Mitigation and Performance Recovery Using Earned Value

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TCM - Cost Engineering on My Mind

AACE® International's 54th Annual Meeting

Atlanta, Georgia

Patrick M. Kelly, PSP

- **Degree:**
  - B.S. Ocean Engineering (1996)
- **University:**
  - US Naval Academy
- **Years of Experience:**
  - 11 (incl. Civil Engineer Corps)
- **Professional Field:**
  - Contracting, Project Manager, Project Controls Manager (Scheduling, Claims & Disputes Resolution). Managed aviation, industrial, commercial, infrastructure and critical structures assignments, and other projects nationwide, providing construction and contract management, schedule analysis, impact analysis, cost evaluation, entitlement analysis, and other claims and dispute resolution services.
- **Something you do not know about me:**
  - Patrick doesn't like to reveal too much about himself

Chris Carson, PSP, PMP, CCM

- **Corporate Director of Project Controls, Alpha Corporation**
  - Responsible for standards, processes, and procedures for a team of schedulers, analysts, and project managers in multiple office locations
  - Provided seminars for hundreds of scheduling professionals in CPM scheduling methodologies, and manages the in-house training program at Alpha
- **Certifications:** PSP, CCM (Certified Construction Manager - CMAA), PMP (Project Management Professional - PMI)
- **University:** University of Virginia, Mechanical Engineering, 1972
- **Professional Field:** 37 years of experience in Construction Management, CM Services especially Scheduling, Estimating, Claims
- **Active in AACEi**
  - Co-Author for "Identifying the Critical Path" RP, author for "Recovery Scheduling" RP
  - Co-author for "Schedule Design" RP, currently underway, participating author for "Forensic Schedule Analysis" RP
- **Active in PMI College of Scheduling**
  - Managing Director for Scheduling Excellence writing "Best Practices and Guidelines for Scheduling" and "Best Practices and Guidelines for Schedule Impact Analysis"
- **Active in CMAA (Construction Management Association of America)**
  - Served on 9 person committee revising the Time Management Chapter of the CMAA's CM Standards of Practice
- **Something you do not know about me:**
  - I am a proud grandfather of two girls and a boy
  - I was given an award for "Significant Contributions to the Scheduling Industry" at the 2009 CoS national conference

Overview

Overview

- **This paper discusses the practical use of Earned Value metrics and calculations in monitoring and controlling schedule slippage, and, more importantly, in identifying appropriate mitigation plans to regain time.**
- **Earned Value Management can be used to:**
  - **Identify the specific trades or scopes of work that are contributing to poor performance.**
  - **Fashion an appropriate isolated and detailed mitigation strategy to provide steps for the improved performance necessary.**
- **This presentation provides an innovative look, from an Earned Value perspective, at the needs within the schedule database to support schedule compression.**
- **The program illustrated will provide a process and graphical displays to define and promote more practical steps to aid mitigation than just reporting on EV metrics.**

Introduction

Brief Background on EVMS

- **Earned Value Management began as a set of 35 Cost/Schedule Control Systems Criteria (C/SCSC) imposed by the DoD on industrial firms wishing to do business in a cost-reimbursable or incentive contract.**
- **EVM subsequently has grown beyond the factory floor and become an important supplementary analysis tool to the use of Critical Path Method scheduling in construction applications.**

Brief Background on EVMS

- **The CPM schedule, as the primary project management tool on the construction project, will measure the contractor's progress against his baseline plan.**
  - **CPM schedule is used to generate the baseline Budgeted Cost of Work Scheduled (BCWS) Curve, which will form the basis of EVM analysis throughout the project.**
  - **Use of EVM metrics provides additional understanding of the project's health by adding texture to the analyst's understanding of:**
    - Critical Path delay
    - Non-Critical Path slippage and float erosion
    - Performance in particular areas of work or in particular trades.

Schedule Compression

- **Projects sometimes slip behind schedule, and the late predicted completion date can be unacceptable or unsustainable to the parties to the contract.**
  - **This paper does not discuss cause or compensability of the slippages, delays, or mitigation actions.**
  - **Regardless of who is paying, the EVM metrics can aid the scheduler in determining a successful mitigation strategy.**
- **Common causes of slippage:**
  - **Design Clarity**
  - **Planning Efforts**
  - **Project Management & Production**
  - **Change Management**

Key EVM Metrics

Schedule Analysis and Forecasting	Cost Analysis and Forecasting
Schedule Variance (*Are we ahead or behind schedule?*) ***SV = EV - PV***	**Cost Variance** (*Are we under or over budget*?) ***CV = EV - AC***
Schedule Performance Index (*How efficiently are we using time?*) ***SPI = EV / PV***	**Cost Performance Index** (*How efficiently are we using our resources?*) ***CPI = EV / AC***
Time Performance Ratio (*What are the effects of slippage issues on activity duration?*) ***TPR = AD / OD***	**To-Complete Performance Index** (*How efficiently must we use our remaining resources?*) ***TCPI = (BAC – EV) / (BAC – AC)***

-From PMI's *Practice Standard for Earned Value Management*

Key EVM Metrics

- **Each of these metrics has the ability to guide a schedule analyst, during the schedule compression process, by highlighting specific areas of slippage, or by highlighting specific areas of success upon which the contractor should capitalize.**

