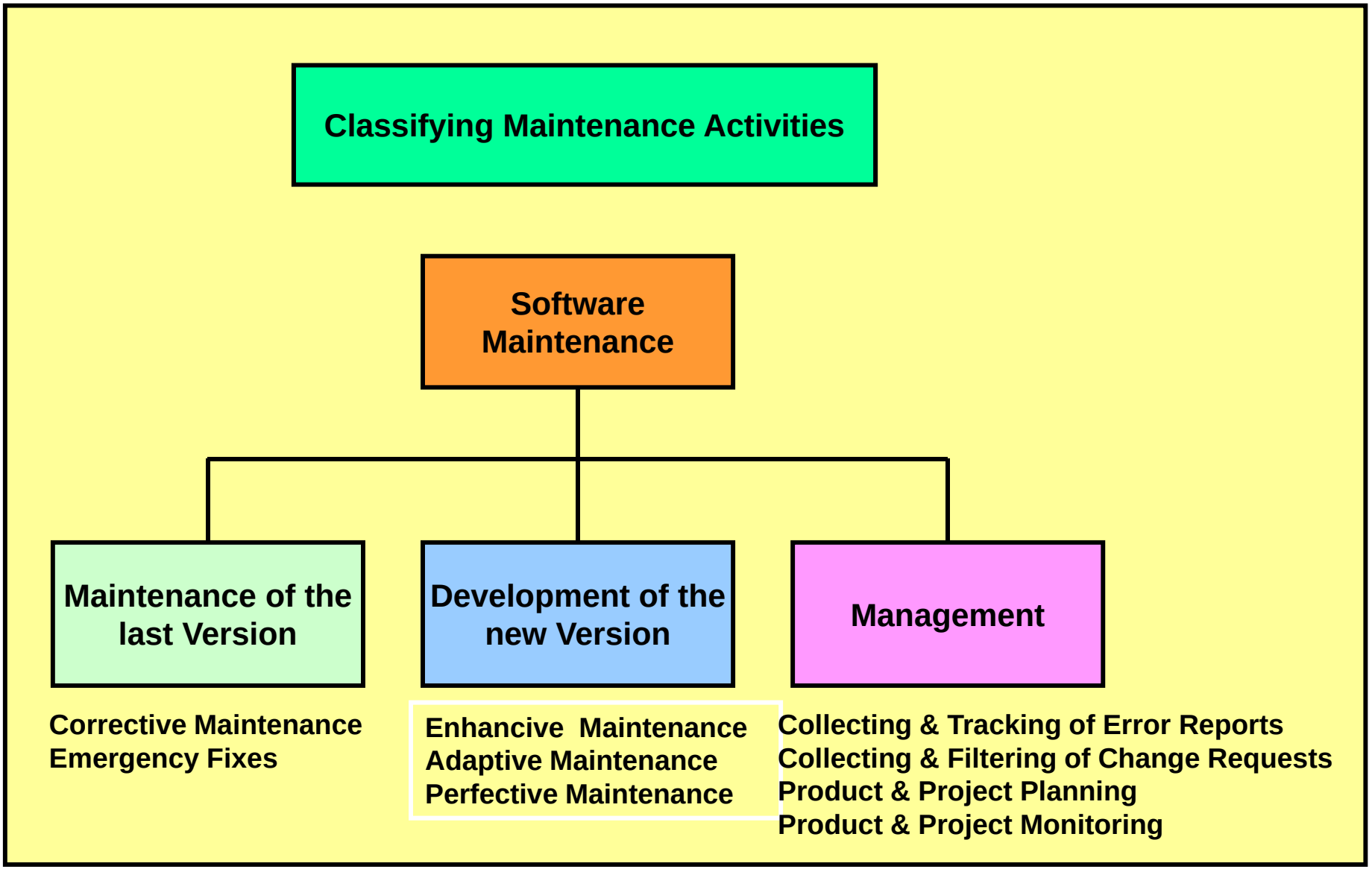
