MANAGEMENT TECHNOLOGIES

Planning Every Step.....Every Step As Planned

Predicting Project Completion Date Using Earned Value Management

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PMI R.E.P. Project Management Institute

Presentation Outline

- Refresher on EVM concepts
- The Problem with SPI
- The Earned Schedule Concept
- Comprehensive Example
- Research Results
- Earned Schedule Maturity
- Conclusions
- References and Contact Information

What Could be New About EVM?

- In the 1900's.....
  - EVM used in DoD, NASA, DoE, DoT, elsewhere
  - Provided Cost and Schedule Variances (CV, SV)
  - Computed Cost and Schedule Performance Indices (CPI, $SPI_{\$}$)
  - Produced "Estimated *Cost* at Complete" (EAC)
- 21st Century Improvements to EVM
  - Provides SV in *time* units
  - Computes SPI_t based on *time* units
  - Produces "Estimated *Date* of Completion"

- **Refresher on EVM concepts**
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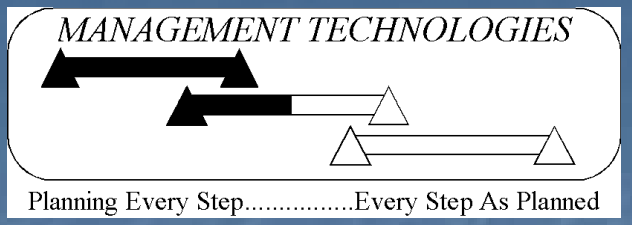


Refresher on Earned Value Concepts

How earned value management is different from cost reports and schedule updates.

Basic EVM Concepts

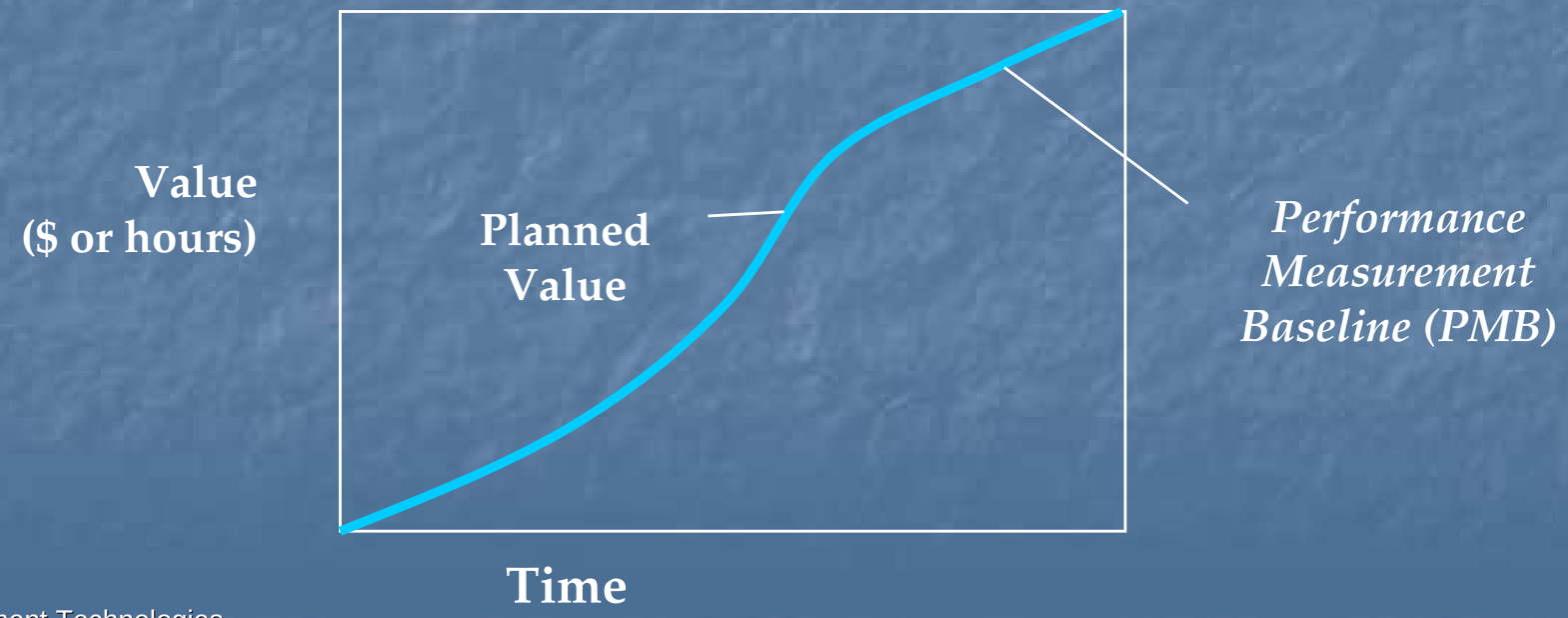
- Relate the money spent to the work done
  - Combines schedule status with cost information
  - Requires common "units" of measure
- Fundamental concepts
  - The work has value equal to its budget
  - The project "equity" is the sum of *the value of* all work done to-date
  - Building the equity (Earned Value) should equal the budget planned for the work done (*spend appropriately)*
  - The equity should accumulate at the rate planned *(stay on schedule)*

The Three Key Elements of EVM

- Only three terms (two we already have)
- Planned Value (PV)
- Actual Cost (AC)
- *Earned Value (EV)*

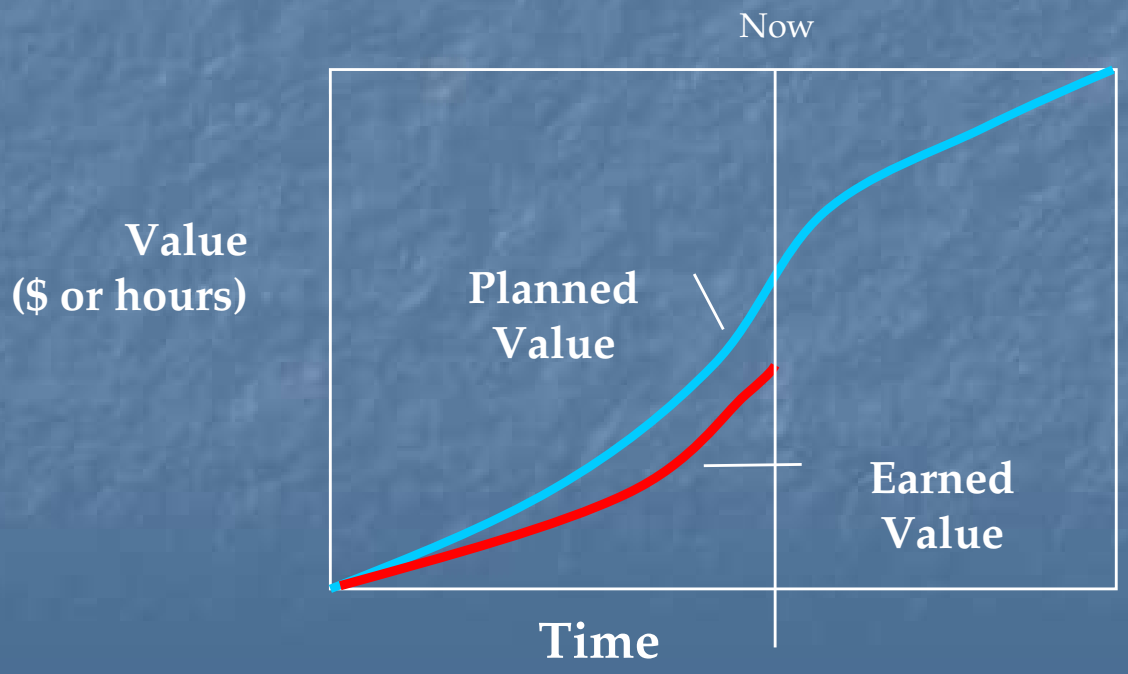
The Planned Value (PV)

