

Using GIS To Support New Pipeline Construction And Material Procurement

By Abhay Chand, PetroIT India, Gurgaon, India and Mike Gloven, PE, PetroIT Americas, Denver, CO

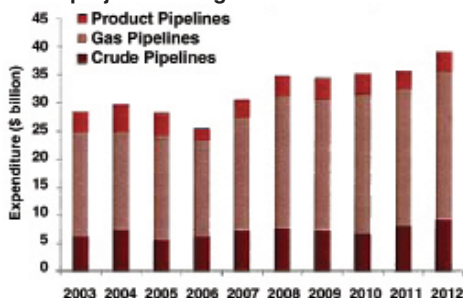
The geographic nature of managing materials delivery and construction activities for pipelines and facilities provides a unique opportunity to use GIS technology to reduce project risks and improve overall project productivity. Materials and construction comprise 80-90% of total installation costs, and as such, delays in the chain of material delivery and construction activity become the primary source of cost and schedule sensitivities. This article presents a GIS-based solution that manages all material and construction activity from project inception through commission and hand-off to operations.

The solution tracks the daily progress and geospatial location of materials and activities, processes all data on a nightly basis against a baseline plan and checks field inputs against an extensive quality assurance library so that project issues can be proactively managed on a daily basis. The Web-based platform provides secured access for all stakeholders to visualize and report status and issues at any time during the project through the use of a project dashboard. At completion of the project, all documentation is provided in a geo-referenced format that may be easily integrated into the company's operating enterprise.

Worldwide Pipeline Construction

According to a study by Douglas-Westwood and an article in the January 2008 *Pipeline & Gas Journal* entitled "2008 Worldwide Pipeline Construction Report," more than 144,000 miles of new pipeline are in various stages of planning, design, engineering and construction worldwide at an estimated cost of more than \$30 billion a year. This historic level of activity is being driven by changes in supply patterns,

A \$180 billion market for onshore pipeline projects through 2012



Onshore Pipeline Market — Total Project Costs by Product 2003-2012 (\$ billion)

Source: "The World Onshore Pipelines Report 2003-2012" Douglas-Westwood Ltd.

overall infrastructure upgrade and replacement, and a more rapid increase in energy demand in developing areas of the world.

Project Challenges

High levels of construction activity are presenting numerous challenges to the industry in reliably advancing projects from the drawing board to commission and operations. Project management and engineering talent are in limited supply, construction spread availability is limited and raw materials are in high demand. In addition, the increase in construction work in a resource-constrained market has resulted in an upward trend in prices and steady shift of project risk from the EPCM contractor to the asset owner.

Role Of GIS

Technology packaged with the trained practitioner offers solutions to these challenges, especially in the area of productively managing the construction process and providing prompt transparency of critical issues to decision-makers, managers and specialists. Although there are numerous technologies supporting the productive execution of pipeline construction, this article focuses on a few areas where GIS technology was used to support critical phases of construction and material delivery, leading to the end objective of a safe project completed as designed, on time and on budget.

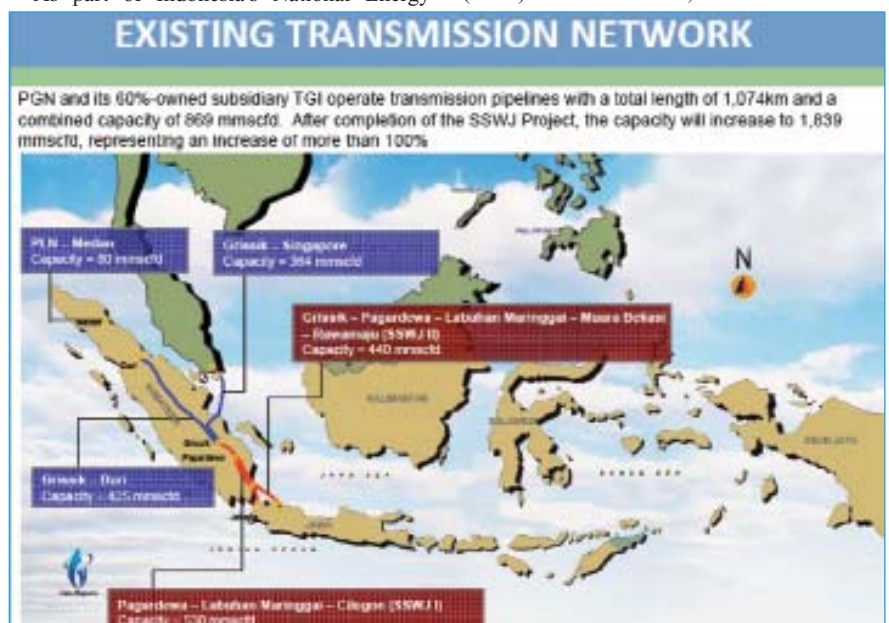
Case Study

As part of Indonesia's National Energy

Policy, its state-owned Gas Transmission Company (PGN) has put in place a multi-year program to continue to build-out its gas transmission and distribution grid, and provide for facilities to export liquefied natural gas (LNG). Its Trans-Indonesia Integrated Gas Network is the primary system of this build-out which links main reserve basins and sources of supply to demand centers and export facilities.

Gas transmission and distribution facilities are being developed in South Sumatera and West Java, which includes the South Sumatera – West Java Gas Transmission Pipeline Phase II Project from Grissik to Rawa Maju. The projects referenced by this article include the design, material procurement, installation, testing, and commissioning of PGN and other pipelines in India and the Middle East utilizing a GIS-enabled CMS (construction management solution).

PGN engaged an engineering consultant, Penspen (PMC), to provide assistance in the provision of engineering and procurement services including construction management and supervision and to assist PGN in undertaking the overall project management role on behalf of PGN. During the Front End Engineering Design (FEED) stage of this project, PGN and PMC decided to deploy a Web-based GIS-enabled Construction Management System (CMS) to aid the owner, consultant and con-



tractor with the productive execution of construction activities through daily field-based monitoring, and onsite and remote management of critical issues.

An important criterion of CMS selection was the ability for the system and project data to be seamlessly integrated into the PGN enterprise after commissioning.

CMS Overview

PGN selected a product named "PipeTrak", a construction management solution developed by Petro IT of New Delhi, India. PipeTrak is a Web-based CMS application supported by an APDM data model which works with ESRI and Google-based GIS mapping technology.

For this project, PipeTrak was deployed at project inception and used to support pre-construction (initial route survey, material planning, land/RoW acquisition, permitting, etc.); construction and commissioning (daily activity tracking, material tracking, resource management, etc.); and post-commissioning (as-built, project EDMS, integration of project data into enterprise, etc.). All data was geo-referenced, providing a spatial perspective, and revisions and changes to the asset are tracked creating an interlinked history.

The CMS was used for these projects to database the pipe details as well as all mechanical and chemical test results, starting from the steel coil used in pipe production to the final pipe product. The installation of the pipe, its welding, NDT and repair details captured at the time of construction are also archived in

an inter-related manner.

This data is linked to the exact physical location of the pipe on the pipeline alignment through the GIS. Thus it provides a geo-referenced database of the pipeline asset that becomes a strategic resource for future pipeline operations as the data captured during construction is related to data captured during operations, (such as cathodic protection data or inline inspection) which provides for in-depth analysis of events and situations that otherwise would not have been possible.

Benefits Of GIS-Based CMS

Numerous benefits were realized and lessons learned through the use of a geo-enabled CMS. Data was collected with hand-held devices or data forms at each of these locations on a daily basis, allowing real-time tracking of assets. All materials were either bar coded or stenciled so that any activity associated with pipe, valves, flanges, etc. could be tied back to the specific asset.

Each asset was also assigned a spatial location as it progressed through the project from the pipe mill, coating yard, staging location and its final installed location. All data regarding material and activities was stored in a secure, Web-enabled database that allowed qualified personnel to manage the project and issue on a near real-time basis either on-site or remotely.

Centralizing the design data with daily field data allowed the CMS to quickly reveal project



Geo-enabling daily activity allows a direct correlation between progress "March Charts" and map display

issues through an extensive library of quality assurance rule sets. Rules were deployed to track the sequence (time and location) of activity, ensuring that all the proper materials and procedures were utilized. Resolving issues through the use of this geo-enabled rule set saved countless hours and unnecessary delays in the construction process. The result of this approach was improved productivity, reduced

costs and an on-time project allowing for the asset owner to begin generating revenue to recover their investment.

Pre-Survey Vs. Contractor Route Survey

The solution implementation began in the pre-construction survey stages. The planned alignment that was created using the PGN-commissioned initial survey of the route was captured into the CMS. This approved alignment was the basis of monitoring the actual pipeline construction.

Moving into the construction phase, the solution was deployed and implemented directly on the construction camp sites, capturing critical as-built information directly from the source. The first activity to be carried out by the construction contractor was a route survey. The alignments from the contractor's route survey were then overlaid onto the initial commissioned survey to get details on route changes, if any.

In this instance, apart from approved route changes, this overlaying of the two surveys indicated that the contractor and the initial survey did not match for a cumulative length of over 12 km. It was ascertained that errors in the contractor's survey had caused the mismatches.

In the absence of this early identification, the possible repercussions could have been additional efforts in terms of time, energy and finance in obtaining the additional right-of-way, increased pipe material requirements, direct effect on design conditions which may have necessitated reworking the fluid flow simulations.

