Session Title: Scheduling Optimization with Line of Balance and Start-to-Finish Relations
Session Code: EM15CPX01

Ricardo Viana Vargas
UNOPS - UFF

Felipe Fernandes Moreira
UFC

Global Congress 2015
EMEA

Session Objectives

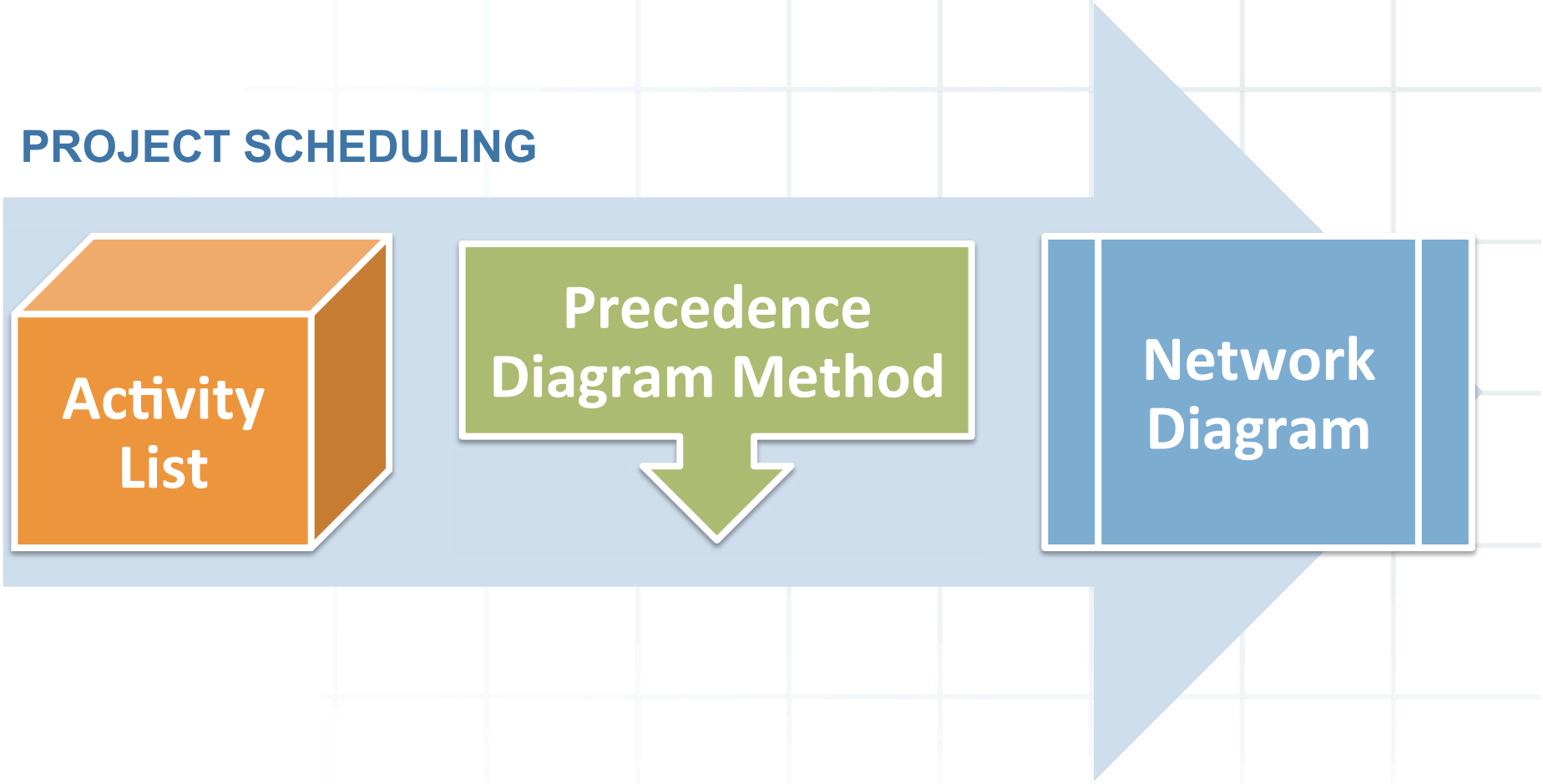
Discuss the applications of the Start-to-Finish relationships

Schedule **optimization** with *LBSM*

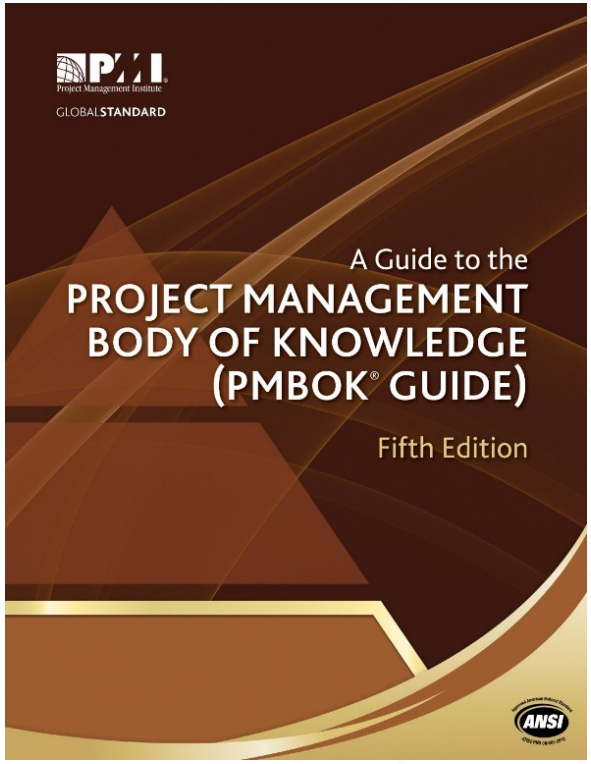
Investigate the **unexpected results** of using *SF* relationships

Project Planning

PROJECT SCHEDULING



Activities Dependencies



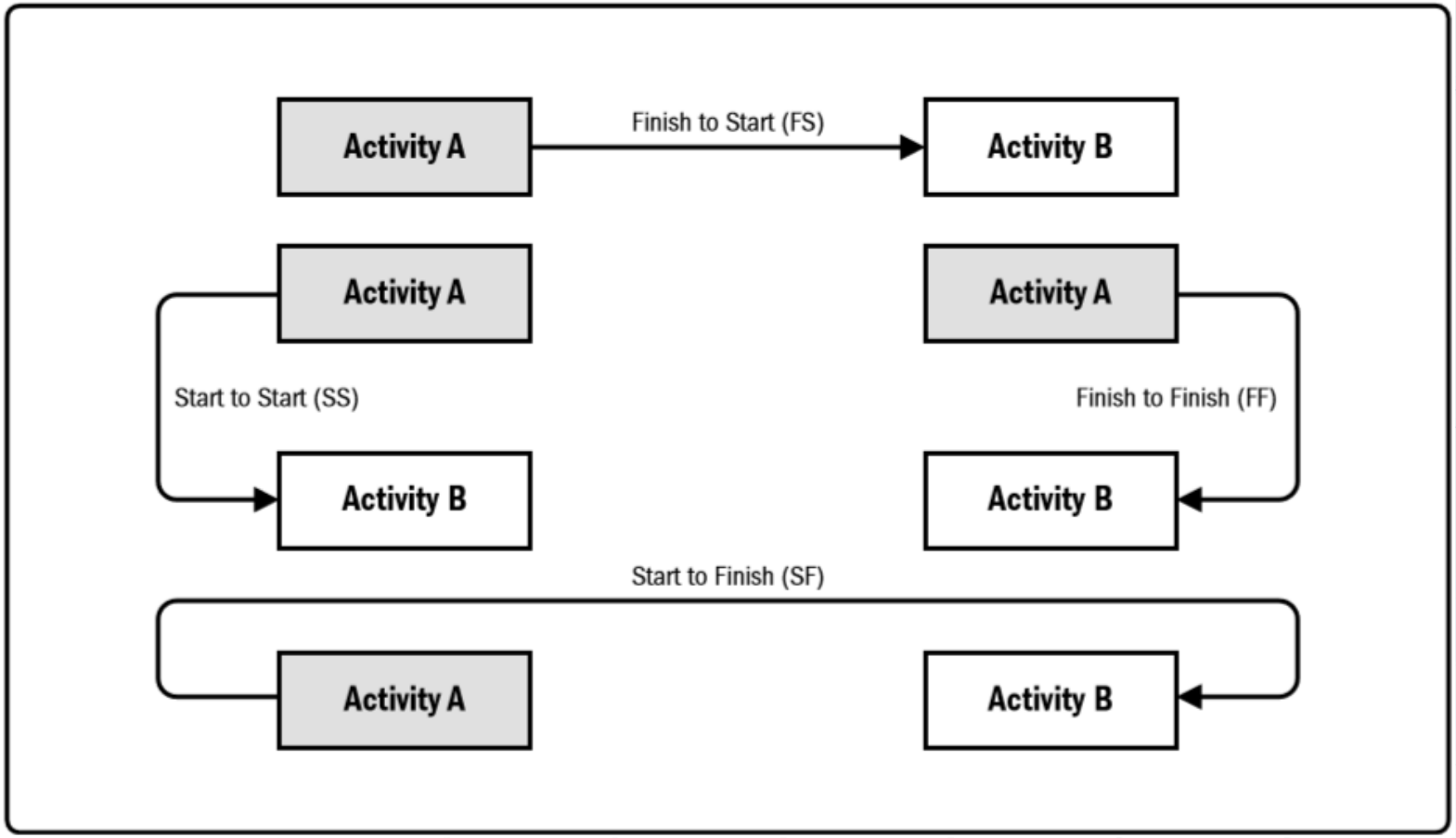
PREDECESSOR → SUCCESSOR

The **PMBOK® 5th edition** makes it explicit:

Logical Relationships ≠ Chronological Relationships

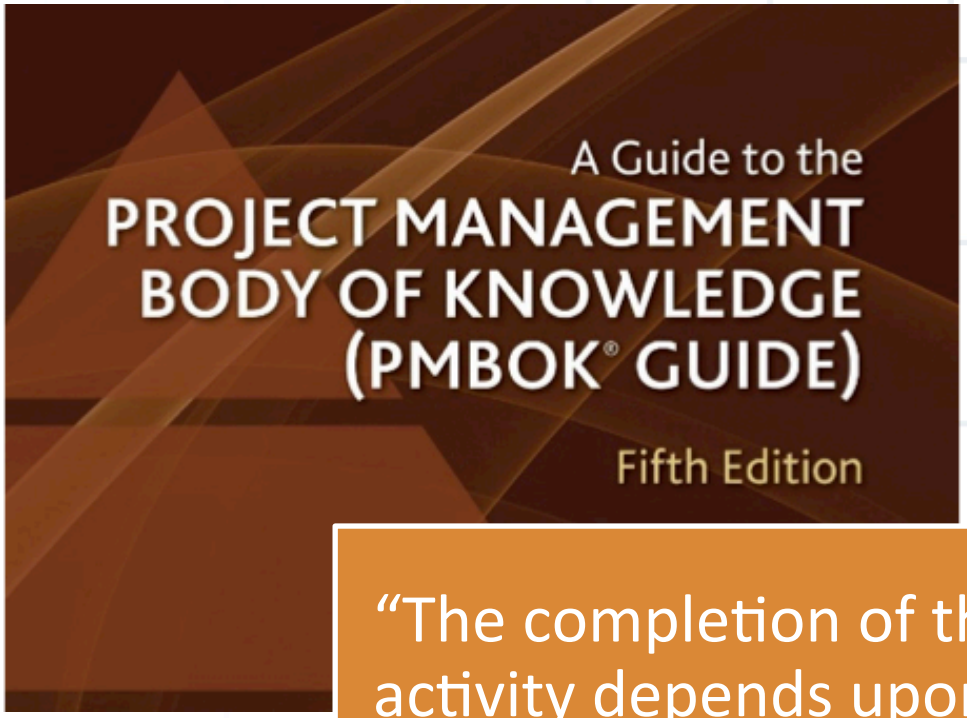
1st to 4th editions: only at the Glossary

Activities Relationships



PMBOK® 5th edition (2013)

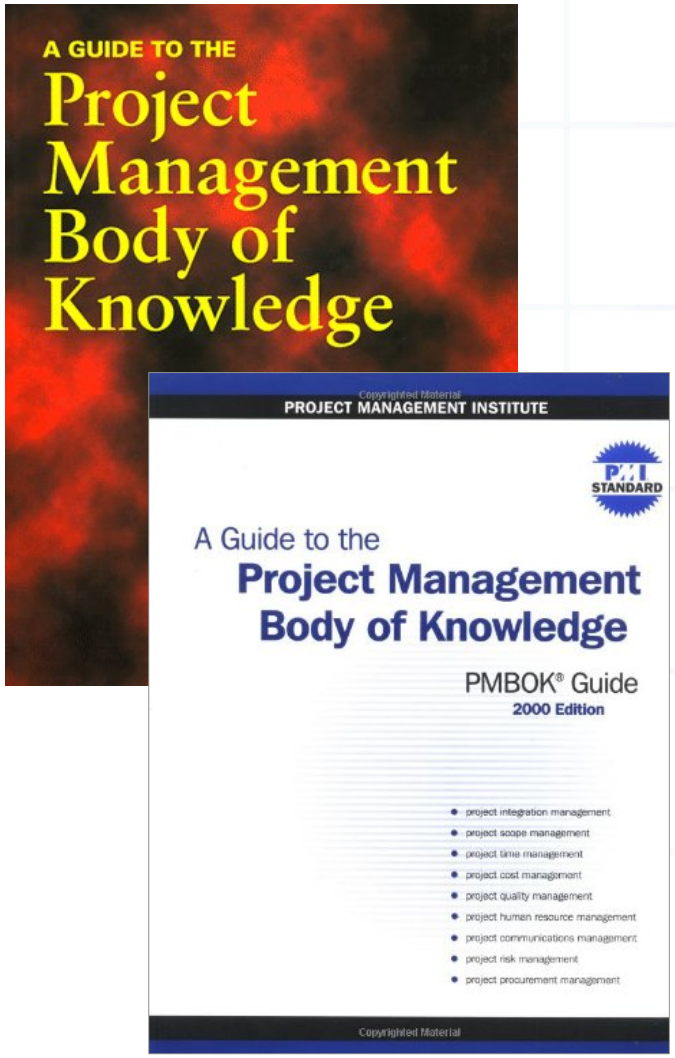
Start-to-Finish ("SF") Relationship



"The completion of the successor activity depends upon the initiation of the predecessor activity."

"SF" is rare – listed only to present all the relationships. *(PMBOK all editions)*

Start to Finish ("SF") Relationship



1st and 2nd editions: typically only professional scheduling engineers use the "SF" relationships

Warns that the usage of relationships other than the most common ("finish-start") **may produce unexpected results**, since their implementation is not consistent

Line of Balance

- Absent from Project Management Body of Knowledge
- Technique used at construction industry at Brazil, Finland and Australia *(HENRICH & KOSKELA, 2006)*
- Related with Lean Construction and Last Planner System
- "**Unit of Production x Time**" Chart
- **Different** from the usual "Activity x Time" Gantt Chart

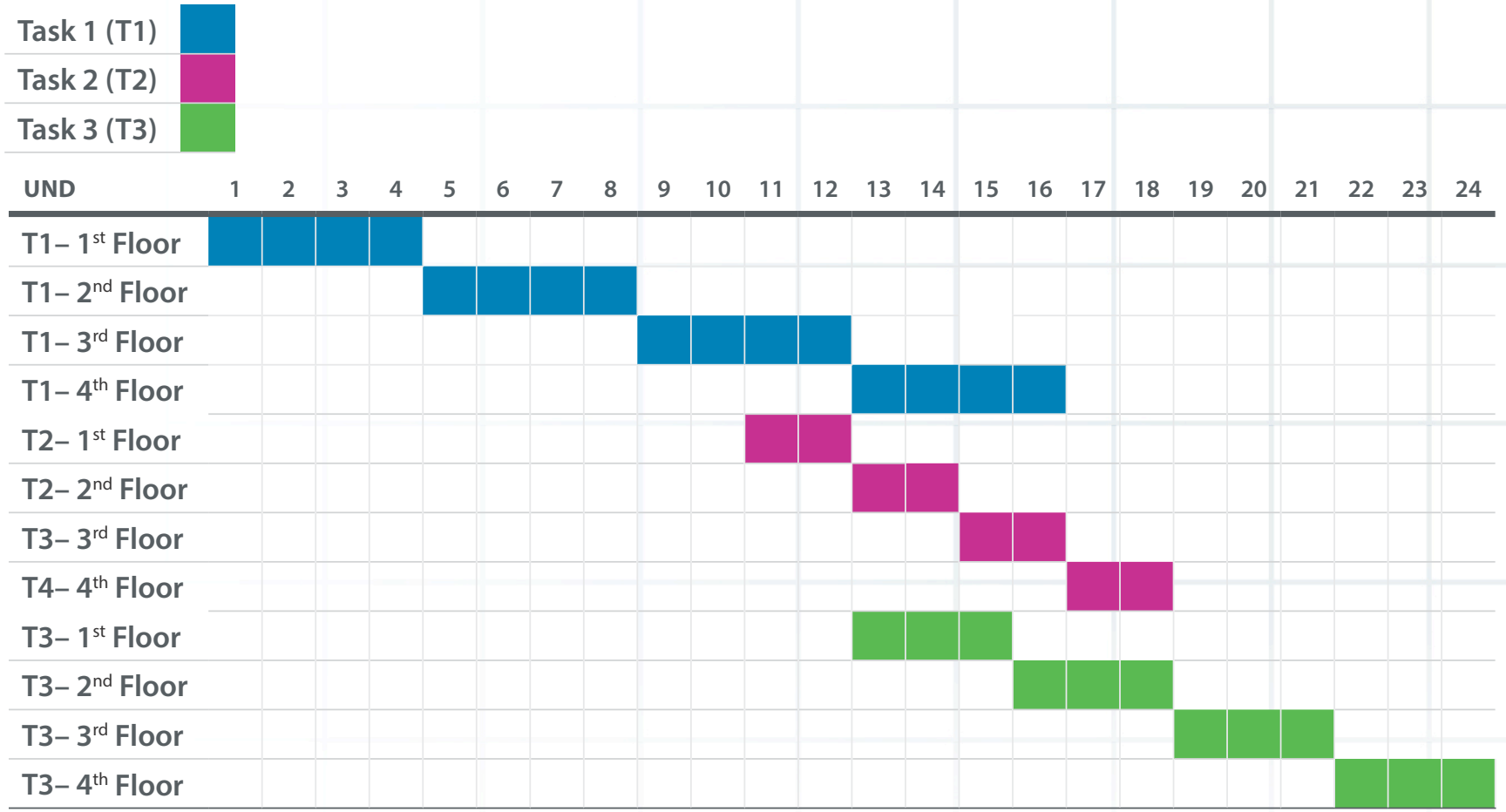
Line of Balance Scheduling Method

- Scheduling according to the rate of production
- Number of working units delivered by a working crew

