Effective pipeline asset management with GIS

Networks of large transmission pipelines form energy highways. These pipelines carry both natural gas and oil over large distances — from remote locations to cities where the products are actually needed. A robust pipeline network is therefore critical for transferring the finished petroleum products to end-users or dependent industries. At the same time, safety is also a very important concern.

The Government of India in association with the Oil & Gas sector has a strong focus on developing a robust pipeline network in various parts of the country. However, numerous challenges occur in the process of planning and finalizing optimum, safe and constructible pipeline routes.

GIS can help Oil and Gas companies overcome these challenges and achieve unmatched outcomes in pipeline route survey, planning, and execution.

Challenges

The process of planning and implementation of gas pipeline routes includes challenges like rugged terrain, landslide, steep sloping ground, extreme weather conditions like flash flood, snowfall, intense summer, environmental sensitivity, major development, etc. Due to these constraints, normal survey procedures fail to give optimum results in pipeline surveying, planning, and execution.

Therefore, it is recommended that Oil & Gas companies use modern technologies for pipeline route optimization. The process involves 3D Modelling Survey using 0.3m /0.4m High Resolution Stereo Satellite Image, followed by the development of an up-to-date GIS Base map using Digital Elevation Model (DEM) and GIS Database with the help of rapid field validation and ortho-rectifications through photogrammetry.

SECON used Esri's ArcGIS platform to customize such a robust system of Pipeline Geographic Information System (PGIS) involving data of pipeline route survey, planning, and execution for GAIL, India's leading natural gas company, helping it deliver unmatched results across the natural gas value chain.

Solutions

GIS mapping and route survey activities for the cross-country pipeline were carried out using modern techniques of surveying. The objective was to achieve optimization of the pipeline route, selection of the most feasible route, and finalization of project planning for engineering including other pipeline related activities. This GIS database comprises of different map layers and associated tables pertaining to pipeline alignment, stations and facilities, dwellings and structures along the pipeline alignment, pipeline depth of cover, points of interest along the route, etc.

Before the finalization of the pipeline route, paper alignment was optimized and validated with the following considerations:

- Safety of public lives, property, and local impact.
- Minimize environmentally sensitive areas, forests, sanctuaries, marine parks, places of worship, burial and public events, annual fairs, mining areas, archaeological importance, etc.
- Future expansion, developments, upcoming projects, townships, layouts, industrial parks, etc.
- Avoid areas likely to have future expansions, especially around built-up/industrial areas.
- Favorable terrain, stable ground, landslips and geologically sensitive areas.
- High ground, deep valleys requiring tunnels and pylons.
- Avoid low lying, flood prone areas, marshy land and waterbodies.
- River crossings will include shortest length between Bank-to-Bank, cross-river at right angles and river course not meandering.
- Land use, Land cover and prevailing cropping pattern.
- Broad information of type of crops / plantation, land use pattern, etc.

- Realignment requirements including provision for possible alignment / alternatives at congested areas.
- Inventory of corridor, terrain, existing road/ railway track details, bridges and structures (type, size and location), intersections and crossings.
- Existing utility services along the alignment (within 300m - 500m corridor).
- Inventory of the existing structures within the 300m corridor.
- Capturing existing NGCPs & GTS BMs at site with photographs and descriptions.
- Identification of best suitable locations for DGPS Control Point with Location sketch.

The process of preparation of up-to-date Base Maps for optimum pipeline route planning and execution included the following steps:

- Procurement and Processing of 0.4 m High Resolution Stereo Satellite Images (HRSI) covering 1.5 Km on either side of pipeline.
- Establishment of Ground Control Network with DGPS
- Post-processing, Geo-metric, Radiometric Corrections, Orthorectification of Satellite Images, Digitization, Vectorization and Compilation and site validation.
- Finalization of pipeline alignment with various options, merits and demerits of each route and approval from competent authority.
- Fixing of pipeline route on ortho-rectified satellite images.
- Generation of Profiles / Alignment Sheet using Ortho-rectified satellite image /DEM.
- Generation of Cross Section drawing from DEM.
- Transferring of Pipeline alignment from HRSI to Ground for VALIDATION /Verification and Fixing of Route.
- Stacking of pipeline route and Monumentation of pillars.
- Population density index survey and class location survey for engineering and designing of pipeline.
- Soil Resistivity Survey, Soil Stratification and Corrosion Survey along the selected route and integration of data / reports in PGIS software.
- Cadastral Survey, geo-referencing of maps and integration of Land Acquisition document for Rights of Land (RoU) Acquisition with PGIS.
- Submission in hard copies and .shp files for entire project deliverables including integration with GIS system.

