Project Management

THE MANAGERIAL PROCESS

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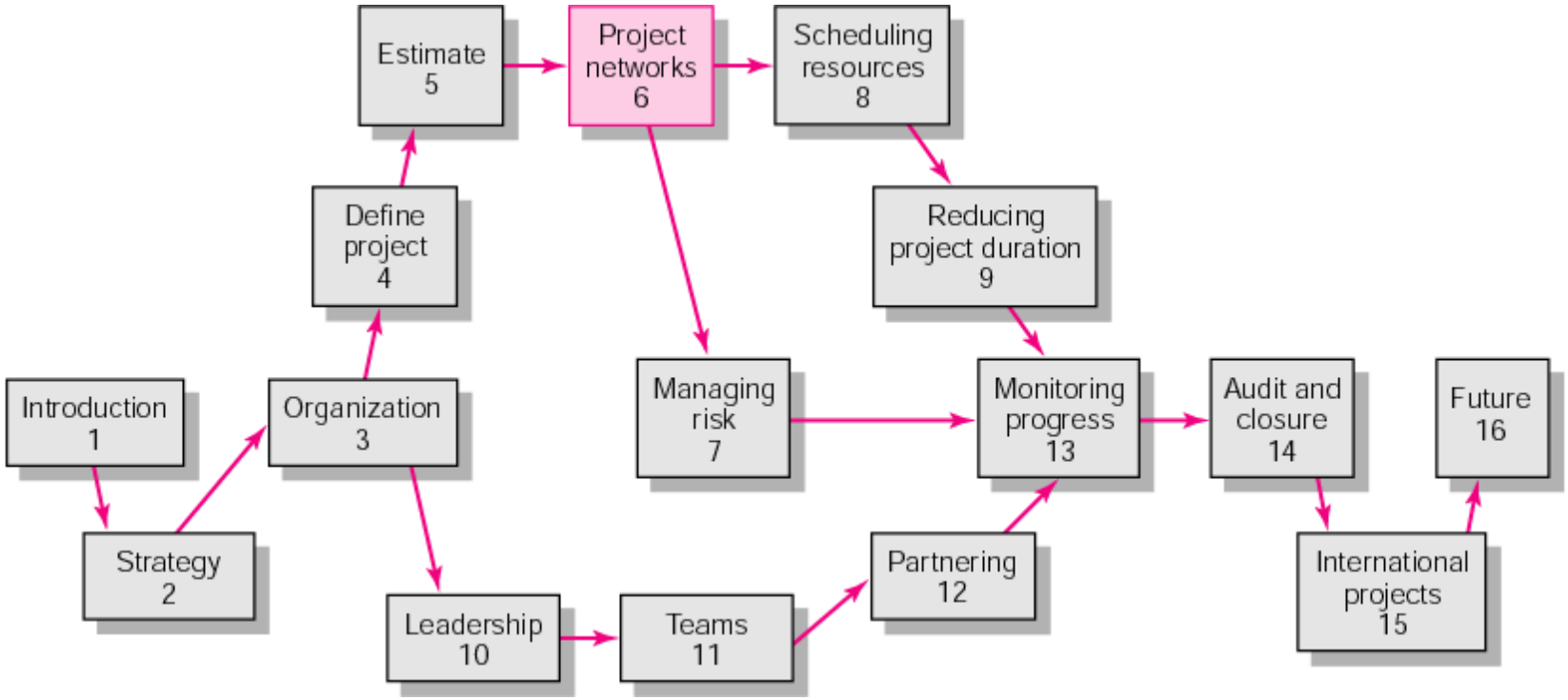
Eric W. Larson
Third Edition

Chapter 6

Developing a Project Plan

PowerPoint Presentation by Charlie Cook



Developing the Project Plan

- The Project Network
  - 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.

From Work Package to Network

WBS/Work Packages to Network

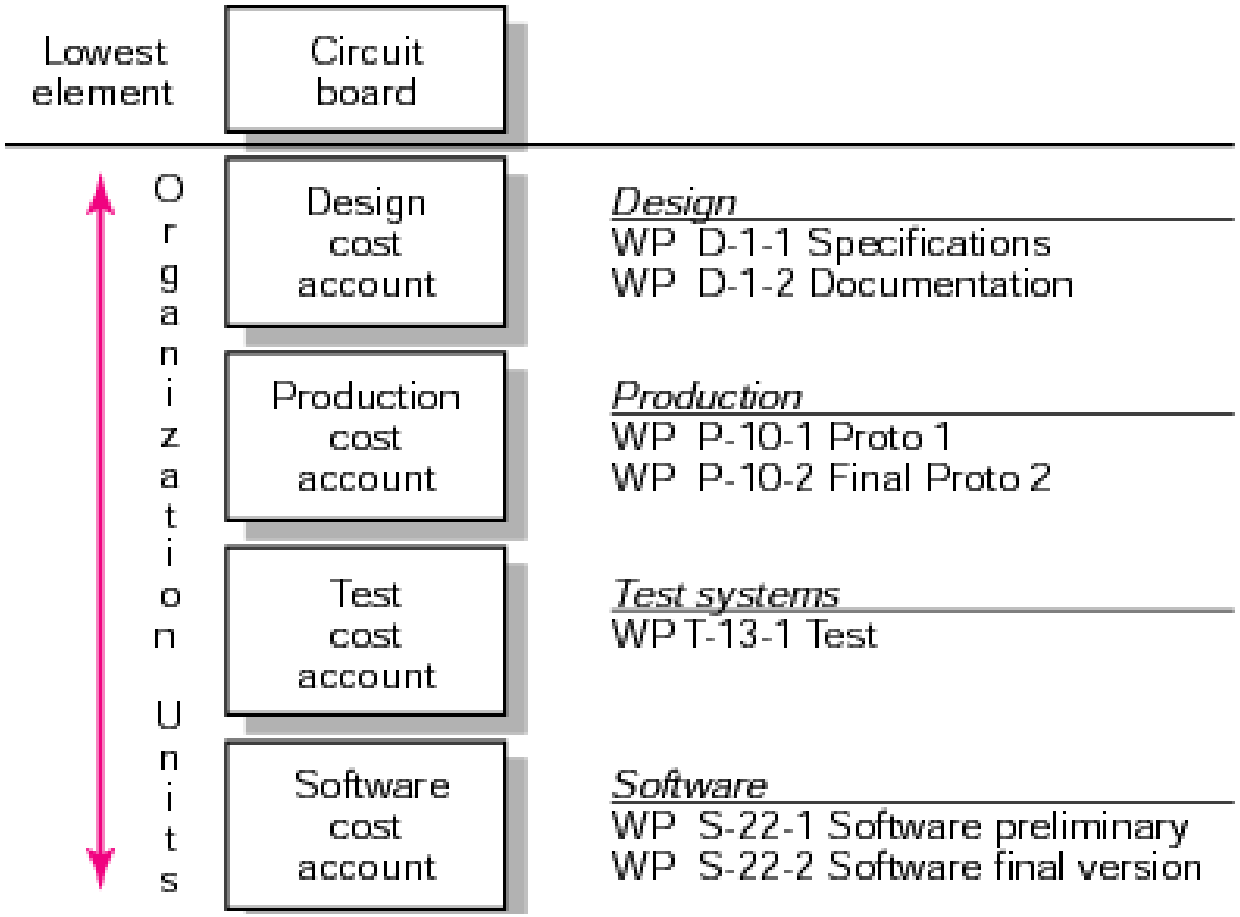


FIGURE 6.1

From Work Package to Network (cont'd)

WBS/Work Packages to Network (cont'd)

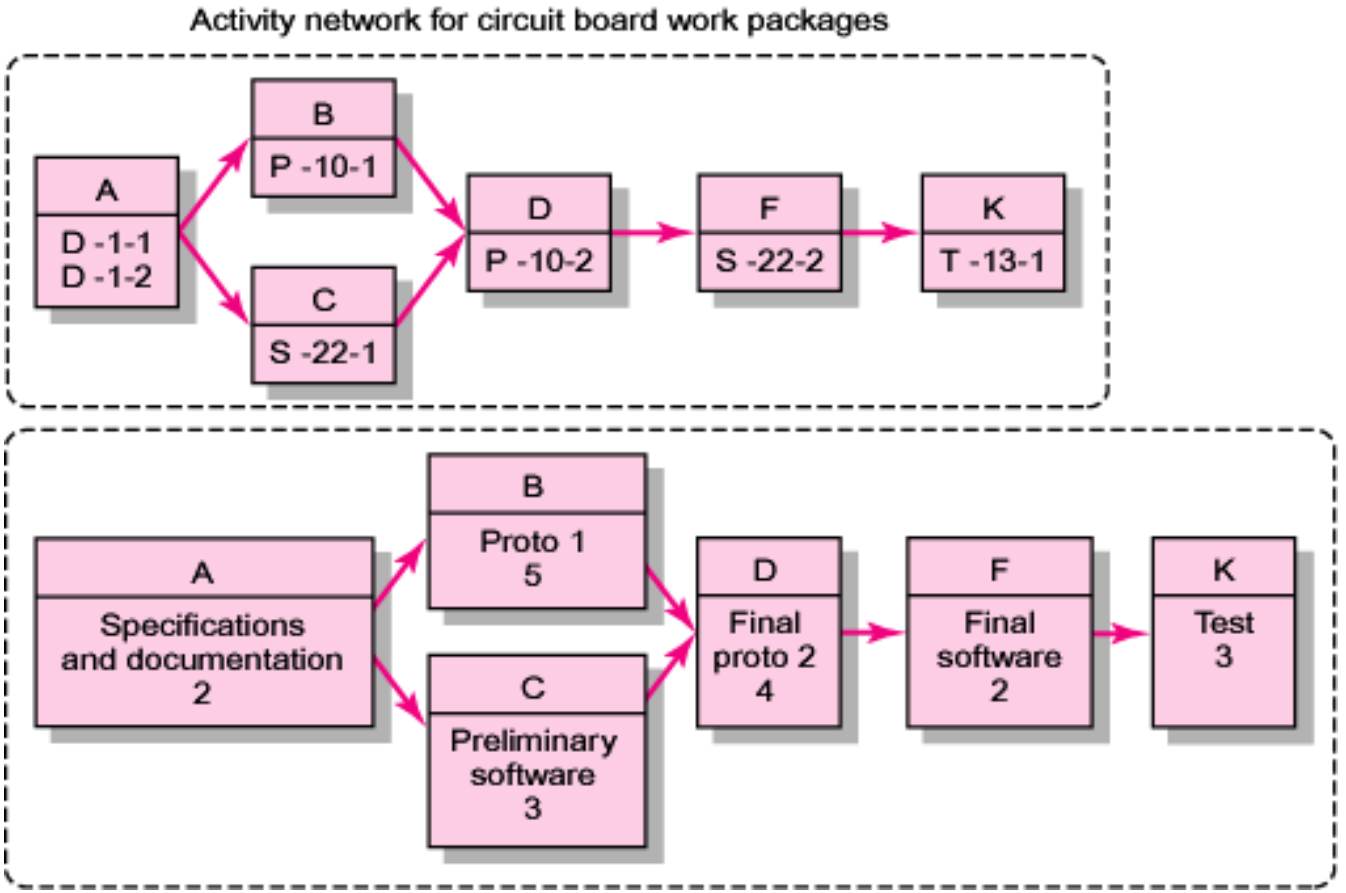
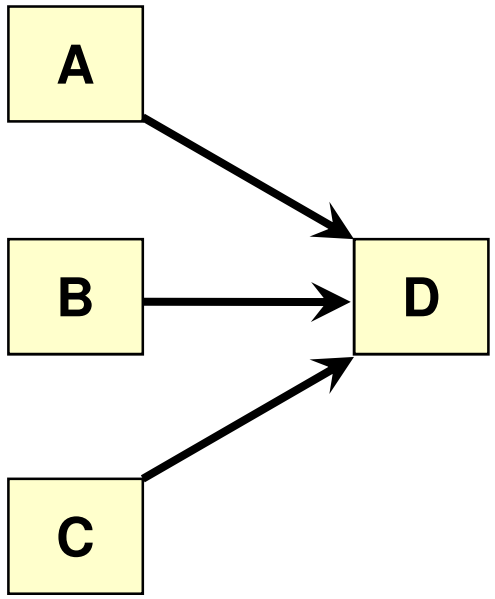


FIGURE 6.1 (cont'd)

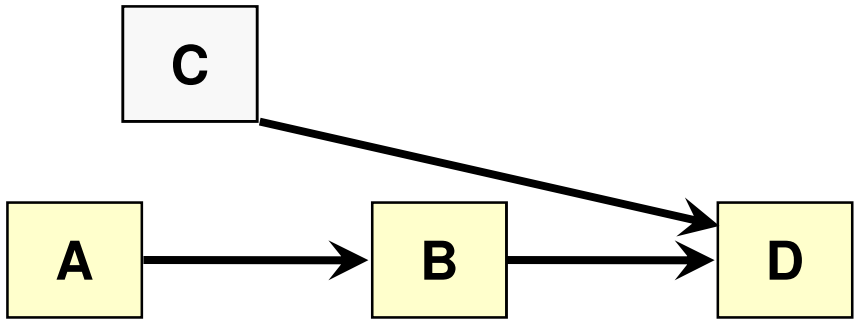
Constructing a Project Network

- 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)

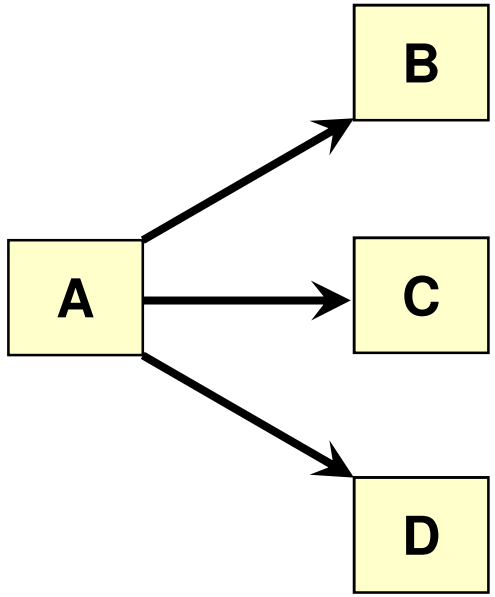
- Terminology
  - **Path:** a sequence of connected, dependent activities.
  - **Critical path:** the longest path through the activity network that allows for the completion of all project-related activities; the shortest expected time in which the entire project can be completed. Delays on the critical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

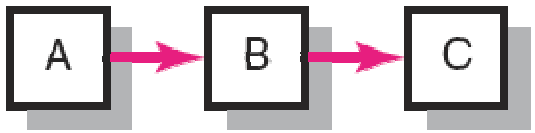
- Terminology
  - **Event:** a point in time when an activity is started or completed. It does not consume time.
  - **Burst Activity:** an activity that has more than one activity immediately following it (more than one dependency arrow flowing from it).
- Two Approaches
  - Activity-on-Node (AON)
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

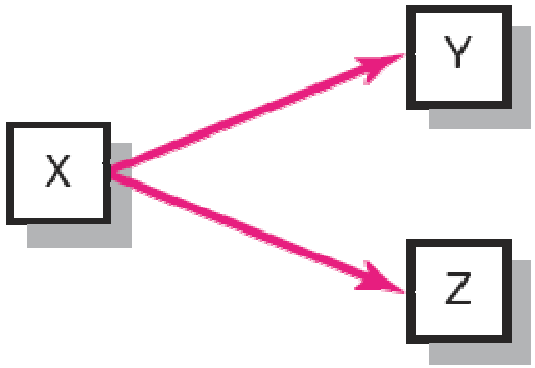
- Networks typically flow from left to right.
- An activity cannot begin until all of its activities are complete.
- Arrows indicate precedence and flow and can cross over each other.
- Identify each activity with a unique number; this number must be greater than its predecessors.
- Looping is not allowed.
- Conditional statements are not allowed.
- 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)



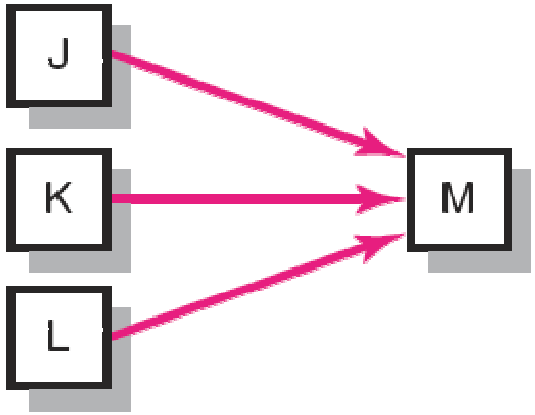
Y and Z are preceded by X

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

(B)

FIGURE 6.2

Activity-on-Node Fundamentals (cont'd)

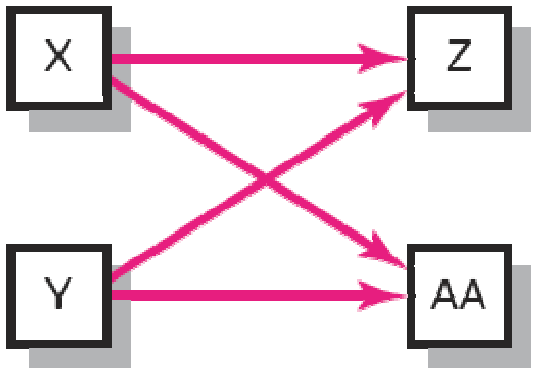


J, K, & L can all begin at the same time, if you wish (they need not occur simultaneously)

but

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

(C)



Z is preceded by X and Y

AA is preceded by X and Y

(D)

FIGURE 6.2 (cont'd)

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

TABLE 6.1

Koll Business Center—Partial Network

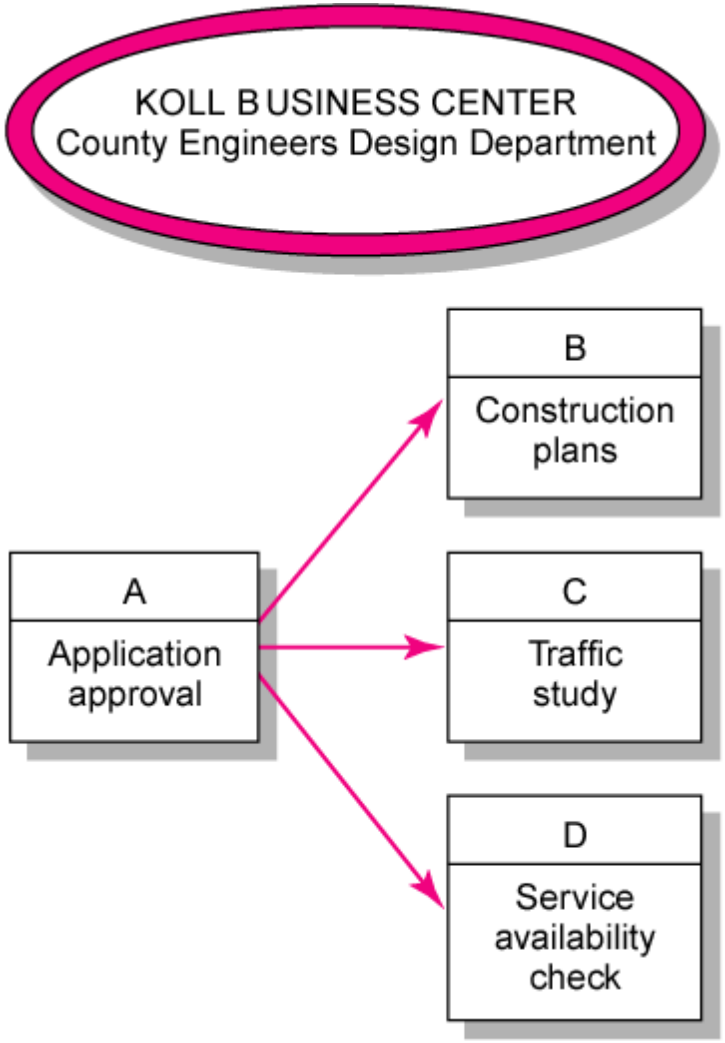


FIGURE 6.3

Koll Business Center—Complete Network

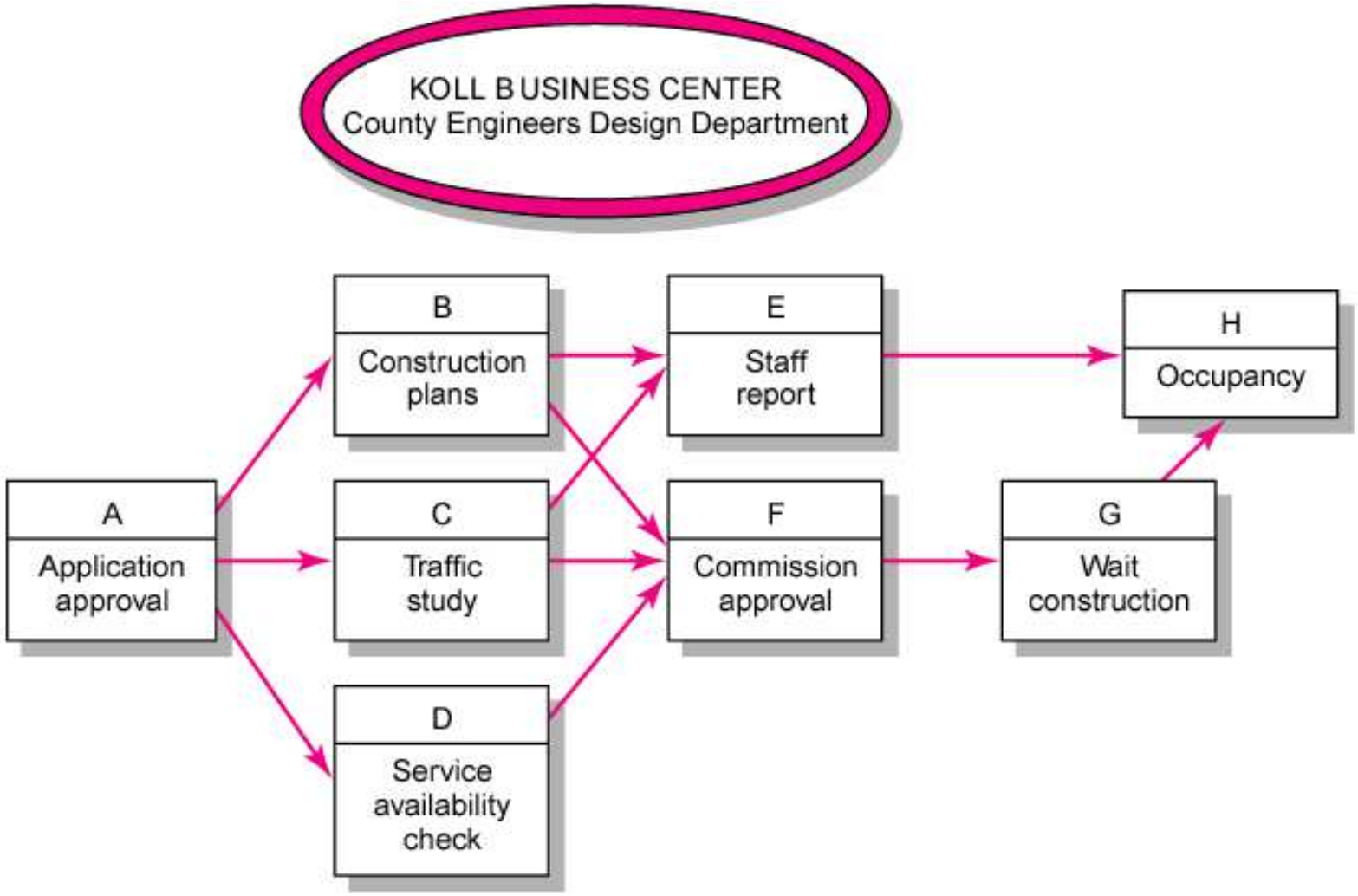


FIGURE 6.4

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 it 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

