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Vienna University of Technology

Engineering Process Improvement in Heterogeneous Multi-Disciplinary Environments with Defect Causal Analysis

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Motivation & Goals

Motivation:

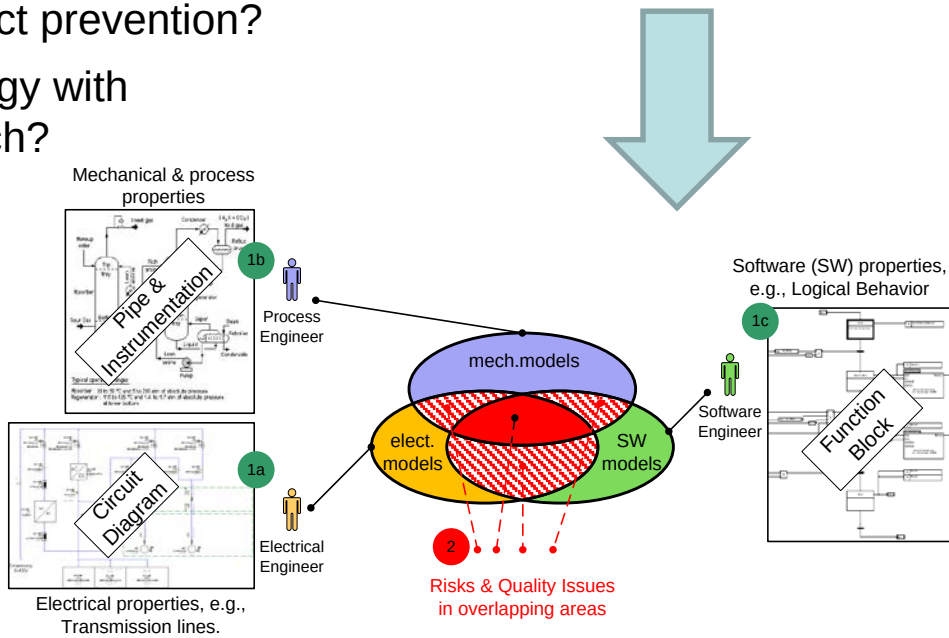
- Heterogeneous and Multi-Disciplinary Engineering (ME) Environments.
- Defects and root causes are hard to find (even across disciplines)

Key research questions focus on:

- How to support stakeholders in efficiently find root causes of defects for future defect prevention?
- How to implement an improvement strategy with the defect causal analysis (DCA) approach?

Goals of the paper:

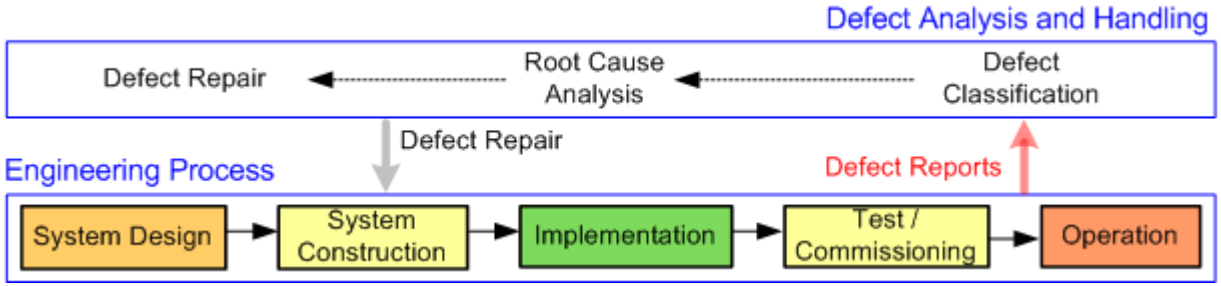
- Adapted DCA Approach & Evaluation
- Improvement strategy with DCA



