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MULTI CRITERIA DECISION MODEL FOR MINING PROJECTS

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ABSTRACT

Multi Criteria Decision Model for Mining Projects is essential for sustainability from both academic and practical standpoint. Model Solution is the fifth phase of the Operation Research process and plethora of methods for analyzing operations has been used. By analyzing data, creating mathematical models and computing most cost benefit of mine operations with programming helped decision making of multi-projects. Based on field investigations, project construction scheduling with PERT, CPM and monitoring helped control of work force allocation and resources to projects. Reorganized projects from existing mines have to be successful by Break Even Point (BEP) Monitoring. Formidable problem is standardization, because of differing mining methods and operations, depending on the type of reserve. The author has developed about 14 computerized data-based models on field investigations in a coal company. Methods are found fruitful for operation planning, scheduling and monitoring for the company, which is making profit now. This paper has attempted to find innovative Project Management solutions for continued viability in mining industry with model programs.

1. Introduction

This paper deals with project management of 'network scheduling', a technique is used extensively to plan, schedule, and monitor large projects and also 'goal programming' to deal with the process of decision making in a business organization. Planning of mine projects depend upon quantity, quality and depth of geological reserve of coal or mineral. Because of anomalies of deposit, no two mines are alike and Feasibility Report is done on detail prospecting. Whether opencast or underground mine main operations are mine transport/winding; extraction drilling & blasting/continuous; loading in dumpers/conveyors/tubs; carrying to surface/pit-top; unloading to bunker/siding; despatch to consumer/buyer. Viability or sustainability is main goal

MULTI CRITERIA DECISION MODEL FOR MINING PROJECTS

GRAPHICAL ABSTRACT

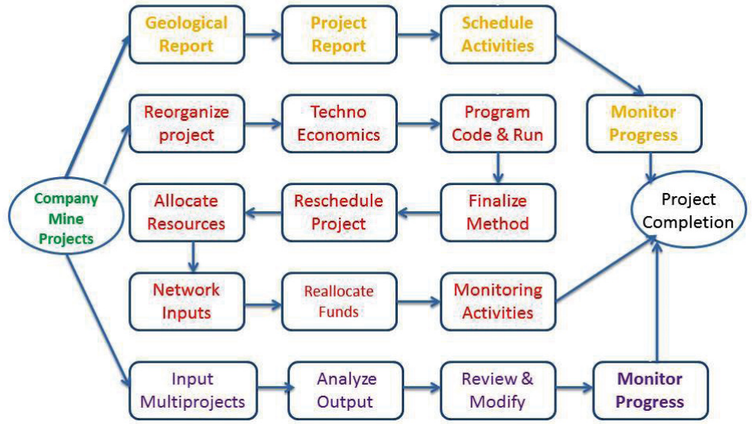

FIGURE 01. *Multi Criteria Decision Model for Mining Projects*

in project report and the author had taken up the research in a large coal company in India, facing closure of many mines for continued losses. Increasing cost of wages and inputs, necessitated method and system study with data collection for development of computerized methods for finding alternative high production technology, revised cost benefits for new and reconstruction projects, apart from scheduling & monitoring. The researcher then attempted to develop programs and models from his life-long experience of working in Indian coal industry, for planning appropriate projects, scheduling and monitoring to minimize time and cost overruns. Coding, compiling of model programs, has been done in JAVA HLL so that different Operating Systems like WINDOWS, MAC, LINUX etc. can been used. List of Computer Model Programs and Runs are shown in **Table 1**.

SN	Chapter / Model	Purpose of Model Program
1	3.1/qep	Quick Evaluation of Projects
2	3.2/bep	Recalculating BEP, reducing Var. Cost
3	3.2/bep2	Revised BEP, on Additional. Investment
4	4/mps	Single Project Scheduling Package-Wise
5	4/mpt	Multi-Project Scheduling for Company
6	5.1/scl	Cost-benefit of Shotcrete Lining in Shafts
7	5.2/stl	Cost-benefit of Track Steel/RCC Sleepers
8	5.3/dre	Cost-benefit in Dam Dredging for Stowing
9	5.4/troq	Opencast Mine Transport Reorganizatio
10	5.5/eqp	Selection of U/G Equipment & Scheduling
11	6.2/snet	Simulation of PERT for Mine Project Scheduling
12	6.3/fecl	Macros for Updating Financial Scheduling
13	6.4/mbo	Key task against Management Positions
14	6.5/dew	Computing. Dewatering Time of a Mi

TABLE 01. *List of computer model programs and runs*

2. New Projects

Once, the Geological Report is available and preliminary study indicates underground method has to be adopted. The researcher has designed a small model program 'qep' based on present concept and run it with practical field and cost data. Project method A1 is for semi-mechanized Bord and Pillar system with tub loading and haulage. Project method A2 is for mechanized Bord and Pillar system with Side Discharge Loader (SDL) and chain conveyors. Project method A3 is for mechanized Longwall with Shearer, Armoured Face Conveyor (AFC), self-advancing hydraulic support etc. Investment decision of projects should be done on:

1) Pay out time- i.e. when Break Even Point is reached, applied here.

2) Average yearly payout- in terms of capital, works, crew, materials etc.
3) Accounting Return or net profit on original investment- used in this ES, as main criterion.
4) Operating Return- indicated in the ES annually.
5) Present worth of Cash flow discounted @10-20%- used for projection over 6 years.
6) Net Profit- is computed excluding taxes and royalties.
7) DCF Return- could be computed from the ES.
8) Sensitivity Analysis- Change in output by change in input- indicated by higher BEP.
9) Actuarial analysis for estimating service life for depreciation- in CIL for 9 years.
10) Incremental cost analysis for marginal cost etc. - computed from the data generated.

Profitability Index (PI) or Return On Investment (ROI) or Discounted Cash Flow (DCF) rate of return are some of the indicators of profits. ROI could be computed from: -

ROI = a+ (b-a) {(ar-1.0)/(ar-br)} = 18% to 28%;

Where, a = initial rate of interest, b = higher interest rate, ar or br = discounted receipts / discounted investment = 1.1 to 1.2. ROE or Return on Equity is given by profit after Tax/ Net worth.

a) In the model program run, with available mine cost data, Longwall method has shown lower A/C Return 10.75 and so ES has indicated as less suitable.
b) In favourable conditions, and if we standardize and indigenously manufacture LWPS, it could be the most suitable method in future. IRR should be 12% at 85% production.
c) In order to achieve very high OMS and profitability, Continuous Miner technology with roof bolting could be adopted even in geologically disturbed areas.

3. Reorganized Projects

In planning reorganized projects from old mines, crossing Break Even Point (BEP) level of production is essential. The researcher has developed 2 Database model programs, 'bep' for Recalculating BEP by reducing Variable Cost and 'bep2' for Revised BEP, on Additional Investment for making an old mine viable.

As mentioned earlier, data are compiled from the cost sheets submitted by the collieries of a company in 3 different months. Since, fixed costs and variable costs are not indicated so they are computed and entered in the records. Assuming 22% of the annual depreciation + interest and 300 is number of working days in a year, it was found that additional investment of 1 million could be neutralized with additional 2 tpd, e.g. as in the PDV_PDV mine. However, this additional investment and ADDL_PROD