Prerequisites and Preparatory Steps

Prerequisites

- **It is essential that the scheduling process, from baseline schedule generation through the schedule updating and monitoring processes, be geared at the outset to record information in such a way that will facilitate simple EVM analysis.**
- **By starting with this end in mind, the scheduler will have at his disposal quick and easy access to the EVM metrics which will supplement his understanding of the CPM schedule, and therefore also his ability to revise and compress the schedule when the need arises.**

Preparatory Steps - Baseline

- **Baseline schedule is fully designed and developed, and captures the complete scope of work.**
- **Baseline schedule is properly cost and resource loaded with accurate information.**
  - **Schedule-based EVM metrics are available and useful, but the full value of EVM only becomes apparent when one can use the metrics generated by cost and resource loading.**
  - **Schedule Analysis and Forecasting:**
    - Schedule Variance
    - Schedule Performance Index
    - Time Performance Ratio
  - **Cost Analysis and Forecasting:**
    - Cost Variance
    - Cost Performance Index
    - To-Complete Performance Index

Preparatory Steps - Baseline

- **Detailed use of Activity Codes**
  - **Codes will create a schedule database that can be exported and manipulated in a spreadsheet later on.**
  - **Detailed use of Activity Coding of the baseline schedule will allow the creation of a BCWS Curve not only for the overall project, but also for each of the trades represented by a Responsibility Activity Code.**
- **Creation of the BCWS Curve**
  - **Can be generated within the schedule software.**
  - **Can be generated within a spreadsheet.**
  - **Curves can be generated on a per-trade basis if Activity Coding is sufficient.**
  - **Curves form the basis of EVM analysis during the updating process.**
- **What happens when there is no resource loading?**
  - **Still possible to run EVM metrics**
    - Analyst loads crews, manpower, duration days, uses other metrics

Preparatory Steps - Updates

- **Typical update preparation and maintenance rules apply.**
- **Additionally, it is important to create additional Activity Codes which will allow for simple collation and analysis of activity-specific EV data, once the schedule database is exported to a spreadsheet.**
- **Continuous coding of activities to track which trades, types of work, areas of work, etc., are impacted by known issues will allow the schedule analyst to make more effective recommendations regarding schedule compression.**

Preparatory Steps - Updates

- **Design and Contract Drawing Clarity:**
  - **In updates, it is important to code activities with an "impact" code which relates specific RFI's to this activity.**
  - **The code should be supplemented by specific information in the activity's log notes or notebook entry; however, the Activity Code is essential for quick and effective EVM analysis within spreadsheets.**
  - **Log notes must record delays to the start of an activity due to Design Clarity issues, as represented by an RFI or other appropriate record documentation, and should also track the start and finish date of RFI review.**
    - If an in-progress activity is affected by a Design Clarity issue, the scheduler should consider the use of the Suspend-Resume function to show the break in progress.
    - Use of this function will also ensure that the activity's Actual Duration is only reflective of the contractor's progress, so that progress-related delays are clearly separated from Design Clarity issues.
  - **Should RFI's or other Design Clarity issues result in changes to the design, the scheduler must appropriately account for the changes in the network, to include alterations to activities, durations, logic, cost loading, and the BCWS curve. This will ensure a fair comparison of the EV to the PV as the project progresses.**

Preparatory Steps - Updates

- **Project Management and Production:**
  - **Proper coding within the baseline schedule should allow for the generation of trade-specific EVM metrics.**
  - **PM staff should:**
    - Continually create impact codes and log notes to represent occasions where particular subcontractors have fallen short of expectations in some way.
    - Code and note any occasion where project progress was delayed or disrupted by the action or inaction of the owner, or by third-party delays.
  - **Assiduous attention to detail in this regard will allow the analyst to separate out those trends which are representative of poor contractor performance from those which were representative of impacts external to the contractor.**
    - Document start delays and production delays in log notes
    - Use Suspend / Resume

Prerequisites and Preparatory Steps

- **Goal is to create a detailed database of uniformly coded information which will yield quick and accurate trending information that can be filtered on a by-trade or other basis, in order to guide the scheduler in development of a compressed schedule.**

EVM in Schedule Compression

EVM in Schedule Compression

- ***Crashing.*** *A schedule compression technique in which cost and schedule tradeoffs are analyzed to determine how to obtain the greatest amount of compression for the least incremental cost. Examples of crashing could include approving overtime, bringing in additional resources, or paying to expedite delivery to activities on the critical path. Crashing only works for activities where additional resources will shorten the duration. Crashing does not always produce a viable alternative and may result in increased risk and/or cost.*
- ***Fast tracking.*** *A schedule compression technique in which phases or activities normally performed in sequence are performed in parallel. An example is constructing the foundation for a building before completing all of the architectural drawings. Fast tracking may result in rework and increased risk. Fast tracking only works if activities can be overlapped to shorten the duration.*

-From PMI's *Body of Knowledge*, Fourth Edition

EVM in Schedule Compression

- **Whether the schedule is to be crashed or fast-tracked, it is essential that the scheduler understand the following:**
  - **Which trades are not performing up to expectations or contractual obligations, and will therefore require additional resources or project management attention in order to meet or exceed current production goals?**
  - **Which trades are exceeding expectations or contractual obligations, and will therefore likely exceed current production goals?**
  - **Delay and responsibility for delay will require CPM analysis, not only EVMS – this is a trending tool that can be used to point out specific trends among trade contractors that will likely affect progress**

