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Operation Management in Construction
Lecture #2 LBMS planning intro

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Topics, Lecture #2

- **Learning objectives of Lecture #2**
- **LBMS planning overview**
- **Interactive planning example (in contact session)**
- **Production System risk**
- **Production System cost**
- **Planning case studies**

- **Introduction of Assignment #1: Production Planning assignment**

Intended learning objectives for this lecture

- ILO 2: **Students can compare and contrast** the similarities and differences of different production planning and control methods
  - *ILO emphasized for planning*
- ILO 3**: Students can calculate** the production system cost of a schedule
  - *ILO introduced: theory of production system cost*
- ILO 4: **Students can explain** the factors related to production system risk of a schedule
  - ILO *emphasized*
- ILO 5**: Students can explain** the significance of work and labor flow and how flow can be achieved in construction
  - *ILO introduced (planning)*
- ILO 9**: Students can analyze** the quality of a location-based schedule
  - ILO introduced

LBMS technical system

Planning system

- Location Breakdown
- Quantities
- Duration calculation
- Layered logic
- LBMS algorithm (CPM+)
- Production system cost
- Production system risk

Controlling system

- Progress data
- Performance metrics
- Detailed planning
- Forecasting
- Control actions

Location hierarchy

Project 1

Quadrant	Floor
Center	Roof
	3
	2
	1
Northwest	Roof
	3
	2
	1
Northeast	Roof
	3
	2
	1
Southwest	Roof
	3
	2
	1
Southeast	Roof
	3
	2
	1

Project 2

Building	Floor	Area
Residential	7	B
		A
	6	B
		A
	5	B
		A
	4	B
		A
	3	B
		A
	2	B
		A
	1	B
		A
	Basement	Garage
Office	9	B
		A
	8	B
		A
	7	C
		B
		A
	6	C
		B
		A
	5	C
		B
		A
	4	C
		B
		A
	3	C
		B
		A
	2	C
		B
		A
	1	B
		A

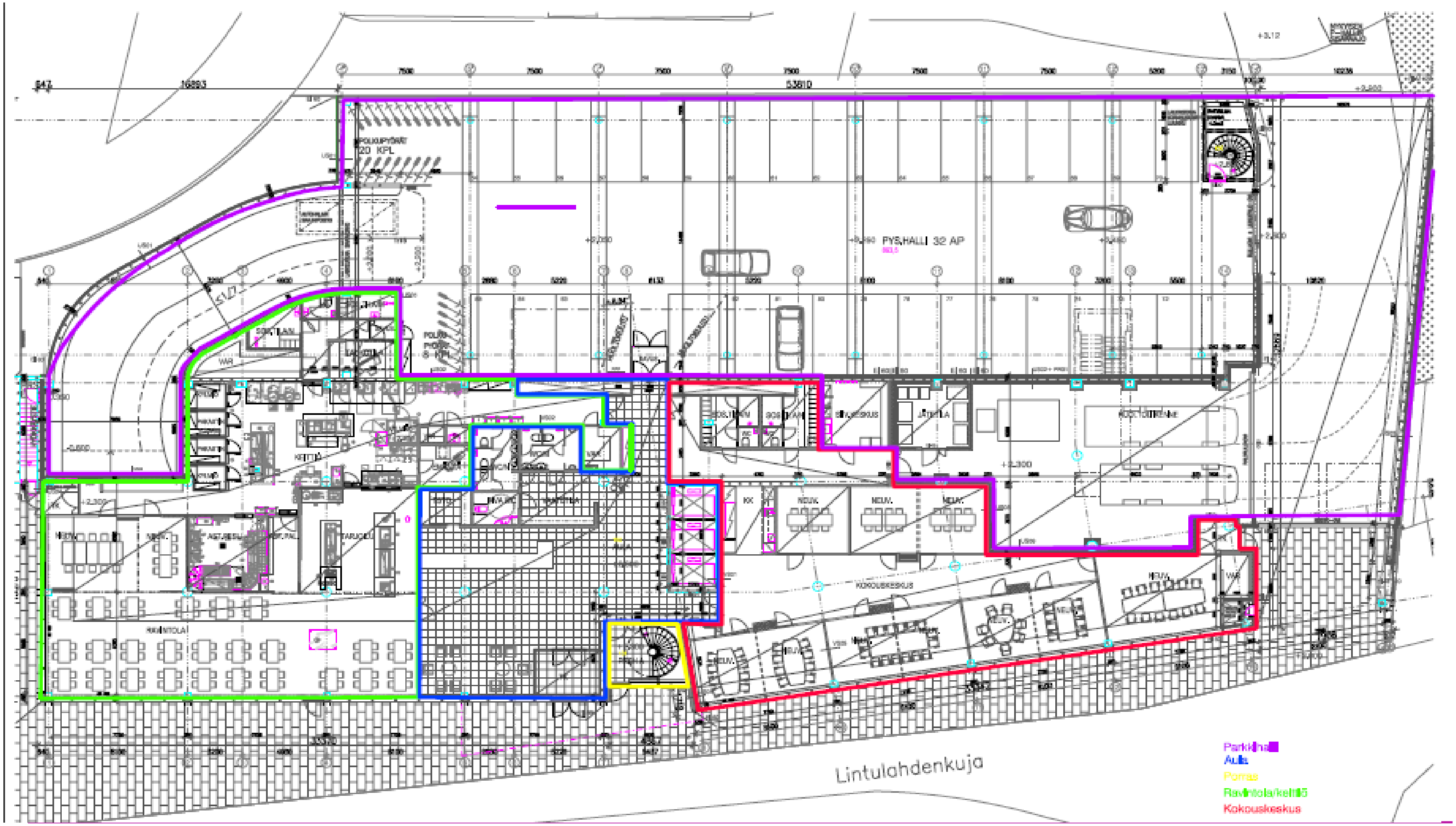
Floor	Area
Tower Roof	STR C
Level 12	STR C
Tower Roof	STR B
	STR A
Level 12	STR B
	STR A
Level 11	STR C
Level 10	STR C
Level 09	STR C
Level 08	STR C
Level 11	STR B
	STR A
Level 10	STR B
	STR A
Level 09	STR B
	STR A
Level 08	STR B
	STR A
Level 04	STR F
Level 03	STR F
Level 02	STR F
Level 01	STR F
Level 03	STR E
Level 02	STR E
Level 01	STR E
Level 04	STR D
Level 03	STR D
Level 02	STR D
Level 01	STR D
Level 07	STR C
Level 06	STR C
Level 05	STR C
Level 04	STR C
Level 07	STR B
	STR A
Level 06	STR B
	STR A
Level 05	STR B
	STR A
Level 04	STR B
	STR A
Level 03	STR C
Level 02	STR C
Level 01	STR C
Level 03	STR B
	STR A
Level 02	STR B
	STR A
Level 01	STR B
	STR A

2	3	4
[INT]	Level 4	Area C&D
		Area A&B
	Level 3	Area C&D
		Area A&B
	Level 2	Area C&D
		Area A&B
	Level 1	Area C&D
		Area A&B
	Lower Level	Area C&D
		Area A&B
[EXT]	East B@3	COURTYARD
	South@3	South
	West B@3	West B
	West A@3	West A
	North@3	North
[SUP]	Level 4	Area D
		Area C
		Area B
		Area A
	Level 3	Area D
		Area C
		Area B
		Area A
	Level 2	Area D
		Area C
		Area B
		Area A
	Level 1	
[SUB]	Lower Level	Area D
		Area C
		Area B
		Area A

Some LBS guidelines

- **Locations must be physical and clearly defined**
- **Top level locations**
  - Structurally independent sections (building / part of building) that can be completed as one entity
  - Separate buildings or separated by module lines / joints
- **Lowest level locations**
  - Small areas where only one **space-critical** task happens at the same time

Example of LBS of one floor



Quantities

- **Estimated by location**
  - Manually – time consuming
  - BIM-based – enables automated updates of quantities

- **Related quantity items can form a task IF the work**
  - Can be done at the same time in one location
  - Has the same logic outside the task
  - Can be completely finished in one location before moving to the next location

Location-based quantities

Same crew performs all items

Man-hours/unit

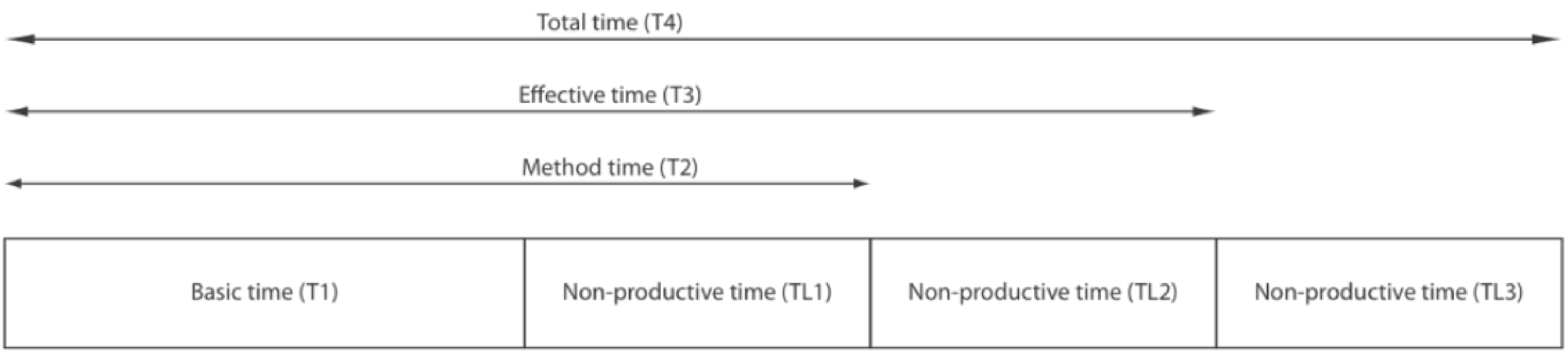
		Section:	A					B					
		Floor:	1	2	3	4	Roof	1	2	3	4	Roof	
Code	Item	Consumption											Unit
365116	Fit prefabricated balcony post units	2,25	7	7	7	7		7	7	7	7	5	NO
355125	Install room-size/square panels	1,8	8	1	1	1		10	1	1	1		NO
335107	Install precast concrete floor slabs	0,6		2	2	2	3		2	2	2	3	NO
345115	Install prefabricated staircases	1,98	1	1	1			1	1	1	1		NO
355115	Install load-bearing room-size/square panels	1,8	8	1	1	1		9	1	1	1	19	NO
335108	Install prefabricated beams	1		32	32	32	32		32	32	32	32	NO
365135	Fit prefabricated balcony roof units	0,62					5					5	NO
355145	Install thin-shell panels	1,8		17	17	17	19	17	17	17		19	NO
365125	Fit prefabricated balcony floor units	1,85		5	5	5			5	5	5		NO
325125	Top layer finishing to concrete floor slabs	1,84	14	6	6	6		14	6	6	6		NO
325115	Install precast dividing walls	1,84	10	15	15	15		16	16	16	16		NO
235150	Install precast concrete hollow core slabs	0,61	28					32					NO
	Total man-hours		**108**	**133**	**133**	**131**	**71**	**157**	**135**	**135**	**105**	**117**	

Consumption rates and optimum crew

- **Building construction**
  - Consumption rate in manhours / unit or machine hours / unit
    - ***Consumption*** *is the inverse of* ***productivity (units / manhour)***
  - Assumes **optimum crew**
    - *Minimum number of people working together to achieve optimum production*
    - *Several optimum crews can be deployed to increase* ***production rate (units / day)***

- **Infrastructure / roads etc.**
  - Typically more machines
  - **Production rate** = units / day
  - Each machine type can have a different production rate / day for the same work.

Which labor consumption to use?

