Evaluation of Truck Dispatch System and its Application using GPS in Opencast Mines- a Case Study of Indian Mines

A THESIS SUBMITTED IN PARTIALFULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF

Bachelor of Technology
In
MINING ENGINEERING

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Under the Guidance of
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Rourkela
2013

National Institute of Technology
Rourkela

CERTIFICATE

This is to certify that the thesis entitled, "**Evaluation of Truck Dispatch System and its Application using GPS in Opencast Mines- a Case Study of Indian Mines**" submitted by **Ch. Dinesh Reddy** in partial fulfilment of the requirements for the award of Bachelor of Technology Degree in Mining Engineering at the National Institute of Technology, Rourkela (Deemed University) is an authentic work carried out by him under our supervision and guidance.

To the best of my knowledge, the matter embodied in the thesis has not been submitted to any other University / Institute for the award of any Degree or Diploma.

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ACKNOWLEDGEMENT

My heart pulsates with the thrill for tendering gratitude to those persons who helped me in completion of the project. The most pleasant point of presenting a thesis is the opportunity to thank those who have contributed to it. Unfortunately, the list of expressions of thank no matter how extensive is always incomplete and inadequate.

I would like to articulate my deep gratitude to my project guide Prof. H.K.NAIK who have always been our motivation for carrying out the project.

An assemblage of this nature could never have been attempted without reference to and inspiration from the works of others whose details are mentioned in reference section. We acknowledge my indebtedness to all of them.

Last but not the least to all of my friends who were patiently extended all sorts of help for accomplishing this undertaking.

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ABSTRACT

Truck haulage now a days is the most common means which is used for moving ore/waste in open-cast mining operations. The truck haulage is usually the costliest unit operation in a truck shovel open cast mining. The advancement in computer coding technology has advanced to a point where there are many truck dispatching systems which will give the potential of advancing truck-shovel productivity and future savings. By trying a dispatching system in any mine can give operational increase In production by minimizing waiting times and can other beneficial advantages can also be obtained through good monitoring, optimal routing. The capacity of the employed truck-shovel fleet counts on the dispatching methodology in use, the intricacy of the truck shovel system and a number of other variables. It is a very common situation in mining that considerable number of analysis of the available techniques is undertaken before dispatching is taken. In many number of cases, computer simulation is the better applicable and effective method of relating the alternative dispatching strategies.

To study about the truck dispatch system (TDS), we have made a choice to make it on the shovel dumper combination using GPS. In TDS system the computer monitors the location and status whether the dumper is full or empty and its heading, velocity of each vehicle in the fleet. The system analyses production numbers, such as haul routes, historic data about drive time to a specific shovel location and the cycle time and time taken to make a complete trip. Trip from the shovel to the dump site and back.

The system then compares these data to most efficiently route all the vehicles. This system counts the number of trips by dumpers. It is given with very good features such as it is easy to learn, it is a user friendly interface capability. There is a very good scope for future development of this kind of system. It can also be used for equipment maintenance system.

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INTRODUCTION

1.1 OVERVIEW

Truck haulage now a days is the most common means which is used for moving ore/waste in open-cast mining operations. The truck haulage is usually the costliest unit operation in a truck shovel open cast mining. The advancement in computer coding technology has advanced to a point where there are many truck dispatching systems which will give the potential of advancing truck-shovel productivity and future savings. Trying a dispatching system in a mine can give operational gains by minimizing waiting times and obtain other beneficial advantages through good monitoring, optimal routing. Capacity of the employed truck-shovel fleet depends on the dispatching methodology in use, the intricacy of the truck shovel system and a number of other variables. It is a very common situation in mining that considerable number of analysis of the available techniques is undertaken before dispatching is taken. In many number of cases, computer simulation is the better applicable and effective method of relating the alternative dispatching strategies.

During designing dispatching systems, it is quite natural attempt to design the best available system compared the performance criteria, but subject to mining and resources constraints. If the number of other available system designs is not very large, the standard ways for solving optimization problems are being used: ranking and selection, and different comparisons with the best. Ranking and selection procedures produce one decision, i.e., which system design will be having the maximum expected performance, while different comparisons with the best provide estimates, i.e., the difference between the probable performance of each system design and the best of the other system designs. However, this theory is not extensively used in practice.

1.2 OBJECTIVES

To study about Truck dispatching systems (TDS) in open cast mines. I have made a choice to make it on the shovel dumper combination using Global Positioning System.

From the computer we can locate and monitor the location and state whether dumper is full or empty, heading, and the speed per distance of each vehicle in the fleet. From the system it can also analyse the production statistics, like haul routes, historic data from drive time to a specific shovel location, and cycle time how much time it takes to make a round trip from the shovel to the dump site and back. The system then allots these data to best efficiency route to all the vehicles. By the real-time access to each and every vehicle's point, we can find out if several trucks are waiting at one shovel and, if so, we can direct them to a different shovel. By this we can prevent bottlenecks and can keep operations moving freely. The dispatch computer can also be used to find out the most efficient location for the truck to dump its load at any given time.

Historically, open-pit mining operations were operated with each truck allocated to a given shovel. Now a days by using modern computer monitoring and control, the best and easy strategy is to dispatch the trucks to whichever shovel will contribute the most to the short-term production objectives. Marty dispatching methods can be used, both heuristic and pseudo optimal.

In shovel dumper combination system the main objectives are

To increase the productivity and to reduce the time of operation.

These are done by:

Minimizing shovel wait time (MSWT): The empty truck in this objective is assigned to the shovel which will be waiting for a truck the longest time, or is expected to be idle next.

Minimizing truck cycle time (MTCT): The primary aim of this strategy is to assign an available empty truck to the shovel which will provide the minimum value for completion of the expected truck cycle time to maximize the total tons or ton-miles per unit of time.

Minimizing truck waiting time (MTWT): The primary aim of this strategy is to assign an empty truck to the shovel where the truck loading operation will be initiated first.

Minimizing shovel saturation (MSS): The primary aim of this strategy rule is to assign the trucks to the shovel at equal time intervals to keep a shovel operating without waiting for trucks. The truck is allocated to the shovel which has the lowest ratio of the current coverage against desired coverage.

CHAPTER-2

Literature Review

Indian surface mining status

Mines where Truck dispatching system is used outside India

Mines where Truck dispatching system is used inside India

2.1 INDIAN SURFACE MINING STATUS

Importance of surface mining in the Indian coal industry with a share of over 80% and 54% respectively of total production in Coal India Limited and SCCL, calls for in depth study of the different ways and methodologies for increasing the production and Performance of surface mining systems in the upcoming years. Even if there will be any surface Mining systems of dissimilar sizes and improvement, there is no sceptical that surface mining systems from small scale to medium scale and mega-sized mines, would call for prominent inputs of fresh technology to be effective costly, eco-friendly and meet the production needs. In striving for new levels of functioning in the competitive environment, technology will be the corpus level for change, where computer technology will play a central role.

Benchmarking of surface mining operations world-wide disclose a yawning gap between the performance potential of the better of the mines and the most forged of the mines and there exists a jussive mood need to span this gap. Since, the scale of operations in opencast coal mines in India has grown by leaps and bounds; the conventional methods like surveying, planning and functioning the mines should be upgraded to reach the demands. A complete host of leading technology products and systems for good, efficient management of surface mines have evolved in the past decade.

2.2 MINES WHERE COMPUTER EQUIPMENT PERFORMANCE MONITRING IS BEING USED OUTSIDE INDIA

Some of the prominent mines where the system is being used:-

1. The Century Zinc Mine, operated by Zinifex in northern Queensland .It is using high precision GPS supplied by APS on two excavators for three years. The ore zone is hosted in grey shale. Identification of ore and waste is difficult. Century will also operate GPS systems on their Bucyrus 495B shovels used for overburden stripping.

2. The Collinsville Coal Mine, owned by Xstrata Coal and operated by Thies Contractors is a mixed coking and thermal surface coal mine in northern Queensland. Overburden stripping is accomplished by a dragline, dedicated stripping dozers and excavator and truck fleets. The mine has two Liebherr 994 excavators and two Liebherr 995s equipped with high precision guidance from GPS.

3. The ore body at Asarco's mission mine at Arizona, the mine uses a high-speed computer system to track each truck and shovel and calculate when a shovel will need a truck to load and which truck will be nearby. This reduces the waiting time for both the shovel and truck. The dispatch system also monitors the trucks' vital signs like oil pressure and temperature, to help prevent breakdowns.

4. U.S. Borax's mine in California's Mojave Desert is the source of nearly half the world's supply of refined borates. Developed a high-precision global positioning system (GPS) for machine counselling. This will help the shovel operators to locate safely in potentially hazardous areas. In addition to protecting people and equipment, the GPS system has also improved the mine's productivity.

5. In the case of the Chuquicamata mine in Russia, about 130 haul trucks are employed along with the GPS truck dispatch system to increase the productivity.

2.3 MINES WHERE COMPUTER EQUIPMENT PERFORMANCE MONITRING IS BEING USED INSIDE INDIA

1. The Northern Coalfields Ltd (NCL), Jayant open cast mine management has recorded an overall increase of seven per cent in the productivity of capital-intensive mining equipment like excavators and trucks with the use of dynamine.

2. Tata Steels application of a Truck Dispatch System at the Opencast Coal Mines located in West Bokaro (in Hazaribagh District of Jhakhand State of India)

3. Truck dispatch systems at Nalco, Damonjodi using the systems of GPS by an Australian company.

CHAPTER-3

Methodology

Unveiling to global positioning system

Unveiling to GLOBAL POSTIONING SYTEMS:

It has been more than 25 years since the introduction of the Global Positioning System (GPS). Uses and applications have grown rapidly and the technology is now well Established and reliable. Almost every mine now use GPS for surveying. A single surveyor can now finish in a few hours when once it took lot of time for people for completing days of tedious field and office work. GPS is employed directly on mining machinery. GPS guidance systems give chance to the operator to complete complex earthmoving designs without the need for field staking. Much advanced systems allow for accurate real time productivity monitoring and the automatic generation of "as-built" in the form of Digital Terrain Maps (DTMs). Before we get onto the central topic, we will try to recollect as to when and where GPS started. The first one called NAVSTAR GPS (Navigation Satellite Timing and Ranging Global Positioning System) was (and still is) a satellite-based radio navigation and the surveying system allowing clear 3 dimensional position, navigation and clock data to suitably equipped users everywhere on a continuous basis.

Opencast coal-mines are operated by continuous blasting and after blasting, excavations which in turn is followed by removal of Over Burden (OB) and retrieval of the coal. In this process of coal mining, two important sub processes viz. removal of OB and recovery of coal are predominant. But most of the effort goes in the removal of OB and this has a major effect on the productivity. In the action of over burden removal, 2 of the equipment viz. Rear Dumper and Excavator play a significant role. After the completion of blasting in an particular zone of the mine has been prepared, the Excavator starts loading the OB into dumper and each dumper goes practically through four different machine states i.e. Waiting (near Loading zone), Loading, Full and Empty (at Dumping zone). This chronology of machine states of a dumper makes one circle. Now it can be empathised that to observe the productivity automatically, one person should monitor the movement of RDs around the allotted Excavator i.e. from the Loading district to Dumping district and back to loading district.

By using the facility provided by GPS Receivers, it is feasible to find out the absolute co-ordinates of any mobile equipment. In extra to that, load sensors, limit alternatives, RF Telemetry etc. are comprised in the system.

There are 24 satellites letting in 3 active spares, active in near circular Orbits in six orbital planes of 55 o inclination at height of about 20,200 km. There are always more than twenty four operational satellites as recent ones are launched to replace more former satellites. Altitude of the orbit is such that the satellites more over once again like the same old track & configuration in every point approximately 24 hours regularly. These satellites will be having 12-hour periods so that minimum 4 satellites will always available for observation and to locate position on ground, sea and air at any time complete the year everywhere in the world. Specially coded satellite signals are provided by GPS that can be processed in a GPS receiver, altering the receiver to calculate position, speed per distance and clock time. Four satellites Signals are required to calculate the four dimensions of X, Y, Z and clock on Earth at any point.

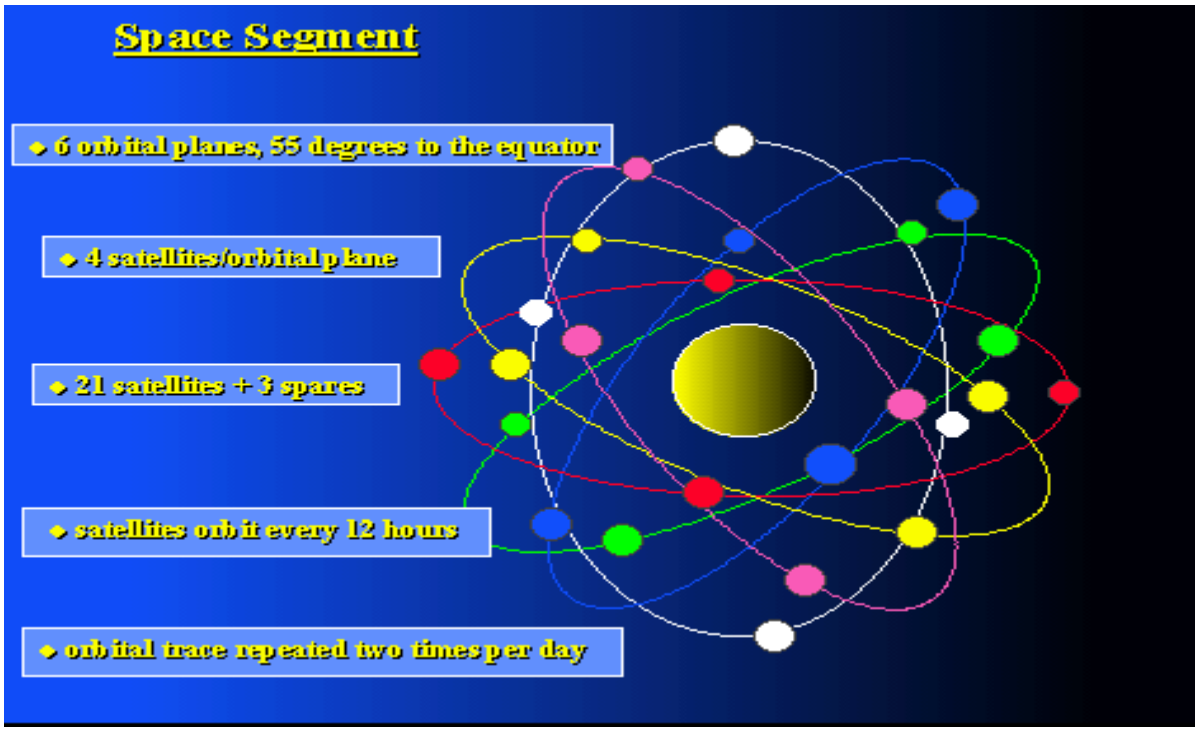


FIG: 1: GPS 24 SATELLITES CIRCLING THE EARTH

We can find out the location everywhere on or above the Earth to within about 300 feet by using GPS. Within less than three feet also greater accuracy can be obtained by correcting the calculated by a GPS receiver to the known fixed location. The significance behind GPS is the calculation of distance or range between the satellites and receiver.

The satellites also tell exactly where they are in their orbits above the Earth. If we people can find out exact distance of ours from a satellite in space, we will be positioning where we are , whether we are on somewhere on the aerofoil of an imagined sphere with its "r" same as the distance covered to the satellite "r". If we will be knowing our exact length from 2 satellites, we can find that we have been positioned unknown location on the line where the 2 spheres cross.in other case if we will be taking a 3rd mensuration, there are chances for only 2 points where we can be positioned. Among these one is usually inconceivable. The GPS receivers have mathematical method acting of terminating the untraceable position. For this GPS system to work, the receiver should know exactly where the satellites locations will be and these satellites should be capable of keeping reliable time.

ANTENNA PLACEMENT

GPS instruments determine the latitude, longitude and elevation of the GPS antenna. Ideally to determine the position of the bucket, the antenna would be placed right on it. However the antenna would not survive in this location, and moreover would be frequently shielded from the sky and thus not receiving satellite signals. On top of the machinery house is a better solution. The GPS determines the position of the antenna, but a functional system requires the system to determine the orientation of the machine. Since shovels and excavators typically stay in one position for some time and rotate in order to move material from the bank to trucks, it is possible to use one antenna offset from the centre of rotation. As the machine rotates the successive positions from the antenna can be used to calculate the position of the centre of rotation. Once knowing the rotation, the orientation of the machine can be calculated as the GPS antenna moves. However this scheme has the disadvantage that the machine must be rotated through at least 120 degrees every time the machine changes position. Using two GPS antennas and two

receivers is more expensive, but gives a faster more accurate result. The preferred locations are the back corners of the centre of rotation, machinery house.

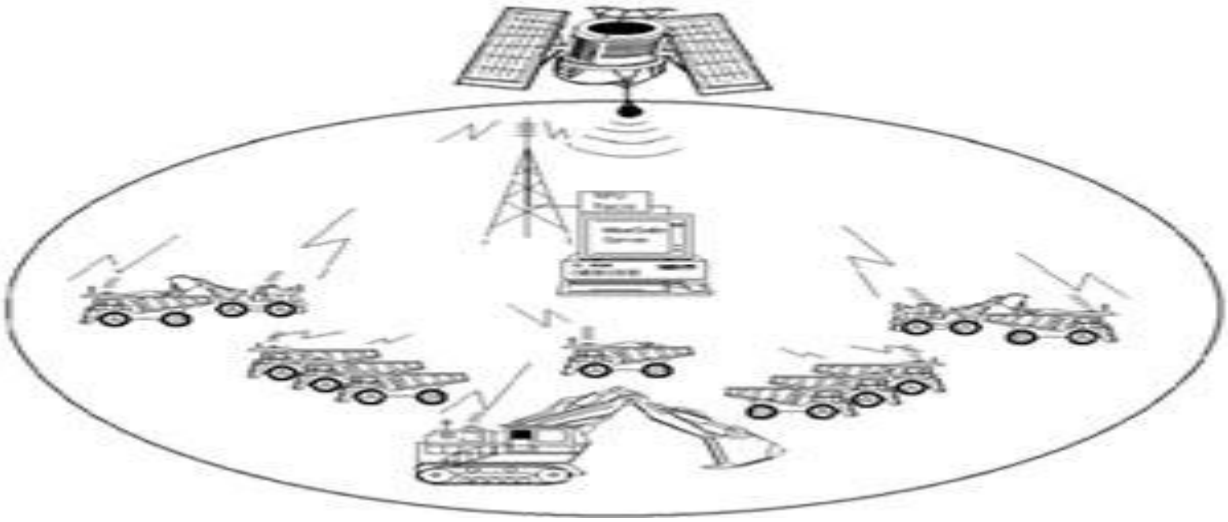


FIG: 2: Showing the GPS action ROTATION PLANE

Knowing the orientation and position of the machinery house enables the position of the boom to be calculated. However the result will be in error if the machine is not rotating in a plane parallel to the earth's geoid. It is necessary to measure the pitch and roll of the machine to correct the result for rotation in an angled plane.

BOOM COMPONENTS

Knowing the position of the machinery house does not get us the position of the bucket. To do that, we need to know the movements of the ropes or beams connecting the bucket to the machinery house. This can be accomplished with a variety of instruments-:

1. Tilt sensors
2. Rotation encoders on rope drums
3. Wire reel sensors on hydraulic cylinders
4. Measurement of fluid flow through hydraulic cylinders

Most reliable and robust solutions are proved by the tilt sensors and encoders.

TILT SENSORS

Many commercially available sensors work with fluid vials. These have variable sensitivities and limited ranges, and many reports in only one axis. However so called nano technology has opened up the possibility of tilt sensors based on other physical effects, such as the movement of minute gas bubbles. A tilt sensor developed for the task of tracking mining equipment must demonstrate a number of capabilities:

1. Rapid response – reporting at a rate of at least 10 times per second.
2. Accuracy – performance to within 0.1 degrees is essential in order to achieve Centimetre level precision on mining scale equipment.
3. Resistance to vibration – the sensor must be capable of filtering out vibration effects.
4. Resistance to overshoot – fluid sensors tend to "slosh".
5. With large Resistance to shock loading – the unit must be capable of withstanding the High g forces associated rocks landing on the boom.
6. Low maintenance requirements.
7. Easy calibration when installed in different orientations
8. Long life – at least 3 years is desirable.

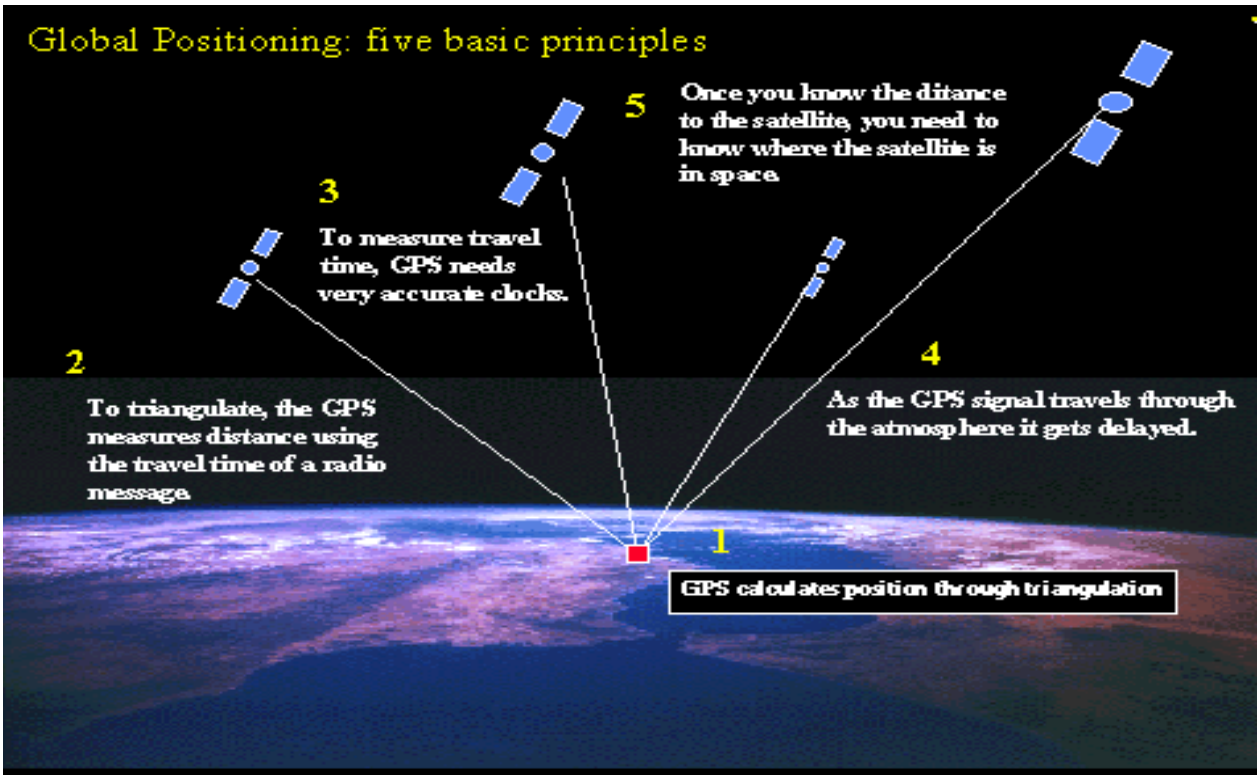


FIG: 3: Showing triangulation by GPS INITIALIZATION

High precision GPS requires the GPS receivers to measure phase differences on both code signals (L1 and L2) from each satellite and the carrier wave itself. Because the wavelength of the carrier wave signal is shorter than the resolution of the code phase, the GPS receiver must resolve the ambiguity in whole wavelengths. This requires at least five satellites and may take some time. For the user this means that after turning on the equipment there will be a delay before the equipment can define a precise position (reaches "lock"). If the delay is lengthy this can be a source of irritation. Some manufacturers' algorithms are more efficient than others and hence require less time to achieve "lock". The more satellites that are available, the shorter the time necessary to Achieve "lock".

COMPUTERS

Computers used on board mining equipment must contend with difficult environmental conditions. When the machines are unattended in the field the temperatures can range from the very cold to the very hot. When the machine is in operation, it is subjected to vibration and sometimes to relatively high dust levels. To be useful to the operator it must be easy to use and be visible under varying ambient light conditions. Rotating hard disks have a short life in this application and must be replaced by solid state memory. At least 2 GB of non-volatile memory is necessary to hold the operating system, system software and complex designs. The computer should have a touch screen for easy operation. It must be fast enough to compute bucket positions and update screen backgrounds in a production situation.

Fig: 4: COMPUTER SCREEN SHOWING THE MOVEMENT OF MACHINES

TELEMETRY

Radio telemetry systems are needed to transmit GPS correction signals, to download designs to the machines and to upload as built DTMs when the job is finished. Many GPS survey units use VHF signals for GPS corrections.

These radios are good for coverage but have inadequate bandwidth to transmit complex designs. UHF radios operating at 400 to 900 MHz provide enough bandwidth to transmit designs. Wireless LAN radios operating at 2.4 GHz allow machines to be connected into the mine's intranet system, or even into the internet for remote connection. Wireless LAN systems have great bandwidth but are limited to line of sight communication and distances up to 2 kilometres. Some of the limitations of wireless LAN can be overcome by meshed systems in which each machine is a repeater. Alternatively a dual system can be installed with UHF or VHF for the mission critical GPS correction factors and other data cached until the LAN connection is established.

FIG: 5: Foreman's vehicle system equipped with wireless LAN to duplicate Shovel operators view.

When machines are connected to the intranet, downloading designs is a simple drag and Drop process. Intranet connection also allows supervisors and engineers to log in and see exactly the screen that the operator is seeing, and thus answer any questions or concerns. Intranet connections for this purpose can be installed on supervisors' vehicles.

3.1 GPS Applications in Mining Industry

GPS embarked the Mining Industry as a rapid and cost-effective instrument for survey. A moving here and there landscape is the very casual agency of mining methods; the shovels and dozers will remove the coal and ore, the shovel and dumper will reshape the mine's aero foil. The constant changes happenings in mining industry can be accessed by real time GPS and heavy equipment operators are provided with the updated operating information. In add on, GPS systems give a rapid and exact solution for substituting and asseverate control points and by calculating the volume of material moved. By using advanced GPS technology heavy machines like dozers draglines can be assessed and used. By using Modern GPS systems we can also track and monitor the scenario and position of dump trucks, given reports to their targets, movements and speed covered per distance and also the amount of the truck's load. GPS live now a days is decorous for observing and bumping of haul trucks or drills and for giving grade assure on shovels. The data obtained can also be tied to a GPS to observe the location position of every equipment, in real-time. As GPS is an all-weather real time, frequently usable, economical and very exact positioning technique, will be having great array of applications in Indian mining industry. The potential areas for usage of GPS in Indian coal industry includes –

3.1.1 Surveying

Various advanced surveying proficiencies like Satellite Remote Sensing, Photogrammetric, Field surveying methods employing digital theodolites, short and long range EDM instruments like Total Station etc., are usable now a days. The major advantages when we use the satellite based GPS proficiency for surveying are:

- GPS mensuration do not require inter-visibility between points whereas the ancient surveying tools used to require line of sight for mensuration
- GPS method gives a 3 D position to the point. In one mensuration, we can get the horizontal and vertical position of the point, where as in ancient old surveying, we need 2 operations one is horizontal traverse for plan metric control and the other is a level loop for height control.

- A very eminent accuracy mensuration can be done in a very short time for baseline lengths of a few 100 meters to few 100 kilometres. It can also provide the very exact accuracy anywhere on earth, and also in any. Whether condition at any point or any temperature conditions.

GPS offers many rewards relatively when we compare with conventional survey methods. As there will be no necessity for a rod person, each surveyor will work alone when required. GPS also needs very much less setup time rather than any traditional surveying equipment, so the team can use its time more effectively. It will also keep a much more conciliatory schedule and can actuate from one area to the next or from one seam to another when it is needed.

CHAPTER-4

MONITORING PROCESS INVOVLVED

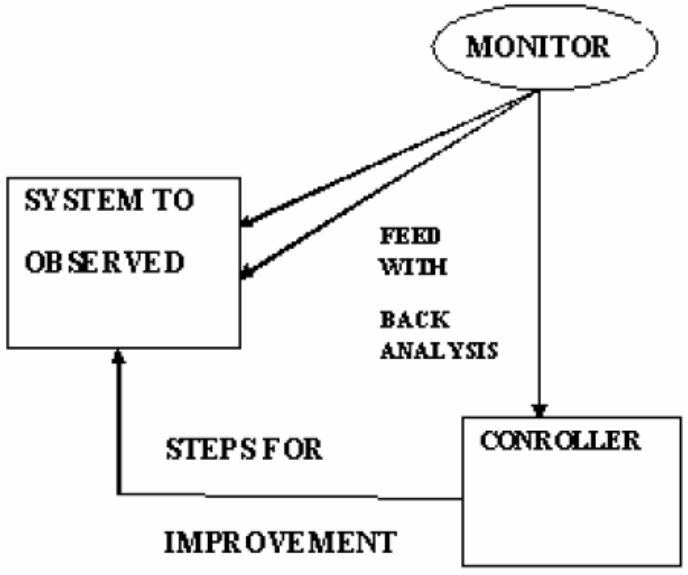
DEVELOPMENT OF A PROGRAMME FOR MONITORING PROCESS INVOLVED

IMPORTANCE OF EQUIPMENT IN OPEN CAST MINES

4.1 PERFORMANCE MONITORING OF EQUIPMENTS

The complete surface mine earthmoving process can be observes and increased by GPS installed heavy earth mining machinery (HEMM). Computer based mine operations management system will involve in tracking of mining equipment, functioning, monitoring and diagnostic systems, sending of loading instructions to dumpers etc. for best control.

The equipment's are very important tools for any productive organization in the modern age. The ameliorate performance of the equipment increases the productivity and production. The equipment that is used in the Open Cast Coal Mines are very high in size and cost. Few hours of break down or idle in machine will cost lakhs and lakhs of money. So functioning should be monitored, and monitoring of the equipment is very vital and required. The term PERFORMANCE, means more utilization and making the availability of the equipment's, economically, minimizing of fuel, energy, lubricants, more than the amount of production etc. The term MONITORING explains uninterrupted keen observation over the system to keep the usage of Equipment's and performance of the equipment, the functioning process can be presented by the following diagram:-

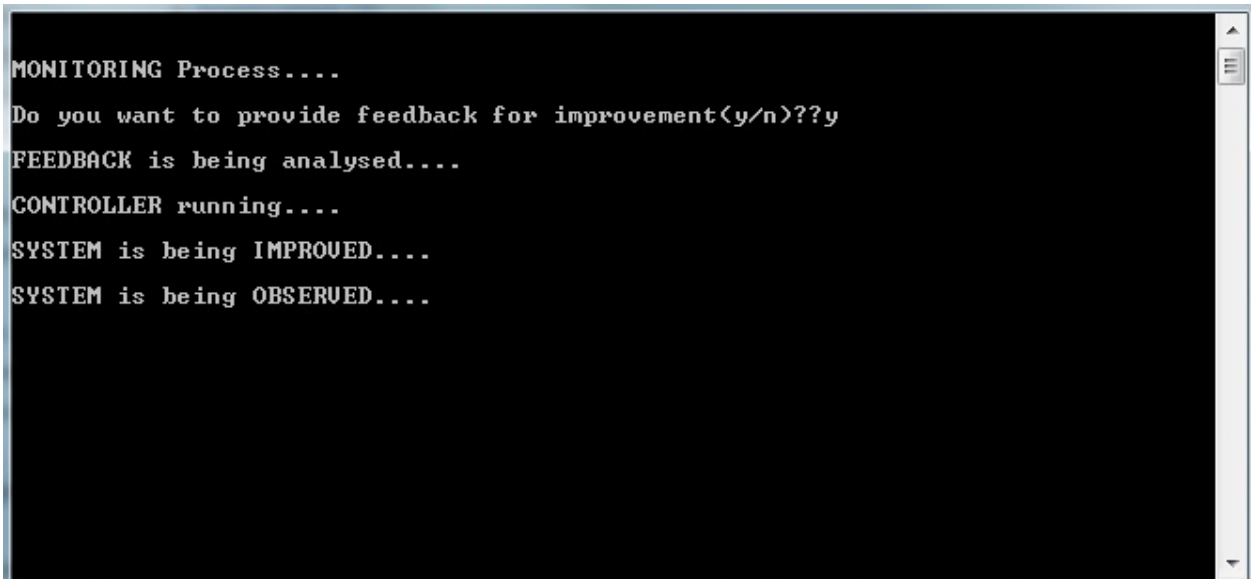


MONITORING PROCESS INVOVLVED

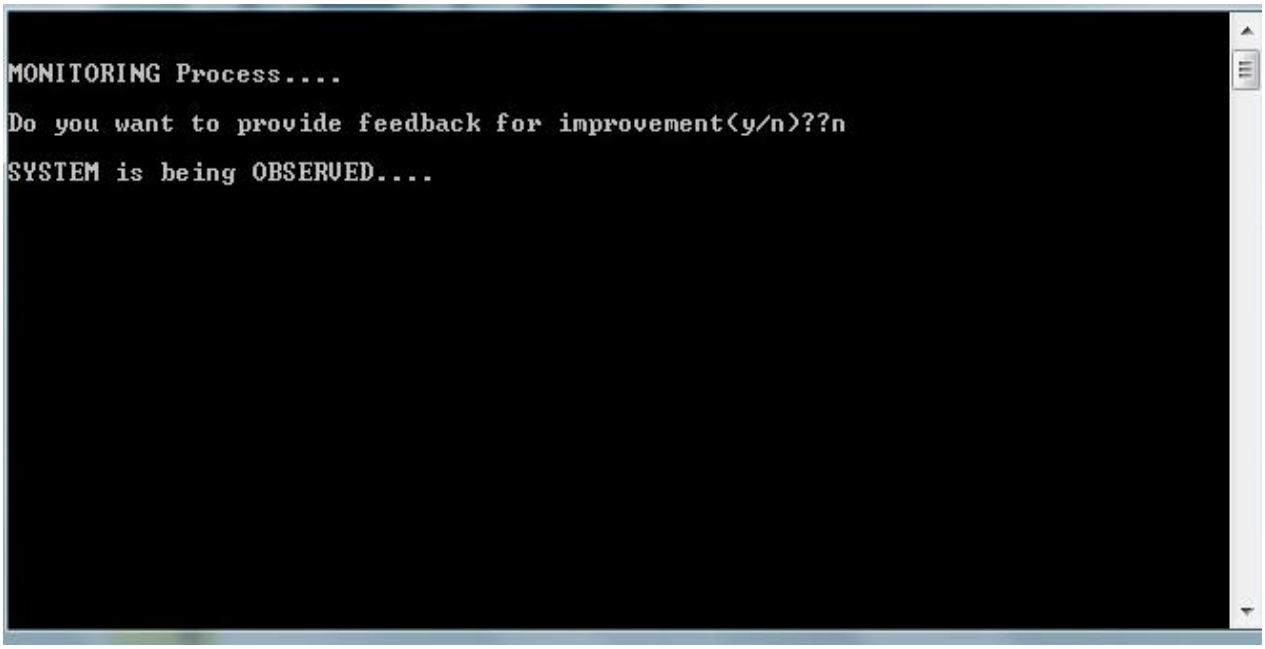
4.2 Programme for Monitoring Process Involved

```
#include<iostream>
#include<conio.h>
Using namespace std;

int main()
{
      Char x;
      cout<<"\n\nMONITORING Process....\n";
      Cout<<"\nDo you want to provide feedback for improvement(y/n)??";
      cin>>x;
      if(x=='y')
      {
          cout<<"\nFEEDBACK is being analysed....\n";
          cout<<"\nCONTROLLER running....\n";
          cout<<"\nSYSTEM is being IMPROVED....\n";
          cout<<"\nSYSTEM is being OBSERVED....\n";
      }
      else if(x=='n')
      {
           cout<<"\nSYSTEM is being OBSERVED....\n";
      }
      else
      {
           cout<<"\nWrong Input!!\n";
    }
    getch();
    return 0;
}
```



Programme for Monitoring Process Involved executed in exe. File



Programme for Monitoring Process Involved executed in exe. File

The two way function monitoring of equipment in an Open Cast Coal Mine. One of the first started one is On-Line Performance monitoring system in which the real time motoring is achieved with the direct interaction of computer. The other one is Off-line or Indirect interaction of computer in which the performances are observed by analysing the present data of the equipment and after that we should take the corrected action. The functioning monitoring system will be having some advantages and also disadvantages. The purpose dissertation work can be achieved by off—line Computer based observing system has been developed due to easiness of implementation of system.

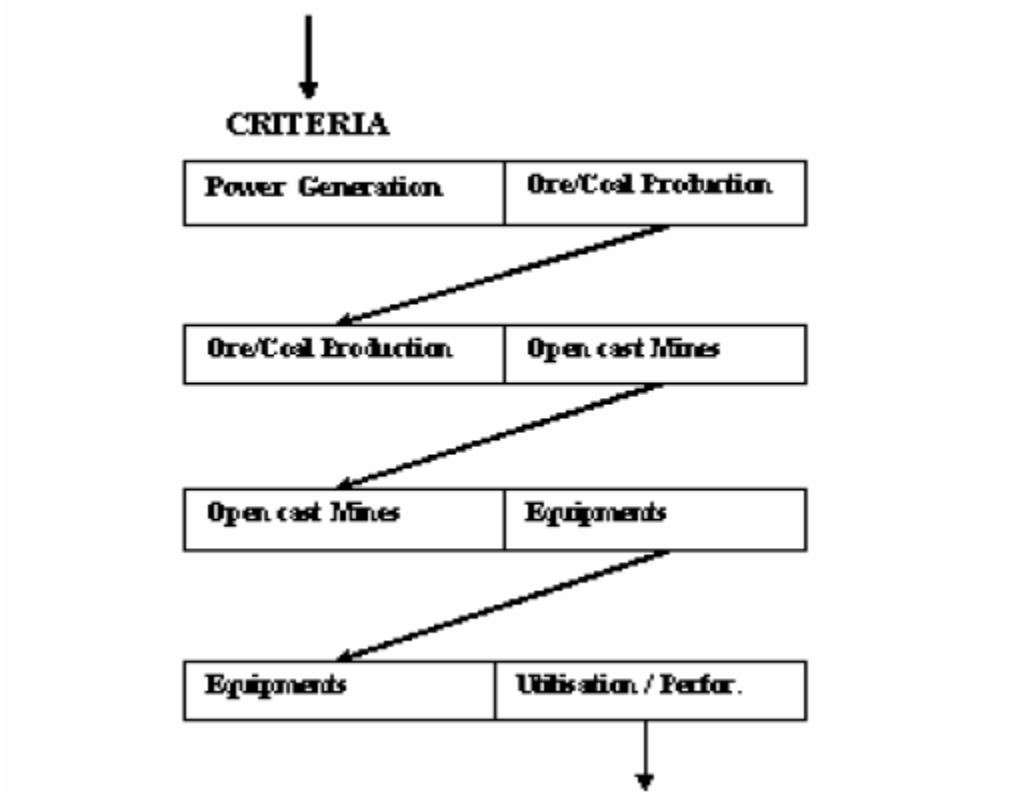
The system which is developed is a very good tool for functioning monitoring of equipment of surface mines on offline functioning basis. It is an integrated tool related to all equipment's in an open cast mine for performance Monitoring.

4.3 IMPORTANCE OF EQUIPMENT IN OPEN CAST MINES

Equipment's are very vital tools of any Productive Organization in the age of modernization. It increases the capacity of production or in other word it is responsible for growth of any Organization. If the past record of any productive organization can be examined then it will he found that by increasing the population of equipment the production as well as productivity can be extensively increased. The past record of Coal India Ltd. shows that huge increase in production was only possible due to introduction of sophisticated mining equipment's.

DESCRIPTION	1999	2013
PRODUCTION	256	980
MANPOWER (in Lakhs)	6.44	7.5
EQUIPMENTS (No's)	6500	23000
PRODUCTIVITY (Output/ton/man shift)	1.99	3,8

The above statistics chows that the production as well as productivity is increased three folds here as the manpower remain almost constant. So introduction of equipment has boost up the production/productivity. The introduction of large no of equipments was mainly in Open Cast Mines. And from Investment point of view or cost contribution point of view all the equipment in the Open cast project takes the major contribution. Cost of one shovel ranges from Rs 3crores to Rs 10crores in India and Dumper cost range from Rs 0.5crores to 3crores in India. Hence one hour downtime of equipments will cost lakhs of rupees in term of depreciation, consumption of fuel and manpower, interest on investment etc. so the equipment utilization and performance monitoring of equipment i.e. production/hour, fuel consumption/ unit of production, spare parts consumption etc. play role for growth of any mines.



Equipment utilization

PROGRAMME FOR EQUIPMENT UTILIZATION

```
#include<iostream>
#include<conio.h>
using namespace std;

class Utilization
{
        public: void Title()
        {
                  cout<< "Utilization\n";
        }
};
class Equipments
{
        public: void Title()
        {
                  cout<< "Equipments\n";
                  nextStep();
        }
        void nextStep()
        {
               Utilization u;
               u.Title();
        }
};
class OpenCastMines
{
        public:
        void Title()
        {
                  cout<< "OpenCastMines\n";
                  nextStep();
        }
        void nextStep()
        {
               Equipments e;
               e.Title();
        }
};
class OreProd
{
        public:
        void Title()
        {
                  cout<< "Ore Production\n";
                  nextStep();
        }
        void nextStep()
        {
               OpenCastMines o;
```

```
                o.Title();
        }
};
class PowerGen
{
        public:
        void Title()
        {
                  cout<< "Power Generation\n";
                  nextStep();
        }
        void nextStep()
        {
               OreProd o;
               o.Title();
        }
};
int main()
{

      PowerGen p;
      cout<<"Criteria for utilization of equipments:\n\n";
      p.Title();
      getch();
      return 0;
}
```

Programme for equipment utilization executed in exe. File

CHAPTER 5

SYSTEM AND SYSTEM ANALYSIS

SYSTEM ANALYSIS OF COMPUTER BASED EQUIPMENT PERFORMANCE MONITORING SYSTEM

DEVELOPMENT OF A PROGRAMME FOR COMPUTER BASED EQUIPMENT PERFORMANCE MONITORING SYSTEM IN C++

5.1 SYSTEM AND SYSTEM ANALYSIS

SYSTEM is a term that can be used in such a wide range of ways which is very difficult to give a definition. The term SYSTEM can be defined as a combination of objects together in some regular interdependence to target certain objectives.

System analysis is a coordinated set of procedure, which relates to the basic issues of design and managing how the man, money and material should he combined to achieve a bigger purpose.

Before designing any system it is very important to perform the system analysis to make the system efficiently eligible and accurate.

Basic characteristics of the use of System Analysis are:-

1. It will be making the designer's aware about the objectives of him.
2. It will seek a mechanism for expecting the prophets' demand on a system.
3. It will establish the procedures for producing a large no of possible solutions and for evaluating efficient methods to search through them.
4. It assembles optimization techniques to find out best alternatives which will suit accordingly.
5. It will suggest strategies for decision making, which can be used to select best possible alternatives.

The Basic Steps of System Analysis are as follows:-

1) DEFINITION OF OBJECTIVES**: -** The main step of system analysis is to identify and clarify the issues. All analysis are based on some set of intention target of the system.

A major part of the analyst job is to target loosely stated goals defined by clients for evaluating the basic purpose of the system.

2. FORMULATION OF MEASURE OF EFFECTIVENESS**: -** The choice of mensuration

Of effectively is useful because it gives the final design of the system. This Mensuration of effectiveness is used to calculate the relative effectiveness of the selected alternatives for meeting the objective of the system. Therefore mensuration of effectiveness must be designed and it also must be quantitative.

3. GENERATION OF ALTERNATIVES**: -** The main purpose of the analysis is to discover the better solutions. In order to find this the long range of feasible solution must be generated. The analysis should be continued to a detailed evaluation of the design option according to the following principal.

1. The main analytical effort should be developed to those other ones which have shown to be most productive.
2. The total effort that is spent on the analysis should not exceed its expected benefits.

4. EVALUATION OF ALTERNATIVES**: -** It is useful to differentiate carefully before the identification of the effects of each alternatives and the selection of the one important solution. The identification of best system consists in associating each Alternative system with its effects like the costs, benefits and impact on the community.

6. SELECTION**: -** The final step of the system analysis are to select alternatives .after evaluation of the alternatives value judgment is applied to select the good and better Alternatives which can satisfy the objectives and fulfils all the criteria.

5.2 SYSTEM ANALYSIS OF COMPUTER BASED EQUIPMENT PERFORMANCE MONITORING SYSTEM

The first Steps for SYSTEM ANALYSIS OF **"**COMPUTER BASED EQUIPMENTS PERFORMANCE MONITORING SYSTEM **"**are given below:-

DEFINITION OF OBJECTIVES: - The main aim of this system is to analyse and develop an effective system which can monitor the performance of the equipment efficiently and effectively. The developed system should be cost effective and easy and simple in operation.

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5.2.1 FORMULATION OF MEASURES OF EFFECTIVENESS**:-** The measures of effectiveness for this system are :

I. It should be cost

II. Easy to handle

III. Less number of personnel to be involved.

IV. It should be accepted by all.

GENERATION OF ALTERNATIVES: - The use of computer in the system may be

1. On line/ real time/ direct involvement

2. Off line /indirect involvement

The computer can be used directly in the system as real time operation or indirectly to improve the utilization or performance of the equipment. In the direct involvement the computer will be attached to the production line directly and will analyse the Performance and give the feedback to the controller or manager who will take some corrective action.

5.3 ONLINE INVOLVEMENT OF COMPUTER

In the past ten to fifteen years this technology has progressed rapidly as the advances in information technology. Sometimes it is called as Global Positioning System and this technology provides an accurate, systematic and cost effective way to collect and control equipment fleet.

The real time operating control of fleet of fleet of equipment using computerized system has two important tasks.

1. The first task is the dispatching the control of whole fleet. The main purpose of the dispatch control is to reduce each dumpers queue time to optimize its effective utilization.

2. The second task is concern with collecting and recording detailed performance data on the dumper fleet operation.

5.3 PROGRAMME FOR COMPUTER BASED EQUIPMENT PERFORMANCE MONITORING SYSTEM IN C++

```
#include<iostream>
#include<fstream>
#include<math.h>
#include<conio.h>
using namespace std;

int main()
{
    int time[3],pos[4],curr[2],pre[2],breakdown,idle,count,i,t;
    float avail,usage,util;
    /*
    time[0]=TotalTime; time[1]=CapacityTime; time[2]=MaintenanceTime;
    pos[0]=Load(x); pos[1]=Load[y]; pos[2]=Unload[x];
pos[3]=Unload[y];
    Curr[0]=Curr[x]; Curr[1]=Curr[y]; Pre[2]=Pre[x]; Pre[3]=Pre[y];
    */

    //Opening & reading from the input file
    string line;
    ifstream iFile("input.txt");
    if(iFile.is_open())
    {
         i=0;
       while(iFile.good() && i<3)
       {
                getline(iFile,line);
                time[i]=atoi(line.c_str());
                i++;
       }
       i=0;
       while(iFile.good() && i<4)
       {
                getline(iFile,line);
                pos[i]=atoi(line.c_str());
                i++;
       }
    }
    else
    {
      cout<<"Unable to open input file";
      getch();
      return 0;
    }
    //Opening the output file
    ofstream oFile("output.txt");
    if(!oFile.is_open())
```

```
    {
           cout<<"Unable to open output file";
           getch();
           return 0;
      }

      //Calculating breakdown and idle time
      breakdown=0, idle=0, count=0, pre[0]=0, pre[1]=0;
      for(t=0; t<time[0]; t++)
      {
            if(iFile.is_open())
            {
               i=0;
               while(iFile.good()&&i<2)
               {
                    getline(iFile,line);
                    curr[i]=atoi(line.c_str());
                    i++;
               }
            }

            if((curr[0]!=pre[0])||(curr[1]!=pre[1]))//CurrLoc!=PrevLoc
            {

if((curr[0]==pos[2])&&(curr[1]==pos[3]))//CurrLoc==UnloadPoint
                count++;
            }
            else
if((curr[0]==pre[0])&&(curr[1]==pre[1]))//CurrLoc==PrevLoc
            {

if(((curr[0]==pos[2])&&(curr[1]==pos[3]))||((curr[0]==pos[0])&&(curr[1
]==pos[1])))//CurrLoc=LoadPoint or CurrLoc=UnloadPoint
                  {
                      idle++;
                  }
                  else
                       breakdown++;
          }

          pre[0]=curr[0], pre[1]=curr[1];
      }

      //calculating availability, utilization and usage time
      avail=(time[0]-time[2]-breakdown)/time[0];
      util=(time[0]-time[2]-breakdown-idle)/time[0];
      usage = time[1]*count;

      //Writing to output file
      oFile<<"Availability Time = "<<avail<<endl;
      oFile<<"Utilization Time = "<<util<<endl;
```

```
	oFile<<"Usage Time = "<<usage<<endl;
	oFile<<"Breakdown Time = "<<breakdown<<endl;
	oFile<<"Idle Time = "<<idle<<endl;

	iFile.close();
	oFile.close();
	cout<<"Automization Completed!! Please check output file for
details.";
	getch();
	return 0;
}
```

The Input to be given: for equipment performance monitoring

Total time

Capacity time

Maintenance time

Load position (x coordinate)

Load position (y coordinate)

Unload position (x coordinate)

Unload position (y coordinate)

Current position (x coordinate)

Current position (y coordinate)

Multiple instances of current position at different times

The Output that we will obtain for the above given input is:

Availability Time

Utilization Time

Usage Time

Breakdown Time

Idle Time

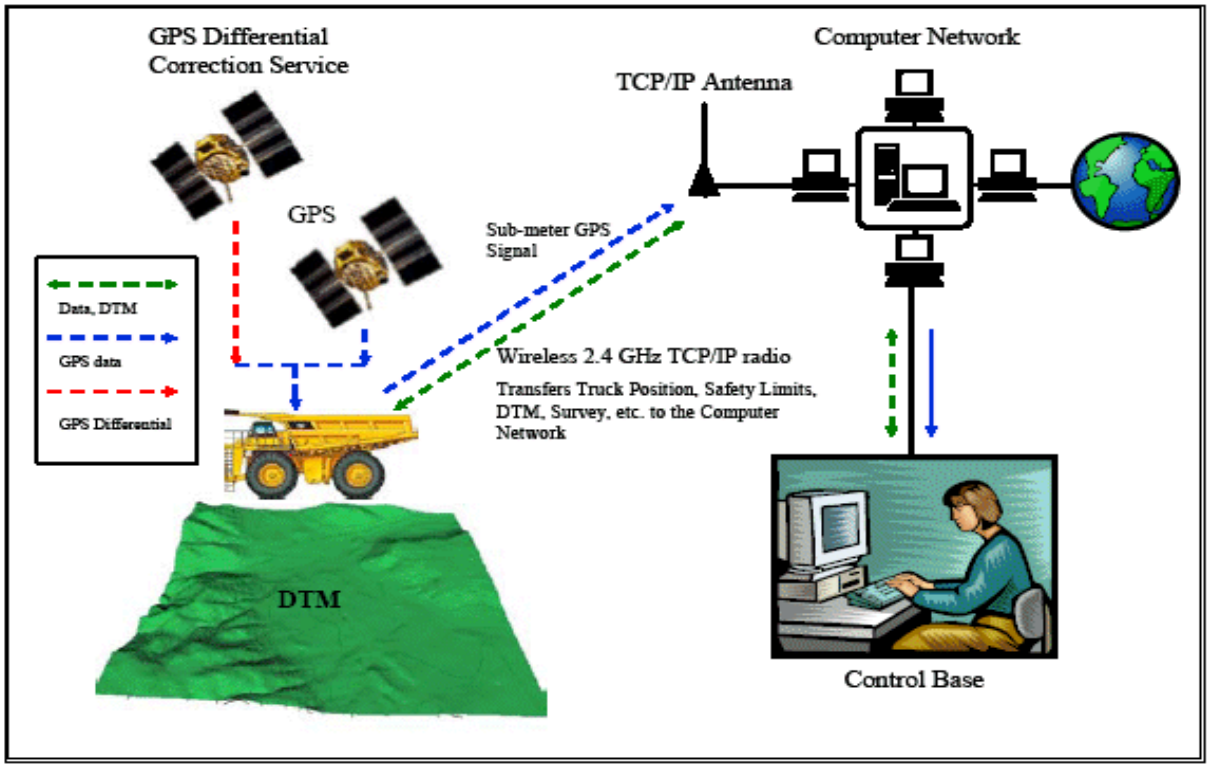
CHAPTER 6

CASE STUDIES

CASE STUDIES

6.1 TDS at West Bokaro collieries

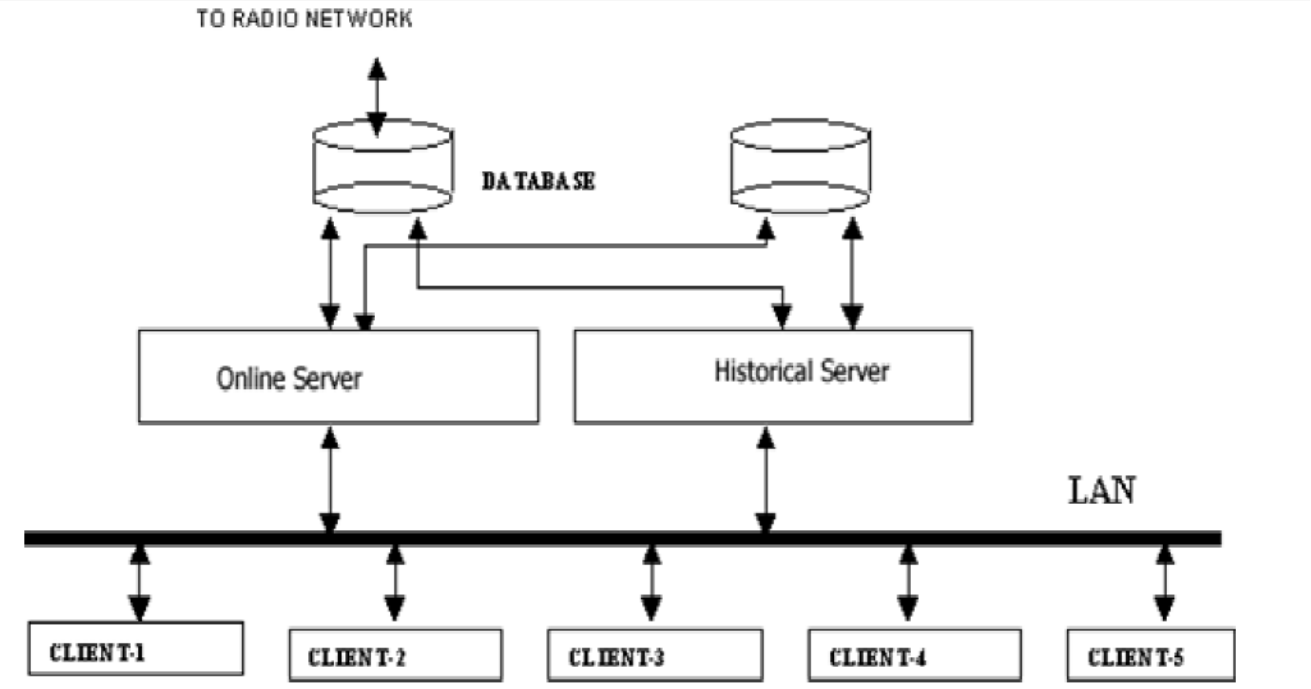
The HEMM capital equipment are movable, and function over a major area of the mine. They constitute a fleet of Excavators and Dumpers. It is required to coordinate the functioning from a central location. An effective and authentic on-line Tracking and Production Monitoring system is required for effective functioning. This explains the application of a TDS in Tata Steels at the Open pit surface Coal Mines located in Hazaribagh District of Jhakhand State of India in West Bokaro. Truck Dispatch System is established on the Global positioning system technology. As it is an opencast mine, Global positioning system is the best solution to locate location of each Dumper & Excavator inside the pit. Real time location (latitude /longitude) of each mobile equipment is transmitted periodically over UHF Telemetry Data Link from mobile equipment to the On-line Server present in the TDS Control Room. As there are two unlike quarries, which indirectly says in effect that there are 2 dissimilar mines, that are separated geographically one is Quarry AB and the other is Quarry E. For all pragmatic requirements, functioning of both these quarries are different and not dependent on each other, so there is autonomous Radio Network, TDS Control Rooms, Server network, Applications of the system, Database stored and Reporting but it is planned to combine these two different TDS Systems by taking the help of Wireless LAN to attain composite reporting and the intended system is able to integrate easily and future expandability. leaving this, the execution of the TDS has meliorated operations so that, the HEMM Operator are able to have better interaction with the mining process and give more value add on information which in turn gives ameliorate production supervising system.



Schematic representation of the configuration used to monitor a remote truck from the central office.

Figure: 6

Tata Steel's West Bokaro colliery now parted into two Quarries. One is Quarry AB and the second one is Quarry E. Functioning and monitoring of these two Quarries are independent of each other. The total no of fleet in west Bokaro colliery are around 70 Nos. of Mobile Equipment, among 70 there are 14 Excavators and remaining are the Rear Dumpers. The complete fleet is equally parted into two; one is for Quarry AB and other one is for Quarry E. Since the operating of these two quarries are independent, two different Central Control Rooms have been built for each quarry that is TDS Control Room located in Quarry AB and TDS Control Room located in Quarry E. Every Mobile Equipment have its ID burnt in the firmware of its TDS Hardware programmed on-board. TDS on-board hardware consists an Intelligent RPU, one GPS Receiver, Telemetry machines and Graphical Touch Screen (GTS) on-board will be used as the Operator personnel interface, keying in late arrivals, logins and seeing their assignments, production statistics.



TDS Control System Architecture
FIGURE: 7

6.1.1 Radio Network

For the transfer of data from the mobile equipment to the base server a radio network is established. Before the radio-network contrive, a complete radio survey is done to bring a good understanding of possible bad coverage areas. There are many areas like at the wall of the cut, behind the spoil piles and reject dumps. It is planned that the radio coverage will be checked regularly as landscape within a mine is dynamic. The functioning of the system depends mostly on the data transmission from both sides, from the mobile equipment to the base station and from the base station to the mobile equipment the transfer of data. Bad radio coverage can give loss of data, which cannot be tolerated.

Two distinguish Radio networks have been installed Within the West Bokaro Mine one for quarry AB and another for Quarry E. To confirm the height of antenna and location of antenna a radio survey should be performed for both Quarries AB and E. After the completion of survey it was concluded that the base antenna for quarry AB will be fixed on top of the tower beside the control room. The base antenna for the quarry E will be fixed on top of the tower outside the control room.

The diagram given below explains the radio network design and locates the GPS system. The GPS system is explained in detail in above section. This is the link for calculating the equipment location and sending this information to the base. On board processor communicates with the GPS receiver and it sends the equipment location through the radio network to the base. During the case of an excavator, this information is also required by the trucks, and the information is directly routed to them.

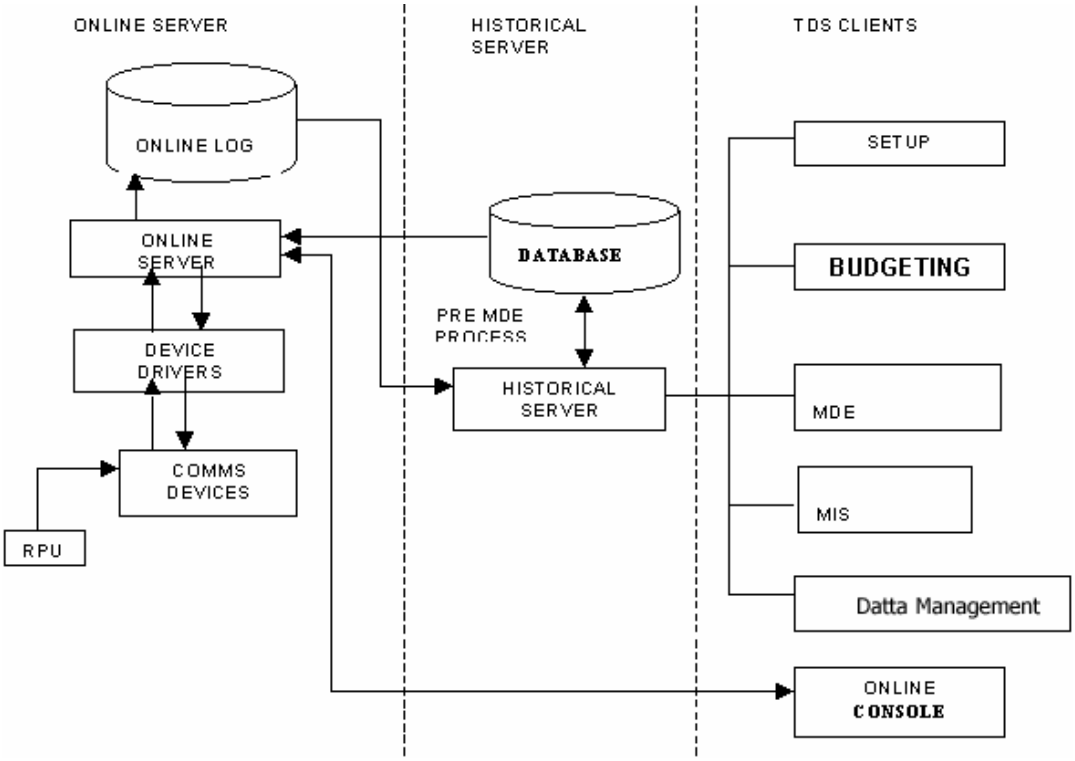


FIGURE 8: TDS Application Architecture

6.1.2 Tier Architecture

Three-Tier architecture comprises of the following components:

a) **Data Base: -** From the Data base, all the data will be coming from the On-line Server, the manually given data by Clients is stored. Now SQL Server 2000 is being used as data base. Each Quarry have its own database. For bringing forth composite reports both databases are calculated.

b) **Off-Line or Historical Server** - Off-line server is the program, which ports database with clients. All doubts from Clients are allotted to Database by the offline Server. So database is not directly access to Client. This helps to secure database from unwanted modifications.

c) **Client Application**: - This application distributed to all the Clients. Application mainly comprises of Manual Data Entry Module, GUI, and Online monitoring Module, Reporting Module, and System Configuration Module. GUI is the Map of the mine in which location (Longitudes, Latitudes) as well other parameters of different on-line observed HEMM's are displayed and updated according to the actual movement of the HEMM's. Reporting Module the primary use of it is for generating different reports about performance of equipment's. The system gives wizard and SQL editor for the making of Report templates, by entering criteria like date so it can be run at any time etc.

The On-line Monitoring module is performance wise similar to GUI but it does not show diagrammatic representation of the HEMM's. Here module on-line data which will come from field devices is shown in tabular form. System Configuration module will take care of many configurations according to the functionality required. Data Entry Module is for typing data for non-monitored HEMM's. So database incorporates information about all the HEMM's.So result reports coming out of system contain full information of all the Mine Machines.

6.1.3 Network Architecture

Though both On-line and Off-line Server Application can be run on one machine (PC), but that will make system to run slow and it will also give slow response to On-line Monitored HEMM's where normally its speed will be crucial. So for minimum functioning of the hardware and software, system will be having two servers, Off-line Server which is Hardware and On-line Server. As On-line server yields information from field devices, so to make sure that data will not be lost and response to On-line Monitored HEMM's is sufficiently accurate and speed, this machine (PC) is normally of good configuration in terms of RAM and Processor. Database will also be lying on this machine. The off-line server will handle the Clients, so that the client doubts can be answered, without becoming tedious process. The Off-line server will be having high RAM. All the Client Machines on the network can run the Client application interfaces, TDS Online Console, TDS manual entry of data for non-monitored equipment and the TDS free format reporting system. Hence, the system maintains data integrity, while simultaneously allowing a great range of user interactions and doubts.

6.2 Case Study of Jayant Opencast Coal Mine, Northern Coalfields Ltd.

DynaMine: Truck Dispatch System

- A global positioning system (GPS)-based, operator-independent truck dispatch system (OITDS) suitable for open cast mines.
- 30 million cubic metres of overburden i.e. the waste product generated during mining operations and around 10 million tonnes of coal per year is handled by the Jayant mine.
- Its fleet consists of 15 excavators having a capacity range from around eight to fourteen cubic metres, number of trucks are around 50 which has a capacity of 85tonne capacity and thirty trucks which are having the one twenty-tonne capacity.
- Entire fleet of excavators and trucks are covered by OITDS system. This system in Jayant o/c mines was gestated in 1999 and was executed in September 2002.

DYNAMINE

DynaMine is a global positioning system (GPS) based truck despatch system suitable for open-cast mines. All the components of DYNAMINE have been contrived to make operational in the bad environmental conditions of mines.

Its main components are:

- An Intel / Risc-based application-cum-database server
- A GPS-based on a vehicle instrument which is called Nirdeshak, for observing the important signs of vehicles, voice / data communication and positioning the location of equipment.
- It is an application package, which is considered to be the heart of the system

DynaMine modules include**:**

Display

- The display is Real-time display for mining operations
- It generates admonishing messages , the messages that are sent by the operator to the control room from (HEMM)
- It consists of a scrolling display of critical production parameters in same time
- It also activates the voice communication with HEMM operators
- The details about the Production, availability, utilization, status by double-clicking the icon of the particular HEMM.

Allocator

- Allocator allots the Dynamic allocation of trucks to excavators
- Allocator also Openings and closes various dumps
- It also Displays the equipment and operator performance and also many critical production parameters in real-time on client machines, and it also displays on large displays installed at the mines office

Survey

- In survey it edits and updates map of the mine, according to the data from mine planning software or from surveying instruments
- Defines blasting segments zones with blast timings, to produce automatic warning information
- Gives information, in case of any HEMM which enters the area during those times
- Defining and editing the profile of dump-points
- Play back the preceding movement of any particular HEMM, in a user-selected time duration with user-controllable speeds for analysing.

Maintenance

- It Records the breakdown failure information of HEMMs
- It Records the preventive functioning activities of HEMMs
- It Maintains a conk down history of HEMMs, to help in conk down analysis
- Mechanically produces a preventive maintenance schedule for HEMMs
- It monitors crucial components of HEMMs, through its interface with the important signal monitoring system

Administration

- Administering the radio communications from the server to HEMMs
- Assembles communicating parameters for voice communications with HEMMs
- Assembles communicating parameters for data communication with HEMMs
- Assembles parameters for the important signals observing hardware
- Real-time showing of the condition of important communication equipment like network controllers, communicating servers, terminal servers, etc.
- Assembles Nirdeshak, network controllers and terminal servers
- By receiving the condition and displays status-related data from network controllers and terminal servers
- Produces and maintains users login rights to various modules

Reports

- The amount of Achieved production
- The Allocation reports allocated accordingly
- Utilization and availability reports of the equipment's
- Conk out analysis reports, etc.

Dynamine application server

- Analysis of HEMM position and condition continuously to take dynamic allocation decision.
- Generates real-time data for feeding to the server for queries about the production data and equipment status on phone through the interactive voice response system
- Contends up and down communication with Nirdeshak units fitted in HEMMs
- Contends user connections from client equipment

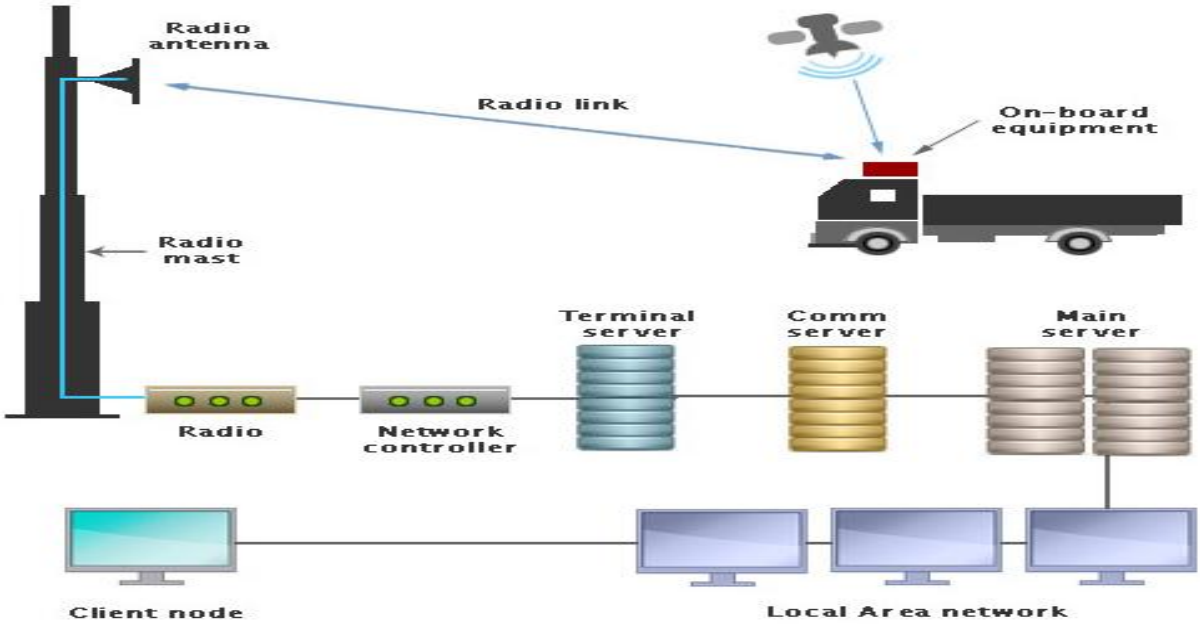


Figure: 9 DynaMine: Truck dispatch system

6.3 Case Study of NALCO Mines

NALCO'S application of a Truck Dispatch System at the Panchpatmali Bauxite Mine situated in southern ODISHA.

This panchpatmali bauxite deposit is a part of *EAST COAST* bauxite deposit which is situated in southern Odisha. Situated at a height of 1350 from mean sea level. Spread over the lat from $18^0$46' to 18^0 55'N & long from 82 dgr57' to 83dgr 4' E. Length of the deposit 21km and avg. width 1.45km. Survey is mentioned in the survey of India top sheets 65J/13 & 65 N/1. Resource evaluation was done by MECL in the grid of 400*400m.Expected reserve is 310MT & minable reserve is 230MT.Whole mines is divided into three parts like north block, central block & south block. Length of central block 7.5km & width 50-2000m.central block has the max reserve of bauxite i.e. 173MT as surveyed by MECL from which the reserve is divided into three grades i.e. A:B:C in the quantity of 26MT,78MT,69MT respectively. Exploration by MECL comprised of

- Topographic surveying & large scale geological mapping i.e. of 1:2000(7.25sqkm) scale.
- Dry drilling in vertical & a few inclined bore hole.
- Deep fitting.
- Sampling of drill collections.

Average mineralisation factor is 0.91.Main bauxite type is Gypsite (80 to 90%) which has max moisture content than other forms. Bauxite has alumina content of 45 to 50% , silica content of 2 to 5%,Ti content of 2 to 3% & Loss of ignition content is 31 to 42%.Exploration was done by Dry drilling & the drill bits used were cashing bits & cashing shoe bits.

Drilling bits	**Nx**	**Bx**
Cashing bits	75mm	54mm
Cashing shoe bits	77mm	67mm

Depth of drilling was done up to 30 to 70m.Bauxite present here is of Relict & vesicular texture. Exploratory drilling by NALCO is being done by vacuum suction drill. Now preproduction drilling is occurring in North block-2 in gridding of 25*25m^2.Drill bits used is tungsten carbide bits. Diameter of bore hole is 50mm & depth of drilling is up to 35 to 45m i.e. Up to 5 to 15 m

depth in the PLK layer. Length of the drill rod is 1.79m. Sample is being taken in every 1 to 1.45m of the drilling. E.g. bore hole no: PN-3395

- Sample-1 taken from drilling up to a depth of 1.45m from ground.
- Sample-2 taken from 1.45 to 2.45 etc.

Sample taken for daily lab testing for quality control is done in two ways i.e.

- Run of mines sample
- Blasting sample

Samples for ROM are taken from the conveyor which are ready for transportation to the zero zone. Each shift samples are taken in every one hour difference. Samples collected in every shift is about '5'among which 3 are boulder samples & 2 are in powdered forms. After collecting these 5 samples a composite sample is prepared for each shift i.e. each sample in A, B & C. Composite sample is prepared by jaw crushing & disc grinder. Initially samples are collected from ROM taken to the crushing yard & put up into the jaw crusher & then put into the disc grinder. After that the sample is sheaved under 30mm mesh. Then again it is put into the disc grinder & sheaved under 60mm meshing. Again the sample is put into the disc grinder & sheaved under the meshing of 120mm mesh. Then 300gm sample is collected & among them 50gm sample is sent to the lab for chemical testing & 250gm of that sample is kept as duplicate sample in geology store.

SURVEY SECTION

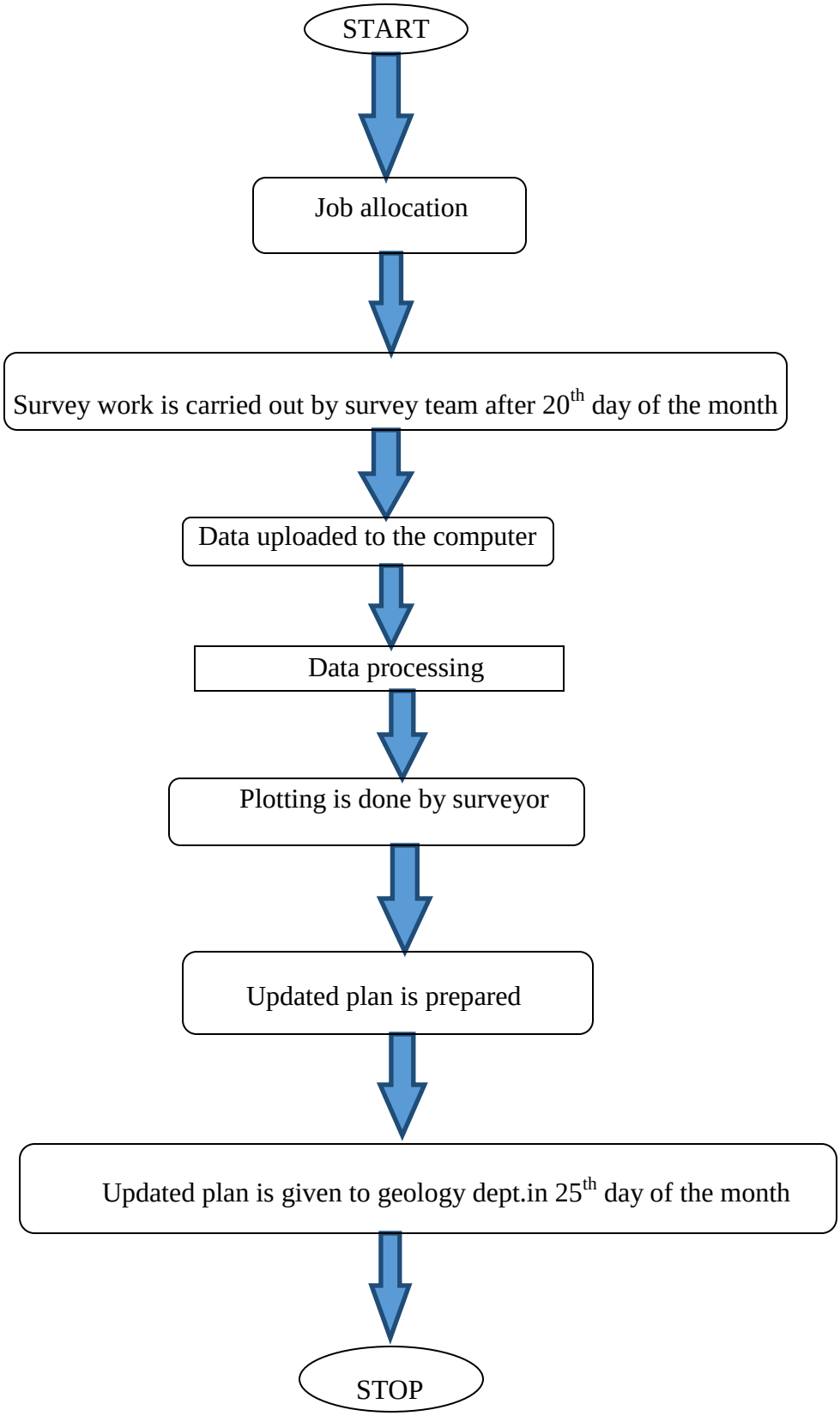
Procedures for surveying advancement of mining faces

Purpose: The purpose of this procedure is to show the advancement of mining areas in order to prepare the periodical excavation plan for achieving the targeted quality & quantity.

Reference: ISO – 9001, 2008 & Clause- 7**,** Total station survey instrument is used. Theodolite, dumpy with distomat can also be can also be used.

- Survey for advancement of faces is carried out by theodolite & distomat from the stations already fixed on the ground called ref. point with predetermined RL & coordinates.

Flow chart for monthly face survey



Procedure for statutory survey:

To outline a procedure for preparation & submission of statutory drawings to DGMS & IBM every year.

Procedure & purpose for preproduction drilling survey: Purpose: The purpose is to get the RLs & coordinates of the points at the centre of 25*25m^2 blocks for pre-production activity.

Scope: pre mining area

Reference: ISO 9001, 2008, CLAUSE: 7

Activity: Geology department gives the demarcated area on the plan for taking up PPD through mine manager.

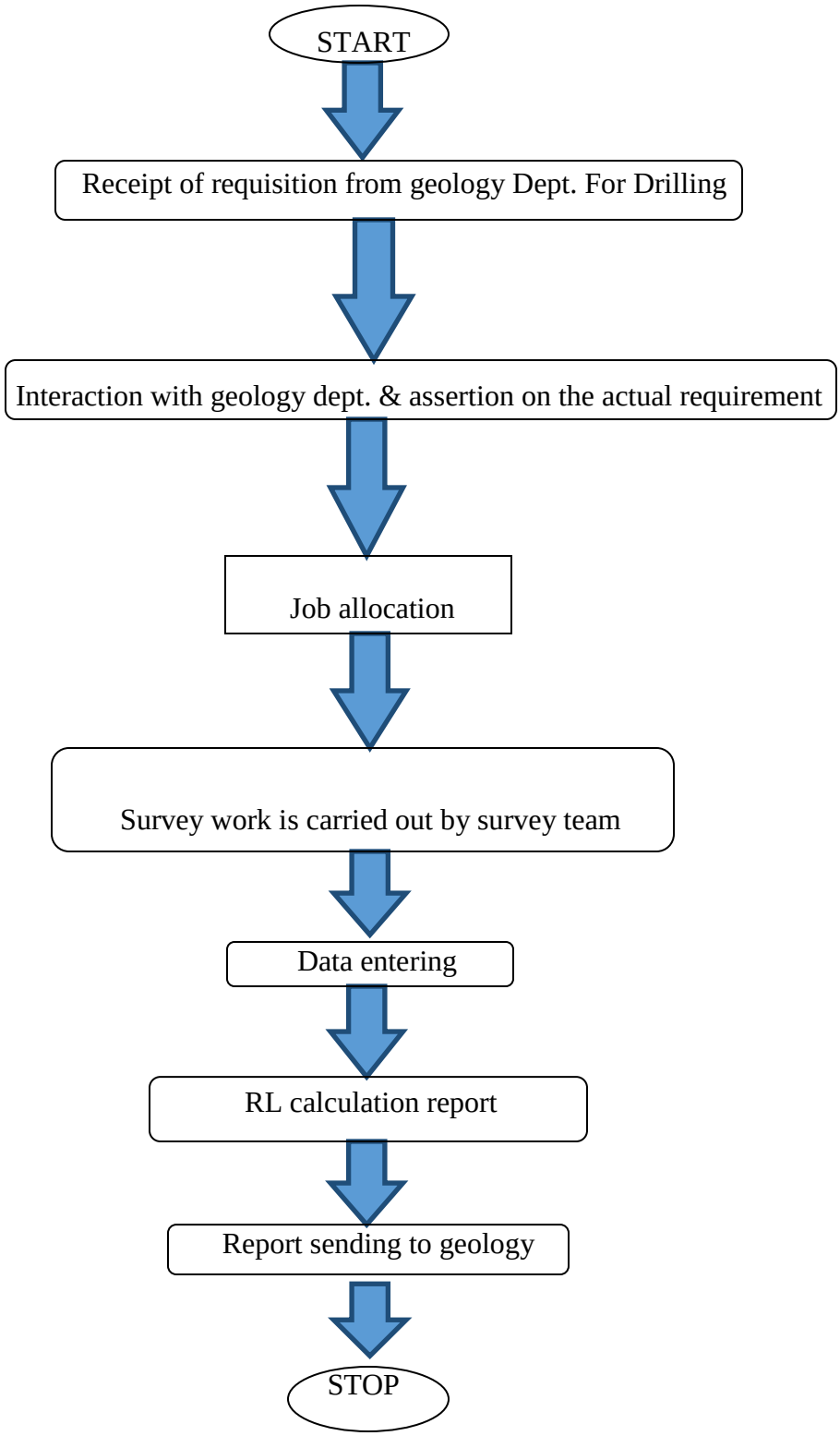
Ref coordinates & RLs are carried to fix bench marks nearer to ppd area. The proposed area is marked by 100*100m^2 blocks followed by25*25m^2 blocks on the field.

