GIS is a tool for Pipeline Management

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Summary
GIS technology has proven to be a key tool for Pipeline Management during construction, commisioning and operation phases. The first challenge was to daily report the progress of pipeline construction activities. Non-gis field crews reporting progress to be summarized in a map report useful for senior management and external organizations. Initial solution was to implement unique geo data repository based on ArcSDE and use linear referencing capabilities of ArcGIS with a custom ArcObjects tool for data loading and reporting. After construction GIS supported Operations Permit request to Peruvian Government and conducted external audits to certify the pipeline, so information was expected to be properly organized. Next solution was to adopt APDM as database model from which generate detailed “AsBuilt” Alignment Sheets and GIS assumed the role of gateway to field records. During Operations phase GIS is expected to support Pipeline Integrity Management by logging “events”, inspections, activities and providing trending capabilities. As response GIS team has recently been implementing a HCA calculation tool, designing an operations and maintenance monthly map report and shared geographic information through a Silverlight gis website based on ArcGIS Server. The facts demonstrated that GIS is a key tool for Pipeline Management during pipeline life cycle.

Keywords
APDM, Alignment Sheets, GIS, Integrity Management, Linear Referencing, Operations, Pipeline.
### 1 Pipeline Construction Phase

#### 1.1 Scenario during construction phase

This paper describes the usage of GIS technology by PERU LNG project during construction, commissioning and operation phases of its natural gas pipeline.

By 4th quarter of 2007, in the south of Peru, a 408 kilometers length natural gas 34” pipeline route was designed. The pipeline was designed to start at Chiquintirca – Ayacucho close to the jungle, go through Andes Mountains up to 4,900 meters of altitude to finally end up at Melchorita LNG Plant facility in the coast, in the south of Lima city. The initial route of the pipeline was going to suffer many re-routes during construction because of environmental preservation and to minimize geotechnical risks.

Before construction begins in any location PERU LNG should have the land easement negotiation in place and acquire government permits of different kinds: environmental, archaeological, special permits for river crossings, road crossings, etc. Accurate and up to date positioning was crucial for permits and easement purposes.

During construction pipeline field engineers in many field crews were going to report pipeline activities in a daily basis. A map report summarizing all field information was required and should be useful for operations and management levels internally as well as externally to government and shareholders.

#### 1.2 Challenges during construction phase

The challenges for GIS technology during pipeline construction were:

- Support with geographic information to pipeline engineers to design re-routes and to define class locations.

- Share up to date pipeline route locations to internal business areas to ensure they ask for permits in the right locations, and the same for land easement negotiation team.

- Report pipeline construction progress based on daily field reports.

#### 1.3 Solutions for construction phase

As an answer to spatial information challenges during construction, GIS technology provided:
- A centralized and unique Geodatabase based on ESRI ArcSDE & Microsoft SQL Server, as the official source of geographic information in the project. This initial Geodatabase was built with information that came from official Peruvian government agencies, diverse contractors (engineering, environmental, easement), field surveyors, satellite imagery.

- Use of ArcGIS Desktop tools to QA/QC permits and easement negotiation data to minimize location errors.

- Design a data workflow and report templates in Microsoft Excel format to be used by field engineers.

- Design a map report with experienced pipeline engineers and managers.

- Develop a custom .NET and ArcObjects application based on Linear Referencing capabilities of ArcGIS Desktop to load tabular data, transform rows to geographic features and generate pipeline construction daily report with an “Alignment Sheet” look.
2 Pipeline Commissioning and Certification Phase

2.1 Scenario during commissioning and certification phase

After construction phase, three main goals needed to be achieved. First PERU LNG 34” pipeline and 18 above ground facilities started a general real testing with natural gas (commissioning) which results were required to be shared with internal business areas and also with government and external organizations.

At the same time the Peruvian Government Energy Supervision Bureau (OSINERMIN) started the pipeline certification process and hired two pipeline auditing companies to do the certification. In this scenario pipeline “As Built” information was required to be properly organized and easy to follow. After successfully conducting audits, the third goal for PERU LNG Pipeline was to apply for a Pipeline Operations Permit (in Spanish “ITB: Informe Tecnico Favorable”). To apply for this request PERU LNG was required to provide – among many other documents - detailed AsBuilt drawings to the Government Energy Supervisor (OSINERGMIN).

