System Engineering Overview

1 Definition

1.1 System

A system is the combination of elements that function together to produce the capability required to meet a need. (By NASA)

1.2 Systems Engineering

Systems Engineering is a transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered systems, using systems principles and concepts, and scientific, technological, and management methods. (By INCOSE)

1.3 Key Concepts

1. Fulfilling a purpose, meeting customer and stakeholder needs.
2. Identifying requirements to build the right system.
3. Considering the entire life cycle.
4. Integrating interdisciplinary elements.
5. Balancing the conflicting requirements.
6. Minimizing Unintended Consequences.
7. Managing risks.

2 Project Life Cycle

2.1 Overview

1. Lifecycle phases decomposition is to organize the development process into smaller manageable pieces.
2. Everything that should be done to accomplish a project is divided into distinct **phases**, separated by **control gates**.

3. Phase boundaries are defined at natural points for project progress assessment and **go/no go decisions**.

4. **Systems engineering done in the early phases has the greatest impact on mission success**.

2.2 Phases Decomposition

Classical phases decomposition is shown below:

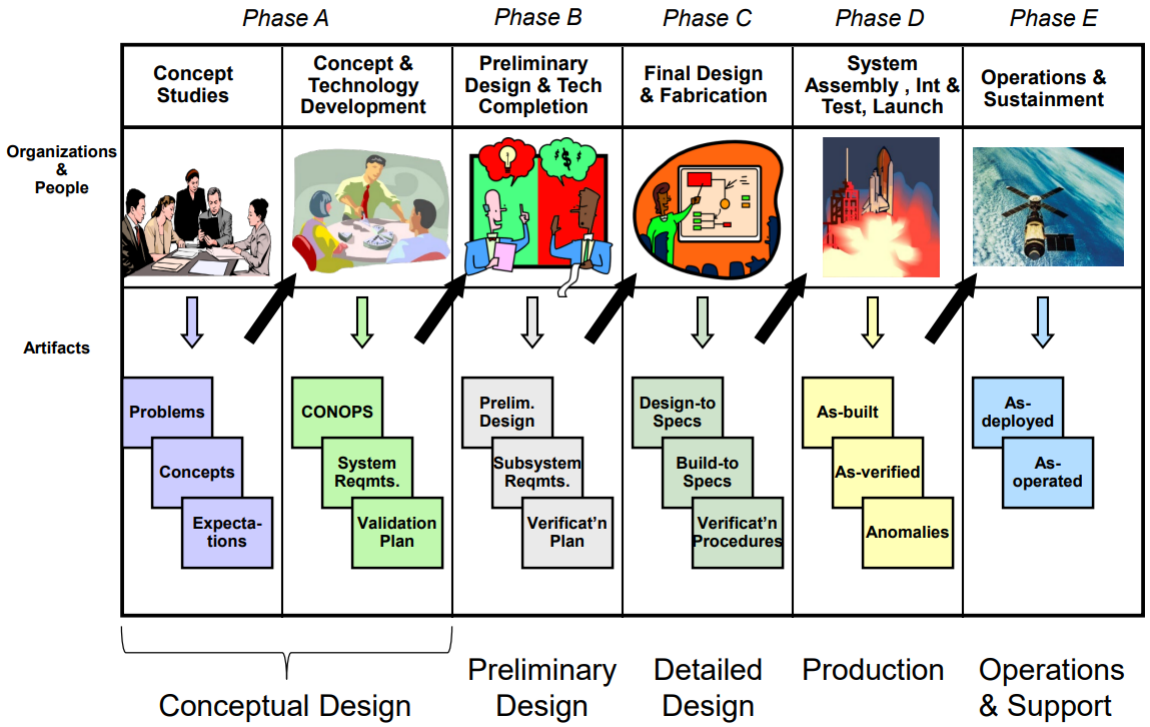

Figure 1: Phases Decomposition.

2.3 Formulation Phases

2.3.1 Pre-Phase A: Concept Studies:

Purpose:

1. Produce a broad spectrum of ideas and alternatives for missions.

2. Define the mission needs, goals and objectives.

3. Develop draft project-level requirements, operations concept, and potential technology needs.

4. Show that at least one mission concept can work.

Control Gate: Complete **Mission Concept Review (MCR)**.