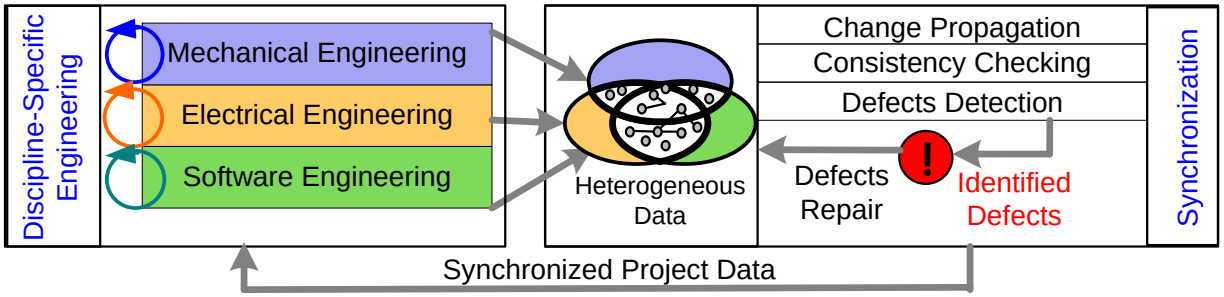
Engineering Process Data in ME Projects

- Goals in ME Projects:
  - Consistent and stable engineering data in related disciplines.
  - Early defect detection and repair.
  - Defect prevention for future projects based on defect causes.

- Traditional and Sequential Engineering Process (derived from our industry partner)

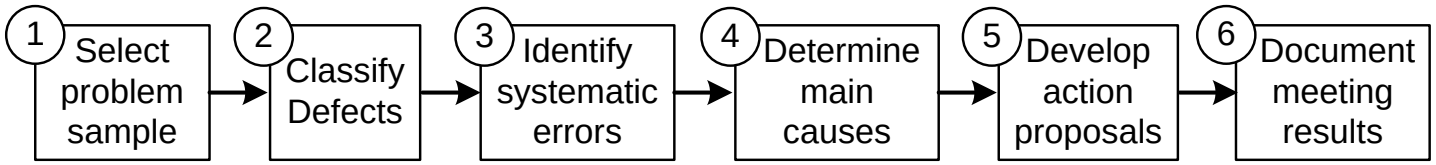


- (Manual) Synchronization in Multi-Disciplinary Engineering Environments



Defect Causal Analysis (DCA)

- DCA has been successfully applied in Software Engineering*.



- Systematic Process Improvement based on DCA
  - Expert Workshop involving different stakeholder.
  - Starting Point: Identified (critical) defects.
  - Goal: Identifying root causes for defect repair and prevention.

- Defect Classification Schemes
  - Set of attributes that describe a defect, e.g., defined by IEEE, IBM, or HP.
  - Focus on Software Engineering → need for extension for multi-disciplinary and heterogeneous engineering projects.

*Kalinowski M., Card D.N., Travassos G.H.: "Evidence-based guidelines to defect causal analysis", IEEE Software 29(4), pp16-18, 2012.

Research Questions & Solution Approach

Research questions include

- How to adapt the DCA process to the context of ME projects?
- How to adapt a defect classification (DC) scheme to the context of ME projects?

Solution Approach

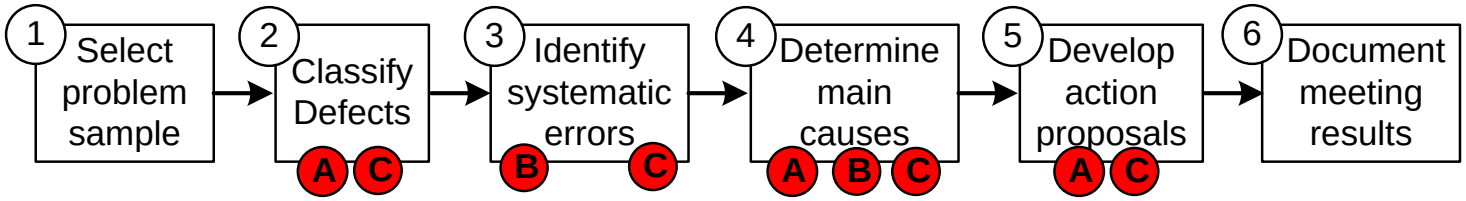
- Adaptation of the DCA process approach and …
- … extension of the defect classification scheme **...**
- … to address multi-disciplinary engineering projects in heterogeneous environments.

Feasibility Study

- Initial feasibility study at our industry partner to address most critical root causes based on DCA findings.
- Implementation of improvement actions to address root causes.
- Second study for evaluation of implemented measures.

