Department of Mining Engineering
ISM Dhanbad

Role and Relevance of Geospatial Technology in Mining Sector

Welcome !

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- The implementation of novel systems and adoption of improvised equipment in mines help mining companies in two important ways: enhanced mine productivity and improved worker safety.
- There is a substantial need of adoption of state-of-the-art automation technologies in the mines to ensure the safety and to protect health of mineworkers.

IT in Mining Industry

During 1960s

mini ERP comprising of preparation of pay rolls, listing of store items, manpower control etc

During 1970s

designing of civil engineering constructions, laying of tracks, roads, etc

During 1980s

MIS, MPS and TDS

During 1990s

GPS and GIS (a visualizing technology that captures, stores, checks, integrates, manipulates and displays data using digital mapping)

Major Application of Geospatial Technology in Mining

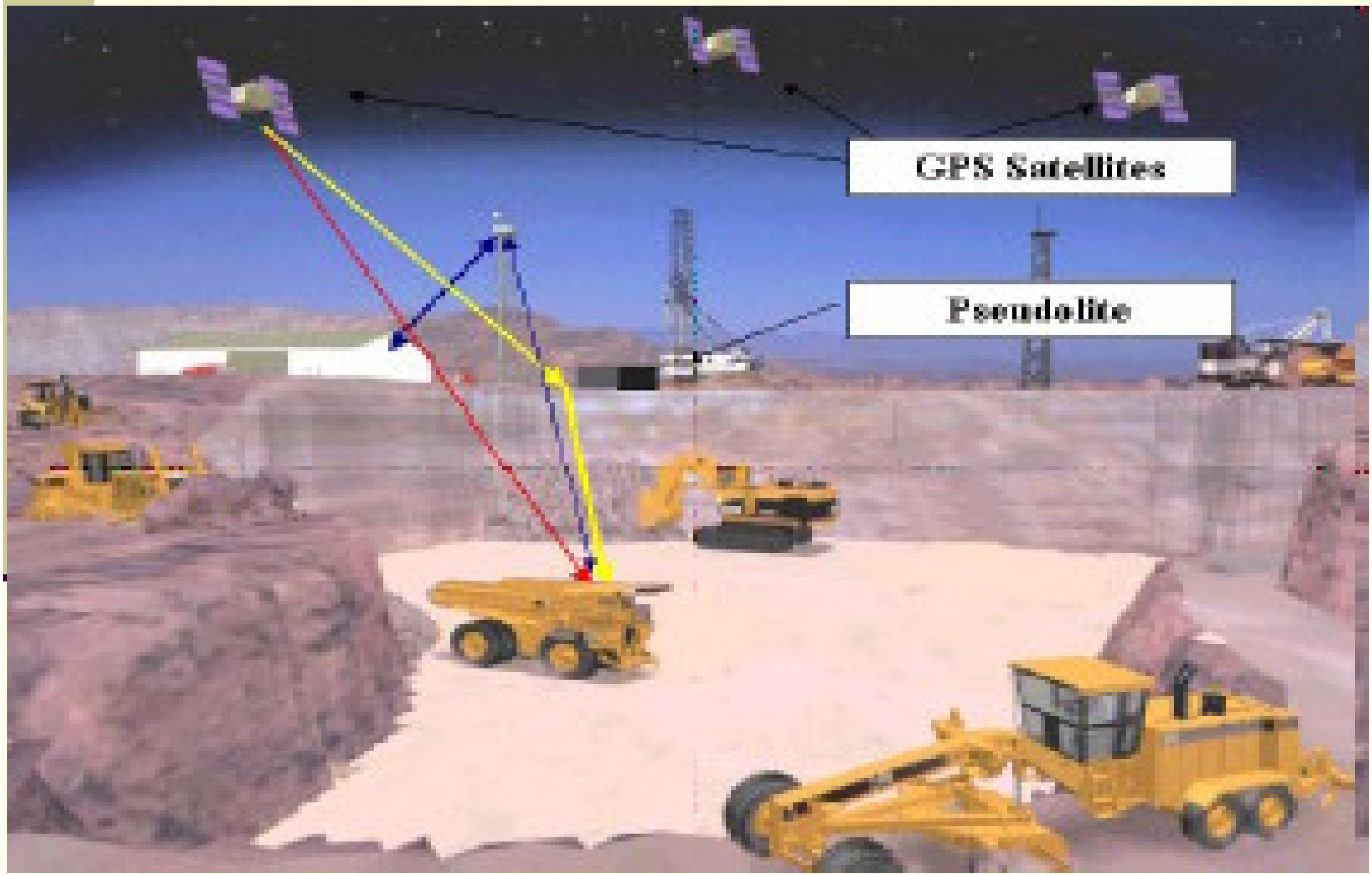
- Semi Automated /Automated Systems
  - Machine health and maintenance monitoring
  - Geo-sensing and artificial intelligence
  - Systems safety and human factors
  - Automated loading, transport and dispatch systems (OITDS)
  - Global Positioning Satellite applications
  - Monitoring of Dump slope stability in an opencast mine using 3D laser Scanners & Slope Stability Radars
  - Remote Survey Vehicles

- GPS, GIS & Remote Sensing: Mine positioning, facility locations and layouts, land use patterns, reclamation & rehabilitation planning
- Alignment and orientation surveys

GPS based systems

- These systems require all mobile equipment to have a GPS receiver, thus allowing having absolute real time position information of the equipment
- Fatalities among equipment operators in open pit mines can be reduced if GPS technology is incorporated in their machines

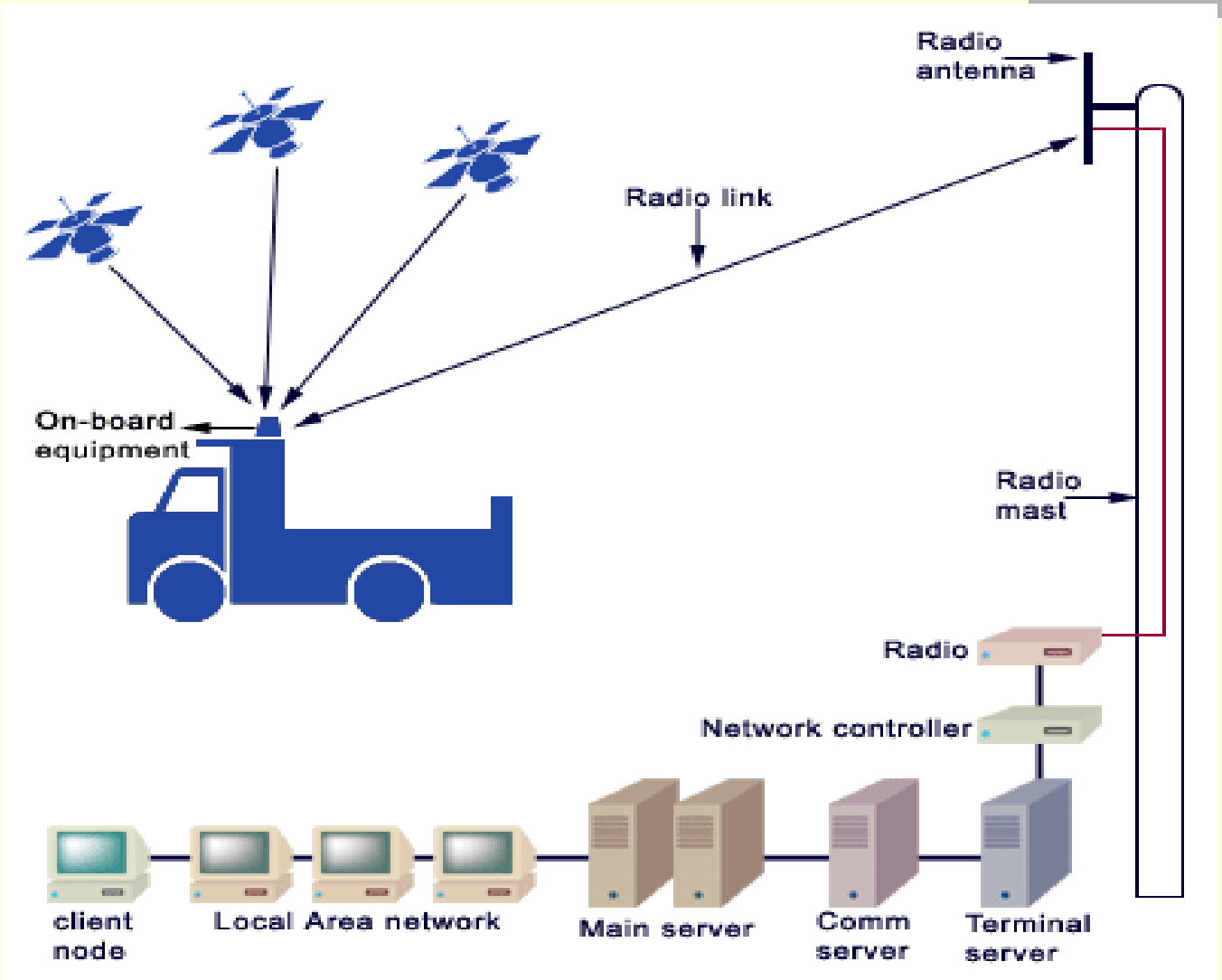
GPS based systems



DynaMine: Online Truck dispatch system (OITDS): a Case Study (CMC Ltd)

- A global positioning system (GPS)-based, operator-independent truck dispatch system (OITDS) suitable for open cast mines at Jayant, NCL
- The Mine handles 30 million cubic metres of mine overburden (the waste product generated during mining operations) and around 10 million tonnes of coal in a year.
- It has a fleet of 15 excavators with a capacity ranging from eight to 14 cubic metres, 50 trucks of 85-tonne capacity and 30 trucks of 120-tonne capacity.
- The OITDS system covers the entire fleet of excavators and trucks.
- This system was conceptualized in 1999 and was implemented in September 2002

DynaMine: Online Truck dispatch system (OITDS): a Case Study (*CMC Ltd*)



DynaMine: Online Truck dispatch system (OITDS): a Case Study (*CMC Ltd*)

- Global positioning system (GPS)-based on-board equipment with voice and data communication facilities and vital signs monitoring devices (VSMDs) is mounted on the excavators and trucks.
- Three communication masts with repeaters are installed at strategic locations to ensure reliable radio communications over an area of around 20 sq km, covering the entire mine.
- Fibre-optic cables are laid over a length of 18 km for LAN connectivity between the main control room and various user locations.
- Around 25 clients are connected to the host application and database server for online monitoring.

DynaMine: Online Truck dispatch system (OITDS): a Case Study (CMC Ltd)

- The system is integrated with the attendance recording system for the operating staff based on card swiping, and manages an automatic crew-mining equipment-allocation facility.
- The system directs each truck to move on optimised route, increasing productivity through a dynamic programming technique.
- The system tracks the movement of mining equipment and maintains a register of warnings

GPS BASED TDS

DAILY SHIFT REPORT

For Date: 08-05-2007 **Shift:** A

Dumper ID	Avl. Hrs.	Opt Hrs.	Avl %	Util %	Trips	Tonnage	TPH
O402	8.0	0.0	100.0	0.0	4.0	200.0	
O403	8.0	0.0	100.0	0.0	6.0	300.0	
O404	8.0	0.0	100.0	0.0	3.0	150.0	
O407	8.0	0.0	100.0	0.0	9.0	540.0	
O408	7.9	0.0	99.8	0.0	8.0	480.0	
O414	7.9	0.0	99.8	0.0	5.0	300.0	
O415	8.0	0.0	100.0	0.0	7.0	420.0	
Total	55.8	0.0	99.94	0.0	42.0	2390.0	Infinity

			Dumping		Out	Stock		Tonnage	Output	Avl %	Util %
Shovel ID	Avl. Hrs.	Opt Hrs.	LRP	NDCMP	Dump	LRP	NDCMP	Handled	in TPH		
E552											
E557											
E559			60.0	290.0	1010.0			1360.0			
E560											
E562			150.0	100.0				1260.0			
E563	7.9				930.0			1180.0		99.7	

Signature (Shift Incharge): _____

DECISION MAKING IN THE MINES DEPENDS ON

- GRAPHIC INFORMATION i.E. Mine plans of various types.
- Information derived from data either collected from field or known from other sources.
- Visual inspection of the site.
- Past information available from records.

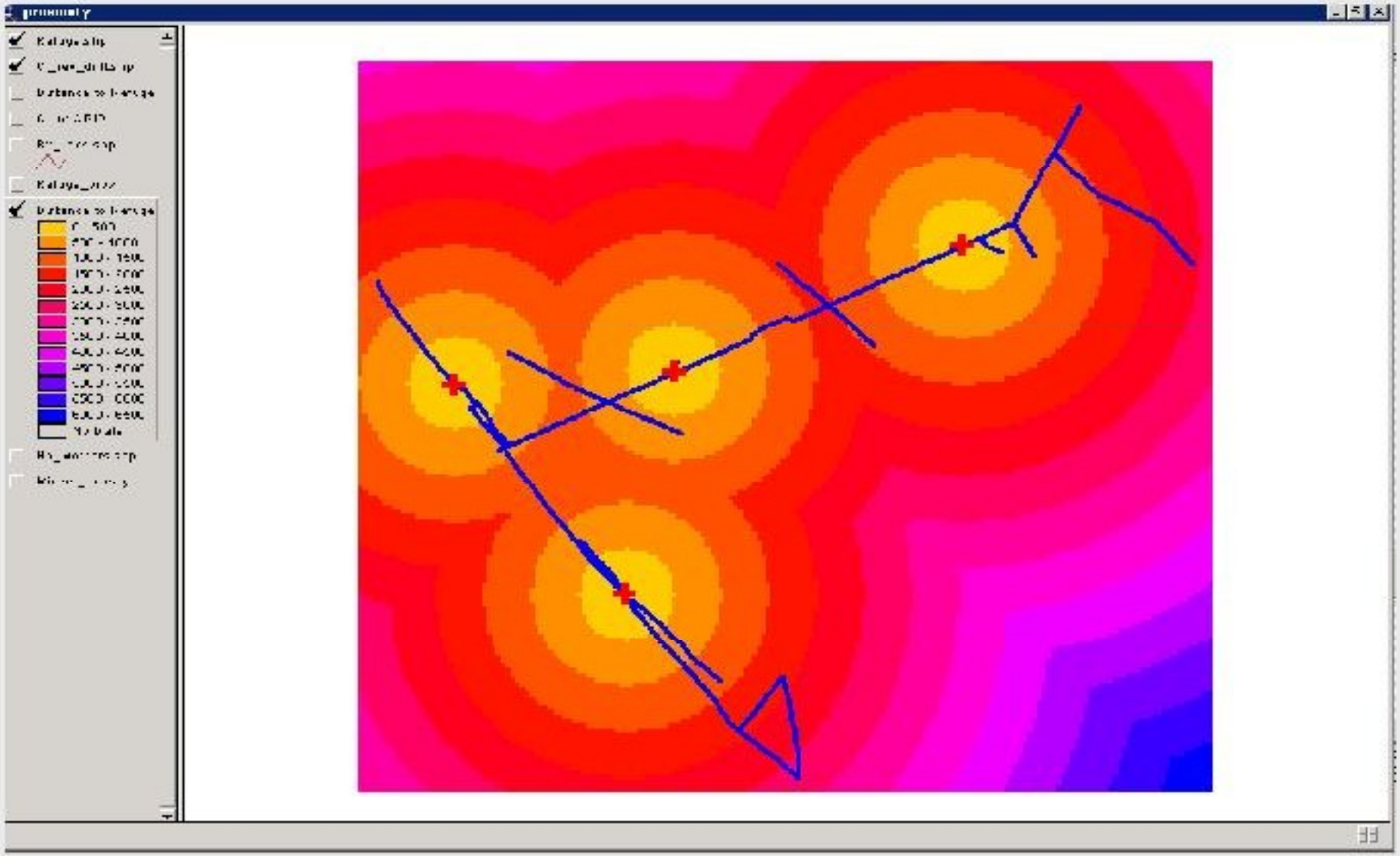
GIS & Remote Sensing

- GIS can contribute in providing a safe working environment in underground mining by performing network analysis and determine the appropriate sites for refuge chambers and facilitate the prompt evacuation of mine personnel

