

Using GIS as a Helping Tool in Gas Pipeline Design

Presented by

Sidney Pereira dos Santos (Petrobras Gas Business Unit)

Gilberto Luis Sanches Hernandes (Petrobras Gas Business Unit)

Alessandro de Souza Diniz (Imagem)

Renato Cabral (Imagem)

Abstract

Natural gas market growth in Brazil will require around US\$ 1.3 billion in pipeline expansion. To meet this challenge Petrobras decided to use a GIS System to manage project information, and to make the information available in a network with accuracy, reliability and security. This paper presents the configuration adopted in the implementation of a pipeline database. The present situation points to a database that can model manage attribute and geographic data in order to maintain the integrity of both. The results of this implementation must be deliverable to the Web environment using a flexible standards and compliant solution.

Introduction

Development of the natural gas market in Brazil in the last ten years has changed from a weak and conservative position to an aggressive and challenging expansion, addressing mainly industrial and power generation markets starting at the year 2001. A remarkable milestone was the start of operation of the Bolivia-Brazil Gas Pipeline on July 1999 for its northern section – from Rio Grande, Bolivia to São Paulo, Brazil – and March 2000 for the southern section – from São Paulo to Porto Alegre inside Brazil. This milestone started natural gas imports to cover growing demands for this environmentally friendly source of energy.

Another milestone was the – Plano Prioritário de Termelétricas – PPT (Priority Plan for Thermo Power Plants) of the Ministry of Mines and Energy (MME), which set conditions for the installation of 55 thermo power plants totaling 20,402 MW of installed capacity. The gas-fired therm power plants included in the PPT plan had an installed capacity of around 18,263 MW, demanding about 88.0 MMm³/d of natural gas up to year 2003.

These milestones have set the base for the expanding the existing gas pipeline network. The existing networks are located in four different and separated regions of Brazil such as CW/SE/S, E, NE and N.

The scenario considered by Petrobras, after the development of the PPT plan and the progress of the plants developers, has considered an installed capacity of 7,600 MW demanding 40 MMm³/d of natural gas.

The expansion projects consists of adding new compressor stations, new custody transfer stations, loops and new gas pipelines, requiring estimated investments of around 1 billions US\$.

All of the expansion projects necessary to address market development required a reliable design approach that would provide data management and integrity for new and existing gas pipeline projects, ready information, and an information structure efficient for all professionals involved in the projects.

The ESRI architecture we adopted is based on ArcSDE, ArcINFO, ArcIMS, ArcVIEW, and meet PETROBRAS GAS BUSINESS UNIT requirements.

This article aims to share the experience we got while implementing the GIS in the UNGN as a *Helping Tool in Gas Pipeline Design*.

About UNGN

PETROBRAS GAS BUSINESS UNIT – UNGN is responsible for the importing of natural gas, and for selling gas to Brazil Local Distribution Companies. It holds the assets of the gas transmission pipeline, and participates as shareholder to most Local Distribution Companies in Brazil. UNGN mission is to develop and to address the natural gas market needs, and to implement the necessary projects and negotiations to achieve its commitment.

Why implement a GIS?

The UNGN challenge was to be ready to implement the new expansion projects in a tight schedule and with a small group. Although the GIS tool requires some time to be properly implemented, guarantees data reliability and integrity, and ensure that all professionals linked to the project will have quick access to updated projects information.

Brazilian gas transportation system consists of four separate gas pipeline networks spread geographically in the CW/SE/S (3510 km), E (139 km), NE (1634 km) e N (280 km), and totaling 5563 km of gas pipeline. The map below shows their locations.



UNGN manages documents and Regulatory Agency requirements related to the gas pipeline networks. GIS system plays a very important role as a design tool for defining routes for a new pipeline project taking into consideration terrain profile, environmental protected area, river crossings and market statistics and other relevant information.

The visualization of the information linked to the geographic context will assist in designing the gas pipeline network expansion, in the evaluation of current environmental licensing process regulation from new distribution alternatives, and others questions related to the territorial administration where patrimonial assets are located.

Implementing guideline

The GIS implementation at UNGN is based on resolving these problems resolution:

- The conversion and maintenance of legacy geographic data;
- The redundancy and distribution of such data;
- The uniform entry of new data;

Why APDM?

Diagramming a data model before its physical implementation is so important that it acts like a blueprint for construct work. Good modeling are essential for communication between the development team members. While the complexity of the system increases, so does the importance of good techniques in modeling. Among factors contributing to the success of GIS implementation, modeling is one of the most important ones.

