CENTROALGORITMI

Universidade do Minho
Escola de Engenharia

Integration between EVM and Risk Management

Proposal of an automated framework

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Introduction

- The use of project management
  - Relatively recent;
  - Motivated by the need for rapid and effective responses to the changing business environment.
- Project monitoring and control
  - One of the components of project management with the greatest need of development;
  - Verify the state of the project during execution;
  - In case the parameters are outside the appropriate range, corrective measures can still be taken;
  - Conclude on project continuity within the parameters considered adequate.
- Risk Management
  - Another way to promote project's success;
  - Minimizing the risk of not achieving the project objectives;
  - Creating early responses to the risks that may arise.
- Earned Value Management (EVM)
  - Monitor and control project status;
  - Values estimated in the planning phase - compared with the project execution values;
  - Determine project's state;
  - Adjustments that lead to project success.

Introduction

- Goals of this research
  - Investigate the linkage between EVM and Risk Management;
  - Build a framework for integrating the two methodologies;
  - Use the framework to create project monitoring and control tools.
- Approach used
  - Similar to that proposed by the Association for Project Management (APM) [1]
  - Based on the Project Management Body of Knowledge (PMBoK®) from PMI [2] and the integration proposed by Hillson [9]
  - Using:
    - ✓ Risk stratification;
    - ✓ Different responses to each form of risk;
    - ✓ Introduction of the various risk components into the EVM methodology.

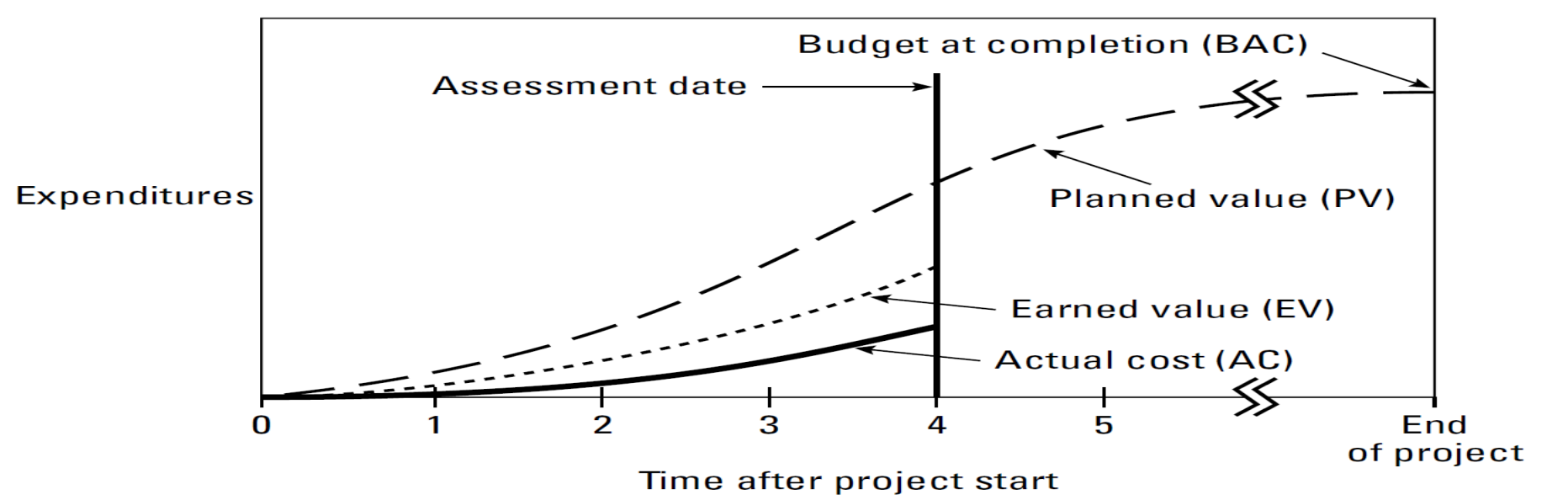
Literature Review and Main Concepts

- The unique nature of the projects creates uncertainty.
- This uncertainty generates several scenarios.
- Uncertain events or conditions may affect one or more project objectives.
- Need to make risk assessment during planning.
- In PMBoK® this area of expertise is called project risk management [2].

- When the project is already in execution, in the monitoring and control phase, it is necessary to have tools that allow the evaluation of the state of the project.
- In case of cost or time slippage, one can act and thus avoid or limit the problem.
- To do this, PMBoK® recommends to use Earned Value Management (EVM) [2].
- In EVM, project performance measured in relation to a cost baseline [3].
  - Metrics to indicate if project is ahead or behind schedule.
  - Metrics to indicate if project is spending more or less than planned.
  - Possibility to predict the total final cost of the project.

