



# **CSE 405**

# **Software Engineering Economics**

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## **2. Software Engineering Life-cycle Economics**

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# What is Life-cycle Economics?

- The Life-cycle Economics is essentially a **process** that **documents** a **product's journey** from **development** to **withdrawal** from the market.
1. Product
  2. Project
  3. Program
  4. Portfolio
  5. Product Life Cycle
  6. Project Life Cycle
  7. Proposals
  8. Investment Decisions
  9. Planning Horizon
  10. Price and Pricing
  11. Cost and Costing
  12. Performance Measurement
  13. Earned Value Management
  14. Termination Decisions
  15. Replacement and Retirement Decisions

# Product

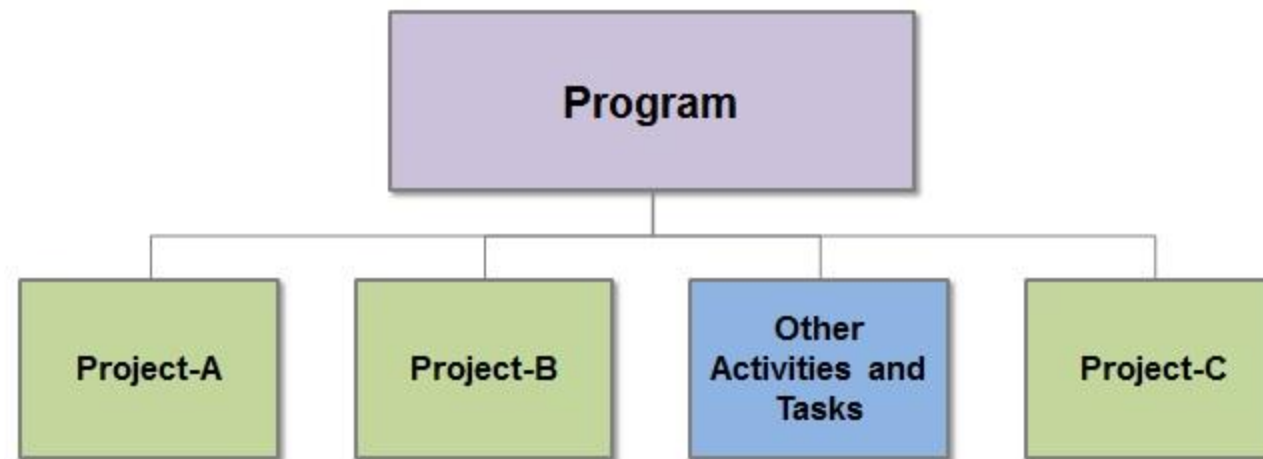
- A product is an **economic good (or output)** that is created in a process that transforms product factors (or inputs) to an output.
  - When sold, a product is a **deliverable that creates both a value and an experience for its users.**
- A product can be a combination of **systems, solutions, materials, and services** delivered internally
  - (e.g., in-house IT solution) or externally (e.g., software application), either as-is or as a component for another product (e.g., embedded software).

# Project

- A project is “a **temporary endeavor undertaken to create a unique product, service, or result**”.
- In software engineering, different project types are distinguished
  - (e.g., product **development**, **outsourced services**, **software maintenance**, service creation, and so on).
- During its life cycle, **a software product may require many projects**.
  - For example, during the product conception phase, a project might be conducted to determine the **customer need and market requirements**; during maintenance, a project might be conducted to **produce a next version of a product**.

# Program

- A program is “**a group of related projects**, subprograms, and program activities **managed in a coordinated** way to obtain benefits not available from managing them individually.”
- Programs are often used to **identify and manage different deliveries** to a single customer or market **over a time** horizon of several years.