- GIS and remote sensing assist the planners in identifying natural hazards such as potential landslides, floods, and earthquakes prior to the construction of production and housing installations

- GIS can be also used for the selection of a housing site that meets safety, scenic, and recreational requirement within reasonable proximity to the mining operation

Safety – Grid: Distance to Refuge Chambers

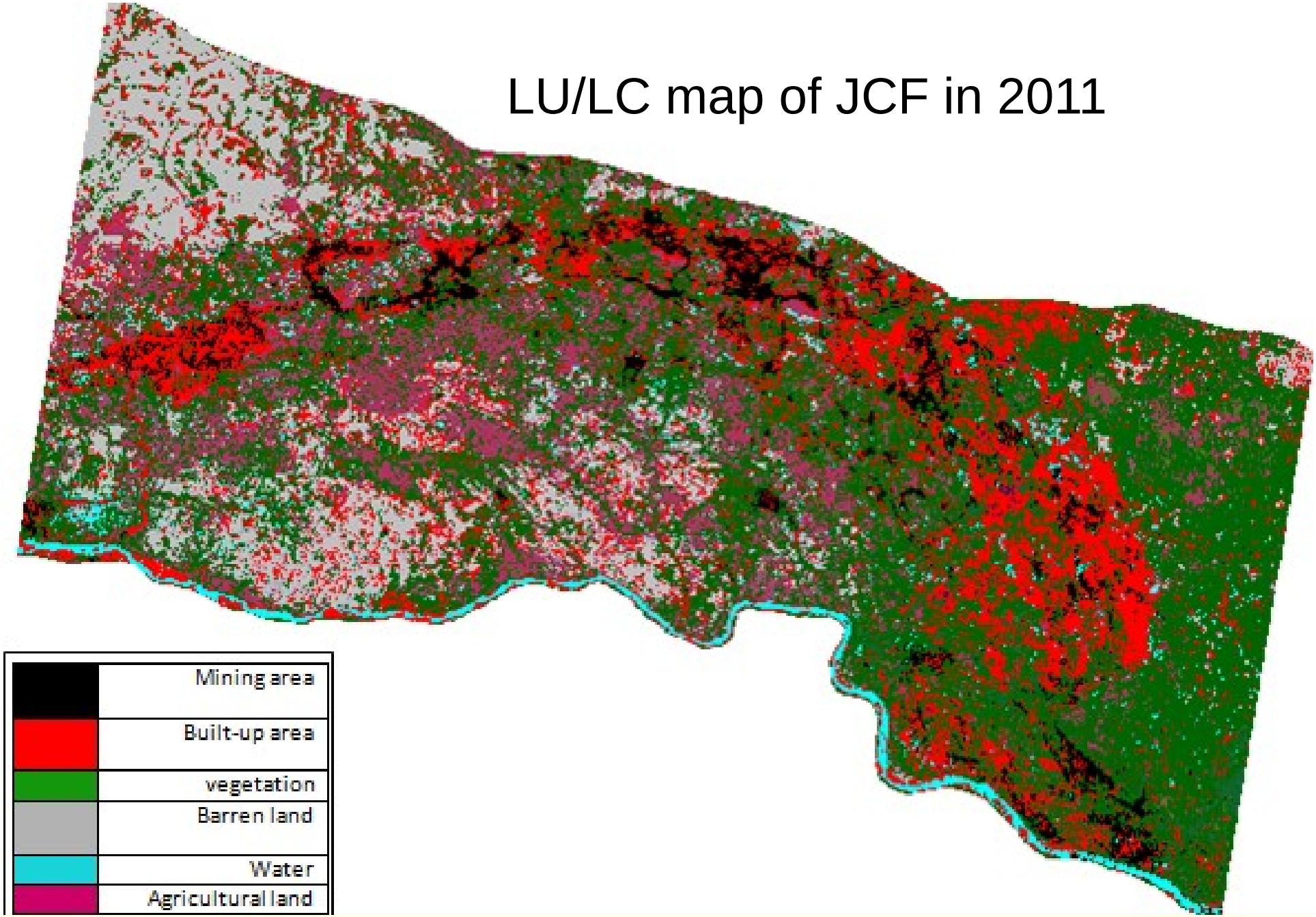


GIS and Remote Sensing

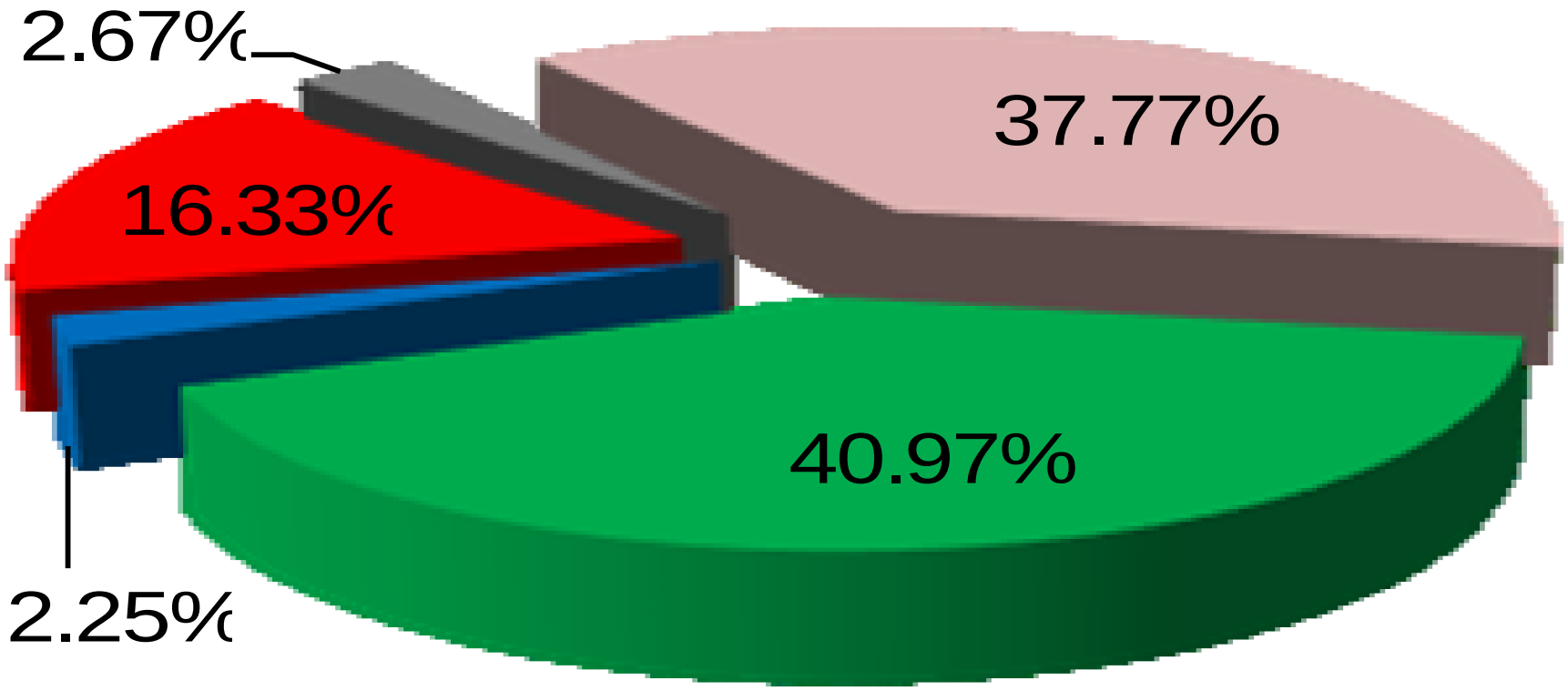
Other applications :

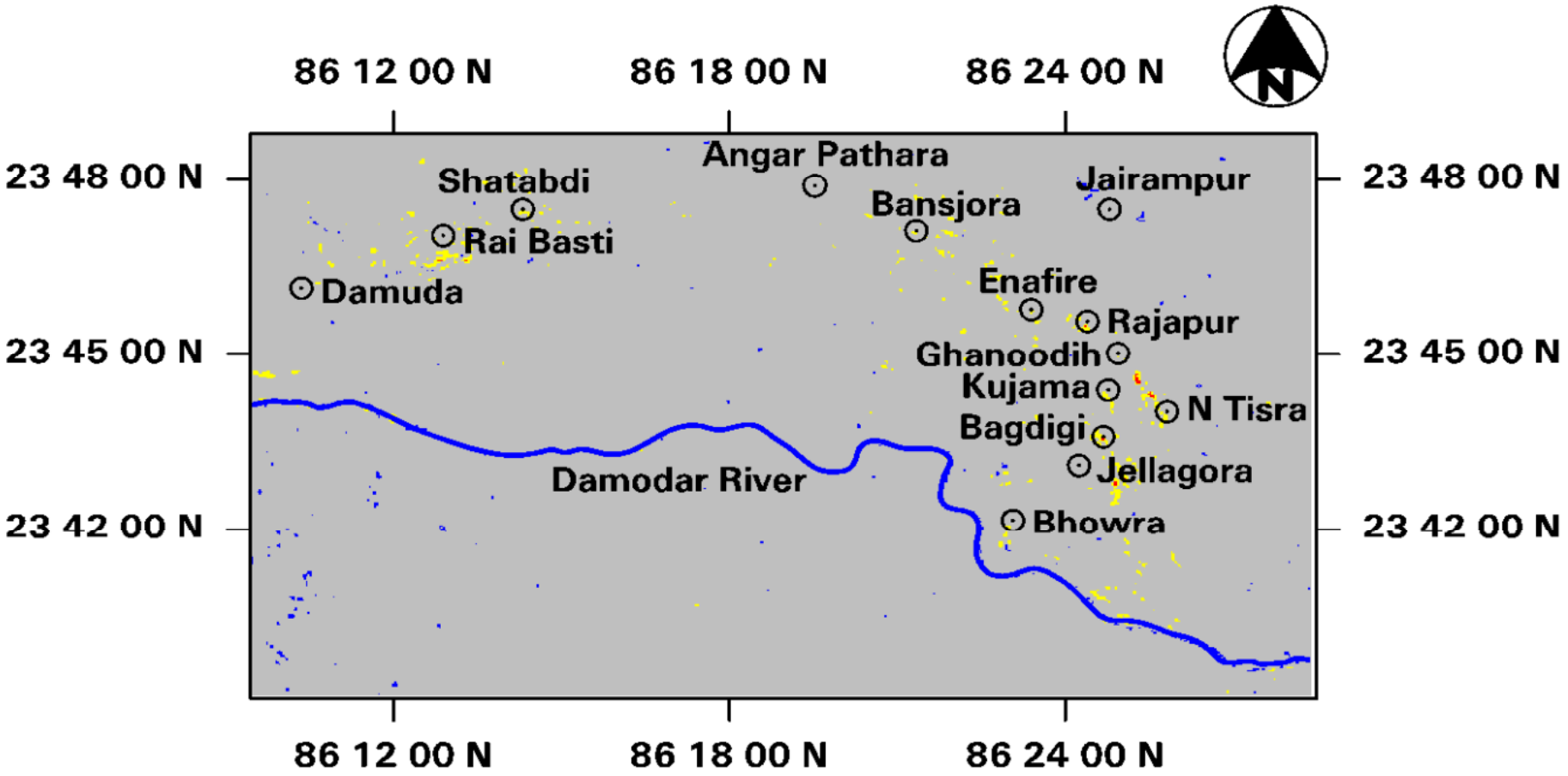
- Assessment of land use and land resource pattern in the mining areas
- Determination of ground deformations and slope stability in the vicinity of open pit mining operations
- Mapping the Mines region with the Remote Sensing technology integrated with GIS
- mapping the regions affected by underground fires and its surrounding areas
- Developing and implementing a rehabilitation plan for the same
- Digital Imaging in the Mining Industry

LU/LC map of JCF in 2011



Land cover in 2011





Legend

Class_Names

Water

Surface Fire

Sub-surface Fire

Scale

10 0 Kilometers

Thermal infrared band and short wavelength infrared bands of Satellite imageries haven been extensive used for detecting and mapping sub-surface coal fires of Jharia

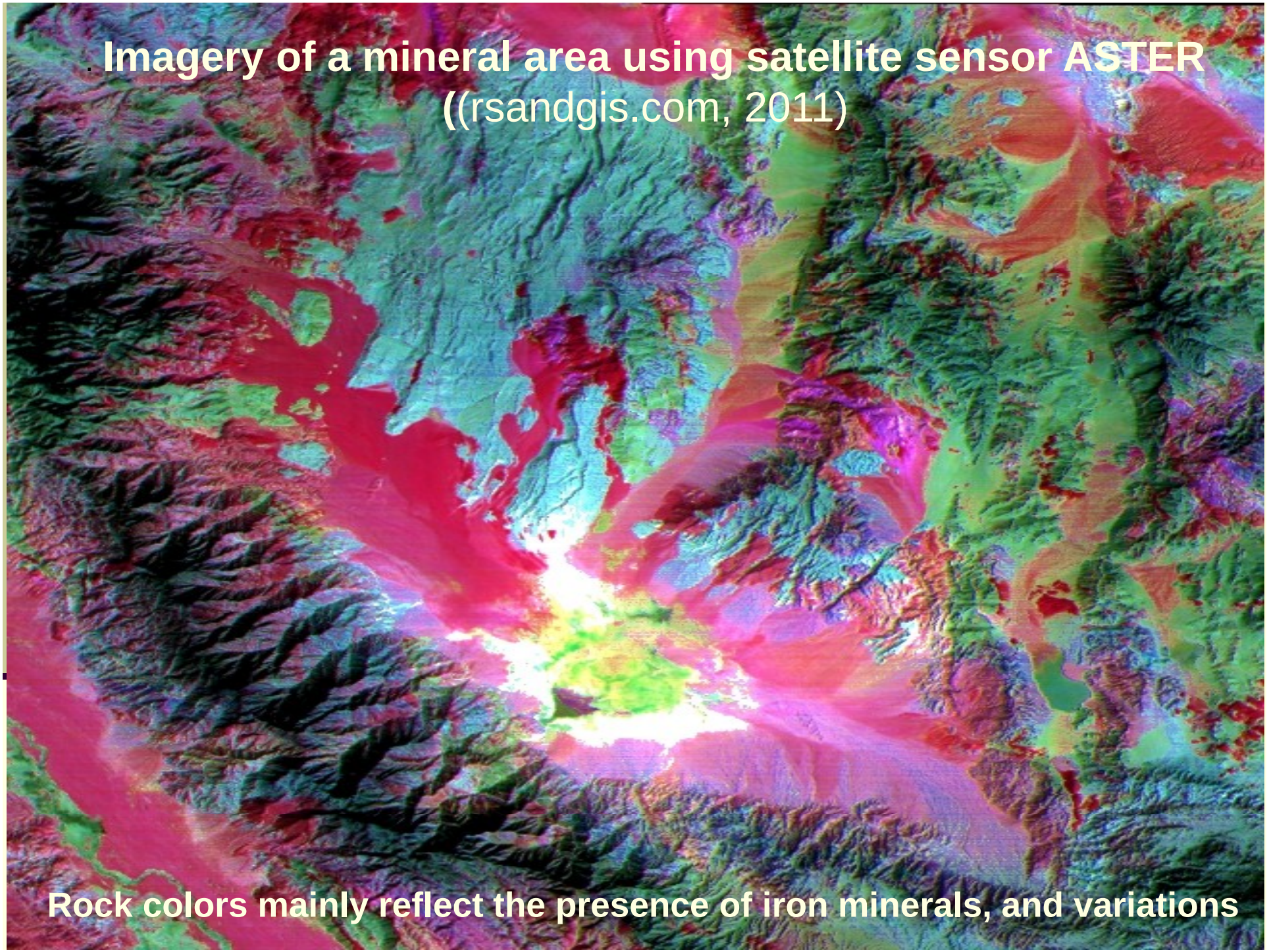
GIS and Remote Sensing

Other applications :

- Land ownership and mineral claims
- Exploration management
- Siting of ore pass, draw points, ramps, shaft, winze, raises, haulways that are within a certain distance of production centers (stopes) and meeting production criteria.
- Querying the production stopes affected by unstable ground conditions, hazardous gas, refractory ore, etc.
- In mine development, GIS can assist the planners in establishing the optimal location for exploration drifts, crosscuts, sublevels, man ways, ventilation shafts

- The use of satellite imagery in mineral exploration, generally a combination of panchromatic and multispectral image information has been used in mineral and petroleum industries over the final decade.