TABLE 6.2

Activity-on-Node Network

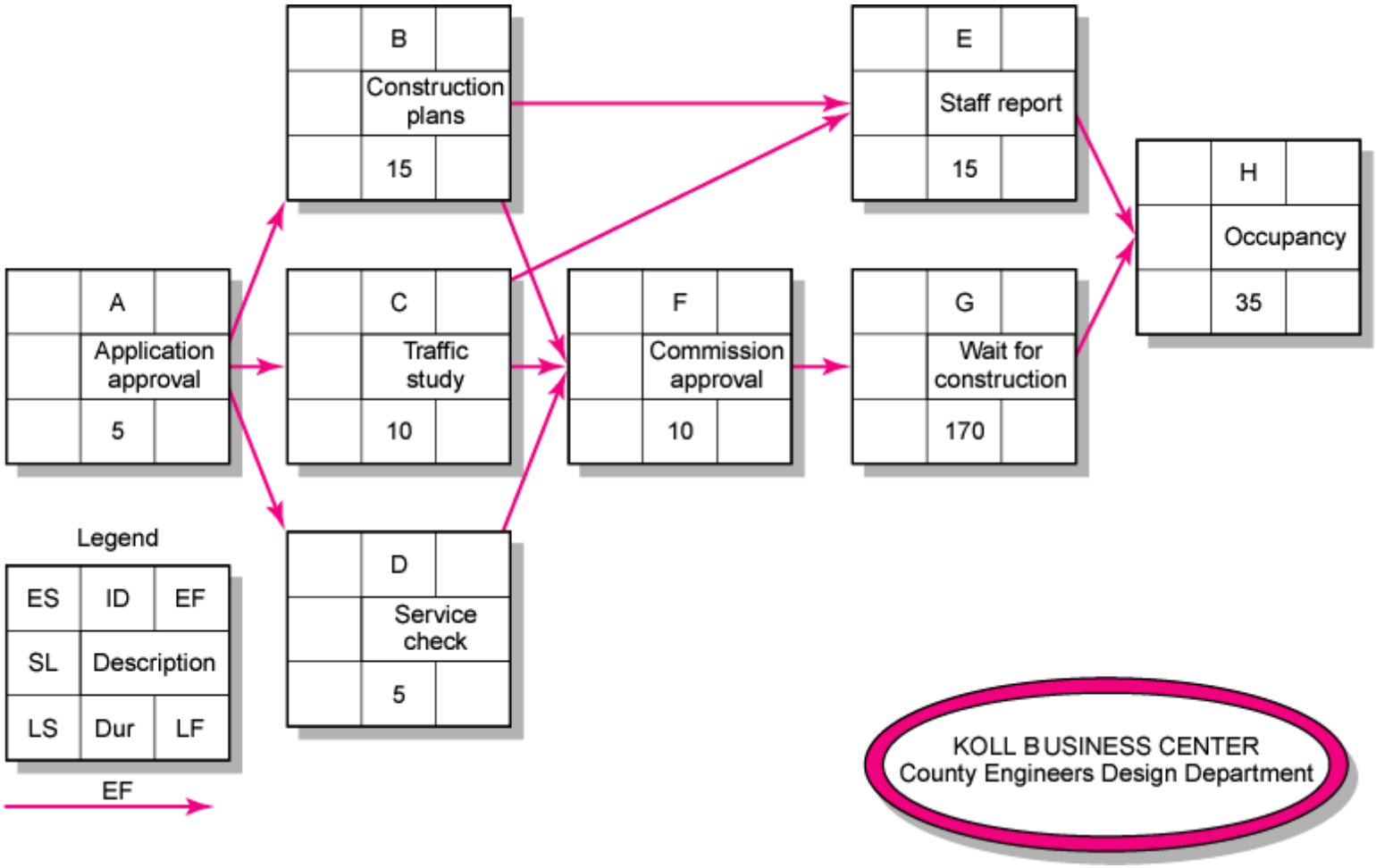


FIGURE 6.5

Activity-on-Node Network Forward Pass

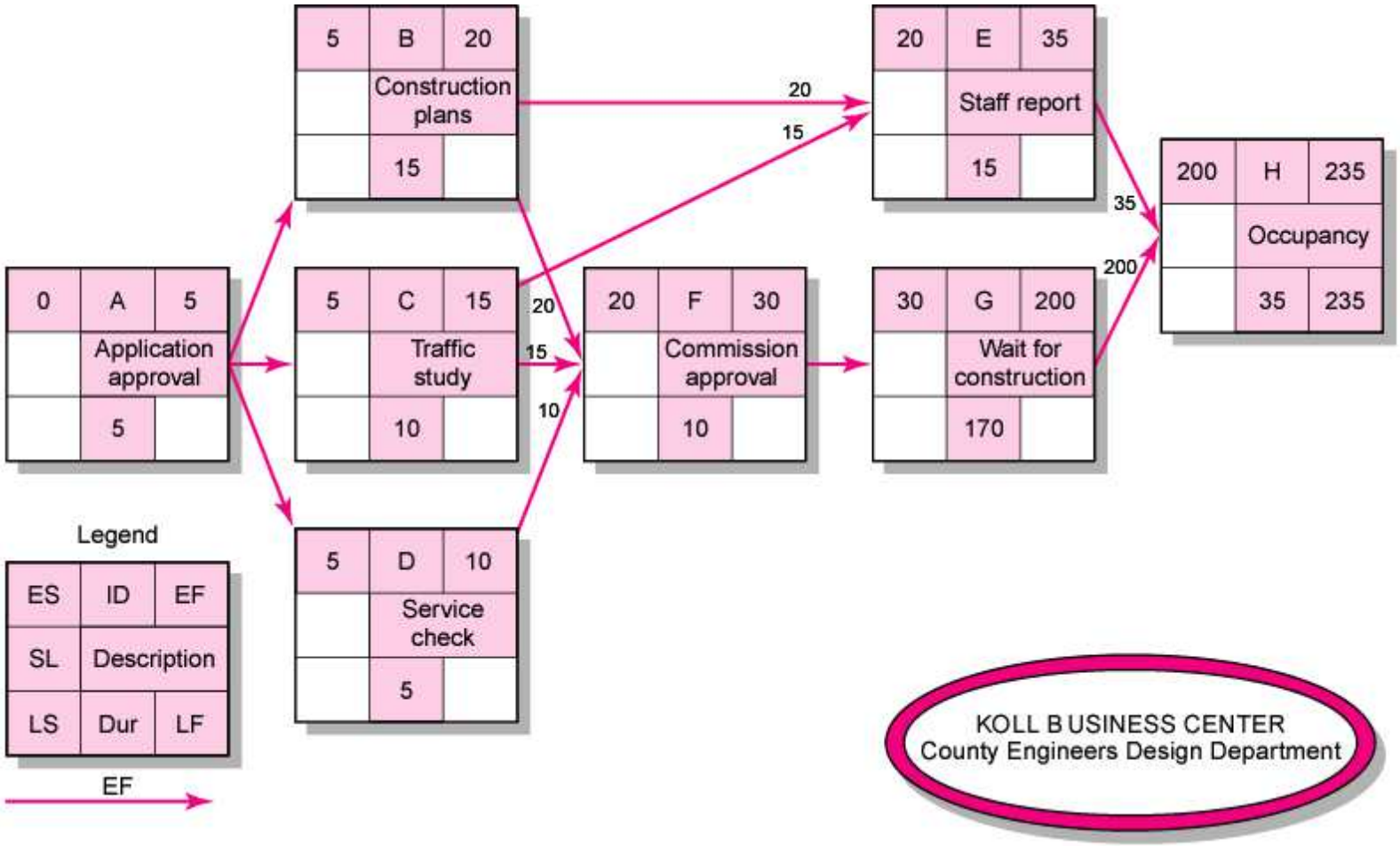


FIGURE 6.6

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

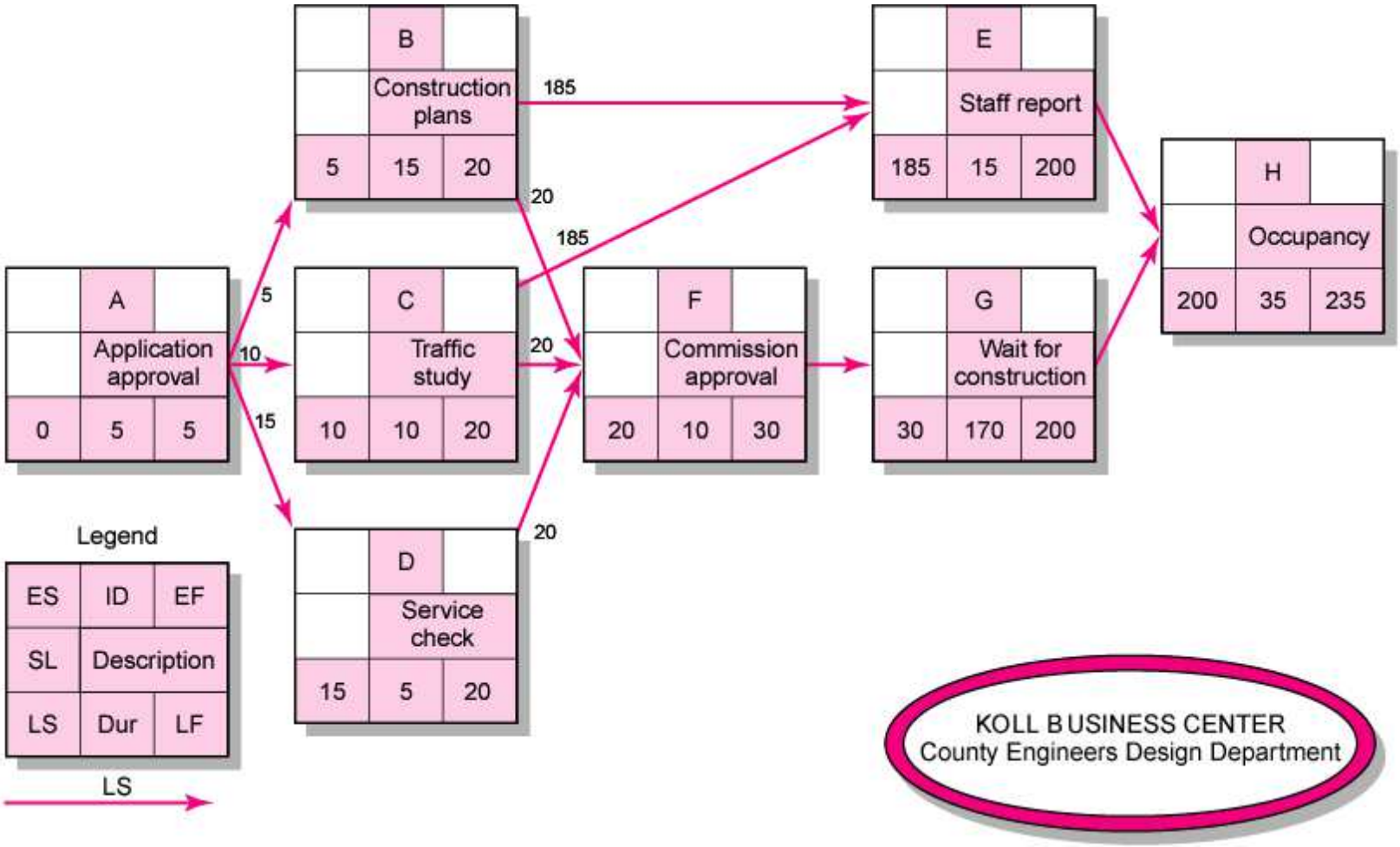


FIGURE 6.7

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 Slack (or Float)

- Slack (or Float)
  - The amount of time an activity can be delayed after the start of a longer parallel activity or activities.
- Total slack
  - The amount of time an activity can be delayed without delaying the entire project.
- The critical path is the network path(s) that has (have) the least slack in common.

Activity-on-Node Network with Slack

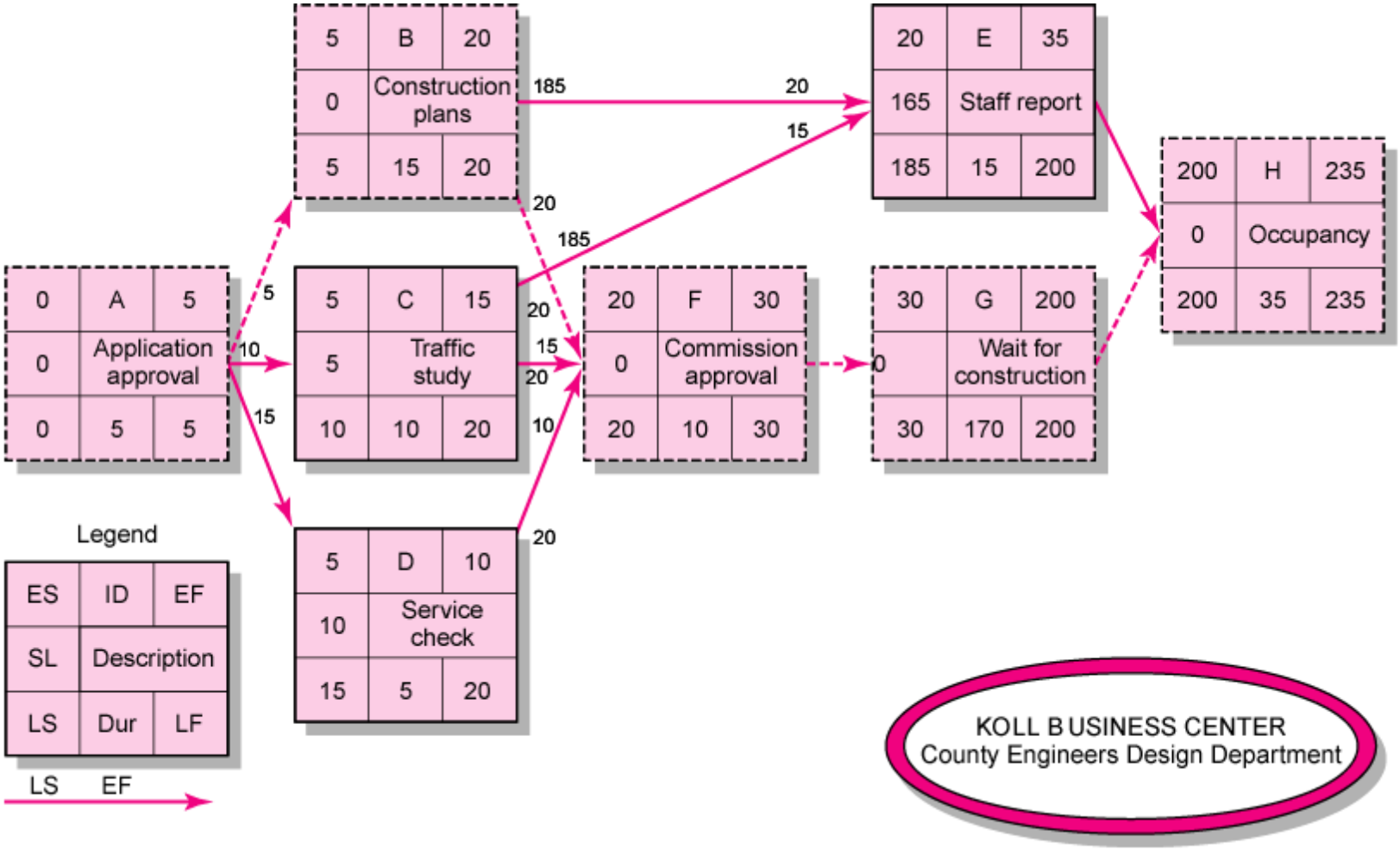


FIGURE 6.8

Practical Considerations

- Network Logic Errors
- Activity Numbering
- Use of Computers to Develop Networks
- Calendar Dates
- Multiple Starts and Multiple Projects

Illogical Loop

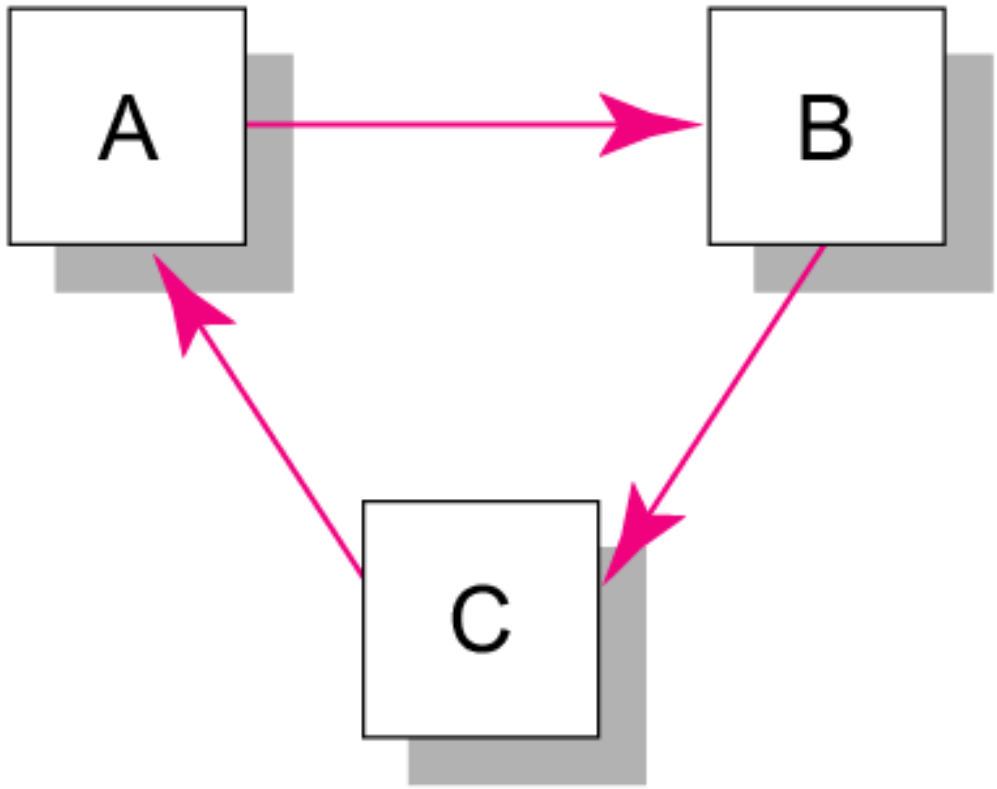


FIGURE 6.9

Air Control Project

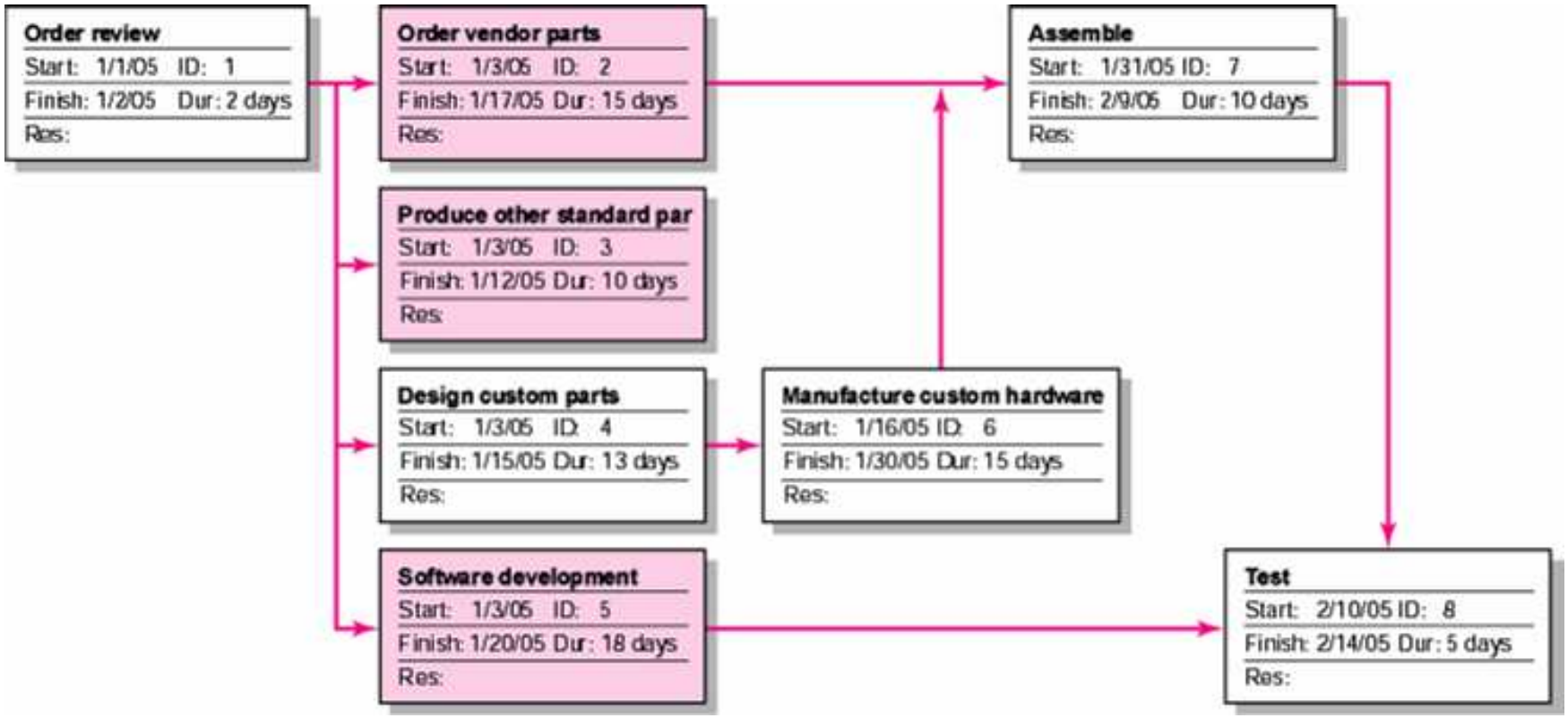


FIGURE 6.10

Air Control Project (cont'd)

ID	Duration	Task Name	Start	Finish	Late Start	Late Finish	Free Slack	Total Slack
1	2 days	Order review	Tue 1/1/05	Wed 1/2/05	Tue 1/1/05	Wed 1/2/05	0 days	0 days
2	15 days	Order vendor parts	Thu 1/3/05	Thu 1/17/05	Wed 1/16/05	Wed 1/30/05	13 days	13 days
3	10 days	Produce other standard parts	Thu 1/3/05	Sat 1/12/05	Mon 1/21/05	Wed 1/30/05	18 days	18 days
4	13 days	Design custom parts	Thu 1/3/05	Tue 1/15/05	Thu 1/3/05	Tue 1/15/05	0 days	0 days
5	18 days	Software development	Thu 1/3/05	Sun 1/20/05	Wed 1/23/05	Sat 2/9/05	20 days	20 days
6	15 days	Manufacture custom hardware	Wed 1/16/05	Wed 1/30/05	Wed 1/16/05	Wed 1/30/05	0 days	0 days
7	10 days	Assemble	Thu 1/31/05	Sat 2/9/05	Thu 1/31/05	Sat 2/9/05	0 days	0 days
8	5 days	Test	Sun 2/10/05	Thu 2/14/05	Sun 2/10/05	Thu 2/14/05	0 days	0 days

