BUFFER MANAGEMENT METHODS
FOR PROJECT CONTROL

ANNELIES MARTENS

5 JUNE 2018
» INTRODUCTION

» STUDY 1

» STUDY 2

» STUDY 3

» STUDY 4

» CONCLUSIONS
» INTRODUCTION

» STUDY 1

» STUDY 2

» STUDY 3

» STUDY 4

» CONCLUSIONS
CHAPTER 1 - INTRODUCTION

ORAS - OPERATIONS RESEARCH & SCHEDULING RESEARCH GROUP

MARIO VANHOUCKE

RESEARCH TOPICS
» project management
» project planning
» project control
» contracting

RESEARCH AWARDS
» Research Collaboration Fund Award (2007) - PMI Belgium
» IPMA Research Award (2008) - IPMA

THE TEAM

PhDs
» 10 PhDs
» recent defense (18/05) → postdoc

PMI BELGIUM CHAPTER
CHAPTER 1 - INTRODUCTION

Dynamic Scheduling

Baseline Scheduling

Risk Analysis

Project control
CHAPTER 1 - INTRODUCTION
CHAPTER 1 - INTRODUCTION

PROJECT START

- foundations
- masonry
- roof
- doors and windows
- electricity and plumbing
- plastering works
- floors
- finishing works

