CHAPTER 1 - INTRODUCTION

PLANNING, SCHEDULING & CONTROL OF CONSTRUCTION PROJECTS

HISTORY

- **19th CENTURY: INDUSTRIAL REVOLUTION:**
  - NEEDED TO KEEP MACHINES BUSY
  - SCHEDULE PRODUCTION TO MEET DEMAND
  - USED LISTS OF TASKS WITH START AND FINISH TIMES
  - NEEDED BETTER GRAPHICAL REPRESENTATIONS
- **WORLD WAR I: HENRY L. GANTT INTRODUCES BAR CHARTS**
  - BAR CHARTS CAN BE ANNOTATED: START & FINISH TIMES, ETC.
  - LISTS FOR MACHINES AND CRAFTSMEN EASIER TO CREATE
  - CAN BE ANNOTATED FOR PROJECT MONITORING & CONTROL
  - NEEDED WAY TO HANDLE COMPLEXITY & CHANGES (PRECEDENCE)
- **1956: CPM (CRITICAL PATH METHOD)**
  - BY DU PONT (WITH RAND AND UNIVAC)
  - CONSTRUCT COMPLEX CHEMICAL PLANTS QUICKLY
  - CPM (USING ACTIVITY ON ARROW NETWORKS)
  - DETERMINISTIC ACTIVITY DURATIONS (NO UNCERTAINTY)
  - CPM COMPUTERIZED BY UNIVAC
- **1956-58: PERT (PROGRAM EVAL'N AND REVIEW TECHNIQUE)**
  - BY U.S. NAVY (WITH BOOZ, ALLEN & HAMILTON MGMT CONSLTS)
  - POLARIS SUBMARINE (FLEET BALLISTIC MISSILE PROGRAM)
  - CONTROL OF MULTIPLE SUBCONTRACTORS
  - PERT (USING ACTIVITY ON ARROW NETWORKS)
  - UNCERTAINTY: PROBABILISTIC ACTIVITY DURATIONS
- **1961: CPM USING ACTIVITY ON NODE / PRECEDENCE NETWORKS**
  - JOHN FONDAHL (STANFORD) & NAVY BUREAU OF YARDS AND DOCKS
  - NETWORK AND RESOURCE ANALYSIS WITHOUT COMPUTER
- **EARLY 60s: PERT/COST**
  - PERT/COST WAS REQUIRED BY FEDERAL GOVMT. FOR ALL WORK
  - CONTRACTORS HAD TO USE PERT/COST (OTHERWISE, NO WORK)
  - INEFFECTIVE—CONTRACTORS KEPT TWO SETS OF BOOKS/REPORTS
- **1967: EARNED VALUE MGMT – C/SCSC (aka C-Spec) – by DOD**
  - C/SCSC = COST/SCHEDULE CONTROL SYSTEMS CRITERIA
  - C/SCSC (INITIALLY) REQUIRED A SET OF 35 CRITERIA
  - CONTRACTORS FREE TO USE ANY COMPLIANT PM SYSTEM
  - C/SCSC IS NOW INDUSTRY STANDARD: ANSI EIA 748-A (32 CRITERIA)
- **1984 – TODAY: PERSONAL COMPUTERS**
  - PERSONAL COMPUTERS HAVE MADE PLANNING, SCHEDULING, AND CONTROL SYSTEMS AFFORDABLE (e.g., Primavera P6, MS Project)
  - CONSTRUCTION CONTRACTS REQUIRE CONTRACTOR-DEVELOPED SCHEDULES AT START OF WORK