2.3.2 Phase A: Concept and Technology Development

Purpose:

1. To determine the feasibility of a suggested new system in preparation for seeking funding.
2. Define mission success, and minimum mission.
3. Perform trade studies to compare mission concept options.
4. Develop a baseline mission concept, including best technical approach, project execution, cost and schedule.
5. Complete the requirements to the subsystem level.
6. Identify requirements flow between and across subsystems.
7. Begin needed technology developments.

Control Gate:

1. Complete **System Requirements Review (SRR)**: Review requirements as baseline for final concept. Establishes the System Requirements baseline.
2. Complete **System Definition Review (SDR/MDR)**: Review baseline for Phase B. Establishes the **Functional baseline.**

2.3.3 Phase B: Preliminary Design & Technology Completion

Purpose:

1. To define the project in enough detail to establish an initial baseline capable of meeting mission needs.
2. Refine concept of operations.
3. Allocate functions and resources (e.g., mass margins).
4. Requirements: continue to refine; define flow to the box level; develop verification matrix.
5. Establish design solution that meets mission needs.
6. Demonstrate that technology development is complete.

Control Gate:

1. **Preliminary Design Review (PDR):** Review requirements, design and operations as baseline for detailed design. Establishes the Allocated baseline, also known as the 'design-to' baseline.
2. **Non-Advocate Review (NAR)**/Confirmation Review.

2.4 Implementation Phases

2.4.1 Phase C: Final Design and Fabrication

Purpose:

1. To design a system (and its associated subsystems, including its operations systems) so that it will be able to meet its requirements.
2. Demonstrate that the detailed system design meets requirements.
3. Demonstrate that the design drawings are complete.
4. Establishes the product baseline, also known as the 'build-to' baseline.
5. Begin fabrication of test and flight article components, assemblies, and subsystems.

Control Gate: Critical Design Review (CDR): Review design drawings and test plans.

2.4.2 Phase D: System Assembly, Integration and Test, Launch

Purpose:

1. To build the subsystems (including operations systems) and integrate them to create the system, while developing confidence that it will be able to meet the systems requirements.
2. Perform system assembly, integration, and test.
3. Verify system meets requirements.
4. Prepare system for deployment.
5. Launch system.
6. Verify deployment and operations.

Control Gate: Flight Readiness Review (FRR): Review system preparedness for launch.

2.4.3 Phase E: Operations and Sustainment

Purpose:

1. To ensure that the certified system is ready for operations.
2. Implement the Mission Operations Plan developed in earlier phases.
3. Collect and archive mission and science data.

Control Gate: Post Launch Assessment Review (PLAR): Review to assess readiness to proceed with full, routine operations. Establishes the Operational (or 'as-deployed') baseline.

2.4.4 Phase F: Closeout

Purpose:

1. Conduct a disposal review.
2. Implement the Systems Decommissioning/ Disposal Plan.
3. Perform analyses of the returned data and any returned samples.