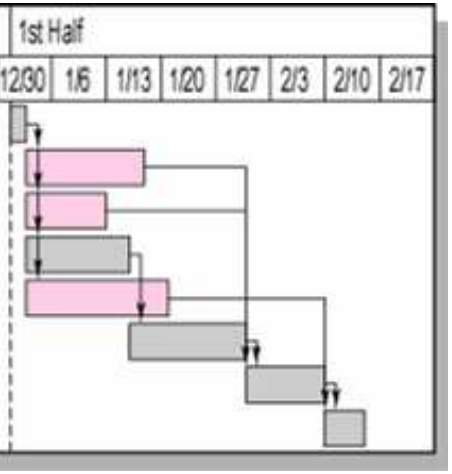


FIGURE 6.11

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

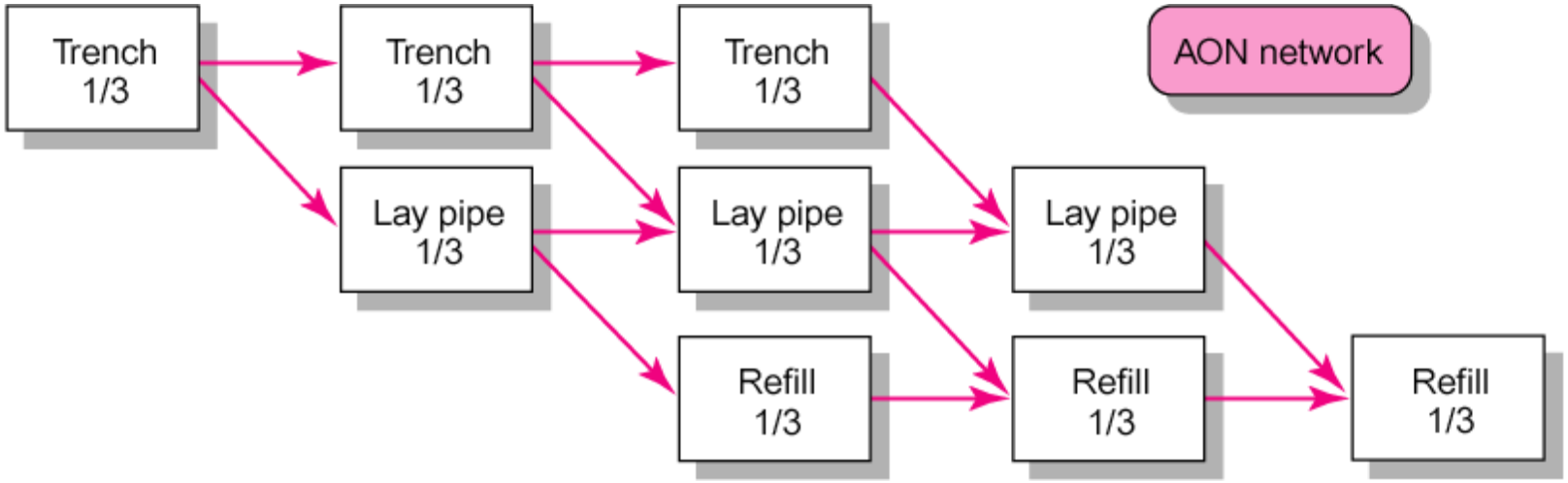


FIGURE 6.12

Use of Lags

Finish-to-Start Relationship

FIGURE 6.13

Start-to-Start Relationship

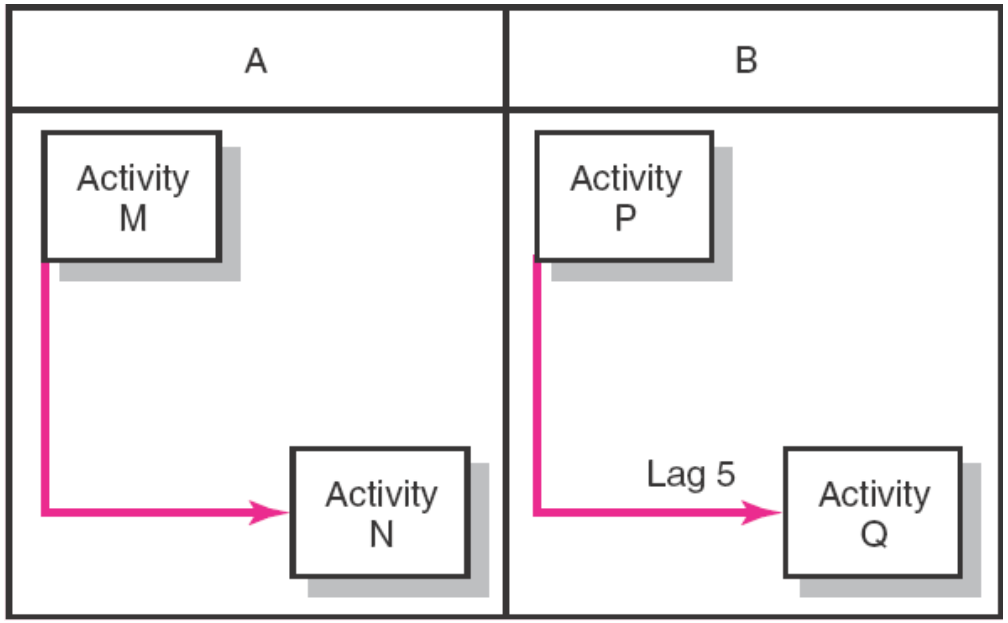
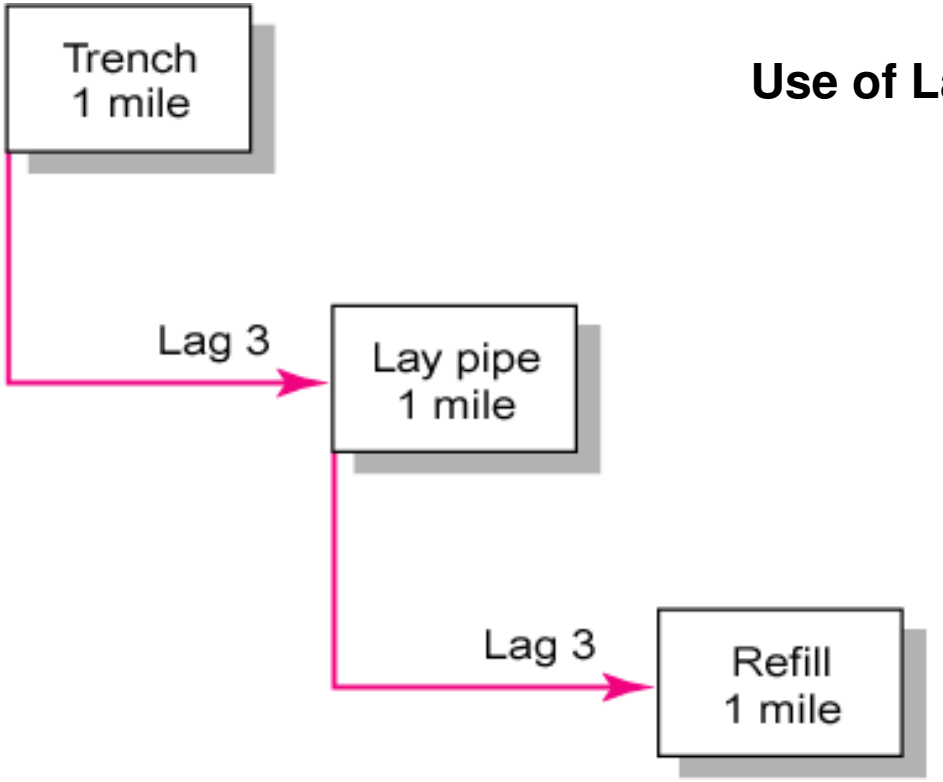


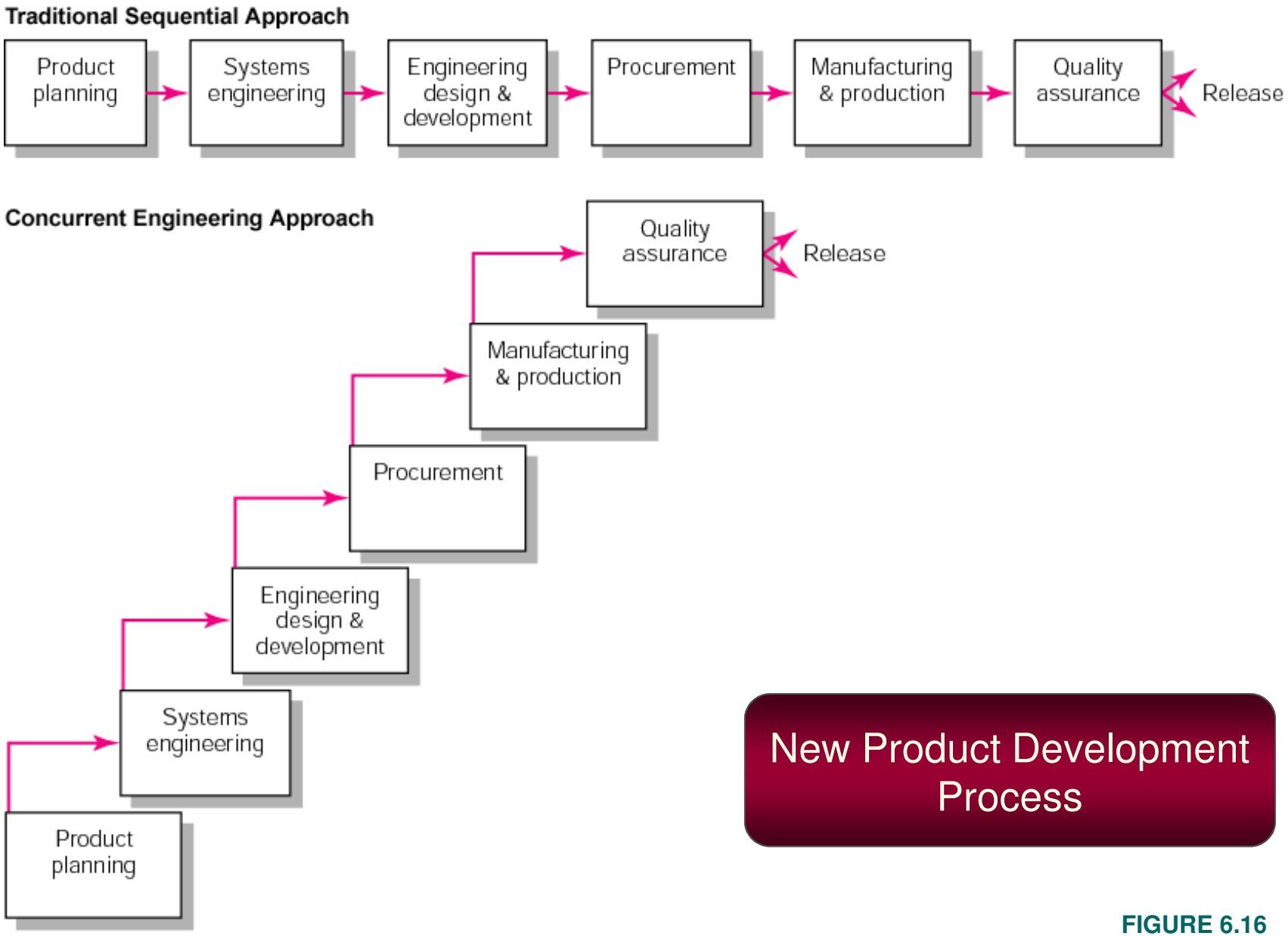
FIGURE 6.14

Use of Lags Cont'd



Use of Lags to Reduce Detail

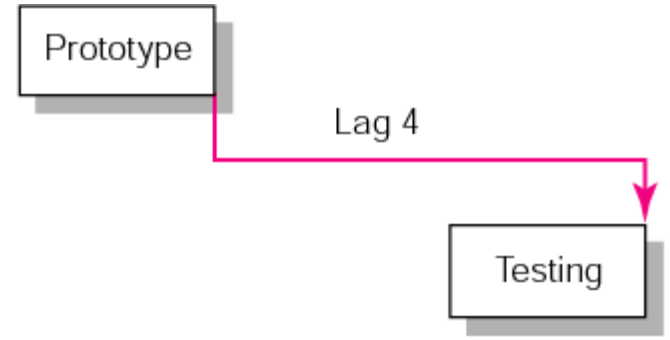
FIGURE 6.15



New Product Development Process

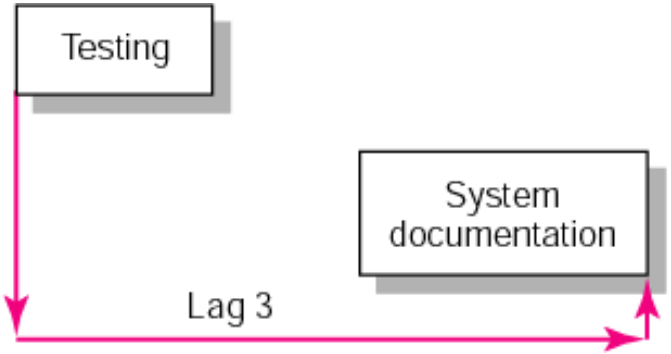
FIGURE 6.16

Use of Lags (cont'd)



Finish-to-Finish Relationship

FIGURE 6.17



Start-to-Finish Relationship

FIGURE 6.18

Combination Relationship

FIGURE 6.19

Network Using Lags

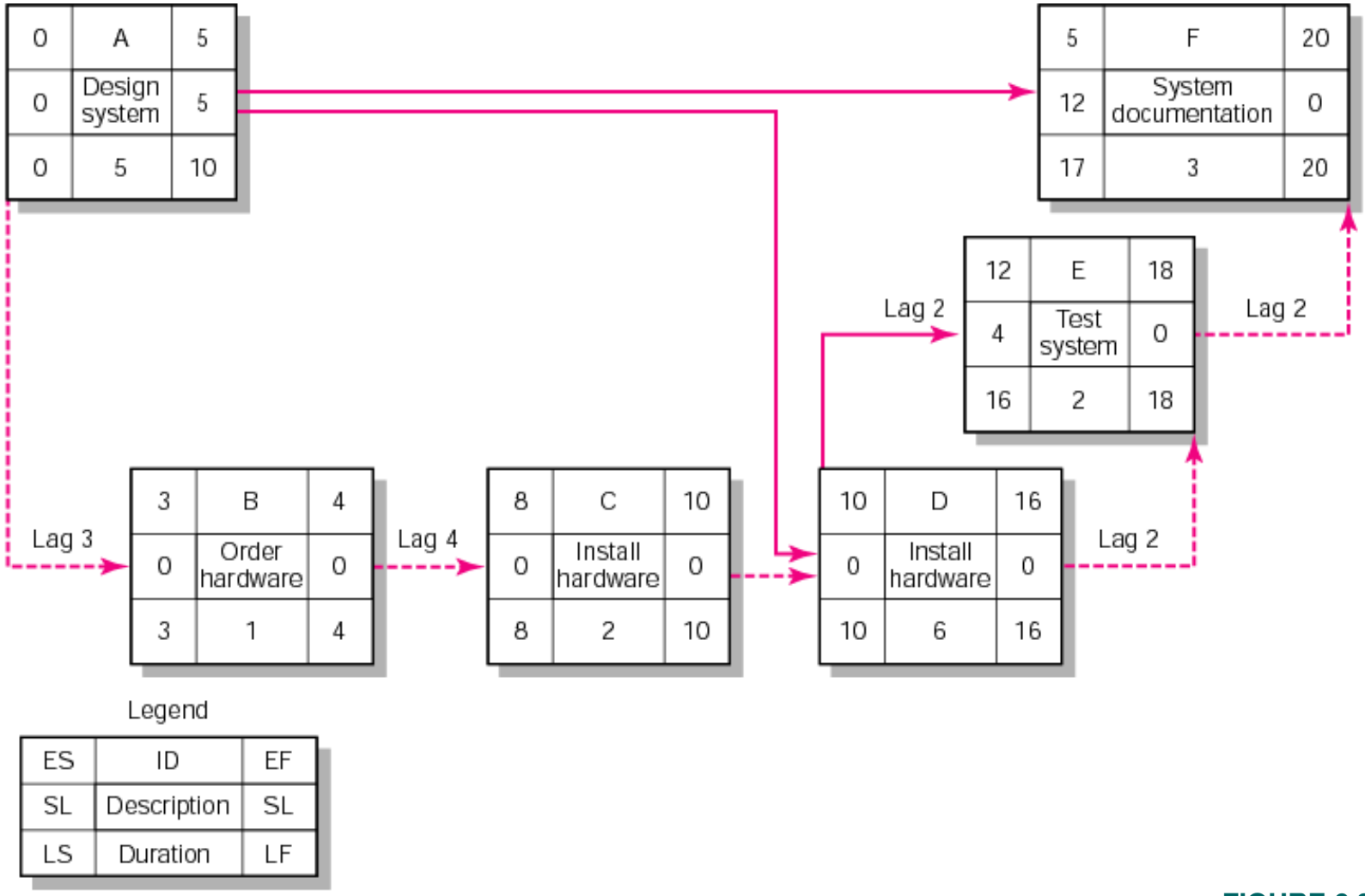


FIGURE 6.20

Hammock Activities

- Hammock Activity
  - An activity that spans over a segment of a project.
  - Duration of hammock activities is determined after the network plan is drawn.
  - Hammock activities are used to aggregate sections of the project to facilitate getting the right amount of detail for specific sections of a project.

