

# TOPICS

**Overview**

**Metrics**

**Estimation**

**Planning**

# **SOFTWARE PROJECT ESTIMATION**

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- **Resources**
- **Decomposition Techniques**
- **Using LOC or FP to Estimate Effort**
- **Effort Estimation by Function**
- **Effort Estimation by Task**
- **Empirical Estimation Models**
- **COCOMO**
- **Putman Estimation Model**

# Overview

## Estimation of:

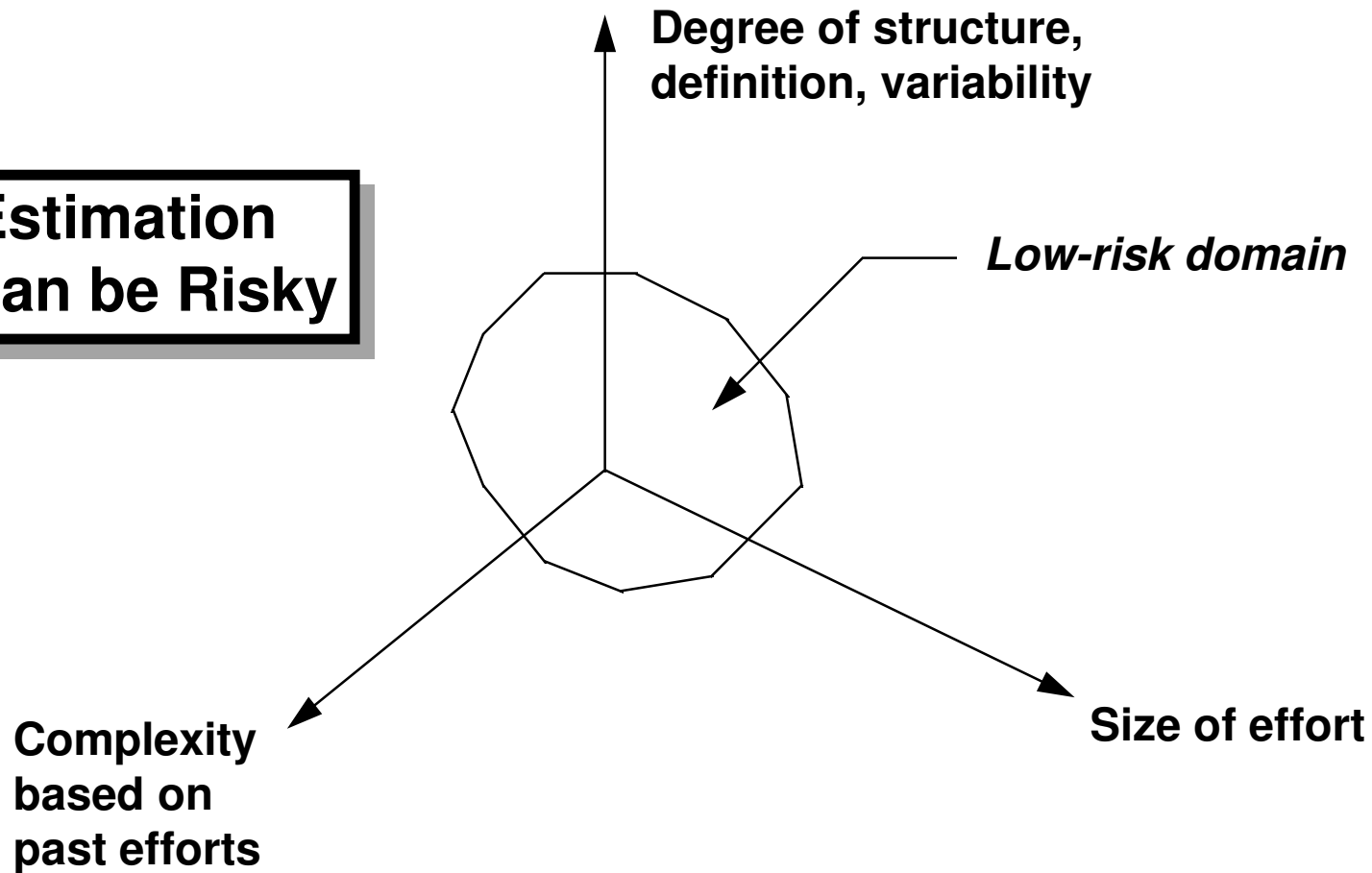
- **resources**
- **costs**
- **schedules**

## Requires:

- **experience**
- **historical information**
- **quantitative measures of qualitative data**