TASKS	DURATION	PREDECESSOR
Task 1	4	-
Task 2	2	Task 1
Task 3	3	Task 2

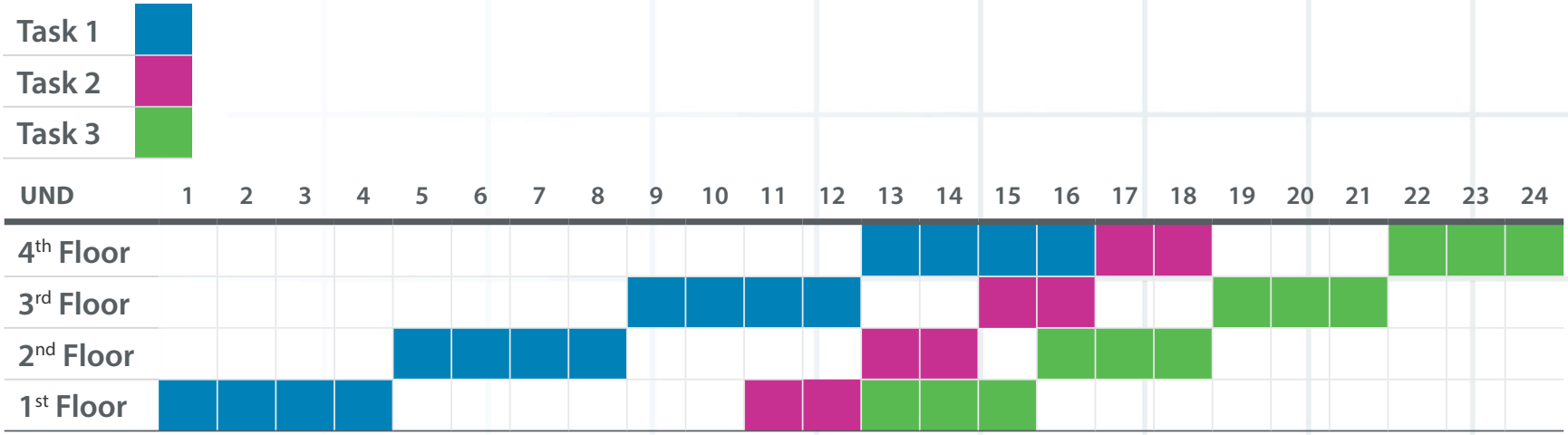
List of Activities

Line of Balance Scheduling Method



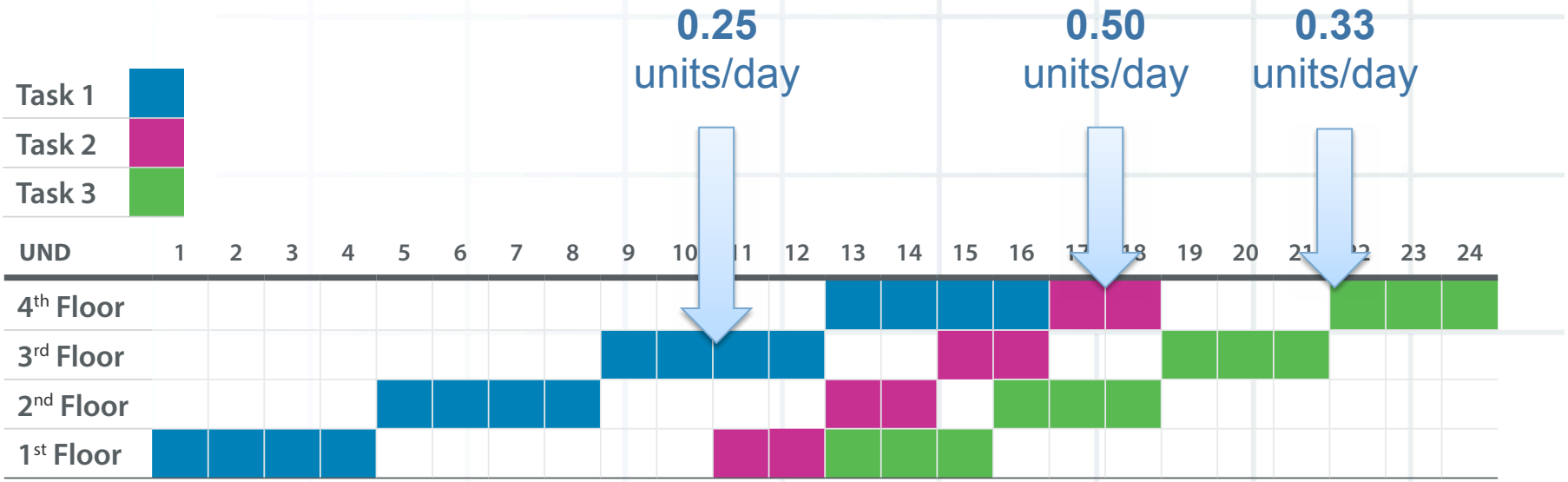
Schedule using the Gantt chart

Line of Balance Scheduling Method



Schedule using the LBSM

Line of Balance Scheduling Method



Schedule using the LBSM

Rate of Activities Production = **Angular Coefficient of each line**

Line of Balance Scheduling Method

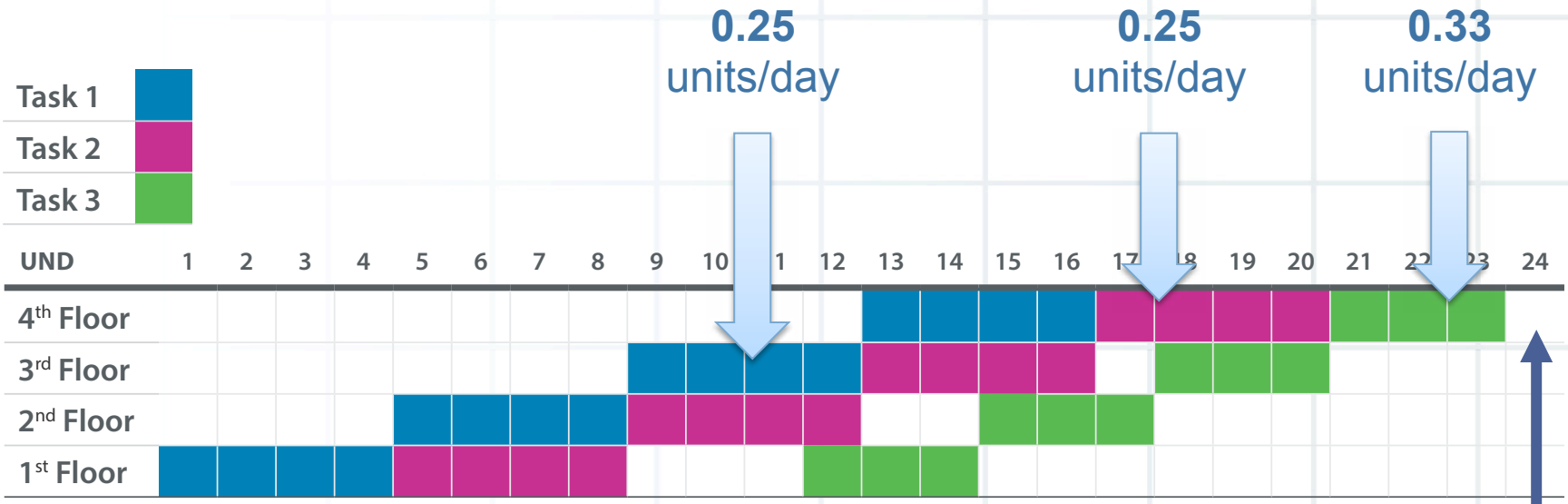
Balancing the lines

Make the rate of production of the activities to be **as similar as possible**

Reduce the Task 2 "speed" (make its angular coefficient smaller)

Reduce its resources by half – increase duration from 2 to 4 days

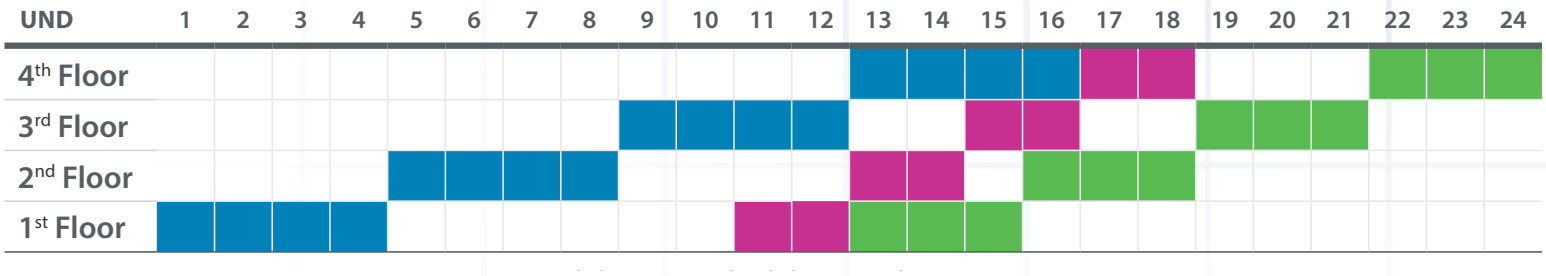
Line of Balance Scheduling Method



Balancing lines to achieve a schedule reduction

Project finishing **earlier**

Line of Balance Scheduling Method



4 lines (4 production units)

