GIS Application for Effective and Efficient Reporting and Information Media in Freeport Underground Mine

Benget HUTAURUK, Drajat SETIAWAN, Sandi NUGRAHA, Indonesia

Key words: GIS, underground mine, survey, PT Freeport.

SUMMARY

PT Freeport underground survey team is currently developing a GIS application to provide information for operations management information regarding tunnel (mine development) progress. Mine development information will be presented in spatial and textual formats. Information will be available to view as weekly, monthly, quarterly and yearly tunnel development advance reports. These will link with Work Instruction Sheets that contain, volumes based on design. Thus, charts of development achievement verses targets can be displayed. It will also include safety aspects (shortest escape way, refuge chamber, etc), equipment location, geology maps including drill hole location, and geotechnical items. It will be a flexible and growing concern, able to improve as the underground operations expand and needs grow. Finally, the GIS will be available online via the intranet allowing the many remote clients (both underground and surface offices – as well as offsite) access to up to date information required for efficient operational decision making

With all the information readily available, accessible online and in standard format it is expected to reduce lost management and supervision currently due to searching for this information and or improve decision making by having previously unavailable information accessible.

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1. INTRODUCTION

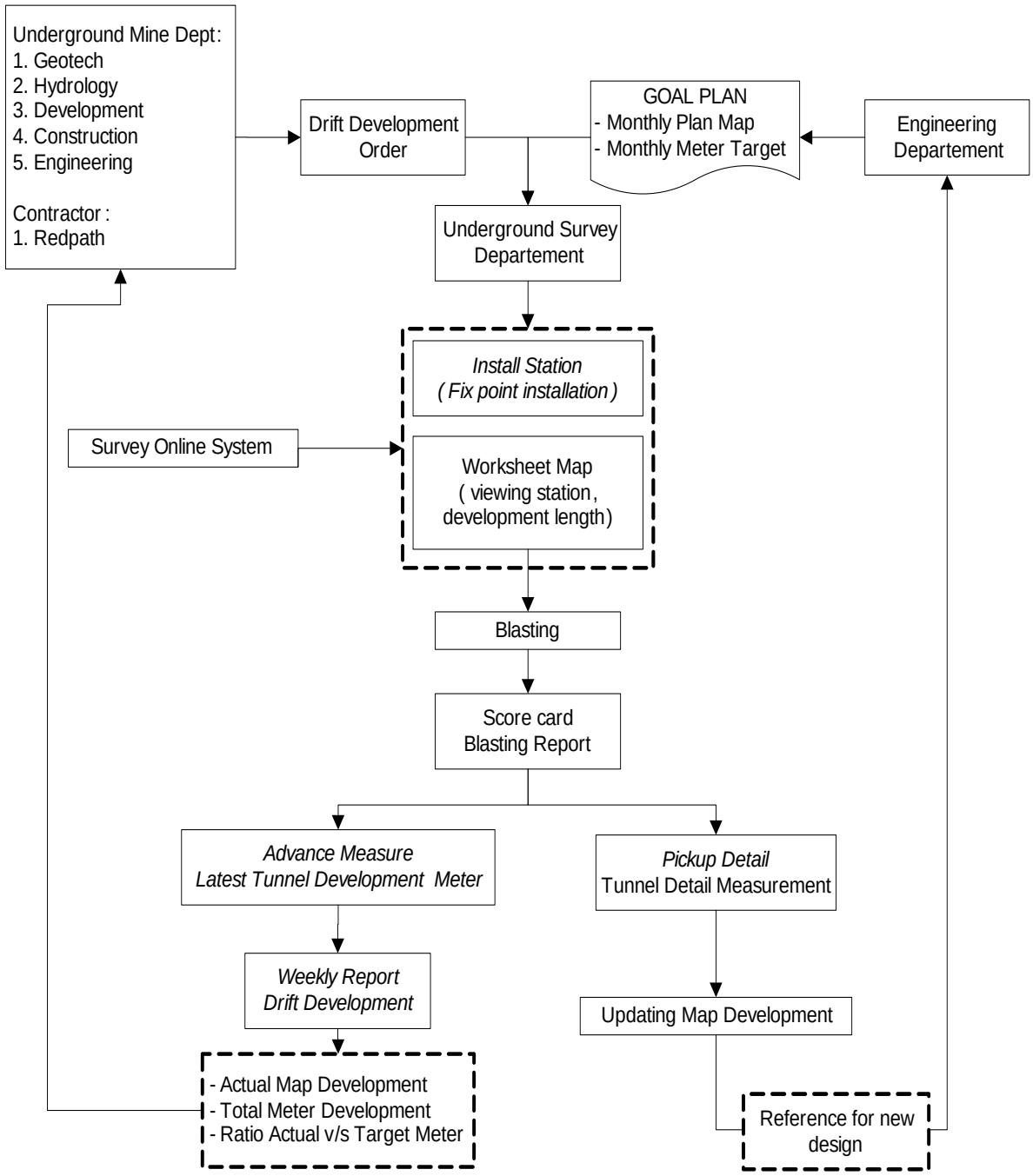
The underground operation of PT Freeport Indonesia is undertaking to ramp production up to the 80k ore production per day from an existing rate of greater then 40ktpd. This will challenge the ability to prepare development ahead of the required production as the tunnel development monthly goal is set to grow significantly. To enhancement support functions in assisting development operations achieve this goal highly efficient coordination and communication between each department is required.
The underground survey department is trying to provide the solution by developing a underground information system based on a Geographic Information System (GIS). In the future, UG survey will use this GIS as a central communication tool between all departments involved. As all of the UG development and facilities design is continuously compared to the actual spatial data and UG survey controls all the 'actual' spatial data it is natural that the UG survey department is the appropriate department to develop such a GIS.
One of the main purposes on the GIS application development is to create automatic reports of the tunnel development. This tunnel development report has involved many departments such as UG development, UG Engineering, UG QA/QC Engineering, UG Survey, UG Cost & Capital, and UG Construction. UG survey department measures and monitors the development advance per day and reported per weekly. The weekly report is finalized every month and compared to the monthly goal. This is currently manual reporting is via spreadsheets and will be replaced by GIS to provide a complete tabular and thematic map report. All of the attribute data on every development area will be integrated into a spatial database.