PLANNED FINISH

Dynamic Scheduling
Baseline Scheduling
Project Control
Risk Analysis

GHENT UNIVERSITY

BELGIUM CHAPTER
CHAPTER 1 - INTRODUCTION

Dynamic Scheduling
Baseline Scheduling
Project Control
Risk Analysis

PROJECT START

PLANNED FINISH

time
CHAPTER 1 - INTRODUCTION

Dynamic Scheduling
Baseline Scheduling
Project Control

Risk Analysis

PROJECT START

PLANNED FINISH

HEAVY RAIN

time
CHAPTER 1 - INTRODUCTION

Dynamic Scheduling
Baseline Scheduling
Project Control

Risk Analysis

PROJECT START
HEAVY RAIN
MIS-COMMUNICATIONS
WRONG MATERIAL DELIVERY
PLANNED FINISH

time

Baseline Scheduling
Dynamic Scheduling
Project Control
CHAPTER 1 - INTRODUCTION

- Dynamic Scheduling
- Baseline Scheduling
- Project Control

Risk Analysis

PROJECT START

HEAVY RAIN

MIS-COMMUNICATIONS

WRONG MATERIAL DELIVERY

EMPLOYEE ILLNESS

PLANNED FINISH

time
CHAPTER 1 - INTRODUCTION

Dynamic Scheduling
Baseline Scheduling
Project Control

Risk Analysis

PROJECT BUFFER

PROJECT START

HEAVY RAIN

MIS-COMMUNICATIONS

WRONG MATERIAL DELIVERY

EMPLOYEE ILLNESS

PLANNED FINISH

DEADLINE

time
CHAPTER 1 - INTRODUCTION
CHAPTER 1 - INTRODUCTION

Dynamic Scheduling
Baseline Scheduling
Project Control

PROJECT START

PLANED FINISH
DEADLINE

PROJECT BUFFER

Risk Analysis

Baseline Scheduling

Dynamic Scheduling

PROJECT CONTROL
CHAPTER 1 - INTRODUCTION

Dynamic Scheduling
Baseline Scheduling
Project Control

PROJECT START

PROJECT BUFFER
PLANNED FINISH
DEADLINE

Risk Analysis
Baseline Scheduling
Dynamic Scheduling
Project Control

time
Chapter 1 - Introduction

Dynamic Scheduling
Baseline Scheduling
Project Control

Project Start
Planned Finish
Deadline

Risk Analysis

Buffer

Time
CHAPTER 1 - INTRODUCTION

Dynamic Scheduling
Baseline Scheduling
Project Control

Risk Analysis

PROJECT START

PLANNED FINISH

DEADLINE

PROJECT BUFFER

time
CHAPTER 1 - INTRODUCTION

Dynamic Scheduling
Baseline Scheduling
Project Control

PROJECT START

PLANNED FINISH

DEADLINE

PROJECT BUFFER

time

Risk Analysis
Baseline Scheduling
CHAPTER 1 - INTRODUCTION

Dynamic Scheduling
Baseline Scheduling
Project Control

PROJECT START

PLANNED FINISH

DEADLINE

PROJECT BUFFER

time

Risk Analysis
CHAPTER 1 - INTRODUCTION
CHAPTER 1 - INTRODUCTION
CHAPTER 1 - INTRODUCTION

MEASURE  EVALUATE
CHAPTER 1 - INTRODUCTION

MEASURE

EVALUATE

TAKE ACTION
CHAPTER 1 - INTRODUCTION

EARNED VALUE MANAGEMENT (EVM)
» progress at the project level
» in terms of planned value (PV), earned value (EV) and actual costs (AC)
» time and cost performance metrics: SPI = EV/PV
  » SPI = 1: schedule progress as planned (EV = PV)
  » SPI < 1: behind schedule (EV < PV)
  » SPI > 1: ahead of schedule (EV > PV)
Chapter 1 - Introduction

Tolerance Limits for Project Control

» thresholds for the performance metrics (for instance SPI)
» warning signals when performance metric is below the threshold
CHAPTER 1 - INTRODUCTION

**TOLERANCE LIMITS FOR PROJECT CONTROL**

- thresholds for the performance metrics (for instance SPI)
- warning signals when performance metric is below the threshold
- different types:
  - *static tolerance limits*: rules of thumb
  - *statistical tolerance limits*: require historical data / Monte Carlo simulations
  - *analytical tolerance limits*: require project-specific information
Chapter 1 - Introduction

**Corrective Actions**
- when warning signals are generated
- actions to get the project back on track
  - *activity crashing*
  - *fast tracking*
  - *variability reducing*
- require managerial effort (time, money, resources…)
CHAPTER 1 - INTRODUCTION

BUFFER MANAGEMENT METHODS FOR PROJECT CONTROL
CHAPTER 1 - INTRODUCTION

BUFFER MANAGEMENT METHODS FOR PROJECT CONTROL

» Earned Value Management:
  monitor progress during execution

» Tolerance limits:
  generate warning signals

» Corrective actions:
  get the project back on track
CHAPTER 1 - INTRODUCTION

BUFFER MANAGEMENT METHODS FOR PROJECT CONTROL

» Project buffer: protect deadline against delays
» Focus on buffer consumption during execution

» Earned Value Management:
  monitor progress during execution

» Tolerance limits:
  generate warning signals

» Corrective actions:
  get the project back on track
CHAPTER 1 - INTRODUCTION

BUFFER MANAGEMENT METHODS FOR PROJECT CONTROL

» Project buffer: protect deadline against delays
» Focus on buffer consumption during execution

» Earned Value Management: monitor progress during execution
» Tolerance limits: generate warning signals
» Corrective actions: get the project back on track

» RQ₁. Progress evaluation: analytical tolerance limits for buffer consumption
» RQ₂. Corrective action taking: integration of analytical tolerance limits and corrective actions to achieve timely project completion
CHAPTER 1 - INTRODUCTION

RQ$_1$: Progress evaluation

Chapter 2

integration of project monitoring and control

Chapter 3

integration of constrained resources

Chapter 4

empirical validation/risk integration

empirical validation

Chapter 5

RQ$_2$: Corrective action taking
CHAPTER 2

RQ₁: Progress evaluation

integration of constrained resources
empirical validation/
risk integration

empirical validation

Chapter 2

integration of project monitoring and control

Chapter 3

empirical validation

Chapter 4

Chapter 5

RQ₂: Corrective action taking

empirical validation
CHAPTER 2

GOAL Generate warning signals during project execution when deadline is expected to be exceeded
CHAPTER 2

GOAL Generate warning signals during project execution when deadline is expected to be exceeded

» correct warning signal: warning signal for project that finishes late
» false warning signal: warning signal for project that finishes early or on time
CHAPTER 2

**Goal** Generate warning signals during project execution when deadline is expected to be exceeded

- **Correct warning signal**: warning signal for project that finishes late
- **False warning signal**: warning signal for project that finishes early or on time

- **Efficiency**: probability that a project will finish late when warning signals are generated
- **Reliability**: probability that a project will finish on time when no warning signals are generated
CHAPTER 2

