TIME FORECASTING USING EARNED SCHEDULE

THE EUROPEAN EXPERIENCE (WITH THE HELP OF THE US)

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Director, EVM Europe

EVM Europe 2013 - Ghent University - Ghent (Belgium)

Agenda

The Start	• The beginnings
Study 1	• Duration forecasting methods
Study 2	• Measuring Time: A Simulation Study
Study 3	• P-Factor
Study 4	• Project time control
C.R.A.	• Concerted Research Actions Program

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C.R.A.	• Concerted Research Actions Program

The Start

2001

Scheduling Workshop in Antwerp

An Academic meets a Practitioner

The Topic: Project Time Control

SCHEDULE

- Problems in real life:
  - Schedule tracking is difficult
  - Often the busy PM = scheduler
  - Delays announced too late
- Question: are there other time control methods?
  - Schedule Risk Analysis (for time critical projects)
  - Earned Value Management

2003: Methods using SV / SPI

- The Measurable News, March 2003, “Forecasting Project Schedule Completion With Earned Value Metrics”, D.S. Jacob
    - Earned Duration
    - ED = AD x SPI
- Project Management Journal Volume 34, Number 4, December 2003, “Earned Value Project Management Method and Extensions”, F.T. Anbari
    - Planned Value Method
    - TV = SV / PVRate

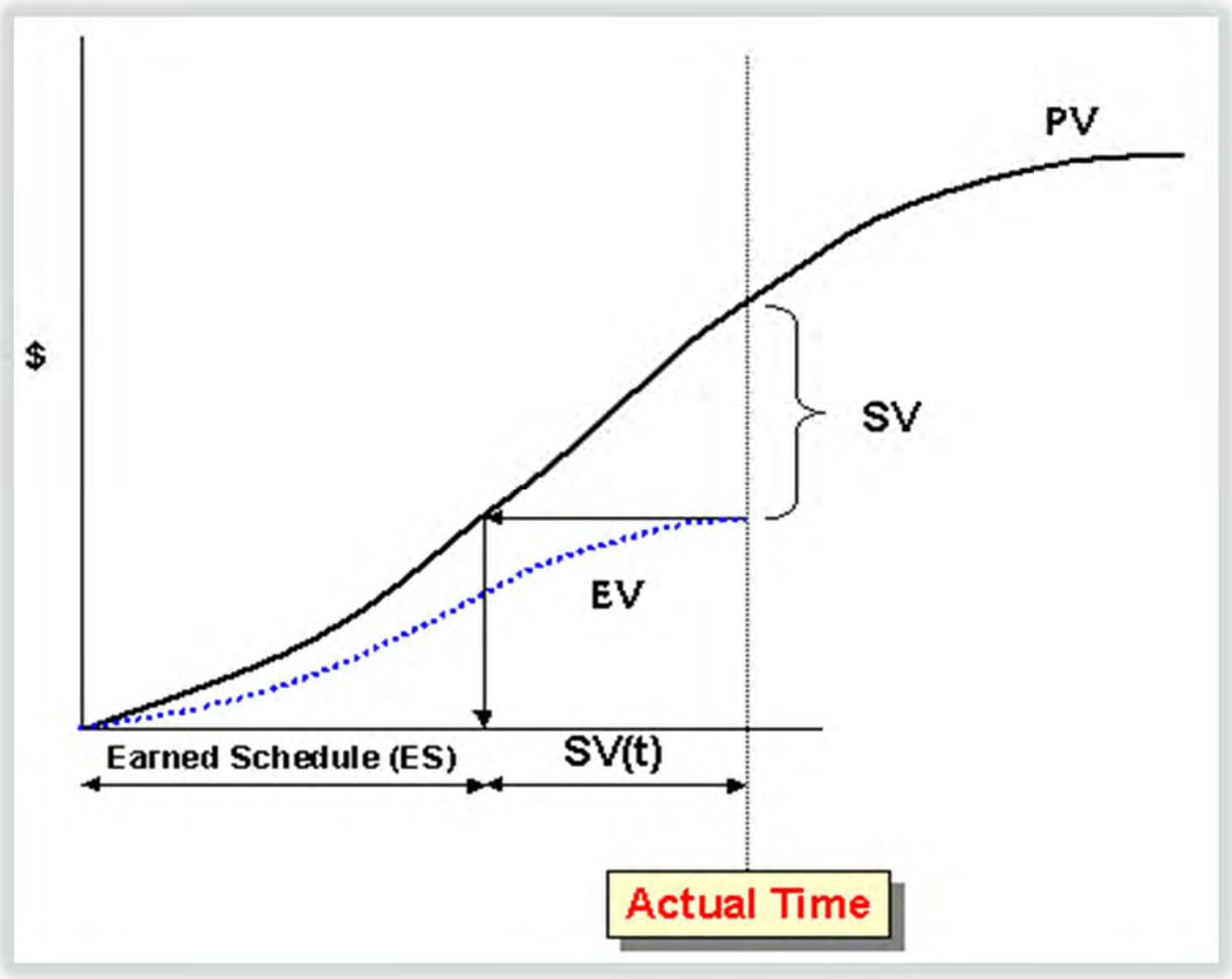
2003: Earned Schedule

- The Measurable News, March 2003, “Schedule is Different”, Walt Lipke
  - Description of quirky behaviour SPI
  - Introducing Earned Schedule Concept

- The Measurable News, Summer 2003, “Earned Schedule: A Breakthrough Extension to Earned Value Theory? A Retrospective Analysis of Real Project Data”, Kym Henderson
  - Initial validation of ES

- The Measurable News, Spring 2004, “Further Developments in Earned Schedule”, Kym Henderson
  - Prediction capability introduced

SV vs. SV(t)



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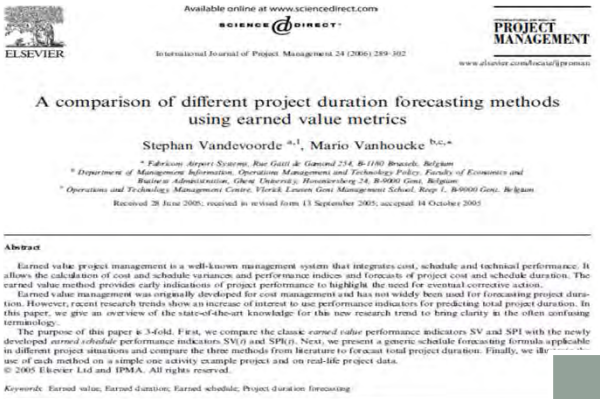
Study 1: Time Forecasting - Overview



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International Journal of Project Management 24 (2006) 289–302
PROJECT MANAGEMENT
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A comparison of different project duration forecasting methods using earned value metrics

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[b] Department of Management Information, Operations Management and Technology Policy, Faculty of Economics and Business Administration, Ghent University, Hoveniersberg 24, B-9000 Ghent, Belgium
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Abstract

Earned value project management is a well-known management system that integrates cost, schedule and technical performance. It allows the calculation of cost and schedule variances and performance indices and forecasts of project cost and schedule duration. The earned value method provides early indications of project performance to highlight the need for eventual corrective action.

Earned value management was originally developed for cost management and has not widely been used for forecasting project duration. However, recent research trends show an increase of interest to use performance indicators for predicting total project duration. In this paper, we give an overview of the state-of-the-art knowledge for this new research trend to bring clarity in the often confusing terminology.

The purpose of this paper is 3-fold. First, we compare the classic *earned value* performance indicators SV and SPI with the newly developed *earned schedule* performance indicators SV(*t*) and SPI(*t*). Next, we present a generic schedule forecasting formula applicable in different project situations and compare the three methods from literature to forecast total project duration. Finally, we illu[illegible] use of each method on a simple one activity example project and on real-life project data.

Keywords: Earned value; Earned duration; Earned schedule; Project duration forecasting

Getting the 1st ES reference in a peer reviewed international journal

IJPM Paper

	Planned value method [Anbari, 2003]		Earned duration method [Jacob, 2003]		Earned schedule method [Lipke, 2003]	
Baseline	SAC	Schedule at Completion	PD	Planned Duration	PD	Planned Duration
Status of the project (duration)	PVR	Planned Value Rate (BAC/PD)	ED	Earned Duration (AD/SPI)	ES	Earned Schedule
	AT	Actual Time	AD	Actual Duration	AT	Actual Time
	SPI	Schedule Performance Index (EV/PV)	SPI	Schedule Performance Index (EV/PV)	SPI(t)	Schedule Performance Index Time (ES/AT)
	SV	Schedule Variance (EV-PV)	SV	Schedule Variance (EV-PV)	SV(t)	Schedule Variance Time (ES-AT)
	SV TV	Time Variance (SV/PVR)	—	—	—	—
	CR	Critical Ratio	—	—	SCI(t)	Schedule Cost Index
Duration measures	**EAC(t)**		**EAC(t) = AD + (PD - ED) / PF**		**EAC(t) = AD + (PD - ES) / PF**	
	$EAC(t)_{PV1}$	Estimate of Duration at Completion(PD-TV)	$EAC(t)_{ED1}$	Estimate of Duration at Completion PF = 1	$EAC(t)_{ES1}$	Estimate of Duration at Completion PF = 1
	$EAC(t)_{PV2}$	Estimate of Duration at Completion (PD/SPI)	$EAC(t)_{ED2}$	Estimate of Duration at Completion PF = SPI	$EAC(t)_{ES2}$	Estimate of Duration at Completion PF = SPI(t)
	$EAC(t)_{PV3}$	Estimate of Duration at Completion (PD/SCI)	$EAC(t)_{ED3}$	Estimate of Duration at Completion PF = SCI	$EAC(t)_{ES3}$	Estimate of Duration at Completion PF = SCI(t)

- Description of SPI / SV vs. SPI(t) / SV(t)
- Description of duraton forecasting methods
- Application of methods on 3 sets of real life project data

IJPM Paper

- Conclusion:

> "Earned Schedule was the only method which showed satisfying and reliable results during the whole project duration"

- Recommendation:

> "In order to generalise the results found in this study, we will test the three concepts on projects based on a full factorial simulation experiment, rather than relying on a (small) set of real life projects."

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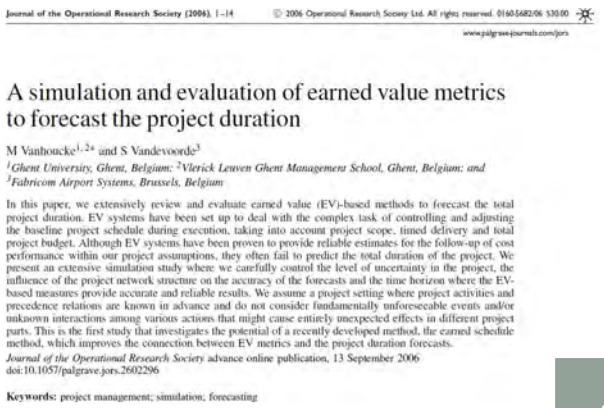
Study 2: Measuring Time



Journal of the Operational Research Society (2006), 1–14

www.palgrave-journals.com/jors

A simulation and evaluation of earned value metrics to forecast the project duration

M Vanhoucke[1,2]* and S Vandevoorde[3]

[1]*Ghent University, Ghent, Belgium;* [2]*Vlerick Leuven Ghent Management School, Ghent, Belgium; and* [3]*Fabricom Airport Systems, Brussels, Belgium*

In this paper, we extensively review and evaluate earned value (EV)-based methods to forecast the total project duration. EV systems have been set up to deal with the complex task of controlling and adjusting the baseline project schedule during execution, taking into account project scope, timed delivery and total project budget. Although EV systems have been proven to provide reliable estimates for the follow-up of cost performance within our project assumptions, they often fail to predict the total duration of the project. We present an extensive simulation study where we carefully control the level of uncertainty in the project, the influence of the project network structure on the accuracy of the forecasts and the time horizon where the EV-based measures provide accurate and reliable results. We assume a project setting where project activities and precedence relations are known in advance and do not consider fundamentally unforeseeable events and/or unknown interactions among various actions that might cause entirely unexpected effects in different project parts. This is the first study that investigates the potential of a recently developed method, the earned schedule method, which improves the connection between EV metrics and the project duration forecasts.

