



Aalto University
School of Engineering

Operation Management in Construction

Lecture #3 LBMS controlling intro

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Associate professor

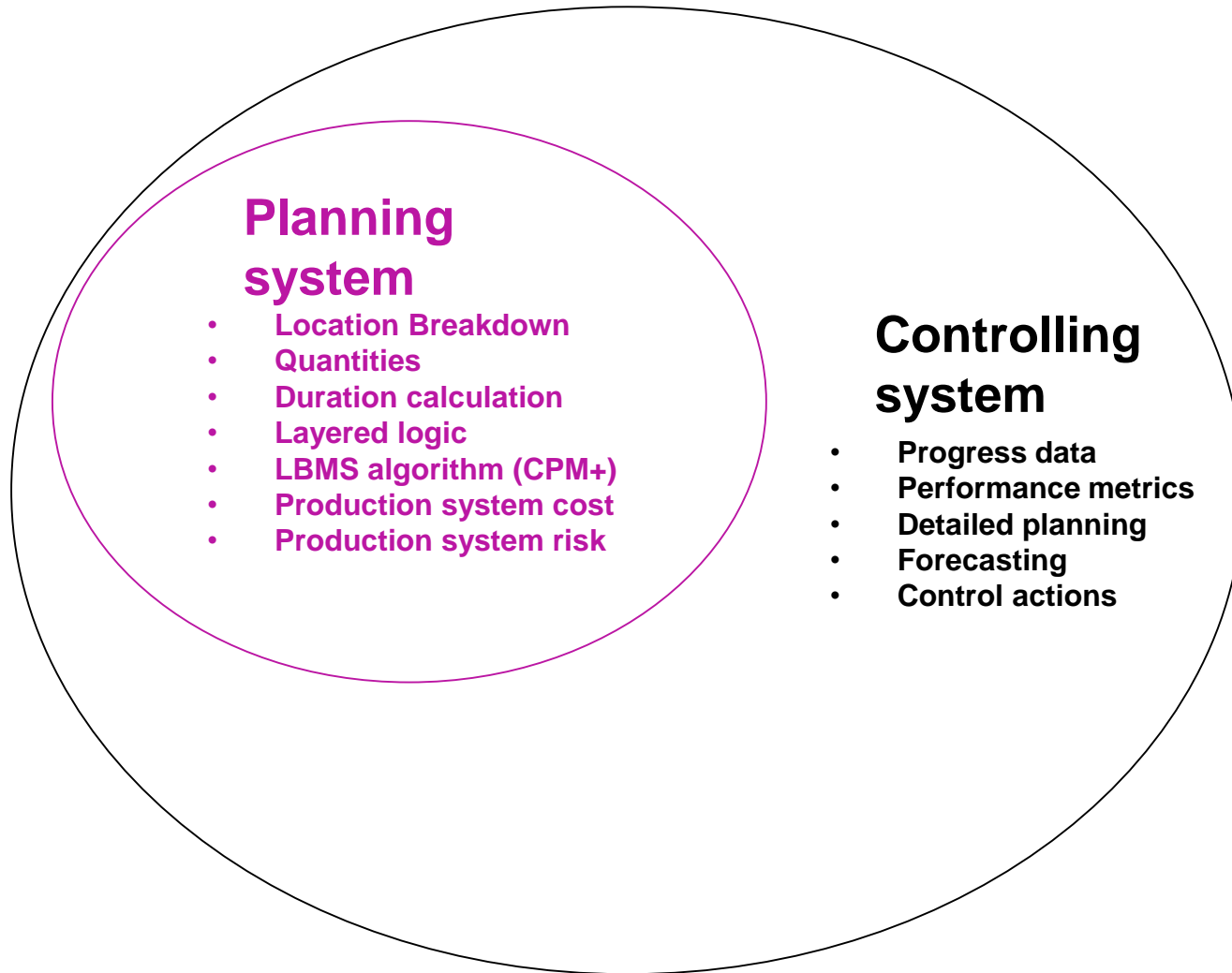
Topics, today's lecture #3

- **Learning objectives of Lecture #3**
- **LBMS controlling overview**
- **Cascading delays in construction**
- **Controlling case studies**

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 controlling*
- ILO 5: **Students can explain** the significance of work and labor flow and how flow can be achieved in construction
 - *ILO reinforced*
- ILO 8: **Students can** make production control decisions based on the schedule using the Location Based Management System
 - *ILO emphasized*

LBMS technical system



Progress data

- **Progress data for each task and location:**
 - Start dates
 - Finish date or quantities completed / % completed
 - Actual crew size (no. of people)
 - Actual worked hours
 - Suspensions (e.g. No work on Tuesday)
- **Daily / Weekly depending on project**
 - Real time in the future?

Progress data

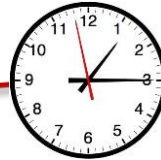
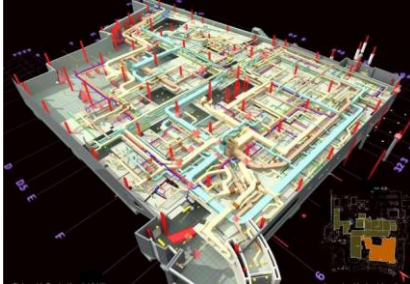
- **Manual data collection**
 - *Distributed*
 - *Centralized*
- **Digital data collection**
 - *Distributed*
 - *Centralized*
- **Automation in the (near) future?**

