STUDENT PAPER[1]

Earned Value Management: Adapted for use in Underground Mining Operations

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Abstract

Time to production line is very important for ore production in major facilities of block caving mining such as Draw Point, Grizzly and Chute in extraction level to ensure the ore production flows as planned so the comprehensive project planning and scheduling, "real-time project monitoring, measuring and controlling are key to achieving the project completion target.

Underground construction projects that support the operation absolutely need accurate and real-time project monitoring, measurement, control and reporting to allow the project manager to manage the project and to respond to any problems that will affect the project completion promptly.

This paper is developed to introduce how the earned value management (EVM) method can be successfully used as a tool to generate real project monitoring, measuring and control in an underground mining project.

In this paper, the author demonstrates the use of Earned Value Management in underground mining operations using the block caving method and concludes that EVM could be applied effectively in the operation's activity.

Keywords: block caving, draw point, real-time monitoring, Earned Value Analysis, SPI, operational applications of earned value management

Introduction

Underground Mining with block caving (figure 3) method is a concatenated process of several activities that have dependency among others such as Mine Planning and Engineering, Mine Development, Underground Construction, Production and Ore Flow. It is "the lowest production cost" (Butcher, Steffen, Robertson, & Kirsten, 1999) and has been applied to large scale extraction of various metals and minerals, sometimes in thick beds of ore but usually in steep to vertical masses.

[1] *Student papers are authored by graduate or undergraduate students based on coursework at accredited universities or training programs. This paper was prepared by Mr. Wibiksana as a result of a course delivered by Dr Paul Giammalvo of PT Mitratata Citragraha in Jakarta, Indonesia. The paper was submitted to the Association for the Advancement of Cost Engineering International (AACEi) in 2012 in fulfillment of the certified cost engineer (CCC/E) requirements, for which the author was a successful applicant.*

As shown in (figure 1), underground construction is one of the activities in the mining operation process cycle that has special challenge because it not only deals with its own project risks and constraints but also has to deal with operational requirements.

This paper is developed to introduce how earned value management (EVM) method can be successfully used as a tool to generate real project monitoring, measuring and control in underground mining project.

Ore production major facilities of block caving mining such as Draw Point, Grizzly and Chute are the major projects for underground construction, beside other projects such as ventilation door, concrete road, sump pump, and other supporting facilities. Draw Point is the point in extraction level where the caved ore is extracted (figure 4); this extraction point is constructed along the panel drift under the cave below the ore body (figure 2); the extracted ore is dumped to the Grizzly i.e. the facility where the ore extracted from Draw Point is sized and flows directly to the transfer raise which is controlled by a mechanical chute at the bottom of the transfer raise before being loaded to the UG dump truck.

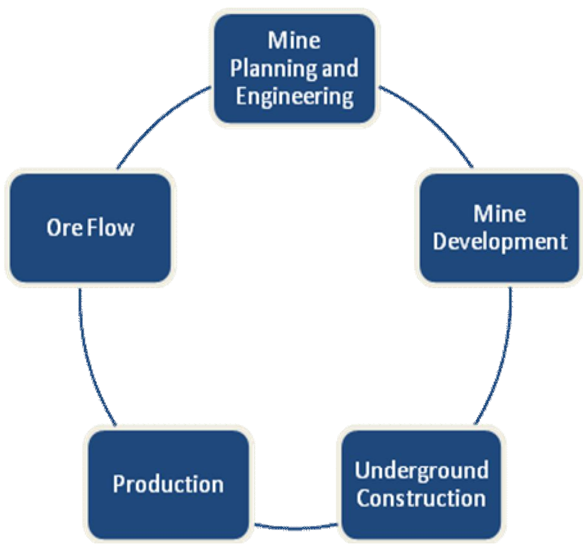


Figure 1. Underground Mining Block Caving Process Cycle [i]

The underground construction project is one of the major activities in block caving mining method, as it drives directly to the production output.

There are some aspects that drive the ore production such as [ii]:

- Draw Point sequences i.e. the order and timing by which the draw point should be incorporated into production.
- Active area: i.e. the number of draw points that should be developed per period.
- Draw rate: i.e. how fast can the material be extracted from the draw points to provide the best value for the operations.
- Draw constraint: i.e. identification of main operational constraint that limits the productivity of draw point.
- Draw profile: i.e. what should be the distribution of tonnages within active panel to guaranty the global stability of the mine.

- Geotechnical Constraint.

The timing of draw point to ready the production line is very important, as by nature block caving method it to allow gravity to break the overlaying rock, the cave line will continue move heading to the construction area during production. Failure of development of the draw point on time will cause the cave line to move closer to the construction area and create the potential un-safe zone for construction activity and at the end will effect the production opportunity.

