



Mine Inventory Mapping and Management System with Special Reference to Mines and Mineral Act of India in Geospatial Context

I. Introduction

Mining is considered as one of the important component of the economy of a developing as well as developed country. It adds to the national income of a country and generates results in employment. Mining is the process of extraction of valuable minerals or other geological materials from the earth from an ore-body, seam which forms the mineralized package of economic interest to the miner.

In India, Mining Acts, 1952 covers all the part included in the process of mining licensing, ownership, role of both central as well as state government at the same time it provides protecting to the workers through its different provisions which deals with the working hours and the wages of the workers.

As per the Mines Act in India,

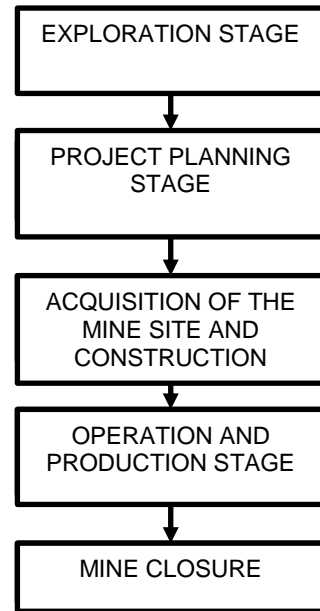
- 'Mine' means any excavation where any operation for the purpose of searching for or obtaining minerals has been or is being carried from the earth by means of tunneling and shafting as well as it includes open working or quarries.
- 'Leased Area' means the area specified in the mining lease within which mining operations can be undertaken and includes the non-mineralized area required and approved for the activities falling under the definition of mine as referred to in the Mines Act 1952;
- 'Mining Lease' means a lease granted for the purpose of undertaking mining operations, and includes a sub-lease granted for such purpose;
- 'Mining operations' means any operations undertaken for the purpose of winning any mineral.

Mines & Minerals (Development & Regulation) Act 1957 says that no mining lease shall be granted by the State Government unless it is satisfied that there is a mining plan duly approved by the Central Government or by the State Government, in respect of such category of mines

as may be specified by the Central Government, for the development of mineral deposits in the area concerned.

To obtain licensing, the lessee need to submit an application accompanied with series of documents along with the prescribed fee to the concerned State Government. It is the discretion of the concerned State Government either to grant or refuse to grant license or lease on the basis of grounds mentioned in the Act. The government grants the license with a time period of the lease for which the license is valid. And after the expiry of the prescribed period it can be renewed.

There are five stages in the mining operation – Exploration, Project planning, Acquisition of mine site, Operations and production stage and Mine closure. There is an enormous requirement for the extraction of minerals which impose pressure on mining industry to continue extracting minerals, while at the same time it is mandatory to comply with environmental and legal compliance issues.



Most mining information has a spatial component that can be represented in a map form, including financial and asset information. Managers and mineral economists are using GIS in their daily activities for the evaluation of corporate assets. All of the tabular data used to assess a mining prospect or existing operation can be spatially referenced and accessed as needed. Geographical information System (GIS) technologies create efficiency and productivity opportunities in all stages of mineral exploration and mining. GIS enables a mineral exploration geologist and mine operator to mine competitively, efficiently, intelligently, safely, and environmentally.

It is important to identify and digitize the mining lease boundaries as per the requirements of Indian Bureau of Mines to prevent encroachment of mining plots and illegal activities. This would yield a complete decision-support system for monitoring mining operations. This can be achieved by preparing geo-referenced maps of the required areas of interest demarcating the mining lease boundaries along with the integration of the survey maps with satellite imagery.

II. Problem Statement

Every state in India has several mining leases. Due to high demand of specific minerals in the market and cater to the demand of the industries many illegal mining activities are carried out for generating revenue through alternative malpractices. In the process the state government loses a lot of revenue from legitimate sources. The geology and mining department of the state government has initiated verification of the mining lease boundary by resurveying the lease area and then comparing the same with the earlier approved lease map to check the discrepancies, if any. Through conventional techniques it requires lot of time and manpower.