Step 1: iCONS – real time data



1. What is Intelligent Construction Site?

Intelligent products



Real time



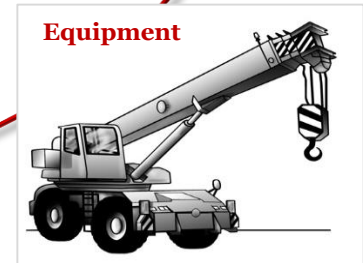
Materials



Production Control System

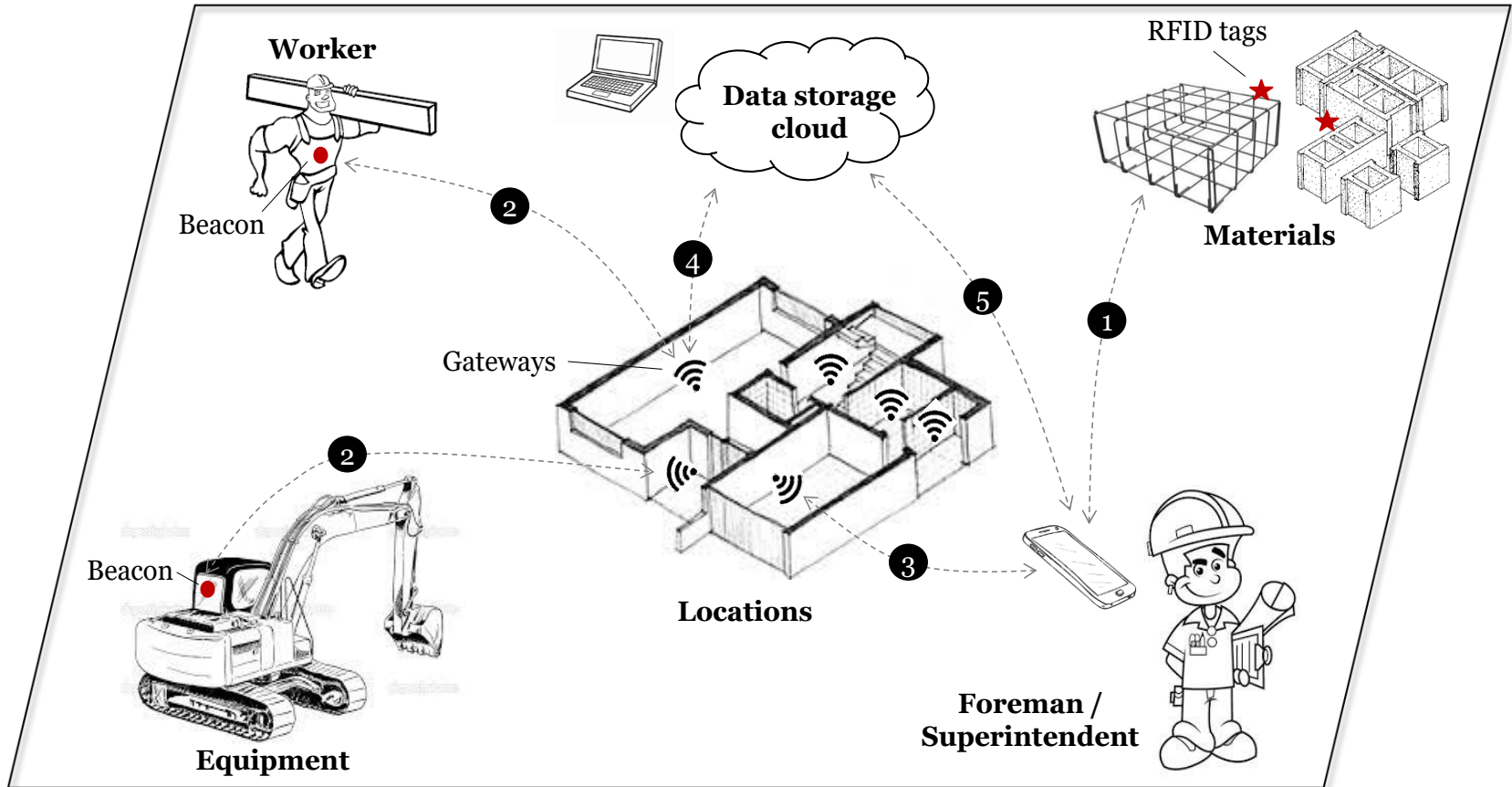


Labor

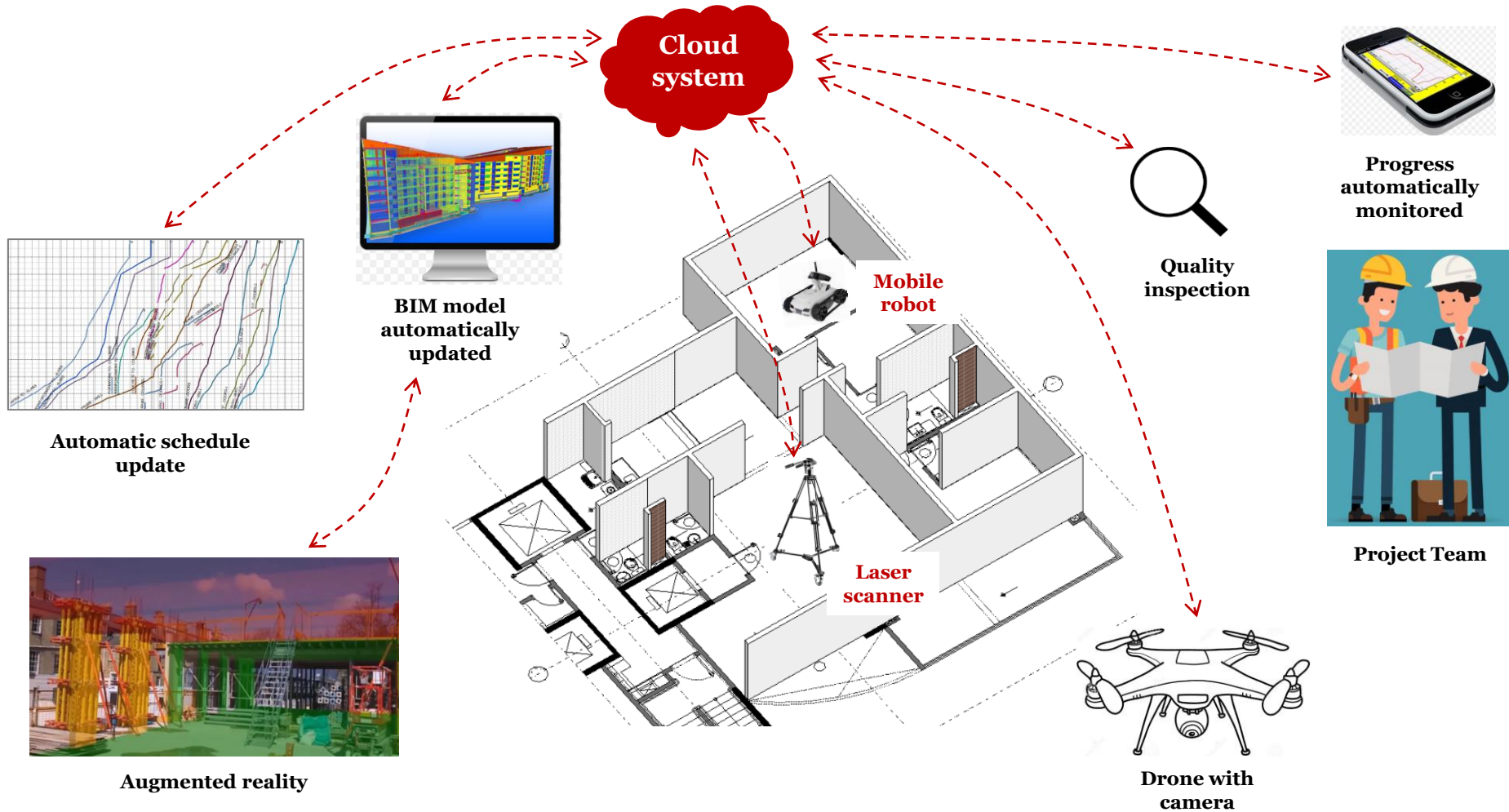


Equipment

ICONS



Step 2: Reality Capture



LBMS: Visualization of status – control chart

5	✓			
4	✓	45% or 323m2		
3	✓	✓	23% or 53No.	
2	✓	✓	✓	
1	✓	✓	✓	
	Task 1	Task 2	Task 3	Task 4