Hammock Activity Example

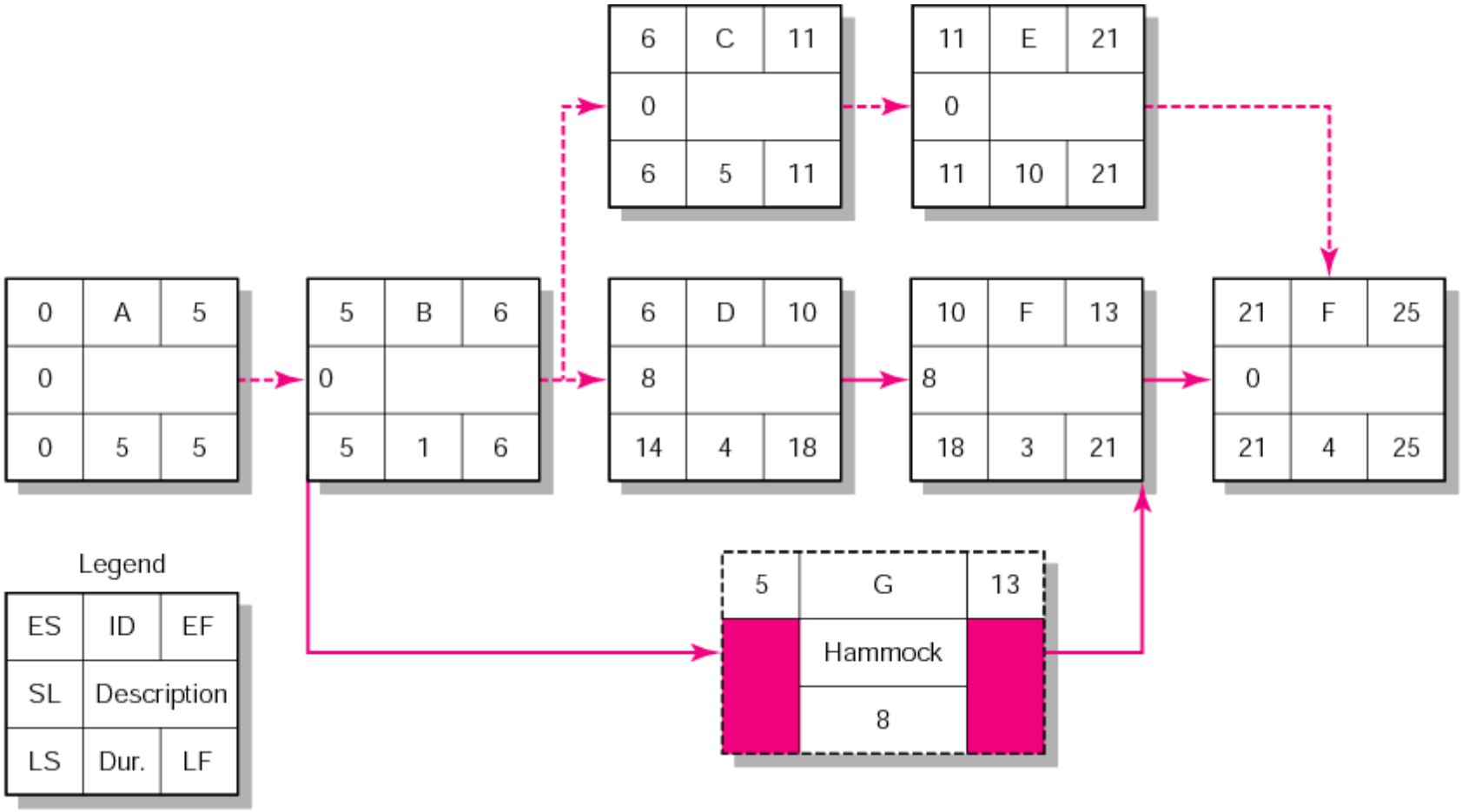


FIGURE 6.21

Key Terms

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

Activity-on-Arrow Network Building Blocks

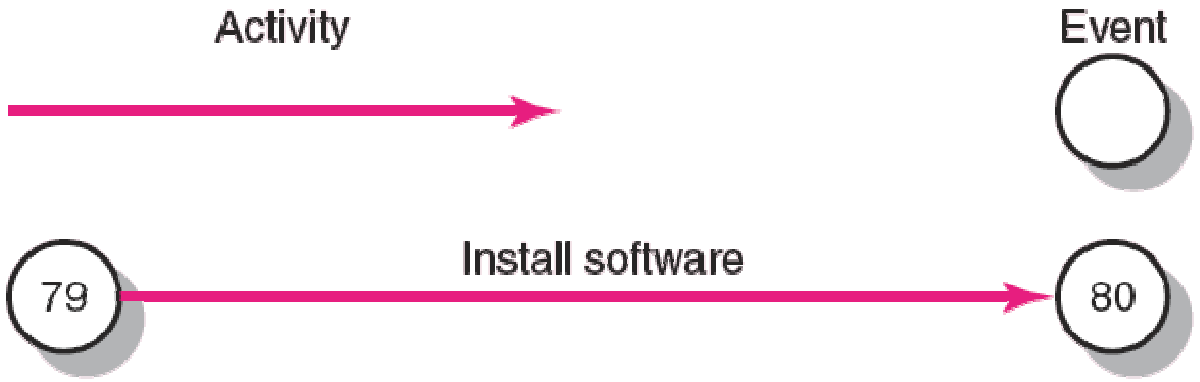
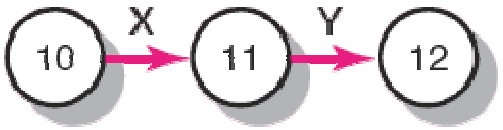


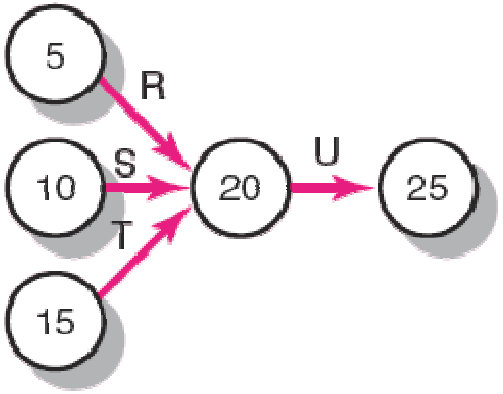
FIGURE A6.1

Activity-on-Arrow Network Fundamentals



Y is preceded by X

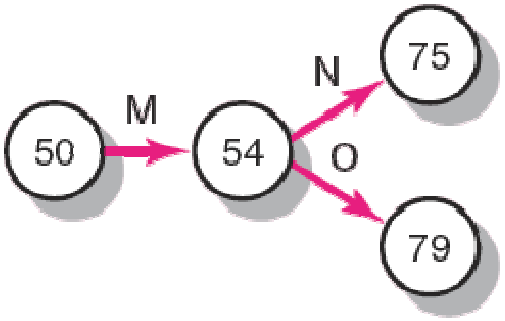
(A)



U is preceded by R, S, T

R, S, T can occur concurrently, if you wish

(B)



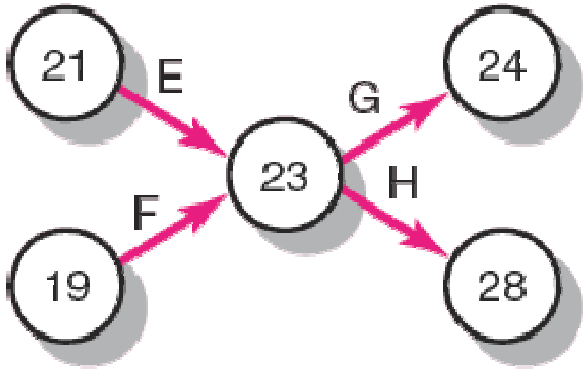
N and O are preceded by M

When M is complete, N and O can occur concurrently, if you wish

(C)

FIGURE A6.2

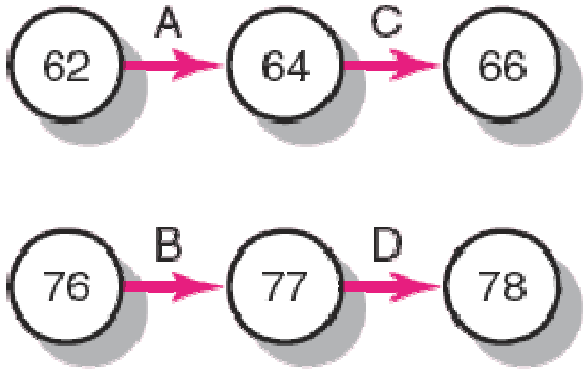
Activity-on-Arrow Network Fundamentals



E and F must precede G and H

E and F can occur together, if you wish
G and H can occur together, if you wish

(D)



A must precede C
B must precede D

Path A–C is independent of path B–D

(E)

FIGURE A6.2 (cont'd)