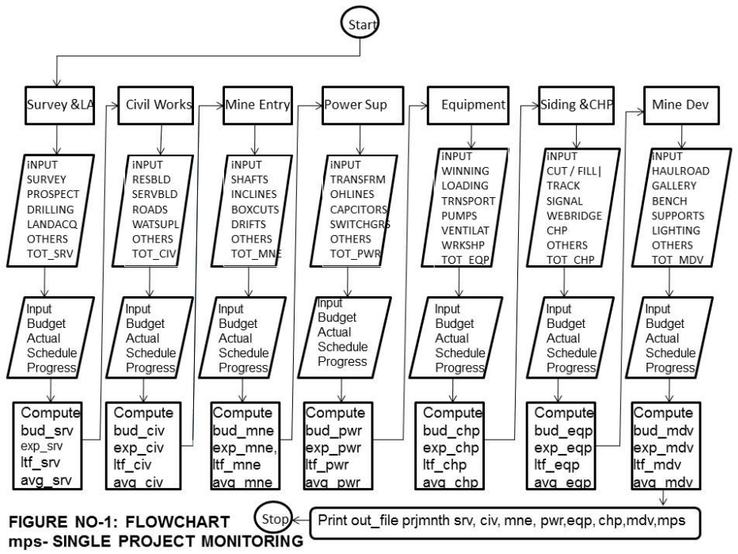

FIGURE NO-1: FLOWCHART mps- SINGLE PROJECT MONITORING

FIGURE 01. *Flowchart - mps - Single Project Monitoring*

required would be higher accordingly. Again, the program computed revised total break-even point of the colliery. Random checks can be made of any mine in database for showing TOT_BEP after ADL_INV is made in a mine, without changing databases. The database program run shows BKL_MRA has TOT_BEP: 723 t and even with ADL_INV: of ₹80 lakhs, like SDL set TOT_BEP increases by only about 56 t

Program run of 'bep2'shows KNT_TPS has BRK_EVN_PT with VAR_COS of ₹131.42/t. A random run of model program 'bep2' for displaying revised BRK_EVN_PT lessened by 50t, with reducing VAR_COS of the mine is shown without changing databases. Once, the techno-economics of coalmine

4. Multiprojects

Construction of opencast and underground projects has different sets of activities; yet have to be structured in common format for computing purposes. Activities were scheduled on PERT networks and CPM (Critical Path Method) was applied to minimize longest activity path time. Combining clearly different activities in to common packages and running 'mps' for individual projects and then feeding them in to 'mpt' and yielding company-wise output for any month. All the packages are further divided into sub-packages and totaling is made head-wise, applicable for all types of mining, in conformity of budget heads. The model program 'mps' for computing the entries of a single project and model program 'mpt' for different projects of a company in a particular month, with budget vs. actual and %schedule vs. %progress for monthly monitoring.

Individual project run data files for the month are named and saved logically, for example like 'rjmju.eqp' file means for project rjm for the month june and for equipment package, tot_civ is total for civil package and 'rjmju.tot' means total of all packages. **Figure 1** shows Flowchart of program of single project 'mps' of a company.

Next in the program run for company output data the input file names for each project are input package wise and the program automatically computes by totaling the figures by mpt.java run and saved in identifiable file codenames like 'eclju. srv' for company ECL for June for survey package or eclju.tot for total for the company, 'cmy_mdv' means total for company in mine development. **Figure 2** displays the Flowchart of Multi-Project program 'mpt' total for company.

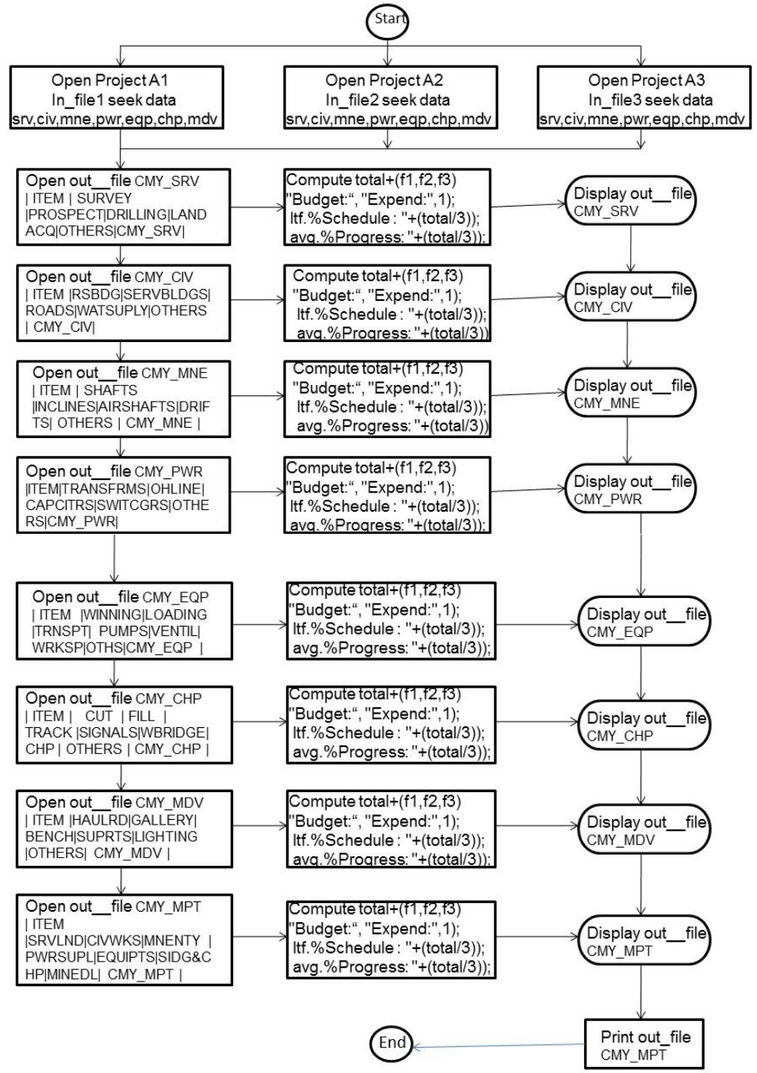

FIGURE 02. *Flowchart for mpt - Multi Project Monitoring*

Such single page summary for a month of project monitoring budget, expenditure, and % schedule and % progress and are very useful for top management and ministry for quick review for deciding remedial actions for slippage. **Table 2** shows output of program run for multi-projects of a company.

5. COST BENEFIT FOR REORGANIZATION

Improvement of methods and systems, could plan better projects to schedule and monitor. Cost Benefit Analysis before planning, with new emerging methods can make successful projects.

5.1 Shaft Lining

One of the major causes of deferring deep underground mining has been extremely high cost of shaft sinking and lining. Future possibility of sinking with pre-split blasting with shotcrete lining has been studied as Indian coal-measure rocks are stronger. The model program 'scl' run makes some projections and coded in this program are 'netsave'- expected net saving, 'conlicst'- saving in concrete lining cost, 'exvcst'- saving in excavation cost, 'wincst' - saving in winch and shuttering cost, 'slcst'- shotcrete lining cost, 'diam'- diameter of the finished shaft, 'depth'- of the shaft in m etc. The model program run with different diameters and depths showing the cost benefit by applying shotcrete lining compared to monolithic concrete lining. The savings are higher for larger size shafts. In the program run, net savings have been computed, from 29.38 million for 5mΦ, 100m depths; to 59.69 million, for 7m Φ, 450 m depth, compared to conventional monolithic concrete lining in shafts.

5.2 Improved Track and Support

Conservation of forest and timber is required and use of Steel or RCC sleepers for track and roof-bolts for support. Most traditional underground mines have track haulage as the main coal production transport system. A S&T project of Ministry of Coal, of which the author was the project leader, model program 'stl' determined the cost benefit and accordingly scheduling and prioritization of mines for implementation. In the model program, data were the price of TS1 - Timber Sleeper 0.61m gauge = ₹20; TS2-Timber Sleeper 1 m gauge= ₹70; SS1-Steel sleeper 0.61m gauge - ₹300, SS2- Steel Sleeper 1m gauge= ₹500.

The 'stl' model program writes the data according to format statement, like column-colliery, name, TYP- type, NTS- no. of timber sleeper, DCOST- dog nail cost, NSS-no. of steel sleepers= 80% NTS, as life could be 20 years against 4 years of timber found; YRPR- yearly production, and CP-coal price. Then, assignment statement, TC-timber-track cost, SC-steel track cost, type '*'-metre gauge, TTC-total timber-track cost, DSAV- derailment saving, and CB-cost benefits etc. are coded in the program. It has been established by the computer program run, that although the price of timber sleeper is 1/5th of the steel sleeper, in the long run the designed steel sleeper is cost effective. It could be observed from the program run that projected cost saving by adopting steel sleeper was quite considerable and the savings ranged from ₹1.2 to 4.9 million per year.

TABLE NO-2

MULTIPROJECT SCHEDULING SUMMARY FOR A COAL COMPANY

File names begin with project and month codes. Packages are indicated by extension names of files. Budgets and Expenditures are in Rs.lakhs cumulative for the company. %Schedules are as per late finish months of activities in annual networks, averaged counting from the month of review for the activities in sub packages of all projects of the company. %Progress is in percent of scheduled activities in sub packages of networks.