APDM developed from the ISAT model, an important work of data base standardization for the pipeline industry. In contrast to APDM, ISAT are only gives guidance to the use of the spatial information.

The model adaptability is another important factor. No matter how hard the central characteristics of the model in general to the companies, there are equally important for the current regulations that vary country by country.

Goals

The main purpose of GIS System is to provide efficient data integration and integrity, retrieval and sharing to a growing community of users. We installed a GIS pilot project using ArcIMS and a data bank in 3 months time. We planned to enhance the system under a one year contract with a more complete structure based on ArcSDE, ArcIMS, ArcGIS and ArcPad all from ESRI. Included in our planning was the implementation of the APDM, which will help us have complete control over the pipeline data, so important to decision support in the operation and maintenance and for expansion design.

Interface

The applicable user interfaces are the key to the success of the system. Users with different profiles and abilities need to have access to the information with the same efficiency.

The concern for the development team is to make the user feels they has a friendly system, independently of having access to the information bank through desktop application, or via Intranet.

The communication between the development team and the potential users inside UNGN is important part of this implementation's first stage. Analyzing the potential users profiles and the interfaces are being specified from a more generic level, for one more specifically dedicated to the GIS.

Customized application for data catalog - GPC

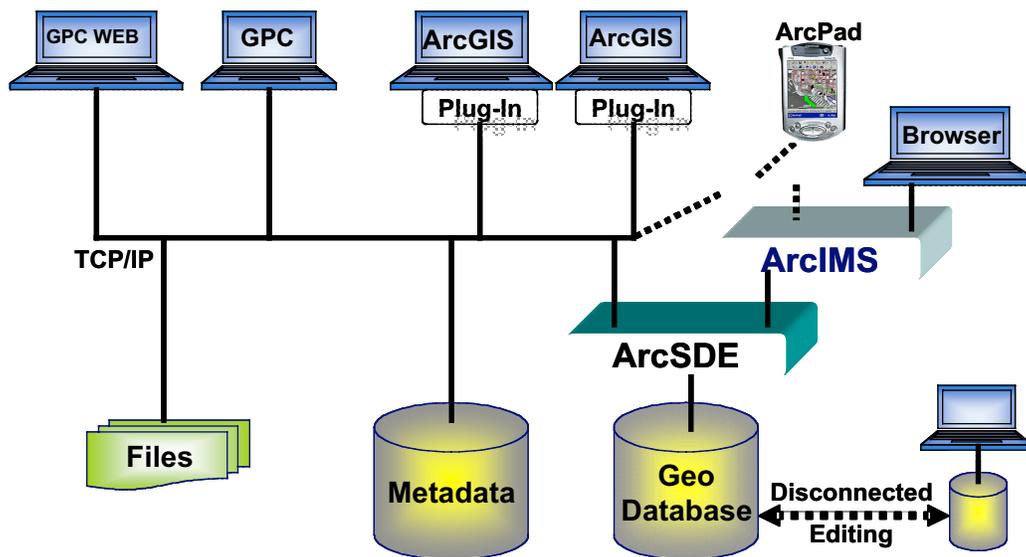
One of the UNGN needs is to register the whole data flow, from its acquisition or generation, to the processing and entry in to the system. The Gas Pipeline Catalog application – GPC – records the raw data, in its original format as an electronic data manager.

After the data is recorded the system issues an administrative order to GIS specialist, who processes the data and inserts it in the database in compliance with APDM model.

At this point, it is important to highlight a clear functional division: all the data entry in APDM geo-database is made by a dedicated professional, and maintaining within the GIS.

This is a very important strategy for the UNGN, because it guarantees the internal workflow of the data, and limits the costs of acquisition of software licenses, and writing the database, and training.

Architecture



ArcGIS desktop for data conversion

The data that appears in the initial part of the workflow has two paths related to one or more space features.

(1) When related to a figure, attached document or inspection report, it will be stored directly through the GPC. Then the user indicates the geographic object to which this data is related, and the system adds the relationship integrity for that time.

(2) When the data is a geometry, a spreadsheet, or related to a geographic feature (as the pipeline, for example), after data entry is validated, it is converted to the Geodatabase format through ArcCatalog or ArcToolBox.

ArcMap is used in spatial analyses, and maps generation in portable format for distribution on demand (ArcPublisher).

