Chapter 3 프로젝트 관리 (Project Scheduling(PERT/CPM))

usually used for non-repetitive jobs such as building or road construction and ship building

* 개발 project의 유형(pp.57-58, <도표 3-1>)

<1> Introduction

(1) Project management

① Project : a series of related jobs usually directed toward some major output and requiring a significant period of time to perform

- Work breakdown structure (<도표 3-2, 3-3>) :
  project, task, subtask, work package, activity

② Project management : management activities of planning, directing, and controlling resources to meet the technical, cost, and time constraints of a project

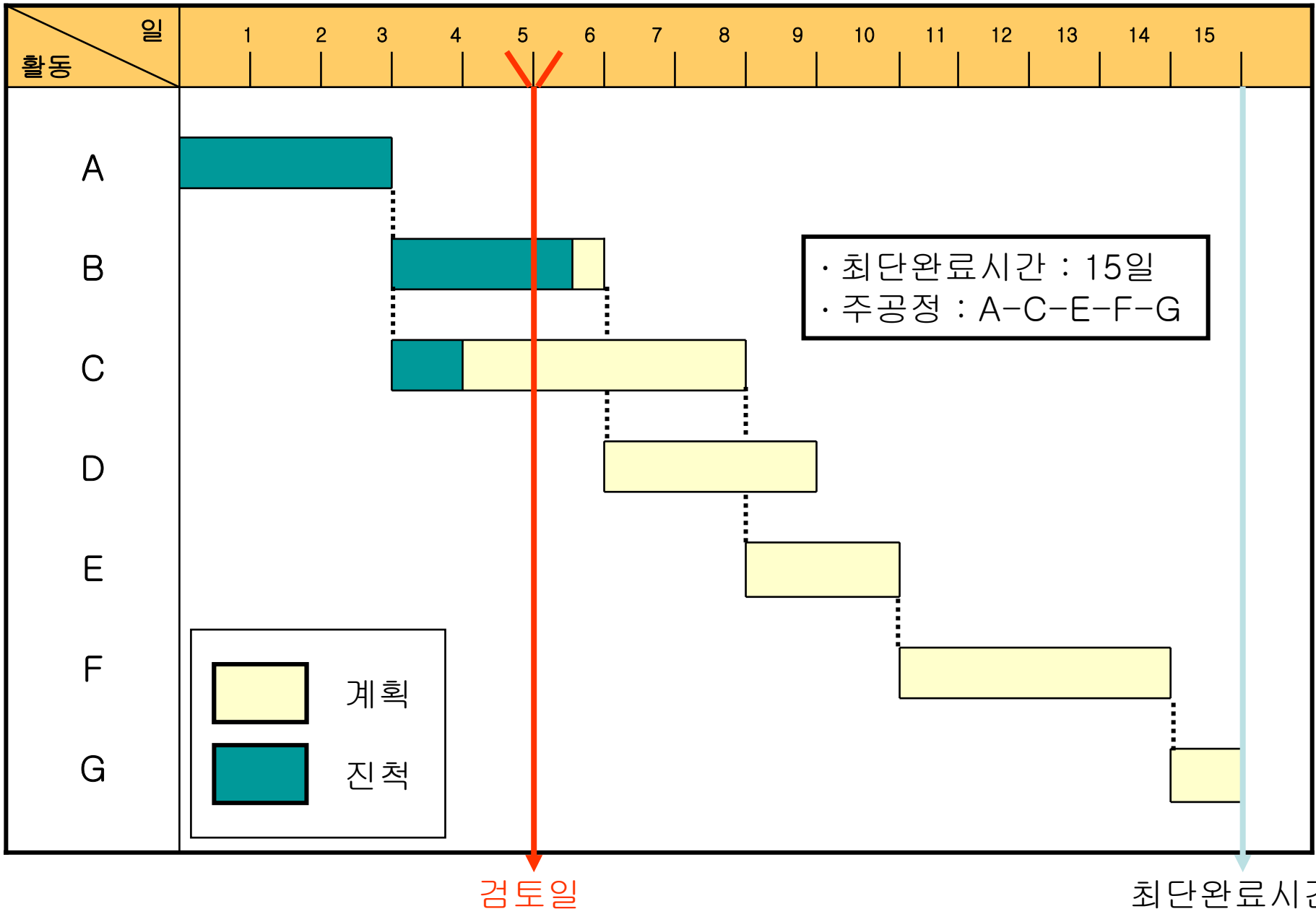
③ Project control charts : <도표 3-4>

*Gantt Chart : shows planned and actual progress for a number of tasks displayed against a horizontal time scale

(예)

활 동	내 용	활동시간(일)	직전 선행활동
A	제품 설계	3	-
B	중간조립품 X 제작	3	A
C	중간조립품 Y 제작	5	A
D	중간조립품 X 시험	3	B
E	중간조립품 Y 시험	2	C
F	최종조립	4	D, E
G	시험작동	1	F

■ 신제품 시생산 프로젝트의 간트도



(2)Organizational structure (pp.58-62)

① Pure project (project organization)
② Functional project (functional organization)
③ Matrix project (matrix organization) : multiple command system

<2> Network-Planning Models

(1) History

•PERT (Program Evaluation and Review Technique) :

U.S. Navy in 1958.(R&D tools for the Polaris Missiles)

