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Systemic Design Engineering

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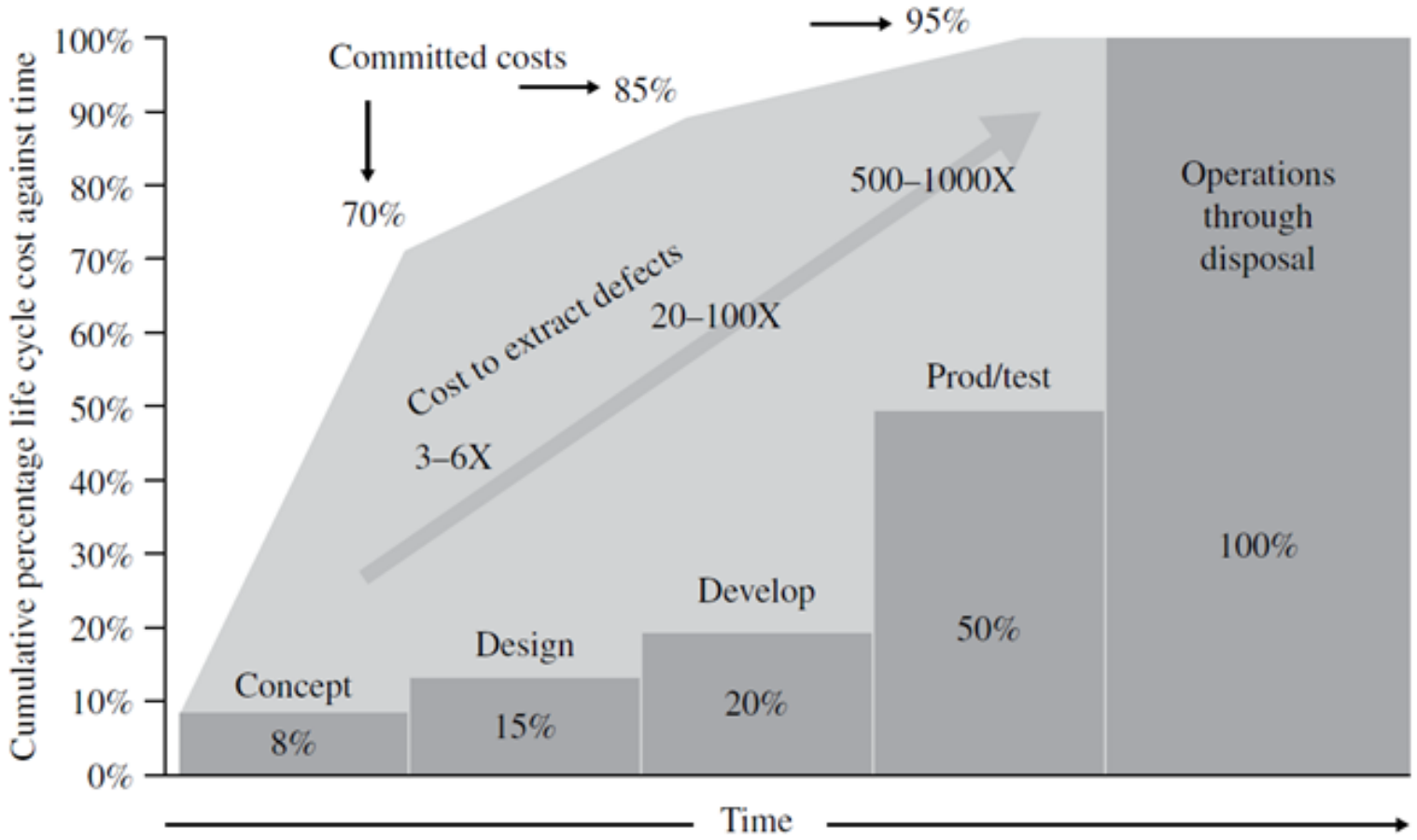
Outline

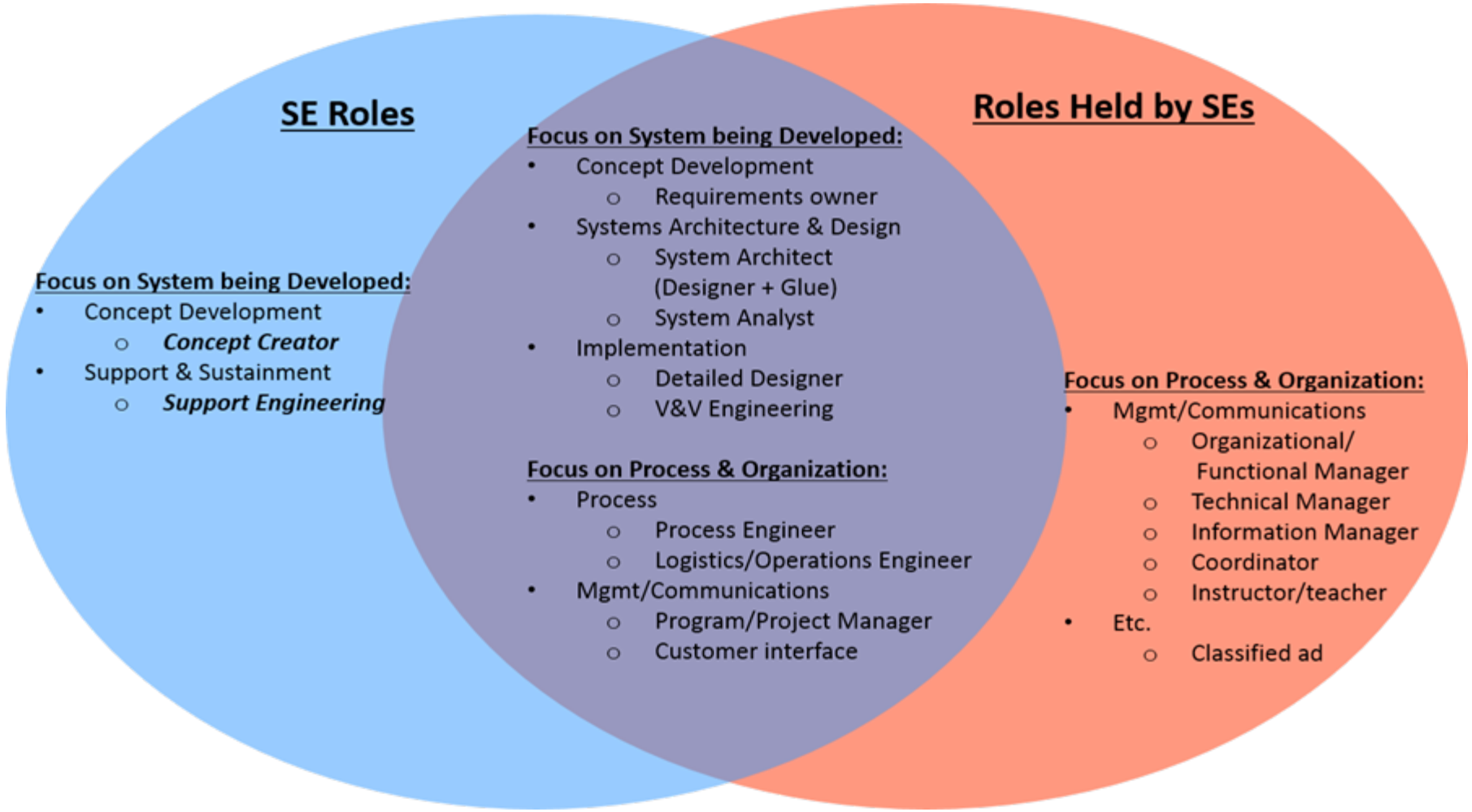
- Motivation for “Design” Emphasis
- Existing Design Paradigms
- Systemic Design Engineering (SDE)
- SDE Educational Example
- Summary


