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# Software Engineering

## Topic 9

## Estimation for Software Project and Project Scheduling

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# Acknowledgement

These slides have been adapted from Pressman, R.S. (2015). *Software Engineering : A Practioner's Approach. 8th ed*. McGraw-Hill Companies.Inc, Americas, New York. ISBN : 978 1 259 253157. Chapter 33 and 34

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# Learning Objectives

## LO 4 : Analyze the software project management

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# Contents

- Software Project Planning
- Software Scope
- Resources
- Project Estimation
- Empirical Estimation Models
- Estimation for OO Projects
- Estimation for Agile Projects
- The Make-Buy Decision
- Project Scheduling
- Earned Value Analysis (EVA)

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# Software Project Planning

The overall goal of project planning is to establish a pragmatic strategy for controlling, tracking, and monitoring a complex technical project.

Why?

*So the end result gets done on time, with quality!*

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# Software Project Planning

## Project Planning Task Set-I

- Establish project scope
- Determine feasibility
- Analyze risks
  - Risk analysis is considered
- Define required resources
  - Determine require human resources
  - Define reusable software resources
  - Identify environmental resources

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# Software Project Planning

## Project Planning Task Set-II

- Estimate cost and effort
  - Decompose the problem
  - Develop two or more estimates using size, function points, process tasks or use-cases
  - Reconcile the estimates
- Develop a project schedule
  - Scheduling is considered
    - Establish a meaningful task set
    - Define a task network
    - Use scheduling tools to develop a timeline chart
    - Define schedule tracking mechanisms

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# Software Project Planning

## Estimation

- Estimation of resources, cost, and schedule for a software engineering effort requires
  - experience
  - access to good historical information (metrics)
  - the courage to commit to quantitative predictions when qualitative information is all that exists
- Estimation carries inherent risk and this risk leads to uncertainty

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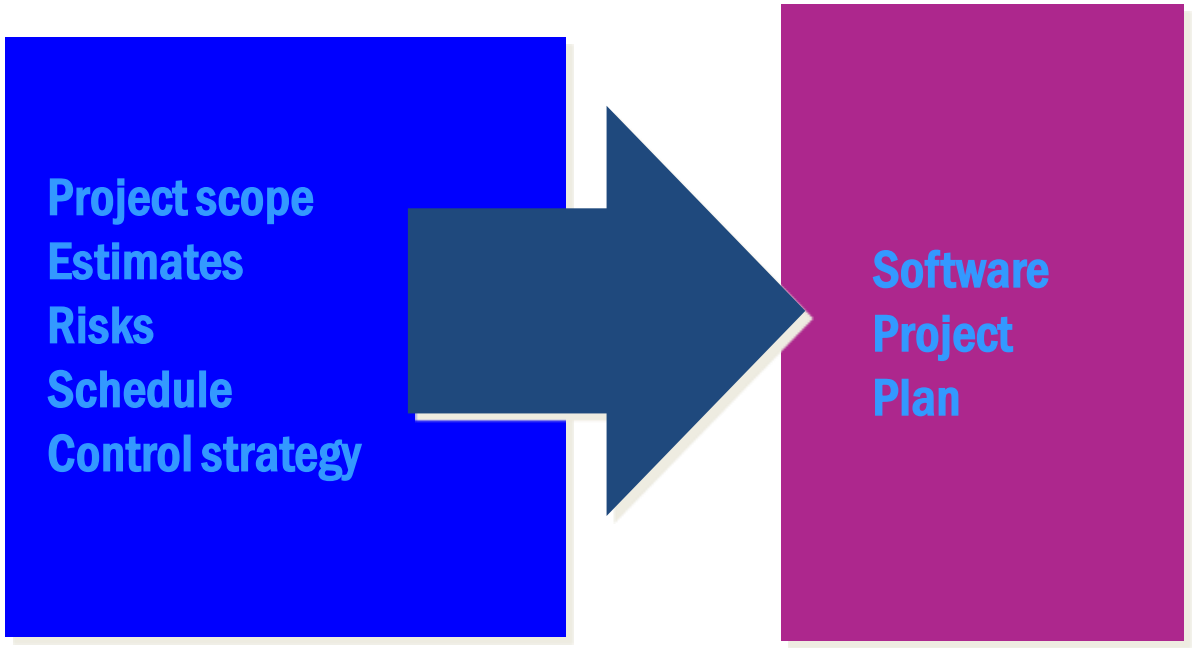
# Software Project Planning

## Write it Down!



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# Software Scope

## To Understand Scope

- Understand the customers needs
- understand the business context
- understand the project boundaries
- understand the customer's motivation
- understand the likely paths for change
- understand that ...

***Even when you understand, nothing is guaranteed!***

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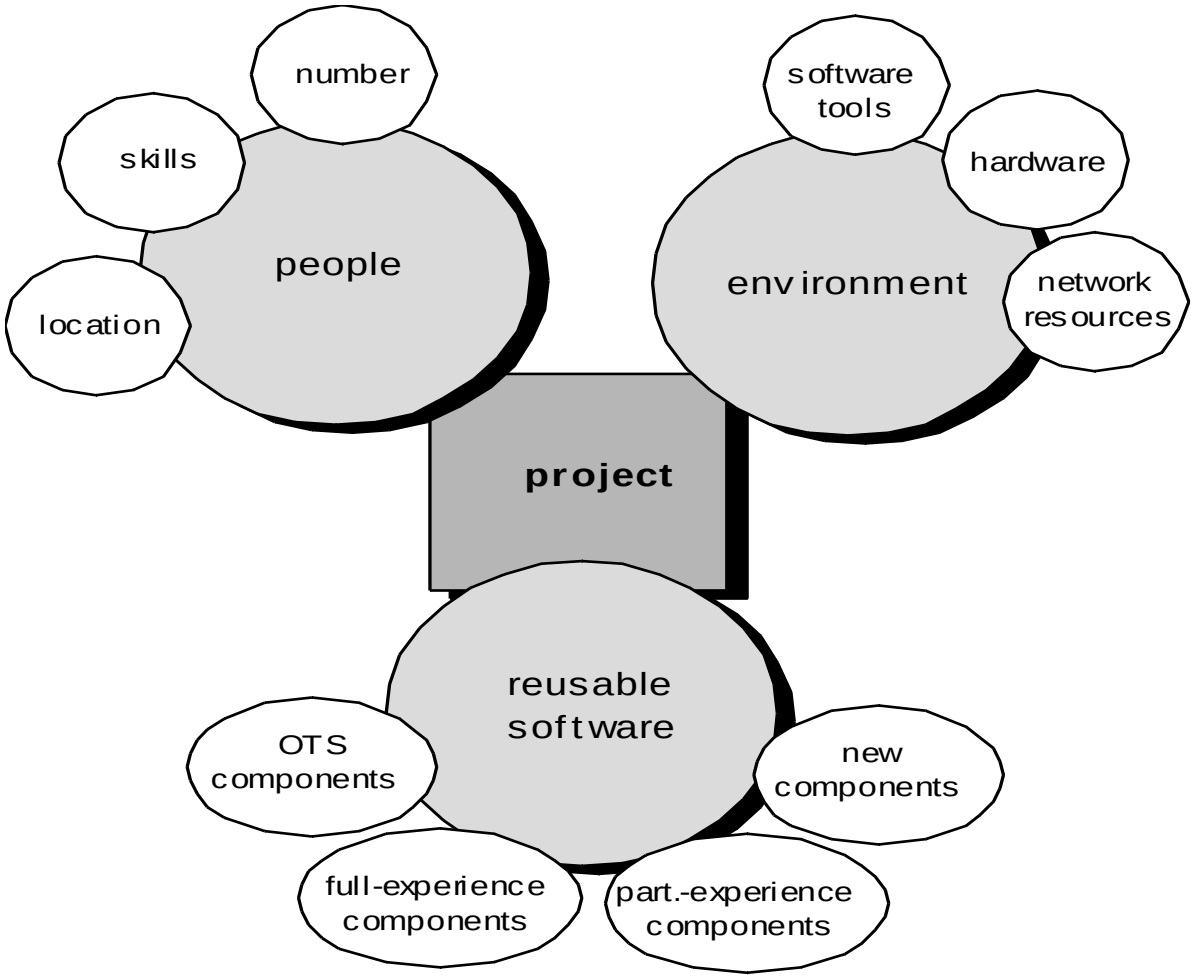
# Resources



