Aalto University
School of Engineering

Operation Management in Construction
Lecture #1 - Introduction

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Associate professor

Short Bio

- **Operations management experience 2000-**
  - 3 start-ups related to software
  - Dozens of real projects as consultant
  - Especially production planning and control
  - PhD + book + ~50 publications on the topic
- **Professor at Aalto 2015-**
  - Operations management, design management
  - Time-related disputes on the side

Topics, Lecture #1

- **Course Introduction**
  - Learning Objectives
  - Lectures and assignments
  - Workload
  - Readings
  - MyCourses discussions
  - Grading
- **What kind of production is construction?**
- **Overview of planning methods**

Intended Learning Objectives

- ILO 1**: Students can explain** the nature of production in construction
- ILO 2: **Students can compare and contrast** the similarities and differences of different production planning and control methods (Drawing Gantt Charts, CPM, LBMS, Takt planning, Last Planner System)
- ILO 3**: Students can calculate** the production system cost of a schedule
- ILO 4: **Students can explain** the factors related to production system risk of a schedule
- ILO 5**: Students can explain** the significance of work and labor flow and how flow can be achieved in construction
- ILO 6**: Students can discuss** how digitalization can be used to guide production planning and control decisions
- ILO 7: **Students can** plan a location-based schedule of a real project using the Location Based Management System
- ILO 8**: Students can** make production control decisions based on the schedule using the Location Based Management System
- ILO 9**: Students can analyze** the quality of a location-based schedule
- ILO 10: **Students can collaborate** in multi-disciplinary teams

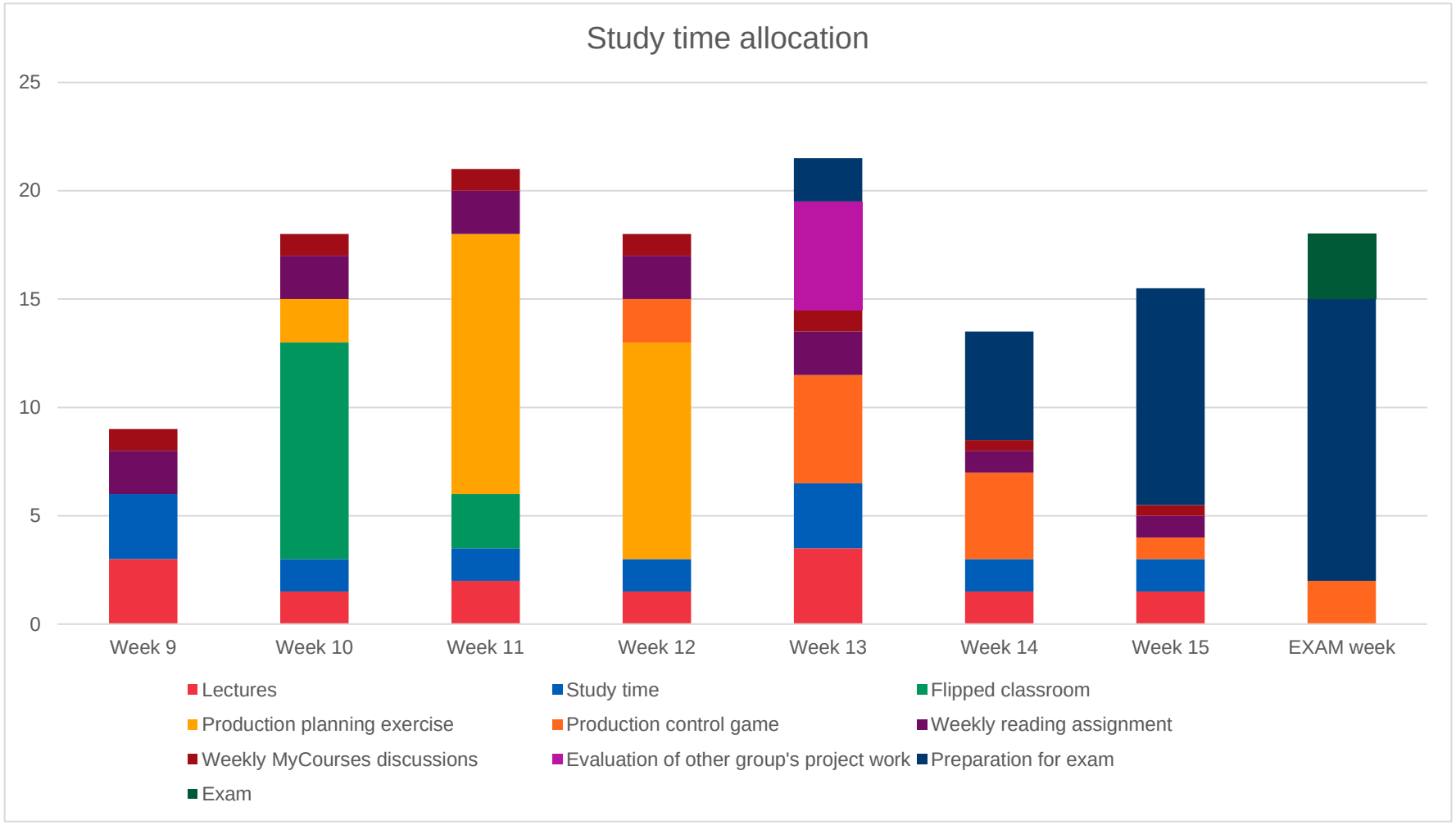
Lectures and assignments

	Week 9		Week 10		Week 11		Week 12		Week 13		Week 14-15	
	1.3.	3.3.	8.3	10.3	13.3	17.3	22.3	24.3	27.3	31.3	5.4	14.4
Lectures (ILOs)	Intro (1,2)	Location-based planning Intro (2,3,4,5,9)	Location-based production control intro (2,5,8)	Software tutorial for group assignment (7,10)	Flipped classroom (2,5)	Mid-assignment software tutorial (7,10)	Guest lecture - takt planning and control case studies	Controlling software tutorial (8)	Lean production simulation game (1,2,5)	Lean Construction intro (1, 5)	Integrating Last Planner System and location-based methods (5,8)	Digital Twin Construction - future trends (6)
Assignments (ILOs)				PRODUCTION PLANNING GROUP ASSIGNMENT (3,7,10)				PEER REVIEW OF ASSIGNMENT (9)				
			FLIPPED CLASSROOM PREP (2,5)					PRODUCTION CONTROL GAME (5,8)				
	Continuous MyCourses forum discussions (all ILOs)											
	Readings for every lecture											

Intended Learning Objectives

1. **Students can explain** the nature of production in construction
2. **Students can compare and contrast** the similarities and differences of different production planning and control methods (Drawing Gantt Charts, CPM, LBMS, Takt planning, Last Planner System)
3. **Students can calculate** the production system cost of a schedule
4. **Students can explain** the factors related to production system risk of a schedule
5. **Students can explain** the significance of work and labor flow and how flow can be achieved in construction
6. **Students can discuss** how digitalization can be used to guide production planning and control decisions
7. **Students can** plan a location-based schedule of a real project using the Location Based Management System
8. **Students can** make production control decisions based on the schedule using the Location Based Management System
9. **Students can analyze** the quality of a location-based schedule
10. **Students can collaborate** in multi-disciplinary teams