Literature Review and Main Concepts

- EVM (base variables) [2]
  - Planned Value (PV): The approved budget for the work scheduled to be completed by a specified date. Note: The total PV of a task is equal to the task's Budget At Completion (BAC).
  - Earned Value (EV): The approved budget for the work actually completed by a specified date.
  - Actual Cost (AC): The costs actually incurred for the work completed by the specified date.



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Literature Review and Main Concepts

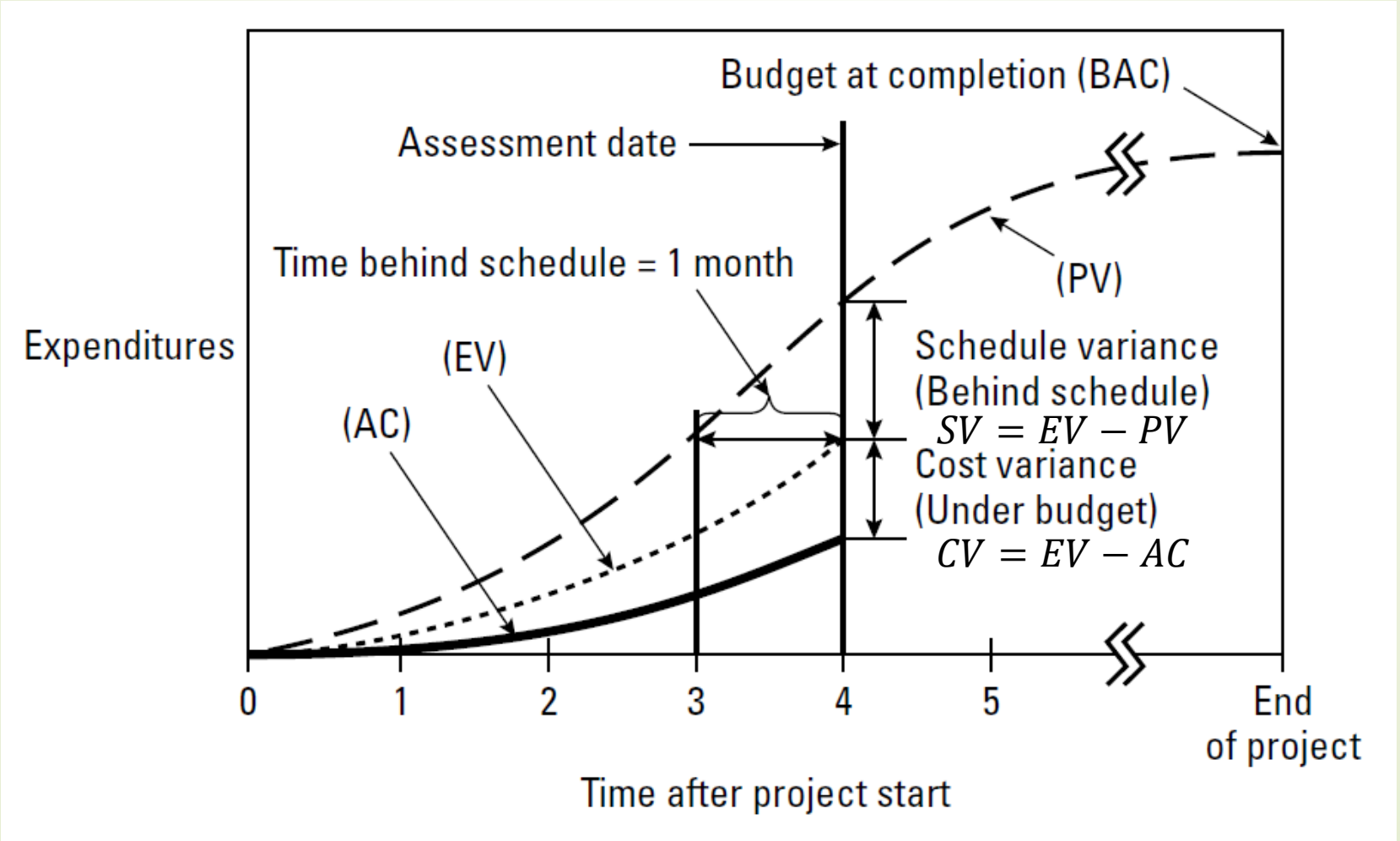
- EVM (performance indicators) [2]
  - Schedule Variance (**SV**): The difference between the amounts budgeted of the work done and the work planned.