COMPANY: ECL PROJECTS: JRA, KTD, RJM TYPE: UG, OC RMONTH: JUNE'95
CAPACITY (MT/Y)-17.6 SANC_BUDGET (Rs.Crs)-1619.8 MILESTONES-77

SURVEY AND LAND ACQUISITION

ITEM	SURVEY	PROSPECT	DRILLING	LANDACQ	OTHERS	CMY_SRV
Budget:	291.51	646.74	541.54	1306.58	508.91	3295.29
Expend:	240.32	666.78	529.32	1270.42	454.27	3161.12
%Schedule:	60.41	51.46	55.82	54.08	53.71	55.09
%Progress:	76.75	74.39	82.41	83.62	75.51	78.54

CIVIL WORKS

ITEM	RESBLDGS	SERVBLDGS	ROADS	WATSUPLY	OTHERS	CMY_CIV
Budget:	2824.98	2123.22	667.11	594.32	261.87	6471.49
Expend:	2611.80	1704.34	546.59	286.74	215.95	5365.42
%Schedule:	30.33	28.00	30.66	28.00	31.00	29.60
%Progress:	28.66	26.33	29.33	26.33	29.00	27.93

MINE ENTRY

ITEM	SHAFTS	INCLINES	AIRSHAFTS	DRIFTS	OTHERS	CMY_MNE
Budget:	3612.67	1141.85	1568.80	528.36	5270.68	12122.35
Expend:	3341.14	1127.38	1397.40	517.38	5078.91	11462.19
%Schedule:	30.12	27.18	29.00	28.41	55.72	34.08
%Progress:	30.41	25.46	28.00	26.35	56.72	33.39

POWER SUPPLY

ITEM	TRANSFRMS	OHLINE	CAPCITRS	SWITCGRS	OTHERS	CMY_PWR
Budget:	4987.46	946.71	215.62	4850.03	351.09	11350.90
Expend:	4132.82	762.02	188.06	4308.33	330.83	9722.04
%Schedule:	59.33	59.66	55.66	60.00	56.33	58.20
%Progress:	56.33	49.66	52.00	52.33	49.33	51.93

EQUIPMENTS

ITEM	WINNING	LOADING	TRNSPORT	PUMPS	VENTILAT	WORKSHOP	OTHERS	CMY_EQP
Budget:	8269.45	2981.01	2893.23	3879.28	2004.96	352.33	283.46	20663.72
Expend:	7029.38	2793.81	2728.92	3290.77	1852.58	327.68	258.01	18281.15
%Schedule:	30.33	29.00	31.66	31.33	26.00	28.66	27.66	29.23
%Progress:	29.33	27.66	30.33	29.66	24.66	27.66	26.00	27.90

SIDING & CHP

ITEM	CUT	FILL	TRACK	SIGNALS	WEBRIDGE	CHP	OTHERS	CMY_CHP
Budget:	559.95	365.09	236.98	318.97	342.55	376.81	131.13	2331.48
Expend:	179.60	91.16	64.42	240.90	129.73	350.09	85.96	1141.86
%Schedule:	30.37	30.02	31.24	31.38	27.37	37.01	35.71	31.97
%Progress:	28.04	28.44	29.07	29.38	25.41	34.10	32.70	29.59

MINE DEVELOPMENT

ITEM	HAULROAD	GALLERY	BENCH	SUPPORTS	LIGHTING	OTHERS	CMY_MDV
Budget:	259.80	4797.86	156.60	3391.71	528.29	363.83	9498.09
Expend:	247.50	4077.08	143.70	2690.71	465.59	327.88	7952.46
%Schedule:	0.00	56.70	0.00	52.77	53.07	57.71	36.71
%Progress:	0.00	52.08	0.00	44.71	48.08	46.75	31.93

MULTIPROJECT SCHEDULING

ITEM	SRVLAND	CIVWORKS	MINENTRY	POWERSUPL	EQUIPMENTS	SIDG&CHP	MINEDEVEL	CMY_MPT
Budget:	5410.40	8677.58	18812.12	20357.62	29405.66	4662.98	17709.98	105036.32
Expend:	5234.71	6617.04	18032.20	17219.08	29178.10	2283.78	14708.12	93273.03
%Schedule:	46.05	47.05	36.51	46.45	47.42	38.92	31.39	42.11
%Progress:	43.26	42.22	36.74	46.31	43.65	36.45	28.69	39.62