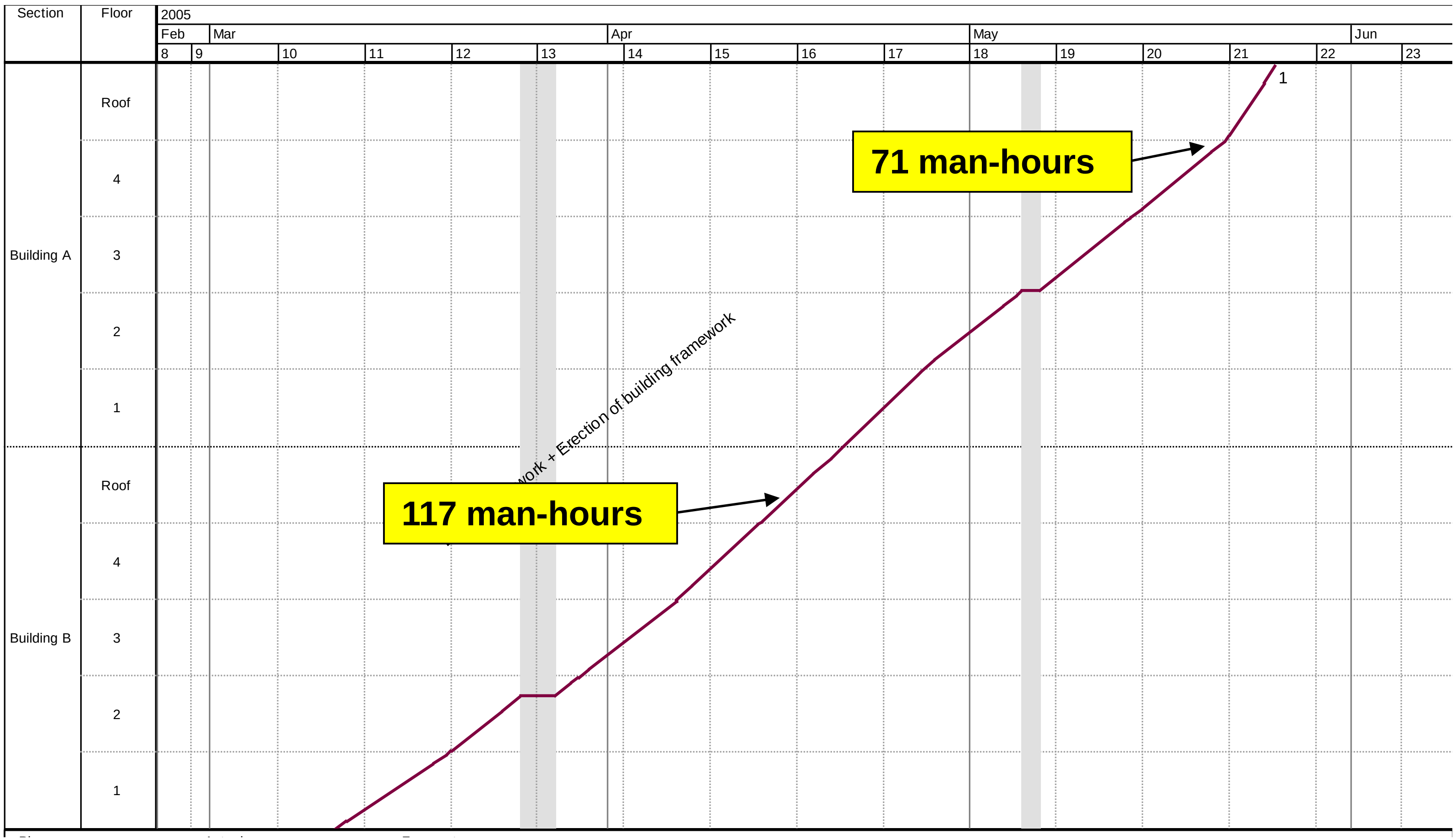


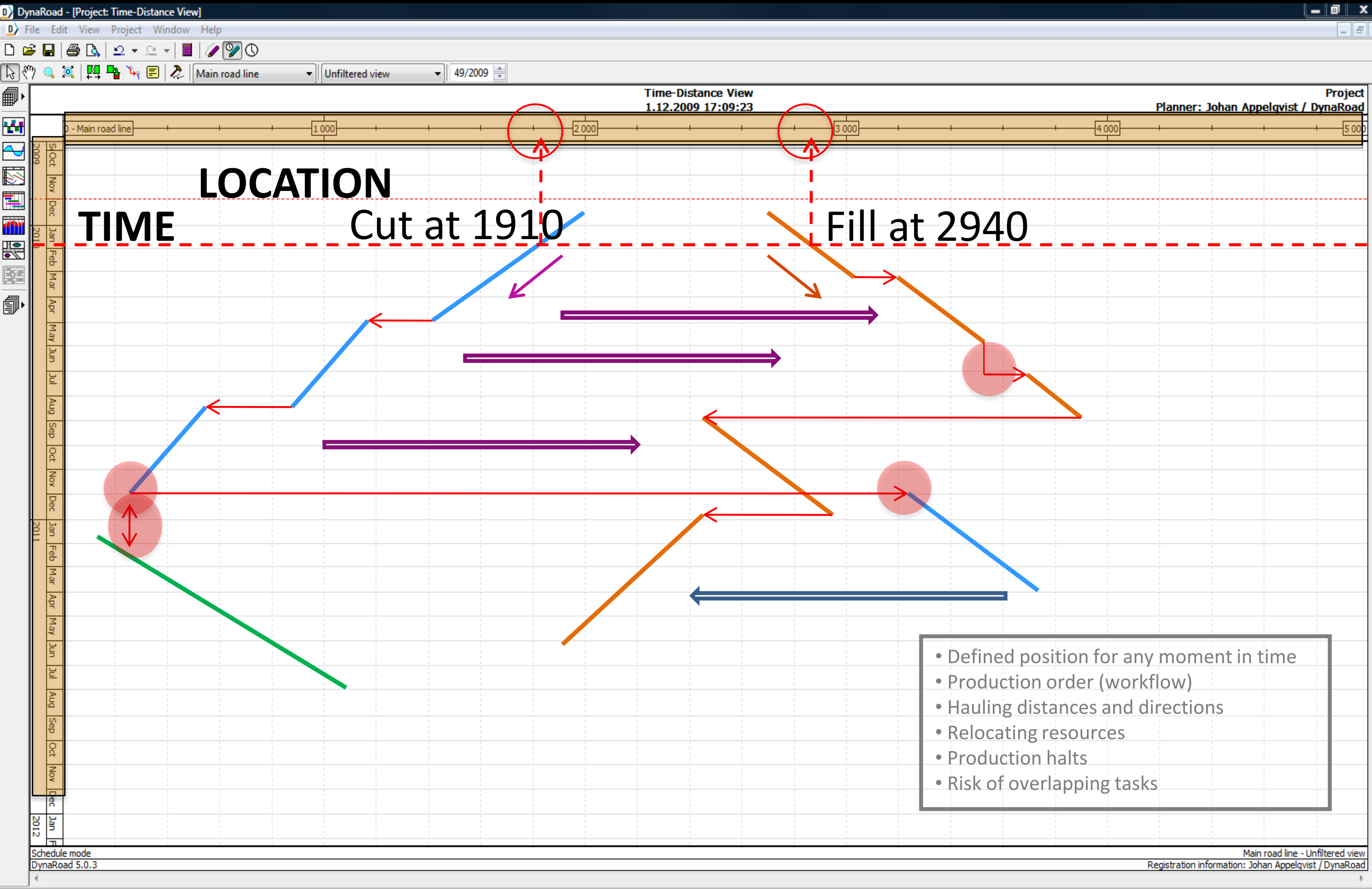
- **”Effective time” 10-20% more than Method time**
  - **Includes ”normal” disruptions of less than 1 hr**
- **Total time T4, 10-30% more than Effective time**

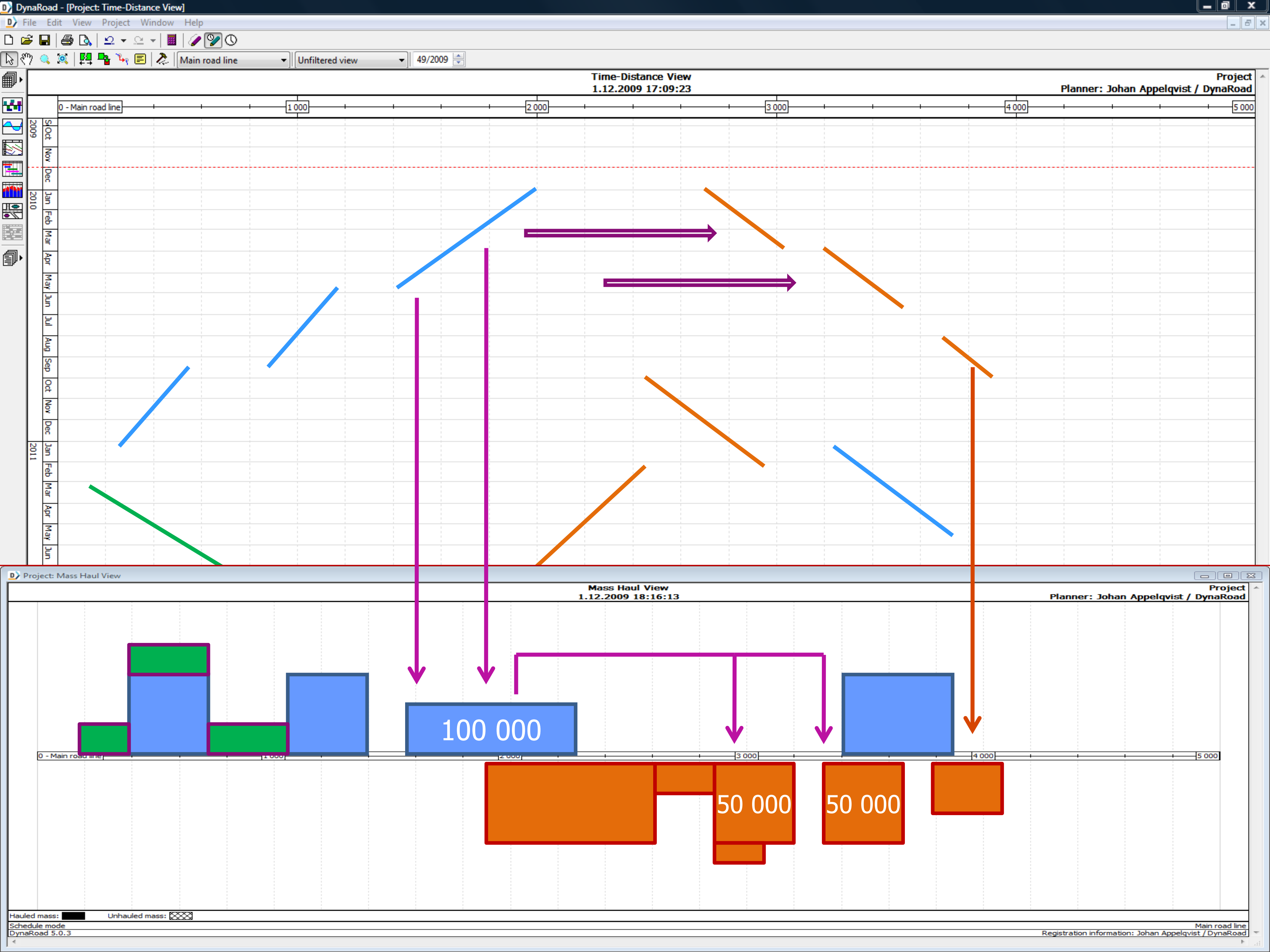
- **= a lot of waste in productivity estimates!**

Source: Koskenvesa, Koskela et al. (2010)

From quantities to duration




DynaRoad - [Project: Time-Distance View]
File Edit View Project Window Help
Main road line
Unfiltered view
49/2009
Time-Distance View
1.12.2009 17:09:23
Project
Planner: Johan Appelqvist / DynaRoad
0 - Main road line
1 000
2 000
3 000
4 000
5 000
LOCATION
TIME
Cut at 1910
Fill at 2940
2009
2010
2011
2012
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan
• Defined position for any moment in time
• Production order (workflow)
• Hauling distances and directions
• Relocating resources
• Production halts
• Risk of overlapping tasks
Schedule mode
DynaRoad 5.0.3
Main road line - Unfiltered view
Registration information: Johan Appelqvist / DynaRoad


DynaRoad - [Project: Time-Distance View]
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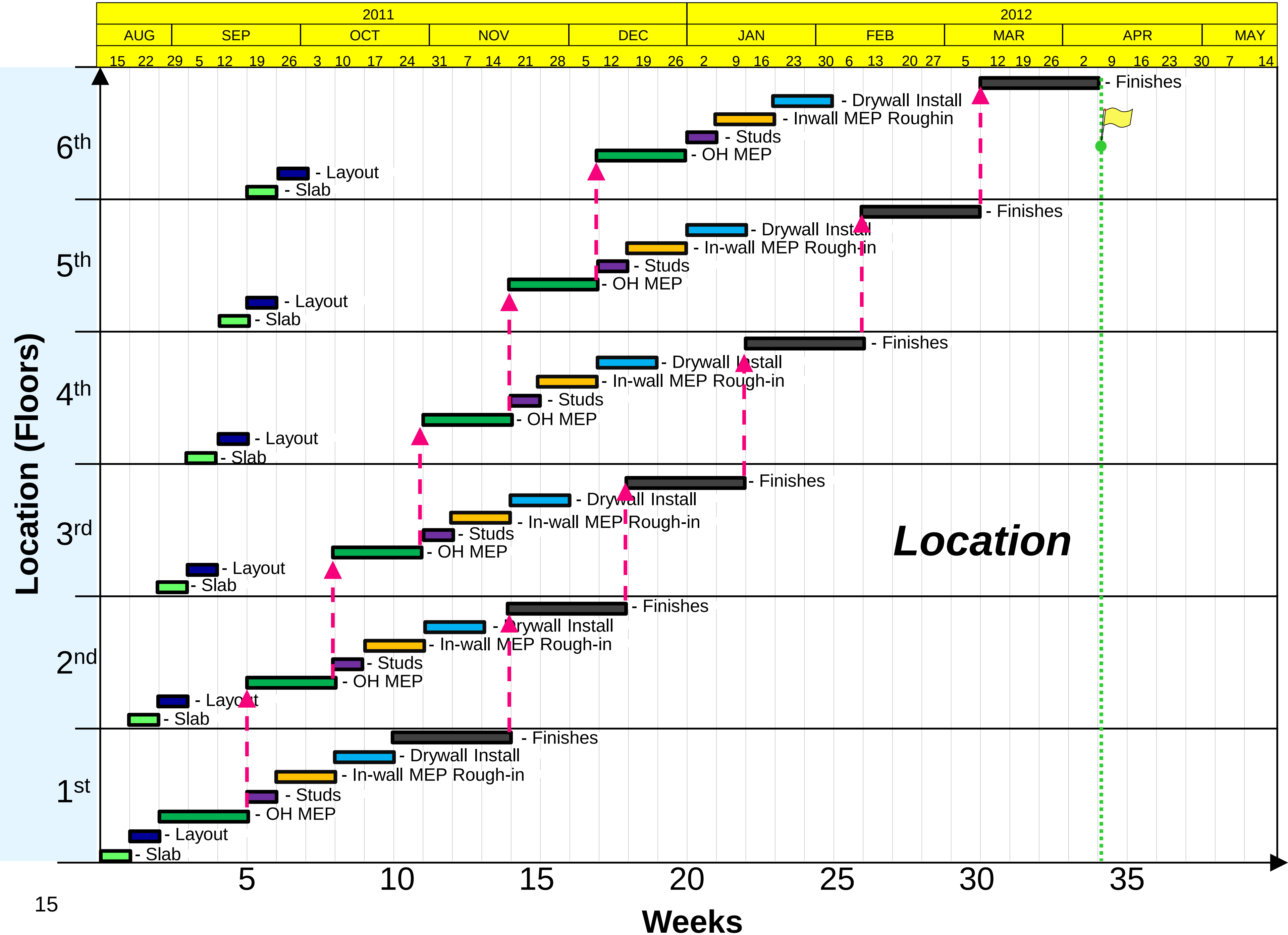
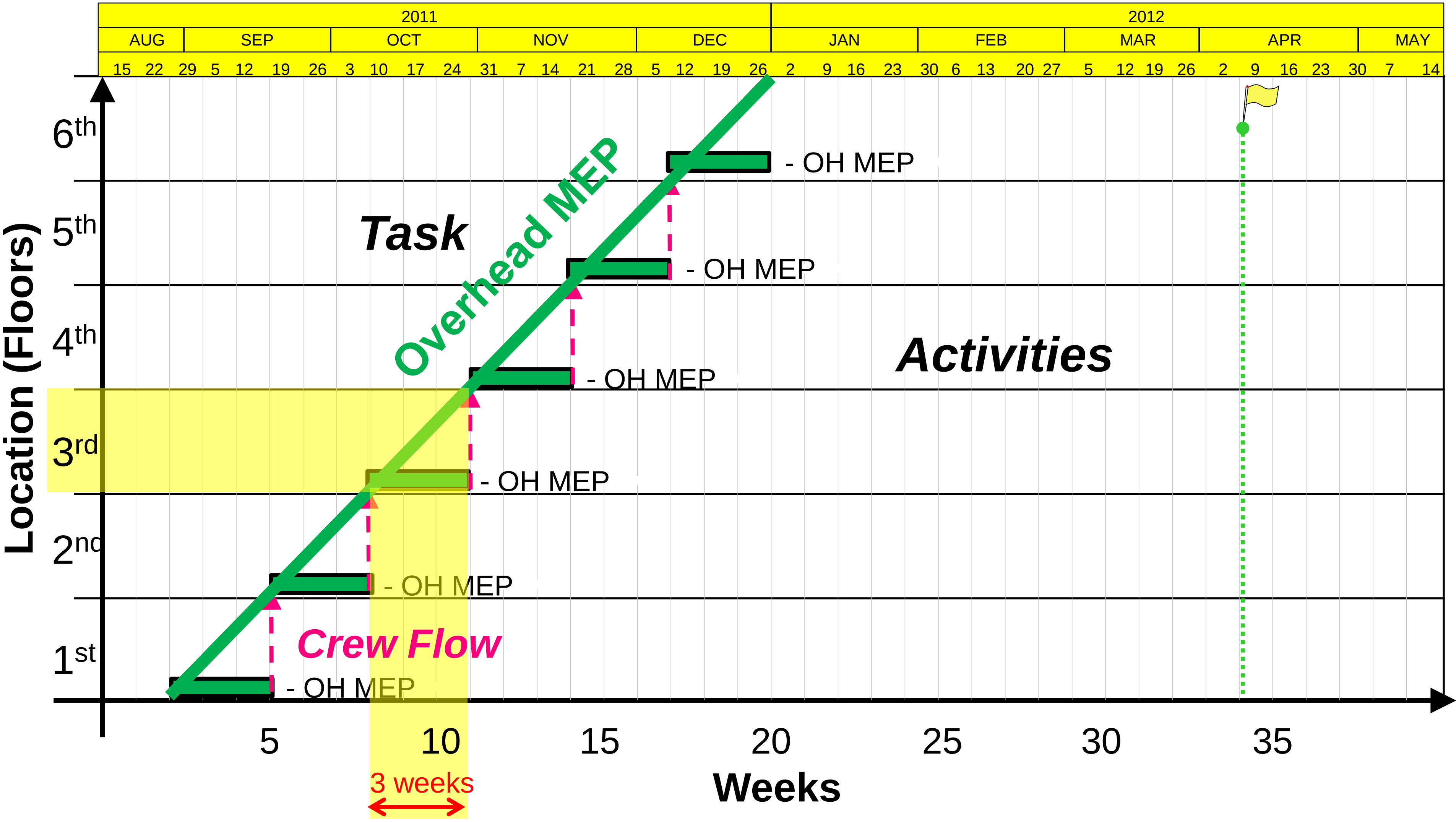
Project
Planner: Johan Appelqvist / DynaRoad
0 - Main road line
1 000
2 000
3 000
4 000
5 000
2009
2010
2011
Oct Nov Dec Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Jan Feb Mar Apr May Jun
Project: Mass Haul View
Mass Haul View
1.12.2009 18:16:13
Project
Planner: Johan Appelqvist / DynaRoad
100 000
50 000
50 000
Hauled mass:
Unhauled mass:
Schedule mode
DynaRoad 5.0.3
Main road line
Registration information: Johan Appelqvist / DynaRoad