$$Schedule\ Variance\ (SV)\ =\ Earned\ Value\ (EV)\ -\ Planned\ Value\ (PV)$$

  - Cost variance (**CV**): The difference between the amount budgeted and the amount actually spent for the work performed.

$$Cost\ Variance\ (CV)\ =\ Earned\ Value\ (EV)\ -\ Actual\ Cost\ (AC)$$

Literature Review and Main Concepts



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Literature Review and Main Concepts

- EVM (performance indicators) [2]
  - Schedule Performance Index (**SPI**): The ratio of the approved budget for the work performed to the approved budget for the work planned.

$$Schedule\ Performance\ Index\ (SPI) = \frac{Earned\ Value\ (EV)}{Planned\ Value\ (PV)}$$

  - Cost Performance Index (**CPI**): The ratio of the approved budget for work performed to what you actually spent for the work.

$$Cost\ Performance\ Index\ (CPI) = \frac{Earned\ Value\ (EV)}{Actual\ Cost\ (AC)}$$

Literature Review and Main Concepts

- EVM (performance indicators) [5,50]

$$SV = EV - PV \qquad CV = EV - AC$$

Interpretations of Cost and Schedule Variances			
Variance	***Negative***	***Zero***	***Positive***
Schedule	Behind schedule	On schedule	Ahead of schedule
Cost	Over budget	On budget	Under budget

$$SPI = {}^{EV}/_{PV} \qquad CPI = {}^{EV}/_{AC}$$

Interpretations of Cost and Schedule Performance Indicators			
Index	***Less than 1.0***	***1.0***	***Greater than 1.0***
Schedule	Behind schedule	On schedule	Ahead of schedule
Cost	Over budget	On budget	Under budget

Literature Review and Main Concepts

- Both PV and EV are based on the Performance Measurement Baseline (PMB), which is built from the Work Breakdown Structure (WBS) and its schedule in the planning phase.
- This plan, with the budget based on the work packages per month, can be used to measure project performance.

Project	WBS		Budget	Jan	Feb	Mar	Apr	Mai	Jun	Jul	Ago	Sep	Oct	Nov	Dec
	Phase 1														
	1.1	Work package 1	20	5	15										
	1.2	Work package 2	40		30	10									
	1.3	Work package 3	60			10	20	15	15						
	Phase 2														
	2.1	Work package 1	20							16	4				
	2.2	Work package 2	35						6	7	5	7	6	2	2
TOTAL			**175**	5	45	20	20	15	21	23	9	7	6	2	2
Cumulative				5	50	70	90	105	126	149	158	165	171	173	175

PBM - Performance Measurement Baseline

Literature Review and Main Concepts

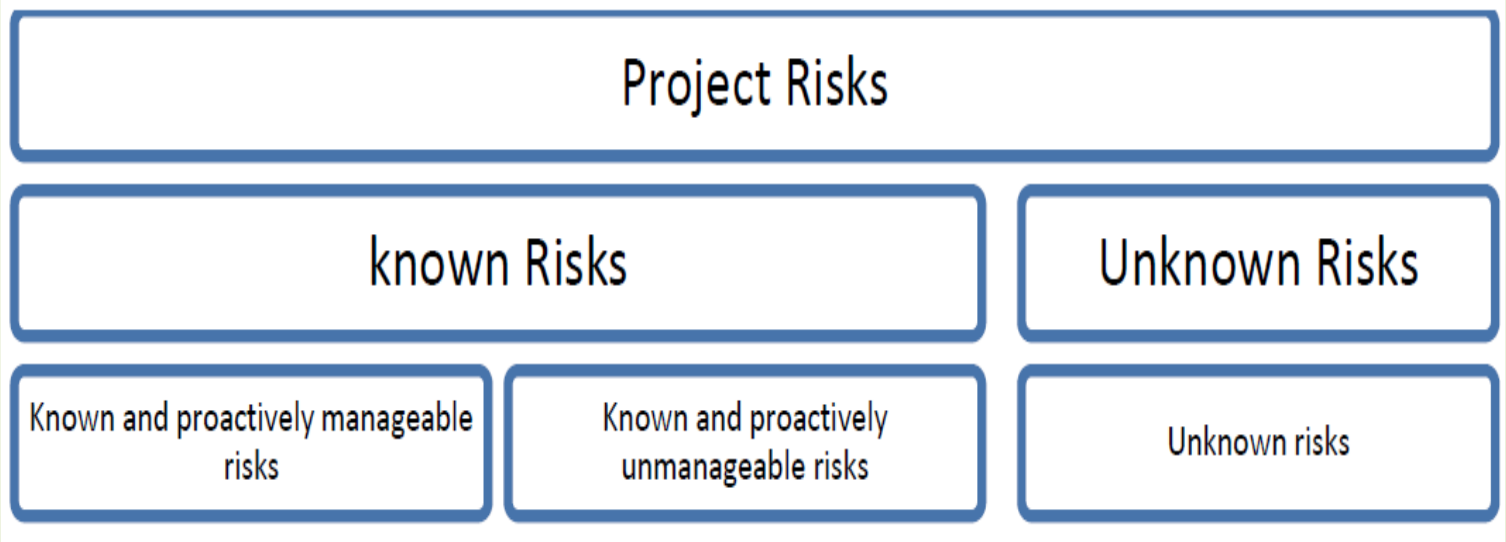
- It is also necessary to have a technique that matches the physical progress of the work [4].

