



**7-9 February, 2012**

**THEME: Geo-Budget: Enabling Sustainable Growth**

**Mining Lease Survey using Hybrid Technology  
i.e High Resolution Satellite Image, DGPS and ETS  
– A Case study on Thakurani Iron Ore Mines, Barbil,  
Keonjhar, Orissa, India.**

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***Abstract***

Growth and prosperity of a nation depends on the search, development, governance and management of its mineral resources. Due to increased competition, liberalization and globalization worldwide, the market for minerals have been growing both in diversity and magnitude terms. The minerals and mining industry is a key segment of the Indian economy, with India being highly endowed with vast mineral resources. Orissa is one of the largest mineral bearing states in India which has approximately 600 mines and over 2400 people and firms involved in mining or trading in mineral product. Mining in India is in news almost everyday unfortunately for the wrong reasons and Orissa is in shadow of perhaps one of its biggest mining scam i.e. illegal mining. The Mines Department in the state has begun verification of the mining lease boundary, for which a survey is required within the stipulated time. The traditional methods of survey to delineate and demarcate the mining lease boundary with reference to the earlier cadastral base mining lease map are time consuming. Further, the traditional surveys are “Unprojected” Surveys, hence linking them to topographic maps is an involving task. The modern survey technique using Differential GPS with geo-referenced high resolution satellite image can overcome this limitation in a GIS environment and as a result the cadastral maps can be geo-referenced.

The present paper based on a case study in Thakurani Iron Ore Mines Lease area of Barbil, Keonjhar district highlights the processing methodology involved for delineation of mining lease boundary within a stipulated time and later technically compare and authenticated the same with the earlier approved lease map. The steps involved in this process are DGPS and ETS survey, ortho-image preparation from high resolution stereo pair image using network adjusted DGPS control points, digitization and geo-processing of cadastral revenue map, original mining lease map and their integration in a GIS environment.

This study highlights the possibilities that geospatial system can now offer a solution to the administrators, surveyors and most importantly to the Lessee of the Mines during the renewal as well as fresh application for mining lease and activities. Further, this gives the advantage of any other geo-referenced information related to mining and enable advanced mineral management by geo-referencing the individual mining belt into a single database creating a suitable environment for easy monitoring mechanics.

**Introduction**

Orissa holds a pre-eminent place amongst the states of India in mineral resources with large deposits of major and minor minerals and the receipts from mines and minerals constitute the largest source of revenue of the state. There are a total of 605 mining leases covering an area of 99,932 hectares in the state and considered as one of the most

profitable sectors. To cater to the demand of the industries illegal mining activities has been practised in many places in the country and Orissa is one of the victims of the illegal mining activity. In the process the state loses a lot of revenue. Thus, the mining department has begun verification of the mining lease boundary by resurveying the lease area, then by comparing the same with the earlier approved lease map, which requires a lot of time and manpower from various departments by conventional verification process. The modern technology using differential GPS (DGPS)/ Electronic Total Station (ETS), remote sensing technique (interpretation of high resolution satellite image) in a GIS environment can be a suitable method to solve the above problem in a cost and time effective manner.

The present paper based on a case study taken as a pilot project for Mining Department of Government of Orissa in Thakurani Iron Ore Mines (Sarada Mines) lease area of Barbil, Keonjhar district. The study highlights the methodology involved for delineation of mining lease boundary within a stipulated time and later technically comparing the same with the earlier approved lease map. 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.

### **Study Area**

Thakurani Iron Ore mines having a lease area of 947 ha.(Fig-1) is situated in Joda-Barbil Mining circle of Keonjhar district of Orissa which is well connected by roads and railway from Jamshedpur (150 km.), Rourkela (140 km.) and can be approached by National highway from the district headquarter Keonjhar (80 km.). The area presents a highly rugged landform and can best be described as ridge and valley topography belonging to the Koida-Noamundi Group of rocks, is a part of the famous horse-shoe shape (U shape) synclinorium (Iron Ore Super Group). The iron ore deposits are associated with the banded iron formation (BIF) and are structurally deformed with the parent rocks.