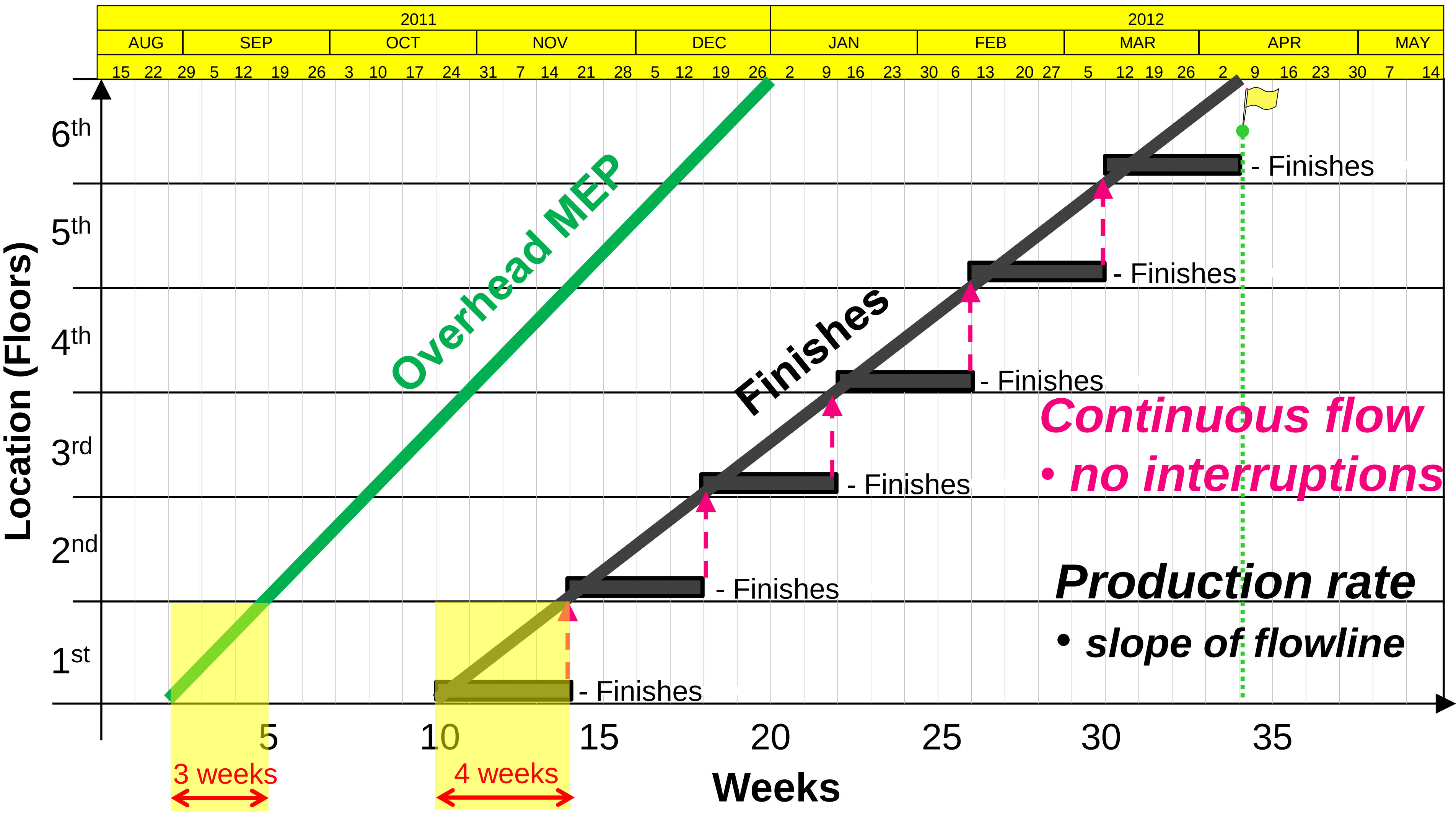
2011
2012
AUG SEP OCT NOV DEC JAN FEB MAR APR MAY
15 22 29 5 12 19 26 3 10 17 24 31 7 14 21 28 5 12 19 26 2 9 16 23 30 6 13 20 27 5 12 19 26 2 9 16 23 30 7 14
Location (Floors)
6th
5th
4th
3rd
2nd
1st
- Slab
- Layout
- OH MEP
- Studs
- In-wall MEP Rough-in
- Inwall MEP Roughin
- Drywall Install
- Finishes
Location
5 10 15 20 25 30 35
Weeks