Journal of the Operational Research Society advance online publication, 13 September 2006
doi:10.1057/palgrave.jors.2602296

Keywords: project management; simulation; forecasting

A comparison and evaluation of forecasting metrics based on a simulation approach on a large set of project networks

Creating Project Database

- Create a database of networks with a controlled topological structure by the use of a network generator
- So we guarantee we have a very large set of networks that can and might occurr in practice
- To control the design of the networks 4 indicators are used:
  - Network indicator: Serial or parallel network (SP)
  - Activity indicator: Activity distribution (AD)
  - Precedence relations indicator: Length of arcs (LA)
  - Float indicator: Topological float (TF)

(Based on: Vanhoucke, M., Coelho, J.S., Debels, D., Maenhout, B. and Tavares, L.V., 2008, “An evaluation of the adequacy of project network generators with systematically sampled networks”, European Journal of Operational Research, 187, 511–524

Network Indicators

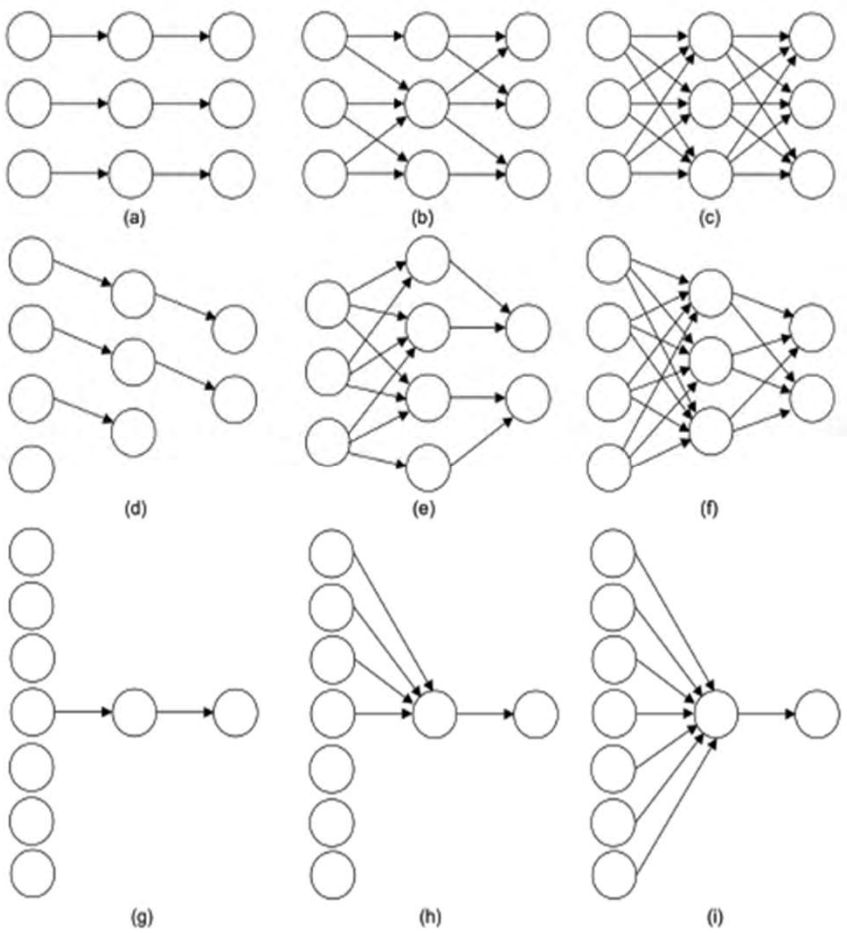
Project Network

Serial/Parallel (SP)

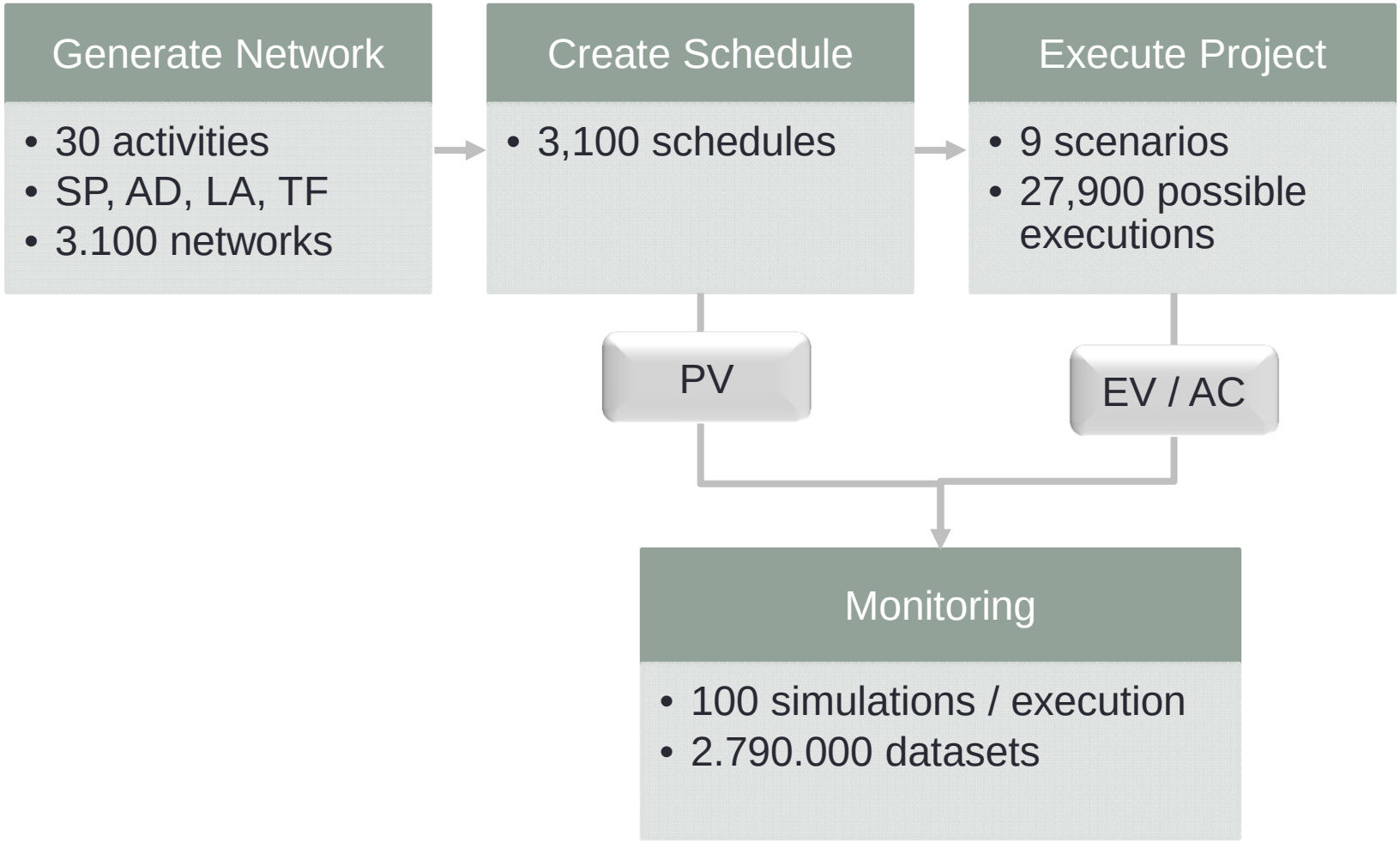
Activity Distribution (AD)

Length of Arcs (LA)

Topological Float (TF)



Simulation Setting



PMI BE June 2007

PMI BE Chapter Event 12/06/2007

PMI BE Research Collaboration Fund
5.000 €

Awarded to

Prof. Dr. Mario Vanhoucke

To support further EV/ES research

(for buying additional computer power)

Research Finding 1

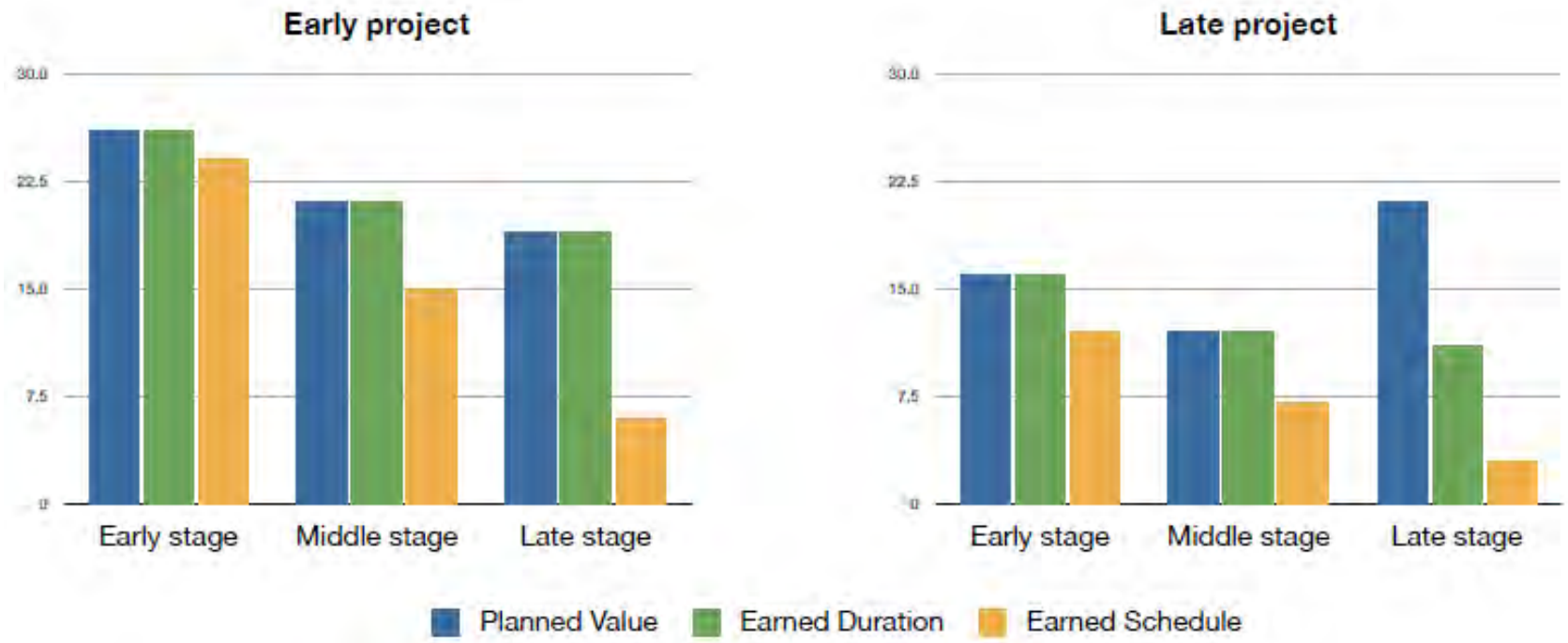
Journal of the Operational Research Society, 2007, 58 : 1361-1374 , "A simulation and evaluation of earned value metrics to forecast the project duration.", M. Vanhoucke, S. Vandevoorde

Table 1 The forecast accuracy (MAPE) of the three methods for the nine scenarios

	PV1	*PV2*	*PV3*	*ED1*	*ED2*	*ED3*	*ES1*	*ES2*	*ES3*
Scenario 1	0.106	0.128	0.481	0.112	0.128	0.249	**0.076**	**0.099**	0.270
Scenario 2	0.114	0.095	0.101	0.121	0.095	0.087	**0.094**	**0.036**	**0.054**
Scenario 3	0.067	0.080	0.254	0.066	0.080	0.175	**0.055**	**0.064**	**0.164**
Scenario 4	0.035	**0.071**	0.426	**0.023**	**0.071**	**0.229**	0.033	0.092	0.237
Scenario 5	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**	**0.000**
Scenario 6	0.024	**0.051**	0.416	0.021	**0.051**	**0.242**	**0.019**	0.063	0.273
Scenario 7	0.042	**0.077**	0.409	**0.032**	**0.077**	**0.222**	0.034	0.093	0.227
Scenario 8	0.100	0.090	0.119	0.102	0.090	0.102	**0.076**	**0.031**	**0.067**
Scenario 9	0.061	0.064	0.232	0.064	0.064	0.132	**0.046**	**0.032**	**0.142**

The results reveal that the ES method outperforms, on the average, all other forecasting methods.