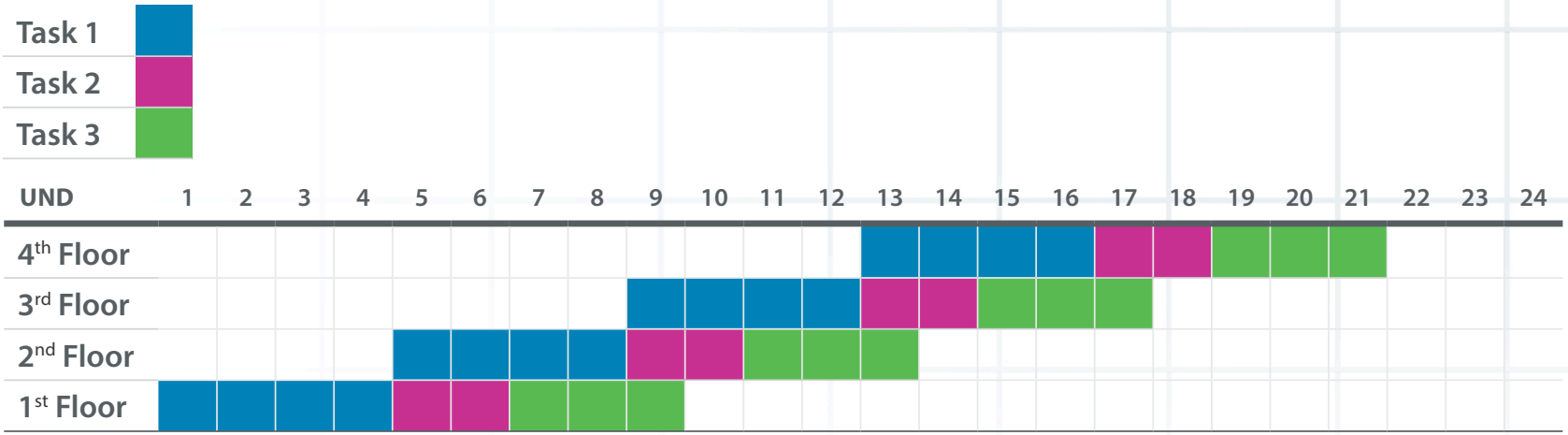
Line of Balance Scheduling Method

$$Simplification\ Factor = \frac{100\ unit \times 20\ tasks/unit \times 1\ line/task}{100\ unit \times 1\ line/unit} = 20$$

- Significant reduction of lines
- The bigger the number of repetitions, the bigger the reduction
- Applicable at all sort of repetitive processes
  - Eg.: Construction of 100 km, with 20 tasks for each kilometer

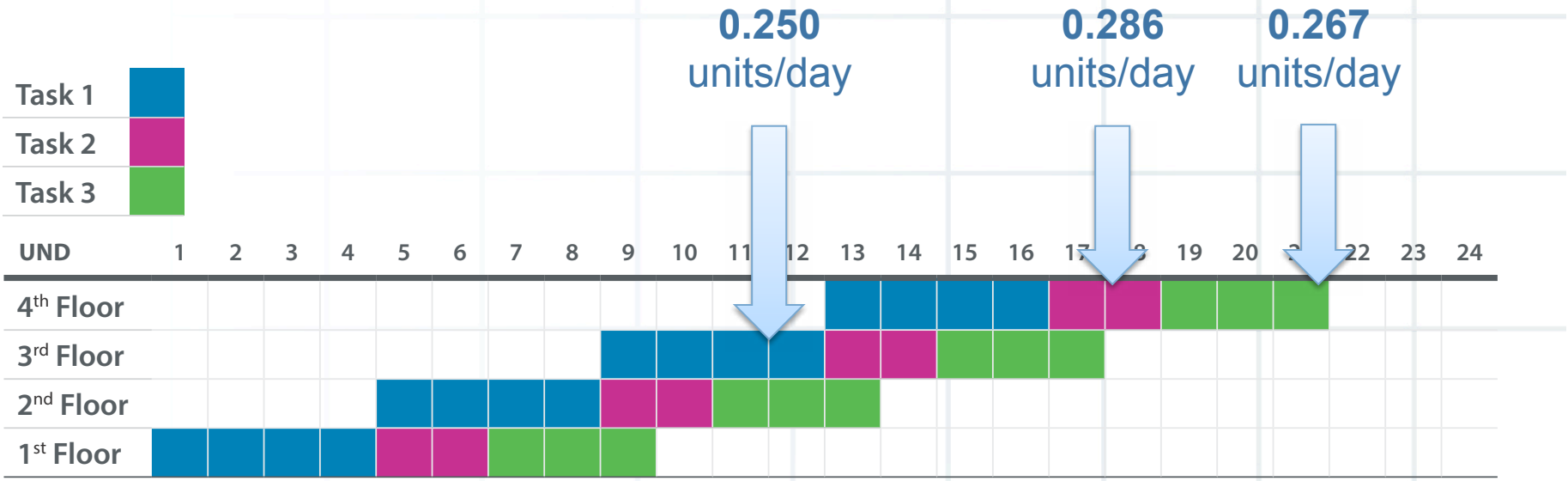
Line of Balance Scheduling Method

- Construction industry: tasks are scheduled continuously *(KENLEY & SEPPÄNEN, 2010)*
- Could be scheduled without this restriction

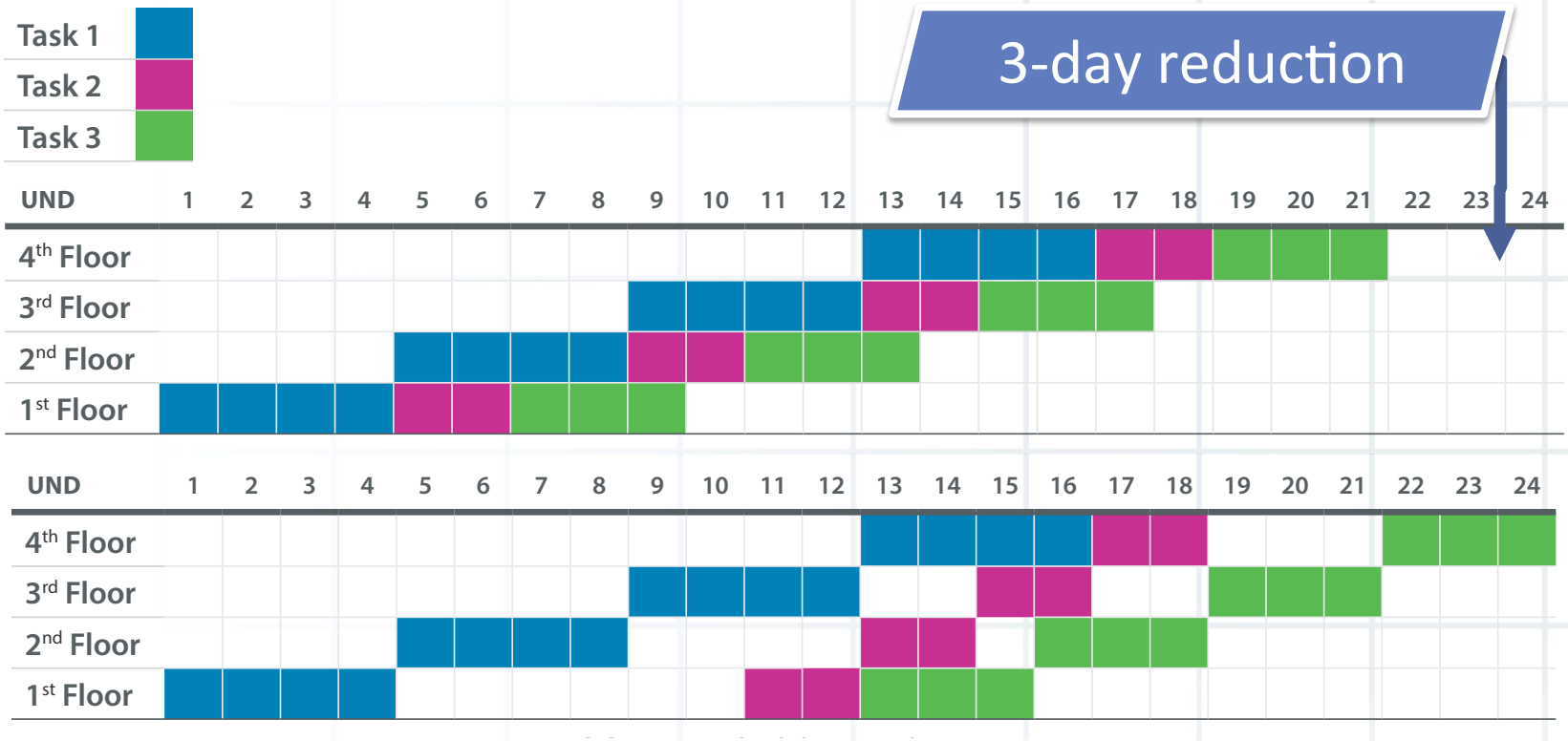


Line of Balance without the continuity of repetition

Line of Balance Scheduling Method



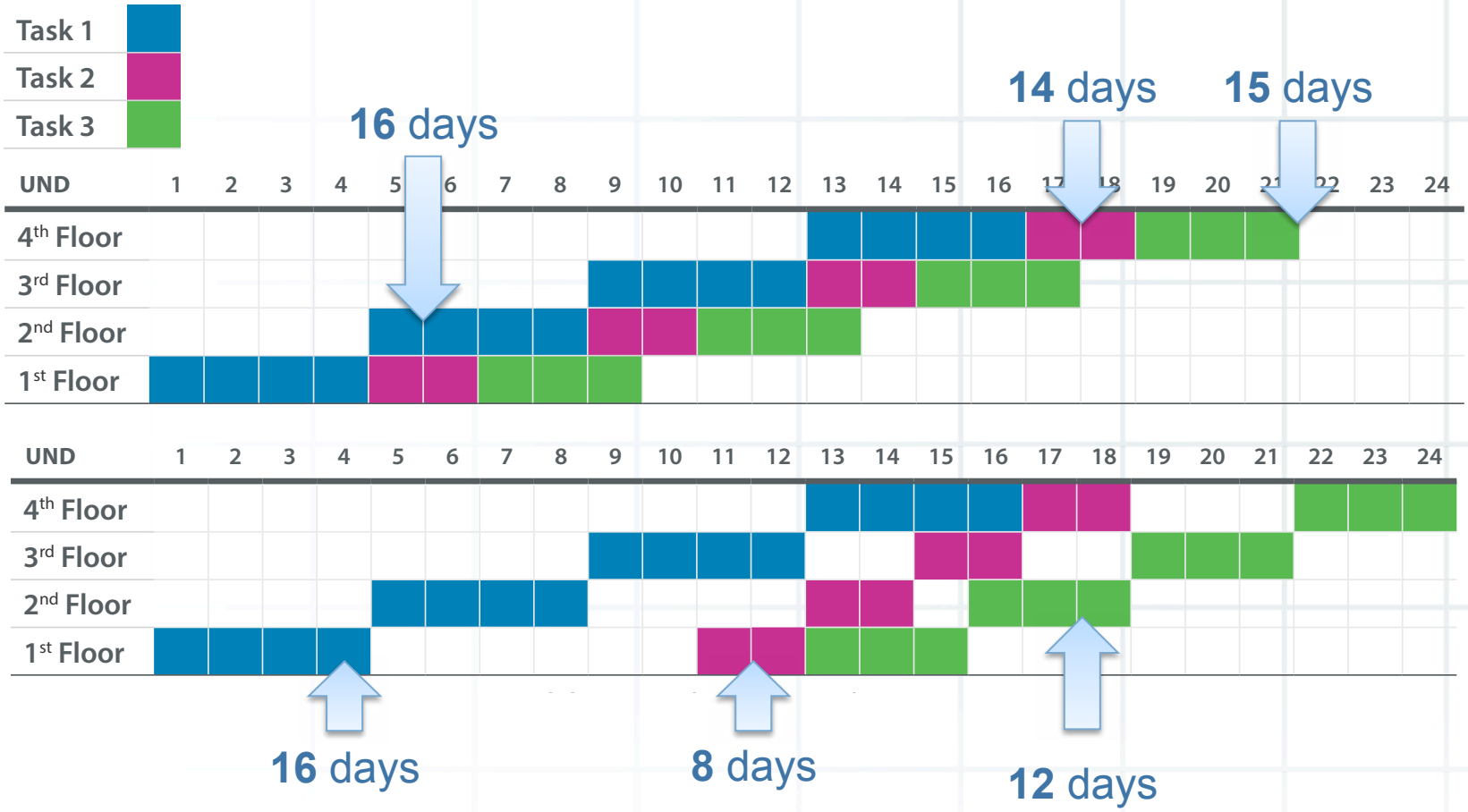
Line of Balance Scheduling Method



Line Balacing = **Schedule Reduction**

Line Balacing is a **"Crashing Method!"**

Line of Balance Scheduling Method

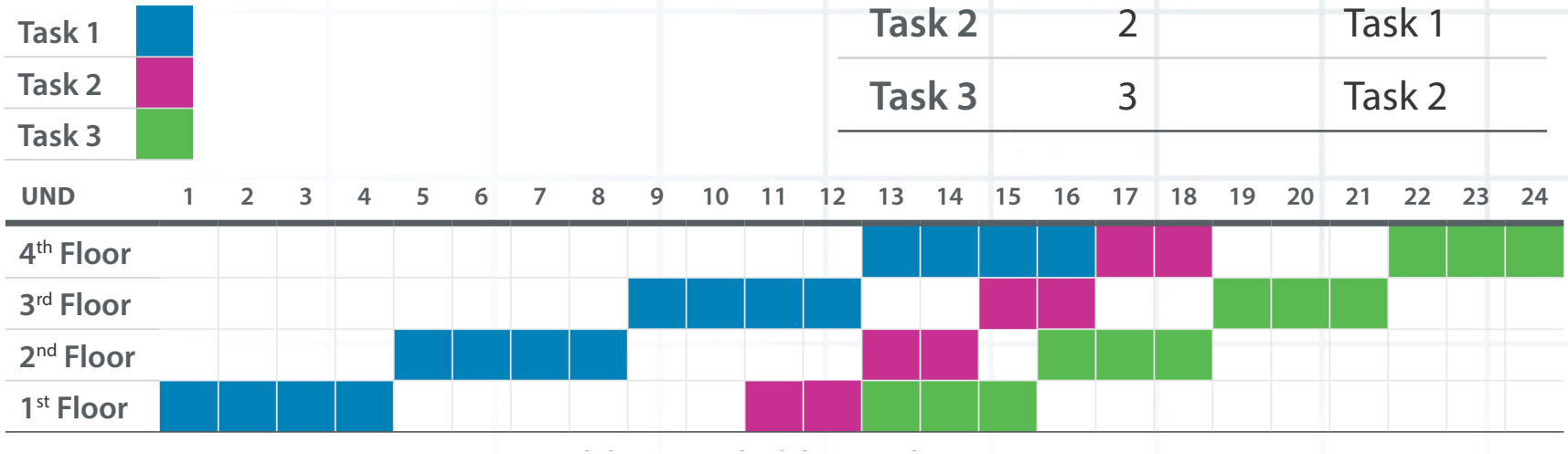


Breaking the continuity restriction will increase the total time of resource allocation!

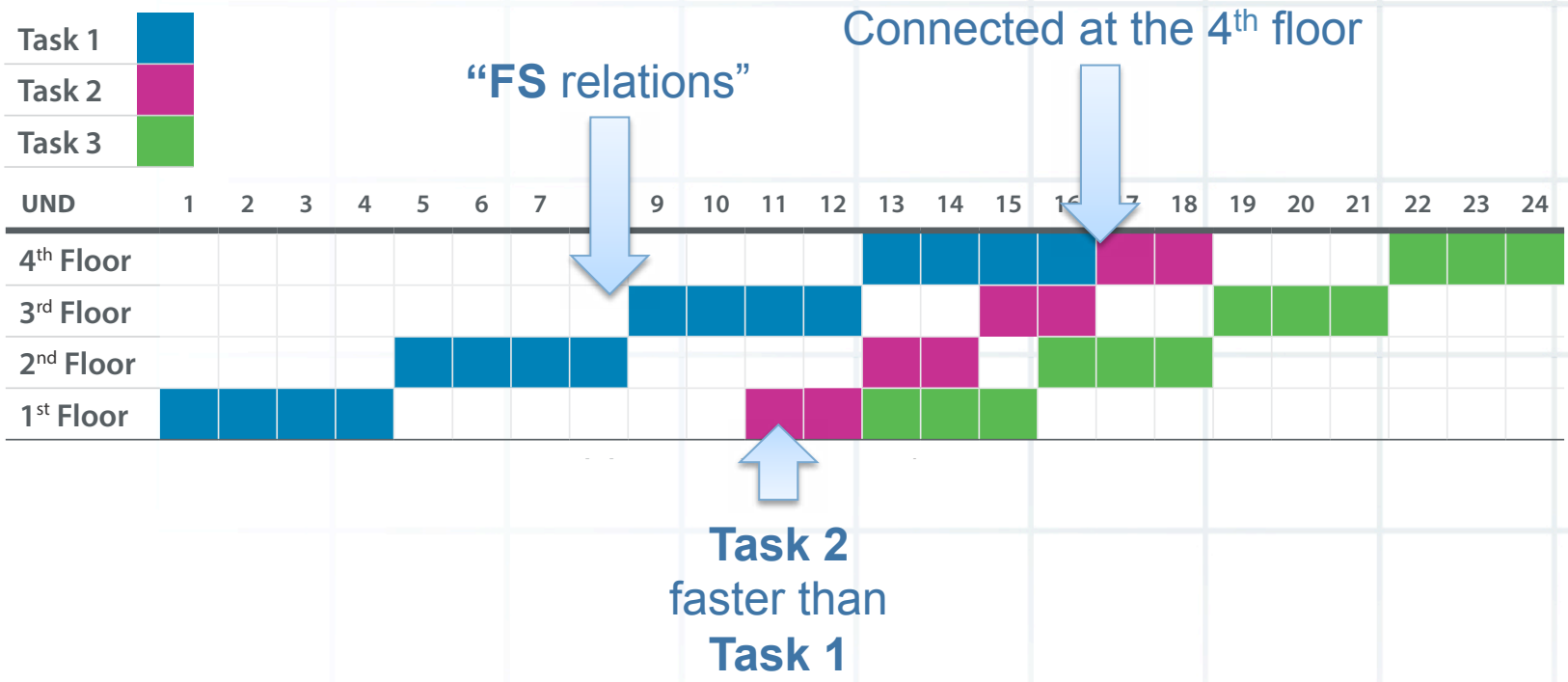
“SF” relation for continuous sequencing of tasks

Peculiarity: how to model this schedule?