2. PTFI UNDERGROUND DEVELOPMENT

Tunnel development activity requires a solid communication and coordination between departments in the Underground Mine Division. Using GIS Communication and coordination and can be done easily, because information can be read and analyzed easier than viewing tabulated data sets.

2.1 Tunnel Development Activity

The tunnel development activities which involve many departments can be described as in the diagram below:

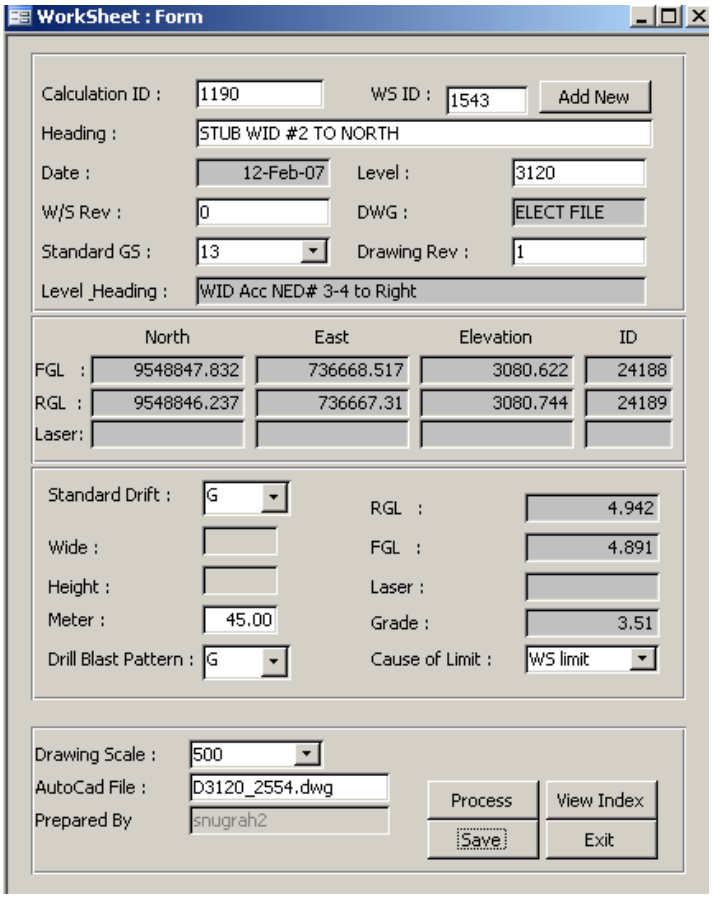

Underground Mine Dept:
1. Geotech
2. Hydrology
3. Development
4. Construction
5. Engineering
Contractor :
1. Redpath
Drift Development Order
GOAL PLAN
- Monthly Plan Map
- Monthly Meter Target
Engineering Departement
Underground Survey Departement
Install Station
(Fix point installation)
Survey Online System
Worksheet Map
(viewing station, development length)
Blasting
Score card
Blasting Report
Advance Measure
Latest Tunnel Development Meter
Pickup Detail
Tunnel Detail Measurement
Weekly Report
Drift Development
Updating Map Development
- Actual Map Development
- Total Meter Development
- Ratio Actual v/s Target Meter
Reference for new design

For supporting the GIS development, UG survey department has made several prior automation processes to help collect and store the data into a database. The processes which are already automated and stored into a database are:

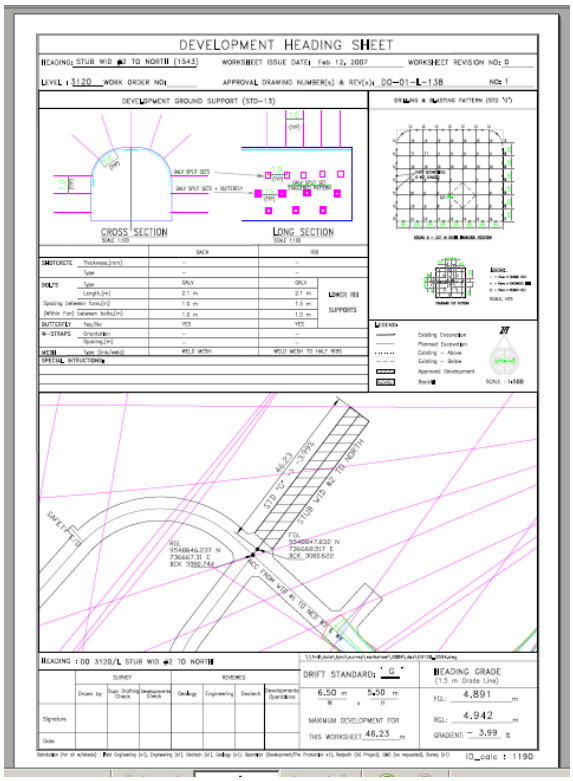
- Worksheet development and approval process
- Daily blasting report process

2.2 Worksheet Automation

UG operations need survey guidance to mine the planed tunnels. The guidance by survey consists of two stations (FGL and RGL) marked for the centerline, four wall plugs marked for the grade and a worksheet instruction. Station and wall plugs are installed in the field while worksheets are prepared prior to the field work in the office. The worksheet contains all of information about the tunnel development. It will show a design map & previously developed nearby actual tunnel development, station & wall plugs position. It also includes information about ground support type, drilling pattern type and drift design size, as well as certain warnings such as old exploration drill holes that might be intersected. To provide the worksheet, UG survey has developed their database to create the worksheet automatically. The surveyor will only need to input all of the survey station installation data and then a drafting operator will load the coordinates. This process is in a database combined with Auto Cad using the VBA connection.



