

IPMC 2005 Fall Conference

Earned Schedule Status Update and Early Adopter Applications Feedback

Facilitators

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Earned Schedule [ES] Presentation Overview

- About Earned Schedule
- Principles of Earned Schedule
- Earned Schedule indicators, and predictors
- Update on progress against the Earned Schedule Action Plan (2004)
- Status update on the research being undertaken to test the validity of the Earned Schedule theory



Earned Schedule [ES] Presentation Overview

- Feedback on the experience and lessons learned from the application of the Earned Schedule by early adopters
 - SAF/AQX
 - Lockheed Martin
 - Boeing
 - Belgium
- Criteria for Acceptance & the Way Forward
- Wrap up and Final Q&A



About Earned Schedule

- Created in Summer 2002
- Published March 2003, *The Measurable News*
- Kym Henderson initial validation & first adopter
- Presentations made
 - IPMC, CPM (2003, 2004, 2005)
 - Australia, UK, Japan, Sweden, Belgium
- Several Papers available (references)
- *"Emerging Practice"* in new EVM Practice Standard
- PMI-CPM plans to create ES area on website

http://www.pmi-cpm.org/

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About Earned Schedule

- PMI-CPM 2005 Conference keynote address
 Blaise Durante, SAF Acquisition Executive
 - Air Force application to quarterly reviews
 - Incorporation into Department of Defense schools
 - EVM Tool Vendor incorporation promoted



About Earned Schedule

- Early Adopters
 - EVM Instructors
 - PMA, Management Technologies ...
 - Boeing Dreamliner®, Lockheed Martin, US State Department, Secretary of the Air Force
 - Several Countries
 - Australia, Belgium, Sweden, USA ...
 - Applications across weapons programs, construction, software development, ...
 - Range of project size from very small and short to extremely large and long duration



Earned Value Basics



\$



So, what's the problem?

- Traditional schedule EVM metrics are good at beginning of project
 - Show schedule performance trends
- But the metrics don't reflect real schedule performance at end
 - Eventually, all "budget" will be earned as the work is completed, no matter how late you finish
 - SPI improves and ends up at 1.00 at end of project
 - SV improves and ends up at \$0 variance at end of project
 - Traditional schedule metrics lose their predictive ability over the last third of project
 - Impacts schedule predictions, EAC predictions

Project managers don't understand schedule performance in terms of budget

Like most of us!



Earned Schedule Concept





Table of Earned Schedule Formulae

Metrics	Earned Schedule	ES _{cum}	ES = C + I number of complete periods (C) plus an incomplete portion (I)				
	Actual Time	AT _{cum}	AT = number of periods executed				
	Schedule Variance	SV(t)	SV(t) = ES - AT				
Indicators	Schedule Performance Index	SPI(t)	SPI(t) = ES / AT				
	To Complete Schedule	TSPI(t)	TSPI(t) = (PD - ES) / (PD - AT)				
	Performance Index		TSPI(t) = (PD – ES) / (ED – AT)				
Predictors	Independent Estimate	IEAC(t)	IEAC(t) = PD / SPI(t)				
	at Completion (time)		IEAC(t) = AT + (PD - ES) / PF				
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Earned Schedule Terminology Parallels EVM

	EVM	Earned Schedule
	Earned Value (EV)	Earned Schedule (ES)
Status	Actual Costs (AC)	Actual Time (AT)
	SV	SV(t)
	SPI	SPI(t)
Future	Budgeted Cost for Work Remaining (BCWR)	Planned Duration for Work Remaining (PDWR)
Work	Estimate to Complete (ETC)	Estimate to Complete (time) ETC(t)
	Variance at Completion (VAC)	Variance at Completion (time) VAC(t)
Prediction	Estimate at Completion (EAC) (supplier)	Estimate at Completion (time) EAC(t) (supplier)
	Independent EAC (IEAC) (customer)	Independent EAC (time) IEAC(t) (customer)
	To Complete Performance Index (TCPI)	To Complete Schedule Performance Index (TSPI)



