Network Planning

- Purposes of network planning
  - Determine the intended timing of activities
  - Determine the estimates of resource requirements
  - Develop a comprehensible “picture” of the project.
  - Take a proactive approach in order to prevent errors
  - Minimize the effects of uncertainties on the project’s success factors.
- Note that timing and resources interact.

Network Planning

- The fundamental element of time planning is developing a project network.
- The network depicts the tasks and the logical precedence structure between these activities.

Time Planning

Types of precedence relations between activities:

- **Finish - Start:** One task cannot start until the other has finished.
- **Start - Start:** Unless one of the tasks has started, the other cannot start.
- **Start - Start with time lag:** A certain time has to pass after one task has started until the other starts.

Let’s assume the following represent *finish-start* precedence relation:

<table>
<thead>
<tr>
<th>Task</th>
<th>Immediate predecessors</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>-</td>
</tr>
<tr>
<td>B</td>
<td>A</td>
</tr>
<tr>
<td>C</td>
<td>B, D</td>
</tr>
<tr>
<td>D</td>
<td>-</td>
</tr>
<tr>
<td>E</td>
<td>D</td>
</tr>
<tr>
<td>F</td>
<td>E</td>
</tr>
</tbody>
</table>

Bar (Gantt) chart:
Developing Project Network

- Developing a network takes time (thus costs money). Is it worth it?
  - Provides a graphic display of the flow and sequence of work that is easy to understand.
  - Provides the basis for scheduling and resource planning.
  - Yields a realistic estimate for total project time.
  - Easy to update when unexpected events occur.
  - Helps identify critical activities (whose delay will most probably delay the entire project).

Developing Project Network

- Integrating WBS and the network is crucial.
- The hierarchical nature of WBS allows different levels of managers to “visualize” the project plan at different levels of detail.
  - The milestone plan, in the form of a bar chart, shows the level of detail useful for top management, showing only the major deliverables.
  - Work-packages are used to develop a detailed network for the first-line managers.

Developing Project Network

- Not only time, but also cost and resource plans can be “rolled up” from the work-package level to the top level.
  - Deliverables and sub-deliverable in WBS must be designed so that after roll-up managers at different levels can obtain plans/reports that can be useful for them.

Developing Project Network

- Network terminology
  - Activity: Element of a project that takes time. Usually one or more work packages.
  - Merge activity: Activity with more than one immediate predecessor activity.
  - Burst activity: Activity with more than one immediate successor activity.
  - Parallel activities: Activities that can take place simultaneously.
  - Path: A sequence of connected activities.
  - Critical path: Longest path(s) through the network.
  - Event: Represents a point in time.

Rules:
- Draw networks from left to right.
- Each activity has a unique identification number.
- An activity’s identification number should be larger than the activities’ preceding it.
- Loops (cycles) are not allowed.
- Conditional statement (e.g. if this happens then …) are not allowed.
- If there are multiple start or finish activities, a common start or finish node is used.
Developing Project Network

- **Laddering**
  - Consider a pipe laying project. Three basic activities:
    - dig a trench, lay the pipe, refill the trench
  - Let’s say the pipeline is 5 km long: You cannot dig the entire trench before laying the pipe.

```
Trench Lay pipe Refill
```

- Instead: break activities into segments and “ladder” them

```
Trench 1/3
Lay pipe 1/3
Trench 1/3
Lay pipe 1/3
Refill 1/3
Refill 1/3
Refill 1/3
```

Developing Project Network

- Calculating the earliest and latest times (numbers in the nodes represent activity durations):

```
Start A 3 B 5 C 3 D 2 E 2 F 5 Finish
```

- Total slack (float) for an activity = LS - ES (or LF - EF)

Free slack:
Amount an activity can be delayed without delaying early-start (ES) of activities following it.

Using Time Lags

- A lag is the **minimum** amount of time a dependent activity must be delayed to begin or end.
- Uses for start-to-start time lags
  - Instead of using laddering.
  - Concurrent engineering practice that compresses the total product development time.
- Uses for finish-to-start time lags
  - Modelling ordering of parts: 1 day takes to place to order, 14 days to receive it.
- Uses for finish-to-finish time lags
  - Painting multiple layers.

Using Time Lags

- It is possible to have multiple time-lags attached to a pair of activities.
  - Usually an start-to-start and finish-to-finish
- Network calculations with time lags
  - forward and backward pass procedures are the same as the ones for finish-to-start case with no time lags.
    - Difference is in checking the time lag relationships’ effects on the activities’ times.
Estimating Activity Times

• Guidelines
  – Responsibility:
    • at the work-package level estimates should be made by person(s) most familiar with the task.
    • Those responsible for getting the job done on schedule should determine the estimated times.
    – They will have less bias due to imposed deadlines.
    – Their judgement will be based on experience.
    – They will do their best to materialize their estimates.

– Normal conditions:
  • Estimates should be based on normal conditions, efficient methods and a normal level of resources.
  • A consensus is required in the organization as to what “normal conditions” mean.

– Time Units:
  • All task time estimates need consistent time units.
  • In practice “workday” is the most frequent choice.
  Other alternatives:
    – calendar days, workweeks, minutes, shifts

– Independence:
  • Estimators should treat the task as independent of other tasks in the WBS.
  • Top managers tend to aggregate many tasks into one estimate and “deduce” the durations of individual tasks from this aggregate. It is better to obtain estimates from first-line managers who consider tasks independently.
  • If tasks are in a chain, opportunity should not be given to modification of estimates so that total chain time meets an arbitrary schedule (imposed).

– Contingencies
  • Work package estimates should not include allowances for contingencies.

– Estimate errors
  • The project management culture should allow estimate mistakes and errors to occur.
    – Punishment leads to future estimates being inflated.
    – Trust in the project management culture will results in more realistic estimates.