Intended workload (5 credits = 135 hr)



Evaluation 1-5 based on:

- **Final exam 50% (mandatory to pass)**
  - Open books MyCourses exam
  - One question per ILO 1-9 + one extra question
- **Assignments 25 % (all three mandatory)**
  - Production planning assignment – team assignment 40 %
  - Peer evaluation report – individual assignment 20 %
  - Production controlling assignment 40 %
- **Participation 25% (optional)**
  - Attending lectures
  - Participating in MyCourses discussions
  - Self-assessment of lecture participation (readings and activity)

Participation / MyCourses Discussions

- **Max 30 points total**
  - 1 point per attended lecture (except Flipped Classroom and production control simulation 27.1, 10.2. are worth 2 points) – enter in Presemo after each lecture
  - Good preparation for lecture AND/OR active participation during lecture (self-evaluated, max 2 bonus points per attended lecture, max 10 extra points) - enter in Presemo for each lecture
  - Good MyCourses forum posts – initiating or continuing discussions (1 point / post)
- **MyCourses: Discussions between lectures on lecture topics, assignments, readings**
- **Comment on:**
  - What remained unclear? What was not realistic? Does this work in practice? What is important?
  - Add your own work experience and examples and try to apply the theory

Bonus points for participation

- **Readings/ preparation:**

  0: I did not watch the videos or read the readings of the lecture

  1: I watched the videos AND I read the readings AND prepared a list of key points and questions related to the reading topics AND made sure that those key points and questions were addressed during the contact session

- **Participation**

  0: I participated in small group discussions / class activities

  1: I actively participated in small group discussions and listened to what others had to say and was ready to change my opinion when necessary. At the end of small group discussions, I made sure that the ideas of the group were shared with others, for example by using Presemo or sharing the ideas with the class.

Assignments (25 % of total grade)

- **Assignment #1: Planning assignment (40%)**
  - Groups of 3 (up to 20 groups)
  - Choose from 2 projects (Camino Medical office building or Juslenia office/lab project) and from 2 methods (Takt / LBMS)
  - Watch the tutorial video + mid-assignment video
  - Join the tutorial session + mid-assignment feedback session
  - Complete a schedule and report based on starting data
  - Evaluate other group members' teamwork skills and participation
  - Scores of Assignment #1 are divided to team members in relation to teamwork score (free riders will get a poor score)
- **Assignment #2: Peer review of planning assignment (20%)**
  - Evaluation report of someone else's assignment
  - Write a report + score the assignment based on evaluation rubric
  - Score of assignment #1 is determined by average of peer evaluation report scores (assignment #2). Each group will get three evaluations.
  - Peer evaluation reports are evaluated by the teacher

Assignments (25 % of grade)

- **Production control assignment (40%)**
  - Watch the tutorial movie + join the tutorial session
  - Status data is given 2 x / day for two weeks and is entered to the controlling software
  - Possible actions are discussed on MyCourses, actions impact the outcome of the next round
  - Complete the simulation and report
  - Evaluated by the teacher

Readings

- **Assigned readings before each lecture**
- **Read through the material, note any questions (extra point for doing this)**
- **Pair / group discussions related to readings and videos in the beginning of each lecture**
- **All lecture readings will be part of the final exam**

Exam

- **9 essay questions in 3 hours**
- **Computerized exam**
- **Open books – you can bring all readings, all books, surf the internet but you cannot communicate with others**
  - Note: ChatGPT does not answer these questions well
- **Material includes everything learned during the course**
  - Readings, lectures, class discussions, MyCourses discussions, assignments
- **Demonstrate your learning related to learning objectives!**
  - Theory
  - Practical knowledge gained from your work experience or the various simulations and assignments of the course
  - Cut & paste from readings results in a low score – no answer can be found in one source

Video 2

Learning objectives for this lecture

- ILO 1**: Students can explain** the nature of production in construction
  - *ILO emphasized*

- ILO 2: **Students can compare and contrast** the similarities and differences of different production planning and control methods
  - *ILO initiated*

Empire State Building

- Location-based planning and control
- Levels as the unit of control
- Production methods from manufacturing
- Performance we still cannot match today

Empire State: 1929

- **A 102 story building**
  - *18 months*
  - *one floor per day*
  - *structure finished in 4.5 months*
- **assembly line production**
  - *continuous and aligned*
- **emphasis on controlling the work**
  - *actual quantities in locations were monitored daily*
  - *the work crews were checked to ensure they were working in the correct location three times per day*

Olkiluoto 3 nuclear plant

- Started 2005, planned completion 2009
- November 2018 estimate: completion January 2020. Completed in 2022
- Original estimate: €3,2B. Current estimate €8,5B. World's second most expensive building! Fixed price, so the Owner pays only €5,5B
- In addition, contractor had to pay up to €850M in damages

Länsimetro, part 1

- **Started 2009, original estimated completion fall 2014**
- **Delay 1: 2015, delay 2: august 2016, delay 3: december 2016, delay 4: early 2017 delay 5: finally opened 18 November 2017**
- **Cost overrun by 28%**
  - **Escalation because of extended duration**

Kamppi Center Project, Finland

Project Scope

- 4-year construction project
- €500M.
- Bus terminal, internal parking, six-floor retail, offices, residential units

Project Challenges

- On-site Communications, Scheduling, Coordination of 800 subcontractors and 5000 construction workers on tight urban site above operational subway (Central Helsinki)

Cost Savings

- SRV Group delivered this project six months ahead of schedule resulting in:
  - ***~12.5% schedule improvement***
  - ***6 months faster occupancy (more rent)***
  - ***2 million euros savings in General Conditions alone***

Production in manufacturing

- **Work flows through work stations**
- **Product moves, people and machines stay in place**
- **Work-in-progress can be easily seen (unfinished parts)**

