Software engineering: Architecture-driven Development

Richard Schmidt
Sirrush Corporation
703-919-8531

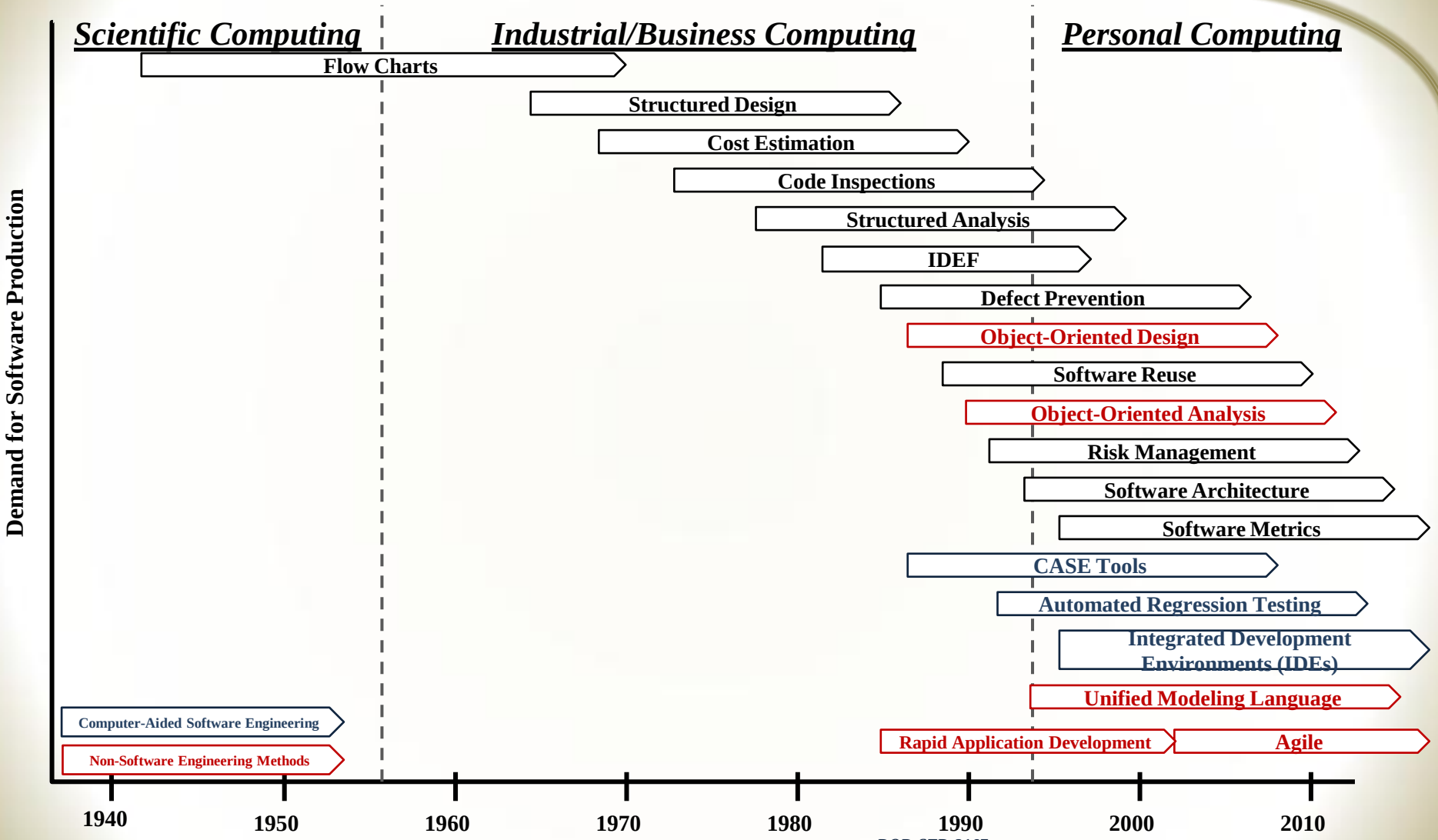
NDIA 15th Annual Systems Engineering Conference
Hyatt Regency Mission Bay
San Diego, California
October 24

Appears in the work Software Engineering, Architecture-Driven Development, published by Morgan Kaufmann, an imprint of Elsevier, Inc.

Overview

- Software Development *CHAOS*
- What is a Software Architecture
- How is a Software Architecture Developed
- Software Engineering Practices
- Software Architecture Design Strategy
- Relationship to Other Software Methodologies

Software Development Trends



Short History of Software Methods, By David F. Rico

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Chaos Reports

In the United States, we spend more than $250 billion each year on IT application development of approximately 175,000 projects. The average cost of a development project for a large company is $2,322,000; for a medium company, it is $1,331,000; and for a small company, it is $434,000. A great many of these projects will fail. Software development projects are in chaos, and we can no longer imitate the three monkeys -- hear no failures, see no failures, speak no failures.

	1994	1996	1998	2000	2002	2004	2006	2009
Successful	16%	27%	26%	28%	34%	29%	35%	32%
Challenged	53%	33%	46%	49%	51%	53%	46%	44%
Failed	31%	40%	28%	23%	15%	18%	19%	24%