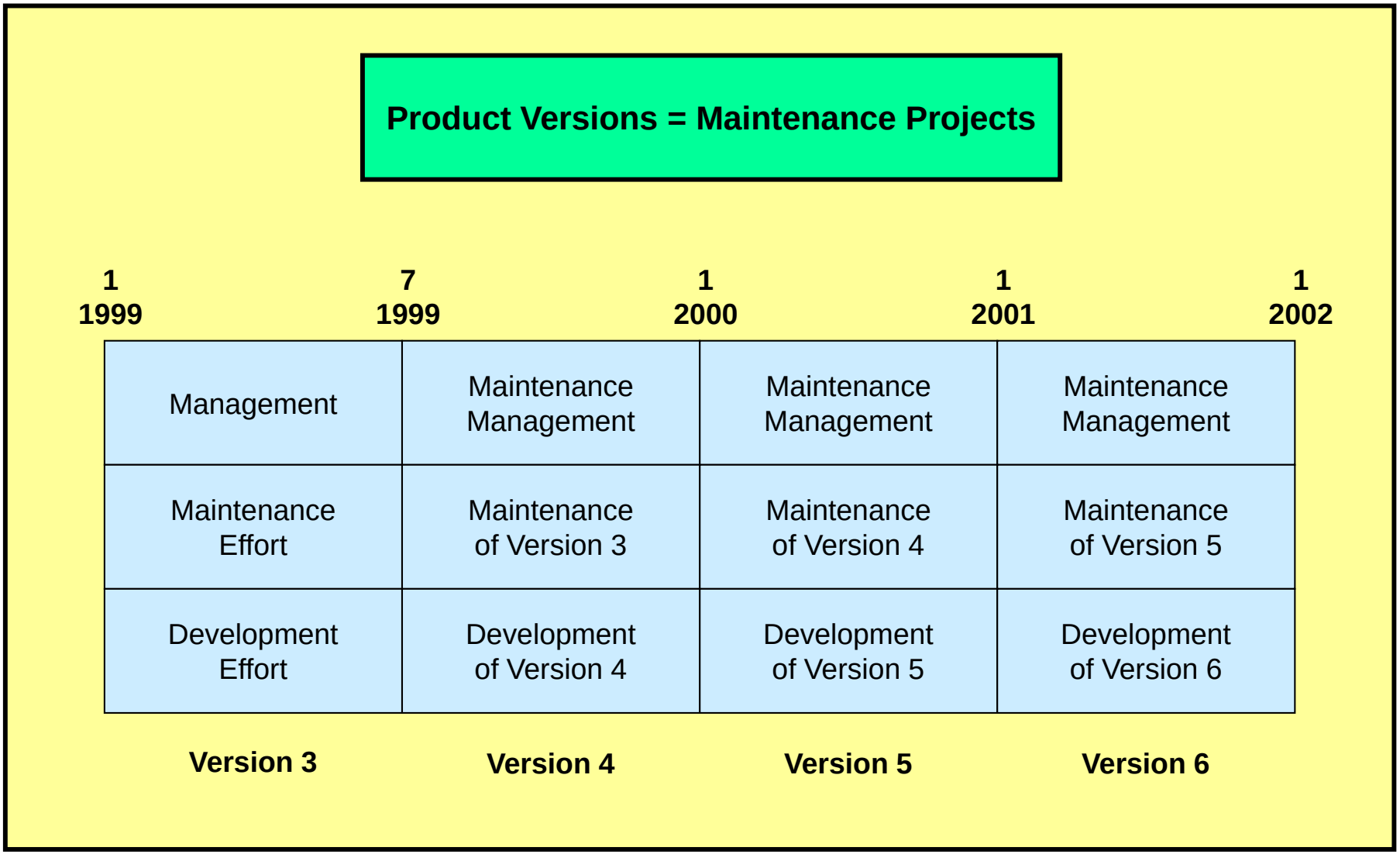
Maintenance Cost Estimation