Late start

Behind

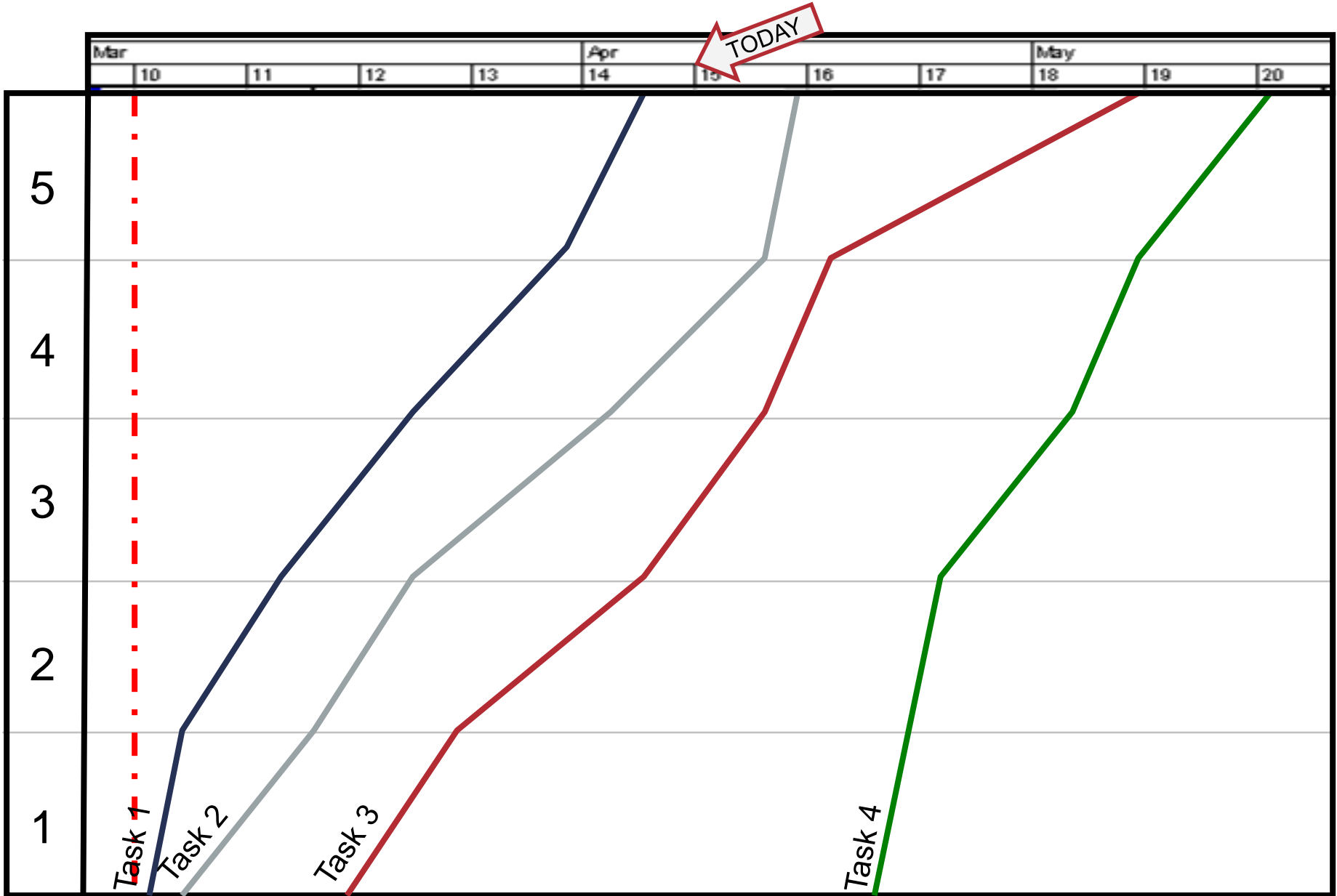
On-time

Complete

Simplified project control

Location based updates

Color coded for clarity



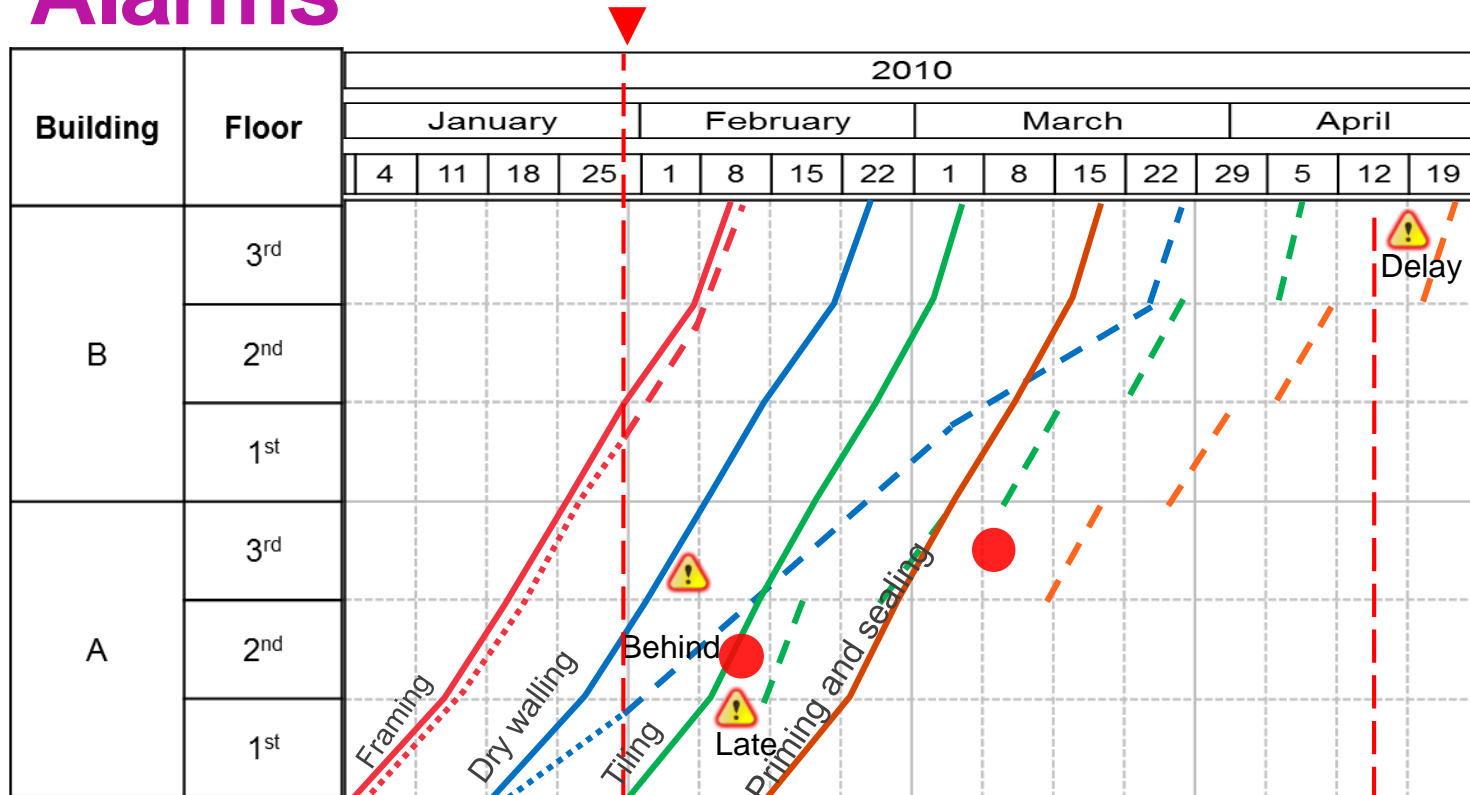
LBMS key performance metrics

- **Actual production rate (units / day)**
 - Actual quantity / duration
 - General Contractor's main interest – how fast production is moving. However, does not measure **productivity**
- **Actual labor consumption (manhours / unit)**
 - Actual manhours / actual quantity
 - A measure of **productivity**. Subcontractor's main interest. Improving productivity helps both the GC and the sub. Informs control action decisions. Harder to get data.

LBMS schedule forecast calculations

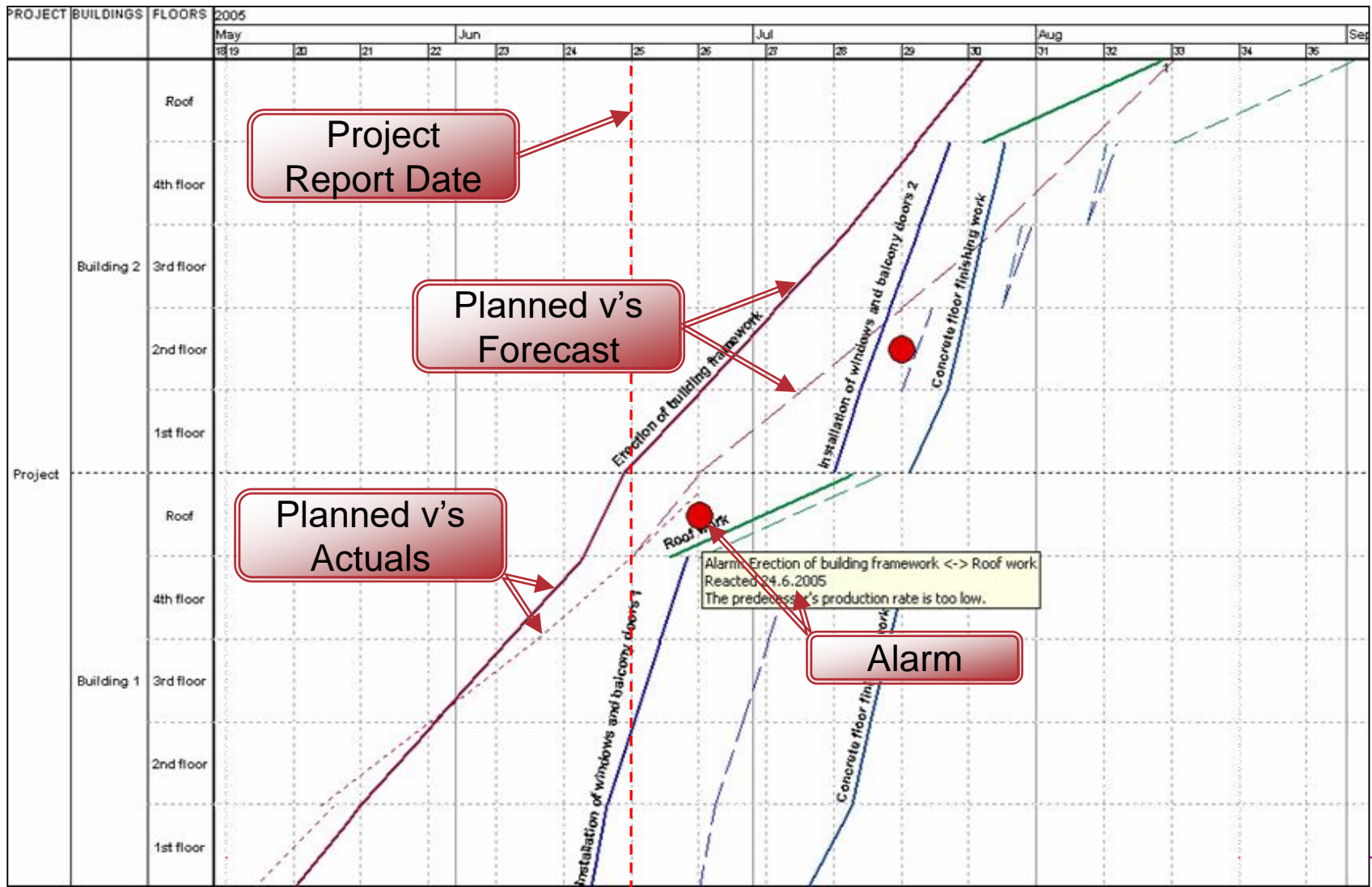
- **Assumptions: (Seppänen, 2009)**
 - Use actual labor consumption
 - Use planned resources
 - Use planned logic
 - If actual progress deviates from planned logic, ignore logic in ongoing locations but resume planned logic in future locations
 - If multiple locations have been started
 - *Assume even split of resources to ongoing locations*
 - *After ongoing locations finish, resume planned behavior (one location at the time)*

Alarms



- **LBMS alarms are generated when predecessor forecast impacts successor forecast**
 - Delaying start
 - Causing a discontinuity

Alarms



Control actions

- **Control actions are responses to alarms**
- **The goal is to prevent an alarm from turning into a problem**
- **Forecast updated based on planned action: (in order of preference)**
 - Root cause analysis and improving productivity
 - Increase / decrease in resources
 - Sequence change
 - Overtime / holiday / weekend work
 - Etc.
- **Update the forecast, not the plan**
 - Each action will change some part of the forecast formula
 - Plan enough actions to prevent the problem

End of video 1

Control actions prevent cascading delays (Seppänen 2009)

