

GIS Revolutionising Working Practice

1 Introduction

GIS or Geographical Information Systems have been improving and advancing as a management tool at an incredible rate since their first use as a land management system in Canada in the 1960's.

Today the GIS is more than a spatial mapping and land management records database, it is now the future technology for design and management of pipelines, the central tool for managing pipelines from project concept to pipeline abandonment.

The present GIS technology, complemented with new generation of electronic data storage and retrieval techniques, the ability to download digital maps and digital aerial photography; aerial laser surveys, video photography, and ground based laser scanning data, has made the collection of land data, incredibly fast, precise, detailed and very economical in comparison with traditional ground surveying techniques.

With the new CAD and GIS interfaces developments making design easier. The collection of key environmental and risk data from the intranet. The ability to share the GIS throughout the company and with clients via the free GIS viewer software and the Internet. Also, the email sharing of GIS image data between colleagues and businesses, combined with the integration of electronic estimating and specialized engineering calculation programs has brought radical changes in how we manage projects, control and operate pipelines.

Also, the development of hand held palm technologies, geographical positioning devices; mobile telephone technology, electronic surveying, have provided instant, accurate data that enables major changes in all forms of pipeline working practices.

Changes which effect pipeline registration, legal and land management, design, procurement, quality assurance, construction, testing, commissioning, operation, emergency response, maintenance, inspection and assurance of pipelines. At all stages of the pipeline life the use of electronic digital technologies centered on the GIS is saving time and money. Giving better access to data and more accurate up-to-date information, which is revolutionising the current pipeline working practices.

2 **The background to the development of SUTL's GIS.**

SembCorp Utilities Teesside Ltd, was purchased from Enron in April 2003 Enron purchased the site and its facilities from ICI December 1998 and since the fall of Enron has become a stand-alone major utility provider to the Teesside chemical industries. In addition SUTL manages and owns the largest estate of chemical and industrial plants in the UK, there are over 60 chemical and chemical related companies based on the SUTL complex on Teesside. As well as that SUTL owns and operates its own power station and water treatment works. It owns and controls the major distribution and products pipeline corridors connecting all other Teesside Chemical Industries. (Before 1998 it was formally the ICI Distribution and Products Business)

SembUtilities Solutions a sub-business of SUTL, designs, builds, and maintains over 1500 km of chemical and utility pipelines, of which some 900km are third party owned. Of these over 700km are major accident high hazard pipelines.

SembUtilities Solutions has been developing their GIS systems for the management of the pipeline corridors since 1995.

During Enron the GIS was made a separate sub business to provide services throughout the greater Enron Company. This supported the initial GIS's development and enabled the development of the GIS in many wider engineering and corporate applications.

GIS technology is used through out the SUTL business and has become the corporate graphical information database and SembUtilities Solutions tool.

Also, during the Enron phase the SembUtilities Solutions and GIS business's expanded and moved outwardly from Teesside, becoming an international asset management business, with specialized services in pipeline design, inspection construction and shut down management.

The Pipelines on the SUTL corridors are owned and operated by over 20 business, most of the major petrochemical companies in the UK are based on Teesside. SembUtilities Solutions and SUTL manage all the registration, safety documentation, corridor operation, emergency response and asset management of the third party pipelines.

SembUtilities Solutions with the assistance of GIS technologies and our new web developments provides our third party pipeline owners and our parent business with a competitive successful, economic, pipeline intellectual property and asset management services.

3 Pipeline Design

The GIS technologies are used in all stages of pipeline design, enabling instant preliminary estimates and proposals, and accurate detailed design.

The GIS is now the main tool for recording of contracts and land agreements, route development, incorporating the route hazard, carrying out the pipeline risk analysis, the environmental impact surveys, and the generation of the HSE registration and maps. A tool for total integration of design.

3.1 Pipeline Proposals and Estimates

The speed at which the use of GIS can collect, collate and produce accurate route proposals and estimates is breath taking, it is a magnitude of 10 times quicker than conventional pipeline proposal and estimating procedures.

Estimates and proposals on SUTL's existing land and infrastructure take hours rather than weeks, and days rather than months anywhere else in the UK or the western world. Anywhere where aerial photography and digital mapping exists and the data is available from the web, the process is accelerated.

In remote areas of the world the accuracy may drop due to the use of satellite mapping data but in all cases time spent in finding the maps, developing the route, assessing the route and producing the estimate has been dramatically reduced when using a GIS in comparison with conventional drafting methods.