SIX RESOURCES OF PLANNING

- **PLANNING A PROJECT NEEDS INFO ON SIX CRITICAL RESOURCES**
  - LABOR, EQUIPMENT, MATERIALS, SPACE, MONEY, TIME
- **LABOR - HUMAN RESOURCES**
  - EFFICIENT USE OF MANPOWER – ELIMINATE IDLE TIME, HIGH DEMANDS, EXCESSIVE HIRING AND FIRING
  - SPECIAL SKILLS – MAY NEED TO TRAIN PEOPLE
  - GEOGRAPHICAL LOCATION – MAY NEED TO BRING PEOPLE FROM DISTANT AREAS
- **EQUIPMENT**
  - SELECTION DEPENDS ON TYPE OF PROJECT, MATERIALS USED, PLACEMENT METHODS, ETC.
  - EQUIPMENT SELECTED MUST BE AVAILABLE WHEN NEEDED
  - RENTAL VS PURCHASE/OWN DECISIONS
  - MULTI-PROJECT EQUIPMENT SCHEDULING ISSUES
  - CRUCIAL FOR HEAVY CONSTRUCTION – HIGHWAYS, EARTHMOVING, TUNNELS, DAMS, ETC.
- **MATERIALS**
  - TYPE AND QUANTITY DICTATED BY PLANS AND SPECS
  - MUST ARRIVE ON TIME, STORED, AND TRANSPORTED TO JOB
- **SPACE**
  - MATERIALS LAYDOWN AREAS
  - EQUIPMENT STORAGE AND OPERATING SPACE
  - SPACE UTILIZATION AND REUSE OVER TIME
- **MONEY**
  - CONTRACTOR'S OPERATIONS MUST BE FINANCED
  - CONTRACTOR'S COMPENSATION LAGS EXPENSES
    - CONTRACTOR MUST SECURE A LINE OF CREDIT
    - STAY WITHIN CREDIT LIMITS
  - FINANCIAL ARRANGEMENTS MUST BE MADE IN ADVANCE, TO THE SATISFACTION OF THE LENDERS
- **TIME**
  - CONTRACT DOCUMENTS SPECIFY/REQUIRE
    - START TIME (NOTICE TO PROCEED)
    - FINISH TIME (SUBSTANTIAL COMPLETION DATE)
    - PROJECT DURATION
    - SPECIFIC MILESTONE DATES
  - CONTRACTOR HAS OTHER PROJECTS THAT COMPETE FOR THE SAME RESOURCES
  - WEATHER IMPOSES WORK CONSTRAINTS AND COSTS

HIERARCHY OF SCHEDULES

- A WELL-PLANNED PROJECT USES A SERIES OF SCHEDULES THAT DEPICT THE UTILIZATION OF ALL SIX RESOURCES
- **ACTIVITY SCHEDULE**
  - BASIC CONSTRUCTION ACTIVITY TIME SCHEDULE IS DONE FIRST
  - SHOWS HOW THE WORK TASKS WILL BE DONE OVER TIME
  - IS THE MOST IMPORTANT
    - OTHER SCHEDULES DEPEND ON IT
    - REQUIRES A LOT OF ATTENTION
- **MATERIALS SCHEDULE**
    - MATERIALS TYPE AND QUANTITY ARE COMPUTED FOR COST-ESTIMATING FROM PLANS AND SPECS
  - MUST BE RELATED TO CONSTRUCTION TASK SCHEDULE TO
    - FACILITATE ORDERING
    - INSURE DELIVERY
    - ARRANGE FOR STORAGE, PROTECTION, ETC.
    - MINIMIZE STORAGE NEEDS, BREAKAGE, AND THEFT
- **EQUIPMENT SCHEDULE**
  - IDENTIFY UTILIZATION OF EQUIPMENT BY ACTIVITIES OVER TIME
  - FACILITATE DECISIONS: USE OWN vs RENTAL vs PURCHASE
  - EFFECTS ON CASH-FLOW, CAPITAL EXPENDITURES
  - ARRIVAL AND DEPARTURE TIMES
  - MULTI-PROLECT SCHEDULING ISSUES
- **LABOR SCHEDULE**
  - LABOR NEEDS DEPEND ON WORK, MATERIALS AND EQUIPMENT SCHEDULES
  - LABOR SCHEDULE SHOWS CRAFT AND WORK TASKS OVER TIME
  - MUST ALSO INCLUDE PROCUREMENT, TRANSPORTATION, HOUSING, TRAINING
  - LOOK FOR EFFICIENT UTILIZATION – MINIMIZE HIRING AND FIRING
- **SPACE SCHEDULE**
  - SPACE UTILIZATION AND REUSE OVER TIME
  - MATERIALS LAYDOWN AREAS, DELIVERY TIMES
  - EQUIPMENT SELECTION, STORAGE AND OPERATING SPACE
- **MONEY (CASH FLOW) SCHEDULE**
  - SHOWS MONEY COMING AND GOING OUT OVER TIME
  - DIFFERENCE IS AVAILABLE CASH (OR DEFICIT THAT MUST BE FINANCED)
  - DEPENDS ON ALL OTHER SCHEDULES
- IN REALITY ALL SCHEDULES ARE CREATED AT THE SAME TIME
- ITERATIONS AND ADJUSTMENTS ARE NEEDED TO ARRIVE AT FINAL SCHEDULES

