

## Project Management, Cost Estimation, and Team Organizations

- Software Project Management
- Cost Estimation
- Managing People

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## Project Management

- Poor management is the downfall of many software projects
  - Delivered software was late, unreliable, cost several times the original estimates and often exhibited poor performance characteristics
- Software project management is different from other engineering management
  - product is intangible
  - still no clear understanding of the software process or evaluation criteria
  - most software projects are new and technically innovative
- Good management cannot guarantee project success, but bad management usually results in project failure!

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## Management Activities

- Proposal writing
  - overview, estimates, justification
- Project costing
  - software cost estimation
- Project planning and scheduling
  - milestones, options to minimize risks
- Project monitoring and reviewing
  - progress, compare to schedule and planned costs, predict problems
- Personnel selection and evaluation
  - skill, experience, training, resources
- Report writing and presentation
  - primary summary documentation and progress reviews

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## Project Planning and Scheduling

- Project planning determines a project schedule based upon
  - project constraints (delivery, staff, budget)
  - project parameters (structure, size, functions)
  - project milestones and deliverables
- Planning and scheduling must estimate risk associated with each decision
- Project scheduling involves separating work into tasks and predicting task completion
  - coordinate parallel tasks to optimize work force
  - allow for problems
- Schedule must be periodically revised with progress

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## Types of Plans

- Quality plan
  - Describes the quality procedures and standards that will be used in the project
- Validation plan
  - Describes the approach, resources and schedule used for system validation
- Configuration management plan
  - Describes the configuration management procedures and structures to be used
- Maintenance plan
  - Predicts the maintenance requirements of the system, maintenance cost and effort required
- Staff development plan
  - Describes how the skills and experience of the project team members will be developed

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## The Project Plan

- Introduction
  - Briefly describes the objectives of the product and sets out the constraints (budget, time, etc.)
- Project Organization
  - Describes the way in which the development team is organized
- Risk analysis
  - Describes possible project risks and risk reduction strategies
- Hardware & Software resource requirements
  - Hardware/Software required to carry out the development
- Work breakdown
  - Breakdown of the project into activities, identification of milestones and deliverables
- Project schedule
  - Describes the dependencies between activities, the estimated time required to reach each milestone and the allocation of people to activities
- Monitoring and reporting techniques
  - Describes the management reports which should be produced

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## IEEE 1058.1, 1987 SW Project Management Plan

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**1. Introduction**

- 1.1. Project Overview
- 1.2. Project Deliverables
- 1.3. Evolution of the Software Project Management Plan
- 1.4. Reference Materials
- 1.5. Definitions and Acronyms

**2. Project Organization**

- 2.1. Process Model
- 2.2. Organizational Structure
- 2.3. Organizational Boundaries and Interfaces
- 2.4. Project Responsibilities

**3. Managerial Process**

- 3.1. Management Objectives and Priorities
- 3.2. Assumptions, Dependencies, and Constraints
- 3.3. Risk Management
- 3.4. Monitoring and Controlling Mechanisms
- 3.5. Staffing Plan

**4. Technical Process**

- 4.1. Methods, Tools, and Techniques
- 4.2. Software Documentation
- 4.3. Project Support Functions

**5. Work Packages, Schedule, and Budget**

- 5.1. Work Packages
- 5.2. Dependencies
- 5.3. Resource Requirements
- 5.4. Budget and Resource Allocation
- 5.5. Schedule

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## Work Breakdown Structure

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= one way of breaking down the major activity into smaller components

Example:

```

graph TD
    CP[Compiler Project] --> Design
    CP --> Code
    CP --> IT[Integration and Test]
    CP --> WM[Write manual]
    Code --> Scanner
    Code --> Parser
    Code --> CG[Code generator]
  
```

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## GANTT Charts

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Project control technique for scheduling, budgeting, and resource planning

Example: Gantt chart for simple compiler project

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## GANTT Charts - 2

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Gantt charts can also be used for resource allocation and staff planning

Example:

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## PERT Charts

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A PERT (Program Evaluation and Review Technique) is a network of boxes (or circles) and arrows

- Boxes (or circles) represent activities, arrows show the dependencies of activities on one another
- Activity at the head of the arrow cannot start before activity at the tail of the arrow is finished
- Critical paths for the project are shown bold

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## Software Cost Estimation

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- Principal components of project costs derive from
  - hardware and software including maintenance
  - travel and training
  - effort (cost of paying software engineers)
- Initial cost estimation should be based on firm, complete requirements
- Continual cost estimation is required to ensure that spending is in line with budget
- Software Cost Estimation should use multiple techniques to predict costs:
  - historical cost information relating metrics and costs
  - analogies to similar systems
  - expert "guesstimation"
  - hierarchical estimations

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## Factors affecting Software Pricing

