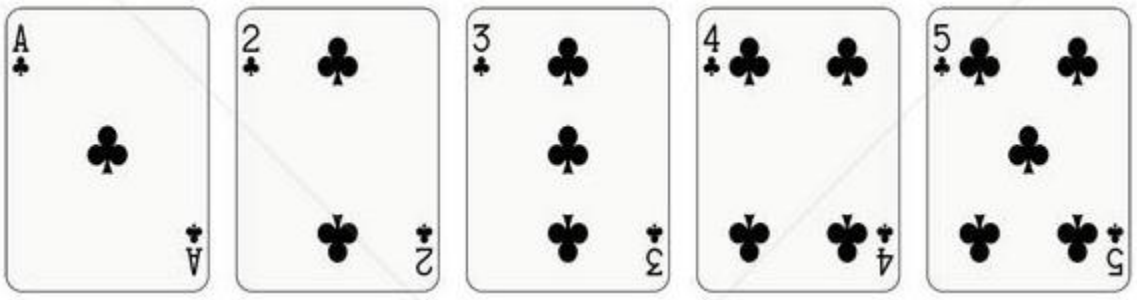
Mid-term Report （11.4）

- Based on assignments 1-4, each group gives a presentation based on the two roles:
  - Homework team.
  - Virtual anti-COVID-19 software team.
- The presentation is 10 minutes following with 3 minutes' Q&A (from teacher or other students).
- Note: The presentation can be recorded before hand, or given in class.

Who will give the presentation?

Team 1 - THUgs

Seq	Student Name
1	Sahand Sabour 山姆
2	Jayee Li 李嘉仪
3	Run Xuan Yang 杨润轩
4	Kembabazi Barbara Gamukama Yihong 懿虹
5	Henry Zheng 郑嘉恒



Randomly selected student!

Project Cost Management

Yong ZHANG

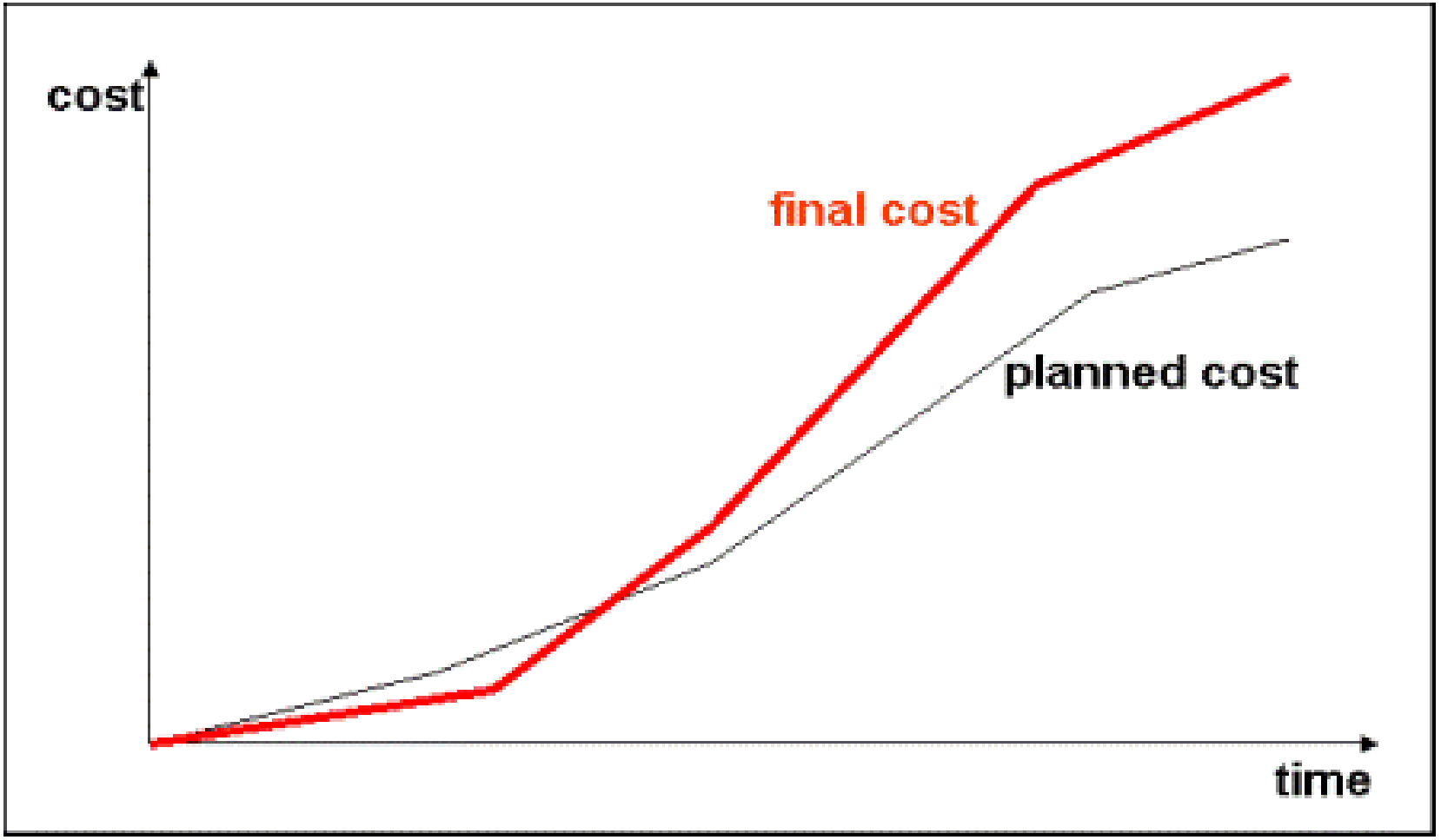
October, 2020

清華大學
Tsinghua University

Contents

- Importance
- Basic Principles
- Plan Cost Management
- Estimate Costs
- Determine Budget
- Control Costs
- Software

Overrun: The additional percentage or dollar amount by which actual costs exceed estimates



Overrun

- CHAOS: 180% 1994 → 43% 2010
- Harvard Business Review(2011) 27%
  - One in six of all projects studied contained a “black swan”. These IT black swan projects had an average cost overrun of 200 percent and a schedule overrun of almost 70 percent.
- Two bad examples:
  - Internal Revenue Service (IRS) of US(50B in 1990s),
  - National Health Service (NHS) of UK (26B, 2002)

What is cost?


中国人民银行
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GB64596422
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100
BANCO CENTRAL DE LA REPUBLICA ARGENTINA
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CIEN PESOS
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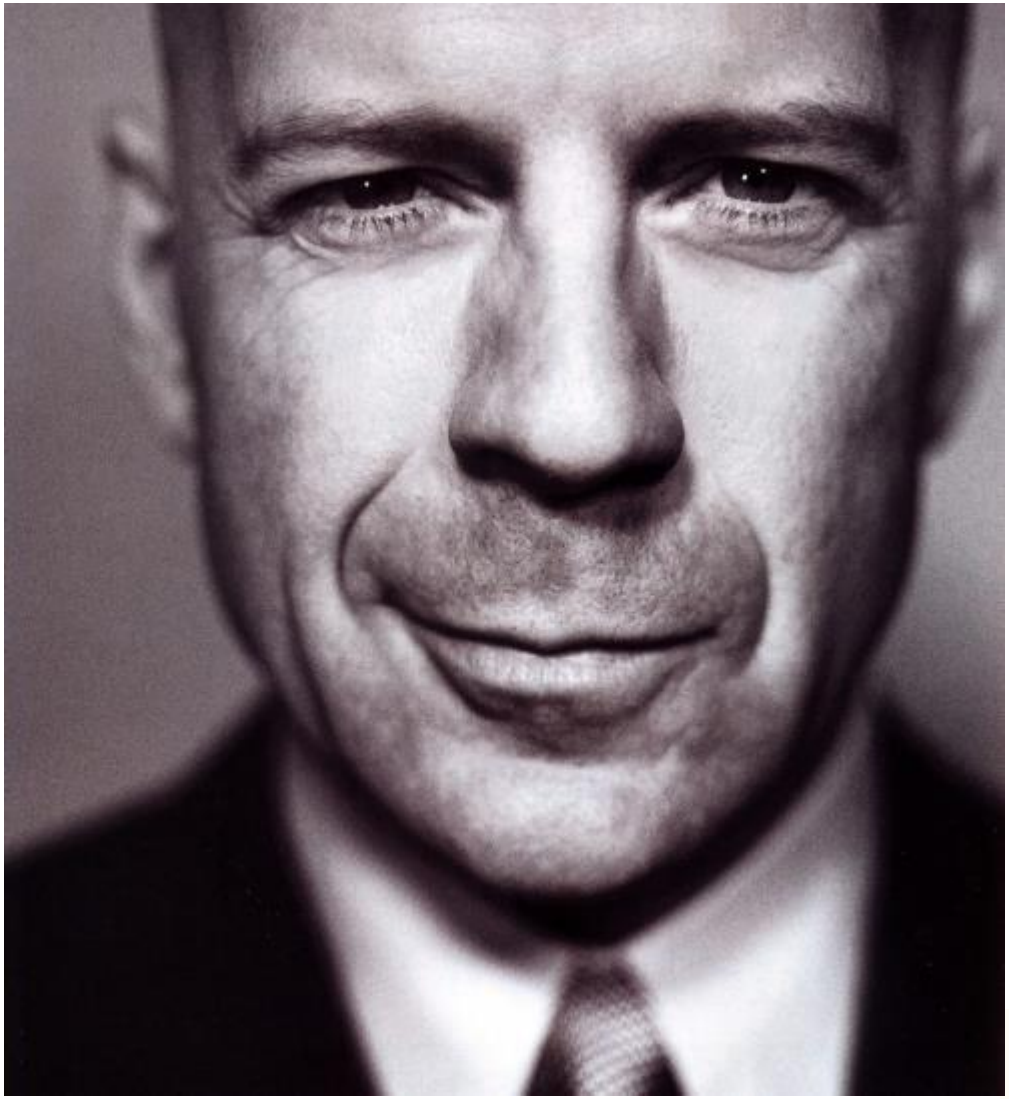
Cost

- Accountants usually define cost as a resource sacrificed or foregone to achieve a specific objective
- Webster's dictionary: "something given up in exchange"

Budget

- The cost estimate of the project and individual work items over time

How do IT professionals react to overrun?



Reasons for Overrun

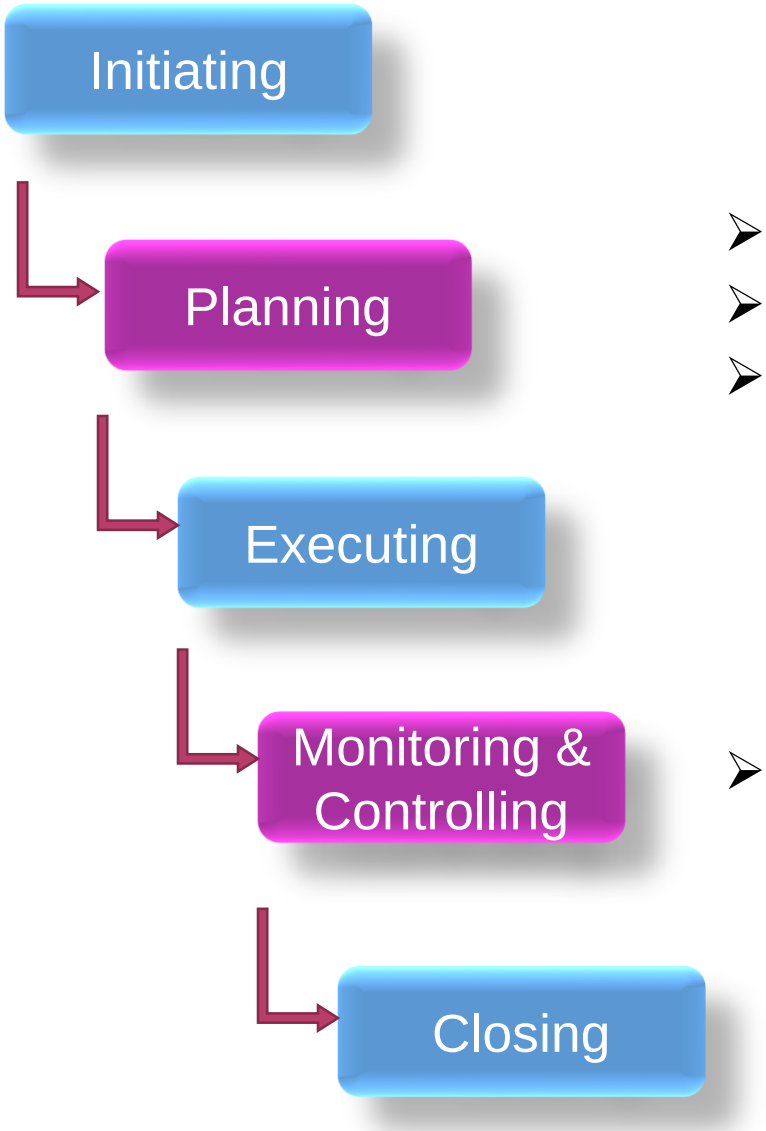
- Unclear project requirements
- Preparing cost estimate is a job for accountants
- New technology or business process

Costs grow and failures are to be expected, right?

Project Cost Management

- Includes the processes involved in planning, estimating, budgeting, financing, funding, managing, and controlling costs so that the project can be completed within the **approved** budget.

- It is the project manager's job to satisfy project stakeholders while continuously striving to reduce and control costs



- Plan cost management
- Estimate costs
- Determine budget

- Control costs

Contents

- Importance
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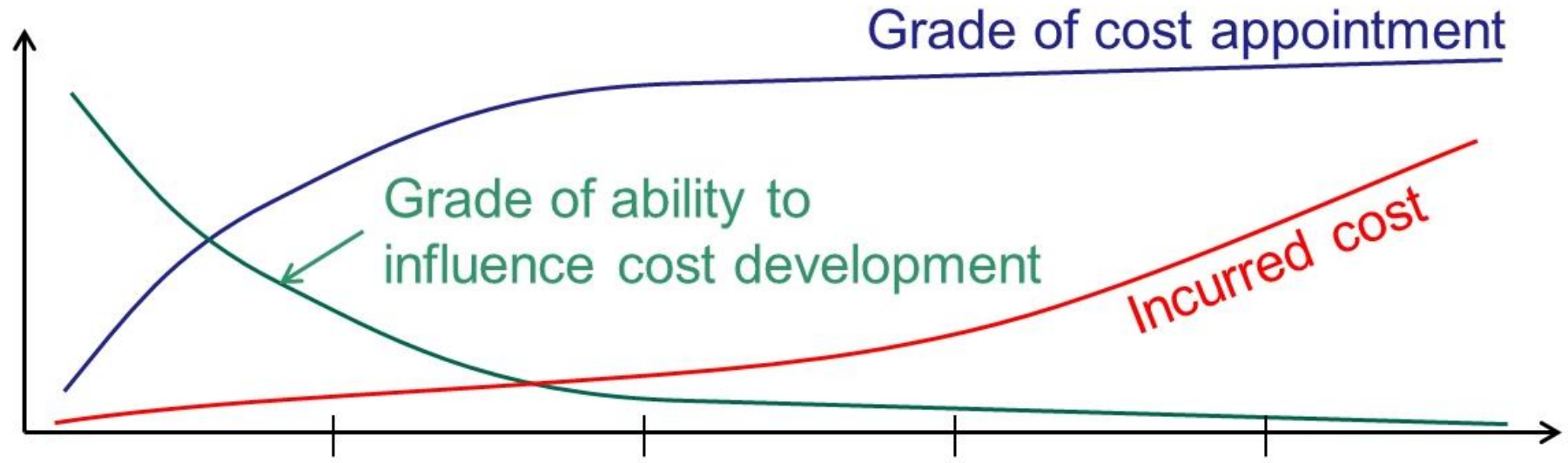
Concepts

1. **Profit**s are revenues minus expenditures
2. **Profit margin** is the ratio of profits to revenues
3. **Life cycle costing** considers the total cost of ownership, or development plus support costs



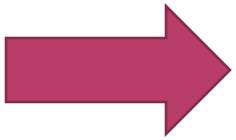
Concepts

1. **Profit**s are revenues minus expenditures
2. **Profit margin** is the ratio of profits to revenues
3. **Life cycle costing** considers the total cost of ownership, or development plus support costs
4. **Downtime costs** include the cost to bring the system back up, staff cost to make up for the lost work in production during the system downtime, and direct and indirect lost revenue

Decision Dependency

Project cost management should consider the effect of project decisions on the subsequent recurring cost of using, maintaining, and supporting the product, service, or result of the project.