Koll Center Project: 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

TABLE A6.3

Partial Koll Business Center AOA Network

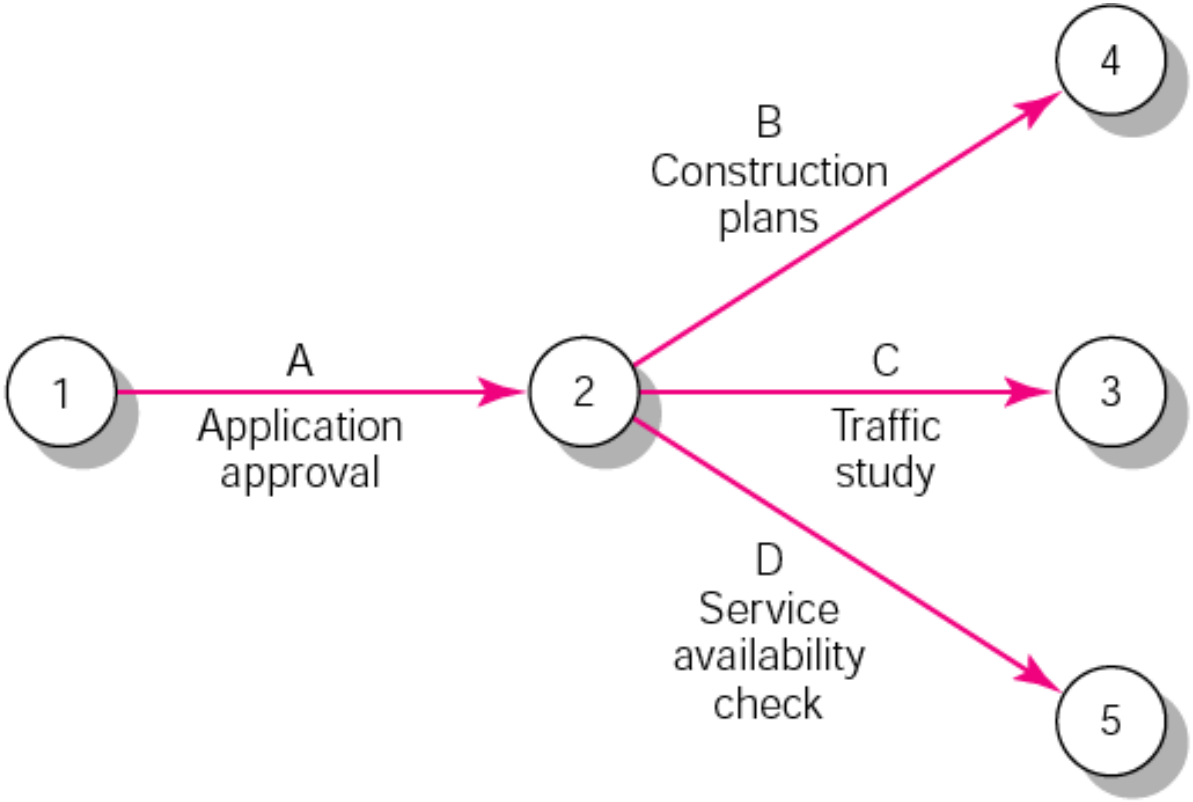


FIGURE A6.3

Partial AOA Koll Network

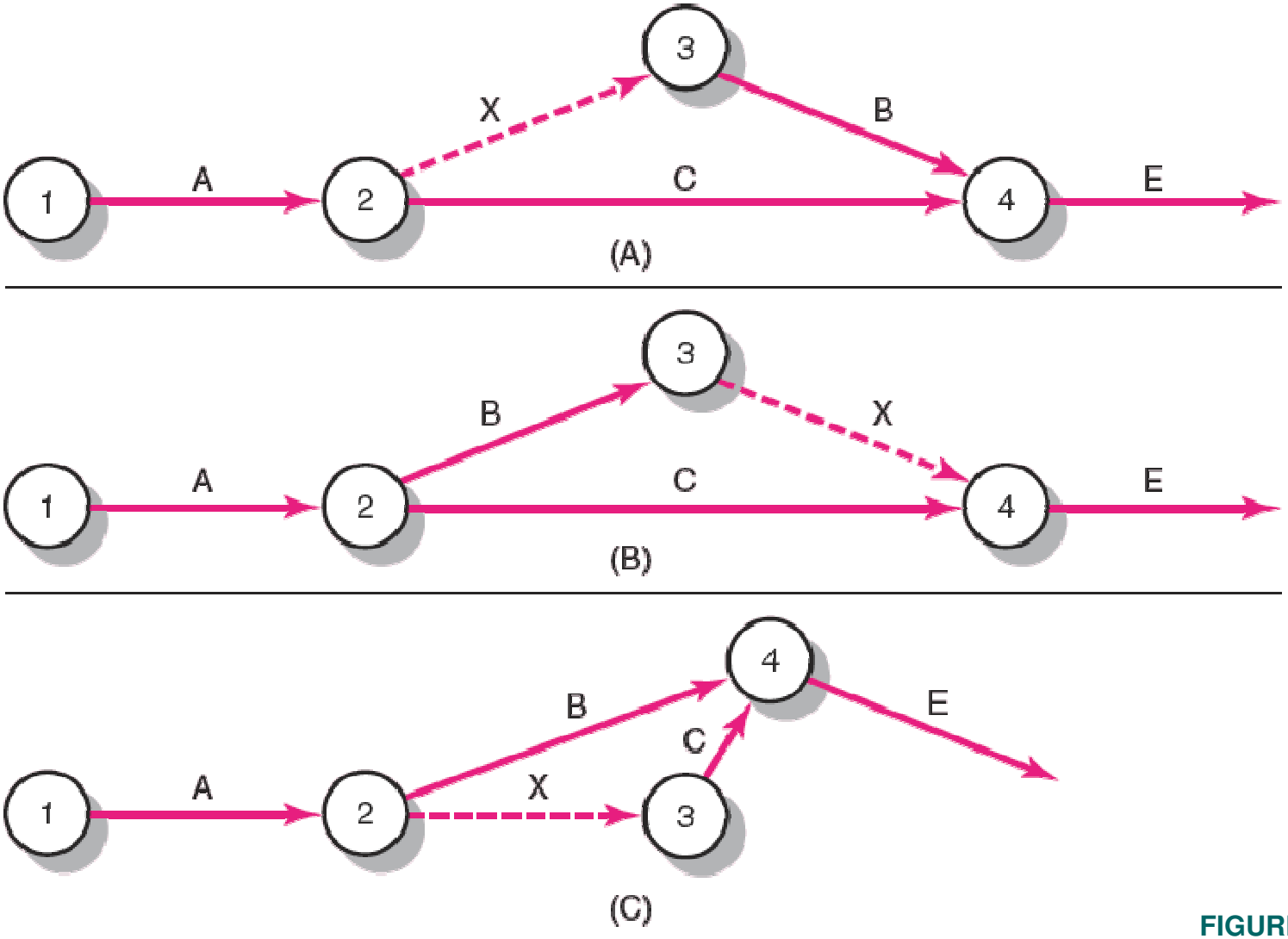


FIGURE A6.4

Partial AOA Koll Network (cont'd)

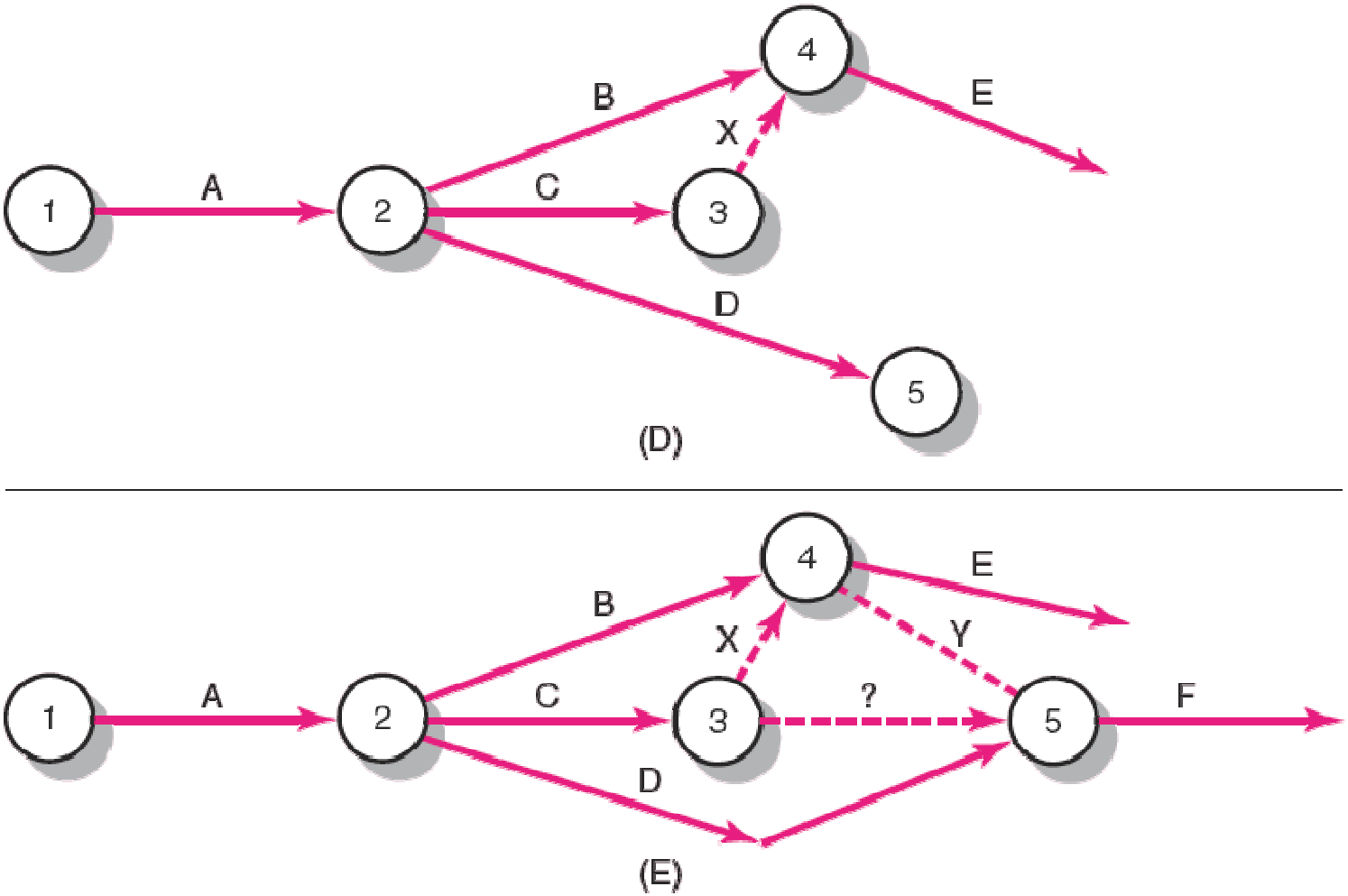


FIGURE A6.4 (cont'd)