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- ❑ Market opportunity
  - Moving into new markets --> low pricing
- ❑ Cost estimation uncertainty
  - If organization is unsure of its cost estimate, it may increase its price
- ❑ Contractual terms
  - Customer may be willing to allow the developer to retain ownership of the source code and reuse it in other projects
- ❑ Requirements volatility
  - If requirements are likely to change offer lower price to win the contract. After contract has been awarded, high prices may be charged for changes to the requirements
- ❑ Financial health
  - Sometimes it may be better to make a small profit or break even than to go out of business

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## Factors used in cost estimation models

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Group	Factor
Size attributes	Source instructions Number of routines Number of output formats Number of personnel
Program attributes	Type Complexity Language Required reliability
Personnel attributes	Personnel capability / continuity Hardware experience Application experience Language experience
Project attributes	Tools and techniques Customer interface Requirements definition

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## Algorithmic Cost Modeling

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- ❑ Model built by analyzing the attributes and costs of completed projects
  - metrics usually measure attributes of finished product (so predictions may be inaccurate)
  - metrics typically include size or function points (external interactions)
  - margin of error low if product is well-understood, model well calibrated to local organization, product is similar to previous projects, language and hardware choices are pre-defined
- ❑ Most algorithmic estimation models have an exponential component

$$\text{Effort} = C \times \text{PM}^s \times M$$

- C ..... complexity factor
- PM ... some product metric (size metric or functionality metric)
- M ..... multiplier, made up by combining different process, product and development attributes
- s ..... exponent (usually close to 1) reflecting the increasing effort for large projects

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## Algorithmic Cost Modeling: The COCOMO Model [Boehm, 1981]

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- ❑ Uses 3 different models depending on the complexity of the project:
  - *Simple project:* Well-understood applications developed by small teams.  
 $\text{PM} = 2.4 (\text{KDSI})^{1.05} \times M$
  - *Moderate project:* More complex projects where team members may have limited experience of related systems.  
 $\text{PM} = 3.0 (\text{KDSI})^{1.12} \times M$
  - *Embedded project:* Complex projects where the software is part of a strongly coupled complex of hardware, software, regulations, and operational procedures  
 $\text{PM} = 3.6 (\text{KDSI})^{1.20} \times M$

KDSI . . . number of thousands of delivered source instructions

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## The COCOMO Model – 2

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- ❑ In the basic COCOMO model the multiplier M is 1 (starting point for cost estimation)
- ❑ Intermediate model adds other product attributes as factors (multipliers):
  - product attributes (reliability, database size, etc.)
  - computer attributes (storage constraints, stability of hard/software)
  - personnel attributes (experience of personnel)
  - project attributes (use of software tools, development methods)
- ❑ Complete model decomposes total system in estimating costs (system is made up of sub-systems)

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## Project Duration and Staffing

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- ❑ Project managers have also to estimate
  - how long a software product will take to develop
  - when how many people will be needed to work on the project
- ❑ More people working on a project also requires more communication overhead
- ❑ COCOMO estimation:
  - Simple projects  $\text{TDEV} = 2.5 (\text{PM})^{0.38}$
  - Intermediate projects  $\text{TDEV} = 2.5 (\text{PM})^{0.35}$
  - Embedded projects  $\text{TDEV} = 2.5 (\text{PM})^{0.32}$

– NOTE: COCOMO model does not include number of project engineers working on the project !

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## Management Structure

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❑ Traditional hierarchical management structure

```

graph TD
    SDV[Software Director/VP] --> PM1[Program Manager]
    SDV --> PM2[Program Manager]
    PM1 --> P1[Project Manager]
    PM1 --> P2[Project Manager]
    PM1 --> P3[Project Manager]
    P1 --> TL1[Team Leader]
    P1 --> TL2[Team Leader]
    P2 --> TL3[Team Leader]
    P2 --> TL4[Team Leader]
    P3 --> TL5[Team Leader]
    P3 --> TL6[Team Leader]
    PM2 --> P4[Project Manager]
    P4 --> TL7[Team Leader]
    P4 --> TL8[Team Leader]
    SDV --> QM[Quality Manager]
    QM --> QTL1[Quality Team Leader]
    QM --> QTL2[Quality Team Leader]
  
```

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## Team Organization

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- ❑ Large software systems require a coordinated team of software engineers for effective development
- ❑ Team organization involves devising roles for individuals and assigning responsibilities
- ❑ Organizational structure attempts to facilitate cooperation
- ❑ For long-term projects, job satisfaction is extremely important for reduced turnover
- ❑ Need mix of senior and junior engineers to facilitate both accomplishing the task and training
- ❑ Adding people to a project introduces further delays