Project	WBS		Budget	% Complete	Earned Value
	Phase 1				
	1.1	Work package 1	20	100%	20
	1.2	Work package 2	40	100%	40
	1.3	Work package 3	60	100%	60
	Phase 2				
	2.1	Work package 1	20	80%	16
	2.2	Work package 2	35	60%	21
TOTAL			**175**		**157**

Physical progress of work by the end of July

EVM and Risk Management Integration Model Developed

- Based on the approach of EVM to Risk management presented in PMBoK® [2], Practice Standard for Earned Value Management [5] and Practice Standard for Project Risk Management [6], the different types of risks were summarized.



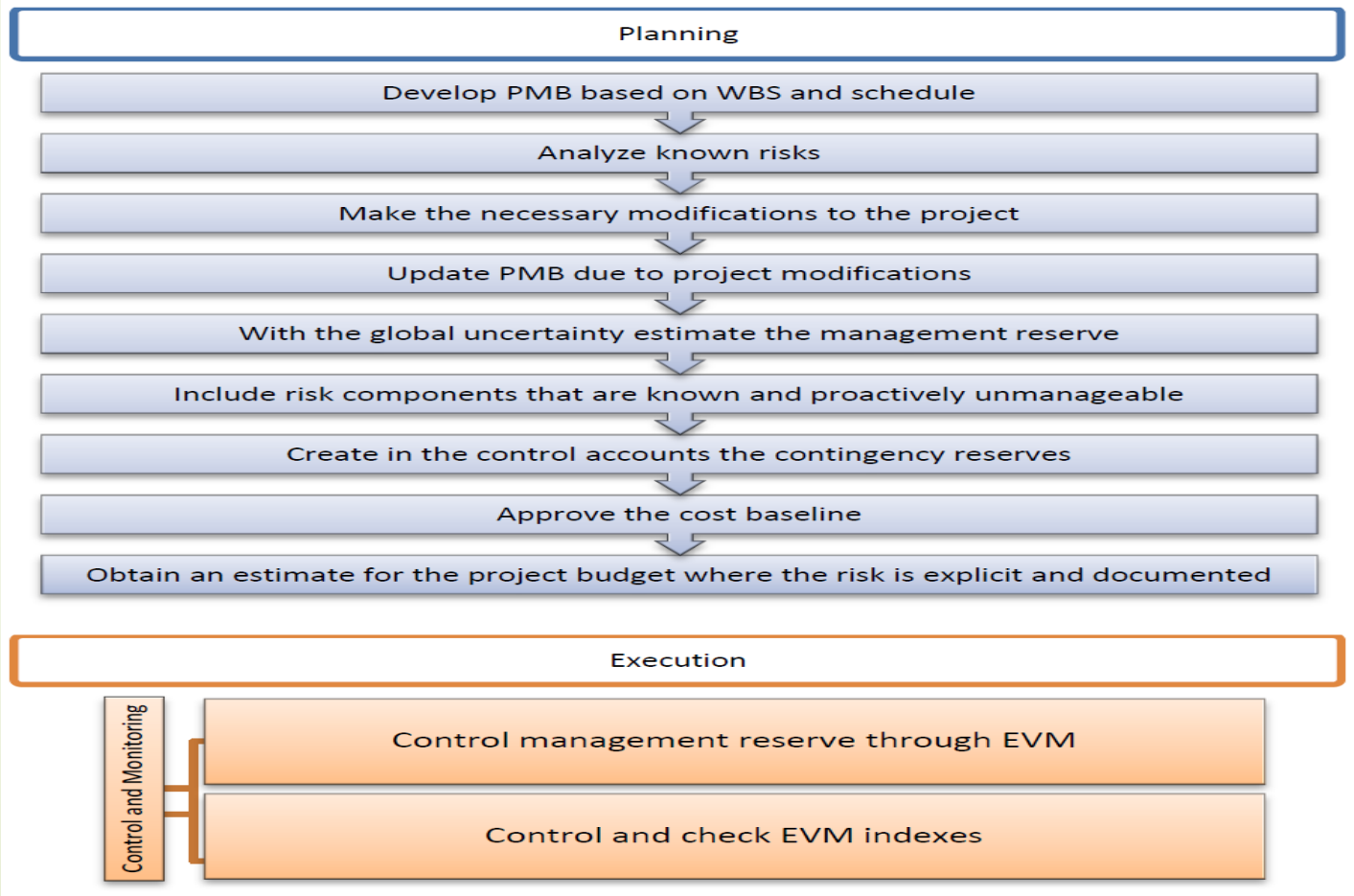
Summary of project risks

EVM and Risk Management Integration Model Developed

- Steps to deal with the known and proactively manageable risks:
  - Risks identification, characterization and documentation.
  - Qualitative analysis (probabilities and impact on project objectives, prioritization of risks).
  - Develop responses (avoiding, transferring, mitigating or accepting the risk).
- Avoiding, transferring, and mitigating cause cost and time project changes.
- Project changes brought about by the qualitative analysis translate into a more realistic Cost Baseline and therefore better EVM indices.