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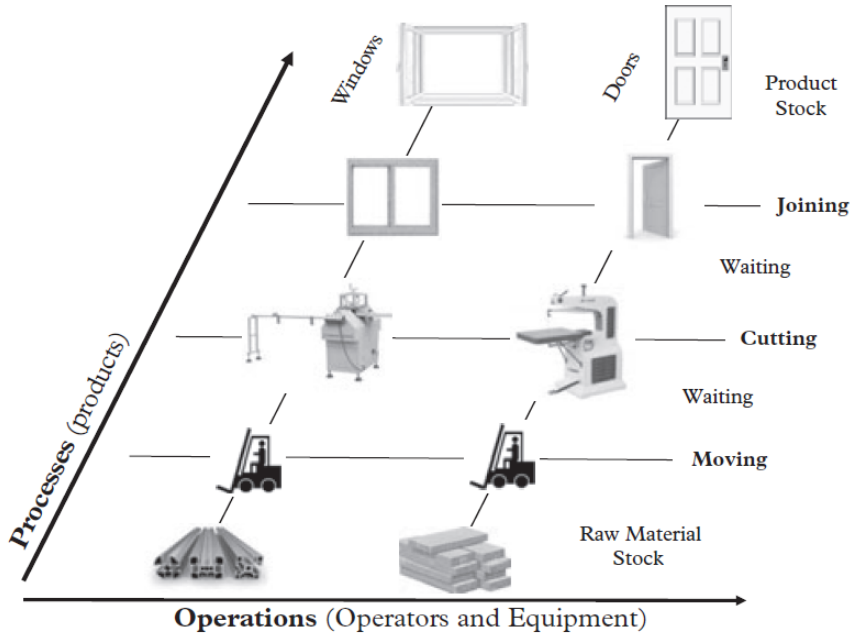


Figure 1 Operations and processes in manufacturing, based on 'The Structure of Production' by Shingo and Dillon (1989)

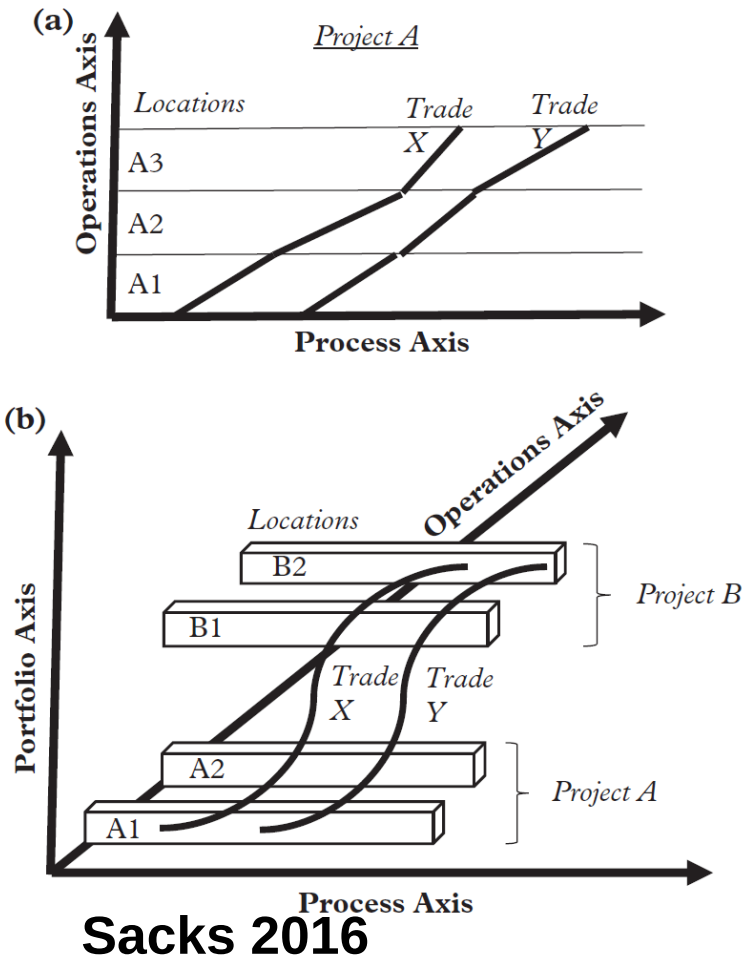
Source: Sacks 2016

Production in construction

- **Product stays in place**
- **Workers and equipment move through locations**
- **Repetitive processes, non-repetitive locations**
- **Work-in-progress is everywhere**
- **Waste is harder to see**
- **Multi-project environment**

Three kinds of flow: Portfolio, Process and Operations (PPO model, Sacks 2016)

- **Portfolio Flow:**
  - **Resources flow from project to project**
- **Process Flow:**
  - **Flow of work in location**
  - **Measure by placing a camera in location**
- **Operations Flow:**
  - **Flow of workers through locations**
  - **Measure by placing a camera on helmet of worker**



