Duration and cost of activity depends on the amount and type of resources used.

Assuming more workers will normally reduce time and will change its cost.

This relationship between activity time and cost called time-cost Trade off.
**Time-Cost Trade-Off**

*Why do we need to reduce project time?*

- Finish the project in a predefined deadline date
- Recover early delays to avoid liquidated damages
- Free key resources early for other projects
- Avoid adverse weather conditions that might affect productivity
- Receive an early completion-bonus
- Improve project cash flow

---

**Time-Cost Trade-Off**

*What is the way to reduce activity duration?*

- Working extended hours (Over time)
- Offering incentive payments to increase the productivity
- Using additional resources
- Using materials with faster installation methods
- Using alternate construction methods or sequence
**Time-Cost Trade-Off**

**Activity Time-Cost Relationship**

- Decreasing activity duration will increase its cost

![Graph showing the relationship between time and cost for different activity durations](attachment:image.png)

**Normal duration & Normal cost**

**Crash duration & Crash cost**

---

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**Time-Cost Trade-Off**

**Activity Time-Cost Relationship**

> For simplicity, linear relationship is adopted

![Diagram](image)

**Time-Cost Trade-Off**

**Activity Time-Cost Relationship (Example)**

> Consider the following options

<table>
<thead>
<tr>
<th>Estimated daily production (square meter)</th>
<th>Crew size (men)</th>
<th>Crew formation</th>
</tr>
</thead>
<tbody>
<tr>
<td>166</td>
<td>5</td>
<td>1 scaffold set, 2 labors, 2 carpenter, 1 foreman</td>
</tr>
<tr>
<td>204</td>
<td>6</td>
<td>2 scaffold set, 3 labors, 2 carpenter, 1 foreman</td>
</tr>
<tr>
<td>230</td>
<td>7</td>
<td>2 scaffold set, 3 labors, 3 carpenter, 1 foreman</td>
</tr>
</tbody>
</table>

Consider the following rates: Labor LE 96/day; carpenter LE 128/day; foreman LE 144/day and scaffolding LE 60/day
**Time-Cost Trade-Off**

**Activity Time-Cost Relationship (Example)**

- 8400 Sq meters of scaffolds

<table>
<thead>
<tr>
<th>Crew size</th>
<th>Duration (days)</th>
<th>Cost (LE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>50.6 (use 51)</td>
<td>51 x (1x60 + 2x96 + 2x128 + 1x144) = 33252</td>
</tr>
<tr>
<td>6</td>
<td>41.2 (use 42)</td>
<td>42 x (2x60 + 3x96 + 2x128 + 1x144) = 33936</td>
</tr>
<tr>
<td>7</td>
<td>36.5 (use 37)</td>
<td>37 x (2x60 + 3x96 + 3x128 + 1x144) = 34632</td>
</tr>
</tbody>
</table>

Activity Time-Cost Relationship (Example)

<table>
<thead>
<tr>
<th>Cost (LE)</th>
<th>Duration (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>33000</td>
<td>30</td>
</tr>
<tr>
<td>33200</td>
<td>35</td>
</tr>
<tr>
<td>33400</td>
<td>40</td>
</tr>
<tr>
<td>33600</td>
<td>45</td>
</tr>
<tr>
<td>33800</td>
<td>50</td>
</tr>
<tr>
<td>34000</td>
<td>55</td>
</tr>
<tr>
<td>34200</td>
<td></td>
</tr>
<tr>
<td>34400</td>
<td></td>
</tr>
<tr>
<td>34600</td>
<td></td>
</tr>
<tr>
<td>34800</td>
<td></td>
</tr>
</tbody>
</table>

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**Time-Cost Trade-Off**

**Project Time-Cost Relationship**

- Project direct cost = summation of direct cost of individual activities
- Indirect cost comprises site and head office overheads
- Project indirect cost = daily indirect cost x project duration
- Direct cost increases as project duration decreases
- Indirect cost decreases as project duration decreases
**Shortening Project Duration (Optimum Duration)**

- It might be necessary to shorten project duration to meet specific deadline
- Or to determine the optimum project duration that is correspond to the least project total cost
- Many approaches can be used
- Heuristic Cost-Slope method will be applied

---

**Procedure for Shortening Project Duration**

- Draw the project network.
- Perform CPM calculations and identify the critical path, use normal durations and costs for all activities.
- Compute the cost slope for each activity from the following equation:

\[
\text{cost slope} = \frac{\text{crash cost} - \text{normal cost}}{\text{normal duration} - \text{crash duration}}
\]
Time-Cost Trade-Off

Procedure for Shortening Project Duration

- Start by shortening the activity duration on the critical path which has the least cost slope and not been shortened to its crash duration.
- Reduce the duration of the critical activities with least cost slope until its crash duration is reached or until the critical path changes.
- When multiple critical paths are involved, the activity(ies) to be shorten is determined by comparing the cost slope of the activity which lies on all critical paths (if any).

Having shortened a critical path, you should adjust activities timings, and floats.

The cost increase due to activity shortening is calculated as the cost slope multiplied by the time of time units shortened.

Continue until no further shortening is possible, and then the crash point is reached.

The results may be represented graphically by plotting project completion time against cumulative cost increase.
**Time-Cost Trade-Off**

### Example Application

- Consider the following project
- Indirect cost LE 125/day
- Crash to 49 days

<table>
<thead>
<tr>
<th>Activity</th>
<th>Preceded by</th>
<th>Normal</th>
<th>Crash</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Duration (day)</td>
<td>Cost (LE)</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td>12</td>
<td>7000</td>
</tr>
<tr>
<td>B</td>
<td>A</td>
<td>8</td>
<td>5000</td>
</tr>
<tr>
<td>C</td>
<td>A</td>
<td>15</td>
<td>4000</td>
</tr>
<tr>
<td>D</td>
<td>B</td>
<td>23</td>
<td>5000</td>
</tr>
<tr>
<td>E</td>
<td>B</td>
<td>5</td>
<td>1000</td>
</tr>
<tr>
<td>F</td>
<td>C</td>
<td>5</td>
<td>3000</td>
</tr>
<tr>
<td>G</td>
<td>E, C</td>
<td>20</td>
<td>6000</td>
</tr>
<tr>
<td>H</td>
<td>F</td>
<td>13</td>
<td>2500</td>
</tr>
<tr>
<td>I</td>
<td>D, G, H</td>
<td>12</td>
<td>3000</td>
</tr>
</tbody>
</table>

**Total direct cost LE 36500**
**Time-Cost Trade-Off**

**Example Application**
- Activity G has the least cost slope 60 LE/day
- Crash G by 2 days, cost increase by 2 x 60

---

**Time-Cost Trade-Off**

**Example Application**
- Activity I has the least cost slope 75 LE/day
- Crash I by 2 days, cost increase by 2 x 75
**Example Application**

- Activity A has the least cost slope 100 LE/day
- Crash A by 2 days, cost increase by 2 x 100

**Example Application**

- Activity H & G has the least cost slope 100 LE/day
- Crash H & G by 2 days, cost increase by 2 x 100
Time-Cost Trade-Off

Example Application

- Activity C & B has the least cost slope 350 LE/day
- Crash H & G by 2 days, cost increase by 2 x 350

<table>
<thead>
<tr>
<th>Duration</th>
<th>Direct cost x 1000 LE</th>
<th>Indirect cost x 1000 LE</th>
<th>Total cost x 1000 LE</th>
</tr>
</thead>
<tbody>
<tr>
<td>59</td>
<td>36.50</td>
<td>7.375</td>
<td>43.875</td>
</tr>
<tr>
<td>57</td>
<td>36.62</td>
<td>7.125</td>
<td>43.745</td>
</tr>
<tr>
<td>55</td>
<td>36.77</td>
<td>6.875</td>
<td>43.645</td>
</tr>
<tr>
<td>53</td>
<td>36.97</td>
<td>6.625</td>
<td>43.595</td>
</tr>
<tr>
<td>51</td>
<td>37.17</td>
<td>6.375</td>
<td>43.545</td>
</tr>
<tr>
<td>49</td>
<td>37.87</td>
<td>6.125</td>
<td>43.995</td>
</tr>
</tbody>
</table>
Time-Cost Trade-Off

Example Application

LE x 1000

Time (days)