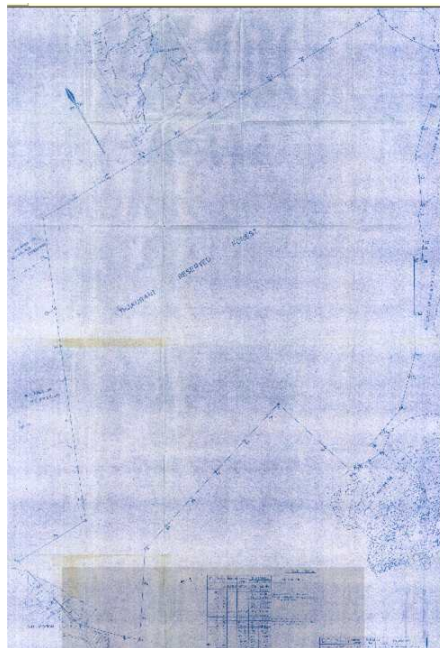


FIG-1

Scanned Map of Mining Lease Area  
Of Sarada Mines, Joda, Keonjhar

## Methodology

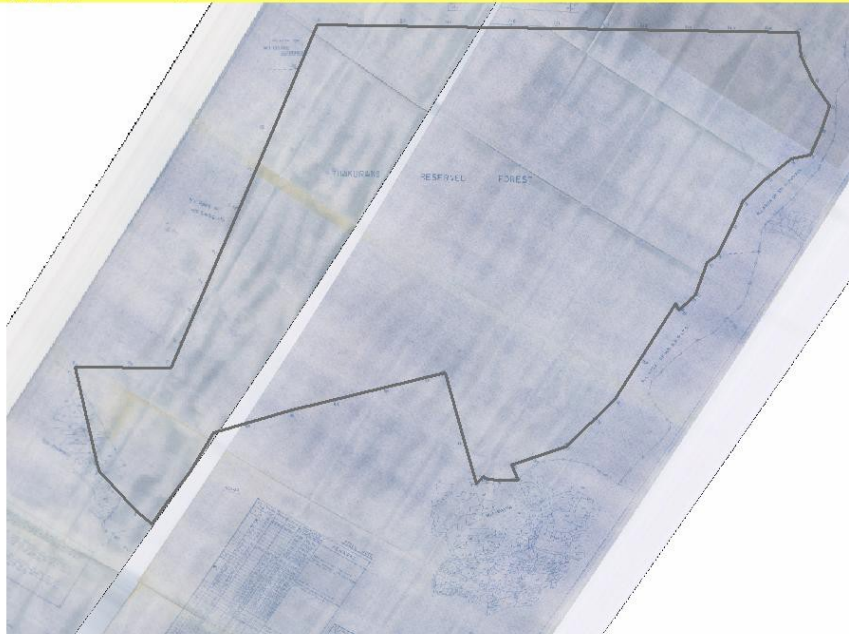
### Ortho-image Preparation

The study area falls in a high relief and hilly terrain. Ortho-image is required to maintain the planimetric accuracy. For this purpose high resolution satellite stereo pair image of Worldview II with a spatial resolution of 0.5 m. has been obtained along with 1.8 m. multi-spectral image. Co-ordinates of Ground control points have been collected from the established and network adjusted points of SOI as well as control point network (4km x 4km) created under NLRMP project under Cadastral Resurvey Project using dual frequency DGPS for Keonjhar district. Leica Photogrammetry suite was used for generation of DEM as well as ortho-image for this study. This software uses bloc triangulation procedure taking the internal and external orientation using both sensor recorded DGPS observations from the header files of digital stereo pairs as well as GCPs taken from the study area. The RMS for the triangulation was .300 pixels. DEM of spatial resolution of 2 m. was created which was then edited properly to create a good surface image. The ortho image was created using the raster DEM as well as digital stereo pair images of spatial resolution of .5 meter. The multi spectral data of WV-II was ortho rectified using DEM created using PAN WV-II stereo data and resolution merge of both MX and PAN created having 0.5 meter spatial resolution for this study.

### Geo-referencing of Maps

Taking 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(Fig-3).

**FIG-3 Mining Lease Map – Geo Referenced with DGPS Surveyed Points**



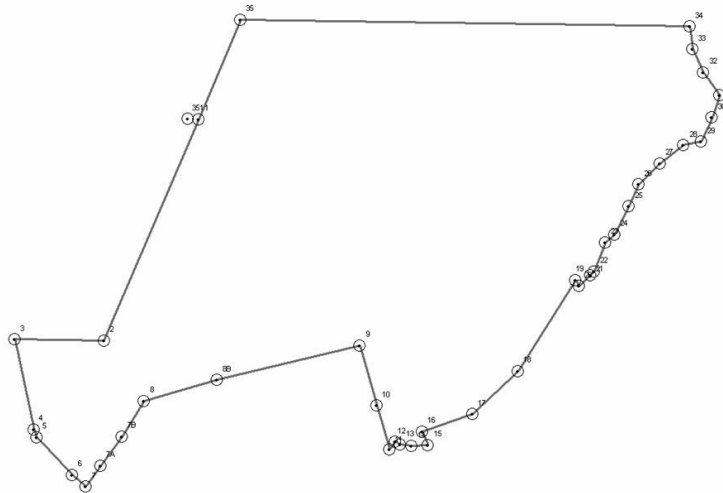
Revenue cadastral maps of the area are digitized and geo-referenced with the ortho-image taking the bijunctions, trijunctions, roads, ponds and the habitation area of the cadastral map with the corresponding features of the image.

## DGPS/ ETS survey of lease boundary

To assess the present situation (actual possession) of the lease pillars and lease boundary the survey has been 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 have been undertaken taking reference from the temporary GCP's so established.