TABLE 02. *Output of program run for multi-projects of a company.*

5.3 Strata Control Cost Benefit

Among the various methods of stowing for filling voids after extraction of coal, sand stowing is the most prevalent, as compared to costlier crushed stone, pneumatic or high speed belt stowing, etc. A committee was constituted to find cheaper alternative with the author as the leader. Dredging of dams and utilization of coarse sand through pipelines, could be multi-purpose cheaper alternative. Approximate capital cost for pumps and pipelines, used in the computer model program 'dre' run. It could be seen, from the sample run of the model program 'dre', that annual net saving ranged from ₹1.3 million for Maithon- BCCL pipeline to ₹137 million for Maithon- Maithon rivulet pipeline. By pipeline, it is assumed saving of 5 km and 15 per m3 for 1.0 mill. m3 per year of 'svtk'= ₹150 million. Actual gain in saving in hydel generation would be more, as the reservoir is replenished with water after evacuation of sand.

Most of the dams are silted up as per international findings in 40 years and DVC dams have exceeded that period. The silt collected from separator-bunker can be utilized in brick-making etc. Most of the recent capacity slurry pipelines utilize Centrifugal type pumps, mounted on a dredger capable of transporting large size lumps up to 4" size. Discounting all savings in flood control, power generation and truck transport, the cost per m3 of sand worked out by computer simulation to ₹10-17/m3 at peak capacity of pipelines.

5.4 Steep Quarry Transport

Construction and maintenance of paved haul roads is very costly, especially in small quarries and patch deposits. Specially designed bucket elevator near the box-cut of the quarry can be of great advantage. Several quarries were studied for projecting cost benefits, including saving in diesel cost. Quarry-bed Crusher, electrically driven bucket elevator and bunker with screen for steam and slack coal were considered. A model program 'troq' was compiled and run, with data input of mine name, life, no with capacity of shovels, no. of dumpers, depreciation and interest, fuel and maintenance, dumper, cost, truck cost, conveyor length, depreciation and interest, power and maintenance and yearly production.

There will be greater utilization of shovels, especially in small quarries. Surplus dumpers and trucks could be shifted to new or other mines resulting in more production. There should be more Over Burden (OB) removal, as haul roads would be solely used for the purpose. The program run output showed, accrued saving ranged from Rs.40.10/t, in RJ-RJM mine to Rs.1175.62/t in MU-SHP mine. Irrevocably the fact stands out that there is considerable justification in reorganization to electricity driven vertical or steep transport in opencast, especially small mines.

6. UNDERGROUND MACHINERY

The most problematic situation today is viability of underground mining and appropriate high productive technology is required for reorganization. The model program 'eqp' has considered 4 types of face equipment sets, commonly used in Indian coalmines, namely Side Discharge Loader (ESDL), Load Haul Dumper (ELHD), Continuous Miner (ECHMN) and Longwall Shearer with Power Support (ELWPS). Here, prefix E stands for equipment set, for the type of face. The variable names have been codified and data types-namely SLNO, COLLIERY, COE (Cost of Equipment), POC (Production of Coal/y), DIT (Depreciation and Interest), PMT (Power & Maintenance), SC (Store Cost), WC (Wage Cost), OC (Other Cost), PC (Production Cost), CP (Cost of Production), and CB (Cost Benefit in Rs./t). The cost of equipments have been shown with switchgears and declared in DATA statement, in Rs. Millions – ACNV (Armored Conveyor), BCNV (Belt Conveyor), CCNV (Chain Conveyor), SDL, LHD, CNMN (Continuous Miner) and LWPS.

The program is designed with a subroutine for selecting Equipment Type, with input of Shear Strength of roof stone (SSR), coal (SSC), floor stone (SSF), seam thickness (CST), largest faultless panel (LFP) etc. EQTYP selection has been based on the parameters in the program. EQTYP=ELWPS if LFP>100 Hectares and SSR<100 bar; =ECNMN if SSC<20 and LFP>50; =ELHD if CST>5 and SSF>80; =ESDL if CST<4 and SSF>100. For capital intensive LWPS, favorable geological conditions should be ensured before introduction, at least 1 km2, i.e.100 hectares should be without any major fault. The roof should be cavable and shear strength of roof-stone should be preferably less than 100 kg/cm2.