MOTIVATION
inspiration
desire
action
dream
goals
success
wish
incentive
ambition
innovation
drive
hunt
$
dreams
motivation
goal

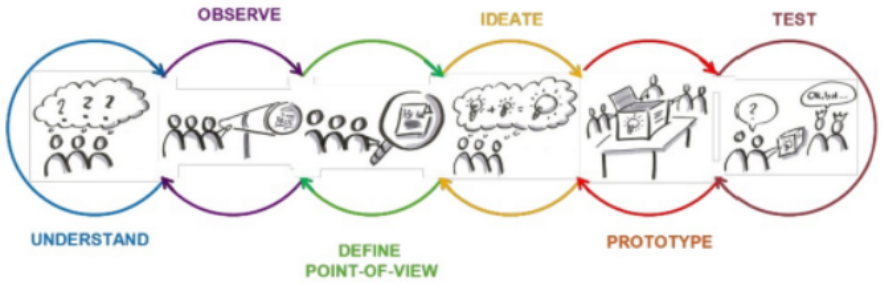
Importance of Design



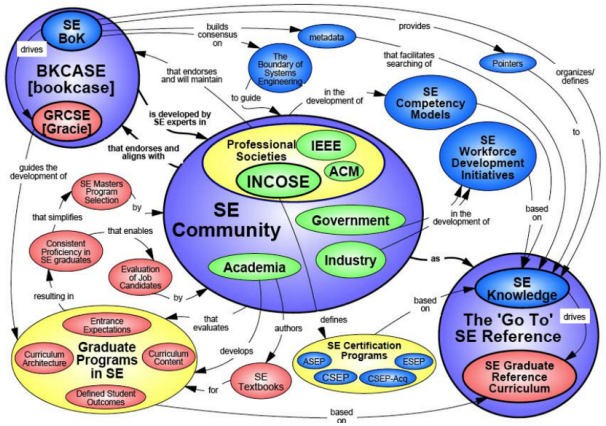
SE Roles


SE Roles
Focus on System being Developed:
• Concept Development
o Concept Creator
• Support & Sustainment
o Support Engineering
Focus on System being Developed:
• Concept Development
o Requirements owner
• Systems Architecture & Design
o System Architect (Designer + Glue)
o System Analyst
• Implementation
o Detailed Designer
o V&V Engineering
Focus on Process & Organization:
• Process
o Process Engineer
o Logistics/Operations Engineer
• Mgmt/Communications
o Program/Project Manager
o Customer interface
Roles Held by SEs
Focus on Process & Organization:
• Mgmt/Communications
o Organizational/ Functional Manager
o Technical Manager
o Information Manager
o Coordinator
o Instructor/teacher
• Etc.
o Classified ad

