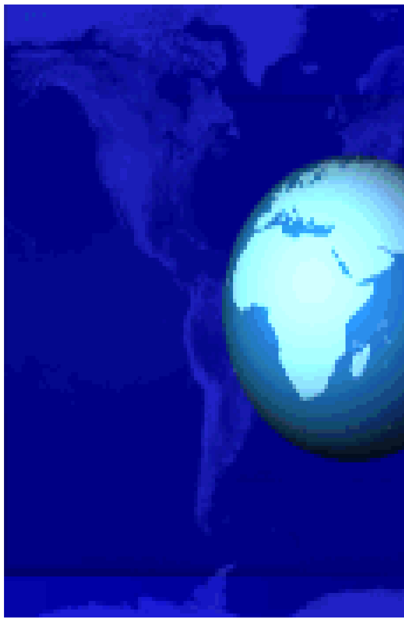


Software Project Planning

Software Project Planning

After the finalization of SRS, we would
estimate size, cost and development time
project. Also, in many cases, customer may
know the cost and development time even
finalization of the SRS.

Software Project Planning

In order to conduct a successful software pro
must understand:

- Scope of work to be done
- The risk to be incurred
- The resources required
- The task to be accomplished
- The cost to be expended
- The schedule to be followed

Software Project Planning

Software planning begins before technical work starts, c
the software evolves from concept to reality, and culm
when the software is retired.

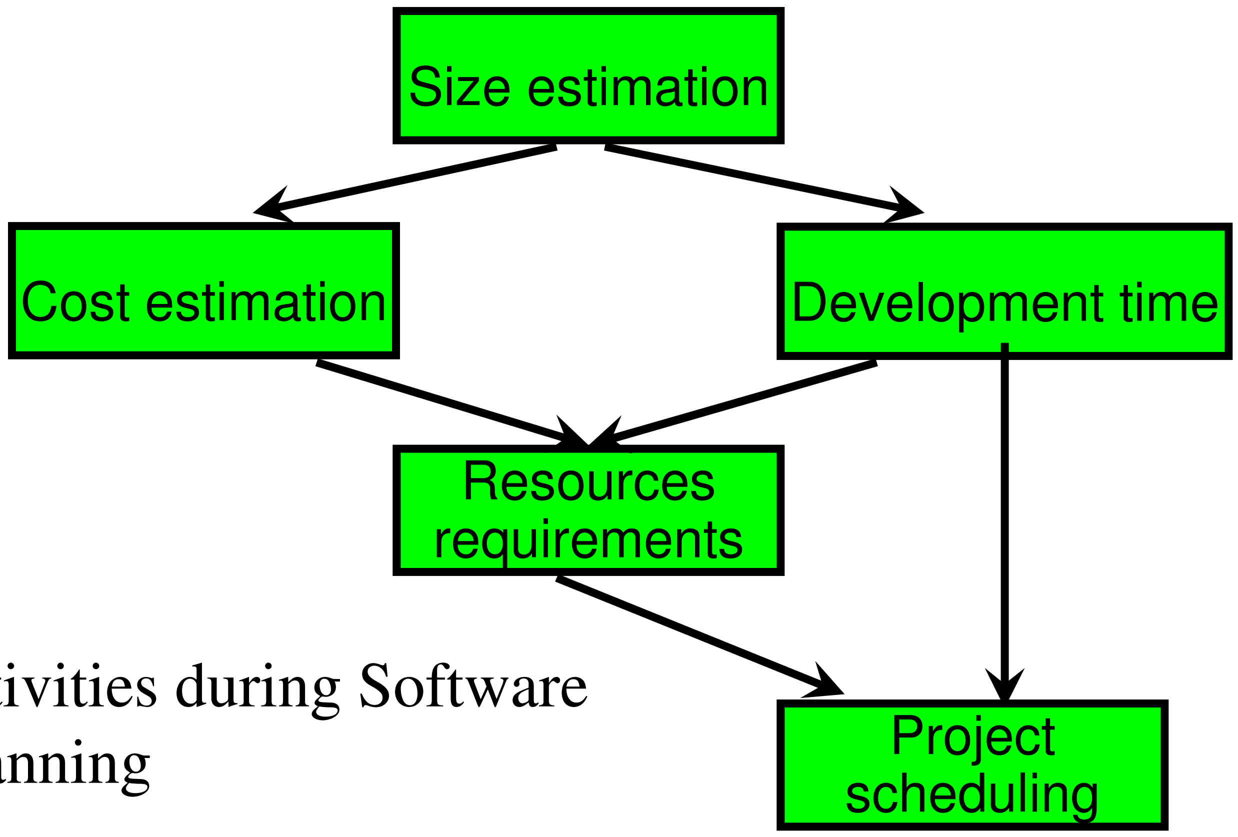


Fig. 1: Activities during Software Project Planning

Size Estimation

Lines of Code (LOC)

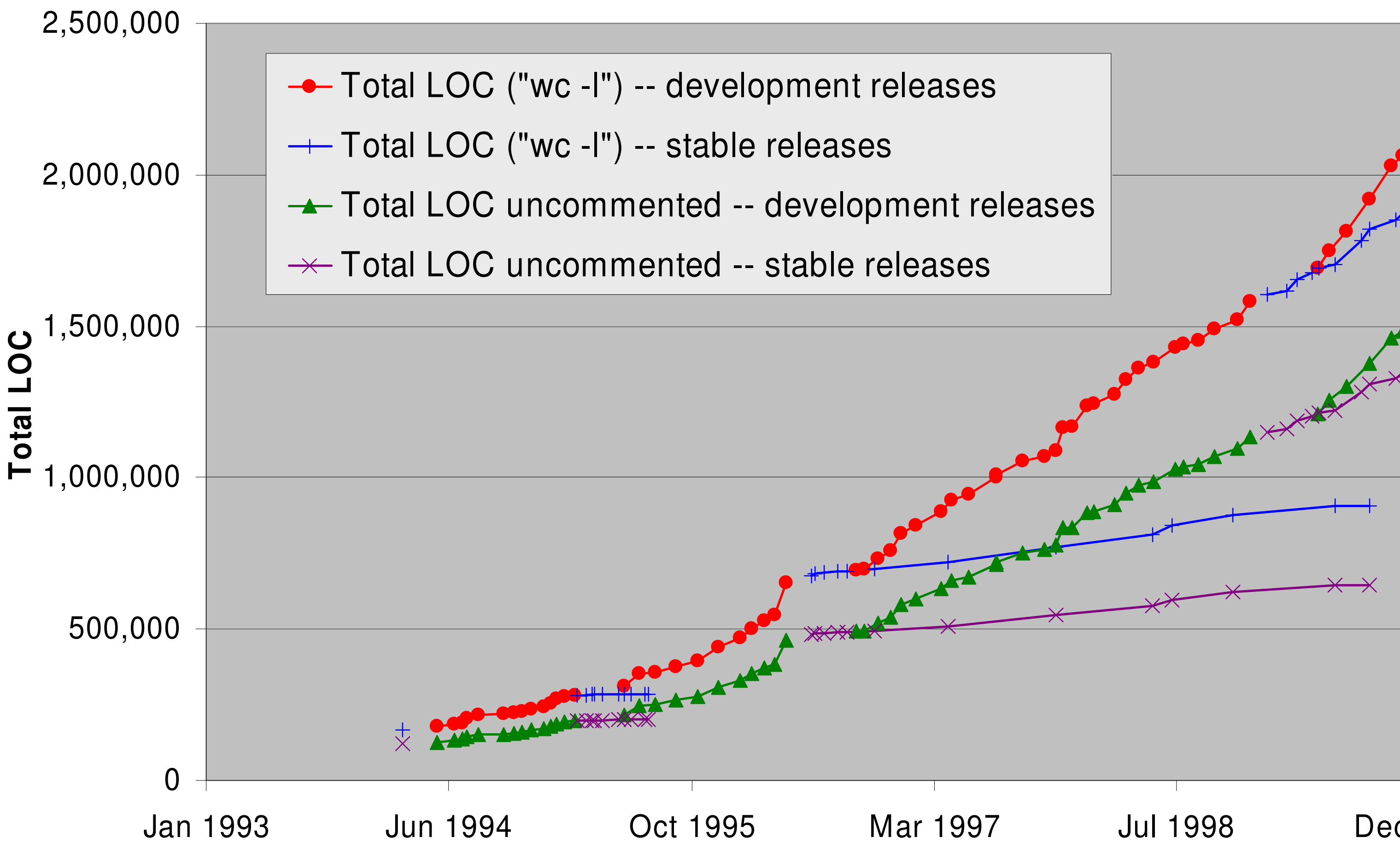
If LOC is simply a count of the number of lines then figure shown below contains 18 LOC .

When comments and blank lines are ignored, the program in figure 2 shown below contains 17 LOC.

Fig. 2: Function for sorti

1.	int. sort (int x[ ], int n)
2.	{
3.	int i, j, save, im1;
4.	/*This function sorts array x in a
5.	If (n<2) return 1;
6.	for (i=2; i<=n; i++)
7.	{
8.	im1=i-1;
9.	for (j=1; j<=im; j++)
10.	if (x[i] < x[j])
11.	{
12.	Save = x[i];
13.	x[i] = x[j];
14.	x[j] = save;
15.	}
16.	}
17.	return 0;
18.	}

Growth of Lines of Code (LOC)



Software Project Planning

Furthermore, if the main interest is the size of th
for specific functionality, it may be reasonable
executable statements. The only executable sta
figure shown above are in lines 5-17 leading to
13. The differences in the counts are 18 to 17 t
can easily see the potential for major discrep
large programs with many comments or progra
in language that allow a large number of desc
non-executable statement. Conte has defined lin
as:

Software Project Planning

"A line of code is any line of program text tha
comment or blank line, regardless of the nu
statements or fragments of statements on the l
specifically includes all lines containing progra
declaration, and executable and non-e
statements".

This is the predominant definition for lines of c
by researchers. By this definition, figure show
has 17 LOC.

Function Count

Alan Albrecht while working for IBM, recog
problem in size measurement in the 197
developed a technique (which he called Functi
Analysis), which appeared to be a solution to
measurement problem.

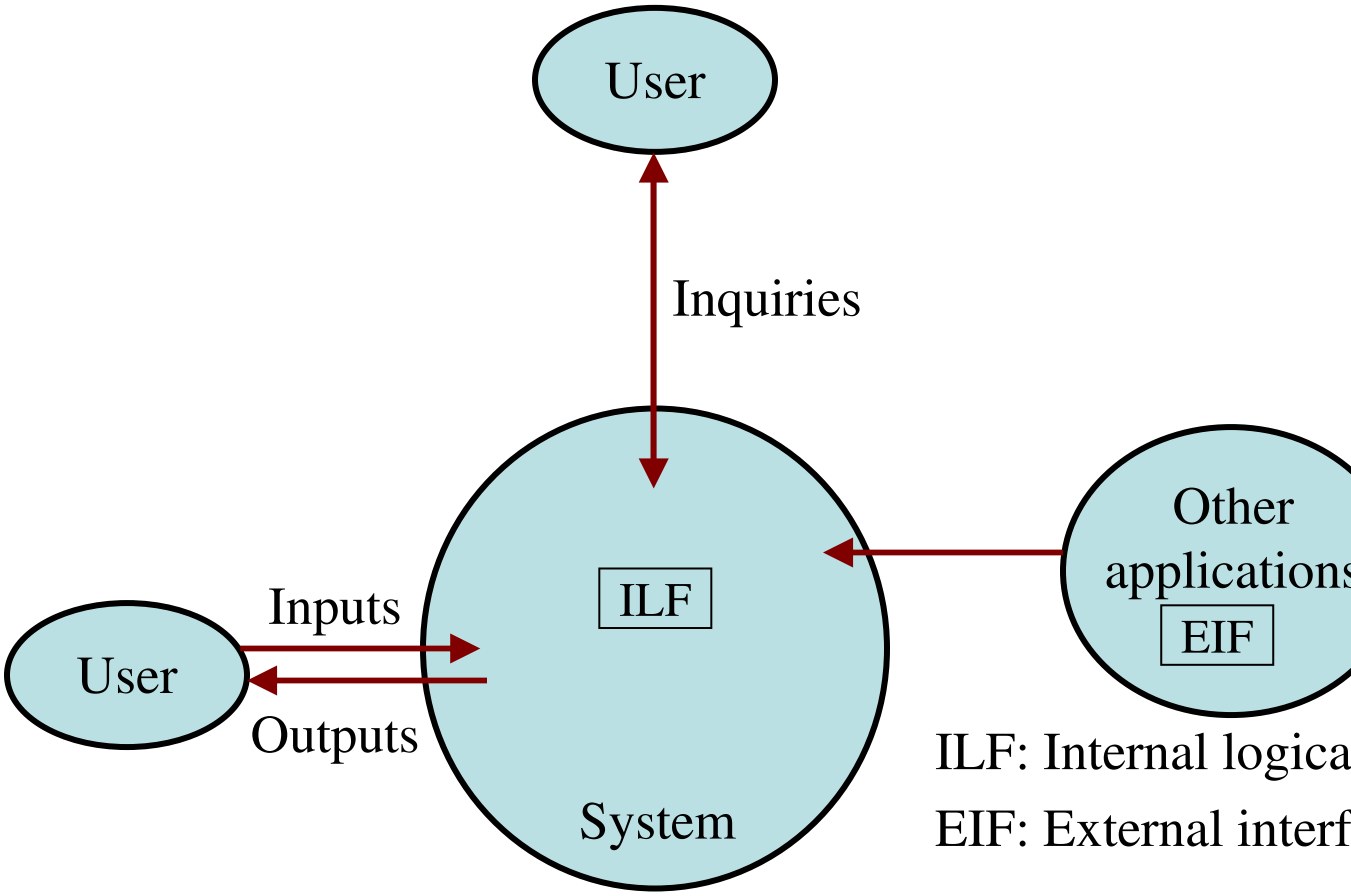
Software Project Planning

The principle of Albrecht's function point analys
is that a system is decomposed into functional ur

▪ Inputs	:	information entering
▪ Outputs	:	information leaving t
▪ Enquiries	:	requests for instant ac information
▪ Internal logical files	:	information held with system
▪ External interface files	:	information held by that is used by the sy analyzed.

Software Project Planning

The FPA functional units are shown in figure given



ILF: Internal logica

EIF: External interf

Fig. 3: FPAs functional units System

Software Project Planning

The five functional units are divided in two categ

(i) Data function types

- Internal Logical Files (ILF): A user identifiable logical related data or control information m within the system.

- External Interface files (EIF): A user identifiable logically related data or control information refe the system, but maintained within another syst means that EIF counted for one system, may be another system.

Software Project Planning

(ii) Transactional function types

- External Input (EI): An EI processes data or control that comes from outside the system. The EI is an process, which is the smallest unit of activity that is to the end user in the business.
- External Output (EO): An EO is an elementary p generate data or control information to be sent system.
- External Inquiry (EQ): An EQ is an elementary pro made up to an input-output combination that resu retrieval.

Special features

- Function point approach is independent of the tools, or methodologies used for implementation do not take into consideration programming la data base management systems, processing har any other data base technology.
- Function points can be estimated from rec specification or design specification, thus n possible to estimate development efforts in early development.

Software Project Planning

- Function points are directly linked to the sta
requirements; any change of requirements c
be followed by a re-estimate.
- Function points are based on the syste
external view of the system, non-technical
the software system have a better understa
what function points are measuring.

Software Project Planning

Counting function points

Functional Units	Weighting facto	
	Low	Average
External Inputs (EI)	3	4
External Output (EO)	4	5
External Inquiries (EQ)	3	4
External logical files (ILF)	7	10
External Interface files (EIF)	5	7

Table 1 : Functional units with weighting facto

Software Project Planning

Table 2: UFP calculation table

Functional Units	Count Complexity			Complexity Totals	Functi Unit T
External Inputs (EIs)	☐	Low x 3	=	☐	
	☐	Average x 4	=	☐	
	☐	High x 6	=	☐	☐
External Outputs (EOs)	☐	Low x 4	=	☐	
	☐	Average x 5	=	☐	
	☐	High x 7	=	☐	☐
External Inquiries (EQs)	☐	Low x 3	=	☐	
	☐	Average x 4	=	☐	
	☐	High x 6	=	☐	☐
External logical Files (ILFs)	☐	Low x 7	=	☐	
	☐	Average x 10	=	☐	
	☐	High x 15	=	☐	☐
External Interface Files (EIFs)	☐	Low x 5	=	☐	
	☐	Average x 7	=	☐	
	☐	High x 10	=	☐	☐
Total Unadjusted Function Point Count					☐

The weighting factors are identified functional units and multiplied with the fu units accordingly. The procedure f calculation of Unadjusted Function Point (given in table shown above.