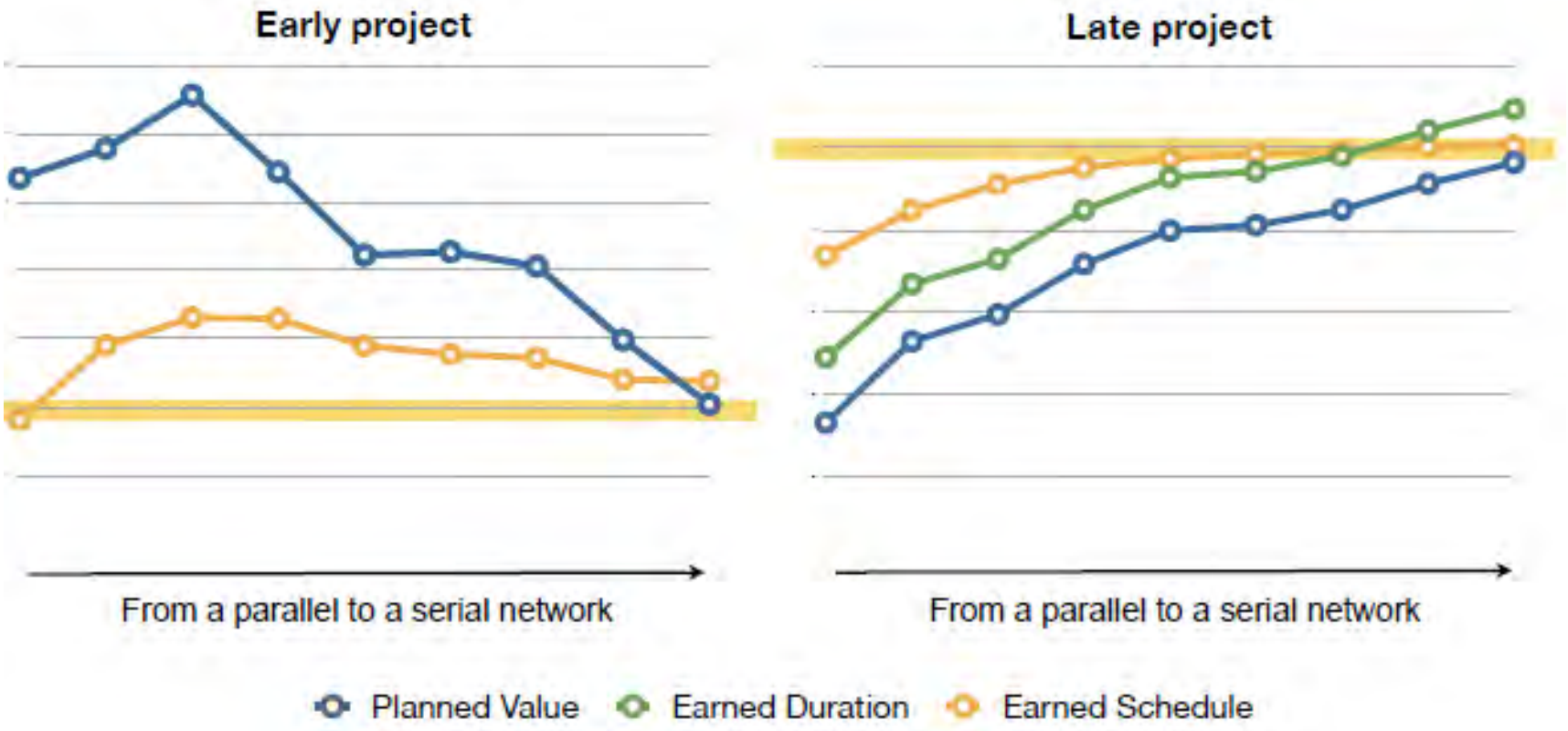
Research Finding 2



The earned schedule method outperforms the other methods at all stages during the project cycle,

All other methods make the quirky mistake from the 50% à 60% percentage complete,

Research Finding 3



The network structure as measured by the SP-indicator has a clear influence on the forecast accuracy.

IPMA 22nd World Congress, Rome

IPMA Research Award 2008
Mario Vanhoucke

Measuring time – A project performance simulation study

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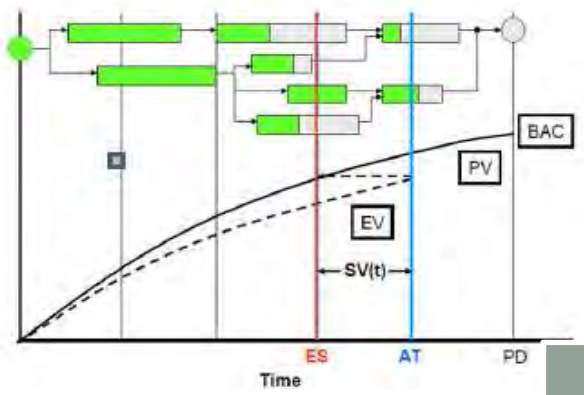
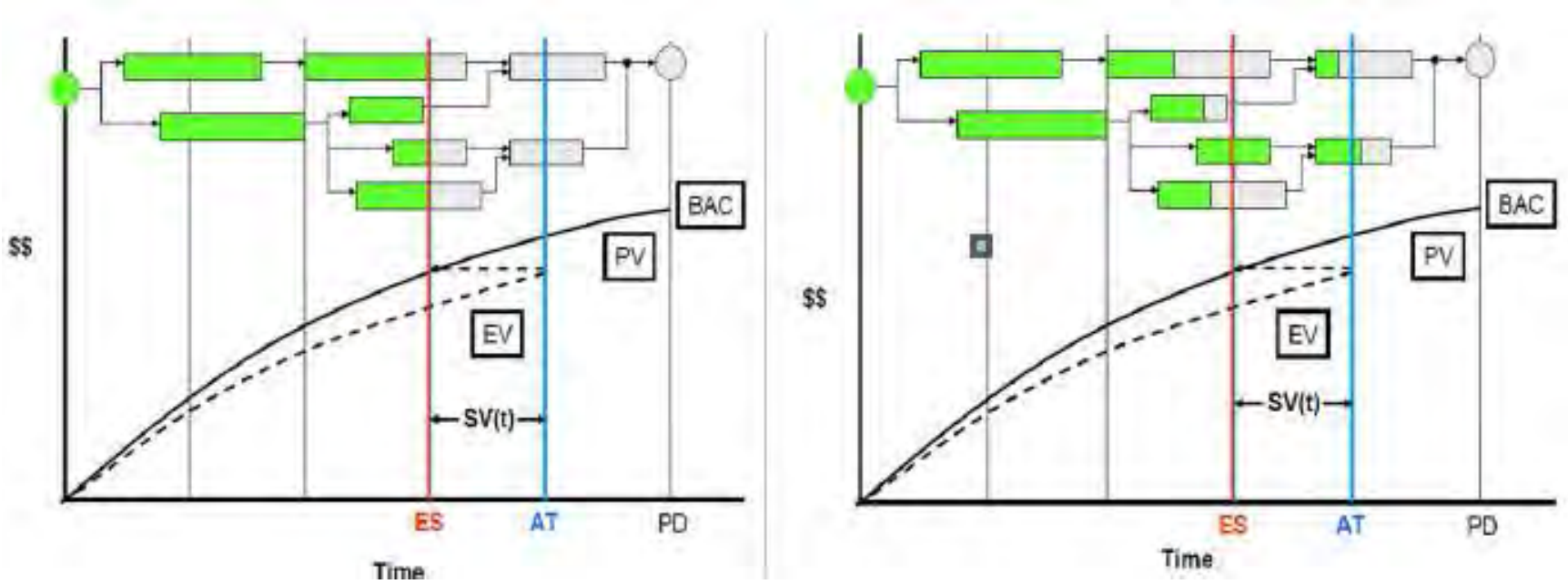
Study 3: Schedule Adherence



Examining the P-Factor (schedule adherence)

Schedule Adherence

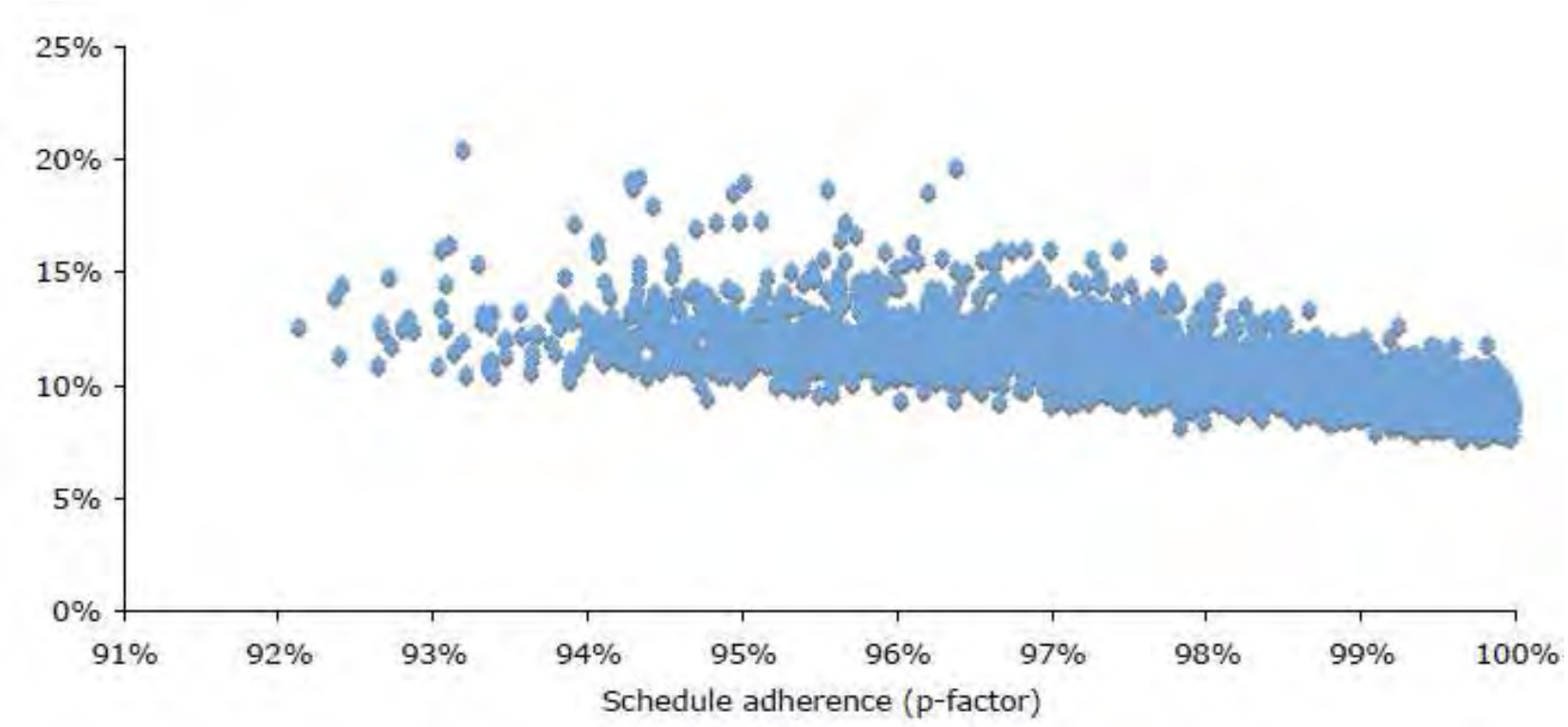


$$p = \frac{\sum_{i \in N} min(\mathrm{PV}_{i,\mathrm{ES}}, \mathrm{EV}_{i,\mathrm{AT}})}{\sum_{i \in N} \mathrm{PV}_{i,\mathrm{ES}}}$$