The centre pt. of 25*25m^2 blocks are located on the block centre.

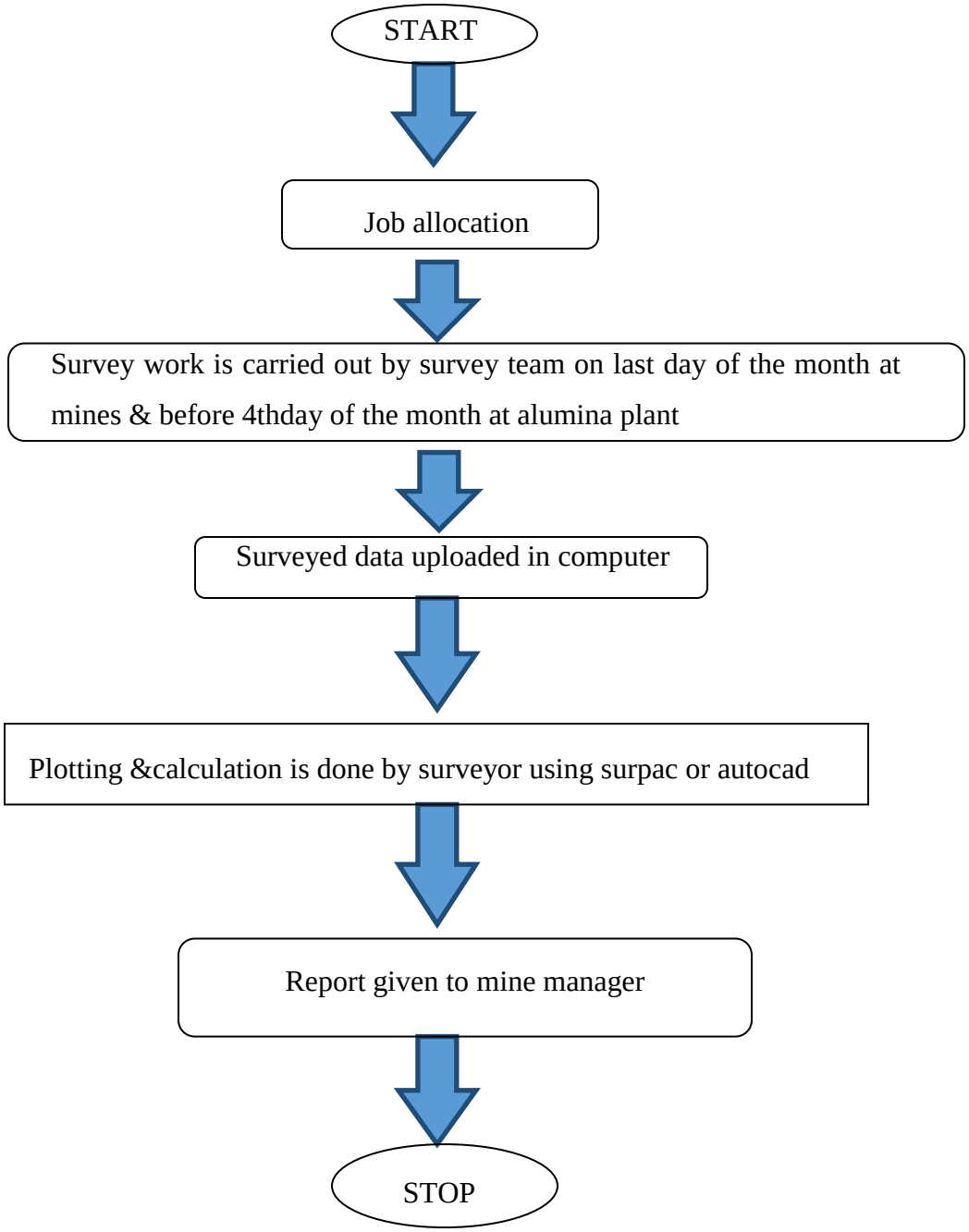
RLs are taken at the centre point of each block with reference to the bench mark fixed nearby through total station, dumpy or theodolite & distomat.

Surveyed data are recorded in total station or noted in the level book and distomat field record book as applicable. The RLs & coordinates of each pt. on the centre of the 25*25m^2.

PPD process flow chart:



Stockpile Survey Flow chart:



Purpose: purpose of stockpile survey to assess the quantity of bauxite & coal at alumina plant & mines.

Activity: Carried out on last day of every month & between 4thday of month at alumina plant. Stockpile survey for coal at the end of September & March to assess stock position of coal. Field surveys for stockpile by T.S. or theodolite & distomat.

Surpac Vision

This Is The Integrated Geology, Resource Modelling, Mine Planning And Production Software. Surpac Vision is the world's most popular geology and mine planning software, supporting open pit and underground operations and exploration projects. The software delivers efficiency and accuracy through ease-of-use, powerful 3D graphics and workflow automation that can be aligned to company-specific processes and data flows. Surpac addresses all the requirements of geologists, surveyors, and mining engineers in the resource sector and is flexible enough to be suitable for every commodity, ore body and mining method. Its multilingual capabilities allow global companies to support a common solution across their operations.

Benefits

- Comprehensive tools include: drill hole data management, geological modelling, block modelling, geostatistics, mine design, mine planning, resource estimation, and more.
- Increased efficiencies within teams result from better sharing of data, skills and project knowledge.
- All tasks in Surpac can be automated and aligned to company-specific processes and data flows.
- Software ease-of-use ensures staff develop an understanding of the system and of project data quickly.
- Surpac is modular and easily customised.
- Surpac reduces data duplication by connecting to relational databases and interfacing with common file formats from GIS, CAD and other systems.
- Integrated production scheduling with Gemcom MineSched™.
- Multilingual support: English, Chinese, Russian, Spanish, German and French.

EXCAVATION, DRILLING, BLASTING, TIME STUDY

In this Panchpatmali bauxite mines as the deposit is uneven blanket type in which the % of the alumina & silica is not constant i.e. zigzag type deposit. So a special type of surface mining method is used i.e. trench mining method in which at each level faces of different deposits is developed in trench forms .Trenches are developed with avg. width of 75m. Initially when the trench is developed on a level it is called as pilot trench. From that at other levels different faces are developed as trench forms .Then on each level advancement is done by excavating the faces in each cycle by 12 to 15 m.

The bauxite deposit is in a heterogeneous format which is sand witched in between Laterite & PLK (Partial laterite khondalite) in uneven depths. From the top 'TOP soil' is there with a max depth of 0.75m.Then laterite layer is present up to a depth of max 4.5m.After that bauxite deposit is there with a range 14m to 30m having avg. depth of 14.6m .Among them up to 8m depth bauxite deposit is something harder, so excavation & face advancement is done by drilling & blasting which is called as TOP BAUXITE layer. Then the other 6 to 7m deposit is somewhat softer called as BOTTOM BAUXITE LAYER. But the bottom most part of this bauxite deposit is also zigzag type with the PLK in which the silica % is up to 20%. So the BOTTOM BAUXITE layer is divided into two parts i.e. 1st part is up to 4m. From which excavation is done by ripping & dozing. Then the last 2 to 3 layer is excavated by selective mining as, if precaution is not taken, bauxite would be contaminated by PLK which has very high % of silica. If the bauxite deposit up to 30m depth & the TOP BAUXITE layer is more than 8m depth sub trench mining method is used in which TOP BAUXITE layer is divided into sub trenches of 8m depth & excavation is done by sub trench to sub trench, then the same procedure is applied for the BOTTOM BAUXITE layer for excavation.

Blast holes are made by Blast hole drill. It is operated by hydraulic force having drill bits as roller bits. Blast holes are made up to a diameter of 150mm & to a depth of 8m in bauxite deposit & 6m in the over burden deposit.

Here the blast hole pattern used is staggered type in which spacing is 5m & burden is of 4m. Generally explosive used for blasting is 20kg per metre of the hole. So on an avg. explosive is filled up to 6m of the hole & rest 2m is used for stemming. So avg. 100 to 120kg explosive is

required for a single hole. Among them 30% is BOOSTER & 70% is BASE that can be COLUMN explosive or ammonium nitrate- fuel oil. Avg. 1200MT explosive is required for a year. For storage of explosives 2 magazines are there i.e. one for ammonium nitrate & the second one for BOOSTER & COLUMN explosive. Both are having capacity of 25T.

Velocity of Detonation (VOD) of BOOSTER is BOOSTER is 4500 to 6000m/s. explosive is cap sensitive type. So for explosion of this DTH nonel is used having delay time of 475ms. In BOOSTER there is a high % of TNT than in column. COLUMN explosive is activated by BOOSTERs. VOD for COLUMN explosive is 3000 to 4000m/s. Two types of Nonels are used i.e.

- TLD
- DTH

TLDs used are of two types i.e. 17ms & 42ms. 17ms type is used for front line & 42ms type is used in 2nd line & later. DTH Nonels used are of two type's i.e.

- 475ms for bauxite having length of 9m
- 500ms for OB having length of 6m
- Due to front lie arrangement of 17ms & later arrangement of 42ms type TLDs in the blasting max free face is available for individual blast holes. So that better fragmentation occurs & vibration is reduced.1st

TLD network is detonated then individual hole is fragmented by DTH. With this type of arrangements we can detonate more than 50 holes also in a single throw. But it couldn't be possible in a elec. Detonator network as we can manage up to a network of 10 blast holes with the available types. In electronic detonator network the delay time for hole to hole & row to row can at max 75ms.if delay exceeds there would be a misfire. So as here for blasting more than 40 holes is required the Nonel. The blasting works, location of blasting & quantity of explosive used are recorded in a record book with a serial number.

Example I

Date of blasting in J/Bauxite is 6/2/2013. No. of blast holes drilled are 42 having 150mm diameter. Spacing is 5m & burden is 4m. Depth of blast hole is 8m. Metre blasted is 336m. Types of explosives used are BOOSTER & AMMONIUM NITRATE. Shakti boost of 1250kg from mag/1 & ammonium nitrate of 2950kg from mag/2 is used. Teldetnonels are used i.e.

- 475ms: 80
- 42ms: 54
- 17ms: 26
- SDD used are 2. Expected tonnage is 13500T.

Example II

Date of blasting in O/Bauxite is 8/2/2013. No. of blast holes drilled are 38 having 150mm diameter. Spacing is 5m & burden is 4m. Depth of hole is 8m. Meter age blasted is 304m. Types of explosives used are Shakti boost of 1125kg from mag/1 & Shakti base of 900kg & AN of 1600kg from mag/2 is used. Teldetnonels are used i.e.

- 475ms: 72
- 42ms: 72
- 17ms: 24

  SDD used are 2 & expected tonnage is 11500T.

In a shift the running equipment's are updated in a record. Avg. 25 equipment's are operated in a shift i.e.

- 12 dumpers
- 5 loading equip.
- 2 drills
- 2 water sprinklers
- 2/3 ripper dozers
- 2 auxiliary equipment

So in each shift up to 35 operators are required in A & B; in 'C' shift 6 operators are required. Cumulative trips taken from different trenches in a shift are recorded in a record book.

Example: **Table 1: Number of trips covered in the operation by rear dumper**

SHIFT: A 19/2/2013

AREA OF OPERATON	**NO. OF TRIPS**
N: 3/OB	31
N: 4/OB	50
N: 5/BAUXITE(HE-10)	30
N: 5/BBAUXITE	46
L/BXT	73

Total trips: 230

DRILLING	AREA OF OPERATION	DRILLING METER
DRILL-10	N: 3/BXT- 21*8	168

Total: 168m.

DRILLING	**OB EXCAVATION**	**BAUXITE EXCAVATION**	**BAUXITE PRODUCTION**
168m	4050T	7165T	4890T

MACHINE AVAILABILITY FOR NEXT SHIFT

- Backhoe excavator: HEM- 1,3,6,8,9,10
- Front end loader: WLL - 10,13,14,15,16,17,18,19,20,21
- Haul pak Dumpers : HD- 1) 50T: 2,4,5,10,11,17,18,19
  2) 55T: 1, 2,4,5,6,8,10,11,12,13
- Ripper Dozer: RDM- 7,8,9,11,13,14,15
- Blast hole Drill: BHD – 7,9,10,11,12

AUXILIARY EQUIPMENTS

Rock breaker: HRB – 2

Motor Grader: MGR – 4

Water Sprinkler: WSM – 7

Wheel Dozer: WD – 3

The above equipment's are available for use in the next shift i.e. is in 'B' shift. Again at the end of shift 'B' availability of the machineries is recorded in the record book for reference of the next day. In the C shift only feeding of the crusher hoper is done by bucketing by loaders & tripping of the dumpers from stock pile; no excavation is done from the trenches.