Worksheet form

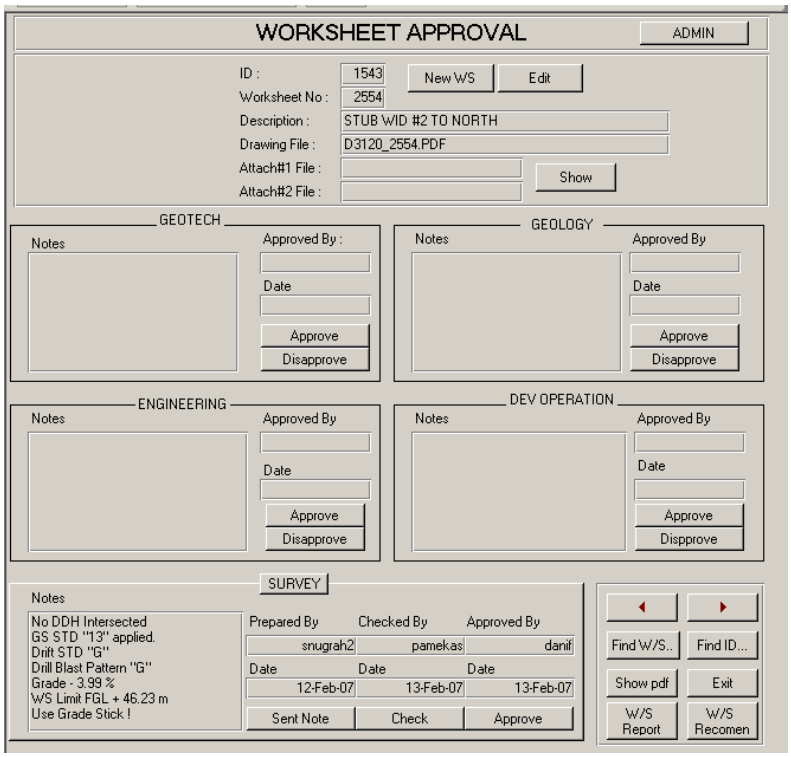


Worksheet sample

The worksheet paper is then upload into a server whereby approval is sought from all the departments involved in the tunnel development process, before it is used by the UG development department. The main purpose of the approvals in every department are:

- UG Geology: gave the rock classification and possibility of the diamond drill intersection with the planed drift
- UG Geotech: gave the ground support recommendation based on the existing rock classification on the planed drift.
- UG Engineering: gave the appropriate tunnel dimension and direction aspect according to their existing design.
- UG Survey: provide and make sure all of guidance in direction, grade and tunnel breakthrough possibility.

The approved worksheet is then used by UG development department to drift the tunnel.



Worksheet Approval Form

2.3 Daily Blast Report Automation

At every shift end, the UG Operation superintendent will record all of the tunnel advancement blasting performed The amount of tunnel advancement is determined as an order from Engineering based on the weekly plan which is broken down from the monthly goal plan. This daily blast report will became a predicted advance reference for the survey department to monitor. Every blast will is multiplied by a factor to convert it into advance length prediction based on specific tunnel and rock types in each area. Daily blast records will also be input and recorded automatically into the database. The advanced tunnel development should follow the worksheet guidance distance which has been approved previously by all departments in the UG Mine Division.
Daily blast advance prediction will be validated by survey measurements every week.

2.4 Tunnel Development Map

The tunnel advance measurements will be drawn in AutoCAD automatically using the database system. The drafter will only need to input the station ID and length of measurement. Length difference between last actual face compare to the new face will be the weekly actual tunnel development advance result. It will be the source to the time based development advance drifting report (weekly, monthly, quarterly and yearly report). The GIS development