with

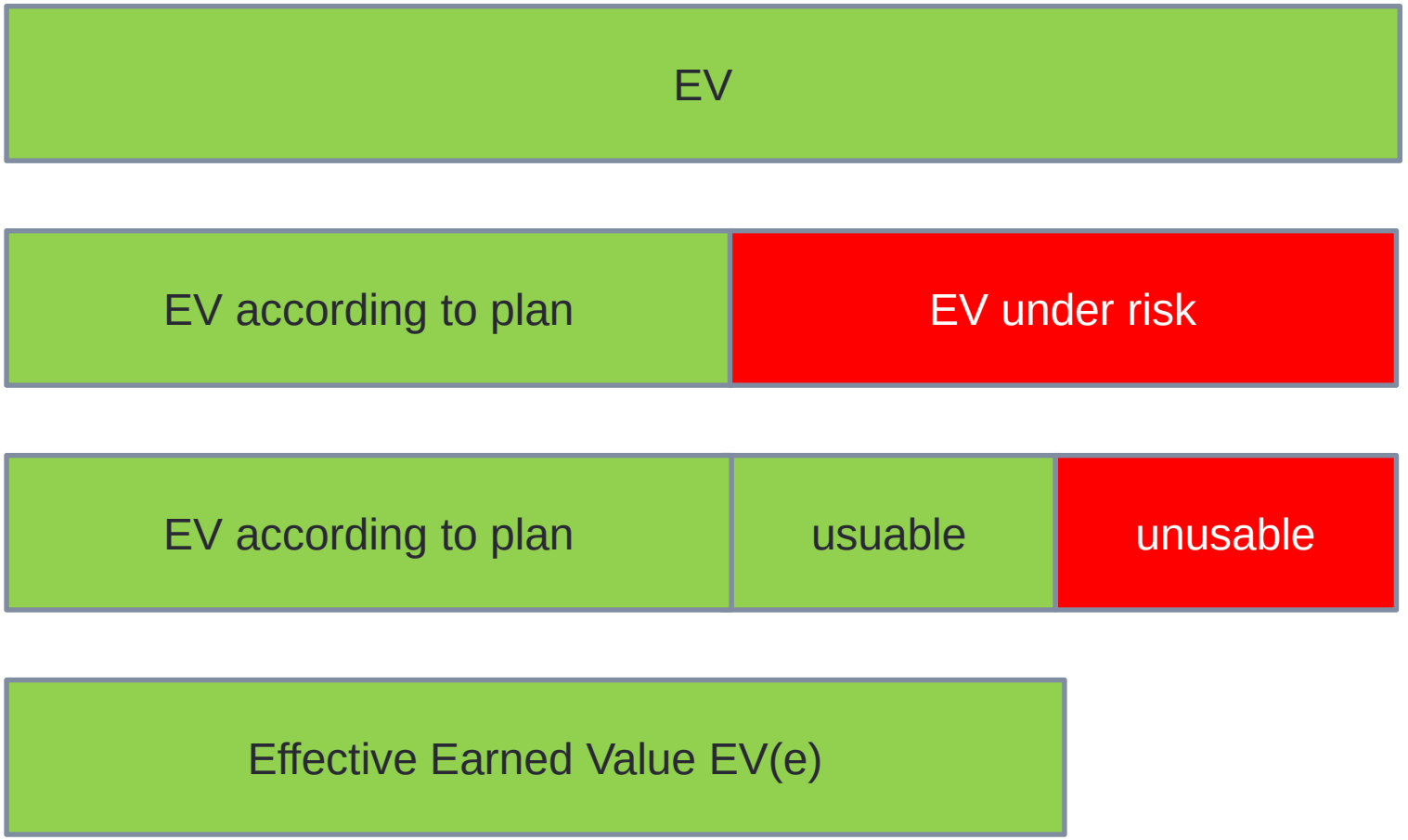
p	Schedule adherence = 1: perfect schedule adherence < 1: lack of perfect schedule adherence
N	Set of activities in the project
$PV_{I,ES}$	Planned value of activity i at time instance ES
$EV_{I,AT}$	Earned value of activity i at the actual time AT

Research Finding P-Factor

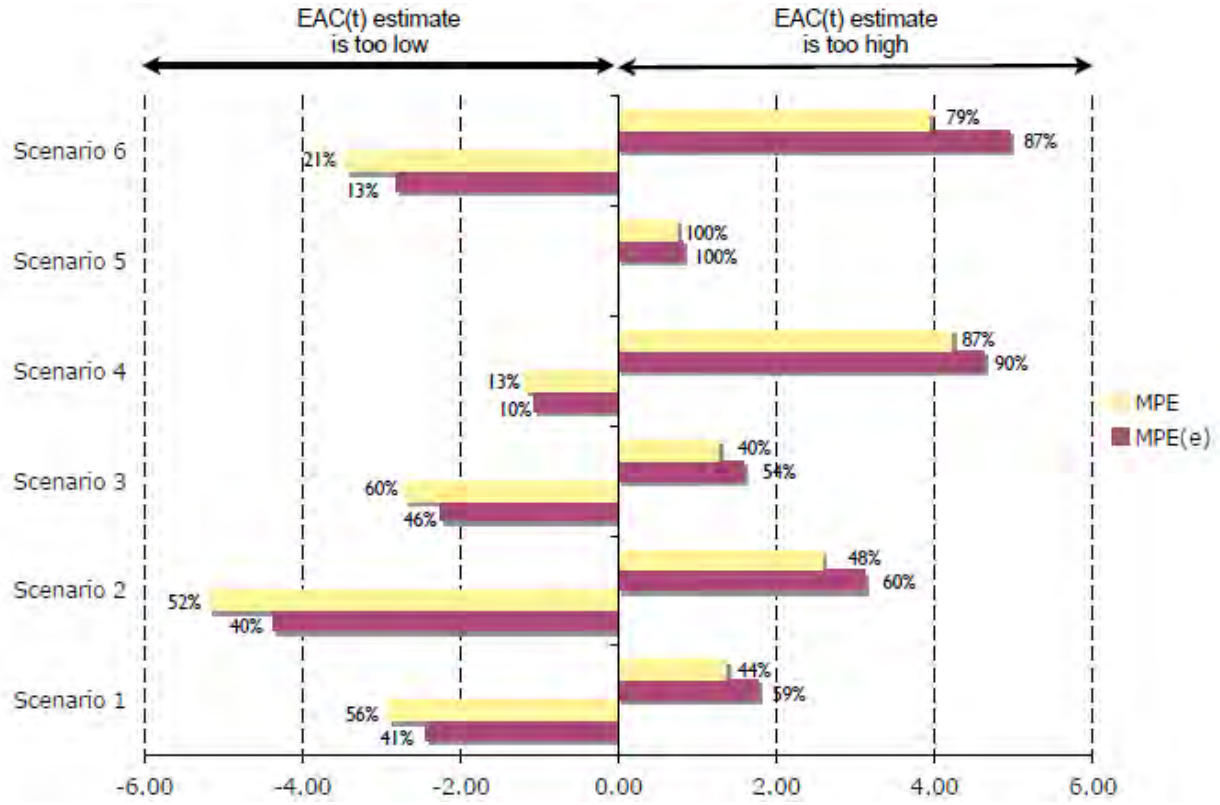


High P-Factors lead to more accurate forecasts, and thus acts as a warning signal.

Effective Earned Value



Prelimanary Research Finding EV(e)



The use of effective earned value to improve the forecast accuracy of time prediction is limited.

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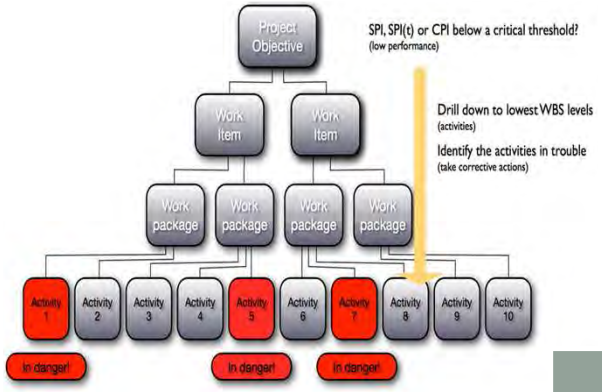
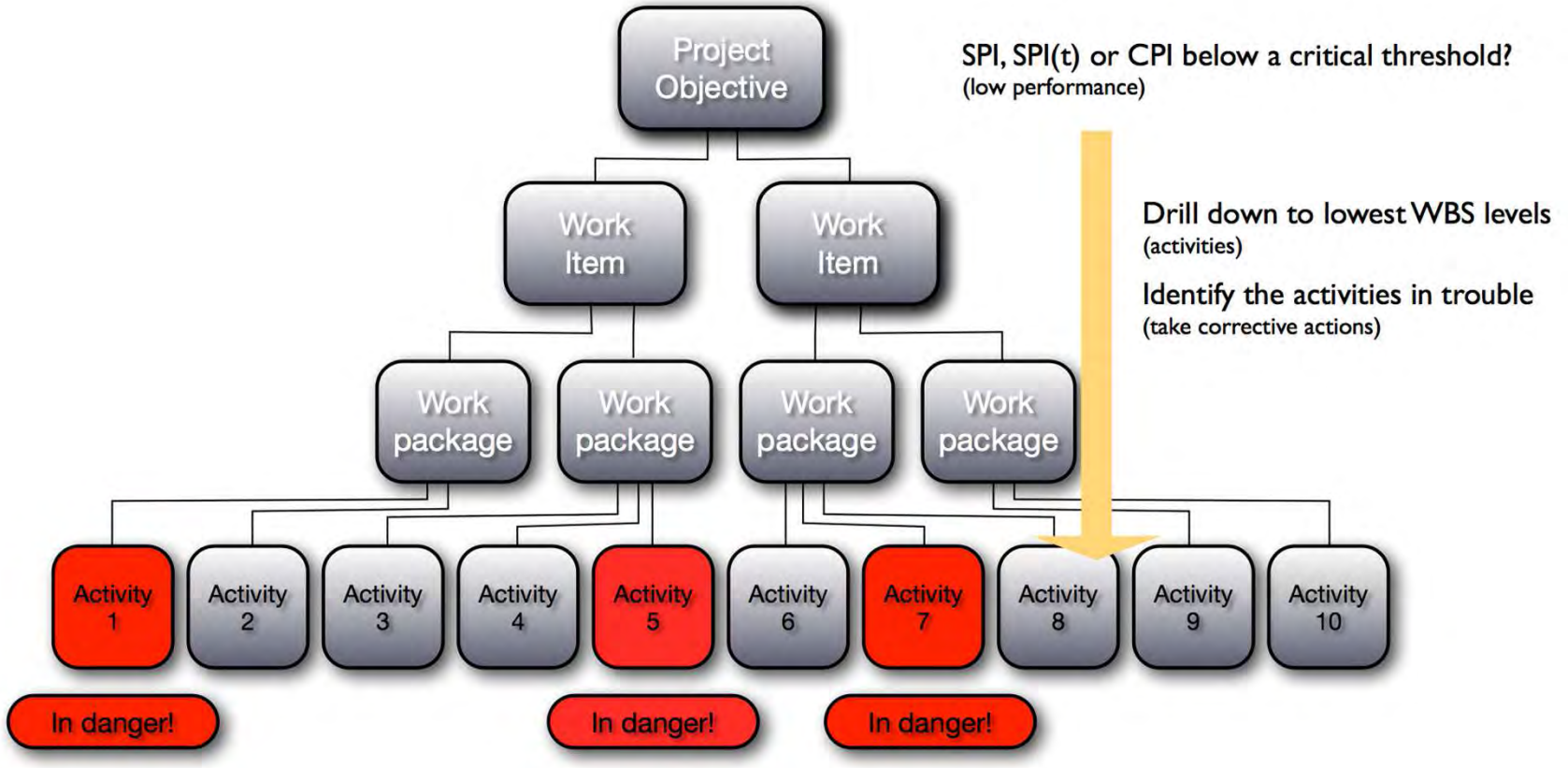
Study 4: Project Time Control