Activity-on-Arrow Network

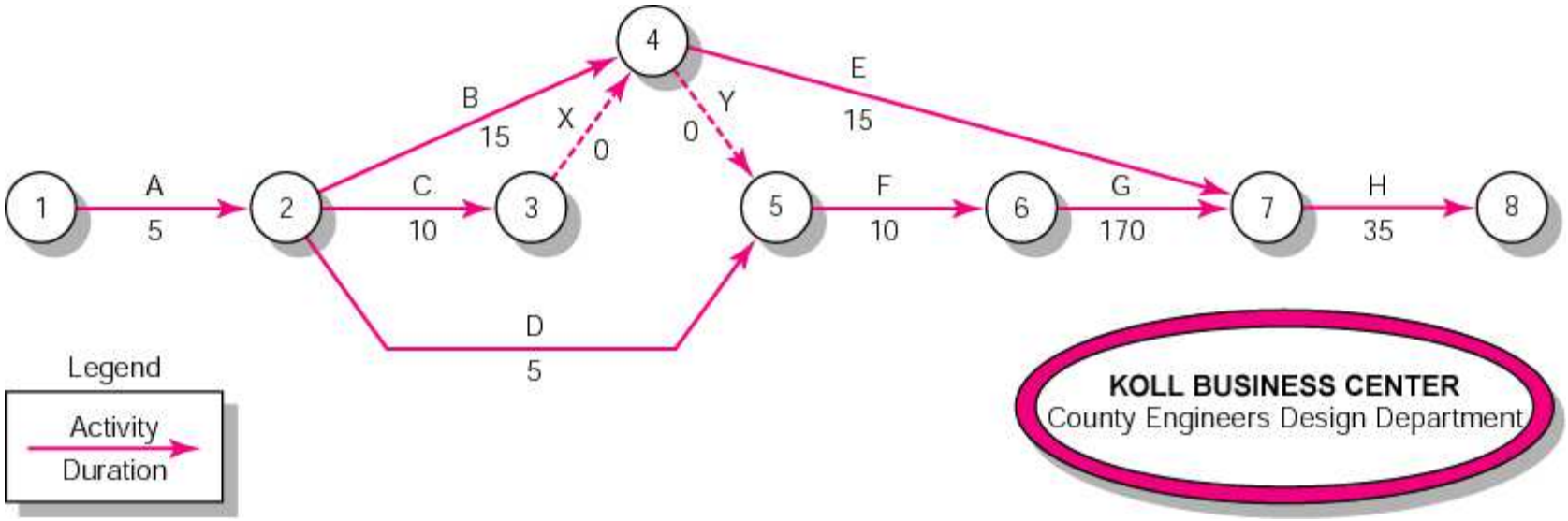


FIGURE A6.5

Activity-on-Arrow Network Forward Pass

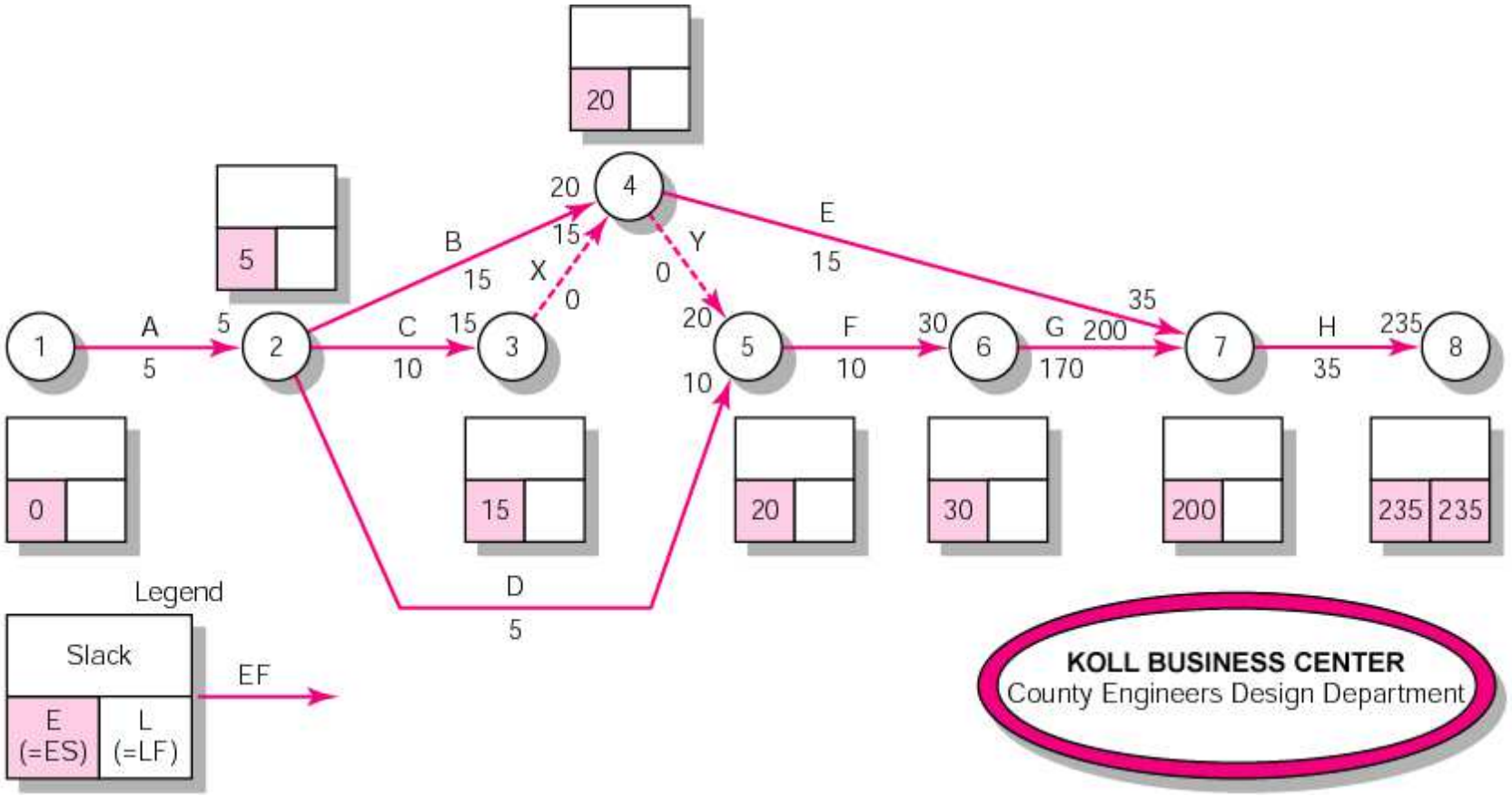


FIGURE A6.6

Activity-on-Arrow Network Backward Pass

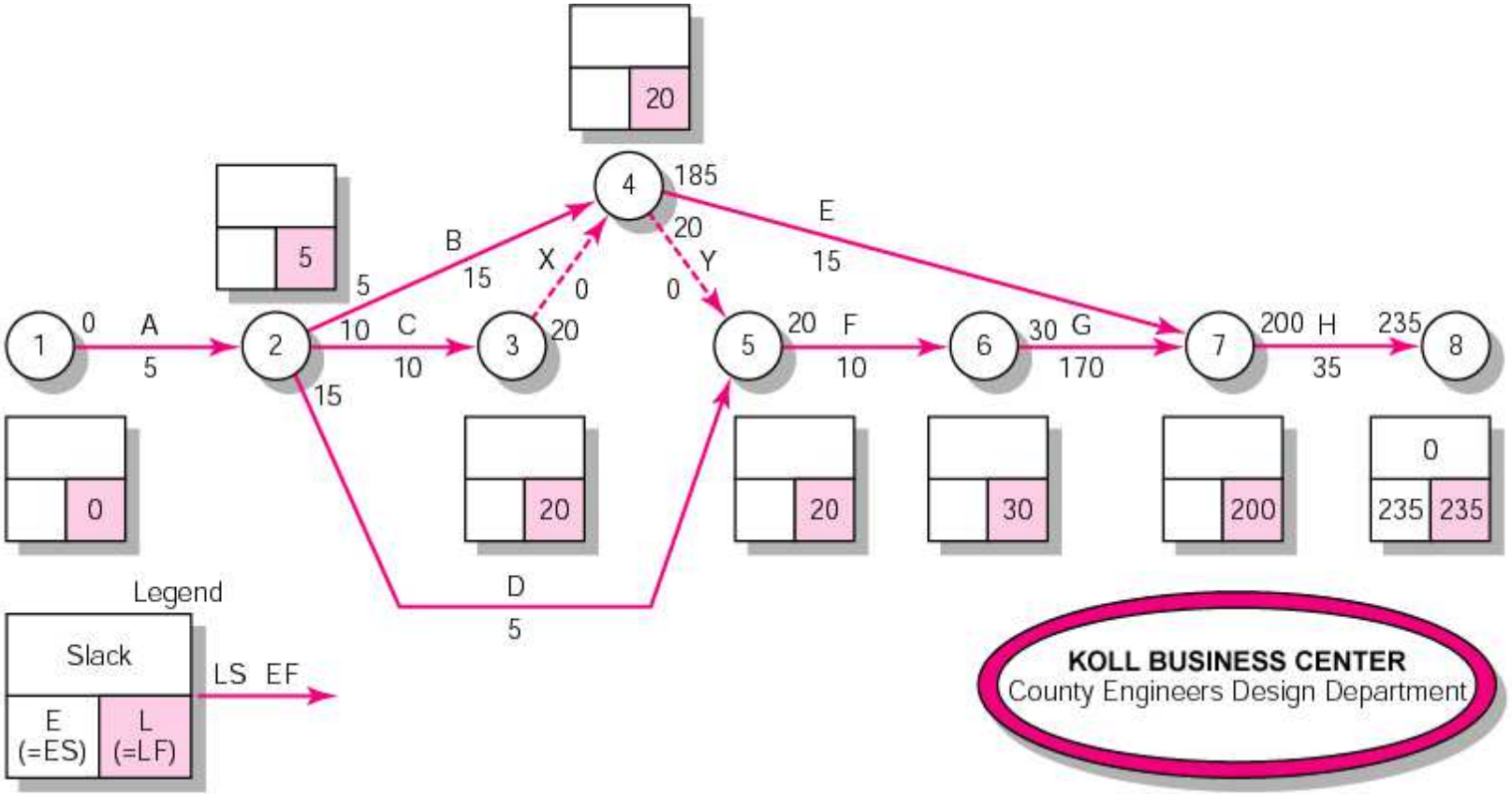


FIGURE A6.7

Activity-on-Arrow Network Backward Pass, Forward Pass, and Slack

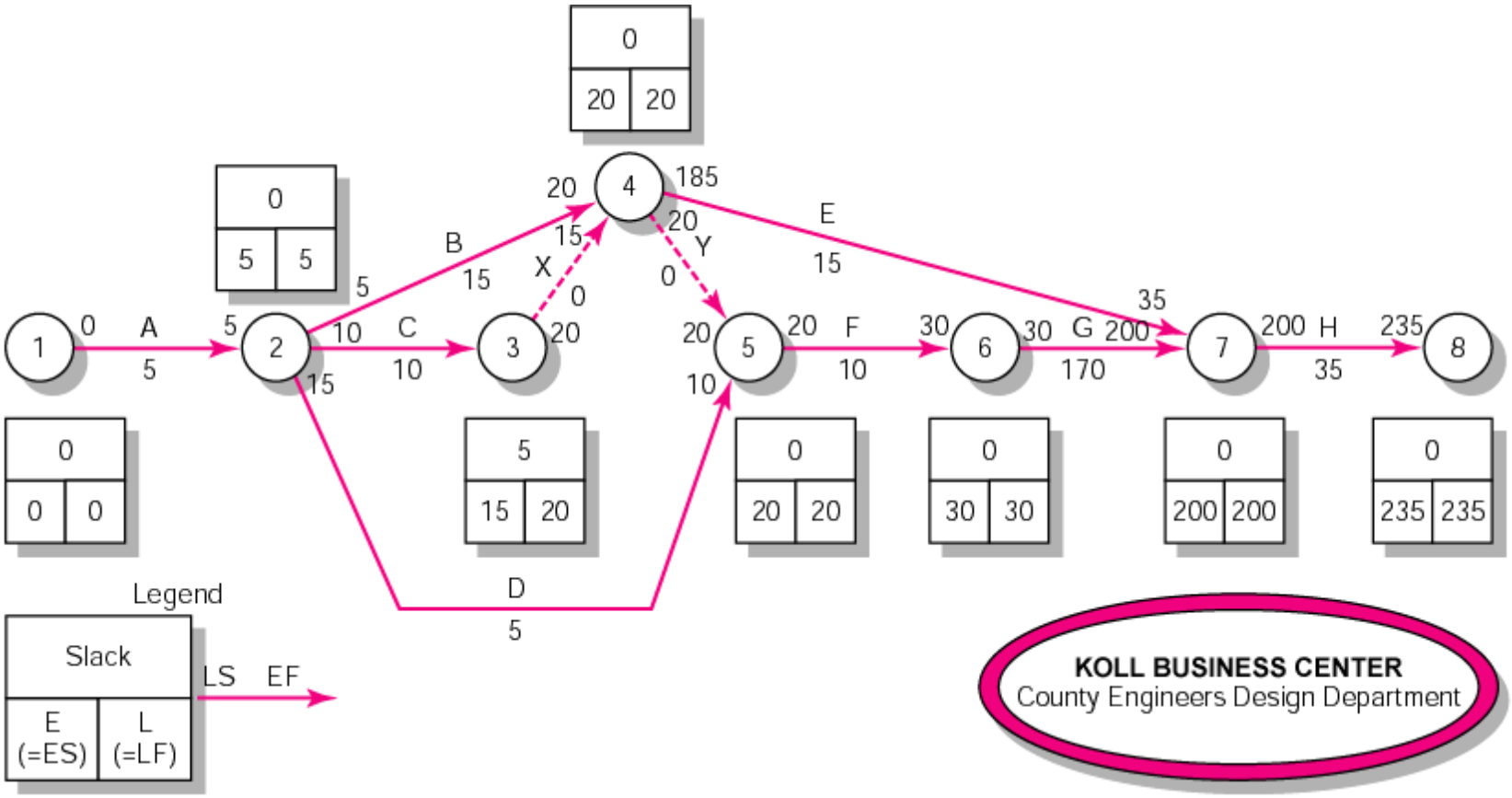


FIGURE A6.8

Air Control Inc. Custom Order Project—AOA Network Diagram

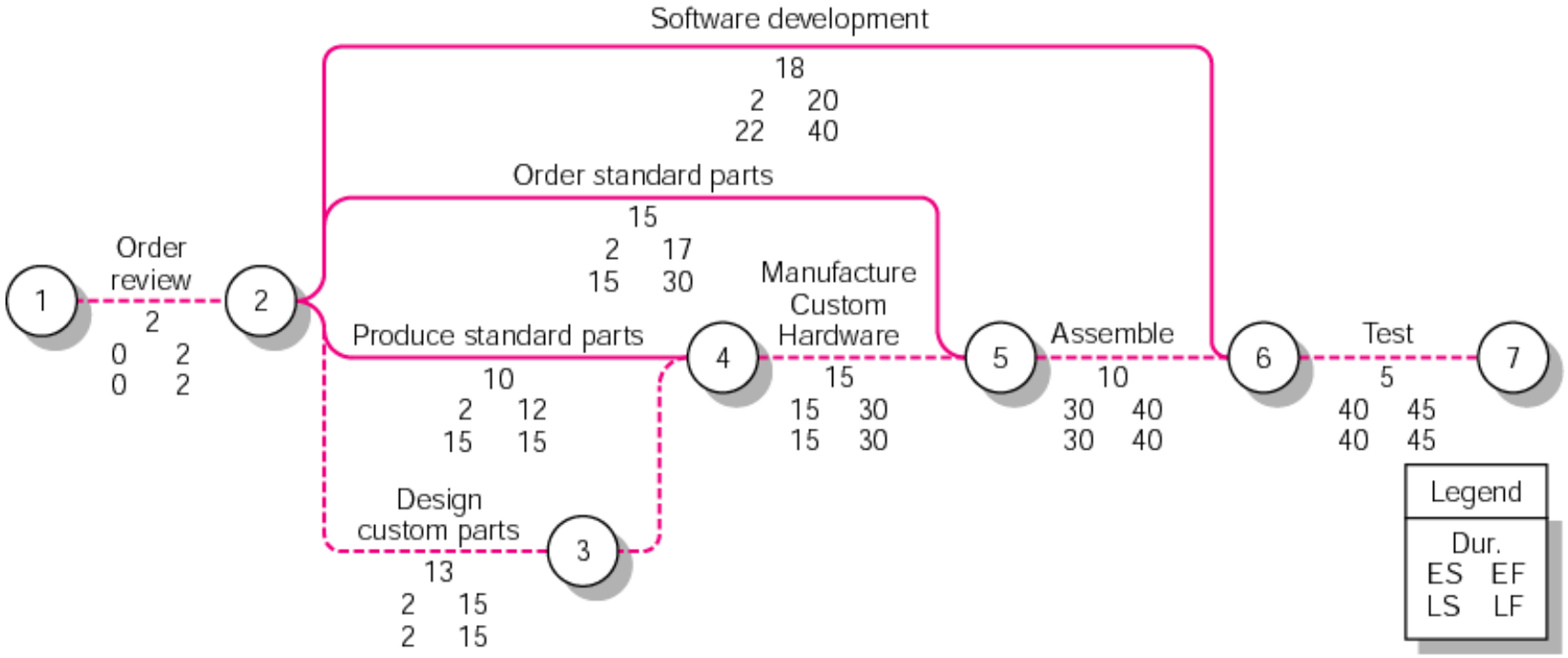


FIGURE A6.9

Comparison of AON and AOA Methods

AON Method

Advantages

1. No dummy activities are used.
2. Events are not used.
3. AON is easy to draw if dependencies are not intense.
4. Activity emphasis is easily understood by first-level managers.
5. The CPM approach uses deterministic times to construct networks.

Disadvantages

1. Path tracing by activity number is difficult. If the network is not available, computer outputs must list the predecessor and successor activities for each activity.
2. Network drawing and understanding are more difficult when dependencies are numerous.

AOA Method

Advantages

1. Path tracing is simplified by activity/event numbering scheme.
2. AOA is easier to draw if dependencies are intense.
3. Key events or milestones can easily be flagged.

Disadvantages

1. Use of dummy activities increases data requirements.
2. Emphasis on events can detract from activities. Activity delays cause events and projects to be late.

TABLE A6.2