1. Classifying Maintenance Activities
2. Product Versions = Maintenance Projects
3. Types of Maintenance Costs
4. Calculating Maintenance Project Costs
5. Estimating Correction Costs
6. Calculating the Error Correction Effort
7. Estimating Effort for Error Correction
8. Predicting the Number of Errors
9. Estimating Error Correction Costs
10. Estimating Evolution Costs
11. Measuring System Size
12. Adjusting System Size through Complexity
13. Adjusting System Size through Quality
14. Specification-based Change Estimation
15. Code-based Change Estimation
16. Measuring previous Productivity
17. Impact Analysis of new Requirements
18. Estimating Evolution Costs
19. Costs of Software Maintenance Management
20. Maintenance Management Activities
21. Estimating Management Overhead Costs
22. Calculating Overall Maintenance Costs

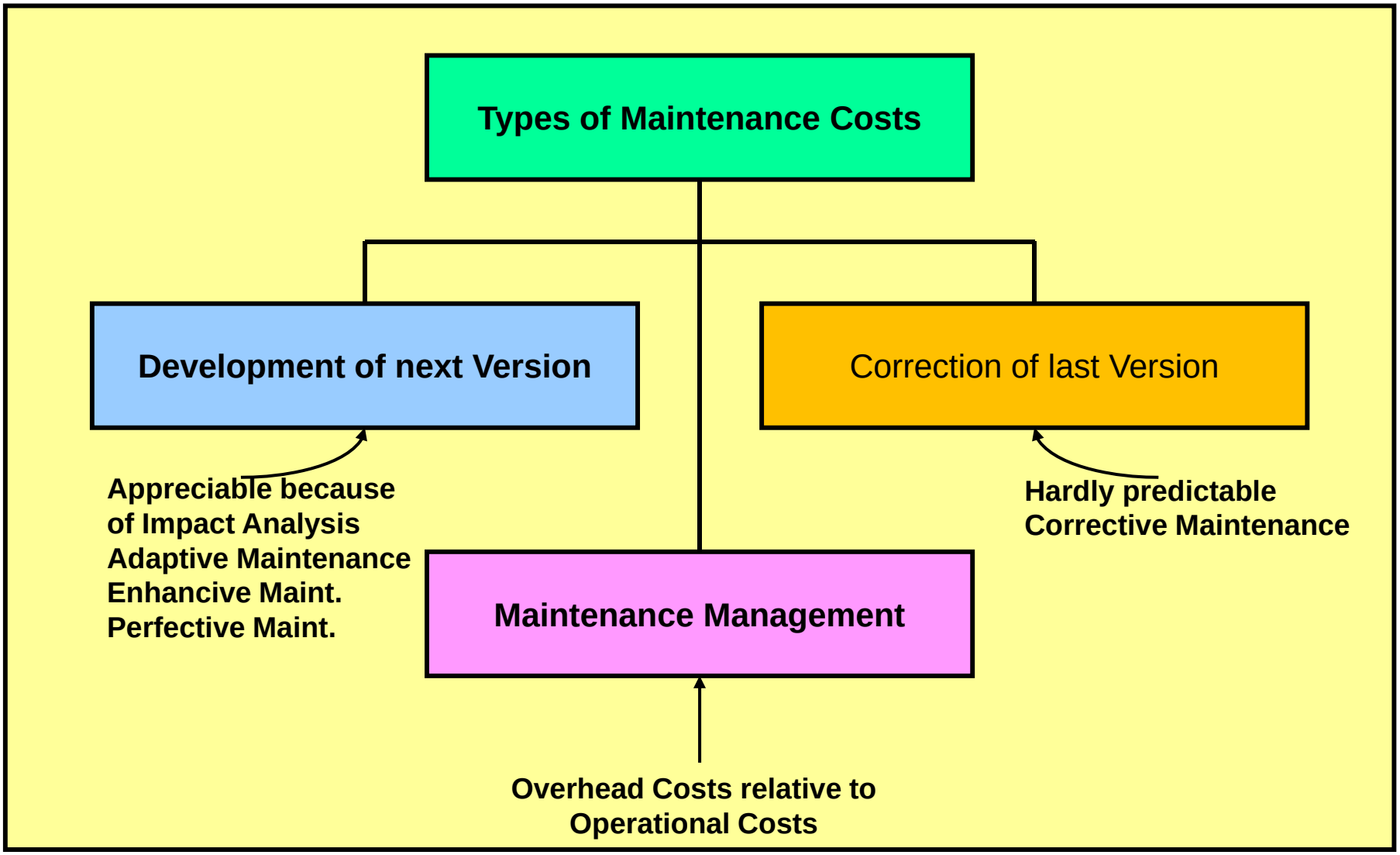
Classifying Maintenance Activities



Product Versions = Maintenance Projects



Types of Maintenance Costs



Calculating Maintenance Project Costs

Calculation of Maintenance Project Costs requires combining several different costs

Maintenance Project Costs = Costs of Development of the new Version
+ Costs of Correction of the last Version
+ Costs of Maintenance Management

Costs of new Version are computed based on the size of the added functions and data

Costs of correction are based on the number of errors to correct

Estimating Correction Costs

Estimation of Correction Costs

1. **Counting of Error Reports so far**
   Version_1 = 16 Error Reports
   Version_2 = 12 Error Reports
2. **Calculating Efforts of Error Correction so far**
   Version_1 = 30 Person Days = 1.4 PD per Error
   Version_2 = 20 Person Days = 1.6 PD per Error
3. **Estimation of Error Reports for the next Version**
   Version_3 = Number of Errors
4. **Estimation of Error Correction Efforts for the next Version**