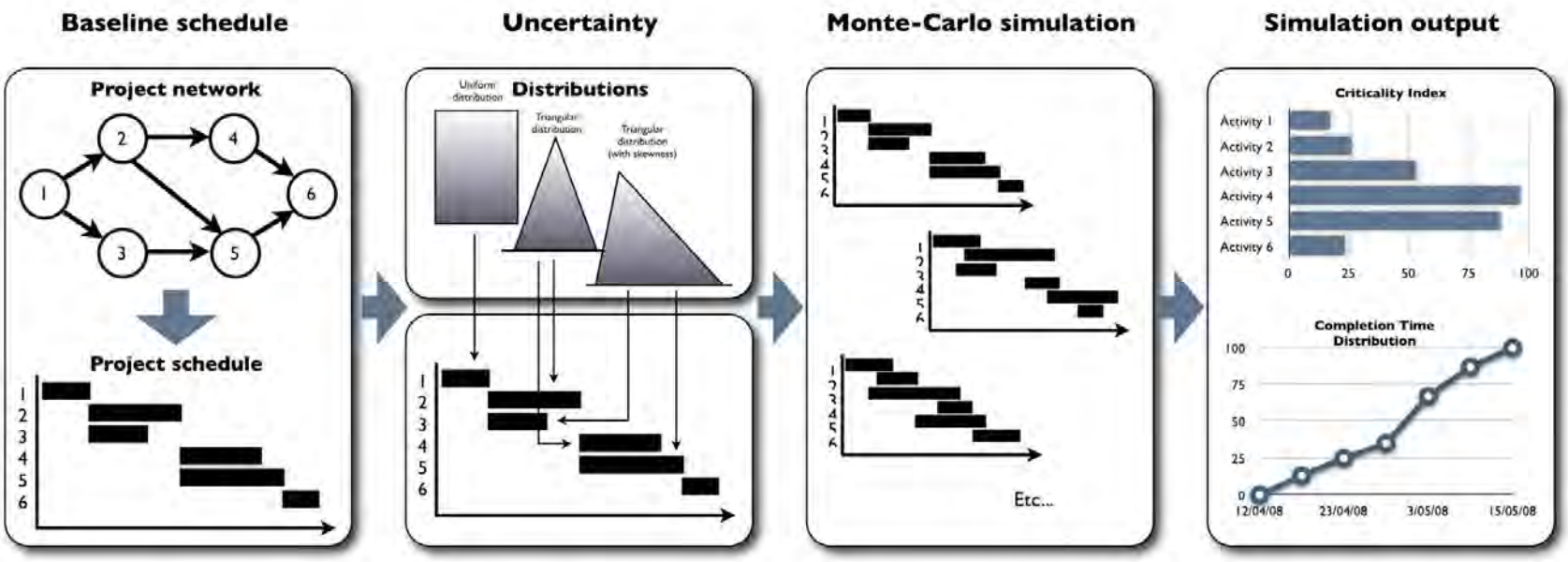


Is there an alternative for improving time forecasting accuracy for projects with parallel networks?