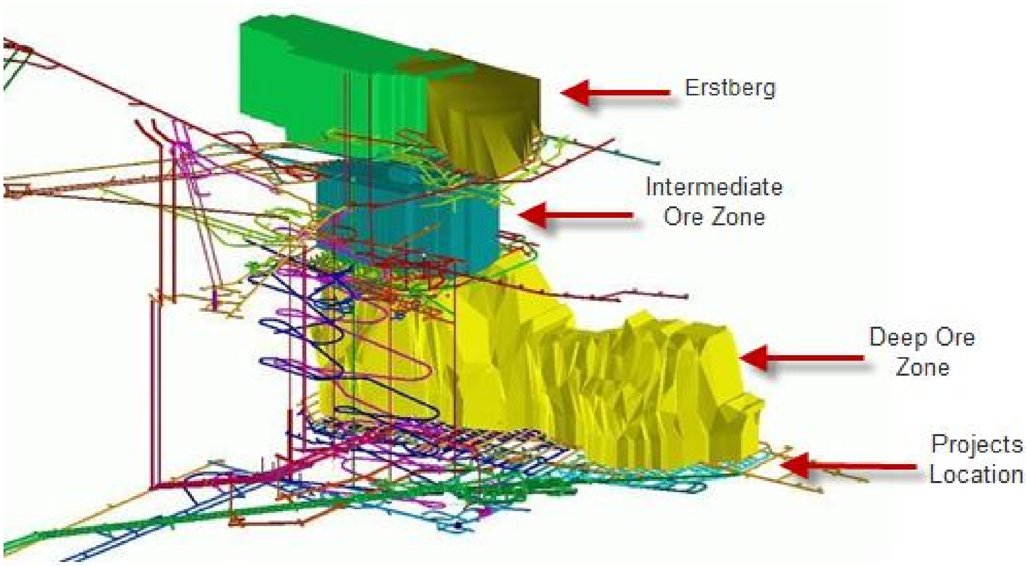


Figure 2. Underground Mining Ore Body [iii]

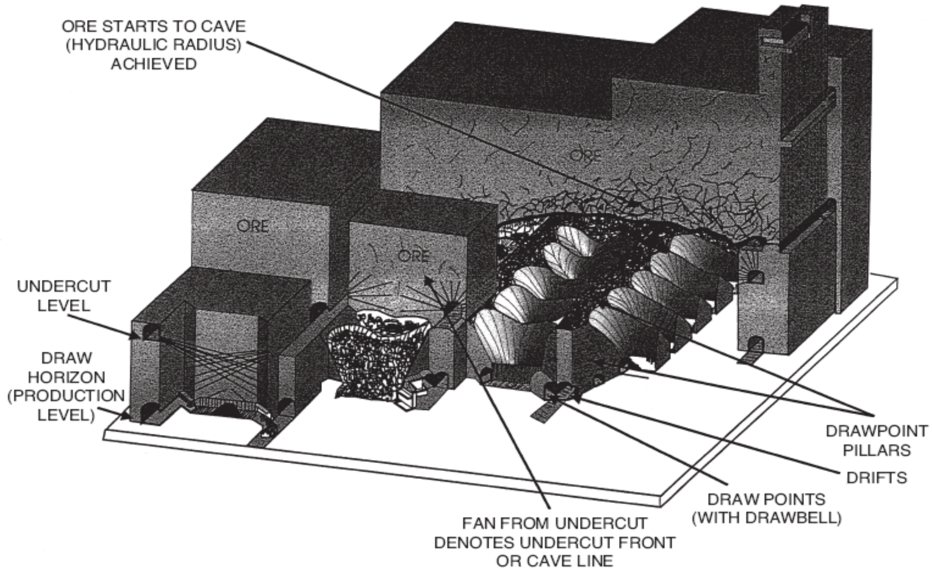


Figure 3. Trackless Block Caving [iv]

Figure 4. Illustration of underground block cave method [v]

Figure 5. Draw Point Construction – Concrete Floor and Embedded Rail [vi]

Figure 6. Full Draw Point Construction – Wall and Roof Meshing and Forming [vii]

Figure 7. Half Draw Point Forming and Meshing [viii]

Figure 8. Completed Full Draw Point [ix]

The Challenge

The Underground Construction department is planned to construct hundreds of draw points, tens of grizzlies and chutes in total, with very short construction durations for each activity. The project management team has to ensure every single facility is delivered on time.

A comprehensive planning and construction schedule is a must, all resources requires should be well prepared such as materials availability, concrete supply, workforce, mobile equipment, support facilities (electricity, ventilation, ground support) and construction method. Project's risks in term of safety, technical and logistic should be clearly identified, assessed, mitigated and responded to over the time of project. But those efforts are not enough to make the project successful without continuously monitoring, measuring and controlling the activity during execution to ensure it deliver as per plans and prompt response to any deviations.

The traditional way on project monitoring, measurement and controlling which only presents actual progress against the total budget or plan and reported in weekly, biweekly or monthly basis will not be suitable for the project with very short duration.

Underground construction projects need the accurate and real-time project monitoring, measurement, control and reporting to allow the project manager to manage the project and to promptly respond to any problems that will affect the project completion.

The Initiative: Earned Value Management (EVM) Implementation.

Driven by the requirement for accurate and real-time project monitoring, measurement and controlling tools, the project management team starts implementing Earned Value Management (EVM) based monitoring and reporting system that would be easily updated by field project team, with minimum wording but presenting the valuable project information on time.

Earned Value Management (EVM)

Earned Value Method based report presents project's schedule, cost and scope performances in certain period and since inception with the ability to be expanded to forecast the project performance at the completion.

The very popular EVM indicators are:

SPI = BCWP / BCWS (equation 1)

CPI = BCWP / ACWP (equation 2)

BCWP = Physical % Complete x BAC (equation 3)

Where:
SPI = Schedule Performance Index
CPI = Cost Performance Index
BCWS = Budget Cost Work Schedule
ACWP = Actual Cost Work Performed
BCWP = Budget Cost Work Performed
BAC = Budget at Completion

The Implementation of EVM using Microsoft® Excel® Spreadsheet

Project Management Team uses Microsoft® Excel® spreadsheet with the consideration that all of the field project team is familiar with this software already and customizable to project requirements.

Underground Construction Department has several types of typical major routine projects named: Draw Point, Grizzly and Mechanical Chute, but this paper will demonstrate how to implement the EVM to draw point project only. Actually it can also be applied to any other underground mining projects with the same approach.

By default the construction schedule uses 24/7 working calendar divided into 3 working shifts i.e. day shift, swing shift and night shift. This schedule is used to support the operation's requirement that also runs in the same time roster.

Scope Identification

The draw point has a few types of design depending on the ground condition and we named it as Half Draw Point (HDP), for draw point with half concrete wall in the panel drift as shown in (figure 7) and Full Draw Point (FDP) for draw point with full concrete wall and roof in the panel drift and draw area (figure 8). Each type has the typical work break down structure (WBS); the different is only in quantity/volume of concrete in the wall and roof draw point. In draw point project the WBS reflects work packages.

This WBS intentionally developed in certain structure as shown in (figure 9) to allow efficient tracking in terms of time period i.e. by work package that has short duration; with this approach we could accurately measure the progress for each DP in very short period.

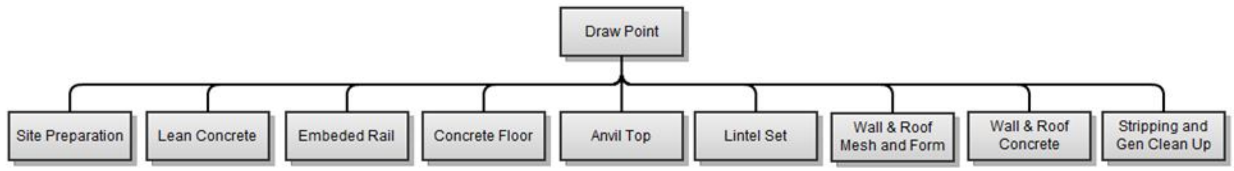


Figure 9. Draw Point Standard WBS [x]

The typical draw point work packages are:

1. Site Preparation, is the preparation of location prior to construction commenced.
2. Lean Concrete is the low strength of concrete poured to level the ground floor prior to high strength concrete floor.
3. Embedded Rail, is the steel rail embedded in the concrete floor at draw point area to reduce concrete abrasion due to loader bucket.
4. Concrete Floor, is the top high strength concrete floor (figure 5)
5. Anvil Top, the activity name is taken from the concrete abrasion resistance product which the activity is to apply the abrasion resistance to the top of concrete at draw point area.
6. Lintel Set, is the steel structure portal erected at the draw point area for HDP and at draw point and panel area for FDP (figure 6)
7. Wall and Roof Mesh and Form, is the steel mesh and wooden form that is installed prior to concrete pouring at wall side and roof (figure 7)
8. Wall and Roof Concrete, is the concrete poured at the wall and roof.
9. Stripping and General Clean Up, is the final activity in draw point construction to stripping the wooden concrete form and cleaning up the area before the construction team hands over the facility to operations.

Baseline Estimate

The cost and schedule baseline is the key to the project performance measurement because the entire performance indicators will always be compared with these baselines. The draw point's cost baseline is developed using bottoms up estimate which includes direct cost elements of Labor, Material and Equipment. The indirect cost portion is covered in another cost of account, because the intention to use EVM in this project is to know exactly the performance at the field only. Separate project cost control systems which cover the fully loaded cost is generated by project control team.

The draw point typical baseline cost estimate (table 1) is for illustration only.

		Budget (USD)		Budget Duration (Shift)	
No	WBS	HDP	FDP	HDP	FDP
1	Site Preparation	$ 2,018	$ 2,018	4.00	4.00
2	Lean Concrete	$ 2,306	$ 2,306	3.00	4.00
3	Embeded Rail	$ 3,460	$ 3,460	3.00	3.00
4	Concrete Floor	$ 2,883	$ 2,883	4.00	8.00
5	Anvil Top	$ 2,595	$ 2,595	3.00	3.00
6	Lintel Set	$ 2,883	$ 19,460	3.00	15.00
7	Wall & Roof Meshing & Forming	$ 4,901	$ 8,332	16.00	40.00
8	Wall & Roof Concrete	$ 4,324	$ 7,784	5.00	10.00
9	Stripping & General Clean-Up	$ 3,460	$ 6,227	4.00	8.00
	Total	**$ 28,829**	**$ 55,064**	**45.0**	**95.0**

Table 1. Draw point typical baseline cost [xi]

Project Schedule

Draw Point Construction is one of the projects that run under operation mode, the project produces two types of repetitive deliverable i.e. Half Draw Point (HDP) and Full Draw Point (FDP), both types have typical activities as well as sequences.

The monthly target draw point completion is measured by the unit of Half Draw Point Equivalent (HDP Eqv) because HDP is the major type of draw point constructed. The equivalency is calculated based on US$ amount budgeted, in this case 1 HDP = 0.52 FDP.

The draw point project schedule is more to the target of draw point completion per month, the number of equivalent draw point target is equally spread over the shift period in the month because of that, the BCWS in EVM chart is become a straight line rather than “S” shape. The straight line shape of BCWS in this operation’s project has not significant impact to execution of the projects, but it give a flexibility to the construction crew to move around the project locations been given each month and to keep maintain the productivity as targeted, also this approach reduces the draw point construction project scheduling development efforts every month.

In this case the EV calculation simulation is using the schedule to complete 12 HDPs equivalent (eqv) per month, with certain draw point locations, and to accommodate the opportunity to exceed the monthly target or if the main target draw point areas have problems, the alternative draw point candidates are also prepared in monthly plan (table 2). In this project the draw point is named by the draw point location such as P#1G DP 11W – HDP, it is mean P#1G = Panel/Drift/Tunnel number 1G, DP 11 W = Draw point number 11 West, HDP= draw point type is Half Draw Point.

WBS #	Drawpoint Name	Last Month Progress	% Progress To Complete	Plan This Month	Plan This Month (HDP Eqv)	Unit Rate	Target Value	Weight	
P1G-11W	**P#1G DP 11W - HDP**	**0%**	**100%**	**100%**	**1.00**	**$ 28,829**	**$ 28,829**	**100%**	
P1G-11W-1	Site Preparation	0%	100%	100%	0.07	$ 2,018	$ 2,018	7%	Activity Level
P1G-11W-2	Lean Concrete	0%	100%	100%	0.08	$ 2,306	$ 2,306	8%	
P1G-11W-3	Embeded Rail	0%	100%	100%	0.12	$ 3,460	$ 3,460	12%	
P1G-11W-4	Concrete Floor	0%	100%	100%	0.10	$ 2,883	$ 2,883	10%	
P1G-11W-5	Anvil Top	0%	100%	100%	0.09	$ 2,595	$ 2,595	9%	
P1G-11W-6	Lintel Set	0%	100%	100%	0.10	$ 2,883	$ 2,883	10%	
P1G-11W-7	Wall & Roof Meshing & Forming	0%	100%	100%	0.17	$ 4,901	$ 4,901	17%	
P1G-11W-8	Wall & Roof Concrete	0%	100%	100%	0.15	$ 4,324	$ 4,324	15%	
P1G-11W-9	Stripping & General Clean-Up	0%	100%	100%	0.12	$ 3,460	$ 3,460	12%	
P1G-19W	**P#1G DP 19W - HDP**	**0%**	**100%**	**100%**	**1.00**	**$ 28,829**	**$ 28,829**	**100%**	Activity Level hidden
P1I-7W	**P#1I DP 7W - HDP**	**0%**	**100%**	**100%**	**1.00**	**$ 28,829**	**$ 28,829**	**100%**	
P1E-11W	**P#1E DP 11W - HDP**	**50%**	**50%**	**50%**	**0.50**	**$ 28,829**	**$ 14,415**	**100%**	
P1E-12E	**P#1E DP 12E - HDP**	**50%**	**50%**	**50%**	**0.50**	**$ 28,829**	**$ 14,415**	**100%**	
P1E-13E	**P#1E DP 13E - HDP**	**0%**	**100%**	**100%**	**1.00**	**$ 28,829**	**$ 28,829**	**100%**	
P1E-14E	**P#1E DP 14E - HDP**	**0%**	**100%**	**100%**	**1.00**	**$ 28,829**	**$ 28,829**	**100%**	
P1E-12W	**P#1E DP 12W - HDP**	**0%**	**100%**	**100%**	**1.00**	**$ 28,829**	**$ 28,829**	**100%**	
P1G-19E	**P#1G DP 19E - HDP**	**0%**	**100%**	**100%**	**1.00**	**$ 28,829**	**$ 28,829**	**100%**	
P1G-20E	**P#1G DP 20E - HDP**	**0%**	**100%**	**100%**	**1.00**	**$ 28,829**	**$ 28,829**	**100%**	
P1G-20W	**P#1G DP 20W - HDP**	**0%**	**100%**	**100%**	**1.00**	**$ 28,829**	**$ 28,829**	**100%**	
P1J-7E	**P#1J DP 7E - HDP**	**0%**	**100%**	**100%**	**1.00**	**$ 28,829**	**$ 28,829**	**100%**	
P1E-13W	**P#1E DP 13W - HDP**	**0%**	**100%**	**100%**	**1.00**	**$ 28,829**	**$ 28,829**	**100%**	
P1E-14W	**P#1E DP 14W - HDP (Alternative)**	0%	100%	0%	-	**$ 28,829**	**$ -**	**100%**	
P1E-14E	**P#1E DP 14E - HDP (Alternative)**	0%	100%	0%	-	**$ 28,829**	**$ -**	**100%**	
P1E-15E	**P#1E DP 15E - HDP (Alternative)**	0%	100%	0%	-	**$ 28,829**	**$ -**	**100%**	
P1E-13W	**P#1E DP 15W - HDP (Alternative)**	0%	100%	0%	-	**$ 28,829**	**$ -**	**100%**	
				Total HDP Eqv Target	**12.00**				