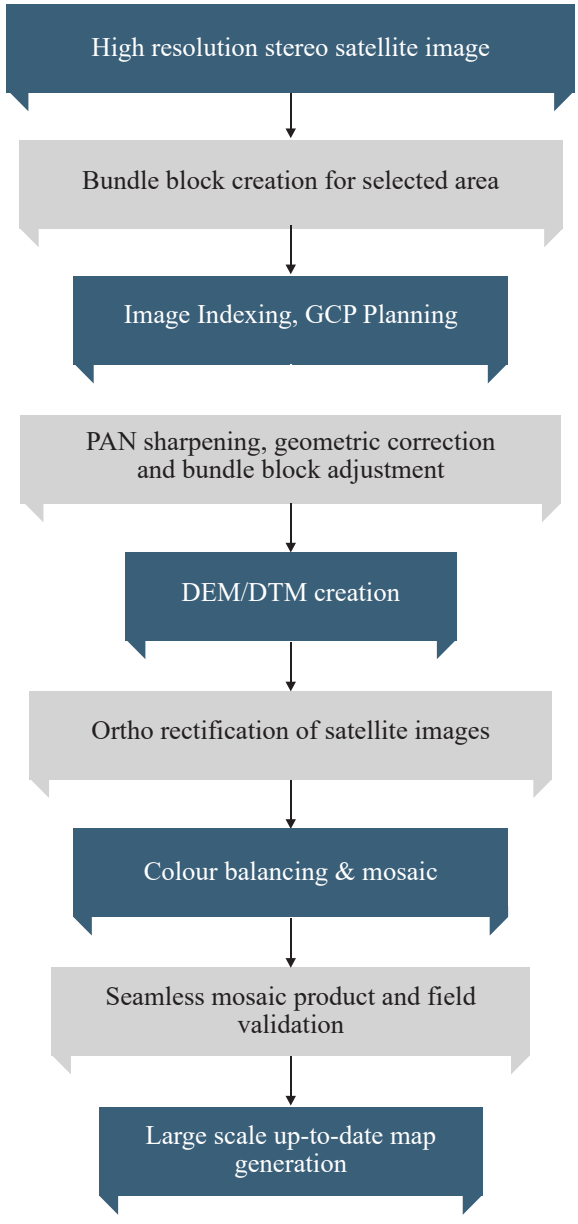

Fig 1: Process Flow Chart for Preparation of Up-To-Date Base Map

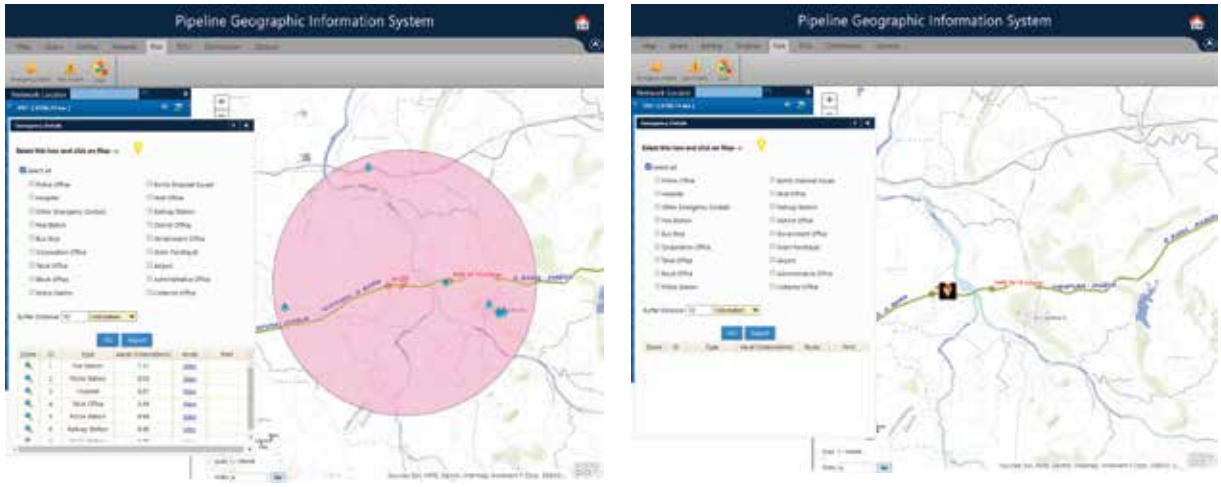

Fig 2: Pipeline Geographic System

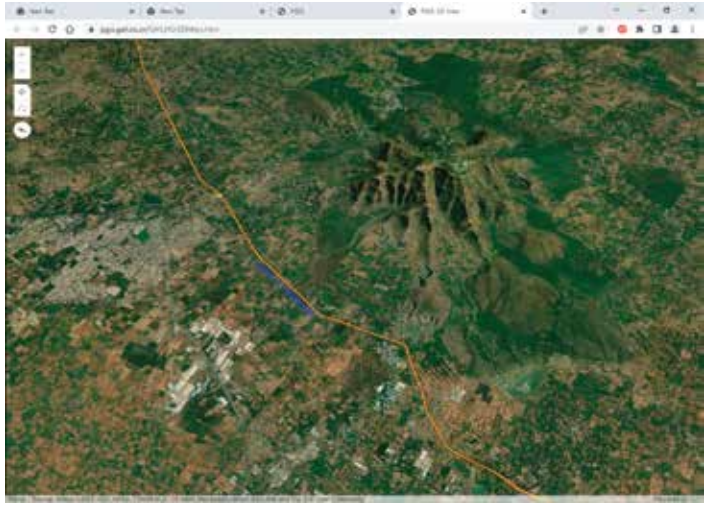

Fig 3: Pipeline 3D View

Outcomes

The innovative technologies, based on Esri's ArcGIS brought unmatched excellence in the pipeline route management process. The Alignment Profile and DEM Generated using HRSI were useful for planning the pipeline network. The up-to-date base map prepared using High Resolution Satellite Images and Digital Elevation Model (DEM) generated for AOI included information like land use information, terrain, vegetation information, topographical features, dwelling, developments, etc. along the pipeline, administrative jurisdiction, important locations, access to emergency location and more. The maps could help during emergencies, specific affected locations can be identified easily using DEM and also residence/dwellings information. Data integrated with GIS can be used for the updation of Population Density Index (PDI) data, emergency location details from time to time at regular intervals, etc. 3D-GIS converts complex infrastructure networks into easy-to-understand visualization. Also, with the use of GIS, the operation and maintenance of pipeline have also become easier since pipeline sections requiring due attention can become immediately noticeable.