Precise geo-coordinate of the pillars in the mining lease area are 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 was prepared using the coordinates of the pillars in geographic lat./long. as well as UTM projection with WGS 84 spheroid and datum(Fig-2).

**FIG-2 Mining Lease Boundary Prepared From DGPS Surveyed Points**



## GIS analysis

The surveyed boundary shape file from DGPS/ETS survey, geo-referenced cadastral village boundary, geo-referenced mining lease boundary have been superimposed on the ortho image in ARCGIS(Fig-5). The perimeter and area of different layers were analysed (Fig-4).



Mining Lease Boundary – Prepared from DGPS Surveyed Points and from Angle & Distance specified over Lease Map  
FIG-4

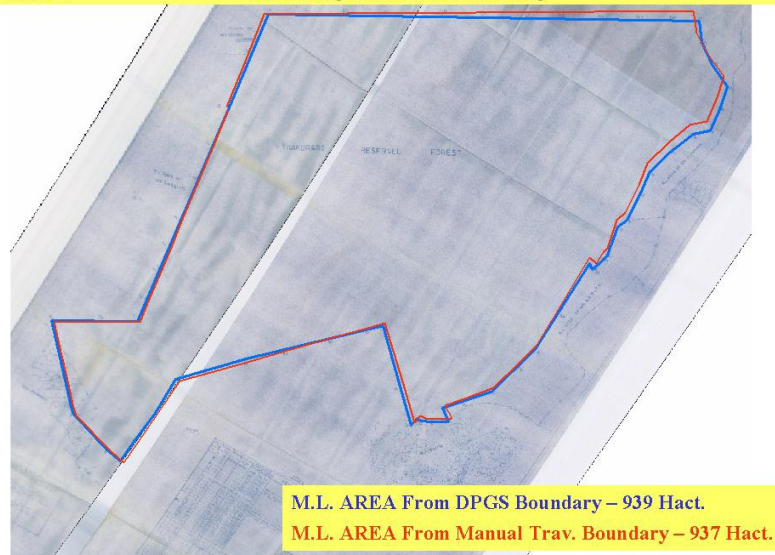
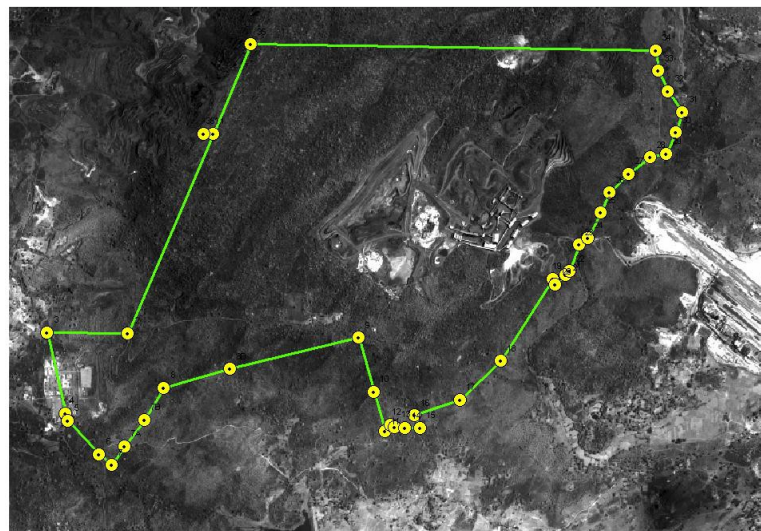


FIG-5 DGPS SURVEYED BOUNDARY SUPERIMPOSED OVER ORTHO IMAGE



The area from different sources are shown below

Lease area as per record	- 947.00 ha
Lease area from DGPS/ ETS survey	- 937.00 ha.
Lease area from existing lease map	- 938.35 ha.
Lease area from angle & distance calculation	- 939.65 ha.

### Results and Conclusion

Results obtained from the present study show that there is a slight difference in area allotted to the lessee and actual area found from the survey. The difference may be due to the survey technique used during allotment time and present high precision survey. However, any difference in allotment area and possessed area can be differentiated by this method. It is also observed that the different methods of lease boundary extraction are fitting to the ortho image where the lease boundary is clearly visible on the image at many places due to boundary clearance. It is difficult to interpret the boundary solely from the ortho image itself.

The study highlights the possibilities that all the mining lease area can be geo-referenced into a single co-ordinate system. This will work as the base line data in future to have a solution to the administrator, surveyors and most importantly to the lessee during any boundary discrepancies. This will lead to a proper mine plan preparation as each and every point within the lease are referenced. Further this gives the advantage of linking any other geo-referenced information related to mining activity to design individual mineral information system as well as a single database system for the mining belt. The mine plans can also be attached to this information system.

This type of database will help to assess and monitor the mining area in terms of revenue, environment and development.

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