EVM in Schedule Compression

- **By exporting the schedule database to a spreadsheet, the scheduler can examine the historical data to gain an understanding of the performance of each trade.**
- **At a minimum, the scheduler should export the following data fields from the schedule database into a spreadsheet:**

Activity ID
Activity description
Original duration
Actual duration
Percent complete
Early start
Early finish
Actual start
Actual finish

Budgeted cost
Actual cost
Cost Percent Complete
Phase
Work Area
CSI Division
Type of Work
Responsibility/Subcontractor
Issue Codes
Resources

Export or copy trending data into table in preparation for pivot tables or charts

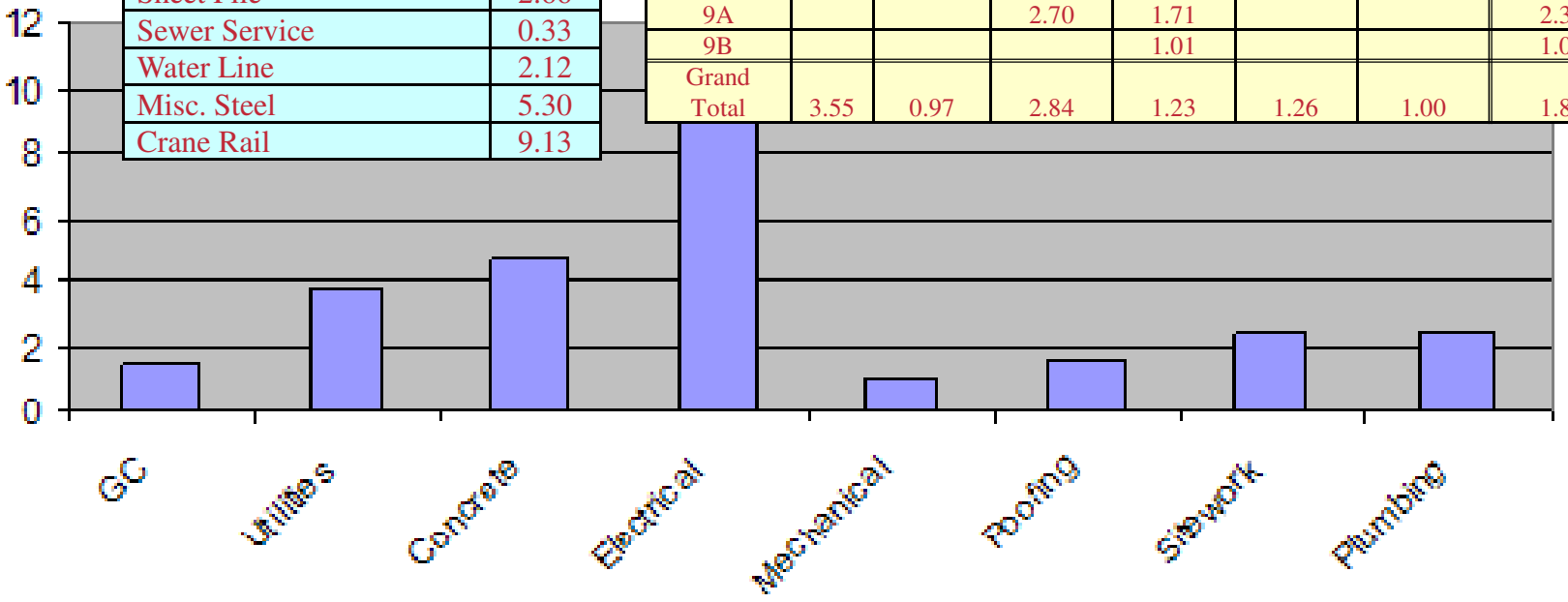
	2005								2006						
	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul
Percent Complete	23.00	27.30	32.50	37.40	40.80	44.50		50.20	53.00	59.00	63.00	73.00	79.00	85.00	89.00
Critical Activities	189	141	596	713	705	756			12	170	454	11	200	36	82
LP Activities			171	107	191	142		519	6		6	6	26	25	22
Logic Changes	3,151	209	153	286	695	134		771	3,505	57	194	526	69	78	78
Out of sequence															69
Number of Activities	2,287	2,289	2,285	2,313	2,317	2,326			2,776	2,777	2,780	2,807	2,808	2,812	2,816
In Progress	54	44	54	47	46	49			67	75	84	76	92	121	107
Complete	212	249	304	372	454	535			855	1,044	1,280	1,601	1,850	2,007	2,208
Missed ES	32	35	25	23	18	25			24	30	28	29	44	37	25
Missed EF	27	26	25	37	29	39			59	47	60	38	78	82	101
Missed Both	33	38	45	65	76	102			114	115	244	191	292	396	377
Early ES											15	12	8	5	0
Early EF											7	13	13	4	3
Early Both											0	31	8	2	1
Project TPR	2.18	3.09	1.77	1.64	1.57	3.01	2.12	3.42	3.30	1.97	2.19	2.95	1.96	2.53	2.52
BCWS ($M)	15.89	25.11	34.66	40.00	41.48	48.64	53.79	57.30		67.67		75.00	80.62	83.33	93.09
BCWP ($M)	8.90	22.10	30.50	36.40	36.50	42.80	46.80	51.00	56.40	60.90	60.70	72.00	78.20	82.50	82.37
ACWP ($M)	4.6	17.40	27.70	27.70	37.20	38.30	43.40	45.90	52.20	55.20	60.40	70.00	76.5	80.60	81.75
CPI	1.90	1.37	1.22	1.11	0.98	1.12	1.08	1.11	1.08	1.10	1.00	1.03	1.02	1.02	1.01
SPI	0.56	0.88	0.88	0.91	0.88	0.88	0.87	0.89	0.70	0.90		0.96	0.97	0.99	0.88