   Version_3 = ? Person Days = PD per Error x Number of Errors

Calculating Error Correction Effort

Calculating Error Correction Effort

- Effort per Error so far
- Size of last Version in
  - Lines of Code or
  - Statements or
  - Function Points or
  - Data Points or
  - Object Points
- Complexity of last Version in
  - Interface Complexity,
  - Control Flow Complexity,
  - Condition Complexity,
  - Inheritance Complexity,
  - Data Flow Complexity,
  - Language Complexity etc.
- Quality of last Version in
  - Modularity,
  - Flexibility,
  - Testability,
  - Conformity etc.
- Size, Complexity and Quality of current Version

Estimating Effort for Error Correction

Estimation of Effort for Error Correction

Effort per Error so far = 1.6 PD

Differences between the last and the current Version

Version	Size	x	Complexity	adjusted Size	x	Quality	adjusted Size	Difference
Last:	20,000 0.7/0.5		0,7 = 1.4	29,000 0.5/0.6		0.6 0.8	22,400	
Current:	22,000 0.75/0.5		0,75 = 1.5	33,000 0.5/0.55		0,55 0.9	29,700	
Diff:	2,000		0.05	5,000		0.05	7,300	= 1.3

Effort per Error = 1.6 x 1.3 = 2.0 PD per Error Correction

Projecting the Number of Errors

Estimation of Number of Errors

Last Error Number	= 52
Last System Size	= 20,000
Last Error Density	= 52 / 20,000 = 0.0026
Last Test Coverage	= 0,82
Last uncovered Portion	= 20,000 x (1.00 - 0.82) = 3,600
Last uncovered Error Density per uncovered Portion	= 3,600 / 52 = 69 [1 pro 69] (Statements, Function Points, Object Points)
Current System Size	= 22,000
Current Test Coverage	= 0,85
Current uncovered Portion	= 22,000 x (1.00 - 0.85) = 3,300
Estimated Number of Errors	= 3300 / 69 = 48
Estimated Error Density	= 48 / 22,000 = 0.0022

Estimating Error Correction Costs

Estimation of Error Correction Costs

Version	Size	Coverage	Effort per Error	Error	Effort over all
Version_1	17,000	0.75	1,4	56	78.4
Version_2	20,000	0.82	1,6	52	83.2
Version_3	22,000	0.85	2,0	48	96.0