Limit the number of decision reviews



Increase the resulting product's operating costs

Costs of Downtime for IT applications

Type of IT Applications	Cost/Minute
Securities trading	$73,000
Enterprise Requirements Planning (ERP)	$14,800
Order processing	$13,300
Electronic Commerce	$12,600
Supply Chain	$11,500
Point of sale (POS)	$4,700
Automatic teller machine (ATM)	$3,600
E-mail	$1,900

The Standish Group International, "Trends in IT Value, " (www.standishgroup.com) (2008)

- When Facebook was down for 20 minutes on September 3, 2014, they lost a little more than $22,453 for every minute or more than $500,000.
- On August 19, 2013, Amazon.com went down for about 30 minutes, costing them $66,240 per minute or nearly $2 million.
- For Fortune 1000 companies, the average cost of an infrastructure failure is $100,000 per hour; the average cost of a critical application failure is $500,000 to $1 million per hour, or $8,300 to $16,600 per minute.10
- In 2014, the average annual cost of unplanned application downtime in Fortune 1000 companies was $1.25 billion to $2.5 billion

Concepts

5. **Cash flow analysis** is a method for determining the estimated annual costs and benefits for a project and the resulting annual cash flow
6. **Tangible costs** or **benefits** are those costs or benefits that an organization can easily measure in dollars
7. **Intangible costs** or **benefits** are costs or benefits that are difficult to measure in monetary terms, such as goodwill and prestige.

Concepts

8. **Direct costs** are costs that can be directly related to producing the products and services of the project
9. **Indirect costs** are costs that are not directly related to the products or services of the project
10. **Sunk cost** is money that has been spent in the past. Sunk cost should be forgotten, even though it is often difficult to think that way.

Learning curve theory

- When many items are produced repetitively, the unit cost of those items decreases in a regular pattern as more units are produced.
- Help estimate costs on projects that involve the production of large quantities of items.
- Apply to the mount of time required to complete some tasks

Learning curve theory

- Wl nit
  cos s
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  pro
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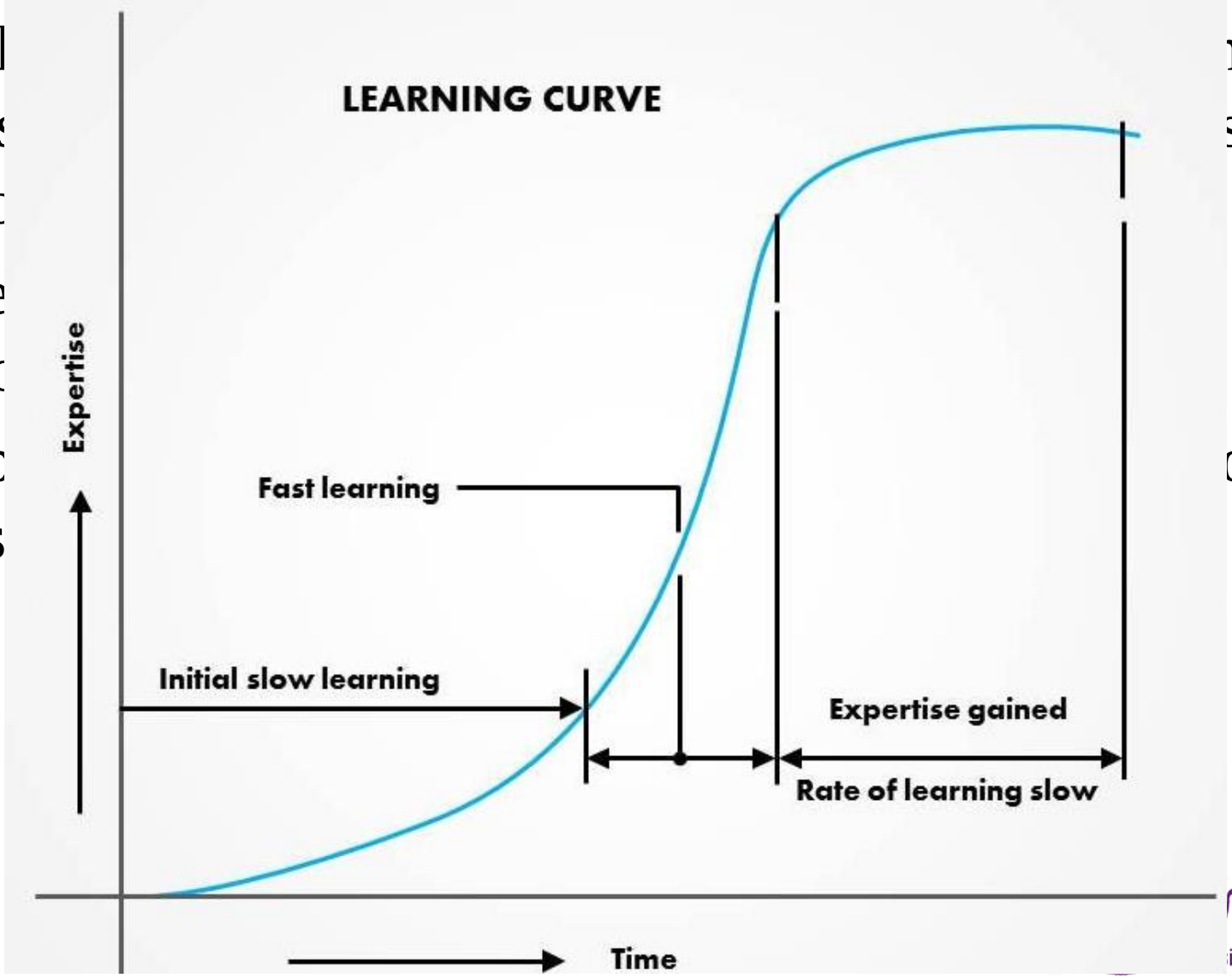
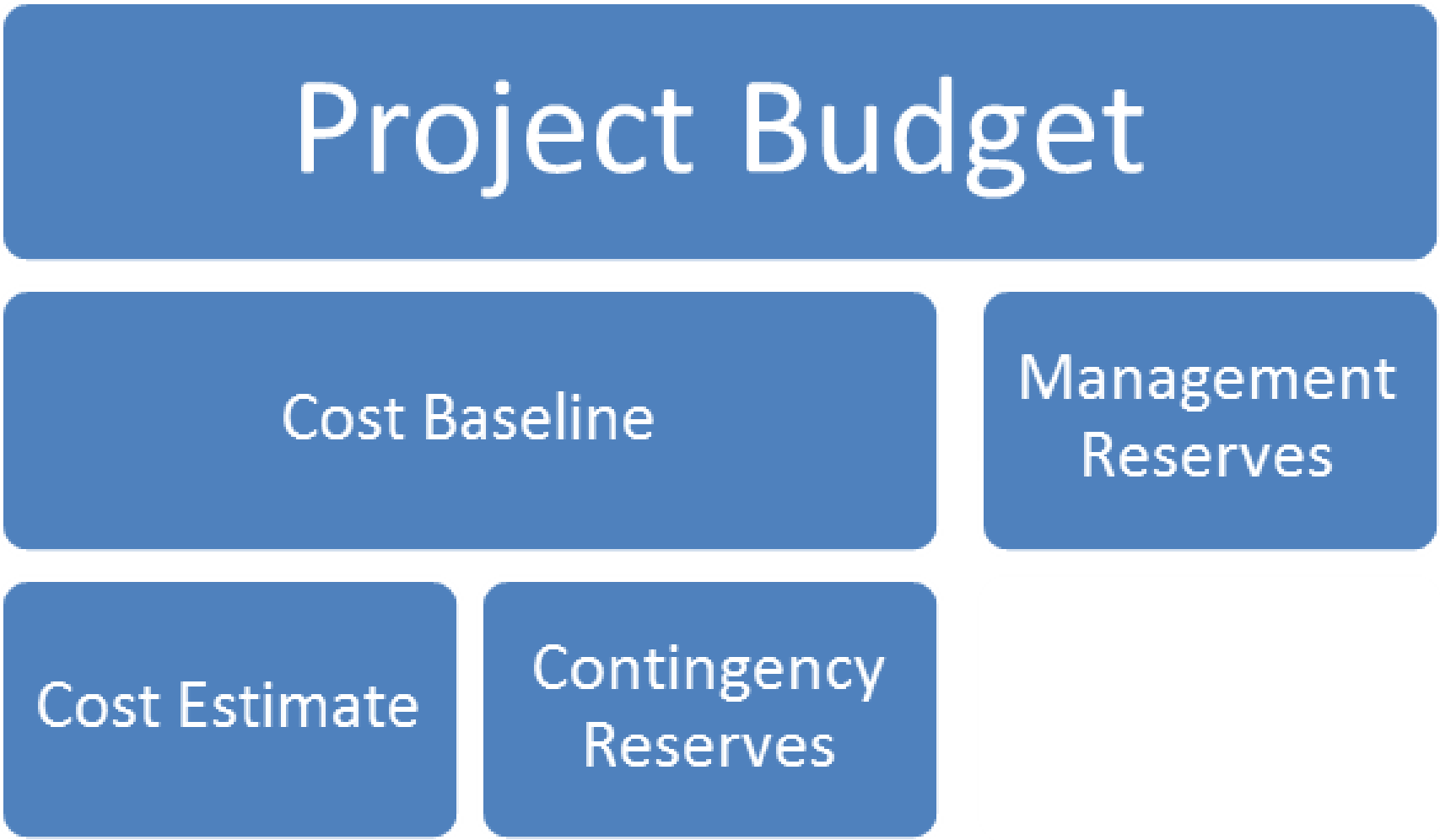


