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**THE PRACTICAL APPLICATION**

**OF**

**EARNED VALUE PERFORMANCE MEASUREMENT**

**BY**

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**OF**

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## **1 AIM OF PAPER**

The aims of this presentation is to review practical methods that may be used for managing projects using Earned Value Performance Measurement methods.

## **2 PRINCIPALS OF EARNED VALUE PERFORMANCE MEASUREMENT - EVPM**

### ***2.1 Programme or Project?***

Before starting on EVPM we will look at the difference between **Programme Management** and **Project Management**.

Programme Management is when there is a limited set of resources and projects are added into the programme and undertaken on a priority basis. Each Project is normally managed as a stand-alone project and all the projects reported collectively as a programme. Some Projects may not have a firm completion date due to their low priority and end up being pushed back in time. Often projects share a common budget pool.

A project may be part of a programme or standalone, but is different in principal as it normally has a fixed end date, has an assigned budget and the project is resourced up to complete the work. A project of this nature may be part of a programme and would normally have first call on internal resources. This is the type of project we will discuss the application of EVPM techniques.

### ***2.2 Project Control Phases***

There are two main phases of project control:

- Planning – before the start of project execution.
- Control – during execution.

It is NOT possible to measure progress when the work is not scoped, estimated and scheduled then. An accurate scope, estimate schedule are prerequisites for good Project Control.

### ***2.3 Staged Approach to Project Management***

If there is insufficient detail to achieve a detailed scope, estimate and schedule then the project should be broken down into “Stages” and it is important ensure that each stage is estimated and scheduled in detail.

It is essential that the deliverables of a preceding stage include a detailed estimate and schedule for the next stage. This task should not be left to the project manager at the start of a phase when he is trying to initiate a project.

At owner or client level most projects require several phases and the baseline schedule and budget for each phase should be set before the commencement of each phase. A contractor may often have a single of stages project to execute.

Usually there will be a master project schedule and budget setting out major milestones that have to be met. Each stage is then scheduled within the milestones.

#### **2.3.1 Project Planning Activities**

Planning a project, or a phase of a project, will typically include the following activities:

- Scope definition
- Estimate
- Schedule
- Capital approval or award of contract

#### **2.3.2 Control**

In the control phase of a project the following activities take place.

- Assigning of work & and the completion of the work.
- Recording the cost and hours for the work completed.
- Recording the quantity of work completed.
- Scope Change & Variation Management.
- Assessment of the productivity during the work.
- Corrective action for work over cost or behind time.

### ***2.4 Control Methods - Committed Cost or Earned Value***

There are two principal methods of controlling projects.

- Committed Cost and
- Earned Value Performance Measurement

### 2.4.1 Committed Cost

Committed Cost Management is suited to projects where the main expenditure is price/lump sum contracts. The focus in committed cost management is to compare the value of contracts plus variations against the Budget.

Typical Report Headings for a project managed by committed cost method would be

- |     |                        |   |
|-----|------------------------|---|
| 1.  | Original Budget        | Derived from original estimate.           |
| 2.  | Current Budget.        | Original Budget plus approved variations. |
| 3.  | Total Commitment.      | Total value of contracts let              |
| 4.  | Expenditure to Date    | Invoices paid against Contracts           |
| 5.  | Outstanding Commitment | 3-4                                       |
| 6.  | Estimate to Complete.  | Unawarded Work                            |
| 7.  | Forecast At Completion | 6+3                                       |
| 8.  | Forecast Variation     | 7-2                                       |
| 9.  | Forecast Last Period   |   |
| 10. | Forecast Change        | 7-9                                       |

A typical example from a project from a Committed Cost Project is below:

Description	Budget	Commitment	Expend	Outstand Commit	Estimate to Complete	Forecast
<b>Total</b>	<b>\$192,146</b>	<b>\$43,878</b>	<b>\$29,238</b>	<b>\$14,640</b>	<b>\$131,329</b>	<b>\$175,086</b>
01 PCIS Development Testing Meeting	\$0	\$624	\$624	\$0	\$0	\$ 624
02 Prepare Scope Schedule & Estimate	\$6,670	\$5,478	\$5,478	\$0	\$0	\$ 5,478
03 Design Development Testing	\$16,159	\$8,667	\$8,667	\$0	\$1,778	\$ 10,445
04 Prepare Development Test Plan	\$7,449	\$2,248	\$2,248	\$0	\$4,182	\$ 6,430
05 Test Plan Review	\$974	\$169	\$169	\$0	\$0	\$ 169
06 Design Mod's for Production.	\$23,359	\$2,764	\$2,764	\$0	\$21,429	\$ 24,193
07 Design Review	\$974	\$0	\$0	\$0	\$974	\$ 974
08 Manufacture of Design Modifications	\$28,673	\$10,407	\$1,597	\$8,810	\$3,718	\$ 14,125
09 Installation	\$2,665	\$196	\$196	\$0	\$2,469	\$ 2,665
10 Test ( Pre- Production)	\$6,434	\$0	\$0	\$0	\$6,434	\$ 6,434
11 Prepare Test Report	\$2,064	\$0	\$0	\$0	\$2,064	\$ 2,064
12 Machine Test Accepted	\$2,335	\$0	\$0	\$0	\$2,335	\$ 2,335
13 Manufacture of Design Modifications.	\$37,358	\$5,830	\$0	\$5,830	\$37,358	\$ 43,188
14 Commissioning Test Procedure	\$450	\$0	\$0	\$0	\$450	\$ 450
15 Review Testing Procedures	\$974	\$0	\$0	\$0	\$974	\$ 974
16 Hazard Evaluation Study	\$2,923	\$0	\$0	\$0	\$2,923	\$ 2,923
18 Remove	\$3,300	\$0	\$0	\$0	\$2,252	\$ 2,252
19 Re-Install	\$2,252	\$517	\$517	\$0	\$1,735	\$ 2,252
17 Pre-operational Testing	\$3,300	\$0	\$0	\$0	\$3,300	\$ 3,300
20 Wet Commissioning	\$2,252	\$0	\$0	\$0	\$2,252	\$ 2,252
21 Hand Over For Production Testing	\$450	\$0	\$0	\$0	\$450	\$ 450
22 Production Test	\$4,504	\$0	\$0	\$0	\$4,504	\$ 4,504
23 Internal Review & Acceptance	\$1,949	\$0	\$0	\$0	\$1,949	\$ 1,949
24 System Testing & Acceptance	\$450	\$0	\$0	\$0	\$450	\$ 450
25 Project Meetings	\$34,226	\$6,858	\$6,858	\$0	\$27,348	\$ 34,206

The schedule is often not integrated into the cost management of committed cost projects.

This method does give useful information but will not tell you if the work is being completed according to the schedule and is not likely to give you early warning of potential project over runs

### **2.4.2 Earned Value Performance Measurement**

The focus of EVPM is to compare:

- How much work was scheduled,
- How much work was performed and
- The actual cost of the work performed

These parameters are then used to predict how far ahead or behind time the project will be at completion and how much more or less than budget the project will cost.

EVPM method is suited to

- Work being completed in man hours or resource hours, and
- For work that may be completed out of sequence.

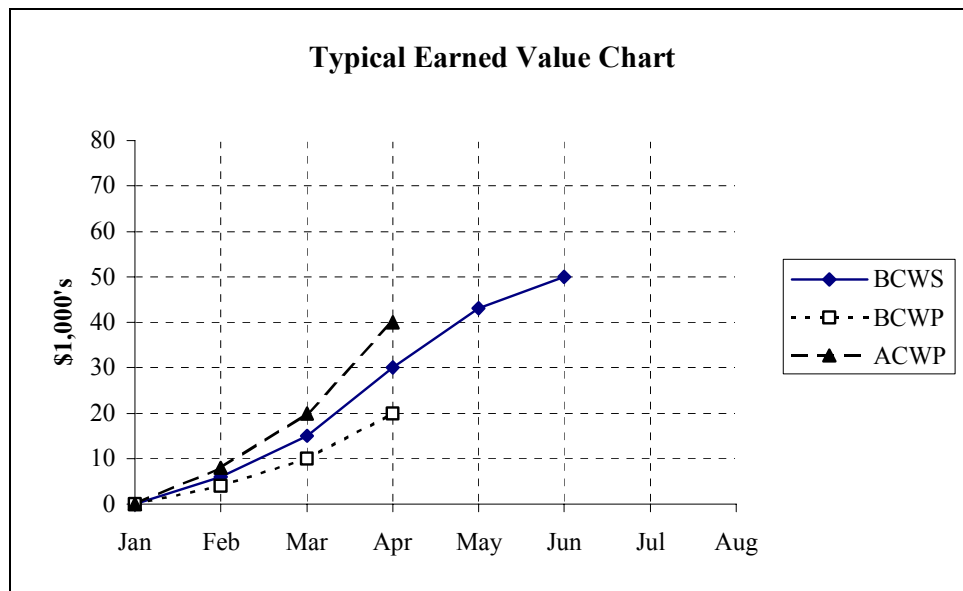
Earned Value may be applied to

- Individual activities
- Groups of Activities, therefore simplifying cost collection into Cost Accounts or Cost Codes
- Resources or Groups of Resources or
- Whole Projects

### **2.5 Basic C/SCSC Terminology.**

- The work scheduled is titled “The Budgeted Cost of Work Scheduled”, BCWS.
- The value work performed is titled “The Budgeted Cost of Work Performed”, BCWP.
- The cost of work performed is titled “The Actual Cost of Work Performed”, ACWP.

