### "Earned Schedule" The Concept, Initial Evaluation and Potential Benefits

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## Purpose

- To describe
  - The concept and formulation of Earned Schedule and the Earned Schedule Indicators
  - Describe the findings of an evaluation of the retrospective application of Earned Schedule
- Outline the potential application and benefits of Earned Schedule to
  - EVM practitioners
  - Other Performance Management stakeholders

### Overview

- The Earned Schedule Concept and Theory Walt
  - EVM Basics
  - The Problem
- The Earned Schedule Solution Walt
  - The Earned Schedule (ES) metric
  - Schedule Variance (time): SV(t)
  - Schedule Performance Index (time): SPI(t)
- Retrospective Evaluation Kym
  - Early Finish projects
  - Late Finish projects
- Application and Potential Benefits Kym
- Summary & Observations Kym

#### **Background to Earned Schedule Concept Development**

- Software Division at the Oklahoma City Air Logistics Center
  - SEI SW-CMM Level 4 achieved Nov 1996
  - Level 4 evolved ⇔ Statistical Process Control (SPC)
  - SPC ⇔ Defect Prevention (SEI SW-CMM Level 5)
  - SPC applied to EVM indicators
  - Several statistical applications created
  - SV and SPI flaw is intolerable for reliable statistics
  - Solution needed to "save" the statistical applications

#### **Earned Value Basics**



Time

5

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### **Earned Value Cost and Schedule Variances**



Note: Project completion was scheduled for Jan 02, but completed Apr 02.

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#### **Earned Value Cost and Schedule Performance Indices**



Note: Project completion was scheduled for Jan 02, but completed Apr 02.

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#### **Earned Schedule: The Concept**



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### **Earned Schedule: The Formulae**

• EScum is the:

Number of completed BCWS time increments BCWP exceeds + the fraction of the incomplete BCWS increment

EScum = C + I where:

C = number of time increments for  $BCWP \ge BCWS$ 

 $I = (BCWP - BCWSc) / (BCWSc_{+1} - BCWSc)$ 

• ESperiod(n) = EScum(n) - EScum(n-1)

## **Earned Schedule: The Schedule Indicators**

#### The Earned Schedule Indicators

• Schedule Variance (time):

SV(t) = ES - AT, where AT = actual time

• Schedule Performance Index (time):

SPI(t) = ES / AT

- Key Points:
  - ES Indicators constructed to behave in an analogous manner to the EVM Cost Indicators, CV and CPI
  - SV(t) and SPI(t) not constrained by BCWS calculation reference
  - SV(t) and SPI(t) provide <u>duration</u> based measures of schedule performance

#### **Schedule Variance Comparison**



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### **Schedule Performance Index Comparison**



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## **ES vs EVM Schedule Indicators**

Earned Schedule	Earned Value
SV(t) and SPI(t) valid for entire project, including early and late finish	SV(\$) and SPI(\$) validity limited to early finish projects
Duration based predictive capability analogous to EVMs cost based indicators	Limited prediction capability No predictive capability after planned completion date exceeded
Facilitates Cost – Schedule Management (using EVM and ES)	EVM Management focused to Cost

# **Retrospective Application Study Method**

- 1. Calculate the time phased ES measures and metrics
- 2. Incorporate SV(t)
  - a) Into a standard EVM CV and SV(\$) graphical report on a secondary y axis
  - b) Compare the behaviour of SV(t) with SV(\$)
- 3. Incorporate SPI(t)
  - a) Into a standard EVM CPI and SPI(\$) graphical report
  - b) Compare the behaviour of SPI(t) with SPI(\$)
- 4. Analyse the results obtained
- 5. Consider additional applications for ES

## Late Finish Project: SV(\$) and SV(t)



# **Late Finish Project Analysis**

- No EVM data prior to week 11
- SV(\$) and SV(t) show strong correlation until week 19
- Week 20 (The week of the project's scheduled completion)
  - Client delay halted project progress until resolution in Week 26
- SV(\$) static at -\$17,500 in spite of schedule delay

#### Before trending to \$0 at project completion

- SV(t) correctly calculates and displays
  - Week on week schedule delay
  - Project -14 week schedule delay at completion

### Conclusion

 SV(t) provides greater management utility than SV(\$) for portraying and analysing schedule performance

# Late Finish Project: SPI(\$) and SPI(t)

#### SV(\$) and SV(t) conclusions consistent for SPI(\$) and SPI(t)



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## **Early Finish Project: SV(\$) and SV(t)**