Data Conversion, Acquisition, and Maintenance

Loading Data often is the most important and difficult process of any GIS implementation. The conceptual task planned by a team, with successful cases of GIS projects. It based on three basics questions:

- What is the purpose of loading data?
- Where is the data?
- Is the data s consistent with the ArcGIS geodatabase model?

The focus team concluded that the most important data is the **Petrobras Gas Network**. These data is to be load consistently and it can be a reference for the subsequent Petrobras pipeline routes.

The actual scenario of **Petrobras Pipe Route** data was analyzed to provide a good idea of future tasks. Data was stored on hard disk in **CAD and Raster** format, and had the necessary information to be added into the ArcGIS pipeline model. “*As built documents*” produced by oil and gas transport organization – **Transpetro**, served as the main data source to the ArcGIS pipeline data model.

The As Built Document shows the pipe route with spatial reference and elevation information. All attribute information like diameter, casing, valves and their relative positioning was the key to implement this project. There are more than two hundred files at the scale of *1:1000*, for *184 Km* of pipe with almost all of the necessary information.

Another data source was an internal website called *Webdutos*. The website holds the main operation information like pressure test, wall thickness and diameter too. These attributes was taken into account to implement the model.

Considerable effort was put into adapting the available data to simplify the conversion processes. Furthermore, the CAD Files spatial reference was *South American SAD 69* separated by two zones: *23S* and *24S*. Due to Brazil’s large territorial extent, ***South American 1969 Geographic Coordinate System*** was chosen to comprise all geometry feature network in a geodatabase. All geometry comprised at both zones must have their spatial reference transformed to the same geodabase *geographic coordinate system*.

Following the relative and absolute positioning concept, some sheets were created to have the pipe route events with their relative positioning along the entire linear feature. So, it became easier to manipulate the data through *Add Routes Events Tool* from ArcGIS to get the correct entities positions along the pipe route of Petrobras Gas Network, and then ArcMap Load Objects tool could be running to import them. The default model was updated to comprise Petrobras land base data. A comparison of the older version ArcGIS pipeline and the new one was carried out. It could be notice that the new model matched the Petrobras Natural Gas work better than the old one, but it had no object to storage of land base data. So, the newer model was adopted, and the development team decided to import the Geobase Feature Dataset from the old version.

Intranet powered GIS

ArcIMS used for distributing not only data, but also the GIS capacity through easy and friendly tools. The map service makes use of a common browser. The user does not need to install anything on its terminal. There are functionalities in ASP for fast access via menus and combo boxes. With few interactions the user, with no ability in GIS, can access information and visualize it graphically.

Rendering

The APDM Model is based on complex shapes of geographic representation, such as geometric net, dynamic segmentation and tables of events. Moreover, the geographic representation of these elements requires a proper symbology that makes sense to the user.

The representation of a valve must show the user the nature of the equipment.

The ArcMap Server, extension of the ArcIMS allows quality representation, of data on intranet. ArcReader allows to do the same on the network, where ArcIMS is not needed (data is published via ArcGIS extension that is called Publisher).

Technical Specifications

The system architecture counts on a joint data server with the applications WEB server.

- Windows 2000 Server
- Pentium IV
- 512 MB RAM
- 2.4 GHz processor

In choosing the ArcIMS as a data server, the scalability that the system provides proved to be very important. The UNGN knows that its customers portfolio can increase, and with it, the number of accesses. It is important that the system might be extended with no need to reconfigure or rebuild.

Conclusion

The GIS implementation is a complex task. There are some important aspects involving data base design, modeling, infrastructure, and data integrity.

The planning and the execution of the UNGN GIS implementation process have addressed not only these aspects, but also focused on the involvement of new user and intended to get their fidelity.

This work is expected to increase the efficiency of use of data acquired by the UNGN or generated by its service providers. An organized workflow and friendly interface, allow users to integrate and continue enhancing this very important and powerful tool.

Acknowledgements

Special thanks to Petrobras Gas Business Unit for making this information available and to Andrew Zolnai for reviewing this paper and to Imagem (ESRI Brazil Distributor).

Sidney Pereira dos Santos
Business Consultant
Petrobras Gas Business Unit
Av. República do Chile, 65, Sala 1201
Rio de Janeiro, RJ 20031-912
Telephone: 55 21 2534 9960
Fax: 55 21 2534 7940
Sidney.ps@petrobras.com.br