# Line Of Balance

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# Intended Learning Outcomes

- Define the principles of Line of Balance (LOB)
- Demonstrate the application of  LOB
- Understand the importance of LOB
- Understand the process of applying LOB

# Line of Balance (LOB)

- **Definition**

  A simple diagram to show location and time at which a certain crew will be working on a given operation.

- Focuses on **balancing the time** taken for individual activities by either re-distribution of resource or by reducing process waste.

# Line of Balance (LOB)

- LOB is a Planning methodology to **optimize resources** used
- LOB is a **Good Visual tool** that lets us see if a construction program can be achieved with the minimum waiting time between tasks
- It is primarily used on projects that have **repeated elements** like Highways, Pipelines, High-rise buildings, hotel bedrooms, bridge etc.

# Benefits of LOB

- Continuous resource use
- Less starts and stops
- Crews will develop a learning momentum
- Improve productivity by 20 %
- Save **money** and **time**
- Faster planning process
- Superior Visual control

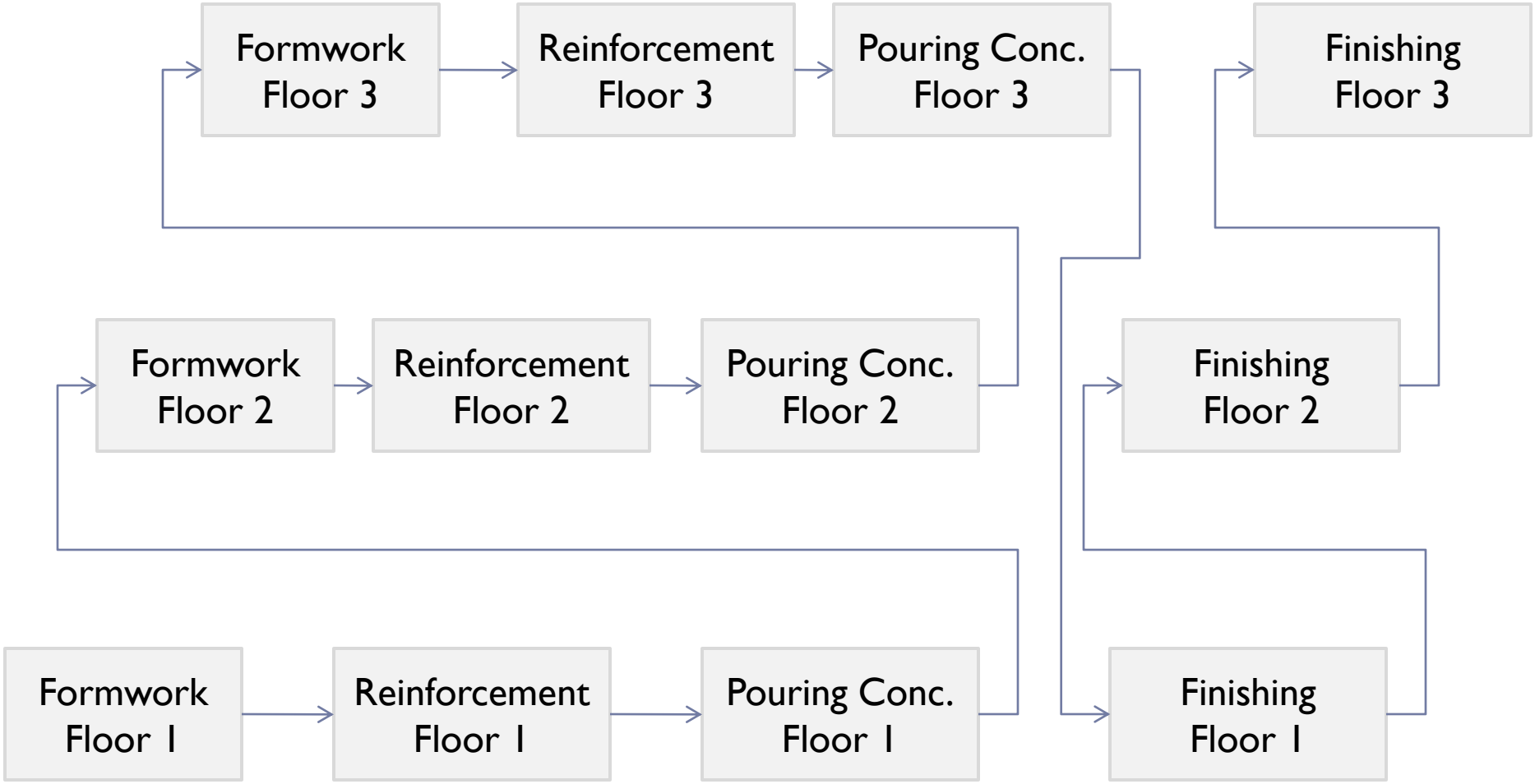
# Faster planning process

- Less tasks
- Less links
- Faster program creation
- Less time to understand & interpret
- Easy to try ‘what-if’ scenarios