# Portfolios

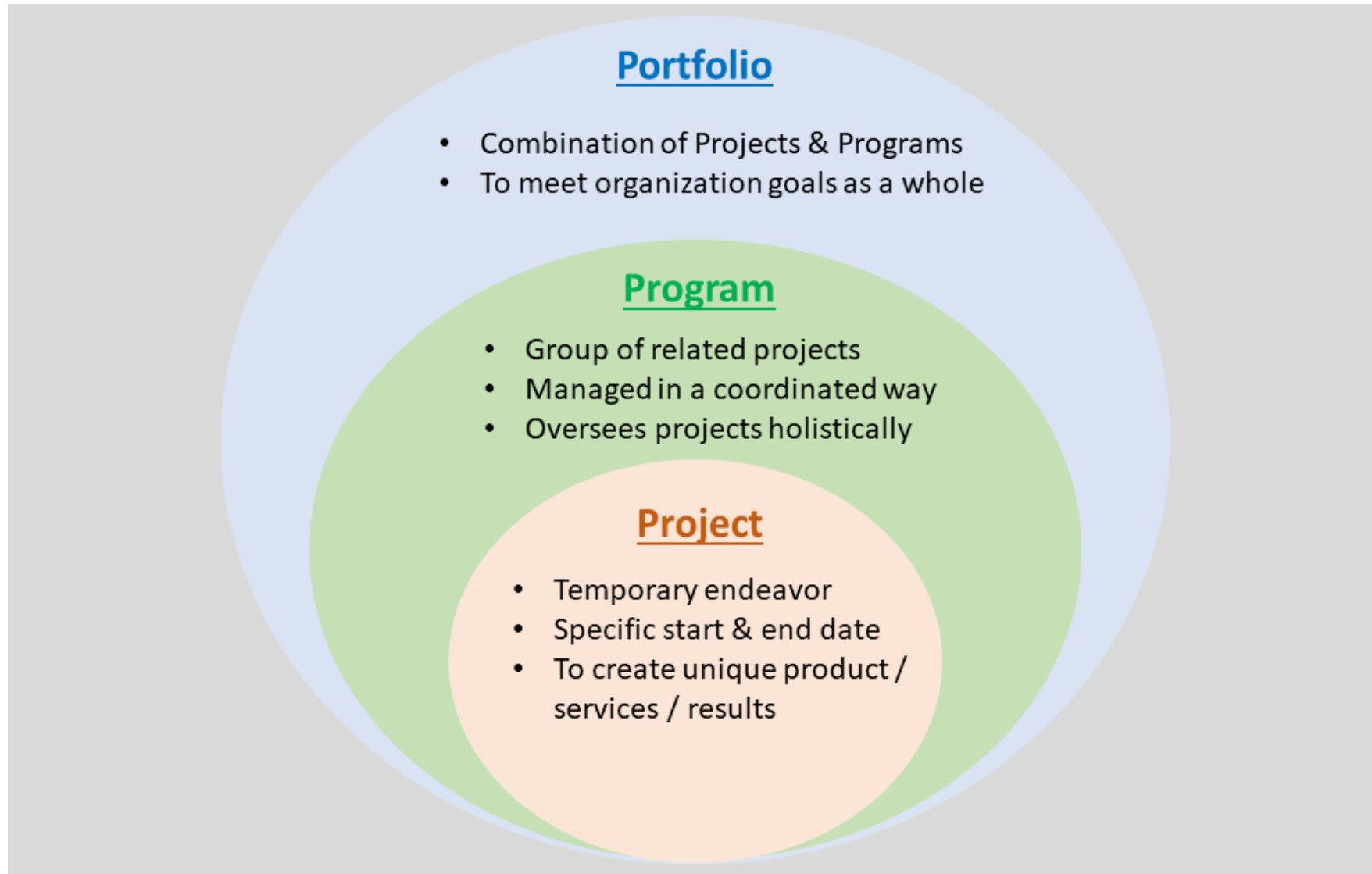
- Portfolios are “projects, **programs**, subportfolios, and **operations managed as a group to achieve strategic objectives.**”
- Portfolios are used to group and then manage simultaneously all assets within a business line or organization.
- Looking to an entire portfolio makes sure that **impacts of decisions** are considered, such as
  - **resource allocation to a specific project—which means that the same resources are not available for other projects.**

