Line Of Balance

Dr. Ahmed Elyamany

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

Location Based Management

- LBM is a production control system that integrates **planning**, **scheduling**, and **control**.
- **Tasks** are defined by **production rates**, **resource consumption** and **quantities**.
- The placement and interrelated dependencies of tasks are defined by technical **dependencies**, **locations**, and **continuity requirements**.

Location Based Management

- Is a scheduling and control technique that is believed to offer advantages in building construction compared with CPM and PERT.
- LBM includes important aspects that are omitted in CPM and PERT such as continuous work flow and location constraints.

Location Based Management

- LBM combines **production rates**, **quantities**, and **resource consumption** in specific **locations** to estimate the **duration** of tasks.
- In LBM, similar activities are collected in tasks and displayed as a single line (***production lines*** or ***flow lines***) over multiple locations.

Location Based Management

The result allows **schedulers and managers** to evaluate whether construction **crews** can perform their work **undisturbed** by **aligning rates of production**.

Activity-based
versus
location-based
scheduling and control

- Construction scheduling and control is divided into **two** main methodologies:
- **Activity-based** and **Location-based**.
- **Activity-based** methods include The critical path method (**CPM**) and the program evaluation and review technique (**PERT**).
- **Activity-based** methods depend solely on technical relationships between activities in the schedules governed by technical constraints.
- **Activity-based** methods highlight the activities that should be considered **critical**

Activity-based methods criticism

- Do not include any algorithm, calculation, or consideration for solving the **practical organization problems** of the on-site production process.
- The assumptions that **unlimited resources** are available and that **personnel can be hired and fired** freely are erroneous

Activity-based methods criticism

- Were never intended for projects that are **sensitive to resource limitations** and **continuous workflow** because the methods originated in the aerospace and military industries.
- Lacking **work continuity** and learning effects

Activity-based methods criticism

- Does not contain elements that ensure a **smooth procession of crews** from unit (Location) to unit with no conflict and no idle time for workers and equipment.
- Difficult to manage on **repetitive projects**, due to discrete management of similar activities in different locations.

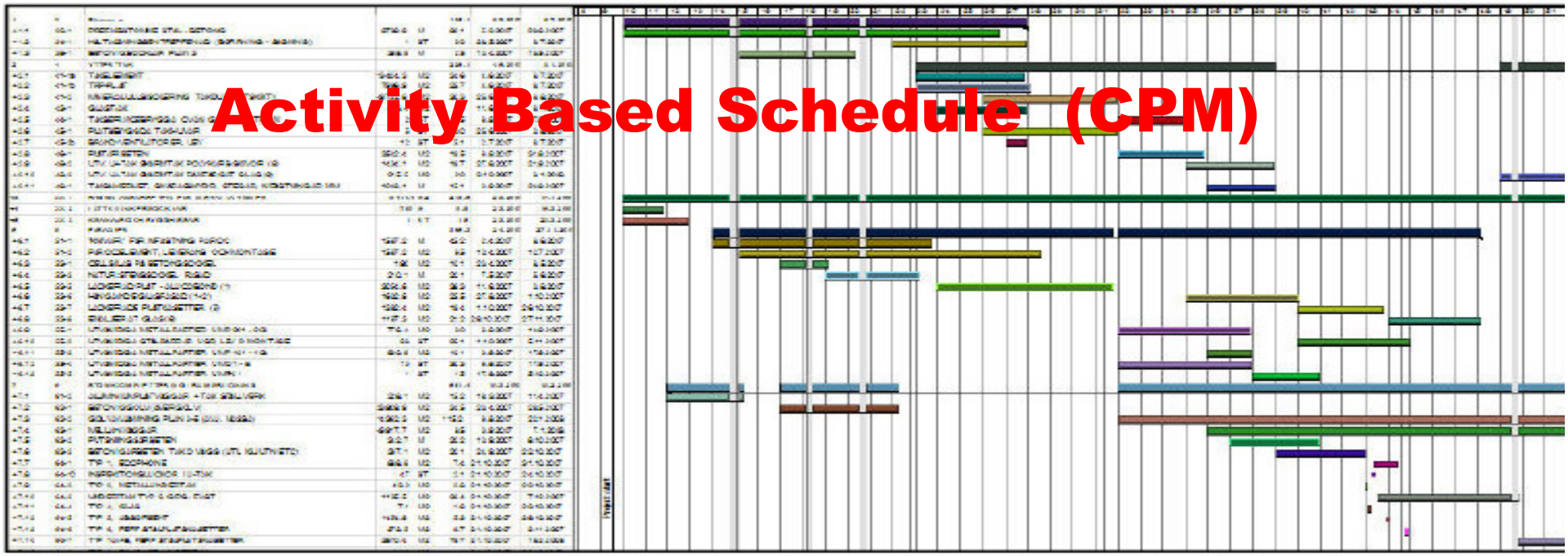
Activity-based methods criticism

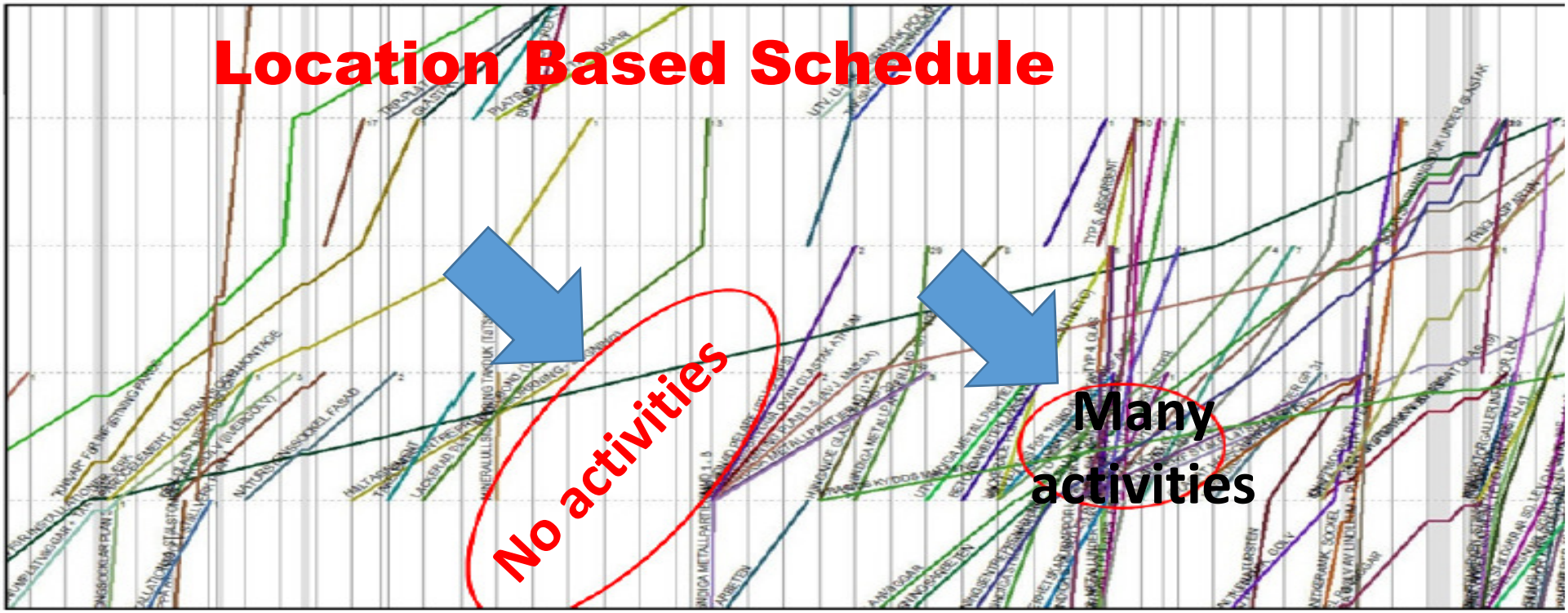
- Many attempts to solve the **short comings of the original CPM and PERT techniques**:
  - **Resource leveling**
  - **Optimization of cost and time relationships**.
  - Communicative abilities of CPM addressed by linking CPM schedules with **3D modeling** of building components.
  - Improving health and safety procedures and flow optimization through **lean construction** principles.

location-based methods

Contains numerous methods that only differ slightly from modern LBM. These include:

- **line of balance scheduling**,
- linear scheduling method,
- vertical production method,
- Repetitive project model,
- velocity diagrams,
- time space scheduling,
- Construction planning technique,
- time Location Matrix Model,
- disturbance scheduling
- horizontal and Vertical logic scheduling


Activity Based Schedule (CPM)


Location Based Schedule
No activities
Many activities

Location Based Management

Working at the **same time and in the same location** **negatively** affects the work of construction crews because **technical constraints are not respected**.

Location Based Management

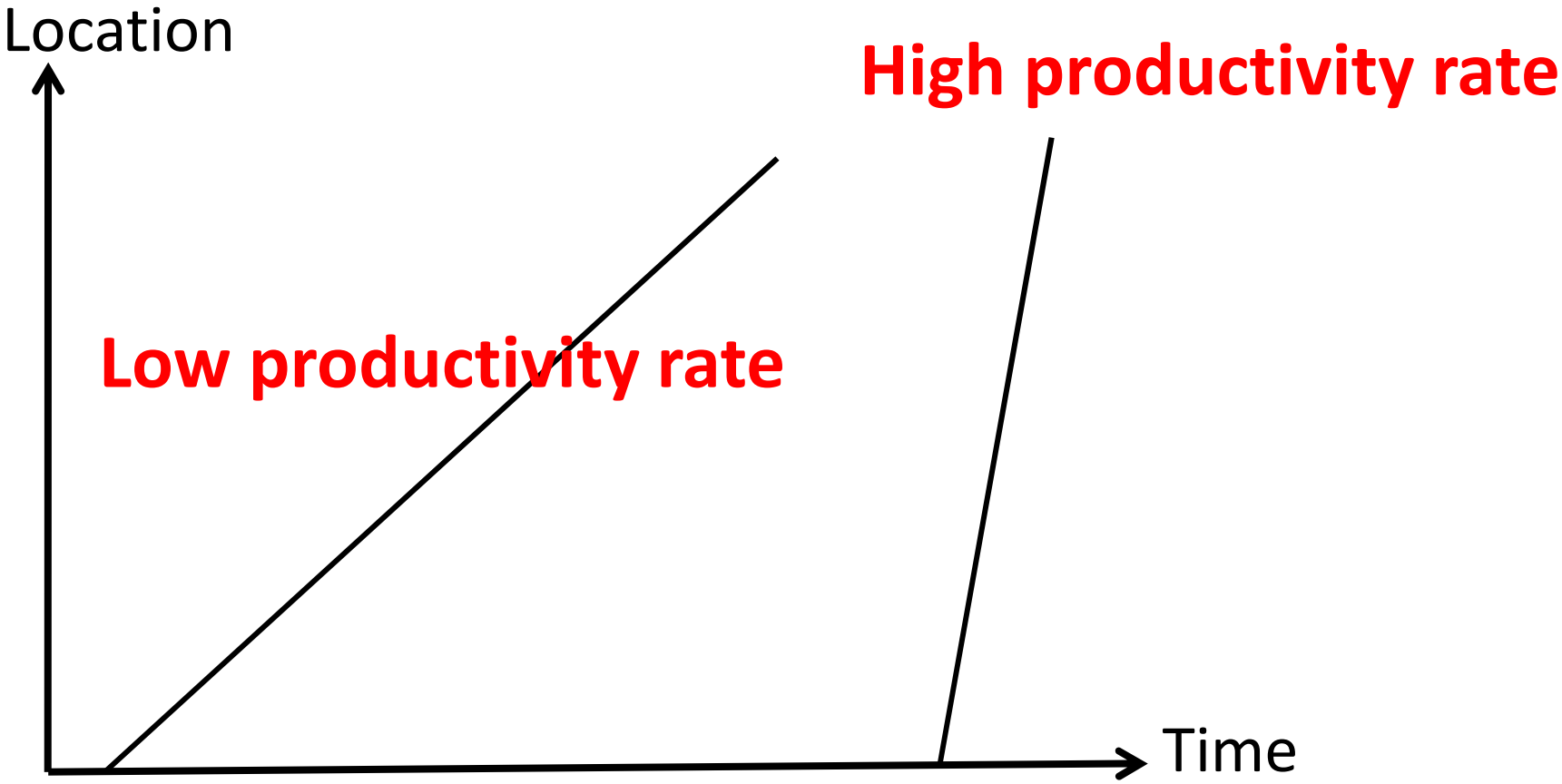
The **location-based schedule** illustrates areas not utilized for production, allowing the **project manager** to exploit **vacant areas** of the build site by **moving work crews** to those **locations**.

Location Based Management

The location-based schedule illustrates productivity problems.

The **flow lines** reveal tasks that are completed at a comparatively **slower rate**, which not only affects a **project's lead-time**; it can also result in **discontinuous production**.

Location Based Management



Line of Balance (LOB)

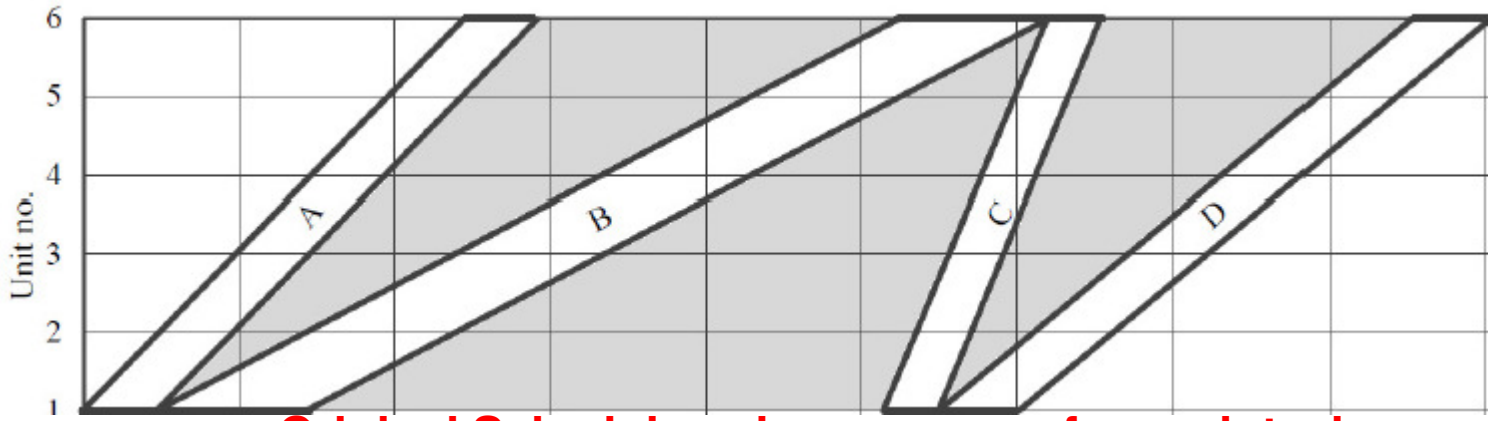
- **Definition**

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

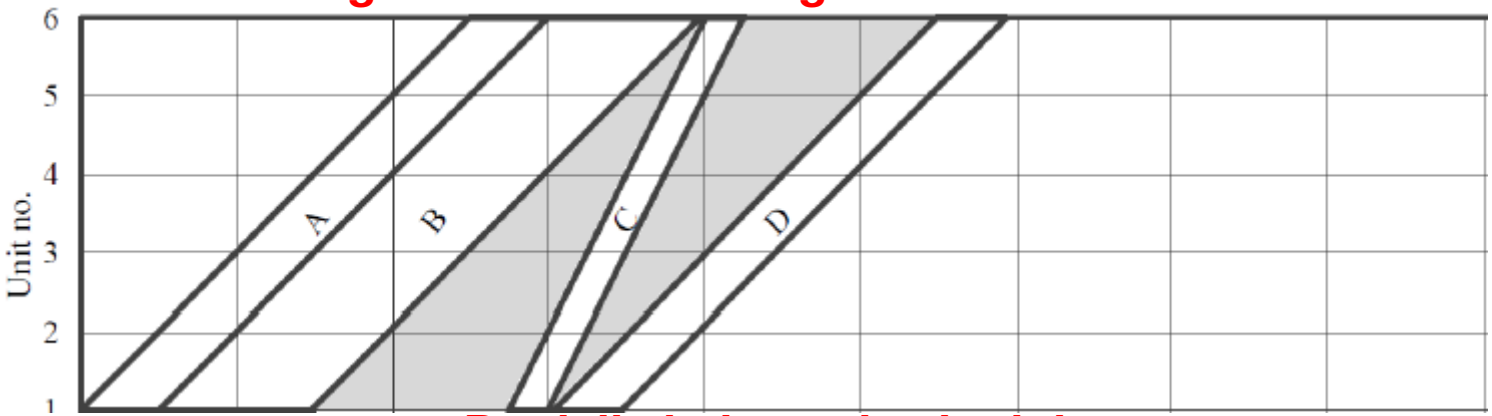
- Is a **Good Visual tool** that lets us see if a construction program can be achieved with the minimum waiting time between tasks

Line of Balance (LOB)

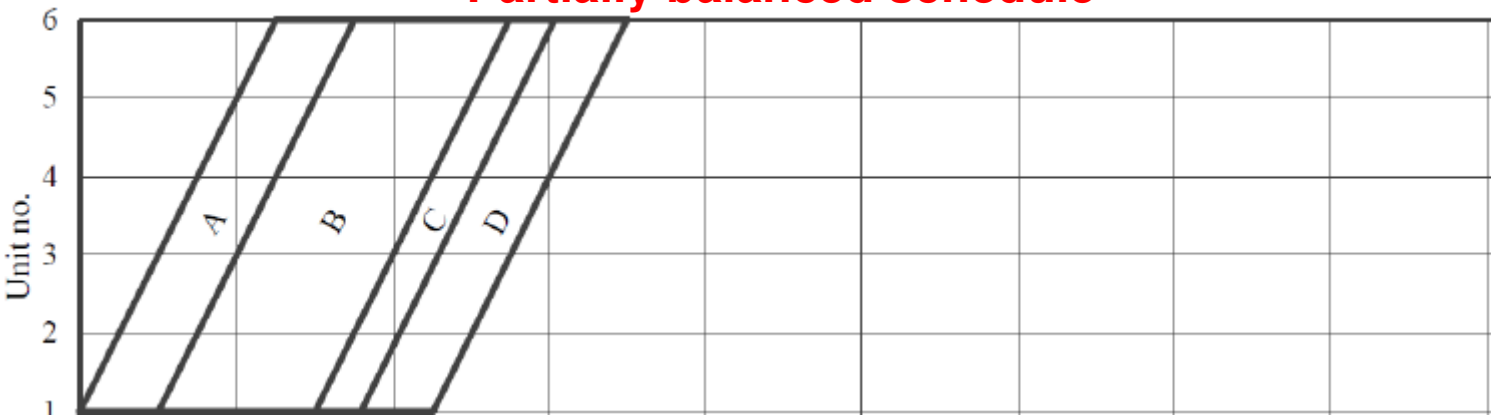
- Is a scheduling methodology to **optimize resources** used.
- Resources are used to **balance out** tasks by adding **additional crews** to **slower tasks**.
- The fully aligned schedules contain **no float**.



Original Schedule using one crew for each task



Partially balanced schedule



Fully balanced schedule

Line of Balance (LOB)

- Is primarily used on projects that have **repeated elements** like Highways, Pipelines, High-rise buildings, hotel bedrooms, bridge etc.

Benefits of LOB

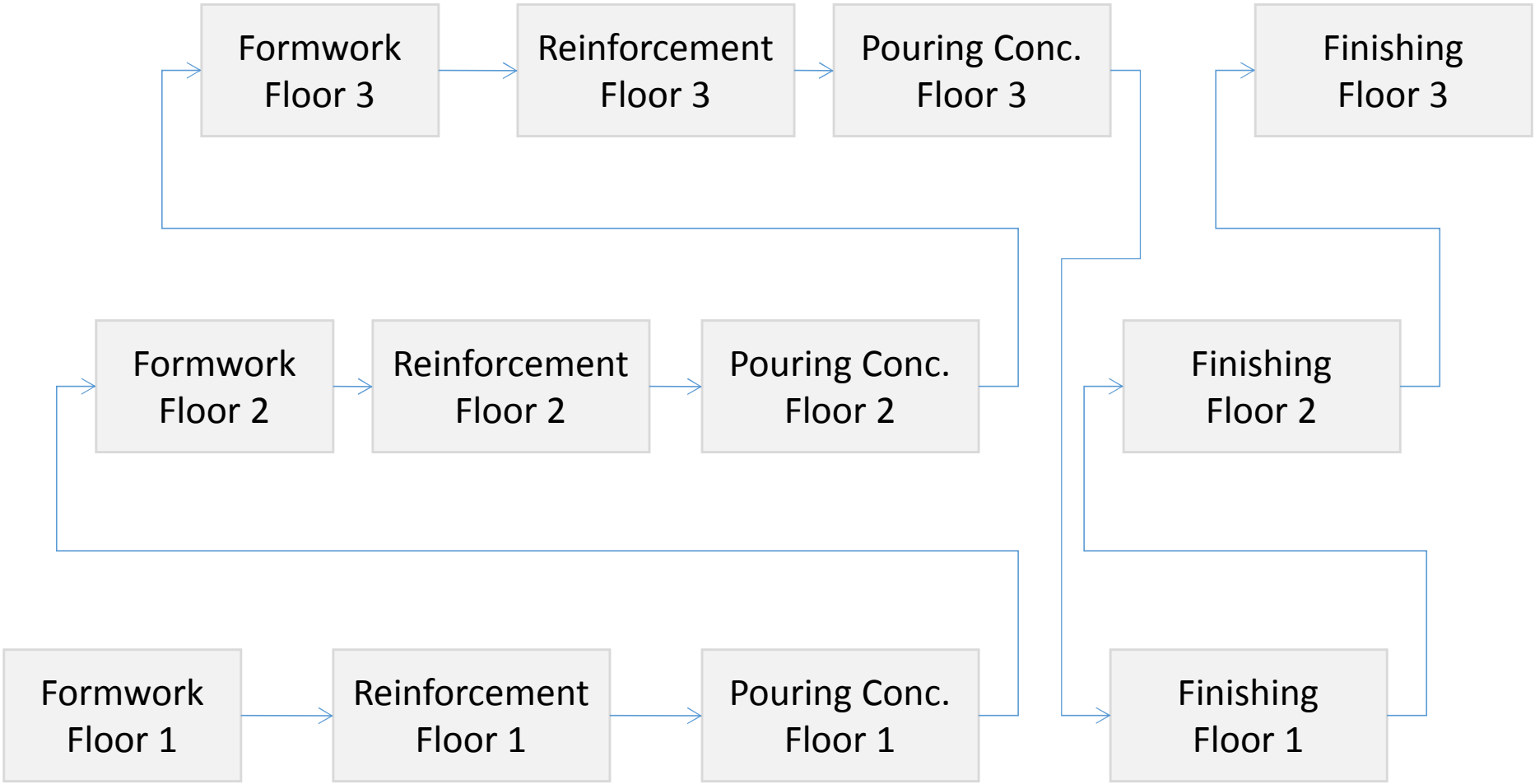
- Continuous resource use
- Less starts and stops
- Crews will develop a learning momentum
- Improve productivity by 20 %
- Save **money** and **time**
- Faster scheduling process
- Good Visual control

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
- **<u>Total: 120 CPM activities, 266 links</u>**

Activity-based



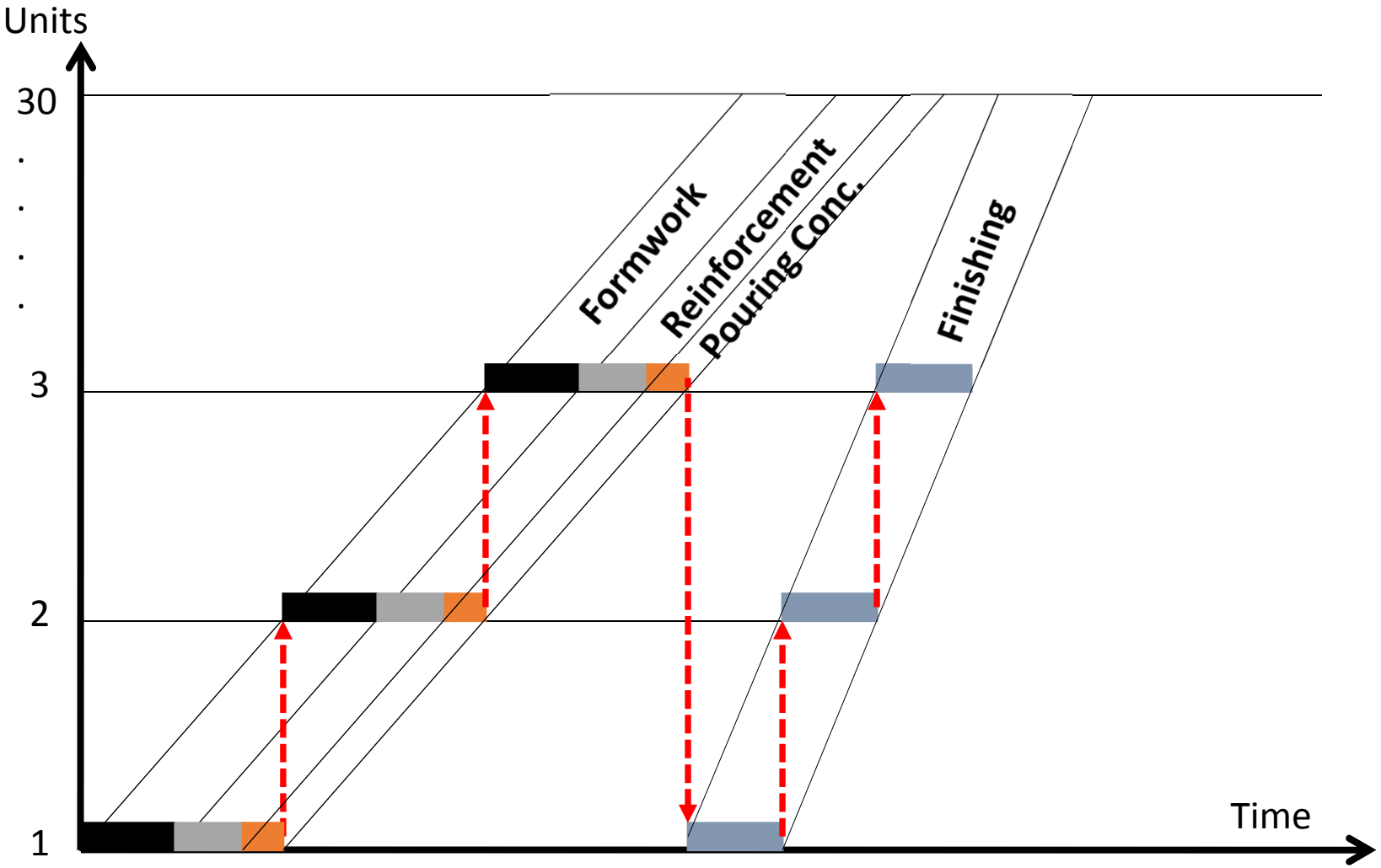
Location-based

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

➢ **Less tasks**

➢ **Less links**

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.

LOB Calculations

- 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.

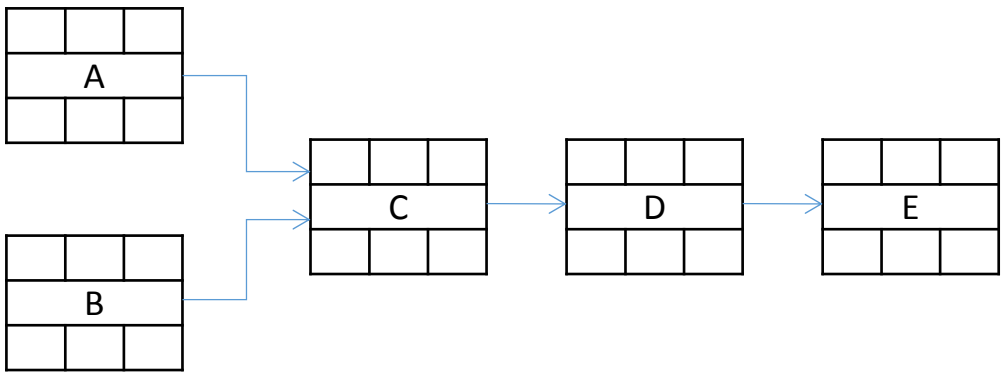
LOB Calculations

- The analysis also involves determining the **start** and **finish** times of all activities in all **units** and the crews' assignments.

LOB Diagrams

1. Production Diagram

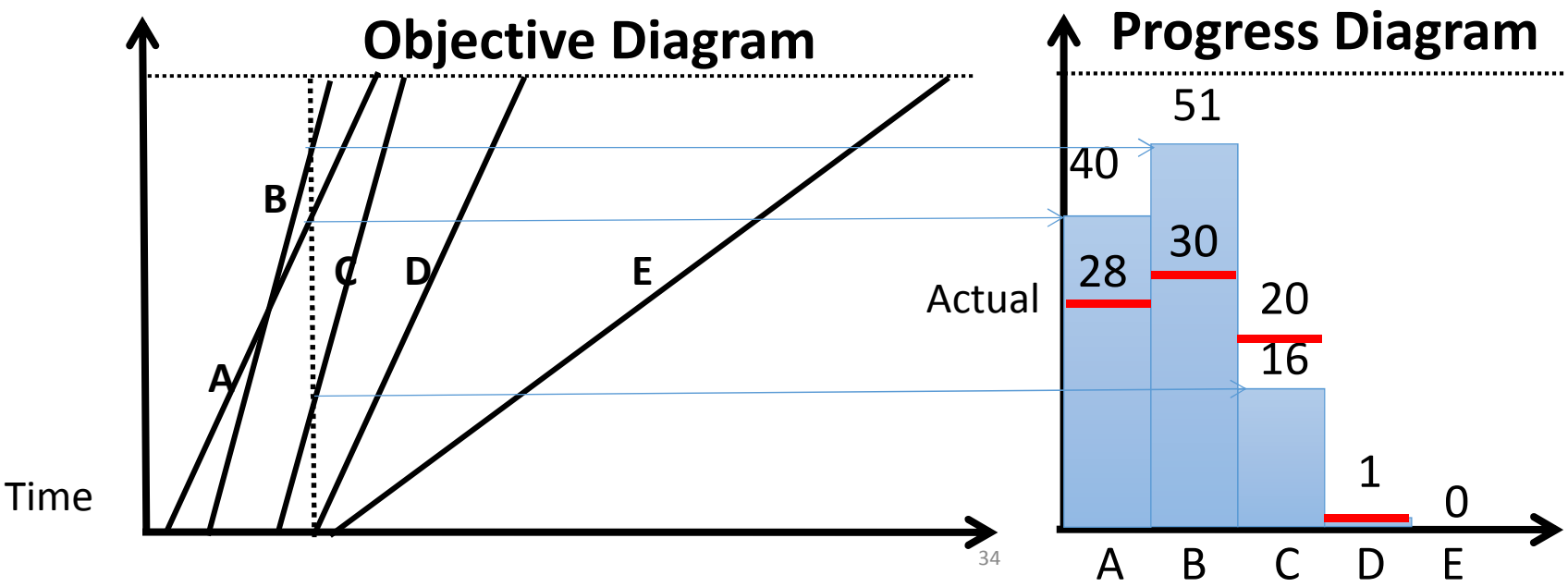
   Shows the relationships of the activities for a single unit.



LOB Diagrams

2. Objective Diagram

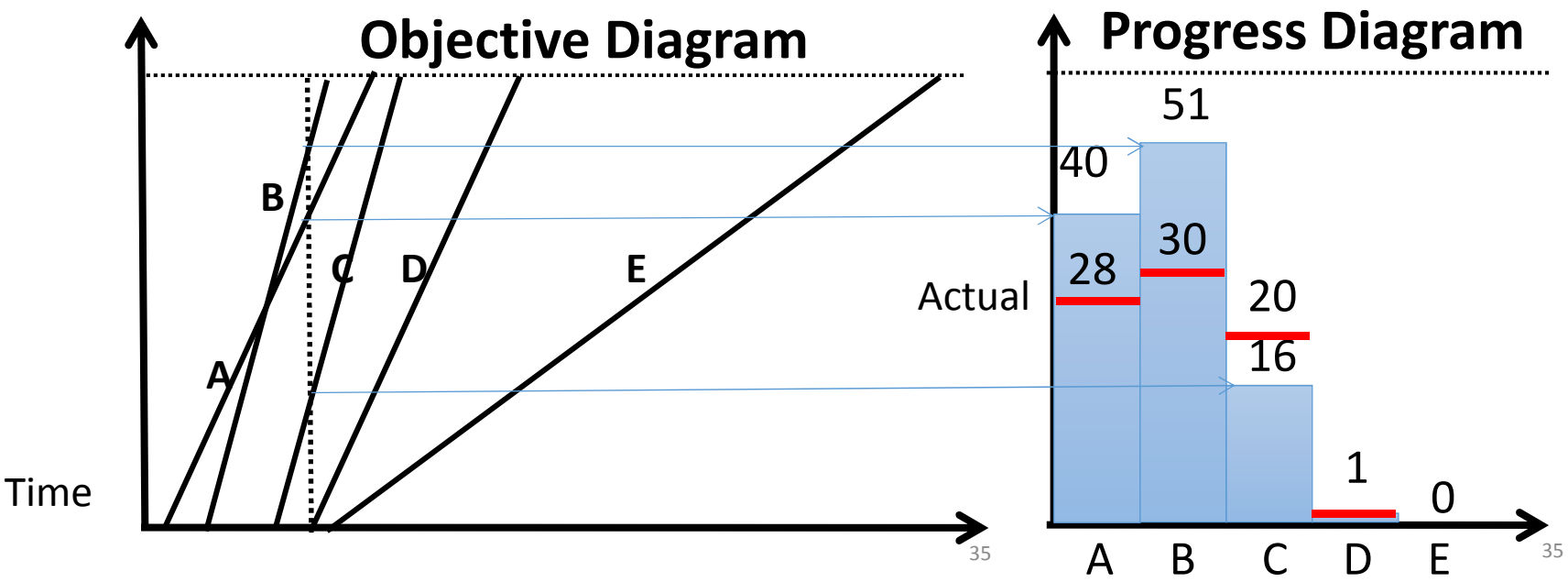
Used to plot the planned or actual number of units produced vs. time.



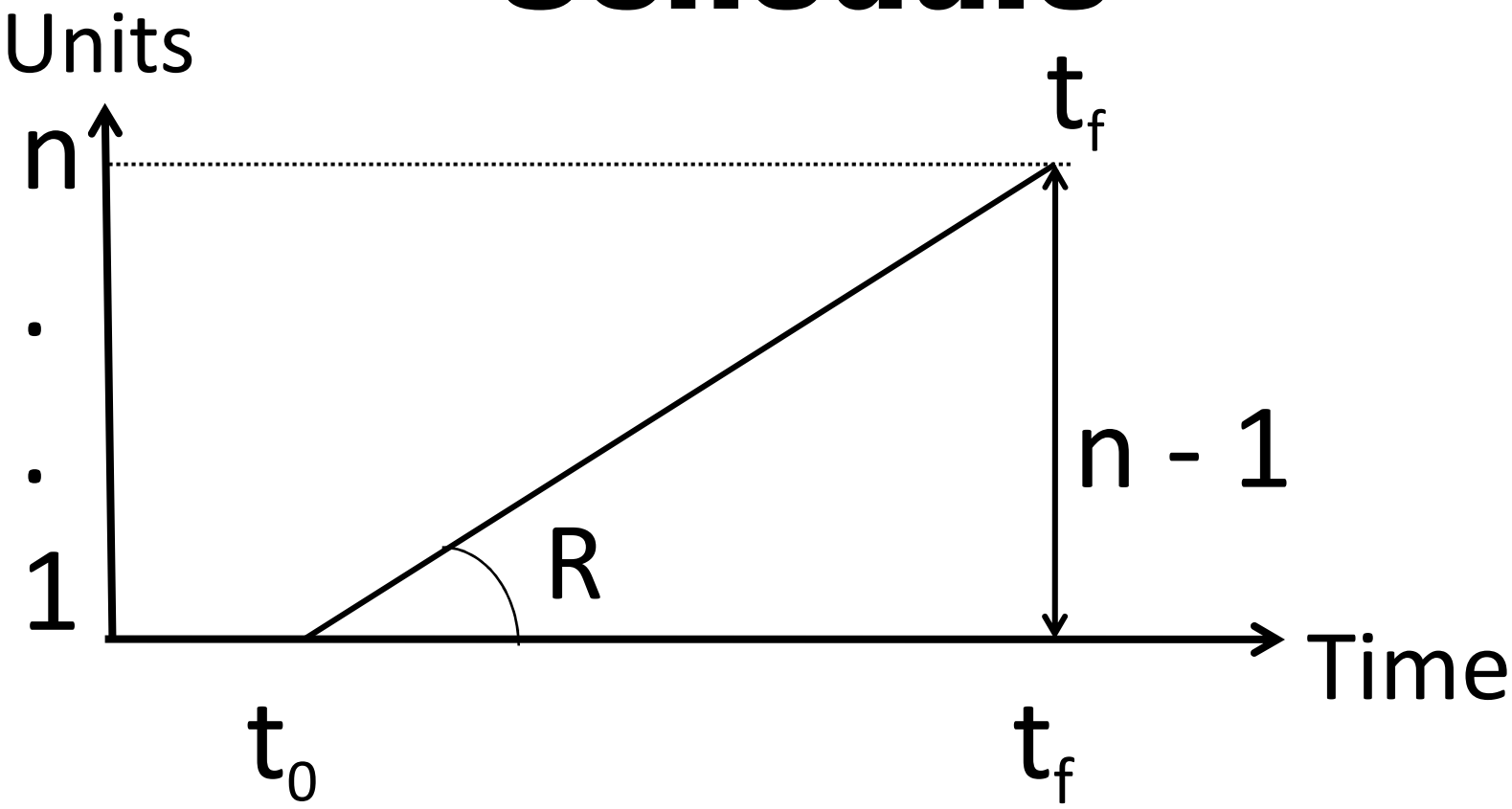
LOB Diagrams

3. Progress Diagram

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



Drawing the LOB Schedule



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

Drawing the LOB Schedule

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

LOB Calculations

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

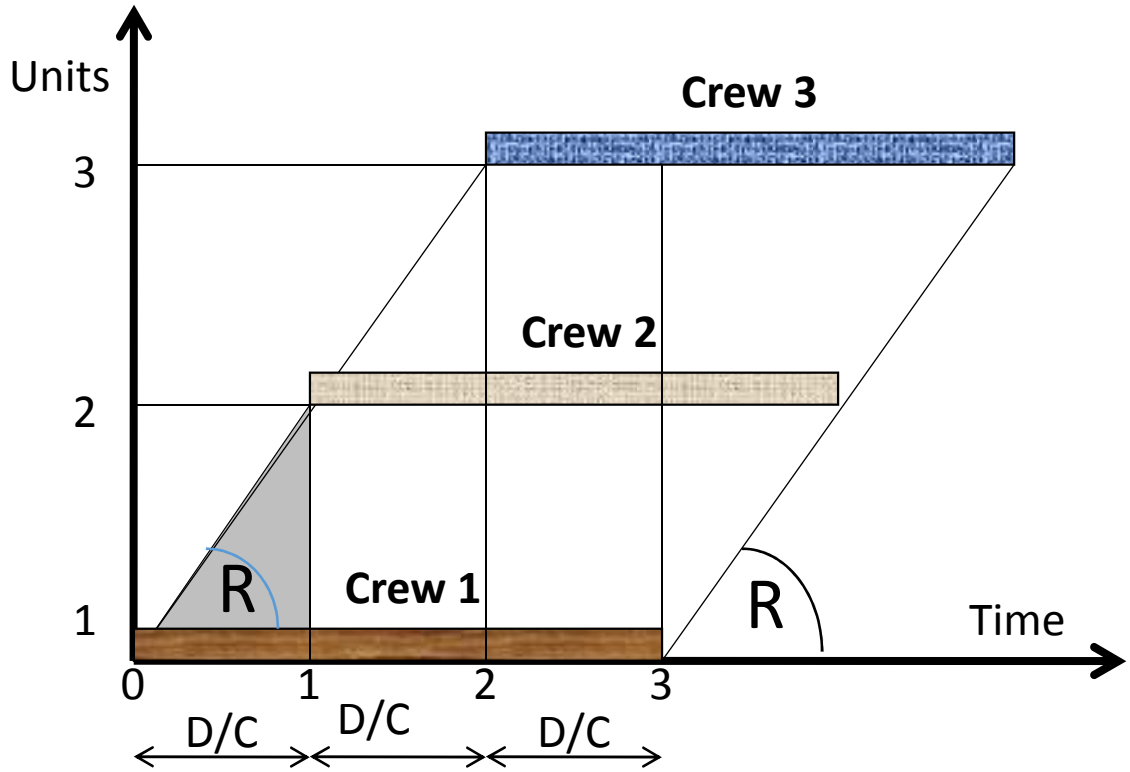
Crew Synchronization

- 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

Crew Synchronization

- Slope of the shaded triangle in becomes:

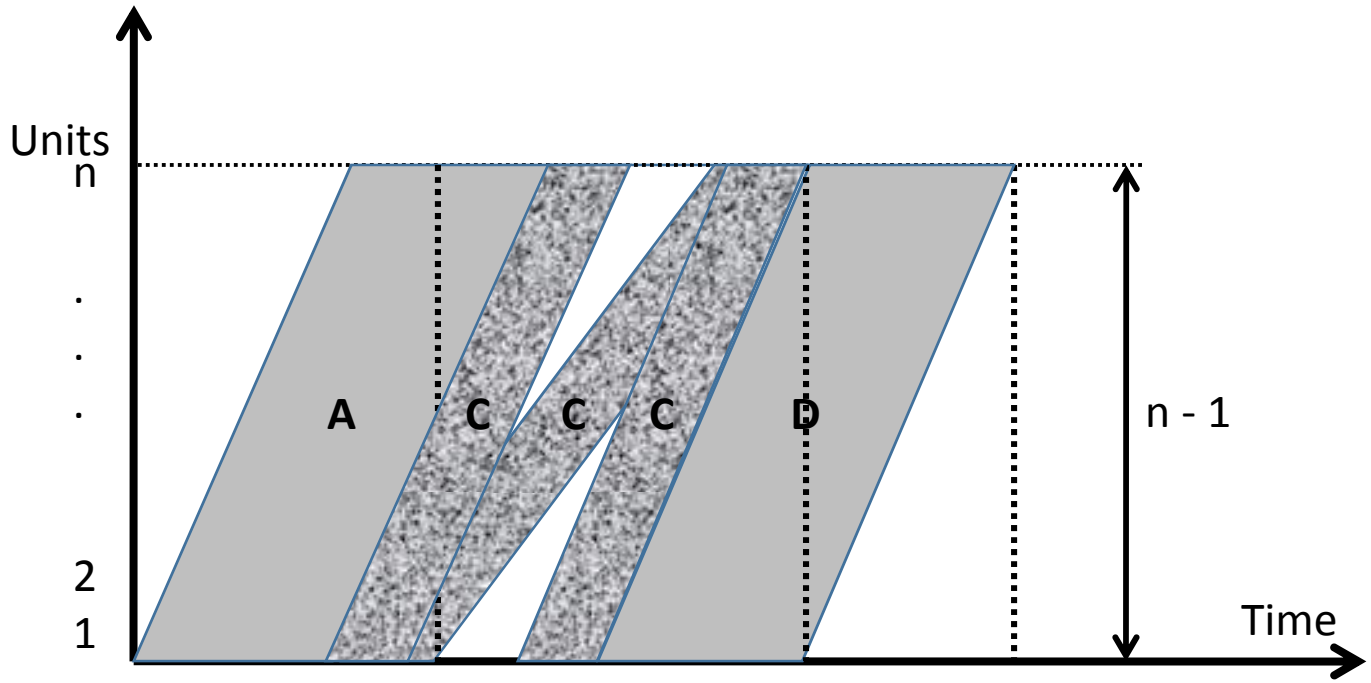
R = 1 / (D / C) *Then:* ***C = D x R***

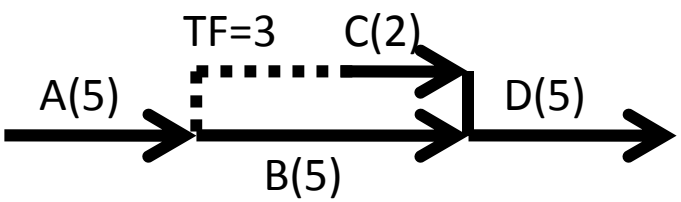


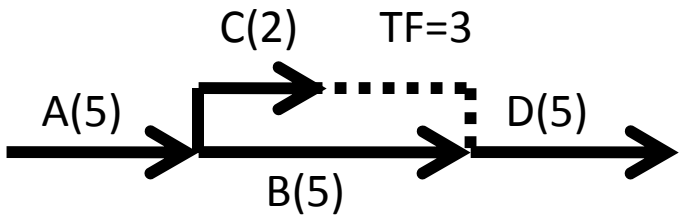
Calculating Resource Needs

- $Ri = (n - 1) / (T_f - T_0)$
- $Ci = Di \times Ri$
- $Cai = \text{Round Up } (Ci)$
- $Rai = Cai / Di$

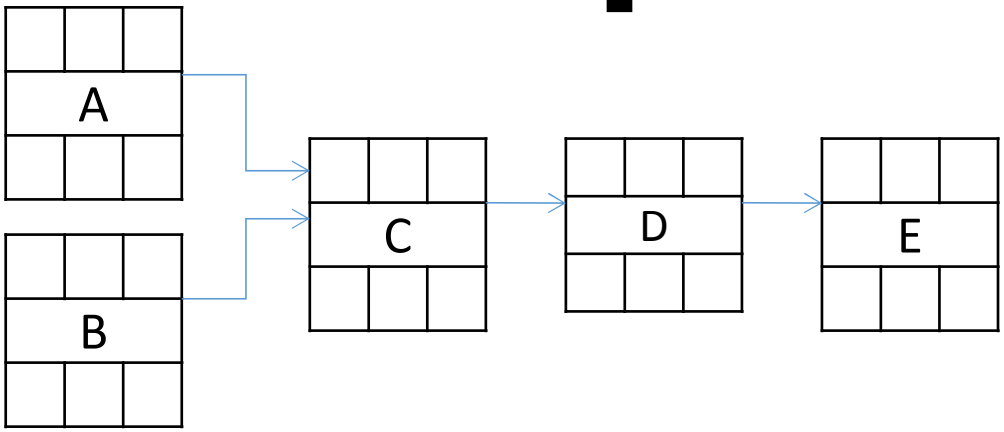
Calculating Resource Needs







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

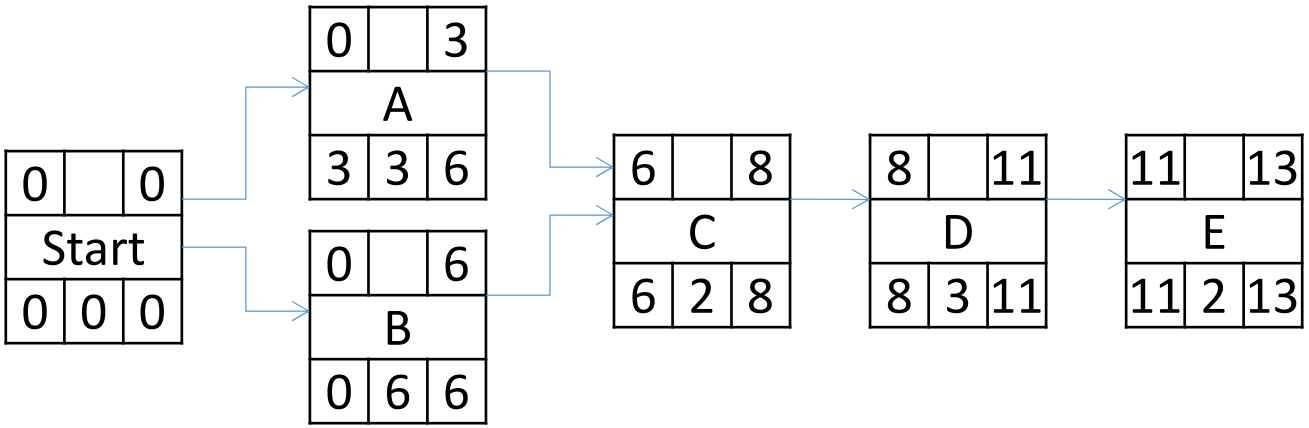
Required ; draw LOB at month 16

Example

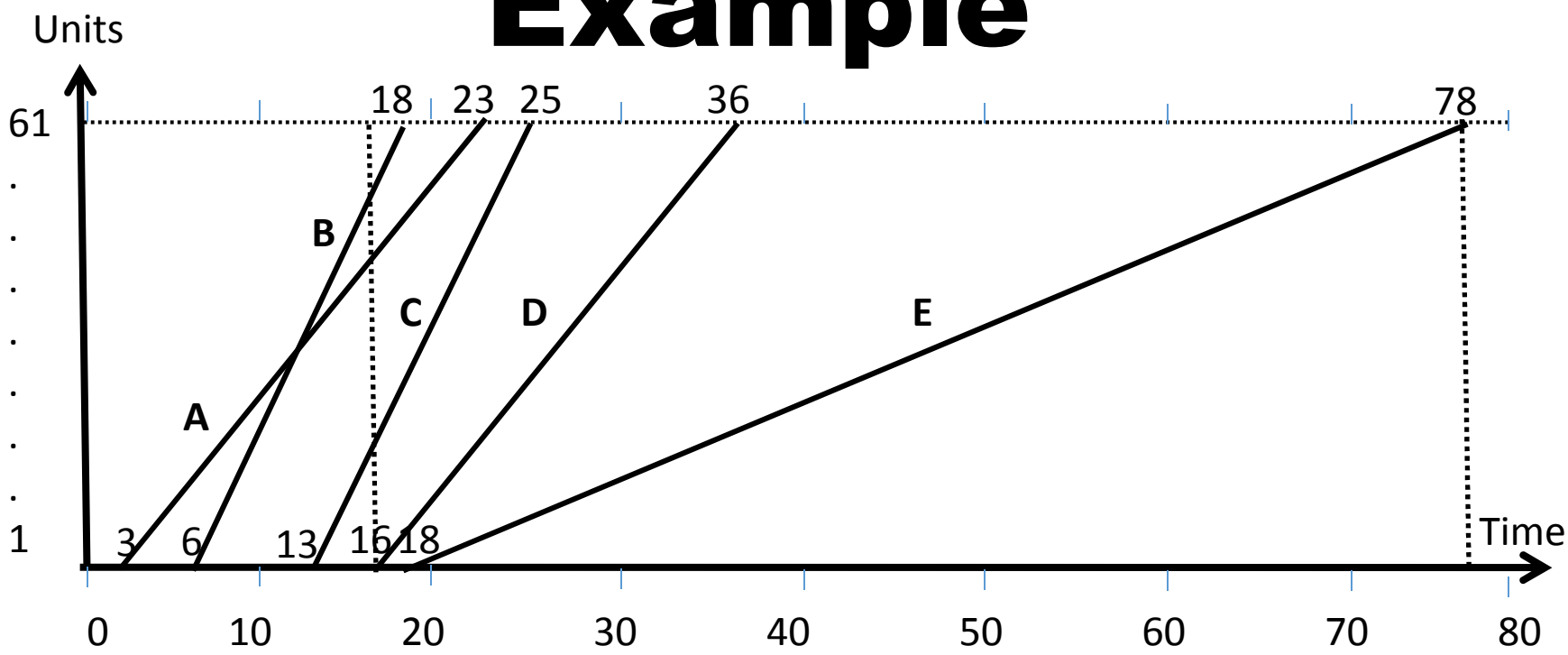
- $R = 1 / (D / C)$
- $D = C/R$

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



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

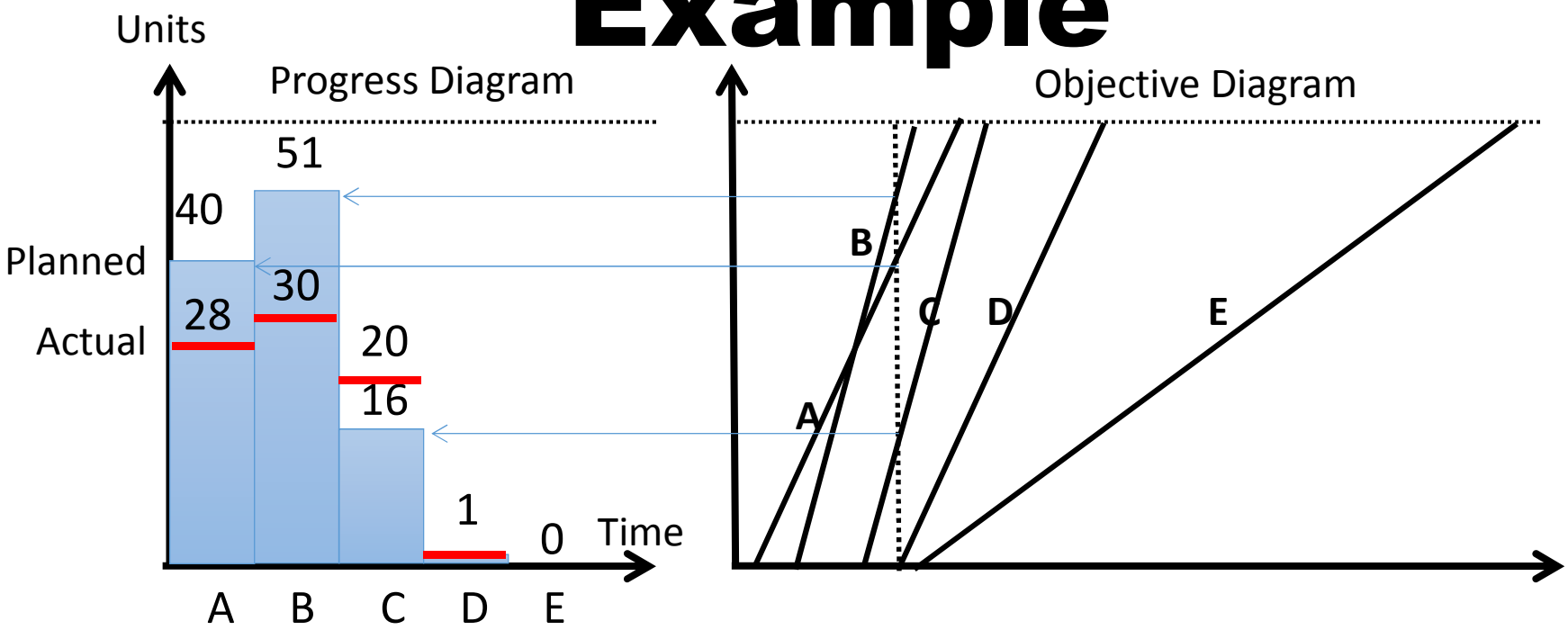
For C: RC=RB>RA, buffer from top

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

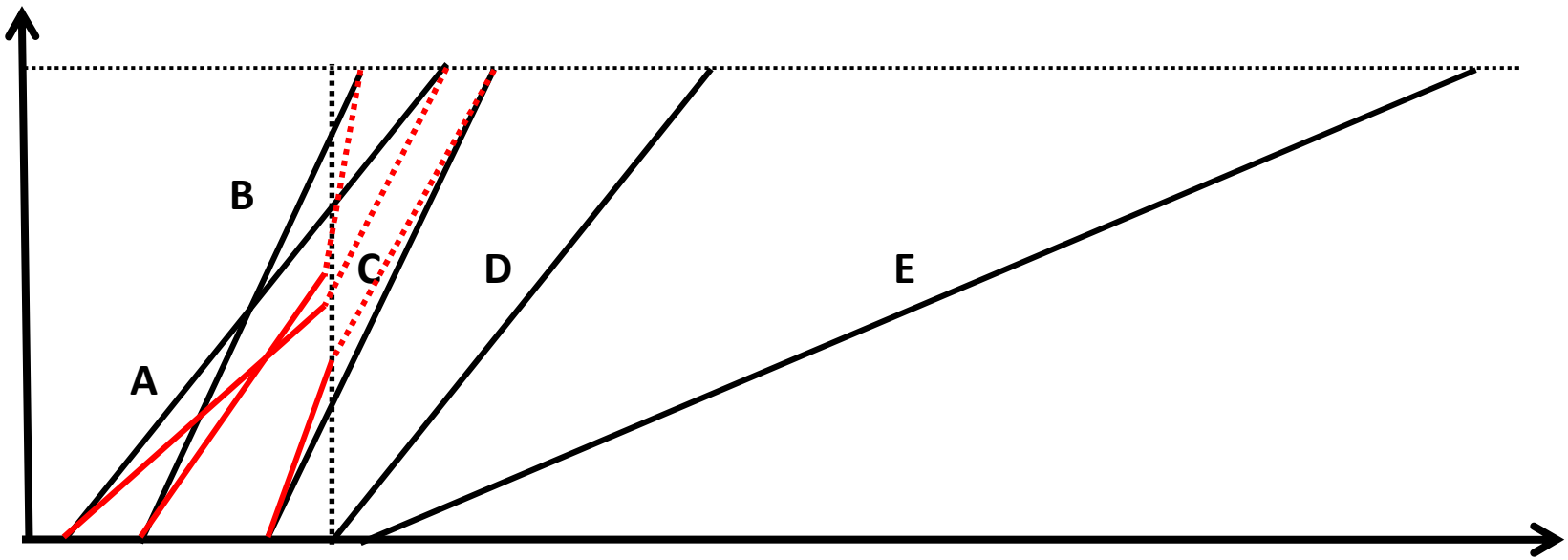
16=3+(x -1)/3, x=40

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

16=13+(x -1)/5, x=16

16=16+(x -1)/3, x=1

Example



Thanks