# Activity-based vs. Location-based

- ***Activity-based***
  - 30 floors, 4 activities in each location = 120 activities
  - Formwork-reinforcement-pouring on the same floor = 60 links
  - Pouring – formwork next floor = 29 links
  - Pouring – finishes two floors below = 28 links
  - Internal links in finishes to prevent resource overlapping = 29 links
  - **Total: 120 CPM activities, 266 links**

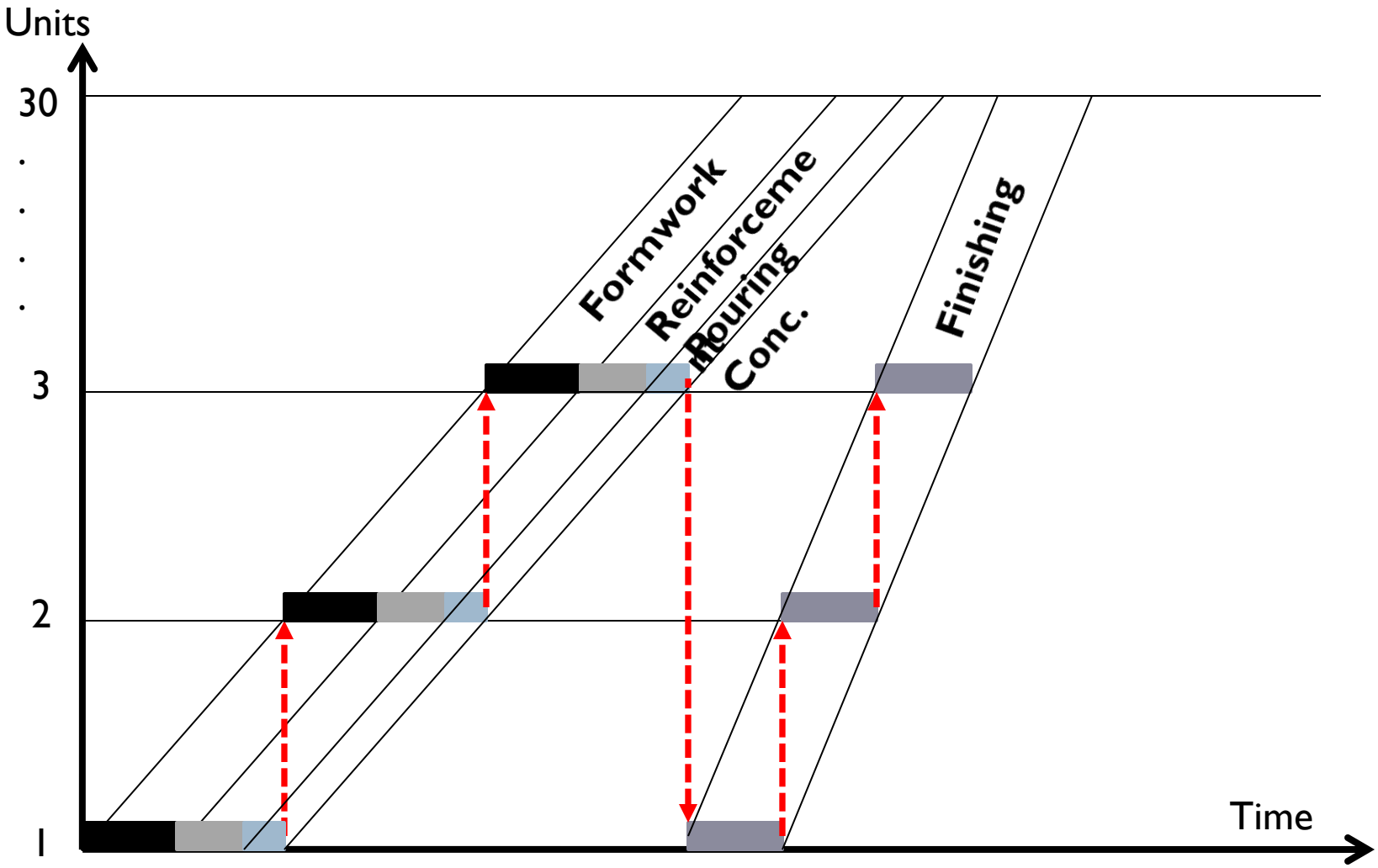
# Activity-based



# Activity-based vs. Location-based

- ***Location-based***
  - 4 tasks flowing through locations
  - 4 links between activities
  - 4 links inside activities
  - **<u>Total: 4 tasks, 8 link</u>**

# Location-based



# Superior project control

- Easy to interpret
- Clear uncomplicated displays
- Simple to manage
- Easy to monitor
- Effortless progress updates
- Effective control