TASKS	DURATION	PREDECESSOR
Task 1	4	-
Task 2	2	Task 1
Task 3	3	Task 2



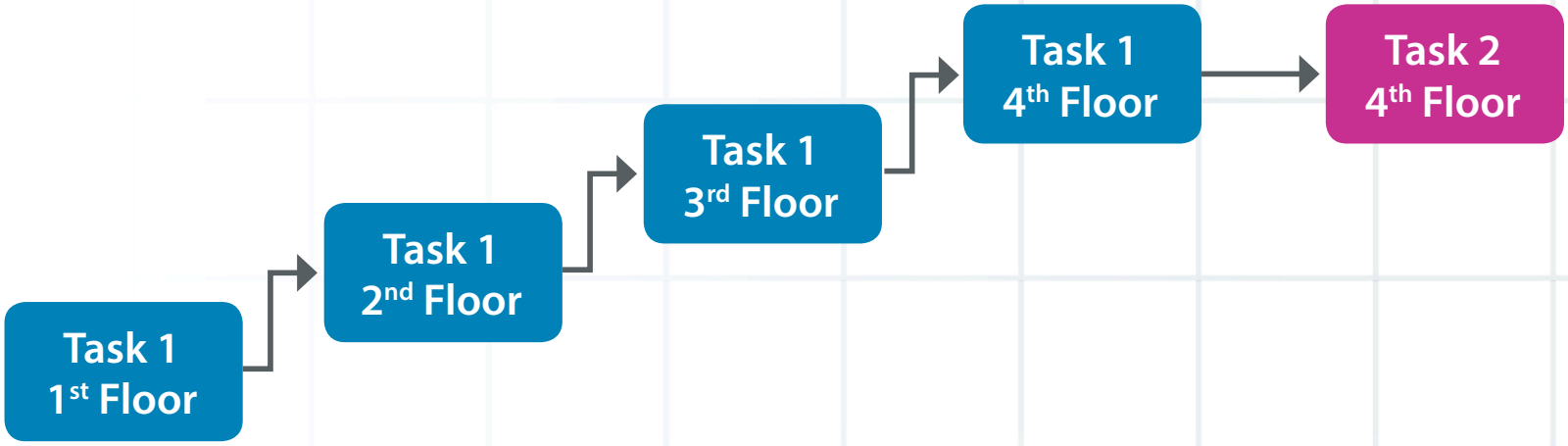
“SF” relation for continuous sequencing of tasks



Task 1 on the 4th floor defines the start date of **Task 2** on the 4th floor

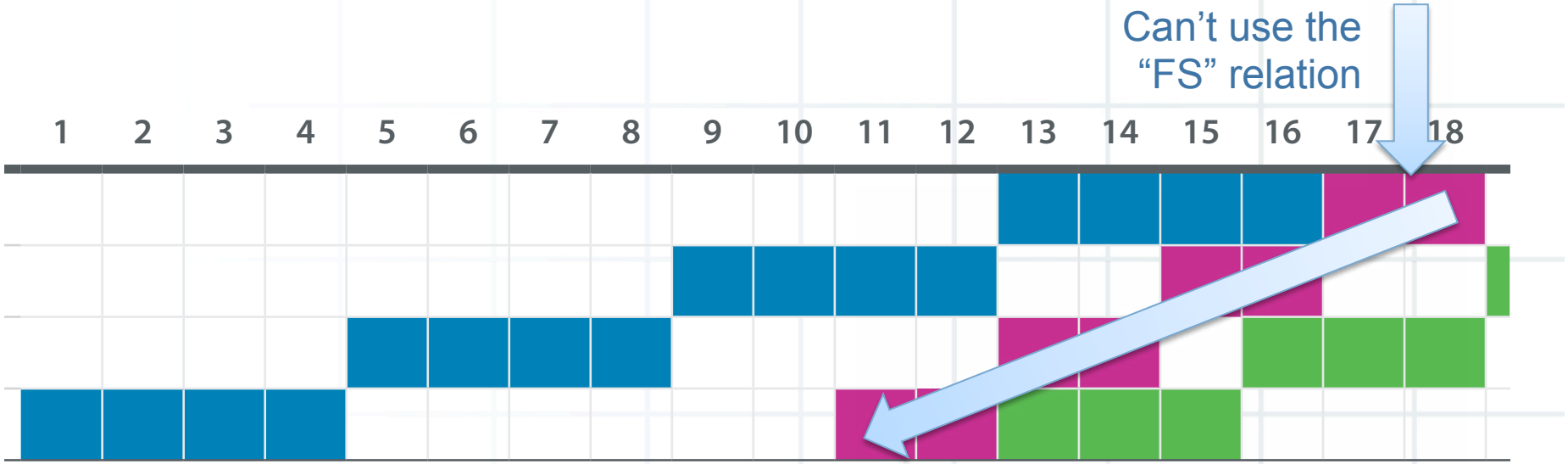
The last task offers the time constraint for the task progression!

“SF” relation for continuous sequencing of tasks



Network Diagram with the logical relationship between tasks

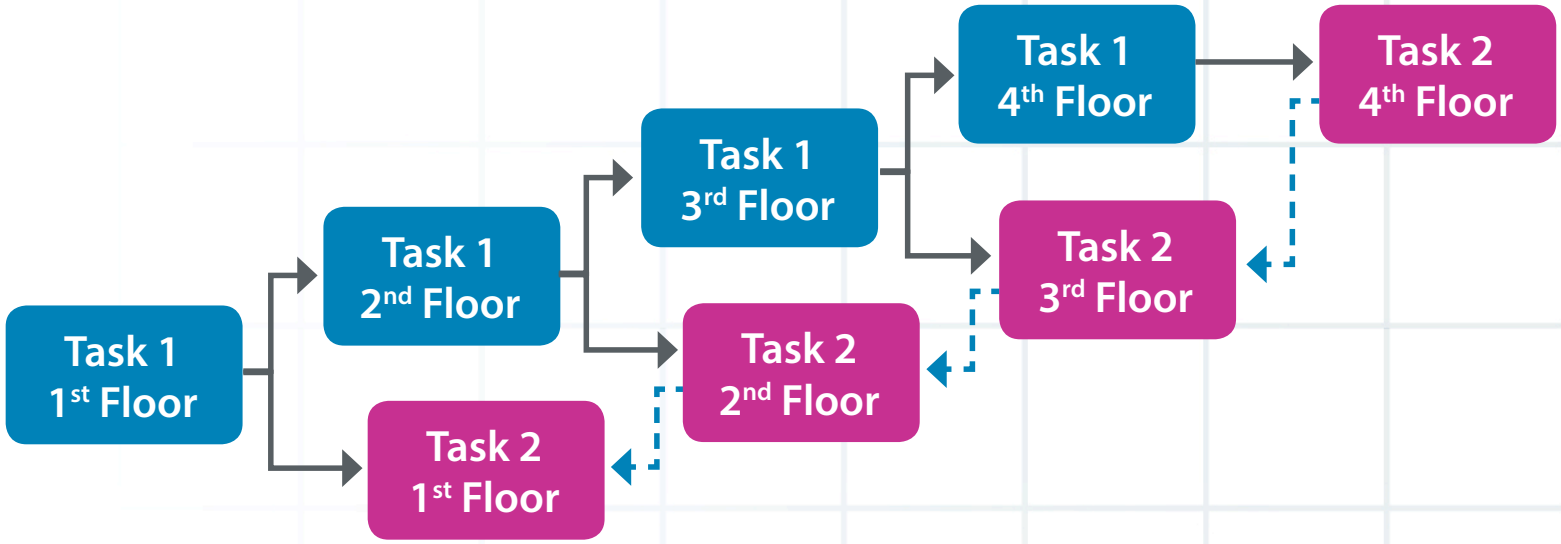
“SF” relation for continuous sequencing of tasks



Time constraint is transmitted “downward” from 4th to 1st floor.

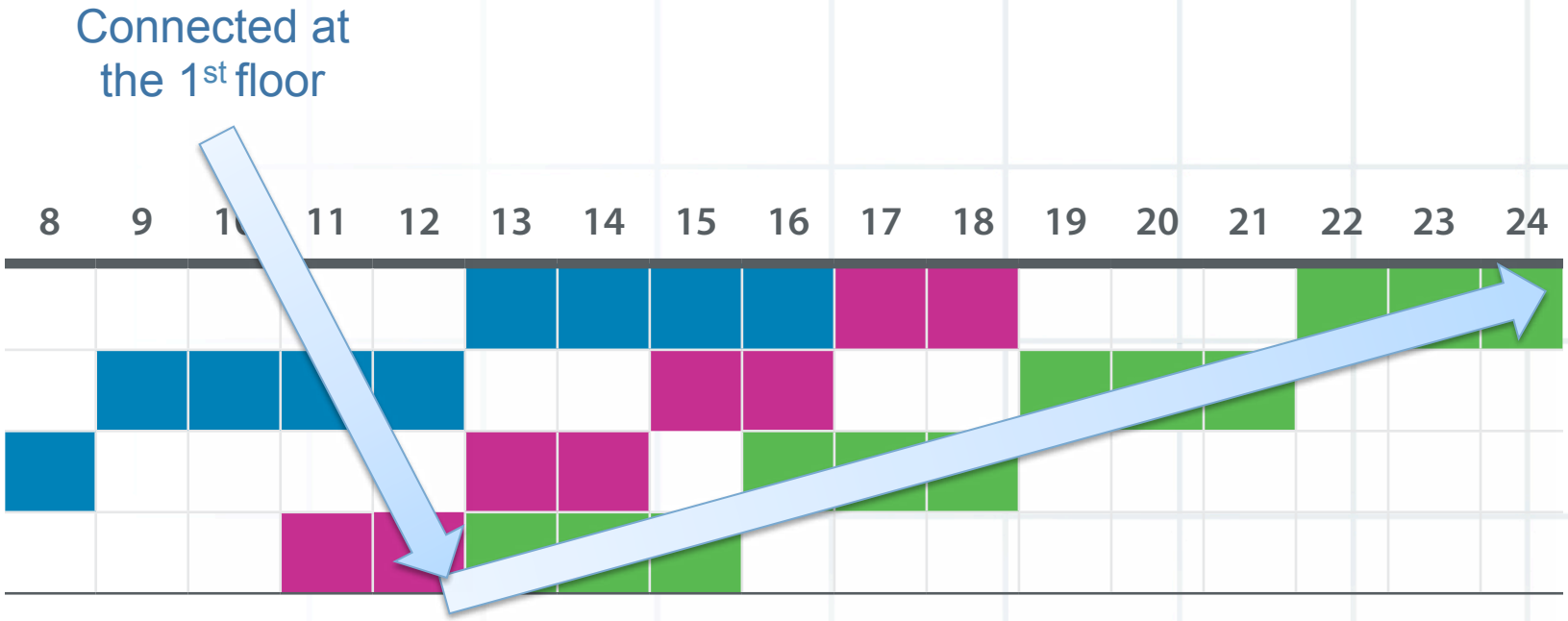
Done with the “SF” relation.