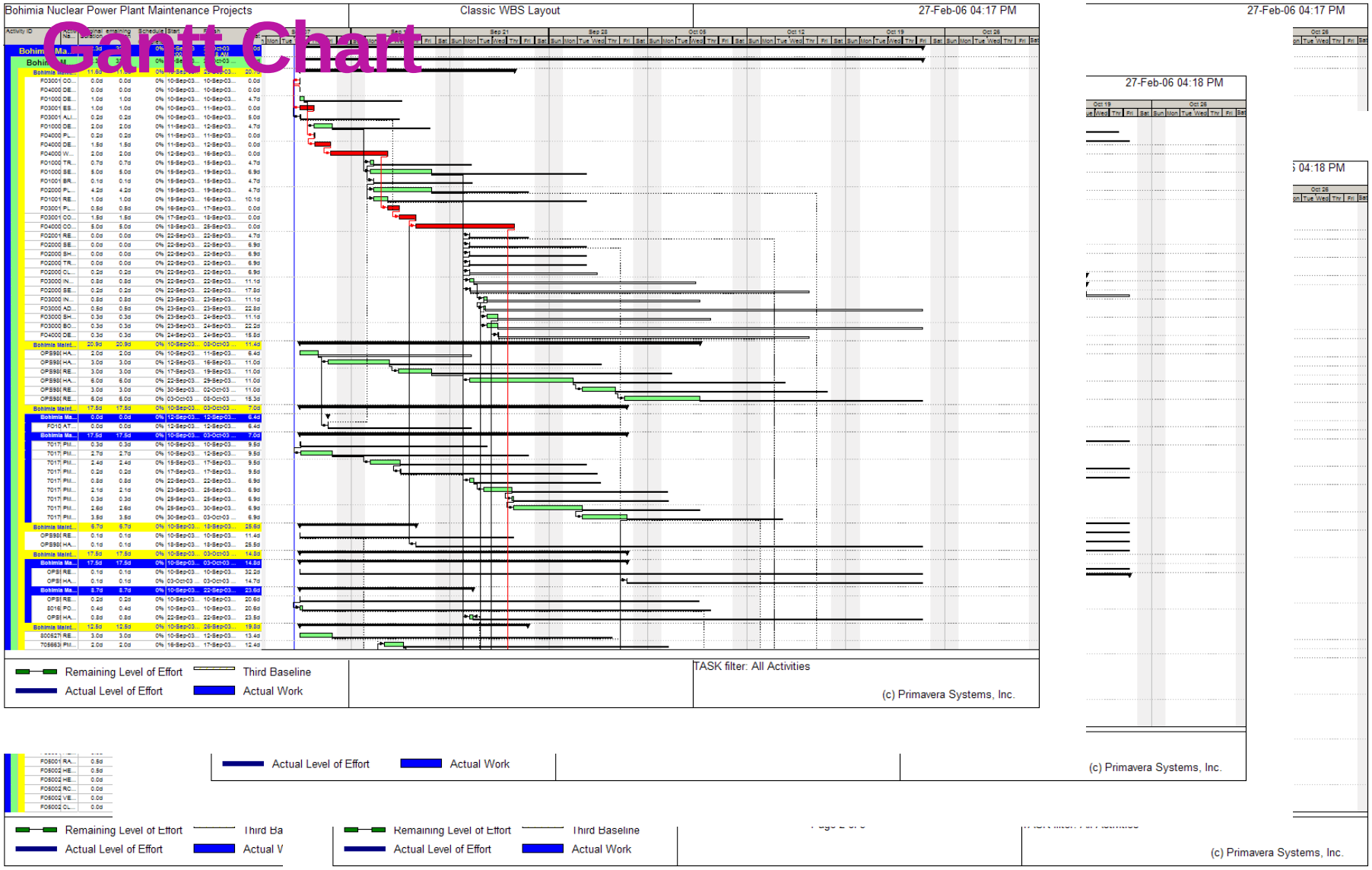
Sacks 2016

Three important angles of planning

Technical	Visual	Process
How are durations calculated?	What does the schedule look like?	Who participates and how?
Is the schedule based on resources	E.g. Bar charts, flowlines, sticky notes	How are delays considered? How are time extension claims handled?
How are start and finish dates calculated?	How are changes reported?	How are schedules approved by parties?
What kind of buffers are there in the schedule?		When can the schedule be updated?

Stickies

Gantt Chart



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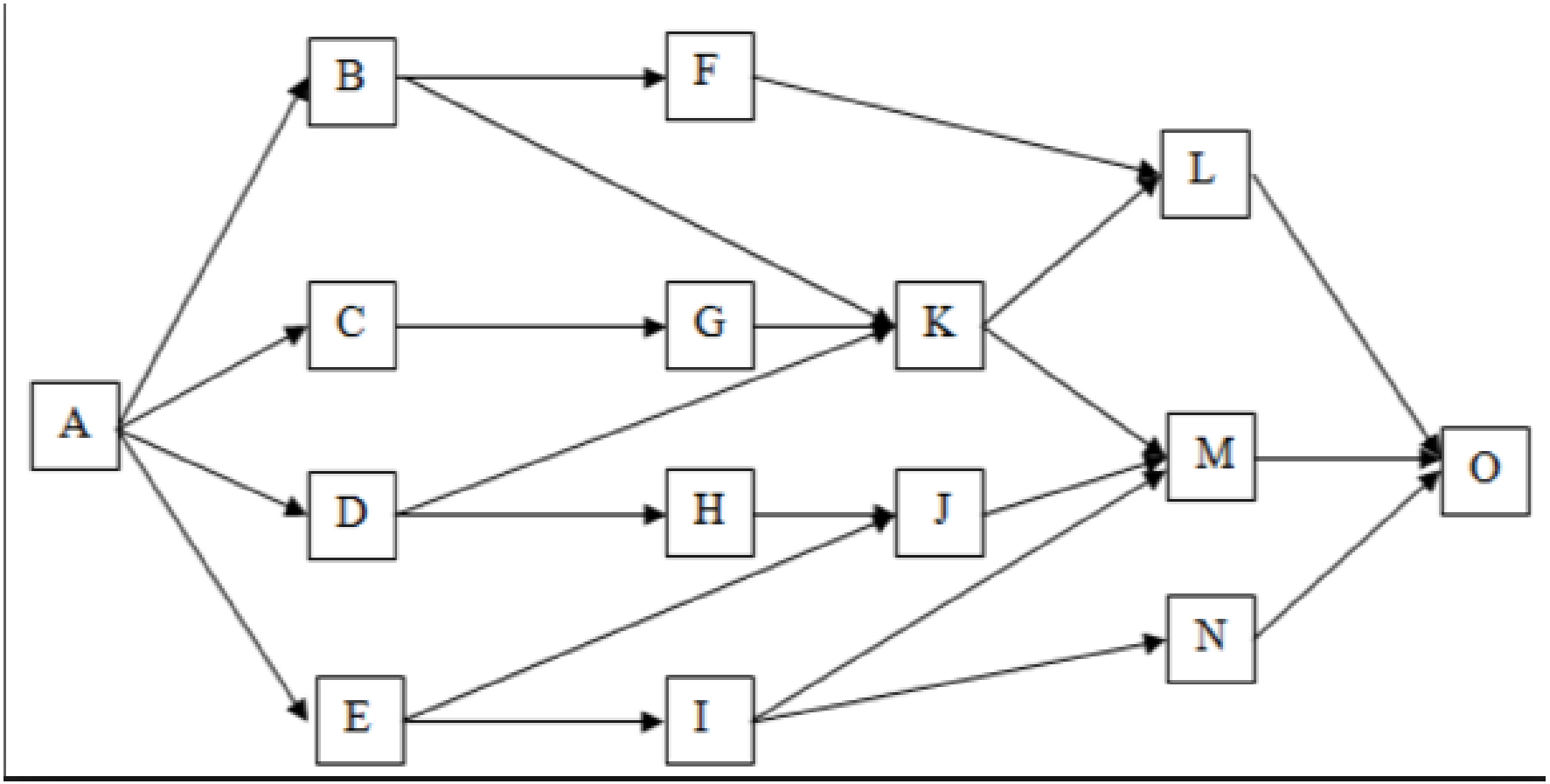
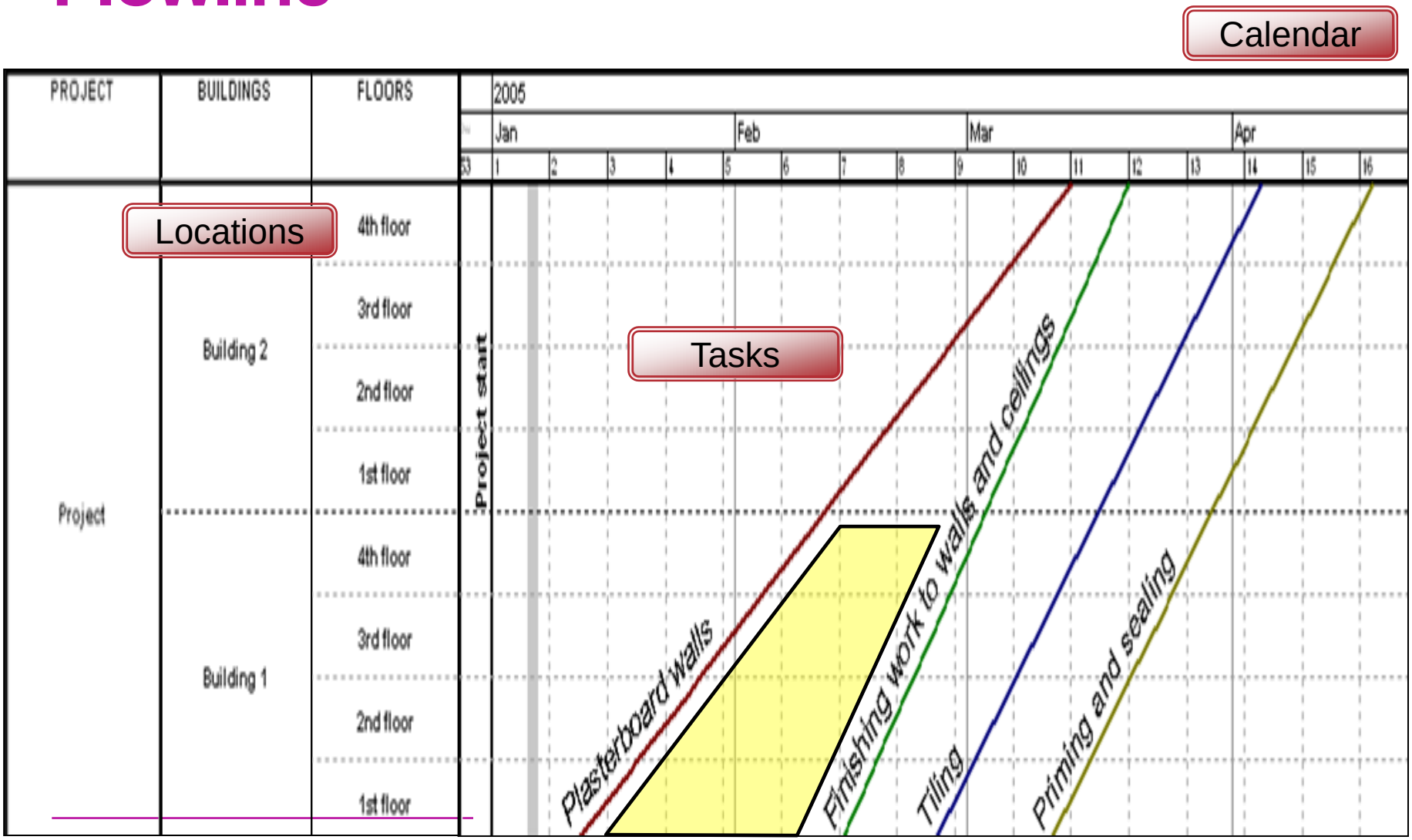
Network diagram