Scheduling depended upon the amount of likely cost benefit to be achieved, budget position, fund reallocation according to the company's priorities, infrastructure, power, manpower availability, marketability of coal and so on. Pre-Feasibility Report can be made using the model 'eqp' to select appropriate equipment set.

7. SCHEDULING & MONITORING MODELS

When cost benefit analysis is encouraging by designed program run with realistic data for a new or reorganized method, then planning for scheduling is logical next step.

7.1 Opencast Project Monitoring

The VAX computer used for the exercise was installed at CMPDIL, Hdqrs. at Gondwana Place, Ranchi. The mainframe computer had much software, including two software packages on project management, CPM and VUE, of which VUE had additional graphic network capability and so was chosen for developing a large opencast coal mine project scheduling model.

Computerized AON PERT diagram, created by the same set of input data of SNB project based on Flowchart of monitoring of the Opencast Project Network. The activity name is followed by duration in brackets, e.g. coal production sec-A. Since, the project has been rescheduled, there was very little float, found in the chart. The critical activities, are shown by bold lines, on the bar chart, as computed by the compiler

Although, most mainframes are not working, in some places serving as an archive, as better Mini and PC are coming up with improved versions of software. New techniques were applied by the researcher for numerous advantages of reviewing computerized networks. Review could be done any date; Activities could be split, deleted, inserted or even relocated with change of dependencies, With change of start dates and resources, the compiler automatically computes, all remaining parameters of the network.

7.2 Underground Project Monitoring

Combining all activities in a system of packages, a project network of an underground mine codenamed SAT, was computerized. The project was designed to produce 1.2 Mt of coal per year. 2 new shafts, 7.2 m Φ had been sunk and were being equipped. All activity bar chart of SAT project, with McProject program of Apple McIntosh PC was designed. The Activity Table of SAT Project, with resources and responsibility. Activity bar chart of skip installation with MS-Project Windows program with Computerized PERT network with MS_PROJECT and difference in design was noticeable. Critical Path Method indicated rescheduling and programed. Individual scheduling activity data can be entered from any scheduling software in to summary single page project monitoring report in 'mps' and then for company 'mpt' model program runs.

7. 3 Capital Budget Monitoring

Because of geo-mining problems, rescheduling has to be resorted to very often and adjusting fund scheduling. Resource allocation as per schedule is essential, like men, money, machinery and materials of which money is the most important, as it can arrange other resources.

The Financial Scheduling of Projects of a subsidiary coal company, as proposed monthly, with names of the mines coded, for obvious reasons. The spreadsheet columns and rows are required to be updated every month, a model 'macro' program has been designed by the researcher with minimum keystrokes for automatic cursor movement, for input of data, saving and

printing. Moreover, in the spreadsheet, cell formulae have been incorporated for automatic computing of assigned variables, totals etc. Monthly financial scheduling, showing the columns that need not be changed every month of all projects of a company. In multi-project financial allocation, as per priority of projects and criticality of activities some re-appropriation of budget between different heads and projects have to be made with joint meetings and exigencies of the situation, considering total fund availability resource smoothing.

7. 4 Project Responsibility Scheduling

In large projects, overlap of duties and functions create confusion among executives and performance suffers. A model program 'mbo' was created, for charting the key tasks for different management positions according to conditions in the coalmine project. Decision Chart and the query based computer program is able to produce a revised Decision Chart, of any month for any project. On detail studies, outcome of this process to standardize coal project 24 key tasks against 13 different management positions in coal industry.

Job Effectiveness Description JED of a mine Project Manager, developed by the researcher, based on study. Model program run of 'mbo' for a particular project for the Review Month was obtained. The executives in green colored boxes should actively cooperate for the key task area shown, those in yellow color to help whenever required and those in red color need not bother for this key task and concentrate on their routine duties. Objective Setting by Action Plan, Responsibility scheduling with Decision Chart by Confidence Factor CF and result is exemplified. In coding 'mbo' 24 key tasks for 13 different management positions were taken by the researcher and sample run mbo. bat displays for a particular project for certain month.