Reserves

- Dollars included in a cost estimate to mitigate cost risk by allowing for future situations that are difficult to predict
- **Contingency reserves** allow for future situations that may be partially planned for and are included in the project cost baseline. (**Known unknowns**) For example, 20% turnover of IT personnel
- **Management reserves** allow for future situations that are unpredictable. (**Unknown unknowns**) For example, PM gets sick for two weeks.



Agile/Adaptive Environments

- Project with high degrees of uncertainty or those where the scope is not yet fully defined may not benefit from detailed cost calculations due to frequent changes. How?

- In cases where high-variability projects are also subject to strict budgets, what should the PM do?

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Plan Cost Management

The process of defining how the project costs will be estimated, budgeted, managed, monitored and controlled.

Inputs	Tools & Techniques	Outputs
1. Project charter 2. Project management plan 3. Enterprise environmental factors 4. Organizational process assets	1. Expert judgment 2. Data analysis 3. Meetings	1. Cost management plan

Key benefit: it provides guidance and direction on how the project costs will be managed throughout the project

A Cost Management Plan

- Units of measure – labor hours/days
- Level of precision – round up or down
- Level of accuracy – acceptable range (e.g. +/-10%)
- Organizational procedures links – **control account** (WBS component)
- Controls thresholds – a specified amount of variation
- Rules of performance measurement – how often actual costs will be tracked and to what level of detail
- Reporting formats – format and frequency
- Additional details

Contents

- Importance
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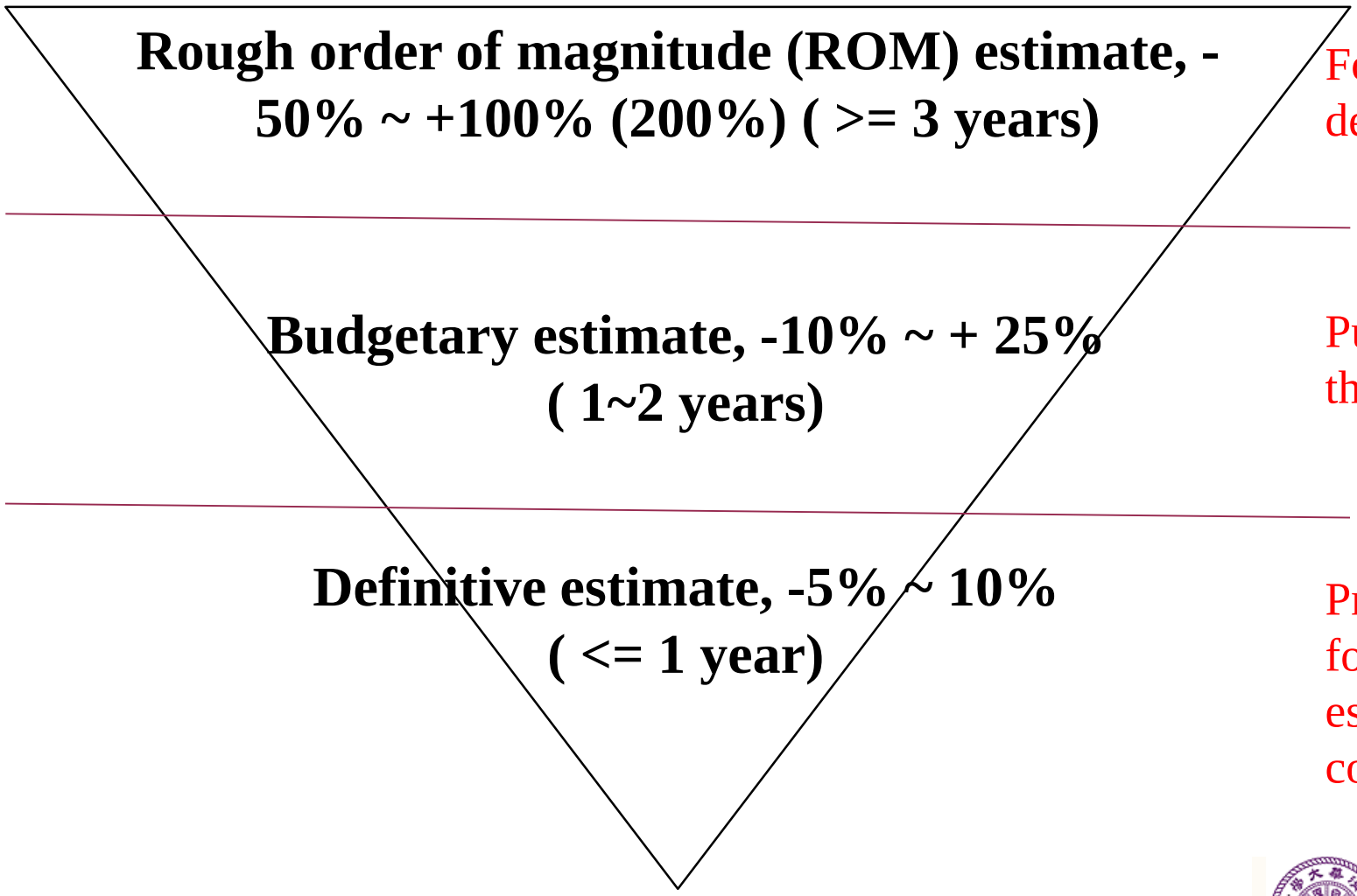
Estimate Costs

The process of developing an approximation of the cost of resources needed to complete project activities.

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Project documents 3. Enterprise environmental factors 4. Organizational process assets	1. Expert judgment 2. Analogous estimating 3. Parametric estimating 4. Bottom-up estimating 5. Three-point estimating 6. Data analysis 7. Project management information system 8. Decision making	1. Cost estimates 2. Basis of estimates 3. Project documents update

Key benefit: it determines the monetary resources required for the project

Types of Cost Estimates



For selection decisions

Puts dollars in the budget plans

Provides details for purchases, estimates actual costs

Cost Trade-offs

- Make versus buy
- Buy versus lease
- Sharing of resources

Full-time Equivalent (FTE) Staff

TABLE 7-3 Maximum FTE by department by year

Department	Year 1	Year 2	Year 3	Year 4	Year 5	Totals
Information systems	24	31	35	13	13	116
Marketing systems	3	3	3	3	3	15
Reservations	12	29	33	9	7	90
Contractors	2	3	1	0	0	6
Totals	41	66	72	25	23	227

Cost Estimation Tools and Techniques

- **Expert Judgment**
- **Analogue** estimates or top-down estimates. Use the actual cost of a previous, similar project as the basis for estimating the cost of the current project.
  - Easily result in too low an estimate
- **Bottom-up** estimates involve estimating the costs of individual work items or activities and summing them to get a project total
  - Usually time-intensive and therefore expensive to develop
- **Three-point** estimates involve estimating the most likely, optimistic, and pessimistic costs for items

Parametric estimating

- Parametric estimating uses project characteristics (parameters) in a mathematical model to estimate project costs
- Most reliable when the historical is accurate
- COCOMO II model

Cost of a Software Project

The cost in a project is due to:

- the requirements for **software**, **hardware** and **human resources**
- the cost of *software development* is due to the human resources needed
- most cost estimates are measured in ***person-months (PM)***