# LOB Calculations

- The objective of using LOB is to achieve a **resource-balanced schedule** by determining the suitable crew size and number of crews to employ in each repetitive activity.
- This is done such that:
  1. the units are delivered with a rate that meets a pre-specified deadline
  2. the logical CPM network of each unit is respected
  3. crews' work continuity is maintained.
- The analysis also involves determining the **start** and **finish** times of all activities in all **units** and the crews' assignments.

# Three diagrams are used in LOB

1. Production Diagram

   Shows the relationships of the activities for a single unit.

2. Objective Diagram

   Used to plot the planned or actual number of units produced vs. time.

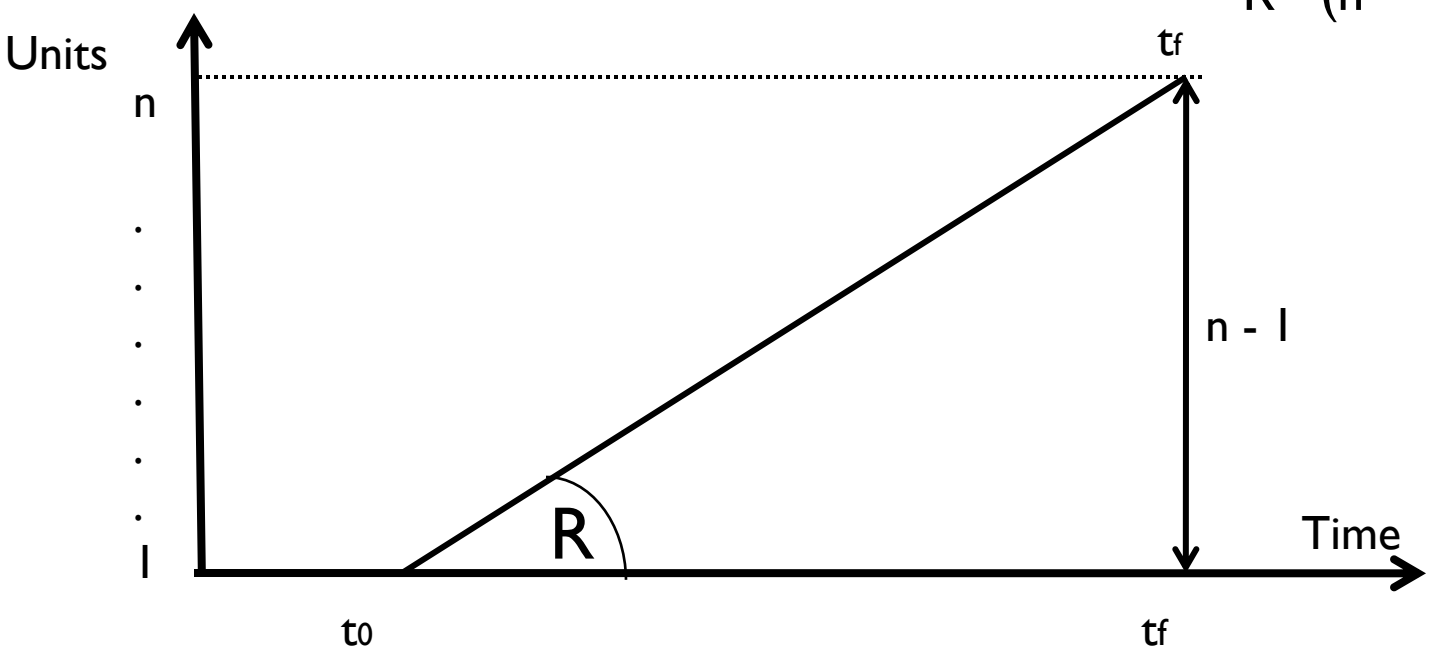
3. Progress Diagram

   Shows the number of units for which the activity has completed .