7.5 Crisis Management Scheduling

Quick scheduling of activities is very important in any disaster or crisis on strategies with allocation of responsibilities by phone, wireless etc. Coal mining is very disaster-prone and numerous catastrophes have taken place owing to fire, explosion, inundation, roof-fall etc. in which many employees lost their lives. Disaster struck at Mahabir Colliery, west of Raniganj town of ECL, a subsidiary of CIL on 13th Nov'89 at 4 AM, when there was sudden inrush of water from old workings of upper Nega (R-VIII) seam to working Narainkuri (R-VII) seam. Water swirled down inundating the pit-bottom of the working pits A & B and lower workings of the mine.

Based on data collected from the mine a computer program was coded for calculation of dewatering-time of a flooded mine, in crisis scheduling for PC application. In model program 'dew' inputs of STAT_VOL (Static volume of water underground), SEPG_WAT (Make of water), DEW_RAT (Dewatering rate), FLB_RAT (into the mine through surface fissures), are made for computing DEW_TIME in days (for dewatering). A sample run of the model program, with incremental dewatering and flow-back rates of water, showed that ALT_NO 10 in the program run came close to reality, when after about a month, 6 dead bodies were recovered.

Disaster management scheduling, as accomplished, between 13/11/89 and 16/11/89, was recorded The researcher's contribution was acclaimed by international journals like Reader's Digest, June '91 issue in English, Oct '91 issue in Hindi, January'92 issue in Dutch and in many other language editions. Mahabir capsule rescue is still a world record of its type, 65 employees in 4 days, in contrast to rescue of the 33 miners trapped deep underground for 69 days, in mine in Chile, who got trapped on 5 August and brought up on 14 October 2010.

7.6 Close Monitoring of Projects

Mine projects are based on detailed geological investigations and report and Feasibility or Project Report can be widely different depending upon the features of mineral deposit. After going through several levels of scrutiny, the Feasibility Report is finally sanctioned as Project Report. Schedule of activities and milestones are outlined in the Project Report with estimated cost, spread over a few years of construction. It has been found very often that because of geological anomalies and operational problems the activities have to be rescheduled. This is usually done, while framing the annual plan, with budget reallocation, but monitoring continues on monthly basis.

Because of ease of rescheduling and monitoring, computer applications are being developed and used apart from utilizing off the shelf project/portfolio software. The author has catalogued more than 300 such software like MS, Agile, BrightWork, ChangePoint, Prism, SharePoint, Vienna Advantage are major players in developing templates and Project Management Institute (PMI) is leading certification agency. Usually, Quarterly MIS reports of large mining projects are to be sent for company headquarters and Ministry.

8. CONCLUSIONS

Project management in mines has to be oriented to the goals of the company, and choices have to be made on the best alternative, among many choices. The author could include in this brief paper, only salient points of best method on data analysis and programming on scheduling and monitoring. All algorithm, flowchart and program runs could not be included in the paper. The major solutions to the problems identified are given below: -

1) The researcher has analyzed the results of hundreds of World Bank aided projects, indicating that success or failure depended upon proper planning of all project operations.
2) Master Networks of projects should have 3 levels of monitoring based on - i) L-1 network with emphasis on package and milestones on graphic level, ii) L-2 network is more detailed and resource based and iii) L-3 network with detailed sub package and activity for review, evaluation.
3) Optimizing techniques, in multi-project scheduling of resources, indicate that heuristic based procedures are realistic for practical problem solving.
4) Master Control Network originally provided in Project Reports, has to be revised for various reasons, geological anomalies, delays, failures etc.
5) Due to frequent delays of activities, especially in critical path, schedules are upset and have to be crashed.
6) Coordination of activities between various agencies and supply of timely inputs suffer, because of procedural delays in a public sector set up.
7) Due to escalation of prices of essential inputs as also change of activities for anomalies in geology, Revised Cost Estimates (RCE) have to be made and sent for approval of Government.
8) Monitoring packages, sub-packages with activities rescheduling has to be done properly as inputs in Multi-Project program for proper output and review by management.

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