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# Project Estimation

- Project scope must be understood
- Elaboration (decomposition) is necessary
- Historical metrics are very helpful
- At least two different techniques should be used
- Uncertainty is inherent in the process

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# Project Estimation

## Estimation Accuracy

- Predicated on ...
  - the degree to which the planner has properly estimated the size of the product to be built
  - the ability to translate the size estimate into human effort, calendar time, and dollars (a function of the availability of reliable software metrics from past projects)
  - the degree to which the project plan reflects the abilities of the software team
  - the stability of product requirements and the environment that supports the software engineering effort.

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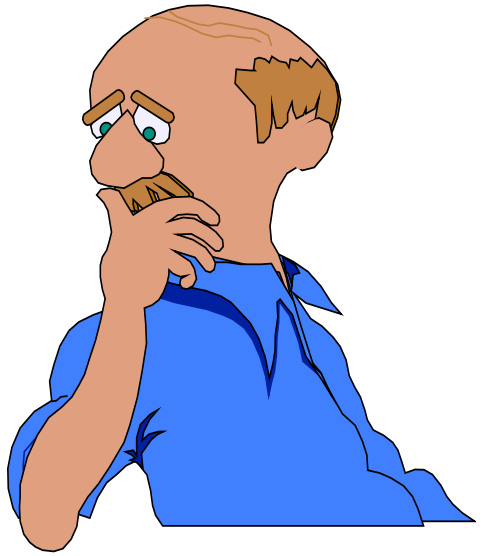
# Project Estimation

## Estimation Techniques

- Past (similar) project experience
- Conventional estimation techniques
  - task breakdown and effort estimates
  - size (e.g., FP) estimates
- Empirical models
- Automated tools



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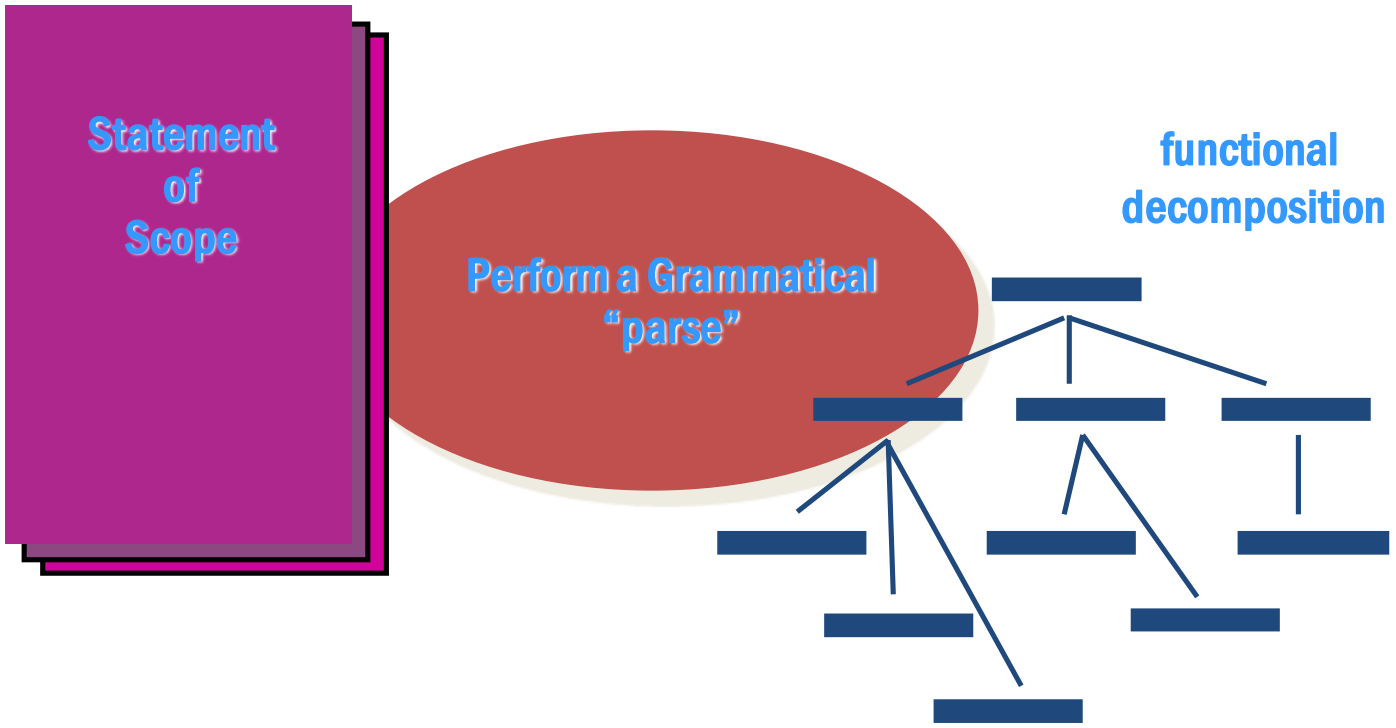
# Project Estimation