Plus the accuracy and quality of the data in the estimate in comparison with hand-drafted proposals is immeasurable better. This clearly enables better planning, better understanding of the route and access, better communication of the data.

The GIS technology enables the land map data and aerial photographic data to be down loaded within hours for any location. Also, enables the down loading of preliminary environmental SSSI data, historic site data, rivers, parks and nature reservations.

Digital aerial photography, available for the whole UK updated every 4 years, has a pixel size of 250mm. This is so accurate that it has surpassed the OS electronic maps. Thus the collection and collation of data it is extremely quick, simple, accurate and economical in comparison with slow conventional ground route surveys and manual mapping techniques.

Also, the accuracy gained in front-end GIS design pays for itself by major reductions in design man-hours, more accurate procurement costs, reduction on construction man-hours, and greater accuracy in construction due the large volume of good information.

On SUTL's Teesside area where, there is well-established routes and pipeline data the accuracy of the estimates are within 10% of the final cost. On new routes we are still providing good first time proposal estimates in the region of 20% to 25% of the final costs.

This is a marked improvement on conventional pipeline projects, where the data is so poorly defined that project risks are downloaded to the pipeline contractors, giving large swings and contingencies in project estimates

The beauty of the GIS is that the GIS measures the pipeline route itself, as you draw and alter the route it corrects its measurement. Reducing the manual checking required on conventional projects. The GIS provides the length as accurate as the route you have chosen. You can also, drop the pipeline route data immediately into your electronic estimating programs and quickly produce sensible accurate estimates.

The GIS aerial mapping allows most major detail to be identified. It simplifies interfaces with local authority and major utility providers by supplying them with email images of the specific routes, for their searches of local underground services.

Again this revised information can be scanned into and scaled within the GIS, or transferred electronic into the GIS providing quick more accurate route details for estimating and design.

With companies intranets and free to near free GIS viewers, the route can instantly be electronically distributed to all relevant project personnel, engineers, estate managers, including commercial managers for team working, and contract agreements

The GIS in the estimating process is an ideal tool for discussions with clients as it can be used live on plasma screens. Also, detailed views can be emailed as jpps to quicken agreement of details, between departments and clients.

This electronic flexibility cuts the development and estimating time improves the project estimates and greatly reduced the costs, radically changing the current pipeline working practices.

3.2 Land Management Pipeline Route Agreements

Land Management, estate contracts, pipeline wayleave agreements, access agreements etc. are all simplified by the use of the GIS technology.

On existing SUTL land the retrieval and modification of the new pipeline wayleave is accelerated to a few hours. The process is vastly simplified as each land area's legal documents are already filed in the GIS estates database file

This makes the retrieval of the existing data instant and simplifies the update to the posting back on the GIS the new data. It is then readily available for all who have access to this information.

This reduction in time for document searches to minutes and improves design, construction, operation and estates interfaces with each other and landowners, greatly improves relationships and speeding up the project process.

The GIS is now becoming the main tool for route records, land records, storage and retrieval of land management agreements. Yes even lawyers and solicitors can and do use the GIS when given the facilities on their office PC.

3.3 Risk, Environmental Impact, Historic and Geological Route Assessments

The GIS is the perfect tool for analyzing any of the above route assessments.

It is particularly ideal for risk evaluations requiring analysis of population densities, this is because of the Ordnance and Survey's National Building Data Set, the digitizing of the postal register and parish records. The combining of these records with the GIS buffering and statistical analysis tools, makes the route population risk analysis a simple process.

In addition using the GIS has two bonuses

- 1) It set the database datum for future population encroachment reviews.
- 2) It gives the pipeline owner a pipeline infringement address database for pipeline neighbours, safety notification and safety exercises.

Thus the pipeline wall thickness or design factors for the route can be quickly accessed improving the accuracy of the estimate or defining the cost implications of extra protection to the pipeline.

The down loading of environmental, local councils, geological and historic route data from the various environmental, civil, historic agencies and national body internet sites, give the main bulk of the environmental impact, geological and historic route studies. Also, this assembled data can be issued out in electronic or paper to environmental, and geological assessment companies for further refinement. This accelerates the review process. Also, simplifies and enable the updating of the GIS database. Making and collecting an electronic environmental, historic, geological, assessment datum for route surveys in the future.

This aids the rapid issue of the route risk contours to the county emergency planning authorities enabling quick consents to the pipeline route.