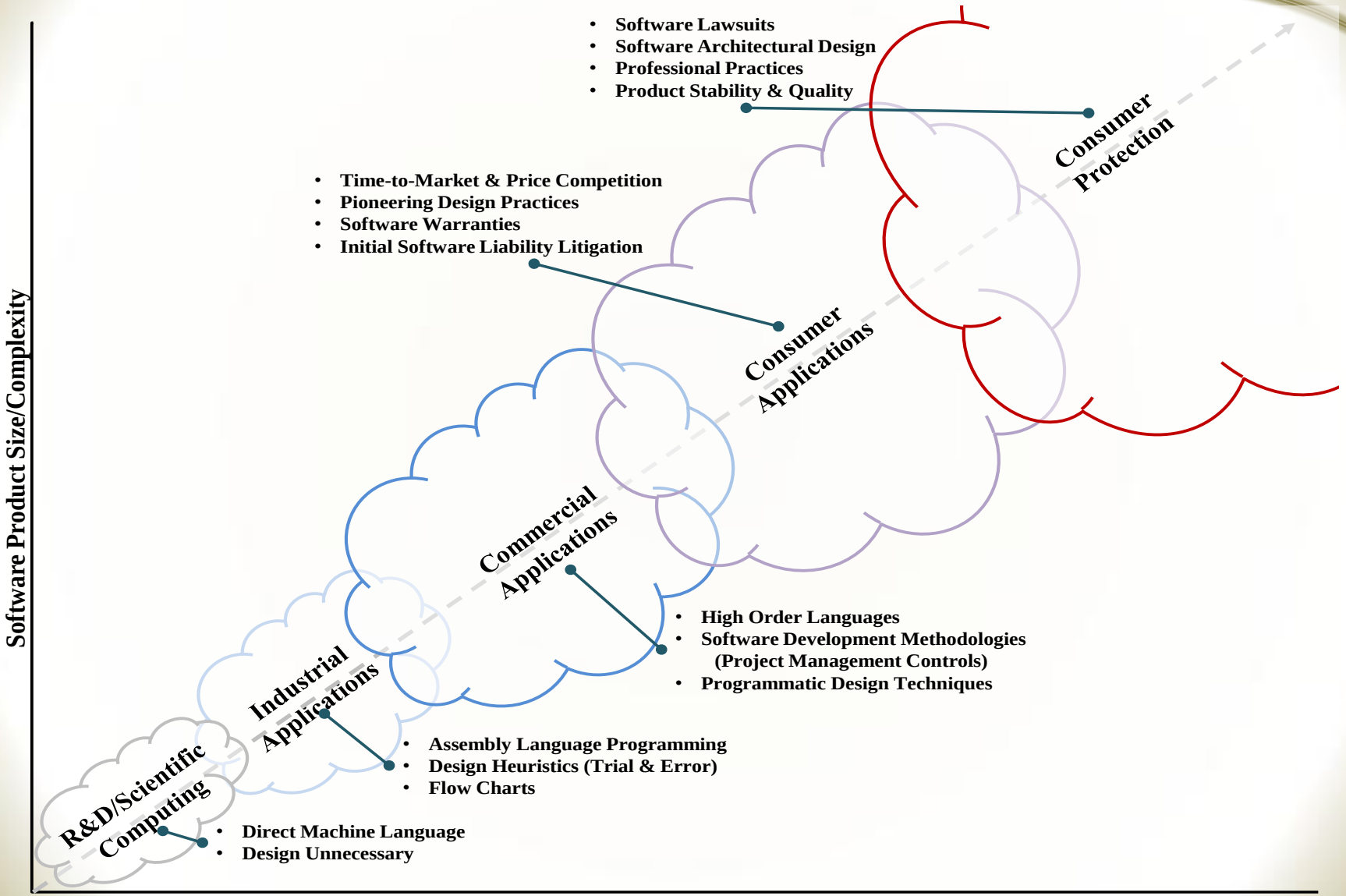
When a bridge falls down, it is investigated and a report is written on the cause of the failure. This is not so in the computer industry where failures are covered up, ignored, and/or rationalized. As a result, we keep making the same mistakes over and over again.

CHAOS, The Standish Group Report, 1995

Why Such CHAOS?

- Computer technology's rapid transition into Industrial, Commercial & Consumer systems/products
- Majority of Software R&D
  - Initially Programming Language focused (1950-1985)
  - Programming productivity focused (1985-2010)
- Software development project management emphasis on documentation
  - Inadequate design methodologies
  - Software Professional untrained in "product" design
- Software workforce demand exceeded availability of skilled professionals
- Variety of software application domains
- No sponsored research to establish formal software design practices

Software As a Critical Material



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Applying Systems Engineering Practices

"The Government's present system for procuring software does not meet the Government's needs and wastes resources. The application of **"systems engineering"** disciplines is needed to remedy the procurement system's defects. . . Software Development is a complex process that requires modern **"systems engineering"** techniques."

Bugs In The Program,
Problems in Federal Government Computer Software Development and Regulation,
Staff Study by the Subcommittee on Investigations and Oversight,
Congress, September 1989

What are **"systems engineering"** disciplines ?

How can **"systems engineering"** be adapted to development of software product?

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What is Architecture-driven Development?

- Establishing a Requirements Baseline
  - Balance the needs and expectations of all stakeholders
  - Provides a basis for *DESIGNING* the software product
  - Establishes the basis for software acceptance testing
- Establishment of a comprehensive software product design
  - Functional basis for ensuring product performance
  - Structural basis for software implementation
- Software Post-development Processes Specifications
- Full traceability throughout the software architecture
  - Software Specifications, Functional Specifications, Physical Specifications
- Basis for continual planning and resource allocation
- Architectural Design Decisions
  - Risk-based decision-making
  - Focus on project success criteria

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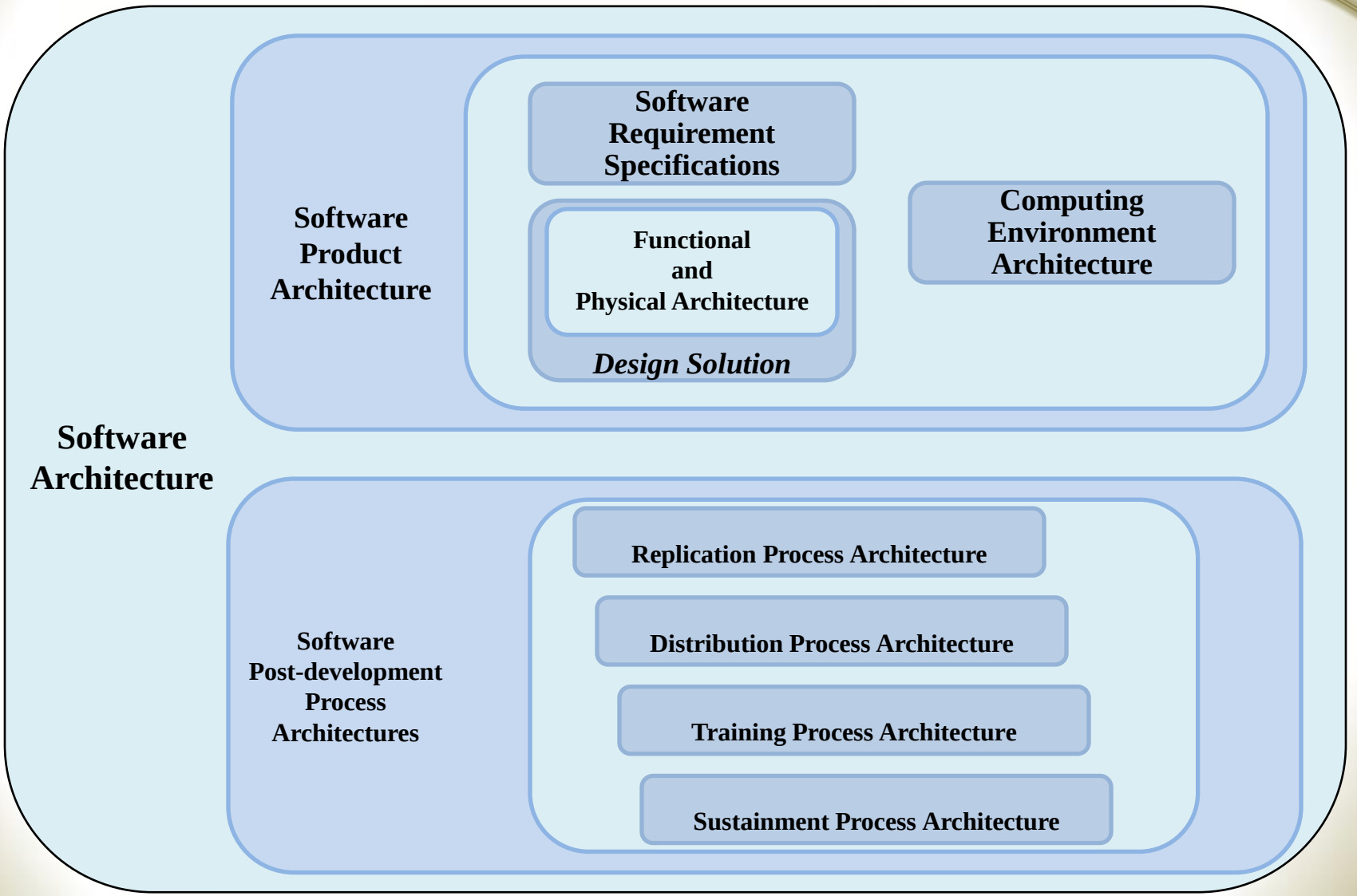
Software Architecture