Version_3 = (22,000 x (1 - 0,85) / 69) = 48 x 2 = 96

Correction Effort = 96 Person Days

Estimating Evolution Costs

Estimation of Evolution Costs

1. **Measure Size, Complexity and Quality of the last Version**
   Justified_Size = Bare_Size x Complexity x Quality
2. **Measurement of the Impacts of new Requirements (Enhancements, Adaptations, Perfections)**
   % Change = % Enhancement
   + % Adaptation
   + % Perfection
3. **Measure Productivity so far**
   Productivity = Adjusted Impact Area / Person Days
4. **Estimate Effort for new Version**
   Version_4 = Person Days = Change Portion / Productivity

Measuring the System Size

Measurement of the System Size

Lines of Code	**= Lines over all – Comment Lines – Empty Lines**
Statements	**= Declarations + Procedural Statements**
Data Points	**= Data Entities x 8 (Tables, Structures, Classes)** **+ Data Keys x 4** **+ Data Relations x 2** **+ Data Attributes x 1**
Object Points	**= Classes x 4** **+ Methods x 3** **+ Associations x 2** **+ Variables x 1**
Function Points	**= Inputs x (3:6)** **+ Outputs x (4:7)** **+ Interfaces x (5:10)** **+ Data Entities x (7:15)**

Adjusting System Size through Complexity

Adjusting System Size through Complexity

Complexity = Median of (0,700)
- **Data Complexity (0.720)**
- **Data Flow Complexity (0.760)**
- **Interface Complexity (0.920)**
- **Control Flow Complexity (0.600)**
- **Condition Complexity (0.480)**
- **Branching Complexity (0.640)**
- **Language Complexity (0.780)**

Complexity Factor = Complexity / Median Complexity
(1.4) = (0.7) / (0.5)

Adjusted Size = Raw Size x Complexity Factor
(28.000) (20.000) x (1.4)

Adjusting System Size through Quality

Adjusting System Size through Quality

Quality = Median of
- **Maintainability (0.500)**
- **Testability (0.600)**
- **Reusability (0.420)**
- **Conformity (0.720)**
- **Modularity (0.640)**
- **Flexibility (0.560)**
- **Readability (0.800)**
- **Portability (0.480)**

Quality Factor (0.83) = Median Quality / Quality = (0.5) / (0.6)

Justified Size (22.400) = Bare Size x Quality Factor = (28.000) x (0.8)

Specification based Change Request Cost Estimation

```
+-------------------------------------------------------------------+
|                  Specification based Cost Report                  |
| Product    : GEOS                                                 |
| System     : NOSTRO                                               |
| Project    : Harry                                 Date : 03.11.01|
| Repository : d:\tools\maintain\softanal\cmfanal\output\METRICS     |
+-------------------------------------------------------------------+
|                 Change                     Adjusted Monthly  Person|
| Metric Quantity   Rate  Complexity Quality Quantity Product  Months|
+-------------------------------------------------------------------+
| Stmnts:   1680 X 0.500 X  1.528  X  0.917 =    1176 /  480 =   2.45|
| Dat_Pt:    773 X 0.500 X  1.528  X  0.917 =     541 /  152 =   3.56|
| Obj_Pt:   1116 X 0.500 X  1.528  X  0.917 =     781 /  152 =   5.14|
| Fct_Pt:    161 X 0.500 X  1.528  X  0.917 =     112 /   36 =   3.13|
| Median:      0 X 0.500 X  1.528  X  0.917 =       0 /   00 =   3.57|
+-------------------------------------------------------------------+
```

Code based Change Request Cost Estimation

```
+-------------------------------------------------------------------+
|                          Code based Cost Report                   |
| Product    : GEOS                                                 |
| System     : NOSTRO                                               |
| Project    : CR2                                  Date : 11.09.01 |
| Repository : d:\maintain\softrepo\tables                          |
+-------------------------------------------------------------------+
|                 Change                      Adjusted Monthly  Person  |
| Metric Quantity   Rate  Complexity Quality Quantity Product  Months  |
+-------------------------------------------------------------------+
| Stmnts:    333 X 0.500 X  1.028  X  0.595 =     101 /  500 =   0.20  |
| Dat_Pt:     65 X 0.500 X  1.028  X  0.595 =      19 /  150 =   0.13  |
| Obj_Pt:    425 X 0.500 X  1.028  X  0.595 =     129 /  140 =   0.93  |
| Fct_Pt:    108 X 0.500 X  1.028  X  0.595 =      33 /   32 =   1.03  |
| Median:      0 X 0.500 X  1.028  X  0.595 =       0 /   00 =   0.57  |
+-------------------------------------------------------------------+
```