- The schedule (plan) to build project equity from zero to the total project value
- The expected gain in project equity as each piece of work is completed
- Previously "budgeted cost of work scheduled" (BCWS)



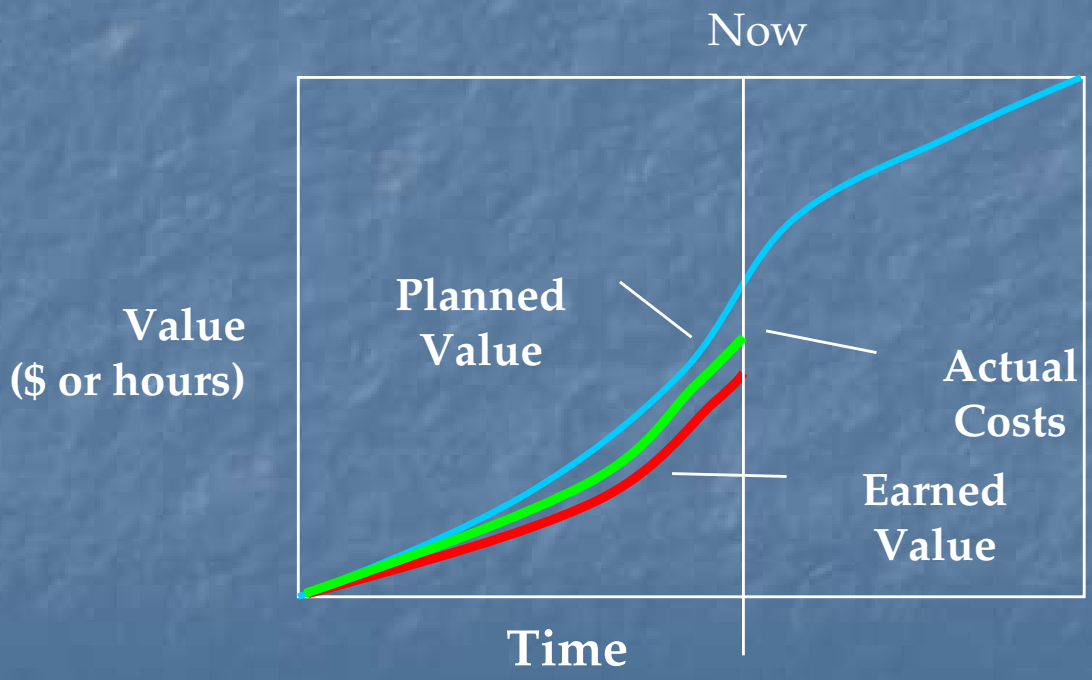
The Earned Value (EV)

- The project equity gained, *regardless of the cost to accomplish the work*.
- The gain in project equity as a result of completed work
- Previously "budgeted cost of work performed" (BCWP)

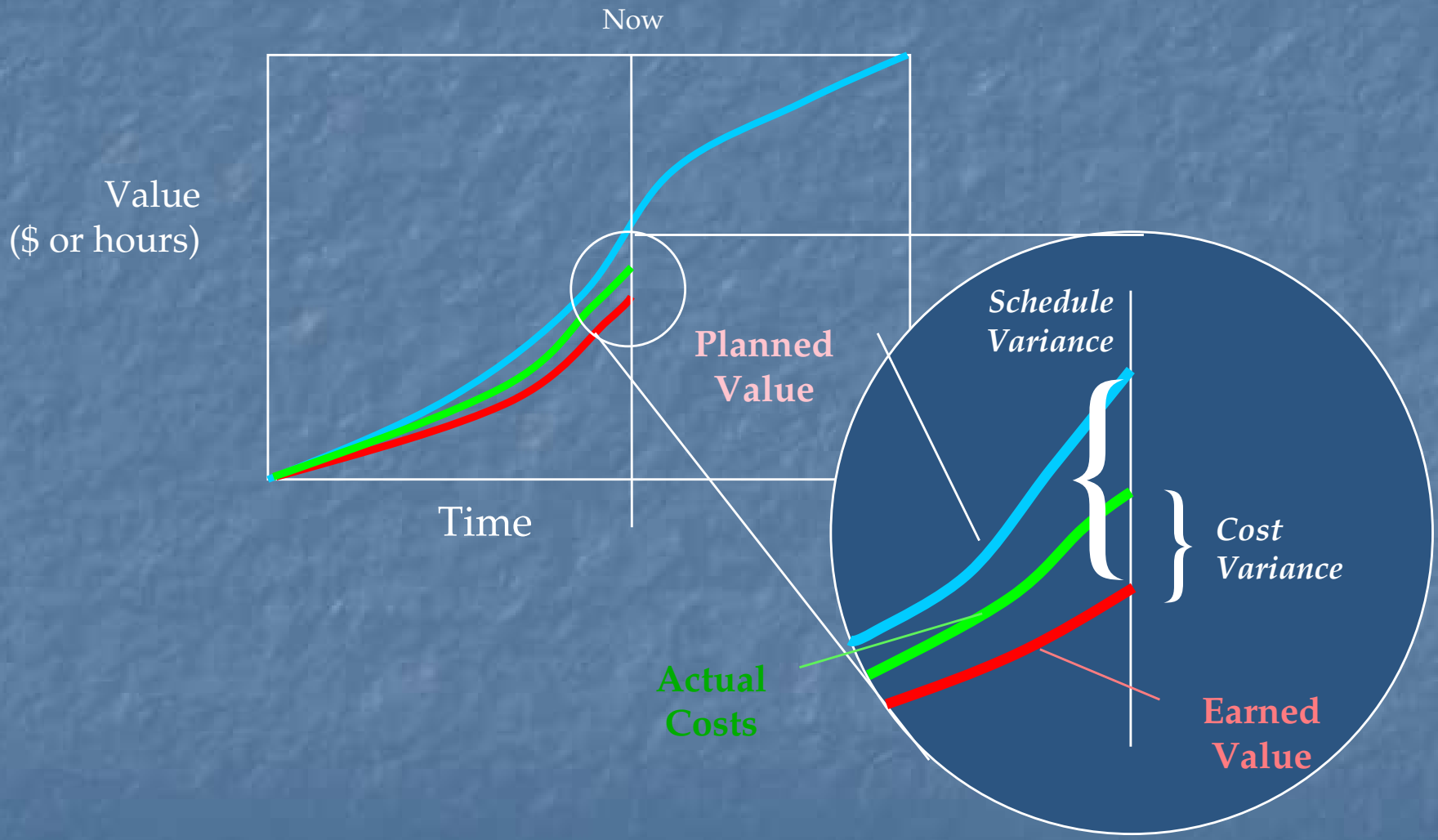


The Actual Cost (AC)