Flowline Diagram – Overhead MEP

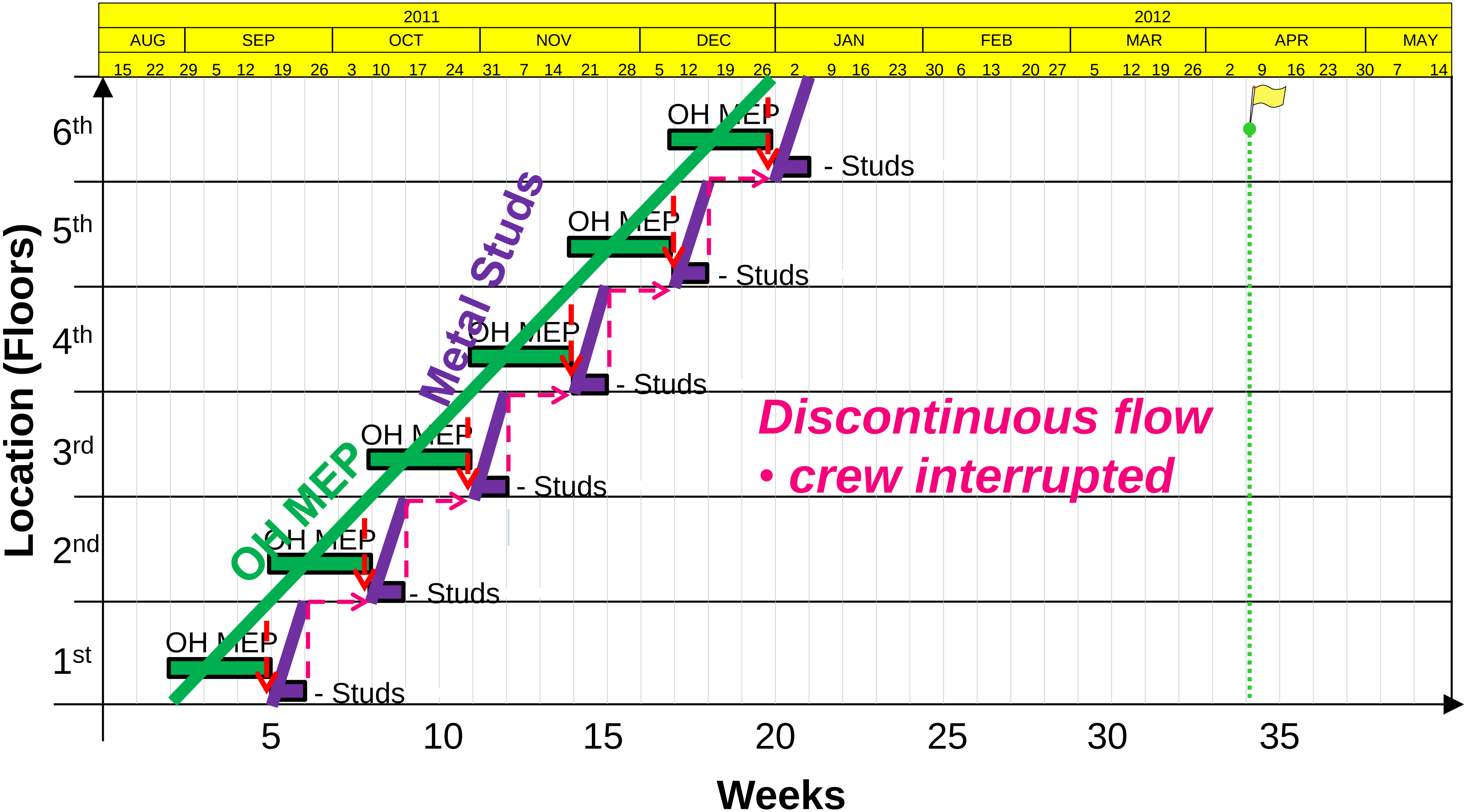


Flowline: graphical representation of movement of crews over time

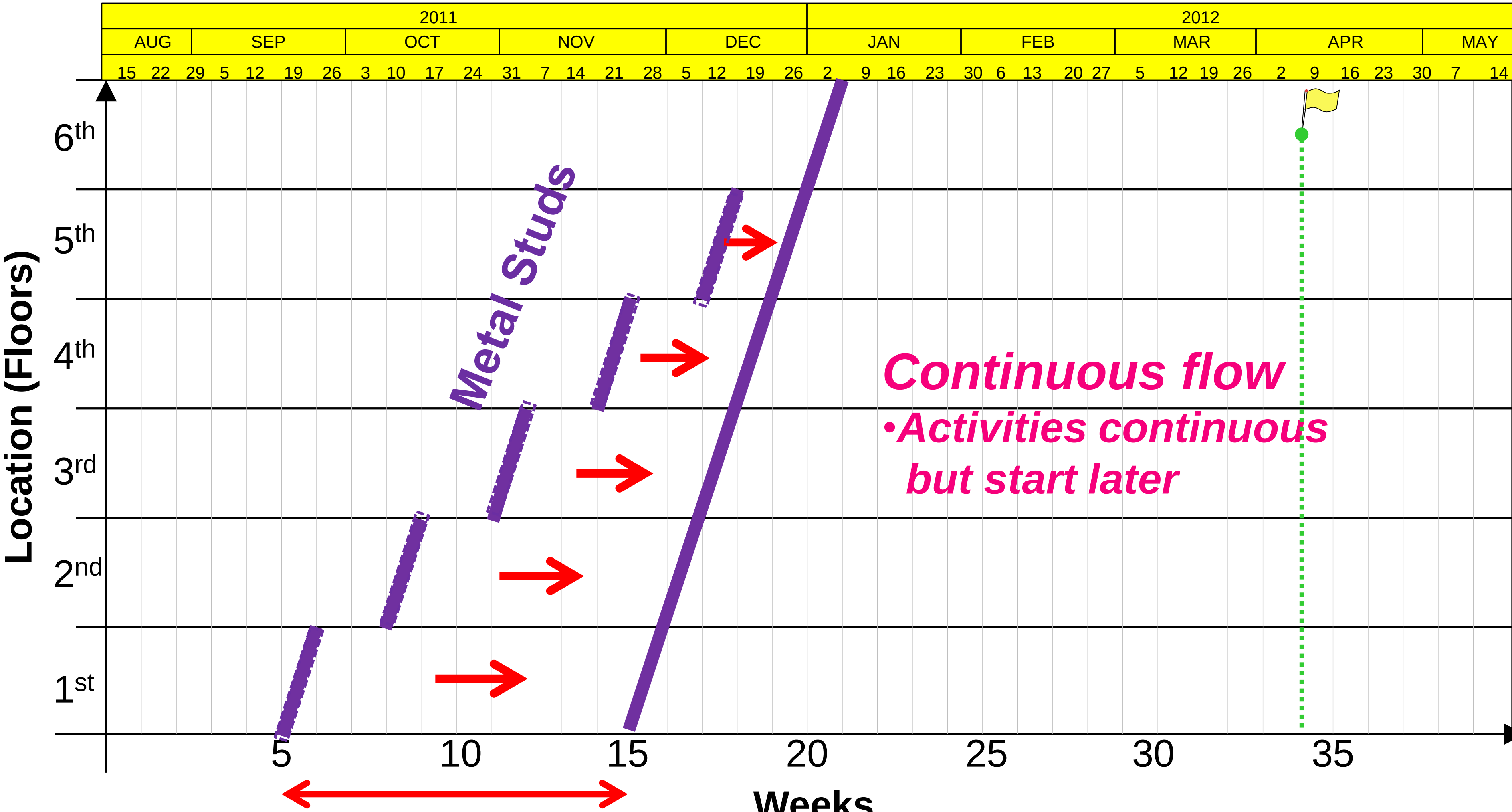
Flowline Diagram



Flowline Diagram

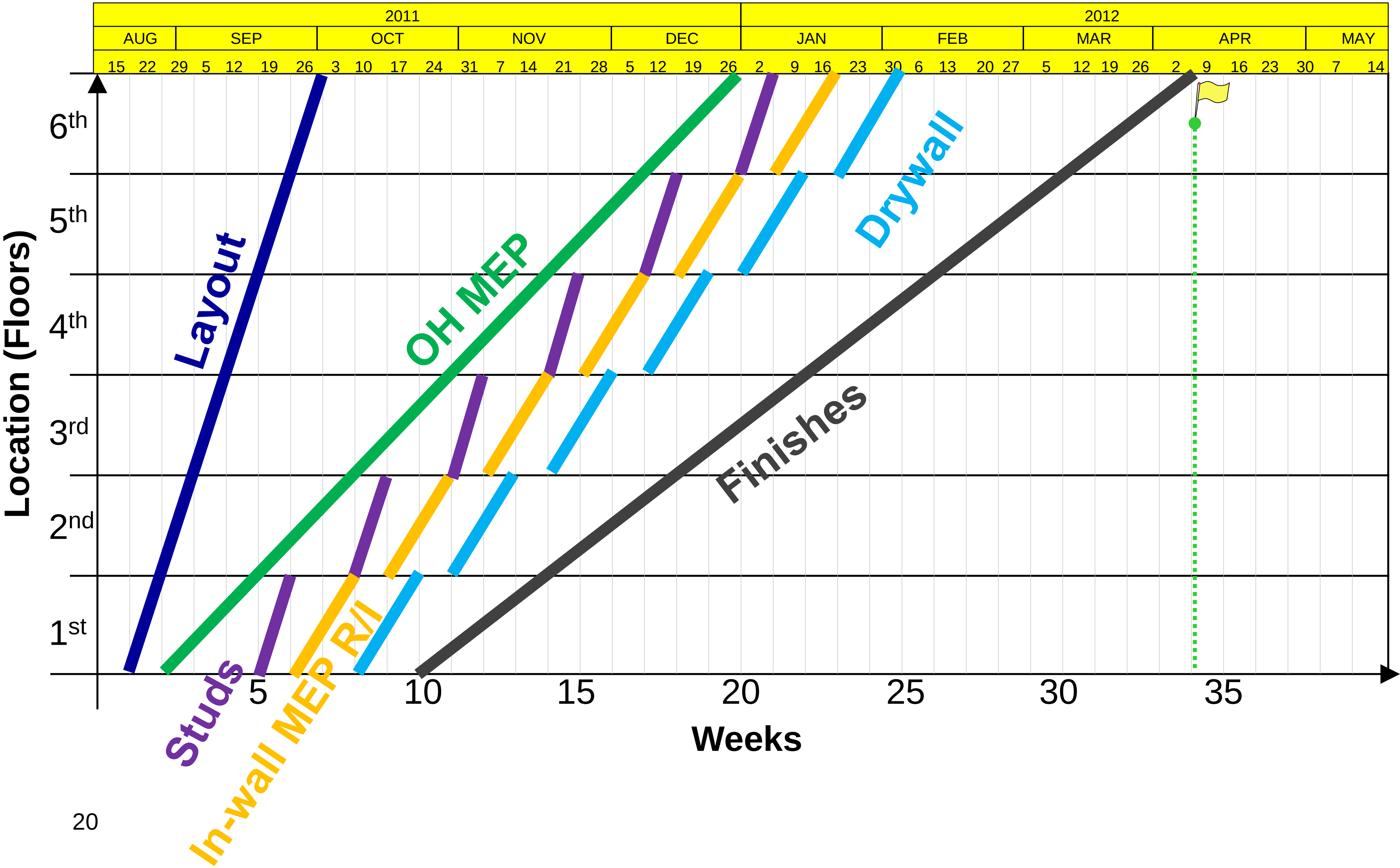


Flowline Diagram – Continuous Flow

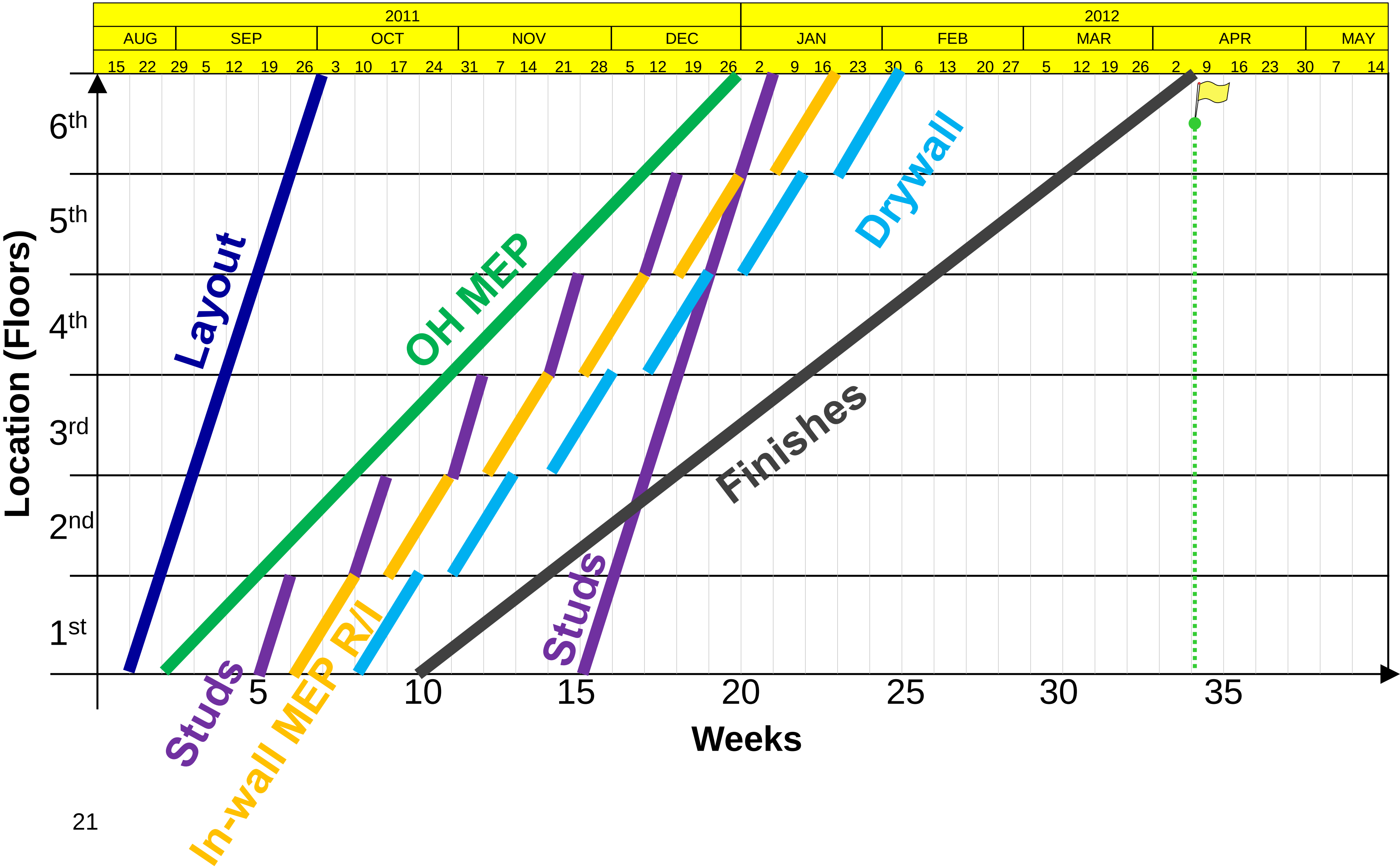


Start delayed until work can proceed continuously

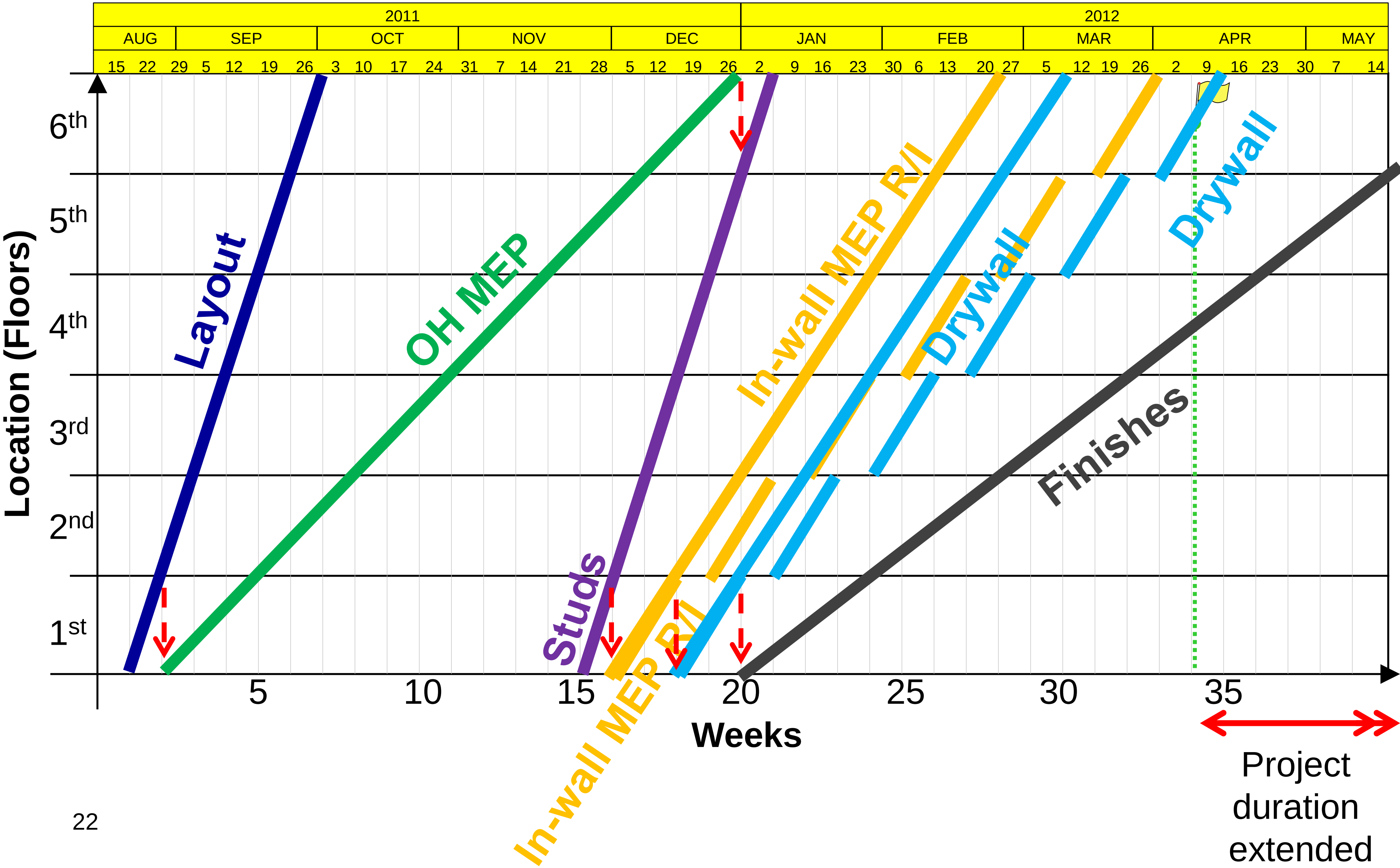