## Functional Decomposition



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# Project Estimation

## Conventional Methods: LOC/FP Approach

- compute LOC/FP using estimates of information domain values
- use historical data to build estimates for the project

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# Project Estimation

## Example: LOC Approach

| Function | Estimated LOC |
|---|---|
| user interface and control facilities (UICF) | 2,300 |
| two-dimensional geometric analysis (2DGA) | 5,300 |
| three-dimensional geometric analysis (3DGA) | 6,800 |
| database management (DBM) | 3,350 |
| computer graphics display facilities (CGDF) | 4,950 |
| peripheral control (PC) | 2,100 |
| design analysis modules (DAM) | 8,400 |
| *estimated lines of code* | 33,200 |

**Average productivity for systems of this type = 620 LOC/pm.**

**Burdened labor rate =$8000 per month, the cost per line of code is approximately $13.**

**Based on the LOC estimate and the historical productivity data, the total estimated project cost is $431,000 and the estimated effort is 54 person-months.**

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# Project Estimation

## Example: FP Approach

| Information Domain Value | opt. | likely | pess. | est. count | weight | FP-count |
|---|---|---|---|---|---|---|
| number of inputs | 20 | 24 | 30 | 24 | 4 | 97 |
| number of outputs | 12 | 15 | 22 | 16 | 5 | 78 |
| number of inquiries | 16 | 22 | 28 | 22 | 5 | 88 |
| number of files | 4 | 4 | 5 | 4 | 10 | 42 |
| number of external interfaces | 2 | 2 | 3 | 2 | 7 | 15 |
| count-total | | | | | | 321 |

The estimated number of FP is derived:

$$FP_{estimated} = count\text{-}total \times [0.65 + 0.01 \times \Sigma (F_i)]$$

$$FP_{estimated} = 375$$

organizational average productivity = 6.5 FP/pm.

burdened labor rate = $8000 per month, approximately $1230/FP.

Based on the FP estimate and the historical productivity data, total estimated project cost is $461,000 and estimated effort is 58 person-months.

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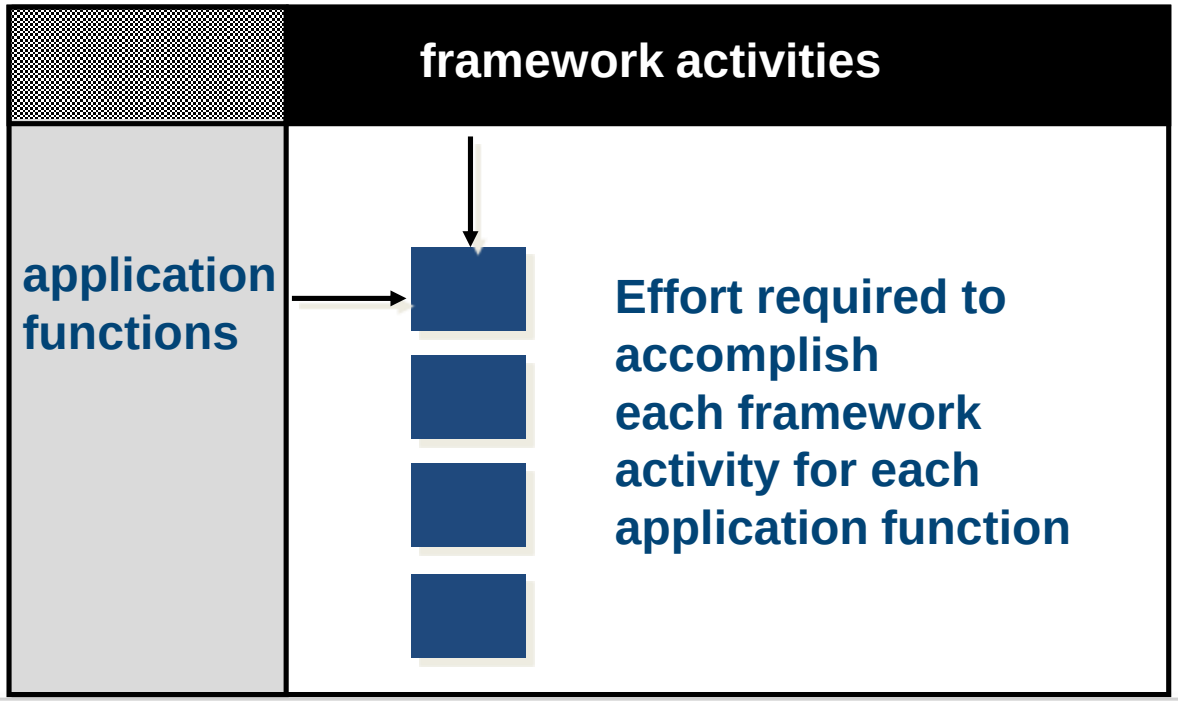
# Project Estimation

## Process-Based Estimation

Obtained from "process framework"



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# Project Estimation

## Process-Based Estimation Example

| Activity → | CC | Planning | Risk Analysis | Engineering | | Construction Release | | CE | Totals |
|---|---|---|---|---|---|---|---|---|---|
| Task → | | | | analysis | design | code | test | | |
| | | | | | | | | | |
| Function | | | | | | | | | |
| ▼ | | | | | | | | | |
| UICF | | | | 0.50 | 2.50 | 0.40 | 5.00 | n/a | 8.40 |
| 2DGA | | | | 0.75 | 4.00 | 0.60 | 2.00 | n/a | 7.35 |
| 3DGA | | | | 0.50 | 4.00 | 1.00 | 3.00 | n/a | 8.50 |
| CGDF | | | | 0.50 | 3.00 | 1.00 | 1.50 | n/a | 6.00 |
| DSM | | | | 0.50 | 3.00 | 0.75 | 1.50 | n/a | 5.75 |
| PCF | | | | 0.25 | 2.00 | 0.50 | 1.50 | n/a | 4.25 |
| DAM | | | | 0.50 | 2.00 | 0.50 | 2.00 | n/a | 5.00 |
| | | | | | | | | | |
| | | | | | | | | | |
| Totals | 0.25 | 0.25 | 0.25 | 3.50 | 20.50 | 4.50 | 16.50 | | 46.00 |
| | | | | | | | | | |
| % effort | 1% | 1% | 1% | 8% | 45% | 10% | 36% | | |

CC = customer communication CE = customer evaluation

**Based on an average burdened labor rate of $8,000 per month, the total estimated project cost is $368,000 and the estimated effort is 46 person-months.**