# Drawing the LOB Schedule

- Similar rates → parallel lines
- Different rates → lines not parallel
- Conflict points → at the last or first unit

$R = (n - 1)/(t_f - t_0)$



# LOB Calculations

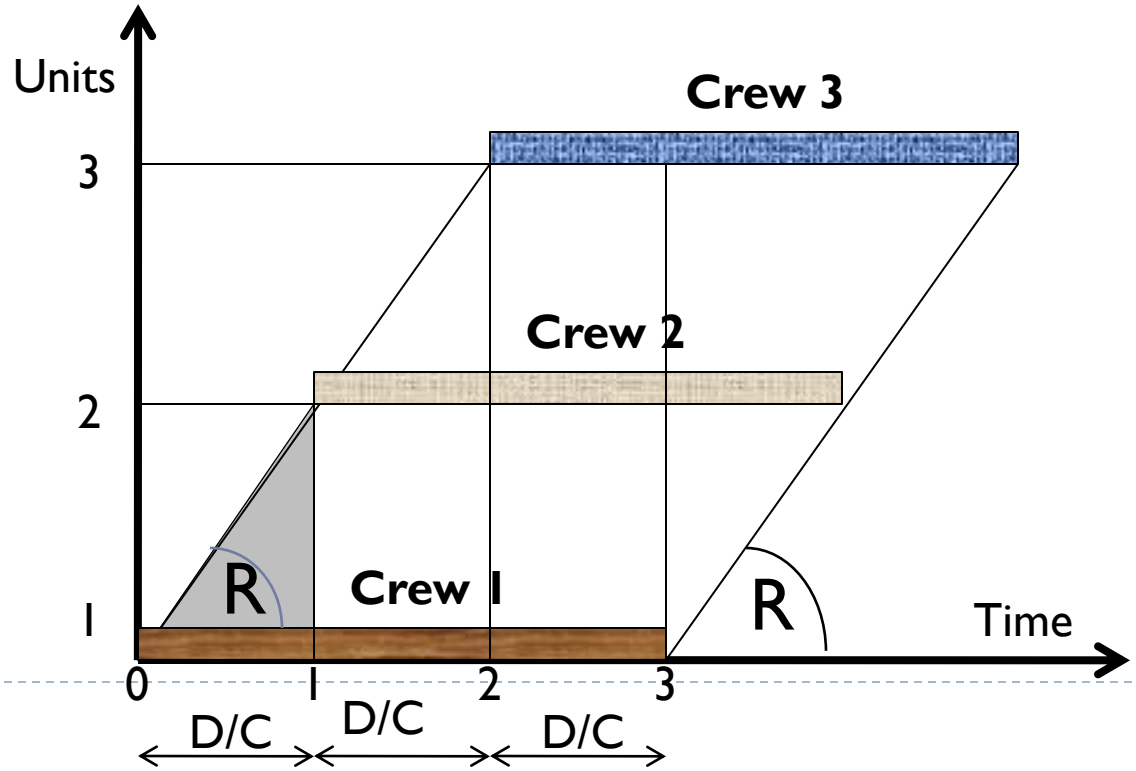
- The CPM-LOB formulation involve:
  - Crew synchronization
  - Calculating resource needs
  - Drawing the LOB schedule

# Crew Synchronization

- A simple relationship between the **duration** taken by a crew in one unit (D) and the **number** of crews (C) to employ in a repetitive activity
- Slope of the shaded triangle in becomes:

$$R = 1 / (D / C)$$

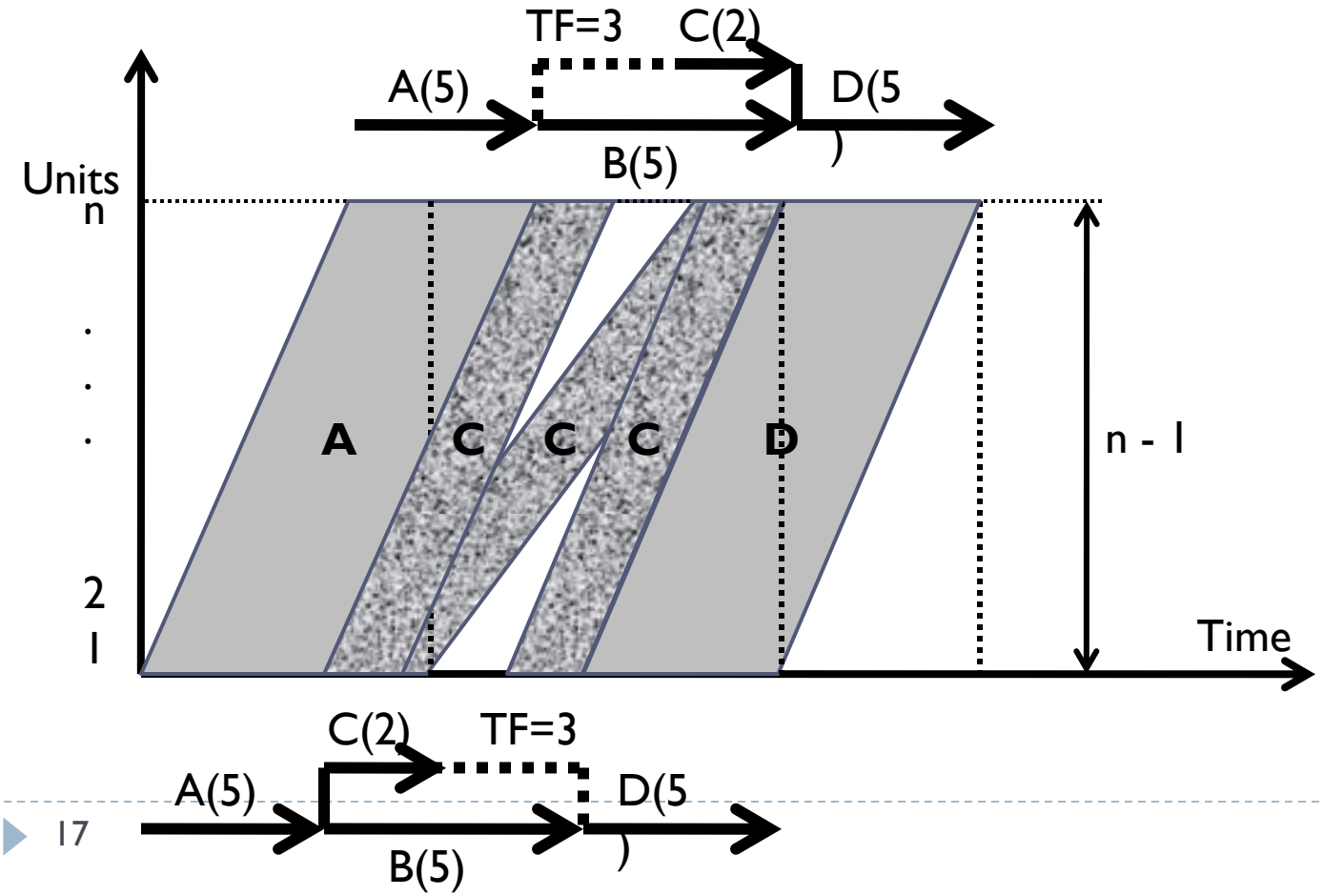
*Then:* $C = D \times R$



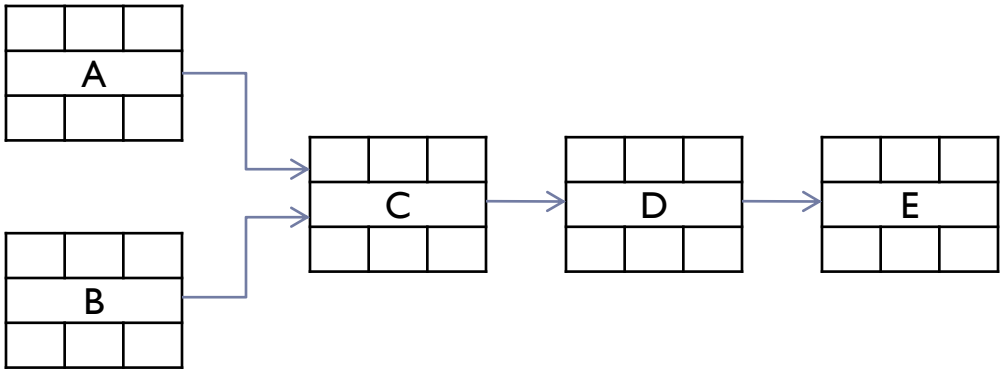
# Calculating Resource Needs

$Ri = (n - 1) / (TL - T1) + TFi$

$Ci = Di \times Ri$ $\quad$ $Cai = \text{Round Up}\ (Ci)$ $\quad$ $Rai = Cai / Di$