- probabilistic activity times
- estimates overall project duration and derives a measure of certainty of meeting the estimate through probabilistic estimation of activity times

•CPM (Critical Path Method) :

DuPont, Inc.(Basis for time & cost estimates of the project for construction industry)

- deterministic activity times
- considers duration estimates over a range of cost levels, and as a result, provides a range of project duration with an associated range of project costs

* PERT and CPM assume there is infinite amount of resources available at any time)

(2)Terms

.Activity : a time-consuming effort required to complete a necessary segment of the project

.Precedence : describes the relationships between two or more activities (immediate predecessors)

.Path : 출발단계에서 최종단계에 이르는 어떤 활동들을 순서대로 연결한 것

.Critical activity : activity, if delayed, will delay the completion of the project (slack time = 0)

.Critical path : sequence of critical activities that connect the project's start and finish events → project completion time

(3)Network Diagramming

① Activity-on-Arc (A-on-A) representation

Activities are represented by arcs in the project network, & events are represented by nodes

② Activity-on-Node (A-on-N) representation

Nodes represent activities, & arcs represent precedence relationships in the project network

(ex) <도표 3-5>

<3> Critical Path Method (CPM)

* Enumeration

(1) CPM with a single time estimate

① ES, EF

- Earliest start time (ES): earliest possible time the activity can begin
- Earliest finish time (EF): earliest possible time the activity can be completed

$$EF = ES + (\text{duration of the activity})$$

** Project duration: $\max_{\text{activities}} \{ EF_{\text{activity}} \}$

t_i: duration of activity i

B_i: set of immediate predecessors of activity i

$ES_i = \max_{j \in Bi} EF_j$

$EF_i = ES_i + t_i$

② LS, LF

- Latest start time (LS):latest time an activity can start without delaying project's completion

- Latest finish time (LF): LF = LS + {duration of the activity}

  LS = ES, LF = EF for the activity that has max EF

A_i: the set of immediate successors of activity i

$LF_i = \min_{j \in Ai} LS_j$ where

$LS_i = LF_i - t_i$

③ Slack Time

- Total slack (TS): maximum time that an activity can be delayed without delaying total completion of the project

$TSi = LSi - ESi = LFi - EFi$

④ Critical Path

- Critical activities: activities that have zero total slack
- Critical path: a path from source to sink through critical activities

(ex) <도표 3-55>

(2) CPM with Three Activity time estimates (pp. 72-75)

- allows uncertainties of activity time (probabilistic network)

① Three duration(time) estimate for each activity

Assume that the uncertainty of each activity's may be described by a beta distribution.

- Optimistic time estimate (*a*): shortest conceivable time under the best possible circumstances
- Most likely time estimate (*m*): most probable time under normal conditions
- Pessimistic time estimate (*b*): time required under worst possible circumstances

Then,

- Expected activity time: (from the assumption of beta distribution)

$$\text{Expected Activity time, } t_e = \frac{a + 4m + b}{6}$$

- Standard deviation of activity time :

$$\text{Activity variance, } \sigma_t^2 = \left(\frac{b - a}{6}\right)^2$$

(ex) <도표 3-7>

② Obtaining CP

Network can be constructed with the same method as in CPM

Project completion time (T)
(using the CLT(under the assumption that activity times are mutually independent))

- follows a normal distribution with
  mean (μ_T) = the sum of t_e of the activities on the critical path
  variance (σ^2_T)= the sum of σ^2_t of the activities on the critical path

$$T \sim N (\mu_T , \sigma^2_T)$$

(i) Probability that the project can be completed by the time D ?

Calculate $$Z = \frac{D - \mu_T}{\sigma_T}$$

Find the probability from the standard normal distribution function table.

(ii) Project completion time that can be achieved with probability p ?

(ex) 예제 3-2

- What is the Probability that the project can be completed within 35 weeks?

- 90%의 확률로 끝낼 수 있는 D 는?

(3) Time-Cost Models in CPM (pp. 76-80)

- Duration of activities can be reduced with additional cost
- Total project costs are the sum of direct & indirect cost
  - Activity direct cost: project 완료기간과 반비례
  - Project indirect cost: project 완료기간과 비례

Problems

What is the optimal cost duration for the project?

Given a due date for the project, what is the minimum cost decision to meet the due date?

Given a budget for the project, what is the earliest completion time of the project?

① Duration/Cost estimates

- Normal time & Normal cost (정상시간, 정상비용; NT, NC): requiring the least amount of money
- Crash time & Crash cost (긴급시간, 긴급비용; CT, CC): minimum possible time for an activity and corresponding cost

Then, cost-time **slope** for an activity i (activity i 를 단위시간 줄이는데 드는 비용, 비용구배)

$$\text{Slope}_i = \frac{CC - NC}{NT - CT}$$

<도표 3-10>

② Which activities should be crashed? By how much?

(an activity with the minimum crashing cost per unit time, an activity on the critical path)

(Minimum Cost Expediting Method (MCX법)

Step 1. Determine the normal schedule (identify critical path)
Step 2. Compute cost change per unit time for each activity.
Step 3. Reduce the schedule (duration of the project) by one time unit comparing $Slope_i$ of activities on the critical path and crashing one with minimum $Slope_i$
Step 4. If there is no more activity to be crashed, stop. Otherwise, go back to Step 3.

(ex) PP.76-80