EVM in Schedule Compression

- **Generate Time Performance Ratio and collate data within a Pivot Table.**

Milestone	HB	HBRC	HRU	JCD	WCE	WM	Grand Total
1	0.78	3.00	30.00	1.00	2.30		4.49
3	1.77		10.75				8.51
4	1.67		1.00	0.83			1.03
5	5.83			0.50		1.00	2.33
70	0.86	1.00			1.00		0.99
90			1.00				1.00
7A	8.40	0.15	1.20	1.45			1.87
7B	3.96	0.05	1.40				2.67
7C	2.01	0.05	1.33				1.48
7D	4.27		0.78				2.52
7E	2.55						2.55
8A	5.60						5.60
8B	4.19						4.19
9A			2.70	1.71			2.32
9B				1.01			1.01
Grand Total	3.55	0.97	2.84	1.23	1.26	1.00	1.84

Type of Work	TPR
Backfill	2.66
Concrete	2.15
Dredging	2.35
Electrical	1.52
Excavation/Backfill Work	3.25
Signing/Marking	5.00
Precast Concrete	3.60
Pile	3.19
Sheet Pile	2.66
Sewer Service	0.33
Water Line	2.12
Misc. Steel	5.30
Crane Rail	9.13



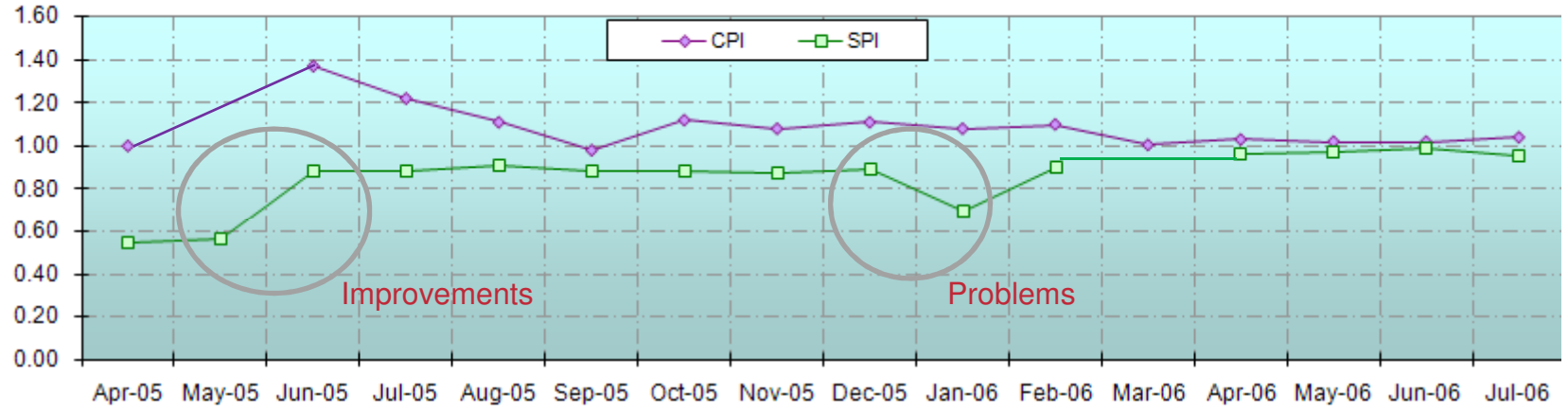
EVM in Schedule Compression

- **Additional EVM metrics can be created by creating pivot graphs of cumulative EV data over time, as represented in the schedule database.**
  - **By filtering the EV data by each of the trade codes, and plotting the cumulative data by month, the EV data for each trade can be compared to the BCWS Curves generated from the baseline schedule.**
  - **From these curve comparisons, SV, CV, SPI, CPI, and TCPI can be generated for each trade.**
- **Causes of the slippage within a particular subcontractor's work will have to be determined through examination of project documentation and interviews with the project staff.**