- Known and proactively unmanageable risks - no way to treat them (impossible to eliminate / the risk has been accepted).
- This type of risk is guaranteed by a contingency reserve.
- EVM indexes are corrected only in case the risk occurs.
- Unknown risks - unspecified project uncertainty - management reserve.

EVM and Risk Management Integration Model Developed

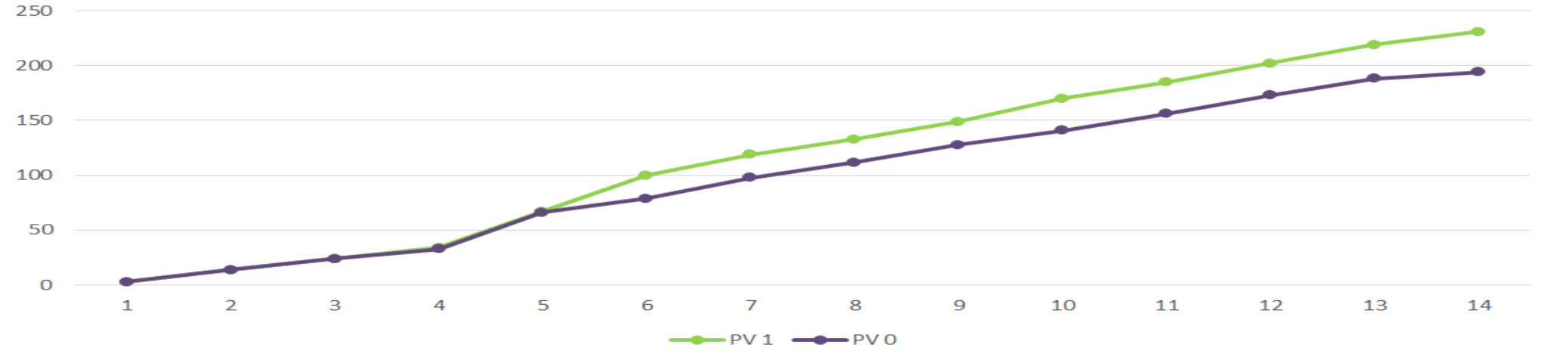
- EVM and Risk Management Integration Framework:



Prototype for Project Monitoring and Control Support

Example of a PMB with cumulative Planned Value (PV)

WBS	Budget	Start	Finish	Duration	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Work package 1	17	1	4	4	3	6	7	1										
Work package 2	47	2	6	5		5	3	9	10	20								
Work package 3	40	5	7	3					20	10	10							
Work package 4	3	8	8	1								3						
Work package 5	25	7	10	4							4	5	8	8				
Work package 6	62	5	13	9					3	3	5	6	8	9	8	10	10	
Work package 7	37	10	14	5										4	7	7	7	12
Total	231				3	11	10	10	33	33	19	14	16	21	15	17	17	12
	Cumulative			PV 1	3	14	24	34	67	100	119	133	149	170	185	202	219	231
				PV 0	3	14	24	33	66	79	98	112	128	141	156	173	188	194