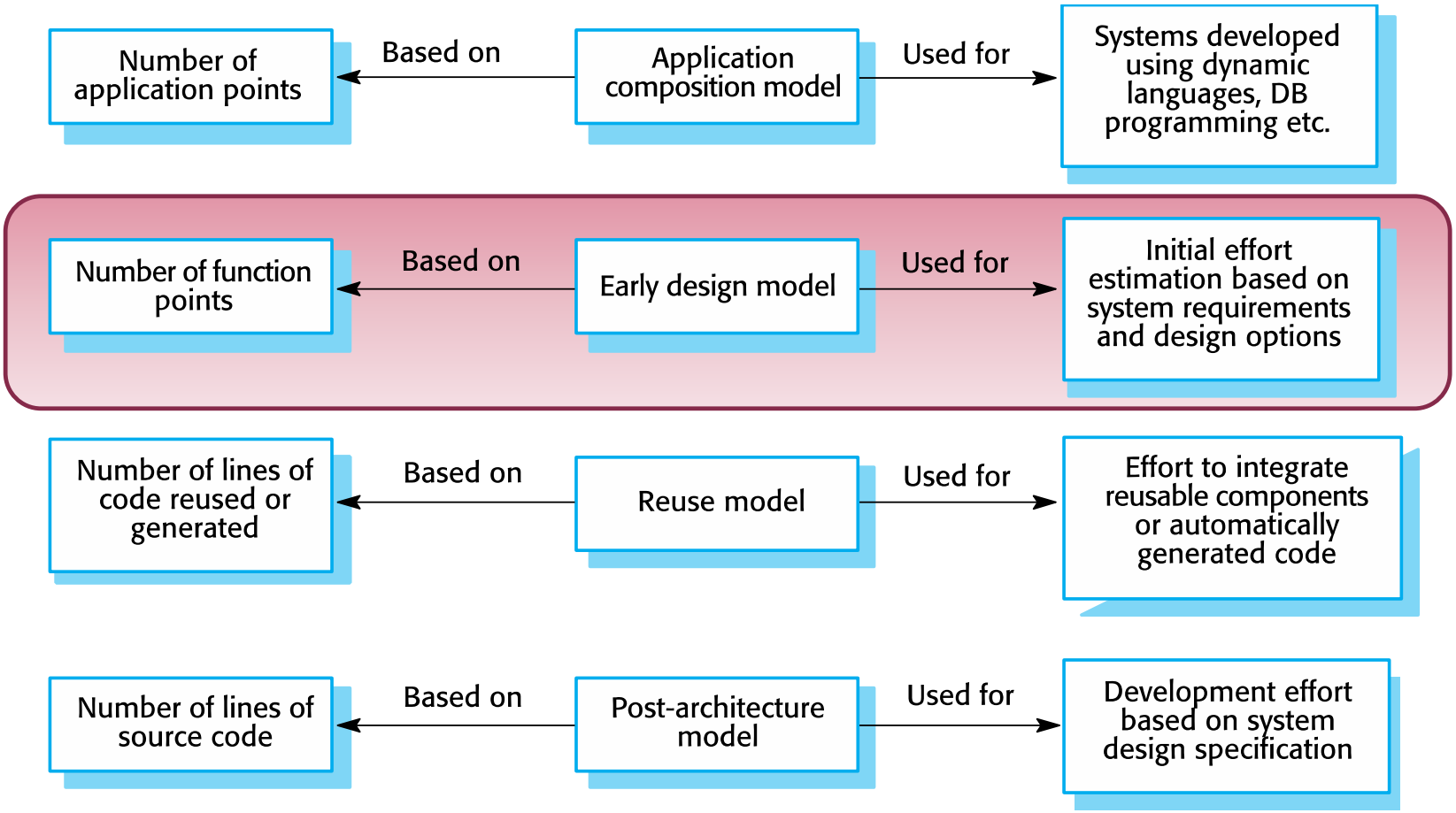
COCOMO Model

- COCOMO: Constructive Costing Model
  - based on a study of hundreds of software projects
  - an open model
  - all of the details are published
- 1981 The original COCOMO by Dr. Barry Boehm "COCOMO 81“
- 1995, 1996, Early papers describing COCOMO II
- Finally published in 2000 in the book "**Software Cost Estimation with COCOMO II**" by Dr. Barry Boehm

COCOMO II Models

- COCOMO II incorporates a range of sub-models that produce increasingly detailed software estimates.
- The sub-models in COCOMO II are:
  - Application composition model. Used when software is composed from existing parts.
  - Early design model. Used when requirements are available but design has not yet started.
  - Reuse model. Used to compute the effort of integrating reusable components.
  - Post-architecture model. Used once the system architecture has been designed and more information about the system is available.

COCOMO Estimation Models



Exponents and Equations

- SLOC :Source Lines of Code
- Definition:
  A. only source lines
  B. source lines created by the project staff
  C. one sloc is one *logical* line of code
  D. *declarations* are counted as sloc
  E. *comments* are not counted as sloc

FP Utility

- **Where is FP used?**
  - ***For Comparing software in a "normalized fashion" independent of op. system, languages, db, etc.***
  - ***For Benchmarking and "Projection" based on "size":***
    - *size -> effort or cost*
    - *size -> development schedule*
    - *size -> defect rate*
  - ***For Outsourcing Negotiation***

Function Points

- **<u>STEP 1</u>:** Measure size in terms of the amount of functionality in a system. Function points are computed by first calculating an ***unadjusted function point count*** **(UFC).** Counts are made for the 5 categories.

Function Points(.)

Category	Description
External inputs	Those items provided by the user that describe distinct application-oriented data (such as file names and menu selections)
External outputs	Those items provided to the user that generate distinct application-oriented data (such as reports and messages, rather than the individual components of these)
External inquiries	Interactive inputs requiring a response
External files	Machine-readable interfaces to other systems
Internal files	Logical master files in the system

Function Points(..)

- **STEP 2:** Multiply each number by a weight factor, according to complexity (**simple**, **average** or **complex**) of the parameter, associated with that number. The value is given by a table:

Parameter	simple	average	complex
users inputs	3	4	6
users outputs	4	5	7
users requests	3	4	6
files	7	10	15
external interfaces	5	7	10

Function Points(...)

- **STEP 3:** Calculate the total **UFP** (Unadjusted Function Points)

- **STEP 4:** Calculate the total **TCF** (Technical Complexity Factor) by giving a value between 0 and 5 according to the importance of the following points:

Function Points(....)

Technical Complexity Factors:

1. Data Communication
2. Distributed Data Processing
3. Performance Criteria
4. Heavily Utilized Hardware
5. High Transaction Rates
6. Online Data Entry
7. Online Updating
8. End-user Efficiency
9. Complex Computations
10. Reusability
11. Ease of Installation
12. Ease of Operation
13. Portability
14. Maintainability

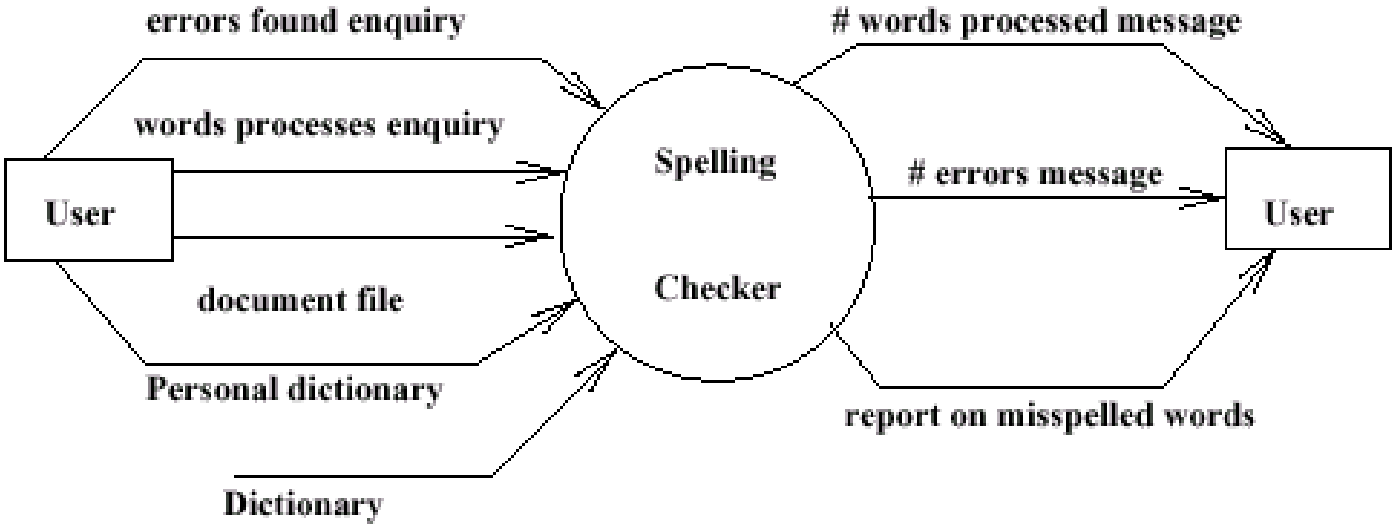
Function Points(.....)