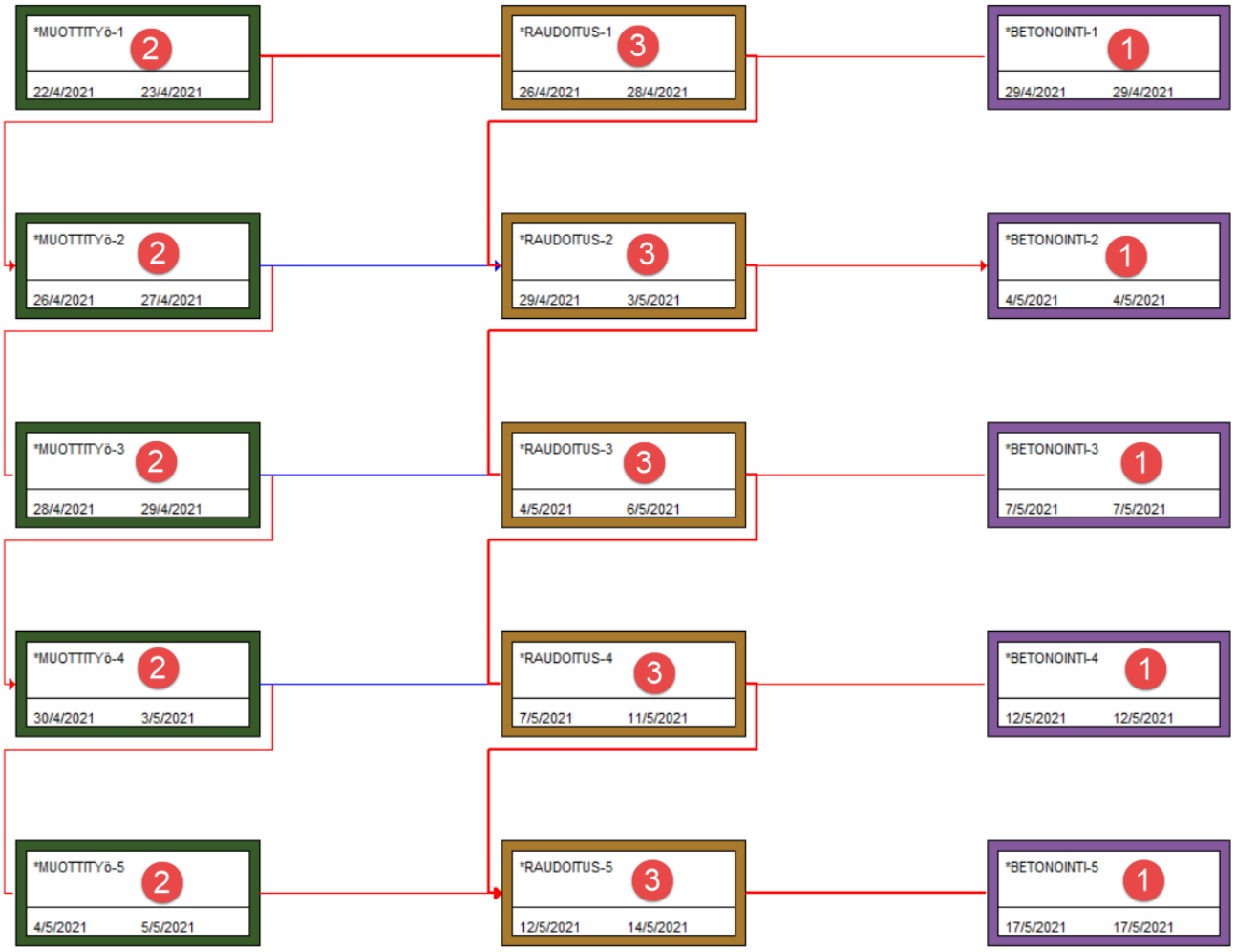


Flowline


Calendar
PROJECT
BUILDINGS
FLOORS
2005
Jan
Feb
Mar
Apr
53
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Locations
Tasks
Project
Building 2
Building 1
4th floor
3rd floor
2nd floor
1st floor
4th floor
3rd floor
2nd floor
1st floor
Project start
Plasterboard walls
Finishing work to walls and ceilings
Tiling
Priming and sealing