Flowline Diagram – Continuous Flow



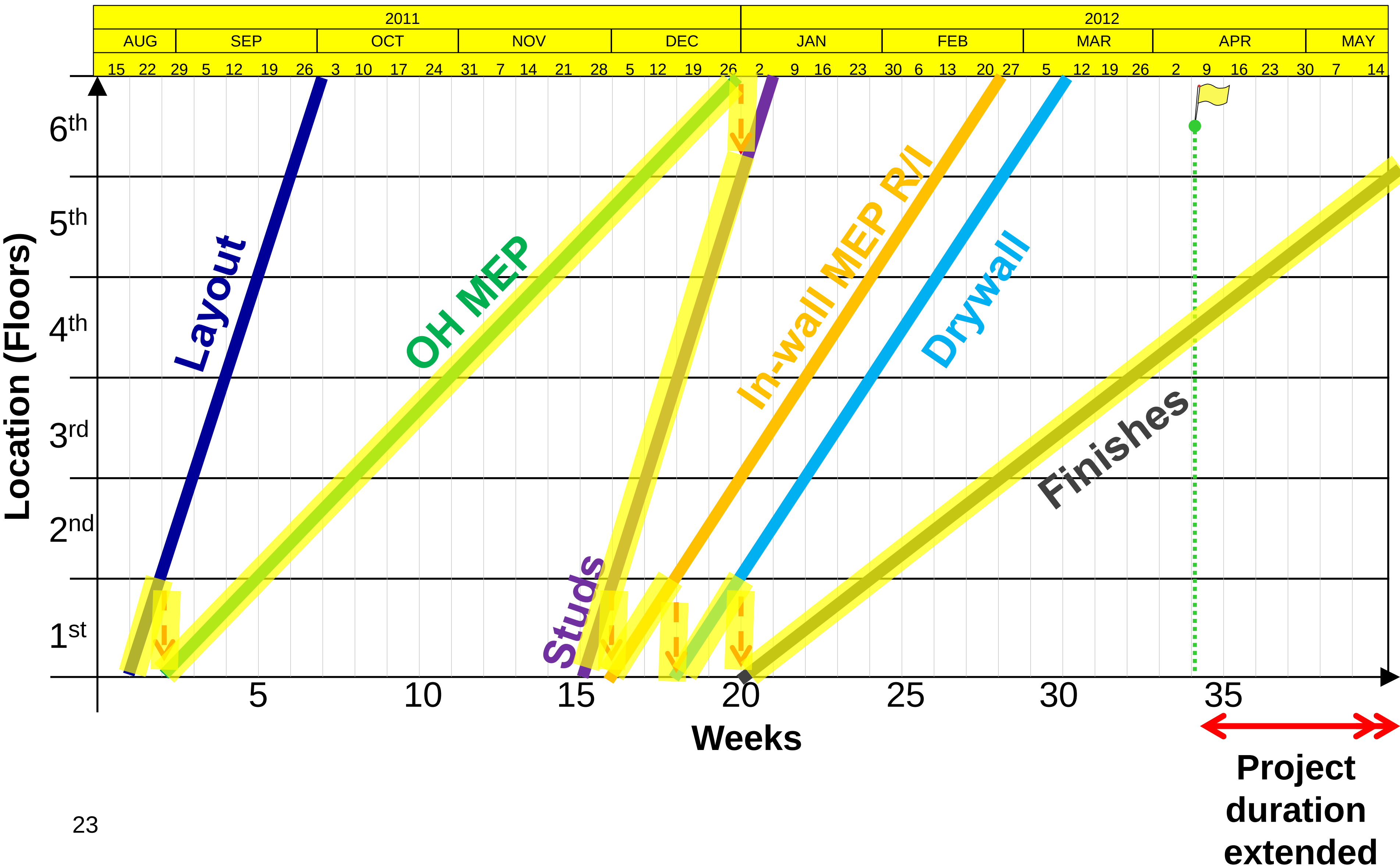
Flowline Diagram – Continuous Flow



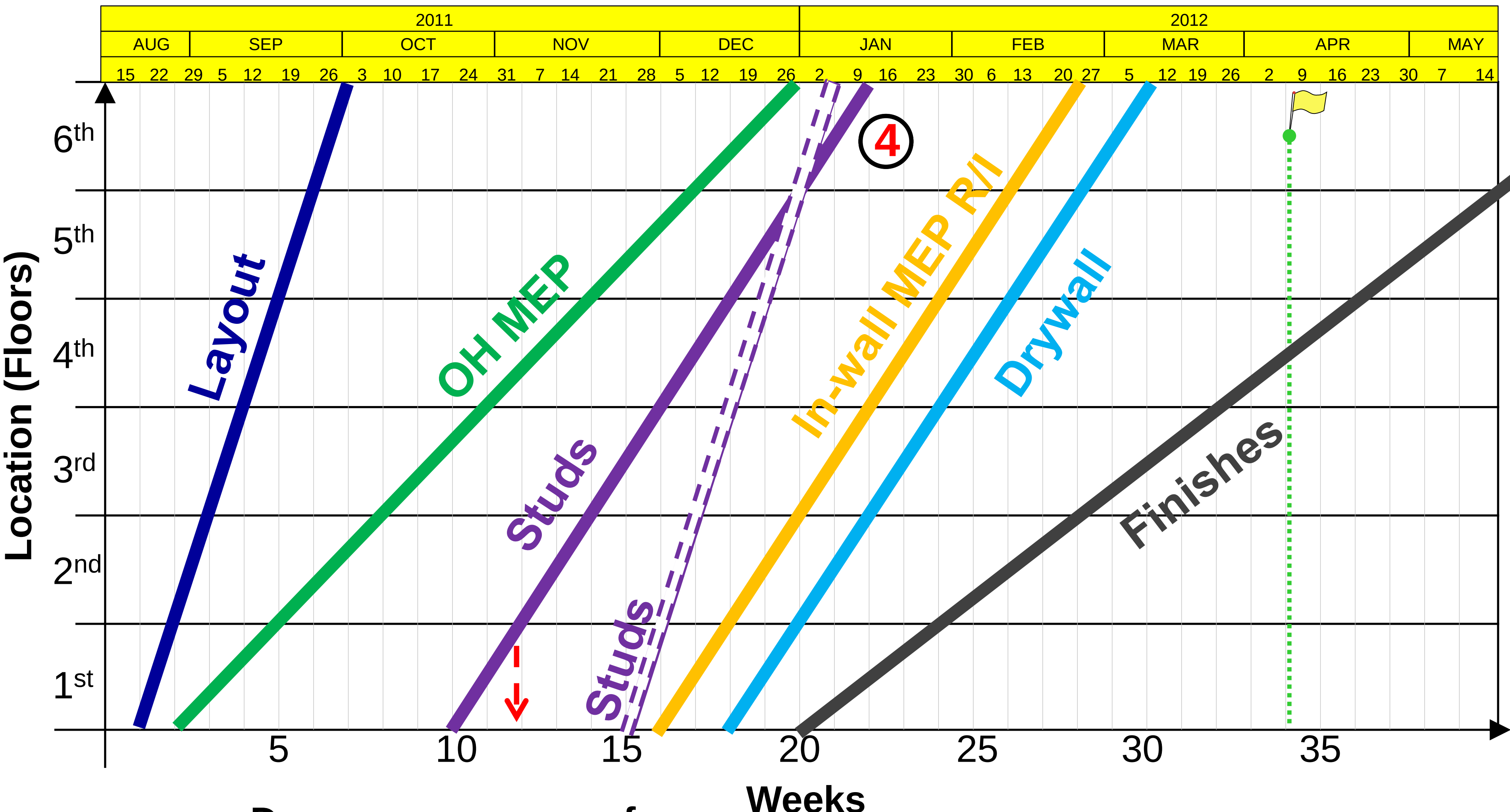
Flowline Diagram – Continuous Flow



Flowline Diagram – Continuous Flow

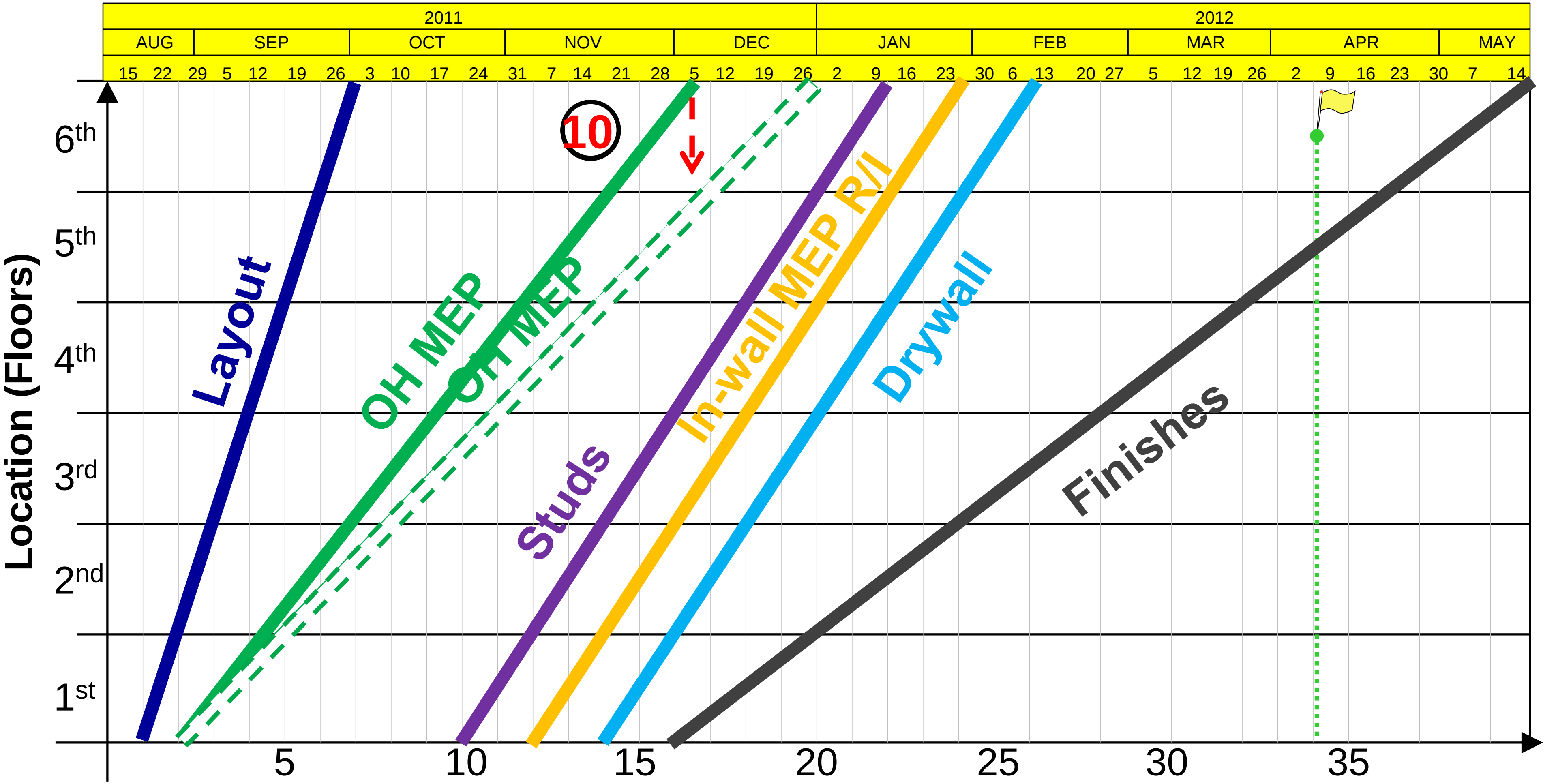


Flowline Diagram – Optimization



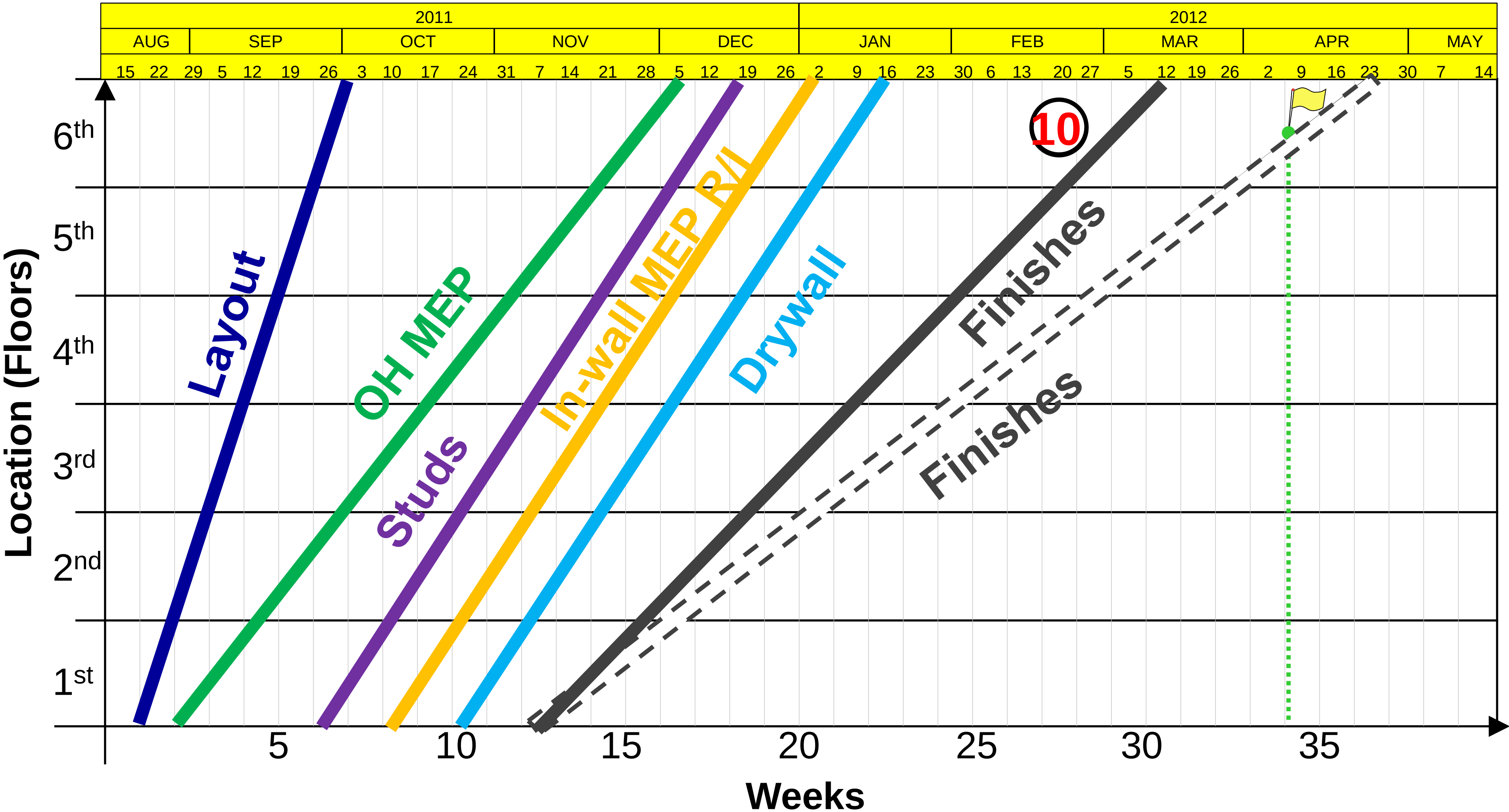
Decrease resources for Metal Studs—slow down