Earned Schedule: 2004 Action Plan Update

- 1) Gain agreement to terminology
- 2) Early adopters continue to adopt, use, and report
 - As reported at this [2005] Conference
- 3) Additional research to confirm "empiric validation"
 - Research using data from US DoD DAES database cancelled (<u>data</u> issues)
 - Research using simulated datasets by University of Ghent, Belgium as a "next step"
 - Work to obtain alterative real project data sets for empiric validation is in progress

4) Earned Schedule accepted as a valid extension to EVM

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ES: 2004 Action Plan Update continued

- Research and paper covering the "bridging" of Earned Schedule to traditional scheduling concepts and analytical techniques
 - Earned Schedule In Action (Henderson)
 - Connecting Earned Value to the Schedule (Lipke)
 - More papers in progress
 - Project Management Journal (Lipke, Anbari, Henderson)
 - University of Ghent, Belgium (VanHoucke, Vandevoorde)
 - Interpolation "Error" and Re-Baselining considerations
 - Other presentations appearing on Internet searches
- 6) Incorporate ES into commercial EVM products
 - Tools vendor interest but no known adoption into an EVM product (yet) Rights Reserved
 Structure
 Construction
 Construction<



ES: 2004 Action Plan Update continued

- 7) Incorporate Earned Schedule updates into:
 - a) PMI-CPM EVM Practice Standard
 - Aiming for full inclusion of Earned Schedule as a valid and accepted extension of EVM in the next EVM Practice Standard update
 - b) Japanese EVM Handbook
 - c) National Earned Value Standards
 - i. ANSI/EAI 748 (USA),
 - ii. AS 4817 (Australia)
 - iii. Others
 - d) Regulatory requirements for EVM
 - i. OMB A-11 Part 7 (USA)

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ii. ....
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Discussion of Current Research

- Directed by: Eleanor Haupt, PMI-CPM President
- Researcher: 1Lt Scott Smith, AFIT Massing Student
- Thesis Advisor: Major Curtis Tenne
- Research Advisor: Dr. David Constantsen
- Purpose: To validate Spatial since the from the Defense Acquisition Executive Commany database
- Methodology. A section of statistical hypothesis testing as used for IE (2/CPI analysis by Drs Christen of and Templin
- Antice a reliable
 Antice a reliable
 Antice a reliable
 Control of schedule performance



Research Results

Results: The historical data collection procedures for the DOD and USAF do not allow for sufficient testing of ES theory at this time. A statistical evaluation concluded that SPI(t) is different than SPI(\$); however, the two variables highly correlated. The result of the are analysis identified that SPI(t) performs similarly to SPI(\$) with the data contained in the DAES database. In order for the ES Theory to be fully investigated, additional data must be collected. This research shows that the necessary data may also not be available despite the best collection efforts. The original schedule and planned duration information is critical to successful evaluation of the ES methodology. (emphasis added)



Potential Future Research Topics

- Validate use of SPI(t) in IEAC formulas
 - Weighted performance factor: wt1 * CPI + wt2 * SPI(t)
 - Composite performance factor: CPI * SPI(t)
- "Burn rate" analysis
 - Average burn rate * IEAC(t) = IEAC

(actual cost per month * estimate of duration = estimate of final cost)

- May improve EAC projections
- Compare predicted IEAC(t) durations against predicted critical path durations



Feedback from Early Adopters

- Feedback on the experience and lessons learned from the application of the Earned Schedule by early adopters
 - SAF/AQX
 - Lockheed Martin
 - Boeing
 - Belgium

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Integrity - Service - Excellence

17th Annual Integrated Program Management Conference



Mr. Edward Witte

EVM POC SAF/AQXR Anteon

September 6, 2005

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Purpose

Provide an overview of the path SAF/AQX is taking to integrate the use of Earned Schedule (ES)





The ES Path









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Practice Symposia Discussion Summarizing Earned Schedule Data

Earned Schedule Executive View

Work Start Date:	August 31, Year 1
Last Baseline:	September 15, Year 2
Next Critical Milestone :	Operational Capability
Critical Milestone Date:	Month Day, Year
Current Schedule Variance [SV(t)]:	2.5 Months
Performance Index [SPI(t)]:	0.93
Estimated Variance at Complete:	8.4 Months
PM Estimated Completion (Current):	September 30, Year 9
Estimated Completion Date [IEAC (t)]:	June 10, Year 10