- The total cost of the completed work
- Previously "actual cost of work performed" (ACWP)



Analyzing Variances From the Plan



Cost Performance Index (CPI)

- "Did the cost of adding "equity" equal the "equity" added?"
- CPI = progress/cost
- CPI = EV/AC
- Greater than 1.0 is good, less than 1.0 is bad
- Example

$$CPI = \frac{EV}{AC} = \frac{WORK\_DONE}{COST\_OF\_WORK\_DONE} = \frac{1000hrs}{1500hrs} = 0.66$$

(this is not good)

Schedule Performance Index (SPI$)

- "Did a month's of schedule produce a month of progress?"
- SPI$ = progress/plan
- SPI$ = EV/PV
- Greater than 1.0 is good, less than 1.0 is bad
- Example

$$SPI_{\$} = \frac{EV}{PV} = \frac{WORK\_DONE}{WORK\_PLANNED} = \frac{1200\,hrs}{1000\,hrs} = 1.2$$

(this is good)

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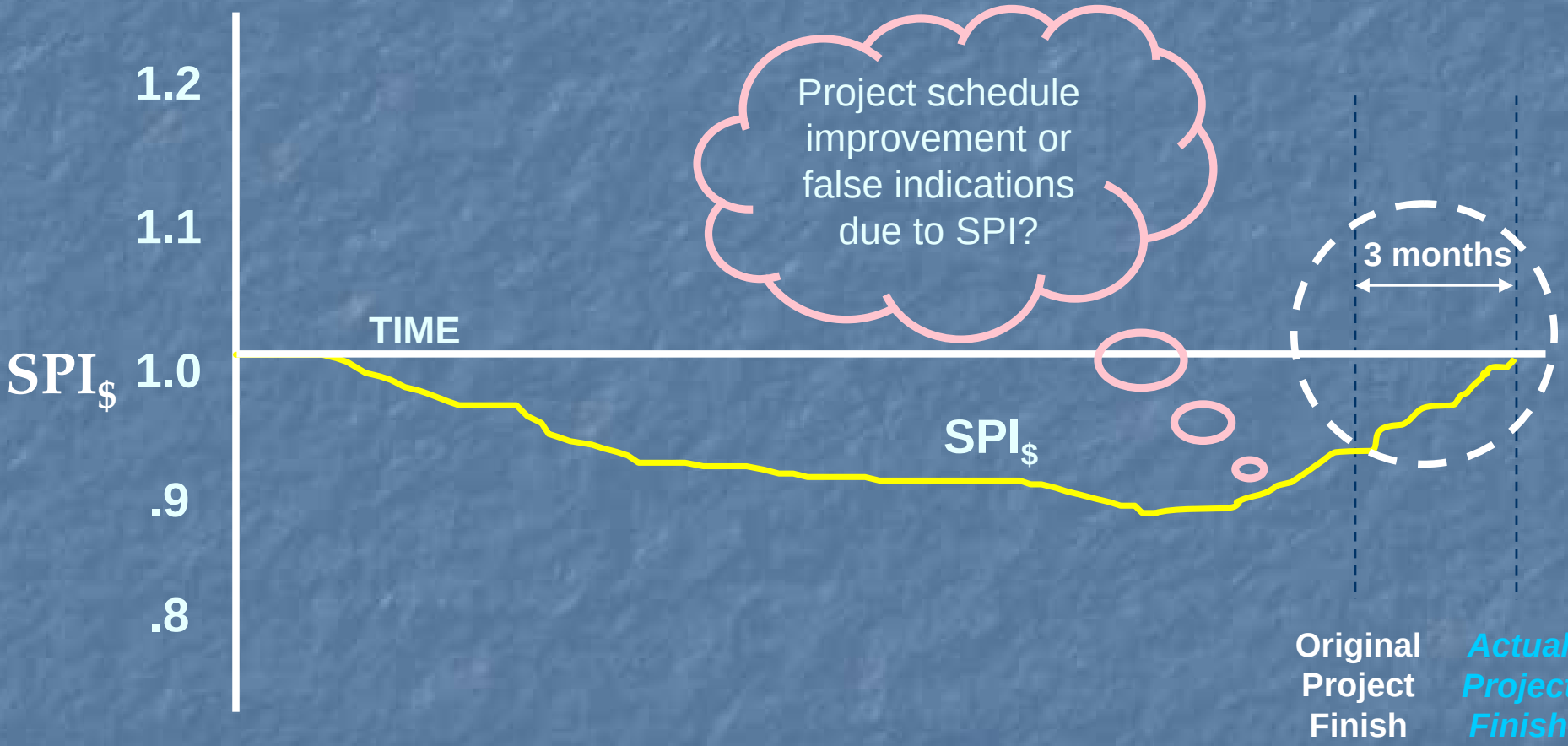
The Problem with SPI

We've been using SPI for 30+ Years,
What could be wrong with it?

Two Serious Problems with $SPI_{\$}$

- $SPI_{\$}$ fails in the end
  - $SPI_{\$}$ = EV/PV
  - At project completion EV = PV
  - $SPI_{\$}$ = EV/PV = PV/PV = 1.0 at project end
  - Implications:
    - At project start SPI is reliable
    - At some point SPI accuracy diminishes
    - Toward the project end it is *useless*
- $SPI_{\$}$ does not show weeks or months of schedule variance
  - What most people want to know and understand

Graphing the Problem with $SPI_{\$}$



Using CPI and $SPI_{\$}$ in Estimating the Final Cost

- Simple extrapolation
- Final cost = cost of work done + (work left/past performance)
- Assumes future performance is same as past (generally true)
- EAC (CPI) = AC+(BAC-EV)/CPI = BAC/CPI
- EAC (CPI, $SPI_{\$}$) = AC+(BAC-EV)/(CPI*$SPI_{\$}$)

Toward the end of the project how accurate can this term be?