# Overview, Continued

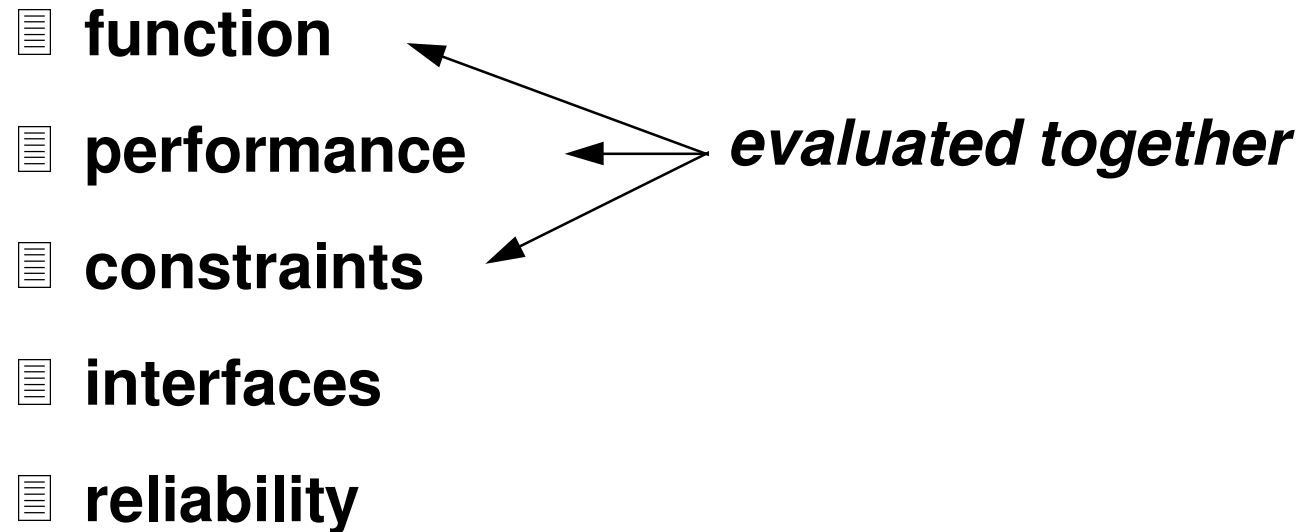
**Estimation  
can be Risky**



# Resources

## Planning Task 1: Software Scope

1. Statement of software scope must be bounded
2. Software scope describes:

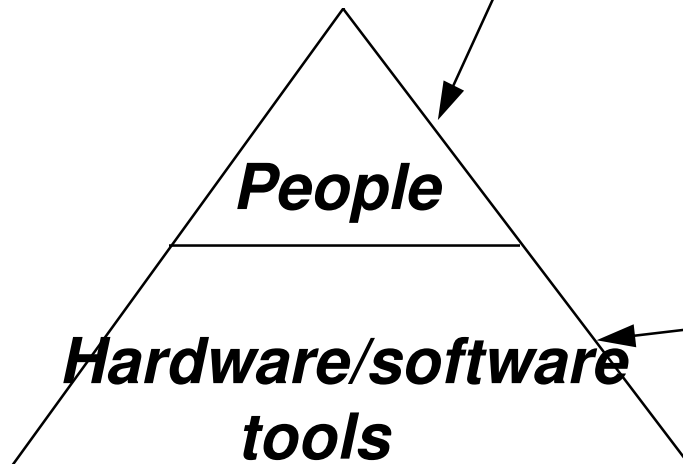


# Resources, Continued

## Planning Task 2: Estimation of Needed Resources

### Specify:

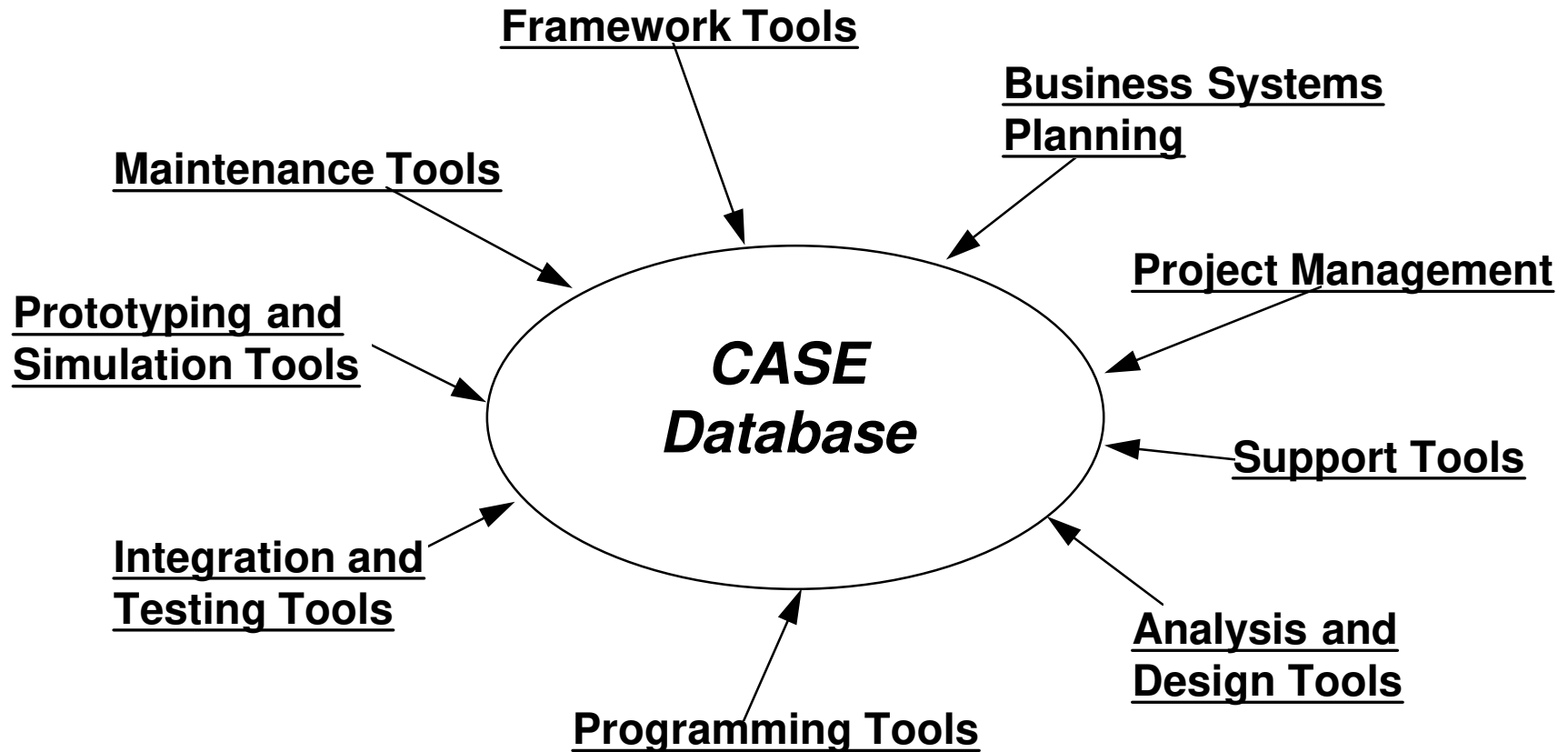
- Required skills
- Availability
- Duration of tasks
- Start date



### Specify:

- Description
- Availability
- Duration of use
- Delivery date

# Resources, Continued



**CASE - Computer-Aided Software Engineering**

# Resources, Continued

## Reuse - A Resource

Two rules:

1. If existing software meets requirements, then  
**acquire and use it!**

2. If existing software can meet requirements with some  
modification, then  
**be careful!**

**The cost of modification can exceed the cost of  
new development!**



# Decomposition Techniques

- **LOC and FP Estimation**
- **Effort Estimation**

# Decomposition Techniques, Continued

## LOC and FP Estimation

The idea is that the person planning the software project:

- creates a bounded statement of the scope of the software
- decomposes the scope into smaller subfunctions
- estimates LOC or FP for each subfunction
- applies baseline productivity metrics (e.g., LOC/person-month) to LOC or FP estimates to produce a cost or effort estimate for each subfunction
- combines estimates for each subfunction to derive estimates for the entire project

# Decomposition Techniques, Continued

## Differences Between LOC and FP

- FP estimation techniques require less detail than LOC
- LOC is estimate directly while FP is estimated indirectly

# Using LOC or FP to Estimate Effort

## 1. Estimate LOC or FP values for each subfunction

- Use historical data (or intuition, if necessary)
- Three estimates: optimistic (o), most likely (m), and pessimistic (b)

## 2. Calculate expected value for each subfunction $E = \frac{a + 4m + b}{6}$

## 3. Apply productivity data to get effort to be expended; two ways:

1. Total expected LOC or FP for all subfunctions and divide this by the expected LOC or FP completed per person-month (estimated from past projects); example:

$$\begin{aligned} \text{Effort} &= 310 \text{ expected FP for project} / 5.5 \text{ expected FP per person-month} \\ &= 56 \text{ person-months} \end{aligned}$$

