# Advanced Software Engineering
(CS6401)

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# **Introduction to Software and Software Engineering** (Lecture-1)

# Organization of this Lecture:

- Nature of software
- Nature of software projects
- What is Software Engineering?
- Programs vs. Software Products
- Software Process
- Introduction to Life Cycle Models
- Summary

# Software

- Instructions (computer programs) that when executed provide desired features, function, and performance
- Data structures that enable the programs to adequately manipulate information, and
- Descriptive information in both hard copy and virtual forms that describes the operation and use of the programs.

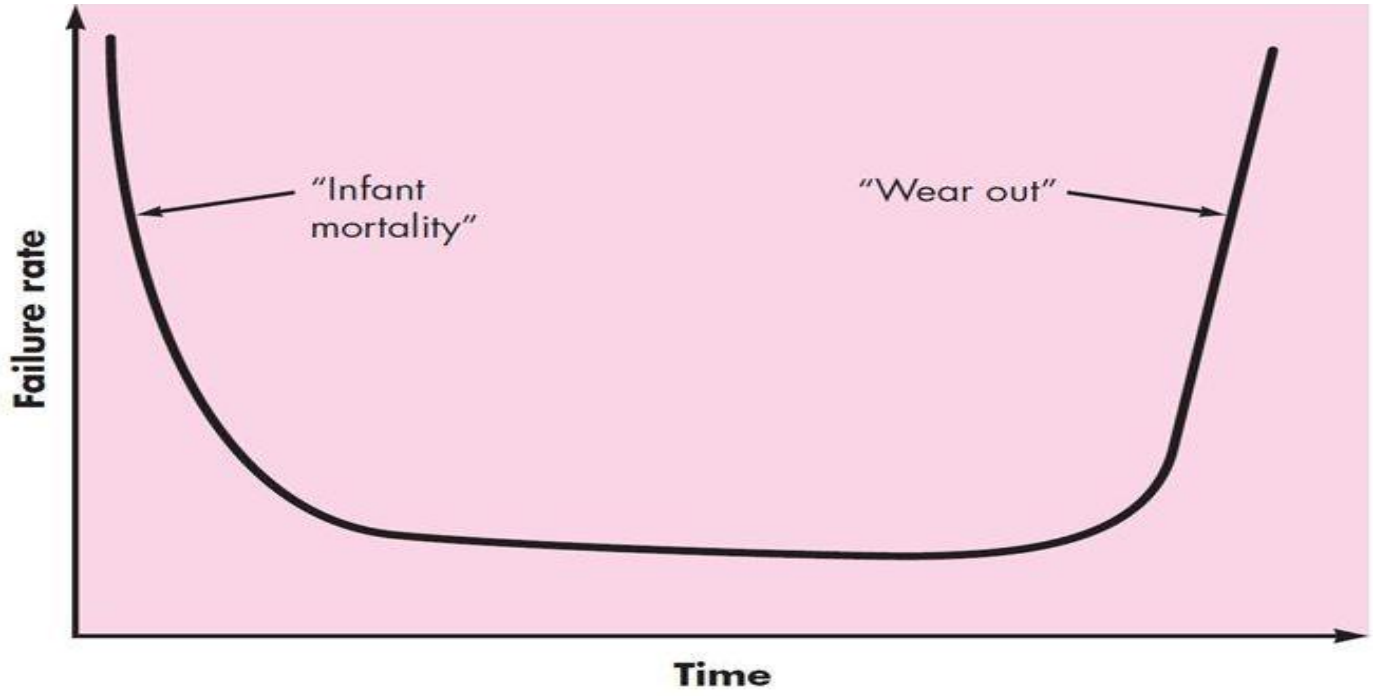
# Characteristics

- **Software is developed or engineered; it is not manufactured in the classical sense.**
  - Similarity exist between software development and hardware manufacturing, but two activities are different.
  - High quality is achieved through good design, but hardware manufacturing introduces quality problems that are easily corrected for software
  - Relationship between people applied and work accomplished is entirely different
  - Both activities require the construction of a product, but approaches are different
  - Software costs are concentrated in engineering; software project management is different from hardware

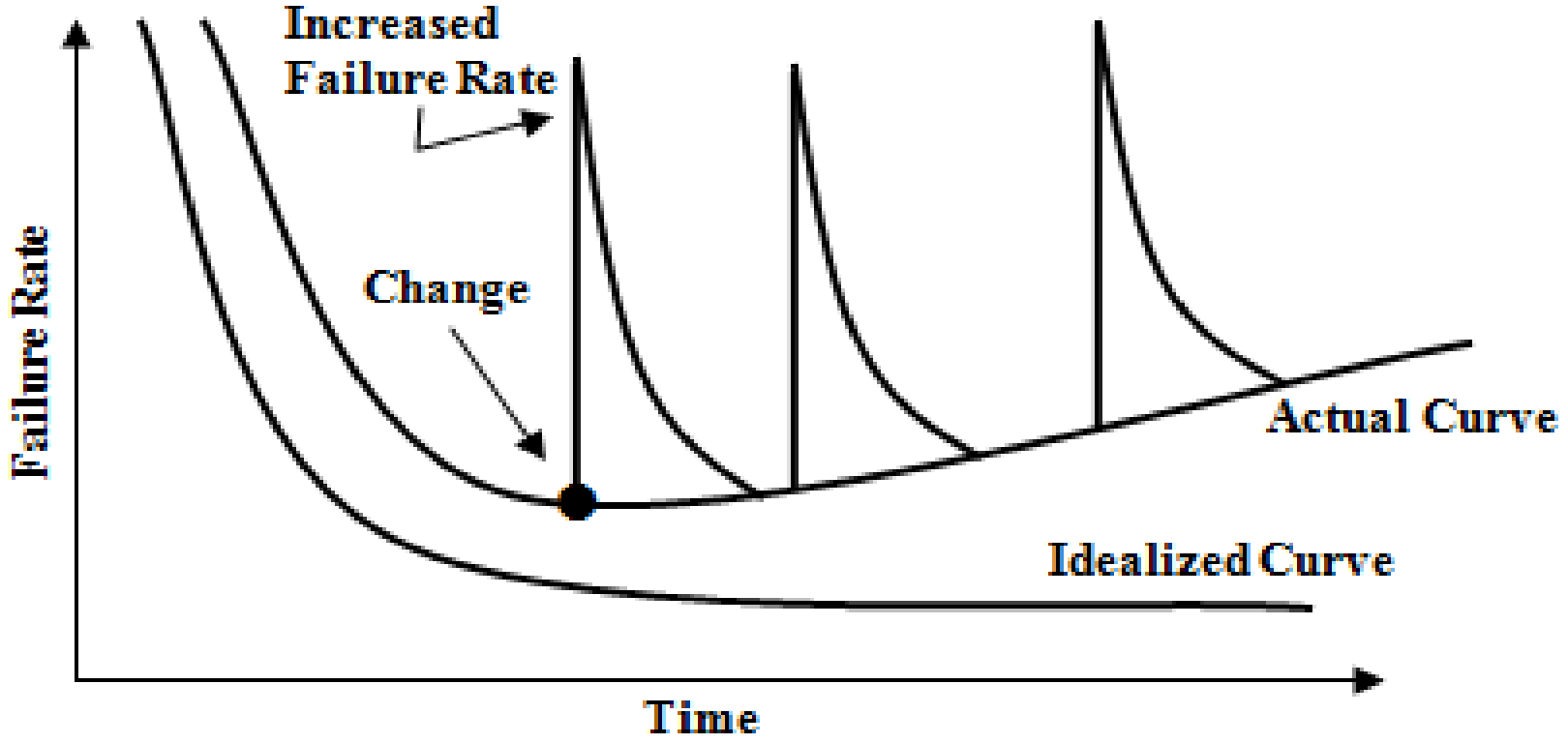
# Characteristics

- **Software does not wear out.**
  - Hardware failure rate resembles Bathtub curve
    - Relatively high failure rates early in its life
    - Often attributable to design or manufacturing defects
    - Failure rate drops to steady-state level due to correction of defects
    - Failure rate rises as hardware components suffer from cumulative effects of dust, vibration, and temperature etc.
  - But software is not susceptible to those environmental maladies.
  - Failure curves of hardware and software are given in the next slide.

# Failure curve for hardware



# Failure curve for software




- Software does not wear out. But it does deteriorate.
- There are no spare parts.

# Characteristics

- **Although the industry is moving toward component-based construction, most software continues to be custom built**
  - Reusable components have been created so that engineer can concentrate on the truly innovative elements of a design
    - Example: Screws used by mechanical engineers
  - It has only begun to be achieved on a broad scale.

# Nature of software projects

- Ubiquitous, used in variety of applications – Business, engineering and scientific applications
  - System Software,
  - Application Software,
  - Scientific Software,
  - Embedded Software,
  - Web applications etc.

- Simple to complex, public usage (example, railway ticket reservation system), single function to enterprise-wide (example, payroll), one location to distributed, batch or real-time, informational to mission-critical etc.

# Major challenges in large projects

- Developing large/complex software application is very challenging
  - Effort intensive
  - High cost
  - Long development time
  - Changing needs for users
  - High risk of failure, user acceptance, performance, maintainability

# Successful software system

- Software development projects have not been always successful (compared to other engineering disciplines).
- When do we consider a software application successful?
  - Development completed
  - It is useful
  - It is usable
  - It is used

# Reasons for failure

- Schedule Slippage – not released at appropriate time
- Cost over-runs
- Does not solve user's problem
- Poor quality of software (may not be maintainable)

# Ad hoc software development results in such problem:

- No planning of development work (e.g., no milestones are defined)
- Deliverable are not defined
- Technical incompetency of developers
- No control over review (Review the progress of the system because enough money is spent in it and keep updated with the recent trends)
- Poor understanding of the user requirements
- Poor understanding of the cost and effort by both developer and user

# Engineering: other disciplines

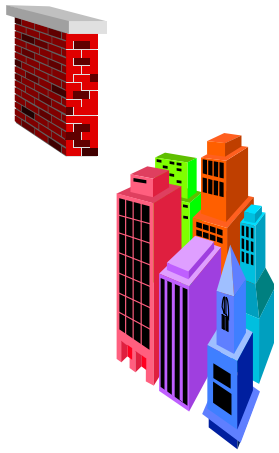
- Large projects common and successfully done
  - building bridges and dams
  - Power plants, Missiles
- Engineering a solution:
  - to design and develop an artefact that meets specifications effectively, cost effectively and ensuring the quality using scientific principles

# Engineering:

- Requires well-defined approach: repeatable, predictable
- Large projects requires managing the project itself
  - Manage people, money, equipment schedule
  - Scale makes big difference: compare building a house, 2-storeyed, or 100-storeyed
- Need a systematic approach and management
- Quality extremely important: relates failures, efficiency and usability
  - People willing to pay for quality.

# What is Software Engineering?

- Engineering approach to develop software.
  - Building Construction Analogy.



- Systematic collection of past experience:
  - techniques,
  - methodologies,
  - guidelines.

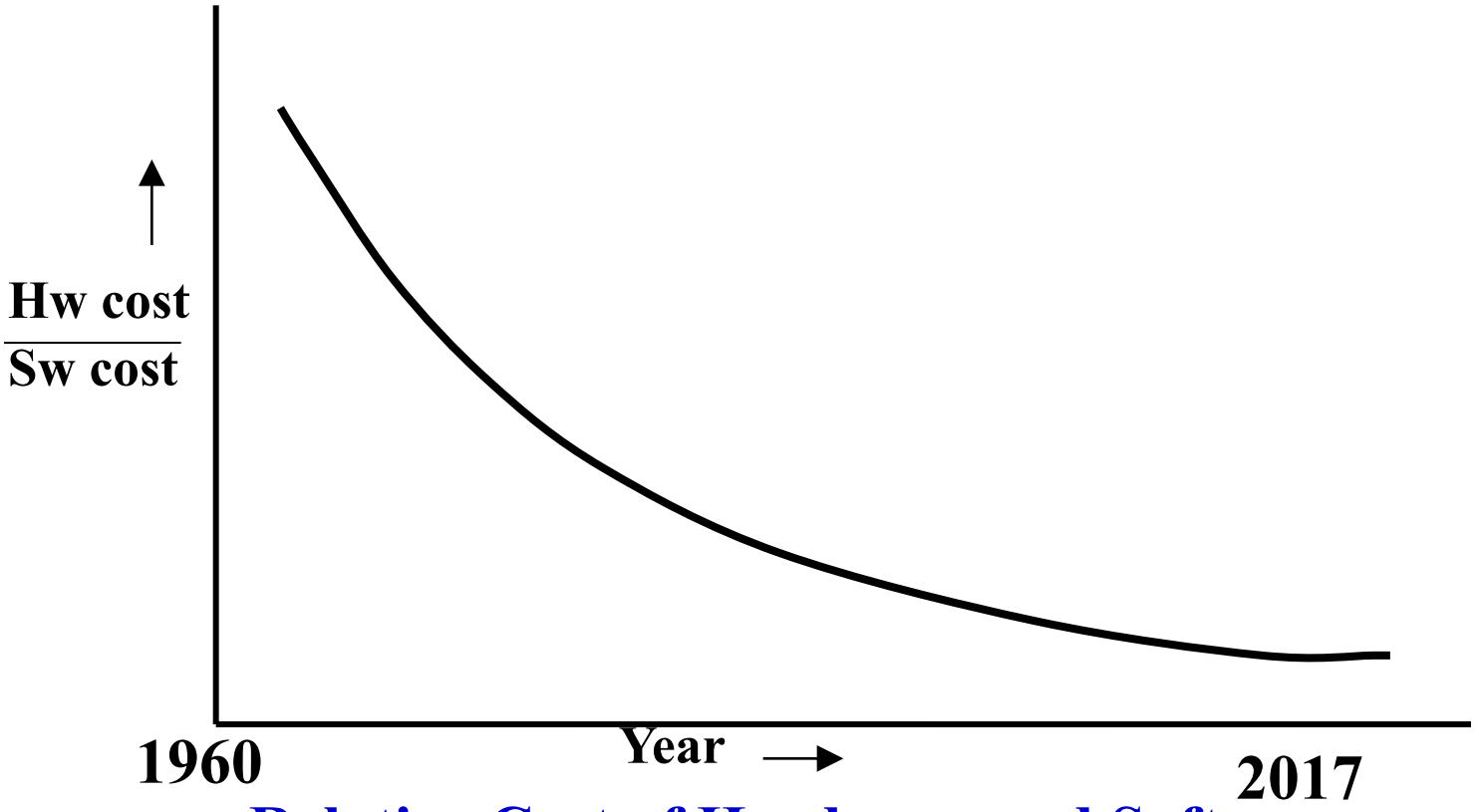
# Engineering Practice

- Heavy use of past experience:
  - Past experience is systematically arranged.
- Theoretical basis and quantitative techniques provided.
- Many are just thumb rules.
- Trade-off between alternatives
- Pragmatic approach to cost-effectiveness

# Software Crisis

- Software products:
  - fail to meet user requirements.
  - frequently crash.
  - expensive.
  - difficult to alter, debug, and enhance.
  - often delivered late.
  - use resources non-optimally.

# Software Crisis (cont.)




**Relative Cost of Hardware and Software**

# Factors contributing to the software crisis

- Larger problems
- Lack of adequate training in software engineering techniques
- Increasing skill shortage
- Low productivity improvements

# Software Crisis (cont.)

- Software Engineering appears to be available to tackle the software crisis.

# Programs versus Software Products

| | |
|---|---|
| • Usually small in size | • Large |
| • Author himself is sole user | • Large number of users |
| • Single developer | • Team of developers |
| • Lacks proper user interface | • Well-designed interface |
| • Lacks proper documentation | • Well documented & user-manual prepared |
| • Ad hoc development. | • Systematic development |

# Computer Systems Engineering

- Computer systems engineering:
  - encompasses software engineering.
- Many products require development of software as well as specific hardware to run it:
  - a coffee vending machine,
  - a mobile communication product, etc.

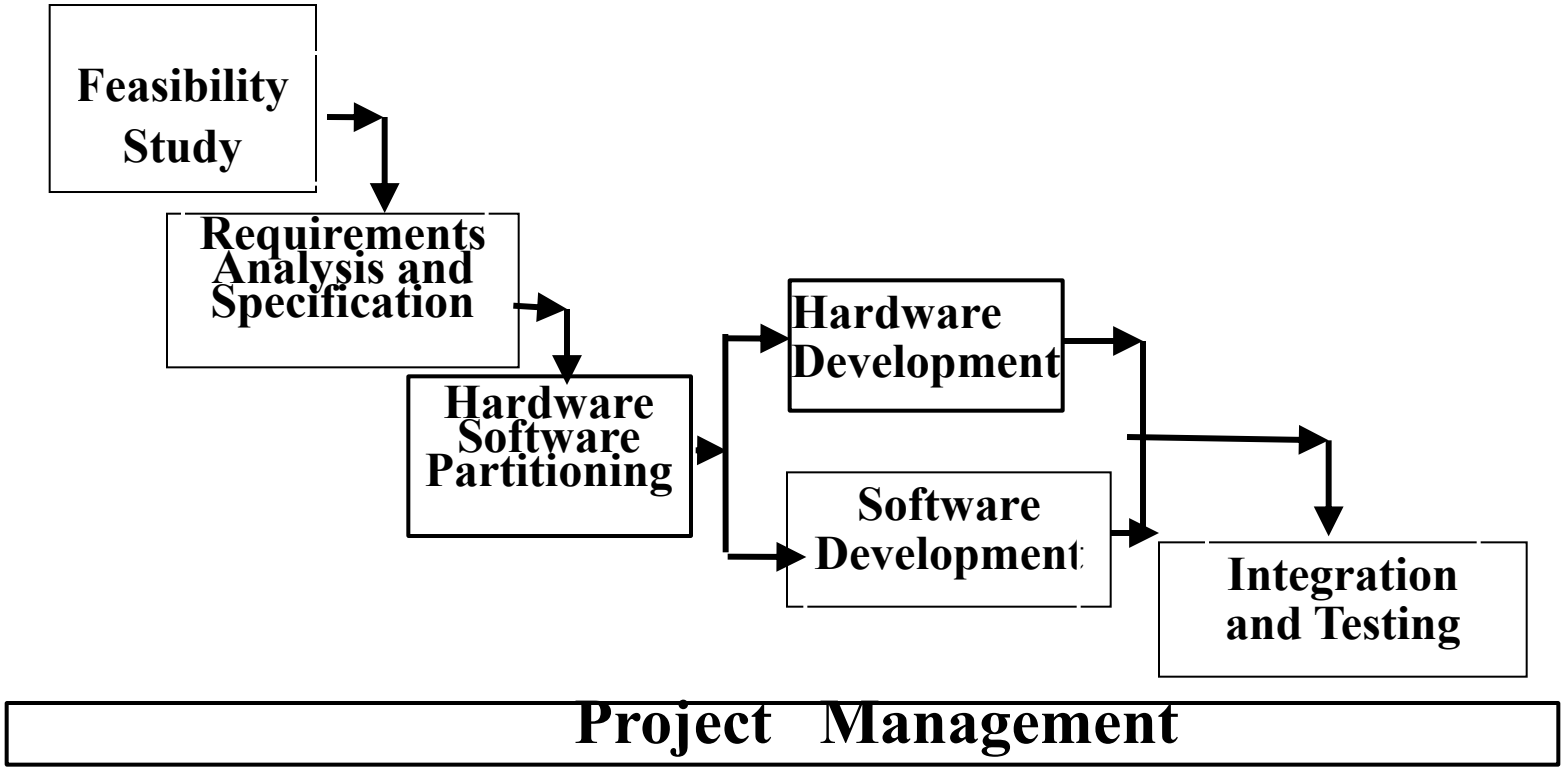
# Computer Systems Engineering

- The high-level problem:
  - deciding which tasks are to be solved by software
  - which ones by hardware.

# Computer Systems Engineering (Cont..)

- Often, hardware and software are developed together:
  - Hardware simulator is used during software development.
- Integration of hardware and software.
- Final system testing

# Computer Systems Engineering (CONT.)



# Large projects:

- Deliverables: architecture, model, structure diagram, electrical cabling layouts
- Standards, regulations, conventions need to be followed (contribute towards success of the software)
- Continuous monitoring is in place to have progress in its developments
- It is difficulty to assess the progress because it does not have any physical dimensions (in case building you can see the storeyed developed to till date)

# Software Projects

- Software is different from other products
- Cost of production concentrated in development (once it is developed its copy will be installed in various places)
- Maintenance consists of making corrections and enhancing or adding functions
- Progress in development is difficult to measure

# Apply engineering approach:

- Hence planning and control even more important in software development
- Attempt estimate cost/effort
- Plan and schedule work
- Involve user in defining requirements
- Identify stages in development
- Define clearly the milestones so that the progress can be measured
- Schedule reviews both for control and quality
- Define deliverables
- Plan extensive testing

Note: We need to put all of these in the form of process and we use this as an engineering approach.

# Job of software developer is difficult

- Dealing with users
  - ill-defined requirements (what they expect from the software is not clearly defined)
  - Concern with ease-of-use and response time
- Dealing with technical people
  - Concerned with coding, databases, file structures etc
- Dealing with management
  - Concerned with return on their investment
  - Cost-benefit analysis
  - Schedule

Note: Balance the expectations of people who are associated with this project.

*For success in large software developments, it is important to follow an engineering approach, consisting of a well-defined process.*

# Software Process

- Process consists of steps/activities to be carried out in a particular order
- Software process deals with both technical and management issues
- Consists of different types of process
- Process for software development:
  - produces software as end-result
  - multiple such processes may exist
  - a project follows a particular process

# Process types

- Process for managing the project
  - Defines project planning and control (supervising the plan)
  - Effort estimations made and schedule prepare
  - Resources are provided
  - Feedback taken for quality assurance
  - Monitoring done

- Process for change and configuration management
  - Resolving requests for changes
  - Defining versions and their compositions
  - Release control

# Process types

- Process for managing above processes themselves
  - Improving the processes based on new tools and techniques
  - Standardizations and Certifications (ISO, CMM)

# Multiple processes

- A large software development company may have multiple development processes
  - For client-server based conventional applications (example, sales processing, payroll etc.)
  - For enterprise-level (ERP) projects based on packages and customization
  - For data-warehousing/decision-support type
- The company may have many projects going under each category. They may refine these processes to suit the type of projects.

# Step in a process

- Each step has a well-defined objective
- Requires people with specific skills (e.g., design of a database, you require certain skills to carry such activity)
- Takes specific inputs and produces well-defined outputs

# Step in a process

- Step defines when it may begin (entry criteria) and when it ends (exit criteria)
  - Example: The phase exit criteria for the software requirements specification phase:
    - Software Requirements Specification (SRS) document is complete, reviewed, and approved by the customer.
  - A phase can start:
    - only if its phase-entry criteria have been satisfied.

# Process step..

- Uses specific techniques, tools, guidelines and conventions.
- Step must be executed as per project plan that gives duration, effort, resources, constraints, etc.

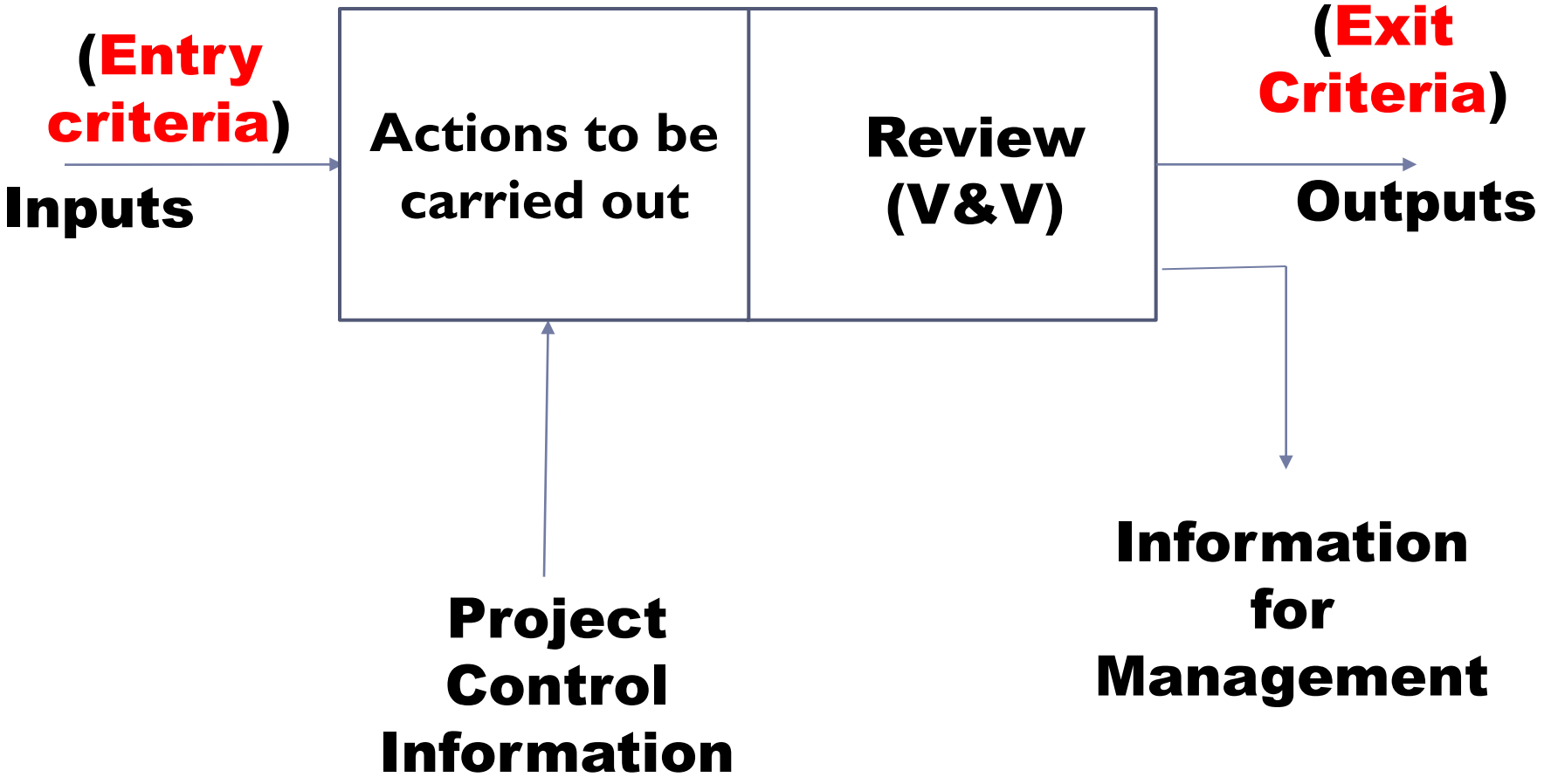
# Process step..

- It must produce information for management so that the corrective actions can be taken
  - For example, effort estimated may be felt not appropriate, in order to deliver within the stipulated time, you may need more people to complete it. Such information should be produced by each step for the management
  - For example, adding more resources

# Process step..

- A step ends in a review (V&V)
  - **Verification:** check consistency of the outputs with inputs (of the step)
  - **Validation:** Check consistency with the user needs (meets the user specification)

# Process step



# Characteristics of a Good Process

- Should be precisely defined – no ambiguity about what is to be done, when, how, etc.
- It must be predictable-can be repeated in other projects with confidence about its outcome
  - **Predictable with respect to effort, cost**:

    **Project 1:** Web-based library application done by 3 persons in 4 months

    **Project 2:** Guest house booking, similar in complexity should also take about 12 person months.
    - We can extrapolate the projects.

# A Good process

- **Predictable for quality:** with respect to number and type of defects, performance
  - Predictable process is said to be under statistical control, when actual values are close to the expected values.
- It supports testing and maintainability
  - Maintenance by third party
  - Follow standards, provide necessary documentation
  - This characteristic differentiates between prototype and product
- Facilitates early detection of and removal of defects
  - Defects add to project cost
  - Late detection/correction is costly

# A Good process

- It should facilitate monitoring and improvement
  - Based on feedback
  - Permit use of new tools and technologies
  - Permit measurements

# Software Life Cycle (or software process)

- series of identifiable stages that a software product undergoes during its life time:
  - Feasibility study
  - requirements analysis and specification
  - design
  - coding
  - testing
  - maintenance

# Life Cycle Model (CONT.)

- a descriptive and diagrammatic model of software life cycle
  - identifies all the activities required for product development,
  - establishes a precedence ordering among the different activities,
  - Divides life cycle into phases.

# Life Cycle Model (CONT.)

- Several different activities may be carried out in each life cycle phase or step.
  - For example, the design stage might consist of:
    - structured analysis activity followed by
    - structured design activity.

# Why Model Life Cycle ?

- A written description:
  - forms a common understanding of activities among the software developers.
  - helps in identifying inconsistencies, redundancies, and omissions in the development process
  - Helps in tailoring a process model for specific projects

# Why Model Life Cycle ?

- Processes are tailored for special projects.
  - A documented process model
    - helps to identify where the tailoring is to occur.

# Life Cycle Model (CONT.)

- The development team must identify a suitable life cycle model:
  - and then adhere to it.
  - Primary advantage of adhering to a life cycle model:
    - development of software takes place in a systematic and disciplined manner.

# Life Cycle Model (CONT.)

- When a program is developed by a single programmer
  - He has the freedom to decide his exact steps.
- When a software product is being developed by a team:
  - There must be a precise understanding among team members as to when to do what,
  - Otherwise, it would lead to chaos and project failure.

# Life Cycle Model (CONT.)

- A software project will never succeed if:
  - one engineer starts writing code,
  - another concentrates on writing the test document first,
  - yet another engineer first defines the file structure
  - another defines the I/O for his portion first.

# Life Cycle Model (CONT.)

- When a life cycle model is adhered to,
  - the project manager can at any time fairly accurately tell,
    - at which stage (e.g., design, code, test, etc. ) of the project is.
  - Otherwise, it becomes very difficult to track the progress of the project
    - the project manager would have to depend on the guesses of the team members.

# Life Cycle Model (CONT.)

- This usually leads to a problem:
  - known as the 99% complete syndrome.

# Summary

- A fundamental necessity while developing any large software product:
  - adoption of  a life cycle model.

# Summary

- Adherence to a software life cycle model:
  - helps to do various development activities in a systematic and disciplined manner.
  - also makes it easier to manage a software development effort.

# Reference


- R. S. Pressman, *Software Engineering A Practitioner's Approach*, McGraw Hill Publications , 2006
- R. Mall, *Fundamentals of Software Engineering*, Prentice Hall of India , 2014
- I. Sommerville, *Software Engineering*, Pearson Education, Asia , 2006
- P. Jalote, *An Integrated Approach to Software Engineering*, Narosa , 2006