Software Project Planning

The procedure for the calculation of UFP in mat
form is given below:

$$UFP = \sum_{i=1}^{5} \sum_{J=1}^{3} Z_{ij} w_{ij}$$

Where i indicate the row and j indicates the column of

W_{ij} : It is the entry of the i^{th} row and j^{th} column of the tab

Zij : It is the count of the number of functional units of
have been classified as having the complexity corres
column *j*.

Software Project Planning

Organizations that use function point methods develop a
determining whether a particular entry is Low, Avera
Nonetheless, the determination of complexity is
subjective.

$$FP = UFP * CAF$$

Where CAF is complexity adjustment factor and is equa
0.01 x ΣF_i]. The F_i (i=1 to 14) are the degree of influe
based on responses to questions noted in table 3.

Software Project Planning

Table 3 : Computing function points.

Rate each factor on a scale of 0 to 5.

0	*1*	*2*	*3*	*4*
No Influence	*Incidental*	*Moderate*	*Average*	*Significant*

Number of factors considered (F_i)

1. Does the system require reliable backup and recovery ?
2. Is data communication required ?
3. Are there distributed processing functions ?
4. Is performance critical ?
5. Will the system run in an existing heavily utilized operational environment ?
6. Does the system require on line data entry ?
7. Does the on line data entry require the input transaction to be built over multiple scr
8. Are the master files updated on line ?
9. Is the inputs, outputs, files, or inquiries complex ?
10. Is the internal processing complex ?
11. Is the code designed to be reusable ?
12. Are conversion and installation included in the design ?
13. Is the system designed for multiple installations in different organizations ?
14. Is the application designed to facilitate change and ease of use by the user ?

Software Project Planning

Functions points may compute the following important n

Productivity	=	FP / persons-months
Quality	=	Defects / FP
Cost	=	Rupees / FP
Documentation	=	Pages of documentation pe

These metrics are controversial and are not universally
There are standards issued by the International Functions
Group (IFPUG, covering the Albrecht method) and
Kingdom Function Point User Group (UFPGU, coverin
method). An ISO standard for function point method is
developed.

Software Project Planning

Example: 4.1

Consider a project with the following functional units:

Number of user inputs	= 50
Number of user outputs	= 40
Number of user enquiries	= 35
Number of user files	= 06
Number of external interfaces	= 04

Assume all complexity adjustment factors and weightin
average. Compute the function points for the project.

Solution

We know

$$UFP = \sum_{i=1}^{5} \sum_{J=1}^{3} Z_{ij} w_{ij}$$

UFP = 50 x 4 + 40 x 5 + 35 x 4 + 6 x 10 + 4

= 200 + 200 + 140 + 60 + 28 = 628

CAF = (0.65 + 0.01 ΣF_i)

= (0.65 + 0.01 (14 x 3)) = 0.65 + 0.42 =

FP = UFP x CAF

= 628 x 1.07 = 672

Software Project Planning

Example:4.2

An application has the following:

10 low external inputs, 12 high external output
internal logical files, 15 high external interface
average external inquiries, and a value of c
adjustment factor of 1.10.

What are the unadjusted and adjusted function point

Solution

Unadjusted function point counts may be calcula
as:

$$UFP = \sum_{i=1}^{5}\sum_{J=1}^{3} Z_{ij} w_{ij}$$

$= 10 \times 3 + 12 \times 7 + 20 \times 7 + 15 + 10 + 12 \times 4$

$= 30 + 84 + 140 + 150 + 48$

$= 452$

FP $= UFP \times CAF$

$= 452 \times 1.10 = 497.2.$

Example: 4.3

Consider a project with the following parameters.

(*i*) External Inputs:

(a) 10 with low complexity

(b) 15 with average complexity

(c) 17 with high complexity

(*ii*) External Outputs:

(a) 6 with low complexity

(b) 13 with high complexity

(*iii*) External Inquiries:

(a) 3 with low complexity

(b) 4 with average complexity

(c) 2 high complexity

Software Project Planning

(*iv*) Internal logical files:

(a) 2 with average complexity

(b) 1 with high complexity

(v) External Interface files:

(a) 9 with low complexity

In addition to above, system requires

i. Significant data communication

ii. Performance is very critical

iii. Designed code may be moderately reusable

iv. System is not designed for multiple installation organizations.

Other complexity adjustment factors are treated as averag the function points for the project.

Software Project Planning

Solution: Unadjusted function points may be counted using tab

Functional Units	Count	Complexity		Complexity Totals	Functi Unit T
External	10	Low x 3	=	30	
Inputs	15	Average x 4	=	60	
(EIs)	17	High x 6	=	102	192
External	6	Low x 4	=	24	
Outputs	0	Average x 5	=	0	
(EOs)	13	High x 7	=	91	115
External	3	Low x 3	=	9	
Inquiries	4	Average x 4	=	16	
(EQs)	2	High x 6	=	12	37
External	0	Low x 7	=	0	
logical	2	Average x 10	=	20	
Files (ILFs)	1	High x 15	=	15	35
External	9	Low x 5	=	45	
Interface	0	Average x 7	=	0	
Files (EIFs)	0	High x 10	=	0	45
Total Unadjusted Function Point Count					424

$$\sum_{i=1}^{14} F_i = 3+4+3+5+3+3+3+3+3+3+2+3+0+3$$

CAF = $(0.65 + 0.01 \times \Sigma F_i)$

= $(0.65 + 0.01 \times 41)$

= 1.06

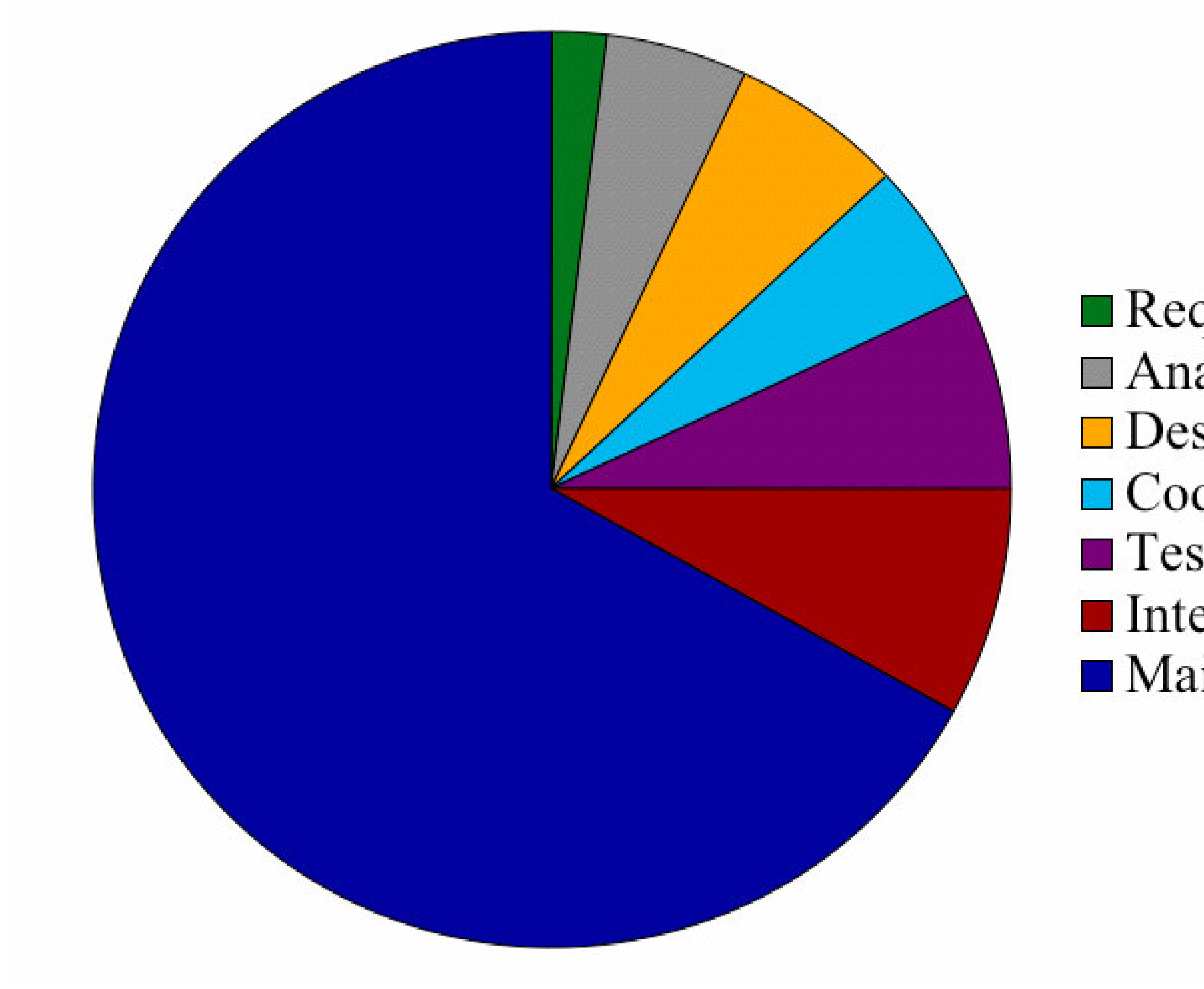
FP = UFP x CAF

= 424 x 1.06

= 449.44

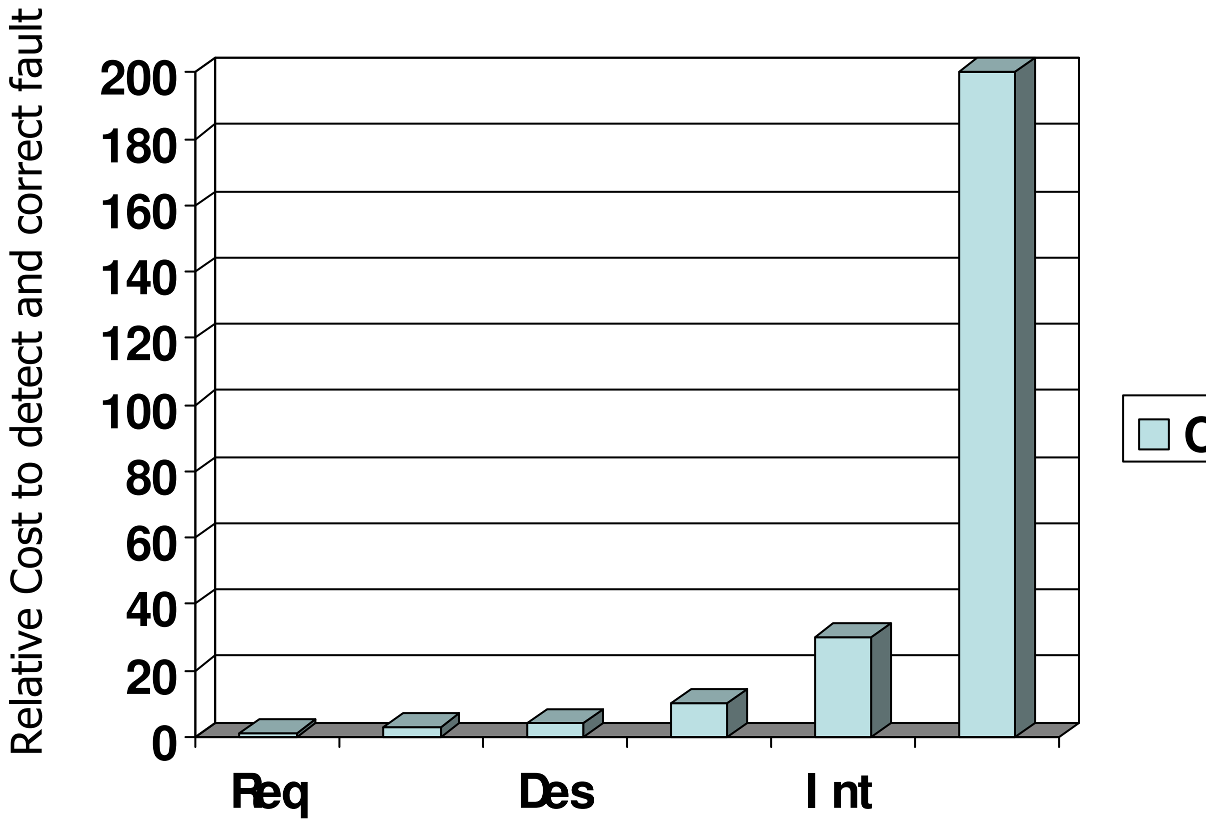
Hence $\boxed{FP = 449}$

Relative Cost of Software Phases



Software Project Planning

Cost to Detect and Fix Faults



Software Project Planning

Cost Estimation

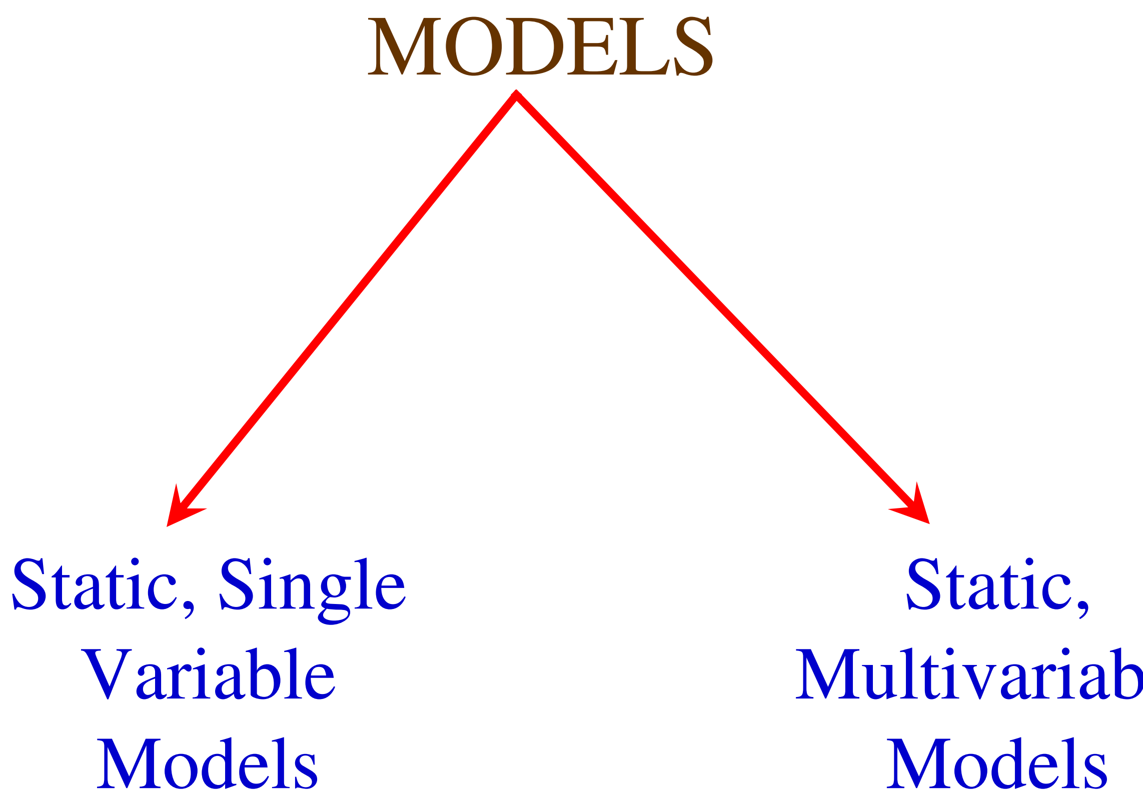
A number of estimation techniques have been develop
having following attributes in common :

- Project scope must be established in advance
- Software metrics are used as a basis from which estimates
- The project is broken into small pieces which are estimatec

To achieve reliable cost and schedule estimates, a numbe
arise:

- Delay estimation until late in project
- Use simple decomposition techniques to generate proje
schedule estimates
- Develop empirical models for estimation
- Acquire one or more automated estimation tools

Software Project Planning



Software Project Planning

Static, Single Variable Models

Methods using this model use an equation to estimate values such as cost, time, effort, etc. They all depend variable used as predictor (say, size). An example common equations is :

$$C = a\,L^{b} \qquad \text{(i)}$$

C is the cost, L is the size and a,b are constants

$$E = 1.4\,L^{0.93}$$

$$DOC = 30.4\,L^{0.90}$$

$$D = 4.6\,L^{0.26}$$

Effort (E in Person-months), documentation (DOC, in pages) and duration (D, in months) are calculated from of lines of code (L, in thousands of lines) used as a predic

Static, Multivariable Models

These models are often based on equation (i), they act
on several variables representing various aspects of
development environment, for example method
participation, customer oriented changes, memory constr

$$E = 5.2\ L^{0.91}$$

$$D = 4.1\ L^{0.36}$$

The productivity index uses 29 variables which are
highly correlated to productivity as follows:

$$I = \sum_{i=1}^{29} W_i X_i$$

Software Project Planning

Example: 4.4

Compare the Walston-Felix model with the SEL m
software development expected to involve 8 person-year

(a)Calculate the number of lines of source code th
produced.