- Imagery from satellite sensors such as ASTER, LANDSAT, GeoEye-1 and WorldView-2 apiece supplying panchromatic and multispectral total color imagery have benefited geologists, scientists and exploration managers in earth sciences due to the sensor containing multiple band colors


Imagery of a mineral area using satellite sensor ASTER
((rsandgis.com, 2011)
Rock colors mainly reflect the presence of iron minerals, and variations

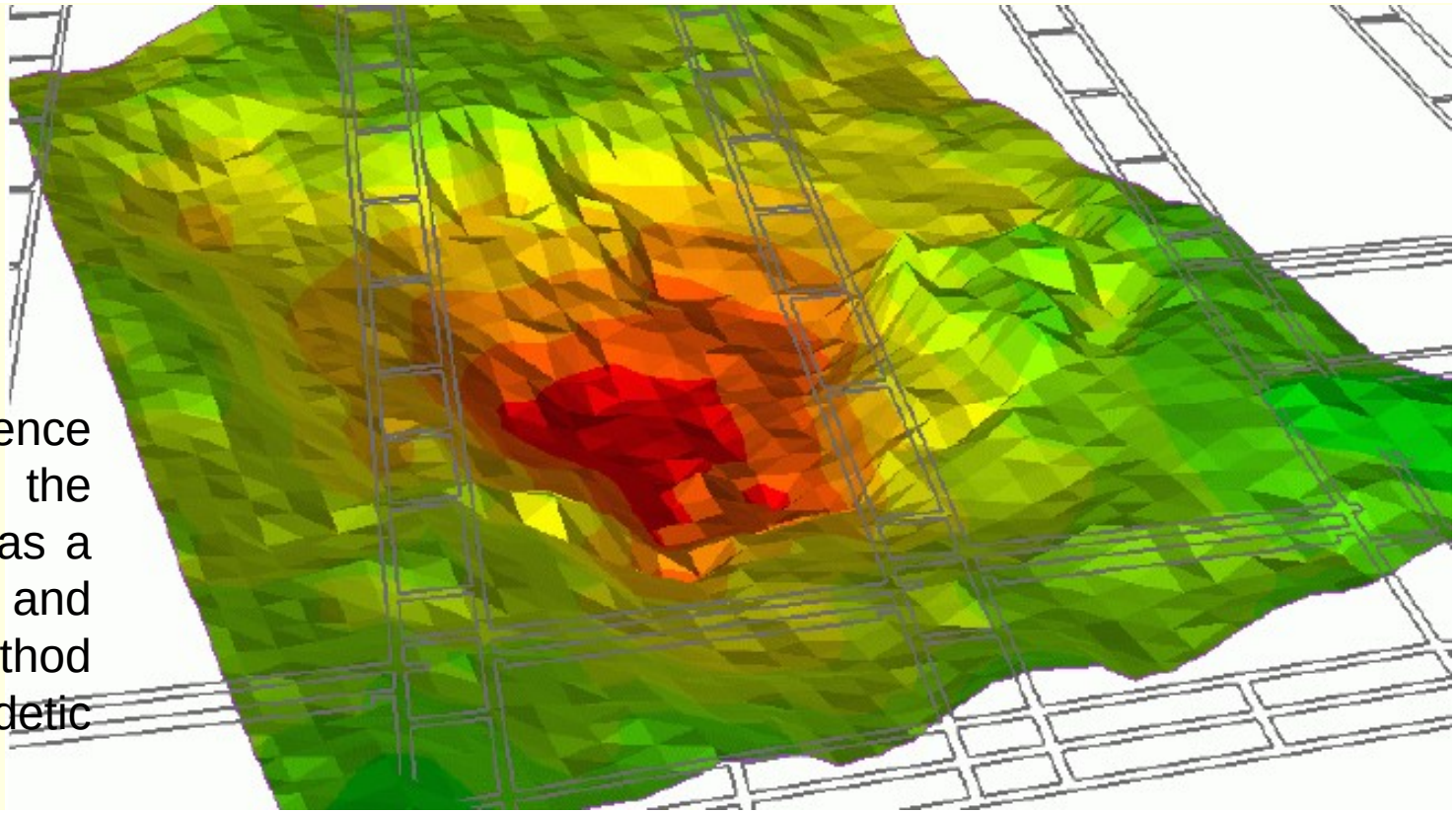
Radar images captured by satellite

Generate ground deformation with InSAR image processing software

Corrections from GPS

Import image into GIS

Spatial analysis, presentation & report



Mine subsidence monitoring using the DInSAR technique as a cost-effective and complementary method to conventional geodetic techniques

3D Laser Scanning

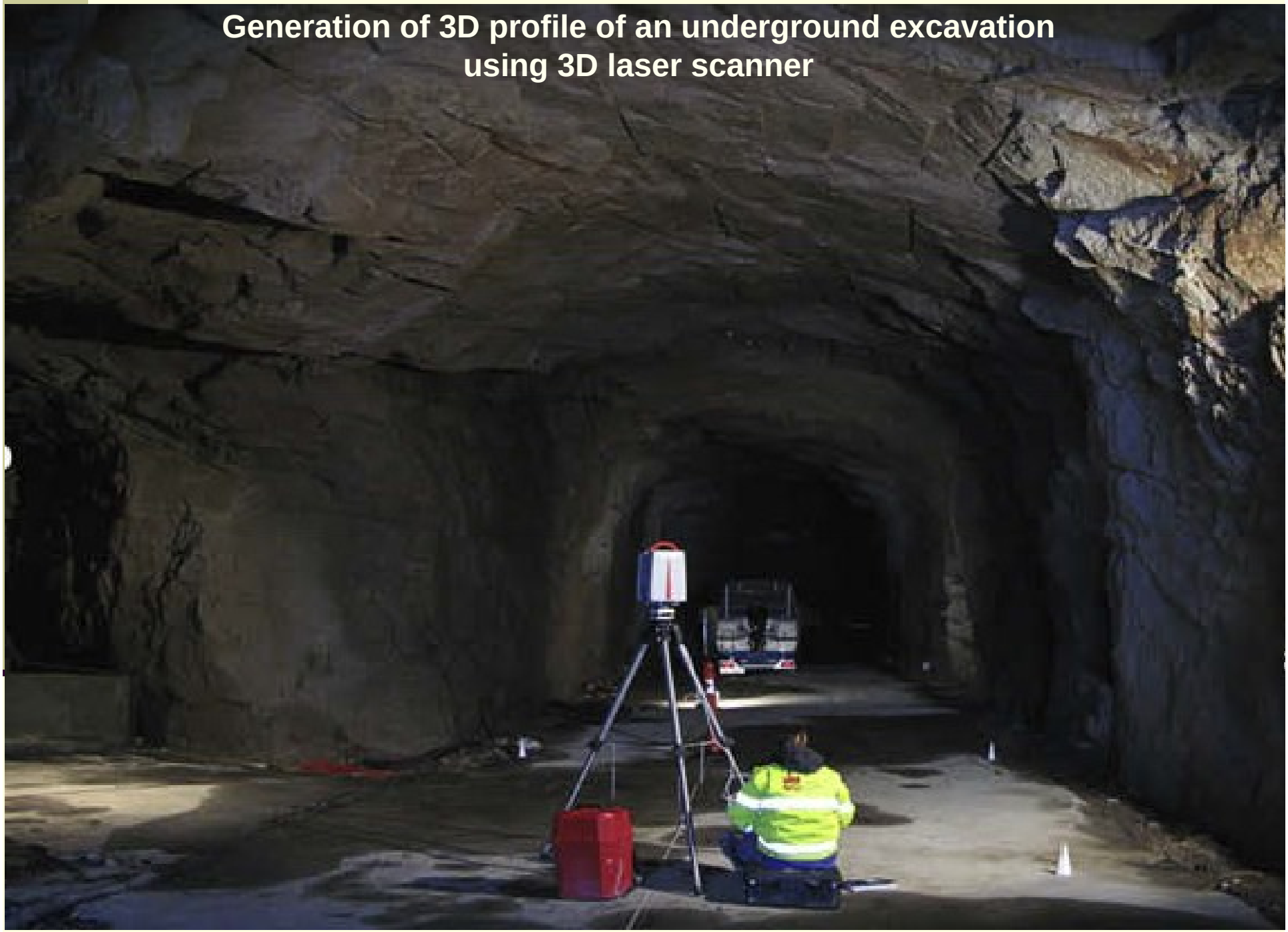
- accurately map, model and interpret geological structures in a pit
- conduct daily or end of month survey - detailed and accurate model of a stope or development face
- contract volume measurement, truck and shovel load measurement and analysis
- survey for pit production measurement, underground development and void survey
- conduct rapid pre- and post-blast surveys
- conduct airborne surveys for reserves assessments (where topography is critical in shallow flat lying deposits)
- conduct stope surveying


Automated Remote Survey Vehicle

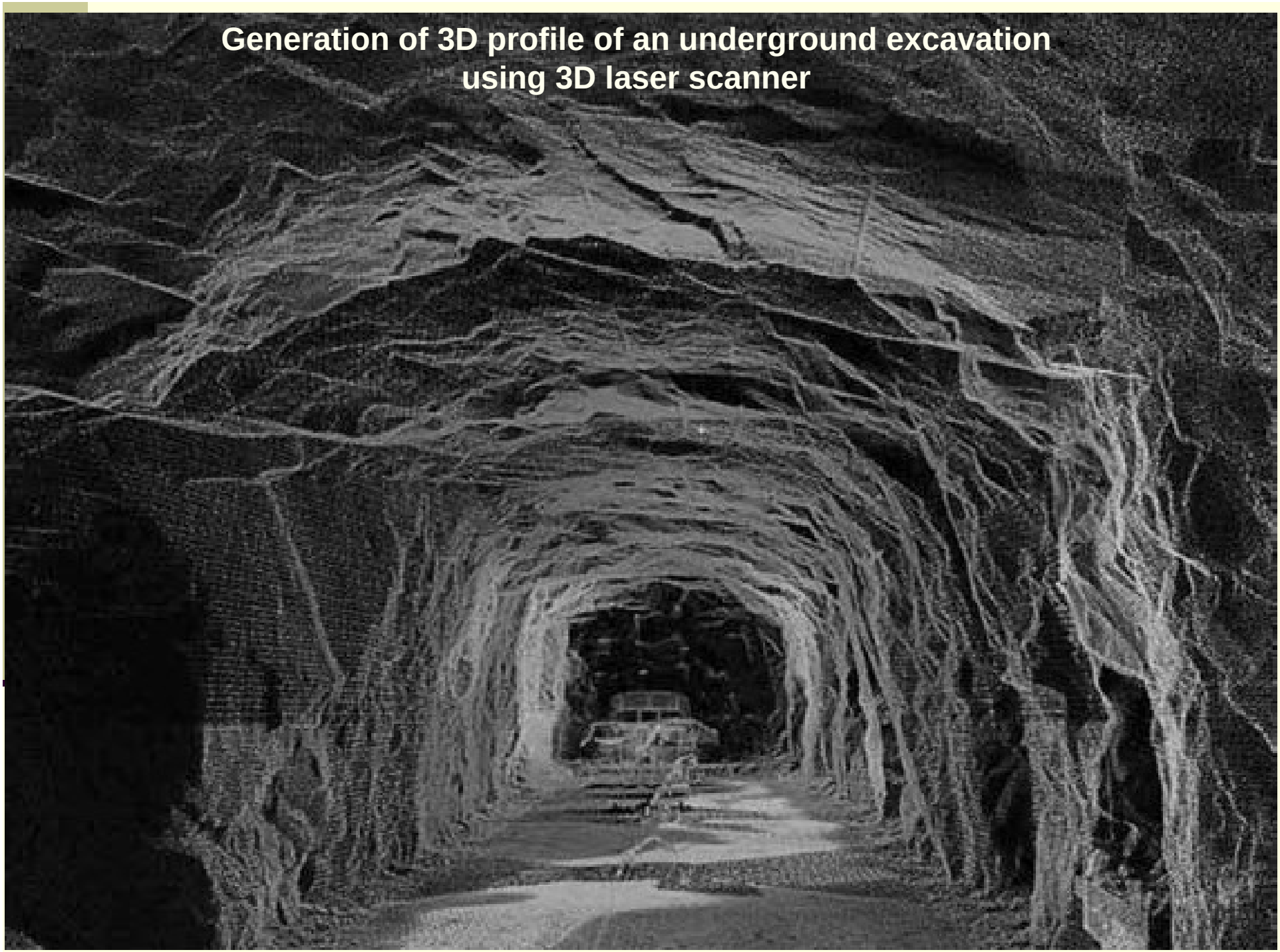

VZ-1000


Leica
LASER APERTURE
ScanStation

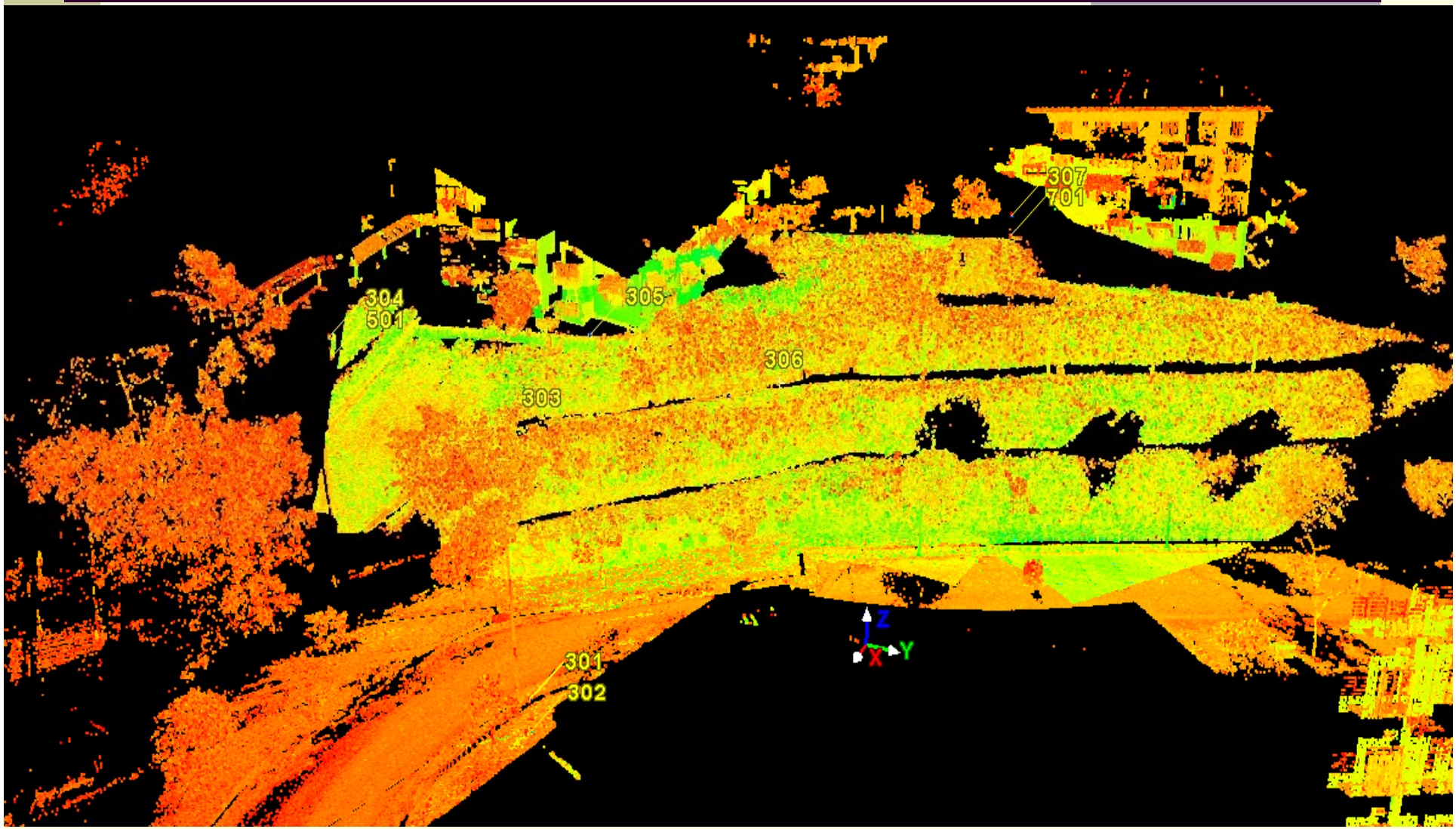
Generation of 3D profile of an underground excavation using 3D laser scanner