The errors in pipeline route alignment carried out by the contractor in his survey were conclusively established and were subsequently corrected by the contractor by carrying out a resurvey at his own cost. It was a very strong validation of the solution's benefits to all stakeholders. A GIS-enabled CMS provides a means to compare detailed survey information, pre-construction and construction work over the life of the project and asset.

Material Tracking

The CMS material tracking feature tracks the manufacture of pipe, coating of pipe, and its delivery to the coating yards and construction site. This project was particularly challenging to track pipe activity as there were four mills supplying bare pipe to four different coating yards and then dispatching the material to two receiving ports.

In addition to tracking location of materials, the system was required to database the pipe detail and all mechanical and chemical test results of the steel coil used in production and the properties of the final pipe product. As pipe progressed through the project, the CMS tracked its location providing transparency through the interactive

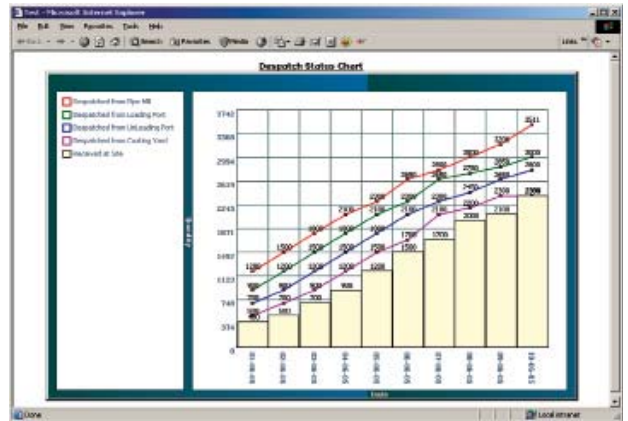
GIS, reporting and built-in EDMS.

PGN and the contractor used the system to trace steel properties and all details of manufacturer and delivery.

Progress Tracking

Transparency through GIS reporting and drill-down into areas of interest provide near real-time information about activity progress and quality assurance issues. As all stakeholders are working off the same locational reference, reporting was aggregated and rolled up to provide a complete inter-related view of progress:

- Compliance reports and checklists generated by the system (pre-hydrotesting/pre-lowering).
- Hyperlinked documentation (Reports signed off by third-party inspectors).



■ Automated alignment sheet generation.

This process of locational aggregation supported the productive management of multiple sections, spreads, contractors and even projects simultaneously. The SSWJ-II Project had four pipeline packages, each being awarded to a separate construction contractor. The deployment of a GIS-based CMS allows the PMC and the owner to access information related to all the packages through a single interface and be able to manage all contractors through a single unified system.

Welder Quality Assurance

The system provided PMC and the construction contractors with daily welder per-

formance data referenced by location. The reports available on the system told them not only which welders in their team had high error rates, but also what kind of errors were being repeated by those welders frequently. This information being linked to the GIS allowed the manager to know where on the line the particular welder was deployed and which sections had been involved in welding since he started work. Because all other information was geo-referenced, it was possible to correlate other important factors such as pipe material, staging yards and even weather to the welder performance.

In one instance the system was used to weed out a welder who had an unusually

high defect rate. The analysis reports from the system showed that the largest proportion of defects caused by him were those of “incomplete fusion.” It was also

found that his speed at completing joints was unusually high. Putting these factors together, it was deduced that he might be turning the current down in order to be able to speed up. This was causing the incomplete fusion and his high speed.

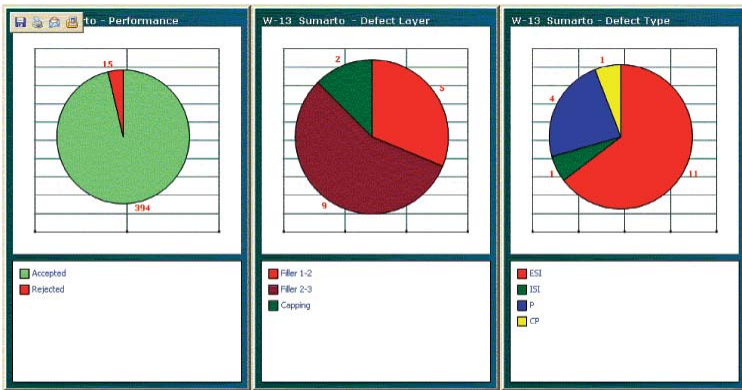
According to the WPS (Welding Procedure Specification) that had been approved by the PGN, they were to follow the specifications as per API 1104. However, it was found that by reducing the currents the welder in question was not following API 1104. It meant that other joints he had welded which had passed through the Inspector’s NDT analysis also could not be allowed.

Commission And Handoff

Historically, once a pipeline has been constructed and commissioned, the operations teams get a data dump (non-homogenous data) as handover from the projects teams. An attempt is then made to cull useful information for operations from it. Compiling such large amounts of data in a meaningful way to assist easy retrieval over a long period and distance (considering the general pipeline life of 35-40 years, average pipeline length being 400 km), is laborious and time-consuming.