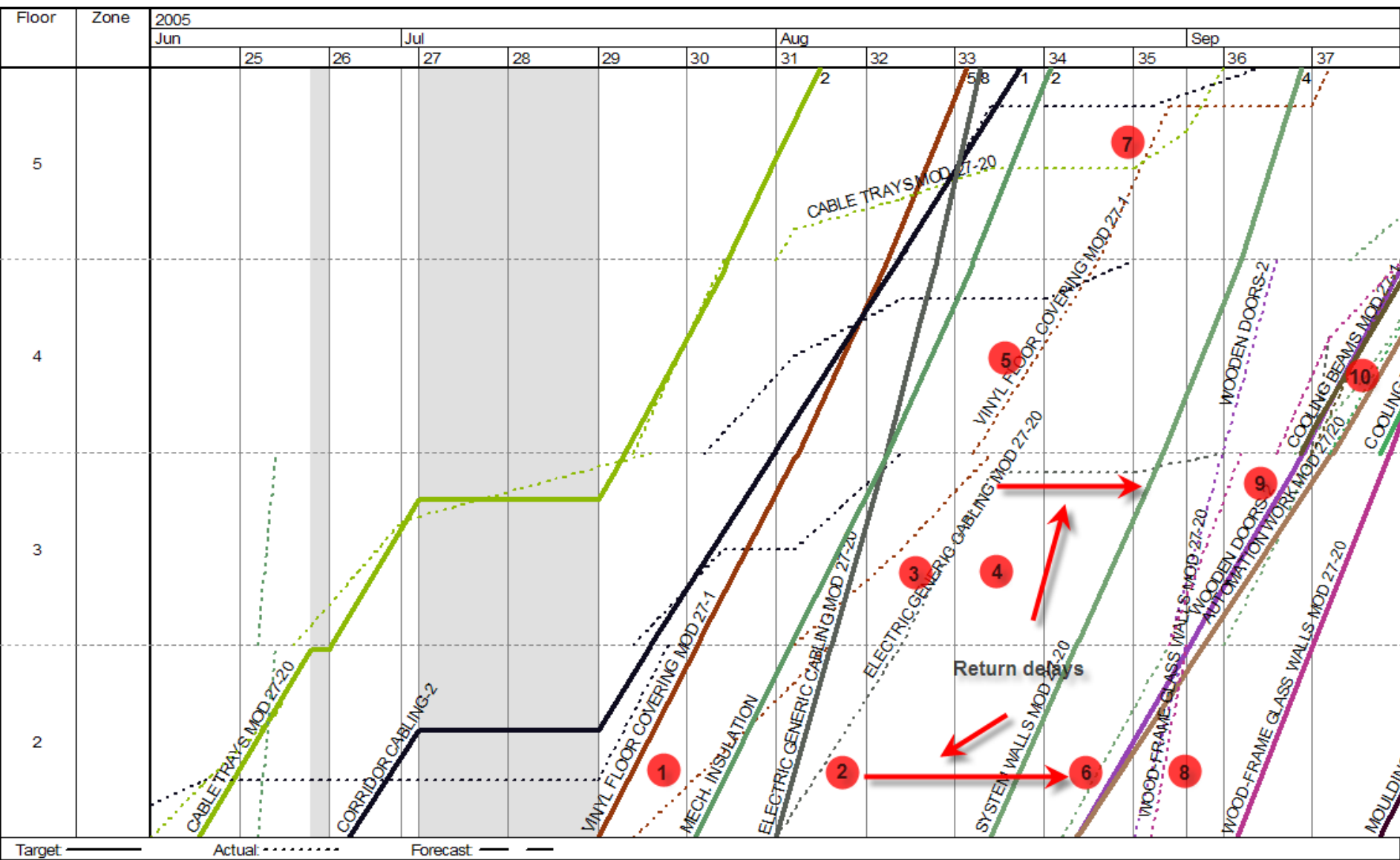
Project type	M2	Start-up delays	Discontinuities	Slowdowns	Total effect of cascading delays / total duration (months)
Retail	6,800	34	36	54	1.5 / 8.5
Retail	10,638	8	20	94	1 / 12
Office	14,528	96	129	132	1.5 / 15

- Cascading delays cause 10+ % increase of project duration
- Productivity loss of 30+ %
- Only 12% of problems discussed in site meetings!

Cascading delays

- **Problems especially in projects without buffers**
- **Most building projects have cascading delays in interior construction phase (MEP + rough-in + finishes)**
- **Delays caused by multiple subcontractors in the same space**
 - *Slowdowns (large, open locations)*
 - *Discontinuities (constrained spaces)*
 - *Start-up delays*
- **Cascading delays make projects unpredictable and chaotic**

Example of cascading delays (Seppänen 2009)



Empirical results about LBMS controlling

- **30 Master's theses in Finland in 1980's and 1990's**
 - **Empirical research on 6 projects (Seppänen & Kankainen 2004)**
 - Just planning continuity is not enough, controlling is critical
 - Discontinuities are the hardest deviation type to recover from
 - Starting too early – slowdowns
 - **Seppänen (2009)**
 - Cascading delay chains, improved forecasting
 - **Kala et al. (2012)**
 - CPM requires more man-hours to operate than LBMS
 - LBMS provides better information for superintendents
 - Subcontractors overestimate their resource consumption (30-40%)
-

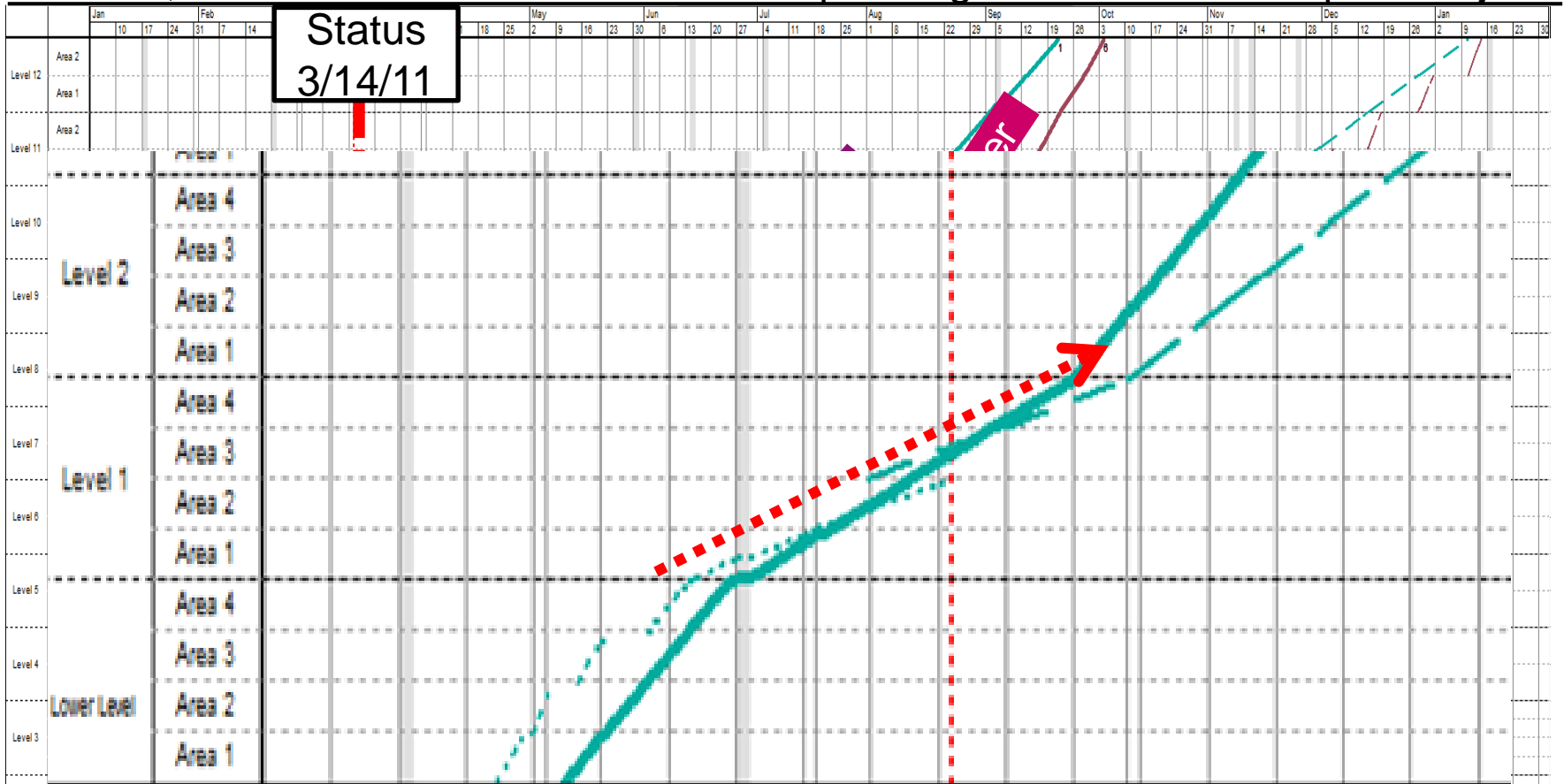
Empirical results about LBMS controlling