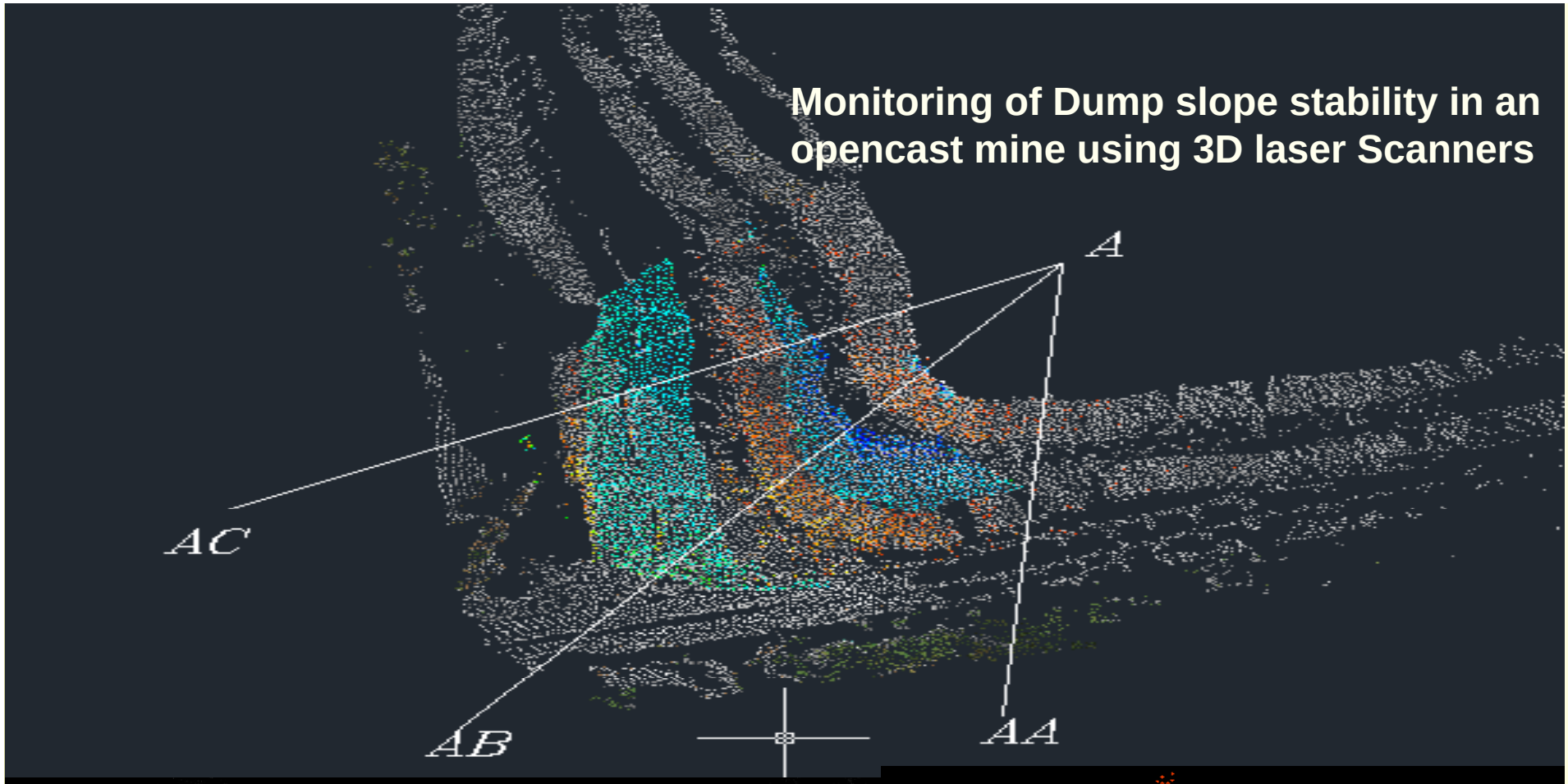
Generation of 3D profile of an underground excavation using 3D laser scanner

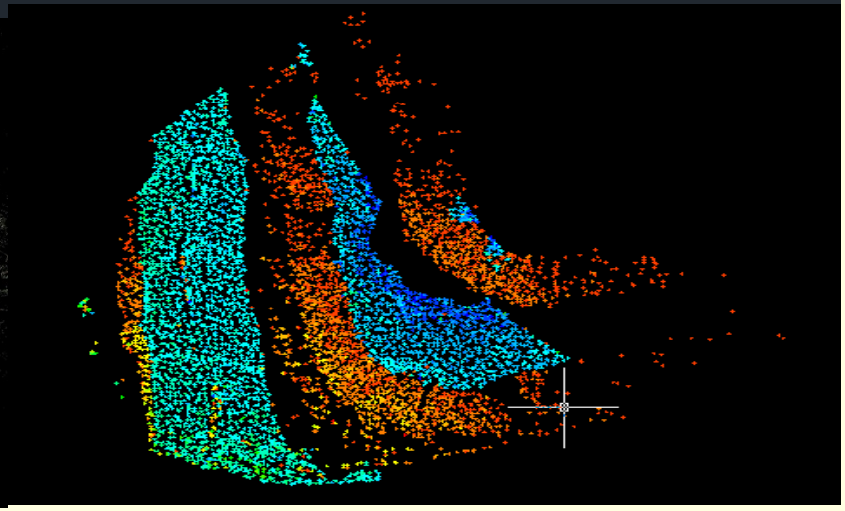


3D point cloud modelling of an opencast benches using Terrestrial Laser Scanner



Monitoring of Dump slope stability in an opencast mine using 3D laser Scanners





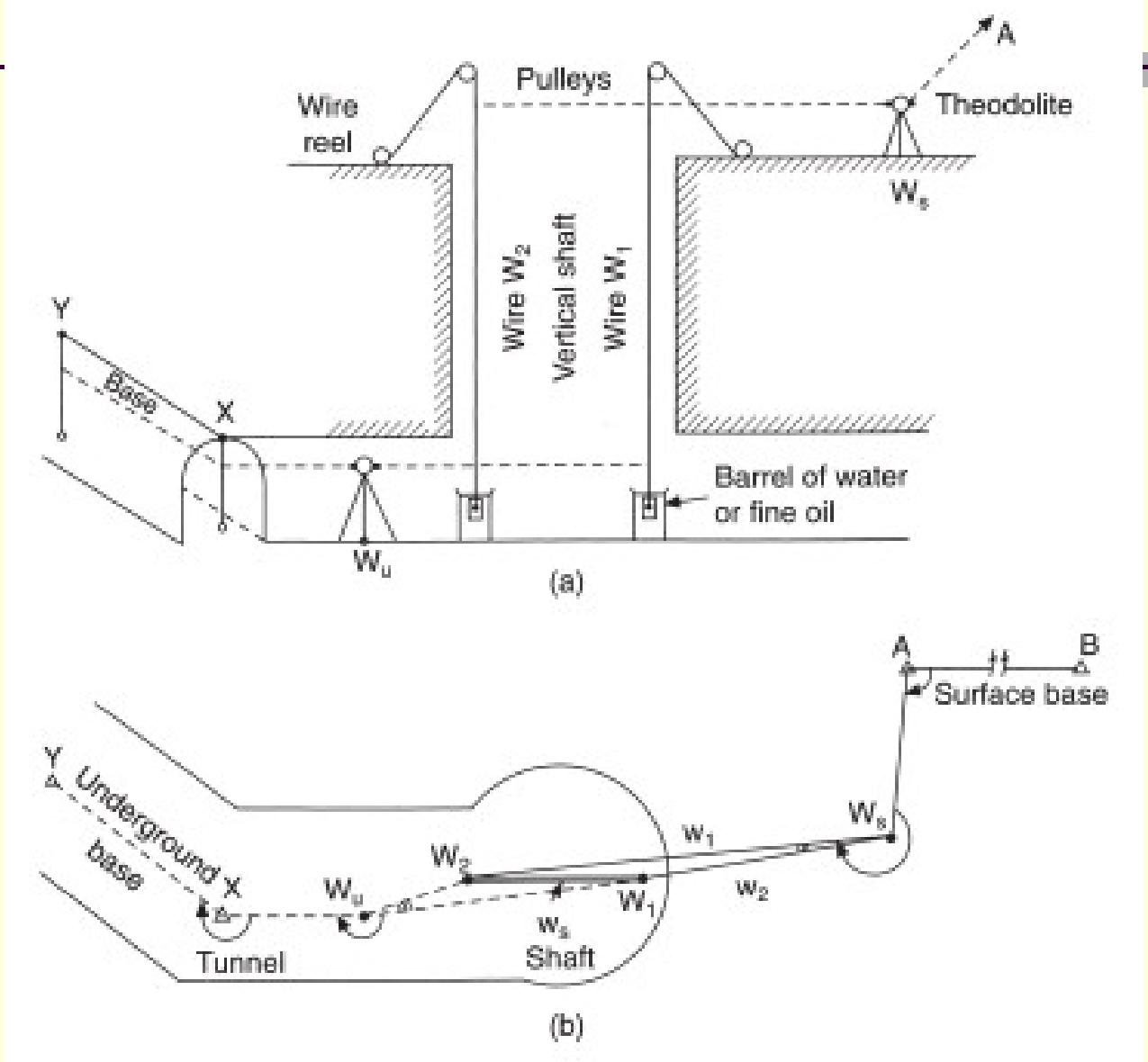
Alignment and Orientation Surveys

Correlation surveys are essential for :

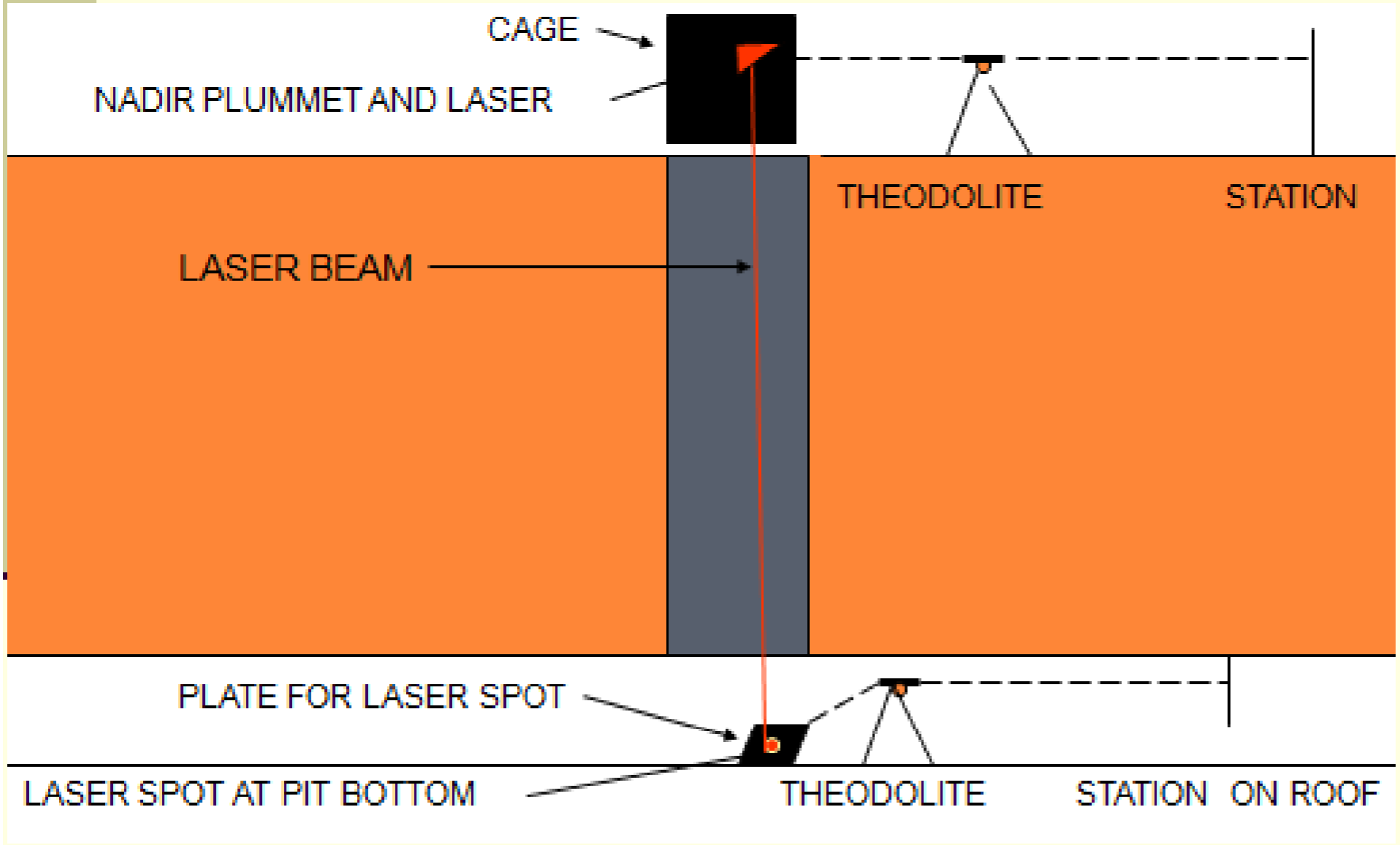
- Correct location of underground workings with respect to the surface features.
- Combined workings of adjacent areas and adjacent seams.
- Connection of underground workings.
- Mine expansion works.