(b)Calculate the duration of the development.

(c)Calculate the productivity in LOC/PY

(d)Calculate the average manning

Software Project Planning

Solution

The amount of manpower involved = 8 PY = 96 person-m

(a) Number of lines of source code can be obtained by re equation to give:

$$L = (E/a)^{1/b}$$

Then

$$L(SEL) = (96/1.4)^{1/0.93} = 94264 \text{ LOC}$$

$$L(SEL) = (96/5.2)^{1/0.91} = 24632 \text{ LOC.}$$

Software Project Planning

(b) Duration in months can be calculated by means of equ

$$D(SEL) = 4.6\ (L)^{0.26}$$

$$= 4.6\ (94.264)^{0.26} = 15 \text{ months}$$

$$D(W\text{-}F) = 4.1\ L^{0.36}$$

$$= 4.1(24.632)^{0.36} = 13 \text{ months}$$

(c) Productivity is the lines of code produced per person/

$$P(SEL) = \frac{94264}{8} = 11783\ LOC / Person - Year$$

$$P(W - F) = \frac{24632}{8} = 3079\ LOC / Person - Years$$

Software Project Planning

(d) Average manning is the average number of persons re
month in the project.

$$M(SEL) = \frac{96\,P-M}{15\,M} = 6.4\,Persons$$

$$M(W-F) = \frac{96\,P-M}{13\,M} = 7.4\,Persons$$

The Constructive Cost Model (COCOMO)

$$\begin{tikzcd}
 & \text{Constructive Cost model (COCOMO)} \arrow[dl] \arrow[d] \arrow[dr] & \\
\text{Basic} & \text{Intermediate} & \text{Detailed}
\end{tikzcd}$$

Model proposed by
B. W. Boehm's
through his book
Software Engineering Economics in 1981

Software Project Planning

$$\begin{tikzcd}
 & \text{COCOMO applied to} \arrow[dl] \arrow[d] \arrow[dr] & \\
\text{Organic mode} & \text{Semidetached mode} & \text{Embedde mode}
\end{tikzcd}$$

Software Project Planning

Mode	Project size	Nature of Project	Innovation	Deadline o the projec
Organic	Typically 2-50 KLOC	Small size project, experienced developers in the familiar environment. For example, pay roll, inventory projects etc.	Little	Not tight
Semi detached	Typically 50-300 KLOC	Medium size project, Medium size team, Average previous experience on similar project. For example: Utility systems like compilers, database systems, editors etc.	Medium	Medium
Embedded	Typically over 300 KLOC	Large project, Real time systems, Complex interfaces, Very little previous experience. For example: ATMs, Air Traffic Control etc.	Significant	Tight

Table 4: The comparison of three COCOMO modes

Basic Model

Basic COCOMO model takes the form

$$E = a_b (KLOC)^{b_b}$$

$$D = c_b (E)^{d_b}$$

where E is effort applied in Person-Months, and development time in months. The coefficients a_b, b_b, c_b given in table 4 (a).

Software Project Planning

Software Project	a_b	b_b	c_b	
Organic	2.4	1.05	2.5	0
Semidetached	3.0	1.12	2.5	0
Embedded	3.6	1.20	2.5	0

Table 4(a): Basic COCOMO coefficients

Software Project Planning

When effort and development time are known, the averag
to complete the project may be calculated as:

$$\text{Average staff size } (SS) = \frac{E}{D}\, Persons$$

When project size is known, the productivity leve
calculated as:

$$\text{Productivity } (P) = \frac{KLOC}{E}\, KLOC / PM$$

Software Project Planning

Example: 4.5

Suppose that a project was estimated to be 40
Calculate the effort and development time for each o
modes i.e., organic, semidetached and embedded.

Solution

The basic COCOMO equation take the form:

$$E = a_b (KLOC)^{b_b}$$

$$D = c_b (KLOC)^{d_b}$$

Estimated size of the project = 400 KLOC

(i) Organic mode

$$E = 2.4(400)^{1.05} = 1295.31 \text{ PM}$$

$$D = 2.5(1295.31)^{0.38} = 38.07 \text{ PM}$$

Software Project Planning

(ii) Semidetached mode

$$E = 3.0(400)^{1.12} = 2462.79 \text{ PM}$$

$$D = 2.5(2462.79)^{0.35} = 38.45 \text{ PM}$$

(iii) Embedded mode

$$E = 3.6(400)^{1.20} = 4772.81 \text{ PM}$$

$$D = 2.5(4772.8)^{0.32} = 38 \text{ PM}$$

Example: 4.6

A project size of 200 KLOC is to be developed development team has average experience on simil projects. The project schedule is not very tight. Calculat development time, average staff size and productivity of

Solution

The semi-detached mode is the most appropriate mode; ke
view the size, schedule and experience of the developmen

Hence $E = 3.0(200)^{1.12} = 1133.12$ PM

$D = 2.5(1133.12)^{0.35} = 29.3$ PM

Average staff size $(SS) = \frac{E}{D} \; Persons$

$$= \frac{1133.12}{29.3} = 38.67 \; Persons$$

Software Project Planning

$$\text{Productivity} = \frac{KLOC}{E} = \frac{200}{1133.12} = 0.1765\,KLOC$$

$$P = 176\ LOC / PM$$

Intermediate Model

Cost drivers

(*i*) Product Attributes

- Required s/w reliability
- Size of application database
- Complexity of the product

(*ii*) Hardware Attributes

- Run time performance constraints
- Memory constraints
- Virtual machine volatility
- Turnaround time

Software Project Planning

(*iii*) Personal Attributes

- Analyst capability
- Programmer capability
- Application experience
- Virtual m/c experience
- Programming language experience

(*iv*) Project Attributes

- Modern programming practices
- Use of software tools
- Required development Schedule

Multipliers of different cost drivers

Cost Drivers	RATINGS				
	Very low	Low	Nominal	High	Ve hi
Product Attributes					
RELY	0.75	0.88	1.00	1.15	1
DATA	--	0.94	1.00	1.08	1.
CPLX	0.70	0.85	1.00	1.15	1.
Computer Attributes					
TIME	--	--	1.00	1.11	1
STOR	--	--	1.00	1.06	1
VIRT	--	0.87	1.00	1.15	1
TURN	--	0.87	1.00	1.07	1

Software Project Planning

Cost Drivers	RATINGS				
	Very low	Low	Nominal	High	Ve hi
Personnel Attributes					
ACAP	1.46	1.19	1.00	0.86	0
AEXP	1.29	1.13	1.00	0.91	0
PCAP	1.42	1.17	1.00	0.86	0
VEXP	1.21	1.10	1.00	0.90	
LEXP	1.14	1.07	1.00	0.95	
Project Attributes					
MODP	1.24	1.10	1.00	0.91	0
TOOL	1.24	1.10	1.00	0.91	0
SCED	1.23	1.08	1.00	1.04	1

Table 5: Multiplier values for effort calculations

Software Project Planning

Intermediate COCOMO equations

$$E = a_i (KLOC)^{b_i} * EAF$$

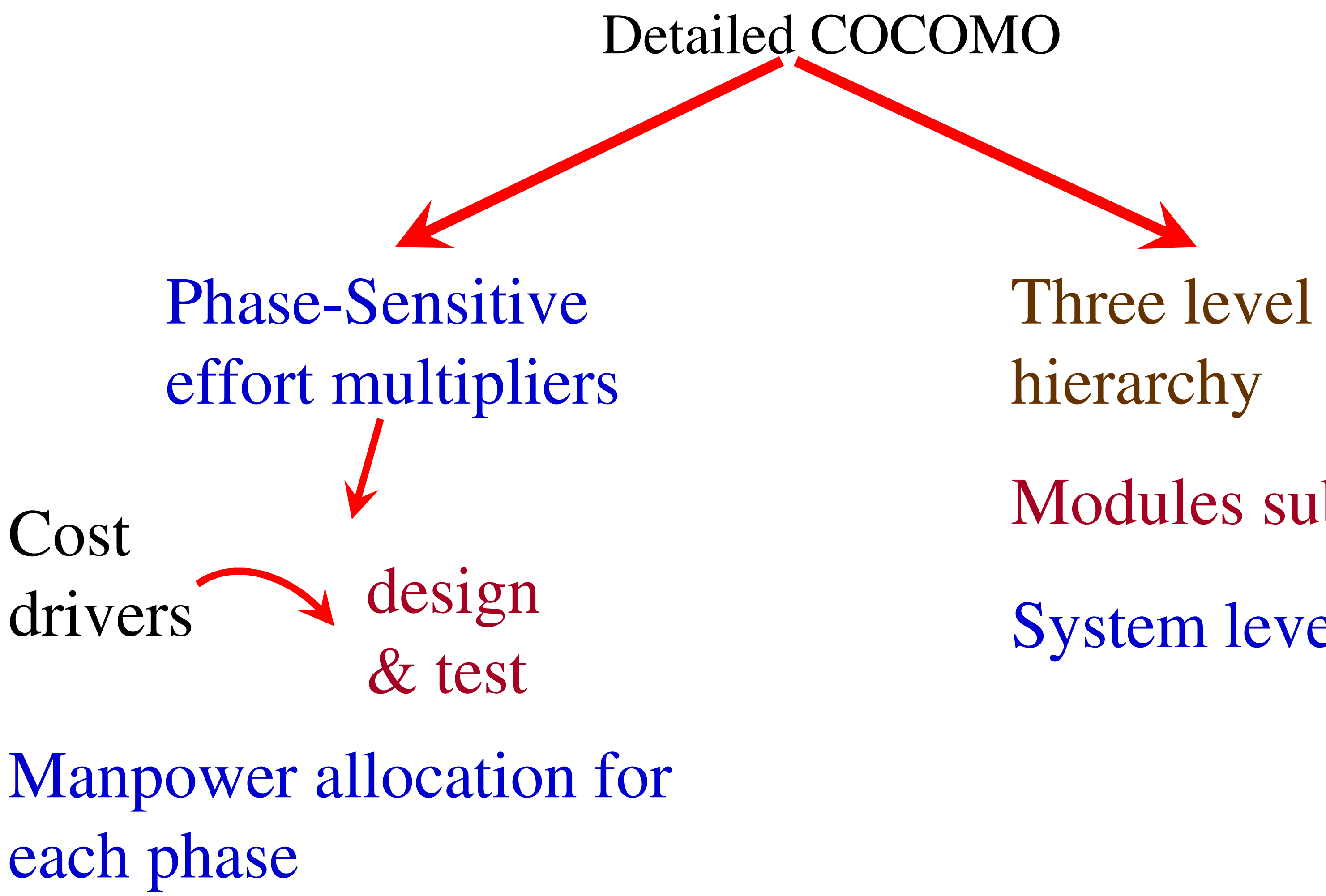
$$D = c_i (E)^{d_i}$$

Project	a_i	b_i	c_i
Organic	3.2	1.05	2.5
Semidetached	3.0	1.12	2.5
Embedded	2.8	1.20	2.5

Table 6: Coefficients for intermediate COCOMO

Software Project Planning

Detailed COCOMO Model



Software Project Planning

Development Phase

Plan / Requirements

EFFORT	:	6% to 8%
DEVELOPMENT TIME	:	10% to 40

% depend on mode & size

Software Project Planning

Design

Effort	:	16% to 18%
Time	:	19% to 38%

Programming

Effort	:	48% to 68%
Time	:	24% to 64%

Integration & Test

Effort	:	16% to 34%
Time	:	18% to 34%

Principle of the effort estimate

Size equivalent

As the software might be partly developed from softw
existing (that is, re-usable code), a full development is
required. In such cases, the parts of design document (I
(C%) and integration (I%) to be modified are estimate
adjustment factor, A, is calculated by means of th
equation.

$$A = 0.4\,DD + 0.3\,C + 0.3\,I$$

The size equivalent is obtained by

$$S\text{ (equivalent)} = (S \times A) / 100$$

$$E_p = \quad {}_pE$$

$$D_p = \tau_p D$$

Lifecycle Phase Values of p

Mode & Code Size	Plan & Requirements	System Design	Detailed Design	Module Code & Test
Organic Small S≈2	0.06	0.16	0.26	0.42
Organic medium S≈32	0.06	0.16	0.24	0.38
Semidetached medium S≈32	0.07	0.17	0.25	0.33
Semidetached large S≈128	0.07	0.17	0.24	0.31
Embedded large S≈128	0.08	0.18	0.25	0.26
Embedded extra large S≈320	0.08	0.18	0.24	0.24

Table 7 : Effort and schedule fractions occurring in each phase of

Lifecycle Phase Values of τ_p

Mode & Code Size	Plan & Requirements	System Design	Detailed Design	Module Code & Test
Organic Small S≈2	0.10	0.19	0.24	0.39
Organic medium S≈32	0.12	0.19	0.21	0.34
Semidetached medium S≈32	0.20	0.26	0.21	0.27
Semidetached large S≈128	0.22	0.27	0.19	0.25
Embedded large S≈128	0.36	0.36	0.18	0.18
Embedded extra large S≈320	0.40	0.38	0.16	0.16

Table 7 : Effort and schedule fractions occurring in each phase of

Distribution of software life cycle:

1. Requirement and product design
   (a) Plans and requirements
   (b) System design
2. Detailed Design
   (a) Detailed design
3. Code & Unit test
   (a) Module code & test
4. Integrate and Test
   (a) Integrate & Test

Software Project Planning

Example: 4.7

A new project with estimated 400 KLOC embedded syste
developed. Project manager has a choice of hiring from t
developers: Very highly capable with very little experi
programming language being used

Or

Developers of low quality but a lot of experience with the p
language. What is the impact of hiring all developers from
other pool ?

Software Project Planning

Solution

This is the case of embedded mode and model is
COCOMO.

Hence $$E = a_i (KLOC)^{d_i}$$

$$= 2.8\ (400)^{1.20} = 3712 \text{ PM}$$

Case I: Developers are very highly capable with very littl
in the programming being used.

EAF = 0.82 x 1.14 = 0.9348

E = 3712 x .9348 = 3470 PM

D $= 2.5\ (3470)^{0.32} = 33.9$ M

Software Project Planning

Case II: Developers are of low quality but lot of experie
programming language being used.

$$EAF = 1.29 \times 0.95 = 1.22$$

$$E = 3712 \times 1.22 = 4528 \text{ PM}$$

$$D = 2.5\ (4528)^{0.32} = 36.9 \text{ M}$$

Case II requires more effort and time. Hence, low qualit
with lot of programming language experience could no
the performance of very highly capable developers wi
experience.