# Portfolio Management





# Project vs Program vs Portfolio





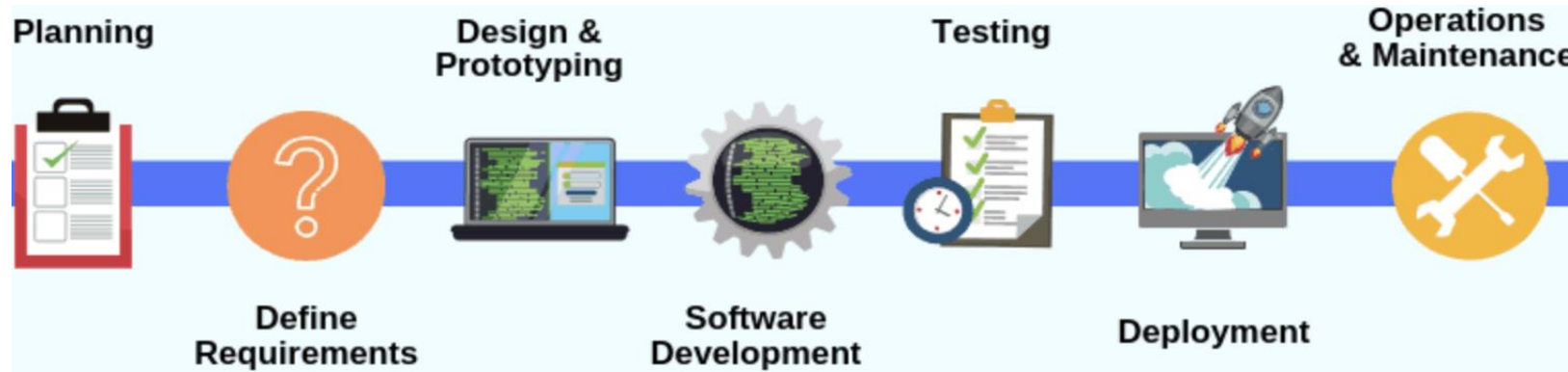


# Product Life Cycle

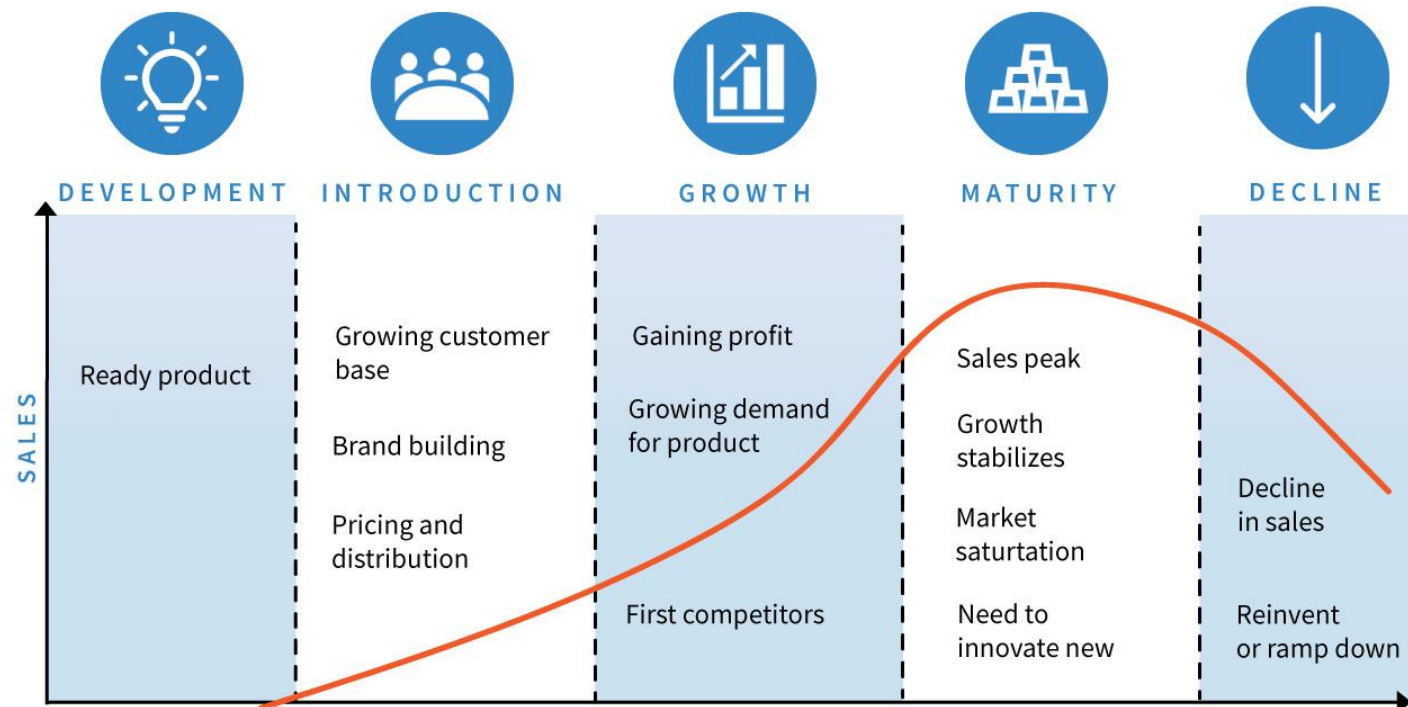
- A software product life cycle (SPLC) includes
  - all activities needed to define, build, operate, maintain, and retire a software product or service and its variants.
- The SPLC activities of “**operate**,” “**maintain**,” and “**retire**” typically occur in a much **longer time frame** than initial software development SDLC
  - Also the **operate-maintain-retire** activities of an SPLC typically **consume more total effort** and other resources than the SDLC activities.
  - The value contributed by a software product or associated services can be objectively determined during the “operate and maintain” time frame.
- **Software engineering economics** should be **concerned** with all SPLC activities, including the **activities after initial product release**.