3.4 Detailed Pipeline Design

From the initial GIS estimate route and the modifications due to environmental and risk studies the GIS pipeline layer information is electronically transferred into AutoCAD terminals for the detail design process. The accuracy is dependent on the survey technique, which varies from 0.5m to 0.05m.

The final route crossings and underground crossing data can now be identified and detail. In the case of above ground pipelines the position of new supports, guides and anchors can now be finalized.

On SUTL managed land and pipeline corridors, the pipelines have grown over the past 55 years, so there are no overall drawings that showed all the pipelines and infrastructure.

SUTL considered this problem and through a number of discussions with survey companies helped to develop and pioneer the aerial laser and video techniques for scanning pipeline corridors.

This technique enabled 82 km of SUTL's pipeline corridors to be captured in 8 hours and processes for 6 months to produce 3 dimensional GIS pipeline drawings of the pipe corridor for all above ground pipelines and corridor infrastructure. This process is currently on going with 90% fully processed into the GIS.

This now gives SUTL and the third party pipeline owners a 3D database of the corridor pipelines. Each pipeline has its own separate database, which holds its registration documentation, engineering, drawings, risk data, inspection data and test records.

For the majority of SUTL's managed pipeline corridors, which are aboveground the accuracy due to laser and video scanning is 0.05m relative to the ground datum, 0.005m between dimensions.

With this base information the development of new pipelines on these corridors can be greatly accelerated and design savings of around 50% have been achieved.

As the GIS is created, the link with legal, civil, process, risk, safety health and environment, pipeline registration, engineering specifications, route drawings, are attached to the pipeline creating the working database for the lifetime operation of the pipeline.

The electronic files from Auto-CAD are then transferred back into the GIS enables the final definition of the individual pipelines and the attachment of the design records to the pipeline.

The real gain is the gain to the operation's and inspection, all now have computer based 3D models of the pipelines and the pipe corridors enabling better operations and control, better, permit control, and radical changes in inspection and the assurance of the pipelines and pipeline corridors.

In all cases the use of satellite, video or laser scans processes with the GIS and CAD interface reducing the pipeline design time and design cost substantially. In addition, due to the accuracy of the data, there is a major reduction in design errors and delays due to technical queries.

As the capital cost of GIS is relatively small, although this can appear initially large if born by one project, the use of this engineering tool begins to pay for its self, over and over, as each new development makes further reductions

4 Pipeline Construction

The GIS is now used to supports construction, enabling quick identification of landowner and occupier and other route contacts, defining construction access requirements; and identifying construction hot spots.

4.1 Aerial Maps and Working Width Drawings

The GIS's aerial mapping and pipeline route drawings can be very useful in generating working width and construction access drawings. These are easily saved in the GIS construction files and made available to construction via the GIS viewer. This gives the construction engineer the online ability to develop route construction method statement, carry out progress reviews with clients and office staff and permit him, using the background aerial photography, to print A4 details at larger scales of the route, to simplify communications with site and landowner personnel. This technology is not difficult, can improve the information to the contractor and cut down the error in the field.

4.2 Aerial Video and Laser Scans

Video and laser scans along with the video records of the forward and overhead view can be made available to the contractor. These records give a clear detailed record of all route furniture before the pipeline installation, and with the GIS route design, and accurate survey data, improve the planning and construction management of the project.

Using the GIS and route video data to reviews construction progress and detail safety issues can enhance morning pre-construction meetings.

Again these records are invaluable in construction planning, construction estimating and in settling landowners disputes. Plus solving the age-old problem of replacement and location of pipeline route furniture.

4.3 Hand held Satellite Surveying, Digital Photography

Hand held surveying complimented with digital video photography can also be used to provide pipeline progress. Again the accuracy of supply of information improves communication and again the data can be attached to the GIS route for construction records.

As the pipeline route on the GIS is located using the same co-ordinates, the use of hand held satellite survey devices is also, an excellent tool to accurately check, locate and confirm construction, locate welds and produce accurate as built records for future computer based inspection.

4.4 GIS Access to Construction Management

At all times, the ability to access the GIS to locate, and retrieve the relevant estates or engineering data shortens construction delays and makes vast improvements to the construction engineers knowledge. Enabling him to make better engineering decisions on construction methods, construction access. Helps reduced conflicts and disputes with contractors, landowners, local authorities and clients.

It is currently estimated that the GIS information available to construction managers and field staff reduces error and assist in savings of around 10% on the construction budget. Note this is variable dependent on the complexity of the location and the project.