# Example




| Activity | A | B | C | D | E |
|---|---|---|---|---|---|
| Production rate | 3 | 5 | 5 | 3 | 1 |
| No of crews | 9 | 30 | 10 | 9 | 2 |

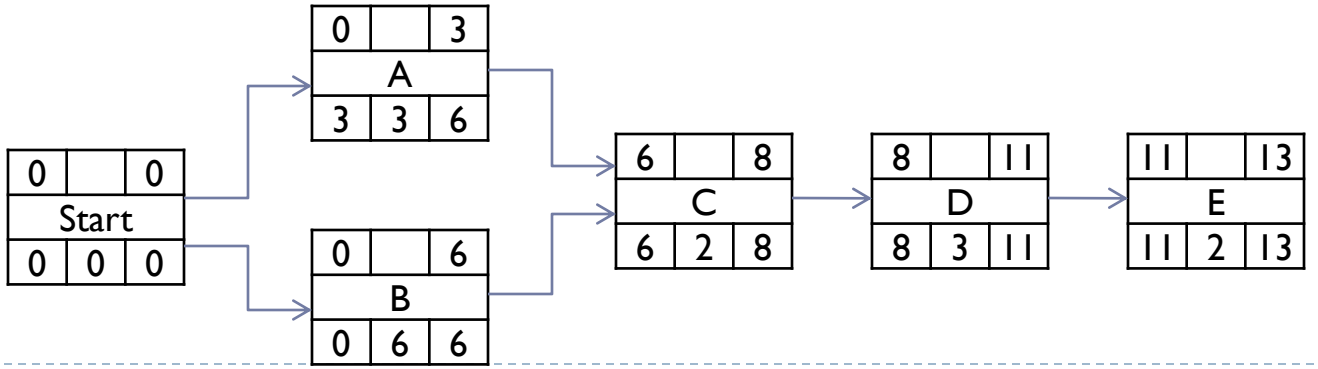
N=61 units

**Required** ; draw LOB at month 16

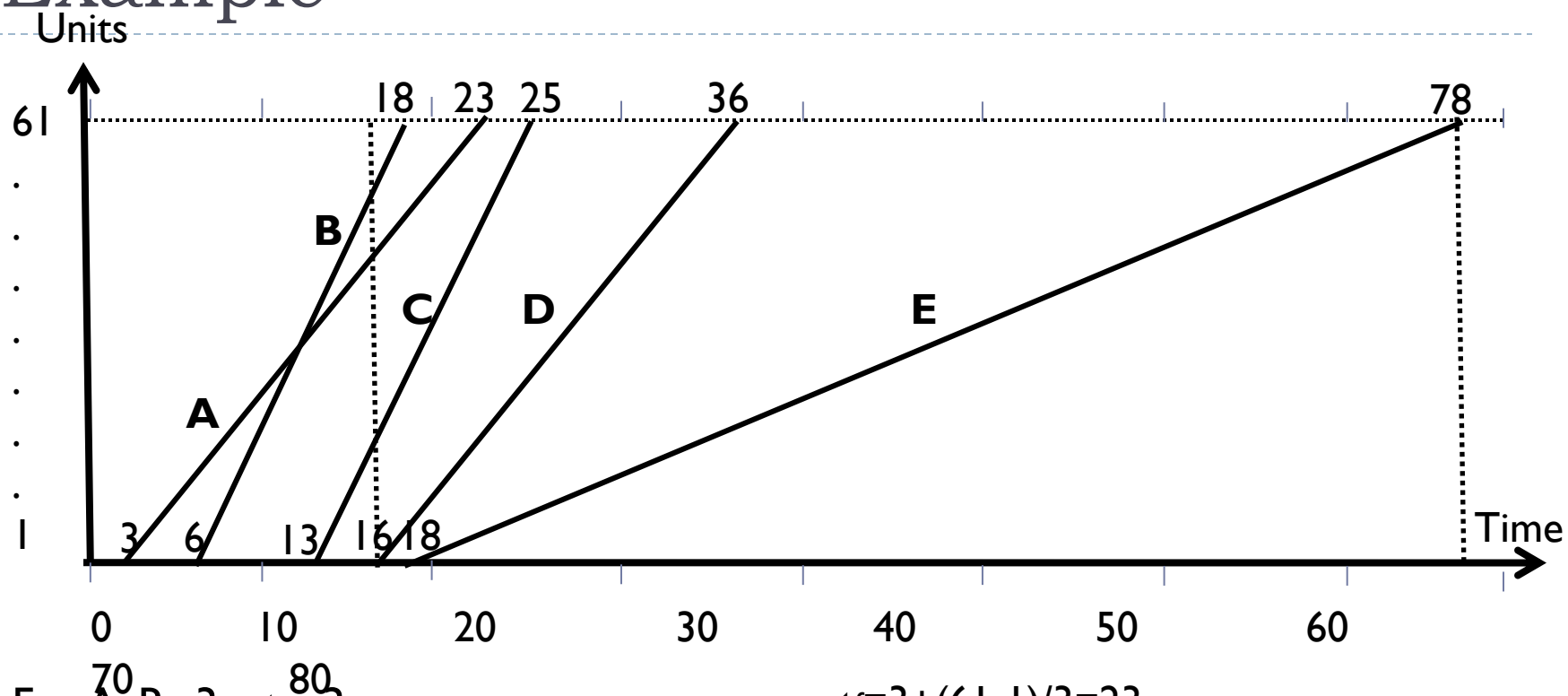
# Example

- ***R = I / (D / C)***
- ***D = C/R***

| Activity | A | B | C | D | E |
|---|---|---|---|---|---|
| Production rate | 3 | 5 | 5 | 3 | 1 |
| No of crews | 9 | 30 | 10 | 9 | 2 |
| Duration | 3 | 6 | 2 | 3 | 2 |