# SDLC vs SPLC

## SDLC



## SPLC



# Project Life Cycle

- Project life cycle activities typically involve five process groups—
  - **Initiating, Planning, Executing, Monitoring and Controlling, and Closing**
- The activities within a software project life cycle are often **interleaved, overlapped, and iterated** in various ways
  - For instance, agile product development within an SPLC involves multiple iterations that produce increments of deliverable software.
- An SPLC should include risk management and synchronization with different suppliers (if any),
  - while providing auditable decision-making information (e.g., **complying with product liability needs or governance regulations**).
- The software project life cycle and the software product life cycle are interrelated; **an SPLC may include several SDLCs**.

# Project Life Cycle



## Initiation

Explore requirements, scope, risks, and benefits.



## Planning

Figuring out teams and dividing projects into tasks.



## Execution

Taking the project plan and putting it into action.



## Monitoring

Checking that the project is on track and adjusting plans as needed.



## Closing

Finishing the project and reviewing to find lessons learned.

# Proposals

- Making a business decision begins with the notion of a proposal. **Proposals relate to reaching a business objective—at the project, product, or portfolio level.**
- **A proposal is a single, separate option that is being considered, like**
  - carrying out a particular software development project or not.
  - Another proposal could be to **enhance an existing software** component, and still another might be to **redevelop that same software from scratch.**
- Each proposal represents a **unit of choice**—either you can choose to carry out that proposal or you can choose not to.
- The whole purpose of business decision-making is to figure out, given the current business circumstances, which proposals should be carried out and which shouldn't.



# Example of Proposal

		ANTIVIRUS PLUS 2013	INTERNET SECURITY 2013	TOTAL SECURITY 2013
i	ANTIVIRUS & ANTISPYWARE	✓	✓	✓
i	BITDEFENDER AUTOPILOT™	✓	✓	✓
i	• NEW BITDEFENDER SAFEPAY™	✓	✓	✓
i	• NEW USB IMMUNIZER	✓	✓	✓
i	ANTIPHISHING	✓	✓	✓
i	SEARCH ADVISOR	✓	✓	✓
i	SOCIAL NETWORKING PROTECTION	✓	✓	✓
i	• ENHANCED PARENTAL CONTROL		✓	✓
i	TWO-WAY FIREWALL		✓	✓
i	ANTISPAM		✓	✓
i	• NEW DEVICE ANTI-THEFT			✓
i	• ENHANCED BITDEFENDER SAFEBOX™			✓
i	TUNE-UP			✓

# Investment Decisions

- Investors make investment **decisions to spend money and resources on achieving a target objective.**
- Investors are either inside (e.g., finance, **board**) or outside (e.g., **banks**) the organization.
- The target relates to some economic criteria, such as
  - **achieving a high return on the investment,**
  - **strengthening the capabilities of the organization,**
  - **or improving the value of the company.**
- **Intangible aspects** such as **goodwill, culture, and competences** should be considered.