- **Evinger et al. (2013) – CPM vs. LBMS floors of same project**
 - CPM floors had 18% higher labor consumption and 10% slower production than LBMS floors
- **Seppänen et al. (2014) – LBMS production alarms and their impacts**
 - 39% of alarms resulted in control actions
 - 65% of control actions increased production rate, 50% successfully prevented production problems
 - It is possible for GC to control production rates of subs!
- An example from this project next

Mar. 14, 2011

Fireproofing

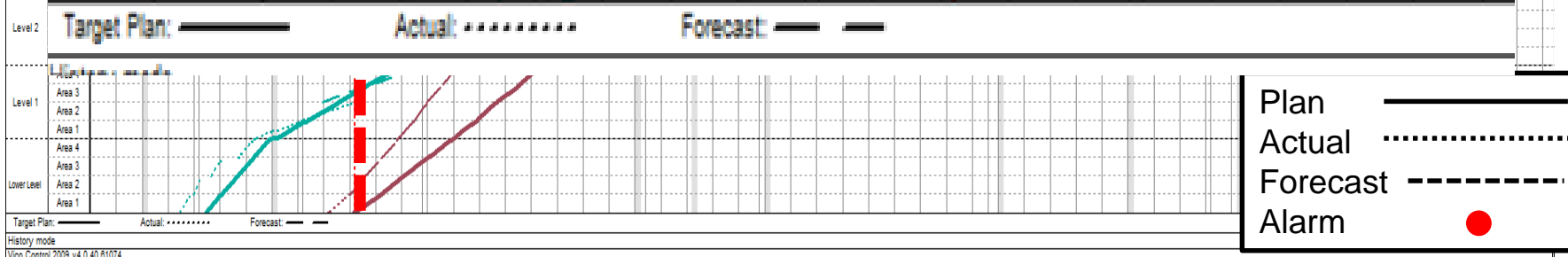
Hospital Project



Status
3/14/11

Legend:

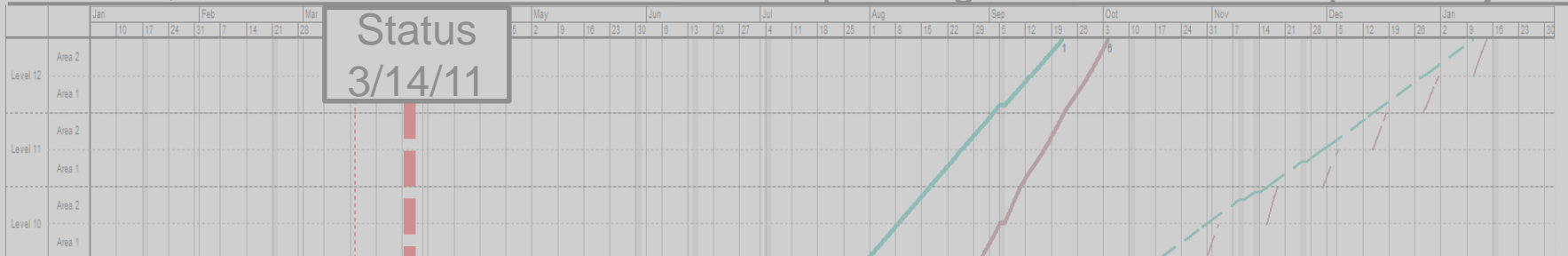
- Plan: Solid black line
- Actual: Dotted black line
- Forecast: Dashed black line
- Alarm: Red circle



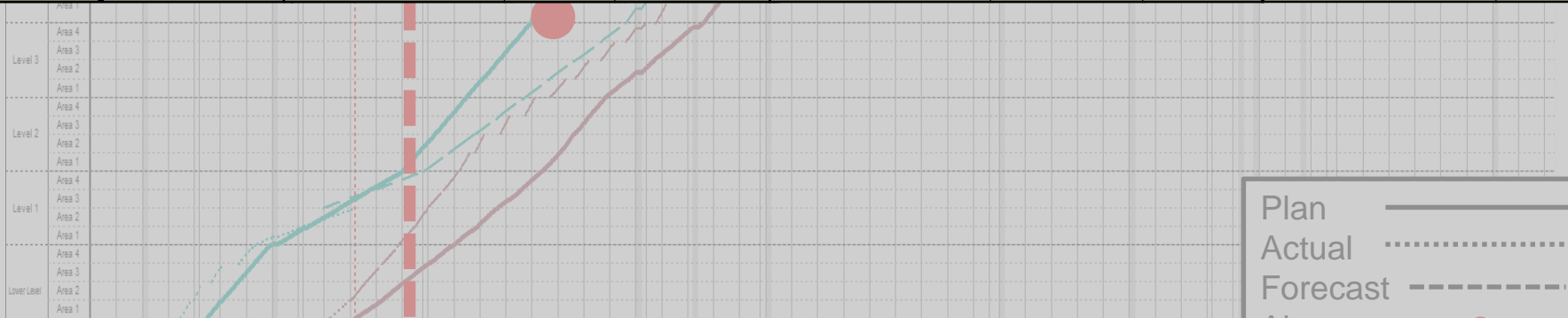
Mar. 14, 2011

Fireproofing

Hospital Project



Name	Target/Estimated			Actual			Delta	
	Production rate units/day	units / day	% Comp	Production rate units/day	units / day	% Comp	Production rate units/day	% Comp
Beam Clips	10,356	SF	15%	13,563	SF	25%	3,207	10%
Fire Proofing	2,000	SF	6%	1,364	SF	15%	-636	9%
Fire Sprinkler	436	LF	0%	541	LF	4%	105	4%