2.5 System Engineering Depictions

2.5.1 Traditional View:

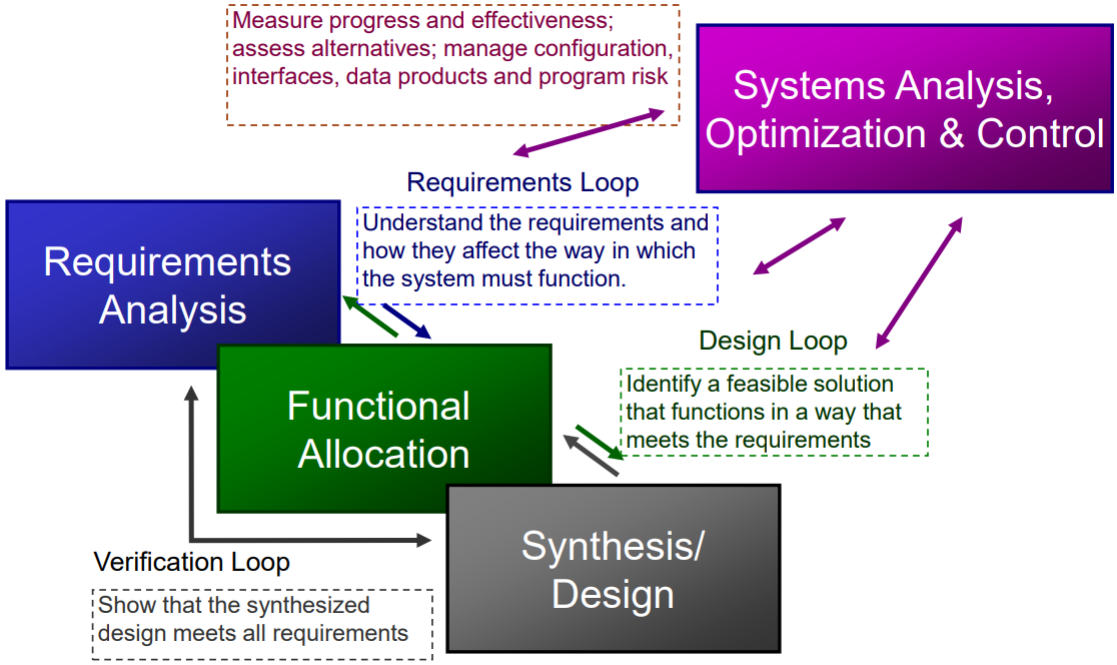

Figure 2: Traditional View of System Engineering.

2.5.2 Waterfall Model

2.5.3 Spiral Model

2.5.4 Agile Model

2.5.5 V Model

2.5.6 Paradigm Shift

2.5.7 Georgia Tech Integrated Product and Process Design (IPPD)

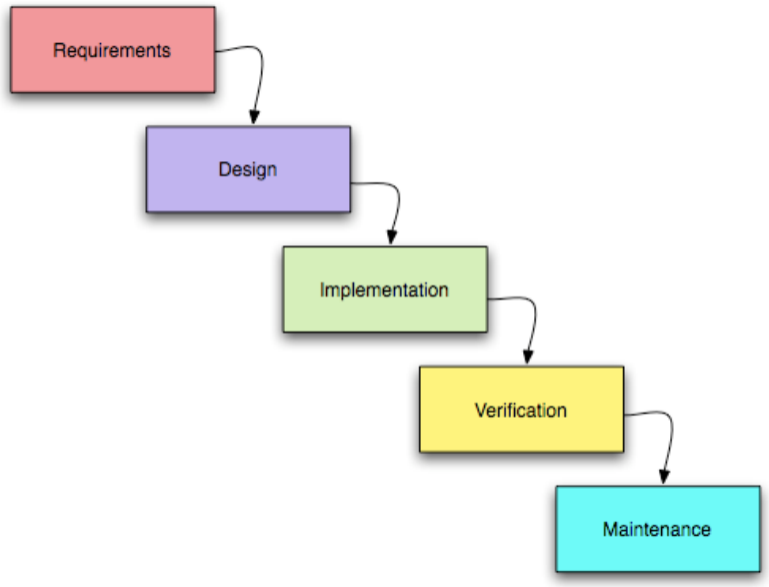

Figure 3: Waterfall Model.