# Example




For A: R=3, $t_0$=3, $t_f$=3+(61-1)/3=23

For B: R=5, $t_0$=6, $t_f$=6+(61-1)/5=18

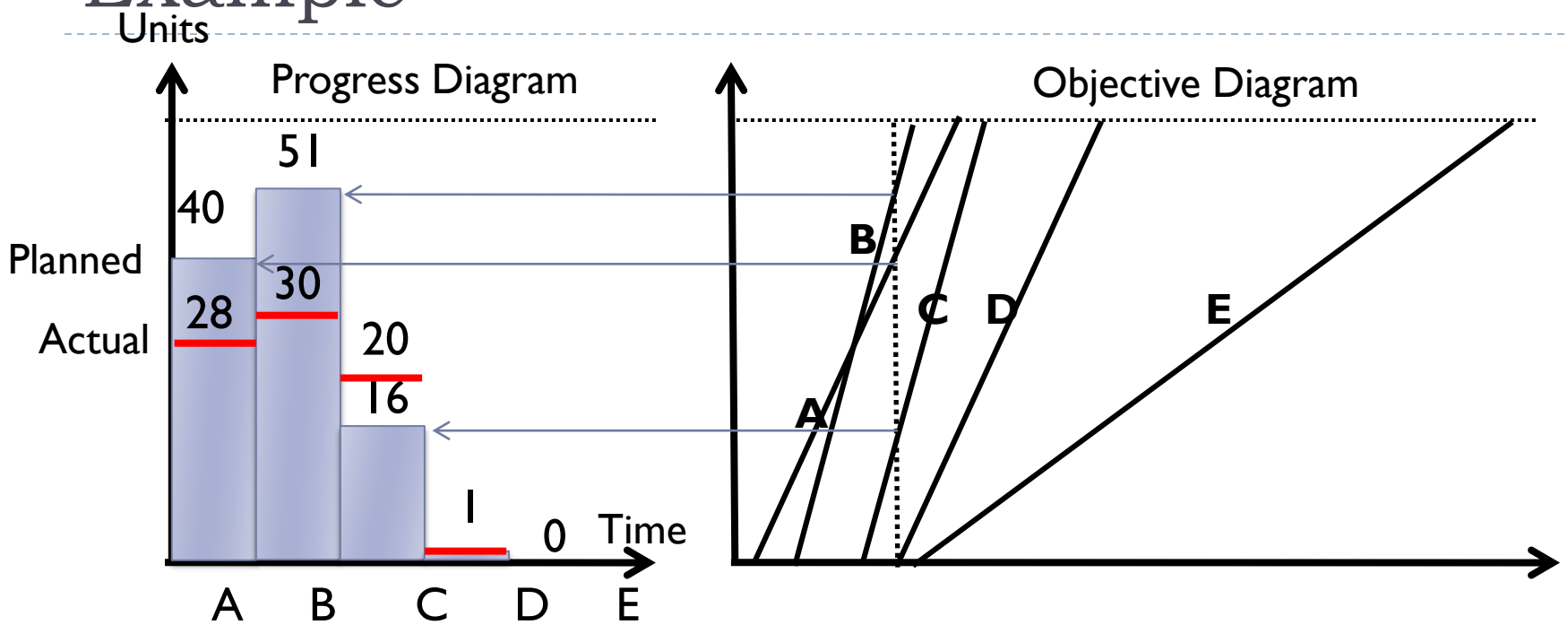
For C: RC=RB>RA, buffer from top

R=5, $t_f$=23+2=25, $t_0$=25-(61-1)/5=13

For D: R=3, $t_0$=13+3=16, $t_f$=16+(61-1)/3=36

