# Systems Engineering

**Chapter 3:**

***Managing Systems Development***



## Outline





## §1. Project Management

- **Project:** A planned undertaking of series of related activities to reach an objective that has a beginning and an end
- Role of systems engineering in project management:
  Fig. 5.1 in [Kossiakoff2011, p.112]



## System Engineer's role as a project manager

- Project manager is responsible for initiating, planning, executing, and closing down the systems development project
- Ensuring that the project meets customer expectations and is within budget and time constraints
- Skills of a system analyst



## Diverse set of skills

- Management
- Leadership
- Technical
- Conflict management
- Customer relationship



## Project Environment

- Continual changes
- Problem solving
- Experience collection

## Example Scheme

- Observation of a problem
- System service request
- Review and Approval of Systems Priority Board
  - Feasibility study: is there sense for the organization from an economic and operational point
- Resources required for project completion
- Detailed project plan



## Project Management Phases

- Initiating
- Planning
- Executing
- Closing down



## Initiating the Project

Which activities are performed to access the size, scope, and complexity of the project and to establish procedures to support later project activities

- Project Initiation Team
- Relationship with the Customer
- Project Initiation Plan
- Management procedures
- Project management environment and project workbook



## Planning the Project

Focus is on defining clear, discrete activities and the work needed to complete each activity within a single project

- Work breakdown structure (WBS)
  - Deliverable oriented decomposition of a project into smaller components
  - Defining and grouping discrete work elements in a way that helps organize the total work scope
- Nearer-term plans are more specific than longer-term plans: Fig.3.8 [Hoffer2011, p.55]



## Planning Activities: Fig.3.9 [Hoffer2011, p.55]

1. Project scope, alternatives, and feasibility
2. Division into manageable tasks: breakdown structure
3. Estimating resources: resource plan
4. Preliminary schedule
5. Communication plan
6. Project standards and procedures
7. Risks identification and assessment
8. Preliminary budget
9. Project scope statement
10. Baseline project plan



## Executing the Project

Putting the Baseline Project Plan into action

- Monitoring project progress
- Managing changes to the Plan
- Maintaining the Project Workbook
- Communicating the Project Status: Table 3.2 [Hoffer2011, p.63]

## Closing down the Project

The final phase that focuses on bringing Project to an end

- Natural or unnatural termination
- Conducting post-project reviews
- Closing the customer contract
- Experience collection, project metrics



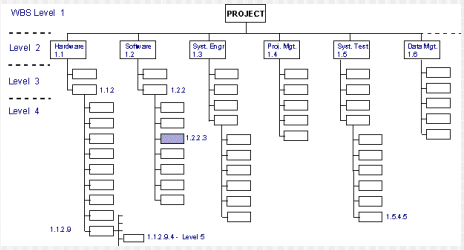
## §2. Representing and Scheduling Project Plans

- Graphical or textual reports
- Gantt charts and network diagrams
- Cost control and estimation
- Critical path method
- Program Evaluation and Review Technique (PERT)



## Work Breakdown Structure (WBS)

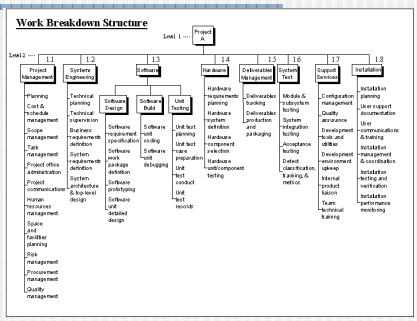
WBS Format for System Development Projects
http://www.hyperthot.com/pm_wbs.htm