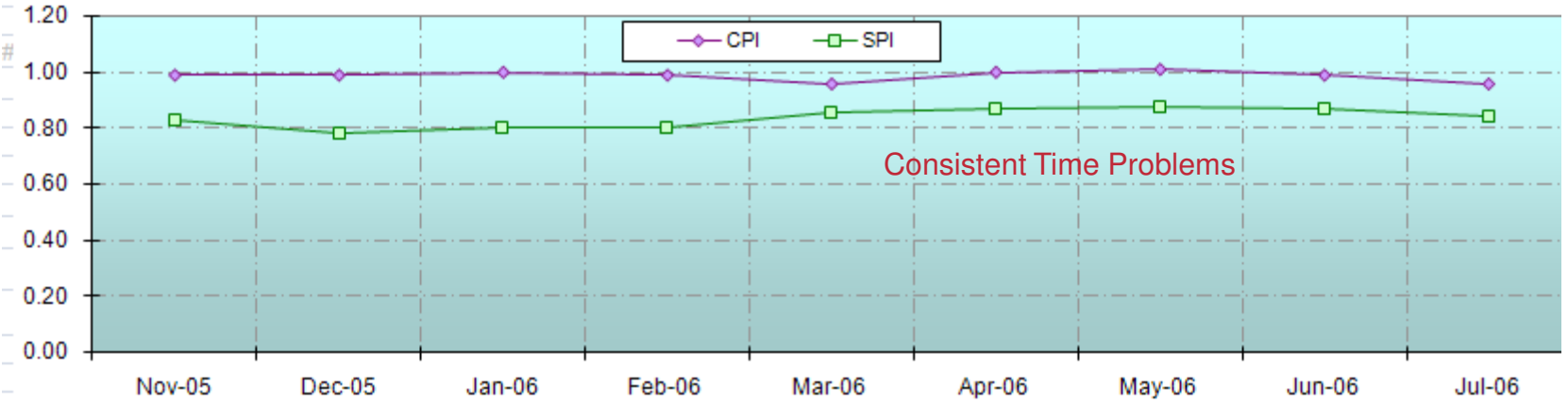
EVM in Schedule Compression

Separating Earned Value curves by trade or location will show very different results from project average Earned Value metrics

HVAC



ELEC

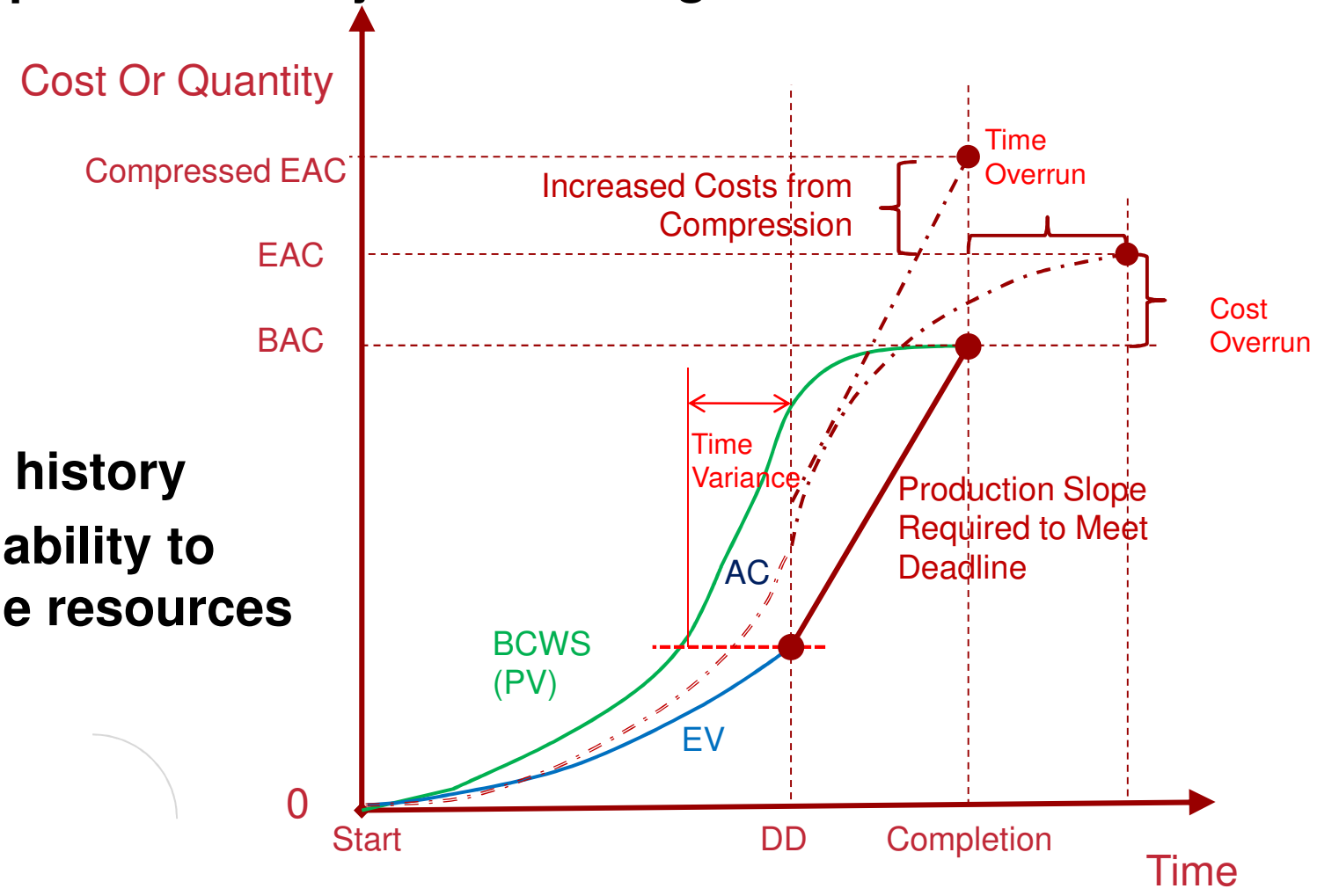


EVM in Schedule Compression

- **Recovery concepts**
  - **Determine slope of EV curve necessary to recover to end of project or milestone**
  - **Graphically**
    - Produce trade specific EVMS curves
    - Identify increased production curve from current time period to end of project
    - Convert production curve to shortened durations
    - Verify ability of trade contractor to supply resources produce durations