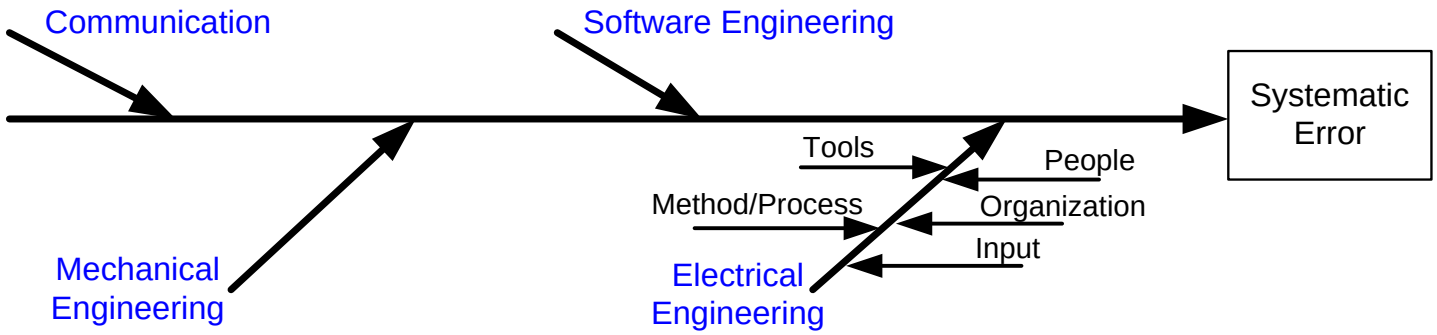
Adapted DCA Process

- Basic Process Steps are similar!



- Adaptation focus on characteristics of multi-disciplinary engineering projects:
  - Different (involved) engineering disciplines (A).
  - Heterogeneous artifacts and data (B).
  - Inter-disciplinary dependencies in project data (C).

→ Adapted Ishikawa diagram*:



*Ishikawa K.: "Guide to Quality Control", Asian Productivity Organization Press, 1986.

Defect Classification Scheme

Defect Classification (DC) scheme for DCA must cover*:

- Defect insertion → to identify the cause of the defect (1).
- Defect detection → to identify a strategy for defect detection method improvement (2).
- Defect type (i.e., nature of defect) → supporting information for both (1) and (2).

Adapted DC scheme based on IEEE consists of 7 attributes:

Insertion Context	**Detection Context**	**Impact**	**Current Status** within Defect Life Cycle
• Discipline	• Discipline	**Rating**	Defect **Type**
• Artifact Type	• Artifact Type	• Priority to fix	Defect **Mode**
• Artifact	• Artifact	• Severity (risk)	
• Activity	• Activity		
• Project Phase	• Project Phase		

Different (involved) engineering disciplines (A)

Heterogeneous artifacts and data (B)

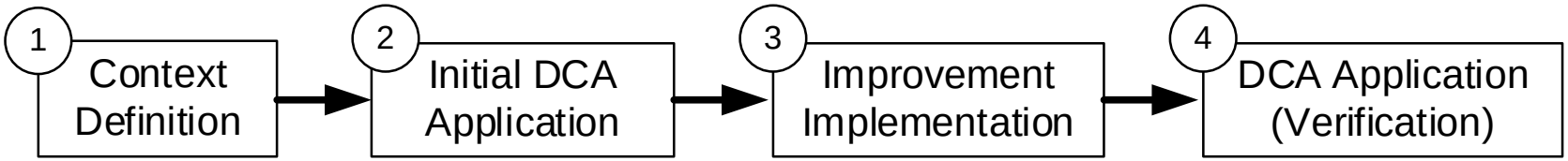
Inter-disciplinary dependencies in project data (C)

* Kalinowski M., Card D.N., Travassos G.H.: "Evidence-based guidelines to defect causal analysis", IEEE Software 29(4), 2012.

Feasibility Study

Study Process Summary

- Feasibility study in 4 steps to evaluate the adapted DCA process.

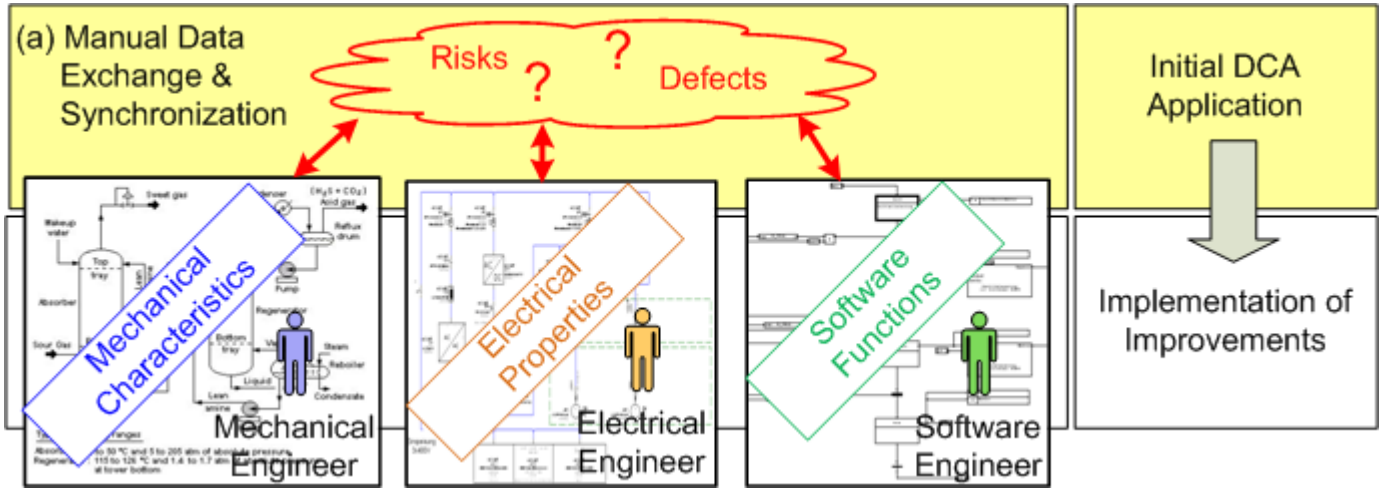


- Context Definition and Study Planning (1)
- DCA Workshops (2) and (4)
  - Involving key stakeholders from our industry partner
  - Focus on the most critical defects.
- Lessons Learned: Identification of an improvement strategy (3)

Context Definition
Feasibility Study

Context

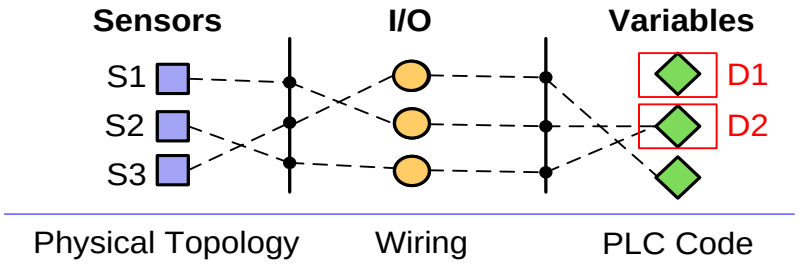
- Automation Systems Development Projects, e.g., Hydro Power Plants.
- Involvement of various disciplines, e.g., mechanical, electrical, and software engineering.
- Isolated tools and data models are not or loosely connected.



Initial DCA Application
Feasibility Study

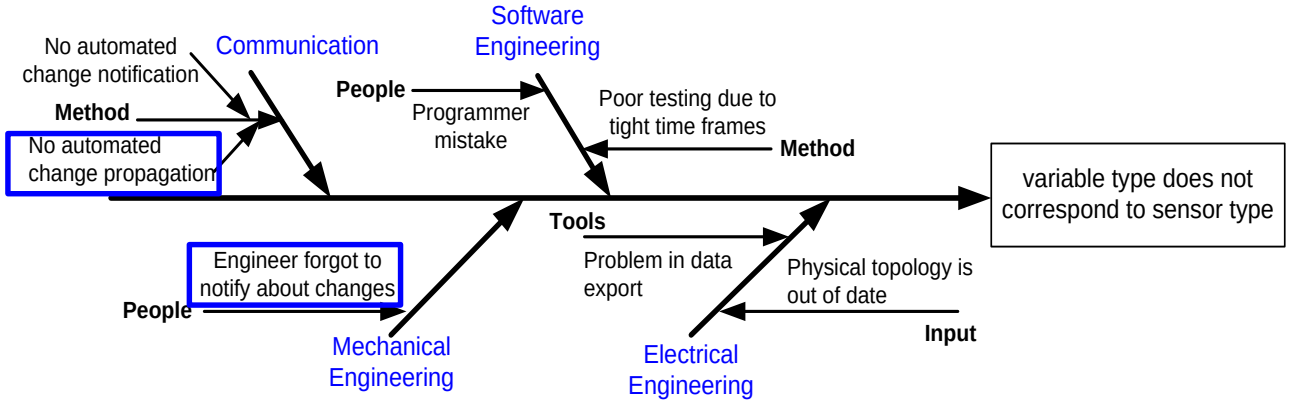
Core Defects and Errors

- Inconsistent Project and Engineering Data.
- Occur in the End-To-End Test.