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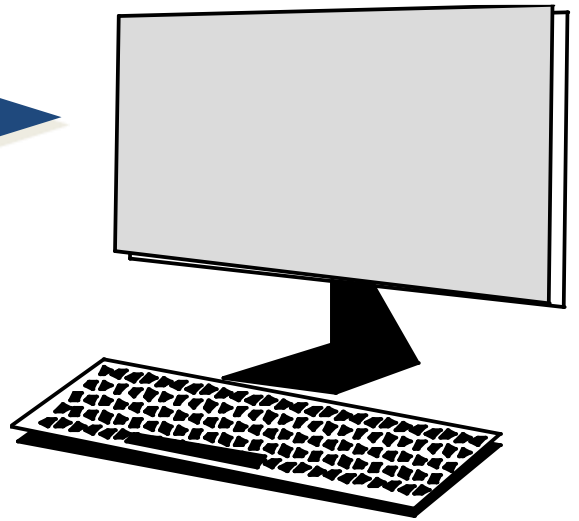
# Project Estimation

## Tool-Based Estimation

project characteristics

calibration factors

LOC/FP data



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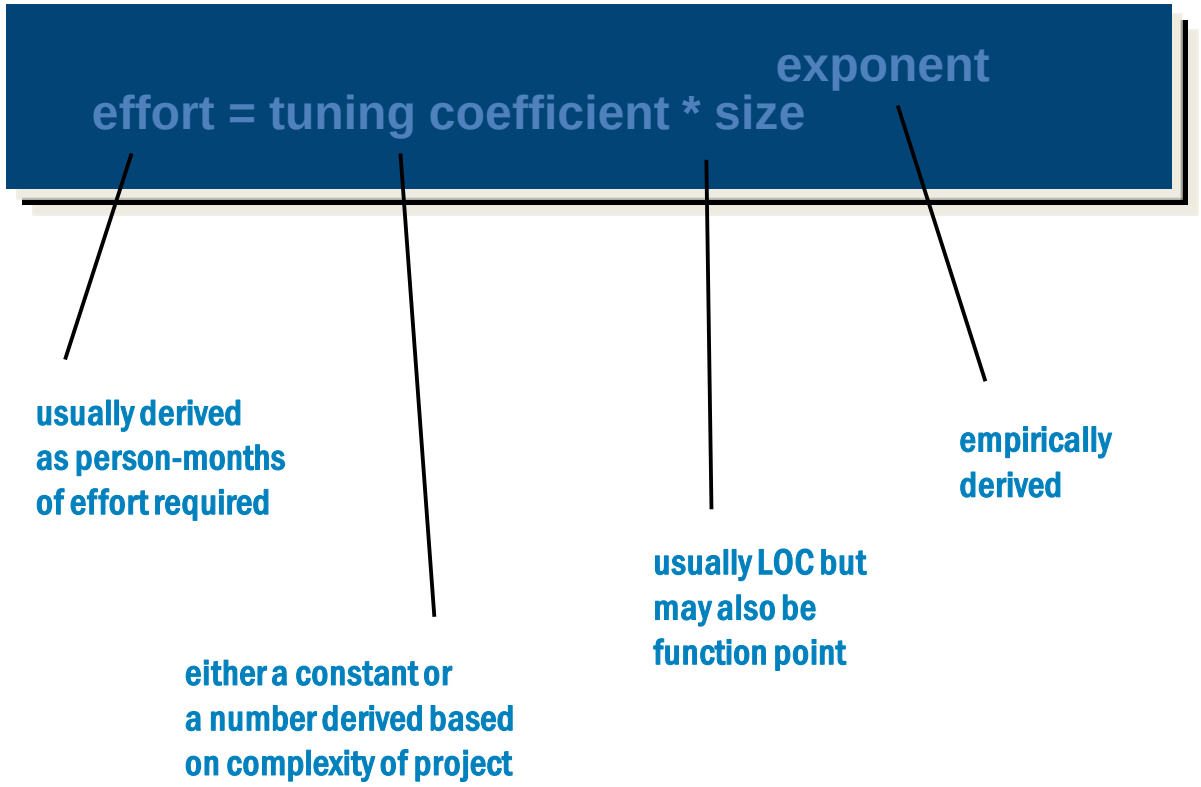
# Empirical Estimation Models

***General form:***



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# Empirical Estimation Models

## COCOMO-II

- COCOMO II is actually a hierarchy of estimation models that address the following areas:
  - *Application composition model.* Used during the early stages of software engineering, when prototyping of user interfaces, consideration of software and system interaction, assessment of performance, and evaluation of technology maturity are paramount.
  - *Early design stage model.* Used once requirements have been stabilized and basic software architecture has been established.
  - *Post-architecture-stage model.* Used during the construction of the software.

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# Empirical Estimation Models

## The Software Equation

*A dynamic multivariable model*

$$E = [LOC \times B^{0.333}/P]^3 \times (1/t^4)$$

where

E = effort in person-months or person-years
t = project duration in months or years
B = "special skills factor"
P = "productivity parameter"

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# Estimation for OO Projects

1. Develop estimates using effort decomposition, FP analysis, and any other method that is applicable for conventional applications.
2. Using object-oriented requirements modeling, develop use-cases and determine a count.
3. From the analysis model, determine the number of key classes.
4. Categorize the type of interface for the application and develop a multiplier for support classes:

| Interface type | Multiplier |
|---|---|
| No GUI | 2.0 |
| Text-based user interface | 2.25 |
| GUI | 2.5 |
| Complex GUI | 3.0 |

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# Estimation for OO Projects

5. Multiply the number of key classes (step 3) by the multiplier to obtain an estimate for the number of support classes.
6. Multiply the total number of classes (key + support) by the average number of work-units per class. Lorenz and Kidd suggest 15 to 20 person-days per class.
7. Cross check the class-based estimate by multiplying the average number of work-units per use-case

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# Estimation for Agile Projects

- Each user scenario (a mini-use-case) is considered separately for estimation purposes.
- The scenario is decomposed into the set of software engineering tasks that will be required to develop it.
- Each task is estimated separately. Note: estimation can be based on historical data, an empirical model, or "experience."
  - Alternatively, the 'volume' of the scenario can be estimated in LOC, FP or some other volume-oriented measure (e.g., use-case count).
- Estimates for each task are summed to create an estimate for the scenario.
  - Alternatively, the volume estimate for the scenario is translated into effort using historical data.
- The effort estimates for all scenarios that are to be implemented for a given software increment are summed to develop the effort estimate for the increment.