Practice Symposia Discussion Example SV(t) Chart

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Overlaying the Summary ES Data with Earned Value Variance Data

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Lockheed Martin

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Earned Schedule – Observations

- Background / Experience
 - Responsible for Earned Value Management (EVM) surveillance at Lockheed Martin, Marietta, GA
 - LM Policy requires Earned Value Surveillance to include
 - Evaluation of the use and proper application of EVM methods and procedures
 - Business and Program Risk
 - EVM performance
 - Aware of Earned Schedule at IPM conference 17 Nov 2003
 - Use Earned Schedule for informal analysis of current programs on going at Marietta, GA facility
 - Presented Earned Schedule concept to Program
 Management Institute (PMI) South East Region Symposium

Schedule Metrics

- ΣCPI has been validated as an accurate forecasting tool for estimating future performance in studies by the DoD and Industry Experts.
- ΣSPI however has diminished predictive capability near the end of a project.
- Observations of EVM Surveillance
 - Once a program has achieved approximately 80% complete (BCWP/BAC), ΣSPI is no longer a useful metric for evaluating performance as the ratio slowly returns to one.
- A better tool was needed for evaluating the later stages of program performance.
 - Earned Schedule does not return to one and remains a valid indicator of performance to the end of a program.

Example – ΣSPI(\$)

\$(000)		Monthly	Σ BCWS	Σ BCWP	SPI(\$)
. ,	Period	BCWS			
	43	\$2,085	\$257,345	\$231,611	.90
	44	\$ 627	\$257,971	\$231,611	.90
	45	\$ 219	\$258,190	\$231,611	.90
	46	\$ 19	\$258,208	\$231,611	.90
	47	\$ 33	\$258,241	\$231,611	.90
	48	\$64	\$258,305	\$231,611	.90

Once 80% complete, monthly gains only have marginal effect on ΣSPI(\$). Smoothing effect is increased by lower monthly budgets typically established in the final phase program

If the project had BCWP
of \$231,611 in month 43
then
SPI(\$) = 0.90
(\$231,611 / \$257,345)

If *NOTHING* was done for the next 6 months SPI(\$) would still equal 0.90 (rounded) (\$231,611 / \$258,305)

Earned Schedule as EVM Analytical Tool

- Earned Schedule (As Advertised 🙂)
 - SPI(t) Does not revert back to one like SPI(\$)
 - Independent Time Estimate At Complete (ITEAC) based on SPI(t) may used to estimate time to complete
- Missouri Method Show Me
- Earned Schedule applied to two unique programs
 - Evaluate SPI(t) vs SPI(t)
 - Evaluate IEAC(t) vs Completion dates

ES in the "Real World" Example 1

- The Project
 - Reporting 99.4% complete as of March 05
- ~ \$260 million dollar contract
 - 48 month duration
 - Planned End Date Dec 2004
 - Latest Estimated Completion Jun 05 (6 month Slip)
- Earned Schedule Calculations
 - Data points for the last 30 months
 - SPI(\$) and SPI(t)
 - IEAC(t) (Planned Duration \div SPI_t)

ES SPI(\$) vs. SPI(t) Tracking



ES for Schedule Completion

Independent Estimate At Complete (Time) – IEAC(t)



ES in the "Real World" Example 2

• The Project

- Reporting 100% complete as of March 05
- ~ \$4.60 million dollar contract
 - 39 month duration
 - Planned End Date Dec 2004
 - Completion Mar 05 (3 month Slip)
- Earned Schedule Calculations
 - SPI(\$) and SPI(t)
 - $-IEAC(t) = (Planned Duration \div SPI(t))$

ES SPI_c vs. SPI_t Tracking





Observations – ES, IEAC(t)

- ES is based on incremental gains against BCWS
 - Observing "true" gains will lead to more volatility of data points similar to monthly CPI.
 - May require several months data to establish actual trend
 - Trend lines may be used to smooth data
- IEAC(t)
 - Revealed degraded schedule performance at end of program
 - Provided early warning signal the program would not complete on time
 - Trend line may be used to smooth data