The chart below shows how the three parameters above may be graphed as a project progresses.



Discussion: What are the implications of the above chart?

1. Are we doing the work fast enough?
2. How far ahead or behind schedule are we?
3. Is it costing us more or less to do the work compared to plan?
4. How much more or less is it costing us?
5. With the current progress how long will it take use to finish the project?
6. On what date will we finish the project?
7. How much will it cost to complete the project?
8. What is the Forecast Cost at Completion?
9. How much over or under Budget will we be?

From the above chart it would be possible to make an assessment of the performance to date and extend it into the future, particularly on activities which are of similar nature.

## ***2.6 Performance Measurement - Cost/Schedule Control Systems Criteria (C/SCSC) Terminology***

C/SCSC terminology is used by a large number of companies and is a standard in the defence industry. It provides standard terms to describe Earned Value calculations, which many people understand. Below are some of the terms that are in common use.

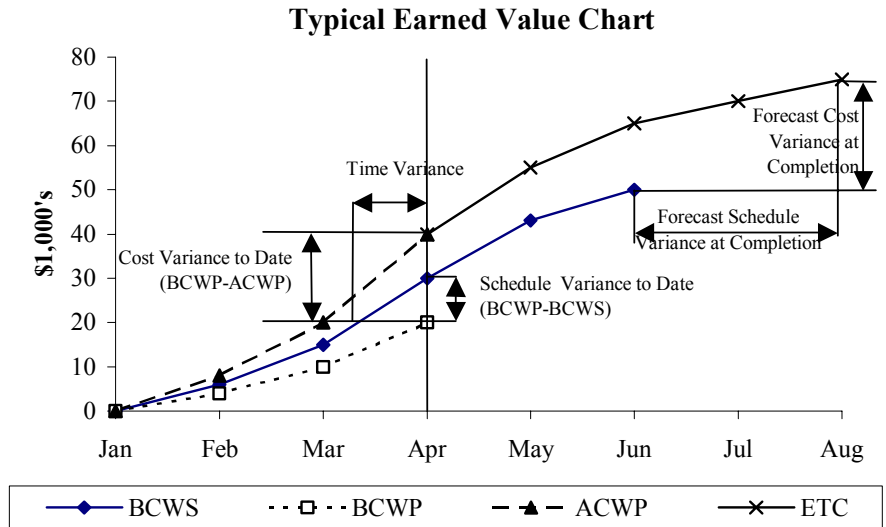
- ACWP Actual Cost of Work Performed
- BCWP Budget Cost of Work Performed
- BCWS Budget Cost of Work Scheduled
- BAC Budget At Completion
- C/SCSC Cost/Schedule Control Systems Criteria (CS<sup>2</sup>)
- CV Cost Variance to date, BCWP - ACWP
- ETC Time Estimate To Complete expressed in Time
- ETC Estimate To Complete
- FAC \$ Forecast at Completion
- FC CV Forecast Cost Variance at Completion (Budget - Forecast)
- FC SV Forecast Schedule Variance at Completion (Baseline End Date - Scheduled End Date)
- FTC CT Forecast To Complete Calendar Time
- SV Schedule Variance to date, BCWP – BCWS

The advantages of adopting C/SCSC terminology are:

- Many people outside your organization will understand it.
- Many software packages use this terminology
- New employees may understand this terminology
- It is clear & concise