Root Cause Analysis

- Lack in interoperability of data models and data.
- No automation supported change propagation/notification



Proposed Solution (Lessons Learned)

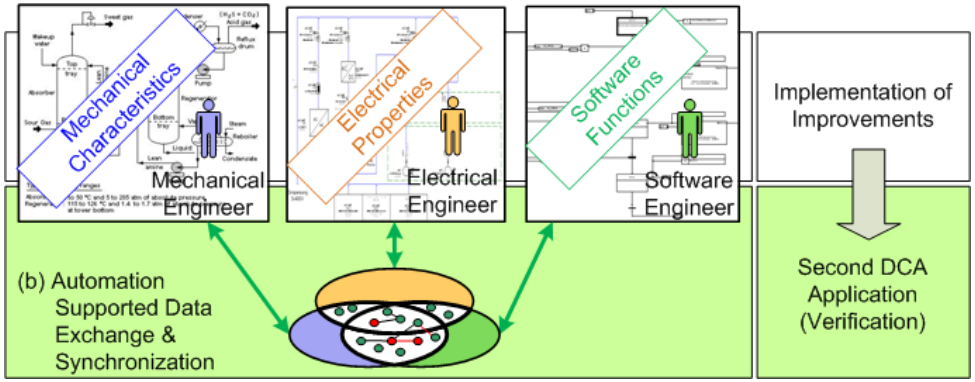
- Tool-Supported synchronization based on semantic technologies with the ASB*.

 *Automation Service Bus (http://cdl.ifs.tuwien.ac.at)

Improvement and Second DCA Application
Feasibility Study

Implemented Improvements

- Synchronization of heterogeneous data models based on common concepts.
- Automated Change propagation / notification → consistent project and engineering data.



However … (the results of the second DCA application)

- Data Model Transformation must be stable and correct.
- Incorrect transformation rules might lead to (systematic) mapping errors but they are easier to handle.

Systematic Error (identified in a second DCA cycle)

- Inconsistent engineering data due to incorrect transformations (model transformation errors)

Improvement Options

- Additional Quality Assurance Step to verify/validate model transformation.

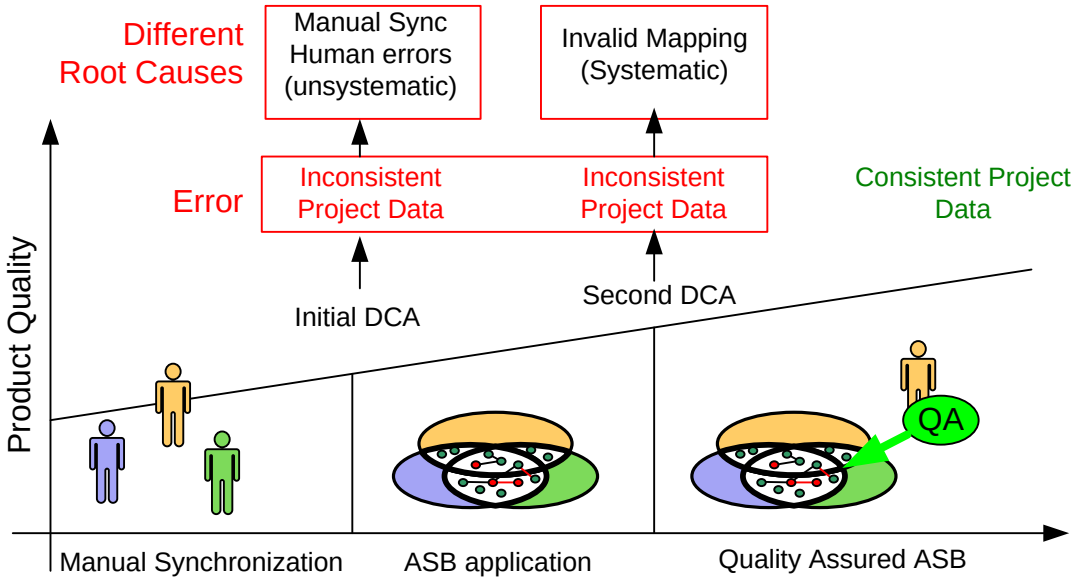
Summary & Future Work

Summary

- Multi-Disciplinary Engineering Projects include additional risks due to distributed and heterogeneous data models that have to be synchronized manually
- DCA enables the identification of root causes of a certain set of defects systematically.
- However DCA and Defect Classification approaches, applied in Software Engineering must be adapted to meet ME projects.
- A sequence of DCA applications can lead to an improvement strategy applicable in ME domains.

Future Work

- Towards tool supported DCA.
- Large-Scale application and Case Study in industry environment.



Thank you ...

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