#	Operation	Dur. (Days)	Quantity Amt	Quantity Unit
1	Demolition	8	Sub	—
2	Foundations	14	18	C.Y.
3	Underground services	6	Sub	—
4	Rough mechanical and electrical	12	Sub	—
5	Structural steel	5	50	Ton
6	Exterior walls	12	4000	S.F.
7	Roof	6	5000	S.F.
8	First floor slab	4	100	C.Y.
9	Second floor slab	6	125	C.Y.
10	Finish mechanical and electrical	12	Sub	—
11	Interior partitions	10	3500	S.F.
12	Paint	8	13,000	S.F.

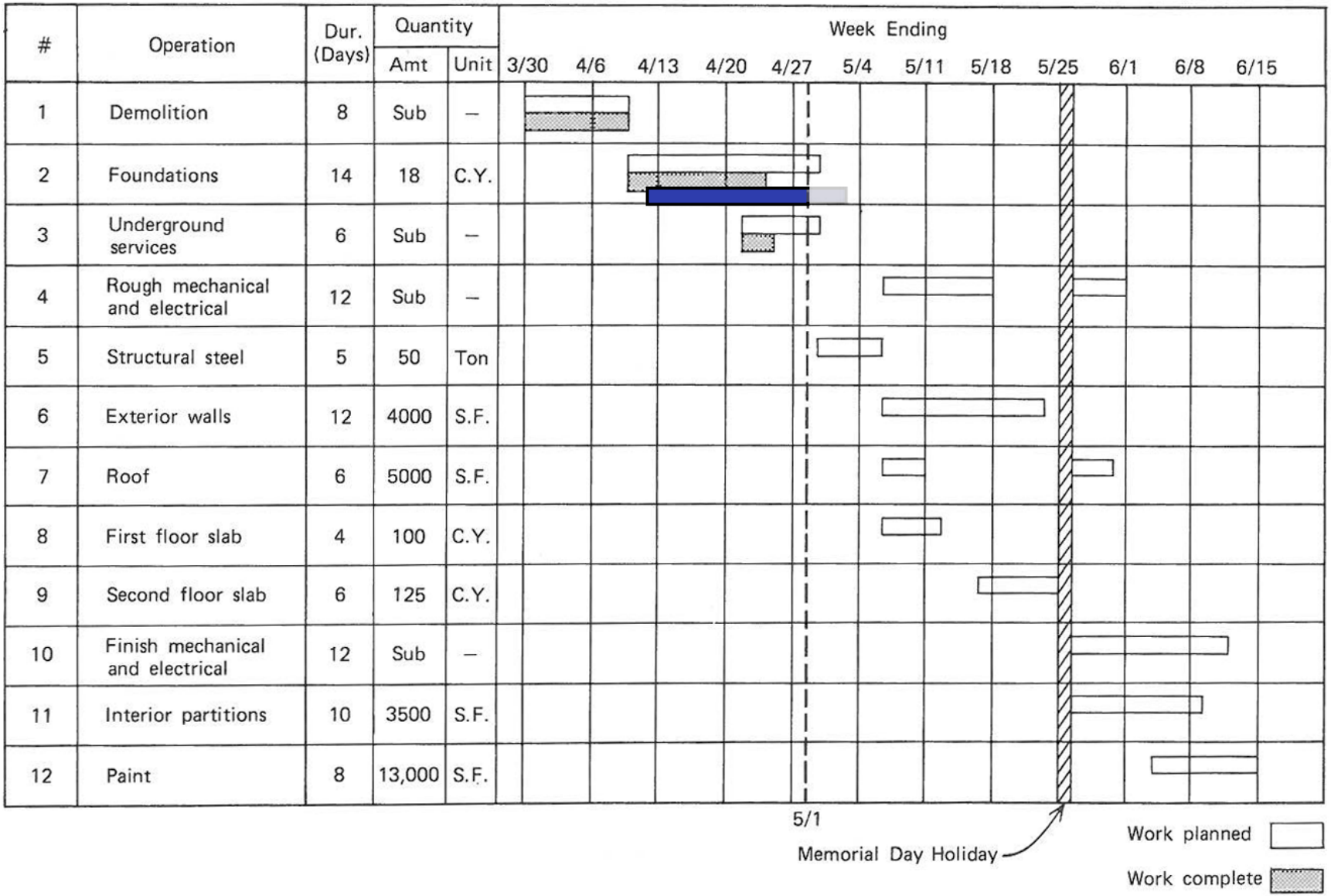

Figure 1.1 Construction schedule—building addition, XYZ Company.

Designing the Schedule Plan 9

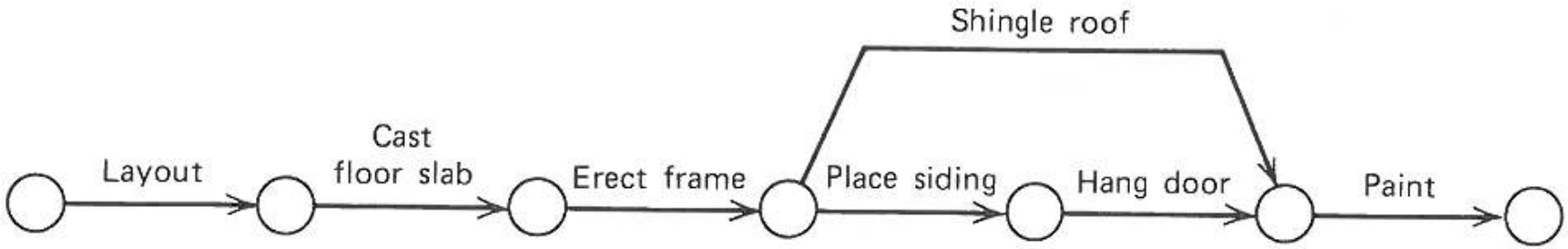

Figure 1.2 Arrow diagram for a small garage.

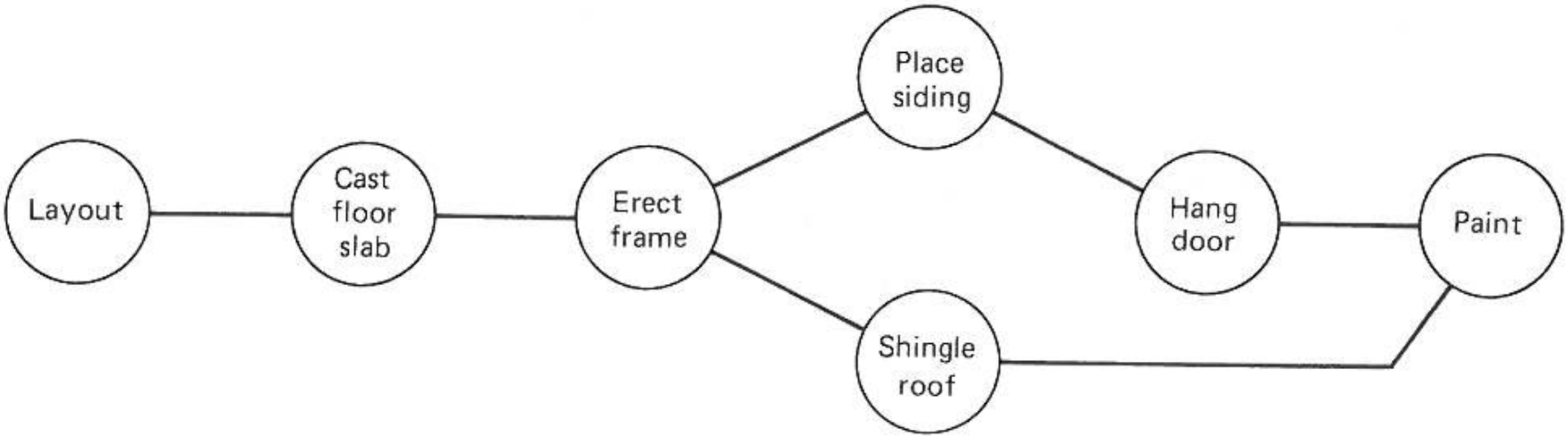

Figure 1.3 Precedence diagram for a small garage.