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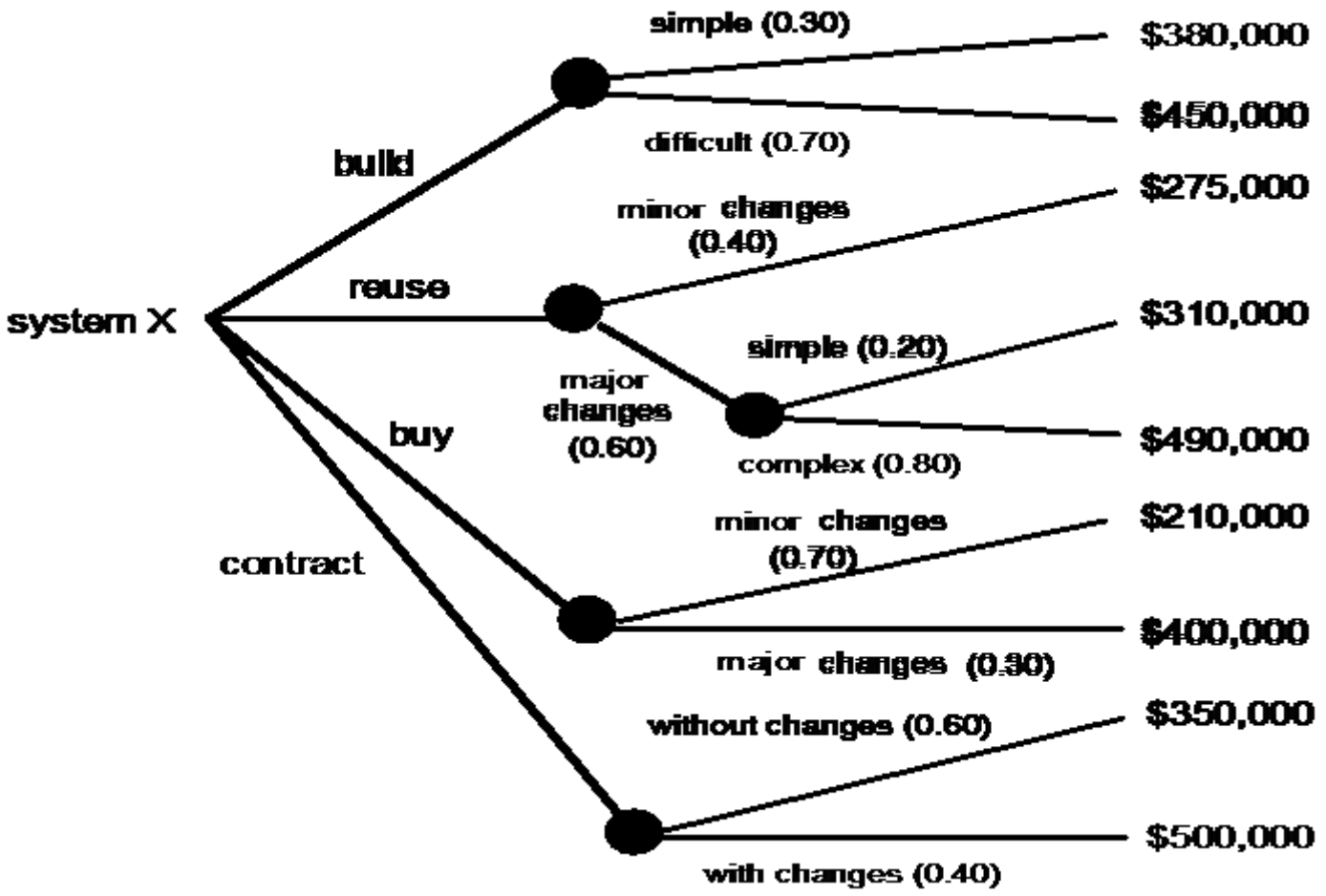
# The Make-Buy Decision



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# The Make-Buy Decision

## Computing Expected Cost

$$\text{expected cost} = \sum (\text{path probability})_i \times (\text{estimated path cost})_i$$

*For example, the expected cost to build is:*

$$\text{expected cost}_{\text{build}} = 0.30\ (\$380K) + 0.70\ (\$450K)$$

$$= \$429\ K$$

*similarly,*

$$\text{expected cost}_{\text{reuse}} = \$382K$$

$$\text{expected cost}_{\text{buy}} = \$267K$$

$$\text{expected cost} = \$410K$$

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# The Make-Buy Decision

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# Project Scheduling

## Scheduling Principles

- Compartmentalization –define distinct tasks
- Interdependency –indicate task interrelationship
- Effort validation –be sure resources are available
- Defined responsibilities –people must be assigned
- Defined outcomes –each task must have an output
- Defined milestones –review for quality

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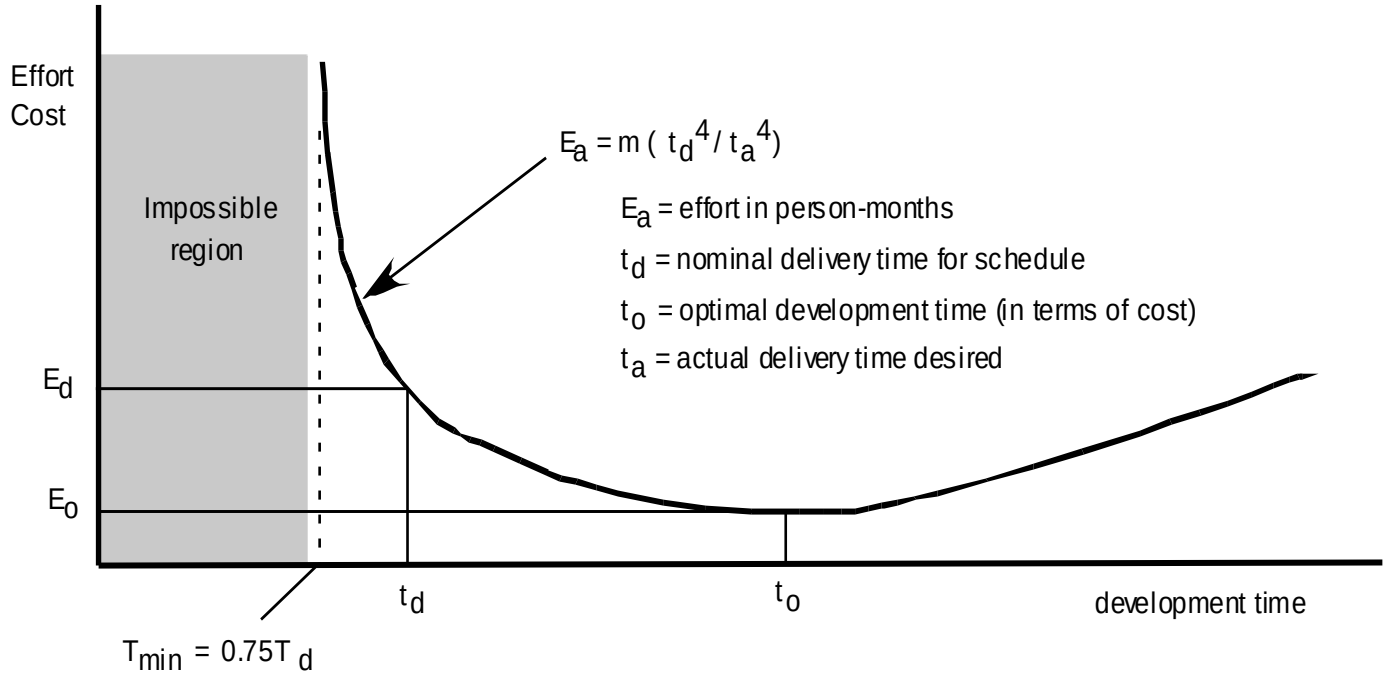
# Project Scheduling