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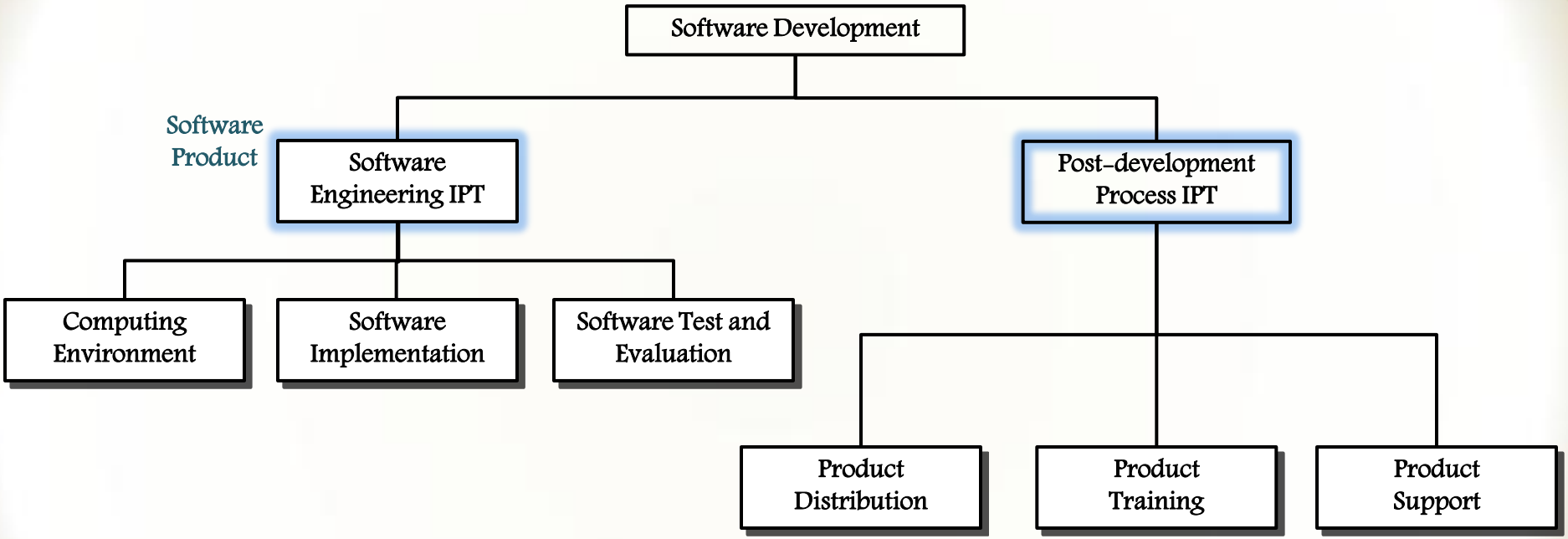
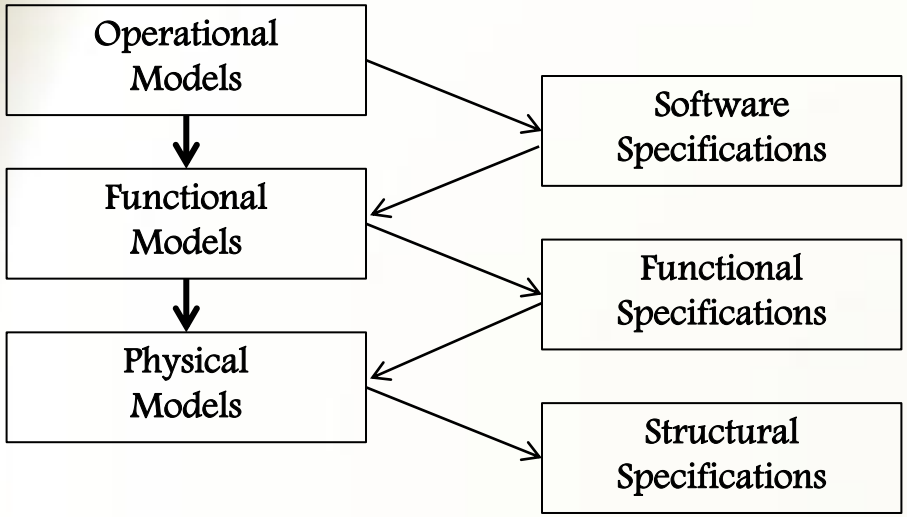
Organizing for Software Engineering



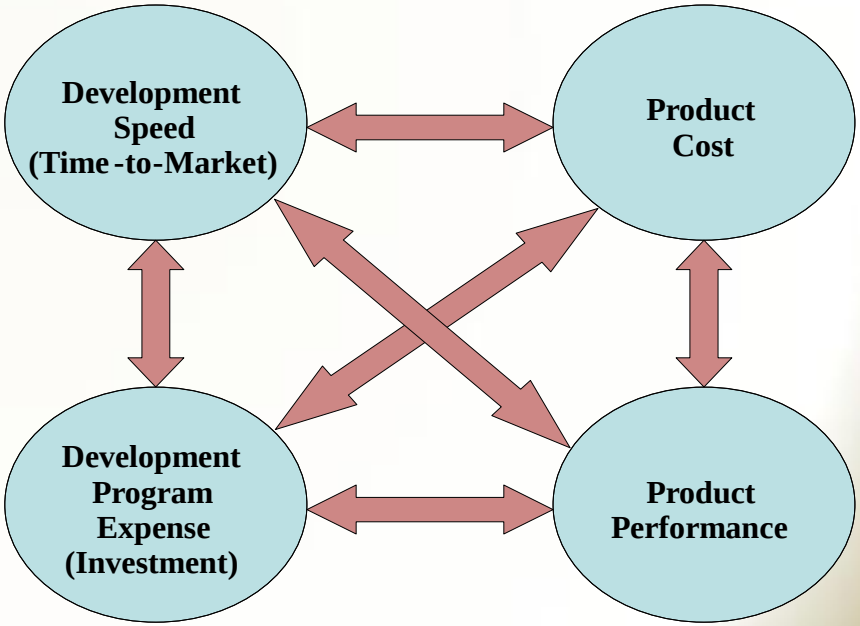
Value of Software Architecture

Provides specifications for every software module, routine or class



Objective architectural decision-making

- Project objectives
- Resource constraints
- Technical challenges
- Risk aware



Basis for Technical and Project Planning

- Software Breakdown Structure
- Work Packages & Dependencies
- Resource Allocations
- Integrated Technical Planning
- Integrated project Planning

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Developing The Software Architecture

