Evaluation of different Systems Engineering Approaches as Solutions to Cross-Lifecycle Traceability Problems in Product Development: A Survey

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Résumé

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Résumé

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Content

- Introduction
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- Traceability Challenges and Problems
- Research Design
- Results
- Conclusion
- References
What is a system?
Set of objects that are in a holistic context and can be distinguished from their environment by the relationships that exist between them [2].
Introduction

➢ **Requirement Engineering (RE)**
Iterative elicitation, analysis, management and documentation of requirements [4].

![Diagram showing changes in requirements during the development life cycle](image)

Fig.2: Changes in requirements during the development life cycle
Traceability and System Engineering

- **Traceability**
  Linking the system objects to track them throughout the system lifecycle, both backward and forward.

- **System Engineering (SE)**
  “Enabling the capture and fulfillment of customer and stakeholder requirements for the system throughout the lifecycle by better traceability of issues and more efficient coordination across an interdisciplinary team.” [5]

Fig. 3: V-Model
Traceability and System Engineering

How does SE enable the traceability?

- It employs "systems thinking" to break down complex issues into components, creating a purpose-driven model. → System Model

- This model guides an interdisciplinary, standardized approach to solve complex tasks through logical step connections. → Procedure concept [3]
Traceability Challenges and Problems

➢ **Method:**
  1. Methods complexity
  2. Trade-off between cost (including time) and quality [6]

➢ **Tool:**
  1. Tool complexity
  2. Tool capability [7]
Traceability Challenges and Problems

- Different SE approaches

Fig.4: Division of SE into specific and universal approaches [8]
Traceability Challenges and Problems

- **Generic System Engineering**
  - Developed by Winzer and Sitte [9]
  - It proposes a common thinking model to derive a unified system model.
  - It consists of a standardized approach, which is divided into the "analysis" (problem identification and system analysis), the “Goal setting” (problem localization) and the "design" (recommendations)

![Generic System Engineering Diagram]

Fig.5: Generic System Engineering [9]
Traceability Challenges and Problems

- **e-DeCoDe**
  - enhanced Demand Compliant Design [11]
  - A technique for system definition, description, modeling, and progressive refinement
  - Matrix-based connection of the system elements

Fig. 6: Generic System Engineering [10]
Traceability Challenges and Problems

- **SoSE**
  - No universally accepted definition for SoS/SoSE

- **MBSE**
  - No Common language for defining stakeholder needs and bringing them into a single model
  - High implementation costs
  - Interaction between the system model and the procedure model

- **GSE**
  - Lack of integration of test processes in the model
Research Questions

- Q1: Which approach is able to define the system more comprehensively?

- Q2: Which approach is focused on managing complexity through a universal modeling methodology applicable in transdisciplinary teams?

- Q3: Which approach establishes the link between requirements and testing?

- Q4: Which approach has a structured procedure concept connected to the system model that maps the lifecycle of a system?

- Q5: Which programs/tool can contribute better to reducing complexity?

- Q6: To what extent are the necessary information available to the system developer during system development?
Research Design

➢ **Topic Area**

- **T1**: System Definition and Delimitation
- **T2**: System Modeling
- **T3**: Integration of Test cases
- **T4**: Structured Procedure Concept
- **T5**: Model Implementation
- **T6**: System Information Integration

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**T1 (System Definition and Delimitation)**: The approach developed shall primarily address the linkage of requirements (lp) to key system parts and artifacts, including processes (lp) and components (lp). Functional requirements shall be linked to the corresponding functions (lp) that the system is intended to perform. The approach should provide a clear boundary between the system and the environment and methodically support their interaction. To enable the treatment of requirements in EN, the approach should also include roles and liability through a person view (lp).

**T5 (Model Implementation)**: As already mentioned, the model should be implemented in a suitable software tool to realize system modeling (lp). The program must visibly and transparently represent the system elements and their interrelationships (lp). In addition, it must have filtering and focusing functions that enable concentration on the essentials or certain elements and thus systematically reduce the complexity of the modeled system (lp). Even more, the software must enable the time-logical arrangement of functions and processes (lp) as well as the storage of system states in order to be able to track phases of project management (lp).

Fig. 7: Examples of evaluation criteria
Result

Methodology

- Lack of general methods for traceability of requirements, including a system model that represents the essential system elements and their interactions with each other and its implementation in a functional tracing tool with a reasonable cost-benefit ratio

- Identify problems

- Deriving topic areas

- Narrowing down the topic

- Literature search

- Evaluate state of the art

- Discover gaps

- 6 topic areas

- Only application of universal SE approaches in product development

- 30 papers and methods are found

- Grading of the methods from 1 to 5 with regard to the defined topic areas

Fig. 8: Methodology of the survey
## Evaluation of different Systems Engineering Approaches as Solutions to Cross-Lifecycle Traceability Problems in Product Development: A Survey

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Conclusion

- Limitations in terms of generic model structure
- Not complete consideration of the important system elements
- Absence of the person view, which complicates the traceability of responsibilities
- Integration of the test processes into the system model
- Integration of the necessary information
- Compared to the MBSE and GSE approaches, the SoSE-based methods have reached the lowest score with regard to the observed topics.
References


References


Thank you so much for your attention 😊