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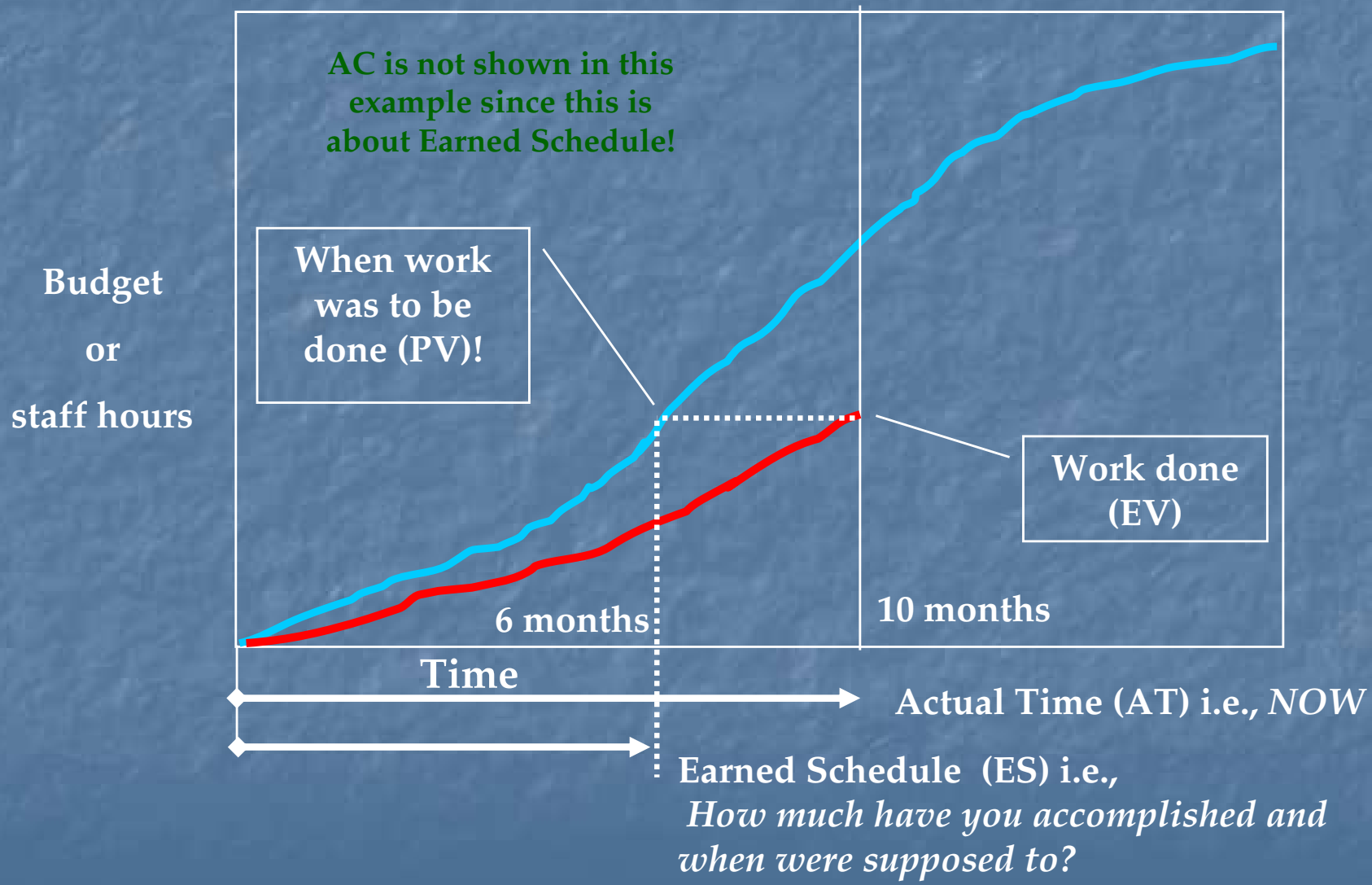
The Earned Schedule Concept

Creating a Schedule Performance Index that is accurate to the end of the project.

At What Point Did I Expect to Attain my Current Earned Value?



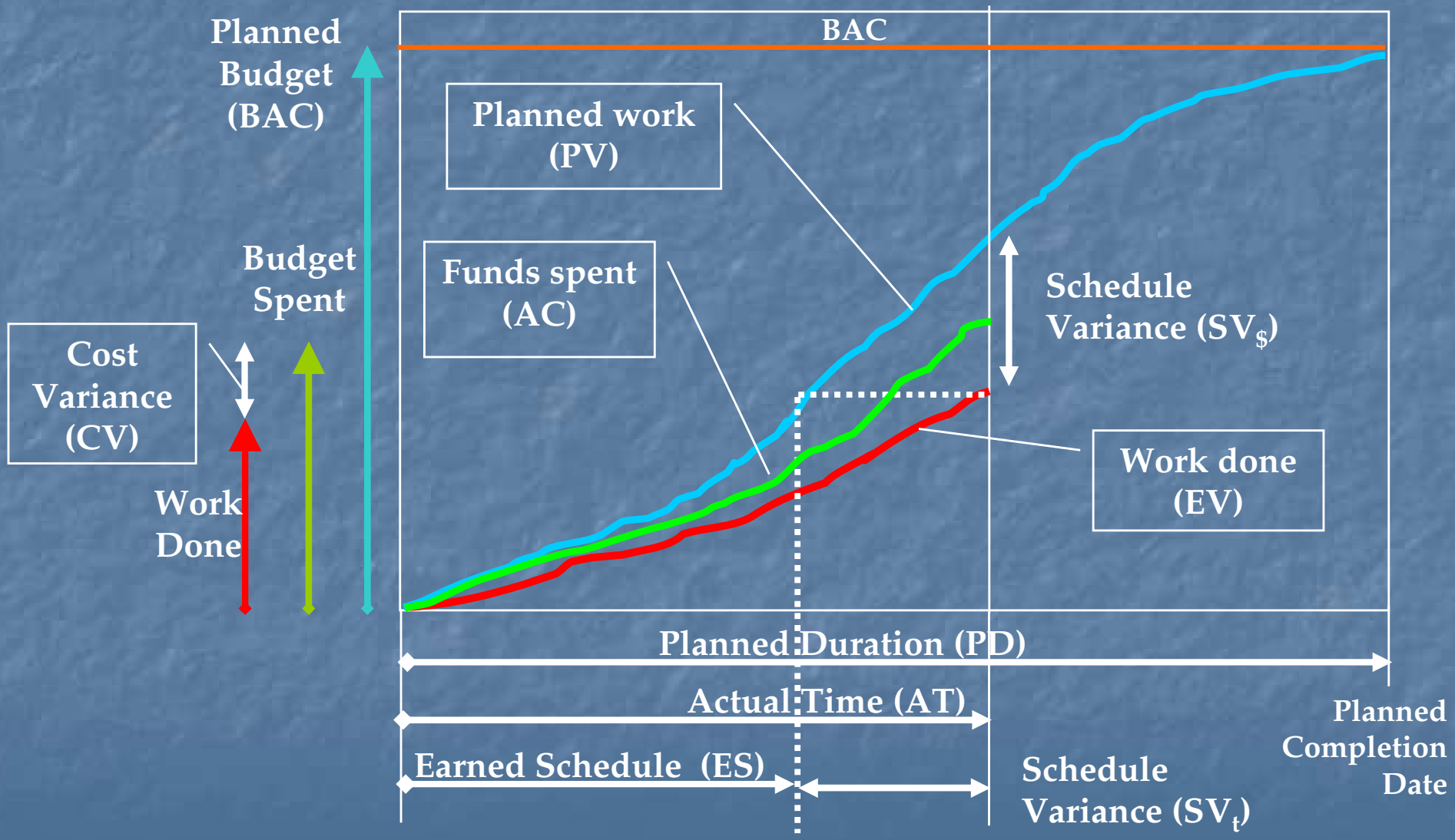
Some New Terms

- AT = Actual Time (now, or data date)
- ES = Earned Schedule (Point in time when *current* progress was *planned* to occur)
- PD = Planned Duration (planned project duration)
- ED = Estimated Duration (estimated project duration)
- PCD = Planned Completion Date (Planned project end date)
- ECD = Estimated Completion Date (Estimated project end date)