ES requires a firm baseline / sound EVM practices – ES will not cure -

- PMF (Performance Measurement Flexline)
- EV "Gaming" Non Critical Completions; Front Loading
- Does not replace Critical Path Method (CPM) analysis, but complements CPM as reported in EVM
- New tool for evaluating completion "optimism" and predicting time to complete
- Bottom Line
 - A better way to analyze EVM schedule performance
 - Significant advancement in Earned Value theory & practice





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ES Experiences by Ing. Stephan Vandevoorde



Stephan Vandevoorde is currently senior project manager at Fabricom Airport Systems, a division of Fabricom-Gti. He has an industrial engineer diploma and is member of PMI, PMI Belgium, Project Management Belgium and PMI College of Performance Management.

He has been working on a number of large-scale international projects (Europe, Asia) across many industries including construction, retail, automotive industry, airport baggage handling systems.

Stephan has extensive experience in the use of EVM techniques to assist in evaluating and predicting project performance, including the newly developed "earned schedule" concept. On several occasions, he has given presentations on different project management topics for V.I.K., Vlerick Management School, Boston University Brussels. In collaboration with I.F.B.D., Stephan is docent for the courses "Earned Value Management" and "Project Management for the Construction Industry".



<u>AGENDA</u>

- 1 Analysis of Projects
 - 1.1 Real Life Project Details
 - **1.2 Performance Indicators**
 - **1.3 Duration Forecasting**
 - 1.4 Assessing Project Duration
- 2 Findings Summarised
- 3 Research efforts

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1.1 Real Life Project Details

Project Data Sets extracted from [1]

Industry Segment: Technology

design, engineer, supply, install & commissioning of airport bagage handling systems

	Project	Category	Budget at Completion	Cost at Completion	Planned Duration (Months)	Actual Duration (Months)
1	Revamp Check-In	Late Finish, Cost Underrun	360.738 €	349.379€	9	13
2	Link Lines	Late Finish, Cost Overrun	2.875.000€	3.247.000€	9	12
3	Transfer Platform	Early Finish, Cost Overrun	906.000€	932.000€	10	9

[1] Vandevoorde St., Vanhoucke M., <u>"A Comparison of different project duration forecasting</u> <u>methods using earned alue metrics</u>", Ghent University, working paper 2005/312, June 2005

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1.3 Forecasting Duration

	Project 1: late finish, cost underrun												
	Jun-02	Jul-02	Aug-02	Sep-02	Oct-02	Nov-02	Dec-02	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03
PD/SPI	10.17	10.80	9.26	9.96	9.88	10.13	9.96	10.15	10.38	9.91	9.59	9.28	9.00
PD/SPI*	10.17	10.80	9.26	9.96	9.88	10.13	9.96	10.15	10.38	11.01	11.72	12.37	13.00
PD/SPI(t)	10.17	10.33	9.83	9.69	9.46	9.64	10.71	11.61	12.48	12.53	12.90	13.06	13.00

(Predicted Durations Months)

	Project 2: late finish, cost overrun											
	Sep-03	Oct-03	Nov-03	Dec-03	Jan-04	Feb-04	Mar-04	Apr-04	May-04	Jun-04	Jul-04	Aug-04
PD/SPI	10.38	11.07	10.41	11.90	10.95	10.78	10.90	10.79	10.98	10.09	9.46	9.00
PD/SPI*	10.38	11.07	10.41	11.90	10.95	10.78	10.90	10.79	10.98	11.21	11.56	12.00
PD/SPI(t)	10.38	13.36	10.20	10.76	10.62	10.76	11.02	11.61	12.08	11.76	11.73	12.00

(Predicted Durations Months)

	Project 3: early finish, cost overrun									
	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03	Oct-03	Nov-03	Dec-03
PD/SPI	9.44	9.35	9.29	9.28	9.20	9.16	9.51	9.49	9.67	10.00
PD/SPI*	9.44	9.35	9.29	9.28	9.20	9.16	9.51	9.49	9.67	10.00
PD/SPI(t)	9.64	9.59	9.82	9.60	9.28	9.24	8.85	8.54	9.00	