Plan ————
 Actual
 Forecast - - - -
 Alarm ●

No.	Date	Production Opportunity/Alarm
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PAI-076	14-Mar-11	Recommendation	Status
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Deploy 3rd gun to do focus gun 2 on production

Response

Owner

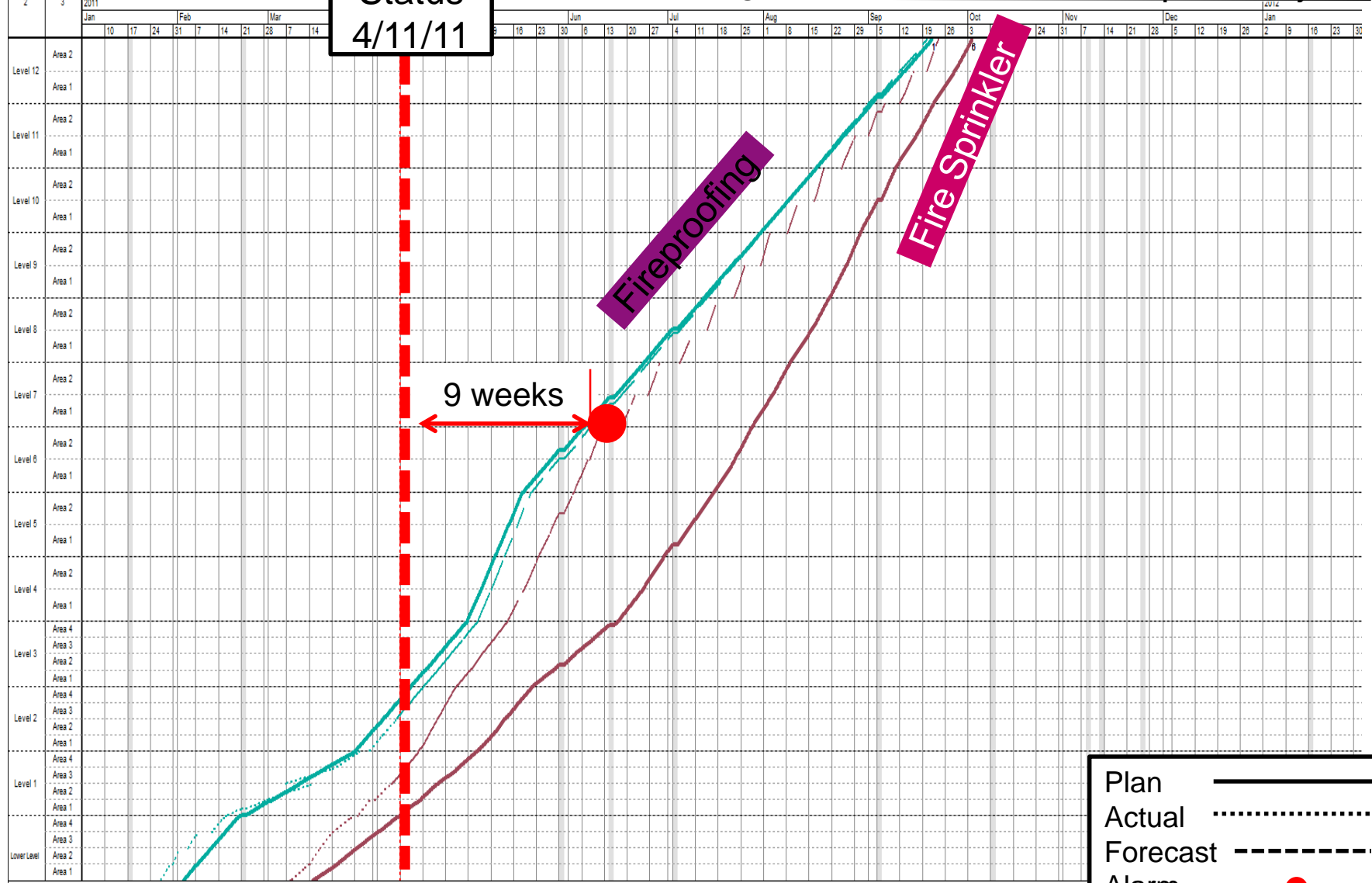
PAI-137	20-Mar-12	consumption rate (taking longer for Duct Mains LL Areas 1 and 4 have systems are holding up the completion of the project)
PAI-136	20-Mar-12	Insulation of ductwork production unnecessarily. Further, the forecast working across the odd tower floor in-wall copper is driving the production of the podium of level 3 is trending slow
PAI-135	20-Mar-12	production drywall from LVL 1 to Ductwork insulation task is trending slow
PAI-134	14-Mar-12	Milestone.
PAI-133	14-Mar-12	In wall plumbing on the even and affect the production drywall continuity.
PAI-132	14-Mar-12	HVAC Branch Piping and Duct Branch tasks are trending too slowly in level 2 podium. This is influencing the start of Insulation and headwall tasks -> in turn this may affect the 80% OH Milestone and Production drywall continuity.
PAI-131	06-Mar-12	Forecast suggests a late March start for lower level HVAC below duct. A forecasted finish is in early July. This may also influence the Duct Branch and Production Framing tasks.