At all times the access to the GIS data for key construction personnel has made management and communications smoother and better. Where GIS has been used the construction teams and the permit issuers feel they benefited from the direct link with the design, the quicker better support and appreciate the additional information and accuracy the GIS has brought to the project.

5 Pipeline Operations

5.1 Current Operation uses.

The GIS is the visual tool for pipeline operations and is ideal for the management of a group of pipeline systems. The larger the number of pipelines or more complexity, the greater benefits from GIS technology, for existing and new pipelines.

The GIS is the intelligence centre of the pipeline operations, or pipeline system operations. Within the GIS is a link to all the intellectual property, pipeline records, geographical information on the companies LAN.

Clicking on the pipeline on the control room operator's pc screen will enable the operator to go to any part of the pipeline. Enable to look at the pipeline and pipeline to showing the live status of the pipeline, the flow and the pressure etc. From there he is be able to open all pipeline records, the land and contact register, the engineering, the operation procedures and the current inspection status of each pipeline.

The GIS as supplied with a newly designed pipeline will contain the fully developed engineering and land database; an electronic data book full of data, containing process data sheets, key communication data, like the pipeline HSE registration; the Pipeline PL2 registration. The engineering line diagrams, flow diagrams, valve data, drawing register and a means to access and display all drawings on that register. The pipeline notification with local emergency services; local emergency response, contact addresses for local land owners/occupier, and all operation and emergency procedures, plus support documentation.

By clicking on key objects on the GIS you will get key procedures, pumps, compressors, Emergency shut down valves, relief valves, patrol and maintenance scheduling frequencies. As the pipeline ages the GIS will supply the information for the process change and hold the records for the modifications, the inspections, and the defect assessment or fitness for service reports.

The SUTL GIS is used for many operation purposes, from valves status on the water system and utility systems, pipeline emergency valve location for emergency operation and control. All data for all registered MAH pipelines on the pipeline corridors and site corridors. (Note: - this data is shared with the local emergency service's vehicle mounted GIS,).

The GIS is also used to assists the permit issuers in their control of modification on the chemical sites and by the operating business's for engineering records and the control and storage of product.

With the use of handheld GIS/GPS tools the operators can now update instantly the pipeline operation status and record the physical status of infrastructure on the routine patrols. The data being fed directly back into the database via downloading of the hand-held devices.

The future benefits in safety, communications with people in the field, reduction of risk and instant response. This means that the pipeline owner-operator can now look at a reduction in his workforce, consider transferring labour from one area to another using the same systems with the cost benefits that this brings.

Again pipeline owners as labour cost increase, will be looking to investing in GIS systems to meet higher and higher legislative requirements for pipeline operations in the western world.

5.2 Emergency Planning and Emergency Audits

Modern pipeline legislation in conjunction with major accident prevention plans, requires the pipeline owner to carry out audits and mock emergency planning exercises, to check the response training in the event of a pipeline leak or rupture.

The use of the GIS, the hand held palm tools and emergency vehicle mounted GIS - GPS are now being used to give the necessary instant access to data to improve safety and produce the best response times.

The GIS is also, used for modeling leak and rupture scenarios and modeling gas cloud and liquid spill dispersals. Using the GIS for incident modeling and dispersal modeling is becoming an essential safety feature in the Chemical industry in the UK.

2 Future Operation Developments.

One of the key future uses of the GIS in pipeline technology is to model flow conditions on multiple pipeline systems and utility supply systems, enabling what if scenarios for valve closures and line failures.

- 1) Modeling who is affect and what supplies can be achieve etc.
- 2) Also the GIS will bring additions like modeling surge in liquid lines, as the route changes the model changes.
- 3) Aerial pipeline temperature surveys analyzing the results of insulation and heat loss form various steam, high temperature product lines and helping to maintain district water supply pipelines.

- 4 Satellite pipeline leak monitoring, and satellite pipeline route patrolling.
- 5 In the future, with the use of the GIS tying into mobile telephones, the office GIS will be able to locate via GPS the location of key equipment, emergency trailers and emergency vans, cranes, operator's vehicles. Anything with GPS and a mobile phone link will be on the GIS; this includes key personnel, and lone workers via their mobile phones. All indicated on the control room GIS 24 hours a day.
- 5 Also, with Web based Pipeline GIS systems the ability to move pipeline teams from one location to another to address revised workscopes, without the workforce requiring to into the office.