## Effort and Delivery Time



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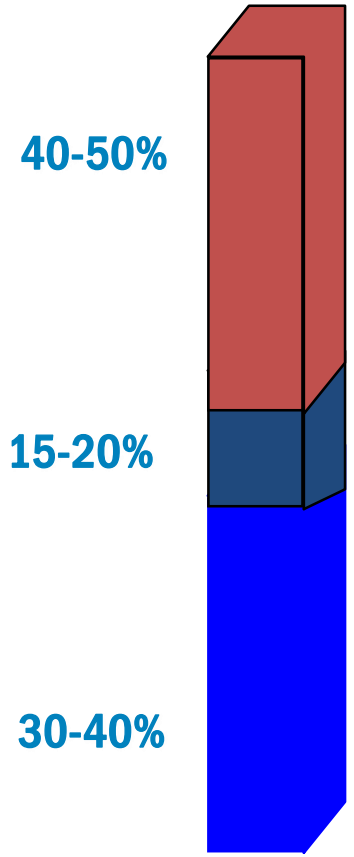
# Project Scheduling

## Effort Allocation




- "front end" activities
  - customer communication
  - analysis
  - design
  - review and modification
- construction activities
  - coding or code generation
- testing and installation
  - unit, integration
  - white-box, black box
  - regression

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# Project Scheduling

## Defining Task Sets

- determine type of project
- assess the degree of rigor required
- identify adaptation criteria
- select appropriate software engineering tasks

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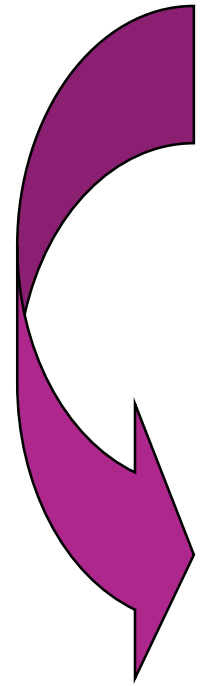
# Project Scheduling

## Task Set Refinement

**1.1 Concept scoping** determines the overall scope of the project.



**is refined to**

Task definition: Task 1.1 Concept Scoping
- 1.1.1 Identify need, benefits and potential customers;
- 1.1.2 Define desired output/control and input events that drive the application;
  - Begin Task 1.1.2
    - 1.1.2.1 FTR: Review written description of need
      FTR indicates that a formal technical review (Chapter 26) is to be conducted.
    - 1.1.2.2 Derive a list of customer visible outputs/inputs
    - 1.1.2.3 FTR: Review outputs/inputs with customer and revise as required;
  - endtask Task 1.1.2
- 1.1.3 Define the functionality/behavior for each major function;
  - Begin Task 1.1.3
    - 1.1.3.1 FTR: Review output and input data objects derived in task 1.1.2;
    - 1.1.3.2 Derive a model of functions/behaviors;
    - 1.1.3.3 FTR: Review functions/behaviors with customer and revise as required;
  - endtask Task 1.1.3
- 1.1.4 Isolate those elements of the technology to be implemented in software;
- 1.1.5 Research availability of existing software;
- 1.1.6 Define technical feasibility;
- 1.1.7 Make quick estimate of size;
- 1.1.8 Create a Scope Definition;

endTask definition: Task 1.1

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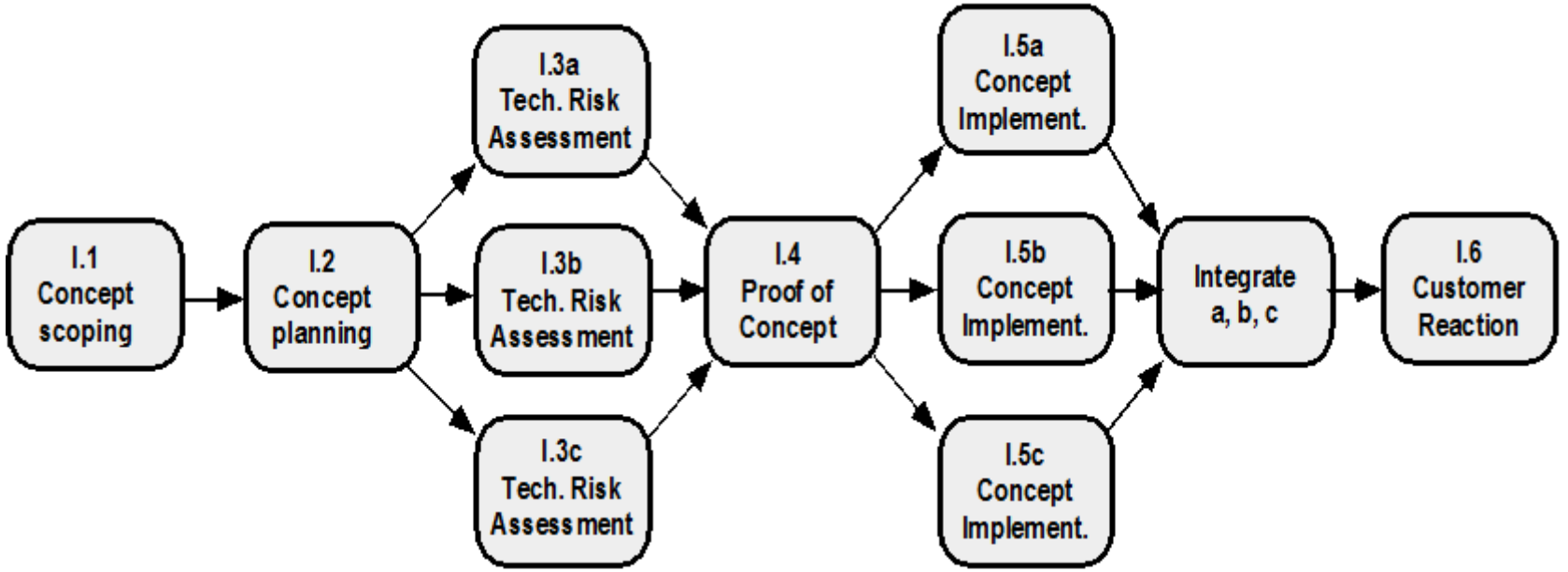
# Project Scheduling