(Predicted Durations Months)

* if AD > PD then AD = PD

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2 My Experience Summarised (1/2)

Schedule Performance Indicators (for early and late finish projects):

- SPI(t) & SV(t) do portray the real schedule performance
- in agreement with [2] [3]

Forecasting Duration (for early and late finish projects):

- at early & middle project stage: pre-ES & ES forecasts produce similar results
- at late project stage: ES forecasts outperform all pre-ES forecasts
- in agreement with [3] [4]

Assessing Project Duration (for early and late finish projects):

 the use of the SPI(t) in conjunction with the TCSPI(t) allows to manage project duration expectations (application as proposed in [4])

ES has been proven invaluable to assess and evaluate project duration

- in agreement with [5]

[2] Lipke Walt, <u>Schedule is Different</u>, The Measurable News, Summer 2003

[3] Henderson Kym, <u>Earned Schedule: A Breakthrough Extension to Earned Value Theory? A</u> Retrospective Analysis of Real Project Data, The Measurable News, Summer 2003

[4] Henderson, Kym, Further Development in Earned Schedule, The Measurable News, Spring 2004

[5] Henderson Kym, Earned Schedule in Action, The Measurable News, Spring 2005

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2 My Experience Summarised (2/2)

Modified table extracted from [6] [7] to show my experience.

ES vs EVM Schedule In	dicators and Predictors
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
Idem	For both early and late finish projects SV(\$) and SPI(\$) validity limited to early and middle project stage
Duration based predictive capability analogous to EVMs cost based indicators	Limited prediction capability. No predictive capability after planned completion date exceeded
For both early and late finish projects prediction capability at all project stages, analogous to EVM cost based indicators	For both early and late finish projects some prediction capability <u>only</u> at early and middle project stage
Facilitates Cost – Schedule Management (using EVM and ES)	EVM Management focused to Cost
Idem	Idem

[6] Lipke Walt, Henderson Kym, Eleanor Haupt, <u>Schedule Analysis and Predictive Techniques Using Earned Schedule</u>, 16th IPM Conference, Virginia 2003, slide 7
 [7] Lipke Walt, Henderson Kym, <u>Earned Schedule ... an extension to EVM theory</u>, EVA-10
 Conference, London 2005, slide 20

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3 Research Efforts (1/3)



Prof. Dr . Mario Vanhoucke

Faculty of Economics and Business Administration, Ghent University

JNIVERSITY Operations & Technology Management Centre, Vlerick Leuven Ghent Management School

www.projectmanagement.ugent.be

---> research ---> activities ---> Project control and earned value systems

State of the Art Report on Forecasting Duration Methods

- 1. Vandevoorde St., Vanhoucke M., <u>A Comparison of different project</u> <u>duration forecasting methods using earned value metrics</u>, Ghent University, working paper 2005/312, June 2005
- 2. paper under submission for publishing in international journal

Simulation & Evaluation of Different Forecasting Methods

- 1. initial results presented at "Early Warning Signals Congress", Crosstalks, V.U.B., Brussels, June 2005
- 2. Vanhoucke M., Vandevoorde St., <u>A simulation and evaluation of earned</u> value metrics to forecast the project duration, Ghent University, working paper 2005/317, July 2005
- paper under submission for publishing in international journal

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3 Research Efforts (2/3)

Extracted results from [8]: Forecast Accuracy and the Completion of Work

Simulation runs performed: 1 run project finish ahead of schedule, 1 run projects finish behind



Plans are made to present the research report "A simulation and evaluation of earned value metrics to forecast the project duration" at the 22nd PMI-CPM Spring Conference 2006.

[8] Vanhoucke Mario, Vandevoorde Stephan, <u>A simulation and evaluation of earned value metrics to</u> <u>forecast the project duration</u>, Working Paper 2005/317, July 2005, Ghent University

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3 Research Efforts (3/3)

- 1. Is PD / SPI(t) a lower bound for final project duration?
- 2. Effect of Rework Cycles on Forecasting
 - 1. EV metrics may be biased due to rework
 - 2. further develop concept of "effective" earned value [9]
- 3. Creation of a Decision Model, translate into a tutorial
- 4. ...
- 5. Your topics and questions are welcome!