III. Problem Analysis

The conventional process takes plenty of time and manpower. The modern technology using differential GPS (DGPS)/ Electronic Total Station (ETS), integrated with 360 degree panoramic

imagery and LiDAR sensors, remote sensing technique (interpretation of high resolution satellite image) in a GIS environment can provide quick solution to the entire process. Just preparation of these maps is not enough. These are to be uploaded in the server and disseminated over the web to the stakeholders. The system and the maps need to be periodically updated.

IV. Approach

The following are the steps that need to be followed

1. The Mining Lease / Prospecting License boundary showing all Khasra numbers / Survey Nos. on a Cadastral Map (Khasra Plan) on a scale of 1:3960 to be prepared
2. The boundary pillars of each mine lease / prospecting license are to be fixed precisely. Each boundary pillars shall be surveyed using DGPS (at least 2 Hours observation) for its ground position.
3. The Geo-referenced mining lease / prospecting licenses map prepared using DGPS to be superimposed on Geo-referenced vectorised cadastral map.
4. On integration, the Geo-referenced mining lease / prospecting licenses map to be duly matched with geo-referenced vectorised cadastral maps.
5. In case of forest areas, the boundary pillars shall be fixed on ground with reference to at least three permanent ground features in and around mining leases / prospecting licenses.
6. The geo-referenced mining leases / prospecting licenses map to be superimposed on latest high resolution satellite data (cloud-free) derived from merging of Cartosat-2 and LISS-IV (Scale 1:5,000) covering an area of 500 meters from the mining lease / applied area boundary. (The satellite data products are available from NRSC, Hyderabad)

The Survey of existing leases (major and minor) , mapping of exploration and mineral bearing areas and mapping / digitization of cadastral maps, land-use land-cover using cadastral maps & toposheets will act as a layer.

As a practice and policy, the superimposed output in the form of soft copy and hard copy to be submitted along with the Mining plan / Scheme of Mining / Progressive Mine Closure Plan and Scheme of Prospecting. The soft copy submission should be in the standard format and digitized maps should be in shape file, which can be imported in any GIS database. The maps produced abiding by the procedures in six points acts as a base for preparation of all statutory as well as working plans of the mines.

Once the map layers are ready they need to be hosted on the internet through a secured data centre to disseminate the services to all the stakeholders

- Design Enterprise GIS architecture to meet the requirements of the state Geology and Mines department
- Supply & installation of GIS Platform for creation, storage and maintenance of geospatial data
- Design and create GIS data model for enterprise wise GIS
- Design of Enterprise GIS application for state department having modules catering to exploration, enforcement and administration departments.
- Integration with existing state department systems and applications

- Testing, training and Go-Live of the system.
- Post-implementation software enhancement, customization & maintenance of GIS platform

As part of the Lease hold area/ mineral bearing / exploration area falling under the jurisdiction of The state government, the envisaged Enterprise GIS Solution to provide:

- Map for one-stop view encompassing integrated solution.
- Ease of visualization for enforcement team under state geology and mines and other law-enforcement departments.
- Visualization of lease-hold and mineral bearing areas.
- Visualization & collation of exploration data and to support exploration activities, including mapping of exploration level wise areas, and integrating Revenue, Forest and other maps.
- Locate, track & evaluate Assets with GIS combined with GPS technologies.
- Spatial-analysis of lease data vs royalty with other parameters. Location tracking of lease owned areas while generating the royalty.
- Geo-tagged grievances from the field.
- Superimposition of different layers for Geospatial and Proximity analysis for identification of areas that can be put on auctioning and improved turnaround time.