Measuring previous Productivity

Measurement of previous Productivity

Adjusted Size of Version$_{(i)}$	= 22,400
Impact Domain of Version$_{(i)}$	= 0.15
Change Portion of Version$_{(i)}$	= 3,360
Effort over all of Version$_{(i)}$	= 360 Person Days
Productivity$_{(i)}$	= Change Portion$_{(i)}$ / Effort$_{(i)}$
9.3 Stmts per PT	= (3,360) / (360)
Productivity so far	= Average (Version 1:n)

that means 10 Productivity Units per Person Day

Impact Analysis of new Requirements

Impact Analysis of new Requirements

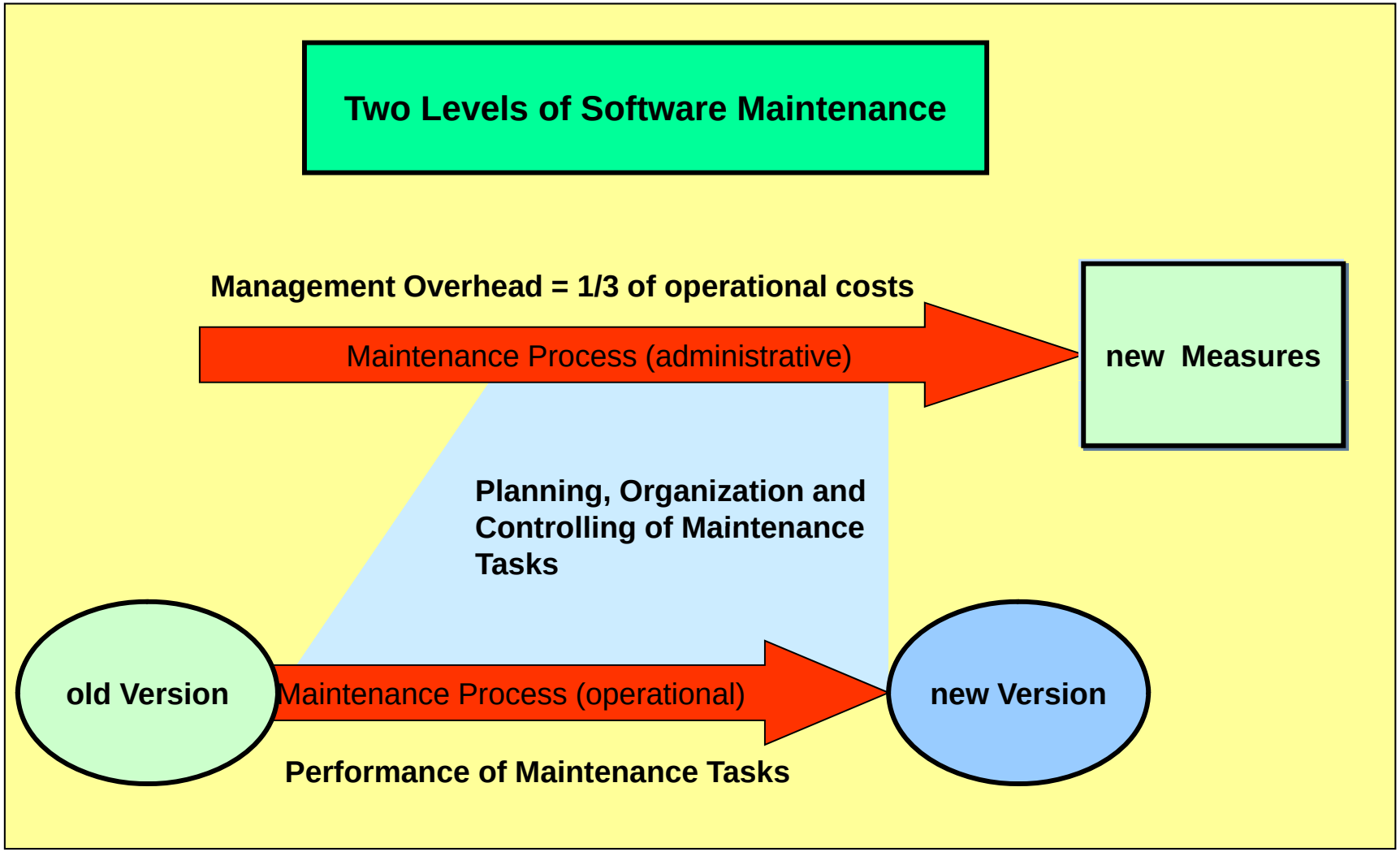
Enhancement Impact (0.060)	**= (Enhancement_1 = 0.030) + (Enhancement _2 = 0.010) + (Enhancement _3 = 0.020)**
Change Impact (0.020)	**= (Change _1 = 0.005) + (Change _2 = 0.005) + (Change _3 = 0.010)**
Perfection Impact (0.020)	**= (Perfection _1 = 0.008) + (Perfection _2 = 0.012)**
Impact over all (0.100)	**= Enhancement Impact(0.06) + Change Impact (0.02) + Perfection Impact (0.02)**