EARNED VALUE CHART WITH CSCSC TERMINOLOGY

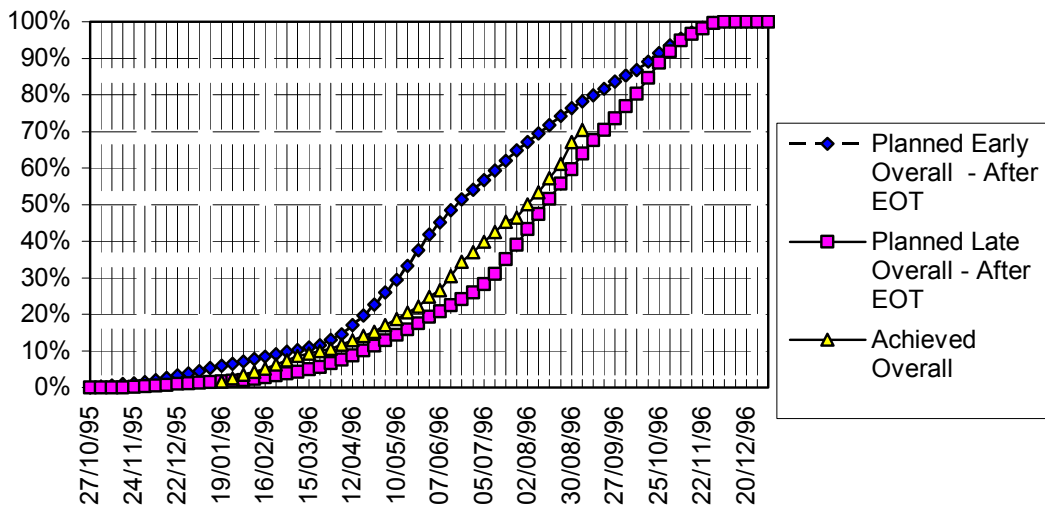


Performance Measurement therefore:

- Measures the performance to date,
- Provides a tool to estimate to Forecast At Completion and
- Variances in time and \$'s to date and
- Variances in time and \$'s at the end of the project.

The intention of Earned Value is that action may be taken to reduce over runs. In many projects only the early S-Curve is plotted. When many activities have float it is often worth while plotting the late curve and keeping progress between the two curves and monitoring the angle of the progress line.

**Overall Progress - % - As At 6/9/96**



### **3 PRACTICAL APPLICATION OF EVPM IN PROJECTS**

There are three stages to EVPM:

- Firstly set the baseline
- Secondly record progress against the baseline
- Review progress and forecast

#### ***3.1 Setting a Baseline***

Earned Value Performance Measurement requires a baseline schedule with costs, hours and deliverables.

This is created by:

- Scoping and Estimating the project using a Breakdown Structure
- Defining Activities and Activity Deliverables
- Applying Costs and Resources to each Activity
- Scheduling the Activities and Calculating Start & Finish Dates

##### **3.1.1 Creating the Breakdown Structure**

The schedule is created in the normal way and it is suggested to use the following types of Activity Codes for activities:

- Phase - Design, Procure, Install, Test
- Discipline – Process, Civil, Mechanical. Electrical Etc
- System – Project Specific
- Sub System – Project Specific
- Area – Physical Area of Project
- Responsibility – Company or Department Responsible
- Who Will Do It – The contractor or team who will perform the work
- Purchase Order or Work Package

##### **3.1.2 Activity and Deliverable Definition**

Activities are usually defined by their deliverable. Try to allocate each activity one type of deliverable with one unit of measurement.

Therefore a piece of equipment which is to be specified, purchased and installed has three activities:

- The specification/data sheet
- The equipment purchase

- The installation

### ***3.1.2.1 Design Deliverables***

A design deliverable may be:

- A single document or
- A group of documents

### ***3.1.2.2 Procurement Deliverables.***

- Each PO is tied to an activity.
- Each PO is allocated a proportion of the Budget as it is awarded.
- When an item is delivered then it accrues the progress in Dollar terms.

### ***3.1.2.3 Installation Progress***

Each Activity is allocated a Quantity of Deliverables.

A deliverable may be:

- Number of tube bundles changed
- m<sup>2</sup> of concrete
- m of pipe

### ***3.1.2.4 Resource Definition***

A resource may be defined as

- People,
- Equipment,
- Materials etc.

Most company cost management systems do not recognise resources and are unable to export them to an EVPM system. Therefore separate systems have developed to manage quantities.

Only some company systems are able to handle resource hours and usually separate systems are created to assign used hours against activities.

### **3.1.3 Scheduling the Activities and Calculating Start & Finish Dates**

The following are required to successfully cost manage projects:

- A competent software product such as Primavera P3.
- Trained or experienced personnel.
- Procedures that everyone follows.

The breakdown structure and activities should be the same as those used in the estimate.

### **3.2 Progress Measurement**

The progress of the project is measured and the schedule progressed on a regular basis, say once a week or once a month.

The following information is recorded for each task:

- Revised Start & Finish dates
- Actual Start & Finish dates
- Number of deliverables complete to Date
- Costs to Date
- Hours to Date
- ETC \$'s to Complete
- ETC Hrs to Complete
- ETC Deliverables to Date

Progress to date, i.e. Activity % Complete, should be based on Deliverables Completed divided by the Deliverables at Completion.