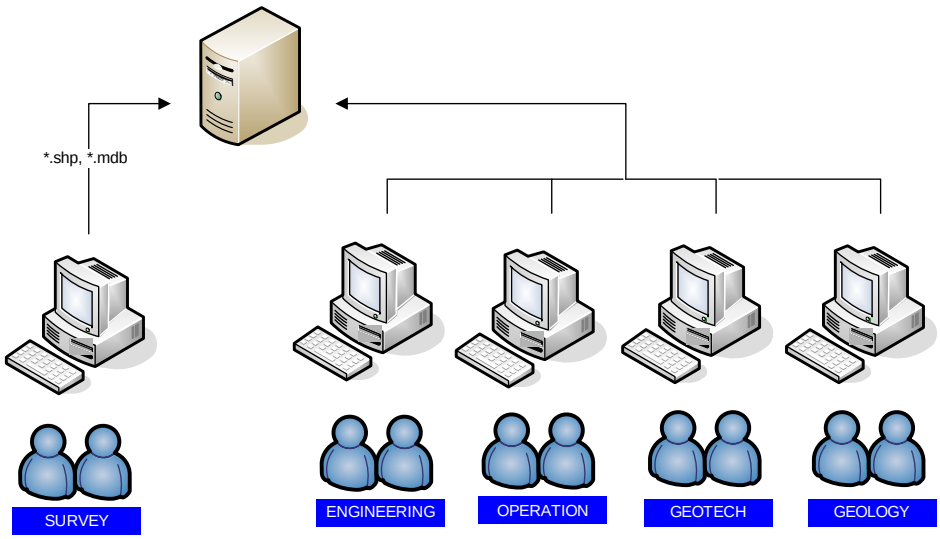
report use the *.Shp converted format from AutoCAD drawing file format. The conversion was done by a drafting operator.

3. SYSTEM ARCHITECTURE AND APPLICATION DESIGN

Specifically this GIS can be defined as a computer base system with capability for recording, storing, selecting, manipulating, and analyzing data with spatial reference. GIS is not only hardware or software or even a combination of both but a combination of five main components; computer hardware, communication network, software, data and personnel who run and maintain the system. Elimination one of the components can reduce the GIS application performance.

Underground GIS is maintained and developed by the UG survey team which is involving other department in the underground mine such as: Geotech, geology, Engineering and UG operations. UG GIS uses ArcEngine from ESRI as the application map engine. This software was chosen based on criteria of ease to develop and capability to embed into VBA as a COM object. In this situation, ArcEngine was embedded into a survey database in a MS Access form (*.mdb). This application was placed in the survey server and users can access the survey server using intranet communication.

Limitation budget and company IT regulation also constrained the selection to high end developer software which maximized the internal source software installed. Finally, it was decided to use MS Access VBA to customize the GIS and allow connection with other related software. It was realized that VBA and MS Access do have they limitations notably MS Access is not spatial database.



UG GIS - Conceptual Design

3.1 User Requirement Analysis

To assure UG GIS will be used by other departments effectively, UG Survey needed to clarify to them their involvement requirements.

Below are the user requirements for the GIS development:

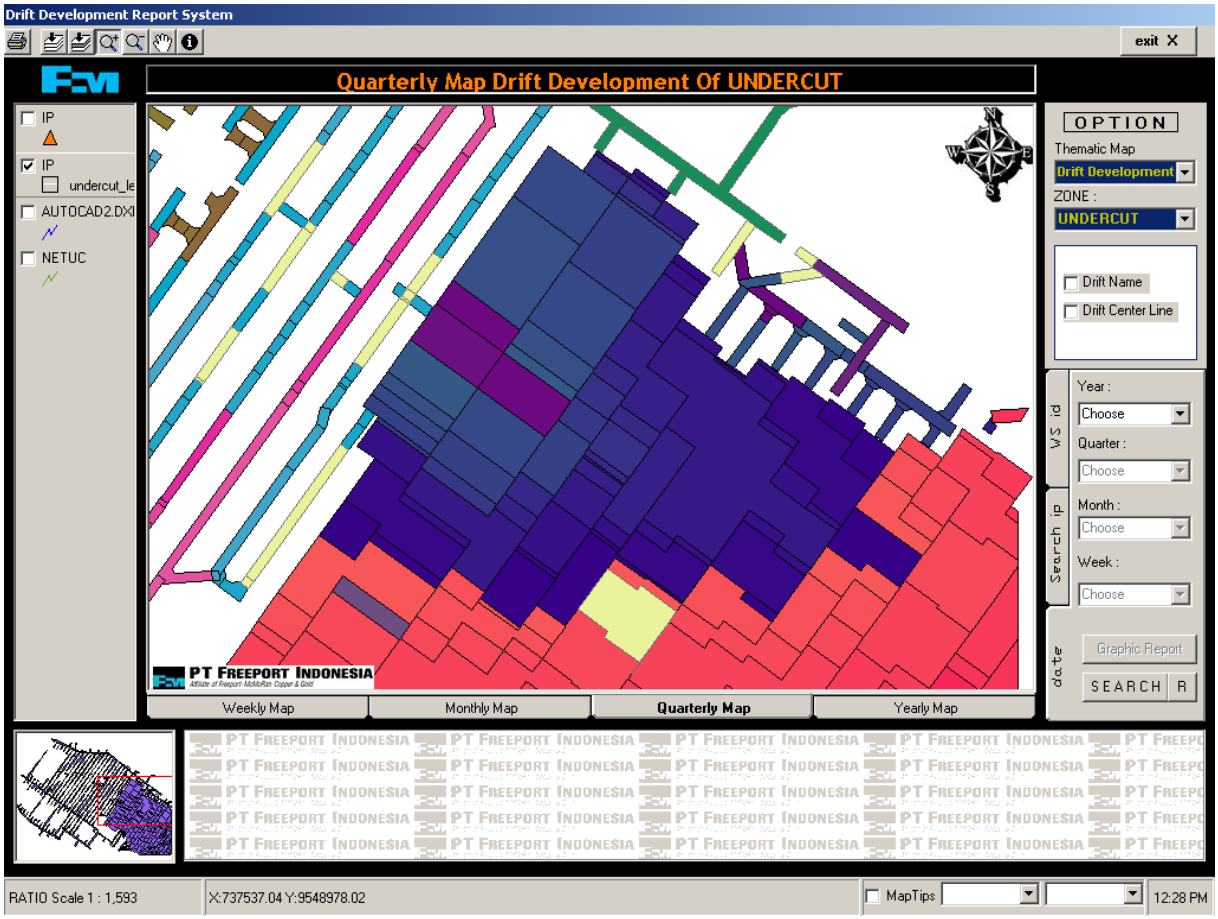
- The drifting advance monitoring and reporting
- UG utilities map
- Shortest route for heavy equipment and safety aspects

3.1.1 Drifting Advance Monitoring and Reporting

The drifting advance is measured based on the distance to the end of the tunnel (the 'face') from the last station installed in that area. The station nearest the heading face is generated from the automatic worksheet database process. UG survey measures all actual advance in each tunnel every week, this activity will validate the tunnel development prediction from daily blasting automation.
The result of the weekly report is automatically plotted into the AutoCAD file and then converted into a shape file in ArcEngine format. Several types of analysis can then be produced by this GIS application. They are:

- Input, collect and store spatial and attribute data such as distance from the last station to face of tunnel, standard ground support, rock type
- Querying spatial and attribute data, i.e. finding all tunnel development on 2nd quarter of year 2006 or find all drift with specific standard ground support.
- Integrating spatial and attribute data, i.e. selecting a tunnel location to find all information while developing.
- Updating spatial and attribute data, i.e. automatically generate the drawing and attribute data to the database.
- Visualize spatial and attribute data
- Perform GIS analysis like overlay, buffering, network, volume calculation and other for specific purpose queries.

Creating dynamic reports like heading development maps displaying all attributes



Generated thematic map per quarterly

3.1.2 Displaying a underground utilities map

In tunneling design, knowing where all of the utilities are installed is an important factor to consider. Ignoring this can cause damage to these facilities, possibly fatality i.e.: diamond drill was to break through to a electric power supply. Collecting the data is still progressing \ while a lot of data from other department already exists. Some of the utilities that we are colleting are:

- Electricity network
- Communication network
- Water pipe network
- Safety facilities (ventilation door, refugee chamber, exit way)

3.1.3 Shortest route analysis

Routing via the shortest distance is useful for two main purposes in UG GIS;

- Planning for emergency evacuation, it is use to define the shortest escape way route.
- Designing the heavy equipment movement route, especially jumbo drills.

Safety of Personnel in underground operations are at risk in any dangerous situations like: spill of toxic gas and fire disaster. These events often require the evacuation of all underground employees. To assist in the planning to reach a safe area, there are two options:

- Reaching the marshalling point, a safe place for the employee to come together before emergency response team are able to respond.
- Reaching a refugee chamber suitable for at most 20 people.

Network analysis was use to design the marshalling point and refugee chamber location in underground.

The second application for routing heavy equipment, especially jumbo drilling machines. This is a very powerful machine for the underground development drifting, but it has very slow movement. The engineer should have a good plan to move this machine efficiently within the wide underground development area at PTFI. UG GIS can solve this problem by network and buffer analysis, which will make it easier to plan the jumbo movement. The engineer is only needed where there is a new area to drill and using the buffer analysis it will search the nearest jumbo location. Combined with network analysis, it will give the shortest route to move the nearest jumbo machine. The engineer can open the water and electricity network map to arrange preparing of the facilities before movement.

4. CONCLUSION

Some of these UG GIS applications can provide communication and coordination efficiently. All of the automation processes above were used to accelerate and simplify the process. The automation was performed in a database to enhance the data inputting and assure a continuous process. The advantages of using UG GIS for the underground development operation are:

- Faster reporting and easier to create thematic map
- Easier to update and maintain all the spatial and attribute data recorded.
- UG management can monitor the development status and decide which areas need to be improved to catch up the goal plan
- All UG departments can create their own report using the UG GIS independently; even for updating the daily report status.
- Easier to analyze the report since it is based on the map, not only in spread sheet format.
- With the complexity of UG tunnels and fix facilities installed, GIS will help guide the engineer in guiding design new tunnel or new facilities.
- Easier for the safety manager to decide if one area needs additional safety facilities i.e. UG refugee chamber or relocate the available refugee chamber to the appropriate location.

The challenge in the future is to implement the GIS into the WB GIS and upload to the intranet network. Using the WEB GIS means more users from the other department can access to the GIS and cost reduction while number of users became larger.

REFERENCES

Longley, Paul A. Goodchild, Michael F. Maguire, David J. Rhind, david W, 2005 *Geographic Information System and Science*, second edition, WILEY.

Burrough P.A and McDonnel RA, 1998 *Principle of Geographical Information System*, New York: Oxford University Press.

BIOGRAPHICAL NOTES

Name: **Drajat Setiawan**
Academic Experience: Geodesy Degree from Institut Teknologi Bandung, Mining Master Degree from Institute Teknologi Bandung.
Current position: Chief Surveyor, PT Freeport Indonesia
Practical Experience: Land Survey, marine survey and Mine Survey
Activities in home:

- member of ISI, Indonesian Surveyor Association
- member of Perhapi, Indonesian Mining Association

Name: **Sandi Nugraha**
Academic Experience: Geodesy Degree from Institut Teknologi Bandung.
Current position: Surveyor, PT Freeport Indonesia
Practical Experience: Land Survey and Mine Survey
Activities in home:

- member of ISI, Indonesian Surveyor Association

Name: **Benget Hutauruk**
Academic Experience: Geodesy Degree from Institut Teknologi Bandung.
Current position: Chief Surveyor, PT Freeport Indonesia
Practical Experience: Mine Survey
Activities in home:

- member of ISI, Indonesian Surveyor Association
- member of Perhapi, Indonesian Mining Association

CONTACTS

Drajat Setiawan, Sandi Nugraha, Benget Hutauruk
PT Freeport Indonesia
OB#2 2nd floor 74 mill
Tembagapura, Papua
INDONESIA
Tel. + 62901418181
Fax + 62901418202
Email: benget_hutauruk@fmi.com; drajat_setiawan@fmi.com; sandi_nugraha@fmi.com
Web site: http://www.fmi.com