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## Team Organizations

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- ❑ Hierarchical organizations minimize and discourage communication, while democratic organizations encourage it
- ❑ Appropriate organization depends on project length and complexity
  - small teams lead to cohesive design, less overhead, more unity, higher morale
  - but some tasks too complex
  - optimal size between 3 and 8
- ❑ Appropriate design leads to appropriate assignment of tasks and appropriate team organization

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## Group Cohesiveness

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- ❑ In a cohesive group, members think of the group as more important than the individuals in it
- ❑ Advantages of cohesive groups:
  - + A group quality standard can be developed
  - + Team members work closely together. Members can learn from each other
  - + Team members can get to know each other's work (continuity can be maintained should a team member leave)
  - + Egoless programming can be practised (programs are regarded as team property rather than personal property)
- ❑ Problems:
  - Irrational resistance to a leadership change
  - Groupthink (consideration of alternatives is replaced by loyalty to group norms and decisions)

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## Group communication

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- ❑ Several factors affect communications in a group
  - Status of the group members
    - Higher-status members tend to dominate communications with lower-status members
  - Personalities in the group
    - If there are too many people in the group who are task-oriented, this may inhibit effective communications (all are concentrated on technical issues and nobody discusses problems)
  - Sexual composition of the group
    - Studies have shown that men and women prefer to work in mixed-sex groups. Within these groups, communications are better than in single-sex groups
  - Communication channels
    - Communications are more effective if anyone in a group can easily contact anyone else

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## Centralized-Control: Chief Programmer Team Approach

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```

graph TD
    CP[chief programmer] --> PM[project manager]
    CP --> LIB[librarian]
    CP --> P[programmers]
    CP --> S[specialists]
  
```

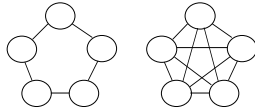
- ❑ Hierarchical organizational structure and matching pattern of communication
  - chief programmer reports to peer project manager
  - programmers report to chief programmer
  - librarian responsible for central repository
  - specialists added as needed
- ❑ Works well with simple tasks that can be grasped by one good engineer, but "single point of failure"

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## Decentralized Control: Democratic Team Approach

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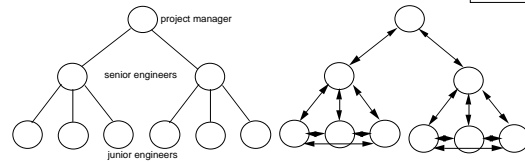
- Ring organization and connected communication
  - decisions made by consensus
  - all work is group work: "egoless programming"
    - leads to higher morale and job satisfaction
    - not appropriate for large teams
- More appropriate for less understood and more complex programs with longer term project

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## Mixed Control

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- Hierarchy with extra communication
  - senior engineers report to project manager
  - junior engineers report to senior engineers
  - control is vested in project manager and senior engineers
  - communication is decentralized among each set of peers and their supervisor
- Limits communication to a small group and realizes benefits of group decisions by vesting authority

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## Assessment of Team Organizations

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- No team organization is appropriate for all tasks
- Decentralized control is best when communication among engineers is necessary for achieving a good solution
- Centralized control is best when speed of development is the most important goal and the problem is well understood
- An appropriate approach tries to limit amount of communication overhead
- An appropriate approach also has to take into account other goals, such as personnel turnover, development of junior engineers, dissemination of specialized knowledge among personnel

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## Training and Motivation

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- Training is not only a way of ensuring that engineers have necessary skills, but also demonstrates an organization's interest in its staff
- Training may also cause problems:
  - Learning new languages may also be very difficult, especially for older programmers (switch of the paradigm, e.g. from FORTRAN to C++/LISP/Prolog, etc.)
  - Programmer training requires consideration of different educational background and experience of programmers
- Motivation of people requires
  - satisfaction of their social needs (time for meeting co-workers, providing places to meet)
  - recognition of achievements
  - giving people responsibility for their own work

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## Risk Management

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- An engineering project is
  - expected to produce a reliable product
  - within a limited time
  - using limited resources
- Risk management
  - identifying project risks
  - assessing their impact
  - monitoring and controlling the risks
- Approaches to reduce risks in Software Engineering
  - Prototyping
  - Incremental delivery
  - Modular design (i.e. handling risks of late changes)

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## Common Risk Items in Software Engineering [Boehm, 1989]

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Risk items	Risk management techniques
Personnel shortfalls	Staffing with top talent; job matching; team-building;
Unrealistic schedules & budgets	Detailed multisource cost & schedule estimation; incremental development; software reuse
Developing the wrong software functions	Organization analysis; mission analysis; user surveys; prototyping; early users manuals
Developing the wrong user interface	Prototyping; scenarios; task analysis; user characterization
Continuing stream of requirements changes	Information hiding; incremental development (defer changes to later increments)
Real-time performance shortfalls	Simulation; benchmarking; modeling; prototyping

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