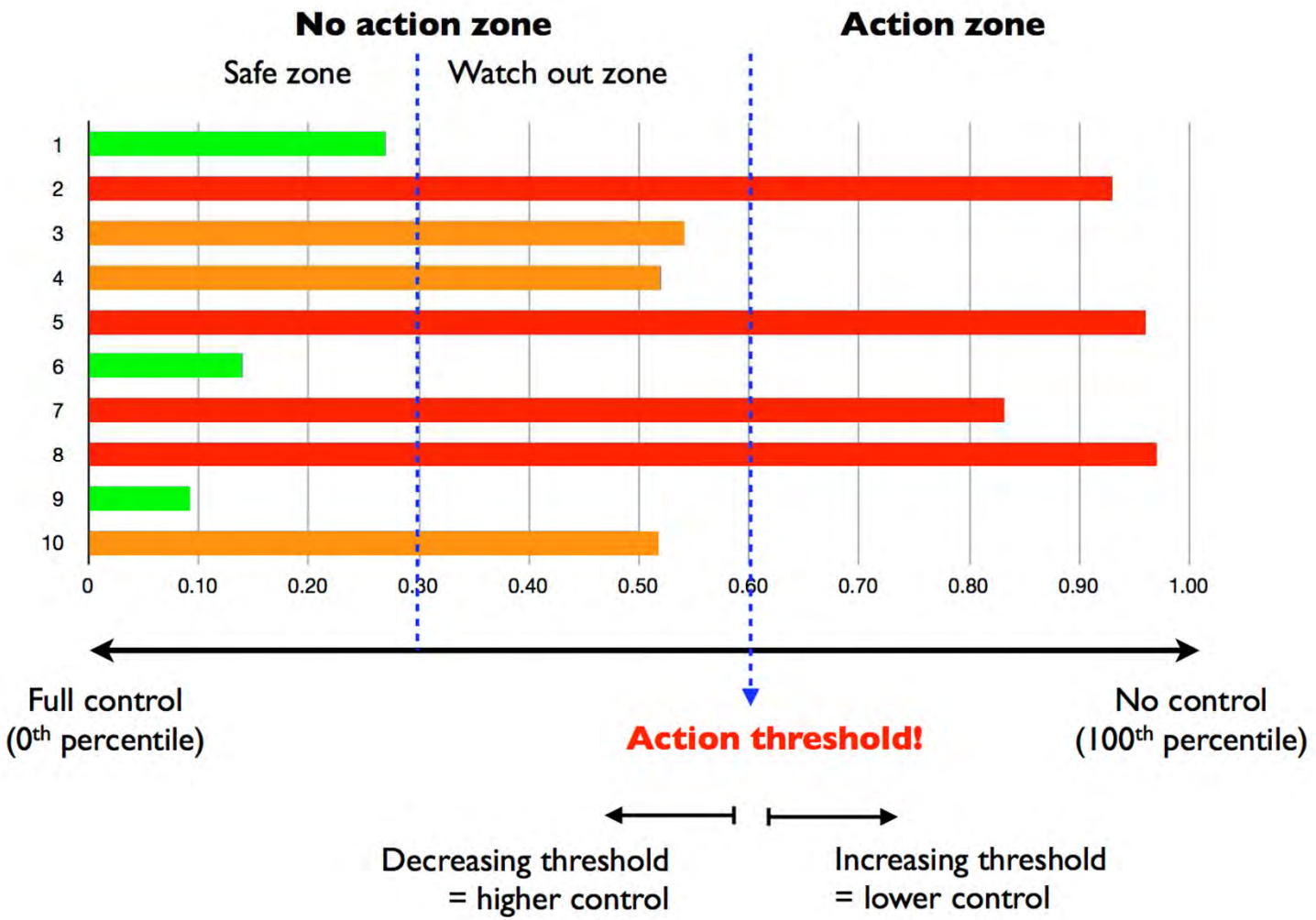
ES: TOP DOWN CONTROL



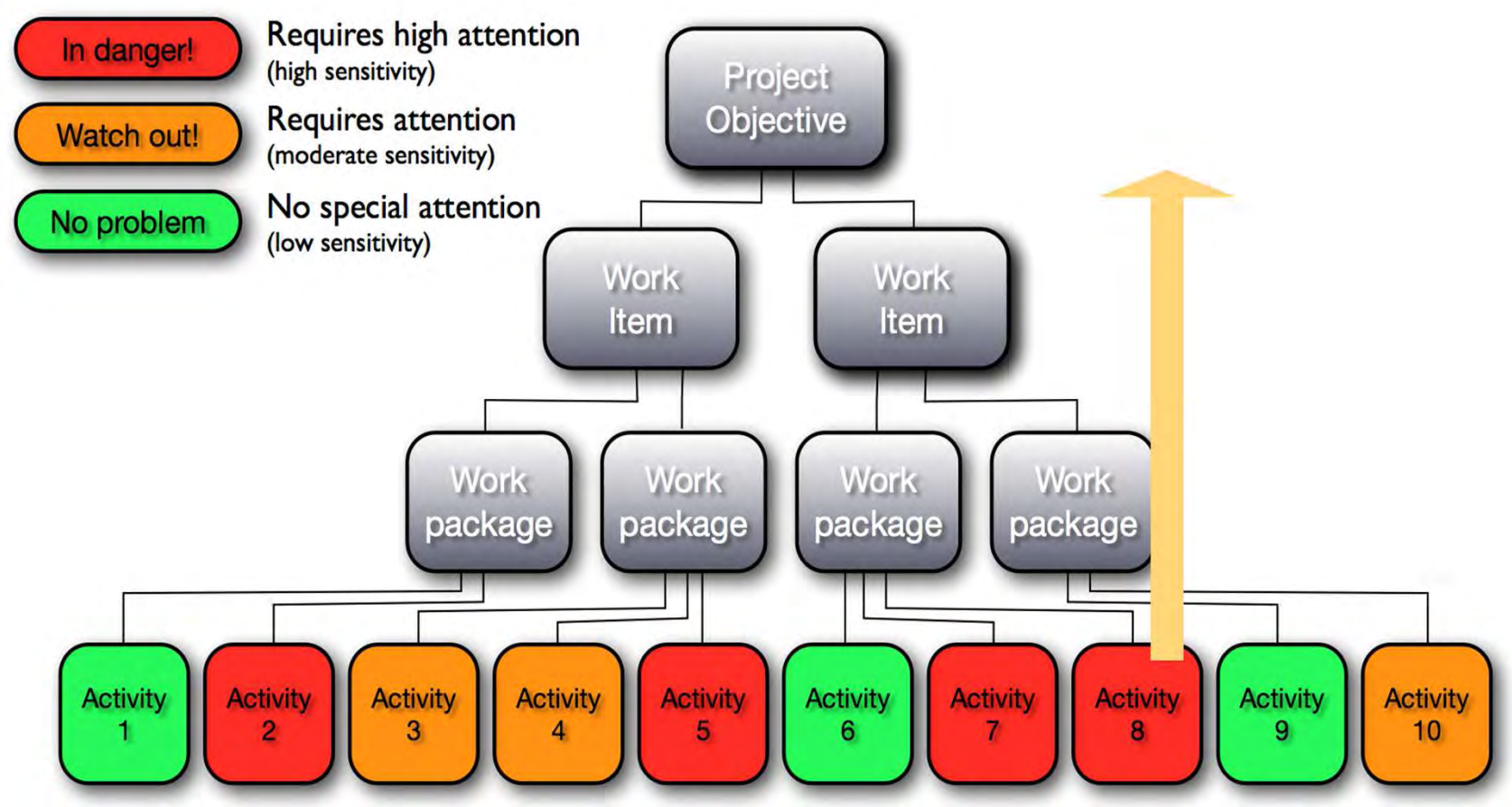
SRA: BOTTOM UP CONTROL



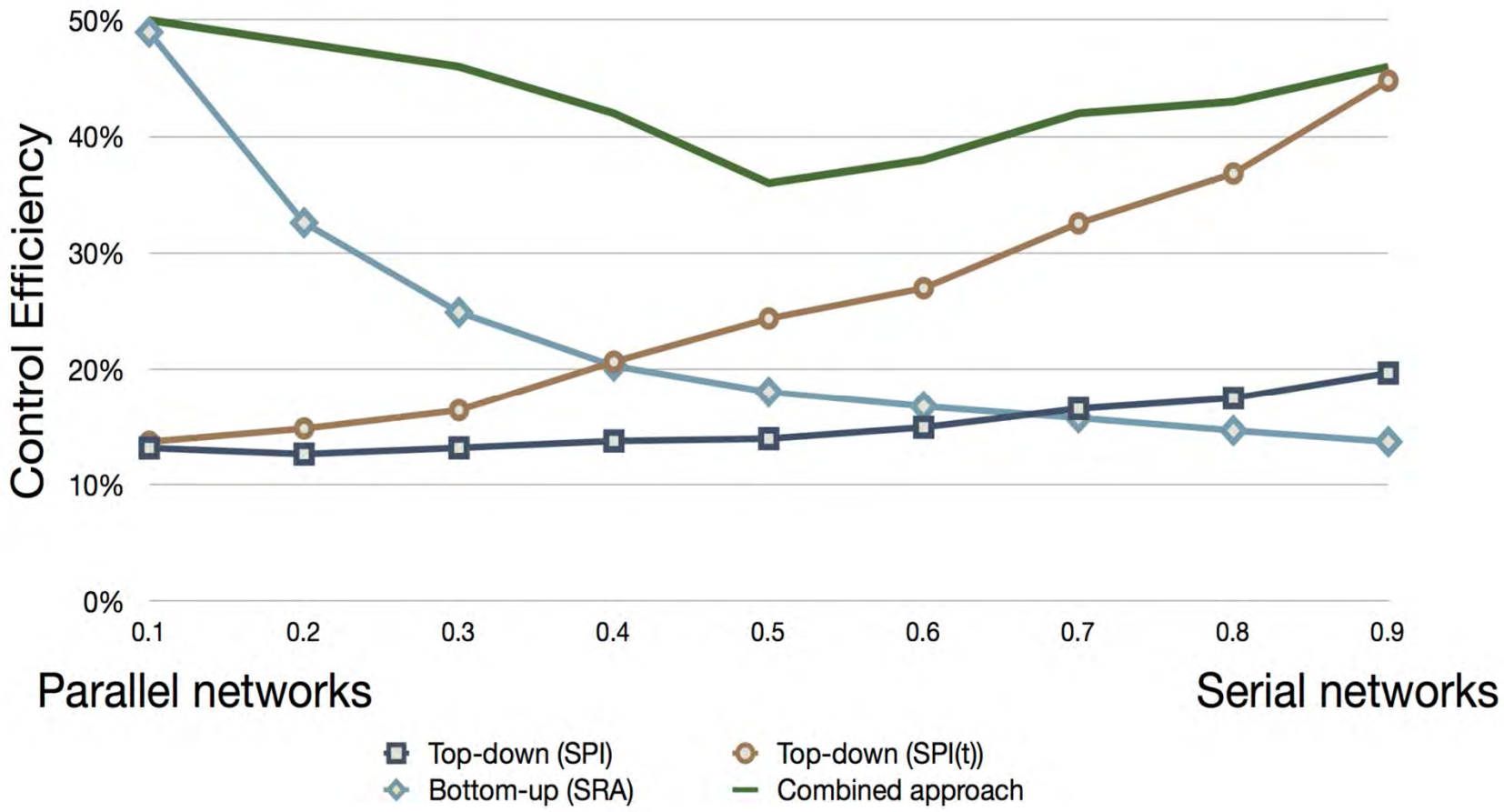
SRA: BOTTOM UP CONTROL



SRA: BOTTOM UP CONTROL

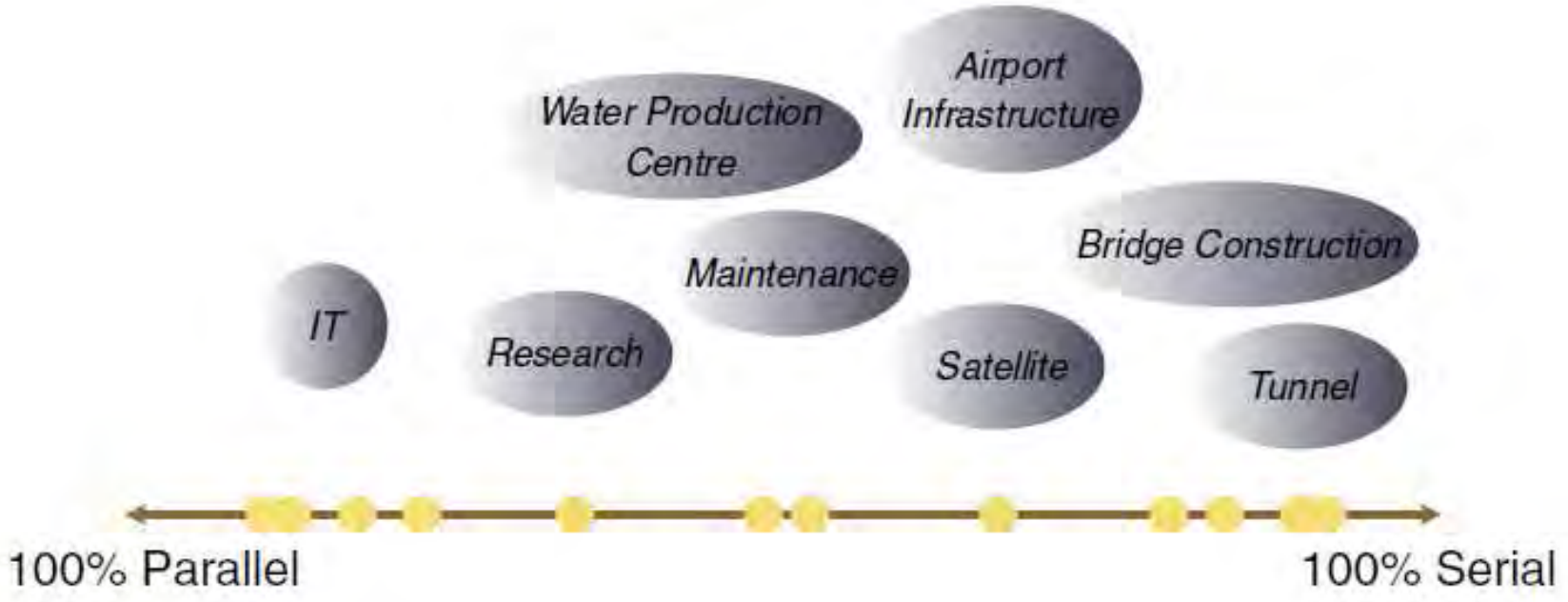


ES vs. SRA

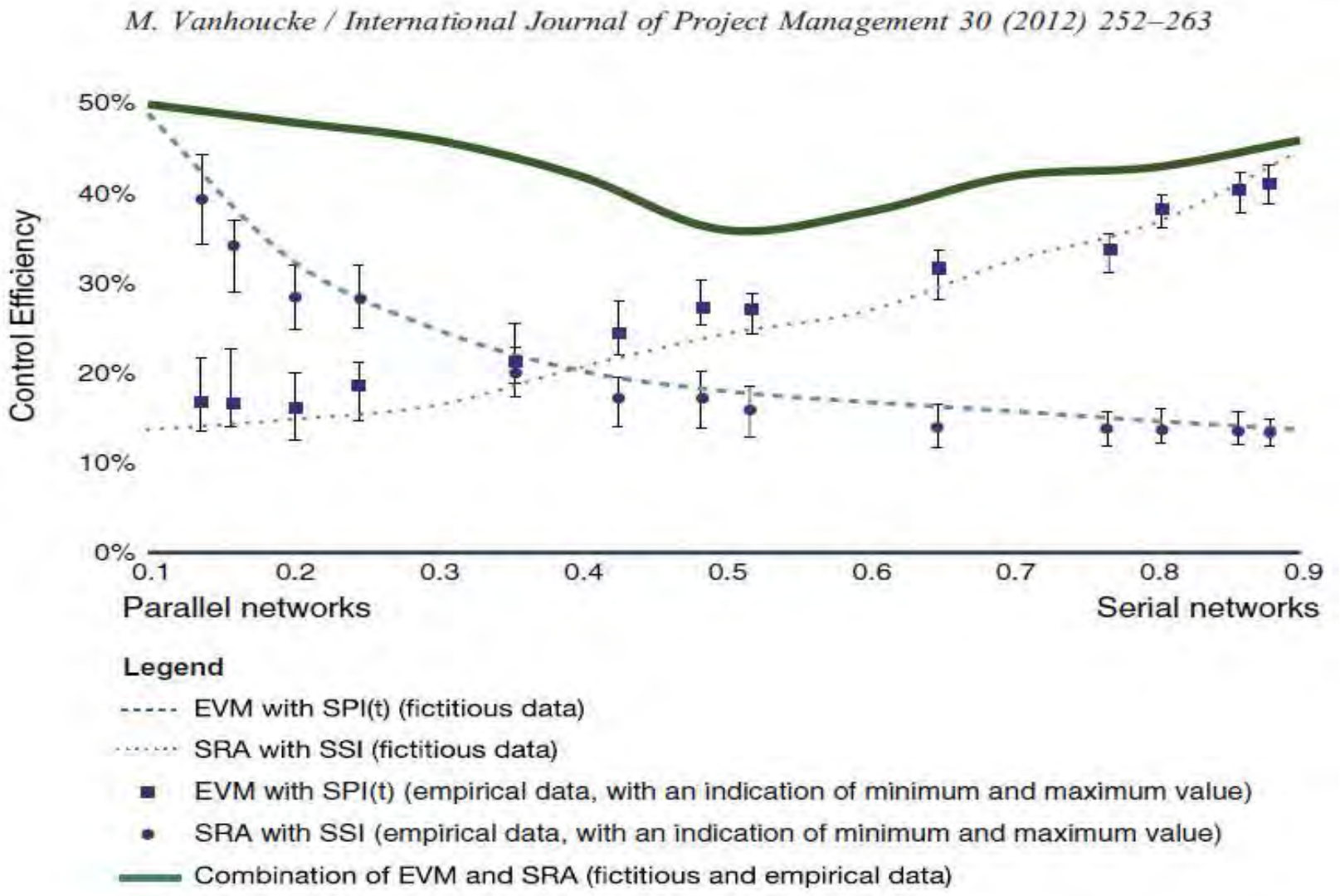

50%
40%
30%
20%
10%
0%
Control Efficiency
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Parallel networks
Serial networks
Top-down (SPI)
Top-down (SPI(t))
Bottom-up (SRA)
Combined approach

Research meets Practice

- Period 2007 – 2010: students of Ghent University collected real life data
  - 8 Belgian companies
  - 48 projects



Research meets Practice



Peer Reviewed Publications

- Vandevoorde, S. and Vanhoucke, M., 2006, “A comparison of different project duration forecasting methods using earned value metrics”, International Journal of Project Management, 24, 289-302.
- Vanhoucke, M. and Vandevoorde, S., 2007, “A simulation and evaluation of earned value metrics to forecast the project duration”, Journal of the Operational Research Society, 58, 1361–1374.
- Vanhoucke, M., 2010, “Using activity sensitivity and network topology information to monitor project time performance”, Omega - International Journal of Management Science, 38, 359-370.
- Vanhoucke, M., 2011, “On the dynamic use of project performance and schedule risk information during project tracking”, Omega - International Journal of Management Science, 39, 416-426.
- Vanhoucke, M., 2012, “Measuring the efficiency of project control using fictitious and empirical project data”, International Journal of Project Management, 30, 252-263.
- Vanhoucke, M., 2012, “Operations Research and Dynamic Scheduling: When research meets practice”, Lecture Notes in Management Science, 4, 1-8.
- Vanhoucke, M., 2013, “Integrated project controls: Using Operations Research methods to improve the efficiency of project control”, Lecture Notes in Management Science, 5, 174-175.