## Define a Task Network



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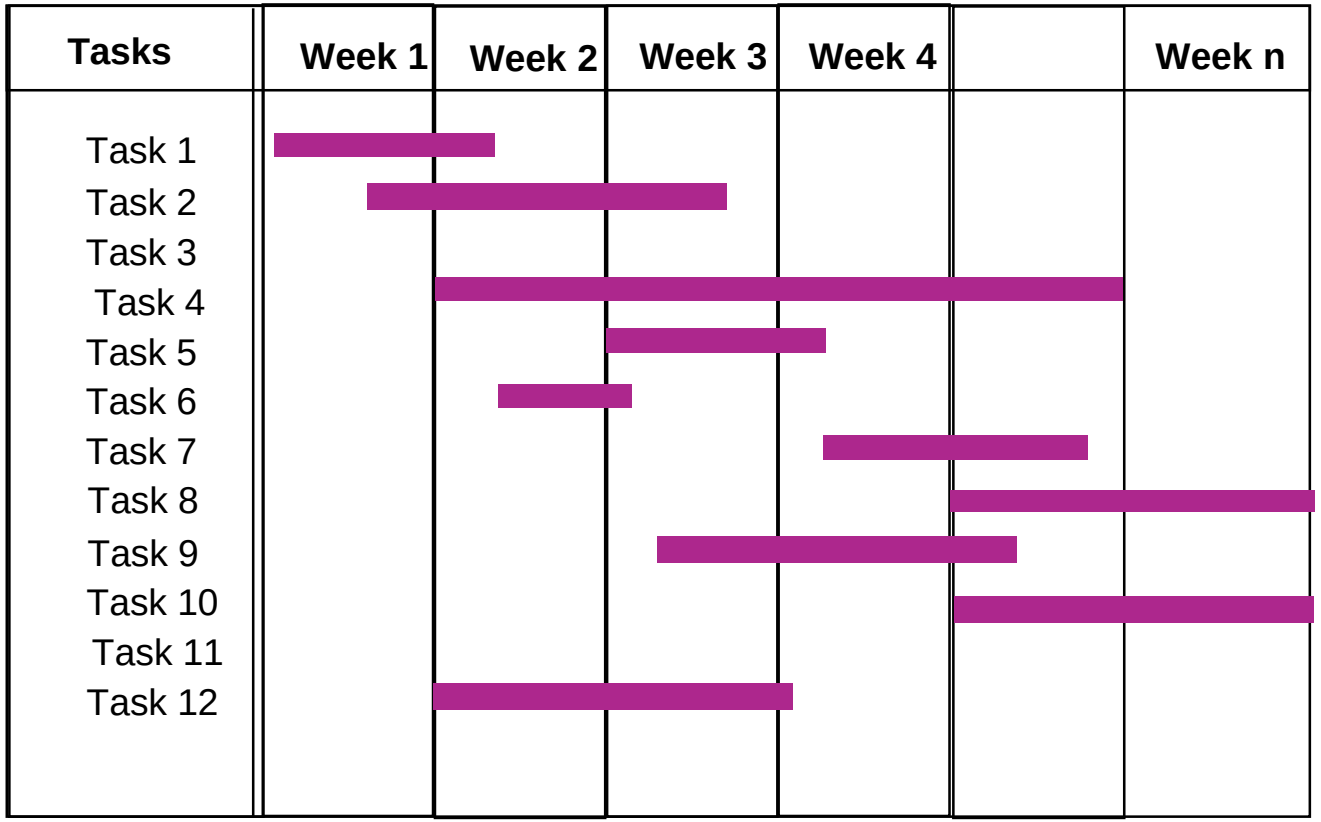
# Project Scheduling

## Timeline Charts



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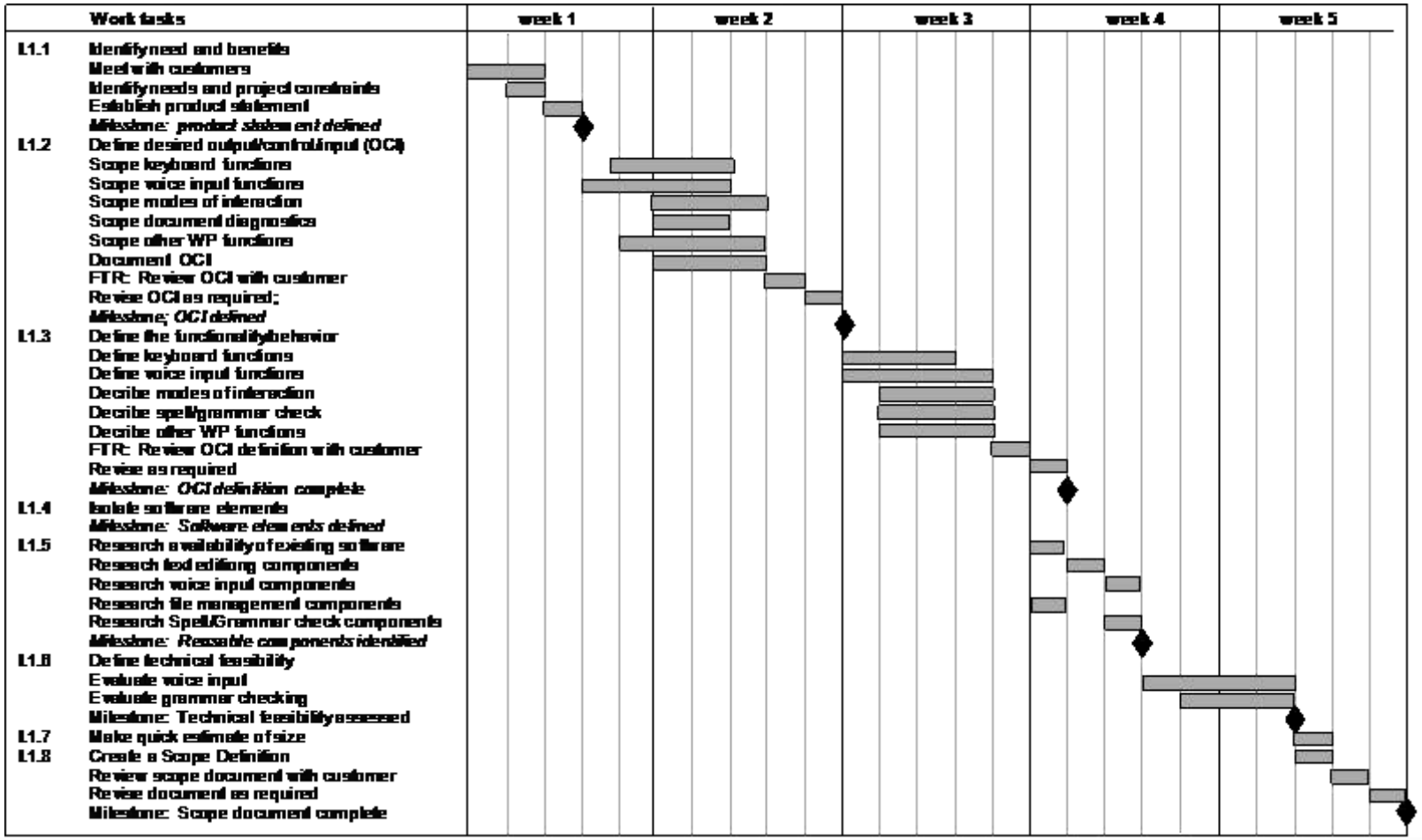
# Project Scheduling