### **3.2.1 Design Progress Measurement**

The document register may be used for measuring the number of deliverables.

- Status points may be used to measure progress. i.e. 10% for starting the document, 50% for completing first draft, 80% for IDR complete & 100% for AFC/AFP.
- Each document is tied to an Activity.
- The aggregation of the progress of all the documents gives the % complete for the Activity.
- Hours and Dollars to date are recorded.
- The Hours and Dollars to Complete may be calculated based on progress to date.

A simple spreadsheet, database or a manual system may be used for recording some or all of the information above.

If a spreadsheet is used one of the following functions may be used to sum the progress all deliverables:

- Pivot Tables
- SUMIF

### **3.2.2 Purchasing Progress Measurement**

It is often worth drawing a separate S-Curve for the committed cost of Purchase Orders, if the orders are not placed on time then the project will not finish on time.

You need to decide how the value is earned and you must earn the value of in progress activities in the same as originally scheduled, so comparing S-Curves is meaningful.

### **3.2.3 Installation Progress Measurement**

At the end of each period the following are recorded:

- The Actual or Expected Start and Finish dates are recorded.
- The Quantity to date and Quantity to complete are established for each activity.
- The Hours and Dollars to date are recorded.
- The Hours and Dollars to Complete may be calculated based on progress to date.

### ***3.3 Forecasting***

Forecast To Completion (often known as ETC or Estimate to Complete) should be calculated for each activity based on remaining work and productivity to date.

Therefore the advantage of collecting costs against activities is that it will better forecasting information when the work is of similar nature.

The estimate to complete is prepared in terms of:

- Time
- Cost and
- Resources

This should be calculated for each activity typically when they are more than 20 to 30% complete.

This information is then returned to the system being used and reports are created showing the progress.

### ***3.4 Variances Forecast Terminology***

The following Variance may be calculated:

- Cost Variance,  $BCWP - ACWP$
- Schedule Variance,  $BCWP - BCWS$
- FC CV Forecast Cost Variance at Completion, Budget - Forecast
- FC SV Forecast Schedule Variance at Completion, Baseline End Date - Scheduled End Date

### 3.5 Report Formats

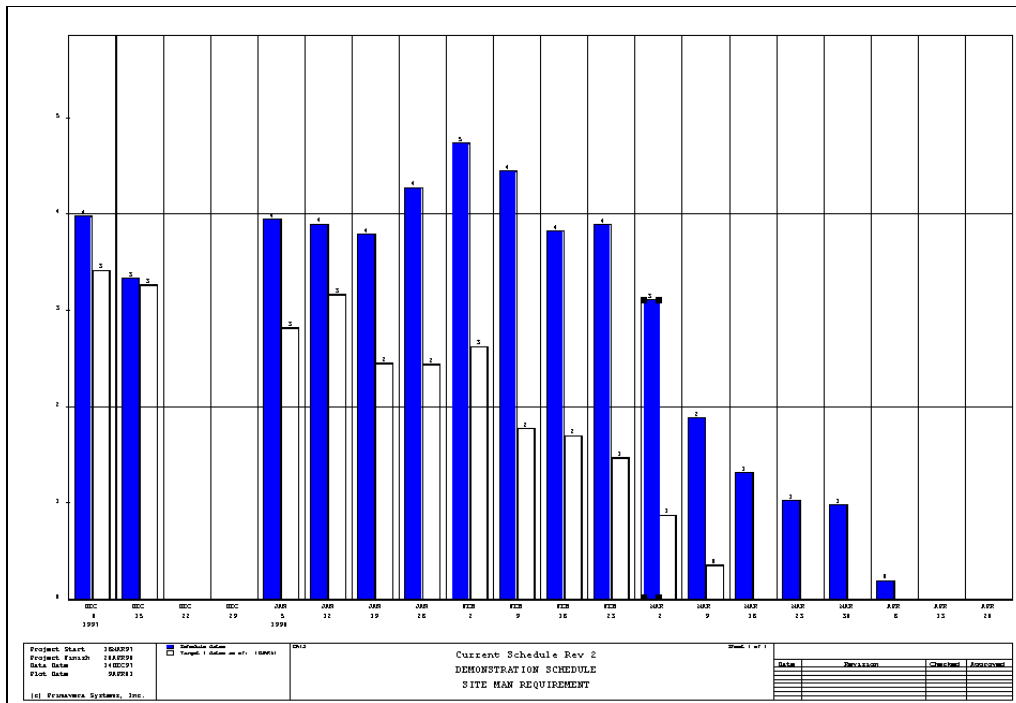
Reports may be Tabular, Histogram or show S-Curves:

- Tabular

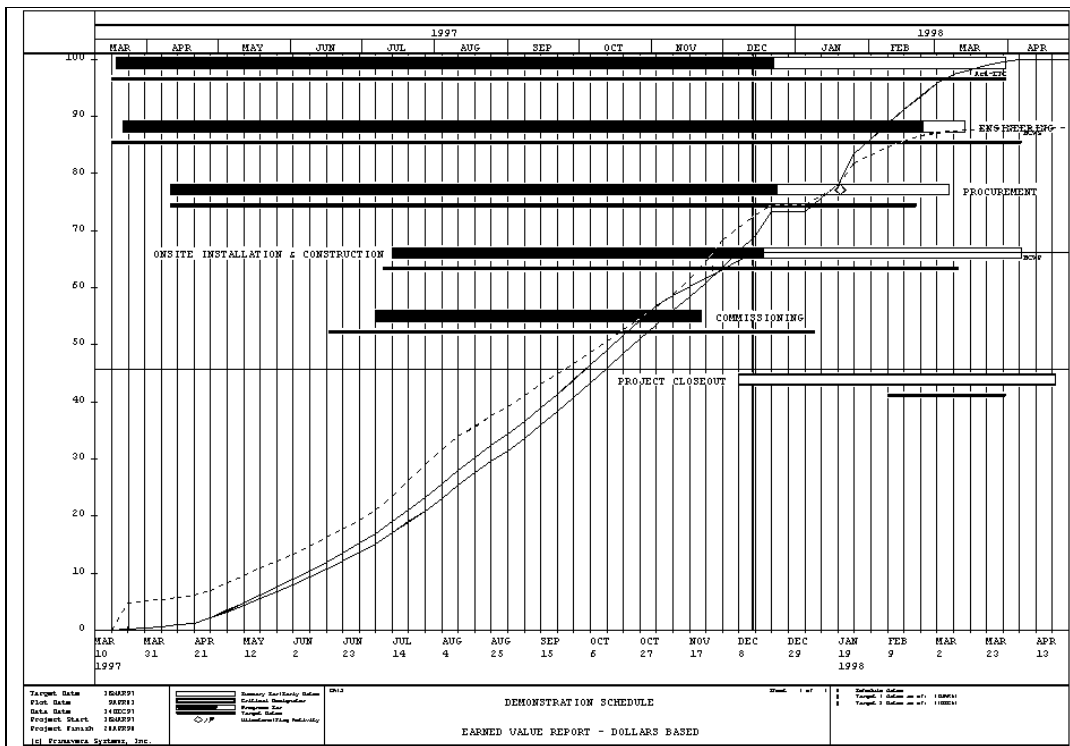
ACTIVITY	DESCRIPTION	BUDGET	ACTUAL
	<b>TOTALS</b>	<b>\$2,244,000</b>	<b>\$2,235,570</b>
100	Tube Bundles	\$1,860,000	\$1,859,768
150	Electrical Cables	\$62,000	\$59,822
200	Spec Blinds	\$5,000	\$4,939
250	Studs, Nuts And Gaskets	\$5,500	\$5,017
300	Electrical Cable Trays	\$34,000	\$33,055
350	Plugs And Sockets	\$48,000	\$47,442
400	Tooth Belts	\$40,000	\$39,815
450	Replacement Soundproofing	\$12,000	\$11,120
500	Unistrut Supports	\$30,000	\$28,205
550	Concrete Supports	\$8,500	\$7,640
600	Lighting	\$18,000	\$18,394
650	Handrails And New Platforms	\$54,000	\$51,922
700	Lifting Frame	\$13,000	\$12,708
750	Cable Glands	\$22,000	\$23,954
800	Structural Plugs	\$15,500	\$15,466
825	Junction Boxes and Relays	\$10,500	\$10,397
850	Walkway Slabs	\$2,500	\$2,450
875	Bleed Valves	\$3,500	\$3,455
880	Bunndle Change Out	\$205,000	\$200,900
975	Misc Purchase Orders	\$50,000	\$78,449
980	Materials	\$167,500	\$160,093
985	Stair Fabrication	\$56,000	\$56,200
990	Wall Material	\$12,528	\$10,840
991	Capping Beam	\$14,000	\$4,850

**THE PRACTICAL APPLICATION OF EARNED VALUE PERFORMANCE MEASUREMENT**

- Histogram



- S Curves





**THE PRACTICAL APPLICATION OF EARNED VALUE PERFORMANCE MEASUREMENT**

Reports may show Dollar, Hours or Deliverables:

- Summary Dollar report:

Activity ID	Activity Description	%	Budgeted Cost	Cost this Period	Cost to Date	Earned Value (BCWP)	Sched Budget (BCWS)	Cost Variance (BCWP-ACWP)	Sched Var (BCWP-BCWS)	Cost to Complete	Cost at Completion	Compl Cost Variance
<b>DEMONSTRATION SCHEDULE</b>												
Total		72	6,893,895	284,347	4,967,068	4,929,712	5,493,436	-37,356	-563,724	2,226,700	7,193,768	-299,873
<b>+ PROJECT MANAGEMENT</b>												
		74	319,725	17,803	229,165	237,573	237,473	8,408	100	116,545	345,710	-25,985
<b>+ ENGINEERING &amp; DESIGN</b>												
		95	514,100	1,694	498,815	489,500	481,028	-9,315	8,472	17,606	516,421	-2,321
<b>+ PROCUREMENT</b>												
		78	3,473,070	90,717	2,659,586	2,693,193	2,867,159	33,607	-173,966	825,788	3,485,374	-12,304
<b>+ ONSITE INSTALLATION &amp; CONSTRUCTION</b>												
		59	2,547,100	173,369	1,553,911	1,490,146	1,889,001	-63,765	-398,855	1,245,647	2,799,558	-252,458
<b>+ COMMISSIONING</b>												
		100	19,300	0	24,827	19,300	18,775	-5,527	525	1,152	25,979	-6,679
<b>+ PROJECT CLOSEOUT</b>												
		0	20,600	764	764	0	0	-764	0	19,962	20,726	-126

- Summary Hour report:

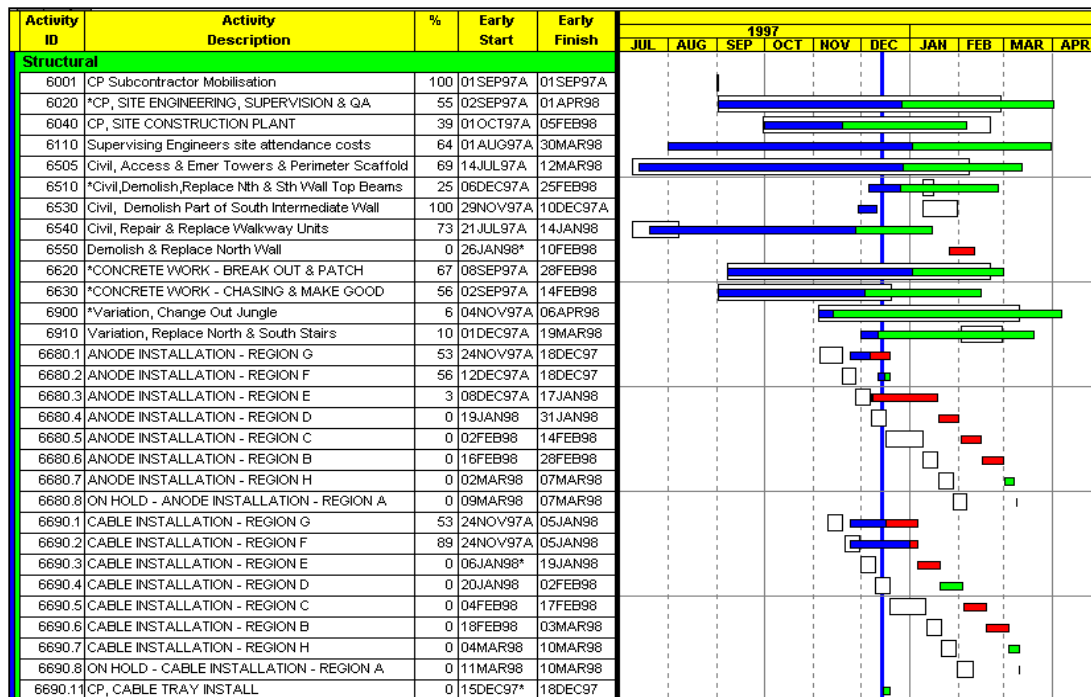
Activity ID	Activity Description	Budget Qty Hrs	Hrs this Period	Hrs to Date (ACWP)	Earned Value (BQWP)	Sched Budget (BQWS)	Cost Var Hrs (BQWP-AQWP)	Sched Var (BQWP-BQWS)	Hrs to Comp (ETC)	Hrs at Comp (FAC)	Comp Hrs Variance
<b>DEMONSTRATION SCHEDULE</b>											
Total		49,601	2,584	32,422	31,091	37,463	-1,331	-6,372	20,569	52,991	-3,390
<b>+ PROJECT MANAGEMENT</b>											
		0	0	0	0	0	0	0	0	0	0
<b>+ ENGINEERING &amp; DESIGN</b>											
		4,911	26	5,132	4,633	4,501	-499	132	214	5,346	-435
<b>+ PROCUREMENT</b>											
		70	0	0	0	0	0	0	70	70	0
<b>+ ONSITE INSTALLATION &amp; CONSTRUCTION</b>											
		44,110	2,547	27,279	26,212	32,723	-1,067	-6,511	20,032	47,311	-3,201
<b>+ COMMISSIONING</b>											
		246	0	0	246	239	246	7	0	0	246
<b>+ PROJECT CLOSEOUT</b>											
		264	11	11	0	0	-11	0	253	264	0