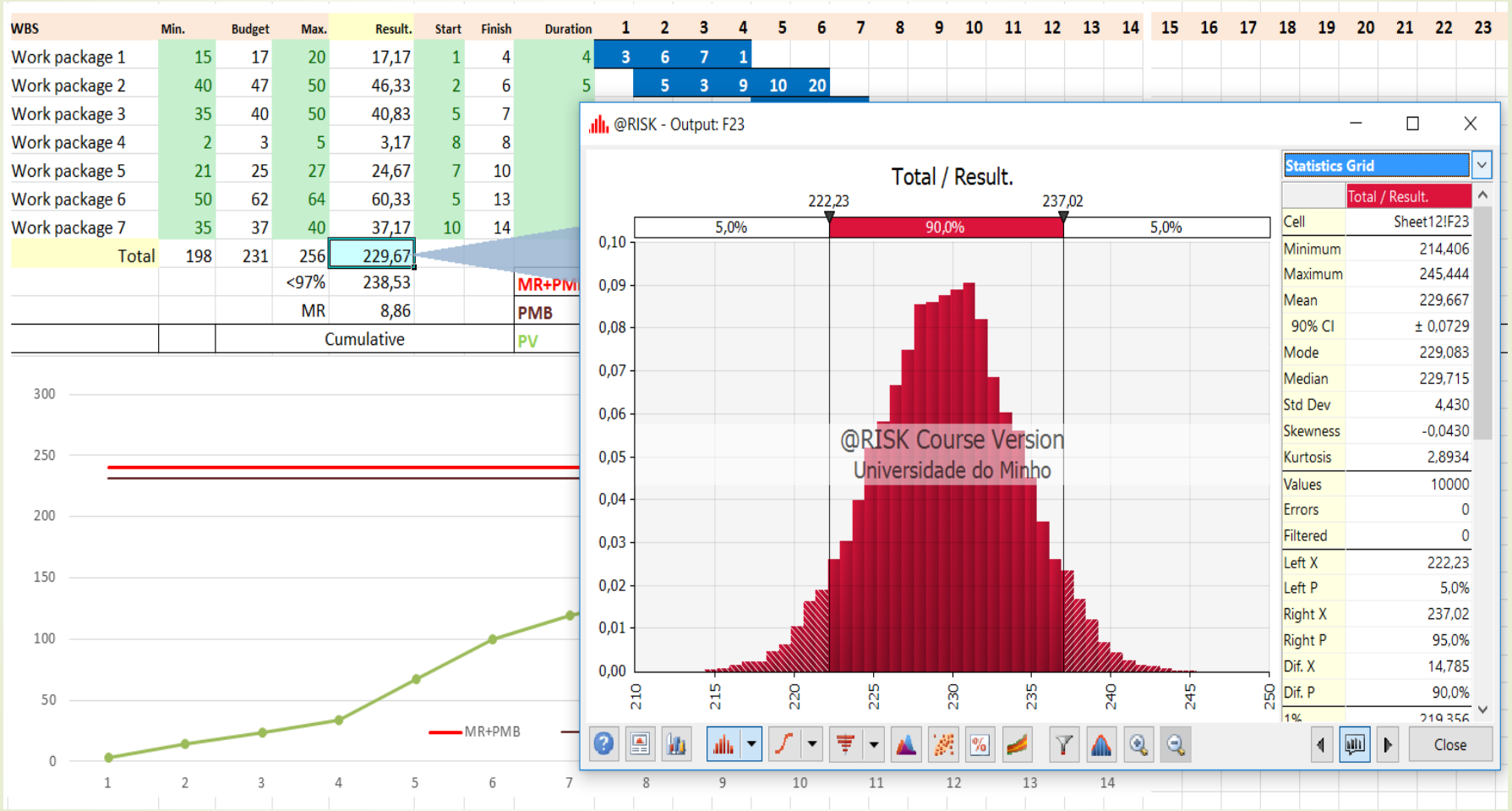


- PV 0 - initial version before the risk analysis
- PV 1 - final approved version after risk analysis

Prototype for Project Monitoring and Control Support

- To estimate the final value of the project, taking into account the uncertainty, we can construct a table with probabilistic distributions associated to cost values.
- Using Monte Carlo simulation [7] with the cost model, we can obtain a probabilistic distribution of the possible cost results for the project.
- For this purpose we used @Risk, an add-in for Microsoft Excel from Palisade Corporation.
- The three point estimation technique of PERT (Program Evaluation and Review Technique) was used to improve the accuracy of the estimates for the costs of the activities [8].
- The management reserve is the amount added to the total project budget to respond to the overall project risk and therefore should be dependent on uncertainty.
- The management reserve was estimated from the 3 point technique in conjunction with the Monte Carlo simulation.