## **Early Finish Project Analysis**

- This project completed 3 weeks ahead of schedule
  - In spite of externally imposed delay between weeks 16 and 19
- SV(\$) and SV(t) show strong correlation over life of project
  - Including the delay period
  - SV(t)'s advantage is calculating delay as a measure of <u>duration</u>

#### With Early Finish projects

 ES metrics SV(t) and SPI(t) have behaved consistently with their historic EVM counterparts

### Conclusion

 SV(t) provides greater management utility than SV(\$) for portraying and analysing schedule performance

# **Early Finish Project: SPI(\$) and SPI(t)**

#### SV(\$) and SV(t) conclusions consistent for SPI(\$) and SPI(t)



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## **Analysis Summary**

 The analysis and conclusions described are consistent for the projects summarised in the following table

	Project	Category	Budget at	Cost at	Planned	Actual
			Complete	Complete	Duration	Duration
			\$ Australian		Weeks	
1	Commercial IT Infrastructure	Late Finish	\$158,899	\$307,738	20	34
	Expansion Project Phase 1					
	[Table Note 1]					
2	Commercial IT Infrastructure	Early Finish	\$112,000	\$53,745	25	22
	Expansion Project Phases 2 & 3					
	[Table Note 2]					
3	Commercial IT Infrastructure	Early Finish	\$270,899	\$361,483	49	46
	Expansion Project Phases 1, 2 & 3 total					
	(overall project) [Table Note 3]					
4	Commercial IT Software Development	Early Finish	\$145,085	\$143,575	19	13
	Project					
5	Commercial IT Infrastructure	Late Finish	\$2,426,094	\$3,870,048	65	83
	Replacement Project (Re-baselined)		(\$3,819,570)		(81)	
	[Table Note 4]					
6	Commercial IT Software Interface	Late Finish	\$219,200	\$409,470	9	23
	Development sub-project (part of #5)					

#### **Other Benefits of Earned Schedule: Independent Estimates of Duration (IED) and Completion Date (IECD)**

Calculation of Independent Estimate of Duration (IED)

IED = Planned Duration / SPI(t)

Independent Estimate of Completion Date (IECD)

IECD = Project Start Date + IED

- Behaviour of IED and IECD is analogous to the EVM cost equivalent, the Independent Estimate at Compete (IEAC)
- Potential Benefits
  - Sanity checking "real schedule" measures
  - Detection of schedule performance trends over time

#### **Other Benefits of Earned Schedule:** Independent Estimates of Duration (IED)



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#### **Other Benefits of Earned Schedule:** Independent Estimates of Completion Date (IECD)



#### **Another Potential Benefit of Earned Schedule:** Use of SPI(t) as an IEAC Performance Factor

Christensen, citing Fleming and Koppelman suggests that SPI[(\$)] "is useful for identifying schedule problems, especially when used with critical path information" and

"Because schedule problems are often resolved by additional spending, an adverse SPI[(\$)] is also predictive of later cost problems."

- SPI(t) may offer greater utility as a performance factor for IEAC calculations, particularly when compared to SPI(\$)
  Due to SPI(t) validity for both early and late finish projects
- More research is needed to confirm this

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Source: The Costs And Benefits Of The Earned Value Management Process; David S. Christensen, Ph.D. Acquisition Quarterly — Fall 1998 http://www.dau.mil/pubs/arq/98arq/chrisevm.pdf

#### **Another Potential Benefit of Earned Schedule:** Example Use of SPI(t) as an IEAC Performance Factor



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## **ES vs EVM Schedule Indicators Recap**

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## **Research to Date Demonstrates**

 SV(\$) and SPI(\$) have predictive utility for Early Finish projects but <u>lose</u> predictive utility for Late Finish projects

#### When predictive utility is needed most

- SV(t) and SPI(t) have predictive utility for both Early <u>and</u> Late Finish projects
- ES measures and metrics are expected to have
  - Utility similar to the EVM cost based counterparts
    - The recognized strength of EVM
  - Greater utility than historic EVM based schedule equivalents
- By extending EVM to include valid <u>duration</u> based measures of schedule performance
  - ES may be a "breakthrough" extension to Earned Value theory

### **Earned Schedule: The Way Forward**

Additional research is required

- More project data for retrospective analysis, especially for large scale projects
- Data from Earned Schedule "early adopters"
- Subject to additional confirmatory research findings:
  - Earned Schedule enhancements into EVM software packages
  - Inclusion of Earned Schedule into EVM practice standards
  - Acceptance of Earned Schedule as a valid extension of EVM

## References

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