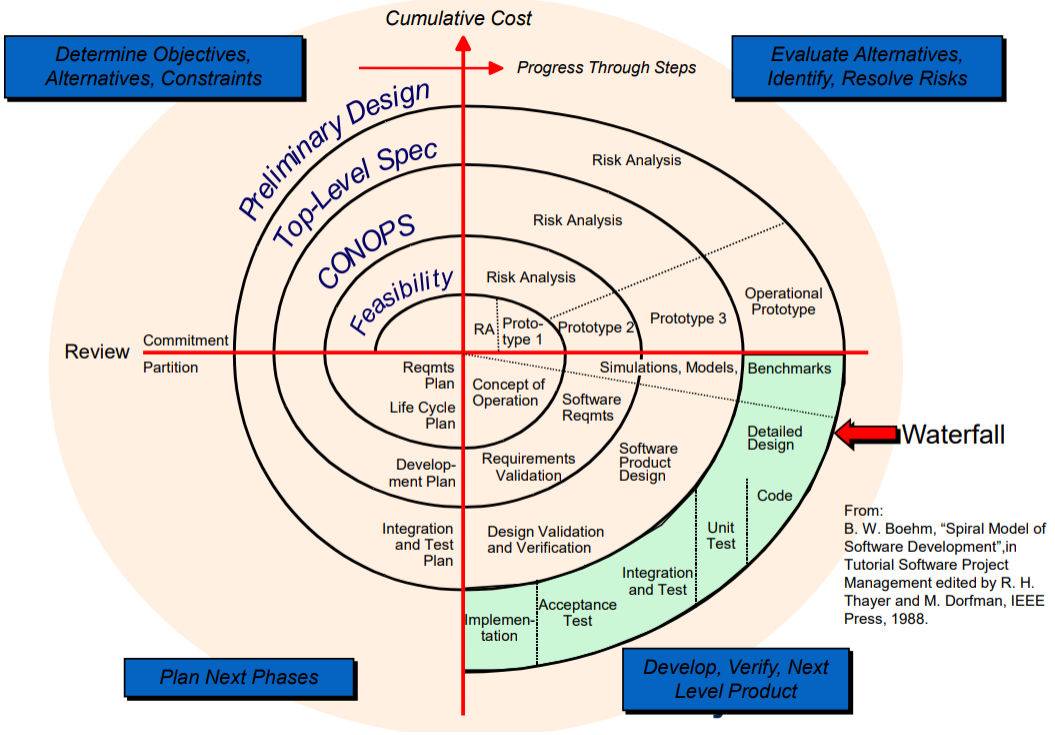

Figure 4: Spiral Model.

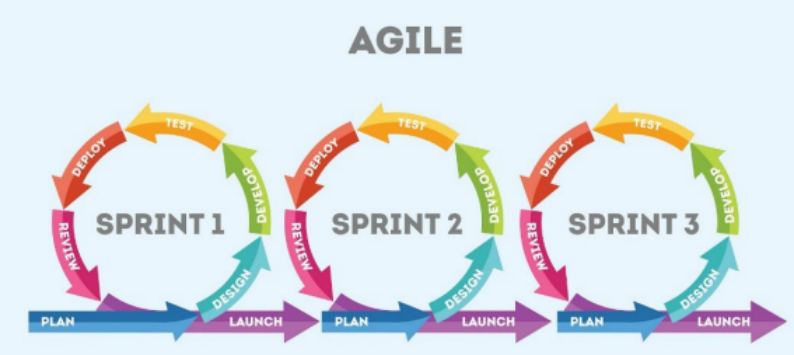

Figure 5: Agile Model.

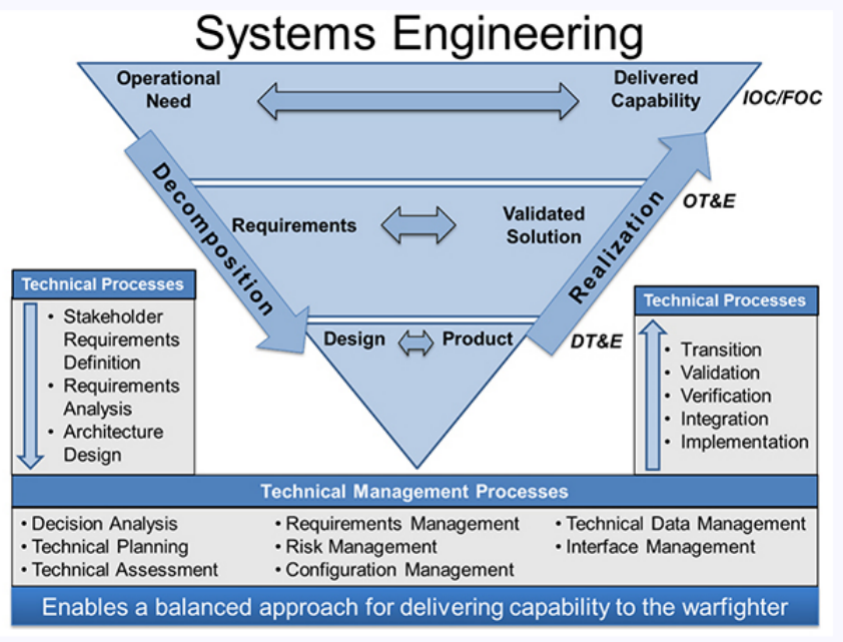

Figure 6: V Model.