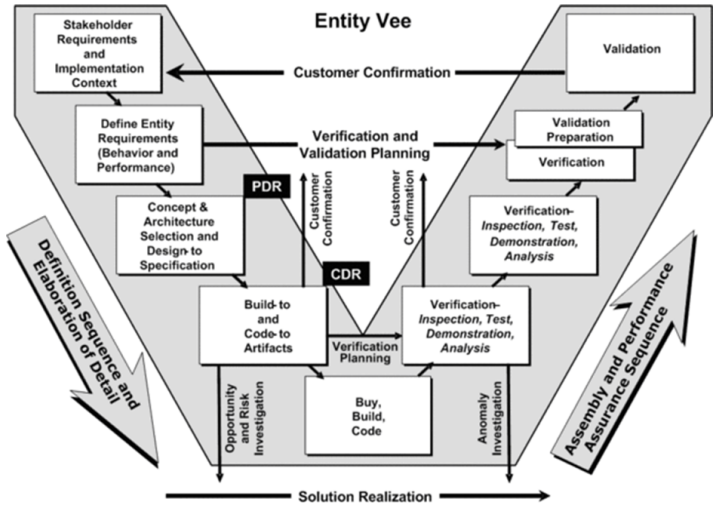
Existing Paradigms



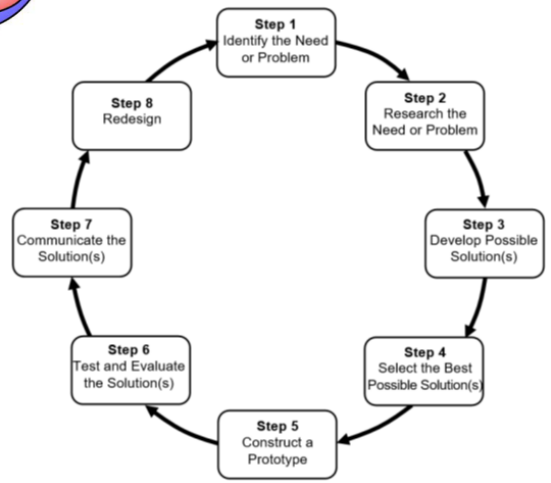
Design Thinking



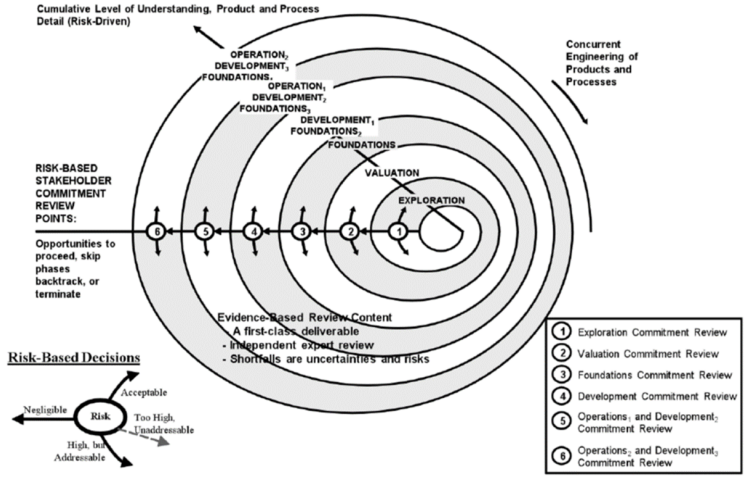
Systems Thinking



Systems Engineering

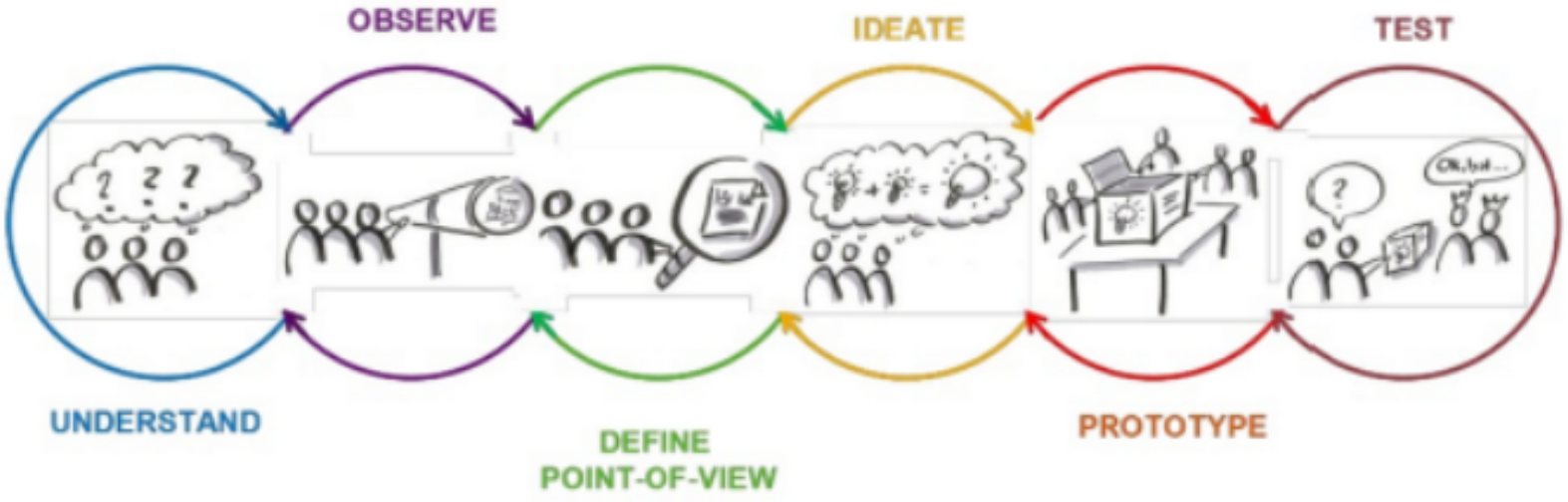


Engineering Design

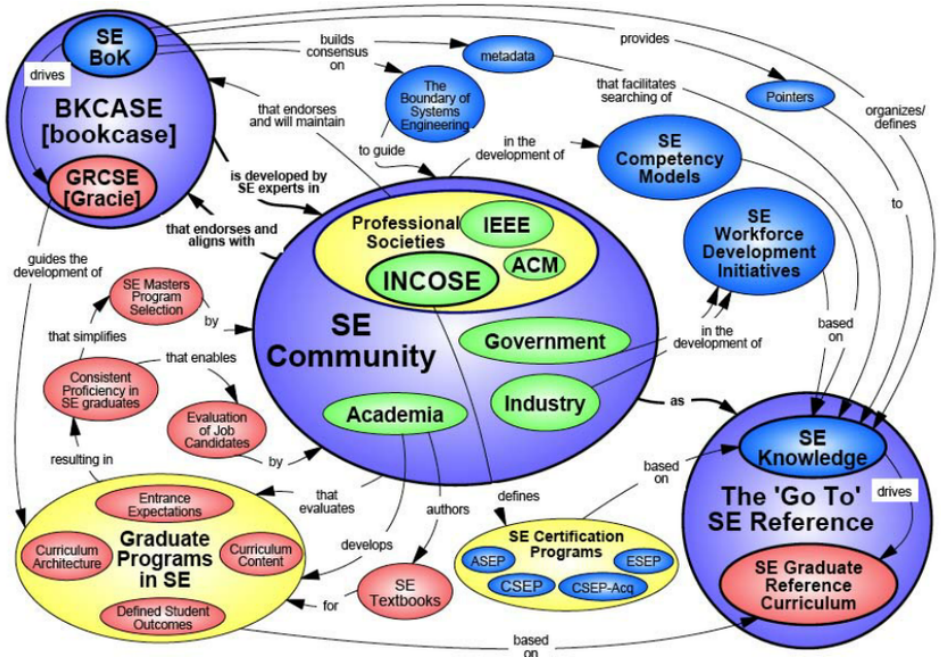


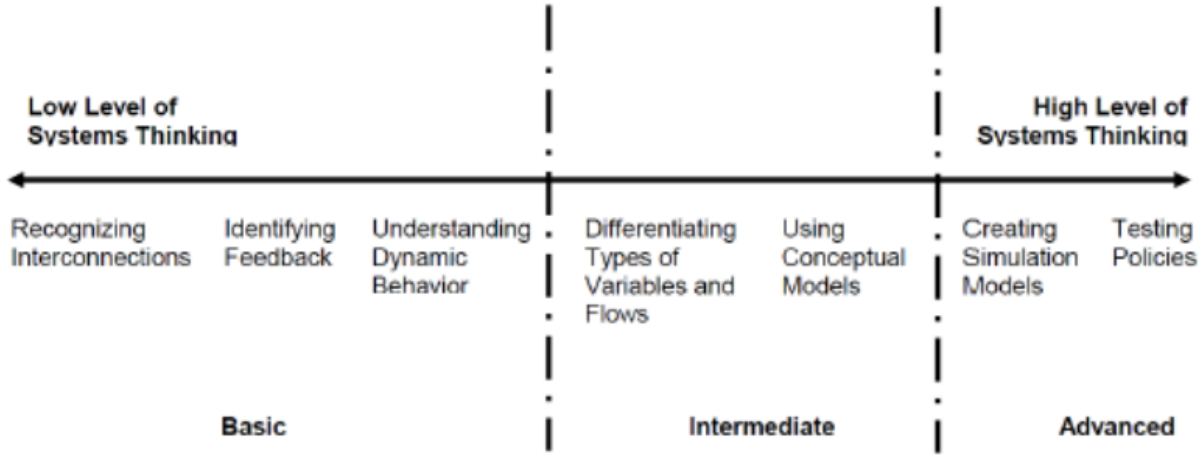
Agile/Software Engineering

Design Thinking

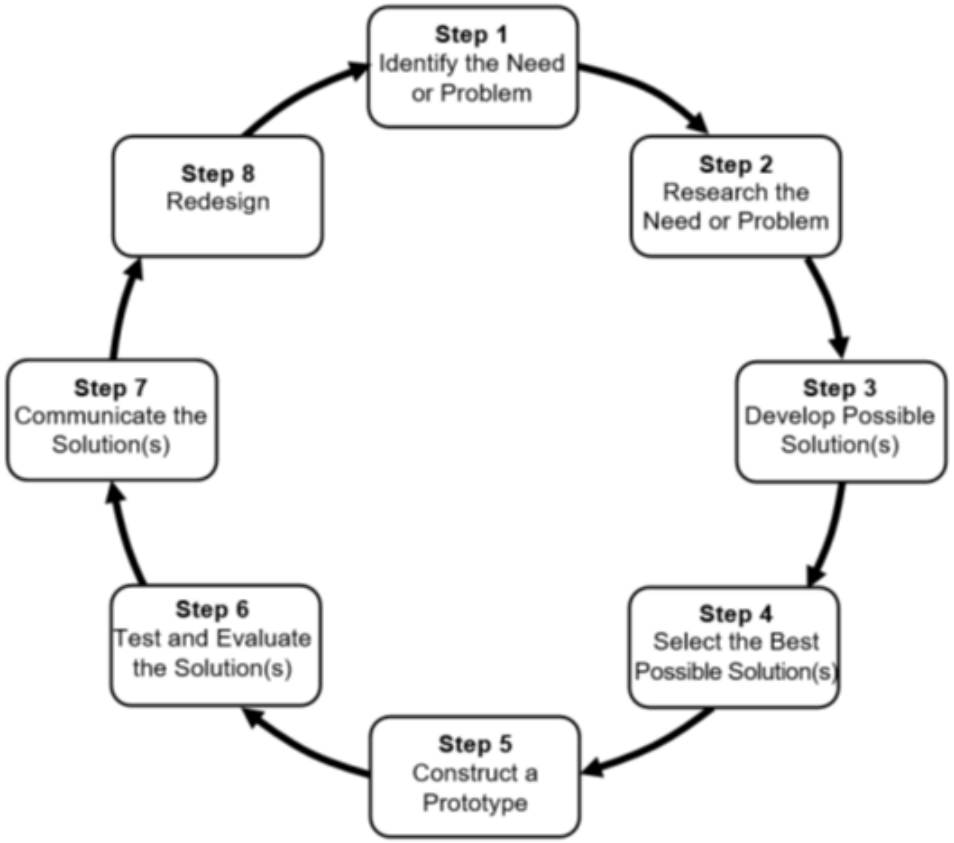


Systems Thinking

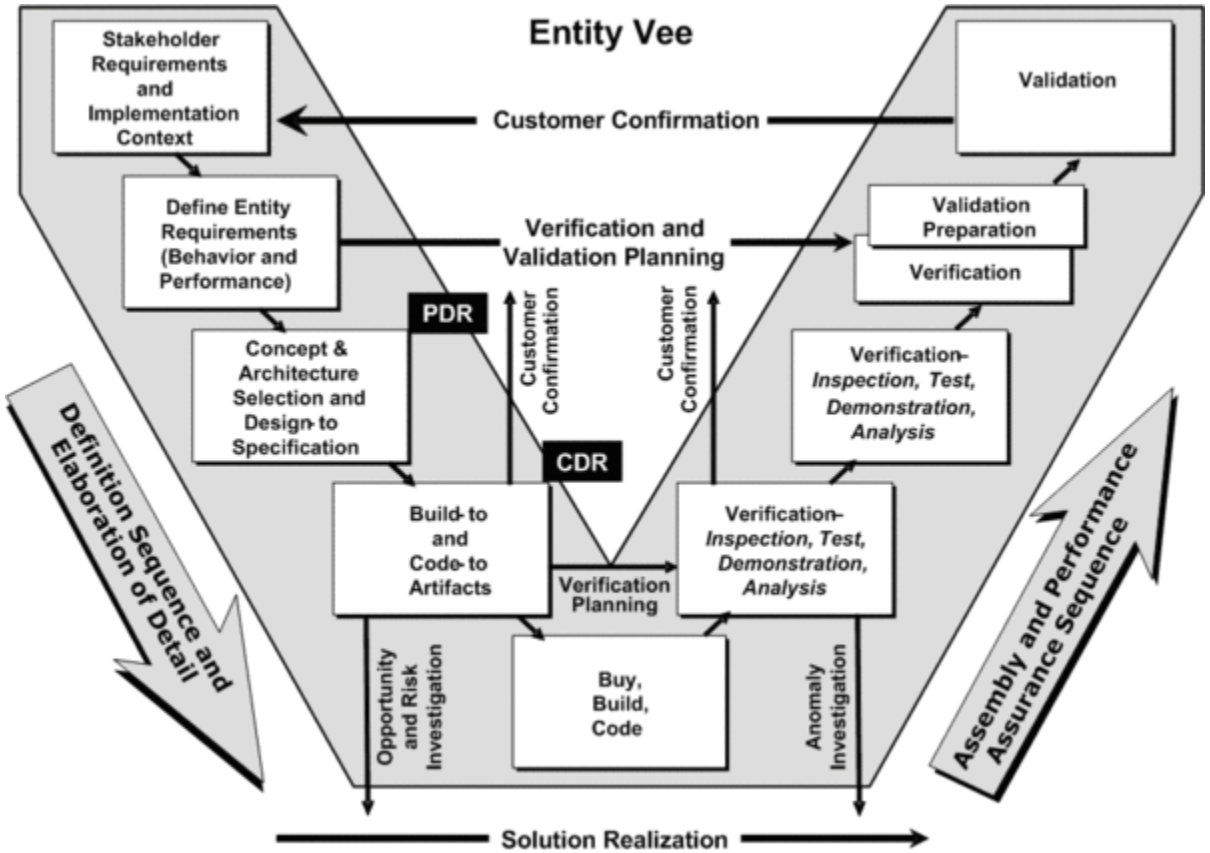




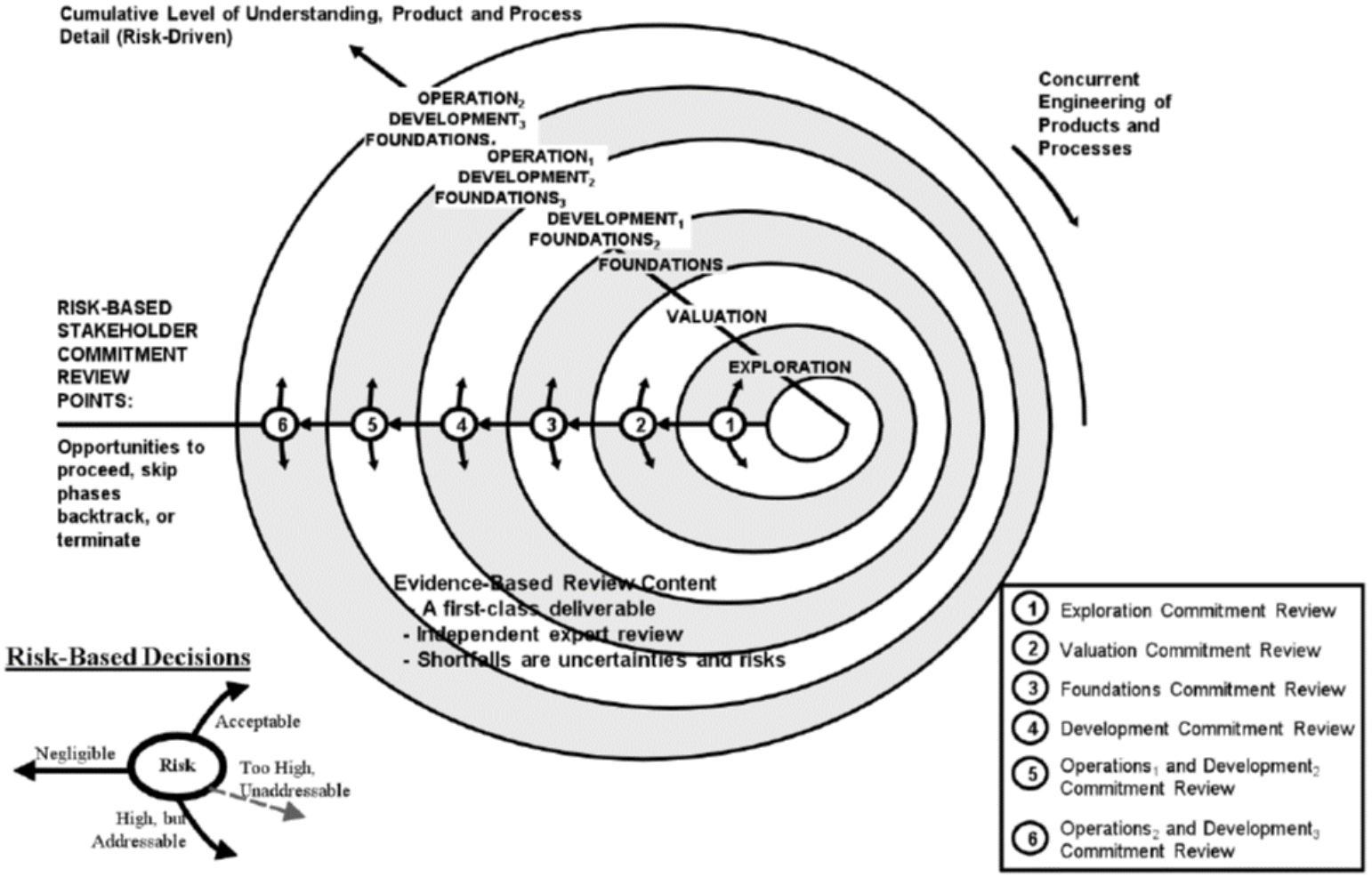
