Systems Engineering

Engineering Development Stage and Post-Development Stage

Maria-Iuliana Dascalu, PhD
mariaiuliana.dascalu@gmail.com

SE Life Cycle Model

- Partitioned into 3 stages and 8 distinct phases:
- Concept development (in SE4)
  - Needs analysis
  - Concept exploration
  - Concept definition
- **Engineering development**
  - <u>Advanced development</u>
  - Engineering design
  - Integration and evaluation
- Post-development
  - Production
  - Operations and support

Advanced Development

Objectives

- to resolve the majority of uncertainties (risks) through analysis and development

- to validate the system design approach

- to obtain the following outputs:
  - a system design specification
  - a validated development model

Activities

- Requirements Analysis — relating functional requirements to needs
- Functional Analysis and Design — identifying performance issues
- Prototype Development — building and testing prototypes of critical components
- Test and Evaluation — validating the maturity of critical components

SE Life Cycle Model

- Partitioned into 3 stages and 8 distinct phases:
- Concept development (in SE4)
  - Needs analysis
  - Concept exploration
  - Concept definition
- **Engineering development**
  - Advanced development
  - <u>Engineering design</u>
  - Integration and evaluation
- Post-development
  - Production
  - Operations and support

Engineering Design

Objectives

- to design system components to performance, cost, and schedule requirements
- to establish consistent internal and external interfaces
- to obtain the following output: components of a new system focused on the final design of the system building blocks

Activities

- Requirements Analysis: identifying all interfaces and interactions
- Functional Analysis and Design: focusing on modular configuration
- Component Design: designing and prototyping all components
- Design Validation: testing and evaluating system components

Configuration Management

- is a systems engineering process that maintains the continuity and integrity of system design
- Configuration baselines defined in major system developments include:
  - Functional Baseline: system functional specifications
  - Allocation Baseline: system development specifications
  - Product Baseline: product, process, and material specifications

SE Life Cycle Model

- Partitioned into 3 stages and 8 distinct phases:
- Concept development (in SE4)
  - Needs analysis
  - Concept exploration
  - Concept definition
- **Engineering development**
  - Advanced development
  - Engineering design
  - <u>Integration and evaluation</u>
- Post-development
  - Production
  - Operations and support

Integration and Evaluation

Objectives

- to integrate the engineered components of a new system into an operating whole
- to demonstrate that the system meets all its operational requirements
- to obtain the following outputs:
  - validated production designs and specifications
  - qualification for production and subsequent operational use

Activities

- Test Planning: defining test issues, test scenarios, and test equipment
- System Integration: integrating components into subsystems and the total system
- Developmental System Testing: verifying that the system meets specifications
- Operational Test and Evaluation: validating that the system meets operational requirements

SE Life Cycle Model

- Partitioned into 3 stages and 8 distinct phases:
- Concept development (in SE4)
  - Needs analysis
  - Concept exploration
  - Concept definition
- Engineering development
  - Advanced development
  - Engineering design
  - Integration and evaluation
- **Post-development**
  - <u>Production</u>
  - Operations and support

Production

Objectives

- to produce sets of identical hardware and software components
- to assemble components into systems meeting specifications
- to distribute produced systems to customers

Engineering for Production (1)

- Concurrent engineering, or product development, has the following features: it is the process of introducing production considerations during development. Production specialists and other specialty engineers are key members of the design team. Therefore, systems engineers must facilitate communications among team members.

- The decision to begin new system development must demonstrate its need, technical feasibility, and affordability. The formulation of realistic system requirements must include a clear sense of the status and trend in manufacturing technology. As technology evolves, requirements must also evolve to stay consistent.

- Production risks are influenced by the nature and maturity of the associated manufacturing methods and are heavily weighted in trade – off analyses of system alternatives.

- Successful production requires that new production processes and materials are validated before acceptance, that component interfaces are compatible with manufacturing processes, and that factory test equipment is validated and ready. The latter is typically demonstrated by production prototypes that have demonstrated product performance.

Engineering for Production (2)

- Unexpected incompatibilities at component interfaces have the following features:
  - They are often first discovered during the integration of prototype components.
  - Corrections of incompatibilities may themselves produce new areas of incompatibility.
- Systems engineers must be knowledgeable of factory production and test acceptance processes. Direction and control of production differs from system development in the following:
  - different tools, experience base, and skills;
  - a different team of specialists — few key personnel carry over from development
- Production risks are frequently not revealed until production prototypes are fabricated and tested. Remedial action is likely to cause expensive delays; therefore, systems engineering expertise is crucial for resolution.

Transition from Development to Production

- Stresses on the transition from development to production result from:
  - insufficient funding for production preparation
  - little or no reserve funds for unexpected problems
  - too little testing of production prototypes
  - schedules held firm even though problems exist

Production Operations

- The planning, design, implementation, and operation of a “ production system ” is a task of comparable complexity to developing the system itself. Architecting of the production system requires:
  – acquisition of extensive tooling and test equipment
  – coordination with component manufacturing facilities
  – organization of a tight configuration management capability
  – establishment of an effective information system with enginery organization
  – training the production staff in the use of new tooling
  – accommodation of both low and high production rates
  – promotion of flexibility to accommodate future product changes

Acquiring a Production Knowledge Base

- Systems engineers must acquire a basic knowledge concerning production processes to be capable of guiding the engineering of a new system. They must focus on advanced technology and new production processes, as well as risk areas as they may be affected by production.

SE Life Cycle Model

- Partitioned into 3 stages and 8 distinct phases:
- Concept development (in SE4)
  - Needs analysis
  - Concept exploration
  - Concept definition
- Engineering development
  - Advanced development
  - Engineering design
  - Integration and evaluation
- **Post-development**
  - Production
  - <u>Operations and support</u>

Operations and Support

Installing, Maintaining, and Upgrading the System

- The application of systems engineering principles and expertise continue to be required throughout the operational life of the system. The operations and support phase includes installation and test, in - service support, and implementation of major system upgrades.

- Interface integration and test can be challenging due to a mix of various organizational units, complex external interfaces, and incomplete or poorly defined interfaces.

Installation and Test

- Installation and test problems can be difficult to solve because installation staff have a limited system knowledge. Systems engineers are seldom assigned until trouble is encountered. However, periodic operational readiness testing is necessary for systems that do not operate continuously. This can help minimize unexpected system problems.

- Where non disruptive installation is required, care to plan the installation procedures, via a hybrid simulation or a duplicate system operating in parallel, is absolutely essential.

In - Service Support

- System software must be subject to strict configuration control to prevent serious deterioration of software quality. In this vein, built - in fault indicators are very valuable for detecting internal faults, although they sometimes produce false alarms. Therefore, field engineers should be knowledgeable about built - in test devices.

- Remedial actions to correct operational problems are difficult to implement: operational personnel are not technical specialists. Furthermore, troubleshooting tools are limited. And materials and processes involved in logistics support themselves constitute a complex system.

Major System Upgrades: Modernization

- Logistics cost is a large part of system cost.
- Advanced features are defined during system development, and advanced planning permits minimum disruption to system operation.

Operational Factors in System Development

- Possible sources of operational knowledge include operational and installation tests — by observing system operations within its environment.
- Assistance from operational and maintenance personnel is invaluable.