- Business Needs and Expectations
- Operational Concepts

Requirements Baseline

Software Requirements Analysis

- Operational Model
- Software Requirement Specifications

Functional Analysis and Allocation

Software Analysis
- Trade-off Analysis
- Risk Assessment
- Complexity Assessment

Functional Architecture

- Functional Behavior Model
- Functional Hierarchy
- Functional Specifications

Software Design Synthesis

Physical Architecture

- Structural Unit Specifications
- Structural Component Specifications
- Component Integration Strategy

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Design Decisions

- It's not the *Decision* that matters – It's the **Rationale**
- **Decision** implies a choice among multiple alternatives
- The important architectural decisions affect software product life-cycle characteristics:
  - Complexity
  - Supportability
  - Extensibility
  - Usability
  - Product Life-cycle Costs
- Architectural Decisions must align technical scope of work with availability of project resources

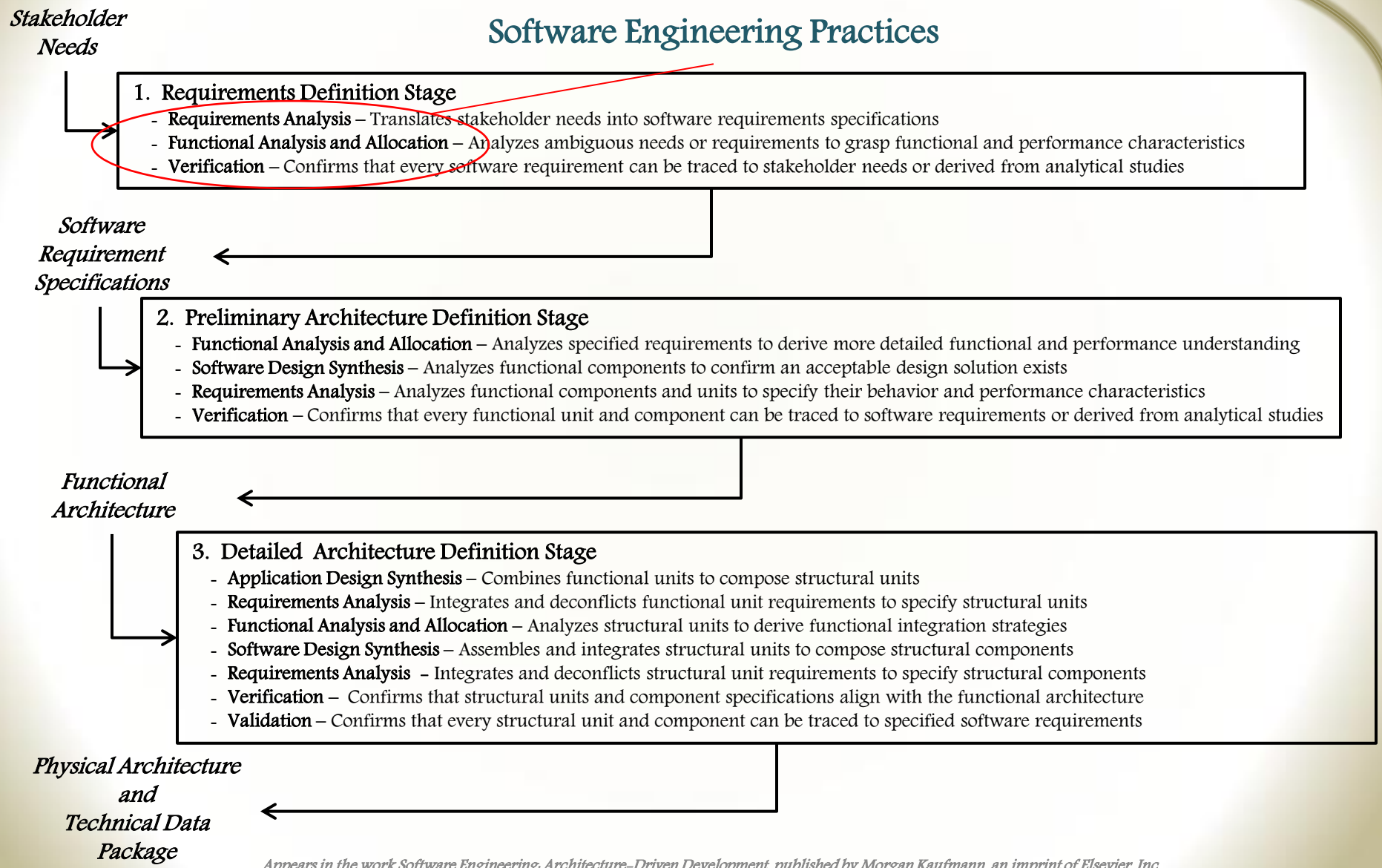
Technical Imperatives

Project Objectives

Technical and Project Risks

- Software development is a technical effort
- All technical challenges impact project feasibility
- All risk to a software development project is technical in nature
  - Insufficient resources should imply a less robust software product
  - Complexity must be simplified
  - Over-stated requirement must be challenged
- Software prototyping should be used to assess technical solution feasibility
  - Never put a prototype on the *CRITICAL PATH*

Deriving the Software Architecture



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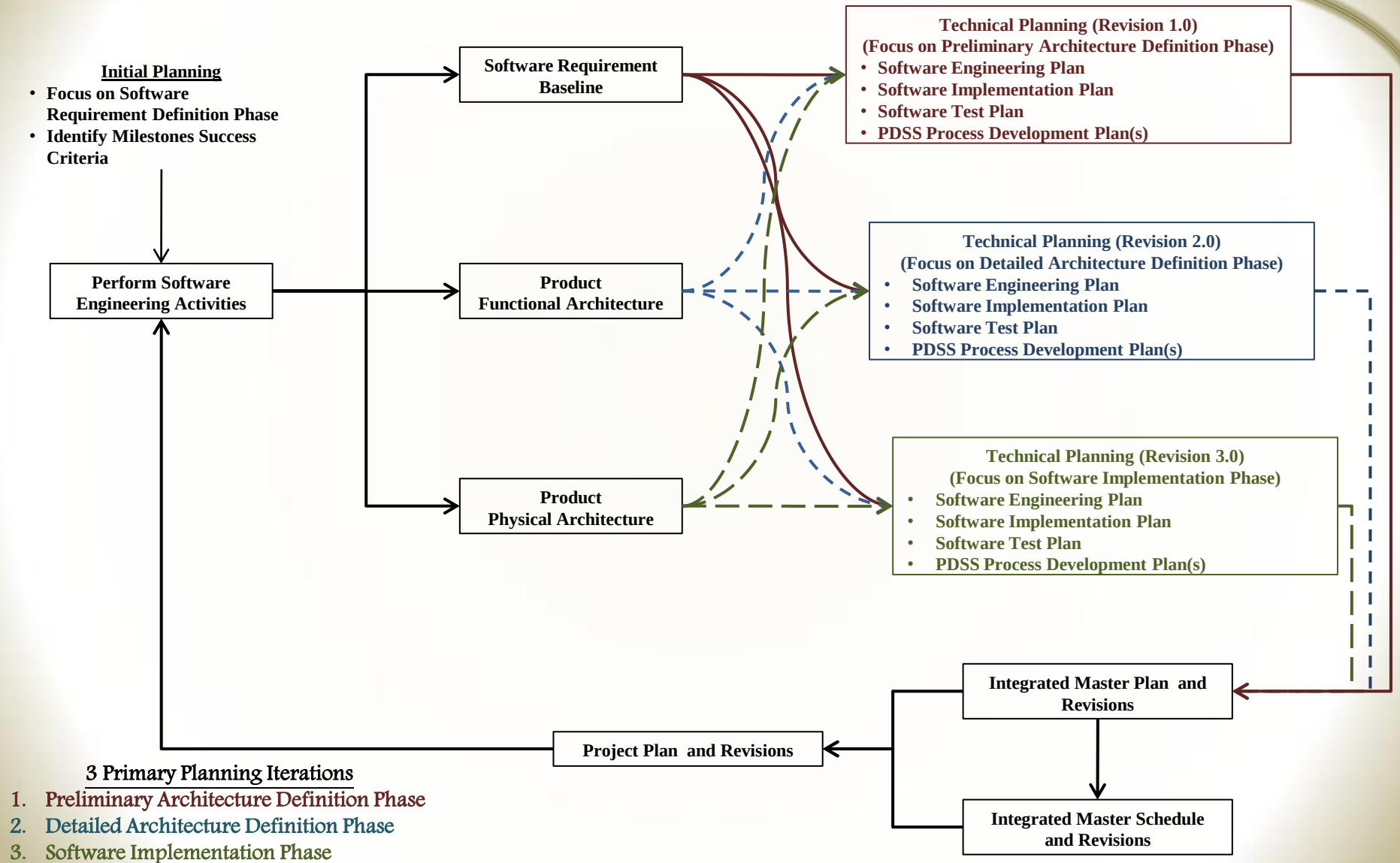
Planning the Software Engineering Effort



3 Primary Planning Iterations

1. Preliminary Architecture Definition Phase
2. Detailed Architecture Definition Phase
3. Software Implementation Phase

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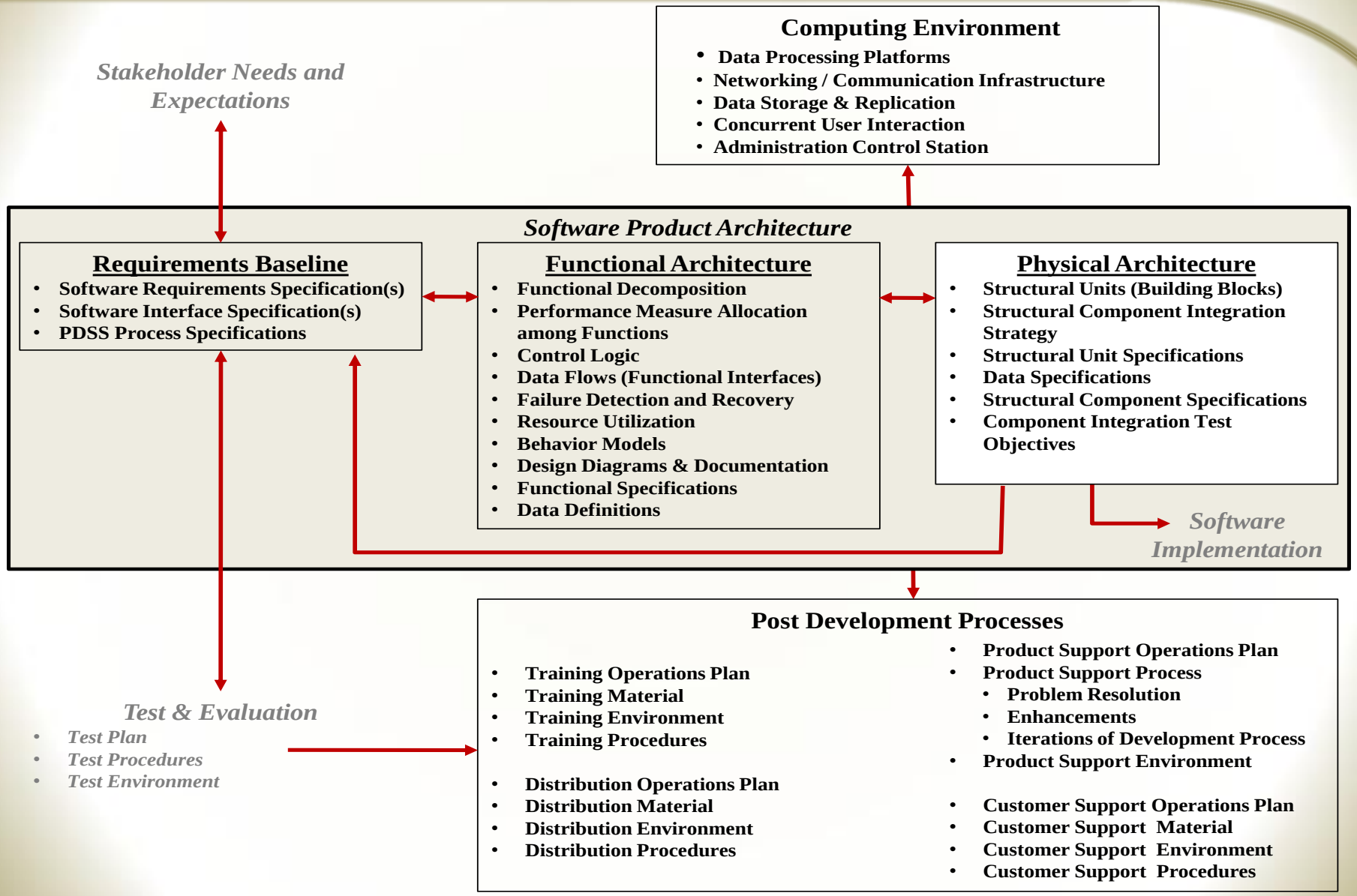
Elements of Software Architecture



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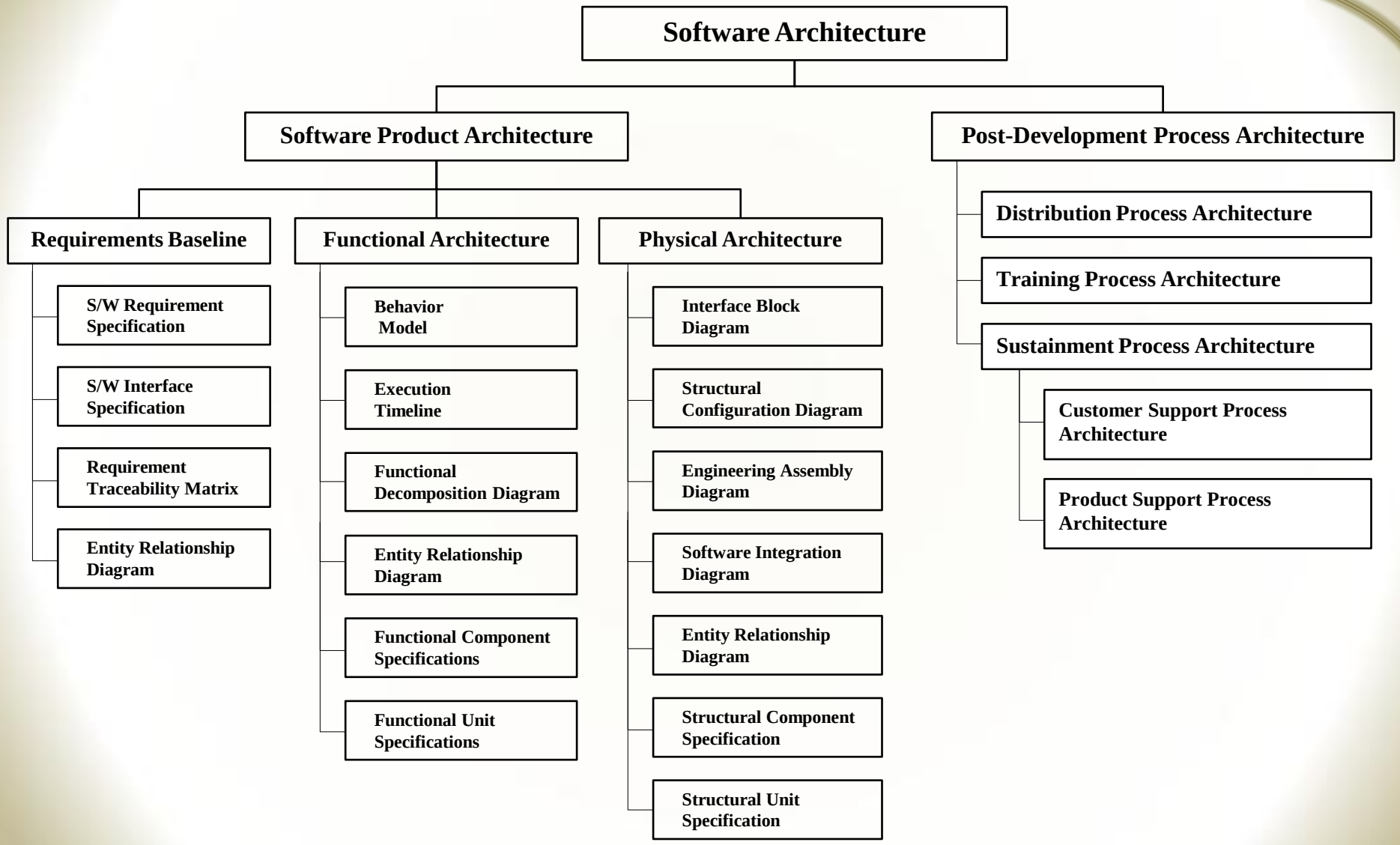
Artifacts of Software Architecture



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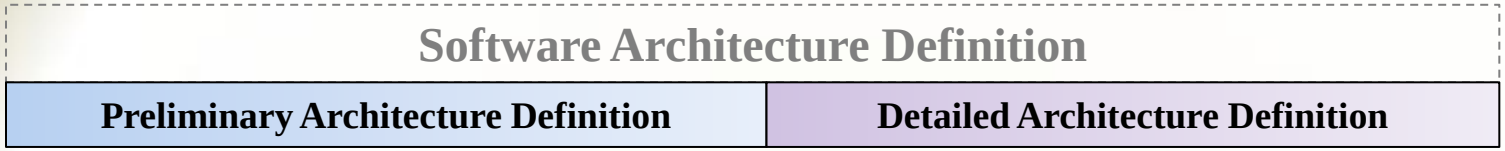
Software Architecture Definition



PDR
Preliminary Design Review

CDR
Critical Design Review

Products of Preliminary Architecture Definition:

- Behavior Model (Data Processing Transactions)
- Functional Hierarchy
- Conceptual Design Structure
- Functional Component Specifications
- Functional Unit Specifications
- Database Transaction Specifications
- Interface Transaction Specifications (Protocols & Messaging)
- User Interface Functional Hierarchy

Products of Critical Architecture Definition:

- Structural Unit Specifications
- Software Integration Strategy
- Structural Component Specifications (Integrated Behaviors)
- Interface Design Documents
- Structural Block Diagrams
- Structural Interface
- User Interface Structural Hierarchy

- **Preliminary Functional Architecture**
- **Initial Structural Design Concept**
- **Preliminary Test Procedures**
- **Updated Requirement Traceability Matrix**

- **Revised Functional Architecture**
- **Completed Physical Architecture**
- **Initial GUI Structural Design**
- **Detailed Test Procedures**
- **Updated Requirement Traceability Matrix**

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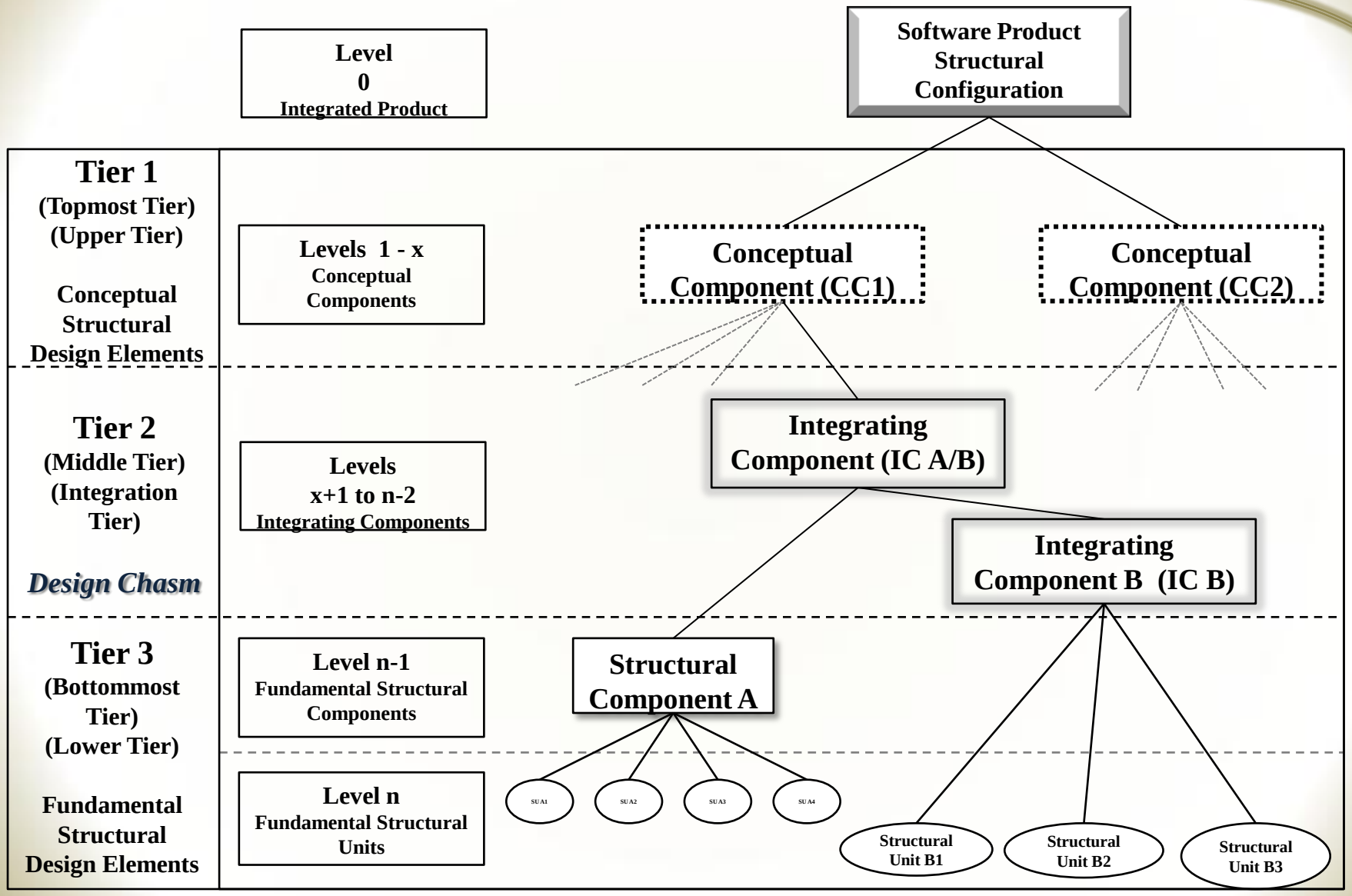
Software Design Chasm



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Software Product Performance

Software Architecture Definition		Software Implementation	
Preliminary Architecture Definition	**Detailed Architecture Definition**	**Unit Implementation**	**Component Integration & Testing**
Establish resource utilization functional specifications: • Allocate resources among functions • Identify resource supervision behaviors	**Establish resource utilization structural specifications:** • Behavioral thread profiles • Structural component specification • Structural unit specification (if desired) • Identify engineering assembly resource utilization stub specifications	**Implement resource utilization requirements:** • Design units with efficient object creation & destruction mechanisms • Implement connection & object pools	**Assess resource utilization :** • Design units with efficient object creation & destruction mechanisms • Implement connection & object pools

Establish the computing resource utilization strategy

- Software design and coding guidelines
- Identify task prioritization strategy
- Identify multi-tasking scheduling strategy
- Identify garbage collection strategy
- Identify resource queuing strategy

Measure computing resource utilization

- Software unit resource consumption and conservation (average & worst-case)
- Integrated component resource consumption and conservation
- Integrated product consumption and conservation

Software performance is predicated on the performance of the Computing Environment

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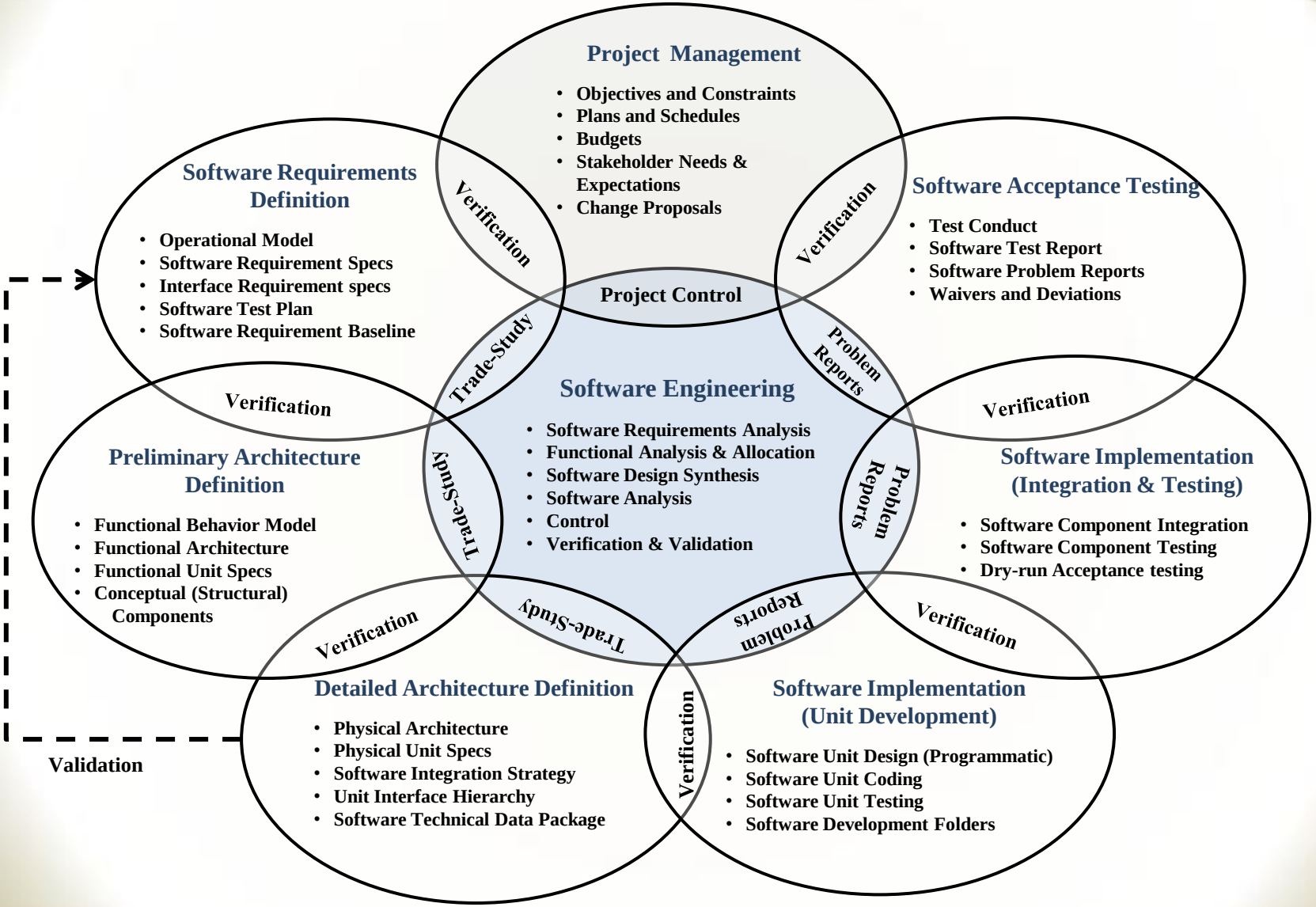
Software Engineering Practices



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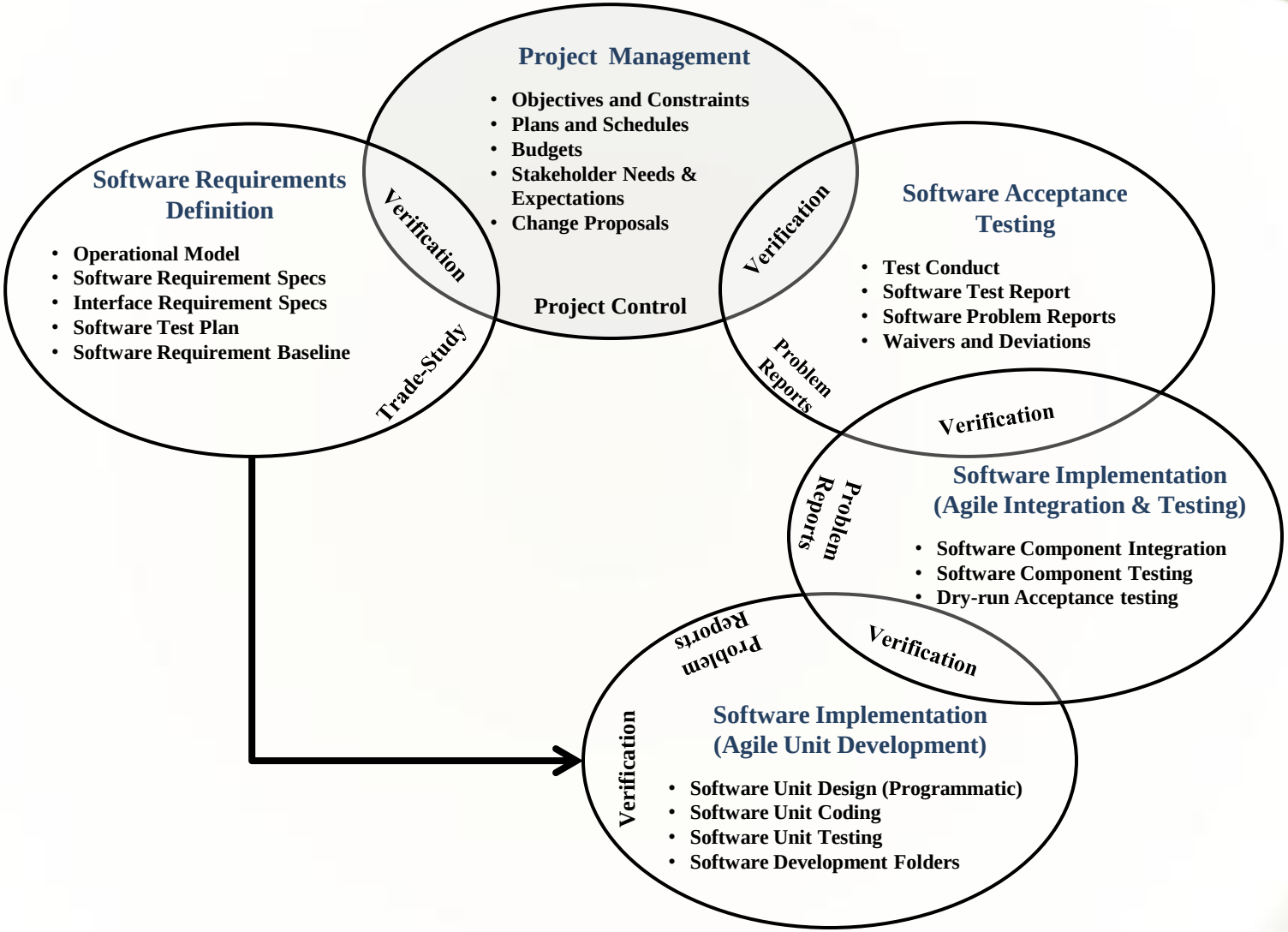

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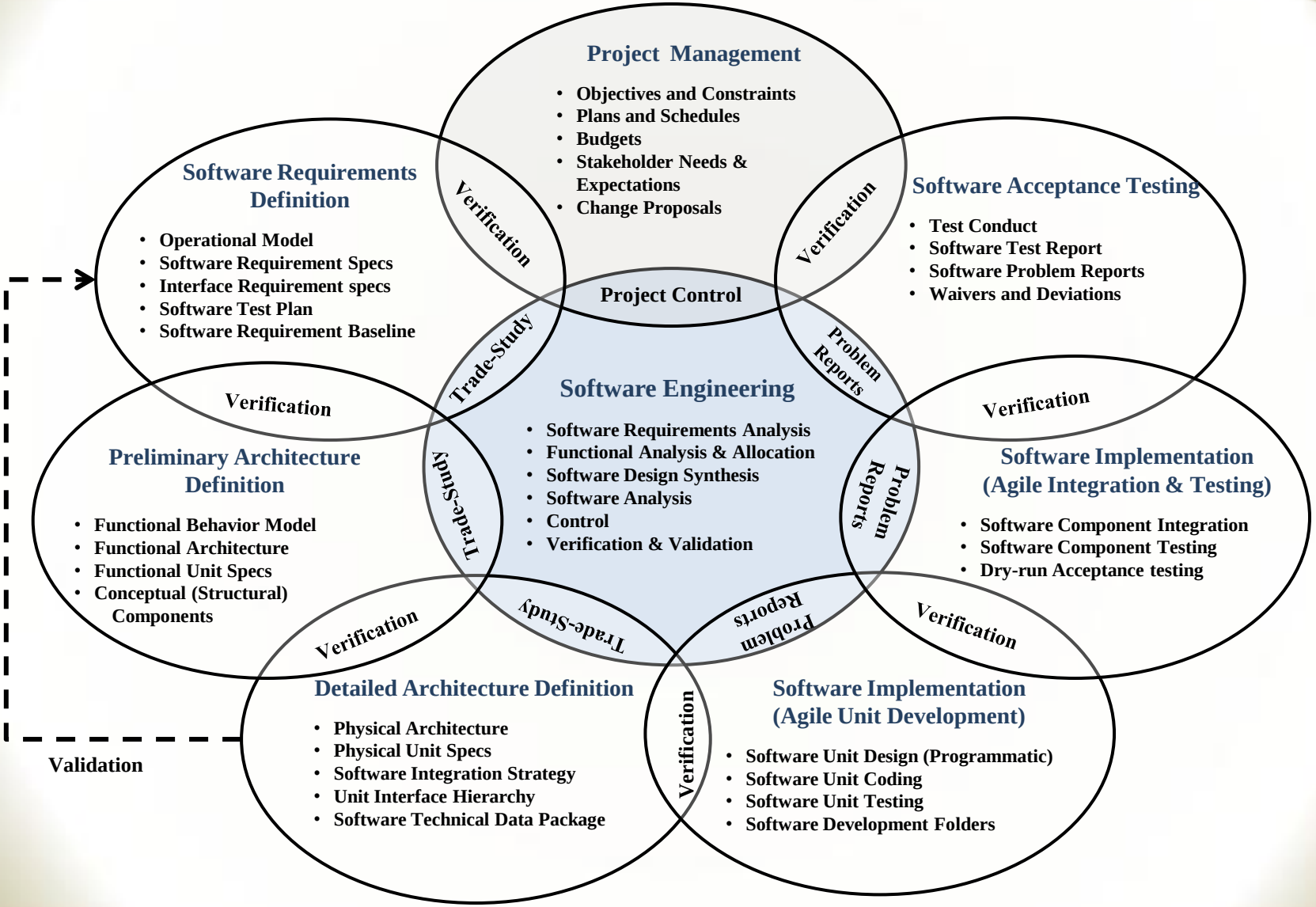
Architecture-driven Software Development



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Summary

- Software Industry is in CHAOS
- Computer technology's rapid growth and employment have prevented software engineering practices from arising
- Software Product Complexity must be corralled
- Application of Systems Engineering Practices is a viable solution
- Architecture-driven approach improves Software Development Probability of Project Success
- Software Functional Decomposition must be complete to enable a bottom-up structural design solution
- Software Methodologies rely on Programmatic Design & Coding (Prototyping) – Hence CHAOS!
- Software Engineering is the little brother of Systems Engineering
  - Software as a "material" offers unique challenges!

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