Table 2. Sample of monthly target plan [xii]

Earned Value Calculation

From the table 2 above we know that the budget for 1 HDP is $28,829 with total target 12 HDPs Eqv to complete in a month, the simple calculate the EV is as follows:

BAC month = 12 HDPs Eqv x $28,829 = $345,948
BCWP = Actual HDPs Eqv Completed x $28,829
BCWS = Planned HDPs Eqv x $28,829
ACWP = Monthly actual cost is retrieved from ERP every month
SPI = BCWP /BCWS
CPI = BCWP / ACWP

Example : Assumption :
1 month = 30 days
1 day = 3 shifts (day, swing, night)
1 month = 90 shifts
Target Plan:
1 month = 12 HDPs Eqv
1 shift = 12 HDPs Eqv / 90 shifts = 0.133 HDPs Eqv
Performance:
Report Period = Shift 50th
Actual achievement = 5.81 HDPs Eqv
BCWP = 5.81 HDPs Eqv x $28,829 = $167,496
BCWS = (50th x 0.133) x $28,829 = $191,713
ACWP = Caclulated at end of the month = N/A
SPI = $167,496 / $191,713 = 0.87
CPI = Calculated after finance month closing = N/A

							Day 1			Day 2			Day 3			Day 4		
WBS #	Drawpoint Name	Last Month Progress	% Progress To Complete	Actual Progress This Month	Weight	Total Prog	DS	SF	NS	DS	SF	NS	DS	SF	NS	DS	SF	NS
P1G-11W	**P#1G DP 11W - HDP**	**0%**	**100%**	**100%**	**100%**	**88%**	2%	2%	2%	2%	4%	4%	6%	6%	3%	5%	3%	0%
P1G-11W-1	Site Preparation	0%	100%	7%	7%	**100%**	25%	25%	25%	25%								
P1G-11W-2	Lean Concrete	0%	100%	8%	8%	**100%**					50%	50%						
P1G-11W-3	Embeded Rail	0%	100%	12%	12%	**100%**							50%	50%				
P1G-11W-4	Concrete Floor	0%	100%	10%	10%	**100%**									25%	50%	25%	
P1G-11W-5	Anvil Top	0%	100%	9%	9%	**100%**												
P1G-11W-6	Lintel Set	0%	100%	10%	10%	**100%**												
P1G-11W-7	Wall & Roof Meshing & Forming	0%	100%	17%	17%	**100%**												
P1G-11W-8	Wall & Roof Concrete	0%	100%	15%	15%	**100%**												
P1G-11W-9	Stripping & General Clean-Up	0%	100%	12%	12%	**100%**												
P1G-19W	P#1G DP 19W - HDP	0%	100%	**100%**	100%	**88%**	2%	2%	2%	2%	4%	4%	6%	6%	3%	5%	3%	0%
P1I-7W	P#1I DP 7W - HDP	0%	100%	**88%**	100%	**71%**					2%	2%	2%	2%	4%	4%	6%	6%
P1E-11W	P#1E DP 11W - HDP	50%	50%	**100%**	100%	**88%**	2%	2%	2%	2%	4%	4%	6%	6%	3%	5%	3%	0%
P1E-12E	P#1E DP 12E - HDP	50%	50%	**88%**	100%	**46%**												2%
P1E-13E	P#1E DP 13E - HDP	0%	100%	**100%**	100%	**88%**	2%	2%	2%	2%	4%	4%	6%	6%	3%	5%	3%	0%
P1E-14E	P#1E DP 14E - HDP	0%	100%	**61%**	100%	**37%**												
P1E-12W	P#1E DP 12W - HDP	0%	100%	**37%**	100%	**5%**												
P1G-19E	P#1G DP 19E - HDP	0%	100%	**61%**	100%	**37%**												
P1G-20E	P#1G DP 20E - HDP	0%	100%	**27%**	100%	**0%**												
P1G-20W	P#1G DP 20W - HDP	0%	100%	**0%**	100%	**0%**												
P1J-7E	P#1J DP 7E - HDP	0%	100%	**27%**	100%	**0%**												
P1E-13W	P#1E DP 13W - HDP	0%	100%	**4%**	100%	**0%**												
P1E-14W	P#1E DP 14W - HDP (Alternative)	0%	100%	**0%**	100%	**0%**												
P1E-14E	P#1E DP 14E - HDP (Alternative)	0%	100%	**0%**	100%	**0%**												
P1E-15E	P#1E DP 15E - HDP (Alternative)	0%	100%	**0%**	100%	**0%**												
P1E-13W	P#1E DP 15W - HDP (Alternative)	0%	100%	**0%**	100%	**0%**												
				Actual Progress (HDP Eqv)			0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.1	0.2	0.2	0.1
				Actual Progress (HDP Eqv) Cum			0.1	0.1	0.2	0.3	0.5	0.6	0.9	1.2	1.3	1.5	1.7	1.8
				Plan HDP Eqv			0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
				Plan HDP Eqv Cum			0.1	0.3	0.4	0.5	0.7	0.8	0.9	1.1	1.2	1.3	1.5	1.6

Table 3 Draw Point Progress Calculation Sheet [xiii]

Project Progress Tracking

Timely, accurate and consistent are the goal of this project performance reporting system, so a user friendly measurement and reporting system should be implemented. The project management team developed a standard shift progress measurement check list (table 4) that was used to record the by shift draw point progress. The field measurement result is uploaded to the Microsoft® Excel ® application in a shared folder in the server by the end of the shift.