Focus 3rd gun on pickup/focus 1st and 2nd gun on pure production

General Super, Fireproofing Sub, Area Super

Apr 11, 2011 Schedule Status Fireproofing Hospital Project

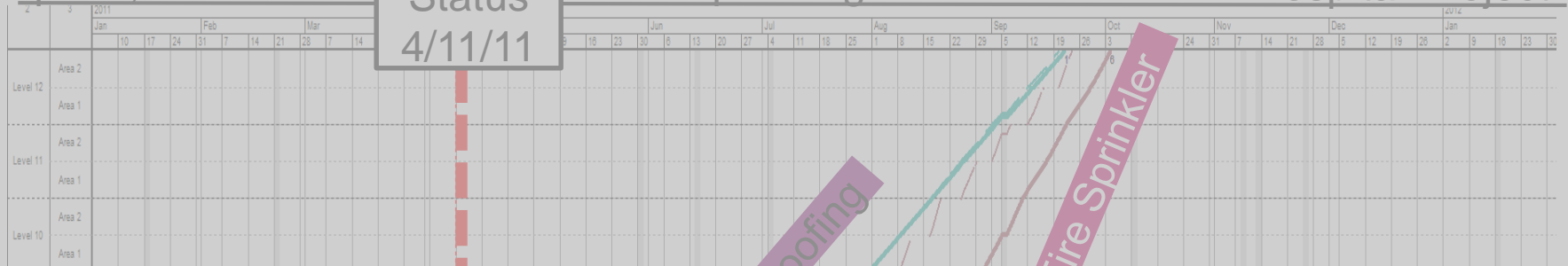
Status
4/11/11



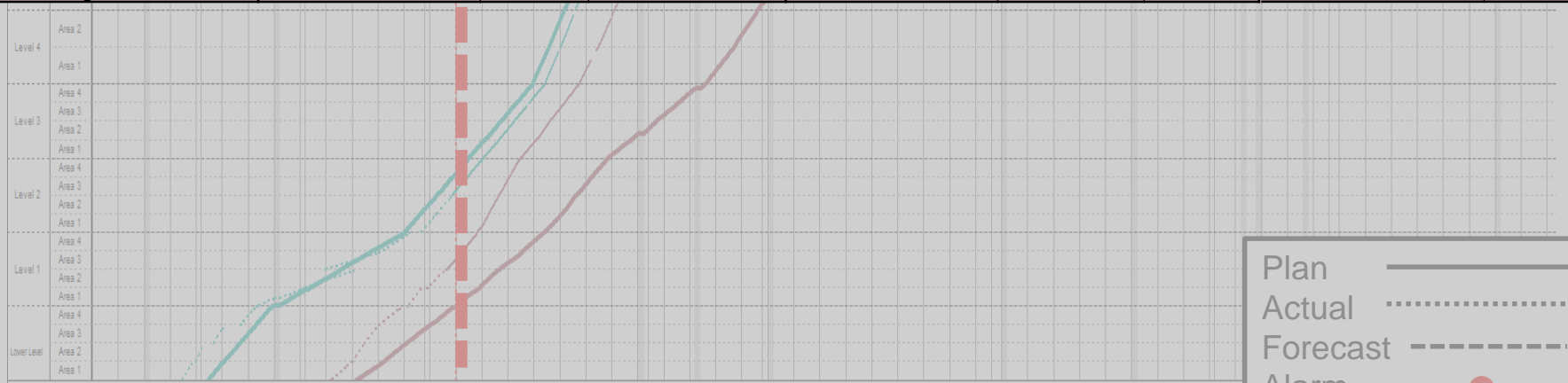
Plan —————
 Actual
 Forecast - - - - -
 Alarm ●

Apr 11, 2011 Schedule Fireproofing Hospital Project

Status
4/11/11



Name	Target/Estimated			Actual			Delta	
	Production rate units/day	units / day	% Comp	Production rate units/day	units / day	% Comp	Production rate units/day	% Comp
Fire Proofing	2,000	SF	30%	2,031	SF	29%	31	-1%
Fire Sprinkler	436	LF	14%	560	LF	19%	124	5%



Legend:

- Plan: Solid line
- Actual: Dotted line
- Forecast: Dashed line
- Alarm: Red circle

No.

Date

Production Opportunity/Alarm

PAI-084

11-Apr-11

Recommendation

Status

Reduce fire proection by 1 journeyman

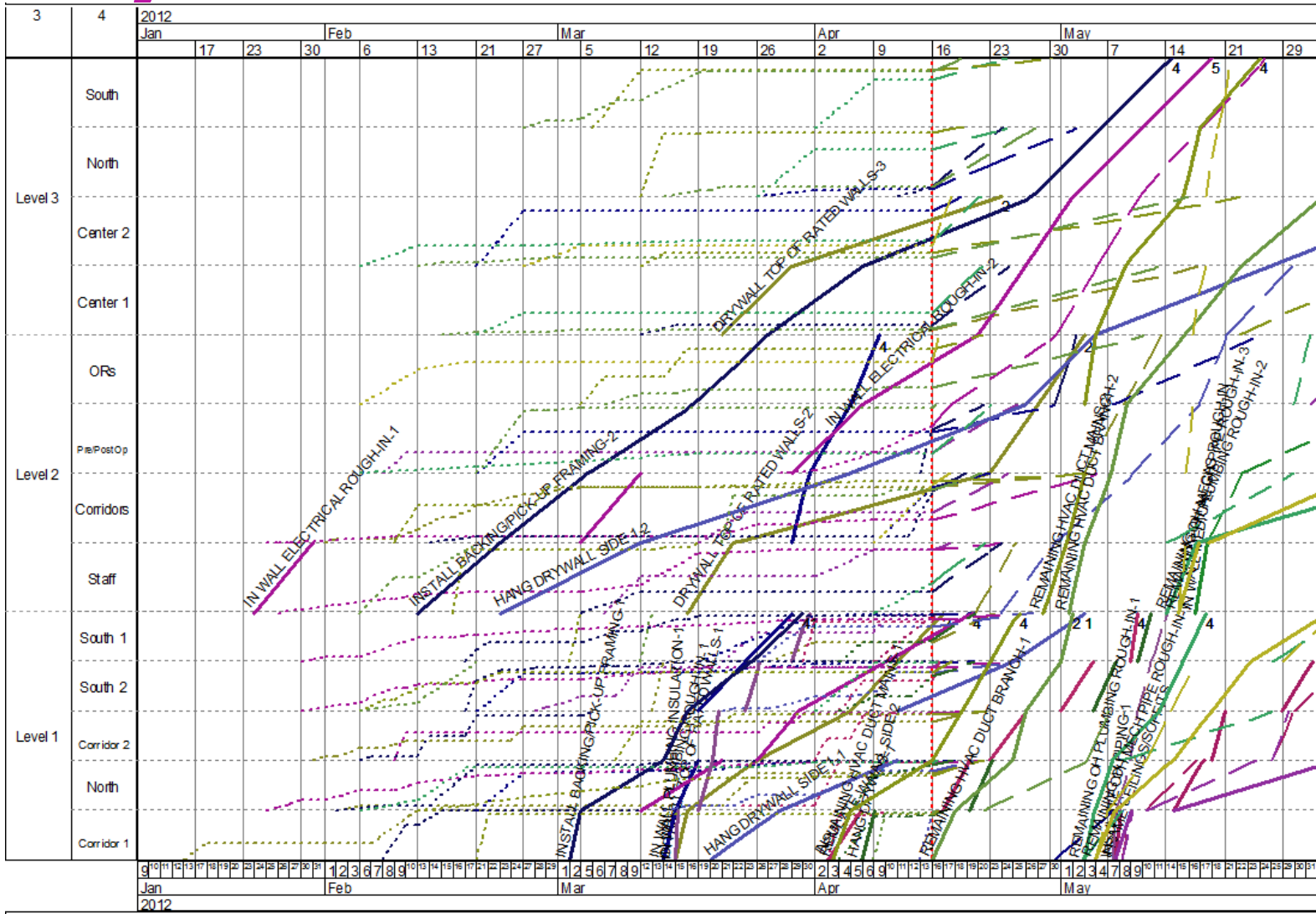
Response

Owner

Production rate in line with target by reducing by 1 resource

General Super, Fire Protection Sub, Area Super

Project in chaos



Thank you Questions & Comments