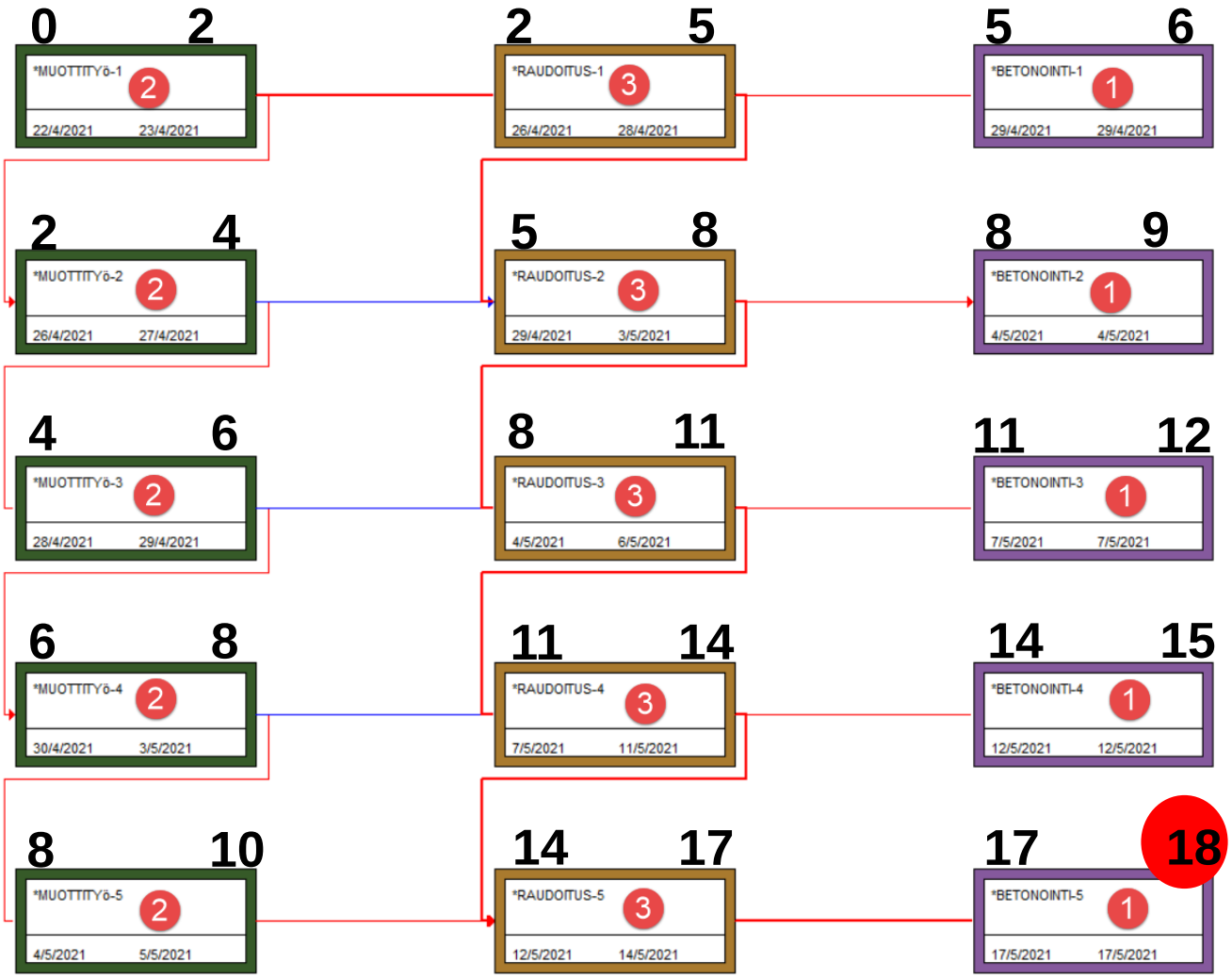
CPM reminder

- **Tasks and their logic links form a network**



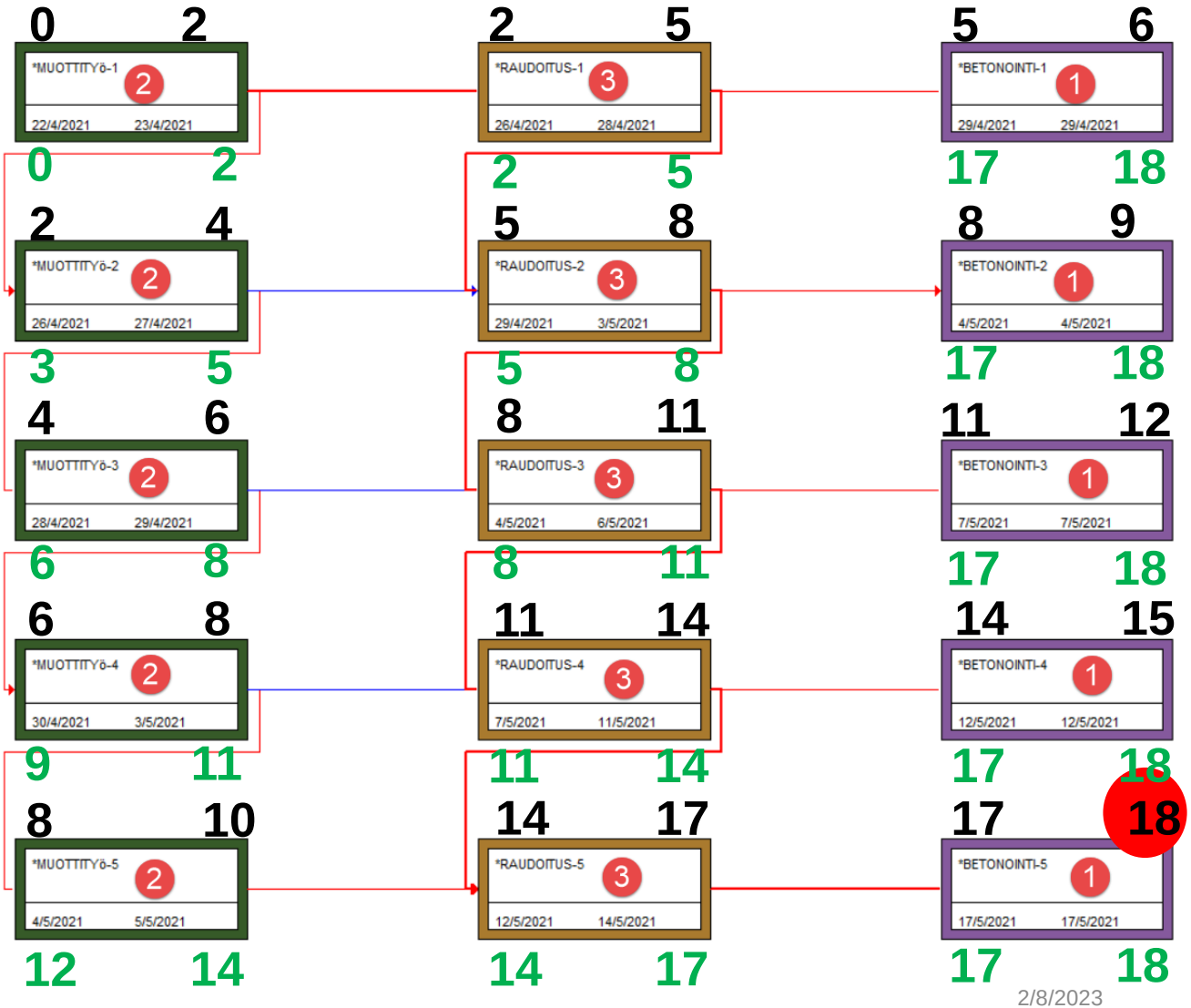
CPM reminder – forward pass

- **Earliest possible dates for each activity**
- **Predecessor finish dates = earliest possible start dates for successors**
- **The finish date of last activity determines project duration**