Some New Formulas

- SV_t = ES - AT (Schedule Variance in time units, note subscript versus $SV_\$$)
  - SV_t = 6 months – 10 months = -4 months
- SPI_t = ES/AT (SPI in time units)
  - SPI_t = 6/10 = 0.6

The Traditional and the New



Traditional and New EVM Analysis Tools

Traditional

$$SPI_{\$} = \frac{EV}{PV}$$

$$CPI = \frac{EV}{AC}$$

$$EAC = \frac{BAC}{CPI}$$

$$SV_{\$} = EV - PV$$

$$CV = EV - AC$$

New

$$SPI_t = \frac{ES}{AT}$$

$$ED = \frac{PD}{SPI_t}$$

$$ECD = start\_date + ED$$

$$SV_t = ES - AT$$

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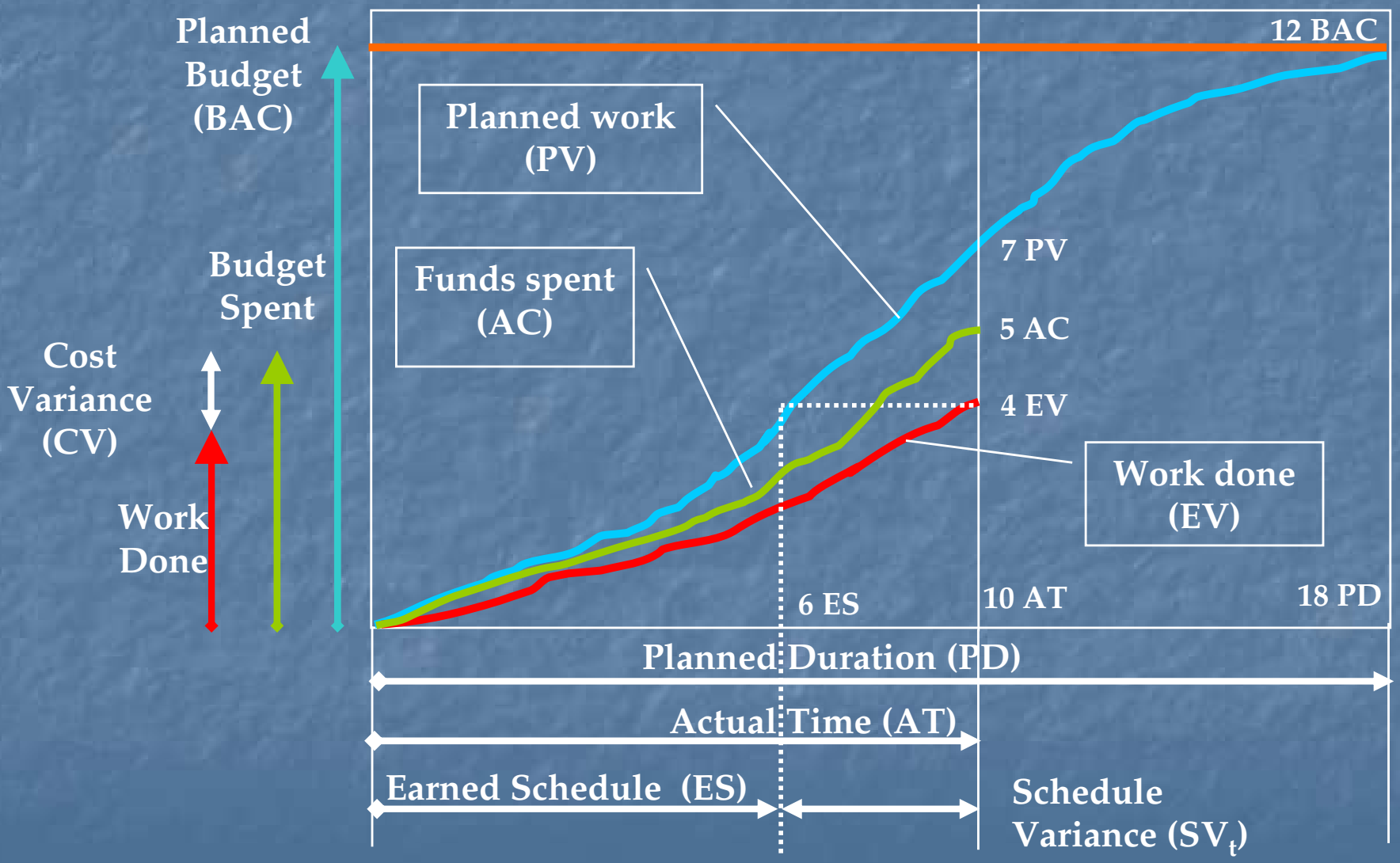
Comprehensive Example

Putting all the pieces together.

Comprehensive Example



Comparing EV and ES Schedule Analysis

Traditional

$$SPI_{\$} = \frac{EV}{PV} = \frac{\$4}{\$7} = 0.57$$

$$SV_{\$} = EV - PV = \$4 - \$7 = -\$3$$

$$ED = ?$$

New

$$SPI_t = \frac{ES}{AT} = \frac{6 months}{10 months} = 0.6$$

$$SV_t = ES - AT = 6 months - 10 months$$

$$SV_t = -4 months$$

$$ED = \frac{PD}{SPI_t} = \frac{18 months}{0.6} = 30 months$$

New Analysis Products

- Schedule performance index {SPI(t) or SPI_t}
- Schedule Variance {SV(t) or SV_t}
- Estimated Duration (ED)
- Estimated Completion Date (ECD)