2.2 Challenges during commissioning and certification phase

The challenges for GIS technology during this phase were:

- Properly organize As-Built information for 34” Pipeline and 18 above ground facilities.
- Design and generate a commissioning map report in daily basis.
- Generate detailed As-Built drawings every 800 meters to provide Peruvian Government with as much pipeline detail as possible.

2.3 Solutions during commissioning and certification phase

GIS technology also provided solutions for this phase, as detailed:

- Define AsBuilt information as a geographic database with related field records and drawings that document where and how a 34” pipeline and 18 above ground facilities are installed.
- Adopt APDM (ArcGIS Pipeline Data Model) as the geodatabase model to store pipeline AsBuilt information.
- Design standard business tables templates in Microsoft Access and SQL Server Express formats to be used by pipeline construction contractor to provide AsBuilt information along with all related field records.

- Write and use ArcObjects (VBA) scripts to load standard business tables to the main Geodatabase as geographic features based on APDM.

- Make GIS database the main gateway to about 150,000 field records (welding, lowering, backfilling, XRay files, NDT reports, hydrostatic tests, negotiation files, etc.) stored in a Document Management System or in a standard File Server.

- Design and deliver a commissioning map report in a daily basis.
- Acquire and implement an Alignment Sheets generator tool based on ArcGIS Desktop that could generate accurate and detailed AsBuilt drawings every 800 meters.

3 Pipeline Operations Phase

3.1 Scenario during operations phase

Once started the pipeline operations phase, PERU LNG project was required to provide to Peruvian Government the Pipeline Integrity Management Plan. To support that effort Pipeline Engineers were expected to accomplish “Threads Analysis” and “High Consequence Areas calculation” based on industry standards. Pipeline team also defined operations and maintenance plan with activities and frequencies, and started to keep track of accomplishment plan and analyze “findings” during this
activities. During this phase it is important to monitor and log any type of “event” along the pipeline, analyze trending and events to promote awareness.

3.2 Challenges during operations phase

During operations the challenges for GIS technologies are mainly oriented to support Pipeline Integrity Management and Environmental Bio Restoration of terrain along the PERU LNG pipeline Right of Way, here some challenges during the first year of operations:

- Provide support to pipeline team for “Threads Analysis” and “High Consequence Areas calculation”.
- Log location and date/time of any type of “event”, inspection, activity or finding along the pipeline route.
- Log all scheduled pipeline operations and maintenance activities in a monthly basis, along with the findings of each activity.
- Provide information, reports and tools for trending analysis to promote awareness.

3.3 Solutions during operations phase

GIS technology provides solutions for geographic information needs during operations phase:

- Acquire high resolution satellite imagery along the pipeline area of influence in a yearly basis. In-house orthorectifying and feature extraction to monitor environmental biorestauration and wetlands, geotechnical risk locations and urban growing (Buildings Intended for Human Occupancy structures).

- Acquire and Implement “HCA Gas Analysis and Calculation” software tool based on ArcGIS Desktop, which follows industry standard rules to determine High Consequence Areas. Provide analysis results to Pipeline team for evaluation/Approval.
- Define Operations and Maintenance activities information workflow, oriented to upload activities locations and findings into main Geodatabase.
- Design and deliver an Operations and Maintenance map report with a summary of activities in a monthly basis.
- Record every event, field inspection, smart pig run (MLG ILI), etc into the main Geodatabase.
- Provide the users with an easy access to geographic information by implementing an Intranet GIS Website based on Microsoft Silverlight, that takes advantage of time aware data and satellite imagery from different years. Dynamic and Cached Map Services were created to meet general maps requirements.

![General Information GIS Website with ArcGIS API for Microsoft Silverlight](image)

**Figure 3.D**
General Information GIS Website with ArcGIS API for Microsoft Silverlight

## 4 Conclusions

4.1 Geographic Informations Systems technology proves to be a key tool for Pipeline Management, based on two strenghts:

- Flexible and powerful map reporting capabilities.
- Geodatabase as unique repository for geographic data related to any type of records or files.

4.2 Senior Management commitment to encourage data workflow for Map Reporting becomes fundamental for a succesfull GIS implementation.

4.3 GIS technology infraestrucure based on ArcGIS was the framework on which other software products were acquired or developed in order to meets users requirements.
References

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