**THE PRACTICAL APPLICATION OF EARNED VALUE PERFORMANCE MEASUREMENT**

- Deliverables

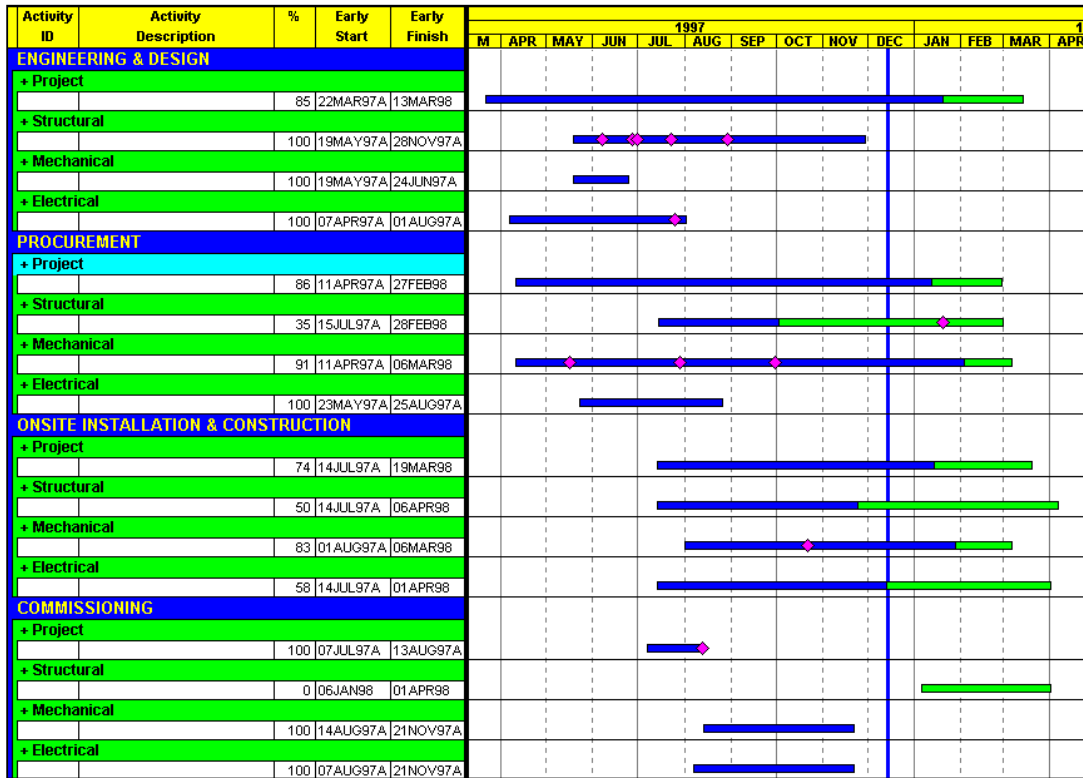
ACT	DESCRIPTION	MEASURED ITEM	NO	UNITS	NO COMP THIS PERIOD	NO COMP LAST PERIOD	NO COMP TO DATE	% COMP
330	Elect/Inst, Lighting Change Out	Lights Installed	43	No		19	19	60%
340	Elec/Inst, Demolition	Meters Conduit	6000	m	300	5700	6000	100%
420	Mech & Elec, Change Out of Bundles	Bundles Changed	3	No	0	1	1	33%
505	Civil Access and Emergency towers & Perimeter Scaffold		13	No	3	6	9	69%
540	Civil, Remove & Replace Walkway Units, 50%	Walkways Complete	37	No	1	36	37	73%

- Detailed Report of Activities



**THE PRACTICAL APPLICATION OF EARNED VALUE PERFORMANCE MEASUREMENT**

- Summary Report of activities



- % Complete of Deliverables, Duration, Cost and Labour Hours:

