UNIVERSITY OF WOLLONGONG IN DUBAI

ECTE250

ENGINEERING DESIGN AND MANAGEMENT 2

Winter 2025/ Spring 2025

Project Management IV

Textbook and Readings

Textbook

- Project Management: the Managerial Process, 6th Edition, by Erik W Larson & Clifford F Gray, McGraw Hill
  - Chapter 6

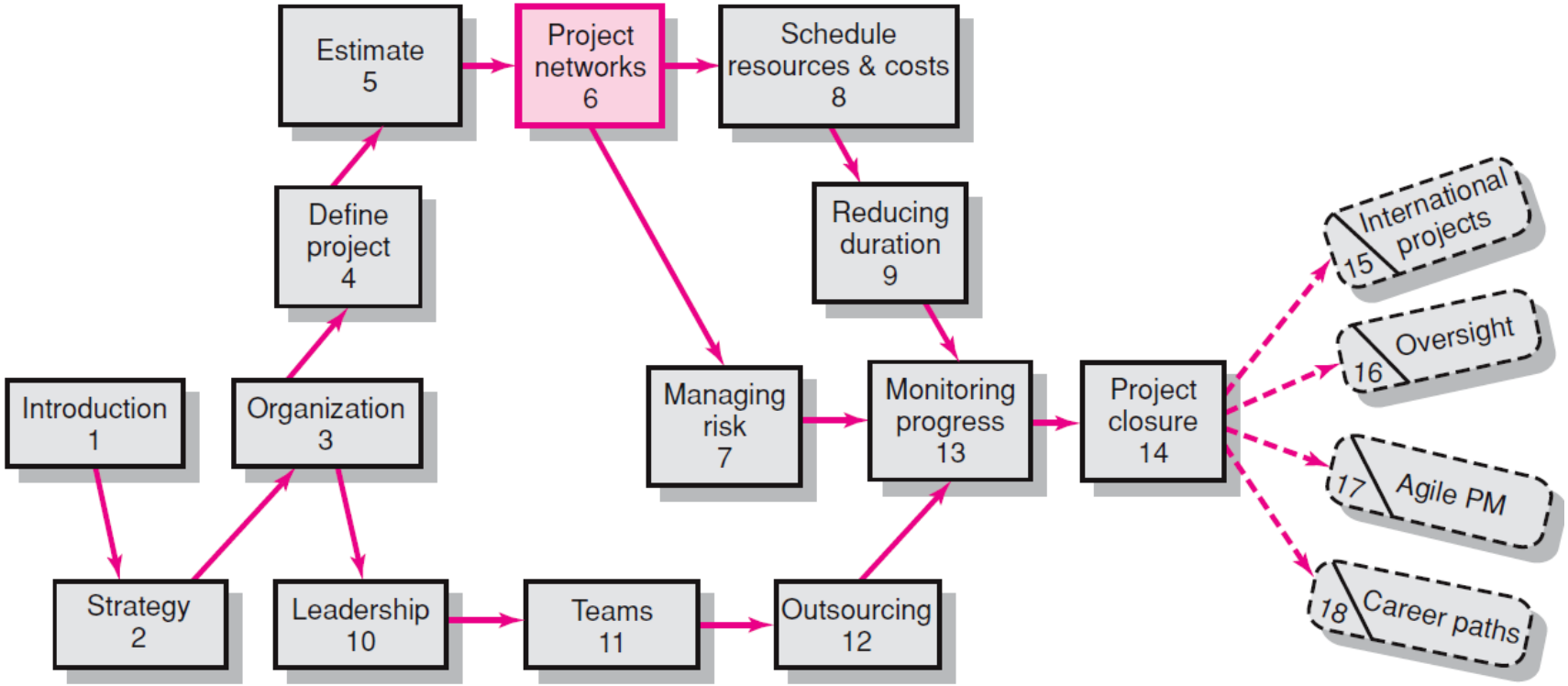
Acknowledgement

- Slides from Project Management: the Managerial Process, by Erik W Larson & Clifford F Gray

Ch. 6

Developing a Project Plan

Where We Are Now



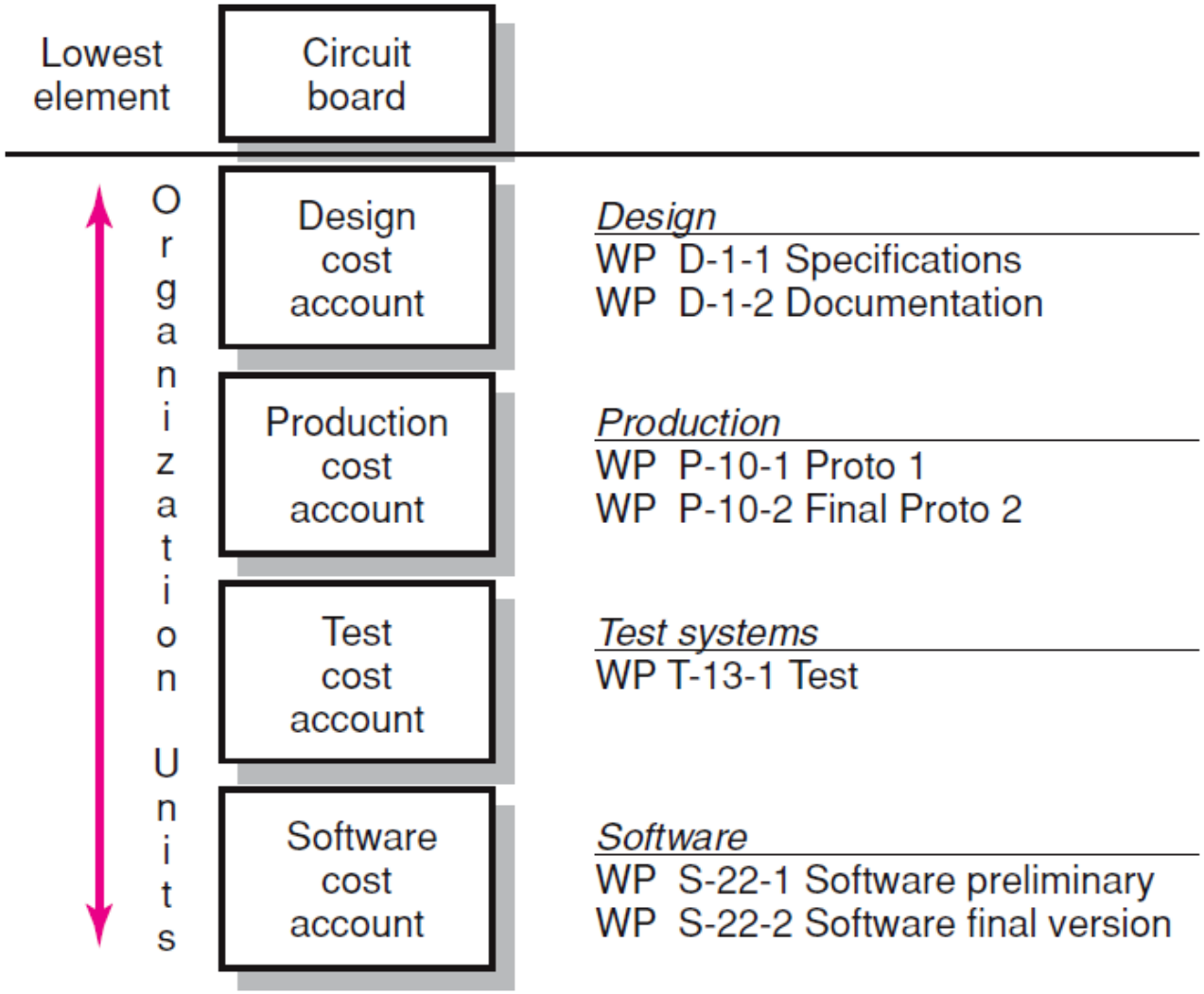
Project Network Diagram (PND)

- Tool used for **planning, scheduling** and **monitoring** the project progress.
  - Allows early corrective feedback
- Developed from WBS
- PND depicts logical sequence and interdependencies of activities.
- Developing a PND cost time (i.e. money) but is worth!
  - It's 75% of the planning process

Developing the Project Plan

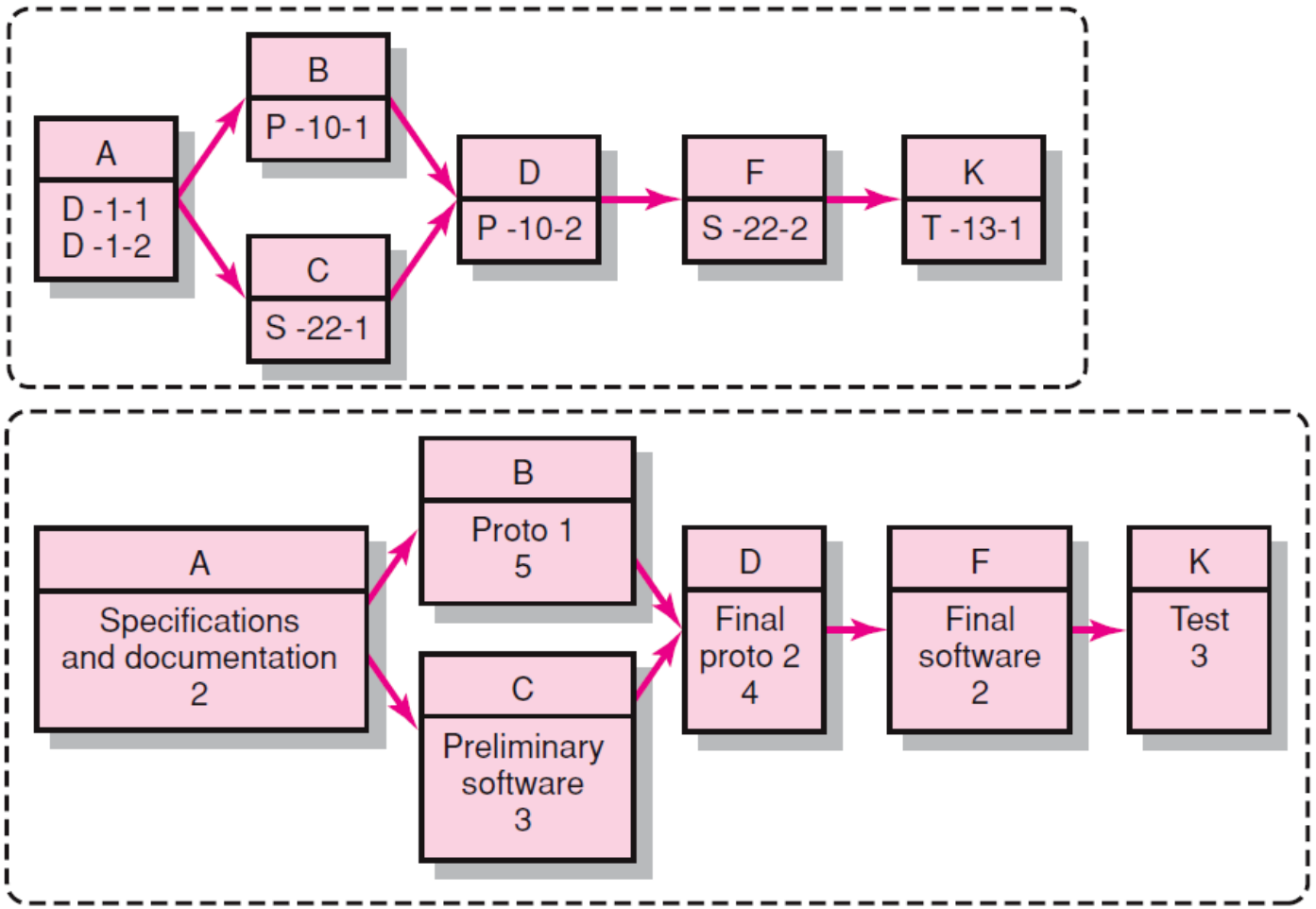
- The Project Network Diagram (PND)
  - A flow chart that graphically depicts the sequence, interdependencies, and start and finish times of the project job plan of activities that is the ***critical path*** through the network.
    - Provides the basis for scheduling labor and equipment.
    - Enhances communication among project participants.
    - Provides an estimate of the project's duration.
    - Provides a basis for budgeting cash flow.
    - Identifies activities that are critical.
    - Highlights activities that are "critical" and can not be delayed.
    - Help managers get and stay on plan.

WBS/Work Packages to Network



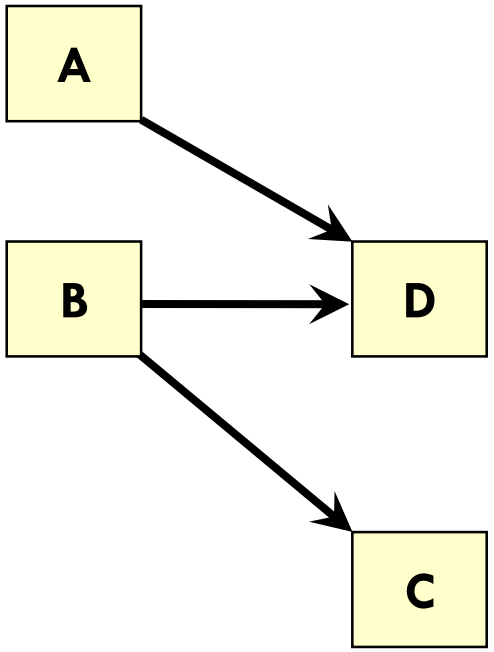
WBS/Work Package to Network (cont'd)

Activity network for circuit board work packages



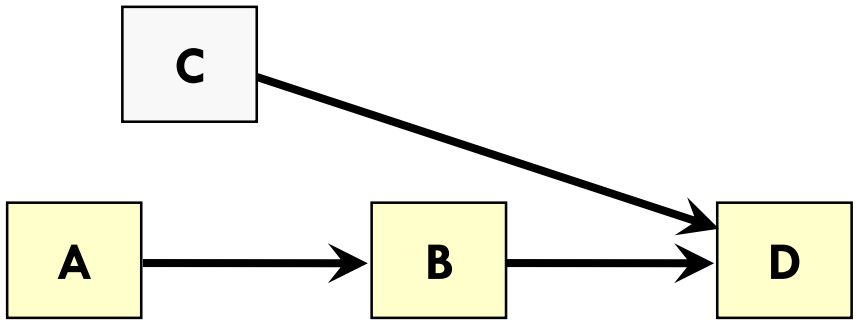
Constructing a Project Network

- Terminology
  - **Activity:** an element of the project that requires time.
  - **Merge Activity:** an activity that has two or more preceding activities on which it depends.
  - **Parallel (Concurrent) Activities:** Activities that can occur independently and, if desired, not at the same time.



Constructing a Project Network (cont'd)

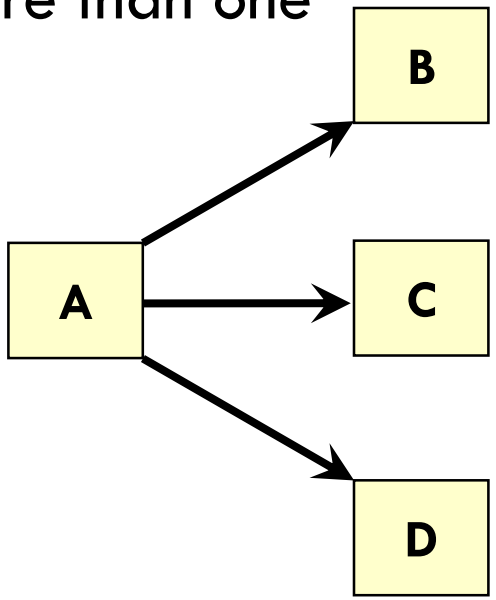
- Terminology
  - **Path:** a sequence of connected, dependent activities.
  - **Critical path:** the longest path through the activity network that allows for the completion of all project-related activities; the shortest expected time in which the entire project can be completed. Delays on the critical path will delay completion of the entire project.



(Assumes that minimum of A + B > minimum of C in length of times to complete activities.)

Constructing a Project Network (cont'd)

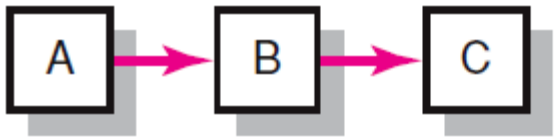
- Terminology
  - **Event:** a point in time when an activity is started or completed. It does not consume time.
  - **Burst Activity:** an activity that has more than one activity immediately following it (more than one dependency arrow flowing from it).
- Two Approaches
  - Activity-on-Node (AON)
    - Uses a node to depict an activity.
  - Activity-on-Arrow (AOA)
    - Uses an arrow to depict an activity.



Basic Rules to Follow in Developing Project Networks

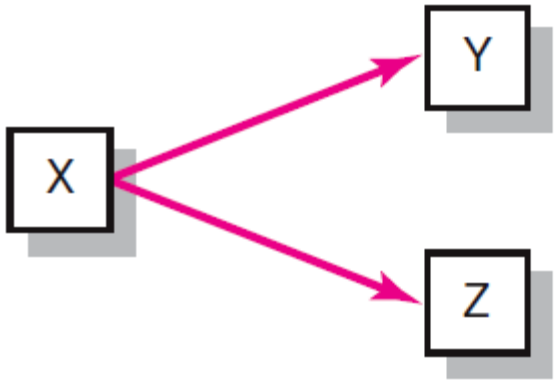
1. Networks typically flow from left to right.
2. An activity cannot begin until all preceding connected activities are complete.
3. Arrows indicate precedence and flow and can cross over each other.
4. Each activity must have a unique identify number that is greater than any of its predecessor activities.
5. Looping is not allowed.
6. Conditional statements are not allowed.
7. Use common start and stop nodes.

Activity-on-Node Fundamentals



A is preceded by nothing
B is preceded by A
C is preceded by B

(A)

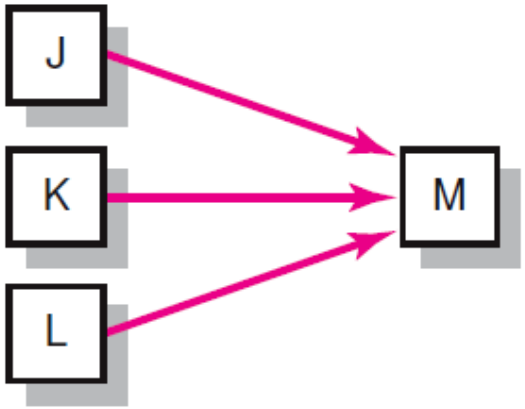


Y and Z are preceded by X

Y and Z can begin at the same time, if you wish

(B) X is a burst activity

Activity-on-Node Fundamentals (cont'd)

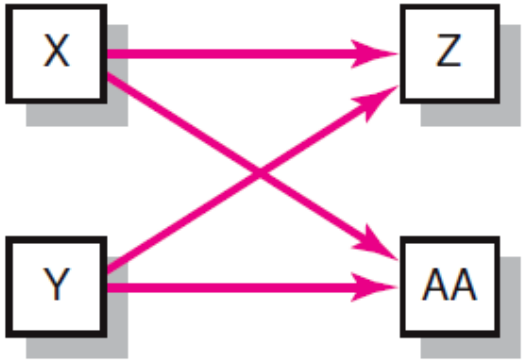


J, K, & L can all begin at the same time, if you wish (they need not occur simultaneously)

but

All (J, K, L) must be completed before M can begin

(C) M is a merge activity



Z is preceded by X and Y

AA is preceded by X and Y

(D)

PND Starting Point

- For each activity (WP):
  - Which activity must be completed immediately before (predecessor activity)?
  - Which activity must immediately follow (successor activity)?
  - Which activity can occur concurrently (in parallel)? *This may not be clear at the beginning*

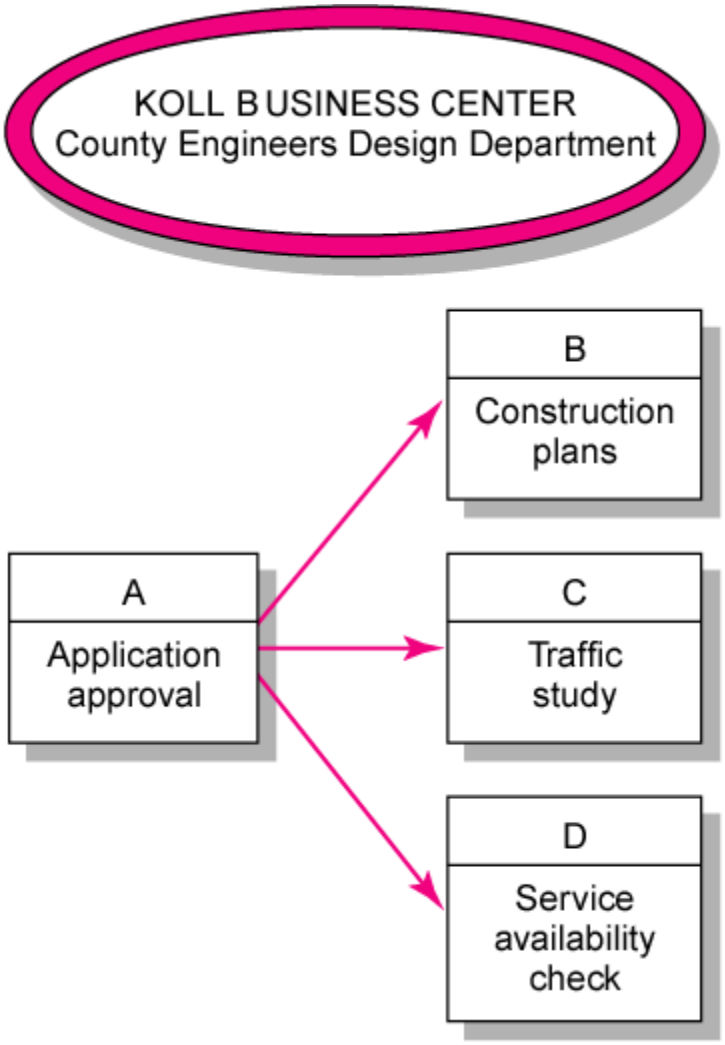
Remember, WP were defined independently of other work packages

Network Information

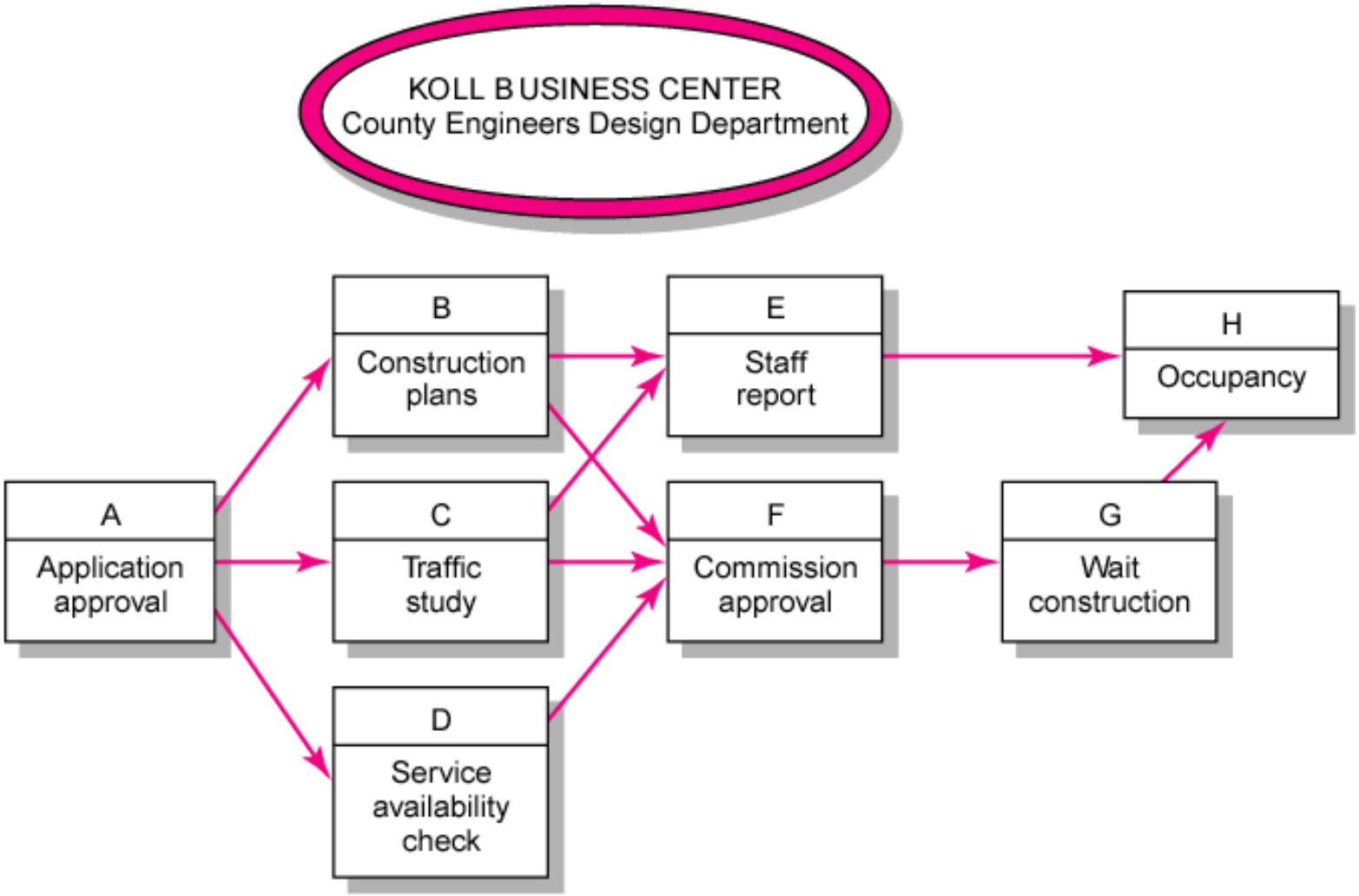
KOLL BUSINESS CENTER
County Engineers Design Department

Activity	Description	Preceding Activity
A	Application approval	None
B	Construction plans	A
C	Traffic study	A
D	Service availability check	A
E	Staff report	B, C
F	Commission approval	B, C, D
G	Wait for construction	F
H	Occupancy	E, G

Koll Business Center—Partial Network



Koll Business Center—Complete Network



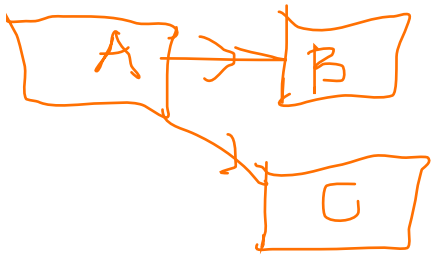
Network Computation Process

- Forward Pass—Earliest Times
  - How soon can the activity start? (early start—ES)
  - How soon can the activity finish? (early finish—EF)
  - How soon can the project finish? (expected time—ET)
- Backward Pass—Latest Times
  - How late can the activity start? (late start—LS)
  - How late can the activity finish? (late finish—LF)
  - Which activities represent the critical path?
  - How long can activity be delayed? (slack or float—SL)

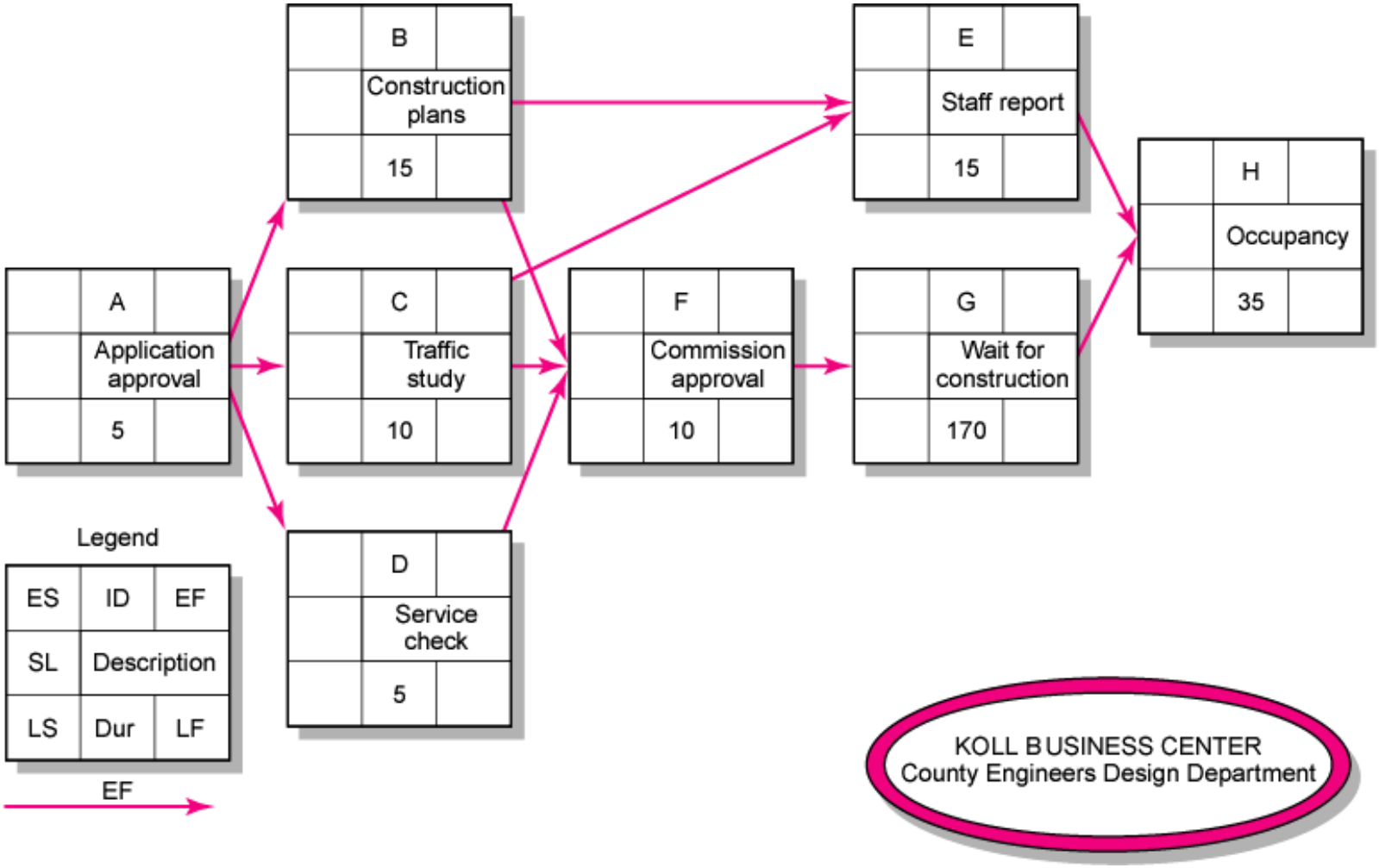
Network Information

KOLL BUSINESS CENTER
County Engineers Design Department

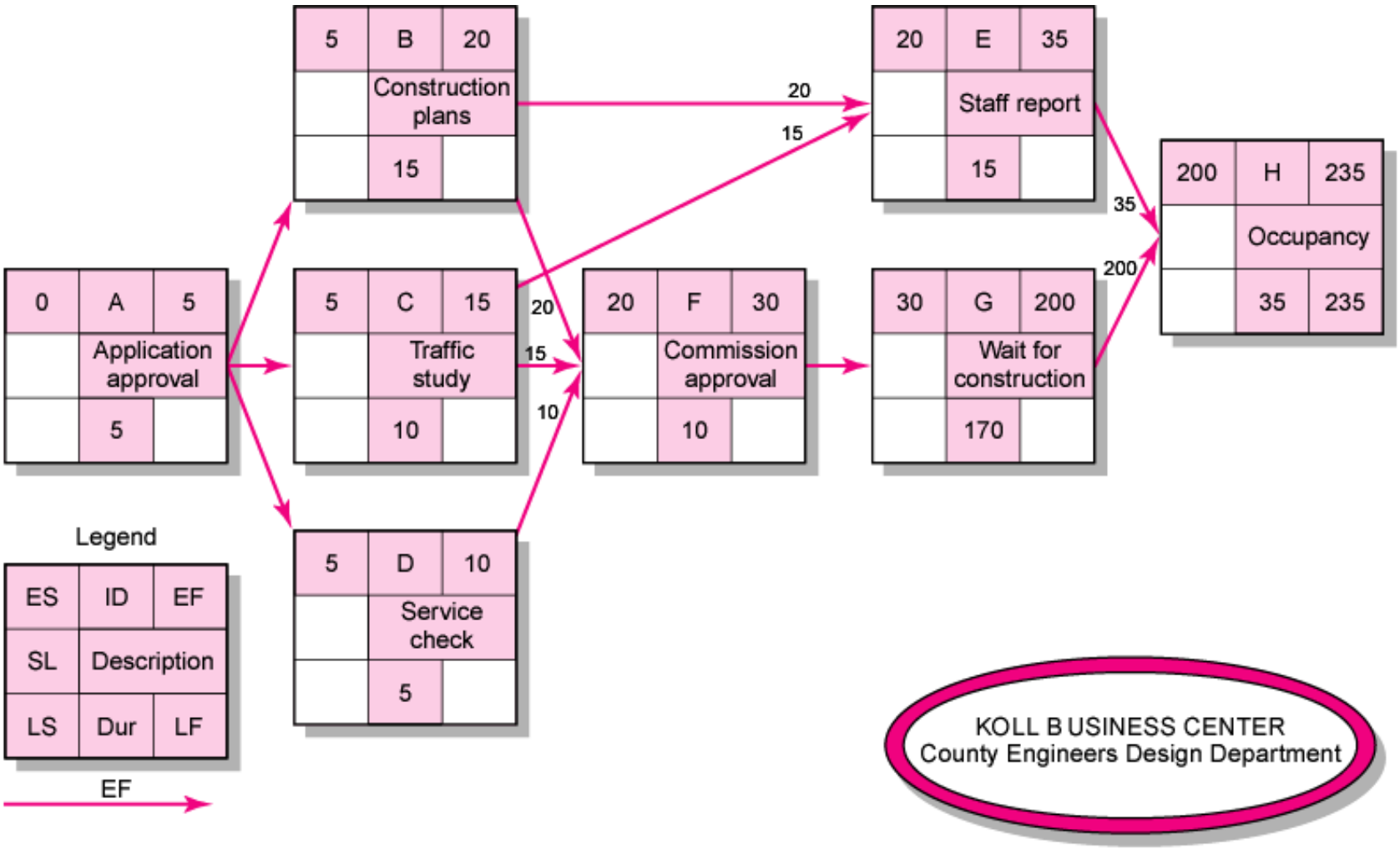
Activity	Description	Preceding Activity	Activity Time
A	Application approval	None	5
B	Construction plans	A	15
C	Traffic study	A	10
D	Service availability check	A	5
E	Staff report	B, C	15
F	Commission approval	B, C, D	10
G	Wait for construction	F	170
H	Occupancy	E, G	35



Activity-on-Node Network



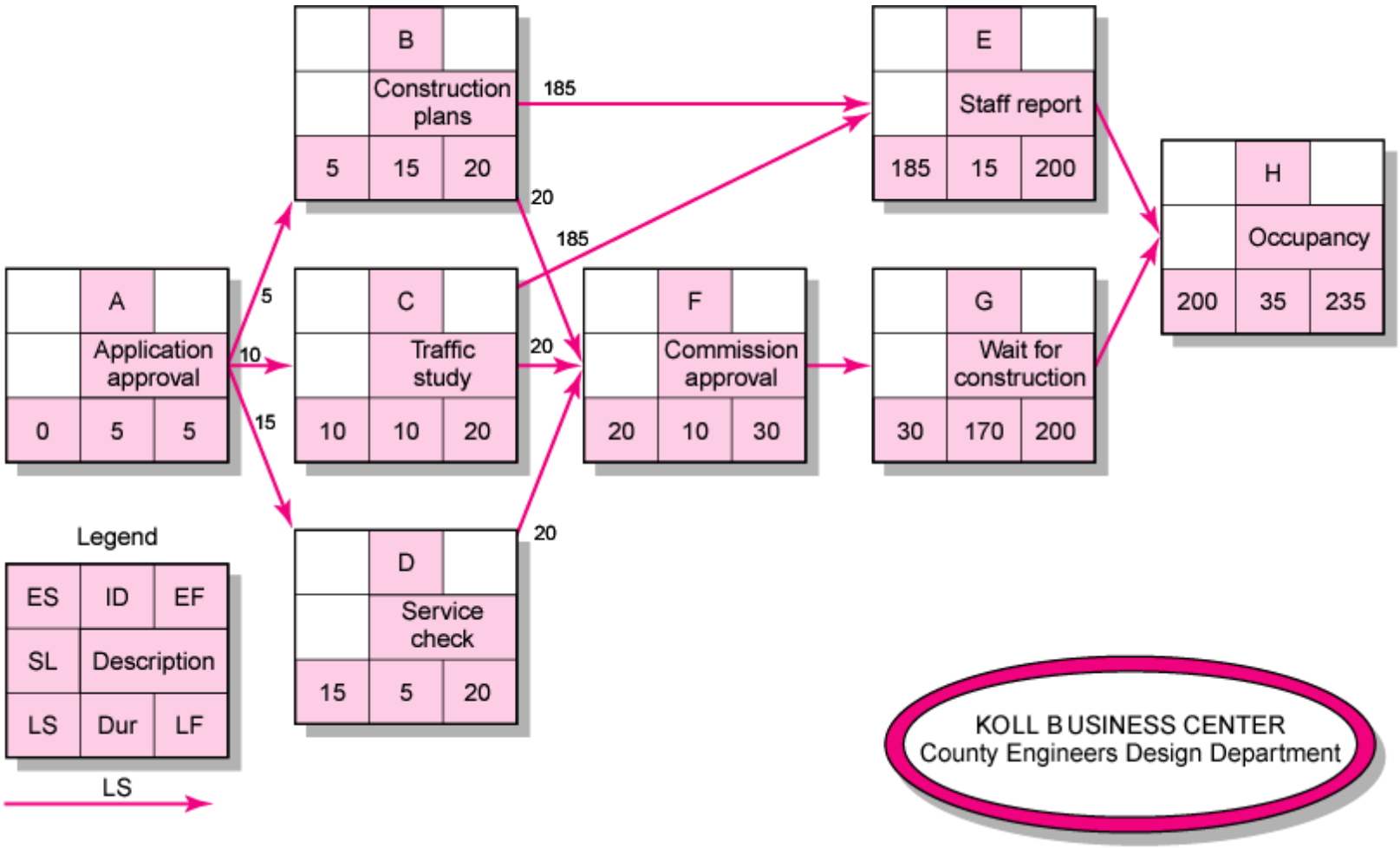
Activity-on-Node Network Forward Pass



Forward Pass Computation

- Add activity times along each path in the network (ES + Duration = EF).
- Carry the early finish (EF) to the next activity where it becomes its early start (ES) ***unless…***
- The next succeeding activity is a merge activity, in which case the largest EF of all preceding activities is selected.

Activity-on-Node Network Backward Pass



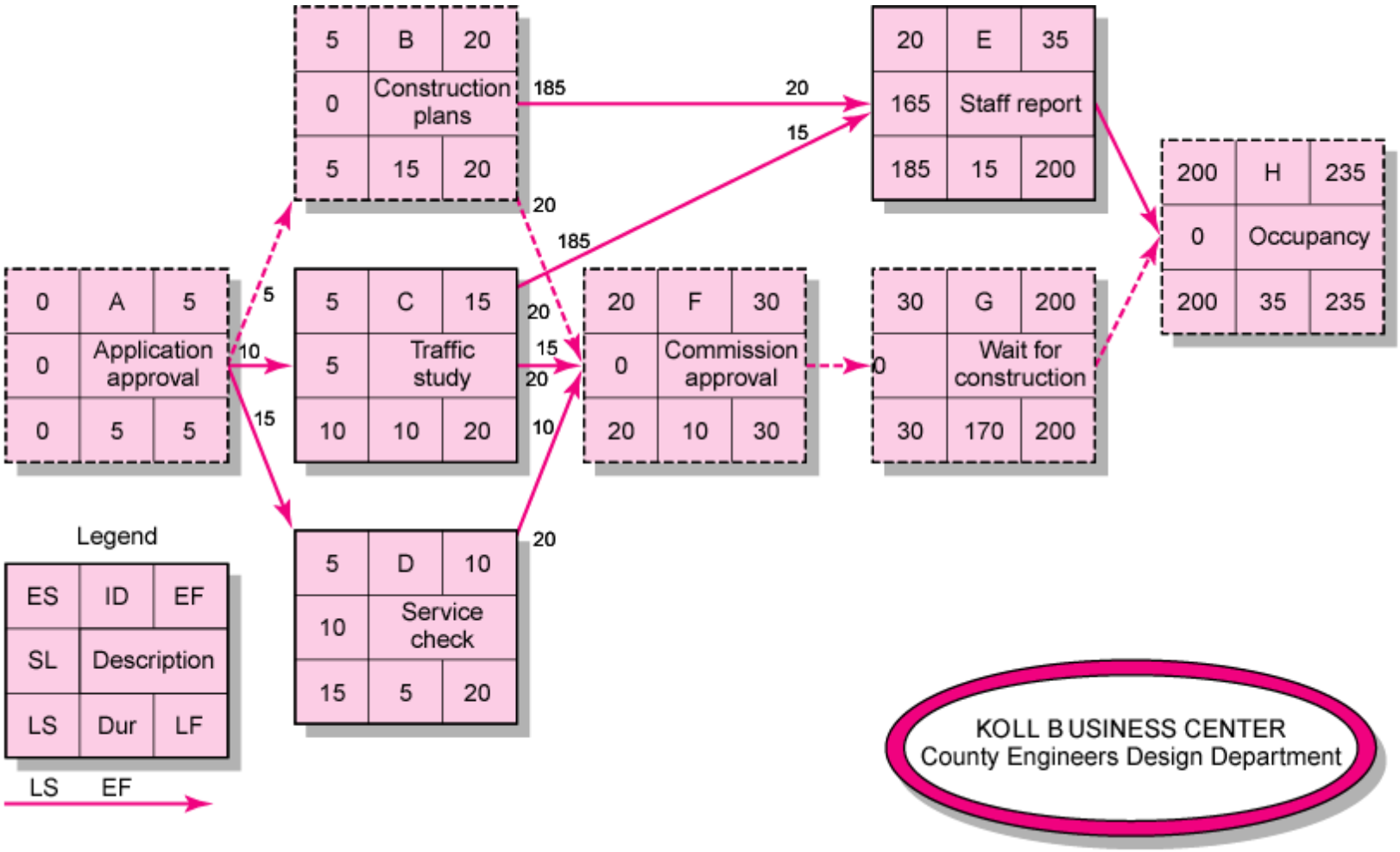
Backward Pass Computation

- Subtract activity times along each path in the network (LF - Duration = LS).
- Carry the late start (LS) to the next activity where it becomes its late finish (LF) ***unless***
- The next succeeding activity is a burst activity, in which case the smallest LF of all preceding activities is selected.

Determining Free Slack (or Float)

- Free Slack (or Float)
  - Is the amount of time an activity can be delayed after the start of a longer parallel activity or activities.
  - Is how long an activity can exceed its early finish date without affecting early start dates of any successor(s).
  - Allows flexibility in scheduling scarce resources.
- Sensitivity
  - The likelihood the original critical path(s) will change once the project is initiated.
  - The critical path is the network path(s) that has (have) the least slack in common.

Activity-on-Node Network with Slack



Slack (SL) = Total Slack (TS) = LS - ES ; or; Total Slack (TS) = LF - EF

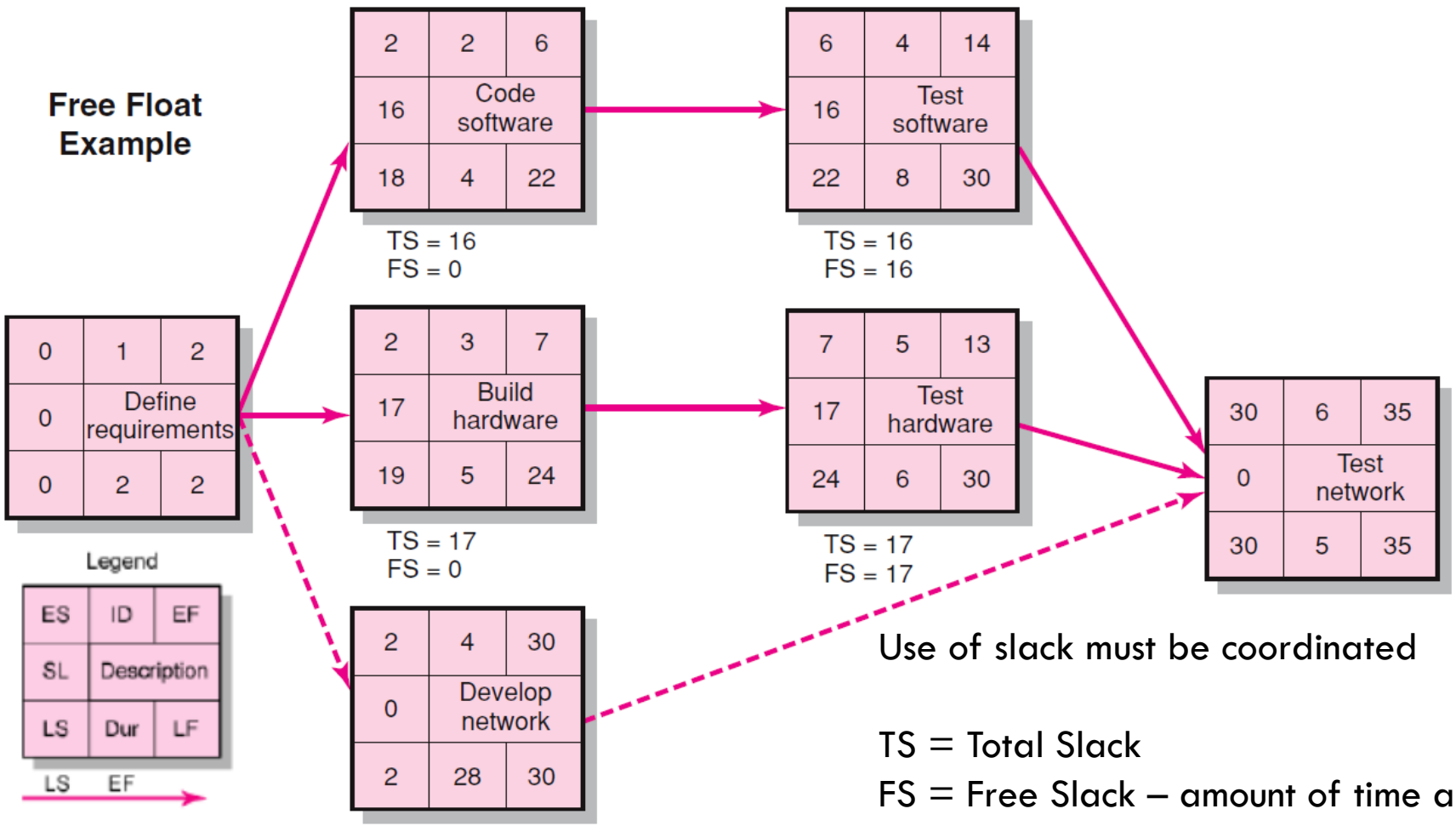
TS is how long is how long an activity can be delayed, without delaying the project completion date. On a critical path, the TS is zero. TS is also known as Slack (SL)

TS is how long is how long an activity can be delayed, without delaying the project completion date. On a critical path, the TS is zero. TS is also known as Slack (SL)

Free Slack Example

Free Slack (FS)= ES of next activity - EF of current activity

Slack (SL) = Total Slack (TS) = LS - ES ; or; Total Slack (TS) = LF - EF



Use of slack must be coordinated

TS = Total Slack

FS = Free Slack – amount of time an activity can exceed its early finish without affecting the early start day of any successor(s)

FS is how long an activity can be delayed without delaying the ES of its successor activity

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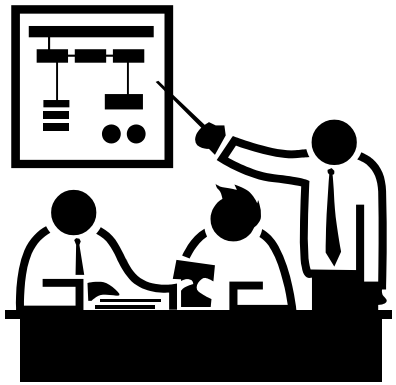
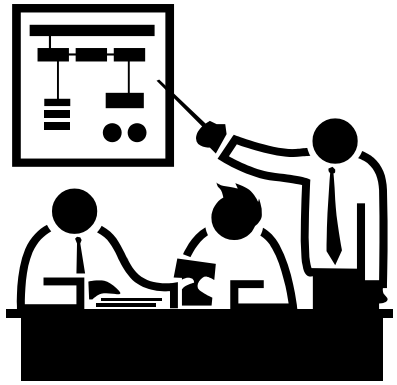
Practical Considerations

- Slack time allows flexibility (important for scarce resources – personnel & equipment used by other parallel resources).
- Tightly manage (or add) resources on critical path (expedite completion)
- Network Logic Errors (no conditional statements, no looping)



Practical Considerations

- Activity Numbering (in ascending order)
- Use of Computers to Develop Networks
  - No errors
  - Gantt Charts
- Use Calendar Dates
- Multiple Starts and Multiple Projects (add a node)



Illogical Loop

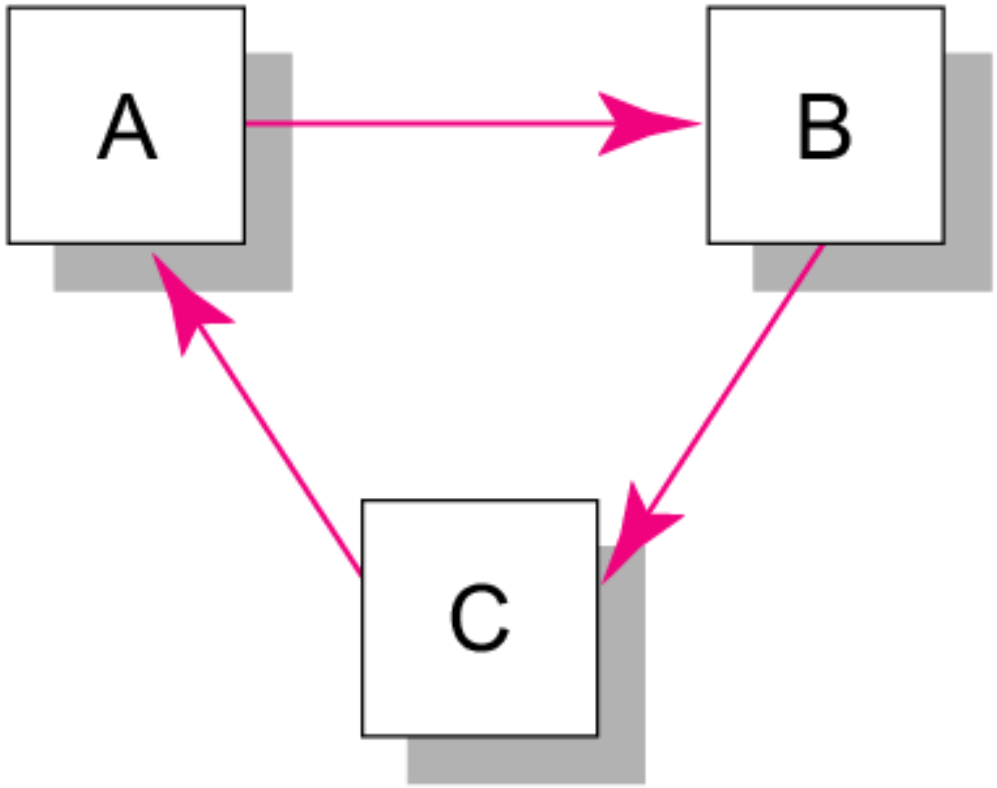


FIGURE 6.10

Air Control Project—Network Diagram

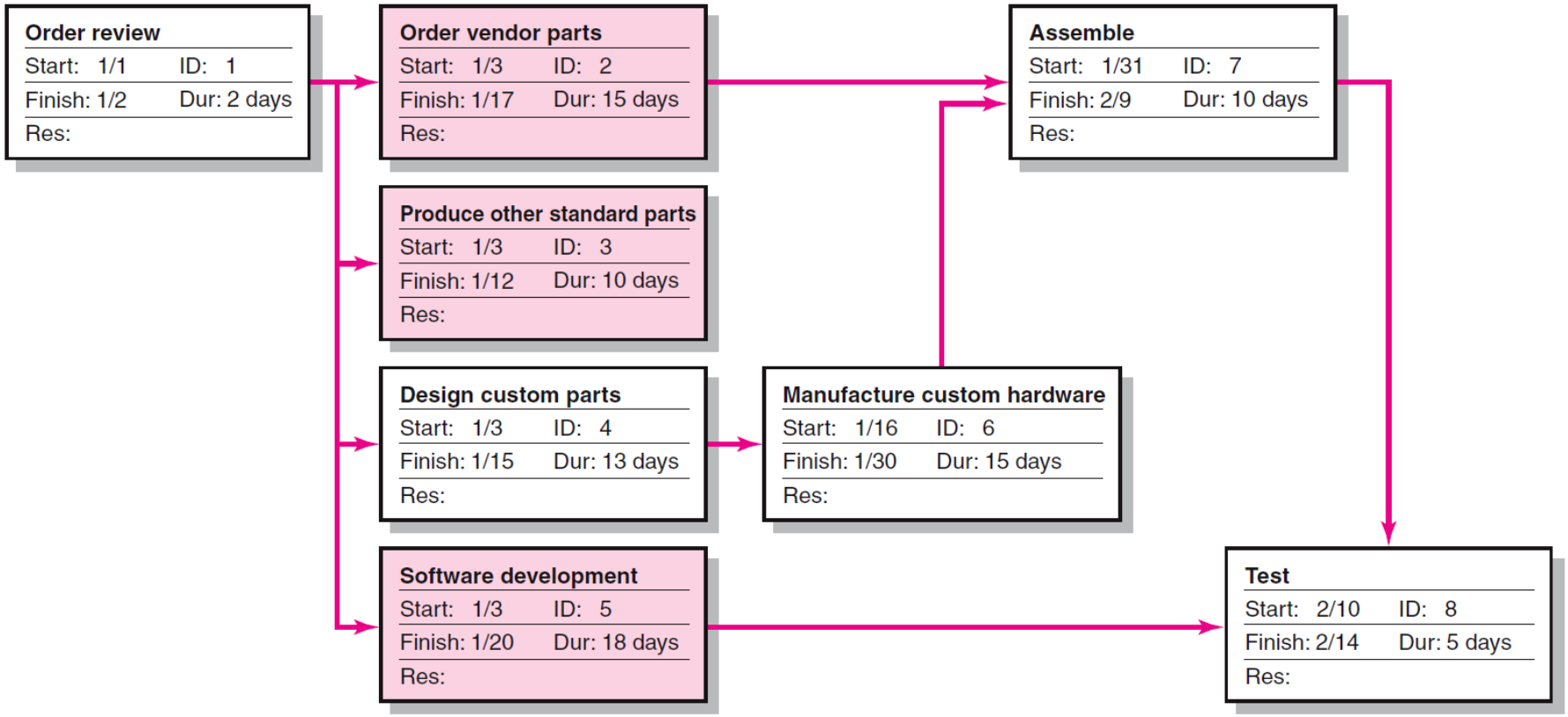
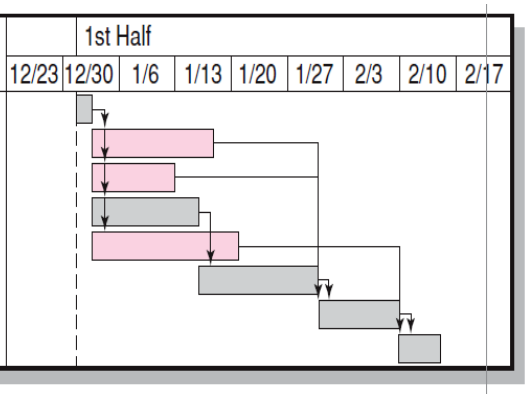


FIGURE 6.11

Air Control Project—Gantt Chart

ID	Duration	Task Name	Start	Finish	Late Start	Late Finish	Free Slack	Total Slack
1	2 days	Order review	Tue 1/1	Wed 1/2	Tue 1/1	Wed 1/2	0 days	0 days
2	15 days	Order vendor parts	Thu 1/3	Thu 1/17	Wed 1/16	Wed 1/30	13 days	13 days
3	10 days	Produce other standard parts	Thu 1/3	Sat 1/12	Mon 1/21	Wed 1/30	18 days	18 days
4	13 days	Design custom parts	Thu 1/3	Tue 1/15	Thu 1/3	Tue 1/15	0 days	0 days
5	18 days	Software development	Thu 1/3	Sun 1/20	Wed 1/23	Sat 2/9	20 days	20 days
6	15 days	Manufacture custom hardware	Wed 1/16	Wed 1/30	Wed 1/16	Wed 1/30	0 days	0 days
7	10 days	Assemble	Thu 1/31	Sat 2/9	Thu 1/31	Sat 2/9	0 days	0 days
8	5 days	Test	Sun 2/10	Thu 2/14	Sun 2/10	Thu 2/14	0 days	0 days

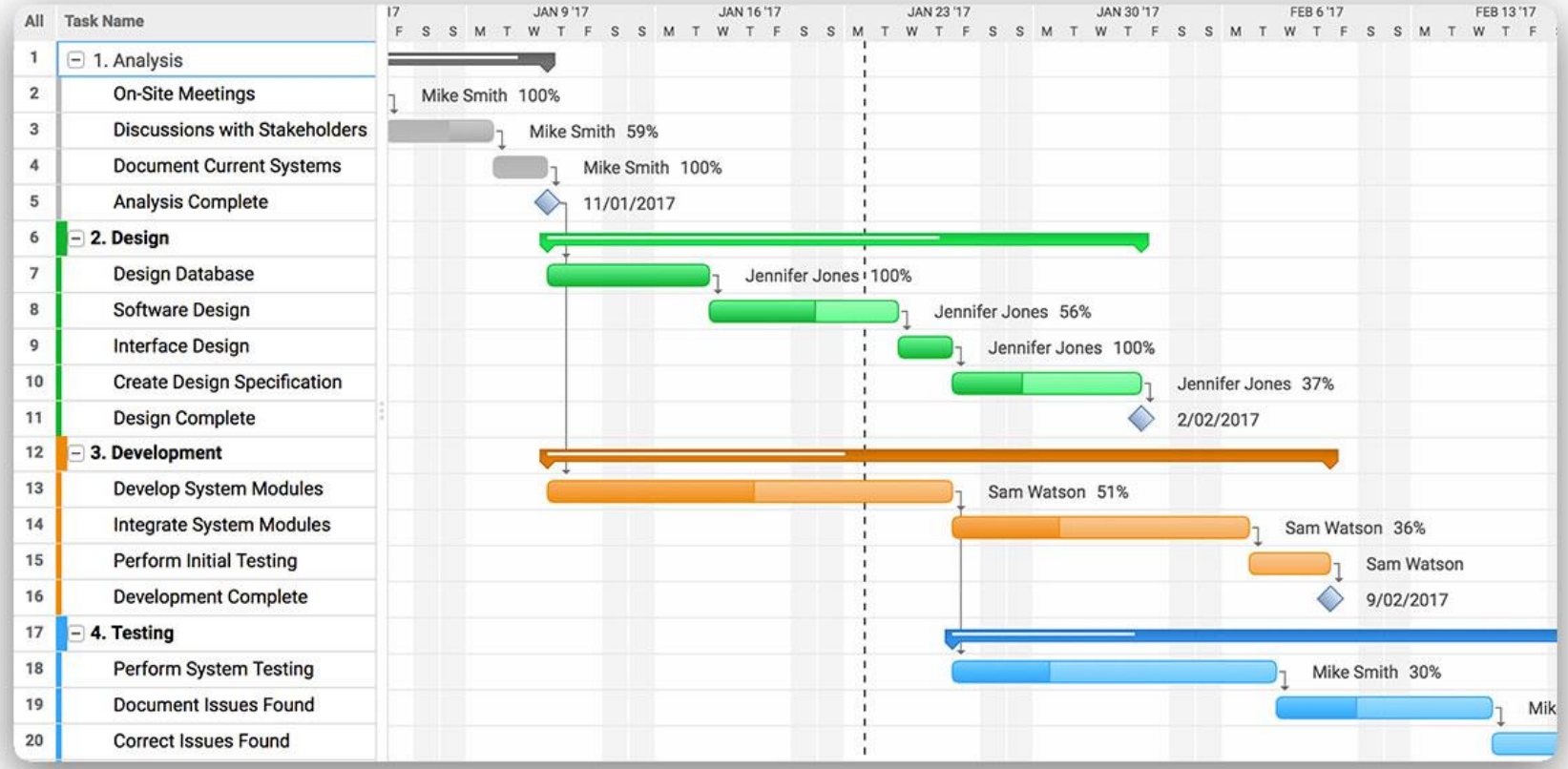


Gantt Chart

- A Gantt chart is a type of bar chart that illustrates a project schedule.
  - This chart lists the tasks to be performed on the vertical axis, and time intervals on the horizontal axis.
  - The width of the horizontal bars in the graph show the duration of each

(source Wikipedia)

Gantt Chart Example



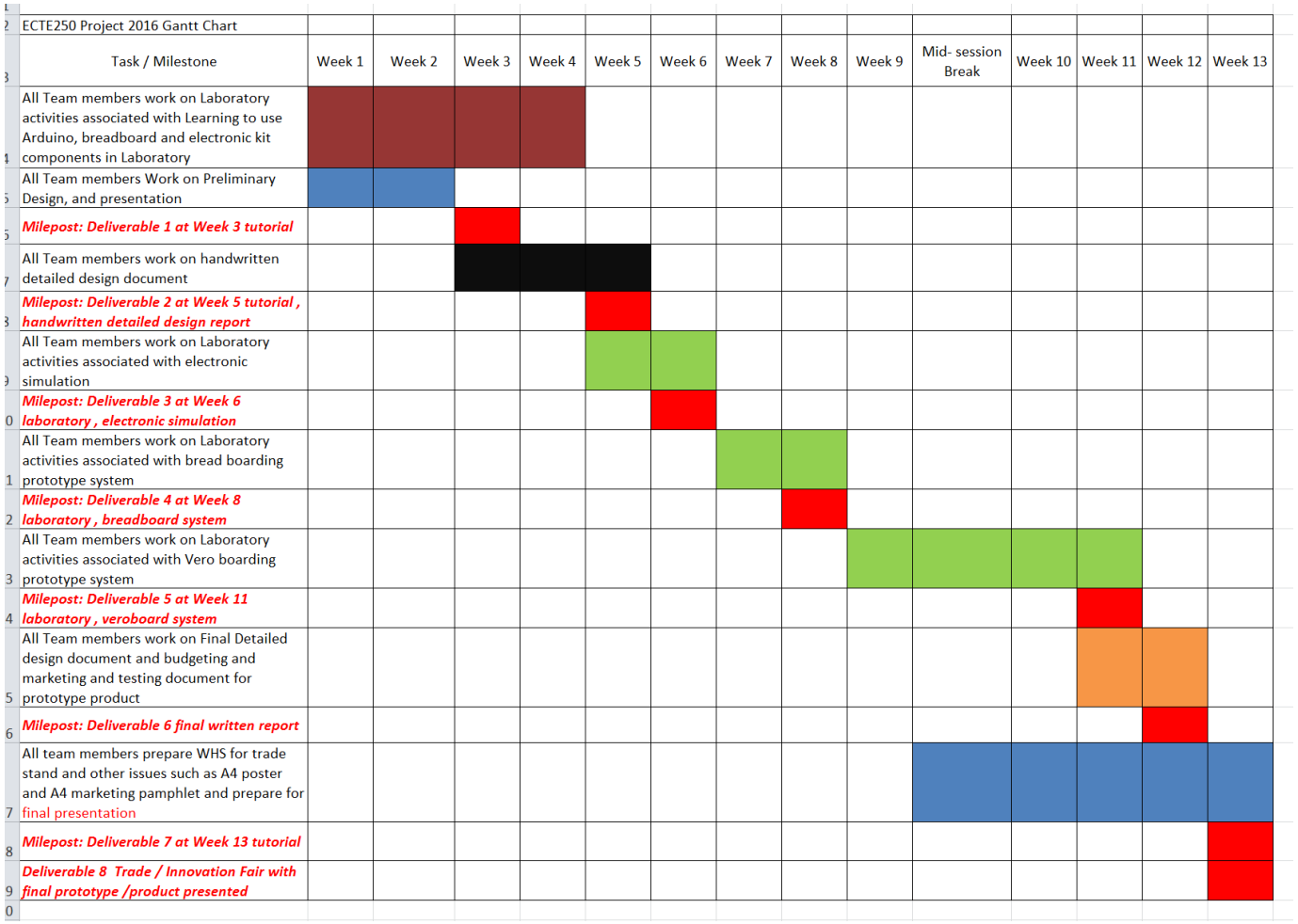
Gantt Chart

- A Gantt chart is created from the PND
- It shows the start and finish date of each task and their relationship to each other.
- A tracking Gantt chart can be used to show progress over time, using a percentage completed for each task and whether ahead or behind against today's date.

Gantt Chart

- A Gantt chart also shows the Critical Path; the longest duration path through the schedule.
- If a task on the Critical Path is delayed by one day, the entire project will be delayed by one day.
- Microsoft Project is the best known tool for creating Gantt charts (you can also use Excel, google docs, etc., but less interactive).

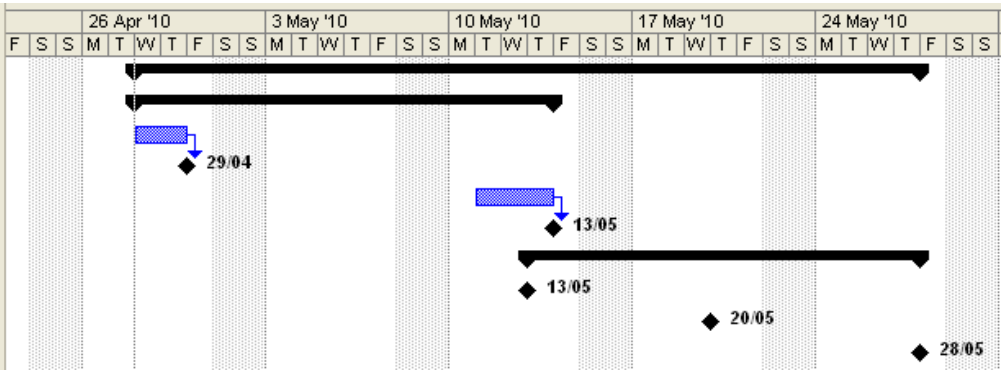
Excel Gantt Chart



ECTE250 Project 2016 Gantt Chart														
Task / Milestone	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Mid- session Break	Week 10	Week 11	Week 12	Week 13
All Team members work on Laboratory activities associated with Learning to use Arduino, breadboard and electronic kit components in Laboratory														
All Team members Work on Preliminary Design, and presentation														
Milepost: Deliverable 1 at Week 3 tutorial														
All Team members work on handwritten detailed design document														
Milepost: Deliverable 2 at Week 5 tutorial , handwritten detailed design report														
All Team members work on Laboratory activities associated with electronic simulation														
Milepost: Deliverable 3 at Week 6 laboratory , electronic simulation														
All Team members work on Laboratory activities associated with bread boarding prototype system														
Milepost: Deliverable 4 at Week 8 laboratory , breadboard system														
All Team members work on Laboratory activities associated with Vero boarding prototype system														
Milepost: Deliverable 5 at Week 11 laboratory , veroboard system														
All Team members work on Final Detailed design document and budgeting and marketing and testing document for prototype product														
Milepost: Deliverable 6 final written report														
All team members prepare WHS for trade stand and other issues such as A4 poster and A4 marketing pamphlet and prepare for final presentation														
Milepost: Deliverable 7 at Week 13 tutorial														
Deliverable 8 Trade / Innovation Fair with final prototype /product presented														

MS Project Gantt Chart

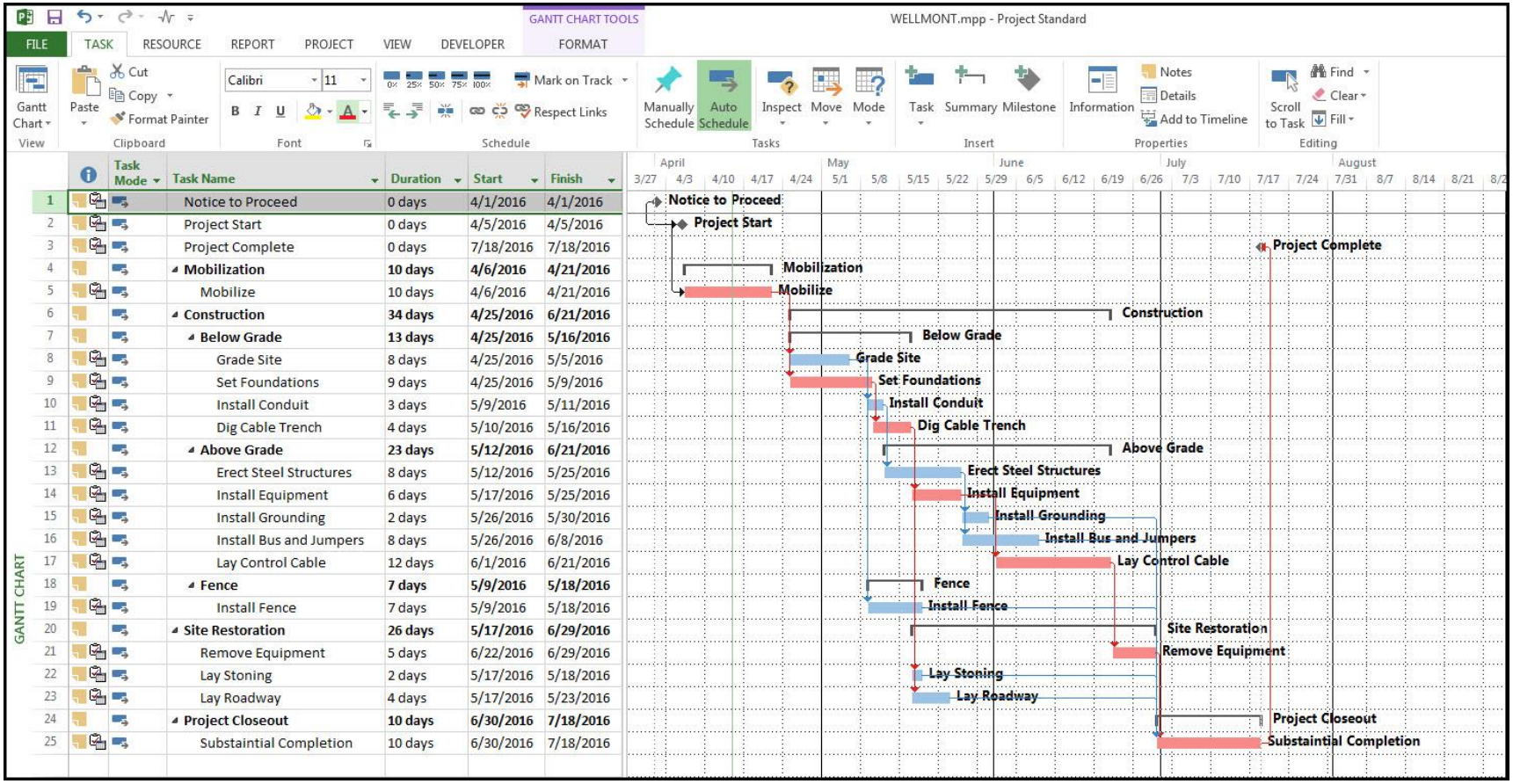
	Task Name	Duration	Start	Finish
1	**Start of Project**	**22 days**	**Wed 28/04/10**	**Fri 28/05/1**
2	**Non-Project Events**	**12 days**	**Wed 28/04/10**	**Thu 13/05/1**
3	ECTE202 Lab Report	2 days	Wed 28/04/10	Thu 29/04/1
4	ECTE202 Lab Report due	0 days	Thu 29/04/10	Thu 29/04/1
5	Exam Preperation	3 days	Tue 11/05/10	Thu 13/05/1
6	Exam	0 days	Thu 13/05/10	Thu 13/05/1
7	**ECTE250 Project**	**11 days**	**Thu 13/05/10**	**Fri 28/05/1**
8	Deadline for purchasing parts	0 days	Thu 13/05/10	Thu 13/05/1
9	Deliverable 4: Spring Session Report	0 days	Thu 20/05/10	Thu 20/05/1
10	Trade Fair - End of Project	0 days	Fri 28/05/10	Fri 28/05/1



MS Project is available in all UOWD lab computers

https://www.youtube.com/watch?v=J9uctgUaEic

MS Project Gantt Chart



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Gantt Chart… that's your plan!

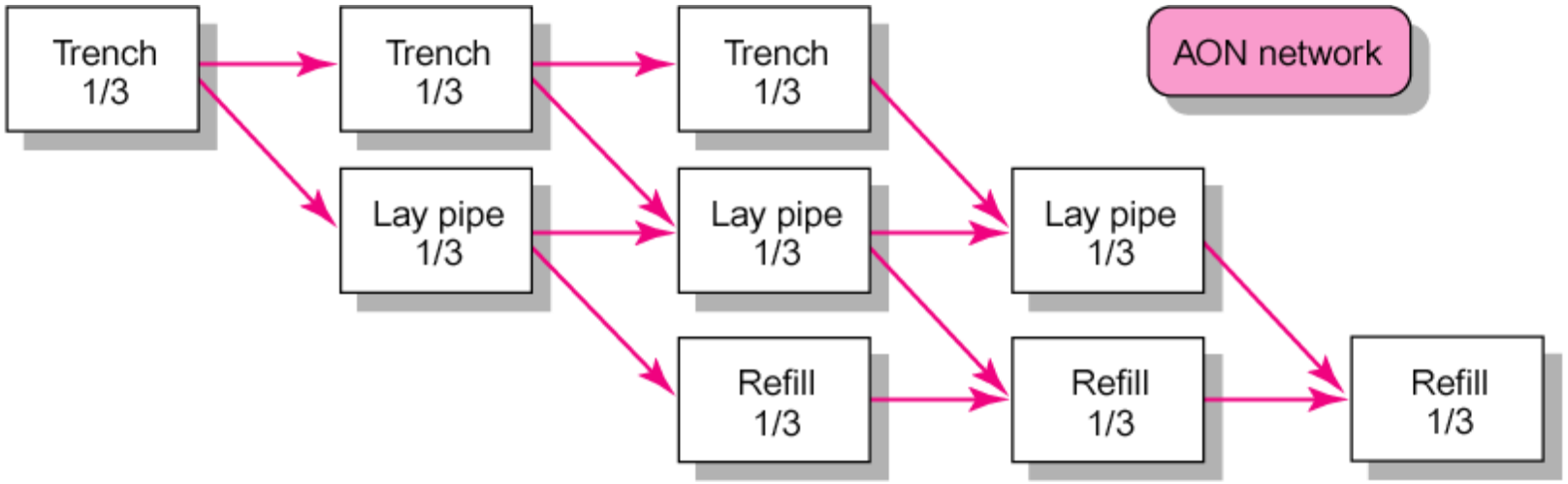
- Your may decide to put names in the final Gantt Chart to identify whose responsible (or use a separate chart for this purpose – create a responsibility chart).

- Also you may choose a more concise way of presenting a Gantt Chart – use tables and headings for tables in Power Point or Word.

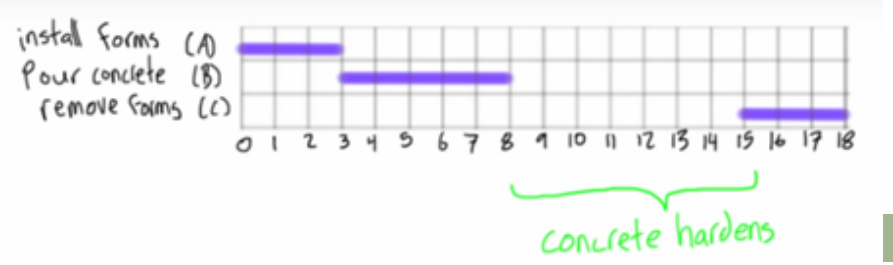
Extended Network Techniques to Come Close to Reality

- Laddering
  - Activities are broken into segments so the following activity can begin sooner and not delay the work.
- Lags
  - The minimum amount of time a dependent activity must be delayed to begin or end.
    - Lengthy activities are broken down to reduce the delay in the start of successor activities.
    - Lags can be used to constrain finish-to-start, start-to-start, finish-to-finish, start-to-finish, or combination relationships.

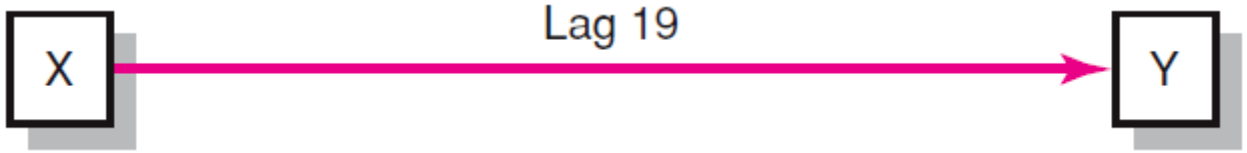
Example of Laddering Using Finish-to-Start Relationship



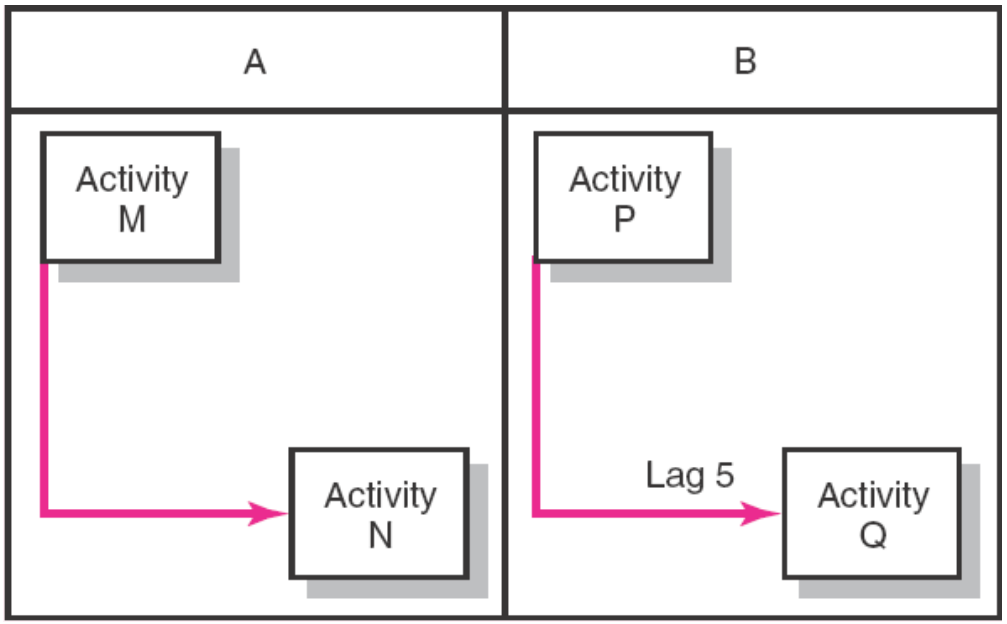
Use of Lags



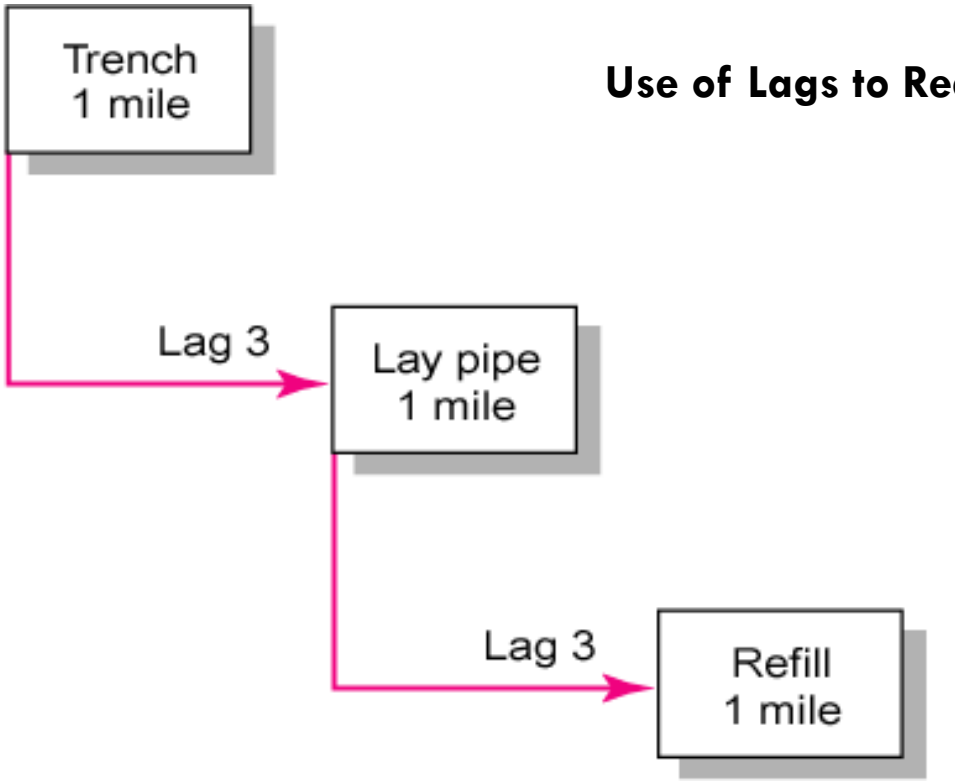
Finish-to-Start Relationship



Start-to-Start Relationship

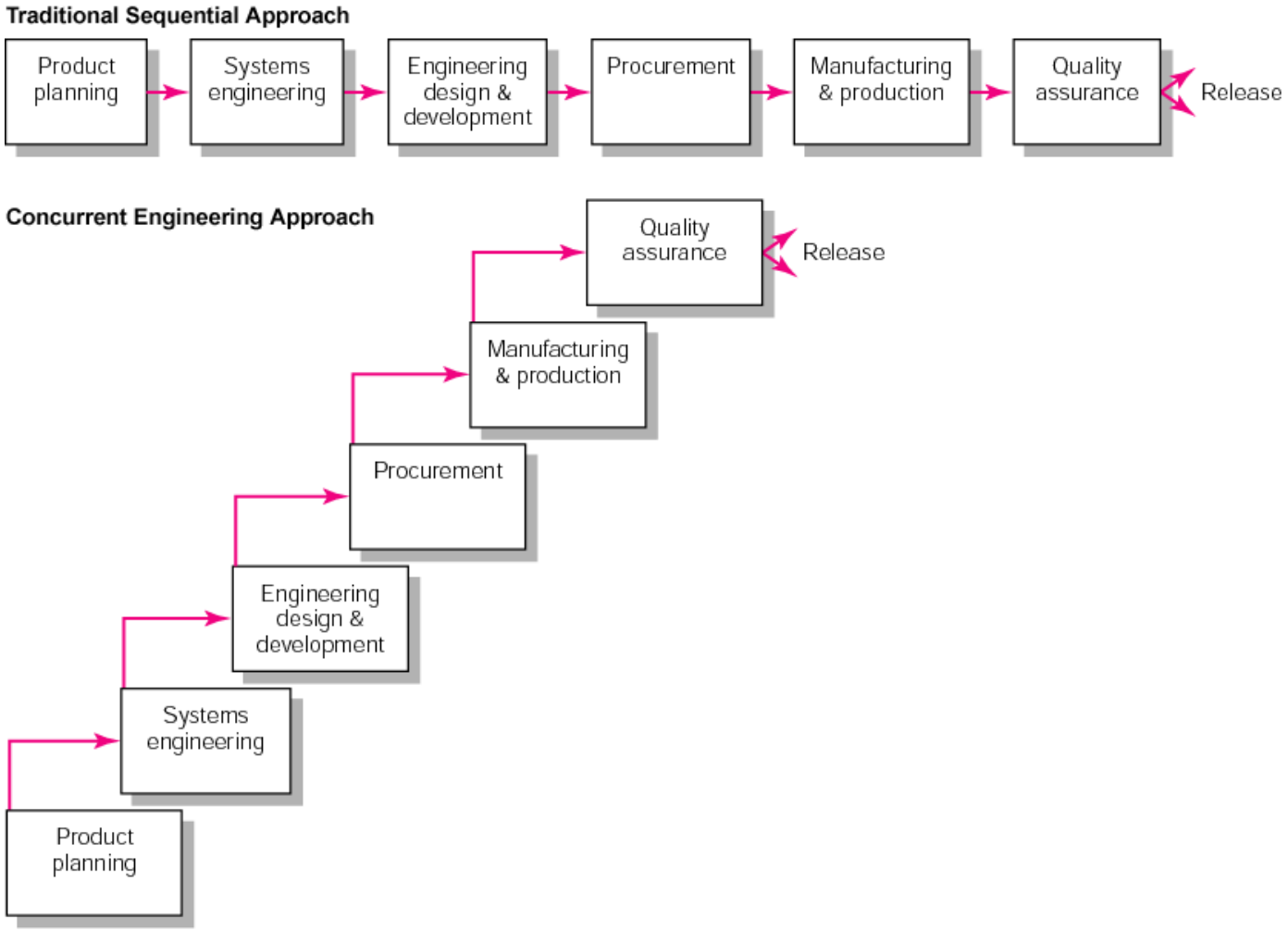


Use of Lags Cont'd

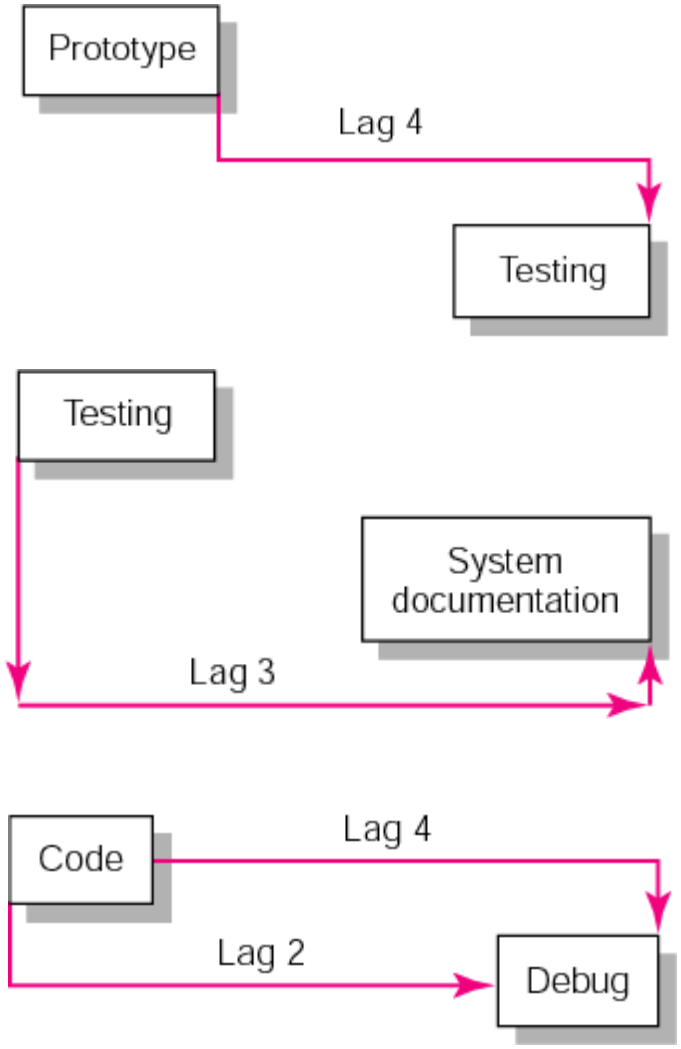


Use of Lags to Reduce Detail

New Product Development Process



Use of Lags (cont'd)

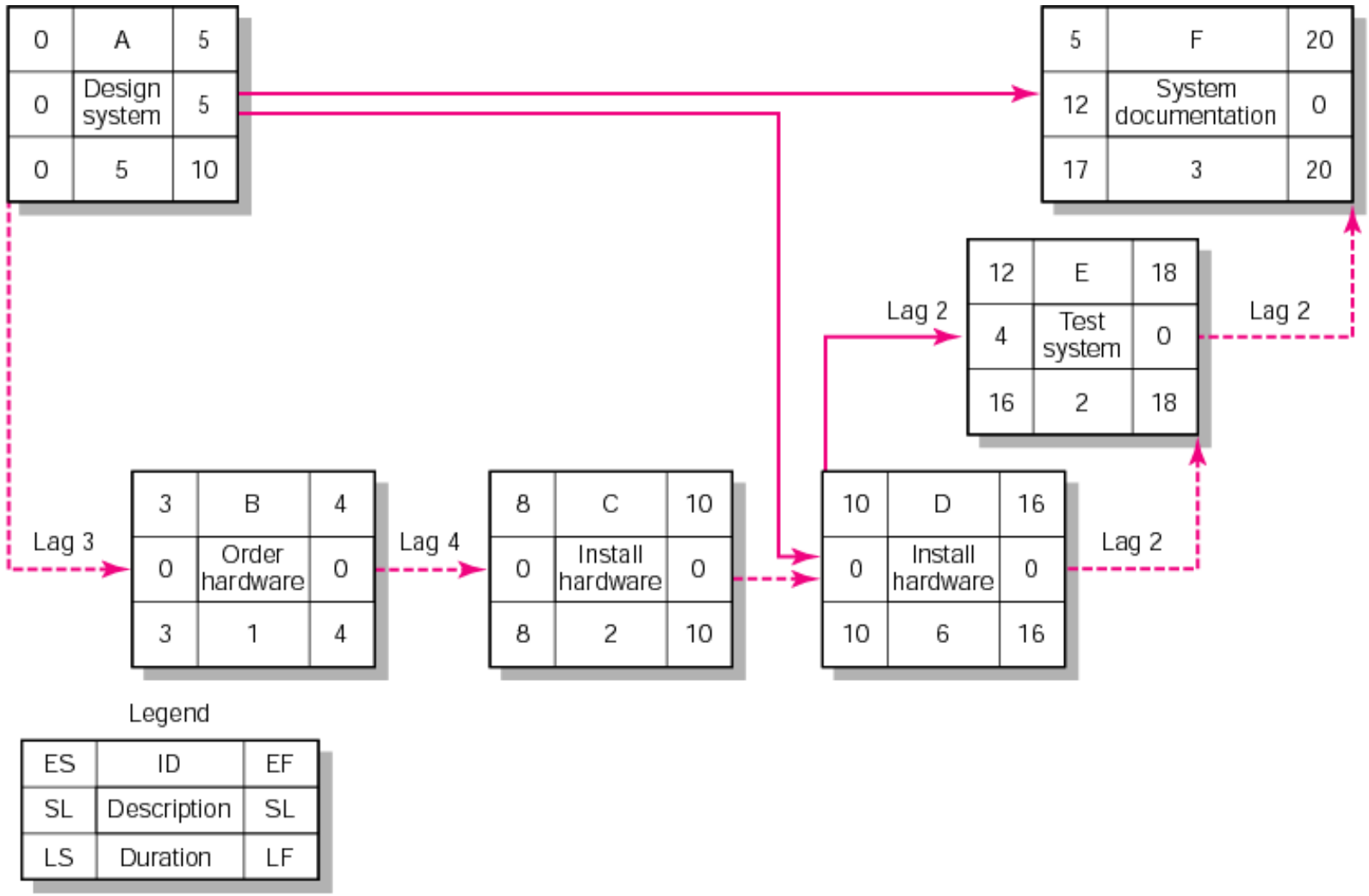


Finish-to-Finish Relationship

Start-to-Finish Relationship

Combination Relationship

Network Using Lags



Key Terms

- Activity
- Activity-on-arrow (AOA)
- Activity-on-node (AON)
- Burst activity
- Concurrent engineering
- Critical path
- Early and late times
- Gantt chart
- Lag relationship
- Merge activity
- Network sensitivity
- Parallel activity
- Slack/float—total and free