# Planning Horizon

- The planning horizon, sometimes known as **the study period**, is the consistent **time frame** over which **proposals are considered**.
- When an organization chooses to invest in a particular proposal, money gets tied up in that proposal— so-called “**frozen assets**.”
  - The economic impact of frozen assets tends to **start high and decreases over time**.
  - On the other hand, operating and maintenance costs of elements associated with the proposal tend to **start low but increase over time**.
- The total cost of the proposal—that is, owning and operating a product—is the sum of those two costs.
- There is a point in time where the sum of the costs is minimized; this is called the **minimum cost lifetime**.
- To properly compare a proposal with a **four-year life span** to a proposal with a **six-year life span**, the economic effects of either cutting the six-year proposal by two years or investing the profits from the four-year proposal for another two years need to be addressed.



# Price and Pricing

- **A price is what is paid in exchange for a good or service.** Price is a fundamental aspect of financial modeling and is one of the four Ps of the marketing mix.
- The other three Ps are **product, promotion, and place.** **Price is the only revenue-generating element amongst the four Ps;** the rest are costs.
- Pricing factors include **manufacturing cost, market placement, competition, market condition, and quality of product.**
- **The needs of the consumer can be converted into demand** only if the **consumer has the willingness and capacity to buy the product.**
- Pricing is initially done during the project initiation phase and is a part of “go” decision making.



# Cost and Costing

- **A cost is the value of money that has been used up to produce something and, hence, is not available for use anymore.** In economics, a **cost** is an alternative that is given up as a result of a decision.
- **A sunk cost is the expenses before a certain time**, typically used to abstract decisions from expenses in the past, which can cause emotional hurdles in looking forward.
- From a traditional economics point of view, **sunk costs should not be considered in decision making.**
- **Opportunity cost** is the cost of an alternative that must be forgone in order to pursue another alternative.



# Cost and Costing

- Costing is part of finance and product management. **It is the process to determine the cost based on expenses** (e.g., production, software engineering, distribution, rework) and on the target cost to be competitive and successful in a market.
- **The target cost can be below the actual estimated cost.** The planning and controlling of these costs (called cost management) is important and should always be included in costing.
- An important concept in costing is the total cost of ownership **(TCO)**. This holds especially **for software**, because **there are many not-so-obvious costs related to SPLC activities after initial product development**.
  - TCO for a software product **is defined as the total cost for acquiring, activating, and keeping that product running.**
  - These costs can be grouped as direct and indirect costs. TCO is an accounting method that is crucial in making sound economic decisions.



# Performance Measurement

- Performance measurement is the process whereby an organization establishes and measures the parameters used to determine whether programs, investments, and acquisitions are achieving the desired results.
- It is used to evaluate whether performance objectives are actually achieved; to control budgets, resources, progress, and decisions; and to improve performance.
- **Earned value management (EVM)** is a project management technique for measuring progress based on created value.
  - It helps to identify possible performance problems at an early stage.
  - A key principle in EVM is tracking cost and schedule variances via comparison of planned versus actual schedule and budget versus actual cost.
  - EVM tracking gives much earlier visibility to deviations and thus permits corrections earlier than classic cost and schedule tracking that only looks at delivered documents and products.



# Earned Value Management

Concept	Explanation	Formula
PV (Planned Value)	Authorized budget assigned to scheduled work	$BAC * \text{Planned \% Complete}$
EV (Earned Value)	The actual project value you've earned	$BAC * \text{Actual \% Complete}$
AC (Actual Cost)	The actual amount you have spent on the project so far	None
SPI (Schedule Performance Index)	To find out whether you are behind or ahead of schedule We are progressing at x% of the rate originally planned	$EV / PV$
SV (Schedule Variance)	To find out how much behind or ahead of schedule you are	$EV - PV$ (- is behind while + is ahead)
CPI (Cost Performance Index)	To find out whether you are within or over budget We are getting \$x worth of work out of every \$1 spent	$EV / AC$
CV (Cost Variance)	To find out how much above or below budget you are	$EV - AC$ (- is over while + is under)
TCPI (To Complete Performance Index)	To forecast whether or not you can stick to your budget	$BAC - EV / BAC - AC$ or $BAC - EV / EAC - AC$
BAC (Budget At Completion)	The budgeted amount for the total work	None
EAC (Estimate At Completion)	The expected total cost for the project	$AC + ETC$ $AC + (BAC - EV)$ $BAC / CPI$ $AC + [(BAC - EV) / (CPI * SPI)]$
ETC (Estimate To Complete)	The expected cost to finish all the remaining project work	$EAC - AC$
VAC (Variance At Completion)	Projected budget surplus or deficit at the end of the project	$BAC - EAC$