Estimating Evolution Costs of the new Version

Estimation of Evolution Costs of the new Version

Change Proportion	**= 10% von 22,400 = 2,240 Productivity units**
Productivity so far	**= 10 pro Person Days**
New Effort	**= Change Proportion / Productivity so far**
New Effort	**= (2,240 / (10)**
New Effort	**= 224 Person Days**

Costs of Software Maintenance Management



Maintenance Management Activities

Maintenance Process Cycle

Maintenance Management = Order Entry Management

Order Analysis

Order Entry

Definition of Version

Management Process

Administrative Cycle

Planning of Version

Release of Version

Version Assignment

Docu

Analysis

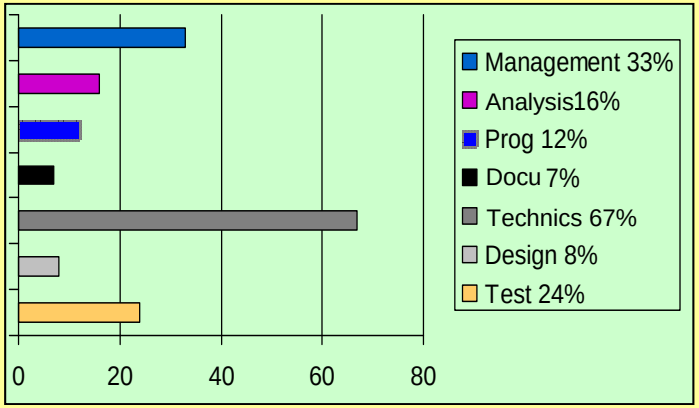
Operational Cycle

Technical Process

Test

Design

Programming



Estimating Management Overhead Costs

Estimation of Management Costs

According to the Experience in the Maintenance Process:

Management = 33% of the Over All Effort

Execution Effort = Correction Effort (96 PD's)
+ Evolution Effort (224 PD's) = 320 PD's

Management Costs = Execution Effort x 0.5
Management Costs = (320) x 0.5 = 160 PD's

Calculating Overall Maintenance Costs

Calculation of
Overall Maintenance & Evolution Costs

Over All Maintenance Effort = Correction Effort
+ Evolution Effort
+ Management Costs

Correction Effort	**= 96 Person Days**
Evolution Effort	**= 224 Person Days**
Management Costs	**= 160 Person Days**
Over All Effort	**= 480 Person Days**

Costs per Person Day = Euro 750

Costs of Maintenance Project = Euro 360 000
(Next Pass through the Life Cycle)