These are a few of the possible and highly probable further developments in Pipeline GIS technology, and there are still others that will emerge as we further develop the tool.

6 Pipeline Inspection

Inspection is another area where the GIS and the GPS are key improvement tools in the location and recording of the pipeline status. They can now be used to locate and recording defect on the spot using a hand held GIS/GPS.

This form of reporting enables the computer generation of inspection reports, the automatic, generation of maintenance and assurance workscopes and with the integration of palm defect assessment programs the on location fitness for services assessment of critical defects.

Using a handheld GIS inspection tool enables the inspector to locate defects accurately, produce common logical reports, and have access to all the technical data and previous inspection records on the site, through out the inspection process.

It simplifies inspection and accurately ties the defect to specific locations, which are repeatable, enabling inspectors and SembUtilities Solutions teams to follow the geographical report and carry out the work on the location, with no errors.

The inspection GIS is the same engineering GIS but this time the inspectors have the access to what they need. The basic engineering data, the pipe and material specs etc, The data generated and stored on these tools would be, the NDT records, welding data, hydrotest data, the previous inspection reports, the written scheme of examination and the latest fitness for services records.

SUTL SembUtilities Solutions has well developed inspection databases and handheld inspection tools that fully integrate the recording of field data on the

GIS. Enabling rapid creation of workscopes and distribution of the information to all relevant parties by simply downloading the hand held tools.

In addition SUTL's inspectors have the new SUTL's defect assessment computer program (Defect) which provides fitness for service assessments of defects in compliance with the latest American and British pipeline standards this includes BS 7910 fitness for services assessments. It accurately geographically locates the defect enabling re-assessment through out the life of the pipeline.

The creation of these SembUtilities Solutions tools have reduced inspection costs substantially and improved working practices by more accurate recording of defects. It has also, made it more cost effective by keeping the inspectors out inspecting and reducing in office report writing.

The GIS enables adoption of a more formal Risk Based Inspection, as it provides the tools to accurately assess risk, locate and assess defects and carry fitness for services assessments in compliance with RBI and national standards and regulations.

The GIS and defect assessment software program allows a complete cross check code comparison of the pipeline standards, it en-powers inspectors in the field, to make the decisions and providing the collection of the inspection data to enable independent validation on the information collected. Also, the GIS location provides the additional location information to assess the pipeline stresses to confirm sound fitness for service assessments.

7 Pipeline Decommissioning, reuse, shutdown and abandonment.

Finally the GIS is the ideal tool to provide pipeline decommissioning schemes; product change studies; demolition and removal schemes, ground reinstatement surveys and accurate pipeline abandonment records.

8 SembUtilities Solutions

From the down load of the hand held inspection devices the computer automatically creates the remedial maintenance work break down. This combined with the client's proposed improvements and modifications can very quickly be created into planned workscopes on the GIS, and shared immediately with all parties.

Like wise as in design the necessary drawings can be produced and the overall work over defined and executed efficiently, making a fast efficient shutdown project with the benefit of major cost savings in efficient working practices.

If additional defects or inspection work is generated during the shut down the use of the handheld reporting data again accelerates the response as the GIS can share

this newfound data instantaneously to all relevant parties. Clients, designers, construction engineers, inspectors and project managers can quickly respond to the new found defects and formulate solutions together to keep the shutdowns on program.

9 Conclusion

The GIS has now come of age, the costs have tumbled to a sensible price and with free or near free GIS viewers, and the GIS on the Internet enabling anyone to have a connection and with the simplicity of use of windows, it is becoming the new corporate software that enables viewing, and sharing of spatial and graphical data. Also enables on the object filing, gives access to the companies' database's and can act as an instant graphical communication tool, within and between companies.

Web based GIS technology will replace the viewer and provided each company with a better system and a better platform to make the GIS accessible to anyone and everyone in the company. It will also, enable more out sourcing of the pipeline activities while maintaining full control of the pipeline assets.

The new technology will enable the pipeline files in the office to be taken to the field and be available to operate and communicate directly with the office, without coming into the office. GIS technology will enable the management of very complex pipeline systems, including their terminal pipe work, safely and efficiently using fewer personnel.

GIS is here to stay, it's the pipeline tool of the future and it use will continue to increase revolutionising our current working practices. This will increase and accelerate as more companies realize the benefits and invest in the new technology. It is estimated that as more and more pipelines use GIS technology the man-hour cost will reduce by a factor of 50%.

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Appendix Photographs and GIS images from SUTL's GIS Systems and Projects.