2. Multiply each subfunction LOC or FP by the adjusted productivity value (based on the estimated complexity of the function) and sum the results for all subfunctions in the project

# Effort Estimation by Function

## CAD Program Example

<i>Function</i>	<i>Optimistic</i>	<i>Most Likely</i>	<i>Pessimistic</i>	<i>Expected</i>	<i>\$/Line</i>	<i>Line/Month</i>	<i>Cost</i>	<i>Months</i>
User interface control	1800	2400	2650	2,340	\$14	315	\$ 32,760	7.4
2-D geometric analysis	4100	5200	7400	5,380	\$20	220	\$107,600	24.4
3-D geometric analysis	4600	6900	8600	6,800	\$20	220	\$136,000	30.9
Data structure mgmt	2950	3400	3600	3,350	\$18	240	\$ 60,300	13.9
Graphics display	4050	4900	6200	4,950	\$22	200	\$108,900	24.7
Peripheral control	2000	2100	2450	2,140	\$28	140	\$ 59,920	15.2
Design analysis	6600	8500	9800	8,400	\$18	300	\$151,200	28.0
Estimated Effort				33,360			\$656,680	144.5

**Estimated Cost: \$ 656,680**

**Estimated Effort: 144.5 person-months**

# Effort Estimation by Task

## CAD Program Example

<i>Function</i>	<i>RA</i>	<i>Design</i>	<i>Code</i>	<i>Test</i>	<i>Total</i>
User interface control	1.0	2.0	0.5	3.5	7.0
2-D geometric analysis	2.0	10.0	4.5	9.5	26.0
3-D geometric analysis	2.5	12.0	6.0	11.0	31.5
Data structure mgmt	2.0	6.0	3.0	4.0	15.0
Graphics display	1.5	11.0	4.0	10.5	27.0
Peripheral control	1.5	6.0	3.5	5.0	16.0
Design analysis	4.0	14.0	5.0	7.0	30.0
<b>Total</b>	<b>14.5</b>	<b>61.0</b>	<b>26.5</b>	<b>50.5</b>	<b>152.5</b>
<b>Rate (\$)</b>	<b>5200</b>	<b>4800</b>	<b>4250</b>	<b>4500</b>	
<b>Cost (\$)</b>	<b>75,400</b>	<b>292,800</b>	<b>112,625</b>	<b>227,250</b>	<b>708,075</b>

**Estimated Cost: \$ 708,075**

**Estimated Effort: 152.5 person-months**

# Empirical Estimation Models

- **Static single-variable model (example: COCOMO)**

$$\text{Resource} = cx^d$$

where

**x is the estimated characteristic (LOC, FP, effort, etc.)**

**c and d are constants derived from data collected from past projects**

- **Static multivariable model**

$$\text{Resource} = cx + dy + \dots$$

where

**x, y, ... and c, d, ... are as above**

- **Dynamic multivariable model**

**Project resource requirements are determined over a series of time steps**

- **Theoretical (example: Putman Estimation Model)**

**Uses equations derived from hypothesized expenditure curves**

# COCOMO

- Involves basic, intermediate, and advanced models
- Basic model:

$$\text{Effort} = a(b) \text{KLOC}^{b(b)} \text{person} - \text{months}$$

$$\text{Development Time} = c(b) \text{Effort}^{d(b)} \text{months}$$

$a(b)$ ,  $b(b)$ ,  $c(b)$ , and  $d(b)$  are determined from the table:

<i>Software Project</i>	<i>a(b)</i>	<i>b(b)</i>	<i>c(b)</i>	<i>d(b)</i>
Organic	2.4	1.05	2.5	0.38
Semidetached	3.0	1.12	2.5	0.35
Embedded	3.6	1.20	2.5	0.32



# **COCOMO, Continued**

**Example of COCOMO basic model on the CAD program:**

$$\text{Effort} = 3.0 (\text{LOC}) ^ 1.12$$

$$= 3.0 (33.3) ^ 1.12$$

$$= 152 \text{ person-months}$$

$$\text{Development Time} = 2.5 (\text{Effort}) ^ 0.35$$

$$= 2.5 (152) ^ 0.35$$

$$= 14.5 \text{ months}$$

**Thus, estimated number of people N is:**

$$N = \text{Effort} / \text{Development Time}$$

$$= 152 / 14.5$$

$$= 11 \text{ people}$$

# Putman Estimation Model

- Data is derived from large projects
- Model is applicable to smaller projects as well
- The distribution of effort is described by the Rayleigh-Norden curve