Flowline Diagram – Optimization



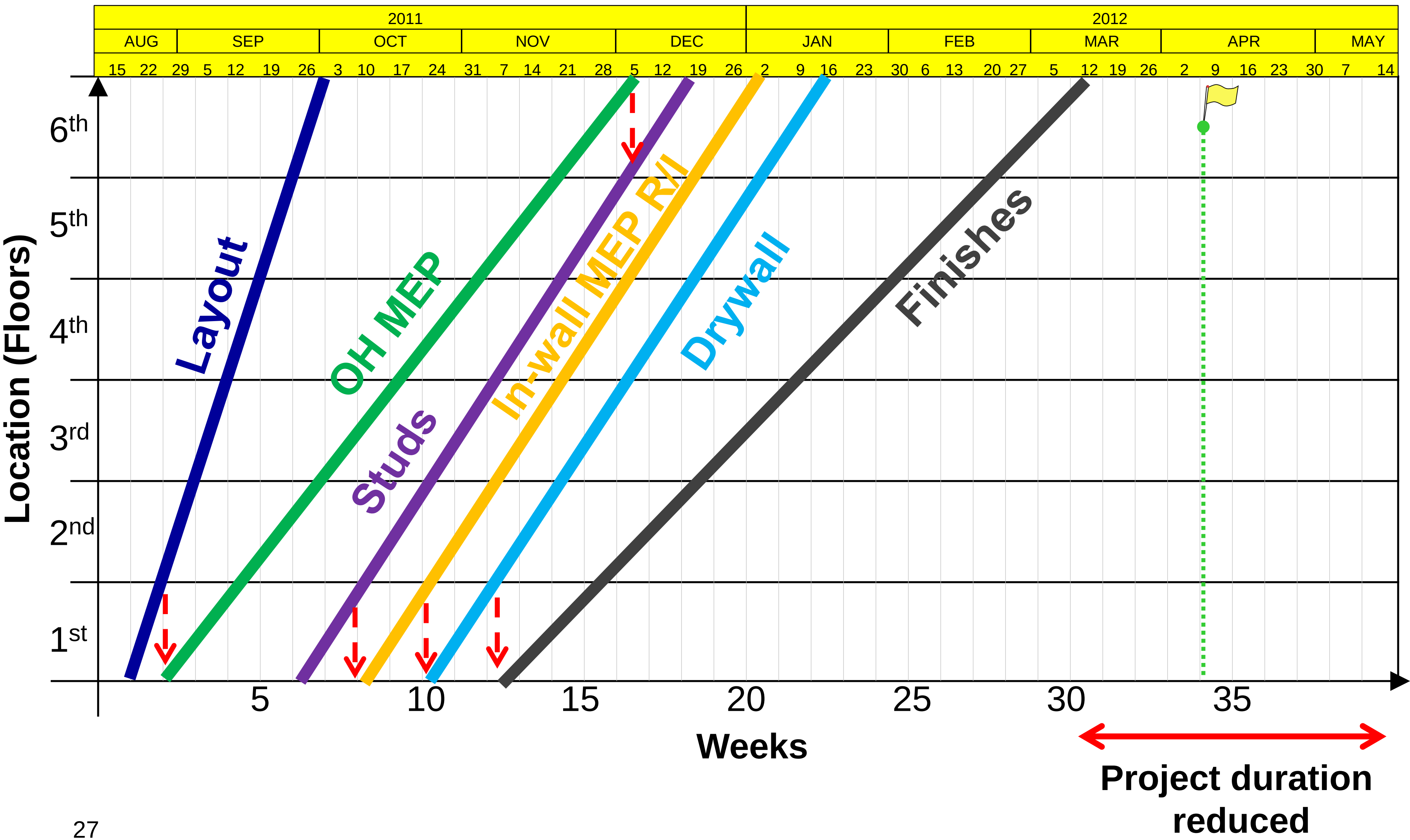
Increase resources for OH MEP

Flowline Diagram – Optimization

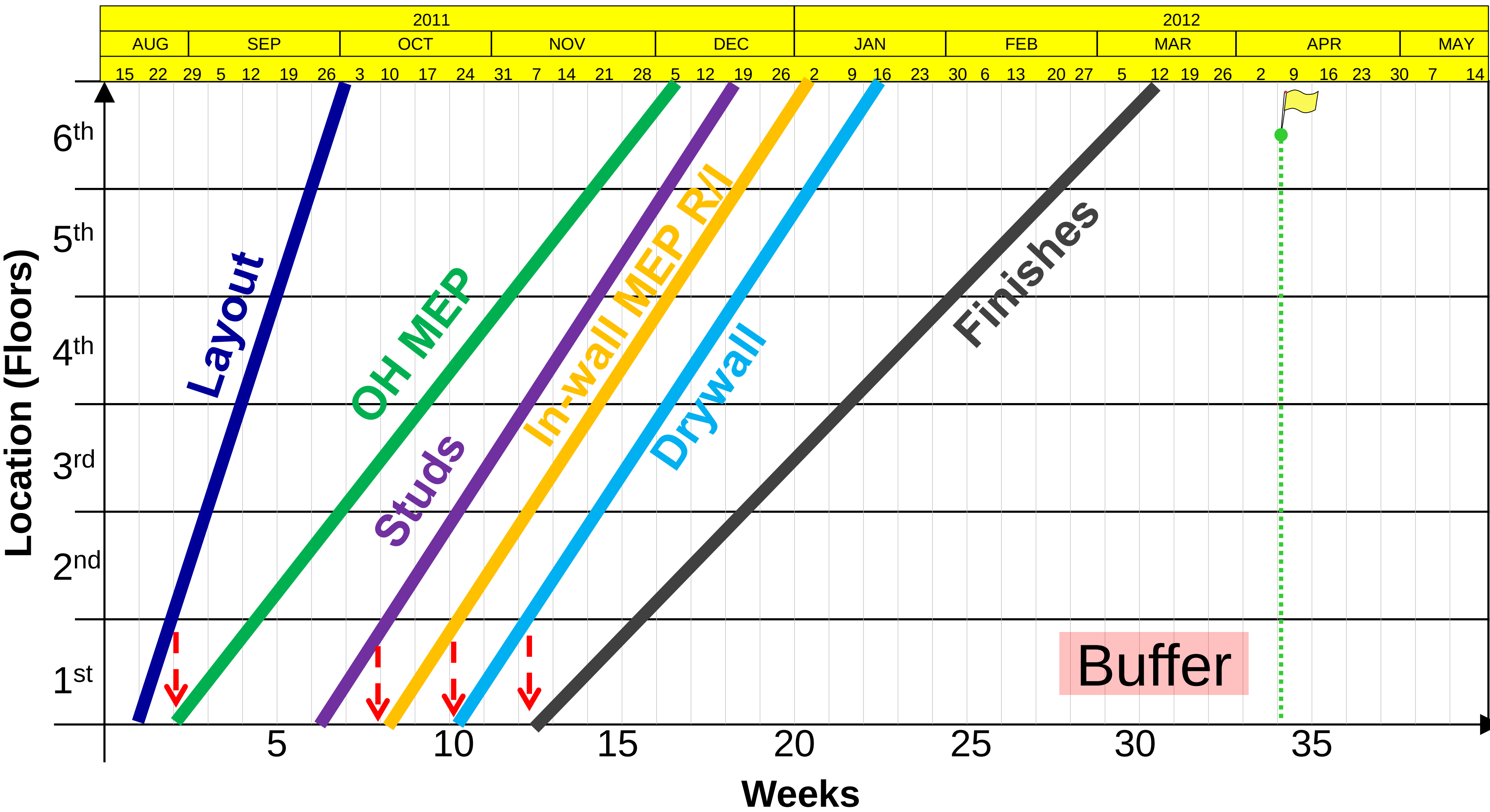


Increase resources for Finishes

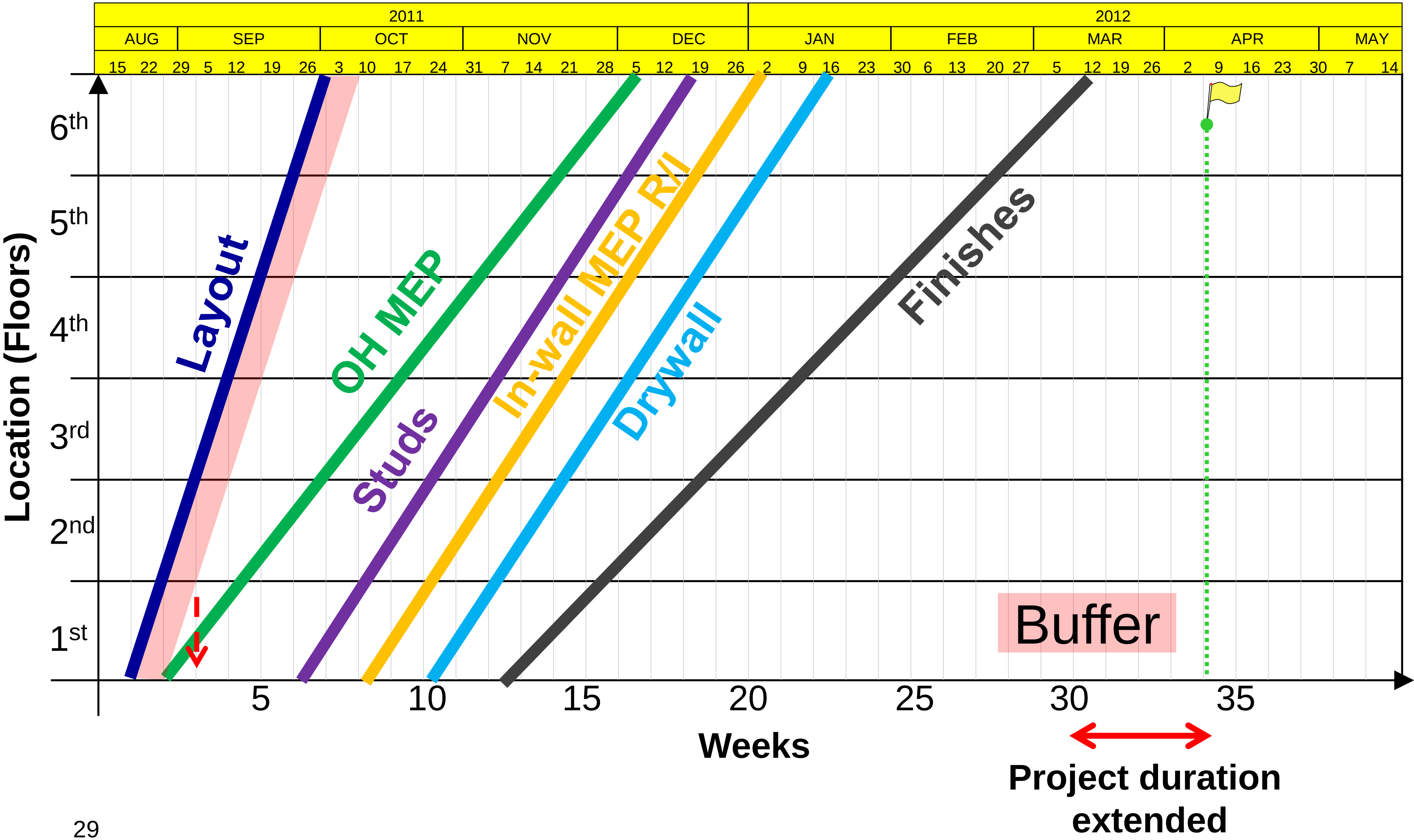
Flowline Diagram – Optimization



Flowline Diagram - Buffers



Flowline Diagram - Buffers



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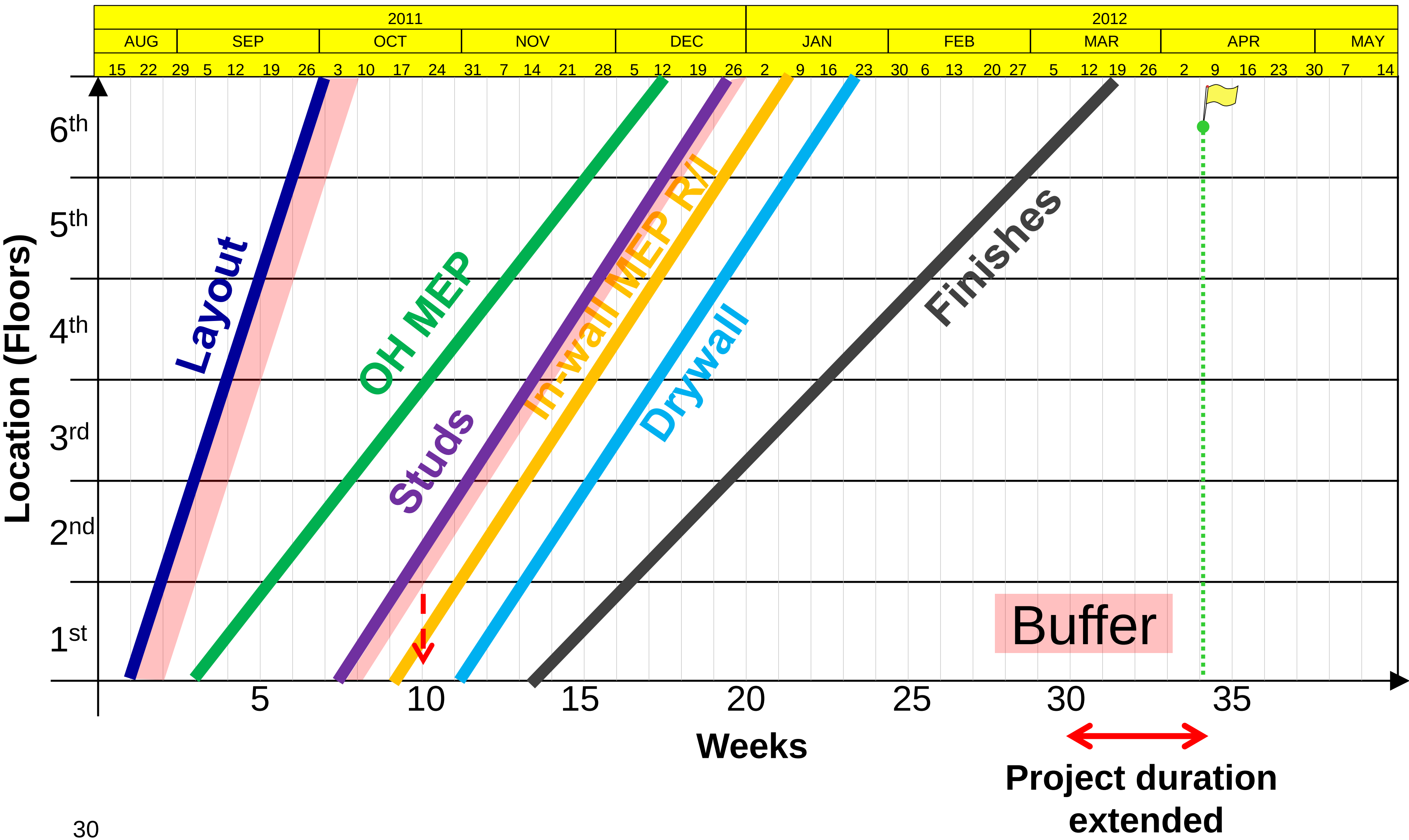

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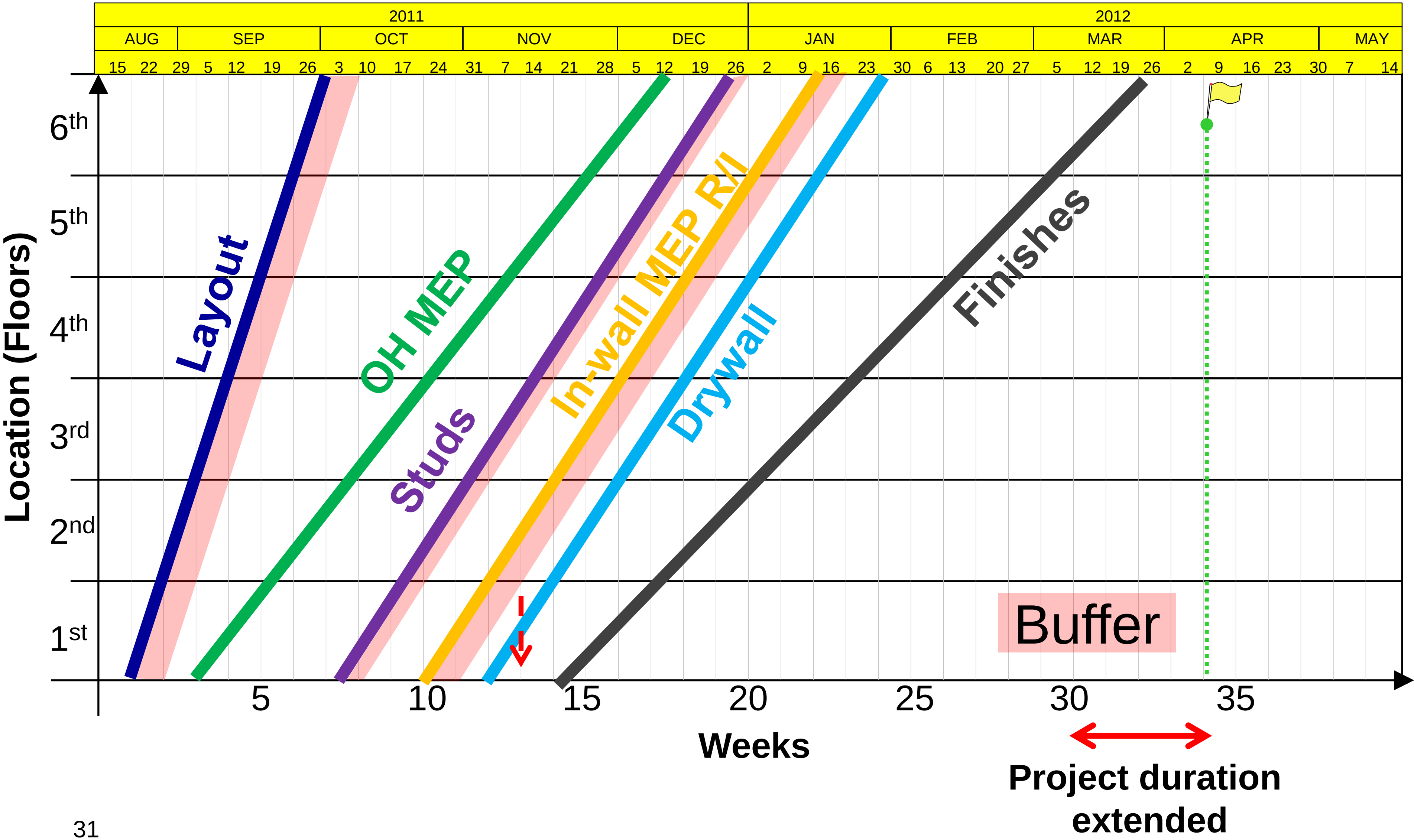
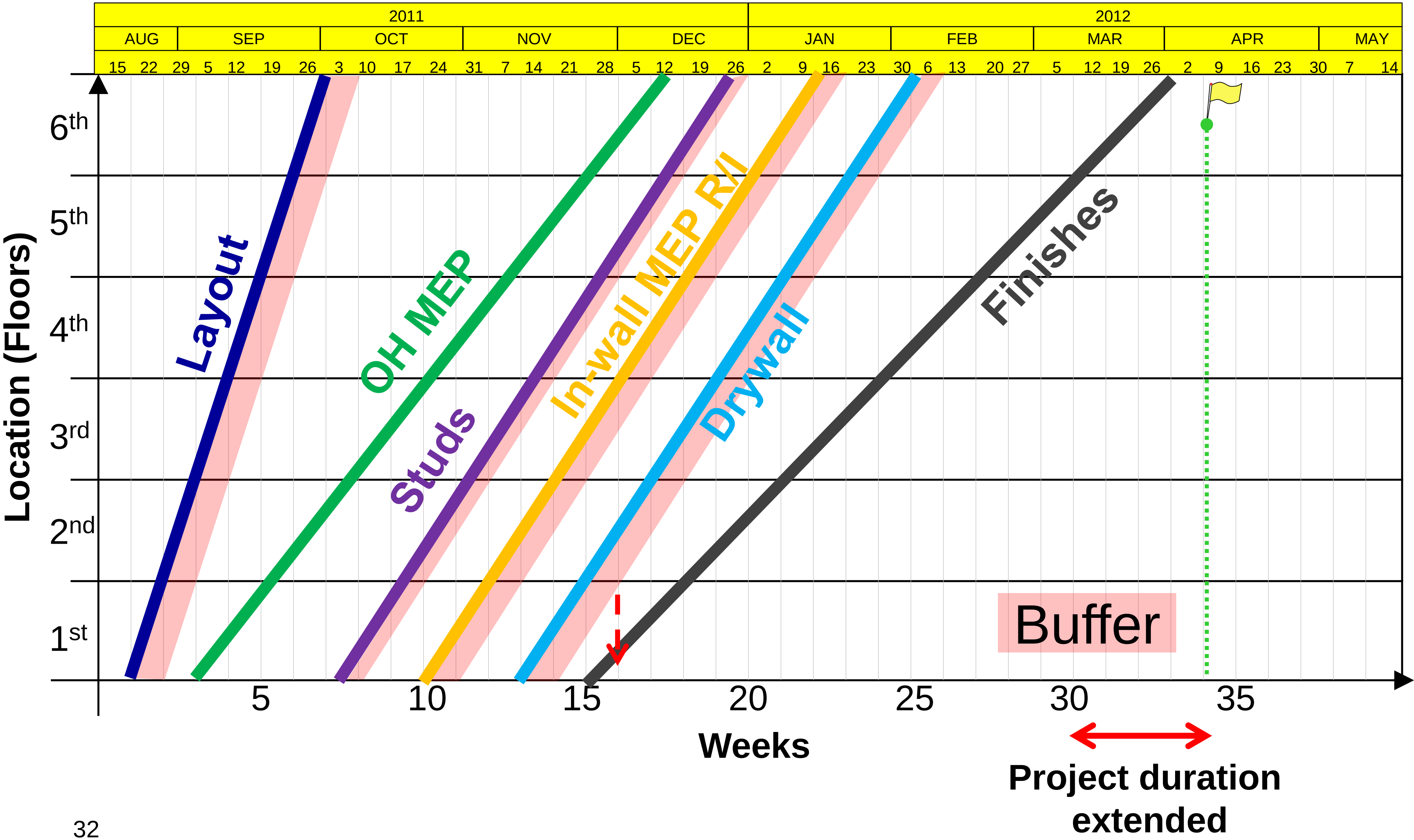


Flowline Diagram - Buffers



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Video 2

Layered CPM Logic – elaborated in the contact session

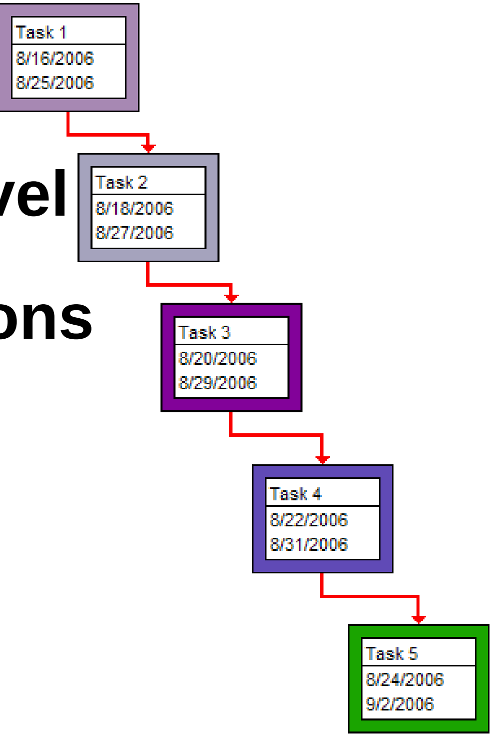
Layer 1: Location-based link

Layer 2: Location-based on higher level

Layer 3: Internal links between locations

Layer 4: location lags

Layer 5: Random CPM links



Production system cost

Production system costs are functions of the schedule

- Direct labor costs
- Overhead costs

Measures the efficiency of the plan

- Better schedule – lower overall production system costs

Motivator for trade contractors to follow the plan

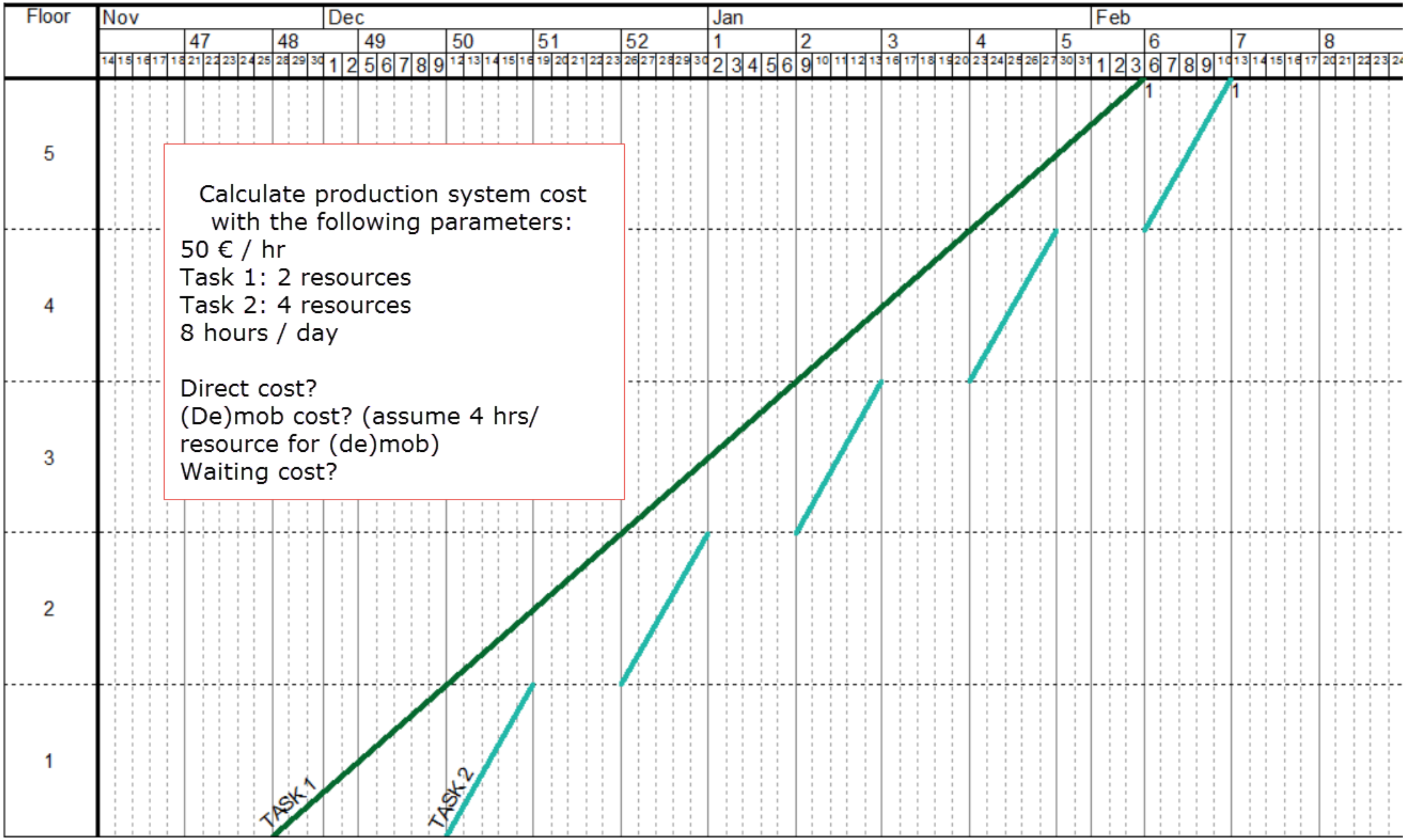
- Trade contractors pay for direct labor costs and any improvement in production system cost affects their bottom line

Production system cost components

- **Working time**
- **Mobilization / demobilization**
- **Waiting time**
- **Moving around**
- **Logistics**
- **Overhead**

Production system cost example

Calculation test



Calculate production system cost with the following parameters:
50 € / hr
Task 1: 2 resources
Task 2: 4 resources
8 hours / day

Direct cost?
(De)mob cost? (assume 4 hrs/ resource for (de)mob)
Waiting cost?