The shift crew's performance is measured by using the shift crew's SPI, because the shift crew most likely works in the same location, and to avoid any shift performance bias between shift crew, the progress measurement checklist has to be signed and accepted by the next shift crew's foreman.

Field project team that is assigned to each shift crew has to complete the shift progress measurement at the end of the shift and input the progress to the Microsoft ® Excel® application in the shared folder in the server. With the scheme shown in figure 10, it allows the project management team to monitor and control the progress every single shift and it became a project dashboard.

Half Drawpoint Shift Progress Check List

Date :

Shift : (Day, Swing, Night)

No	Drawpoint Name	Weigh	DP Name	DP Name	DP Name	DP Name	DP Name	DP Name	DP Name	DP Name	DP Name	DP Name	DP Name	DP Name	DP Name	DP Name	DP Name
1	**Site Preparation**	**7%**															
2	Complete Install Lighting	10%															
3	Complete Install Ventilation	10%															
4	Complete Site Clean Up Draw Area	35%															
5	Complete Site Clean Up Panel Area	45%															
6	**Lean Concrete**	**8%**															
7	Complete Pour Concrete Draw Area	40%															
8	Complete Pour Concrete Panel Area	60%															
9	**Embeded Rail**	**12%**															
10	Complete Setup Rail	100%															
11	**Concrete Floor**	**10%**															
12	Complete form work Draw Point Area	20%															
13	Complete form work Panel Area	25%															
14	Complete pouring Draw Area	20%															
15	Complete pouring Panel Area	25%															
16	Complete Form Stripped and Clean	10%															
17	**Anvil Top**	**9%**															
18	Complete Anvil Top	100%															
19	**Lintel Set**	**10%**															
20	Complete Erection Lintel Set	100%															
21	**all & Roof Meshing & Forming**	**17%**															
22	Complete Install wall mesh Draw Area	15%															
23	Complete Install wall mesh Panel Area	15%															
24	Complete Install Form wall Draw Area	15%															
25	Complete Install Form wall Panel Area	25%															
26	Complete Install roof mesh Draw Area	15%															
27	Complete Install roof wall Draw Area	15%															
28	**Wall & Roof Concrete**	**15%**															
29	Complete concrete pour draw area	60%															
30	Complete concrete pour panel area	40%															
31	**Stripping & General Clean-Up**	**12%**															
32	Complete form stripped Draw Area	40%															
33	Complete form stripped Panel Area	40%															
34	Complete Clean Up	10%															

Measured by ____________________

Approved by ____________________

Next Shift Acceptance ____________________

Table 4 Draw Point Progress Measurement Check List [xiv]

Using the function in Microsoft® Excel® that allows the user to save the excel file to a “web page” type, the final report is published to the server each time the user saves the file.

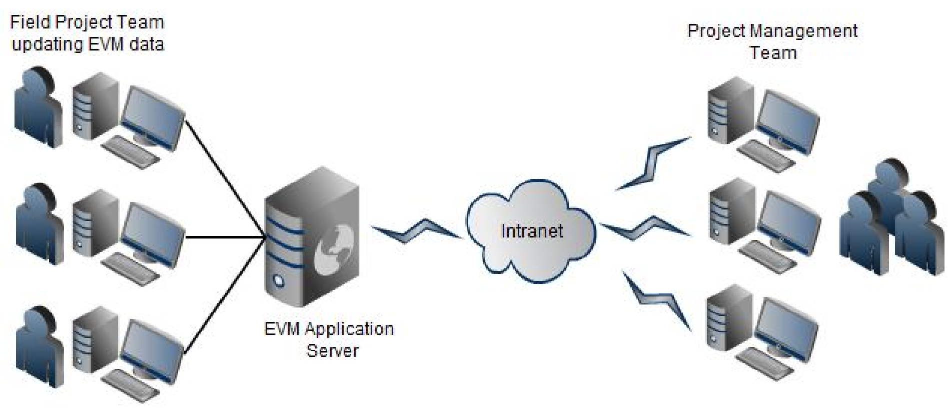


Figure 10. Real-time project reporting system scheme [xv]

The steps to publish Microsoft® Excel® 2010 based project dashboard to Intranet.

1. Assume that the Microsoft® Excel® project dashboard is ready to publish.
2. Open the sheet that contains the project dashboard to be published.
3. "Save as" type "Web Page" and choose the option to save the "selection sheet".
4. Name the file with the easily recognized name such as: "Project Dashboard" etc.
5. Store that file in shared folder that allows the project management team access.
6. Click "Publish"
7. The small windows appears, select the sheet that will be published and check the "Auto republish every time this work book is saved"
8. Click "Publish"
9. Now the project management team and all construction project team could open the web page file in the server.