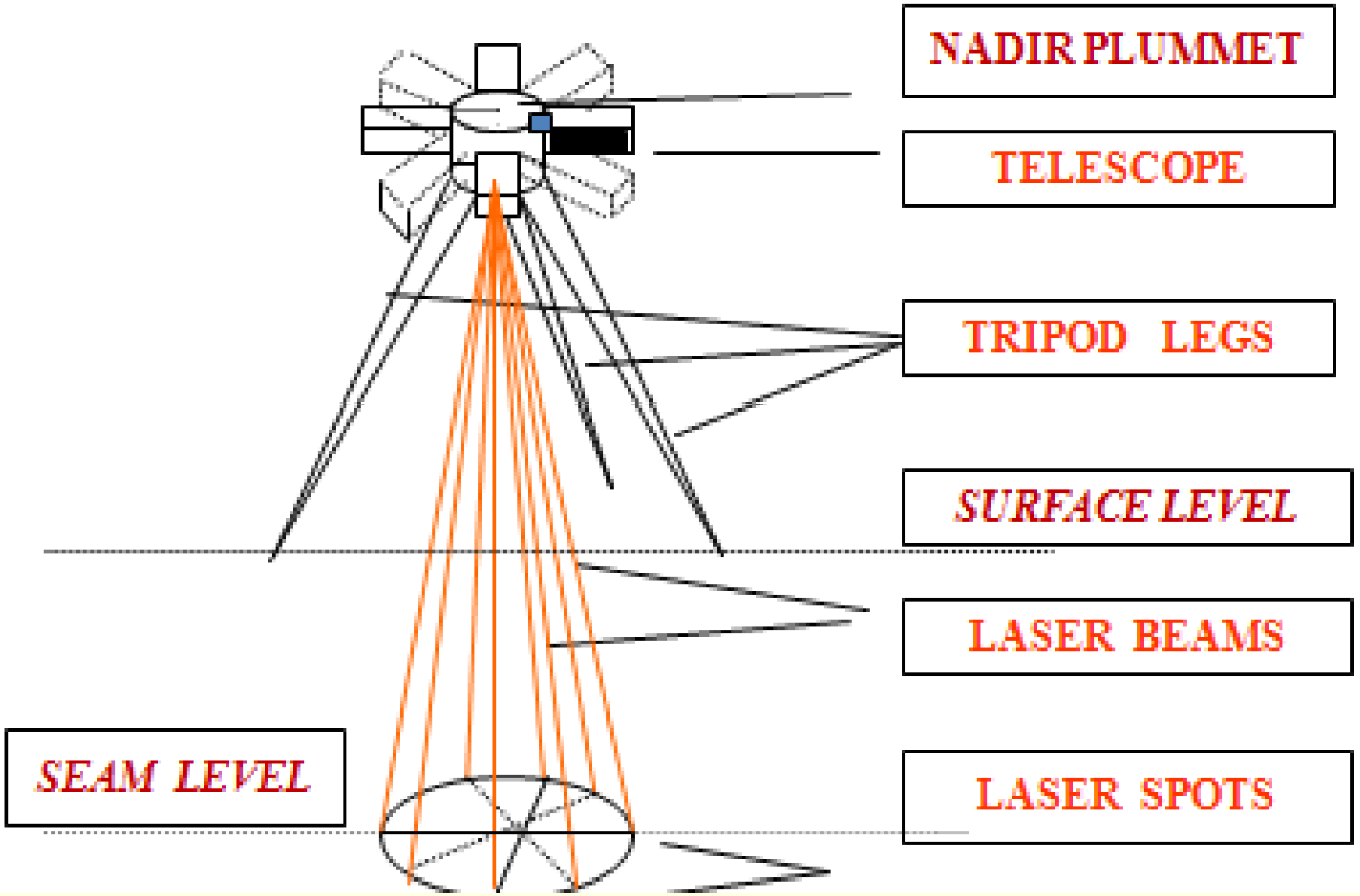
- Coordinates of at least one point in surface coordinate system.
- Bearing of at least one line in surface reference system.
- Height (or r. L.) Of at least one point with respect to the datum or mean sea level.

Correlation by suspension of plumb wires

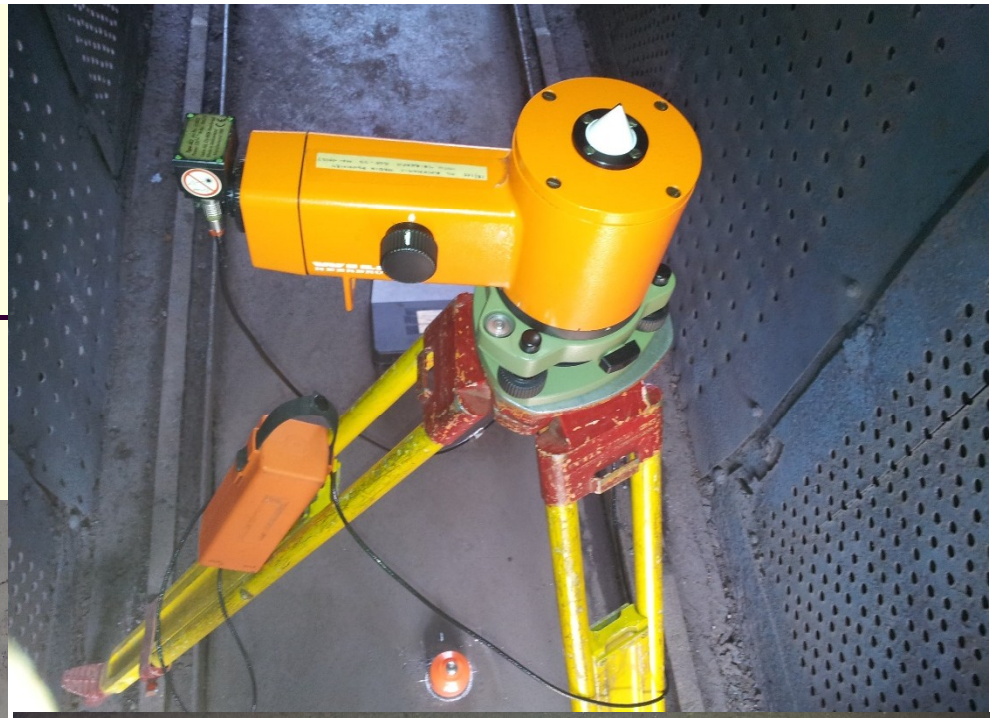


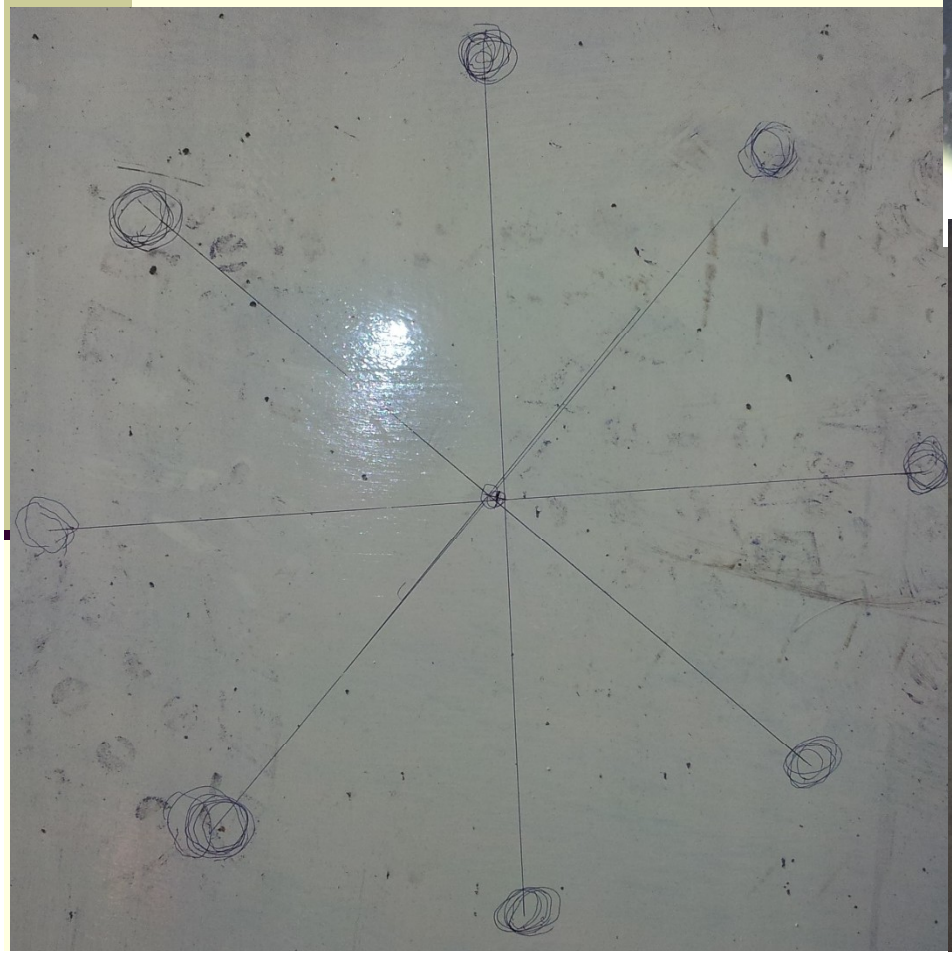
Correlation and alignment by Laser-Gyro combination




NADIR PLUMMET
TELESCOPE
TRIPOD LEGS
SURFACE LEVEL
LASER BEAMS
SEAM LEVEL
LASER SPOTS

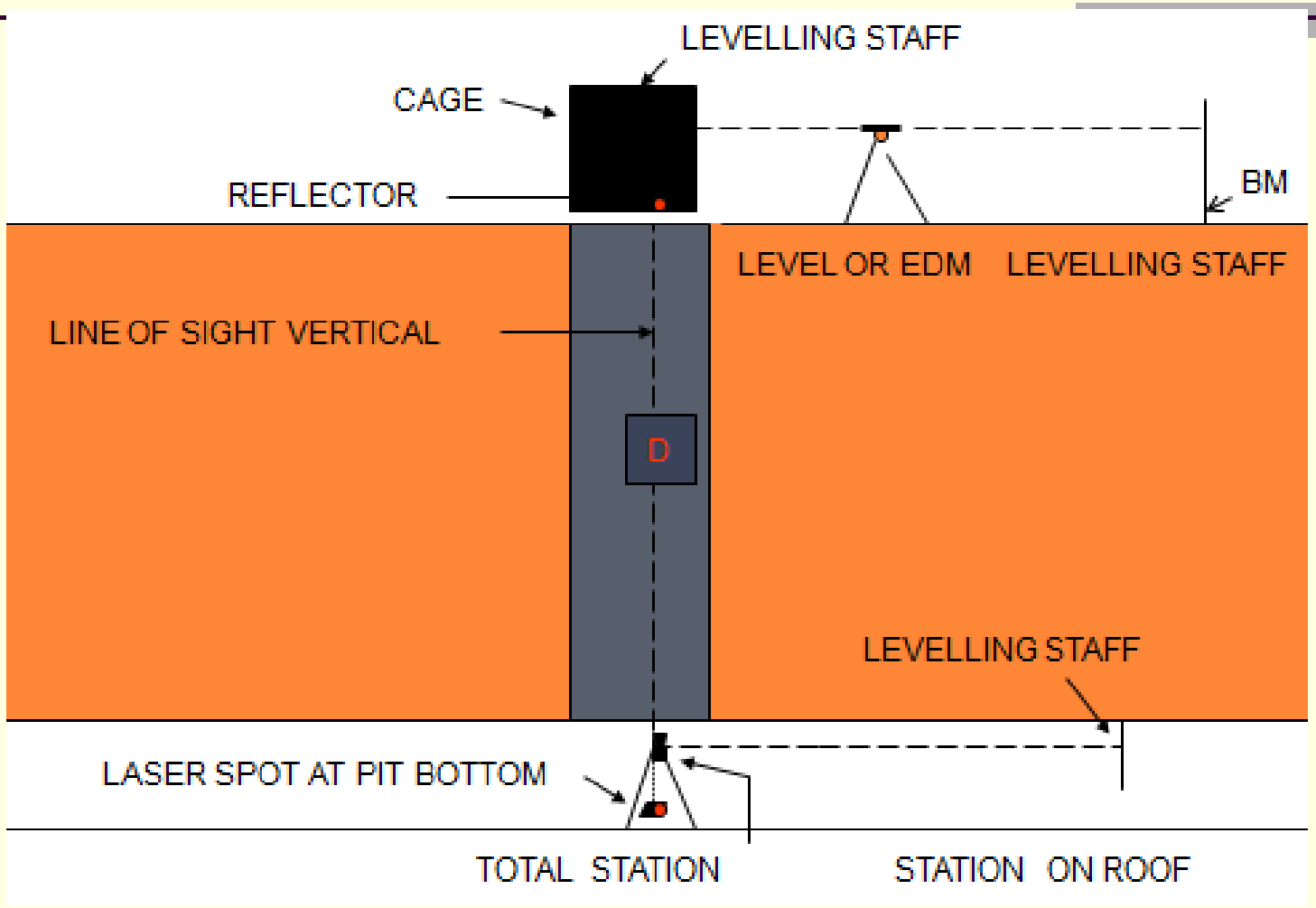
CORRELATION SURVEY AND DEPTH MEASUREMENT IN A SHAFT IN MOONIDIH MINE



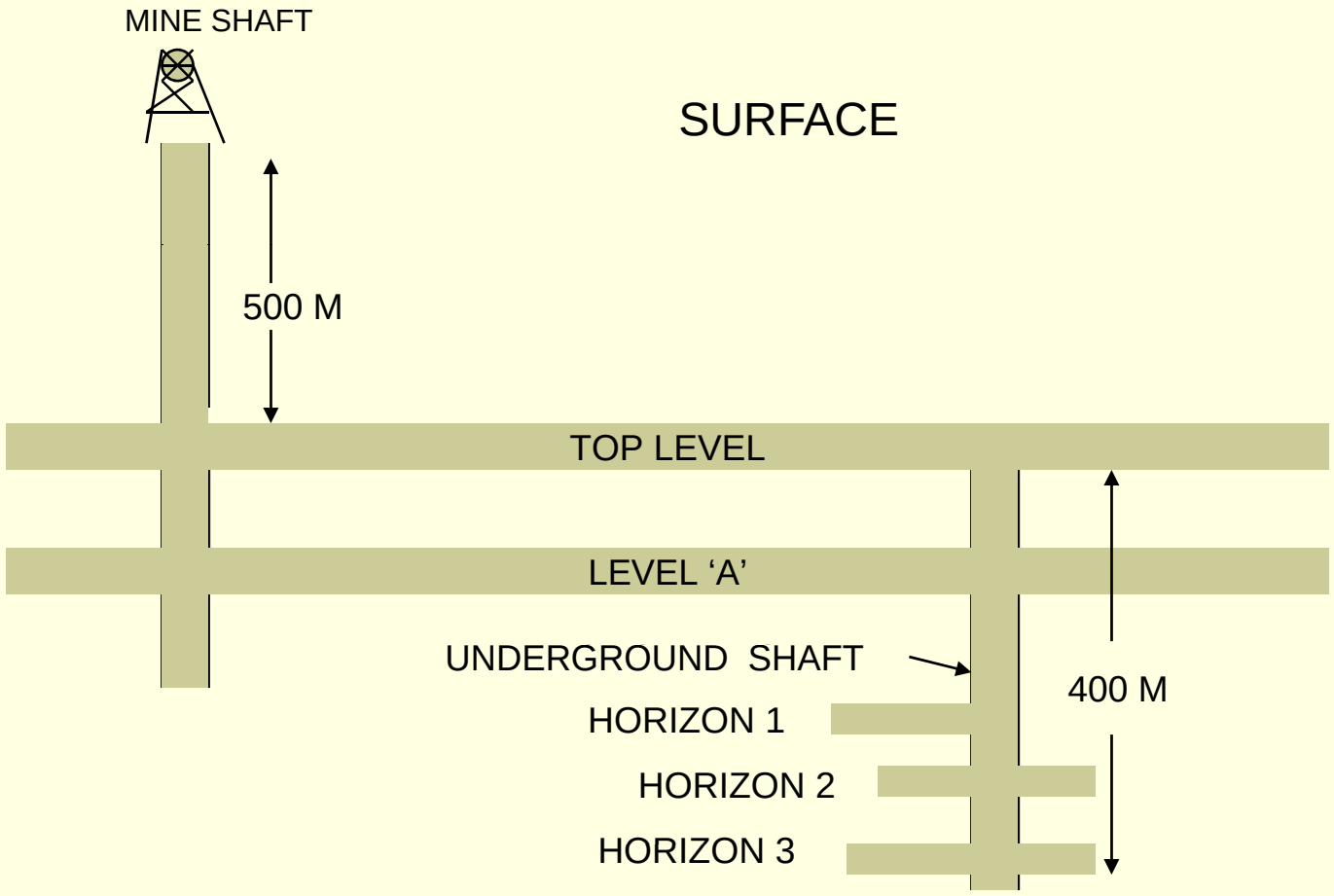


Orientation Surveys by Gyromat 3000

Shaft depth measurement with total station



CORRELATION SURVEY IN A METAL MINE (A CASE HISTORY)