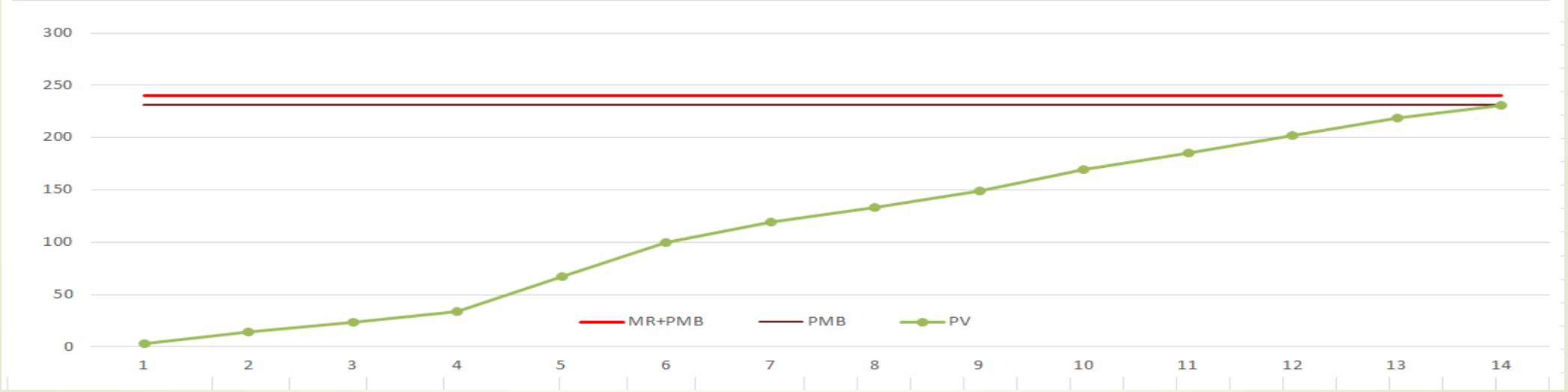
Prototype for Project Monitoring and Control Support



Distribution obtained with the Monte Carlo simulation

Prototype for Project Monitoring and Control Support

WBS	Min.	Budget	Max.	Result.	Start	Finish	Duration	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Work package 1	15	17	20	17,17	1	4	4	3	6	7	1										
Work package 2	40	47	50	46,33	2	6	5		5	3	9	10	20								
Work package 3	35	40	50	40,83	5	7	3					20	10	10							
Work package 4	2	3	5	3,17	8	8	1								3						
Work package 5	21	25	27	24,67	7	10	4							4	5	8	8				
Work package 6	50	62	64	60,33	5	13	9					3	3	5	6	8	9	8	10	10	
Work package 7	35	37	40	37,17	10	14	5										4	7	7	7	12
Total	198	231	256	229,67				3	11	10	10	33	33	19	14	16	21	15	17	17	12
			<97%	238,54			MR+PMB	240	240	240	240	240	240	240	240	240	240	240	240	240	240
			MR	8,87			PMB	231	231	231	231	231	231	231	231	231	231	231	231	231	231
		Cumulative					PV	3	14	24	34	67	100	119	133	149	170	185	202	219	231



Management Reserve and PMB

Prototype for Project Monitoring and Control Support

- Risks identified and not treated proactively are guaranteed by a contingency reserve.