Other Publications

- Vanhoucke, M. and Vandevoorde, S., 2007, “Measuring the accuracy of earned value/earned schedule forecasting predictors”, The Measurable News, Winter, 26-30.
- Vanhoucke, M., 2008, “Project tracking and control: can we measure the time?”, Projects and Profits, August, 35-40.
- Vanhoucke, M. and Vandevoorde, S., 2008, “Earned value forecast accuracy and activity criticality”, The Measurable News, Summer, 13-16.
- Vanhoucke, M. and Vandevoorde, S., 2009, “Forecasting a project’s duration under various topological structures”, The Measurable News, Spring, 26-30.
- Vanhoucke, M., 2010, “Measuring Time: An earned value performance management study”, The Measurable News, 1, 10-14.
- Vanhoucke, M. and Shtub, A., 2011, “Adding value to earned value analysis ”, PM World Today, January, XIII, Issue I.
- Vanhoucke, M., 2012, “Dynamic Scheduling: Integrating Schedule Risk Analysis with Earned Value Management”, The Measurable News, 2, 11-13.
- Vanhoucke, M., 2013, “Project Management using dynamic scheduling: Baseline scheduling, risk analysis and project control”, The Measurable News, 2, 45-50.

Other Publications

National publications

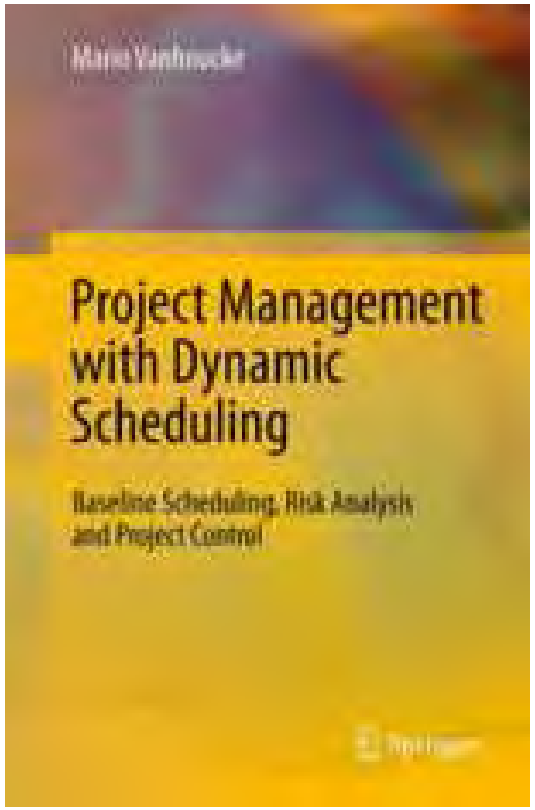
- Vanhoucke, M., 2006, "Waarschuwingssystemen: veel te vroeg of net te laat?", Inleiding hoofdstuk "Technologie, productie en informatica", Management Jaarboek, 121-124.
- Vanhoucke, M. and Vandevoorde, S., 2006, “Waar zit het tijdsaspect in een ‘earned value’-meetsysteem?”, Management Jaarboek, 131-137.

Book chapters

- Vanhoucke, M., 2009, “Static and dynamic determinants of earned value based time forecast accuracy”, in: Handbook of Research on Technology Management’s Planning and Operations, 361-374

Books Published

2009 (ISBN 978-1-4419-1013-4)



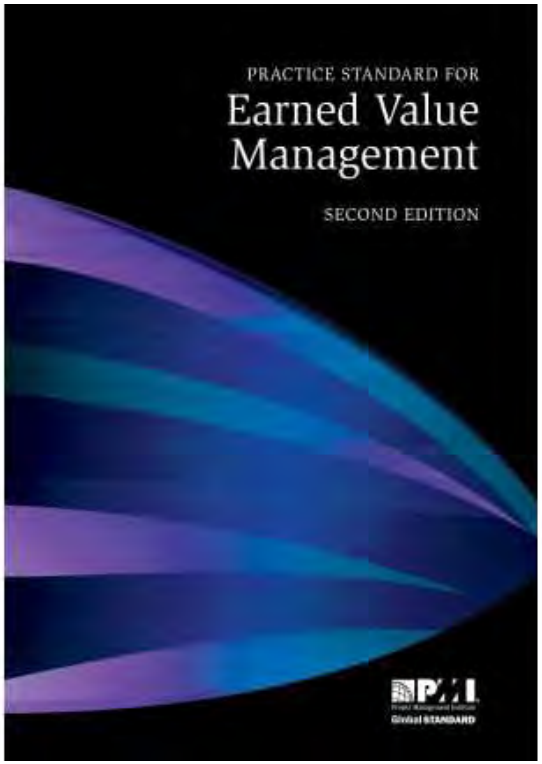
2012 (ISBN 978-3-642-25174-0)

EVA CONFERENCE - November 24-25, 2010
The second annual earned value analysis conference for Europe

eva europe GHENT 2010

PMI Practice Standard for Earned Value Management; Second Edition Update Project

J. Greg Smith



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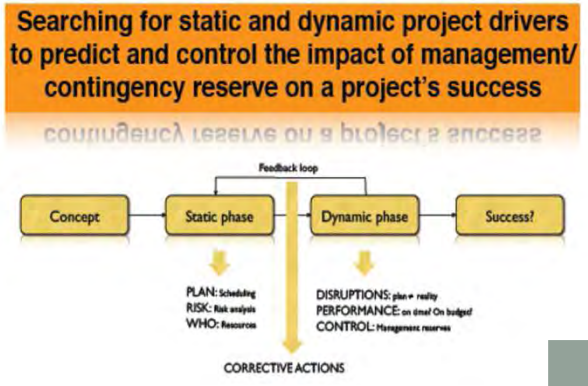
CRA Award Flemish Government



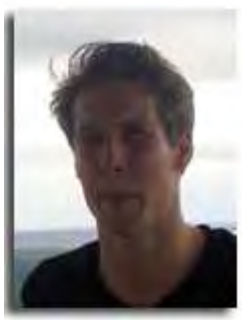
Awarded in 2011

Budget: > 1.200.000 €

Timespan: 2012 – 2018

8 Researchers

CRA: The Team in 2013









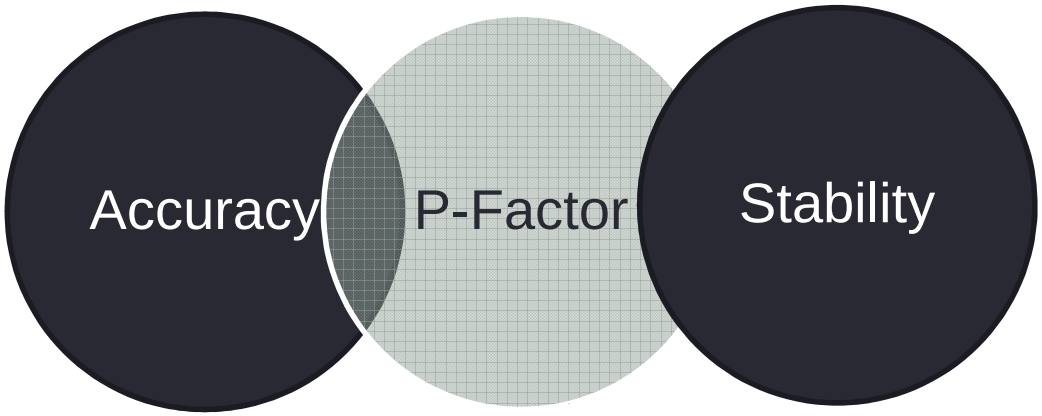
CRA: The Toys

- High Performance Computing system (HPC)
- Biggest supercomputer in Belgium
- Rank 118 (Top500 list of June2012)

- Data size typical similation run: > 1 TB (ca. 1.450 CD's)

Focus 1: Continue “Measuring Time”

- Extending / improving forecasting methods
- Studying schedule adherence (P-Factor)
- Studying forecast quality

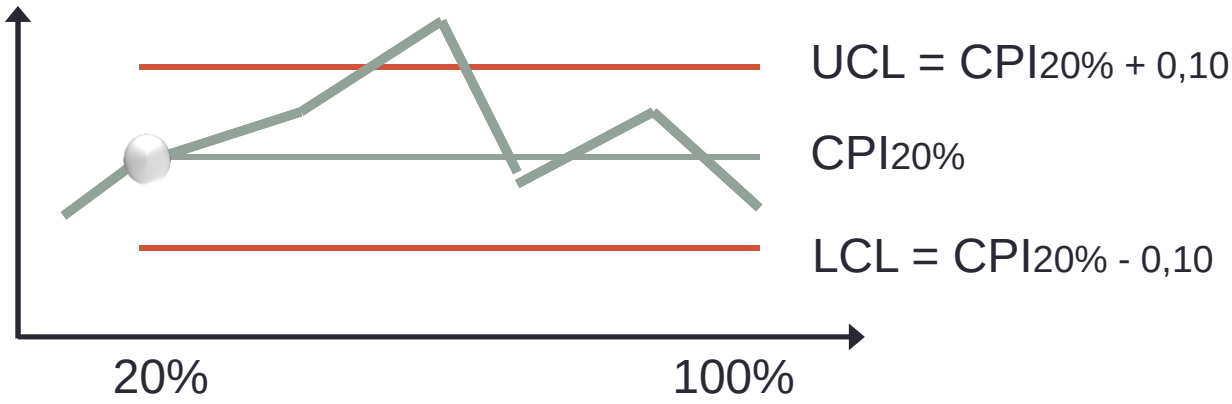


- Stability: how to define thresholds for measuring stability??