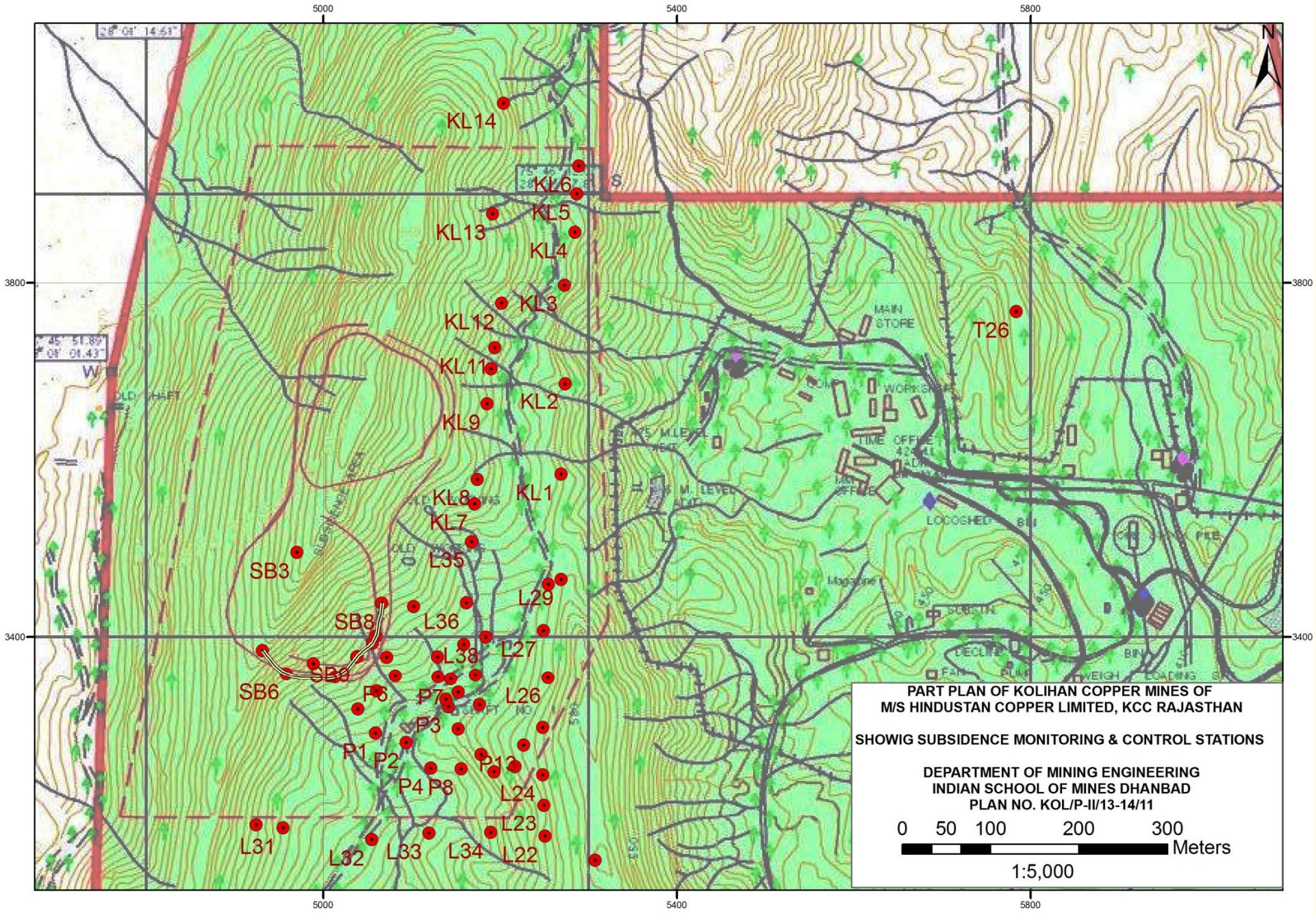


TOTAL STATION, PRECISE LEVEL AND GPS

- Subsidence Monitoring
- Dump slope monitoring
- Control surveys

Subsidence Monitoring

Monitoring of subsidence over the permanent subsidence monitoring station on hilltop using Prism monitoring (EDM) keeping total station on stable ground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KL13
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KL12
KL11
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KL8
KL1
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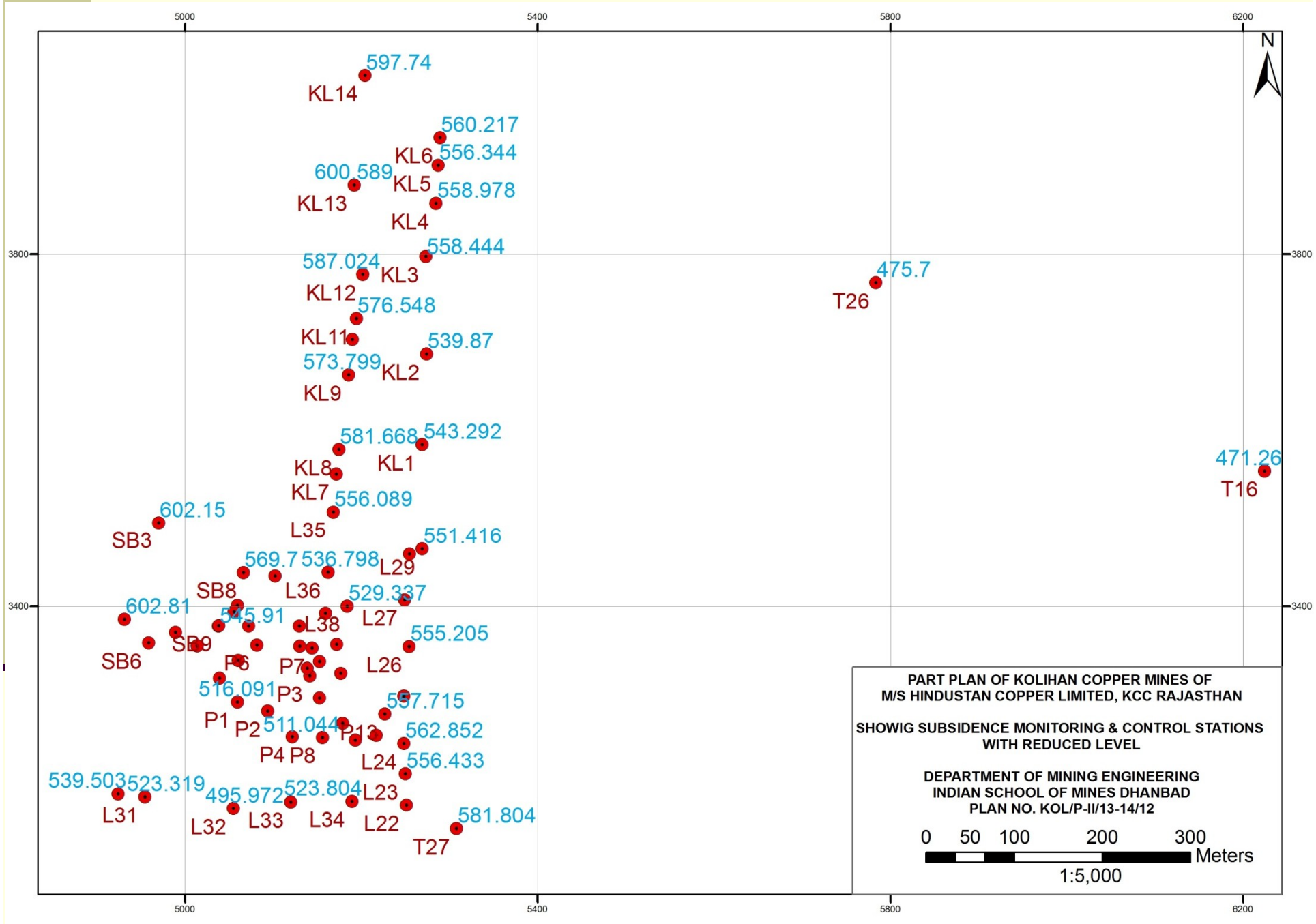
L35
SB3
L29
SB8
L36
L27
L38
SB6
SB9
P6
P7
L26
P3
P1
P2
P12
P4
P8
L24
L23
L31
L32
L33
L34
L22
T26
MAIN STORE
LOCOSHED
PART PLAN OF KOLIHAN COPPER MINES OF
M/S HINDUSTAN COPPER LIMITED, KCC RAJASTHAN
SHOWIG SUBSIDENCE MONITORING & CONTROL STATIONS
DEPARTMENT OF MINING ENGINEERING
INDIAN SCHOOL OF MINES DHANBAD
PLAN NO. KOL/P-II/13-14/11
0 50 100 200 300
Meters
1:5,000


5000
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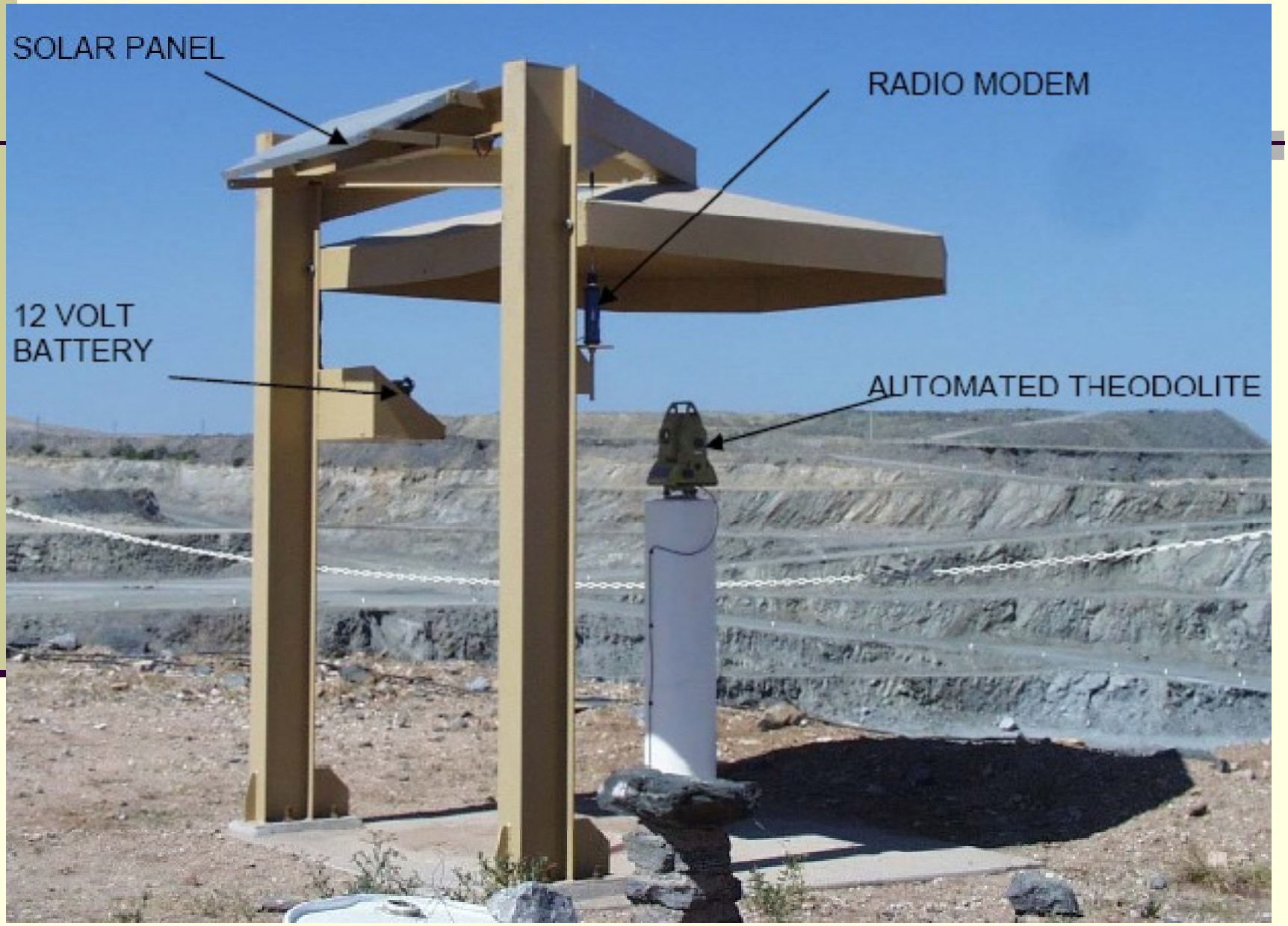
6200
3800
3400
N
597.74
KL14
560.217
KL6
556.344
600.589
KL5
558.978
KL13
KL4
558.444
587.024
KL3
KL12
576.548
KL11
539.87
573.799
KL2
KL9
581.668
543.292
KL8
KL1
KL7
556.089
602.15
SB3
L35
551.416
569.7
536.798
L29
SB8
L36
529.337
602.81
545.91
L27
L38
555.205
SB9
SB6
P6
P7
L26
516.091
P3
597.715
P1
P2
511.044
P13
562.852
P4
P8
L24
556.433
539.503
523.319
495.972
523.804
L23
L31
L32
L33
L34
L22
581.804
T27
475.7
T26
471.26
T16
PART PLAN OF KOLIHAN COPPER MINES OF
M/S HINDUSTAN COPPER LIMITED, KCC RAJASTHAN
SHOWIG SUBSIDENCE MONITORING & CONTROL STATIONS
WITH REDUCED LEVEL
DEPARTMENT OF MINING ENGINEERING
INDIAN SCHOOL OF MINES DHANBAD
PLAN NO. KOL/P-II/13-14/12
0 50 100 200 300
Meters
1:5,000