Production system risk

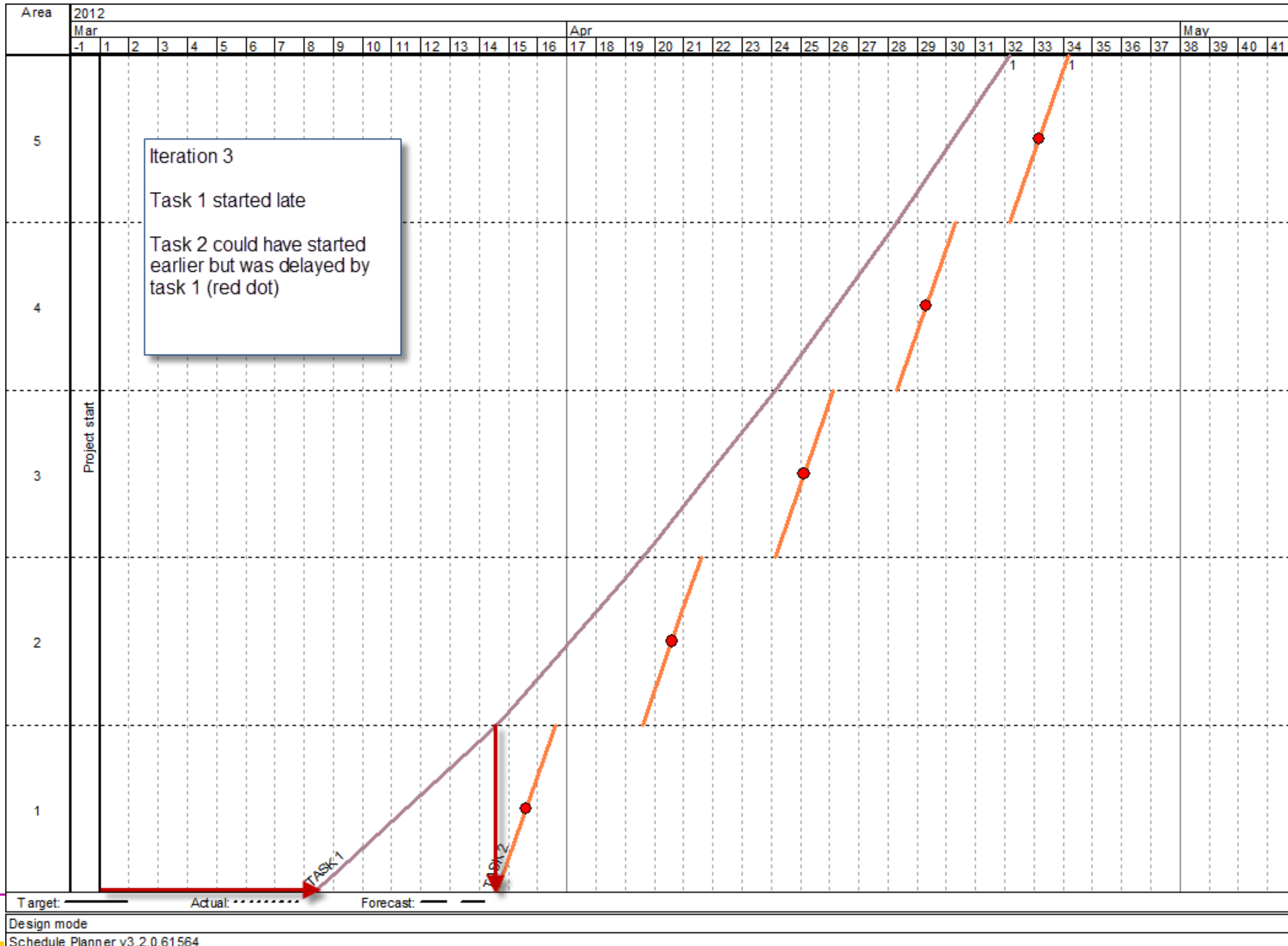
- **Construction has high variability**
  - Most of the variability is coming from external issues (70%)
  - Worker skills / work methods explain a small amount of variability (30%)
- **Variability can be analyzed with risk analysis. LBMS divides variability to:**
  - Variability in start dates
  - Variability in durations
  - Variability in productivity
  - Variability in resource availability
  - Variability caused by return delays

Design issues
Material logistics
Previous tasks
Weather
Resources
Communication

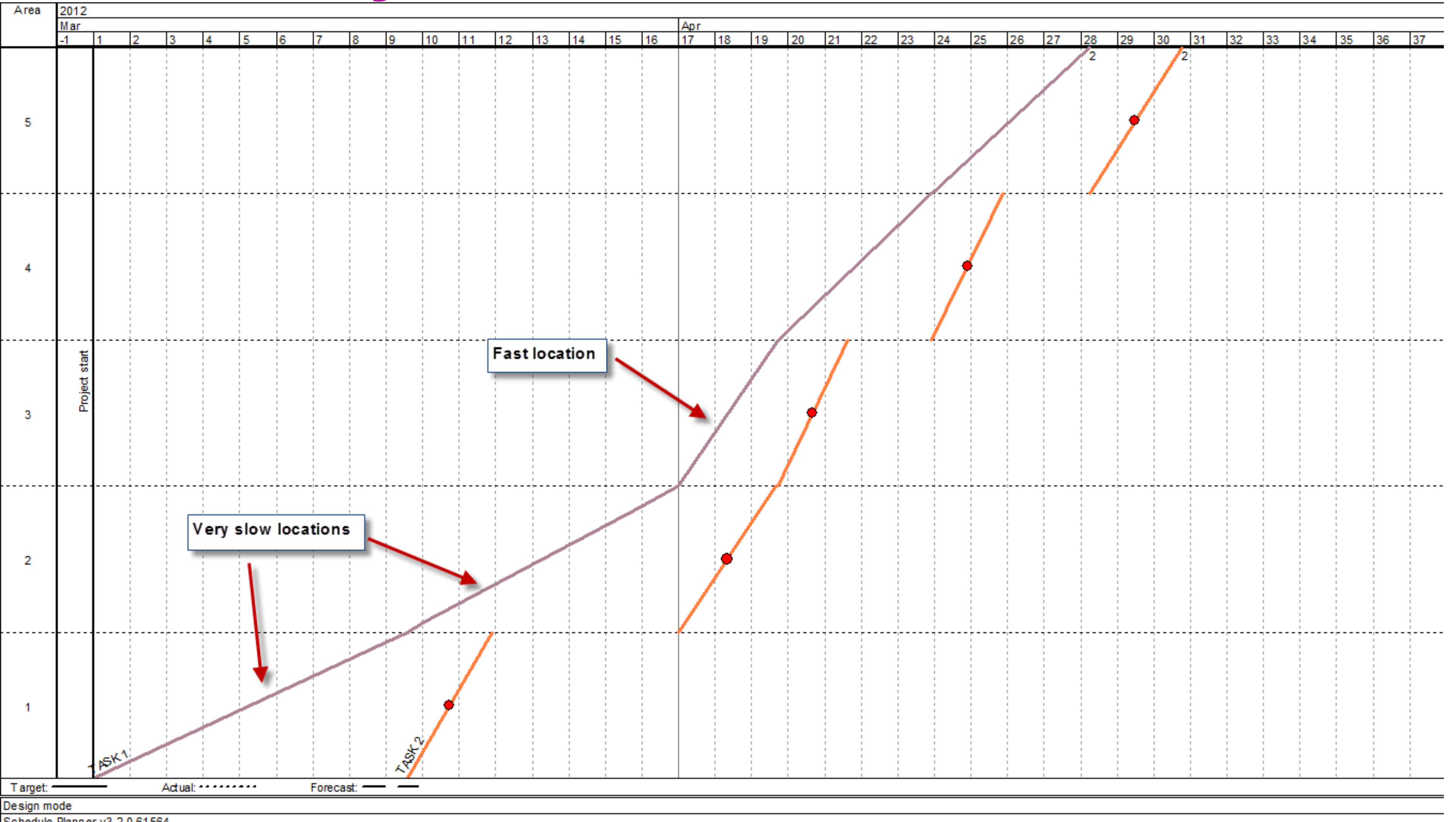
Work methods
Skill differences
Standardization

Optimum
productivity

Variability in start dates



Variability in durations



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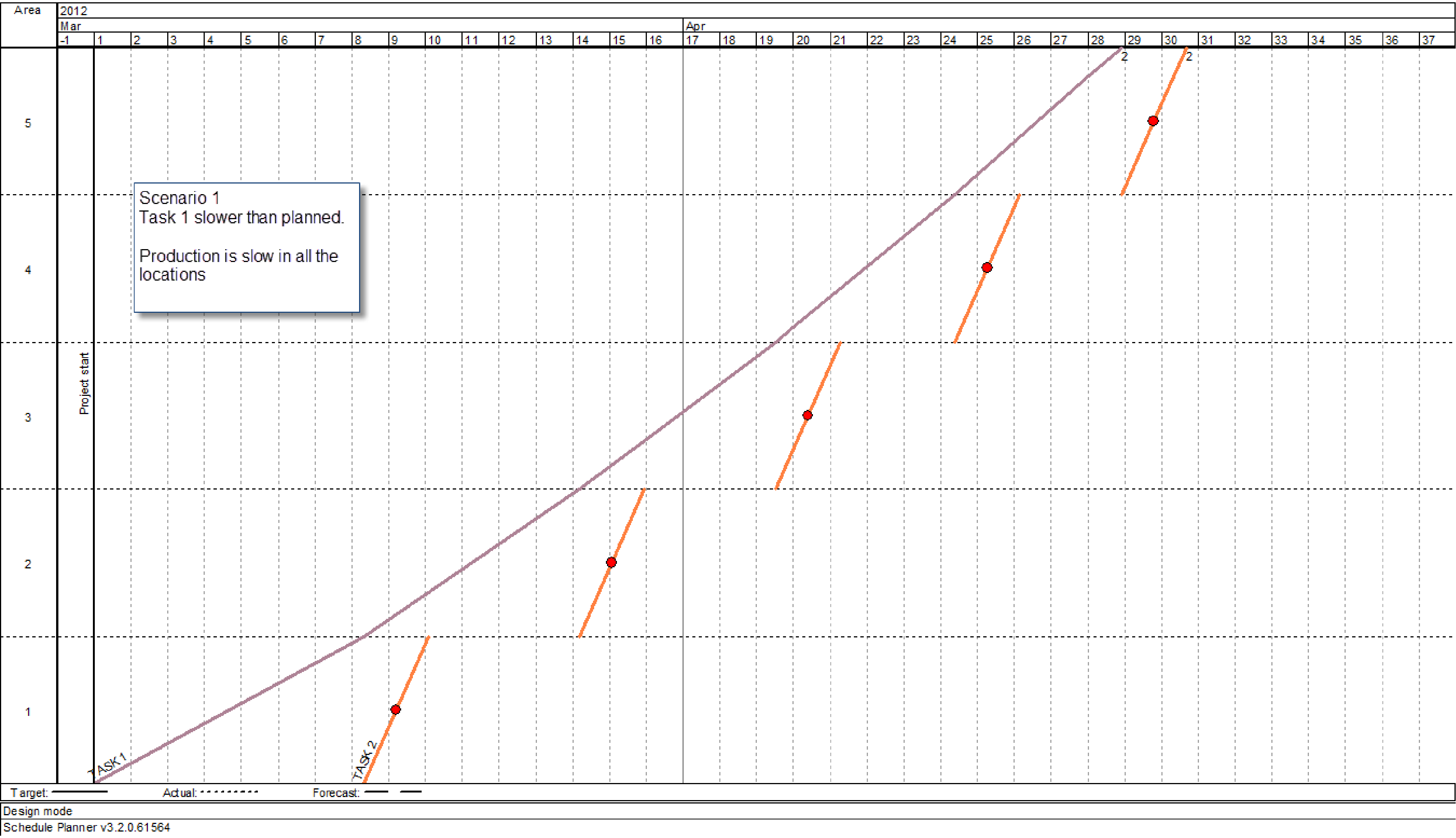
Variability in productivity



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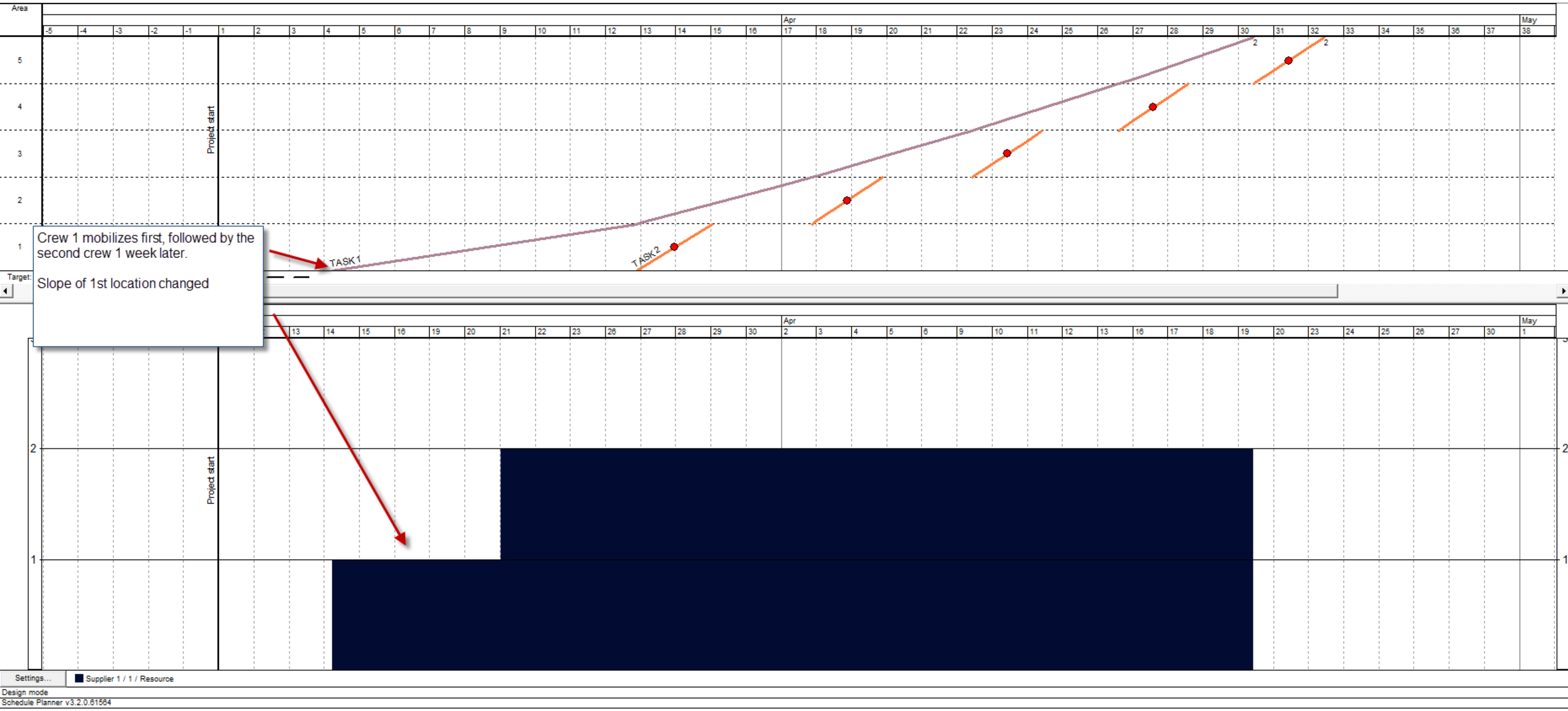
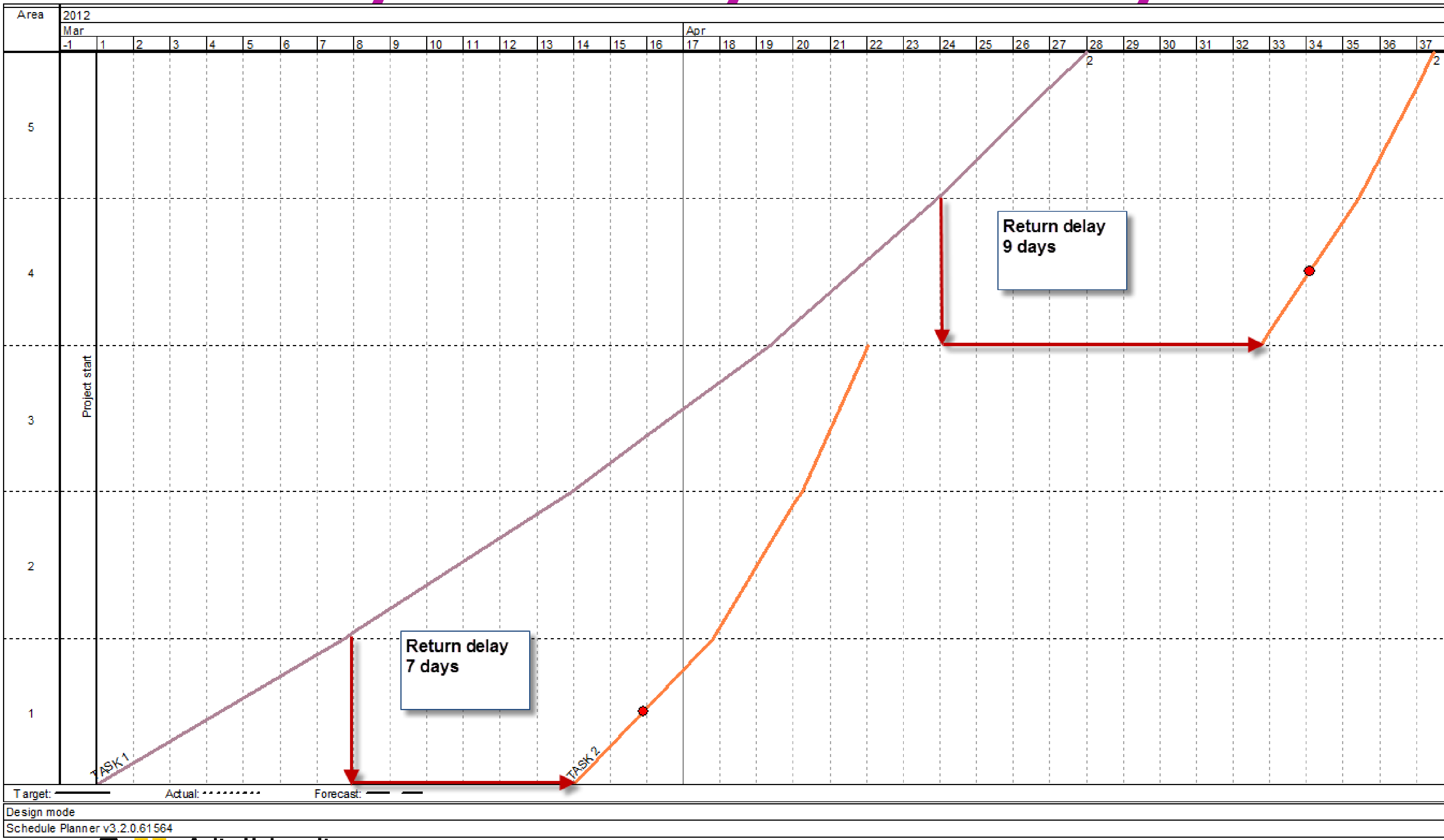
Variability of resource availability