EVM in Schedule Compression

- **Determine production slope for recovery**
- **Use proportions to adjust remaining durations of trade**



- **Check history**
- **Verify ability to provide resources**

EVM in Schedule Compression

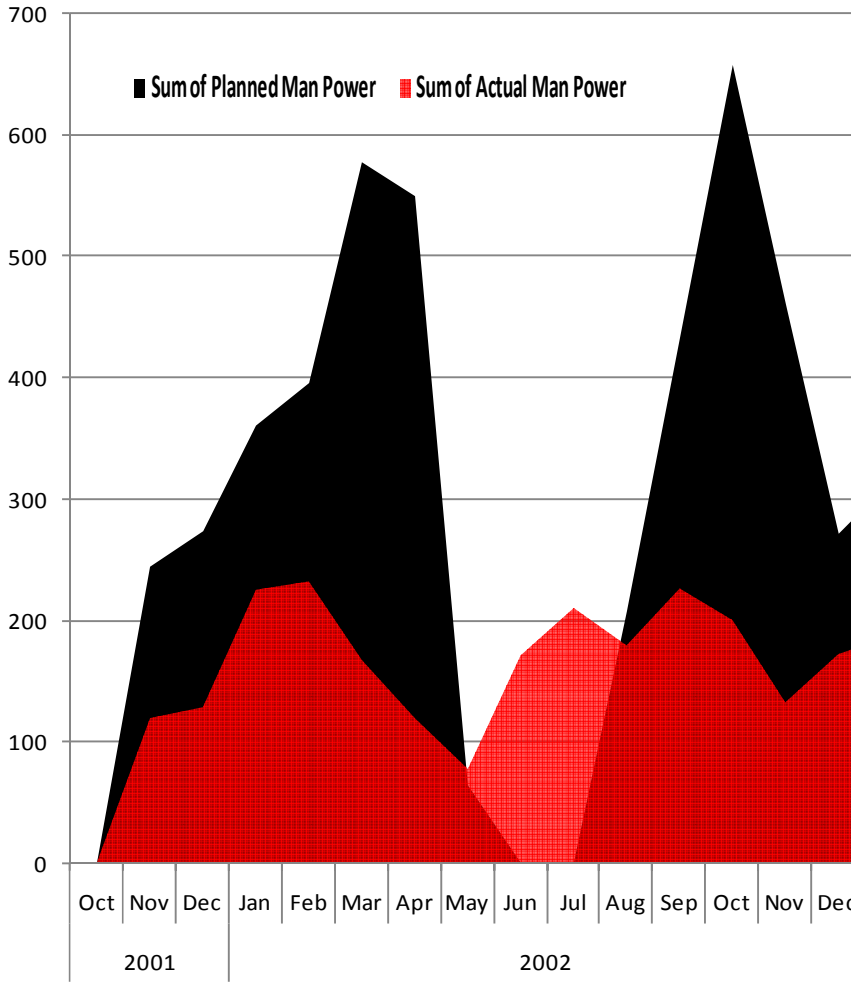
- **In identifying underperforming trades, the scheduler must investigate further to determine why this particular trade was underperforming:**
  - **Did it provide sufficient resources?**
  - **Did the observed resources match planned resources?**
  - **Were Man-Days or Crew-Days spent inefficiently?**
- **However, the comparison of each trade's PV to it's EV will focus the scheduler's attention on that trade, and will prevent the scheduler from creating a mitigation strategy that relies upon subcontractors that have demonstrated an inability to meet their commitments in the baseline schedule.**

EVMS in Schedule Compression

Run resource profile comparisons To show failure to meet planned levels of manpower