## Sample Skeleton WBS

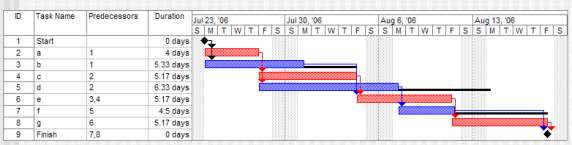
http://www.hyperthot.com/pm_wbs_sw1.htm






## Gantt Chart

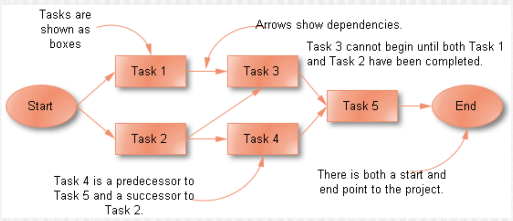
- When a task should begin and end: high-level parts of the plan
- Time overlap of tasks
- Example from http://en.wikipedia.org/wiki/Gantt_chart
  Note (1) the critical path is in red, (2) the slack is the black lines connected to non-critical activities, (3) since Saturday and Sunday are not work days and are thus excluded from the schedule, some bars on the Gantt chart are longer if they cut through a weekend.






## Network Diagram

- Sequence dependence between tasks
- Parallel task execution
- Example from http://www.edrawsoft.com



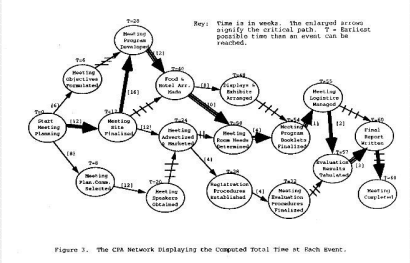
## Critical Path Method (CPM)

- Construct a model of the project that includes
  1. A list of all activities required to complete the project (typically categorized within WBS)
  2. The time (duration) that each activity will take to completion
  3. The dependencies between the activities
- CPM calculates the longest path of planned activities to the end of the project, and the earliest and latest that each activity can start and finish without making the project longer



## Critical Path Example

- By Roger Hiemstra (2000), http://www-distance.syr.edu/edu5900cpa.html





## Expected Time Duration: PERT Method

- The Program (or Project) Evaluation and Review Technique (PERT) is a tool to analyze and represent the tasks involved in completing a given project
- The time needed to complete each task
- The minimum time needed to complete the total project



## Steps of PERT Method

1. Network diagram (activities, milestones, sequence)
2. Estimate Activity Times
   - Optimistic time *T*opt: generally the shortest time in which the activity can be completed
   - Realistic (most likely) time *T*rls: the completion time having the highest probability
   - Pessimistic time *T*psm: the longest time that an activity might require
3. Determine the Critical Path
4. Apply in project management



## The PERT Mathematics

- Expected time and variance (BETA probability distribution works behind):

  $T = (T_{opt} + 4*T_{rls} + T_{psm}) / 6$

  $V = (T_{psm} - T_{opt})^2 / 6^2$



## The PERT Mathematics

1. Calculate *E* and *V* for activities in the critical path
2. The total of all Es is the overall expected completion time for the project
3. The corresponding *V* is added to each activity of the critical path (variance for the entire project)
4. Standard deviation of the project is calculated (square root of the variance *V*)
5. The normal probability distribution is used for calculating the project completion time with the desired probability

## §3. Risk Management

- Unpredictable outcomes can appear at every step
- Risks of performance shortfalls, environmental susceptibility, instability for production
- It requires a change in course with impacts on project cost and schedule
- Challenge of SysEng:
  *Steering a course that poses minimum risks while still achieving maximum results*



## Risk Reduction through the System Life Cycle

- Hypothetical system development: risk decreasing, Fig. 5.3 [Kossiakoff2011, p.121]



## Risk Assessment

- Risk likelihood: probability of failure
  - Prioritization: high, medium, low
- Risk criticality: impact of failure
  - Prioritization: high, medium, low
- Clear responsibility area of SysEng



## Risk Mitigation

- Technical and Management reviews
- Oversight of designated component engineering
- Special analysis and testing
- Rapid prototyping
- Relief on excessive requirements
- Fallback alternatives