For D: R=1, $t_0$=16+2=18, $t_f$=18+(61-1)/1=78

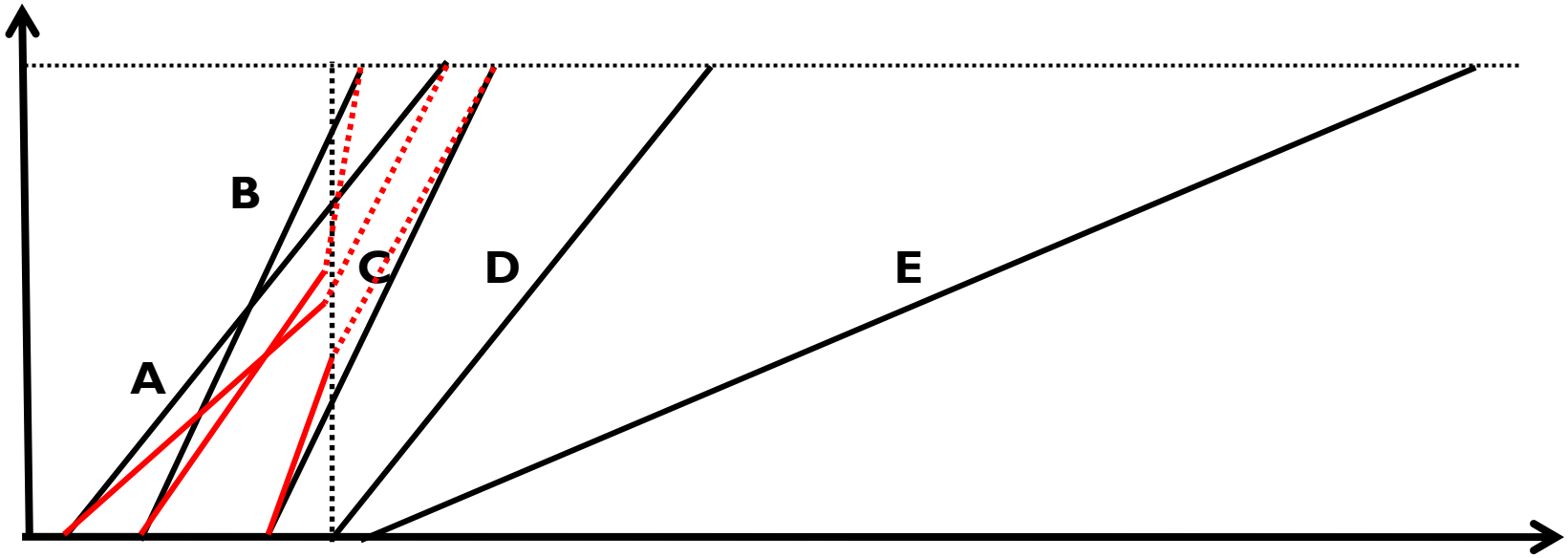
# Example




For A: R=3, $t_0$=3,
For B: R=5, $t_0$=6,
For C: R=5, $t_0$=13,
For D: R=3, $t_0$=16,
For E: x=0

16=3+(x -1)/3, x=40
16=6+(x -1)/5, x=51
16=13+(x -1)/5, x=16
16=16+(x -1)/3, x=1

# Example



# Questions