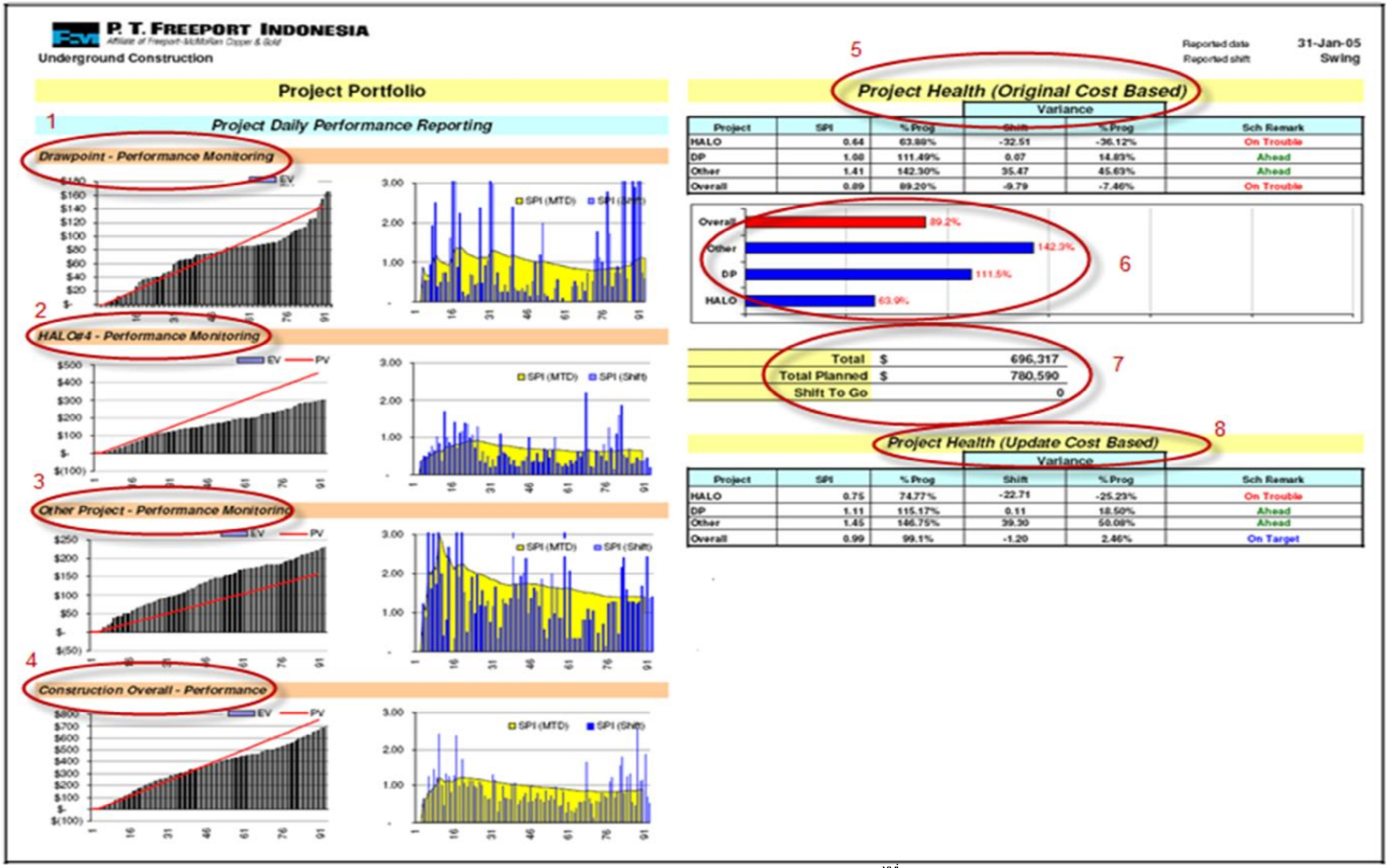
Project Dashboard

The real-time performance dashboard that displays the schedule performance is updated every shift (a 1/3 day basis); this dashboard is developed using Microsoft® Excel®. This project dashboard is not displaying the Cost Performance Index (CPI) because of the different reporting periods between SPI and CPI, where for CPI reports the ACWP data is only available on a monthly basis.

In the real application, Underground Construction Department uses this EVM method not only for draw Point project but also applied to other projects with the same approach. So the project dashboard could display the overall underground construction project performance status every single shift.

The dashboard (figure 11) has some important gauges to measure the project's health and shift crew's performance such as:

1. Project Level - SPI
2. Shift Crew – SPI
3. Project Physical % Complete
4. Schedule alert indicator (on schedule, ahead, on target)



Project Health (Original Cost Based)

Project	SPI	% Prog	Variance: Shift	Variance: % Prog	Sch Remark
HALO	0.64	63.88%	-32.51	-36.12%	On Trouble
DP	1.08	111.49%	0.07	14.83%	Ahead
Other	1.41	142.30%	35.47	45.63%	Ahead
Overall	0.89	89.20%	-9.79	-7.46%	On Trouble

Project Health (Update Cost Based)

Project	SPI	% Prog	Variance: Shift	Variance: % Prog	Sch Remark
HALO	0.75	74.77%	-22.71	-25.23%	On Trouble
DP	1.11	115.17%	0.11	18.50%	Ahead
Other	1.45	146.75%	39.30	50.08%	Ahead
Overall	0.99	99.1%	-1.20	2.46%	On Target

Figure 11. Sample of Project Dashboard [xvi]

Data Interpretation

From the figure 11 above, the charts and indicators could be interpreted as follow.