GOAL  Generate warning signals during project execution when deadline is expected to be exceeded
CHAPTER 2

**GOAL**  Generate warning signals during project execution when deadline is expected to be exceeded

**APPROACH**  Construction of analytical tolerance limits for the buffer consumption using a cost perspective
CHAPTER 2

GOAL  Generate warning signals during project execution when deadline is expected to be exceeded

APPROACH  Construction of analytical tolerance limits for the buffer consumption using a cost perspective
**Goal** Generate warning signals during project execution when deadline is expected to be exceeded

**Approach** Construction of [analytical tolerance limits](#) for the buffer consumption using a [cost perspective](#)
CHAPTER 2

GOAL  Generate warning signals during project execution when deadline is expected to be exceeded

APPROACH  Construction of *analytical tolerance limits* for the buffer consumption using a *cost perspective*
CHAPTER 2

GOAL  Generate warning signals during project execution when deadline is expected to be exceeded

APPROACH  Construction of analytical tolerance limits for the buffer consumption using a cost perspective

VALIDATION  Monte Carlo simulation
   » scenario analysis
   » sensitivity analysis

RESULTS  Equal reliability
          Improved efficiency: especially for parallel projects
INTRODUCTION

STUDY 1

STUDY 2

STUDY 3

STUDY 4

CONCLUSIONS
Chapter 3

RQ₁: Progress evaluation

Chapter 2
- Integration of project monitoring and control
- Integration of constrained resources
- Empirical validation/ risk integration

Chapter 3

Chapter 4
- Empirical validation

Chapter 5

RQ₂: Corrective action taking
CHAPTER 3

**GOAL**  Improve the efficiency and reliability of ATLs by considering a resource perspective

**APPROACH**  » focus on activity work content instead of activity cost
  » focus on *shiftability* of the project phases
CHAPTER 3

GOAL  Improve the efficiency and reliability of ATLs by considering a resource perspective

APPROACH  » focus on activity work content instead of activity cost
          » focus on *shiftability* of the project phases

VALIDATION  Monte Carlo simulation
          » impact of execution policies
          » impact of SP and RC

RESULTS  Improved efficiency compared to cost limits
          Especially for projects with a substantial *shiftability*
Chapter 4

RQ₁: Progress evaluation

Chapter 2 → Chapter 3
- integration of constrained resources
- empirical validation

Chapter 2 → Chapter 4
- empirical validation
- risk integration

Chapter 2 → Chapter 5
- integration of project monitoring and control

RQ₂: Corrective action taking
CHAPTER 4

GOAL
» Improve the efficiency and reliability of ATLs by considering a risk perspective
» Empirical validation of time, cost, resource and risk limits

APPROACH
Focus on activity risk level

VALIDATION
Empirical database (Batselier & Vanhoucke, 2015)
CHAPTER 4

**GOAL**
- Improve the efficiency and reliability of ATLs by considering a risk perspective
- Empirical validation of time, cost, resource and risk limits

**APPROACH**  Focus on activity risk level

**VALIDATION**  Empirical database (Batselier & Vanhoucke, 2015)
CHAPTER 4

GOAL
» Improve the efficiency and reliability of ATLs by considering a risk perspective
» Empirical validation of time, cost, resource and risk limits

APPROACH
Focus on activity risk level

VALIDATION
Empirical database (Batselier & Vanhoucke, 2015)
CHAPTER 4

GOAL  » Improve the efficiency and reliability of ATLs by considering a risk perspective
       » Empirical validation of time, cost, resource and risk limits

APPROACH  Focus on activity risk level

VALIDATION  Empirical database (Batselier & Vanhoucke, 2015)

RESULTS  » RESOURCE LIMITS  highest efficiency (Ch. 3)
          » RISK LIMITS  valuable alternative in case of insufficient data on resources (Ch. 4)
          » COST LIMITS  valuable alternative for irregular projects (Ch. 2)
          » LINEAR LIMITS  sufficient for regular projects (Colin & Vanhoucke 2015)
» INTRODUCTION