## Use Automated Tools to Derive a Timeline Chart



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# Project Scheduling

## Schedule Tracking

- conduct periodic project status meetings in which each team member reports progress and problems.
- evaluate the results of all reviews conducted throughout the software engineering process.
- determine whether formal project milestones have been accomplished by the scheduled date.
- compare actual start-date to planned start-date for each project task listed in the resource table.
- meet informally with practitioners to obtain their subjective assessment of progress to date and problems on the horizon.
- use earned value analysis to assess progress quantitatively.

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# Project Scheduling

## Progress on an OO Project-I

- *Technical milestone: OO analysis completed*
  - All classes and the class hierarchy have been defined and reviewed.
  - Class attributes and operations associated with a class have been defined and reviewed.
  - Class relationships have been established and reviewed.
  - A behavioral model has been created and reviewed.
  - Reusable classes have been noted.
- *Technical milestone: OO design completed*
  - The set of subsystems has been defined and reviewed.
  - Classes are allocated to subsystems and reviewed.
  - Task allocation has been established and reviewed.
  - Responsibilities and collaborations have been identified.
  - Attributes and operations have been designed and reviewed.
  - The communication model has been created and reviewed.

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# Scheduling for WebApp and Mobile Projects

## Seven increments for Web and MobileApps

1. Basic company and product information
2. Detailed product information and downloads
3. Product quotes and processing product orders
4. Space layout and security system design
5. Information and ordering of monitoring srvices
6. Online control of monitoring equipment
7. Accessing control information

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# Scheduling for WebApp and Mobile Projects

## Design the interface for the fourth increment

- Develop a sketch of the page layout for the space design page
- Review layout with stakeholders
- Design space layout navigation mechanisms
- Design “drawing board” layout
- Develop procedural details for the graphical wall layout function
- Develop procedural details for the wall length computation and display function
- Develop procedural details for the graphical window layout function
- Develop procedural details for the graphical door layout function
- Design mechanisms for selecting security system components

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# Project Scheduling

## Progress on an OO Project-II

- *Technical milestone: OO programming completed*
  - Each new class has been implemented in code from the design model.
  - Extracted classes (from a reuse library) have been implemented.
  - Prototype or increment has been built.
- *Technical milestone: OO testing*
  - The correctness and completeness of OO analysis and design models has been reviewed.
  - A class-responsibility-collaboration network has been developed and reviewed.
  - Test cases are designed and class-level tests have been conducted for each class.
  - Test cases are designed and cluster testing is completed and the classes are integrated.
  - System level tests have been completed.

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# Earned Value Analysis (EVA)

- Earned value
  - is a measure of progress
  - enables us to assess the "percent of completeness" of a project using quantitative analysis rather than rely on a gut feeling
  - "provides accurate and reliable readings of performance from as early as 15 percent into the project." [Fle98]

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# Earned Value Analysis (EVA)

## Computing Earned Value-I

- The *budgeted cost of work scheduled* (BCWS) is determined for each work task represented in the schedule.
  - $BCWS_i$ is the effort planned for work task *i*.
  - To determine progress at a given point along the project schedule, the value of BCWS is the sum of the $BCWS_i$ values for all work tasks that should have been completed by that point in time on the project schedule.
- The BCWS values for all work tasks are summed to derive the *budget at completion,* BAC. Hence,

$$BAC = \sum (BCWS_k) \text{ for all tasks } k$$

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# Earned Value Analysis (EVA)

## Computing Earned Value-II

- Next, the value for *budgeted cost of work performed* (BCWP) is computed.
  - The value for BCWP is the sum of the BCWS values for all work tasks that have actually been completed by a point in time on the project schedule.
- "the distinction between the BCWS and the BCWP is that the former represents the budget of the activities that were planned to be completed and the latter represents the budget of the activities that actually were completed." [Wil99]
- Given values for BCWS, BAC, and BCWP, important progress indicators can be computed:
  - Schedule performance index, SPI = BCWP/BCWS
  - Schedule variance, SV = BCWP – BCWS
  - SPI is an indication of the efficiency with which the project is utilizing scheduled resources.

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# Earned Value Analysis (EVA)

## Computing Earned Value-III

- Percent scheduled for completion = BCWS/BAC
  - provides an indication of the percentage of work that should have been completed by time *t.*
- Percent complete = BCWP/BAC
  - provides a quantitative indication of the percent of completeness of the project at a given point in time, *t.*
- *Actual cost of work performed,* ACWP, is the sum of the effort actually expended on work tasks that have been completed by a point in time on the project schedule. It is then possible to compute
  - Cost performance index, CPI = BCWP/ACWP
  - Cost variance, CV = BCWP – ACWP

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# Case Study

## The use of project management tools

- In practical project, the use of project management tools are very effective to manage the project process including:
  - Scheduling
  - Resources
  - Estimation
  - Costing
  - etc

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# Q & A

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# Thank You