The CMS deployment re-engineered this situation on the PGN pipeline to one, where all this mass of information comes together in a single point repository from the initiation

Welder Performance report



stage of the project. Hence, once the line was commissioned, the operations teams already had a completely mapped pipeline with a GIS linked to an as-built database which could form an aid to decision support through:

- Providing information on all as-built aspects and events that describe the pipeline, geo-referenced into a GIS providing a spatial perspective.
- Tracking revisions and changes to the asset over time to create an interlinked history tied to a common geo-reference.
- Providing relevant and focused information to the different user groups in the operating company in a convenient and user-friendly manner.
- Ensuring processed electronic documentation and information handover from multiple project teams in a uniform (homogenous) format, which is seamlessly migrated into operations.
- Providing Web-based access from any location translates to on-demand project progress and detailed asset information.

Material Reconciliation

During the Haban Pipeline Project in Oman (commissioned by PDO) an interesting incident proved conclusively to the owners the benefit of deploying GIS-based CMS. As part of the scope of this project, pipe material was issued to the construction contractor by PDO. During the project, the contractor placed a

Web-based GIS clearly shows benefits of managing the risks of pipeline construction projects by supporting the quick resolution of project issues and management of daily material delivery and construction activities.

request with PDO for additional pipe material of around 640 pipe lengths.

This seemed odd to the owners as, according to their own planning, an additional quantity of only around 600 pipe lengths should have been required. To verify the authenticity of the contractor's claims, PDO decided to perform an analysis utilizing the CMS.

The entire pipe length which had been used for stringing, and thereafter welding, could be seen on the GIS. The GIS also had information on the entire proposed alignment and hence could also give details on the route yet to be completed. Detailed information down to pipe numbers, grade, diameters and thickness were available in the CMS, which also contained very detailed information on the quantity of pipe that had been supplied to the contractors.

Using these sets of information, a system report was generated to reconcile the material and it was found that precisely 592 lengths of pipe were required by the contractors in addition to what they had in stock. PDO averted wastage and achieved a saving which might not have been possible had the system not been available to solve this issue.

Non-Compliances

The CMS had been deployed for tracking construction on a pipeline project in the western state of Gujarat in India. The owners have made the CMS a standard system used for tracking all of their projects (the build-out of the Gujarat state gas transmission grid).

During the course of this project, welding statistics from the system showed an unusually high defect rate in one section. Welding and welder performance reports were brought up from the system. Since each welder's qualifications are stored in the system along with his qualification certificates, the system can determine which welder is authorized to perform a particular procedure or weld.

It was found that the contractor on that particular section was deploying unqualified welders. The contractor had not deployed enough qualified manpower as per the project plan, but wanted to stay on schedule. A non-compliance issue was filed

by the owner's quality control personnel and probable issues were avoided through early detection using the CMS.

Conclusion

A GIS-enabled CMS provides project transparency, decision-making support and productivity improvements not available through normal hard-copy reports or simple database analysis. Decision-makers need to not only know what, but where the issue is located relative to other pertinent data in order to have a more holistic view of the problem at hand.

This article cited several project issues related to centerline design, material requisition, welder performance, progress tracking and post-commission documentation in which each had an element of geospatial relevancy. This application of Web-based GIS clearly shows benefits of managing the risks of pipeline construction projects by supporting the quick resolution of project issues and management of daily material delivery and construction activities. **P&GJ**



Authors: Mike Gloven is president of PetroIT Americas and has more than 20 years of experience in the energy transportation industry. He was most recently president and co-founder of Bass-Trigon, a leading provider of corrosion

management, regulatory compliance, risk assessment, field data acquisition hardware and GIS-enabled risk and consequence analysis tools for the worldwide pipeline industry. Prior to Bass-Trigon, Gloven spent nearly 10 years with Conoco's executive management development program holding positions in engineering, operations and management. He holds a B.S. in mechanical engineering from Louisiana State University and is a registered Professional Engineer in Colorado. He can be reached at mgloven@petroitamericas.com.



Abhay Chand heads PetroIT Ltd. and is responsible for its Asian operations. Following roles in business and corporate development, he has been instrumental in the expansion of the PetroIT to numerous countries involved with

extensive energy infrastructure build-out. He obtained his bachelor's degree in commerce from St. Xavier's Calcutta and a post-graduate diploma in business management from IMI, New Delhi. He is pursuing his MBA from the University of Chicago, Graduate school of Business. He can be reached at achand@petroitg.com.

ACKNOWLEDGEMENT:

This article was planned for presentation at the Geospatial Information & Technology Association (GITA) conference originally scheduled Sept. 22-24 in Houston. The conference was canceled in the aftermath of Hurricane Ike.