- **STEP 5:** Sum the resulting numbers to obtain **DI** (degree of influence)
- **STEP 6: TCF** (Technical Complexity Factor) by given by the formula
  - ***TCF=0.65+0.01*DI***
- **STEP 7:** Function Points are by given by the formula
  - ***FP=UFP*TCF***

Example

Example

The Spell-Checker accepts as input a document file and an optional personal dictionary file. The checker lists all words not contained in either of these files. The user can query the number of words processed and the number of spelling errors found at any stage during processing.



Example (.)

- 2 users inputs: document file name, personal dictionary name (average)
- 3 users outputs: fault report, word count, misspelled error count (average)
- 2 users requests: #treated words?, #found errors? (average)
- 1 internal file: dictionary (average)
- 2 external files: document file, personal dictionary (av).

$$UFP = 4 \times 2 + 5 \times 3 + 4 \times 2 + 10 \times 1 + 7 \times 2 = 55$$

Example (..)

- **Technical Complexity Factors:**
  - **1. Data Communication 3**
  - **2. Distributed Data Processing 0**
  - **3. Performance Criteria 4**
  - **4. Heavily Utilized Hardware 0**
  - **5. High Transaction Rates 3**
  - **6. Online Data Entry 3**
  - **7. Online Updating 3**
  - **8. End-user Efficiency 3**
  - **9. Complex Computations 0**
  - **10. Reusability 3**
  - **11. Ease of Installation 3**
  - **12. Ease of Operation 5**
  - **13. Portability 3**
  - **14. Maintainability 3**
    - **DI =30 (Degree of Influence)**

Example (…)

- Function Points
  - **FP**=UFP*(0.65+0.01*DI)= 55*(0.65+0.01*30)=**52.25**

Relation between LOC and FP

- ***LOC = Language Factor * FP***

- Where
  - **LOC** (Lines of Code)
  - **FP** (Function Points)

Language	LOC/FP
assembly	320
C	128
Cobol	105
Fortan	105
Pascal	90
Ada	70
OO languages	30
4GL languages	20
Java	**46**

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What We Measure

- **Effort** (E): usually measured in **Person-Month** (PM) or **Person-Year** (PY) (Month and Year are working quantities, not calendar)
- **LOC:** lines of code; **KLOC:** kilo lines of code
- **Productivity** (L) **L = LOC/E**: lines of codes corresponding to a deployed effort
- **Personal productivity (L_p)**: lines of codes produced by a person per month (year)
- **H-resources** (P) **P=E/T**: average number of persons delivering the effort E in a time T (if E is in PM or PY)
- **Costhour/month**: usually each category of personnel has a recognised cost per hour/per month
- **Cost=Costhour*hoursmonth*(#months*P)** usually measured in Currency (Euro, Dollar etc.) = **Costhour*hoursmonth*E** (**E** in PM)

Modes in Development

COCOMO

Level of model

	Organic	Semi-detached	Embedded
Basic			
Inter-mediate			
Detailed			

E,T in term of KLOC to be delivered

What is a small software?

50K

Organic Mode: Characteristics

- Small size – up to 50,000 lines of code
- Small, in-house development team
- Experienced in application area
- Non-stringent specifications of function, performance, acceptance tests, interfaces
- Minimal communication overhead
- Stable development environment
- Minimal schedule pressure
- Existing, proven technology

Semi-detached Mode

- Large size – up to 300,000 lines
- Mix of experienced and non-experienced team members in application domain and development environment
- Mix of stringent and non-stringent specifications of function, performance, acceptance tests, interfaces
- Moderate schedule pressure

Embedded Mode

- Any size
- Poor experience with the same type of software
- Stringent specifications of function, performance, acceptance tests, interfaces
- Rigid, formal quality standards
- Close development among hardware, software, and operational procedures
- Leading technology employed
- Strong schedule pressure

Organic Mode: Examples

- Standard engineering, scientific and business modeling systems

$$E = 2.4 \times KLOC^{1.05}$$

$$T = 2.5 \times E^{0.38}$$

Semi-detached Mode

- Standard transaction processing systems
- New usual DBMS
- Innovative command & control systems for inventory and production

$$E = 3.0 \times KLOC^{1.12}$$

$$T = 2.5 \times E^{0.35}$$

Embedded Mode

- Avionic software systems
- Large and complex transaction processing systems
- Real-time systems
- New operating systems

$$E = 3.6 \times KLOC^{1.20}$$

$$T = 2.5 \times E^{0.32}$$

Typical Problems

- Estimates are done too quickly
- Lack of estimating experience
- Human being biased toward underestimation
- Management desires accuracy

Surveyor Pro Project Cost Estimate Created October 5

	# Units/Hrs.	Cost/Unit/Hr.	Subtotals	WBS Level 2 Totals	% of Total
WBS Items					
1. Project Management				**$306,300**	**20%**
Project manager	960	$100	$96,000		
Project team members	1920	$75	$144,000		
Contractors (10% of software development and testing)			$66,300		
2. Hardware				**$76,000**	**5%**
2.1 Handheld devices	100	$600	$60,000		
2.2 Servers	4	$4,000	$16,000		
3. Software				**$614,000**	**40%**
3.1 Licensed software	100	$200	$20,000		
3.2 Software development*			$594,000		
4. Testing (10% of total hardware and software costs)			$69,000	**$69,000**	**5%**
5. Training and Support				**$202,400**	**13%**
Trainee cost	100	$500	$50,000		
Travel cost	12	$700	$8,400		
Project team members	1920	$75	$144,000		
6. Reserves (20% of total estimate)			$253,540	**$253,540**	**17%**
Total project cost estimate				**$1,521,240**	

Surveyor Pro Software Development Estimate Created October 5

1. Labor Estimate	# Units/Hrs.	Cost/Unit/Hr.	Subtotals	Calculations
Contractor labor estimate	3000	$150	$450,000	3000 * 150
Project team member estimate	1920	$75	$144,000	1920 * 75
Total labor estimate			**$594,000**	Sum above two values

2. Function point estimate**	Quantity	Conversion Factor	Function Points	Calculations
External inputs	10	4	40	10 * 4
External interface files	3	7	21	3 * 7
External outputs	4	5	20	4 * 5
External queries	6	4	24	6 * 4
Logical internal tables	7	10	70	7 * 10
Total function points			**175**	Sum above function point values
Java 2 languange equivalency value			46	Assumed value from reference
Source lines of code (SLOC) estimate			8,050	175 * 46
Productivity×KSLOC^Penalty (in months)			29.28	3.13 * 8.05^1.072 (see reference)
Total labor hours (160 hours/month)			4,684.65	29.28 * 160
Cost/labor hour ($120/hour)			$120	Assumed value from budget expert
Total function point estimate			**$562,158**	4684.65 * 120

**Approach based on paper by William Roetzheim, "Estimating Software Costs," Cost Xpert Group, Inc. (2003) using the COCOMO II default linear productivity factor (3.13) and penalty factor (1.072).