Engineering Design



Systems Engineering



Agile Systems/Software Engineering



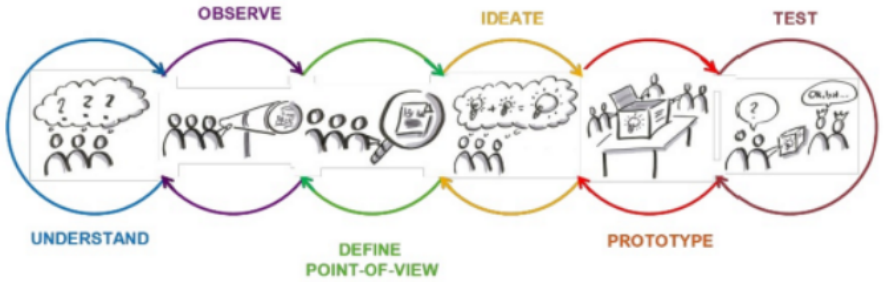
Design Approach Emphasis Comparison

Paradigm	Emphasis	Common Applications
Design Thinking	Empathy; ideation; cross-stakeholder involvement; satisfying needs	Systems with which users directly interact
Systems Thinking	Ecosystems & systemic sustainability; interactions with other products, services or systems; dynamic nature	Products that interact with many other products or markets
Systemic Design	Complex, large-scale systems	Architectural civic projects
Engineering design	Concept generation & selection; prototyping & testing; iteration	Consumer products
Traditional Systems Engineering	System operation, architecture, & decomposition; verification; risk management	Large, complex, capital-intensive products
Agile Systems/Software Engineering	Adaptable, value driven, with continuous risk reduction	Tailorable for technological systems of various types
Systemic Design Engineering	Combines strengths noted above	Tailorable for any type of system

Design Approach Phases

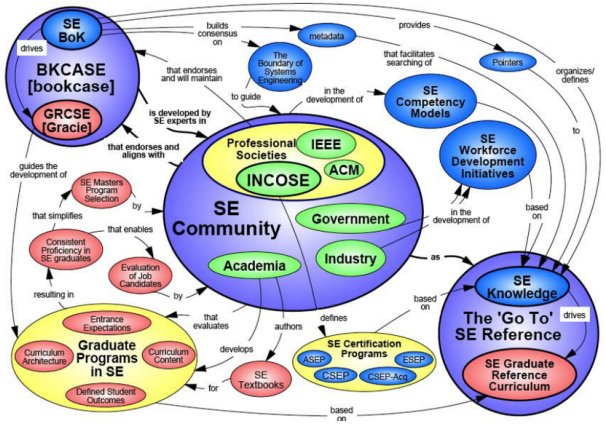
Paradigm	Concept	Architecture & Design	Implementation	Sustainment
Design Thinking	Yes	Partial	No	No
Systems Thinking	Yes	No	No	Yes
Systemic Design	Yes	Partial	No	No
Engineering design	Partial	Yes	Yes	No
Traditional Systems Engineering	Partial	Yes	Yes	Yes
Agile Systems/Software Engineering	Partial	Yes	Yes	Yes
Systemic Design Engineering	Yes	Yes	Yes	Yes

Human Centric



Design Thinking

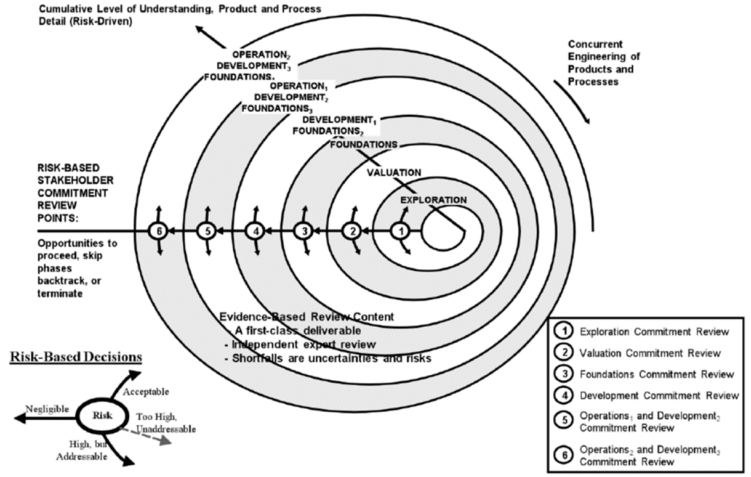
Sustainable



Systems Thinking

Systemic Design Engineering

Executable



Agile/Software Engineering

Objectives

- Approach is logical, easy to follow, and can be taught as part of any curriculum that teaches approaches to problem-solving, complex systems, and product development
- Process promotes exploration of innovative ideas and a systematic way to select the most promising option (engineering design)
- Process results in a low-risk, realizable, and profitable solution (systems engineering)
- Resulting products satisfy a real user need (design thinking)
- Resulting products are sustainable in the changing and increasingly connected marketplace (systems thinking)
- Approach can be used for systems which are human-centric, including complex social systems (systemic design)
- Framework can be tailored to be used on systems and products of all types (agile systems/ software engineering)

Human Centric

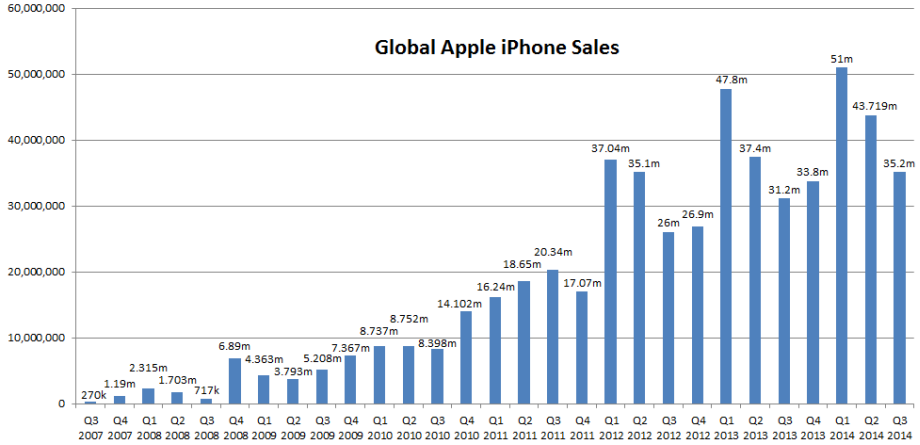
Design Thinking

Sustainable

Systems Thinking

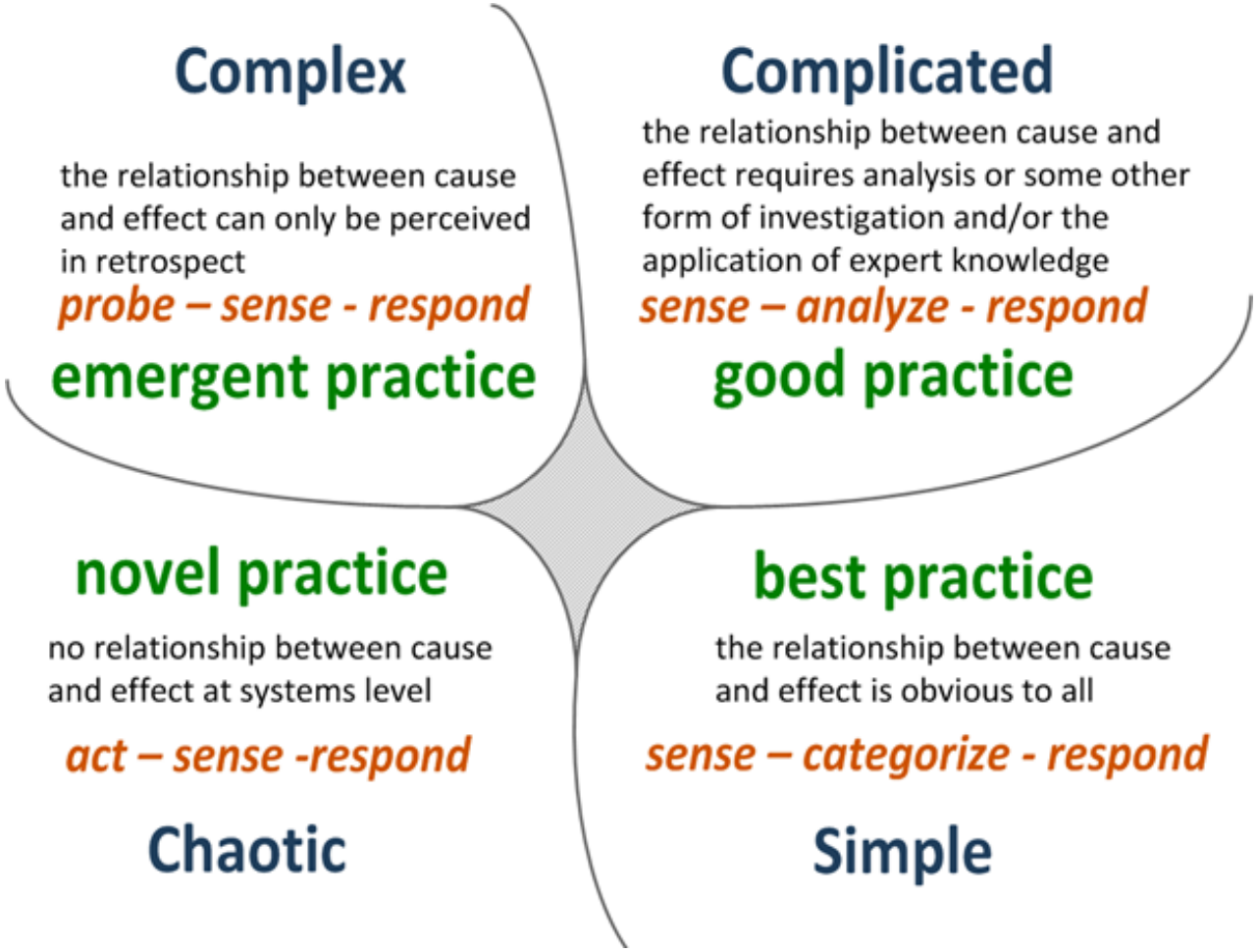
Systemic Design Engineering

Executable



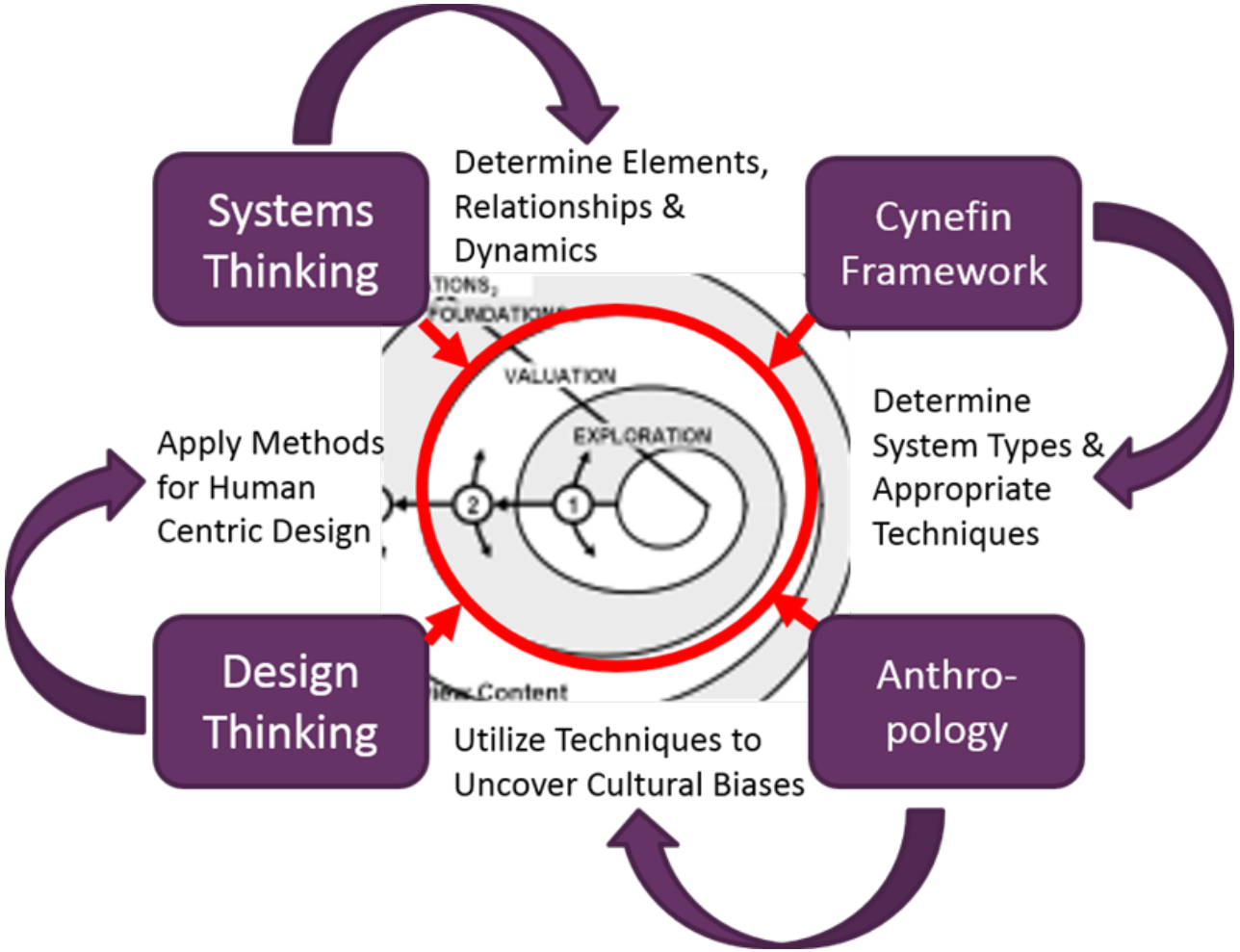
Agile/Software Engineering

Context is Critical

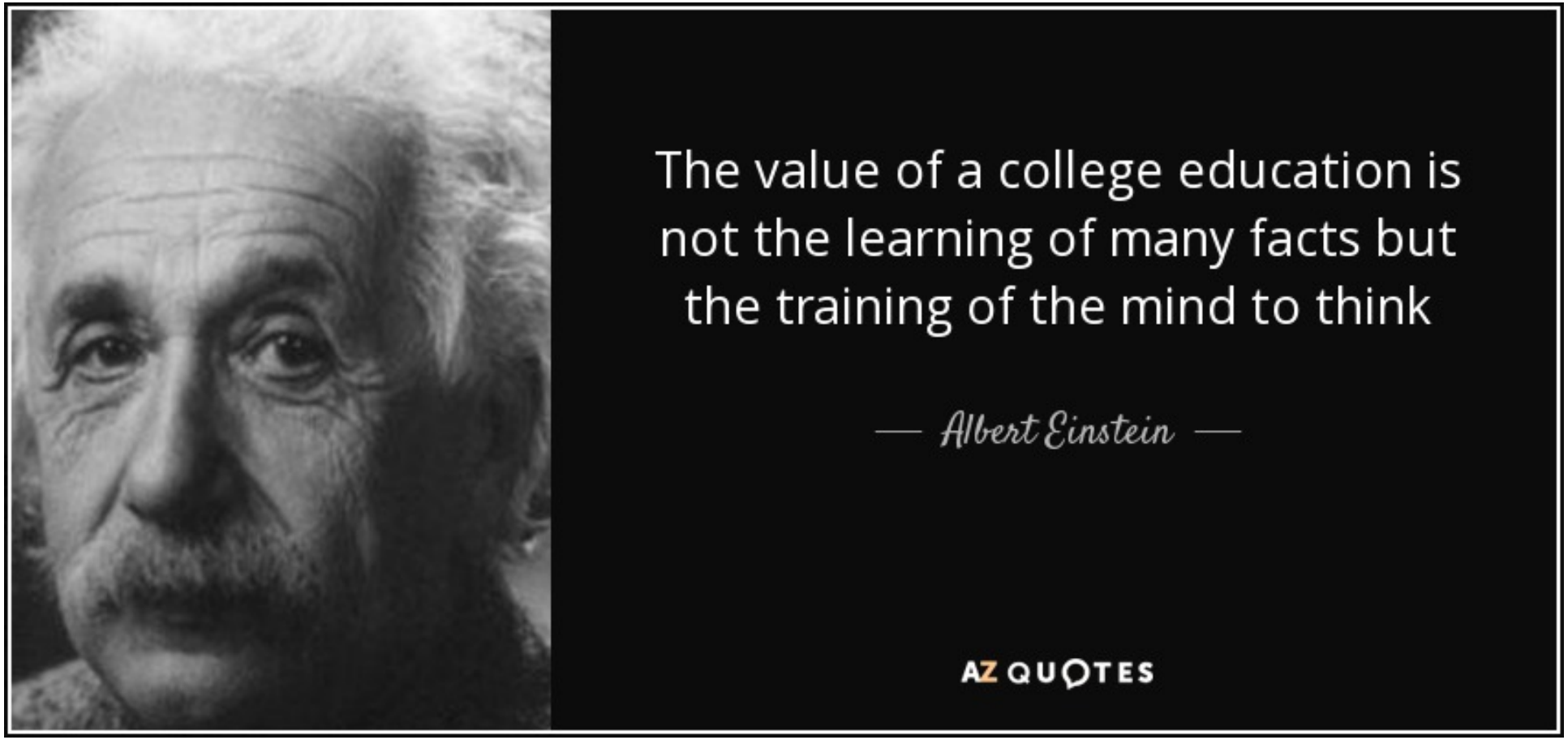


Anthropology in Design

Systemic Design Engineering



Example


The value of a college education is not the learning of many facts but the training of the mind to think
— Albert Einstein —
AZ QUOTES

Systems & Software Engineering

	System Engineering	Cyber-Physical Engineering	Software Engineering	Socio-Technical Systems
Fundamentals	SYS581: Fundamentals of Systems Engineering	SYS5XX: Fundamentals of CPS	SSW 540: Fundamentals of Software Engineering	ES 5(6)21: Fundamentals of Enterprise Systems
Math	Probability and Statistics			
Software	Software Skills			
Life-Cycle Management	Systemic Life-Cycle Management EM 612: Project Management of Complex Systems SSW 533: Cost Estimation and Measurement ES 677: Governing Development			
Conceptualization (requirements)	SYS XXX: Systemic Design Engineering			
Arch & Design	SYS 650: System Architecture and Design SYS 655: Robust Engineering Design	SYS 672: Design of Cyber Physical Systems	SSW 564: Software Requirements Analysis and Architecture SSW 565: Software Design	ES XXX: Policy Design and Analysis
Implementation	SYS 605: Systems Integration	SYS 673: Implementation of Cyber-Physical Systems	SSW 567: Software Testing, Quality Assurance and Maintenance SSW 555: Agile	ES XXX: Building & Modeling the Socio-Technical Ecosystem
