Operations Management

Chapter 3 – Project Management

Outline

- Profil Global Perusahaan: Bechtel Group
- Pentingnya Manajemen Proyek
- Perencanaan Proyek
  - Manajemen Proyek
  - Struktur Pemecahan Pekerjaan (Work Breakdown)
- Skedul Proyek

Outline - Continued

- Pengendalian Proyek
- Teknik Mengelola Proyek: PERT and CPM
  - The Framework of PERT and CPM
  - Network Diagrams and Approaches
  - Activity-on-Node Example
  - Activity-on-Arrow Example
Menentukan Skedul Proyek
  □ Forward Pass
  □ Backward Pass
  □ Calculating Slack Time and Identifying the Critical Path(s)

Variasi Waktu Kegiatan

Three Time Estimates in PERT
  □ Probability of Project Completion

Cost-Time Trade-Offs and Project Crashing

Kritik Terhadap PERT and CPM

Menggunakan Microsoft Project Mengelola Proyek
  □ Creating a Project Schedule Using MS Project
  □ Tracking Progress and Managing Costs Using MS Project

When you complete this chapter you should be able to:

1. Menciptakan Struktur Pemecahan Pekerjaan.
2. Draw AOA and AON networks
3. Complete both forward and backward passes for a project
4. Determine a critical path
Learning Objectives

When you complete this chapter you should be able to:

5. Calculate the variance of activity times
6. Crash a project
7. Use Microsoft Project software to create a project

Bechtel Projects

- Building 26 massive distribution centers in just two years for the Internet company Webvan Group ($1 billion)
- Constructing 30 high-security data centers worldwide for Equinix, Inc. ($1.2 billion)
- Building and running a rail line between London and the Channel Tunnel ($4.6 billion)
- Developing an oil pipeline from the Caspian Sea region to Russia ($850 million)
- Expanding the Dubai Airport in the UAE ($600 million), and the Miami Airport in Florida ($2 billion)
- Building liquid natural gas plants in Yemen ($2 billion) and in Trinidad, West Indies ($1 billion)
- Building a new subway for Athens, Greece ($2.6 billion)
- Constructing a natural gas pipeline in Thailand ($700 million)
- Building 30 plants for iMotors.com, a company that sells refurbished autos online ($300 million)
- Building a highway to link the north and south of Croatia ($303 million)
Strategic Importance of Project Management

- **Microsoft Windows Vista Project:**
  - hundreds of programmers
  - millions of lines of code
  - hundreds of millions of dollars cost

- **Hard Rock Cafe Rockfest Project:**
  - 100,000 + fans
  - planning began 9 months in advance

Karakteristik Proyek

- **Satu Unit**
- **Banyak kegiatan berkaitan.**
- **Sulit perencanaan produksi dan perencanaan persediaan.**
- **Peralatan yang digunakan secara umum.**
- **Tenaga kerja dengan skill yang tinggi.**

Contoh Proyek

- **Building Construction**
- **Research Project**
1. **Planning** - goal setting, defining the project, team organization

2. **Scheduling** - relates people, money, and supplies to specific activities and activities to each other

3. **Controlling** - monitors resources, costs, quality, and budgets; revises plans and shifts resources to meet time and cost demands

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**Kegiatan Pengelolaan Proyek**

- **Planning**
  - Objectives
  - Resources
  - Work break-down schedule
  - Organization

- **Scheduling**
  - Project activities
  - Start & end times
  - Network

- **Controlling**
  - Monitor, compare, revise, action

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**Project Planning, Scheduling, and Controlling**

**Planning the Project**

- Performance
- Set the goals
- Define the project

**Develop work breakdown schedule**

**Identify team/ resources**

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Figure 3.1

<table>
<thead>
<tr>
<th>Before project</th>
<th>Start of project</th>
<th>During project</th>
</tr>
</thead>
<tbody>
<tr>
<td>Timeline</td>
<td>Timeline</td>
<td>Timeline</td>
</tr>
</tbody>
</table>
Figure 3.1

- Before Start of project
- During project
- Timeline
- Budgets
- Delays activities report
- Slack activities report

