ZEIT8226 COURSE NOTES

SYSTEMS ENGINEERING PRACTICE, SEMESTER 1, 2025

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2 COURSE DESCRIPTION

This course provides students with an in-depth understanding of Systems Engineering (SE) as a discipline and a professional practice. Focusing on the entire system lifecycle, from conception through retirement. The curriculum covers the principles, processes, and management techniques required to successfully engineer complex systems. Students will learn to apply a systematic, top-down approach to define stakeholder needs, develop robust requirements, conduct trade-off analyses, and manage system design, integration, and verification. The course emphasizes the practical application of theory through tutorials, assignments, and reference to key industry standards like the INCOSE Systems Engineering Handbook.

2.1 PRIMARY TEXT

- INCOSE (2023). *Systems Engineering Handbook: A Guide for System Life Cycle Process and Activities* (5th ed.). John Wiley & Sons, Inc.

2.2 ASSESSMENTS INFORMATION

1. **PowerPoint Presentation (10%):** A 5-minute presentation on System Life Cycle concepts.
2. **Assignment 1 (45%):** A detailed report answering two questions chosen from topics including Operational Scenarios, Support Concepts, and Systems Engineering Management Plans (SEMP).
3. **Assignment 2 (45%):** A detailed report answering two questions chosen from topics including Trade-off Analyses, Configuration Items (CIs), and System Retirement Aspects.

3 MODULE 1: FOUNDATIONS OF SYSTEMS & SYSTEMS ENGINEERING

3.1 LEARNING OBJECTIVES

- Define a system, system boundary, and System of Interest (SOI).
- Differentiate between interfacing, interoperating, and enabling systems.
- Define Systems Engineering (SE) and explain its core principles.
- Articulate the importance of SE and its return on investment (ROI).

3.2 KEY CONCEPTS & NOTES

- **What is a System?**
    - A system is an **arrangement of parts or elements that together exhibit behaviour or meaning that the individual constituents do not**.
    - Systems can be natural (a forest), designed abstract (software), designed physical (a car), or organizational (a healthcare system).
    - The course focuses on **engineered systems**, which are designed for a specific purpose within an anticipated operational environment.
- **System Boundaries & Context**
    - **System of Interest (SOI):** The specific system being developed or analysed.
    - **System Boundary:** A conceptual line separating the SOI from its environment and external systems.
    - **External Systems:**

        - **Interfacing Systems:** Share a direct physical, data, or energy interface with the SOI (e.g., a runway for an aircraft).
        - **Interoperating Systems:** Interface with the SOI to perform a common function (e.g., a communication system for an aircraft).
        - **Enabling Systems:** Facilitate the SOI's lifecycle but are not part of its operational environment (e.g., a flight simulator or manufacturing system for an aircraft).

- **What is Systems Engineering (SE)?**
    - **Definition:** "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".
    - SE follows a **top-down approach**, starting with the overall system mission and decomposing it into detailed requirements and components. This ensures all parts align with the primary purpose.
    - The core of the SE process is an iterative **Analysis-Synthesis-Evaluation loop**.
- **Why is SE Important?**
    - **Manages Complexity:** Modern systems are often complex integrations of COTS products and software. SE provides the methods to manage this complexity.
    - **Ensures Project Success:** Studies show a strong correlation between SE effort and project performance. Projects with high SE capability are significantly more likely to meet budget, schedule, and technical requirements.
    - **Provides Return on Investment (ROI):** SE identifies and mitigates defects early in the lifecycle when they are far cheaper to fix. The optimal SE effort is typically 10-14% of the total project cost.

3.3 READINGS

- INCOSE SE Handbook: Chapter 1 (Systems Engineering Introduction), Chapter 5.3 (SE Relationships to Other Disciplines).
- ZEIT8226 Slides: 01, 02.

4 MODULE 2: THE SYSTEMS ENGINEERING LIFECYCLE

4.1 LEARNING OBJECTIVES

- Describe the typical stages of a system lifecycle.
- Explain the purpose and function of decision gates.
- Compare and contrast sequential, incremental, and evolutionary lifecycle models.
- Understand the four main groups of lifecycle processes as defined by ISO/IEC/IEEE 15288.

4.2 KEY CONCEPTS & NOTES

- **System Life Cycle Stages**
    - The system life cycle describes the evolution of a system from conception to retirement. The generic stages are: