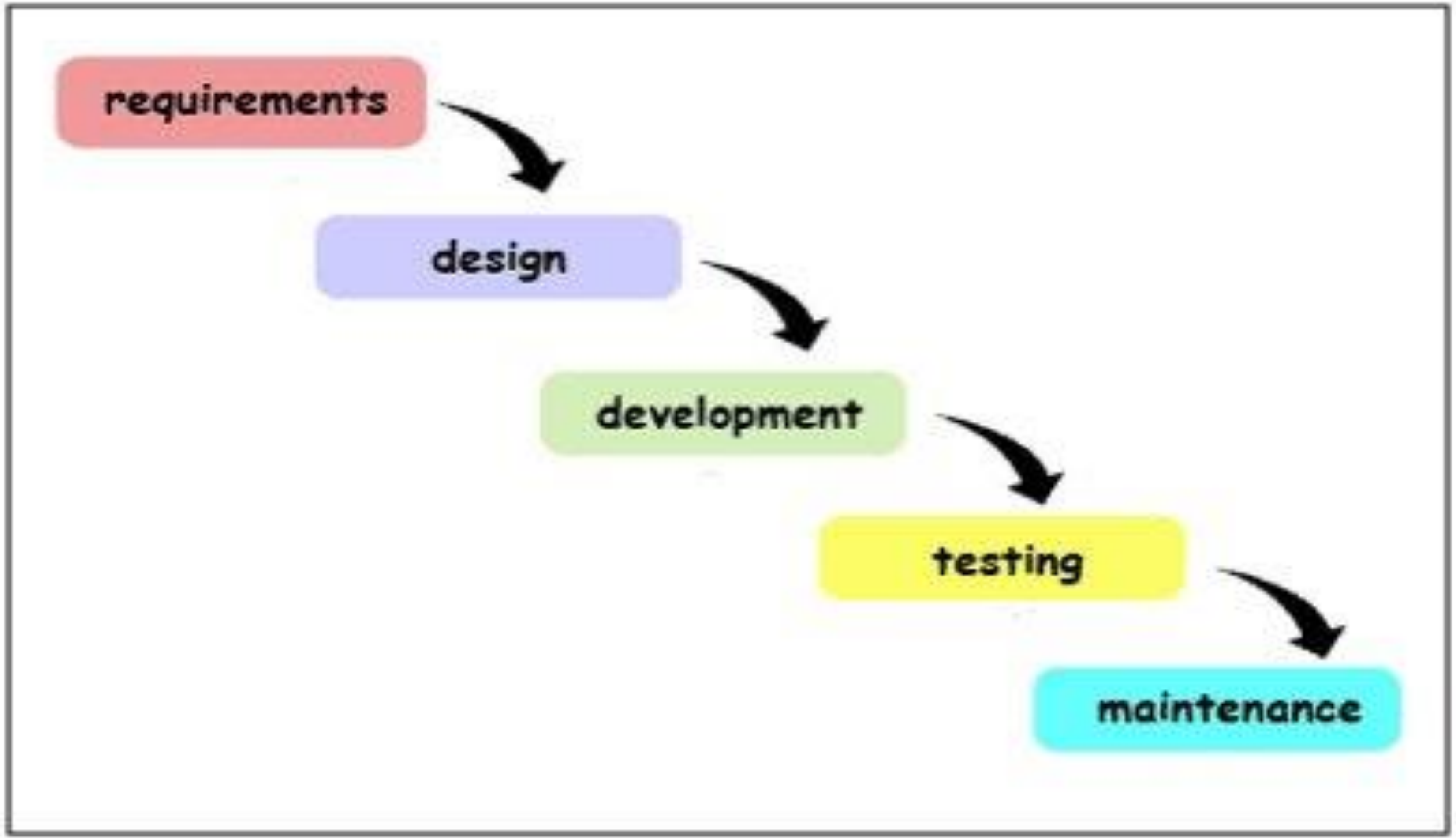
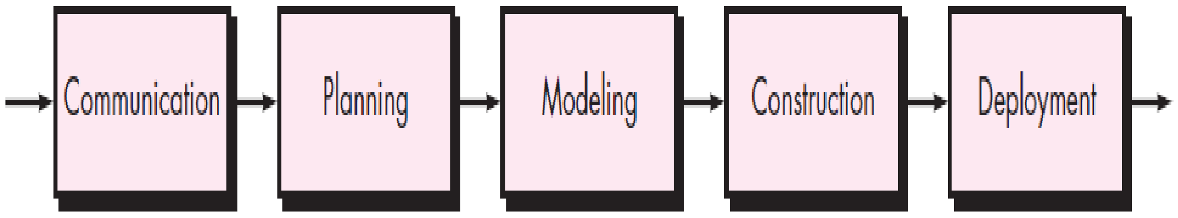
PROCESS MODELS

- Perspective Models: The Waterfall
- Incremental Models: Increment and RAD
- Evolutionary Model: Prototype and Spiral
- Specialized Process Models: Component, Formal Methods, AOSD
- Unified Process Model

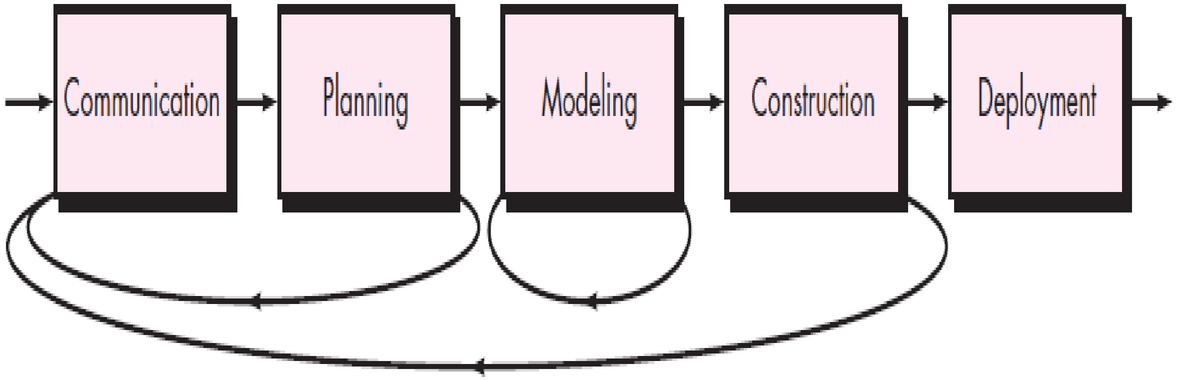
Software Development Life Cycle (SDLC) Phases



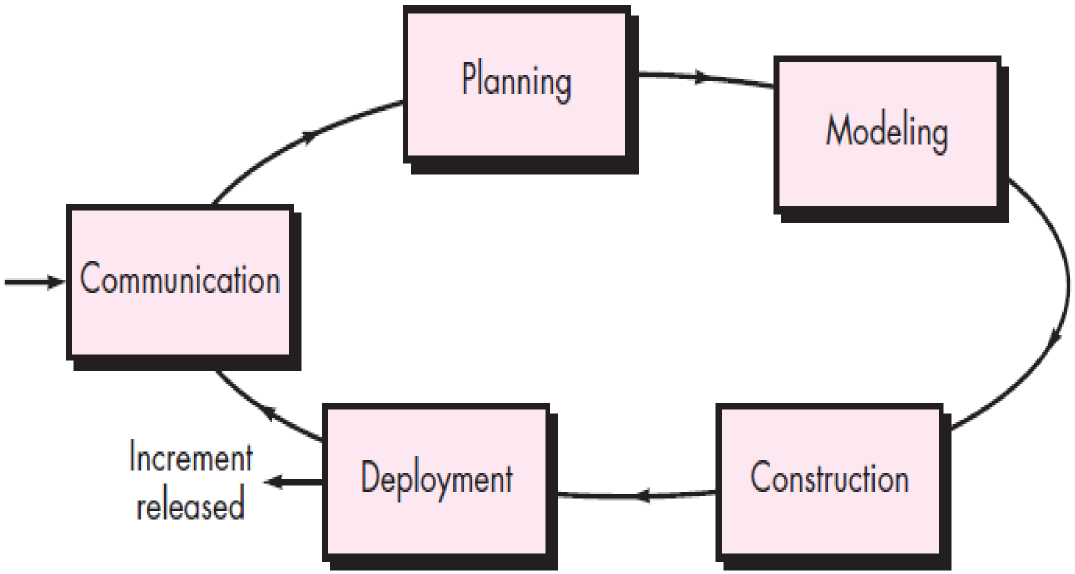
Process Flow



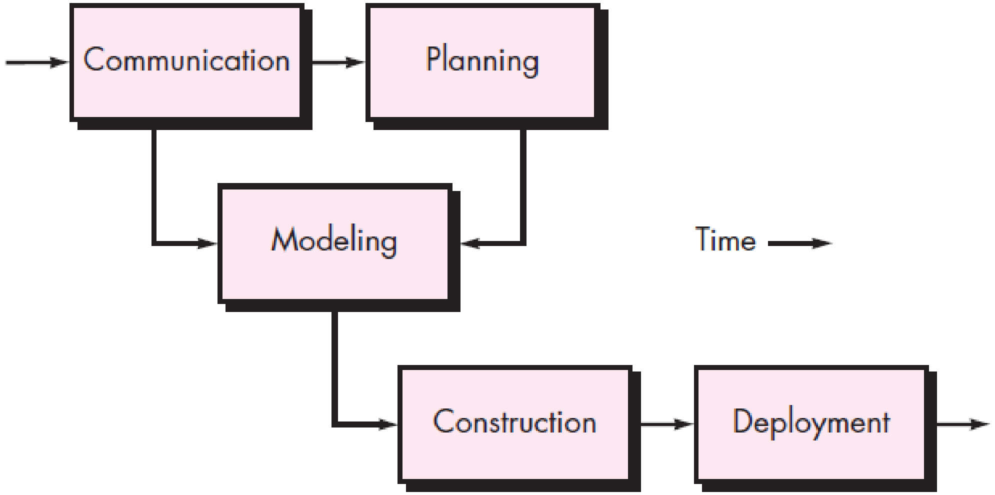
(a) Linear process flow



(b) Iterative process flow



(c) Evolutionary process flow



(d) Parallel process flow

Prescriptive Process Models

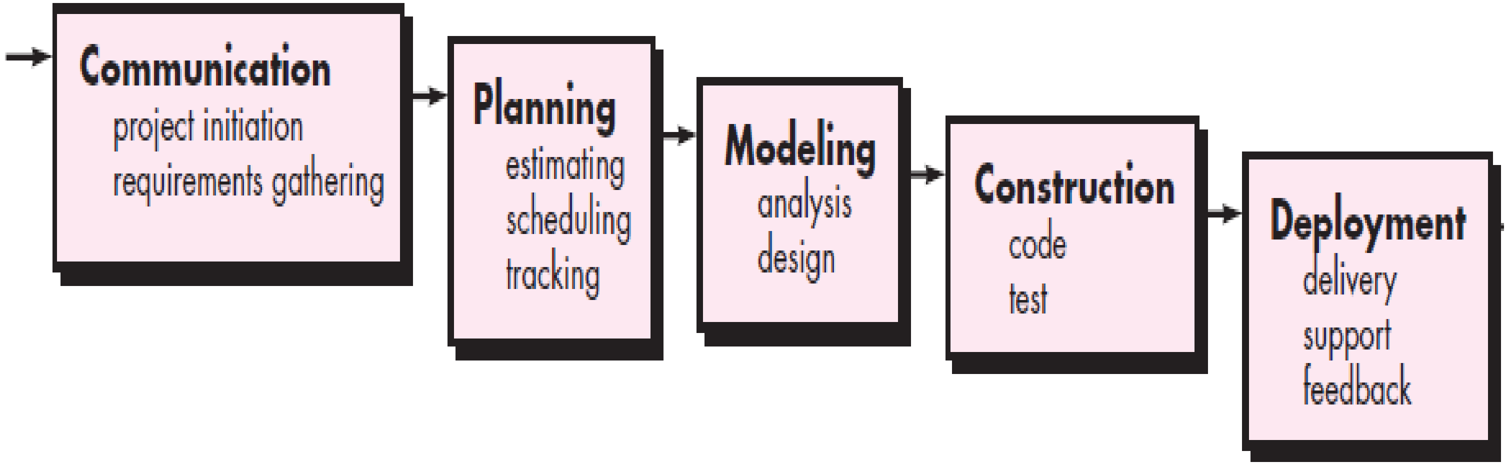
- Often referred to as "conventional" process models
- Prescribe a set of process elements
    - Framework activities
    - Software engineering actions
    - Tasks
    - Work products
    - Quality assurance and
    - Change control mechanisms for each project
- There are a number of prescriptive process models in operation
- Each process model also prescribes a *workflow*
- Various process models differ in their emphasis on different activities and workflow

The Waterfall Model

- Sometimes called the *classic life cycle*
- Suggests a systematic, sequential (or linear) approach to s/w development
- The oldest paradigm for s/w engineering

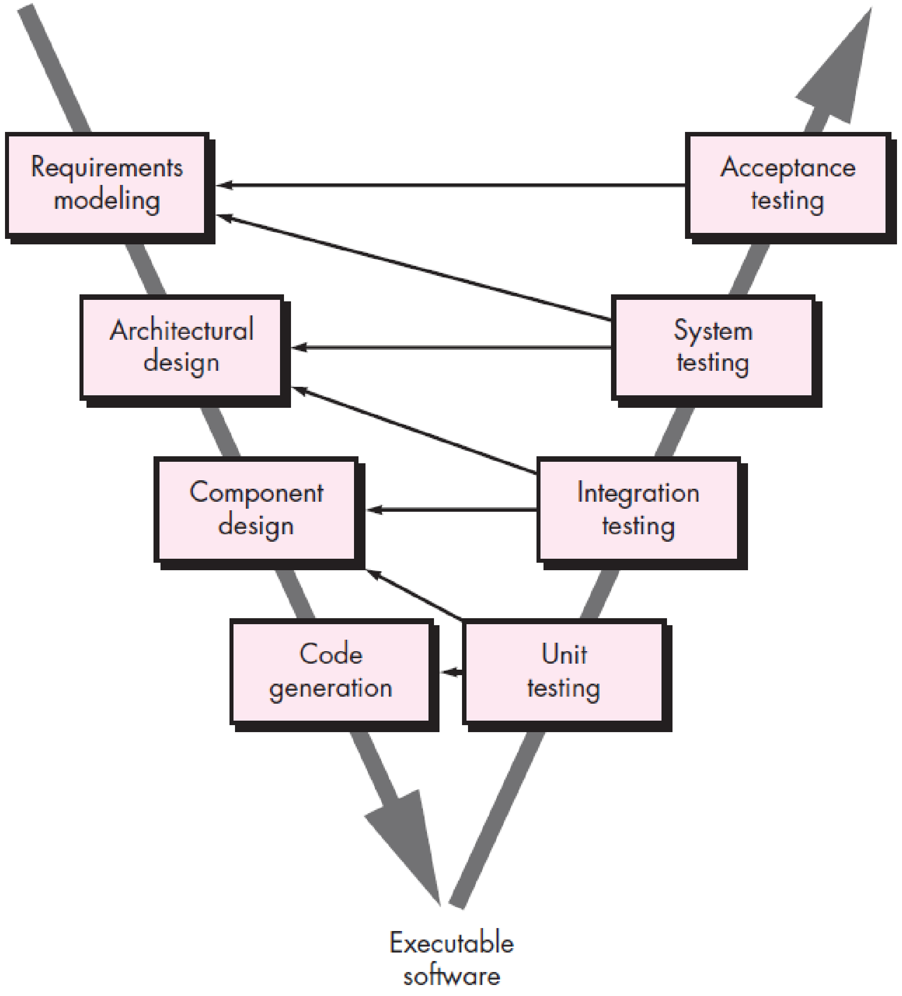
- Works best when –
  - Requirements of a problem are reasonably well understood
  - Well-defined adaptations or enhancements to an existing system must be made
  - Requirements are well-defined and reasonably stable
  - Technology is understood
  - There are no ambiguous requirements
  - Ample resources with required expertise are available freely
  - The project is short

The Waterfall Model



Basic Model

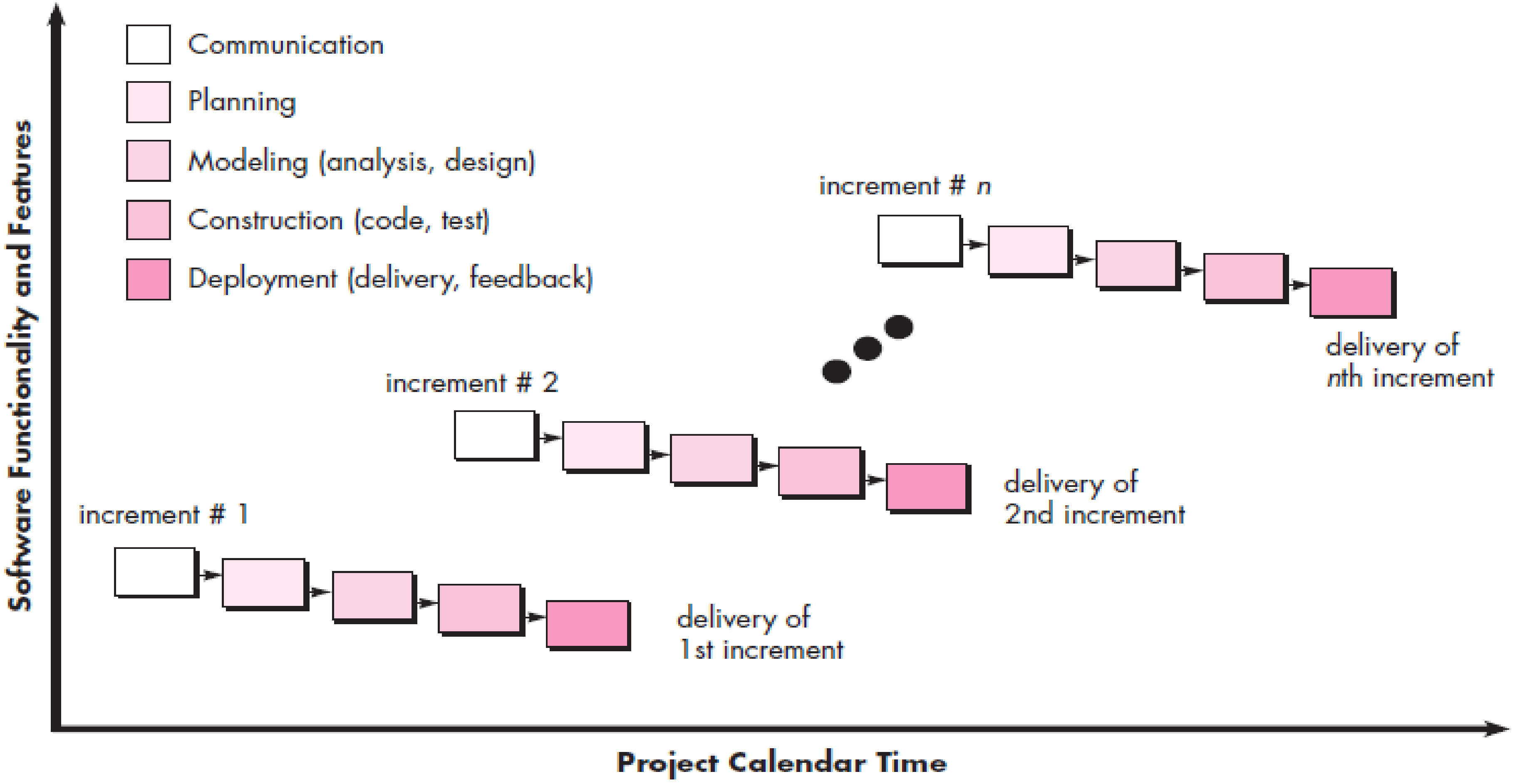
Variations in the Waterfall Model



The Waterfall Model - Problems

- Real projects rarely follow the sequential flow
  - Accommodates iteration indirectly
  - Changes can cause confusion
- It is often difficult for the customer to state all requirements explicitly
  - Has difficulty accommodating the natural uncertainty that exists at the beginning of many projects
- The customer must have patience
  - A working version of the program(s) will not be available until late in the project time-span
  - A major blunder, if undetected until the working program is reviewed, can be disastrous
- Leads to “blocking states” for team members

Incremental Process Models



Incremental Process Models

- Combines elements of the waterfall model applied in an iterative fashion
- Each linear sequence produces deliverable “increments” of the software
- The first increment is often a *core product*
- The core product is used by the customer (or undergoes detailed evaluation)
- Based on evaluation results, a plan is developed for the next increment

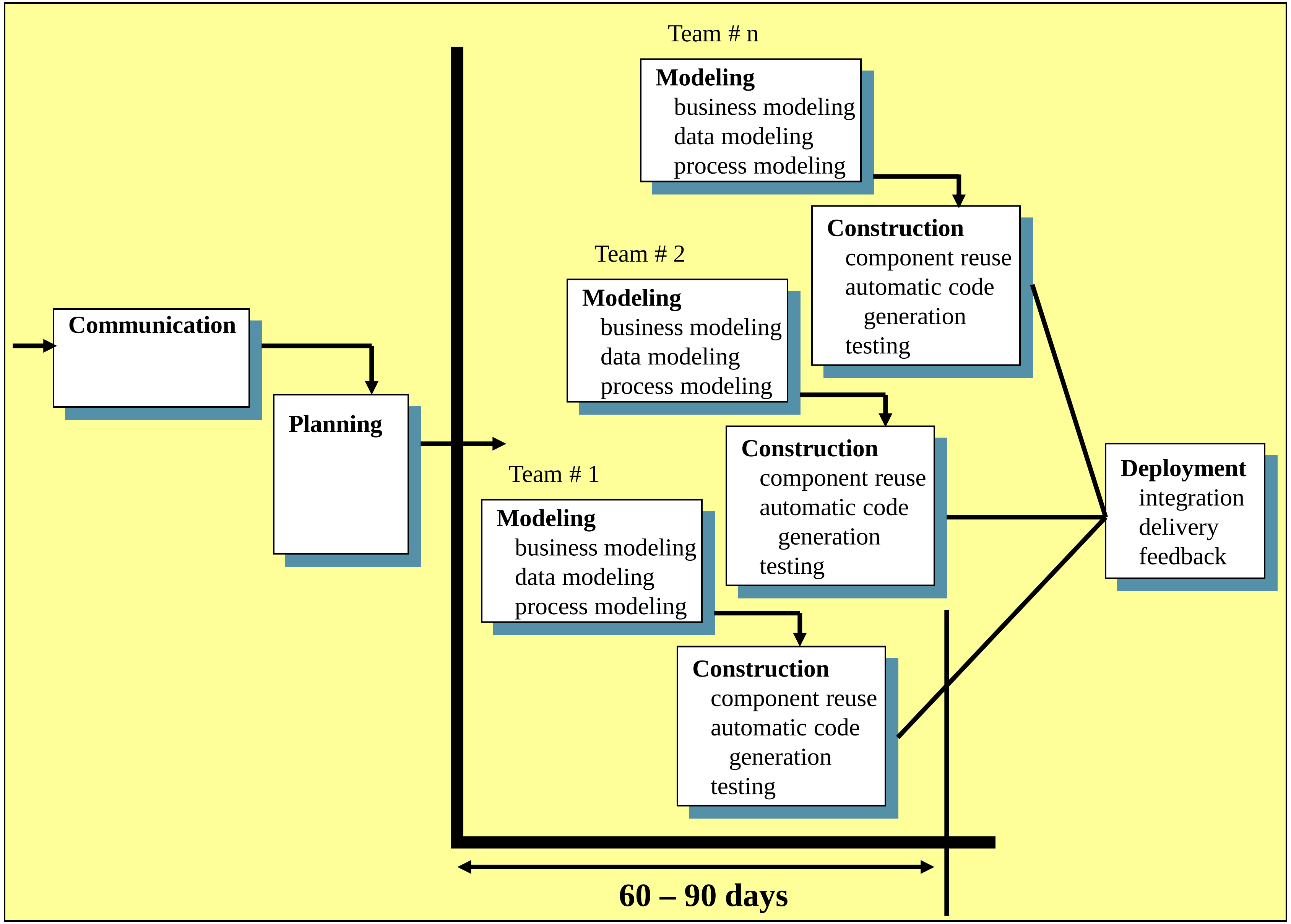
Incremental Process Models

- The incremental process model, like prototyping and other evolutionary approaches, is iterative in nature
- But unlike prototyping, the incremental model focuses on the delivery of an operational product with each increment
- Particularly useful when
  - Staffing is unavailable
  - This model can be used when the requirements of the complete system are clearly defined and understood.
  - Major requirements must be defined; however, some details can evolve with time.
  - There is a need to get a product to the market early.
  - A new technology is being used
  - Resources with needed skill set are not available
  - There are some high-risk features and goals.
- Increments can be planned to manage **technical risks**

The RAD Model

- Rapid Application Development is Incremental Process Model
- Emphasizes on short development cycle
- A “high speed” adaptation of the waterfall model
- Uses a component-based construction approach
- May deliver software within a very short time period (e.g. , 60 to 90 days) if requirements are well understood and project scope is constrained

The RAD Model



The RAD Model

- The time constraints imposed on a RAD project demand "**scalable scope**"
- The application should be modularized and addressed by separate RAD teams
- Integration is required
- Particularly useful when:
  - RAD should be used when there is a need to create a system that can be modularized in 2-3 months of time.
  - It should be used if there's high availability of designers for modeling and the budget is high enough to afford their cost along with the cost of automated code generating tools.
  - RAD SDLC model should be chosen only if resources are available and there is a need to produce the system in a short span of time (2-3 months).

The RAD Model - Drawbacks

- For large, but scalable projects, RAD requires sufficient human resources
- RAD projects will fail if developers and customers are not committed to the rapid-fire activities
- If a system cannot be properly modularized, building the components necessary for RAD will be problematic
- RAD may not be appropriate when **technical risks are high**

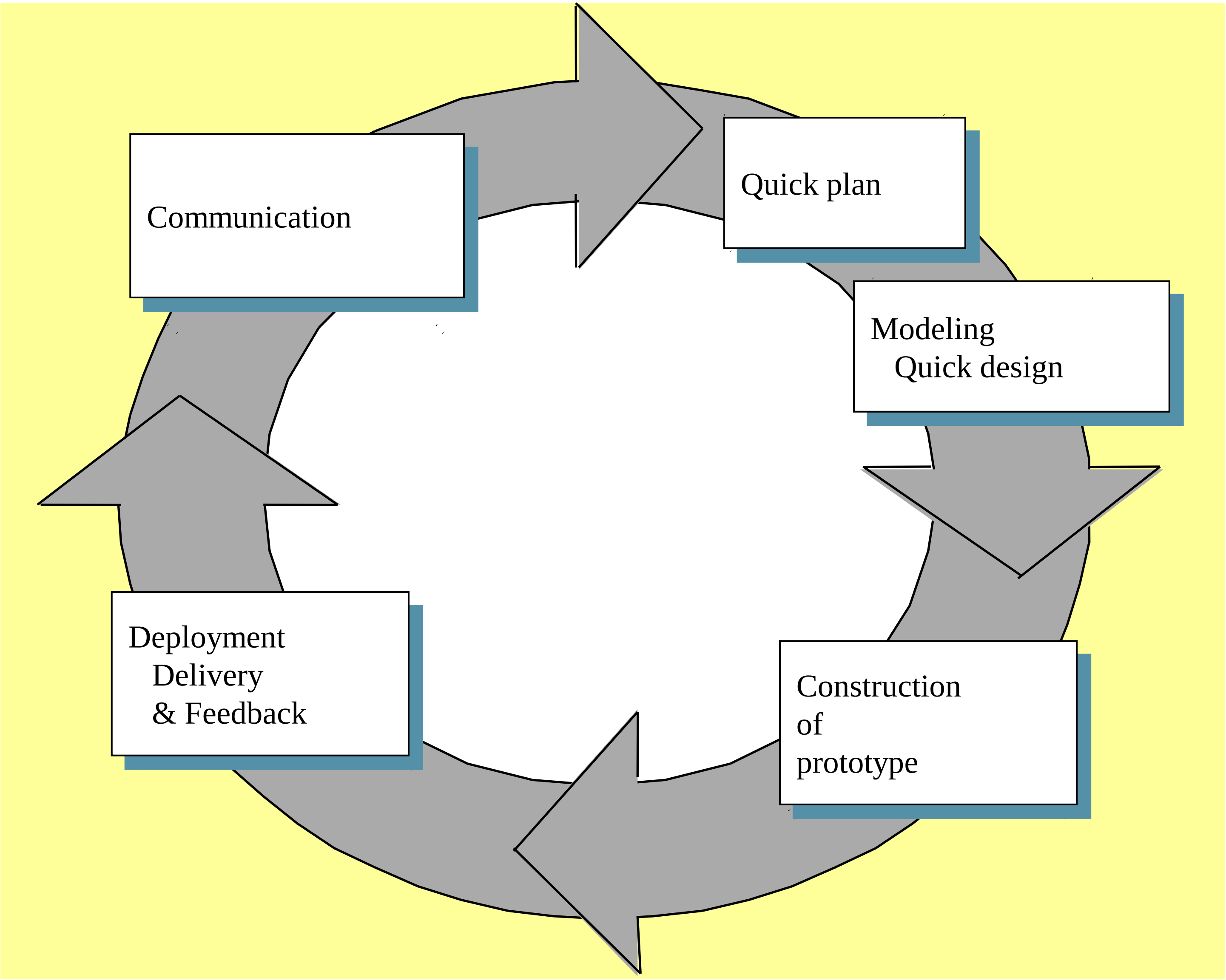
Evolutionary Process Models

- Software, like all complex systems, evolves over a period of time
- Business and product requirements often change as development proceeds, making a straight-line path to an end product is unrealistic
- Evolutionary models are iterative

Prototyping

- Customer defines general objectives but not sure with detailed input, processing and output.
- This model assists the software engineer and the customer to better understand what to be built when requirements are fuzzy.

Prototyping



Prototyping - Problems

- Customers may press for immediate delivery of working but inefficient products
- The developer often makes implementation compromises in order to get a prototype working quickly

The Spiral Model

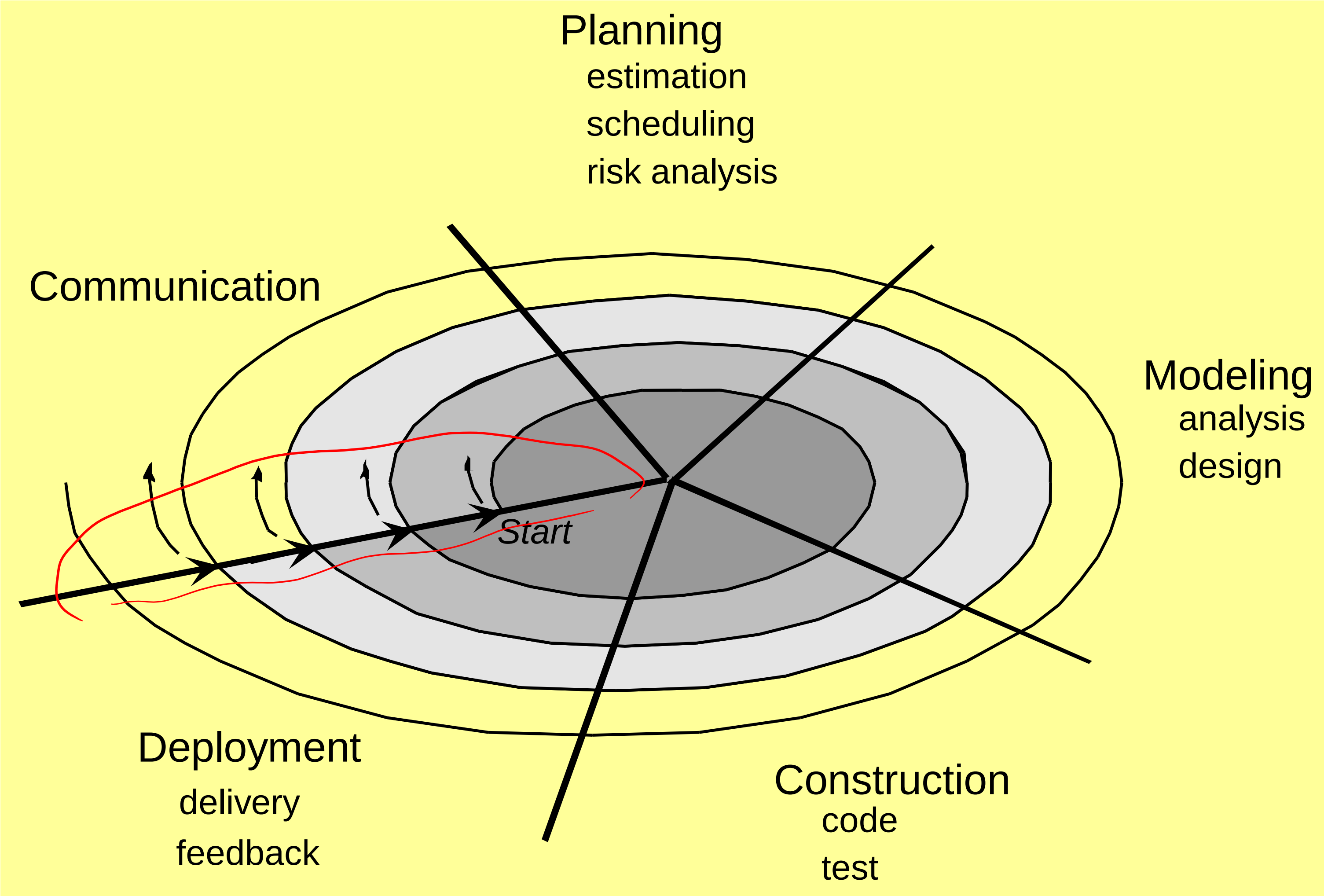
- Couples the iterative nature of prototyping with the controlled and systematic aspects of the waterfall model

- It is a *risk-driven process model* generator

- It has two main distinguishing features
  - Cyclic approach-a combination of work products and conditions that are attained along the path of the spiral

    - Incrementally growing a system's degree of definition and implementation while decreasing its degree of risk
  - A set of *anchor point milestones*
    - For ensuring stakeholder commitment to feasible and mutually satisfactory system solution

The Spiral Model



The Spiral Model

- Unlike other process models that end when software is delivered, the spiral model can be adapted to apply throughout the life of the computer s/w

- The circuits around the spiral might represent
  - Concept development project
  - New Product development project
  - Product enhancement project

- The spiral model demands a direct consideration of technical risks at all stages of the project

Particularly useful when

- When costs and risk evaluation is important
- For medium to high-risk projects
- Long-term project commitment unwise because of potential changes to economic priorities
- Users are unsure of their needs
- Requirements are complex
- New product line
- Significant changes are expected (research and exploration)

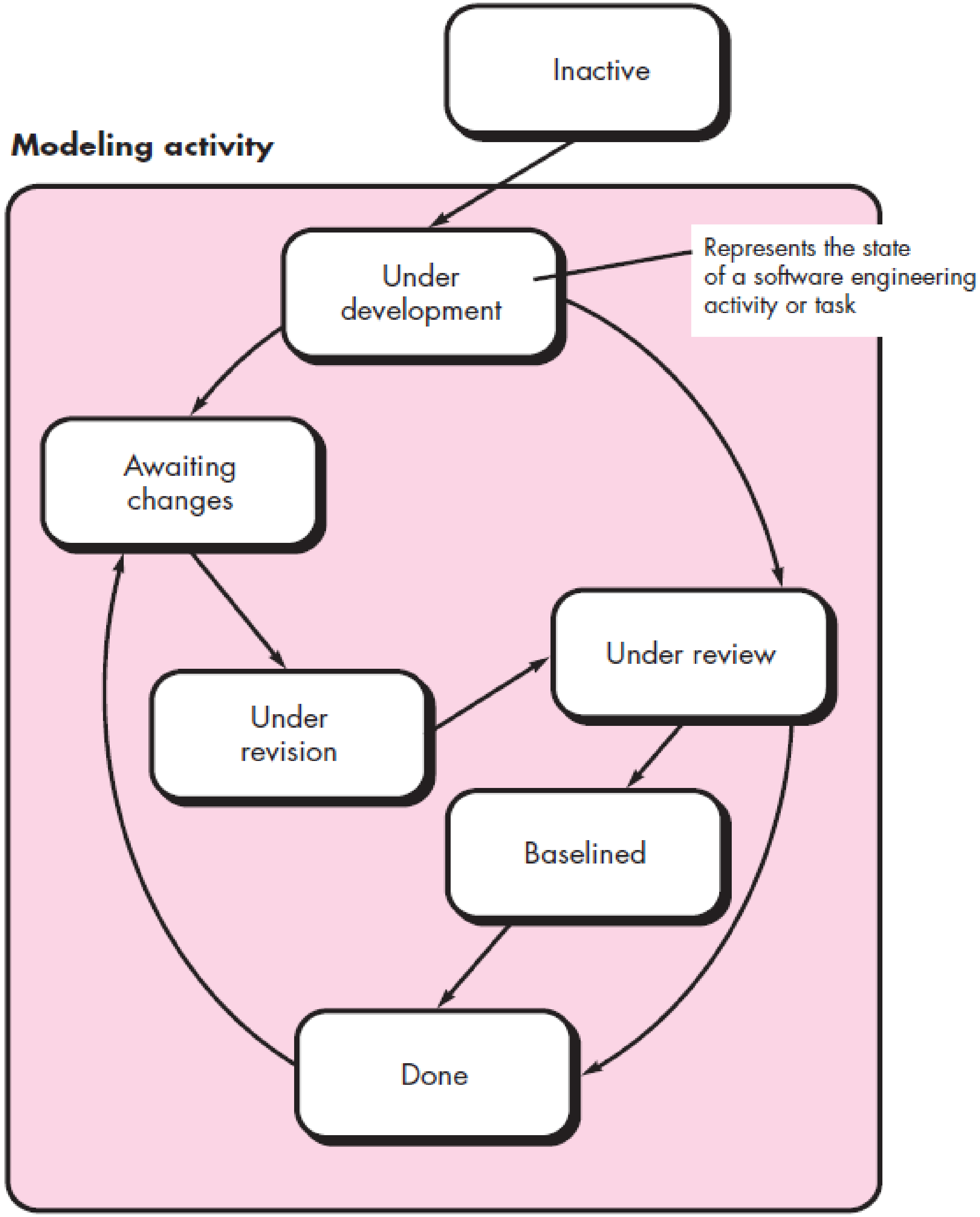
The Spiral Model - Drawbacks

- It may be difficult to convince customers (particularly in contract situations) that the evolutionary approach is controllable.
- It demands considerable risk assessment expertise and relies on this expertise for success.
- If a major risk is not uncovered and managed, problems will undoubtedly occur.

The Concurrent Development Model

- Sometimes called *concurrent engineering*
- Can be represented schematically as a series of framework activities, s/w engineering actions and tasks, and their associated states
- Defines a series of events that will trigger transitions from state to state for each of the s/w engineering activities, actions, or tasks
- Applicable to all types of s/w development
- Defines a network of activities
- Events generated at one point in the process network trigger transitions among the states

The Concurrent Development Model



Weaknesses of Evolutionary Process Models

- Uncertainty in the number of total cycles required
  - Most project management and estimation techniques are based on linear layouts of activities
- Do not establish the maximum speed of the evolution
- Software processes should be focused on flexibility and extensibility rather than on high quality, which sounds scary
  - However, we should prioritize the speed of the development over zero defects. **Why?**

Specialized Process Models

- Take on many of the characteristics of one or more of the conventional models
- Tend to be applied when a narrowly defined software engineering approach is chosen
- Examples:
  - Component-Based Development
  - The Formal Methods Model
  - Aspect-Oriented Software Development

Component-Based Development

- Commercial off-the-shelf (COTS) software components can be used
- Components should have well-defined interfaces
- Incorporates many of the characteristics of the spiral model
- Evolutionary in nature

Component-Based Development

- Candidate components should be identified first

- Components can be designed as either conventional software modules or object-oriented classes or packages of classes

The Formal Methods Model

- Encompasses a set of activities that leads to formal mathematical specification of computer software
- Have provision to apply a rigorous, mathematical notation
- Ambiguity, incompleteness, and inconsistency can be discovered and corrected more easily – not through *ad hoc* review, but through the application of mathematical analysis
- Offers the promise of **defect-free** software

The Formal Methods Model – Critical Issues

- The development of formal models is currently quite time-consuming and expensive
- Extensive training is required
- It is difficult to use the models as a communication mechanism for technically unsophisticated customers

- **Benefits of the Formal Process Model:**

1. **High Assurance:**
2. **Reduced Errors:**
3. **Rigorous Documentation:**
4. **Safety and Regulatory Compliance:**

Aspect-Oriented Software Development (AOSD)

- Certain “concerns” – customer required properties or areas of technical interest – span the entire s/w architecture
- Example “concerns”
  - Security
  - Fault Tolerance
  - Task synchronization
  - Memory Management
- When concerns cut across multiple system functions, features, and information, they are often referred to as *crosscutting concerns*

Aspect-Oriented Software Development (AOSD)

- *Aspectual requirements* define those crosscutting concerns that have impact across the s/w architecture

- AOSD or AOP (Aspect-Oriented Programming) provides a process and methodological approach for defining, specifying, designing, and constructing aspects – “mechanisms beyond subroutines and inheritance for localizing the expression of a crosscutting concern”

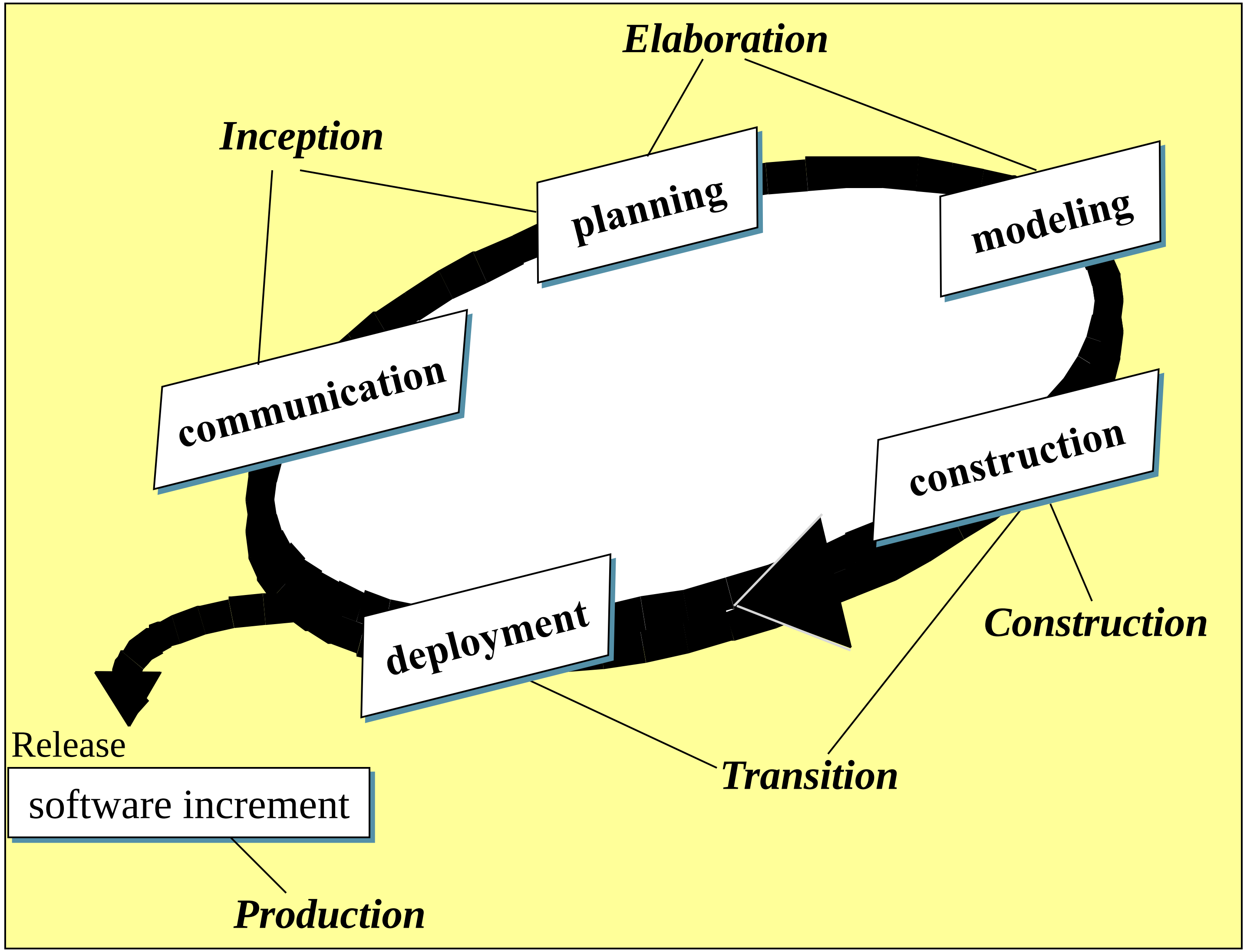
- A distinct aspect-oriented process has not yet matured

- It is likely that AOSD will adopt characteristics of both the spiral and concurrent process models

The Unified Process (UP)

- It is a use-case driven, architecture-centric, iterative and incremental software process
- UP is an attempt to draw on the best features and characteristics of conventional s/w process models
- Also implements many of the best principles of **agile software development**
- UP is a framework for object-oriented software engineering using UML (Unified Modeling Language)

Phases of the Unified Process



Phases of UP - Inception

- Encompasses both customer communication and planning activities

- Fundamental business requirements are described through a set of preliminary use-cases
  - A **use-case** describes a sequence of actions that are performed by an actor (e.g., a person, a machine, another system) as the actor interacts with the software

- A rough architecture for the system is also proposed

Phases of UP - Elaboration

- Encompasses customer communication and modeling activities
- Refines and expands the preliminary use-cases
- Expands the architectural representation to include five different views of the software
  - The use-case model
  - The analysis model
  - The design model
  - The implementation model
  - The deployment model
- In some cases, elaboration creates an "executable architectural baseline" that represents a "first cut" executable system

Phases of UP - Construction

- Makes each use-case operational for end-users
- As components are being implemented, **unit tests** are designed and executed for each
- Integration activities (component assembly and **integration testing**) are conducted
- Use-cases are used to derive a suite of **acceptance tests**

Phases of UP - Transition

- Software is given to end-users for **beta testing**

- The software team creates the necessary support information –
  - User manuals
  - Trouble-shooting guides
  - Installation procedures

- At the conclusion of the transition phase, the software increment becomes a usable software release

Phases of UP - Production

- Coincides with the deployment activity of the generic process
- The on-going use of the software is monitored
- Support for the operating environment (infrastructure) is provided
- Defect reports and requests for changes are submitted and evaluated

Unified Process Work Products

- Inception
  - Vision document
  - Initial use-case model
- Elaboration
  - Analysis model, design model
- Construction
  - Implementation model, deployment model, test model
- Transition
  - Delivered software, beta test reports, general user feedback

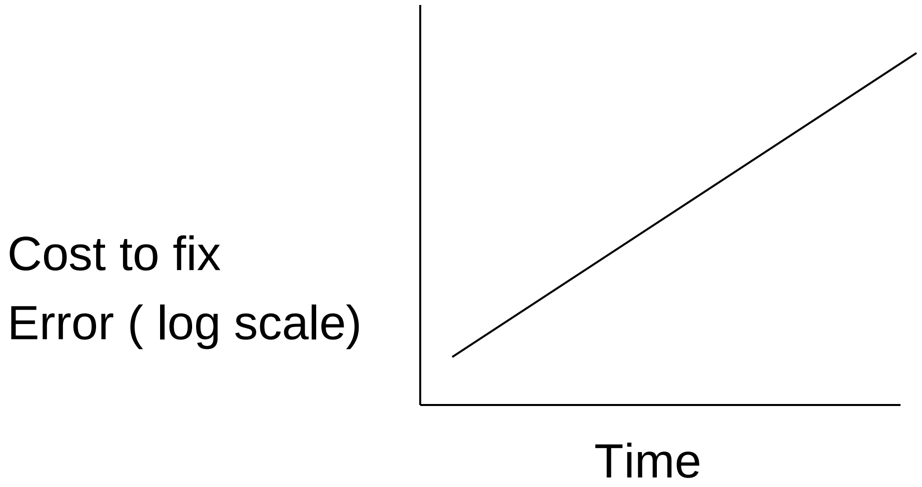
Distribution of effort…

- How programmers spend their time
  - Typing programs 13%
  - Searching and Reading programs 16%
  - Job communication 32%
  - Others 39%
- Programmers spend more time in reading programs than in writing them.
- Writing programs is a small part of their lives.

Defects

- Distribution of error occurrences by phase is
  - Req. - 20%
  - Design - 30%
  - Coding - 50%
- Defects can be injected at any of the major phases.
- Cost of latency: Cost of defect removal increases exponentially with latency time.

Defects…



- Cheapest way to detect and remove defects close to where it is injected.
- Hence must check for defects after every phase.

Factors to be considered for Software Development

- User Satisfaction
- Time
- Quality factors
- Adaptable for changes
- Risk Management
- Evolution