- Time/cost estimates
- Engineering diagrams
- Cash flow charts
- Material availability details

- CPM/PERT
- Gantt charts
- Milestone charts
- Cash flow schedules

Perencanaan Proyek

- Menyatakan tujuan
- Mendefinisikan Proyek
- Memecah Struktur pekerjaan
- Menentukan Sumberdaya
- Membentuk Organisasi

Mengorganisasi Proyek

- Strukturnya sering temporer
- Menggunakan ahli dari seluruh perusahaan.
- Dipimpim Manajer Proyek
  - Coordinates activities
  - Monitors schedule and costs
- Strukturnya organisasi permanen dengan ‘matrix organization’
Contoh Organisasi Proyek

Organisasi Proyek Terbaik Bila:

1. Pekerjaan didefinisikan de tujuan spesifik dan dibatasi waktu.
2. Pekerjaannya unik, relatif unik terhadap organisasi secara keseluruhan.
3. Pekerjaan berisikan tugas yang bertalian satu dengan lainnya dan membutuhkan skill khusus.
4. Proyek sifatnya temporer terhadap organisasi.
5. Proyek melintasi garis-garis organisasi.

Organisasi Matriks
**The Role of the Project Manager**

**Bertanggungjawab dan memastikan hal berikut.**

- Semua kegiatan siap sesuai dengan urutan dan waktu.
- Proyek dan biaya yang d harus disiapkan.
- Proyek memenuhi tujuan kualitas.
- Orang yang ditugasi sehingga menerima motivasi, pengarahan, dan informasi.

**The Role of the Project Manager**

**Highly visible**

**Responsible for making sure that:**

- Pelatih yang baik
- Komunikator yang
- Mampu mengorganisir dari berbagai disiplin ilmu.

**Ethical Issues**

- Bid rigging – divulging confidential information to give some bidders an unfair advantage
- “Low balling” contractors – try to “buy” the project by bidding low and hope to renegotiate or cut corners
- Bribery – particularly on international projects
- Expense account padding
- Use of substandard materials
- Compromising health and safety standards
- Withholding needed information
- Failure to admit project failure at close
Work Breakdown Structure

Level
1. Project
2. Major tasks in the project
3. Subtasks in the major tasks
4. Activities (or work packages) to be completed

Figure 3.3

<table>
<thead>
<tr>
<th>Level</th>
<th>Level ID Number</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.0</td>
<td>Develop/launch Windows Vista OS</td>
</tr>
<tr>
<td>2</td>
<td>1.1</td>
<td>Develop of GUIs</td>
</tr>
<tr>
<td>2</td>
<td>1.2</td>
<td>Ensure compatibility with earlier Windows versions</td>
</tr>
<tr>
<td>3</td>
<td>1.21</td>
<td>Compatibility with Windows ME</td>
</tr>
<tr>
<td>3</td>
<td>1.22</td>
<td>Compatibility with Windows XP</td>
</tr>
<tr>
<td>3</td>
<td>1.23</td>
<td>Compatibility with Windows 2000</td>
</tr>
<tr>
<td>4</td>
<td>1.231</td>
<td>Ensure ability to import files</td>
</tr>
</tbody>
</table>

Project Scheduling

☑ Identifying precedence relationships
☑ Sequencing activities
☑ Determining activity times & costs
☑ Estimating material & worker requirements
☑ Determining critical activities
Purposes of Project Scheduling

1. Shows the relationship of each activity to others and to the whole project
2. Identifies the precedence relationships among activities
3. Encourages the setting of realistic time and cost estimates for each activity
4. Helps make better use of people, money, and material resources by identifying critical bottlenecks in the project

Scheduling Techniques

1. Ensure that all activities are planned for
2. Their order of performance is accounted for
3. The activity time estimates are recorded
4. The overall project time is developed

Project Management Techniques

- Gantt chart
- Critical Path Method (CPM)
- Program Evaluation and Review Technique (PERT)
A Simple Gantt Chart

Time
J  F  M  A  M  J  J  A  S

Design
Prototype
Test
Revise
Production

Service For A Delta Jet

Passengers
- Deplaning
- Baggage
- Fueling
- Cargo and mail
- Galley servicing
- Luggage servicing
- Drinking water
- Cabin cleaning
- Loading
- Service for passengers
- Loading
- Boarding

Cargo and mail
- Deplaning
- Baggage
- Fueling
- Cargo and mail
- Flight services
- Loading
- Service for passengers
- Loading
- Boarding

Project Control Reports

- Detailed cost breakdowns for each task
- Total program labor curves
- Cost distribution tables
- Functional cost and hour summaries
- Raw materials and expenditure forecasts
- Variance reports
- Time analysis reports
- Work status reports
**Network techniques**
- Developed in 1950's
  - CPM by DuPont for chemical plants (1957)
  - PERT by Booz, Allen & Hamilton with the U.S. Navy, for Polaris missile (1958)
- Consider precedence relationships and interdependencies
- Each uses a different estimate of activity times

**Six Steps PERT & CPM**
1. Define the project and prepare the work breakdown structure
2. Develop relationships among the activities - decide which activities must precede and which must follow 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
Questions PERT & CPM Can Answer

1. When will the entire project be completed?
2. What are the critical activities or tasks in the project?
3. Which are the noncritical activities?
4. What is the probability the project will be completed by a specific date?

Questions PERT & CPM Can Answer

5. Is the project on schedule, behind schedule, or ahead of schedule?
6. Is the money spent equal to, less than, or greater than the budget?
7. Are there enough resources available to finish the project on time?
8. If the project must be finished in a shorter time, what is the way to accomplish this at least cost?

A Comparison of AON and AOA Network Conventions

<table>
<thead>
<tr>
<th>Activity on Node (AON)</th>
<th>Activity on Arrow (AOA)</th>
</tr>
</thead>
</table>
| A comes before B, which comes before C | A 
  B
  C |
| A and B must both be completed before C can start | A
  B
  C |
| B and C cannot begin until A is completed | A
  B
  C |

Figure 3.5
A Comparison of AON and AOA Network Conventions

<table>
<thead>
<tr>
<th>Activity on Node (AON)</th>
<th>Activity Meaning</th>
<th>Activity on Arrow (AOA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(d)</td>
<td>C and D cannot begin until both A and B are completed</td>
<td>![Diagram of AON and AOA for (d)]</td>
</tr>
<tr>
<td>(e)</td>
<td>C cannot begin until both A and B are completed; D cannot begin until B is completed. A dummy activity is introduced in AOA</td>
<td>![Diagram of AON and AOA for (e)]</td>
</tr>
</tbody>
</table>

AON Example

Milwaukee Paper Manufacturing’s Activities and Predecessors

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
<th>Immediate Predecessors</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Build internal components</td>
<td>—</td>
</tr>
<tr>
<td>B</td>
<td>Modify roof and floor</td>
<td>—</td>
</tr>
<tr>
<td>C</td>
<td>Construct collection stack</td>
<td>A</td>
</tr>
<tr>
<td>D</td>
<td>Pour concrete and install frame</td>
<td>A, B</td>
</tr>
<tr>
<td>E</td>
<td>Build high-temperature burner</td>
<td>C</td>
</tr>
<tr>
<td>F</td>
<td>Install pollution control system</td>
<td>C</td>
</tr>
<tr>
<td>G</td>
<td>Install air pollution device</td>
<td>B, E</td>
</tr>
<tr>
<td>H</td>
<td>Inspect and test</td>
<td>F, G</td>
</tr>
</tbody>
</table>

Table 3.1
AON Network for Milwaukee Paper

Activity A
(Build Internal Components)

Activity B
(Modify Roof and Floor)

Figure 3.6

AON Network for Milwaukee Paper

Activity A Precedes Activity C

Activities A and B Precede Activity D

Figure 3.7

AON Network for Milwaukee Paper

Arrows Show Precedence Relationships

Figure 3.8
Perform a Critical Path Analysis

- The critical path is the longest path through the network
- The critical path is the shortest time in which the project can be completed
- Any delay in critical path activities delays the project
- Critical path activities have no slack time

