friendly as possible minimizing training requirement and even GIS knowledge from the users' side.
- Contract between Project Sponsor (Petrobras) and Construction Contractor must establish clearly the requirements for the web service which will provide all the information storied, produced and handled by Construction Contractor and their sub-contractors. This web service is part of Construction Contractor's scope of supply

FINAL CONSIDERATIONS

The advantage of using architecture as the one presented in this paper is related to system simplicity and practicality. PCMS concentrates on GIS technology and Data Management. PCMS is a powerful application and a way of interacting many different specialty professionals by a unique interface and therefore speeding up the decision making process.

REFERENCES

1. Petrobras Information. Available at <http://www.petrobras.com.br>. (Visited in March 25, 2011).
2. Santos, S. P., Cabral, R., 2004, A Safe Approach in Implementing a GIS Solution, Twenty-Fourth Annual ESRI User Conference, San Diego, CA.