Example

'C'shift 18/2/2013

AREA OF OPERATION	BAUXITE PRODUCTION	NO OF CYCLE
SP/BXT TO CRUSHER	3802T	20 TRIPS + 250 BUCKETS

These records are necessary for the real time study of the quality & quantity of production & achieving the schedule for next day's operation.

Truck Dispatch System (TDS)

This is the fully computerised Global Positioning System. This has been used in NALCO mines for the last few years. This is used to locate the Positions of different equipment's within the range of the satellite.

There is a Satellite installed for this purpose. This has a particular range. There are several zones called Dark Zones which are out of the range of the satellite or is in a weaker part of it.

The GPS Based Truck Dispatch System implemented at Panchpatmali Bauxite Mine has been a great success in achieving its objectives.

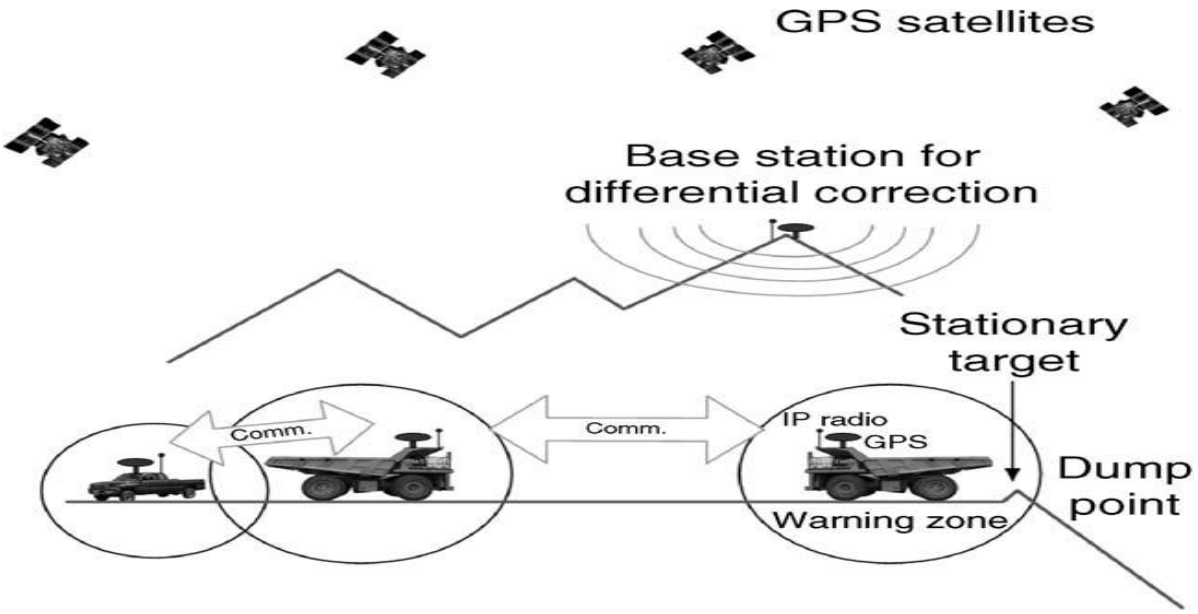


Figure 10: Truck Dispatch System

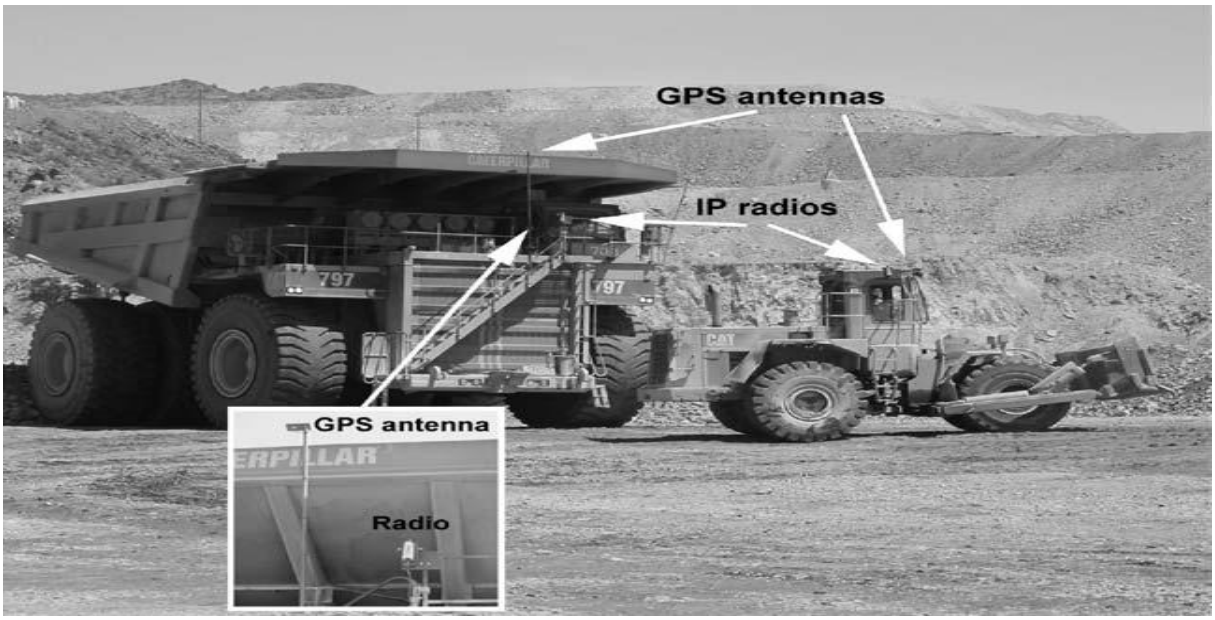


Figure 11: Antenna and Receivers

TDS Interface

The operator screen is provided with the following sequential order of commands to be given:

I) Login

ii) Assign

iii) Arrive

iv) Loading (1st Bucket)

v) Full Bucket

vi) Assign for Unloading at Stockpile/Crusher

vii) Arrival at the assigned position

Table 2: Cycle Time Study of the Excavation at the Loading Sites or Faces

The study is done at the loading trench of N:1/BBXT(WE-9).Loading is done to the Dumpers(55T: 1,2,3).

Dumper no	Trip no.	Arrival at the face	Spotting time	Loading time	Departure from the face	We idle time
3	1	10:55:45 hr.	35sec	4:20 min	11:00:40 hr	0 sec
2	1	11:1:22 hr	1:02 min	4:15 min	11:06:39 hr	0 sec
1	1		22sec	4:52 min	11:14:27hr	0 sec
3	2	11:17hr	35sec	3:14 min	11:21:30hr	0 sec
2	2	11:22:50	49 sec	4:04min	11:28 hr	0 sec
1	2	11:28:20 hr	24 sec	3:44 min	11:32:40 hr	4:27 min
3	3	11:39:16 hr	23 sec	3:54 min	11:43:51 hr	0 sec
2	3	11:44:42 hr	34 sec	3:36 min	11:49 hr	0 sec
1	3	11:47:25 hr	32 sec	4:11 min	11:53 hr	0sec
3	4	12:00 hr	1 min	3:22 min	12:08 hr	0 sec
2	4	12:4:30 hr	25 sec	3:44 min	12:10:10 hr	0 sec
1	4	12:8:6 hr	33 sec	3:30 min	12:14:50 hr	4:03 min

Table 3: Time study from MRS watch room

DUMPER NO.	TRIP	SPOTTING	UNLOADING	ARRIVAL	DEPARTURE
10	1	20 SEC	30SEC	10:14 hr	10:14:50 hr
8	1	1:43min	17 sec	10:18:50 hr	10:20:50 hr
13	1	33 sec	12 sec	10:19:12 hr	10:19:57 hr
5	1	52 sec	24 sec	10:22:05 hr	10:23:21 hr
1	1	16 sec	12 sec	10:24:42hr	10:25:10hr
12	1	30 sec	20 sec	10:28:10 hr	10:29:00 hr
9	1	35 sec	26 sec	10:30:50 hr	10:31:51Hr
10	2	21 sec	26 sec	10:31:04 hr	10:31:51Hr
13	2	26 sec	20 sec	10:34:44 hr	10:35:30hr
12	2	20 sec	14 sec	10:43:48 hr	10:44:22Hr
9	2	38 sec	25 sec	10:47:02 hr	10:48:05Hr
10	3	15 sec	15sec	10:48:40 hr	10:49:10hr
13	3	25 sec	20sec	10:51:15	10:52:00Hr
8	2	17 sec	15sec	11:00:18	11:00:50hr
5	2	30 sec	15sec	11:05:53	11:06:38Hr
1	2	20 sec	15sec	11:09:00	11:09:35hr
9	3	30 sec	18sec	11:12	11:12:55Hr
12	3	20 sec	10sec	11:18:40	11:19:10Hr
10	4	17 sec	15sec	11:22:48	11:23:20Hr
8	3	20 sec	18sec	11:23:40	11:24:18Hr
13	4	27 sec	20sec	11:26:45	11:27:32Hr
5	3	57 sec	20sec	11:26:58	11:28:15Hr
1	3	30 sec	20sec	11:29:55	11:30:45Hr
12	4	20 sec	15sec	11:33:40	11:34:15Hr

There are five groups of personnel who form key links in the smooth and effective operation of the system. These groups comprise -

- Haul truck drivers
- Shovel operators
- Lookout operators
- Crusher operators and
- Mine Engineer

TDS Operators:

The truck driver

The basic actions required of the truck driver are to inform TDS when the truck arrives at a shovel, when it is being loaded, when a dump assignment is required, to confirm arrival at the dump and to an assignment back to a request shovel. Other input required is that relating to the state of the haul truck, being such as experienced, downs or delays the quantity of fuel put in the truck, etc. Communication with the driver is via a 32 character digital display on the operator interface panel.

The shovel operator

The shovel operator has same facilities as basically the truck driver, except that he is required to indicate to TDS information pertaining to the loaded, and when composites being the loading of a truck has been completed.

The lookout operator

The nerve center of the entire operation is the open pit lookout tower. Here there are computer terminals in use, which serves a different function in assisting the lookout operator to control the mining operation.

The crusher operator

The primary function of the crusher operator is to indicate to TDS which ore stockpile he is tipping on and when he commences and finishes crushing a load. The latter information is utilized by TDS within its linear programming calculations to determine the feed rate of trucks to the correct crushers and hence the correct feed rate of trucks to the ore shovels. TDS calculates the optimum stockpile to dump for every particular trucks to optimize the cycle time of the system with minimum waiting.

Mine Engineer

Mine engineering personnel are responsible for the upkeep of the TDS system, particularly with respect to the primary pit configuration data such as haul routes, composite data, production equipment information, etc. As with computer operating systems, TDS has many configurable system parameters which affect the efficiency with which it operates. It is the responsibility of mine engineering personnel to ensure that these parameters are set to optimize the efficiency of the dispatching operation at all times.

Advancement in TDS

All digital inputs of the TDS hardware capture key information like Engine Run Hours, Idle Hours, Over Temperature and Over Pressure, which will assist maintenance. Operators are provided with an easy to use interface.

Operators may also provide with audio visual feedback with regard to messages from the base during loss of communication with the base, and GPS unavailability.

Benefits of TDS

- Real Time Monitoring of Equipment.
- Improved Safety of Operation.
- Improvement in Production and Productivity.
- Reduction in Operational and Maintenance Delays.
- User Friendly & Flexible Reporting System.
- Ease of Re-deployment of resources during breakdowns.

FURTHER SCOPE

- Implementation of Engine Monitoring System (EMS) and Payload Monitoring System (PMS) and their integration with TDS
- Remote Monitoring of TDS through WLAN / VSAT Link / Internet.
- Implementation of Optimization algorithm for resource utilization and facility of Automatic Dispatching

CONCLUSION

- The Truck dispatch system through GPS is a very important and powerful tool for effective mining to increase production rapidly, to decrease time, duration of the mining activities, to increase safety in open cast coal mine.
- Keeping in mind, the future in Indian mining is mostly striving towards automation, so TDS will play a very crucial role in optimization, automation techniques
- It is an integrated system which is related to all equipment's of open cast coal mine for monitoring them continuously. This system starts form the Counting of trips of dumpers, grade quality of the ore, amount of ore removed etc. and the data can be stored in truck dispatch system data base which will be used for further enquiries , reports of production statistics, production to spares parts consumption maintenance performance.

The TDS is very effective and accurate for the purpose of equipment monitoring in an open cast coal mines. The Truck dispatch system has a very good features such as:

- It is easy to learn, it has a very good interface capability, minimum chances of committing errors,
- Recovery of that data is also possible and it is consistent.
- The Truck dispatch system can be used by various category of users and the system has a good quality of portability, reusability and maintainability.
- There is huge scope of development in the TDS.
- After the analysis of the result, the management can take decisions fastly may be related to equipment's, related to operators, or any errors occurred.
- The Computer Based Equipments Performance Monitoring System (CBEPMS) powerful tool for performance monitoring of equipments of open cast coal offline monitoring basis. It is an integrated system related to all equipment of open cast coal mine for performance monitoring. This system starts form the Counting of trips of dumpers production to spares parts consumption / maintenance performance.
- The CBEPMS can be used by different category of users and the system has a good quality of portability, reusability and maintainability there is huge scope of development in the CBEPMS. The CBEPMS will provide a very good result in terms of performance monitoring in open cast coal mine. After getting the analysis result the management can take the decision instantaneously, may be related to equipments.

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