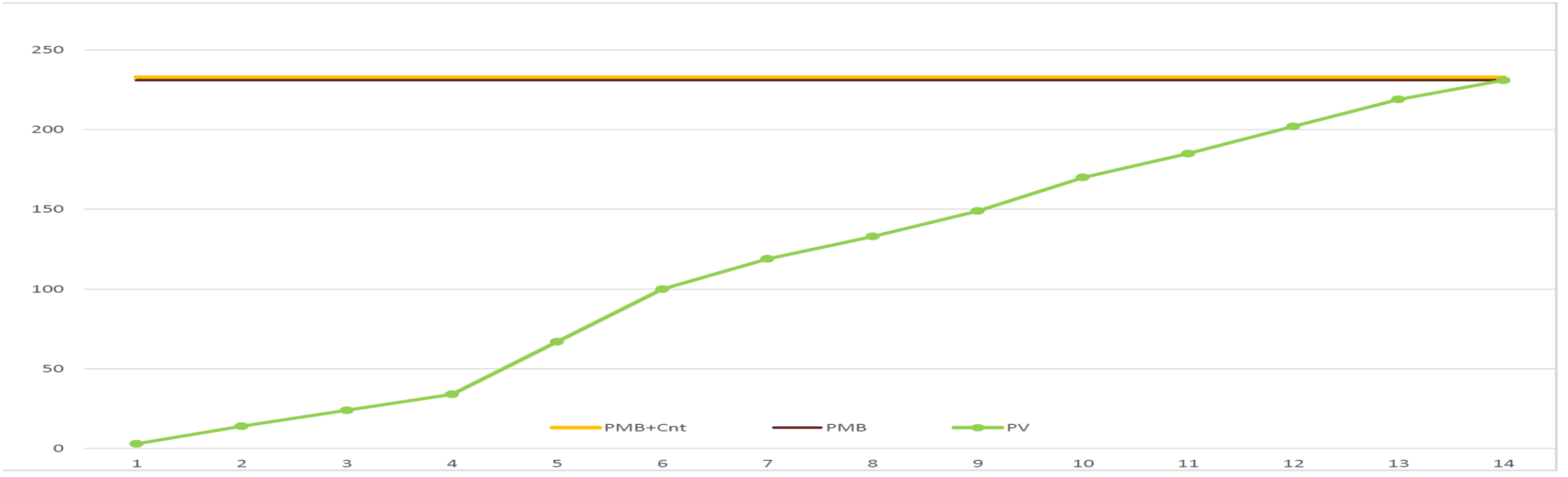
		Risk1			Risk2			Risk3		
WBS	Total	Cost	Prob.	Exp. Cost	Cost	Prob.	Exp. Cost	Cost	Prob.	Exp. Cost
Work package 1	1	10	0,1	1			0			0
Work package 2	0			0			0			0
Work package 3	0			0			0			0
Work package 4	0			0			0			0
Work package 5	0			0			0			0
Work package 6	1			0	5	0,2	1			0
Work package 7	0			0			0			0

Risk exposure table

Prototype for Project Monitoring and Control Support

WBS	Budget	Risk Exp.	Start	Finish	Duration	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Work package 1	17	1,00	1	4	4	3	6	7	1										
Work package 2	47	0,00	2	6	5		5	3	9	10	20								
Work package 3	40	0,00	5	7	3					20	10	10							
Work package 4	3	0,00	8	8	1								3						
Work package 5	25	0,00	7	10	4							4	5	8	8				
Work package 6	62	1,00	5	13	9					3	3	5	6	8	9	8	10	10	
Work package 7	37	0,00	10	14	5										4	7	7	7	12
Contingency		2,00																	
Total	231					3	11	10	10	33	33	19	14	16	21	15	17	17	12

		Total	PMB+Cnt	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233	233
		Total	PMB	231	231	231	231	231	231	231	231	231	231	231	231	231	231	231	231
	Cumulative		PV	3	14	24	34	67	100	119	133	149	170	185	202	219	231		



Risks included on the PMB

Conclusions

- The objective of this work was the proposal of a framework to support the monitoring and control of projects, based on the integration of EVM with Risk management.
- The proposed integration is based on the EVM methodology, risk stratification and a risk management methodology.
- Because EVM is based on the comparison of project execution values with planned values, introducing risk management, we get an EVM with more monitoring and control capabilities.
- Risk is recorded as one of the variables on which EVM depends.
- So the correction of the EVM performance indexes introduced by the risk management increase the quality on the information provided.

Future Research

- Because EVM is dependent on other components of project management, such as WBS, timeline, cost accounting methods, a more advanced framework could include these components.
- The same can be said of risk management, where for example the analysis of known risks requires a well-developed qualitative treatment.
- In the prototype presented, the costs and schedule are manually placed on the PMB page. One possibility of extension would be its interconnection with commercial software, such as MS Project.
- Finally, in the current model, only the influences of the risk in cost were considered, but the time or schedule is also influenced. A natural extension would be the inclusion of time in the framework.

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Cost Variance

Schedule Variance

Schedule Performance Index

Project's success EVM

Automated Framework

Monitor and Control Project

APM

Actual Cost

Risk Management

Earned Value Planned Value

PMBoK

Cost Performance Index

Integration

Thank you!