<table>
<thead>
<tr>
<th>Activity</th>
<th>Description</th>
<th>Time (weeks)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Build internal components</td>
<td>2</td>
</tr>
<tr>
<td>B</td>
<td>Modify roof and floor</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>Construct collection stack</td>
<td>2</td>
</tr>
<tr>
<td>D</td>
<td>Pour concrete and install frame</td>
<td>4</td>
</tr>
<tr>
<td>E</td>
<td>Build high-temperature burner</td>
<td>4</td>
</tr>
<tr>
<td>F</td>
<td>Install pollution control system</td>
<td>3</td>
</tr>
<tr>
<td>G</td>
<td>Install air pollution device</td>
<td>5</td>
</tr>
<tr>
<td>H</td>
<td>Inspect and test</td>
<td>2</td>
</tr>
</tbody>
</table>

Total Time (weeks) 25

Table 3.2
Perform a Critical Path Analysis

Earliest start (ES) = earliest time at which an activity can start, assuming all predecessors have been completed

Earliest finish (EF) = earliest time at which an activity can be finished

Latest start (LS) = latest time at which an activity can start so as to not delay the completion time of the entire project

Latest finish (LF) = latest time by which an activity has to be finished so as to not delay the completion time of the entire project

Figure 3.10

Activity Name or Symbol
ES
EF
Latest Start
Latest Finish
Activity Duration

Forward Pass

Begin at starting event and work forward

Earliest Start Time Rule:

☑ If an activity has only a single immediate predecessor, its ES equals the EF of the predecessor

☑ If an activity has multiple immediate predecessors, its ES is the maximum of all the EF values of its predecessors

ES = Max {EF of all immediate predecessors}
Forward Pass

Begin at starting event and work forward

Earliest Finish Time Rule:

- The earliest finish time (EF) of an activity is the sum of its earliest start time (ES) and its activity time

\[ EF = ES + \text{Activity time} \]

ES/EF Network for Milwaukee Paper

EF of A = ES of A + 2
ES/EF Network for Milwaukee Paper

EF of B = ES of B + 3

EF of B = Max (2, 3)
Backward Pass

Begin with the last event and work backwards

Latest Finish Time Rule:

☑️ If an activity is an immediate predecessor for just a single activity, its LF equals the LS of the activity that immediately follows it

☑️ If an activity is an immediate predecessor to more than one activity, its LF is the minimum of all LS values of all activities that immediately follow it

$$ LF = \text{Min} \{\text{LS of all immediate following activities}\} $$
Backward Pass

Begin with the last event and work backwards

Latest Start Time Rule:

- The latest start time (LS) of an activity is the difference of its latest finish time (LF) and its activity time

\[ LS = LF - \text{Activity time} \]

LS/LF Times for Milwaukee Paper

\[ LF = \text{Min}(LS \text{ of following activity}) \]

LF = EF of Project
LS/LF Times for Milwaukee Paper

- \( LF = \min(4, 10) \)

Computing Slack Time

After computing the ES, EF, LS, and LF times for all activities, compute the slack or free time for each activity.

- Slack is the length of time an activity can be delayed without delaying the entire project.

\[
\text{Slack} = \text{LS} - \text{ES} \quad \text{or} \quad \text{Slack} = \text{LF} - \text{EF}
\]
#### Computing Slack Time

<table>
<thead>
<tr>
<th>Activity</th>
<th>Earliest Start</th>
<th>Earliest Finish</th>
<th>Latest Start</th>
<th>Latest Finish</th>
<th>Slack</th>
<th>Critical Path</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>Yes</td>
</tr>
<tr>
<td>B</td>
<td>0</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>No</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>Yes</td>
</tr>
<tr>
<td>D</td>
<td>3</td>
<td>7</td>
<td>4</td>
<td>8</td>
<td>1</td>
<td>No</td>
</tr>
<tr>
<td>E</td>
<td>4</td>
<td>8</td>
<td>4</td>
<td>8</td>
<td>0</td>
<td>Yes</td>
</tr>
<tr>
<td>F</td>
<td>4</td>
<td>7</td>
<td>10</td>
<td>13</td>
<td>6</td>
<td>No</td>
</tr>
<tr>
<td>G</td>
<td>8</td>
<td>13</td>
<td>8</td>
<td>13</td>
<td>0</td>
<td>Yes</td>
</tr>
<tr>
<td>H</td>
<td>13</td>
<td>15</td>
<td>13</td>
<td>15</td>
<td>0</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 3.3

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#### Critical Path for Milwaukee Paper

![Critical Path Diagram]

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#### ES – EF Gantt Chart for Milwaukee Paper

![Gantt Chart Diagram]

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- A: Build internal components
- B: Modify roof and floor
- C: Construct collection stack
- D: Pour concrete and install frame
- E: Build high-temperature burner
- F: Install pollution control system
- G: Install air pollution device
- H: Inspect and test
**Variability in Activity Times**

- CPM assumes we know a fixed time estimate for each activity and there is no variability in activity times
- PERT uses a probability distribution for activity times to allow for variability

**Variability in Activity Times**

- Three time estimates are required
  - Optimistic time (a) – if everything goes according to plan
  - Pessimistic time (b) – assuming very unfavorable conditions
  - Most likely time (m) – most realistic estimate
Variability in Activity Times

Estimate follows beta distribution

Expected time:
\[ t = \frac{(a + 4m + b)}{6} \]

Variance of times:
\[ \sigma^2 = \left( \frac{b - a}{6} \right)^2 \]

Probability of 1 in 100 of \( < a \) occurring

Probability of 1 in 100 of \( > b \) occurring

Figure 3.12

Computing Variance

<table>
<thead>
<tr>
<th>Activity</th>
<th>Optimistic (a)</th>
<th>Most Likely (m)</th>
<th>Pessimistic (b)</th>
<th>Expected Time ( t = \frac{(a + 4m + b)}{6} )</th>
<th>Variance ( \left( \frac{b - a}{6} \right)^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>.11</td>
</tr>
<tr>
<td>B</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>.11</td>
</tr>
<tr>
<td>C</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>.11</td>
</tr>
<tr>
<td>D</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>4</td>
<td>.44</td>
</tr>
<tr>
<td>E</td>
<td>1</td>
<td>4</td>
<td>7</td>
<td>4</td>
<td>1.00</td>
</tr>
<tr>
<td>F</td>
<td>1</td>
<td>2</td>
<td>9</td>
<td>3</td>
<td>1.78</td>
</tr>
<tr>
<td>G</td>
<td>3</td>
<td>4</td>
<td>11</td>
<td>5</td>
<td>1.78</td>
</tr>
<tr>
<td>H</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>.11</td>
</tr>
</tbody>
</table>

Table 3.4
Probability of Project Completion

Project variance is computed by summing the variances of critical activities

\[ \sigma_p^2 = \text{Project variance} = \sum (\text{variances of activities on critical path}) \]

Project variance:

\[ \sigma_p^2 = .11 + .11 + 1.00 + 1.78 + .11 = 3.11 \]

Project standard deviation:

\[ \sigma_p = \sqrt{\text{Project variance}} = \sqrt{3.11} = 1.76 \text{ weeks} \]

Probability of Project Completion

PT makes two more assumptions:

- Total project completion times follow a normal probability distribution
- Activity times are statistically independent
Probability of Project Completion

What is the probability this project can be completed on or before the 16 week deadline?

\[ Z = \frac{\text{due date} - \text{expected date of completion}}{\sigma_p} \]

\[ = \frac{16 \text{ wks} - 15 \text{ wks}}{1.76} \]

\[ = 0.57 \]

Where \( Z \) is the number of standard deviations the due date or target date lies from the mean or expected date.