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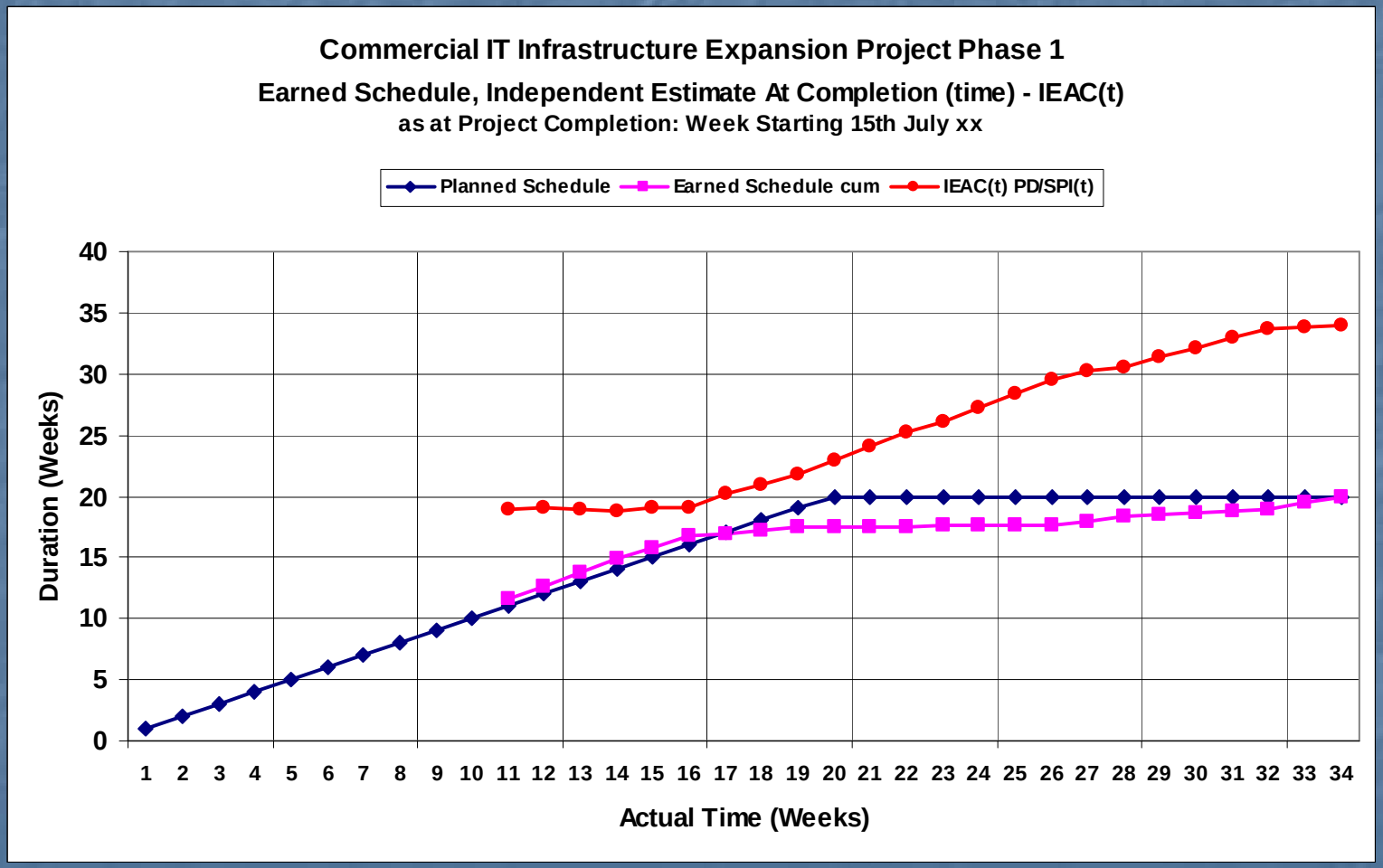
Research Results

Does Earned Schedule really work?

Empirical Evidence (Henderson)

- Findings derived from a small set of real life project data



Henderson, K., 2003, "Earned schedule: a breakthrough extension to earned value theory? A retrospective analysis of real project data", *The Measurable News*, Summer 2003, 21, 13-17

Academic Research
(Vanhoucke)

- Created 3,100 project activity networks
- Constructed a schedule for each network
- Simulated (executed) activity duration and cost in a controlled way (9 execution scenarios, each schedule subjected to each scenario 100 times)
- Monitored and forecasted at each reporting period
- Analysed the data (3.100 x 9 x 100 = 2.790.000 project data sets)

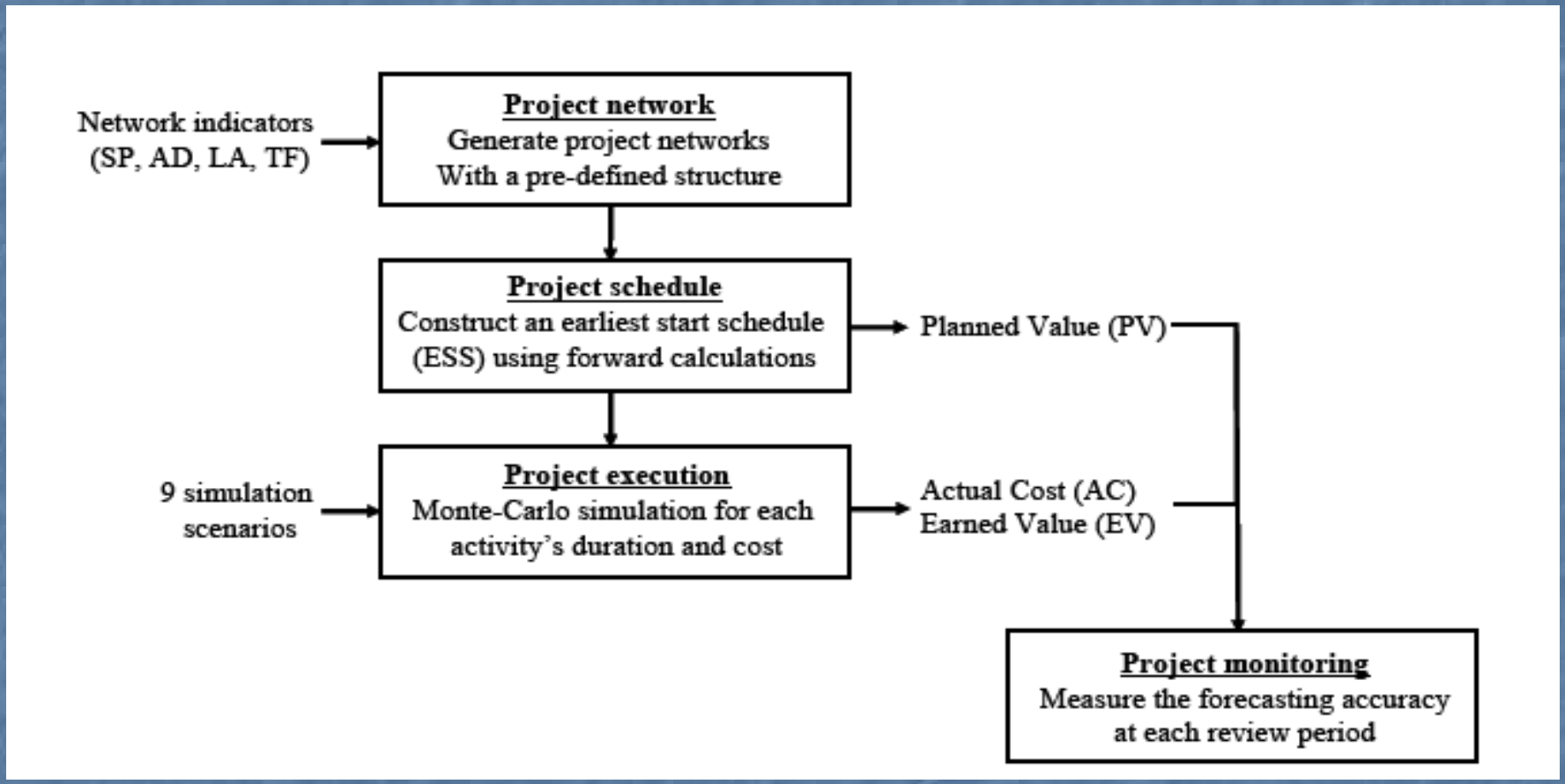
Vanhoucke M., Vandevoorde St., *A Simulation and Evaluation of Earned Value Metrics to Forecast the Project Duration,* Ghent University, Working Paper 2005/312, June 2005