Software Project Planning

Example: 4.8

Consider a project to develop a full screen editor. The major
identified are:

I. Screen edit

II. Command Language Interpreter

III. File Input & Output

IV. Cursor Movement

V. Screen Movement

The size of these are estimated to be 4k, 2k, 1k, 2k and 3k deli
code lines. Use COCOMO to determine

1. Overall cost and schedule estimates (assume values
   cost drivers, with at least three of them being different

2. Cost & Schedule estimates for different phases.

Solution

Size of five modules are:

Screen edit	= 4 KLOC
Command language interpreter	= 2 KLOC
File input and output	= 1 KLOC
Cursor movement	= 2 KLOC
Screen movement	= 3 KLOC
Total	**= 12 KLO**

Software Project Planning

Let us assume that significant cost drivers are

i. Required software reliability is high, i.e.,1.15

ii. Product complexity is high, i.e.,1.15

iii. Analyst capability is high, i.e.,0.86

iv. Programming language experience is low,i.e.,1.07

v. All other drivers are nominal

$$EAF = 1.15 \times 1.15 \times 0.86 \times 1.07 = 1.2169$$

Software Project Planning

(a) The initial effort estimate for the project is obtain
following equation

$$E = a_i\,(\text{KLOC})^{b_i} \times \text{EAF}$$

$$= 3.2(12)^{1.05} \times 1.2169 = 52.91 \text{ PM}$$

Development time $$D = C_i(E)^{d_i}$$

$$= 2.5(52.91)^{0.38} = 11.29 \text{ M}$$

(b) Using the following equations and referring Table 7,
cost and schedule estimates can be calculated.

$$E_p = \quad {}_pE$$

$$D_p = \tau_p D$$

Software Project Planning

Since size is only 12 KLOC, it is an organic small model.
effort distribution is given below:

System Design	= 0.16 x 52.91 = 8.4
Detailed Design	= 0.26 x 52.91 = 13.
Module Code & Test	= 0.42 x 52.91 = 22.
Integration & Test	= 0.16 x 52.91 = 8.4

Now Phase wise development time duration is

System Design	= 0.19 x 11.29 = 2.1
Detailed Design	= 0.24 x 11.29 = 2.7
Module Code & Test	= 0.39 x 11.29 = 4.4
Integration & Test	= 0.18 x 11.29 = 2.0

COCOMO-II

The following categories of applications / projects are i
COCOMO-II and are shown in fig. 4 shown below:

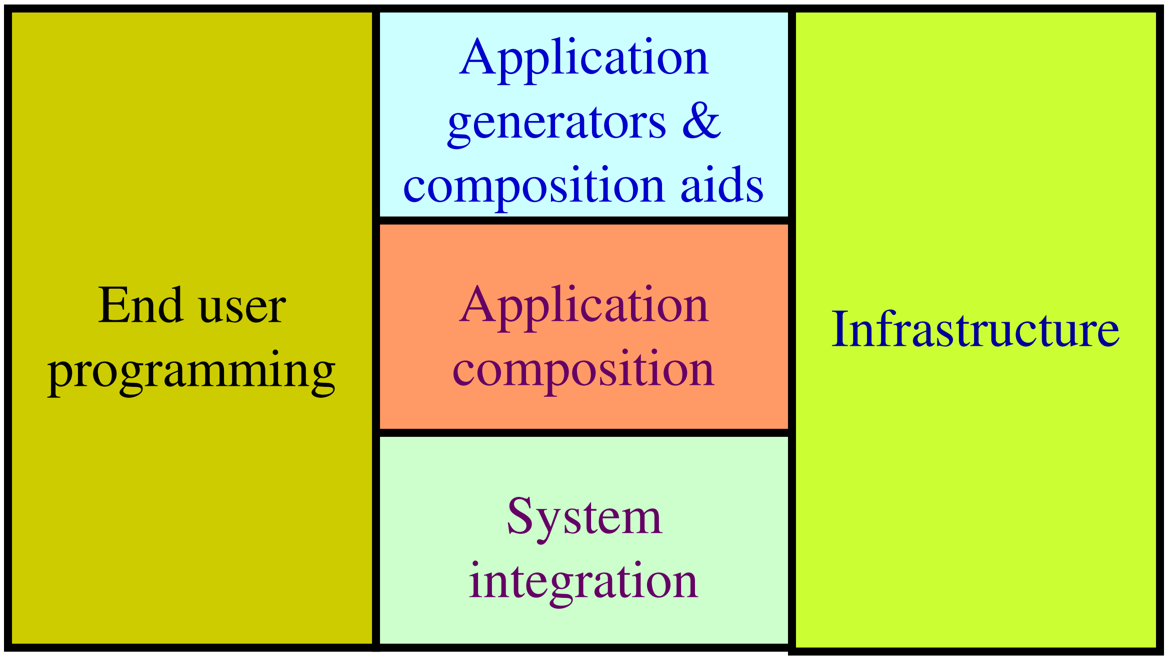


Fig. 4 : Categories of applications / projects

Software Project Planning

Stage No	Model Name	Application for the types of projects	Applica
Stage I	Application composition estimation model	Application composition	In addition composition type model is also use (if any) stage generators, infrastr integration.
Stage II	Early design estimation model	Application generators, infrastructure & system integration	Used in early de project, when less the project.
Stage III	Post architecture estimation model	Application generators, infrastructure & system integration	Used after the co detailed architectur

Table 8: Stages of COCOMO-II

Application Composition Estimation Model

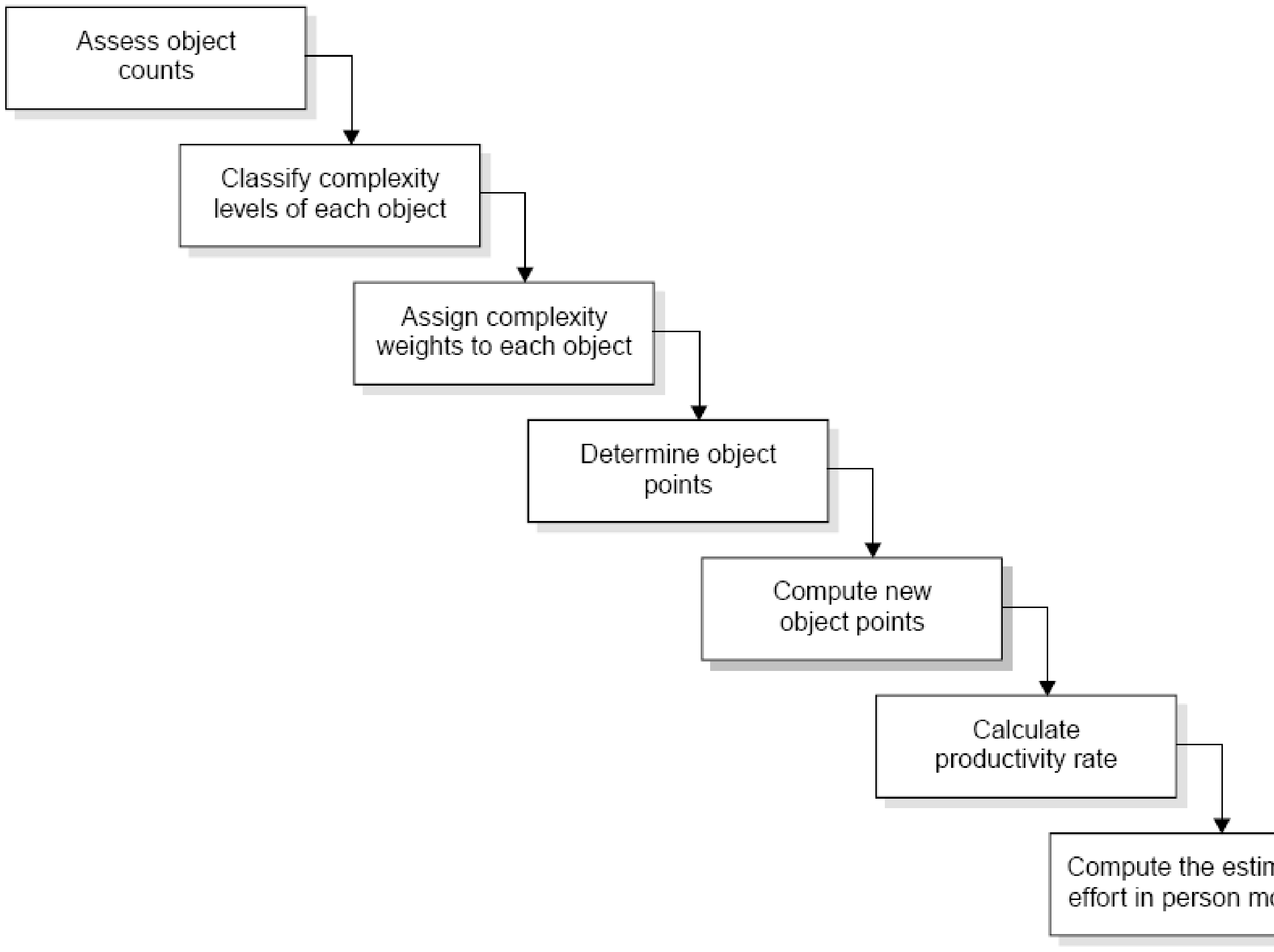
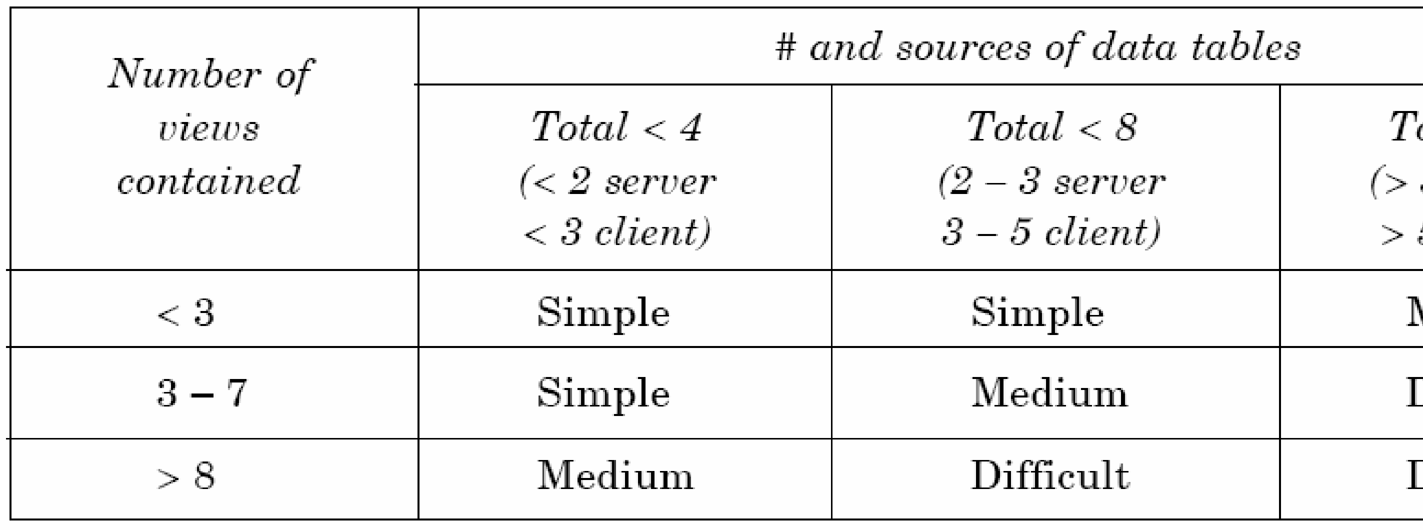

Assess object counts
Classify complexity levels of each object
Assign complexity weights to each object
Determine object points
Compute new object points
Calculate productivity rate
Compute the estin
effort in person mo

Fig.5: Steps for the estimation of effort in person r

Software Project Planning

i. Assess object counts: Estimate the number of screens, r
3 GL components that will comprise this application.

ii. Classification of complexity levels: We have to cla
object instance into simple, medium and difficult comple
depending on values of its characteristics.



Number of views contained	*# and sources of data tables*		
	Total < 4 (< 2 server < 3 client)	*Total < 8 (2 – 3 server 3 – 5 client)*	*To (> >*
< 3	Simple	Simple	M
3 – 7	Simple	Medium	I
> 8	Medium	Difficult	I

Table 9 (a): For screens

Number of sections contained	*# and sources of data tables*		
	Total < 4 (< 2 server < 3 client)	*Total < 8 ($2 - 3$ server $3 - 5$ client)*	*To (> 3 > 5*
0 or 1	Simple	Simple	M
2 or 3	Simple	Medium	D
4 +	Medium	Difficult	D

Table 9 (b): For reports

Software Project Planning

iii. Assign complexity weight to each object : The weight
for three object types i.e., screen, report and 3GL compon
the Table 10.

Object Type	*Complexity Weight*		
	Simple	*Medium*	*D*
Screen	1	2	
Report	2	5	
3GL Component	—	—	

Table 10: Complexity weights for each level

Software Project Planning

iv. Determine object points: Add all the weighted object in
get one number and this known as object-point count.

v. Compute new object points: We have to estimate the p
of reuse to be achieved in a project. Depending on the p
reuse, the new object points (NOP) are computed.

$$\textbf{NOP} = \frac{(\text{object points}) * (100\text{-}\%\text{reuse})}{100}$$

NOP are the object points that will need to be developed an
the object point count because there may be reuse.

Software Project Planning

vi. Calculation of productivity rate: The productivity rat
calculated as:

Productivity rate (PROD) = NOP/Person montl

Developer's experience & capability; ICASE maturity & capability	*PROD (NOP/PM)*
Very low	4
Low	7
Nominal	13
High	25
Very high	50

Table 11: Productivity values

Software Project Planning

vii. Compute the effort in Persons-Months: When PROD
we may estimate effort in Person-Months as:

$$\textbf{Effort in PM} = \frac{NOP}{PROD}$$

Software Project Planning

Example: 4.9

Consider a database application project with the following char

I. The application has 4 screens with 4 views each and
for 3 servers and 4 clients.

II. The application may generate two report of 6 sections e
data tables for two server and 3 clients. There is 1
object points.

The developer's experience and capability in the similar en
low. The maturity of organization in terms of capability
Calculate the object point count, New object points and effo
such a project.

Solution

This project comes under the category of application com
estimation model.

Number of screens = 4 with 4 views each

Number of reports = 2 with 6 sections each

From Table 9 we know that each screen will be
complexity and each report will be difficult complexity.

Using Table 10 of complexity weights, we may calculate
count.

$$= 4 \times 2 + 2 \times 8 = 24$$

$$\textbf{NOP} = \frac{24 * (100 - 10)}{100} = 21.6$$

Software Project Planning

Table 11 gives the low value of productivity (PROD) i.e. 7

$$\text{Efforts in PM} = \frac{\text{NOP}}{\text{PROD}}$$

$$\text{Efforts} = \frac{21.6}{7} = 3.086 \text{ PM}$$

The Early Design Model

The COCOMO-II models use the base equation of the form

$$PM_{nominal} = A * (size)^{B}$$

where

$PM_{nominal}$ = Effort of the project in person months

A = Constant representing the nominal productivity, provisiona

B = Scale factor

Size = Software size

Software Project Planning

Scale factor	Explanation	Remark
Precedentness	Reflects the previous experience on similar projects. This is applicable to individuals & organization both in terms of expertise & experience	Very low means experiences, Extra hig organization is complet this application domain.
Development flexibility	Reflect the degree of flexibility in the development process.	Very low means a well is used. Extra high mea gives only general goals
Architecture/ Risk resolution	Reflect the degree of risk analysis carried out.	Very low means very lit Extra high means comp risk analysis.

Table 12: Scaling factors required for the calculation of the val

Software Project Planning

Scale factor	Explanation	Rem
Team cohesion	Reflects the team management skills.	Very low mean experiences, Extra organization is comp this application doma
Process maturity	Reflects the process maturity of the organization. Thus it is dependent on SEI-CMM level of the organization.	Very low means or level at all and e organization is relate of SEI-CMM.

Table 12: Scaling factors required for the calculation of the

Software Project Planning

Scaling factors	Very low	Low	Nominal	High	Ve hig
Precedent ness	6.20	4.96	3.72	2.48	1.2
Development flexibility	5.07	4.05	3.04	2.03	1.0
Architecture/ Risk resolution	7.07	5.65	4.24	2.83	1.4
Team cohesion	5.48	4.38	3.29	2.19	1.1
Process maturity	7.80	6.24	4.68	3.12	1.5

Table 13: Data for the Computation of B

The value of B can be calculated as:

B=0.91 + 0.01 * (Sum of rating on scaling factors for

Early design cost drivers

There are seven early design cost drivers and are given below:

i. Product Reliability and Complexity (RCPX)

ii. Required Reuse (RUSE)

iii. Platform Difficulty (PDIF)

iv. Personnel Capability (PERS)

v. Personnel Experience (PREX)

vi. Facilities (FCIL)

vii. Schedule (SCED)

Post architecture cost drivers

There are 17 cost drivers in the Post Architecture model. Th
on a scale of 1 to 6 as given below :

Very Low	*Low*	*Nominal*	*High*	*Very High*
1	2	3	4	5

The list of seventeen cost drivers is given below :

i. Reliability Required (RELY)

ii. Database Size (DATA)

iii. Product Complexity (CPLX)

iv. Required Reusability (RUSE)

Software Project Planning

v. Documentation (DOCU)

vi. Execution Time Constraint (TIME)

vii. Main Storage Constraint (STOR)

viii. Platform Volatility (PVOL)

ix. Analyst Capability (ACAP)

x. Programmers Capability (PCAP)

xi. Personnel Continuity (PCON)

xii. Analyst Experience (AEXP)

Software Project Planning

xiii. Programmer Experience (PEXP)

xiv. Language & Tool Experience (LTEX)

xv. Use of Software Tools (TOOL)

xvi. Site Locations & Communication Technology between Si

xvii. Schedule (SCED)

Mapping of early design cost drivers and post archit
drivers

The 17 Post Architecture Cost Drivers are mapped to 7 Early
Drivers and are given in Table 14

Early Design Cost Drivers	Counter part Combined Po Architecture Cost drivers
RCPX	RELY, DATA, CPLX, DOCU
RUSE	RUSE
PDIF	TIME, STOR, PVOL
PERS	ACAP, PCAP, PCON
PREX	AEXP, PEXP, LTEX
FCIL	TOOL, SITE
SCED	SCED

Table 14: Mapping table

Product of cost drivers for early design model

i. Product Reliability and Complexity (RCPX): The cost dri four Post Architecture cost drivers which are RELY, DATA DOCU.

RCPX	*Extra Low*	*Very Low*	*Low*	*Nominal*	*High*	*Very High*
Sum of RELY, DATA, CPLX, DOCU ratings	5, 6	7, 8	9-11	12	13-15	16-1
Emphasis on reliability, documentation	Very Little	Little	Some	Basic	Strong	Very Stron
Product complexity	Very Simple	Simple	Some	Moderate	Complex	Very Compl
Database size	Small	Small	Small	Moderate	Large	Very Larg

ii. Required Reuse (RUSE) : This early design model cost driv
its Post architecture Counterpart. The RUSE rating level
Table 16):

	Vary Low	*Low*	*Nominal*	*High*	*Very High*
RUSE	1	2	3	4	5
		None	Across project	Across program	Across product line

Software Project Planning

iii. Platform Difficulty (PDIF) : This cost driver combines T and PVOL of Post Architecture Cost Drivers.