Sustainment	SYS XXX: Systemic Sustainment SYS 645: Design for System Reliability, Maintainability and Supportability SYS 674: Sustainment of Cyber-Physical Systems (add DevOps) SSW XXX: Sustainment of Software Systems			
Project	SYS800, SSW690, 695			

System Design Engineering Syllabus

A. Introduction & Overview
- Program and Course Overview
- Project Overview
- Lifecycle Process Overview

B. Context – Systems Thinking
1. Systems Perspectives
2. Relationships
3. Dynamics
4. Leverage Points

C. Human Centricity – Design Thinking
5. Design Thinking
6. Identifying Opportunities
7. Identifying Customer Needs
8. Preliminary Product Specifications

D. Conceptualization – Systems Engineering
9. Concept Design
10. Concept of Operations
11. Use Case Scenarios
12. System Requirements
13. Economics & Financial Analysis

E. Integration & Deliverables
14. Model-Centric Engineering Representations
15. Project Presentations
16. Final Report

Summary

- A unified approach to design has been presented which unifies the design processes from systems thinking, design thinking, systemic design thinking, engineering design, systems engineering, and agile systems/software engineering.
- Reviewing each of these disciplines and summarizing their commonalities and strengths has led to an improved understanding of where the methods overlap and what each approach lacks.
- From these observations, a set of criteria has been established and a new approach has been developed that embodies a more comprehensive approach to design.
- A new conceptualization graduate course has been developed and is being deployed using this unified approach.
- The authors look forward to future work in further improving design education and practice.

Questions?

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www.incose.org/symp2017