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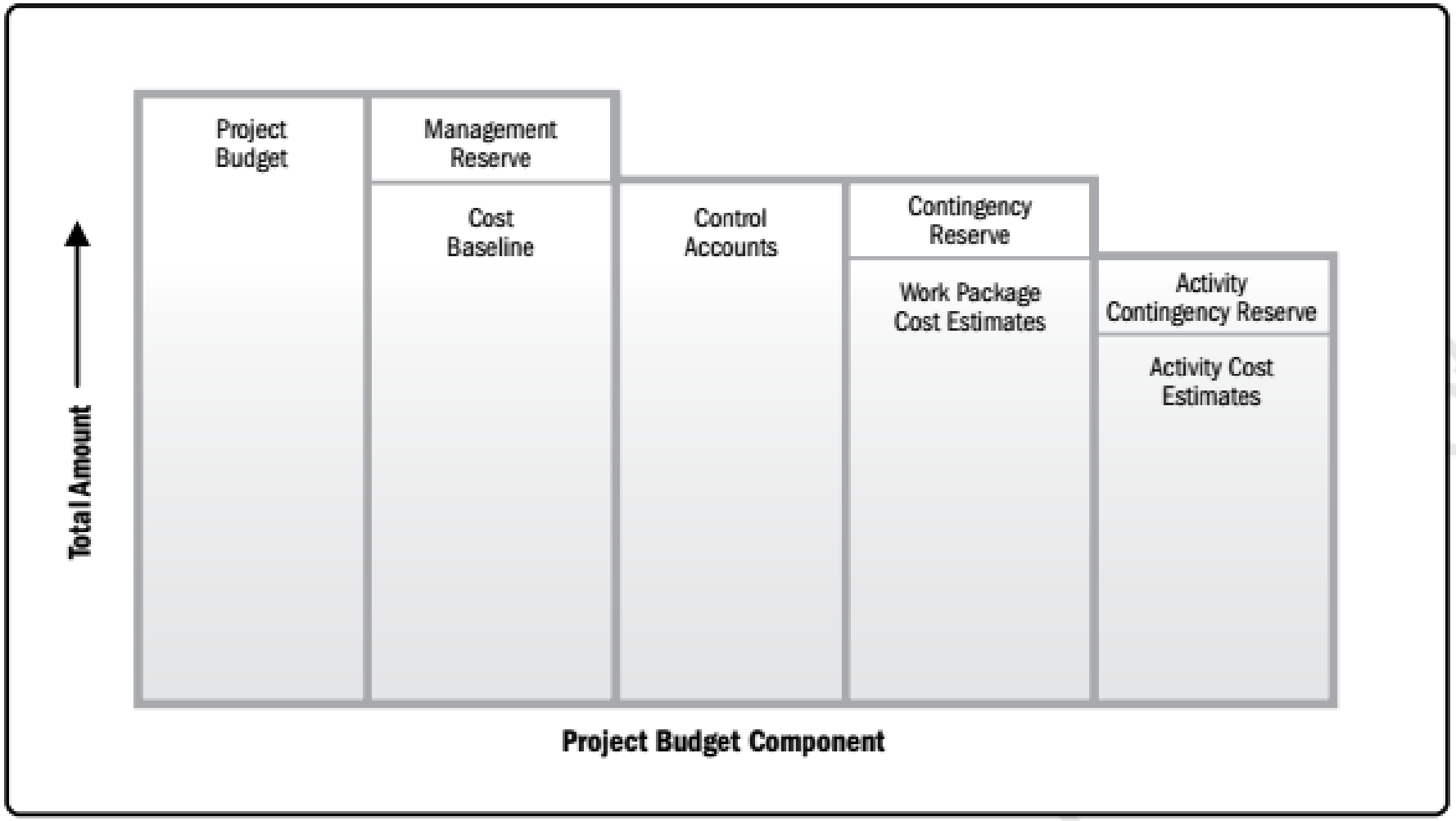
Determine Budget

The process of aggregating the estimated costs of individual activities or work packages to establish an authorized cost baseline.

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Project documents 3. Business documents 4. Agreements 5. Enterprise environmental factors 6. Organizational process assets	1. Expert judgment 2. Cost aggregation 3. Data analysis 4. Historical information review 5. Funding limit reconciliation 6. Financing	1. Cost baseline 2. Project funding requirements 3. Project documents update

Key benefit: It determines the cost baseline against which project performance can be monitored and controlled

Project Budget Components



Project Cost Baseline

A time-phased budget that project managers use to measure and monitor cost performance

Surveyor Pro Project Cost Baseline Created October 10*

	Months												
WBS Items	1	2	3	4	5	6	7	8	9	10	11	12	Totals
1. Project Management													
1.1 Project manager	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	8,000	96,000
1.2 Project team members	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	12,000	144,000
1.3 Contractors		6,027	6,027	6,027	6,027	6,027	6,027	6,027	6,027	6,027	6,027	6,027	66,300
2. Hardware													
2.1 Handheld devices				30,000	30,000								60,000
2.2 Servers				8,000	8,000								16,000
3. Software													
3.1 Licensed software				10,000	10,000								20,000
3.2 Software development		60,000	60,000	80,000	127,000	127,000	90,000	50,000					594,000
4. Testing			6,000	8,000	12,000	15,000	15,000	13,000					69,000
5. Training and Support													
5.1 Trainee cost									50,000				50,000
5.2 Travel cost									8,400				8,400
5.3 Project team members							24,000	24,000	24,000	24,000	24,000	24,000	144,000
6. Reserves				10,000	10,000	30,000	30,000	60,000	40,000	40,000	30,000	3,540	253,540
Totals	20,000	86,027	92,027	172,027	223,027	198,027	185,027	173,027	148,427	90,027	80,027	53,567	1,521,240

Do we need to prepare all the funds at the beginning?

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- Software

Controlling costs

The process of monitoring the status of the project to update the project costs and managing changes to the cost baseline.

Inputs	Tools & Techniques	Outputs
1. Project management plan 2. Project documents 3. Project funding requirements 4. Work performance data 5. Organizational process assets	1. Expert judgment 2. Data analysis 3. To-complete performance index 4. Project management information system	1. Work performance information 2. Cost forecasts 3. Change requests 4. Project management plan updates 5. Project documents updates

Key benefit: The cost baseline is maintained throughout the project

Tools

- Cost change control system – control change
- Performance review meetings – control team
- Performance measurement

Earned Value Management

A methodology that combines scope, schedule, and resource measurements to assess project performance and progress.

Given a cost performance baseline, project managers and their teams can determine how well the project is meeting scope, time and cost goals by entering actual information and then comparing it to the baseline.

Values in EAV

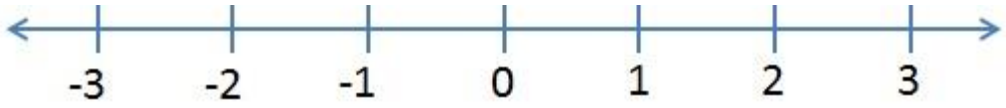
- Planned value (PV): portion of the approved total cost estimate planned to be spent on an activity during a given period
- Actual cost (AC) is the total direct and indirect costs incurred in a accomplishing work on an activity during a given period
- Earned value (EV) is an estimate of the value of the physical work actually completed
  - Rate of Performance(RP) is the ratio of actual work completed to the percentage of work planned to have been completed at any given time.

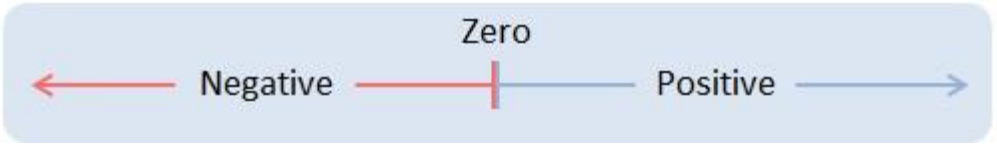
Earned Value Formulas

Term	Formula
Earned value (EV)	EV = PV to date * RP
Cost variance (CV)	CV = EV – AC
Schedule variance (SV)	SV = EV – PV
Cost performance index (CPI)	CPI = EV / AC
Schedule performance index (SPI)	SPI = EV / PV
Estimate at completion (EAC)	EAC = BAC / CPI
Estimate to complete (ETC)	ETC = EAC-AC