PDIF	*Low*	*Nominal*	*High*	*Very High*
Sum of Time, STOR & PVOL ratings	8	9	10-12	13-15
Time & storage constraint	≤ 50%	≤ 50%	65%	80%
Platform Volatility	Very stable	Stable	Somewhat stable	Volatile

Software Project Planning

iv. Personnel Capability (PERS) : This cost driver combin
Architecture Cost Drivers. These drivers are ACAP, PCAP

PERS	*Extra Low*	*Very Low*	*Low*	*Nominal*	*High*
Sum of ACAP, PCAP, PCON ratings	3, 4	5, 6	7, 8	9	10, 11
Combined ACAP & PCAP Percentile	20%	39%	45%	55%	65%
Annual Personnel Turnover	45%	30%	20%	12%	9%

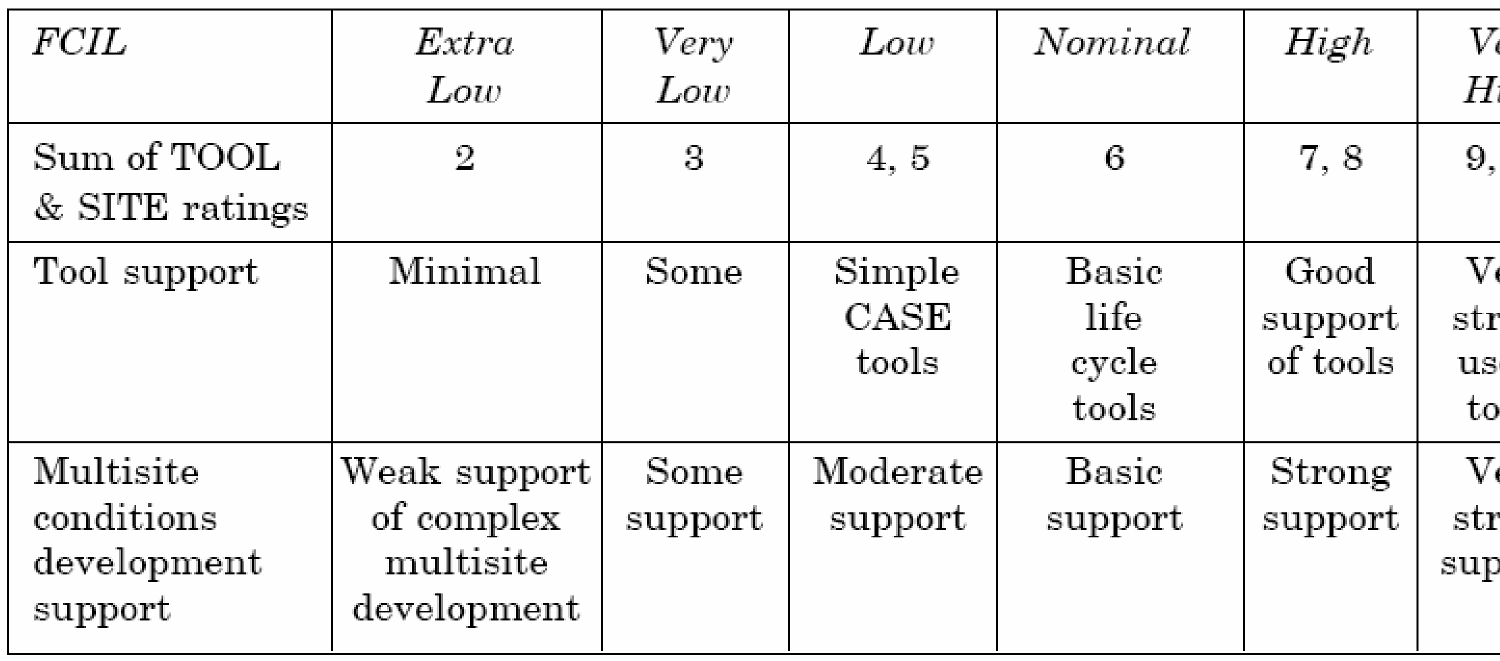
Software Project Planning

v. Personnel Experience (PREX) : This early design driver co
Post Architecture Cost Drivers, which are AEXP, PEXP an

PREX	*Extra Low*	*Very Low*	*Low*	*Nominal*	*High*
Sum of AEXP, PEXP and LTEX ratings	3, 4	5, 6	7, 8	9	10, 1
Applications, Platform, Language & Tool Experience	≤ 3 months	5 months	9 months	1 year	2 yea

Software Project Planning

vi. Facilities (FCIL): This depends on two Post Architecture
which are TOOL and SITE.



FCIL	*Extra Low*	*Very Low*	*Low*	*Nominal*	*High*	*Ve Hi*
Sum of TOOL & SITE ratings	2	3	4, 5	6	7, 8	9,
Tool support	Minimal	Some	Simple CASE tools	Basic life cycle tools	Good support of tools	Ve str us to
Multisite conditions development support	Weak support of complex multisite development	Some support	Moderate support	Basic support	Strong support	Ve str sup

Software Project Planning

vii. Schedule (SCED) : This early design cost driver is the Architecture Counterpart and rating level are given belo 16.

SCED	*Very Low*	*Low*	*Nominal*	*High*
Schedule	75% of Nominal	85%	100%	130%

Software Project Planning

The seven early design cost drivers have been converted
values with a Nominal value 1.0. These values are used for th
of a factor called "Effort multiplier" which is the product of a
design cost drivers. The numeric values are given in Table 15.

Early design Cost drivers	*Extra Low*	*Very Low*	*Low*	*Nominal*	*High*	*Ver Hig*
RCPX	.73	.81	.98	1.0	1.30	1.74
RUSE	—	—	0.95	1.0	1.07	1.15
PDIF	—	—	0.87	1.0	1.29	1.81
PERS	2.12	1.62	1.26	1.0	0.83	0.63
PREX	1.59	1.33	1.12	1.0	0.87	0.71
FCIL	1.43	1.30	1.10	1.0	0.87	0.73
SCED	—	1.43	1.14	1.0	1.0	1.0

Table 15: Early design parameters

Software Project Planning

The early design model adjusts the nominal effort using 7 effo
(EMs). Each effort multiplier (also called drivers) has 7 possib
given in Table 15. These factors are used for the calculatio
effort as given below:

$$PM_{adjusted} = PM_{\text{nominal}} \left[\prod_{i=7}^{7} EM_i \right]$$

$PM_{adjusted}$ effort may very even up to 400% from $PM_{nominal}$

Hence $PM_{adjusted}$ is the fine tuned value of effort in the early de

Software Project Planning

Example: 4.10

A software project of application generator category with
KLOC has to be developed. The scale factor (
precedentness, high development flexibility and low tea
Other factors are nominal. The early design cost drivers
difficult (PDIF) and Personnel Capability (PERS) are hig
are nominal. Calculate the effort in person mon
development of the project.

Software Project Planning

Solution

Here B = 0.91 + 0.01 * (Sum of rating on scaling factors for t

= 0.91 + 0.01 * (4.96 + 2.03 + 4.24 + 4.38 + 4.68)

= 0.91 + 0.01(20.29)=1.1129

$PM_{nominal} = A^*(size)^B$

$= 2.5 * (50)^{1.1129} = 194.41$ Person months

The 7 cost drivers are

PDIF	= high (1.29)
PERS	= high (0.83)
RCPX	= nominal (1.0)
RUSE	= nominal (1.0)
PREX	= nominal (1.0)
FCIL	= nominal (1.0)
SCEO	= nominal (1.0)

Software Project Planning

$$PM_{adjusted} = PM_{nominal} \times \left[\prod_{i=7}^{7} EM_i \right]$$

= 194.41 * [1.29 x 0.83)

= 194.41 x 1.07

= 208.155 Person months

Post Architecture Model

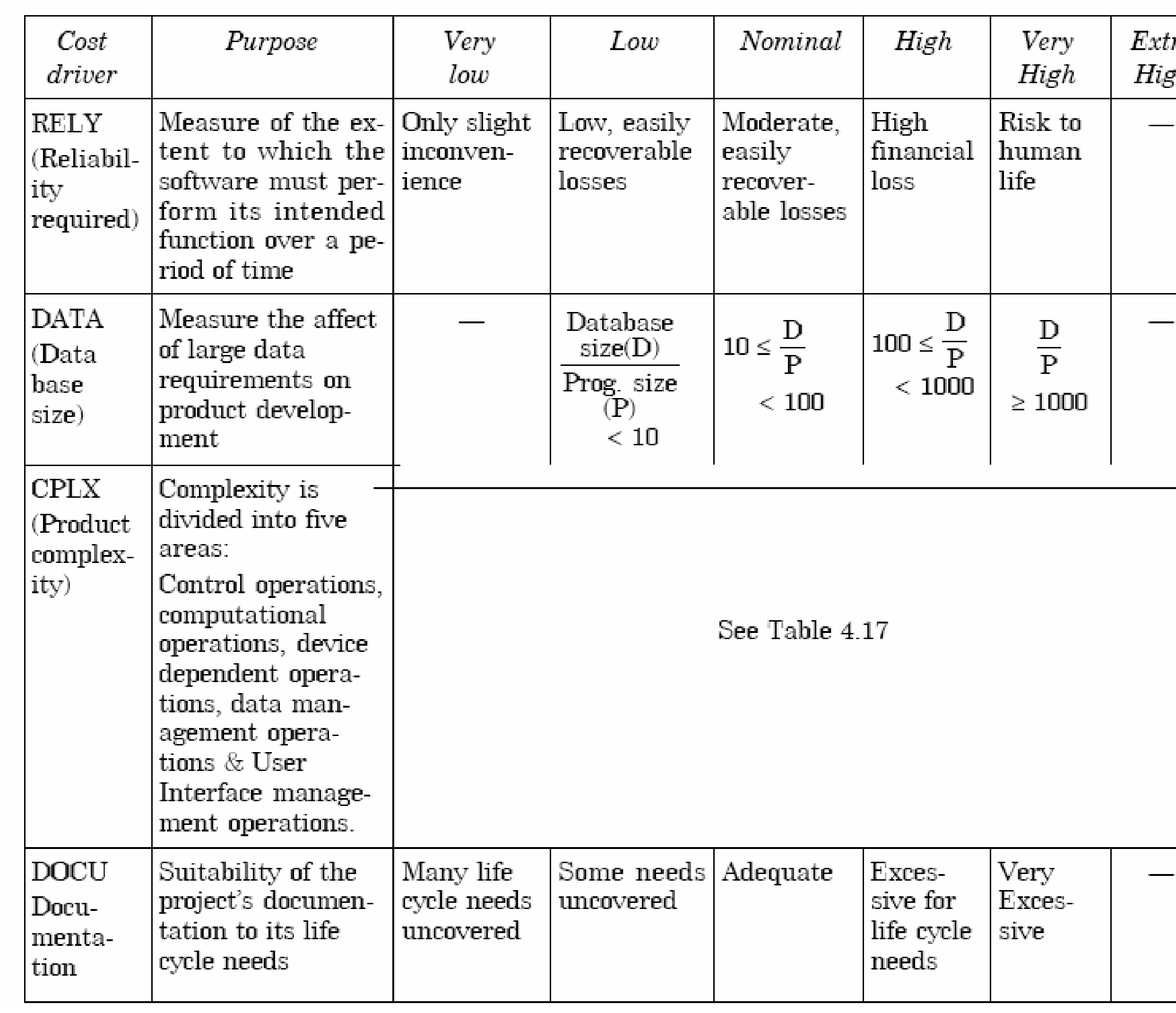
The post architecture model is the most detailed estimation r
intended to be used when a software life cycle architectu
completed. This model is used in the development and ma
software products in the application generators, system in
infrastructure sectors.

$$PM_{adjusted} = PM_{\text{nominal}} \left[\prod_{i=7}^{17} EM_i \right]$$

EM : Effort multiplier which is the product of 17 cost drivers.

The 17 cost drivers of the Post Architecture model are des
table 16.

Software Project Planning



Cost driver	*Purpose*	*Very low*	*Low*	*Nominal*	*High*	*Very High*	*Extr Hig*
RELY (Reliability required)	Measure of the extent to which the software must perform its intended function over a period of time	Only slight inconvenience	Low, easily recoverable losses	Moderate, easily recoverable losses	High financial loss	Risk to human life	—
DATA (Data base size)	Measure the affect of large data requirements on product development	—	$\frac{\text{Database size}(D)}{\text{Prog. size }(P)} < 10$	$10 \le \frac{D}{P} < 100$	$100 \le \frac{D}{P} < 1000$	$\frac{D}{P} \ge 1000$	—
CPLX (Product complexity)	Complexity is divided into five areas: Control operations, computational operations, device dependent operations, data management operations & User Interface management operations.	See Table 4.17					
DOCU Documentation	Suitability of the project's documentation to its life cycle needs	Many life cycle needs uncovered	Some needs uncovered	Adequate	Excessive for life cycle needs	Very Excessive	—

Table 16: Post Architecture Cost Driver rating level summary

TIME (Execution Time constraint)	Measure of execution time constraint on software	—	—	≤ 50% use of a available execution time	70%	85%
STOR (Main storage constraint)	Measure of main storage constraint on software	—	—	≤ 50% use of available storage	70%	85%
PVOL (Platform Volatility)	Measure of changes to the OS, compilers, editors, DBMS etc.	—	Major changes every 12 months & minor changes every 1 month	Major: 6 months Minor: 2 weeks	Major: 2 months Minor: 1 week	Major: 2 week Minor: 2 days
ACAP (Analyst capability)	Should include analysis and design ability, efficiency & thoroughness, and communication skills.	15th Percentile	35th Percentile	55th Percentile	75th Percentile	90th Percentile

Table 16: Post Architecture Cost Driver rating level summary

Software Project Planning

PCAP (Programmers capability)	Capability of Programmers as a team. It includes ability, efficiency, thoroughness & communication skills	15th Percentile	35th Percentile	55th Percentile	75th Percentile	90t Pe til
PCON (Personnel Continuity)	Rating is in terms of Project's annual personnel turnover	48%/year	24%/year	12%/year	6%/year	3%
AEXP (Applications Experience)	Rating is dependent on level of applications experience.	≤ 2 months	6 months	1 year	3 year	6 y
PEXP (Platform experience)	Measure of Platform experience	≤ 2 months	6 months	1 year	3 year	6 y

Table 16: Post Architecture Cost Driver rating level summary

Software Project Planning

LTEX (Language & Tool experience)	Rating is for Language & tool experience	≤ 2 months	6 months	1 year	3 year	6 year	—
TOOL (Use of software tools)	It is the indicator of usage of software tools	No use	Beginning to use	Some use	Good use	Routine & habitual use	—
SITE (Multisite development)	Site location & Communication technology between sites	International with some phone & mail facility	Multicity & multi company with individual phones, FAX	Multicity & multi company with Narrow band mail	Same city or Metro with wideband electronic communication	Same building or complex with wideband electronic communication & Video conferencing	Fully co-located with interactive multimedia
SCED (Required Development Schedule)	Measure of Schedule constraint. Ratings are defined in terms of percentage of schedule stretch-out or acceleration with respect to nominal schedule	75% of nominal	85%	100%	130%	160%	—

Table 16: Post Architecture Cost Driver rating level summary

Software Project Planning

Product complexity is based on control operations, c
operations, device dependent operations, data management o
user interface management operations. Module complexity rat
in table 17.

The numeric values of these 17 cost drivers are given in tab
calculation of the product of efforts i.e., effort multiplier (EM
adjusted is calculated which will be a better and fine tuned v
in person months.

Software Project Planning

	Control Operations	Computational Operations	Device-dependent Operations	Data management Operations
Very Low	Straight-line code with a few non-nested structured programming operators: Dos. Simple module composition via procedure calls or simple scripts.	Evaluation of simple expressions: e.g., A=B+C*(D-E)	Simple read, write statements with simple formats.	Simple arrays in main memory. Simple COTSDB queries, updates.
Low	Straight forward nesting of structured programming operators. Mostly simple predicates	Evaluation of moderate-level expressions: e.g., D=SQRT(B**2-4*A*C)	No cognizance needed of particular processor or I/O device characteristics. I/O done at GET/PUT level.	Single file sub setting with no data structure changes, no edits, no intermediate files, Moderately complex COTS-DB queries, updates.