The Nine Simulation Scenarios

- Critical Path Activities
  - Real Duration < Planned Duration
  - Real Duration = Planned Duration
  - Real Duration > Planned Duration
- Non-Critical Path Activities
  - Real Duration < Planned Duration
  - Real Duration = Planned Duration
  - Real Duration > Planned Duration

Non-critical activities	Critical activities: -	Critical activities: 0	Critical activities: +
-	1 SPI(t) > 1 RD < PD	4 SPI(t) > 1 RD = PD	7 **SPI(t) > 1** RD > PD
0	2 SPI(t) > 1 RD < PD	5 SPI(t) = 1 RD = PD	8 SPI(t) < 1 RD > PD
+	3 **SPI(t) < 1** RD < PD	6 SPI(t) < 1 RD = PD	9 SPI(t) < 1 RD > PD

Research Process



Academic Research Results

- "The results reveal that the Earned Schedule method outperforms, on the average, all other forecasting methods."

Vanhoucke M., Vandevoorde St., *A Simulation and Evaluation of Earned Value Metrics to Forecast the Project Duration,* Ghent University, Working Paper 2005/312, June 2005

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Earned Schedule Maturity

Current state of Earned Schedule development and deployment

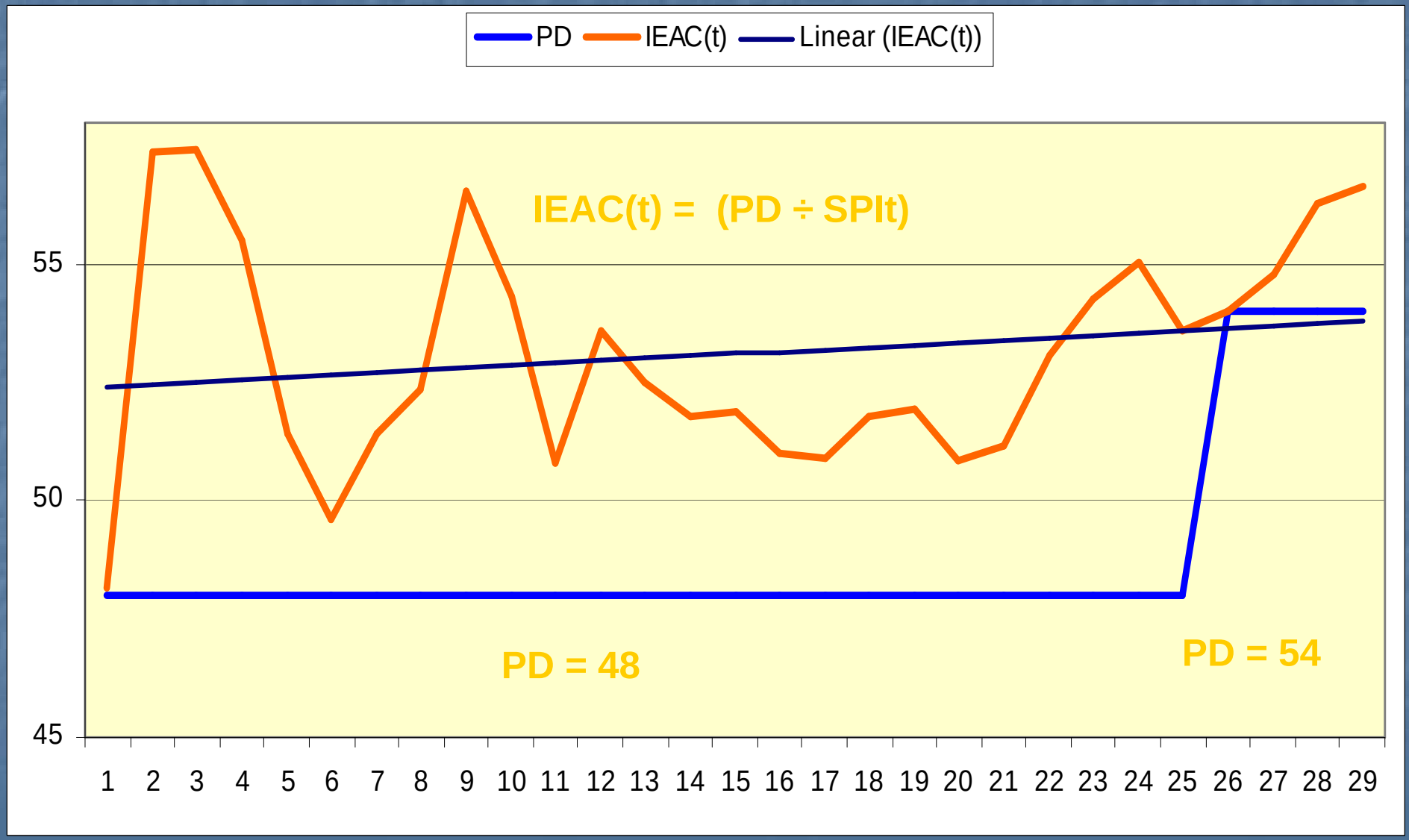
Earned Schedule Maturity

- First paper: March 2003, PMI-CPM Measurable News
- Over twenty presentations and publications
- A growing trend and management expectation
- Yet to appear in commercial EVM software products
- Early Adopters
  - USAF
  - Lockheed Martin
  - Boeing
  - Belgium
  - Management Technologies (education, processes)