# Earned value management example – 1

- So let's imagine we are building a Payroll Software. The project is set to be completed in **10 months** with an estimated cost of **\$500,000**. The project has been running for **5 months** now, the team has **spent \$220,000** and completed an amount of **work worth \$255,000**.
- And now let's analyze this **Earned Value Management** example, from the point of metrics:
  - **Planned Value (PV) = BAC \* 0.5 = \$500,000 \* 0.5 = \$250,000**. 50% of the project time has passed so we calculate 50% of the total project value.
  - **Earned Value (EV) = BAC \* 0.51 = \$500,000 \* 0.51 = \$255,000**. This is equal to the estimated value for the work that has been completed.
  - **Actual Cost (AC) = \$220,000**. This is equal to the amount of money the team has spent so far.
  - **Cost Variance (CV) = EV – AC = \$255,000 - \$220,000 = \$35,000** (+VE is under budget)
  - **Schedule Variance (SV) = EV – PV = \$255,000 - \$250,000 = \$5,000** (+VE is ahead of schedule)
  - **Cost Performance Index (CPI) = EV / AC = \$255,000 / \$220,000 = 1.16** (likely to complete the project for a lower cost than expected)
  - **Schedule Performance Index (SPI) = EV / PV = \$255,000 / \$250,000 = 1.02** (likely to complete the project on time or a little earlier)





# Earned value management example – 2

- So let's imagine we are building a Payroll Software. The project is divided into **5 stages**, each worth **\$20,000** and estimated to last for 1 month. 2 months have passed and 3 of the project stages have been completed for the cost of **\$80,000**.
- And now let's analyze this **Earned Value Management** example, from the point of metrics:
  - **Planned Value (PV) = BAC \* 0.4 = \$100,000 \* 0.4 = \$40,000**. 2 Months into the project, we should have completed 2 stages, each worth \$20,000.
  - **Earned Value (EV) = BAC \* 0.6 = \$100,000 \* 0.6 = \$60,000**. We have actually completed 3 stages of the project.
  - **Actual Cost (AC) = \$80,000**. This is equal to the amount of money the team has spent so far.
  - **Cost Variance (CV) = EV – AC = \$60,000 - \$80,000 = -\$20,000** (-VE is over budget)
  - **Schedule Variance (SV) = EV – PV = \$60,000 - \$40,000 = \$20,000** (+VE is ahead of schedule)
  - **Cost Performance Index (CPI) = EV / AC = \$60,000 / \$80,000 = 0.75** (the project is way over the initial budget, the project will finish early and at a far higher cost.)
  - **Schedule Performance Index (SPI) = EV / PV = \$60,000 / \$40,000 = 1.5** (likely to complete the project on time or a little earlier)

# Termination Decisions

- Termination means to end a project or product. Termination can be **preplanned** for the end of a long product lifetime (e.g., when foreseeing that a product will reach its lifetime) or can come rather **spontaneously** during product development (e.g., when project performance targets are not achieved).
- In both cases, the decision should be carefully prepared, considering always the **alternatives of continuing versus terminating**.
- **Costs of different alternatives must be estimated**—covering topics such as replacement, information collection, suppliers, alternatives, assets, and utilizing resources for other opportunities.
- **Sunk costs should not be considered in such decision making** because they have been spent and will not reappear as a value.



# Replacement and Retirement Decisions

- A replacement decision is made when an organization already has a particular asset and they are considering replacing it with something else; for example, **deciding between maintaining and supporting a legacy software product or redeveloping it from the ground up.**
- Replacement decisions use the same business decision process as described above, but there are additional challenges: sunk cost and salvage value.
- Retirement decisions are also about getting out of an activity altogether, such as when a **software company considers not selling a software product anymore** or a hardware manufacturer considers not building and selling a particular model of computer any longer.
- Retirement **decision can be influenced by lock-in factors such as technology dependency and high exit costs.**

# Summary

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- What is Life-cycle Economics?
- Project vs Program vs Portfolio
- SDLC vs SPLC
- Earned Value Management Examples

# Q & A

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***Any Question?***