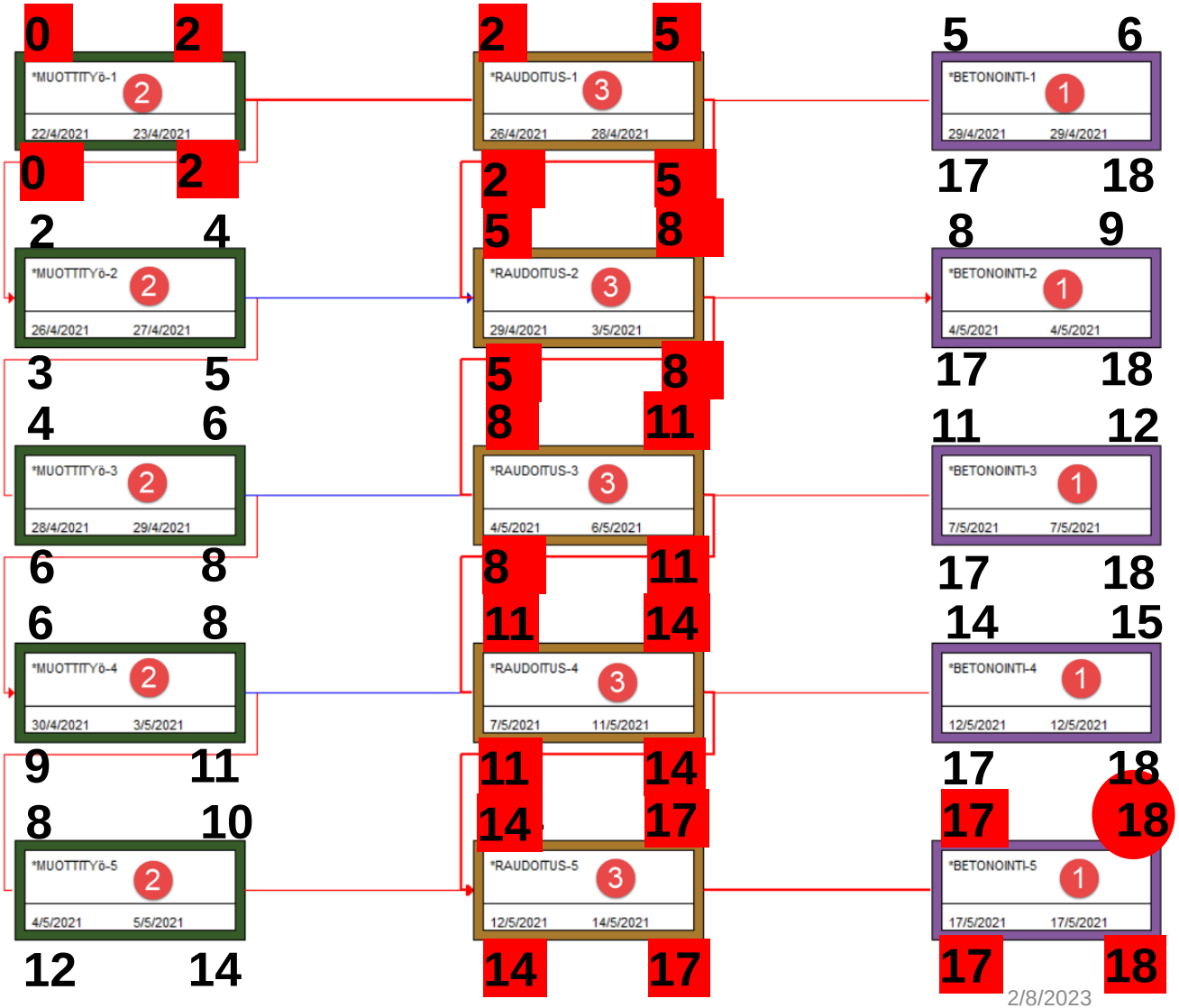
CPM reminder – backward pass

- Latest possible dates determined for each activity (green)
- Minimum of successor late start dates = latest possible start



CPM reminder – critical path

- Critical activities: latest start = earliest start
- Others have float: latest finish – earliest finish



CPM reminder – basic principles

- **Critical path determines project duration**
- **Other activities can be delayed without delaying the project up to their float**
- **Critical path method is used e.g. in delay analysis**