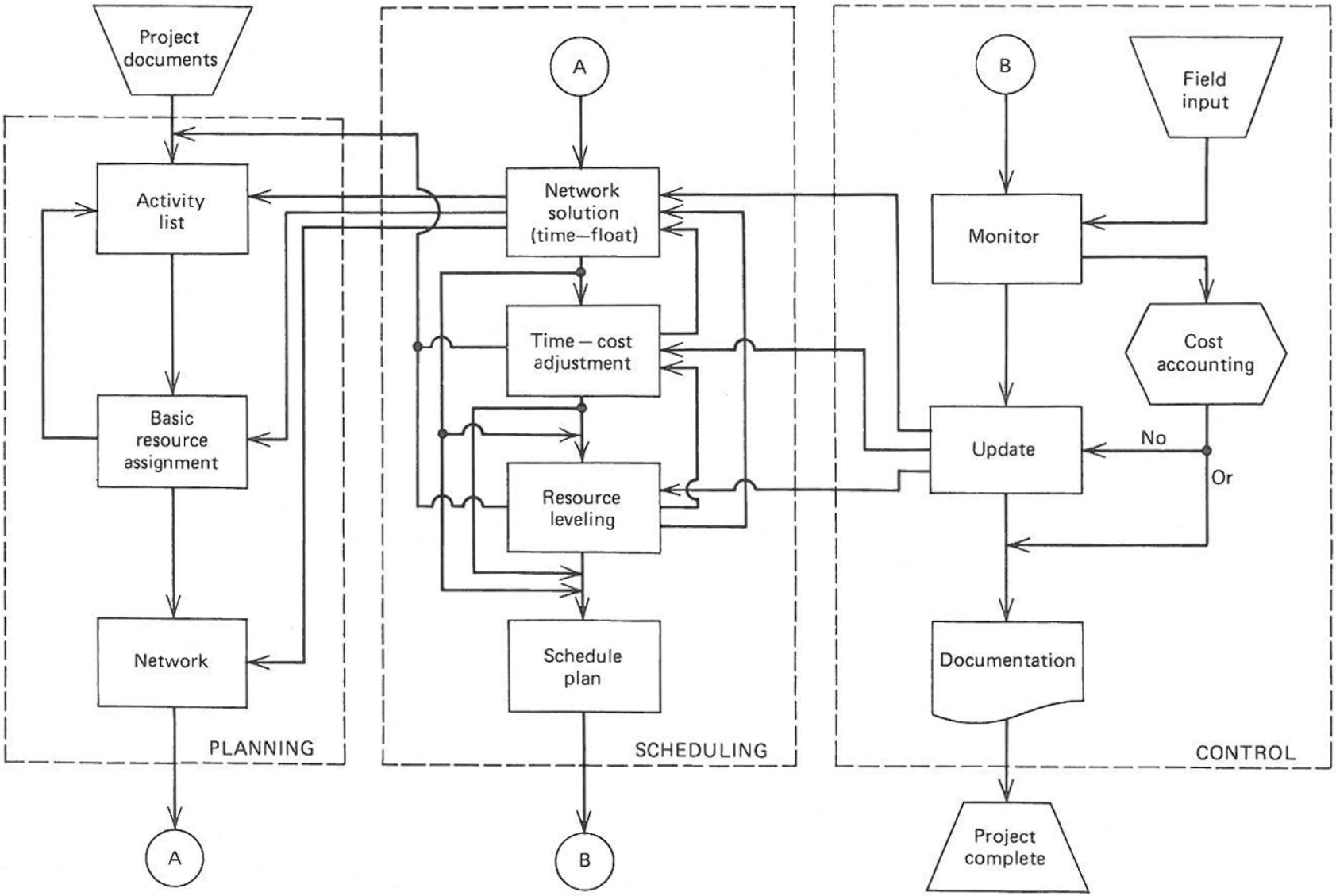

Figure 1.4 The three phases of a critical path networking system.