Table 17: Module complexity ratings

Software Project Planning

	Control Operations	Computational Operations	Device-dependent Operations	Data management Operations
Nominal	Mostly simple nesting. Some inter module control Decision tables. Simple callbacks or message passing, including middleware supported distributed processing.	Use of standard maths and statistical routines. Basic matrix/ vector operations.	I/O processing includes device selection, status checking and error processing.	Multi-file input and single file output. Simple structural changes, simp edits. Complex COTS-DB queries, updates.
High	Highly nested structured programming operators with many compound predicates. Queue and stack control. Homogeneous, distributed processing. Single processor soft real time control.	Basic numerical analysis: multivariate interpolation, ordinary differential equations. Basic truncation, round off concerns.	Operations at physical I/O level (physical storage address translations; seeks, read etc.) Optimized I/O overlap.	Simple triggers activated by da stream conten Complex data restructuring.

Table 17: Module complexity ratings

	Control Operations	Computational Operations	Device-dependent Operations	Data management Operations
Very High	Reentrant and recursive coding. Fixed-priority interrupt handling. Task synchronization, complex callbacks, heterogeneous distributed processing. Single processor hard real time control.	Difficult but structured numerical analysis: near singular matrix equations, partial differential equations. Simple parallelization.	Routines for interrupt diagnosis, servicing, masking. Communication line handling. Performance intensive embedded systems.	Distributed database coordination. Complex triggers. Searc optimization.
Extra High	Multiple resource scheduling with dynamically changing priorities. Microcode-level control. Distributed hard real time control.	Difficult and unstructured numerical analysis: highly accurate analysis of noisy, stochastic data. Complex parallelization.	Device timing dependent coding, micro programmed operations. Performance critical embedded systems.	Highly couplec dynamic relational and object structures. Natural language data management.

Table 17: Module complexity ratings

Cost Driver	Rating				
	Very Low	Low	Nominal	High	Very High
RELY	0.75	0.88	1.00	1.15	1.39
DATA		0.93	1.00	1.09	1.19
CPLX	0.75	0.88	1.00	1.15	1.30
RUSE		0.91	1.00	1.14	1.29
DOCU	0.89	0.95	1.00	1.06	1.13
TIME			1.00	1.11	1.31
STOR			1.00	1.06	1.21
PVOL		0.87	1.00	1.15	1.30
ACAP	1.50	1.22	1.00	0.83	0.67
PCAP	1.37	1.16	1.00	0.87	0.74

Table 18: 17 Cost Drivers

Cost Driver	Rating				
	Very Low	Low	Nominal	High	Very High
PCON	1.24	1.10	1.00	0.92	0.84
AEXP	1.22	1.10	1.00	0.89	0.81
PEXP	1.25	1.12	1.00	0.88	0.81
LTEX	1.22	1.10	1.00	0.91	0.84
TOOL	1.24	1.12	1.00	0.86	0.72
SITE	1.25	1.10	1.00	0.92	0.84
SCED	1.29	1.10	1.00	1.00	1.00

Table 18: 17 Cost Drivers

Software Project Planning

Schedule estimation

Development time can be calculated using PM$_{adjusted}$ as a key f
desired equation is:

$$TDEV_{\text{nominal}} = [\phi \quad (PM_{adjusted})^{(0.28+0.2(B-0.091))}] \quad * \frac{SC}{}$$

where Φ = constant, provisionally set to 3.67

TDEV$_{nominal}$ = calendar time in months with a scheduled constr

B = Scaling factor

PM$_{adjusted}$ = Estimated effort in Person months (after adjustmen

Size measurement

Size can be measured in any unit and the model can b
accordingly. However, COCOMO II details are:

i. Application composition model uses the size in object poi

ii. The other two models use size in KLOC

Early design model uses unadjusted function points. These fu
are converted into KLOC using Table 19. Post architecture
compute KLOC after defining LOC counting rules. If functi
used, then use unadjusted function points and convert it into
Table 19.

Software Project Planning

Language	SLOC/UFP
Ada	71
AI Shell	49
APL	32
Assembly	320
Assembly (Macro)	213
ANSI/Quick/Turbo Basic	64
Basic-Compiled	91
Basic-Interpreted	128
C	128
C++	29

Table 19: Converting function points to lines of code

Software Project Planning

Language	SLOC/UFP
ANSI Cobol 85	91
Fortan 77	105
Forth	64
Jovial	105
Lisp	64
Modula 2	80
Pascal	91
Prolog	64
Report Generator	80
Spreadsheet	6

Table 19: Converting function points to lines of code

Example: 4.11

Consider the software project given in example 4.10. Size ar
(B) are the same. The identified 17 Cost drivers are high reliab
very high database size (DATA), high execution time const
very high analyst capability (ACAP), high programmers capa
The other cost drivers are nominal. Calculate the effort in Pers
the development of the project.

Solution

Here $B = 1.1129$

$PM_{nominal} = 194.41$ Person-months

$$PM_{adjusted} = PM_{\text{nominal}} \left[\prod_{i=7}^{17} EM_i \right]$$

= 194.41 x (1.15 x 1.19 x 1.11 x 0.67 x 0

= 194.41 x 0.885

= 172.05 Person-months

Putnam Resource Allocation Model

Norden of IBM

Rayleigh curve

Model for a range of hardware development pr

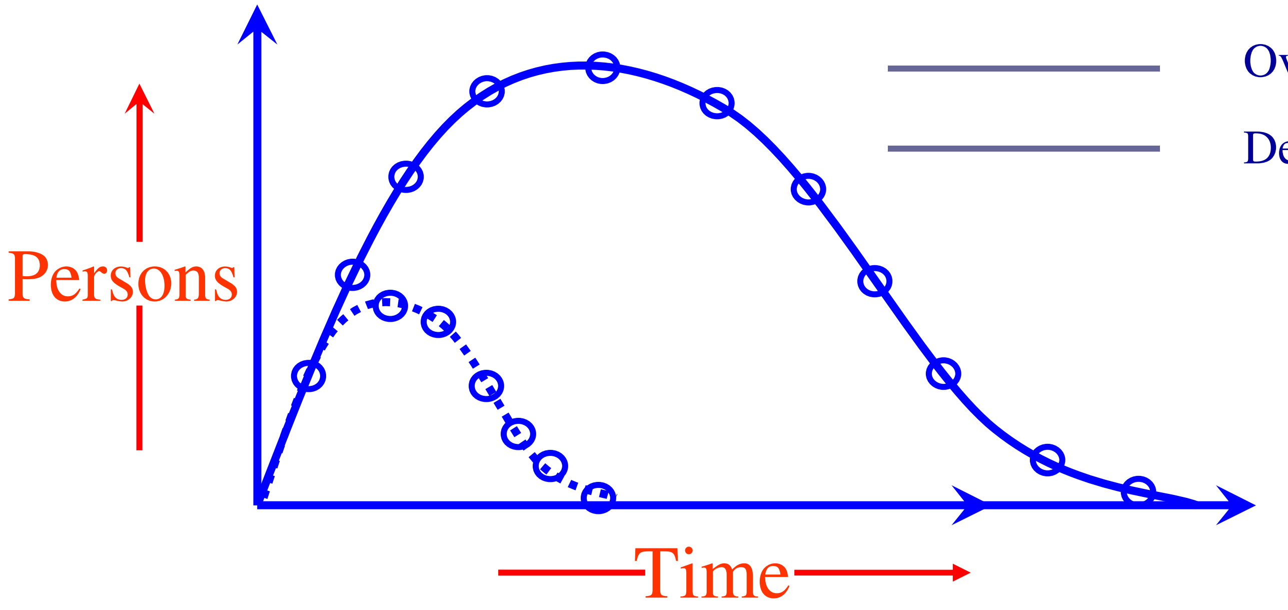


Fig.6: The Rayleigh manpower loading curve

Software Project Planning

Putnam observed that this curve was approximation at project level and software s level.

$$\boxed{\text{No. of projects} = 150}$$

The Norden / Rayleigh Curve

The curve is modeled by differential equation

$$m(t) = \frac{dy}{dt} = 2kate^{-at^2} \qquad \text{---------} \ (1)$$

$\frac{dy}{dt}$	= manpower utilization rate per unit time
a	= parameter that affects the shape of the curve
K	= area under curve in the interval [0, ∞]
t	= elapsed time

Software Project Planning

On Integration on interval [o, t]

$$y(t) = K\,[1-e^{-at^2}] \quad \text{-------------}(2)$$

Where y(t): cumulative manpower used upto time t.

$$y(0) = 0$$

$$y(\infty) = k$$

The cumulative manpower is null at the start of the p
grows monotonically towards the total effort K (area
curve).

Software Project Planning

$$\frac{d^2y}{dt^2} = 2kae^{-at^2}[1-2at^2] = 0$$

$$t_d^2 = \frac{1}{2a}$$

"t_d": time where maximum effort rate occurs

Replace "t_d" for *t* in equation (2)

$$E = y(t) = k\left(1 - e^{\frac{t_d^2}{2t_d^2}}\right) = K(1 - e^{-0.5})$$

$$E = y(t) = 0.3935\ k$$

$$a = \frac{1}{2t_d^2}$$

Software Project Planning

Replace "a" with $\frac{1}{2t_d^2}$ in the Norden/Rayleigh making this substitution in equation we have

$$m(t) = \frac{2K}{2t_d^2} te^{-\frac{t^2}{2t_d^2}}$$

$$= \frac{K}{t_d^2} te^{-\frac{t^2}{2t_d^2}}$$

Software Project Planning

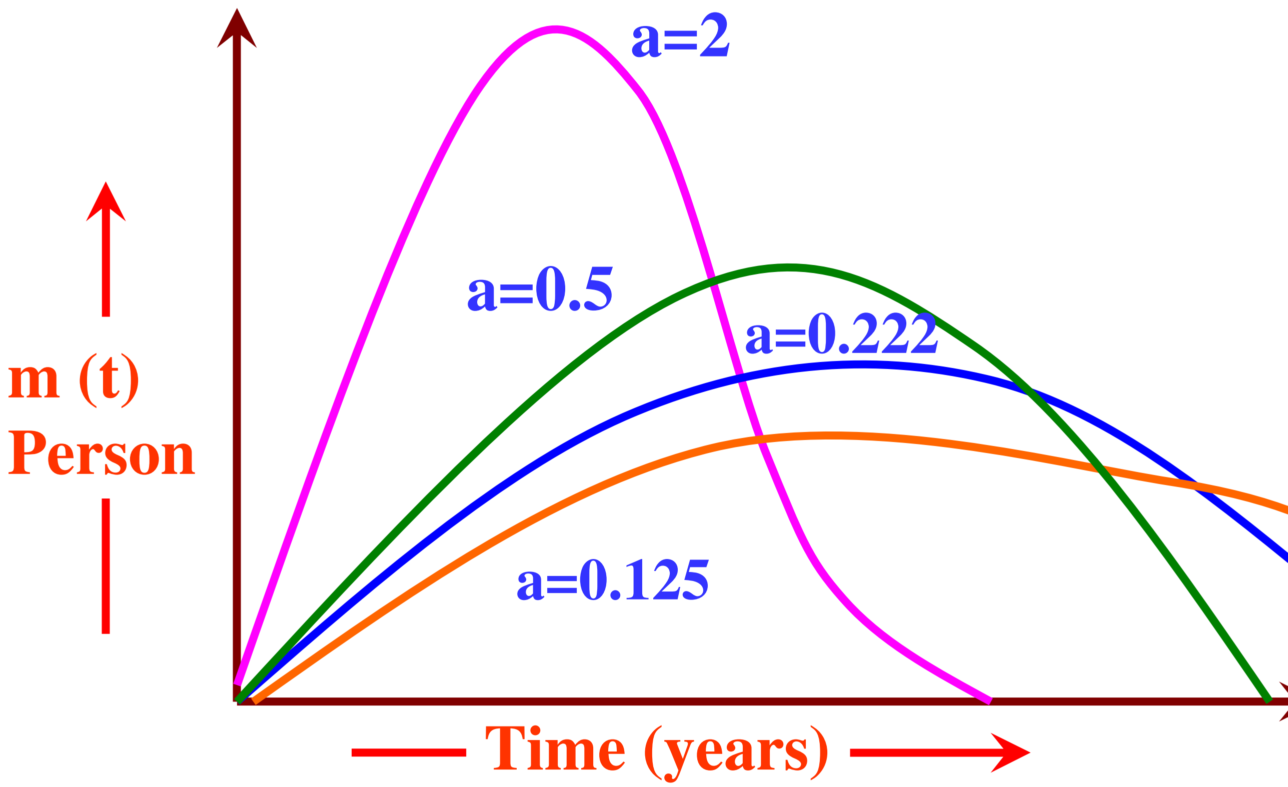


Fig.7: Influence of parameter 'a' on the manpo
distribution

Software Project Planning

At time $t=t_d$, peak manning $m(t_d)$ is obtained and denoted by

$$m_o = \frac{k}{t_d\sqrt{e}}$$

k	= Total project cost/effort in person-years.
t_d	= Delivery time in years
m_0	= No. of persons employed at the peak
e	= 2.71828

Software Project Planning

Example: 4.12

A software development project is planned to cost 95 MY
of 1 year and 9 months. Calculate the peak manning and a
of software team build up.

Solution

Software development cost k=95 MY

Peak development time t_d = 1.75 years

Peak manning $m_o = \dfrac{k}{t_d\sqrt{e}}$

$$\frac{95}{1.75 \quad 1.648} = 32.94 = 33 \ persons$$

Average rate of software team build up

$$= \frac{m_0}{t_d} = \frac{33}{1.75} = 18.8\, persons\,/\,year\ or\ 1.56\ person\,/\,mon$$

Example: 4.13

Consider a large-scale project for which the manpower requ
K=600 PY and the development time is 3 years 6 months.

(a)Calculate the peak manning and peak time.

(b)What is the manpower cost after 1 year and 2 months?

Solution

(a) We know t_d=3 years and 6 months = 3.5 years

NOW $m_0 = \frac{K}{t_d \sqrt{e}}$

$\therefore \quad m_0 =$ 600/(3.5x1.648) $\cong$ 104 persons

(b) We know

$$y(t) = K\left[1 - e^{-at^2}\right]$$

t = 1 year and 2 months

= 1.17 years

$$a = \frac{1}{2t_d^2} = \frac{1}{2 \quad (3.5)^2} = 0.041$$

$$y(1.17) = 600\left[1 - e^{-0.041(1.17)^2}\right]$$

= 32.6 PY

Difficulty Metric

Slope of manpower distribution curve at start tim
some useful properties.

$$m'(t) = \frac{d^2y}{dt^2} = 2kae^{-at^2}(1-2at^2)$$

Then, for t=0

$$m'(0) = 2Ka = \frac{2K}{2t_d^2} = \frac{K}{t_d^2}$$

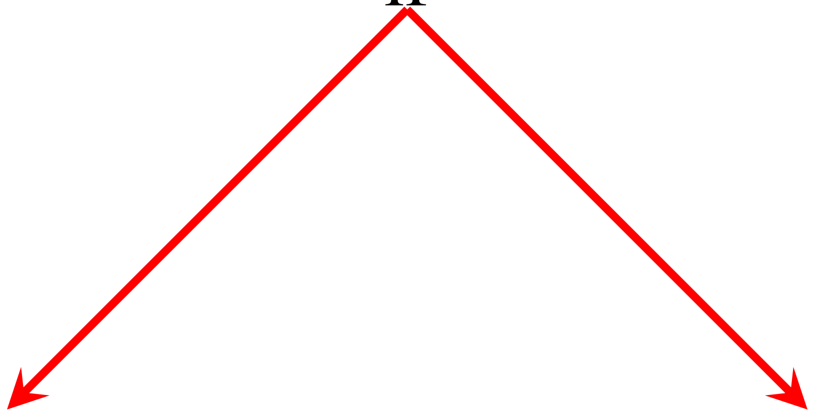
Software Project Planning

The ratio $\frac{K}{t_d^2}$ is called difficulty and denot
which is measured in person/year :

$$\boxed{D = \frac{k}{t_d^2} \text{ persons/year}}$$

Software Project Planning

Project is difficult to develop
if



Manpower demand
is high

When time sche
is short

Software Project Planning

Peak manning is defined as:

$$m_0 = \frac{k}{t_d \sqrt{e}}$$

$$D = \frac{k}{t_d^2} = \frac{m_0 \sqrt{e}}{t_d}$$

Thus difficult projects tend to have a hig
manning for a given development time, which
with Norden's observations relative to the paran

Manpower buildup

D is dependent upon “K”. The derivative of D re
“K” and “t_d” are

$$D'(t_d) = \frac{-2k}{t_d^3} \; persons / year^2$$

$$D'(k) = \frac{1}{t_d^2} \; year^{-2}$$

Software Project Planning

$D^1(K)$ will always be very much smaller than the absol
$D^1(t_d)$. This difference in sensitivity is shown by cons
projects

Project A	: Cost = 20 PY & t_d = 1 year
Project B	: Cost = 120 PY & t_d = 2.5 years

The derivative values are

Project A	: D\` ($t_d$) = -40 & D\`(K) = 1
Project B	: D\` ($t_d$) = -15.36 & D\`(K) = 0.16

This shows that a given software development is time se

Software Project Planning

Putnam observed that

Difficulty derivative relative to time

$\curvearrowright$ Behavior of s/w development

If project scale is increased, the development tin

increase to such an extent that $\frac{k}{t_d^3}$ remains co

around a value which could be 8,15,27.

Software Project Planning

It is represented by D_0 and can be expressed as:

$$D_0 = \frac{k}{t_d^3} \; person / year^2$$

D_0 =8, new s/w with many interfaces & inte
with other systems.

D_0 =15, New standalone system.

D_0 =27, The software is rebuild form existing so

Example: 4.14

Consider the example 4.13 and calculate the diffi
manpower build up.

Solution

We know

Difficulty $D = \frac{K}{t_d^2}$

$$= \frac{600}{(3.5)^2} = 49 \ person / year$$

Manpower build up can be calculated by following equat

$$D_0 = \frac{K}{t_d^3}$$

$$= \frac{600}{(3.5)^3} = 14 \ person / year^2$$

Software Project Planning

Productivity Versus Difficulty

Productivity = No. of LOC developed per perso

$$P \propto D^{\beta}$$

Avg. productivity

$$P = \frac{LOC\ produced}{cumulative\ manpower\ used\ to\ produce\ code}$$

Software Project Planning

P = S/E

$$P = \phi D^{-2/3}$$

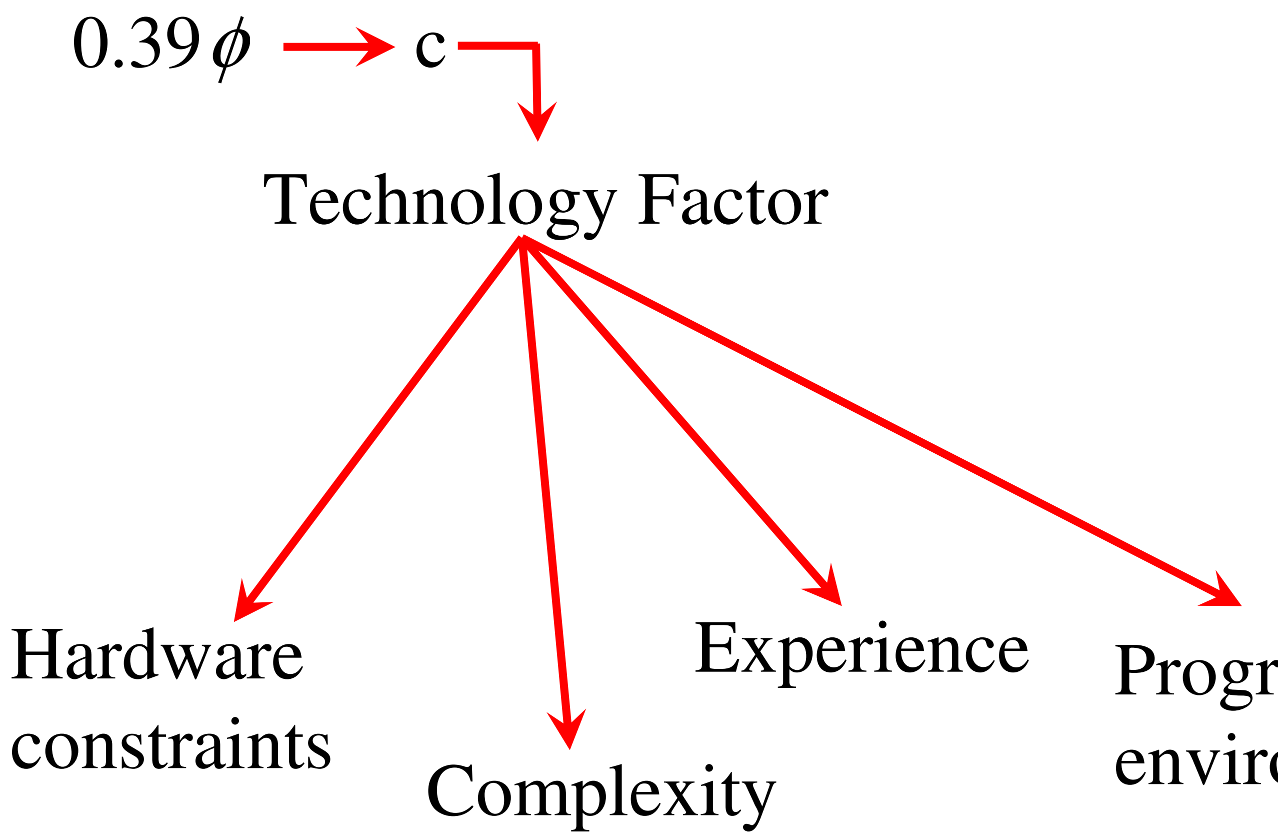
$$S = \phi D^{-2/3} E$$

$$= \phi D^{-2/3} (0.3935\ K)$$

$$S = \phi \left[\frac{k}{t_d^2} \right]^{-\frac{2}{3}} k(0.3935)$$

$$S = 0.3935\,\phi\,K^{1/3} t_d^{\;4/3}$$

Software Project Planning



Software Project Planning

$C \longrightarrow$ 610 – 57314

K : P-Y

T : Years

$$S = CK^{1/3} t_d^{4/3}$$

$$C = S.K^{-1/3} t_d^{-4/3}$$

The trade off of time versus cost

$$K^{1/3} t_d^{4/3} = S / C$$

$$K = \frac{1}{t_d^4} \left(\frac{S}{C} \right)^3$$

Software Project Planning

C = 5000

S = 5,00,000 LOC

$$K = \frac{1}{t_d^4}(100)^3$$

t_d (years)	K (P-Y)
5.0	1600
4.0	3906
3.5	6664
3.0	12346

Table 20: (Manpower versus development time

Development Subcycle

All that has been discussed so far is related to project l
represented by project curve

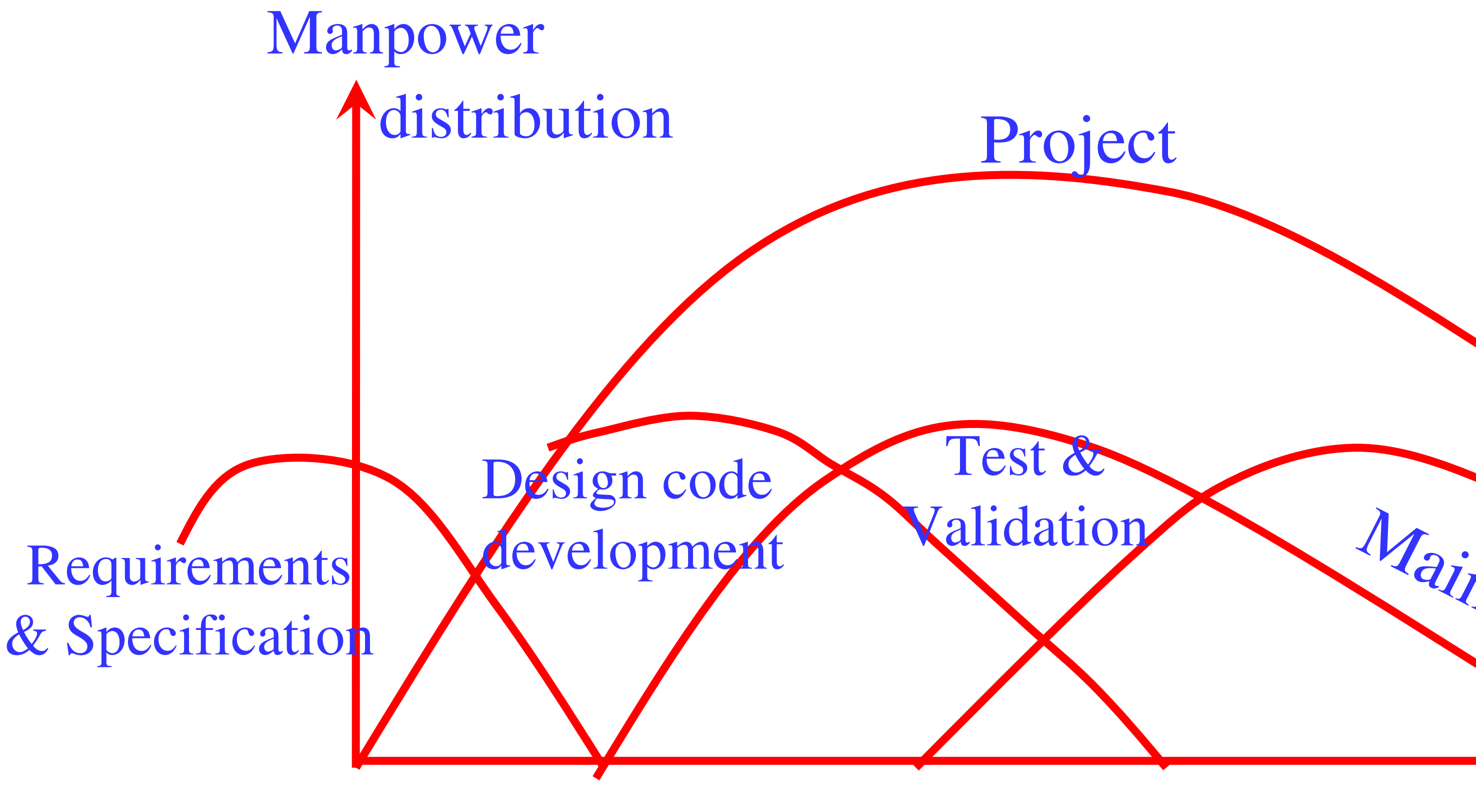


Fig.8: Project life cycle

Software Project Planning

Project life cycle

Project curve is the addition of two curv

Development Curve

Test & Validation Curve

Software Project Planning

$$\therefore\ m_d(t) = 2k_d bt\, e^{-bt^2}$$

$$y_d(t) = K_d\, [1-e^{-bt^2}]$$

An examination of $m_d(t)$ function shows a non-zero v
at time t_d.

This is because the manpower involved in design &
still completing this activity after t^d in form of rewo
the validation of the product.

Nevertheless, for the model, a level of completion
assumed for development.

It is assumed that 95% of the development will be
by the time t_d.

Software Project Planning

$$\frac{y_d(t)}{K_d} = 1 - e^{-bt^2} = 0.95$$

$\therefore$ We may say that $$b = \frac{1}{2t_{od}^2}$$

T_{od}: time at which development curve exhibits manning.

$$t_{od} = \frac{t_d}{\sqrt{6}}$$

Software Project Planning

Relationship between K_d & K must be established.

At the time of origin, both cycles have the same slop

$$\left(\frac{dm}{dt}\right)_o = \frac{K}{t_d^2} = \frac{K_d}{t_{od}^2} = \left(\frac{dm_d}{dt}\right)_o$$

K_d=K/6

$$D = \frac{K}{t_d^2} = \frac{K_d}{t_{od}^2}$$

Software Project Planning

This does not apply to the manpower build up D

$$D_o = \frac{K}{t_d^3} = \frac{K_d}{\sqrt{6}t_{od}^3}$$

Conte investigated that

Larger projects $\longrightarrow$ reasonable

Medium & small projects $\longrightarrow$ overestimate

Software Project Planning

Example: 4.15

A software development requires 90 PY during the total d
sub-cycle. The development time is planned for a duratior
and 5 months

(a)Calculate the manpower cost expended until developme

(b) Determine the development peak time

(c) Calculate the difficulty and manpower build up.

Solution

(a) Duration $t_d = 3.41$ years

We know from equation $$\frac{y_d(t)}{K_d} = 1 - e^{-bt_d} = 0.95$$

$$\frac{y_d(t_d)}{K_d} = 0.95$$

$$Y_d(t_d) = 0.95 \quad 90$$

= 85.5 PY

Software Project Planning

(b) We know from equation $t_{od} = \frac{t_d}{\sqrt{6}}$

$$t_{od} = \frac{t_d}{\sqrt{6}} = 3.41 / 2.449 = 1.39 \ \ years$$

$$\cong 17 \ \ months$$

(c) Total Manpower development

$$K_d = y_d(t_d)/0.95$$

= 85.5 / 0.95 = 90

$$K = 6K_d = 90 \quad 6 = 540PY$$

$$D = K/t_d^2 = 540/(3.41)^2 = 46$$ persons/years

$$D_o = \frac{K}{t_d^3} = 540/(3.41)^3 = 13.6$$ persons/years^2

Example:4.16

A software development for avionics has consum
up to development cycle and produced a size
LOC. The development of project was comple
months. Calculate the development time, total m
requirement, development peak time,
manpower build up and technology factor.

Solution:

Development time t_d = 25 months = 2.08 years

Total manpower development $k_d = \frac{Y_d(t_d)}{0.95} = \frac{32}{0.95} = 3$

Development peak time $t_{od} = \frac{(t_d)}{\sqrt{6}} = 0.85\ years = 10$

$$K = 6K_d = 6 \text{ x } 33.7 = 202 \text{ PY}$$

$$D = \frac{k}{t_d^2} = \frac{202}{(2.08)^2} = 46.7\ pesons / years$$

Software Project Planning

$$D_0 = \frac{k}{t_d^3} = \frac{202}{(2.08)^3} = 22.5\ Persons / year^2$$

Technology factor

$$C = SK^{-1/3} t_d^{-4/3}$$

$$= 3077$$

Software Project Planning

Example 4.17

What amount of software can be delivered in 1 year 10 m
organization whose technology factor is 2400 if a total c
permitted for development effort.

Software Project Planning

Solution:

t_d = 1.8 years

K_d = 25 PY

K = 25 x 6 = 150 PY

C = 2400

We know $S = CK^{1/3} t_d^{4/3}$

= 2400 x 5.313 x 2.18 = 27920

Software Project Planning

Example 4.18

The software development organization developing software has been assessed at technology factor of maximum value of manpower build up for thi software is D_o=7.5. The estimated size to be de S=55000 LOC.

(a) Determine the total development time, t development manpower cost, the difficulty development peak manning.

(b) The development time determined in (a) is consi long. It is recommended that it be reduced by tw What would happen?

Solution

We have $S = CK^{1/3} t_d^{\ 4/3}$

$$\left(\frac{s}{c}\right)^3 = kt_d^4$$

which is also equivalent to $\left(\frac{S}{C}\right)^3 = D_o t_d^7$

then $t_d = \left[\frac{1}{D_0}\left(\frac{S}{C}\right)^3\right]^{1/7}$

Software Project Planning

$$Since \quad \frac{S}{C} = 25$$

$t_d = 3$ years

$$K = D_0 t_d^3 = 7.5 \quad 27 = 202 \ PY$$

Total development manpower cost $K_d = \frac{202}{06} = 33.$

$D = D_0 t_d = 22.5$ persons / year

$$t_{od} = \frac{t_d}{\sqrt{6}} = \frac{3}{\sqrt{6}} = 1.2 \ years$$

Software Project Planning

$$M_d(t) = 2k_d\, bte^{-bt^2}$$

$$Y_d(t) = k_d\,(1-e^{-bt^2})$$

Here $t = t_{od}$

Peak manning $= m_{od} = Dt_{od}e^{-1/2}$

$= 22.5 \times 1.2 \times .606 = 16$

Software Project Planning

III. If development time is reduced by 2 m

Developing s/w at higher manpower build-up

Producing less software

(i) Increase Manpower Build-up

$$D_o = \frac{1}{t_d^7}\left(\frac{S}{C}\right)^3$$

Now t_d = 3 years – 2 months = 2.8 years

$$D_o = (25)^3 / (2.8)^7 = 11.6 \; persons / \; years$$

$$k = D_0 t_d^3 = 254 \, PY$$

$$K_d = \frac{254}{6} = 42.4 \, PY$$

Software Project Planning

$D = D_0 t_d = 32.5$ persons / year

The peak time is $t_{od} = 1.14$ years

Peak manning $m_{od} = D t_{od} e^{-0.5}$

$= 32.5 \times 1.14 \times 0.6$

$= 22$ persons

Note the huge increase in peak manning & n
cost.