“SF” relation for continuous sequencing of tasks



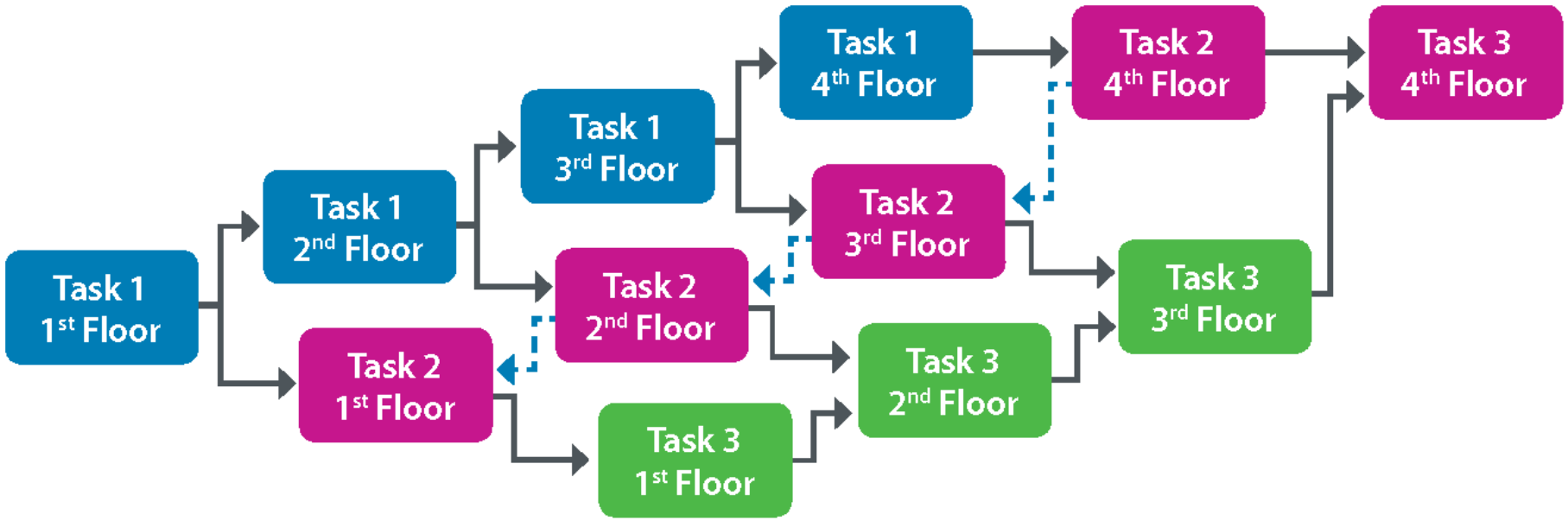
SF relation between the repetitions of Task 2

“SF” relation for continuous sequencing of tasks



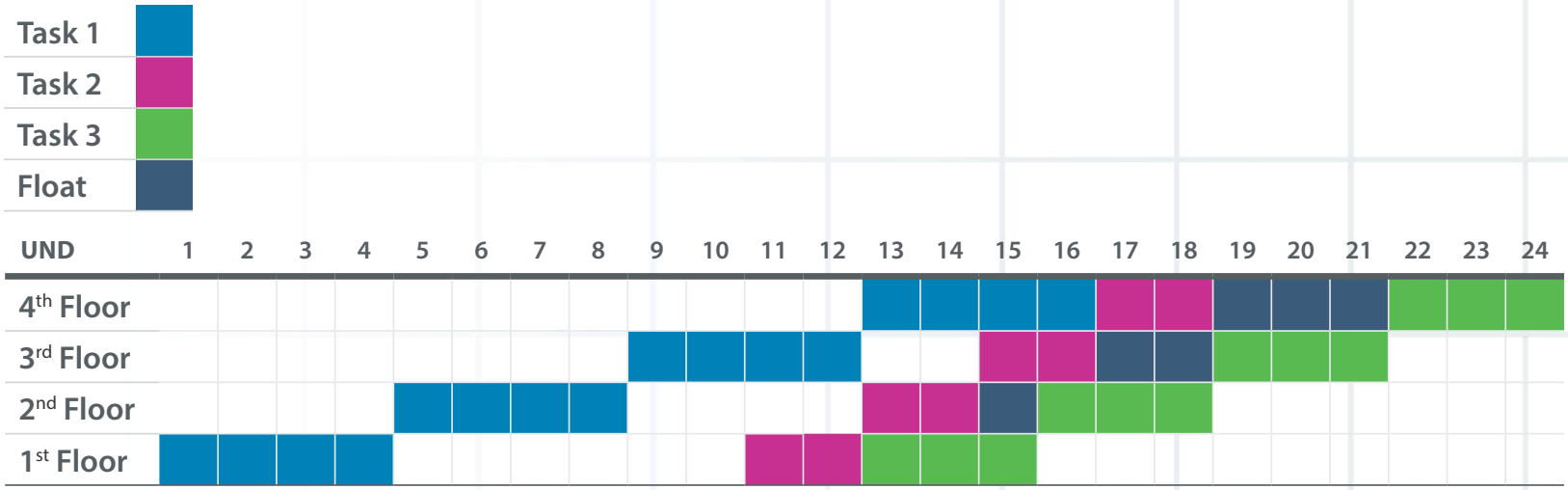
4th floor is no longer the time constraint for the task progression.
Time constraint move “upwards” using the “FS” relation!

“SF” relation for continuous sequencing of tasks



Important: PM softwares will show every task as critical

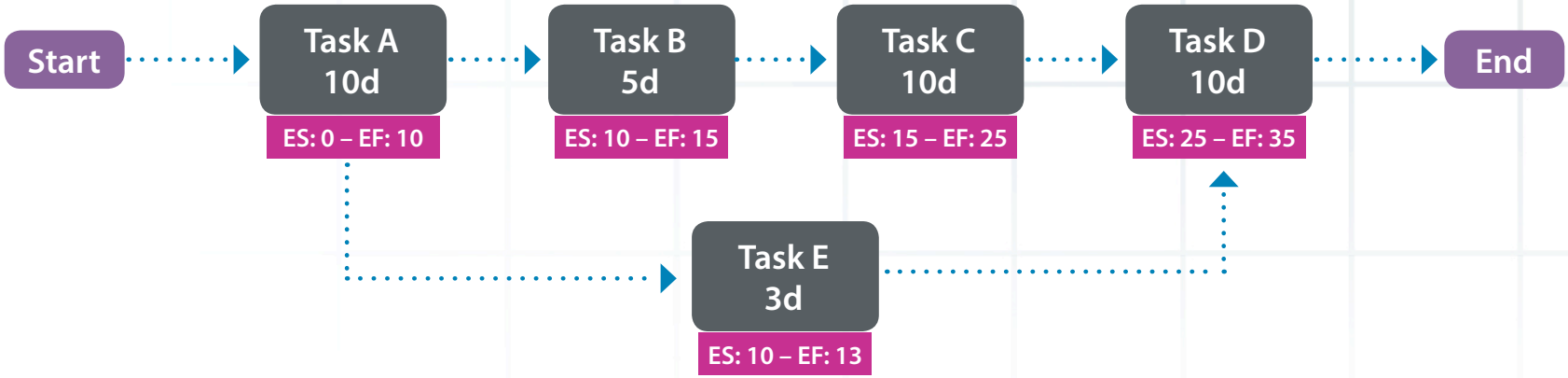
“SF” relation for continuous sequencing of tasks



Task 2 on the 2nd, 3rd and 4th floor are not critical!