LBMS = CPM+

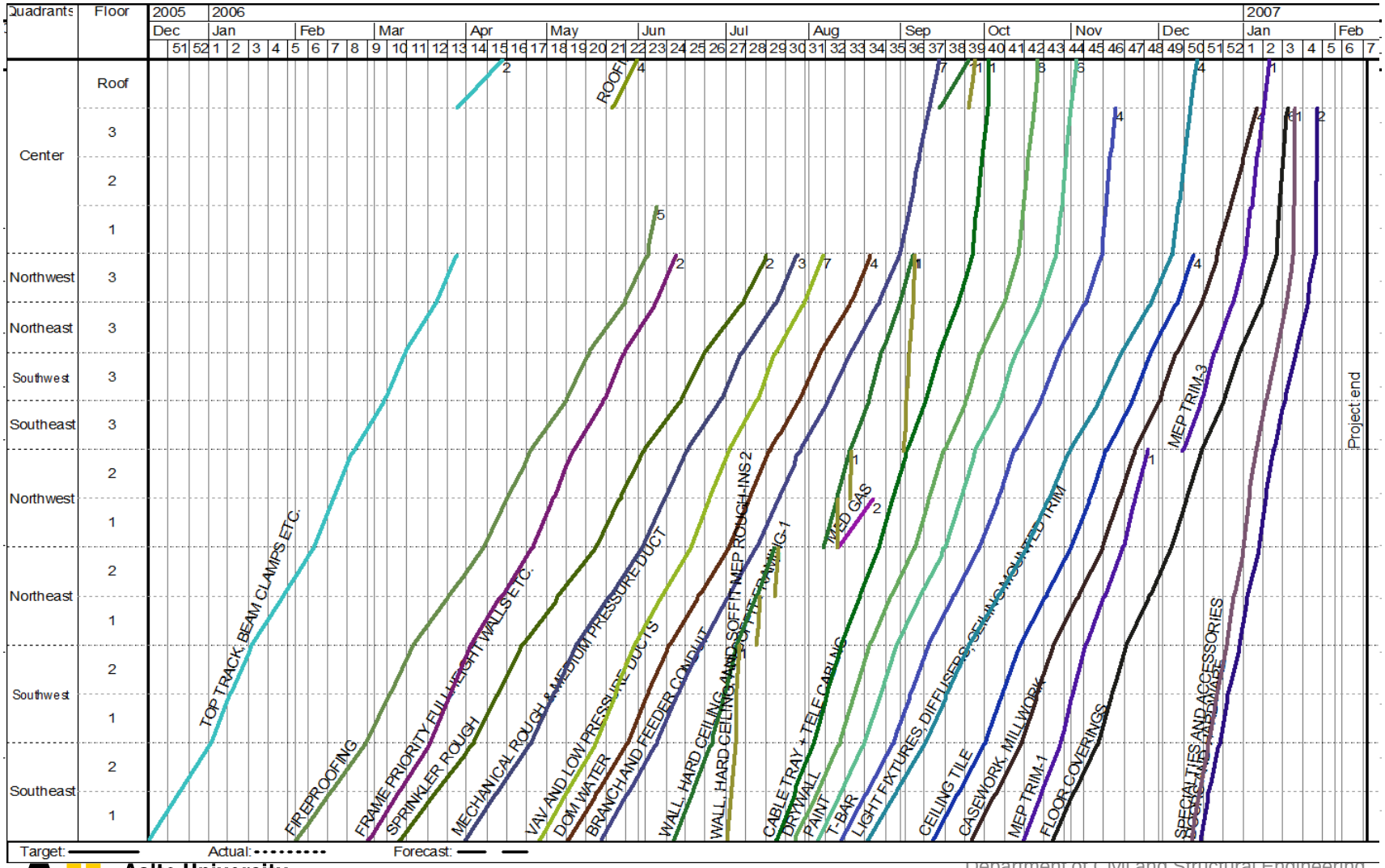
CPM

- Location is not a planning element (can be coded)
- Durations are an input
- Production is a black box
- No ability to plan continuous flow
- Goal: minimize total duration by focusing on critical path, analyze delays

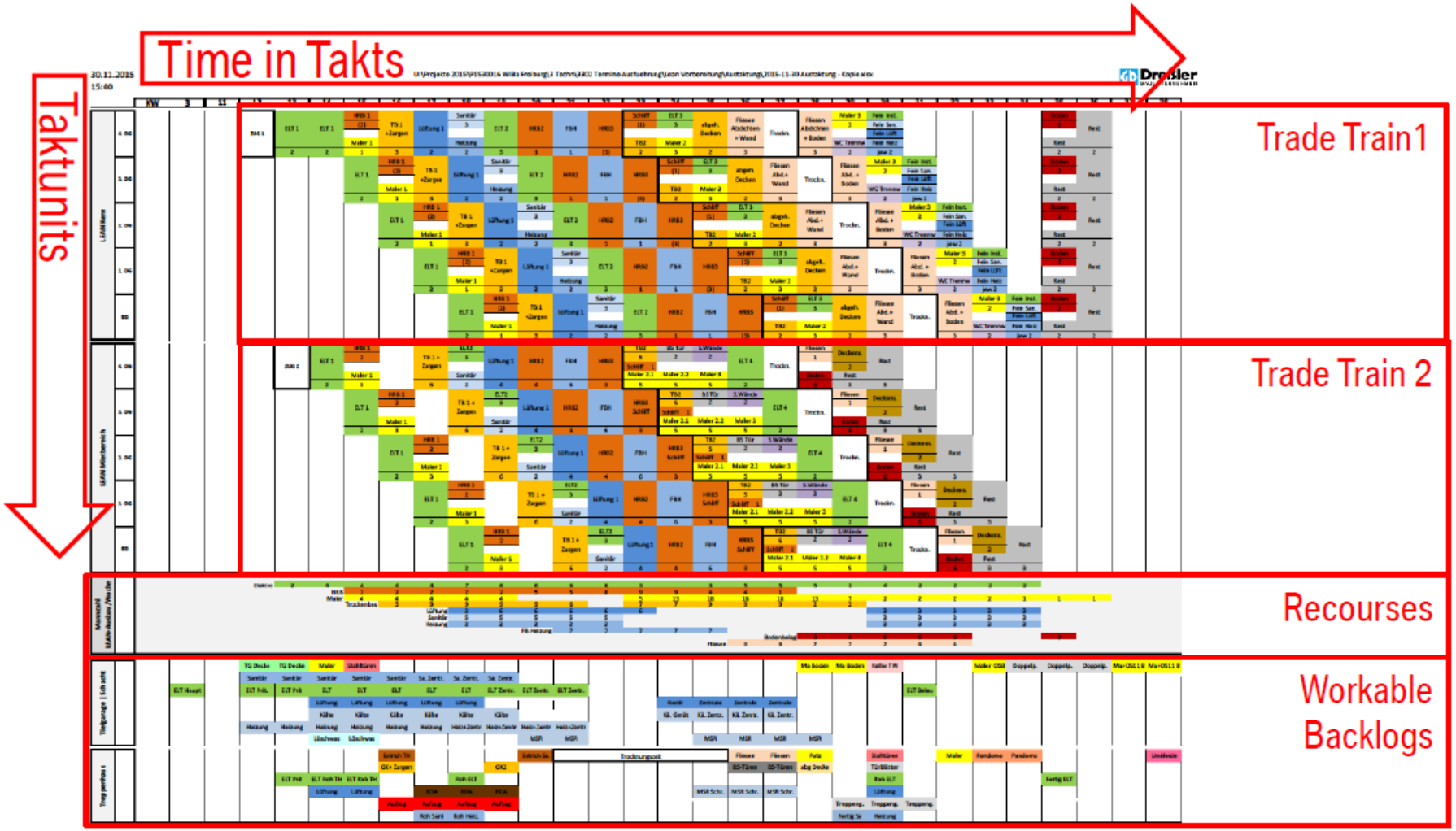
LBMS

- Locations are used to automate logic and decrease complexity
- Durations are an output
- Production explicitly modeled
- Focused on continuous flow
- Goal: minimize total duration while maximizing productivity and minimizing risk by focusing on flow

CPM vs. LBMS in flowline



Takt planning and controlling is a new method in Finland



Thank you
Questions & Comments

Why is Production Planning and Control important?

- **Presemo.aalto.fi/opman 1**

- **Rate the preset responses 1-5 or add your own responses**

Assignments for next lecture

- **Reading assignment – Location Based Management for Construction white paper (available in MyCourses)**
- **Location Based Management for Construction – Planning, Scheduling and Control - Chapter 5 (e-book / hardcopy from library / Amazon.com)**

- **MyCourses discussion**
  - Initiate discussions on Lecture #1 topics
  - What remained unclear? What was not realistic? Does this work in practice? What is important?

Self-evaluate participation – record in MyCourses

- **Readings/ preparation:**

  N/A

- **Participation**

  0: I participated in small group discussions / class activities

  1: I actively participated in small group discussions and listened to what others had to say and was ready to change my opinion when necessary. At the end of small group discussions, I made sure that the ideas of the group were shared with others, for example by using Presemo or sharing the ideas with the class.