CV

Variance





SV

Index

CPI

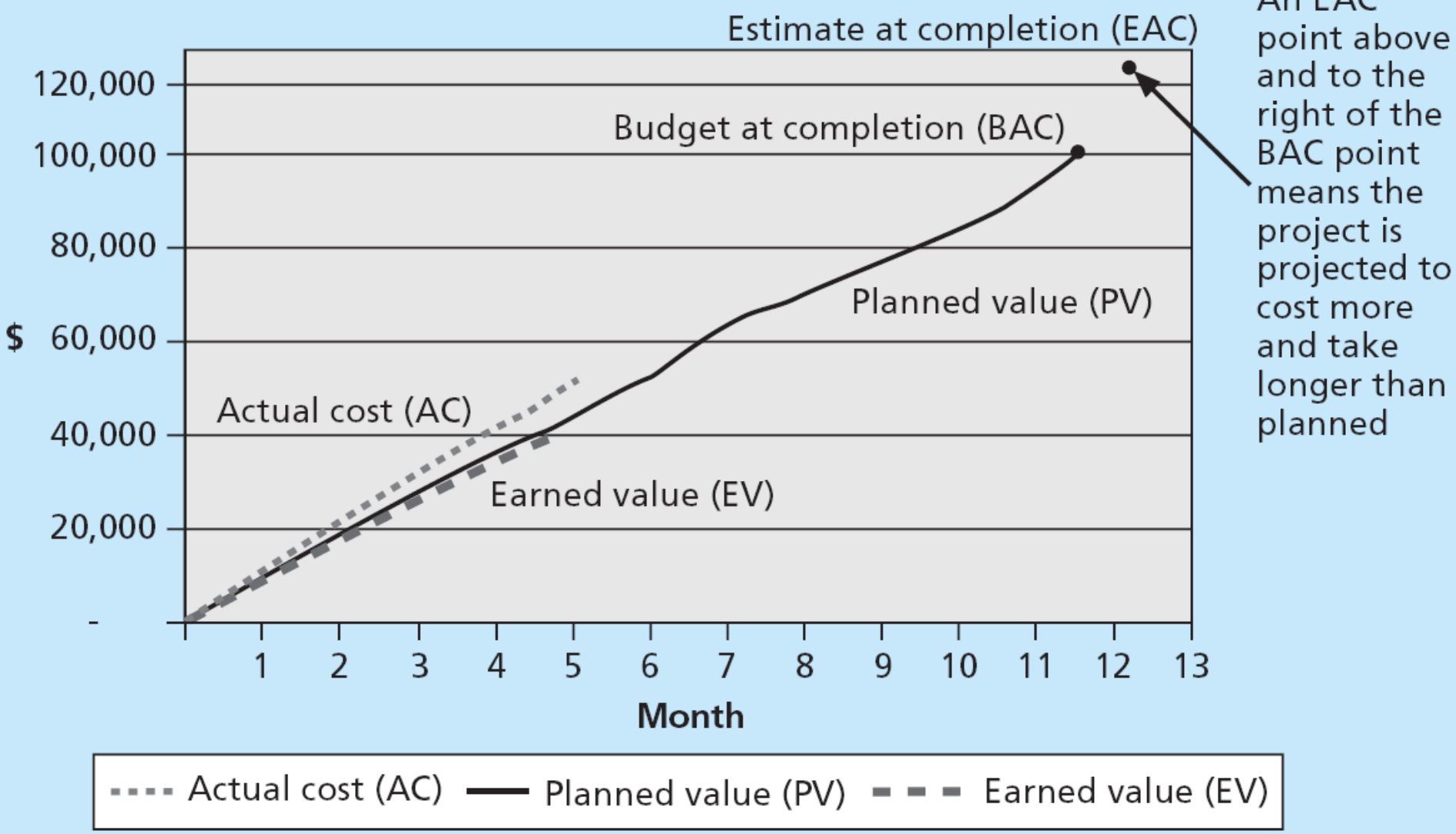
100%

SPI

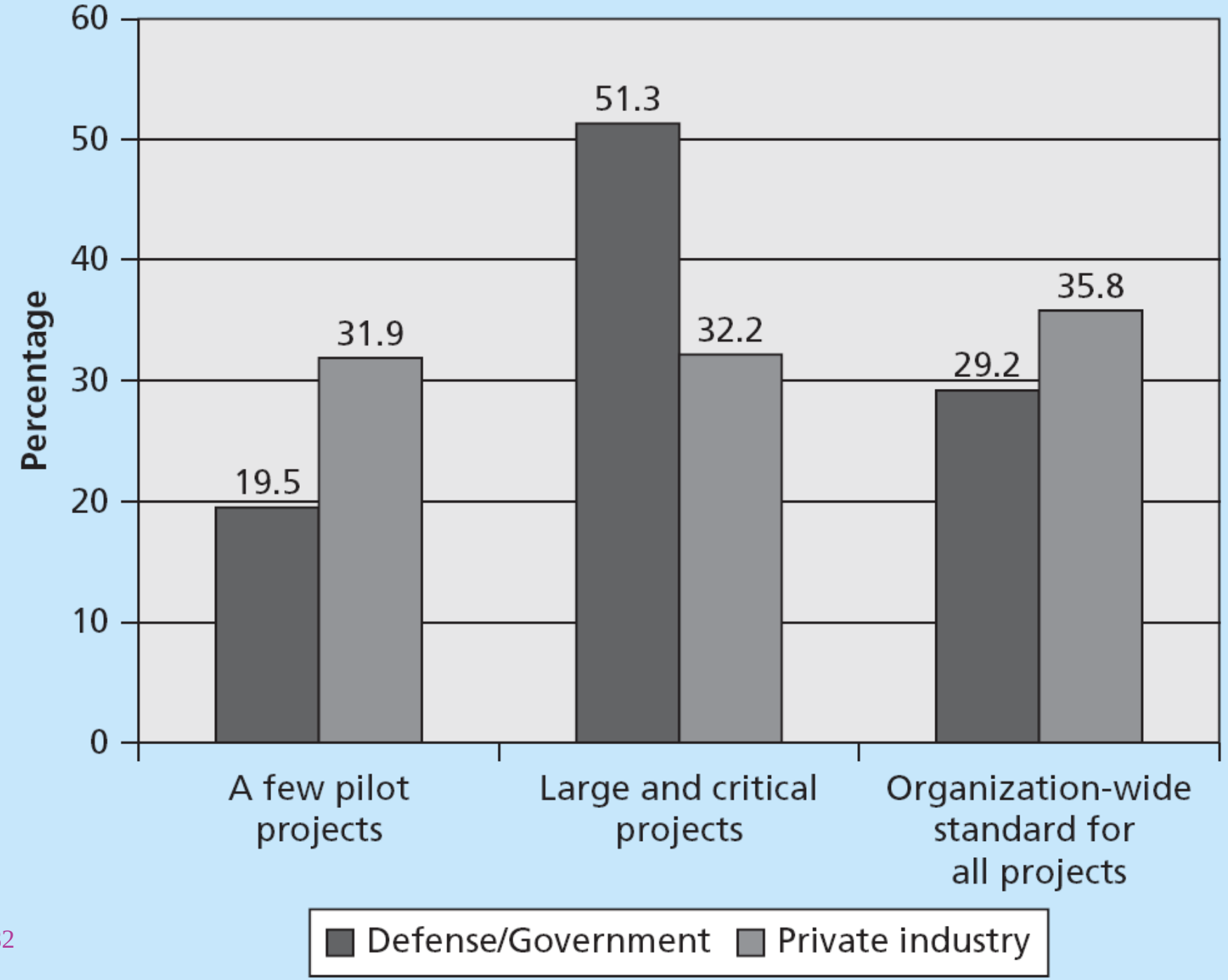
- Negative numbers for cost and schedule variance indicate problems in those areas
- A CPI and SPI of less than one or less than 100 percent also indicate problems

TABLE 7-3 Earned value calculations for one activity after Week 1

Activity	Week 1
Earned value (EV)	5,000
Planned value (PV)	10,000
Actual cost (AC)	15,000
Cost variance (CV)	−10,000
Schedule variance (SV)	−5,000
Cost performance index (CPI)	33%
Schedule performance index (SPI)	50%



Earned value management is an important technique because, when used effectively, it helps top management and project managers evaluate **progress** and make sound management **decisions**.


60
50
40
30
20
10
0
Percentage
19.5
31.9
51.3
32.2
29.2
35.8
A few pilot projects
Large and critical projects
Organization-wide standard for all projects
Defense/Government
Private industry

- Focus on tracking actual performance versus planned performance
- Focus on the importance of percentage completion data in making calculations

Why not Use EVM?

ESTIMATES

Control more projects…

Portfolio Management

1. Put all your projects in one database
2. Prioritize the projects in your database
3. Divide your projects into two or three budgets based on type of investment
4. Automate the repository
5. Apply modern portfolio theory, including risk-return tools that map project risk on a curve

The Importance of Portfolio Management

- Many project managers also want to move on to manage larger projects, become program managers, then vice presidents, and eventually CEOs
- Jane Walton, the project portfolio manager for IT projects at Schlumberger, saved the company $3 million in one year by organizing the organization's 120 IT projects into a portfolio.

Contents

- Importance
- Basic Principles
- Plan Cost Management
- Estimate Costs
- Determine Budget
- Control Costs
- Software

Software

- Spreadsheets
- MS Project
  - Assign costs to resources and tasks
  - Prepare cost estimates
  - Develop cost budgets
  - Monitor cost performance
  - Standard cost reports:
    - Cash flow
    - Budget
    - Over budget tasks
    - Over budget resources
    - Earned value reports

Project Portfolio Management Tools

- 2012, over half of the respondents in two different studies (PMI's PMI Pulse of the Profession™ and a PricewaterhouseCoopers survey) reported frequent use of PPM
- A 2017 report from Gartner says the market for PPM software continues to grow, with annual sales over $2.3 billion
- A study by Forrester estimates that companies are achieving returns of 250 percent from their investments in PPM tools.
- MS project, Planisware …

Thanks!

清華大學
Tsinghua University