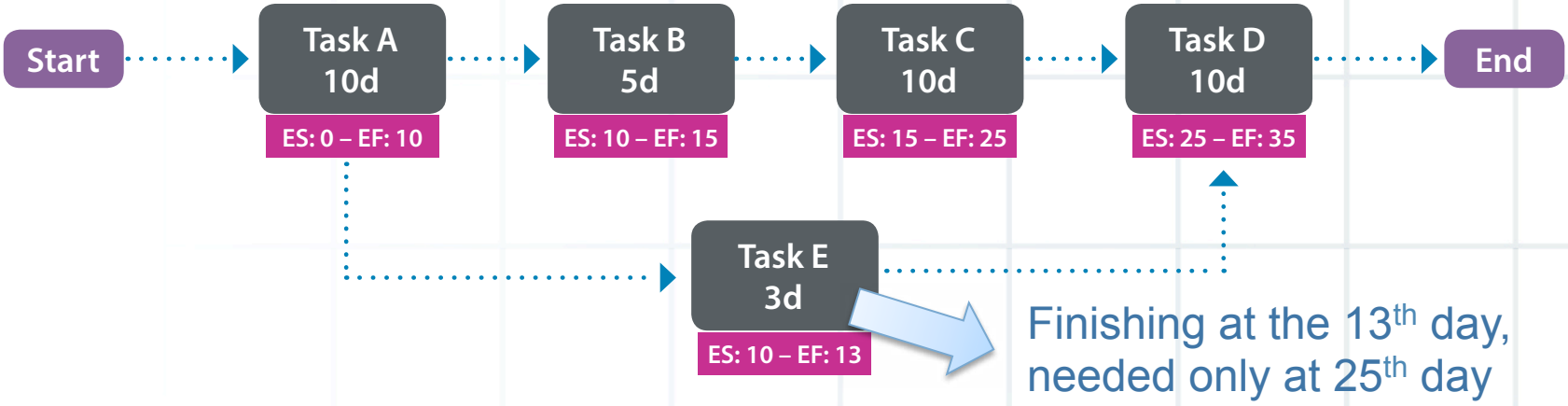
“SF” on optimization of resources (Just In Time)

TASKS	DURATION	PREDECESSOR
A	10	Start
B	5	A
C	10	B
D	10	C, E
E	3	A



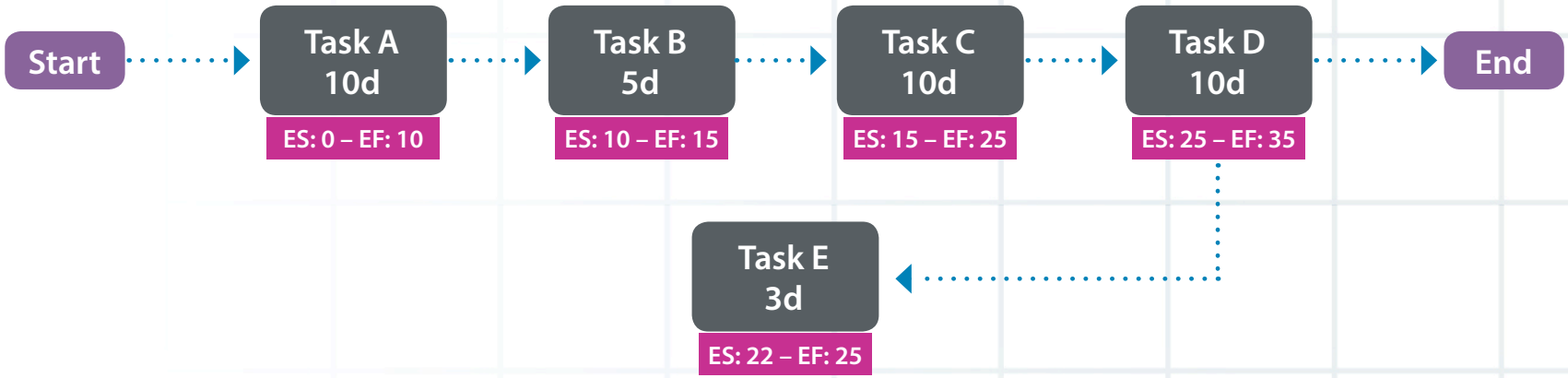
Network Diagram

“SF” on optimization of resources (Just In Time)



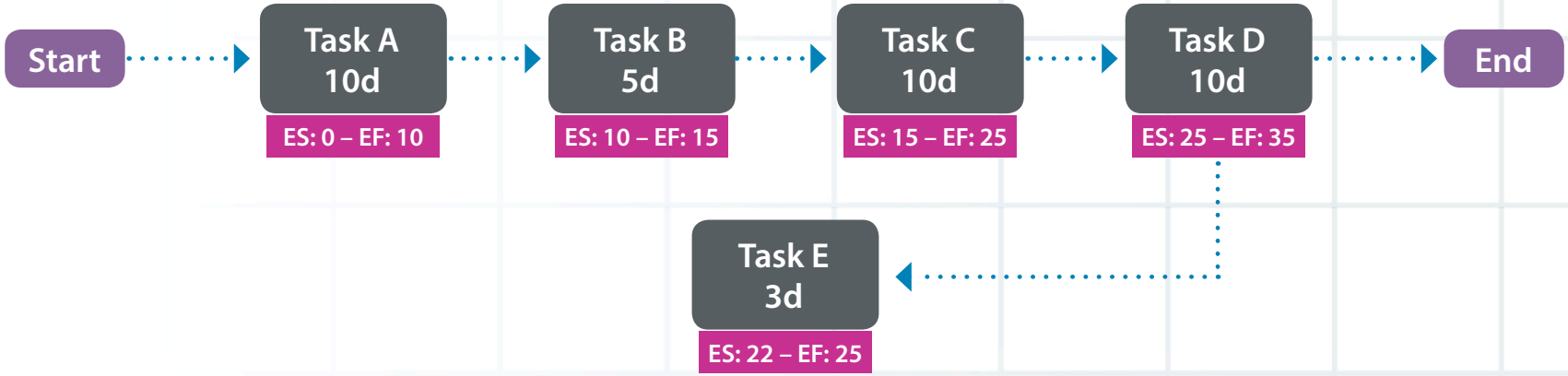
Overproduction in Anticipation – One of the Seven Wastes of Production Systems (OHNO, 1997, and SHINGO, 1996)

“SF” on optimization of resources (Just In Time)



New network diagram with the SF relation

“SF” on optimization of resources (Just In Time)



All the tasks are critical!

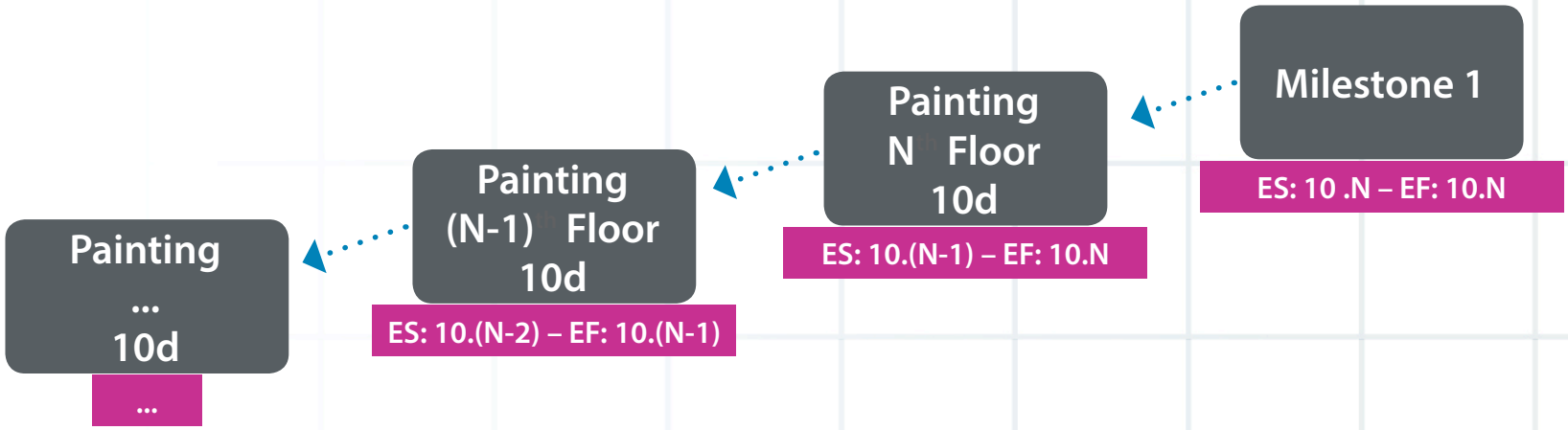
Risk for any delivery or communication between Task A and Task E!

“SF” relation for milestones and support activities

Combination of the first and second uses:

First	when the time constraint is applied to the end of the sequence
Second	Schedule tasks as late as possible right away

“SF” relation for milestones and support activities



Milestone 1 being the end of Painting tasks

“SF” relation on “Backward Planning”

- Consider the end of the project as a Milestone
- Subordinate all of the tasks to this milestones
- The schedule development goes “backwards”, from the end to the start
- Backward Planning, a tool of Critical Chain Project Management *(Kishira, 2009)*
- Similar to the “Drum-Buffer-Rope Scheduling” for manufacturing processes *(COX III & SPENCER, 2002)*

Conclusions

- **“Start-Finish” for:**
  - LBSM
  - Pulling mechanism
  - Milestones and support activities scheduling
  - Backward planning
- **“Unexpected results” are related to the increase at the risk of the project due to:**
  - The removal of floats
  - The increase in communication complexity

Contact Information

Ricardo Viana Vargas

ricardo@ricardo-vargas.com

ricardo-vargas.com

@rvvargas

/in/ricardovargas

+45 4533 7673

Felipe Fernandes Moreira

felipef@gmail.com

/in/felipefmoreira

+55 85 32675722

+55 85 86999108