Geodetic Monitoring of OB dumps using Total Station



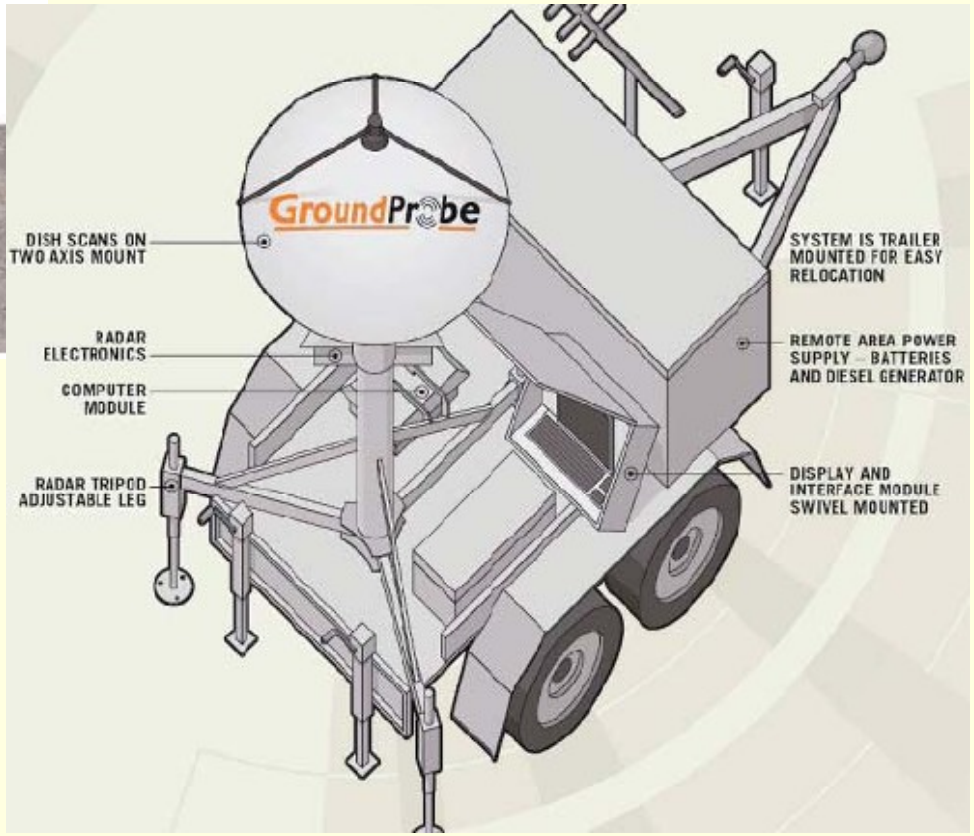
SUSIDENCE MONITORING BY DIGITAL LEVEL

Slope Stability Radar

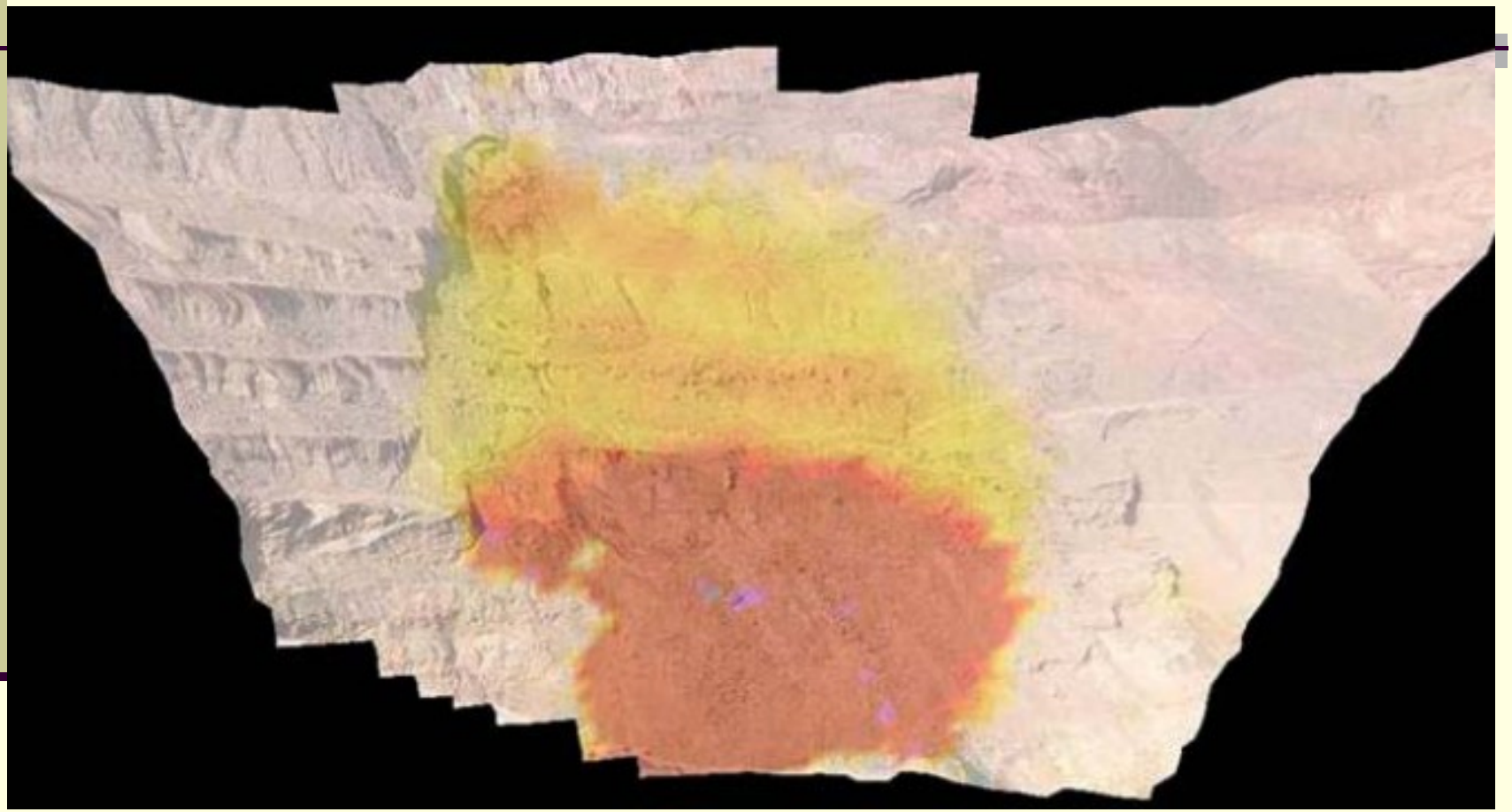
- It provides for high density, high precision measurements of up to **0.2 mm** accuracy.
- The SSR has the ability to cover a broad area simultaneously (approximately **170^0 horizontal** view and **120^0** vertical at ranges between **30m and 850m**, potentially 1400 m at a reduced resolution).
- The system has the ability to **monitor continuously** and depending on the scan range it completes a **scan area after about five to seven minutes**

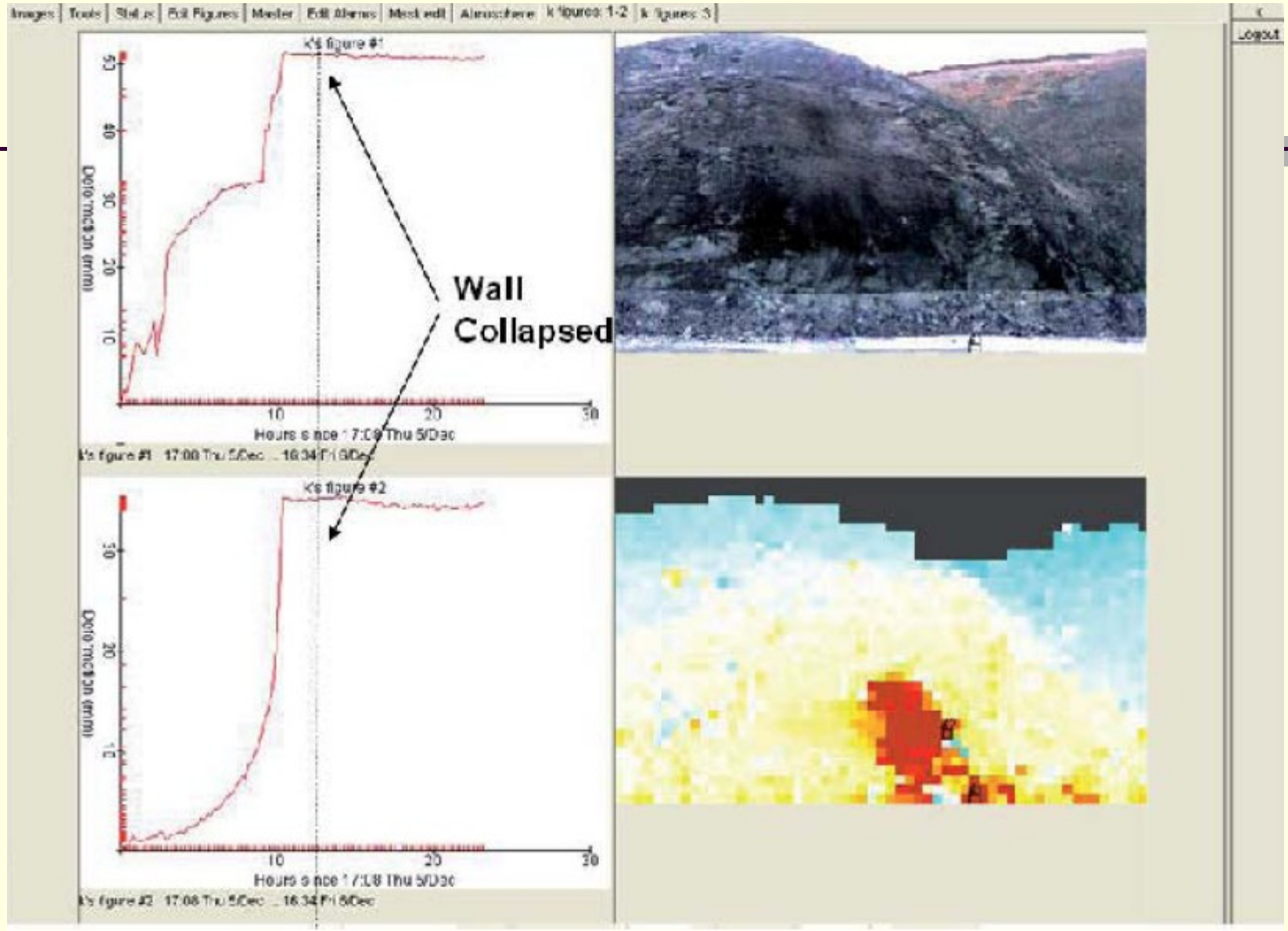
- The slope stability radar utilises the differential interferometry processing technique on a stationary platform positioned 50m to 1700m back from the foot of the wall.
- The system scans a region of the wall in a grid pattern and compares the **phase measurement** of each footprint (pixel) with the first scan to determine the nature of movement on the rock face, and hence the stability of the slope.
- The SSR system has a pixel size of **1m x 1m** at a range of 50 metres and of **15m x 15m** at 850 metres.

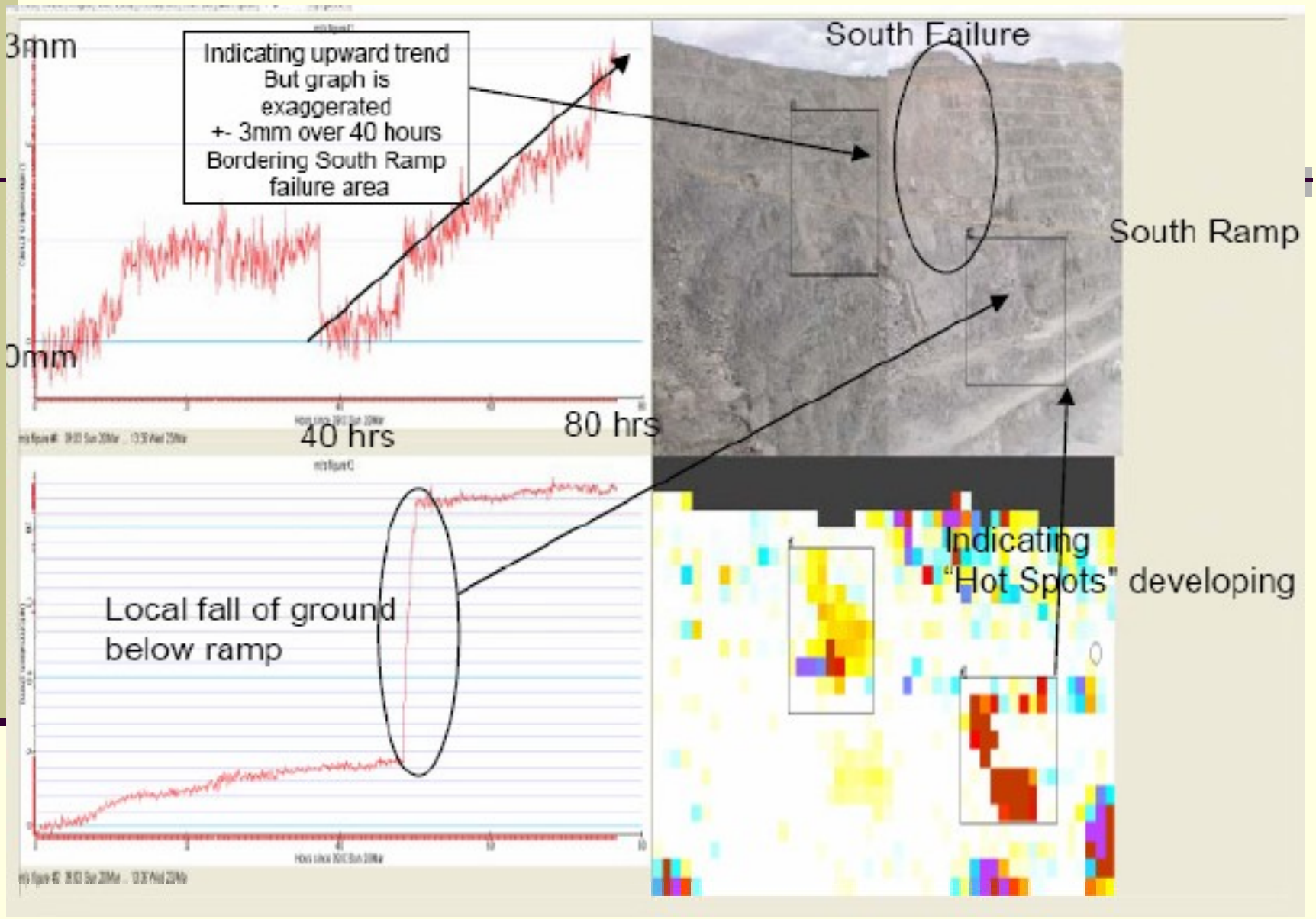

495 QJJ

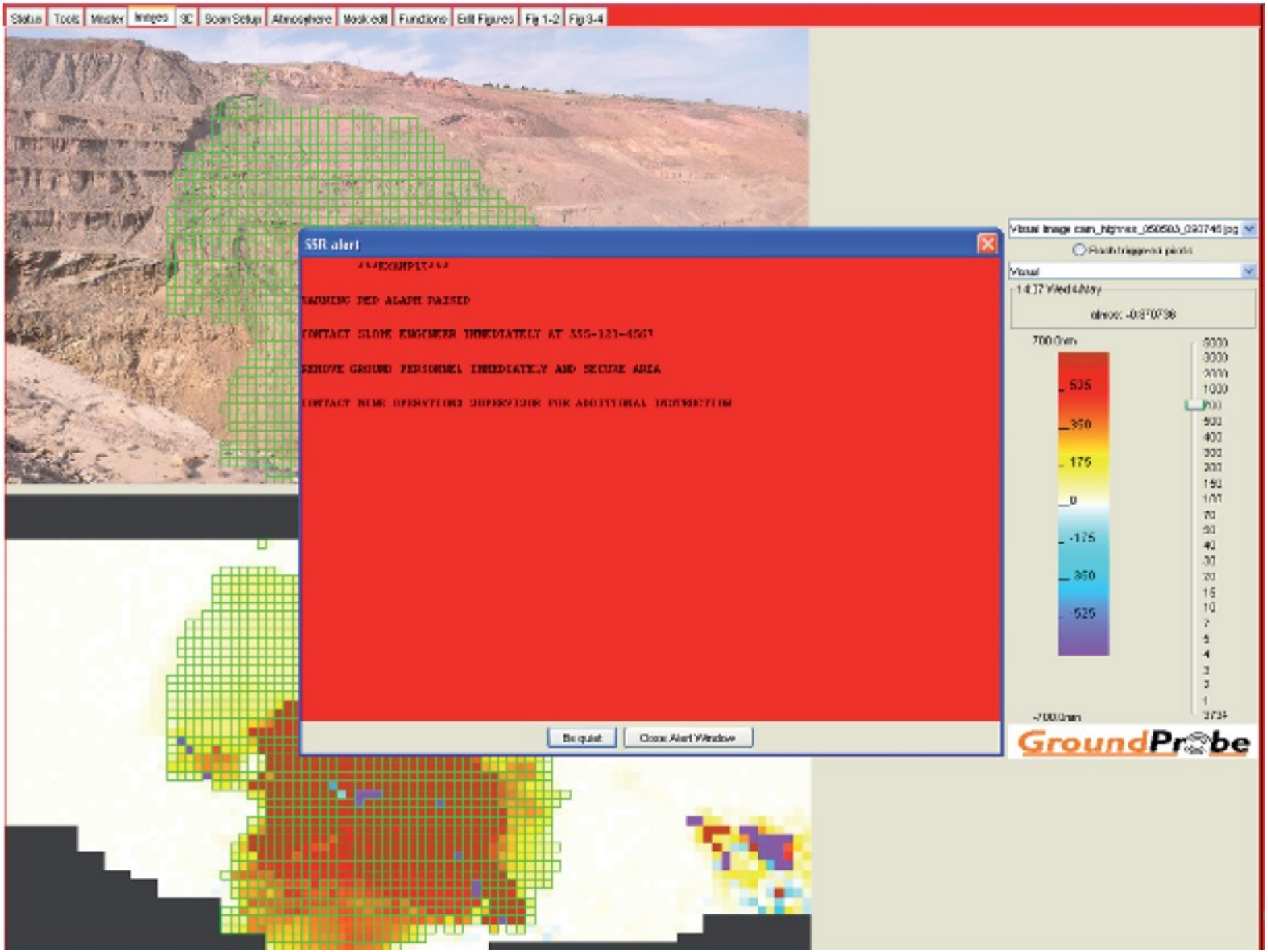

GroundProbe
DISH SCANS ON TWO AXIS MOUNT
RADAR ELECTRONICS
COMPUTER MODULE
RADAR TRIPOD ADJUSTABLE LEG
SYSTEM IS TRAILER MOUNTED FOR EASY RELOCATION
REMOTE AREA POWER SUPPLY – BATTERIES AND DIESEL GENERATOR
DISPLAY AND INTERFACE MODULE SWIVEL MOUNTED

- The system provides immediate monitoring of slope movement without calibration and prior history.
- Scan times are typically every 1 to 10 minutes, depending on the size of the selected scanned area.
- Data can be viewed directly on the SSR unit or uploaded to a remote location via a dedicated radio link.