V. Components of the Solution

- DGPS survey of the Mine lease boundaries
- Satellite imagery procurement
- Data creation
 - Geo-referenced images and maps
 - Digitized maps
 - GIS & MIS data linkages

Methodology includes delineation of mining lease boundary within a specific duration of time and then technically comparing the same with the earlier approved lease map. It is like a change detection techniques. The steps involved are DGPS and ETS survey, ortho-image preparation, digitization and geo-referencing of cadastral revenue maps, original mining lease map and their integration in a GIS environment. For preparation of Ortho-image high resolution satellite stereo pair image of Worldview II needs to be procured from National Remote Sensing Centre, Hyderabad having a spatial resolution of 0.5 m. which needs to be integrated along with 1.8 mts. multi-spectral image. Co-ordinates of Ground control points need to be collected from the established and network adjusted points of Survey of India as well as control point network (4km x 4km) created under State Cadastral I Resurvey Project using dual frequency DGPS. Industry standard Photogrammetry suite needs to be used for generation of DEM as well as ortho-image for this study. With the help of ortho-image, the approved mining lease map is geo-referenced after digitization. The interior angle, distance and bearing from the reference point used during the initial survey for preparation and pillar demarcation of the mining lease map is also considered at the time of geo-referencing.

Revenue cadastral maps of the area needs to be digitized and geo-referenced with the ortho-image taking the various junction points (which are easily identifiable in the ground) of the roads, ponds and the habitation area of the cadastral map with the corresponding features of

the image. To assess the present situation (actual possession) of the lease pillars and lease boundary the survey needs to be carried out by dual frequency DGPS to first transfer the established GCP to temporary GCP's within the mining lease area by way of extension from nearest GCP, through RTK mode of observation. Subsequent observations on each boundary pillar of the mining lease area to be undertaken by taking reference from the temporary GCP's established.

Precise geo-coordinate of the pillars in the mining lease area are to be observed to make a close survey of all the pillars of the mining lease area using dual frequency DGPS in RTK mode / ETS from the temporary GCP. Then lease boundary vector in the form of shape file needs to be prepared using the coordinates of the pillars in geographic lat./long. as well as UTM projection with WGS 84 spheroid and datum.

GIS analysis The surveyed boundary shape file from DGPS/ETS survey, geo-referenced cadastral village boundary, geo-referenced mining lease boundary are to be superimposed on the ortho image in GIS desktop platform.

Application Development

The web based application development should have these functionalities

- A GIS enabled web based Application for Land Information System developed using GIS server and Microsoft silverlight
- Add/Delete/Update the GIS geometry and MIS information
- Searches based on proximity features, attributes and user defined queries with Query Builder
- Attach/view Land/mine related documents to land/mines geometry
- Output in the form of reports, map prints
- All commonly used GIS functionality e.g. navigation (zoom in, out, etc.), measurement, overview, identify etc.

Business Impact and Value differentiators:

- Centralized unified view of GIS data (parcel, mining lease etc.), MIS data (owner, registration info), attached property documents.
- Role base and geographic extent base, access mechanism.
- Varied analysis/search mechanism i.e. proximity analysis, query builder, buffer & attribute search
- Online editing of GIS and MIS data
- 20+ category of documents linked with GIS data with batch linking options
- Khasra record maintenance for updating owner, and other khasra information
- Satellite, cadastre raster display overlaid by vector data
- 40 different reports for head office and unit users
- Hard copy printing of the maps