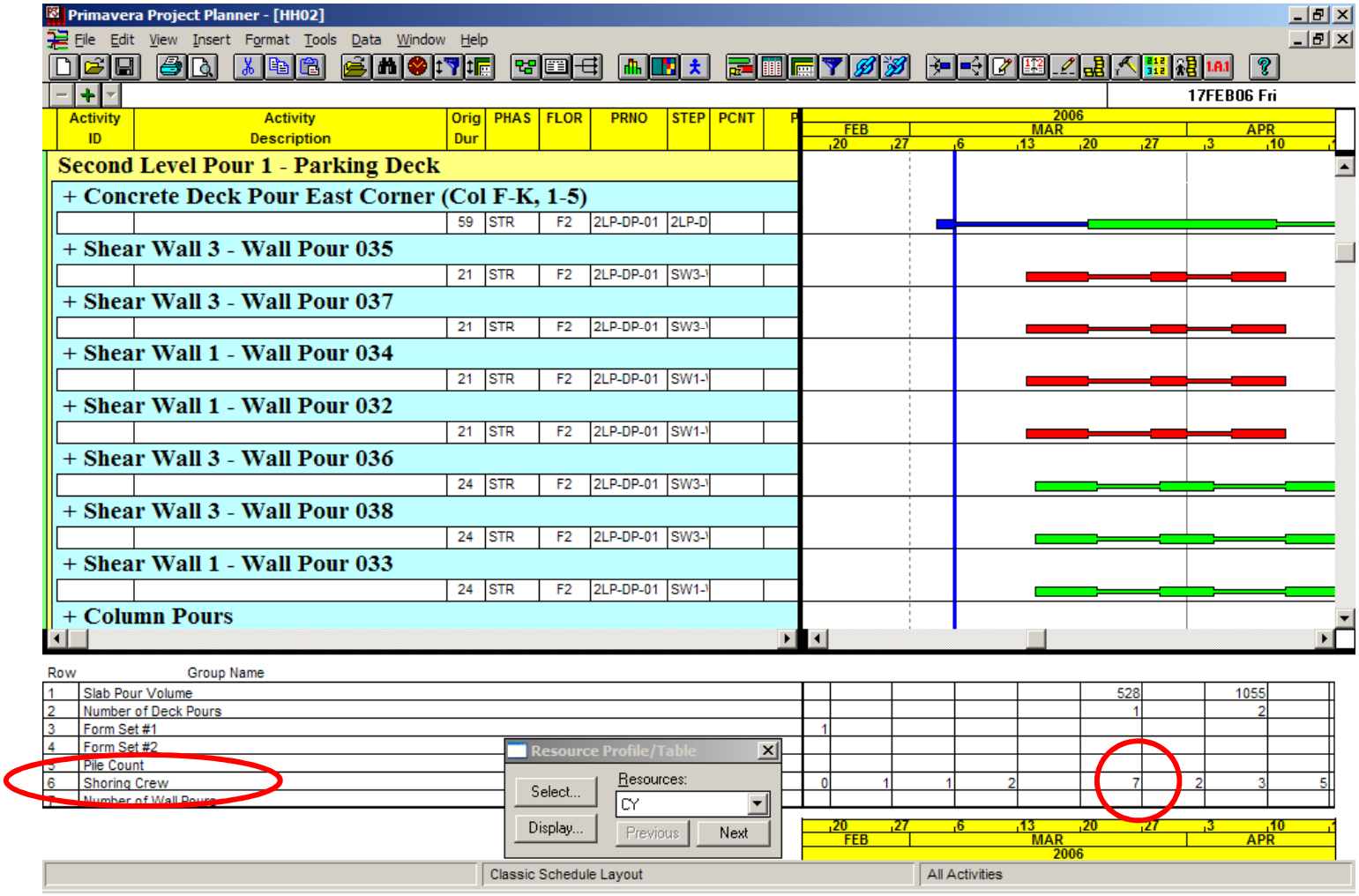
This frames the discussion for any trade contractors that have not met plan, but need to ramp up for schedule mitigation

This also allows the discussion of whether the under-manning can be overcome with the trade contractor for the purposes of mitigation or if another contractor is needed



Resource Analysis

Review individual trade or responsibility – check for predicted overload in the trade work – by crew, by location



EVM in Schedule Compression

- **As the mitigation strategy is implemented within the CPM schedule, the schedule analyst must run resource curves to determine if more resources are needed.**
- **When analyzing the new resource curves, the analyst should ask the following questions for each trade:**
  - **Does the new resource level exceed that which was previously agreed upon with the subcontractor?**
  - **Can the subcontractor provide the new level of resources, and who will bear the burden of the cost of the increased resources?**
  - **If not, can the prime contractor hire additional subcontractors for this trade in order to achieve the increased level of production necessary to compress the schedule?**

EVM in Schedule Compression

- **In order to analyze resources, run a Resource Table.**
  - **Load activities with Crews if the schedule is not resource loaded, and then create a resource table.**
  - **Such a table will visually demonstrate where there may be conflicts with the numbers of crews for each trade. This is a source for slippage which should be discussed with the contractors.**

Planned Resources							
Date	Crew 1 Cut/Fill	Crew 2 Grade	Stone	Pave	Surface Pave	Striping	Total Crews Scheduled
1-Mar	3	5	3	3			14
2-Mar	2	2	3	2			9
3-Mar	3	3	3	3			12
4-Mar	3	2	3	1			9
5-Mar	3	2	3	2			10
6-Mar	3	2	2	3			10
7-Mar	3	2	2	3			10
22-Jun					1	2	3
23-Jun					2	2	4
24-Jun					2	2	4
25-Jun					2	3	5
26-Jun					2	2	4
27-Jun					1	2	3
28-Jun						2	2
29-Jun						2	2

EVMS in Schedule Compression

- **Excellent paper – Al Kuhn, PSP**
  - **use when no resource loading in schedule**
  - **Allows crew loading & analysis**

2007 AACE International Transactions

PS.17

Artificial Resource Loading for Schedule Review

Albert Joseph Kuhn PSP

Many times I have been asked to review a schedule which has no resource loading. This is usually because of contract specifications which have omitted this requirement. In some instances the requirement for a cost loaded schedule has been included. It may be that the specification writer assumed that a