» STUDY 1

» STUDY 2

» STUDY 3

» STUDY 4

» CONCLUSIONS
CONCLUSIONS

RQ₁: Progress evaluation

Chapter 2
- Integration of constrained resources
- Empirical validation/risk integration
- Integration of project monitoring and control

Chapter 3
- Empirical validation

Chapter 4

Chapter 5

RQ₂: Corrective action taking
CHAPTER 5

GOAL  Integrate project monitoring with the corrective action taking process
   » project monitoring: generate warning signals that act as triggers for action
   » corrective actions: take actions to get the project back on track
CHAPTER 5

GOAL  Integrate project monitoring with the corrective action taking process
   » project monitoring: generate warning signals that act as triggers for action
   » corrective actions: take actions to get the project back on track

APPROACH  Combine ATLs of Chapter 2 with variability reducing corrective actions
   » limited effort budget: define relation between applied effort and impact of actions
   » different strategies to select the activities to take corrective actions on
**CHAPTER 5**

**GOAL** Integrate project monitoring with the corrective action taking process
   » project monitoring: generate warning signals that act as triggers for action
   » corrective actions: take actions to get the project back on track

**APPROACH** Combine ATLs of Chapter 2 with variability reducing corrective actions
   » limited effort budget: define relation between applied effort and impact of actions
   » different strategies to select the activities to take corrective actions on

<table>
<thead>
<tr>
<th>Corrective Strategy</th>
<th>Preventive Strategy</th>
<th>Hybrid Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focus on ongoing activities</td>
<td>Focus on future activities</td>
<td>Focus on ongoing and future activities</td>
</tr>
</tbody>
</table>
**CHAPTER 5**

**GOAL** Integrate project monitoring with the corrective action taking process
  » project monitoring: generate warning signals that act as triggers for action
  » corrective actions: take actions to get the project back on track

**APPROACH** Combine ATLs of Chapter 2 with variability reducing corrective actions
  » limited effort budget: define relation between applied effort and impact of actions
  » different strategies to select the activities to take corrective actions on
CHAPTER 5

**GOAL** Integrate project monitoring with the corrective action taking process
  » project monitoring: generate warning signals that act as triggers for action
  » corrective actions: take actions to get the project back on track

**APPROACH** Combine ATLs of Chapter 2 with variability reducing corrective actions
  » limited effort budget: define relation between applied effort and impact of actions
  » different strategies to select the activities to take corrective actions on

**VALIDATION** Monte Carlo simulation

**RESULTS** Parallel projects: corrective and hybrid strategy are most effective
  Serial projects: preventive strategy is most effective
» INTRODUCTION

» STUDY 1

» STUDY 2

» STUDY 3

» STUDY 4

» CONCLUSIONS
CHAPTER 6 - CONCLUSIONS

RQ1. PROGRESS EVALUATION:
RQ1. PROGRESS EVALUATION:
» Analytical tolerance limits combine the **advantages** of static and statistical tolerance limits
  » No historical data or simulated data required: *easy to implement*
  » Incorporation of project-specific characteristics: *efficient and reliable*
RQ1. Progress Evaluation:

» Analytical tolerance limits combine the advantages of static and statistical tolerance limits
  » No historical data or simulated data required: easy to implement
  » Incorporation of project-specific characteristics: efficient and reliable

» Different perspectives can be considered
  » Resource perspective: most efficient, requires the most project-specific information
  » Risk perspective: valuable alternative when resource information is not available
  » Cost perspective: efficient for irregular projects
RQ₂. CORRECTIVE ACTION TAKING:
RQ2. Corrective action taking:

» Both an efficient monitoring process and an adequate corrective action taking procedure are required to achieve project success
RQ2. CORRECTIVE ACTION TAKING:

» Both an efficient monitoring process and an adequate corrective action taking procedure are required to achieve project success

» The most appropriate control strategy depends on the topological network structure of projects
  » Parallel projects: corrective/hybrid strategy
  » Serial projects: preventive strategy
No scientific book!
My first business novel
Annelies Martens
PhD

DEPARTMENT OF BUSINESS INFORMATICS
AND OPERATIONS MANAGEMENT
OPERATIONS RESEARCH & SCHEDULING RESEARCH GROUP

annelies.martens@ugent.be

Ghent University
@ugent
Ghent University