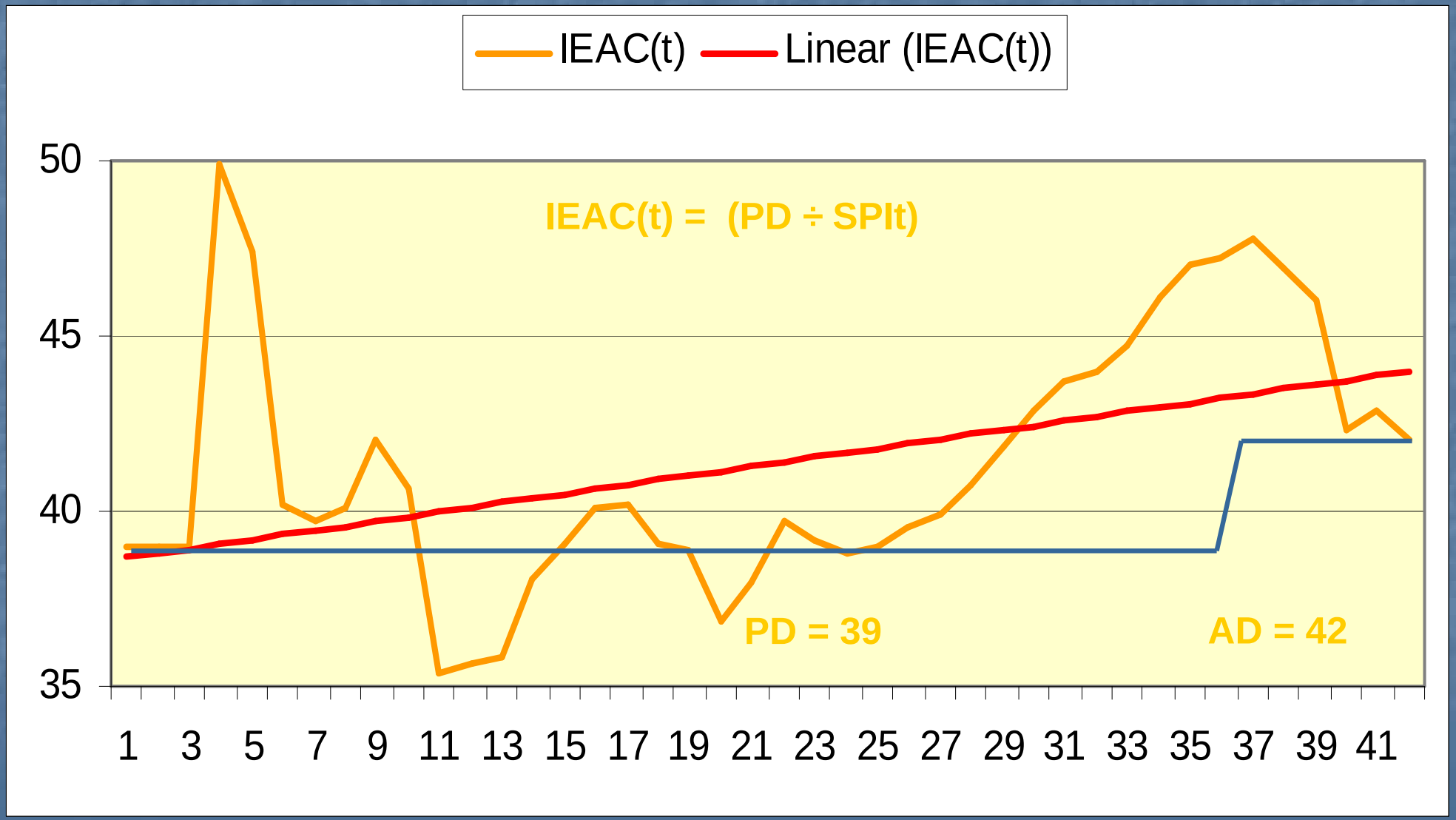
USAF Planning

- Air Force understands the potential of Earned Schedule
- Demonstrate Earned Schedule on a sample set of programs
- Build a body of evidence on a larger set of programs
- Validate the Earned Schedule as a value added program management tool
- Integrate Earned Schedule as a tool in Air Force Acquisition

Lockheed Martin, Program #1



Lockheed Martin, Program #2



The Good News!

- Previously
  - EVM was great at cost management
  - EVM was "ok" at schedule management, *sometimes*
- Now
  - EVM can address both cost and schedule well
  - EVM can estimate
    - Cost at completion
    - Completion date!
  - SPI_t can record project outcome in lessons learned

Credit to Discoverers, Advocates, & Researchers

- Henderson Kym, Earned Schedule: A Breakthrough Extension to Earned Value Theory? A Retrospective Analysis of Real Project Data,The Measurable News, Summer 2003
- Robert Handshuh, New Concept in Earned Value - Earned Schedule, PMI Southeast Regional Conference USA, June 2005
- Walt Lipke & Kym Henderson, Earned Schedule Status Update and Early Adaptor Applications Feedback, 17th IPMC November 2005
- Vandevoorde St., Vanhoucke M., A Comparison of different project duration forecasting methods using earned value metrics, Ghent University, working paper 2005/312, June 2005
  - Approved for Publishing in "International Journal of Project Management"
  - State of the Art Report on Forecasting Duration Methods

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Conclusions

So What?

What We Know About Earned Schedule

- Faithful to the project's end
- Provides a reliable means to calculate an estimated completion date
- Provides a useful schedule performance metric for project history and lessons learned
- May provide a better estimated completion date than critical path methods!

Why use ES?

- More intuitive schedule information
- Schedule variance in *time* units (intuitive to most people)
- Cost variance in *resource ($$)* units
- SPI_t retains utility to project end
  - SPI_t does not automatically creep toward 1.0 near project end
  - SPI_t captures the final project schedule performance data
- Can finally estimate *Project Completion Date*

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Reference and Contact Information

Tell me more!

Seminal Documents

- Lipke, Walter, "Schedule is Different", The Measurable News, March and Summer 2003
- Henderson, Kym, "Further Development in Earned Schedule", The Measurable News, Spring 2003
- Henderson, Kym, Earned Schedule: A Breakthrough Extension to Earned Value Theory? A Retrospective Analysis of Real Project Data, The Measurable News, Summer 2003

The Measurable news is a quarterly publication of the Project Management Institute's College of Performance Management

www.pmi-cpm.org

Other References

- Earned Schedule Status Update and Early Adopter Applications Feedback Presentation facilitated by Walt Lipke and Kym Henderson, 17th IPMC November 2005
- Earned Schedule Leads to Improved Forecasting: Presentation by Walt Lipke, intended for 17th IPMC November 2005
- Earned Schedule in Action:Paper by Kym Henderson, published PMI CPM Journal, The Measurable News "Spring" 2005
- Forecasting Project Schedule Completion by Using Earned Value Metrics, Presentation by Ing. Stephan Vandevoorde, Senior Project Manager, Fabricom Airport Systems and Prof. Dr. Mario Vanhoucke, Ghent University, Belgium, Early Warning Signals Conference, V.U.B. Brussels, June 2005
- Not Your Father's Earned Value: Earned Schedule overview paper by Ray Stratton, published on Projects@Work (http://www.projectsatwork.com) 24 Feb 2005
- Connecting Earned Value to the Schedule:Paper by Walt Lipke, published PMI CPM Journal, The Measurable News, "Winter" 2004

One-Stop Shopping

- Comprehensive Library of EVM and Earned Schedule
  - Papers
  - Presentations

http://sydney.pmichapters-australia.org.au/
Click "Education," then "Presentations and Papers" for .pdf copies

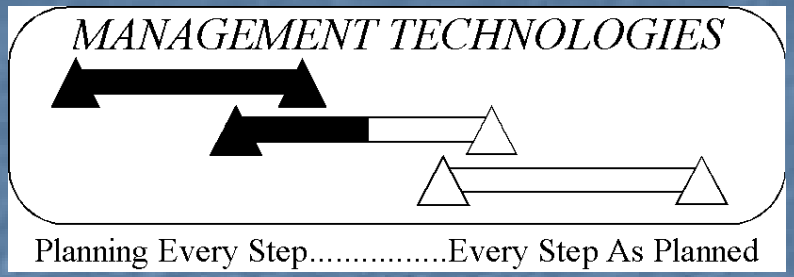
In Closing ……

If you are not practicing Earned Schedule as part of your

Earned Value Management System ……

……you are practicing 20th Century Earned Value Management!

Discussion and Questions



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