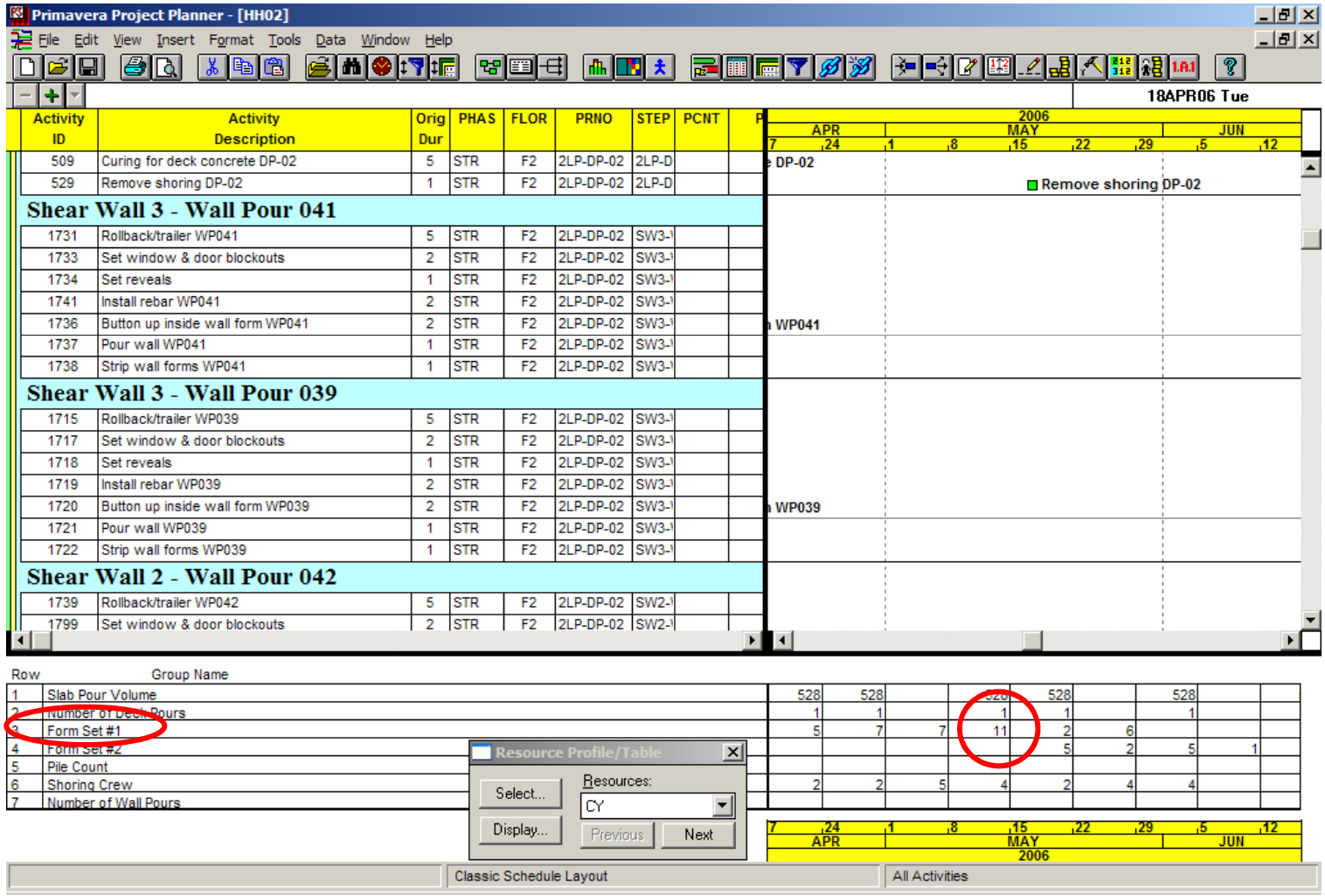
Additional codes can be added at any time directly into the "column" view.

The next step is to add a resource code for each craft into the resource table.

It is strongly recommended that the unit be "crew". This eliminates much time wasted defining the exact number of

Resource Analysis with EV

Set up Crew Resources – Use them to check maximum available limits



Conclusion

Conclusion

- **Trends shown in the EVM metrics can be applied in selecting areas for compression, highlighting the need for additional resources, and checking the realism of a newly developed compressed schedule, prior to implementation.**
- **The scheduler will have the ability to provide accurate and useful recommendations to the project management staff in support of mitigation and recovery efforts.**
- **The use of a good, trade specific Earned Value Management System will provide useful data for use in mitigation efforts as long as there is a mitigation strategy in place and a monitoring system that will provide good, reliable metrics on a periodic basis.**
- **Those metrics must be maintained, analyzed, and used in the mitigation plan to guide the trade contractors as necessary to fulfill the needs for recovery.**

Conclusion

- **This process will also provide early warning of problem trade contractors in advance of the need to mitigate, and when the need arises, the process will lay out guidelines for mitigation, as well as provide the appropriate documentation to encourage and legally support the need for specific trade contractor mitigation.**
- **With proper use of this system, it is also possible to minimize loss of productivity claims by periodic monitoring of the slippage in work, assessing responsibility, and predicting the remaining required production rates, as well as resource requirements, that are necessary to complete on time.**

Mitigation and Performance Recovery Using Earned Value

Questions?

Chris Carson, PSP, PMP, CCM

Corporate Director of Project Controls

ALPHA CONSTRUCTION & ENGINEERING CORPORATION

Chris.Carson@alphacorporation.com

(O) 757-533-9368 (M) 757-342-5524

Patrick M. Kelly, PSP

Project Controls Manager

ALPHA CONSTRUCTION & ENGINEERING CORPORATION

Patrick.Kelly@alphacorporation.com

(O) 757-533-9368 (M) 757-217-6820