[9] Lipke Walt, <u>Connecting Earned Value to the Schedule</u>, The Measurable News, Winter 2004

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Decision Criteria for the Acceptance of Earned Schedule [2004 IIPMC]

- Do the Earned Schedule metrics more accurately portray a projects "real schedule" performance compared to the historic EVM equivalents?
- 2) Does Earned Schedule offer improvements in schedule predictive capability compared to the already existing EVM based schedule predictive techniques?
- 3) Can the Earned Schedule metrics and predictive capabilities be empirically validated using a statistically valid and sample project data set which includes large scale projects and programs?

Earned Schedule should be held to the same level of credibility as EVM; no more and no less

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Review of Earned Schedule

- What is Known about ES to Date (2005 update)
 - Derived from EVM data ... only
 - Provides time-based schedule indicators
 - Indicators do not fail for late finish projects
 - Application is scalable up/down, just as is EVM
 - Schedule prediction is better than any other EVM method presently used
 - SPI(t) behaves similarly to CPI
 - IEAC(t) = PD / SPI(t) behaves similarly to IEAC = BAC / CPI
 - Behavior of SPI(t) compared to SPI(\$) for early and late finish projects corroborated from 3 independent sources
 - Facilitates bridging EVM to the schedule

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Conclusion

"Whatever can be done using EVM for Cost Analysis can also be done using Earned Schedule for Schedule Analysis"

- Earned Schedule
 - A powerful new dimension to Integrated Project Performance Management (IPPM)
 - A breakthrough in theory and application



*the first sche*duling systemson © Walt Lipke



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- Stratton, Ray. (2005) "Not Your Father's Earned Value" Projects@Work (http://www.projectsatwork.com) 24 Feb 2005. Republished PMI Sydney Australia Chapter website with permission
- 2. Henderson, Kym. (2005 Spring) "Earned Schedule in Action". The Measurable News, pp.23-30.
- 3. Henderson, Kym, Earned Schedule: A Breakthrough Extension to Earned Value Theory? A Retrospective Analysis of Real Project Data, The Measurable News, Summer 2003
- 4. Lipke, Walter, Schedule is Different, The Measurable News, March and Summer 2003
- 5. Henderson, Kym, *Further Development in Earned Schedule*, The Measurable News, Spring 2003

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- 1. Jacob, D.S., <u>Forecasting Project Schedule Completion With</u> <u>Earned Value Metrics ... Revisited</u>, Measurable News, College of Performance Management, Summer 2004
- 2. Jacob, D.S., <u>Forecasting Project Schedule Completion With</u> <u>Earned Value Metrics</u>, Measurable News, College of Performance Management, March 2003
- 3. <u>EVM: Earned Value Management Handbook</u>, Japanese Society for Project Management, 2003



Presentations

- 1. <u>Earned Schedule An Emerging Practice</u>, 16th IIPM Conference, November 2004 [Walt Lipke, Kym Henderson]
- Schedule Analysis and Predictive Techniques Using Earned Schedule, 16th IIPM Conference, November 2004 [Walt Lipke, Kym Henderson, Eleanor Haupt]
- 3. <u>Earned Schedule an Extension to EVM Theory</u>, EVA-10 Conference (London), May 2005 [Walt Lipke, Kym Henderson]
- Forecasting Project Schedule Completion by Using Earned Value Metrics, EVM Training at Ghent University (Belgium), January 2005 [Stephan Vandevoorde]

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Presentations

- 5. <u>New Concept in Earned Value Earned Schedule</u>, PMI Southeast Regional Conference, June 2005 [Robert Handshuh]
- 6. <u>Forecasting Project Schedule Completion by Using Earned</u> <u>Value Metrics</u>, Early Warning Signals Congress (Belgium), June 2005 [Stephan Vandevoorde, Dr. Mario Vanhoucke]

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