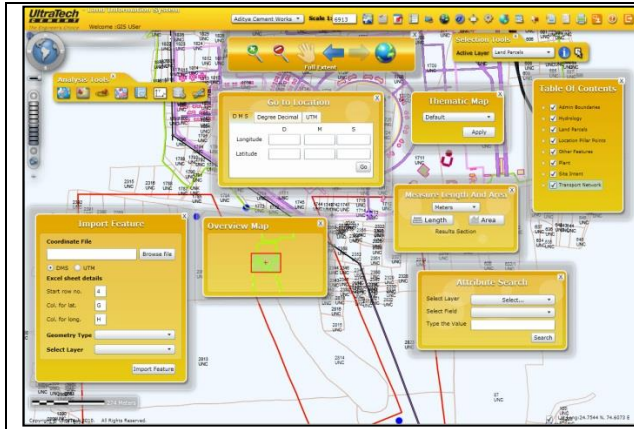


Figure - Basic GIS functionalities

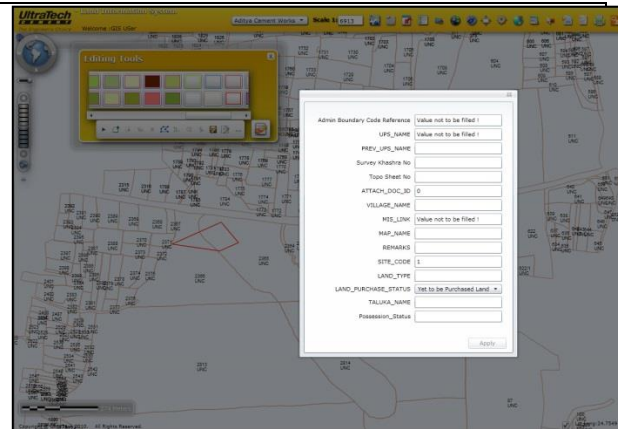


Figure - Online Editing of geometries and their attributes

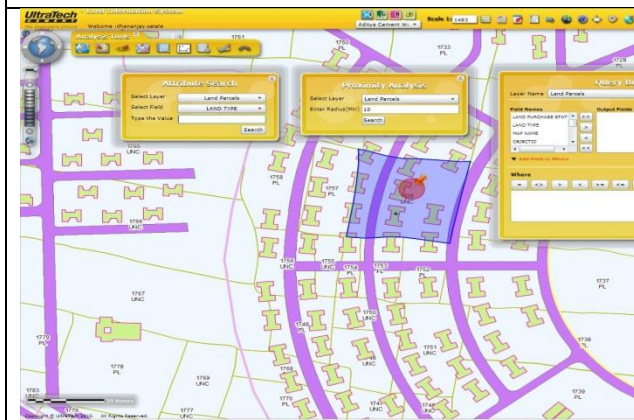


Figure - Update text boxes for all khasra related changes

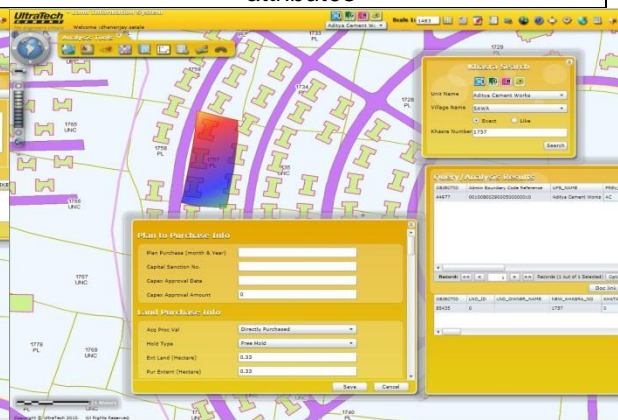


Figure - Query Builder for Mine lease related queries

VI. Benefits to the Stakeholders

State government has their various mines scattered all around the state. By superimposition of the lease boundary with the satellite datasets, it can be assessed that if the mining activities are taking place within or also outside the lease boundary. Once integrated with the Cadastral datasets, then the ownership details of the neighboring plat of lands can be known very easily. It is possible to update all the khasra related changes i.e. changes in the khasra e.g. purchase status, acquisition status etc. along with owner information of the khasra in a single system based on land purchase or for fresh lease applications.

VII. Summary

All mining lease area can be geo-referenced into a single co-ordinate system for the entire state. For all future grant of leases the same system should also be adopted so that there is uniformity in the system irrespective of the individual or agency conducting the surveys and boundary discrepancies can be avoided. The mine plan can be prepared accordingly as each and every point within the lease will be referenced.