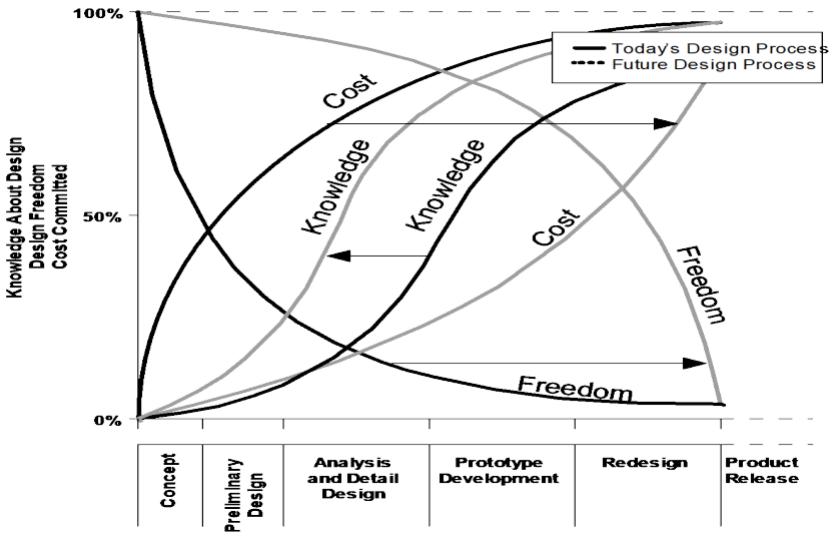

Figure 7: Paradigm Shift.

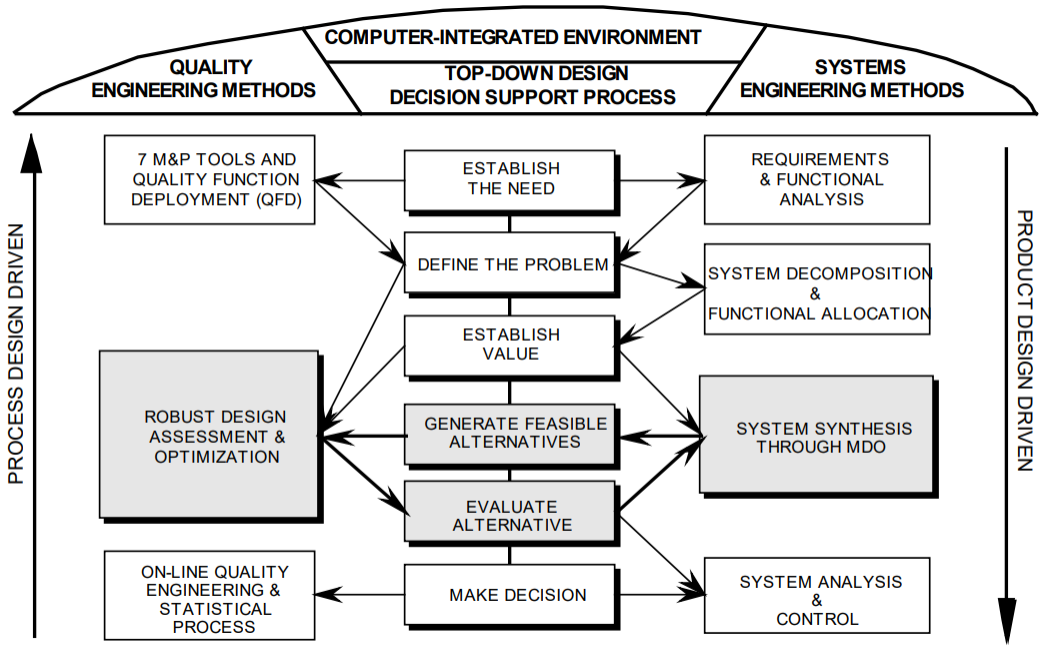

Figure 8: Georgia Tech IPPD Method.