1. SPI chart of Draw Point Project (1), starting 3rd week the schedule performance goes down because the priority changed and resources allocated to another project (3), but then could recover the target at 4th week.
2. SPI chart of HALO#4 Project (2), schedule performance goes down starting 2nd week because the priority changed and resources allocated to another project (3).
3. SPI chart of Other Project (3) got additional resources from Draw Point (1) and HALO#4 (2) project due to priority changed, the performance goes higher than original target.
4. SPI chart of the overall construction (4), it is the rolling up off all construction projects, and it was on track at 1st and 2nd week but then goes lower than the target.
5. The chart no 1, 2 and 3 could also be used as tools to balance the resources among the projects, re-allocating one to another to optimize the overall construction progress.
6. Project Health (Original Cost Based) (5), it is a numerical indicator which displays the Project's SPI, schedule variance in work shift period and physical % complete, and schedule remark such as "in trouble", "ahead" and "on target" if meeting with certain agreed SPI criteria.
7. Chart project % complete (6) shows the Month To Date (MTD) project % complete.
8. Budget vs Earned Value (7); total here means MTD earned Value, Total planned is Monthly Budget, in this dashboard BCWP=$696,317 and BCWS=$780,590 with zero (0) shift to go, it means that this period is the end of month, the SPI = BCWP/BCWS = <1 (behind schedule).
9. Project Health (Update Cost Based), is used when during the project execution the scope changes or any unpredictable situation occurs which requires changes to budget, in this dashboard there were changes in other project scope. It is important to recognize the actual team's efforts and their performance, and they should be compared with the actual scope undertaken.

The Financial Benefit

The main goal of the underground construction project is to support the mining operation. Time to production line is critical, because construction project drives directly to ore production output. Failing to deliver the project on time will cause lost production opportunity and create the potential cost of delay due for repairing un-supporting ground failure.

The Non-Financial Benefit

This system allows all project team at the lowest level to see the value of their works thru the earned value report. It increased the awareness of the project costs as well as created pride in the works; beside that it creates the healthy competition among the crews to achieve the best work value and fosters accountability.

This system was created to give real-time project status, problems that occurred could be identified in very short period of reporting, it gave the chance to the project manager to respond to and resolve problems promptly, and reduced the risk of delays for responding to problems.

This is a reliable project report and has been used from 2004 until now, so it has been 8 years that the Underground Construction department has used this report and used it as a powerful tool for reporting and managing project performance.

With this simple and user friendly reporting, it reduced the effort for reporting and scheduling and increased the reporting accuracy.

Conclusion

Block Caving is one of the methods used in Underground Mining. It is a concatenated process of several activities that have dependency, among others such as Mine Planning and Engineering, Mine Development, Underground Construction, Production and Ore Flow.

Time to production line for ore production major facilities of block caving mining such as Draw Point, Grizzly and Chute are the major project for underground construction is very important as it drives directly to the ore production output.

The comprehensive planning and scheduling of underground construction activity is a must. But it is not enough without controlling and monitoring the planning itself. To be in line with the operations process, a “real-time” project measurement and monitoring system is needed for the projects in operations mode.

The Earned Value Management (EVM), approach with simple and user friendly computer application, is the solution to the requirement for accurate and “real-time” project monitoring, measurement and control of the underground construction project.

The EVM with “real-time” project dashboard has proven to improve the facility time to production line, building the project team’s awareness about project costs, created more pride in the works, created healthy competitiveness among the crew, and fostered more accountability.

Footnotes

i Created by author

ii Rubio, E. Dunbar, W, Scott. (2005) Integrated Uncertainty in Block Cave Production Schedule, Abstract submitted to APCOM 2005, Arizona, Retrieved from: http://cn.gemcomsoftware.com/sites/default/files/whitepaper/PCBC_IntegratingUncertaining.pdf

iii Picture taken from: Presentation slide of Utomo,Teguh (2006), Implementing Earned Value Under Conditions of Variable Budget Using the PMO concept – A Strategic Approach, the presentation to Aceh Rehabilitation and Reconstruction Agency. p.6

iv Picture taken from: Butcher, R.J, (1999, May/June), Design rules for avoiding draw horizon damage in deep level block caves, The Journal of The South African Institute of Mining and Metallurgy, retrieved from : http://www.saimm.co.za/Journal/v099n03p151.pdf

v Picture retrieved from http://www.ptfi.com/operation/underground.asp

vi Picture courtesy of PT. Freeport Indonesia

vii Picture courtesy of PT. Freeport Indonesia

viii Picture courtesy of PT. Freeport Indonesia

ix Picture courtesy of PT. Freeport Indonesia

x Chart created by author

xi Table created by author

xii Table created by author

xiii Table created by author

xiv Table created by author

xv Scheme created by author

xvi Project Dashboard created by author

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