Wall
Collapsed


3mm
Indicating upward trend
But graph is
exaggerated
+- 3mm over 40 hours
Bordering South Ramp
failure area
0mm
40 hrs
80 hrs
South Failure
South Ramp
Local fall of ground
below ramp
Indicating
"Hot Spots" developing


Status
Tools
Monitor
Images
3D
Scan Setup
Atmosphere
Mask edit
Functions
Edit Figures
Fig 1-2
Fig 3-4
SSR alert
WARNING RED ALARM RAISED
CONTACT SLOPE ENGINEER IMMEDIATELY AT 555-121-4567
REMOVE GROUND PERSONNEL IMMEDIATELY AND SECURE AREA
CONTACT MINE OPERATIONS SUPERVISOR FOR ADDITIONAL INSTRUCTION
Be quiet
Close Alert Window
535
350
175
0
-175
-350
-525
GroundProbe

Major Suppliers

Reutech Radar Systems Pty Ltd

http://www.rrs.co.za/

Groundprobe Slope Stability Radar

http://www.groundprobe.com/slopestability.html

Virtual Reality in Mineral Industry

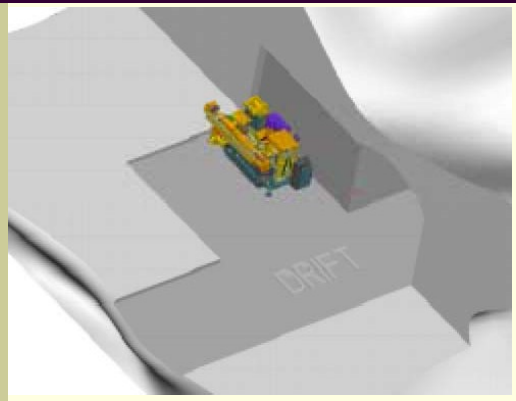
Virtual Reality in Mineral Industry

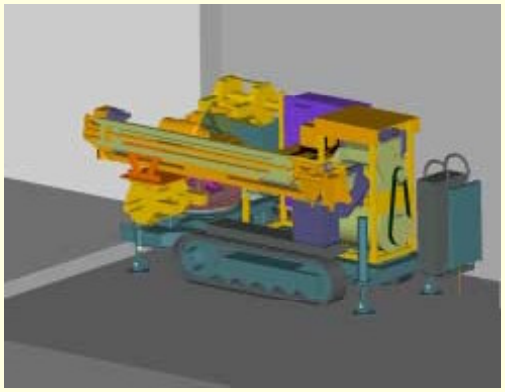
It helps mine planners and designers through a strong capability to visualize overall impact of various factors in a complex mining environment.

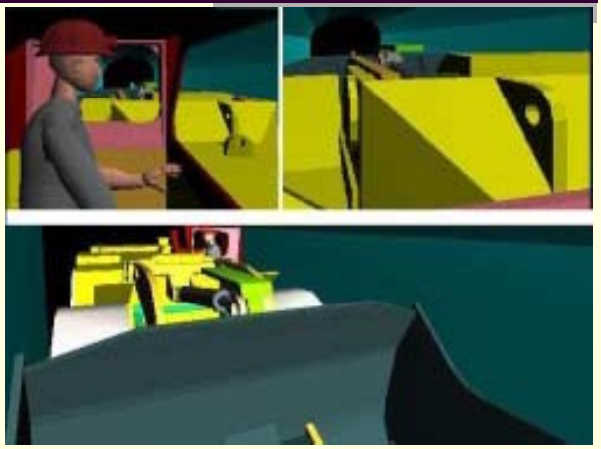
Virtual Reality in Mineral Industry

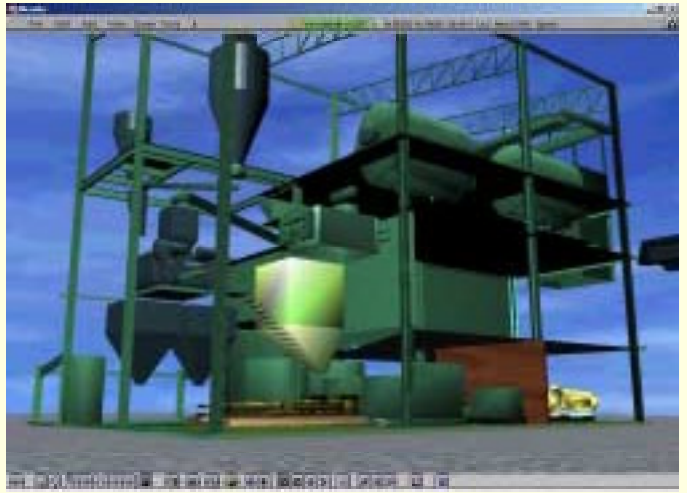
- Mining Equipment Concept development
- Design Review, Operator Input, Maintenance Procedure Review and Simulations
- Development of a simulation / animation model for mine planning
- Presentation of Mining Concepts to an Approving Authority

Virtual Reality in Mineral Industry

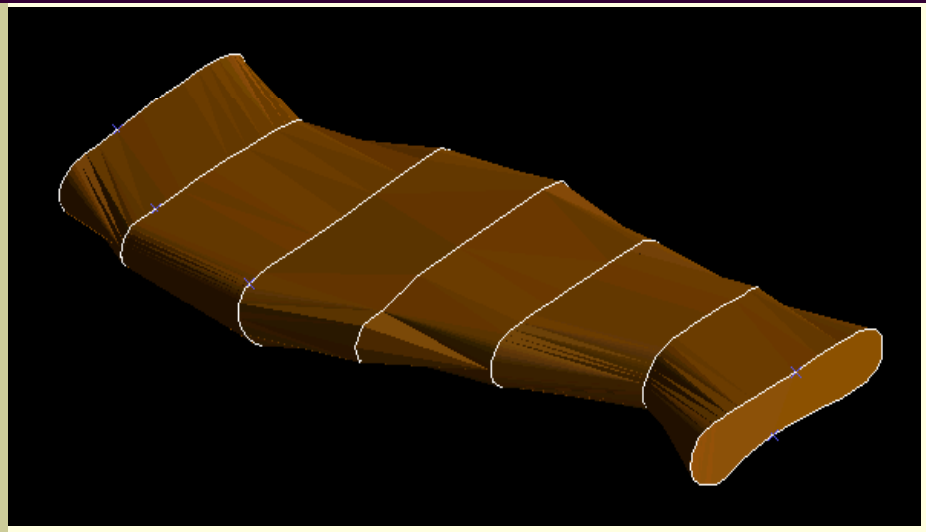




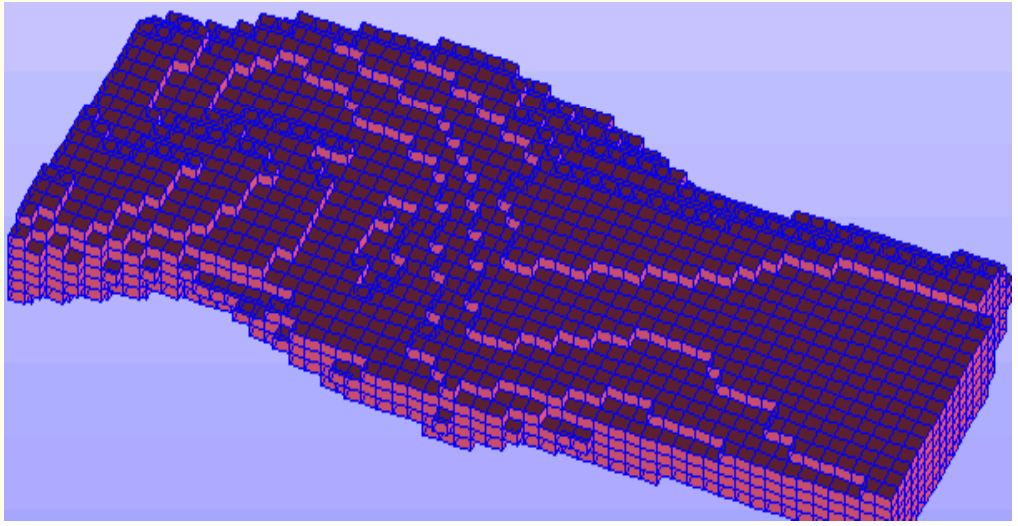


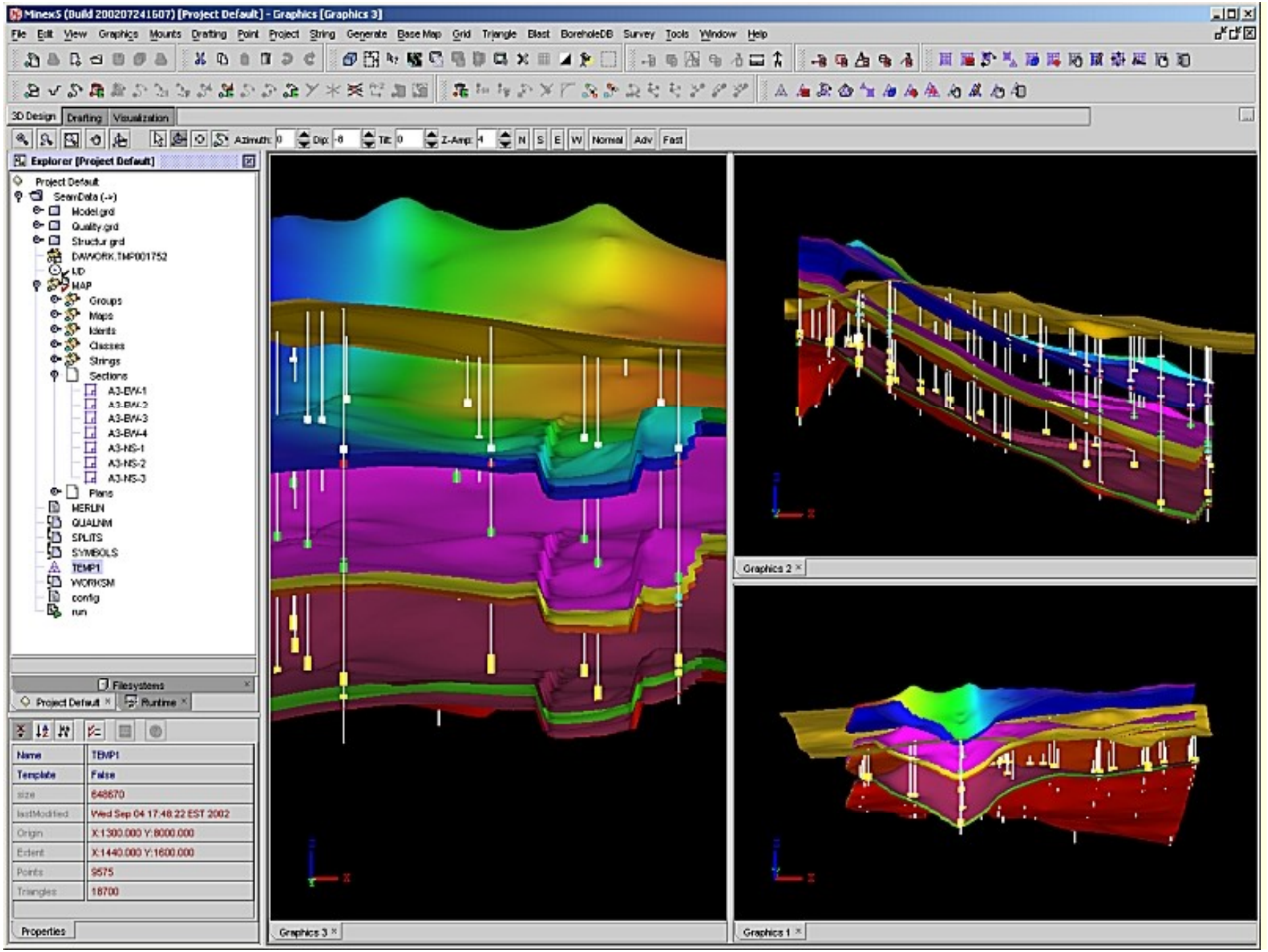


Computer Aided Mine Plan and design



Solid modeling & block modeling of an iron ore deposit using SURPAC




MineXS (Build 20020724160?) [Project Default] - Graphics [Graphics 3]
File Edit View Graphics Mounts Drafting Point Project String Generate Base Map Grid Triangle Blast BoreholeDB Survey Tools Window Help
3D Design Drafting Visualization
Explorer [Project Default]
Project Default
SeamData (->)
Model.grd
Quality.grd
Structur.grd
DAWORK.TMP001752
UD
MAP
Groups
Maps
Idents
Classes
Strings
Sections
A3-EW-1
A3-EW-3
A3-EW-4
A3-NS-1
A3-NS-2
A3-NS-3
Plans
MERLIN
QUALNM
SPLITS
SYMBOLS
TEMP1
WORKSM
config
run
Filesystems
Project Default
Runtime
Name TEMP1
Template False
size 648670
lastModified Wed Sep 04 17:48:22 EST 2002
Origin X:1300.000 Y:8000.000
Extent X:1440.000 Y:1600.000
Points 9575
Triangles 18700
Properties
Graphics 2
Graphics 3
Graphics 1

Conclusion

- There is a substantial need of adoption of state of the art automation technologies in the mines to ensure the safety and to protect health of mineworkers.
- The paper has highlighted some of the applications of Geospatial Technology in the Indian mines for safe mining operations
- Significant developments have been made in the areas of surface and underground communication, robotics, smart sensors, tracking systems etc.

Conclusion

semi-automated / automated mining technologies backboned with information technologies is need of the day

This will satisfy the two most important goals of any mining operation: improved productivity and safer working conditions.