Project Management

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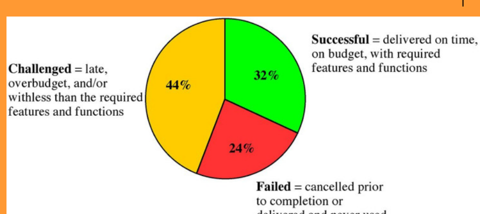
Why Project Management?

- 1/4th of world GDP (10 trillion of 40 trillion) is generated from projects
- More than $100 billion a year wasted on terminated projects in the last decade
- For projects that were not completed on time, they were 225% over their intended completion date.

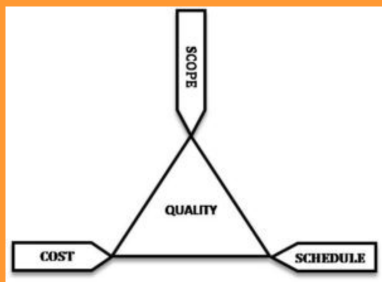
Bureau of Economic Analysis, US Department of Commerce, (2001)

Why Project Management?



CHAOS report Standish Group (2009)

What Project Management



TRIPLE CONSTRAINT TRIANGLE

Project Scheduling

- The *program evaluation and review technique* (*PERT*) and the *critical path method* (*CPM*) are two popular quantitative analysis techniques to help plan, schedule, monitor, and control projects
- Originally the approaches differed in how they estimated activity times
- CPM was a more deterministic technique
- used three time estimates to develop a probabilistic estimate of completion time
- They have become so similar they are commonly considered one technique, PERT/CPMPERT

Purpose of CPM/PERT

- Identify the Critical Activities in a major
- Any delay in these activities can delay the completion of the project

Six Steps of PERT/CPM

1. Define the project and all of its significant activities or tasks
2. Develop the relationships among the activities and decide which activities must precede others
3. Draw the network connecting all of the activities
4. Assign time and/or cost estimates to each activity
5. Compute the longest time path through the network; this is called the *critical path*
6. Use the network to help plan, schedule, monitor, and control the project

General Foundry CASE for PERT/CPM

- General Foundry, Inc. has long been trying to avoid the expense of installing air pollution control equipment
- The local environmental protection agency has recently given the foundry 16 weeks to install a complex air filter system on its main smokestack
- General Foundry was warned that it will be forced to close unless the device is installed in the allotted period
- They want to make sure that installation of the filtering system progresses smoothly and on time

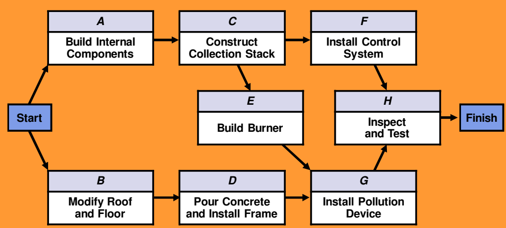
General Foundry Example of PERT/CPM

- Activities and immediate predecessors for General Foundry

ACTIVITY	DESCRIPTION	IMMEDIATE PREDECESSORS
A	Build internal components	—
B	Modify roof and floor	—
C	Construct collection stack	*A*
D	Pour concrete and install frame	*B*
E	Build high-temperature burner	*C*
F	Install control system	*C*
G	Install air pollution device	*D, E*
H	Inspect and test	*F, G*

General Foundry Example of PERT/CPM

- Network for General Foundry



Activity Times

- Time estimates (weeks) for General Foundry

ACTIVITY	OPTIMISTIC, a	MOST PROBABLE, m	PESSIMISTIC, b	EXPECTED TIME, $t = [(a + 4m + b)/6]$	VARIANCE, $[(b - a)/6]^2$
A	1	2	3	2	4/36
B	2	3	4	3	4/36
C	1	2	3	2	4/36
D	2	4	6	4	16/36
E	1	4	7	4	36/36
F	1	2	9	3	64/36
G	3	4	11	5	64/36
H	1	2	3	2	4/36
				25	

How to Find the Critical Path

- To find the critical path, need to determine the following quantities for each activity in the network

1. *Earliest start time* (*ES*): the earliest time an activity can begin without violation of immediate predecessor requirements
2. *Earliest finish time* (*EF*): the earliest time at which an activity can end
3. *Latest start time* (*LS*): the latest time an activity can begin without delaying the entire project
4. *Latest finish time* (*LF*): the latest time an activity can end without delaying the entire project

How to Find the Critical Path

- In the nodes, the activity time and the early and late start and finish times are represented in the following manner

ACTIVITY	t
ES	EF
LS	LF

- **Earliest times are computed as**

Earliest finish time = Earliest start time + Expected activity time

EF = ES + t

Earliest start = Largest of the earliest finish times of immediate predecessors

ES = Largest EF of immediate predecessors

How to Find the Critical Path

- Latest times are computed as

Latest start time = Latest finish time – Expected activity time

LS = LF – t

Latest finish time = Smallest of latest start times for following activities

LF = Smallest LS of following activities

- **For activity *H***

LS = LF – t = 15 – 2 = 13 weeks

How to Find the Critical Path

- Once ES, LS, EF, and LF have been determined, it is a simple matter to find the amount of *slack time* that each activity has

Slack = LS – ES, or Slack = LF – EF

- From Table 13.3 we see activities *A*, *C*, *E*, *G*, and *H* have no slack time
- These are called *critical activities* and they are said to be on the *critical path*
- The total project completion time is 15 weeks
- Industrial managers call this a boundary timetable

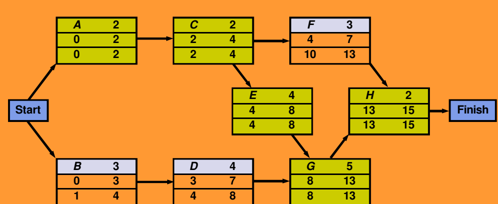
How to Find the Critical Path

- General Foundry's schedule and slack times

ACTIVITY	EARLIEST START, ES	EARLIEST FINISH, EF	LATEST START, LS	LATEST FINISH, LF	SLACK, LS – ES	ON CRITICAL PATH?
A	0	2	0	2	0	Yes
B	0	3	1	4	1	No
C	2	4	2	4	0	Yes
D	3	7	4	8	1	No
E	4	8	4	8	0	Yes
F	4	7	10	13	6	No
G	8	13	8	13	0	Yes
H	13	15	13	15	0	Yes

How to Find the Critical Path

- General Foundry's critical path



Sensitivity Analysis and Project Management

- The time required to complete an activity can vary from the projected or expected time
- If the activity is on the critical path, the completion time of the project will change
- This will also have an impact on ES, EF, LS, and LF times for other activities
- The exact impact depends on the relationship between the various activities
- A *predecessor activity* is one that must be accomplished before the given activity can be started
- A *successor activity* is one that can be started only after the given activity is finished

PERT/COST

- Although PERT is an excellent method of monitoring and controlling project length, it does not consider the very important factor of project cost
- *PERT/Cost* is a modification of PERT that allows a manager to plan, schedule, monitor, and control cost as well as time
- Using PERT/Cost to plan, schedule, monitor, and control project cost helps accomplish the sixth and final step of PERT

Four Steps of the Budgeting Process

1. Identify all costs associated with each of the activities then add these costs together to get one estimated cost or budget for each activity
2. In large projects, activities can be combined into larger work packages. A *work package* is simply a logical collection of activities.
3. Convert the budgeted cost per activity into a cost per time period by assuming that the cost of completing any activity is spent at a uniform rate over time
4. Using the ES and LS times, find out how much money should be spent during each week or month to finish the project by the date desired

Monitoring and Controlling Project Costs

- Costs are monitored and controlled to ensure the project is progressing on schedule and that cost overruns are kept to a minimum
- The status of the entire project should be checked periodically
- The following table shows the state of the project in the sixth week
- It can be used the answer questions about the schedule and costs so far

Monitoring and Controlling Project Costs

- The value of work completed, or the cost to date for any activity, can be computed as follows

Value of work completed = (Percentage of work complete) x (Total activity budget)

- **The activity difference is also of interest**

Activity difference = Actual cost – Value of work completed

- **A negative activity difference is a cost underrun and a positive activity difference is a cost overrun**

Project Crashing

- Projects will sometimes have deadlines that are impossible to meet using normal procedures
- By using exceptional methods it may be possible to finish the project in less time than normally required
- However, this usually increases the cost of the project
- Reducing a project's completion time is called *crashing*

Project Crashing

- Crashing a project starts with using the *normal time* to create the critical path
- The *normal cost* is the cost for completing the activity using normal procedures
- If the project will not meet the required deadline, extraordinary measures must be taken
- The *crash time* is the shortest possible activity time and will require additional resources
- The *crash cost* is the price of completing the activity in the earlier-than-normal time

Four Steps to Project Crashing

1. Find the normal critical path and identify the critical activities
2. Compute the crash cost per week (or other time period) for all activities in the network using the formula

$$\text{Crash cost/Time period} = \frac{\text{Crash cost} - \text{Normal cost}}{\text{Normal time} - \text{Crash time}}$$

Four Steps to Project Crashing

3. Select the activity on the critical path with the smallest crash cost per week and crash this activity to the maximum extent possible or to the point at which your desired deadline has been reached
4. Check to be sure that the critical path you were crashing is still critical. If the critical path is still the longest path through the network, return to step 3. If not, find the new critical path and return to step 2.