(ii) Produce Less Software

$$\left(\frac{S}{C}\right)^3 = D_0 t_d^7 = 7.5 \quad (2.8)^7 = 10119.696$$

$$\left(\frac{S}{C}\right)^3 = 21.62989$$

Then for C=2200

S=47586 LOC

Productivity versus difficult

Example 4.19

A stand alone project for which the size is estimate
LOC is to be developed in an environment suc
technology factor is 1200. Choosing a manpowe
D_o=15, Calculate the minimum development t
development man power cost, the difficulty, the peal
the development peak time, and the development pr

Solution

Size (S)	= 12500 LOC
Technology factor (C)	= 1200
Manpower buildup (D_o)	= 15

Now $$S = CK^{1/3} t_d^{4/3}$$

$$\frac{S}{C} = K^{1/3} t_d^{4/3}$$

$$\left(\frac{S}{C}\right)^3 = K t_d^4$$

Software Project Planning

Also we know $D_o = \dfrac{K}{t_d^3}$

$$K = D_o t_d^3 = D_o t_d^3$$

Hence $\left(\dfrac{S}{C}\right)^3 = D_o t_d^7$

Substituting the values, we get $\left(\dfrac{12500}{1200}\right)^3 = 15 t_d^7$

$$t_d = \left[\frac{(10.416)^3}{15}\right]^{1/7}$$

$$t_d = 1.85 \ years$$

Software Project Planning

(i) Hence Minimum development time (t_d)=1.85 year

(ii) Total development manpower cost $K_d = \frac{K}{6}$

Hence $K = 15 t_d^3$

$$= 15(1.85)^3 = 94.97 \text{ PY}$$

$$K_d = \frac{K}{6} = \frac{94.97}{6} = 15.83\ PY$$

(iii) Difficulty $D = \frac{K}{t_d^2} = \frac{94.97}{(1.85)^2} = 27.75\ Persons / year$

Software Project Planning

(iv) Peak Manning $m_0 = \frac{K}{t_d \sqrt{e}}$

$$= \frac{94.97}{1.85 \quad 1.648} = 31.15 \, Person$$

(v) Development Peak time $t_{od} = \frac{t_d}{\sqrt{6}}$

$$= \frac{1.85}{2.449} = 0.755 \; years$$

(vi) Development Productivity

$$= \frac{No.of \;\; lines \;\; of \;\; code \;\; (S)}{effort \;\; (K_d)}$$

$$= \frac{12500}{15.83} = 789.6 \; LOC/PY$$

Software Risk Management

- We Software developers are extremely optin
- We assume, everything will go exactly as pla
- Other view

    ↘ not possible to predict what is going to ha

    Software surprises

    ↘ Never good news

Software Project Planning

Risk management is required to reduce this
factor

Dealing with concern before it becomes a crisis.

Quantify probability of failure & consequences

What is risk ?

Tomorrow's problems are today's risks.

"Risk is a problem that may cause some threaten the success of the project, but w not happened yet".

Software Project Planning

Risk management is the process of identifying a
and eliminating these problems before they ca
the project.

Current problems &

$$\begin{tikzcd} \text{Current problems \&} \arrow[d, dash] \\ {} \arrow[r] & \text{Potential Problems} \end{tikzcd}$$

Typical Software Risk

Capers Jones has identified the top five risk fa
threaten projects in different applications.

1. Dependencies on outside agencies or facto
   - Availability of trained, experienced pe
   - Inter group dependencies
   - Customer-Furnished items or informati
   - Internal & external subcontractor relati

Software Project Planning

2. Requirement issues

Uncertain requirements

$\searrow$

Wrong product

or

Right product badly

Either situation results in unpleasant surp
unhappy customers.

Software Project Planning

- Lack of clear product vision
- Lack of agreement on product requirements
- Unprioritized requirements
- New market with uncertain needs
- Rapidly changing requirements
- Inadequate Impact analysis of requirements c

Software Project Planning

3. Management Issues

Project managers usually write the risk ma
plans, and most people do not wish to
weaknesses in public.

- Inadequate planning
- Inadequate visibility into actual project s
- Unclear project ownership and decision
- Staff personality conflicts
- Unrealistic expectation
- Poor communication

Software Project Planning

4. Lack of knowledge

- Inadequate training
- Poor understanding of methods, t
  techniques
- Inadequate application domain experien
- New Technologies
- Ineffective, poorly documented or
  processes

Software Project Planning

5. Other risk categories

- Unavailability of adequate testing facilit
- Turnover of essential personnel
- Unachievable performance requirements
- Technical approaches that may not work

Risk Management Activities

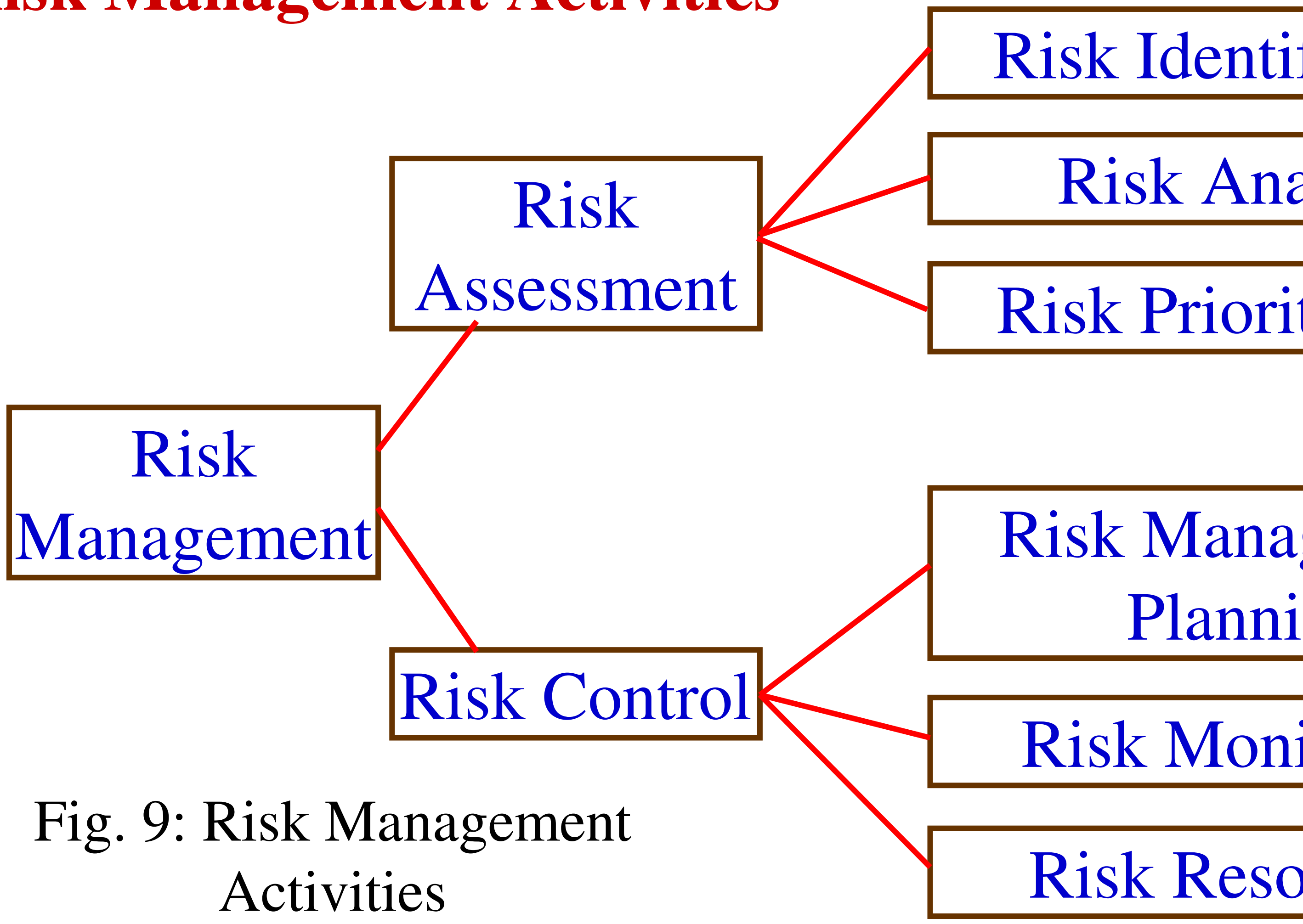


Fig. 9: Risk Management Activities

Risk Assessment

Identification of risks

Risk analysis involves examining how project might change with modification of risk input variabl

Risk prioritization focus for severe risks.

Risk exposure: It is the product of the probability of a loss due to the risk and the potential magnitude of

Software Project Planning

Another way of handling risk is the risk avoidance.
the risky things! We may avoid risks by not u
certain projects, or by relying on proven rather th
edge technologies.

Risk Control

Risk Management Planning produces a plan for de
each significant risks.

- Record decision in the plan.

Risk resolution is the execution of the plans of deal
each risk.

Multiple Choice Questions

Note: Choose most appropriate answer of the following q

4.1 After the finalization of SRS, we may like to estimate
  (a) Size (b) Cost
  (c) Development time (d) All of the above.

4.2 Which one is not a size measure for software
  (a) LOC (b) Function Count
  (c) Cyclomatic Complexity (d) Halstead's program le

4.3 Function count method was developed by
  (a) B.Beizer (b) B.Boehm
  (c) M.halstead (d) Alan Albrecht

4.4 Function point analysis (FPA) method decomposes the system int
units. The total number of functional units are
  (a) 2 (b) 5
  (c) 4 (d) 1

Multiple Choice Questions

4.5 IFPUG stand for
- (a) Initial function point uniform group
- (b) International function point uniform group
- (c) International function point user group
- (d) Initial function point user group

4.6 Function point can be calculated by
- (a) UFP * CAF
- (b) UFP * FAC
- (c) UFP * Cost
- (d) UFP * Productivity

4.7 Putnam resource allocation model is based on
- (a) Function points
- (b) Norden/ Rayleigh curve
- (c) Putnam theory of software management
- (d) Boehm's observation on manpower utilisation rate

4.8 Manpower buildup for Putnam resource allocation model is
- $(a)\, K / t_d^2$ *persons / year*^{2}
- $(b)\, K / t_d^3$ *persons / year*^{2}
- $(c)\, K / t_d^2$ *persons / year*
- $(d)\, K / t_d^3$ *persons / year*

Multiple Choice Questions

4.9 COCOMO was developed initially by

(a) B.W.Bohem (b) Gregg Rothermal

(c) B.Beizer (d) Rajiv Gupta

4.10 A COCOMO model is

(a) Common Cost estimation model

(b) Constructive cost Estimation model

(c) Complete cost estimation model

(d) Comprehensive Cost estimation model

4.11 Estimation of software development effort for organic software i

(a) $E=2.4(KLOC)^{1.05}PM$ (b) $E=3.4(KLOC)^{1.06}PM$

(c) $E=2.0(KLOC)^{1.05}PM$ (d) $E-2.4(KLOC)^{1.07}PM$

4.12 Estimation of size for a project is dependent on

(a) Cost (b) Schedule

(c) Time (d) None of the above

4.13 In function point analysis, number of Complexity adjustment fac

(a) 10 (b) 20

(c) 14 (d) 12

Multiple Choice Questions

4.14 COCOMO-II estimation model is based on

(a) Complex approach (b) Algorithm approach
(c) Bottom up approach (d) Top down approac

4.15 Cost estimation for a project may include

(a) Software Cost (b) Hardware Cost
(c) Personnel Costs (d) All of the above

4.16 In COCOMO model, if project size is typically 2-50 KLOC, then is to be selected?

(a) Organic (b) Semidetached
(c) Embedded (d) None of the above

4.17 COCOMO-II was developed at

(a) University of Maryland (b) University of Southe
(c) IBM (d) AT & T Bell labs

4.18 Which one is not a Category of COCOMO-II

(a) End User Programming (b) Infrastructure Secto
(c) Requirement Sector (d) System Integration

Multiple Choice Questions

4.19 Which one is not an infrastructure software?

(a) Operating system (b) Database manageme

(c) Compilers (d) Result management

4.20 How many stages are in COCOMO-II?

(a) 2 (b) 3

(c) 4 (d) 5

4.21 Which one is not a stage of COCOMO-II?

(a) Application Composition estimation model

(b) Early design estimation model

(c) Post architecture estimation model

(d) Comprehensive cost estimation model

4.22 In Putnam resource allocation model, Rayleigh curve is modeled

$(a)\ \ m(t) = 2at\,e^{-at^2}$ $(b)\ \ m(t) = 2Kt\,e^{-at^2}$

$(c)\ \ m(t) = 2Kat\,e^{-at^2}$ $(d)\ \ m(t) = 2Kbt\,e^{-at^2}$

Multiple Choice Questions

4.23 In Putnam resource allocation model, technology factor ‘C’ is defin

(a) $C = SK^{-1/3} t_d^{-4/3}$ (b) $C = SK^{1/3} t_d^{4/3}$

(c) $C = SK^{1/3} t_d^{-4/3}$ (d) $C = SK^{-1/3} t_d^{4/3}$

4.24 Risk management activities are divided in

(a) 3 Categories (b) 2 Categories

(c) 5 Categories (d) 10 Categories

4.25 Which one is not a risk management activity?

(a) Risk assessment (b) Risk control

(c) Risk generation (d) None of the above

Exercises

4.1 What are various activities during software project plannin

4.2 Describe any two software size estimation techniques.

4.3 A proposal is made to count the size of 'C' programs semicolons, except those occurring with literal strings strengths and weaknesses to this size measure when com lines of code count.

4.4 Design a LOC counter for counting LOC automatically. dependent? What are the limitations of such a counter?

4.5 Compute the function point value for a project with information domain characteristics.

Number of user inputs = 30

Number of user outputs = 42

Number of user enquiries = 08

Number of files = 07

Number of external interfaces = 6

Assume that all complexity adjustment values are moderate.

Exercises

4.6 Explain the concept of function points. Why FPs a
acceptable in industry?

4.7 What are the size metrics? How is function point metric
over LOC metric? Explain.

4.8 Is it possible to estimate software size before coding? Justif
with suitable example.

4.9 Describe the Albrecht's function count method with a suitab

4.10 Compute the function point FP for a payroll program that
employee and a file of information for the current mon
cheque for all the employees. The program is capable o
interactive command to print an individually requ
immediately.

Exercises

4.11 Assume that the previous payroll program is expected
containing information about all the cheques that have bee
file is supposed to be printed and also used by the program
run, to produce a report that compares payroll expenses
month with those of the previous month. Compute functi
this program. Justify the difference between the function
program and previous one by considering how the com
program is affected by adding the requirement of int
another application (in this case, itself).

4.12 Explain the Walson & Felix model and compare with the S

4.13 The size of a software product to be developed has been e
22000 LOC. Predict the manpower cost (effort) by Walsto
and SEL model.

4.14 A database system is to be developed. The effort has bee
be 100 Persons-Months. Calculate the number of lines
productivity in LOC/Person-Month.

Exercises

4.15 Discuss various types of COCOMO mode. Explain th
distribution of effort.

4.16 Explain all the levels of COCOMO model. Assume that
organic software product has been estimated to be 32,000
Determine the effort required to developed the software pr
nominal development time.

4.17 Using the basic COCOMO model, under all three ope
determine the performance relation for the ratio of delivere
lines per person-month of effort. Determine the reasonab
relation for several types of software projects.

4.18 The effort distribution for a 240 KLOC organic m
development project is: product design 12%, detailed desi
and unit test 36%, integrate and test 28%. How would
changes, from low to high, affect the phase distribution of
total effort: analyst capability, use of modern programmi
required reliability, requirements volatility?

Exercises

4.19 Specify, design, and develop a program that implemen
Using reference as a guide, extend the program so that it ca
planning tool.

4.20 Suppose a system for office automation is to be design
from requirements that there will be five modules of size 0
KLOC, 2.0 KLOC, 1.0 KLOC and 2.0 KLOC respectively
and reliability requirements are high. Programmer's c
experience is low. All other factors are of nominal rating. U
model to determine overall cost and schedule estimates. A
the cost and schedule estimates for different phases.

4.21 Suppose that a project was estimated to be 600 KLOC.
effort and development time for each of the three modes
semidetached and embedded.

4.22 Explain the COCOMO-II in detail. What types of categor
are identified?

Exercises

4.23 Discuss the Infrastructure Sector of COCOMO-II.

4.24 Describe various stages of COCOMO-II. Which stage is
and why?

4.25 A software project of application generator category with
of 100 KLOC has to be developed. The scale factor
percedentness, high development flexibility. Other factors
The cost drivers are high reliability, medium databa
Personnel capability, high analyst capability. The other co
nominal. Calculate the effort in Person-Months for the de
the project.

4.26 Explain the Putnam resource allocation model. What are t
of this model?

4.27 Describe the trade-off between time versus cost in Put
allocation model.

4.28 Discuss the Putnam resources allocation model. Derive
effort equations.

Exercises

4.29 Assuming the Putnam model, with S=100,000 , C=
Compute development time t_d and manpower development

4.30 Obtain software productivity data for two or three softwar
programs. Use several cost estimating models discussed i
How to the results compare with actual project results?

4.31 It seems odd that cost and size estimates are developed d
project planning-before detailed software requirements ana
has been conducted. Why do we think this is don
circumstances when it should not be done?

4.32 Discuss typical software risks. How staff turnover pr
software projects?

4.33 What are risk management activities? Is it possible to prio

Exercises

4.34 What is risk exposure? What techniques can be used to
risk?

4.35 What is risk? Is it economical to do risk management? Wh
of this activity on the overall cost of the project?

4.36 There are significant risks even in student projects. Ana
project and list all the risk.