Defining Stability - Thresholds

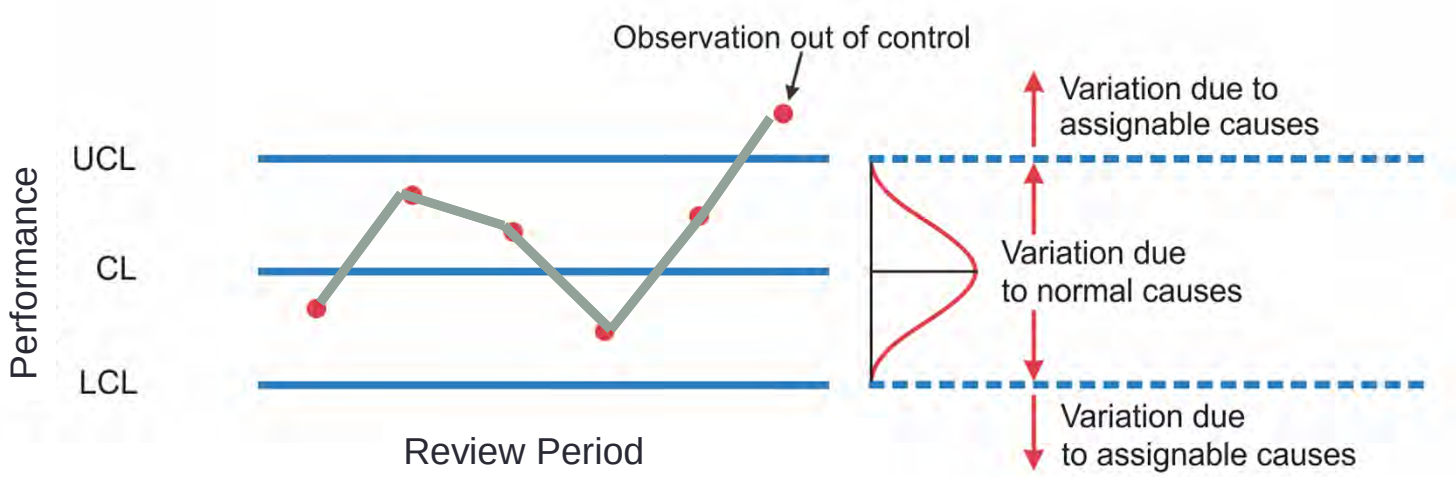
- The “American” way:
  - Emperical finding by studying D.O.D. Contracts (1990-2000)
  - Finding generalised to “all projects” (without proof)

$$\left| CPI_{final} - CPI_{20\%} \right| \leq 0{,}10$$



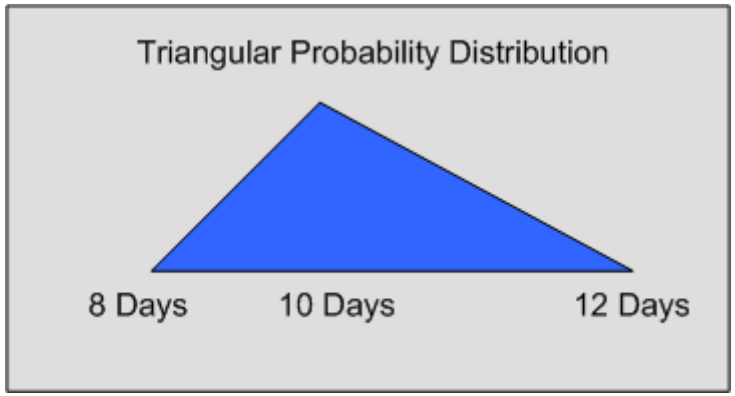
Defining Stability - Thresholds

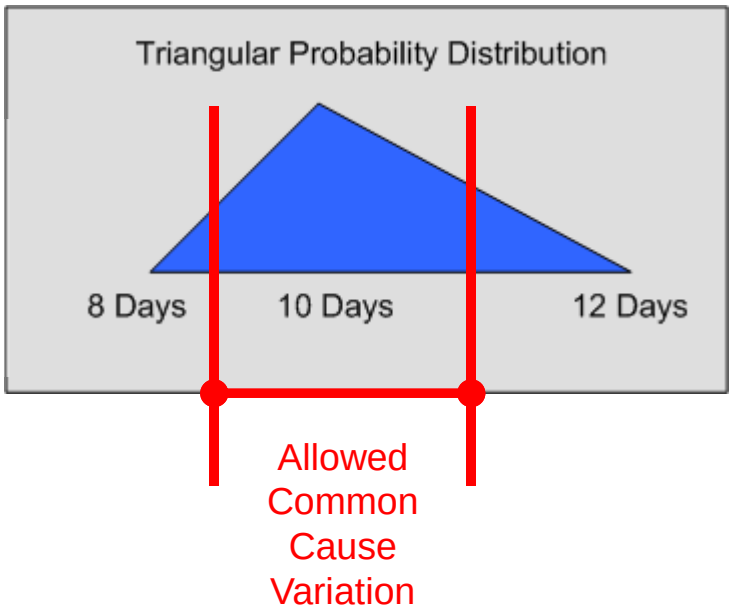
- The “Japanese” way:
  - Use of statistical process control charts
  - But:
    - Use of historical performance data (from other projects)
    - Normalised performance data needed
    - Considered factor has no correlation with other factors
    - Based on continuously processes



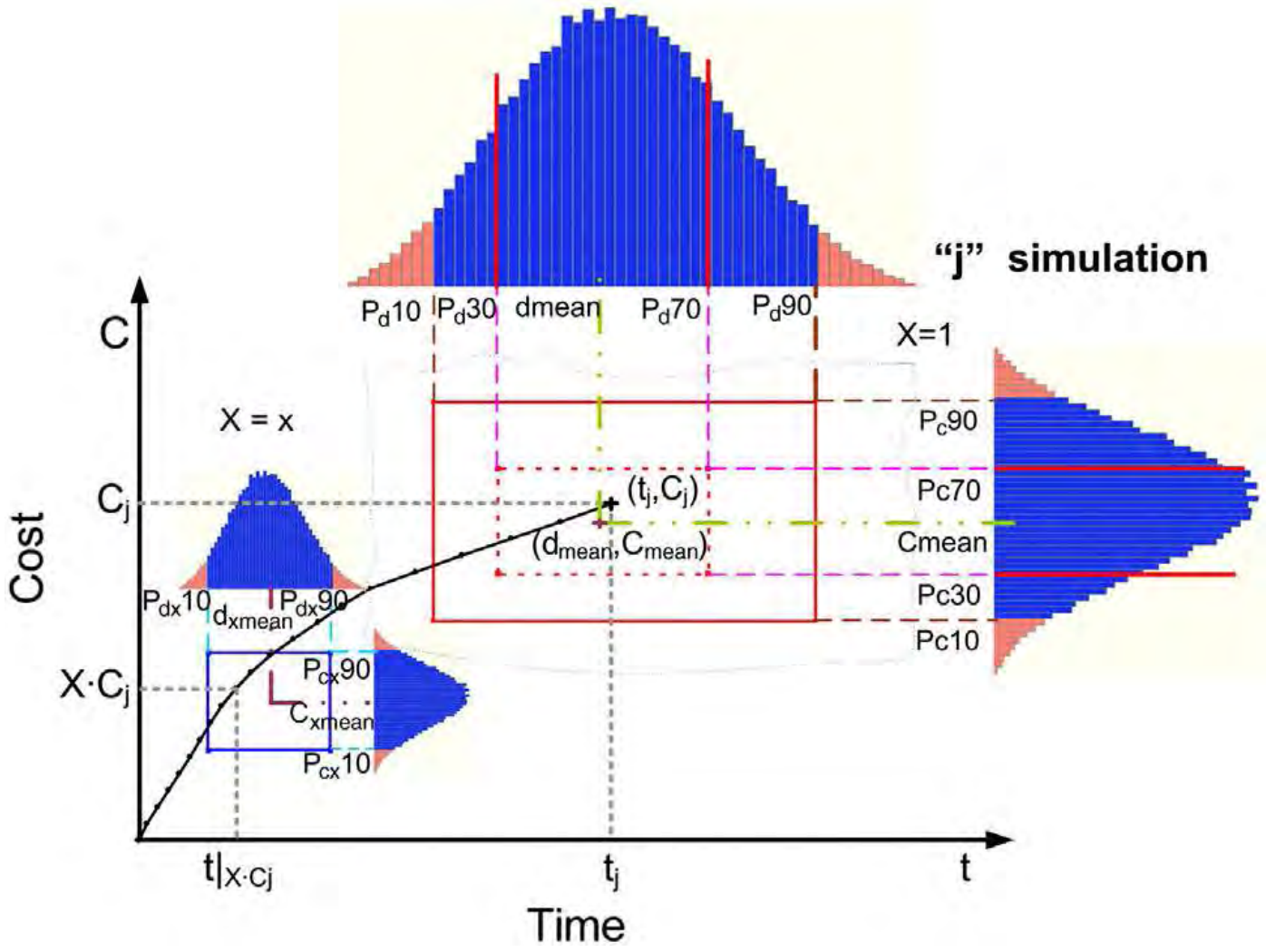
Focus 2: Statistical Project Control

- The proposed “Belgian” way: Statistical Project Control
  - Use of SRA process during planning phase to set thresholds
  - Define allowed common cause variation (natural variation)



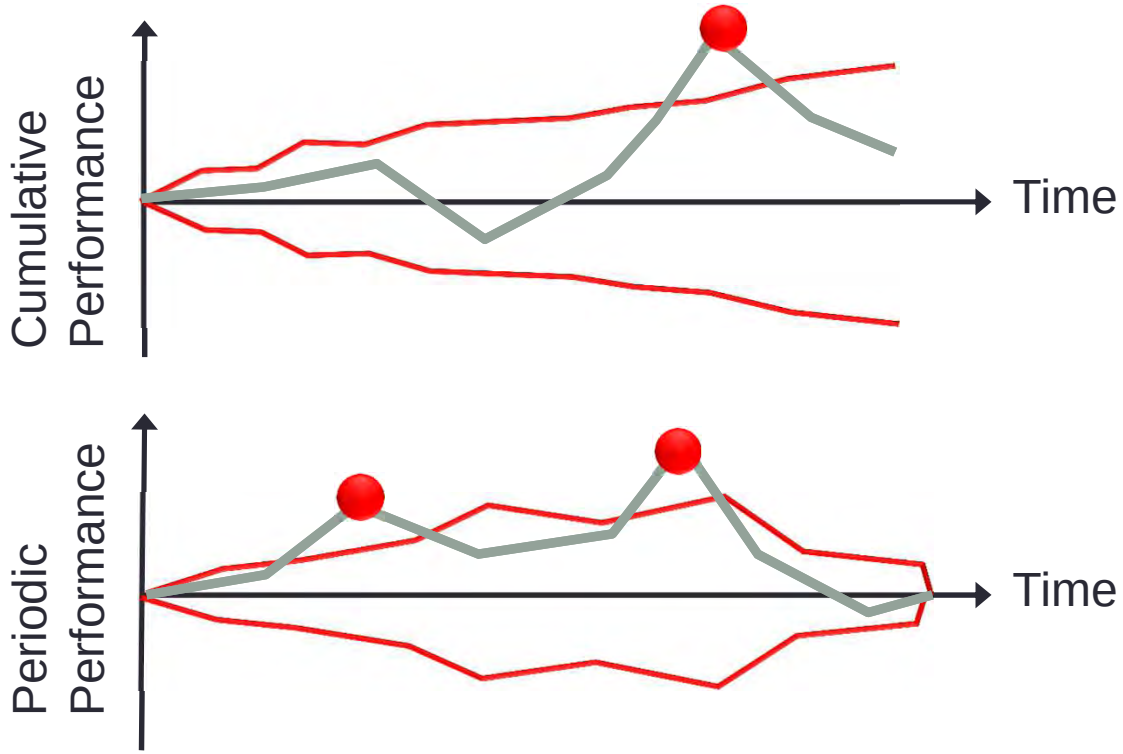


The Proposed Model



The Proposed Model

- Setting thresholds based on risk profiles



- Update thresholds during review by new simulation run
- Method which truly integrates EVM & Risk

Focus 3: Research Meets Practice

- Publish research in top academic journals
- Translate & publish & present research into practical applications
  - Ex. The Measurable News
  - EVM Europe, EVM World, ...
- We need your help:
  - “Real life data” needed
  - Any new ideas? Research suggestions?
- Ghent University Master Thesis Project Control
  - May 2014: 10 works
  - May 2015: 16 works

Stay Tuned for updates

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