Variability caused by return delays



Buffers to protect against risk – capacity buffer

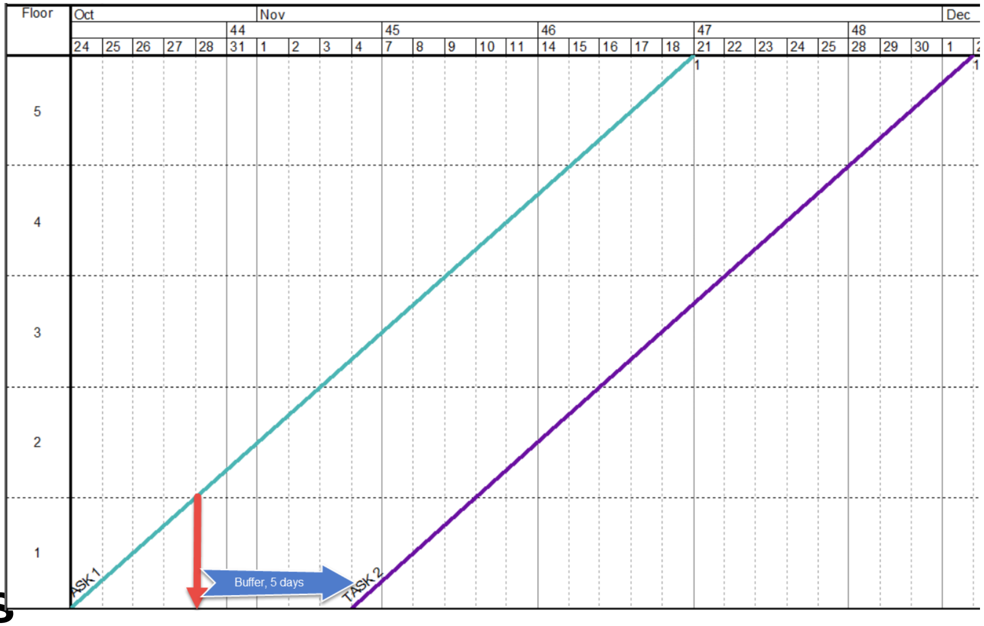
- **If variability / risks cannot be removed, buffers are needed**
- **CAPACITY BUFFER is one way of buffering**
  - Plan with fewer resources than are available for the project

  OR

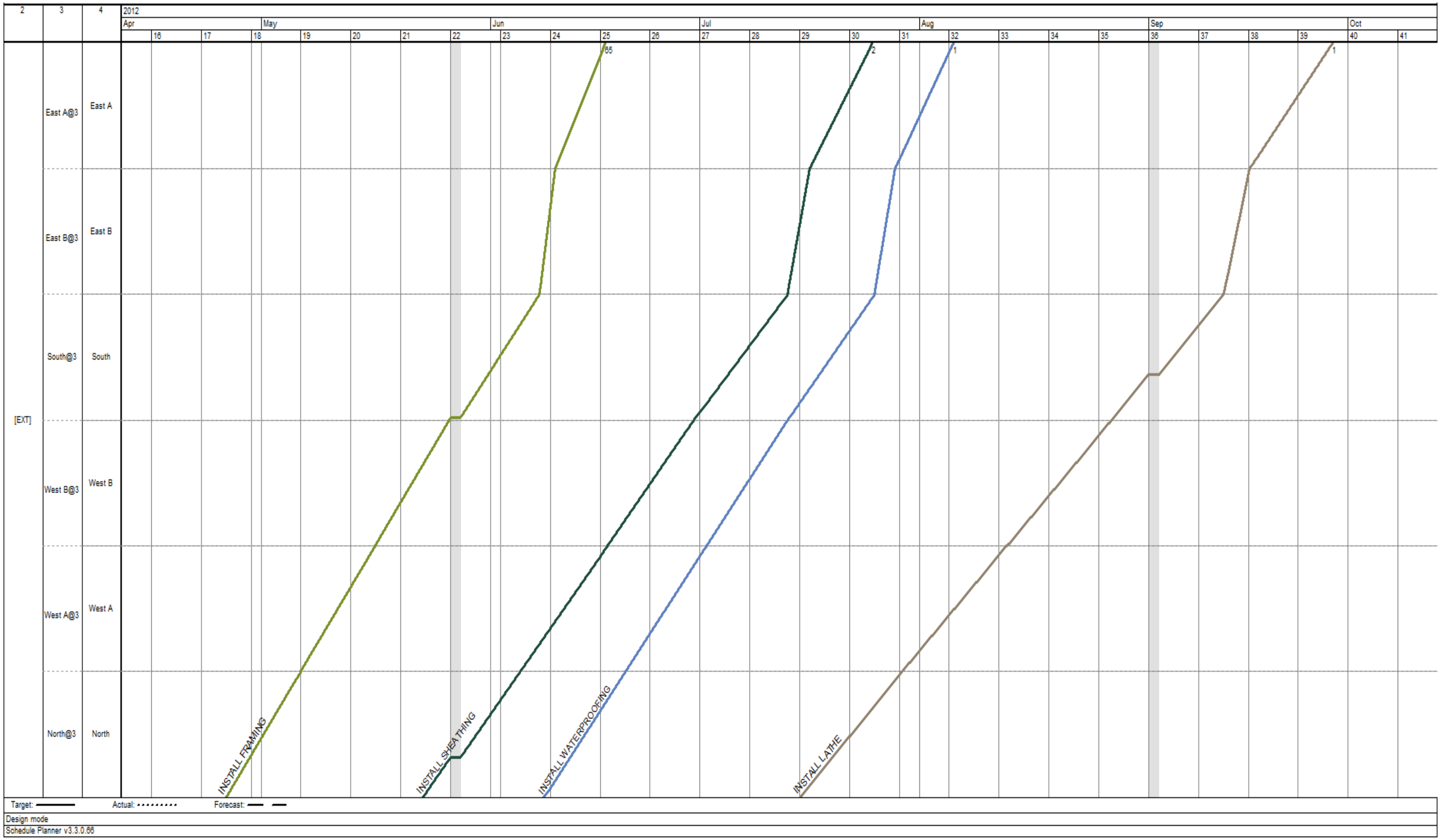
  - Plan with lower production rate
- **”Buffer resources” can work on non-critical tasks**
- **Potential problem: setting goals low may result in low production (Parkinson’s law)**

Buffers to protect against risk – time buffer

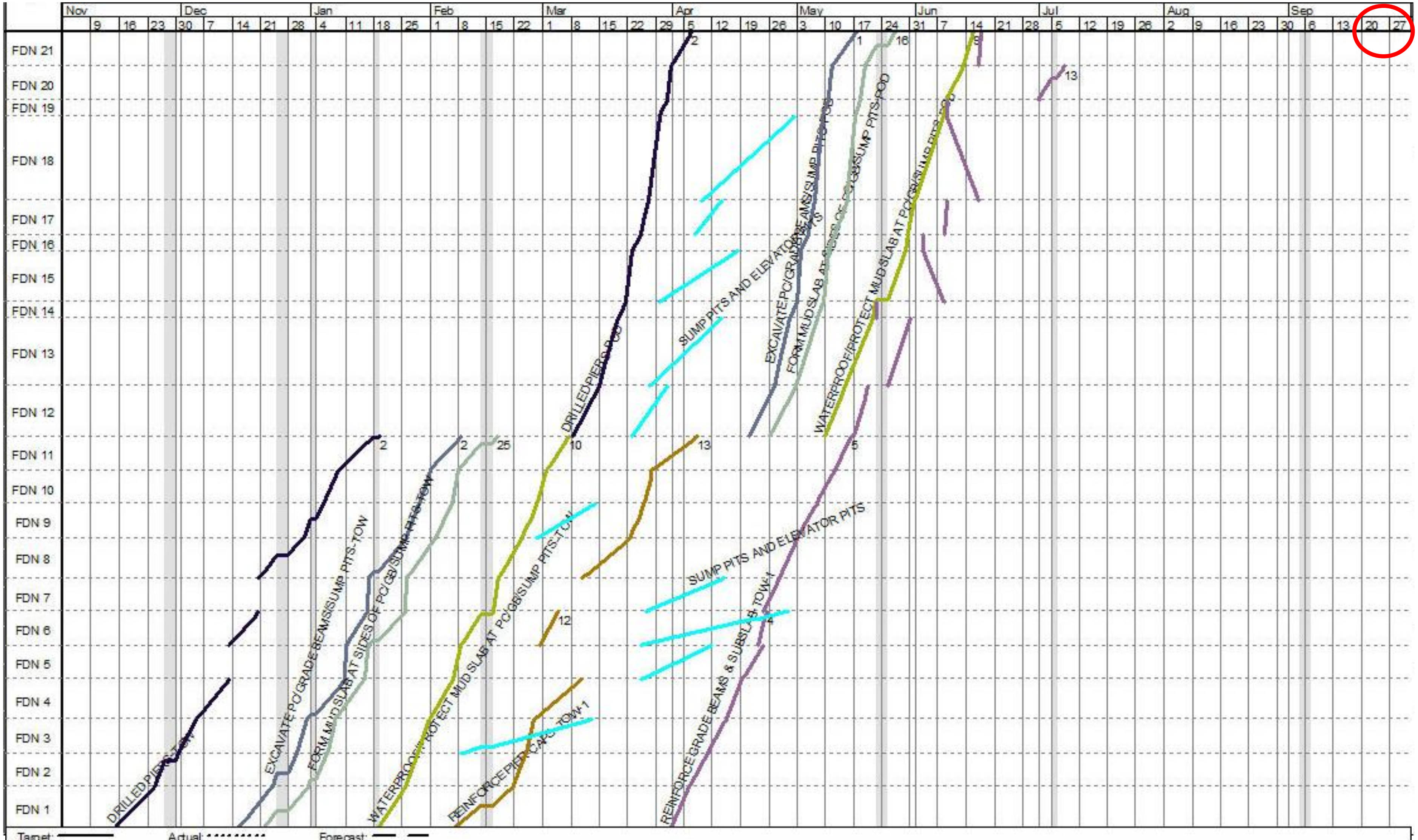
- Time buffers can be added between tasks, construction phases or end of the project
- In LBMS, primarily between tasks
- Time buffers give time to react to deviations and prevent cascading delays
- However, they increase project duration



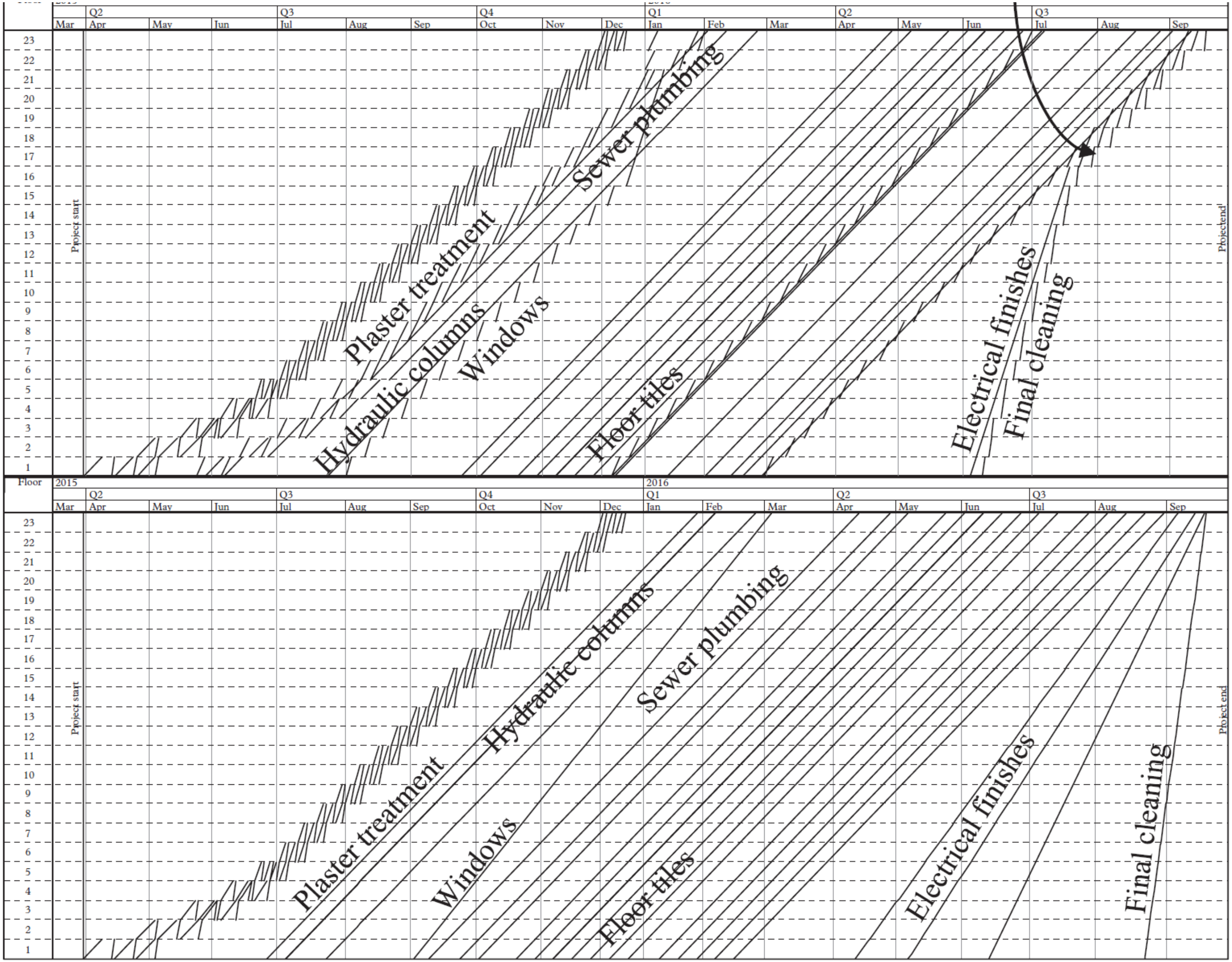
Planning example #1



Model-based Scheduling – 20 % duration compression



Planning example (Olivieri et al. 2018)



Thank you Questions & Comments