From Appendix I
Probability of Project Completion

- Probability (T ≤ 16 weeks) is 71.57%
- 0.57 Standard deviations

Determining Project Completion Time

- Probability of 0.99
- Probability of 0.01
- 2.33 Standard deviations
- Z

Variability of Completion Time for Noncritical Paths

- Variability of times for activities on noncritical paths must be considered when finding the probability of finishing in a specified time
- Variation in noncritical activity may cause change in critical path
What Project Management Has Provided So Far

- The project’s expected completion time is 15 weeks
- There is a 71.57% chance the equipment will be in place by the 16 week deadline
- Five activities (A, C, E, G, and H) are on the critical path
- Three activities (B, D, F) are not on the critical path and have slack time
- A detailed schedule is available

Trade-Offs And Project Crashing

It is not uncommon to face the following situations:

- The project is behind schedule
- The completion time has been moved forward

Shortening the duration of the project is called project crashing

Factors to Consider When Crashing A Project

- The amount by which an activity is crashed is, in fact, permissible
- Taken together, the shortened activity durations will enable us to finish the project by the due date
- The total cost of crashing is as small as possible
Steps in Project Crashing

1. Compute the crash cost per time period. If crash costs are linear over time:

\[ \text{Crash cost per period} = \frac{(\text{Crash cost} - \text{Normal cost})}{(\text{Normal time} - \text{Crash time})} \]

2. Using current activity times, find the critical path and identify the critical activities.

3. If there is only one critical path, then select the activity on this critical path that (a) can still be crashed, and (b) has the smallest crash cost per period. If there is more than one critical path, then select one activity from each critical path such that (a) each selected activity can still be crashed, and (b) the total crash cost of all selected activities is the smallest. Note that the same activity may be common to more than one critical path.

4. Update all activity times. If the desired due date has been reached, stop. If not, return to Step 2.
Crashing The Project

<table>
<thead>
<tr>
<th>Activity</th>
<th>Normal Time (Wks)</th>
<th>Crash Time (Wks)</th>
<th>Normal Cost ($)</th>
<th>Crash Cost ($)</th>
<th>Crash Cost Per Wk ($)</th>
<th>Critical Path?</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>2</td>
<td>1</td>
<td>22,000</td>
<td>22,750</td>
<td>750</td>
<td>Yes</td>
</tr>
<tr>
<td>B</td>
<td>3</td>
<td>1</td>
<td>30,000</td>
<td>34,000</td>
<td>2,000</td>
<td>No</td>
</tr>
<tr>
<td>C</td>
<td>2</td>
<td>1</td>
<td>26,000</td>
<td>27,000</td>
<td>1,000</td>
<td>Yes</td>
</tr>
<tr>
<td>D</td>
<td>4</td>
<td>2</td>
<td>48,000</td>
<td>49,000</td>
<td>1,000</td>
<td>No</td>
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<td>19,000</td>
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</tbody>
</table>

Table 3.5

Crash and Normal Times and Costs for Activity B

\[
\text{Crash Cost/Wk} = \frac{\text{Crash Cost} - \text{Normal Cost}}{\text{Normal Time} - \text{Crash Time}}
\]

Critical Path And Slack Times For Milwaukee Paper

Slack = 0
Slack = 1
Slack = 6
Advantages of PERT/CPM

1. Especially useful when scheduling and controlling large projects
2. Straightforward concept and not mathematically complex
3. Graphical networks help highlight relationships among project activities
4. Critical path and slack time analyses help pinpoint activities that need to be closely watched
5. Project documentation and graphics point out who is responsible for various activities
6. Applicable to a wide variety of projects
7. Useful in monitoring not only schedules but costs as well

Limitations of PERT/CPM

1. Project activities have to be clearly defined, independent, and stable in their relationships
2. Precedence relationships must be specified and networked together
3. Time estimates tend to be subjective and are subject to fudging by managers
4. There is an inherent danger of too much emphasis being placed on the longest, or critical, path
Project Management Software

- There are several popular packages for managing projects
  - Primavera
  - MacProject
  - Pertmaster
  - VisiSchedule
  - Time Line
  - Microsoft Project

Using Microsoft Project

Program 3.1

Using Microsoft Project

Program 3.2
Using Microsoft Project

Program 3.6

Using Microsoft Project

Program 3.7