Using Bayesian Belief Networks for Reliability Management

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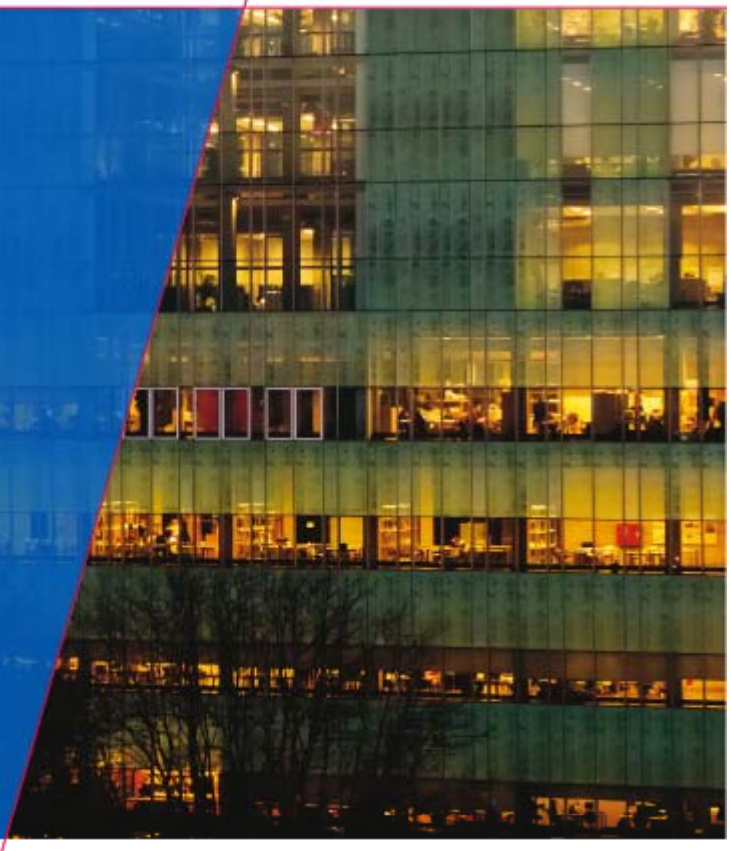

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Where innovation starts

Contents

- Reliability management: issues in practice
- Challenges regarding reliability management
- Chosen method
- Application of the method
- Evaluation of the method in light of the issues

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Issues in practice (I)

- **Question:**
  - **What will the reliability of my new system be, once in the field?**
- **Classical methods to answer this question, where systems are seen as a collection of components, do not work anymore for highly complex systems**
  - **More and more failures are encountered that are not clearly related to components, so-called Soft Reliability**
  - **Various ‘soft’ factors in the development organization and product development process (PDP) may influence how well one is able to manage the reliability. Most of these factors are difficult, if not impossible, to measure quantitatively and not even all are known**

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Issues in practice (II)

- **With these more ‘soft’ factors another approach to managing reliability is required, supported by appropriate method that take into account these factors and especially their qualitative nature and their uncertainty.**

Reliability Prediction & Management Early in Product Development

- **Predict & manage reliability, early in the PDP, when we can easily influence reliability**
- **Challenges related to reliability management early in the PDP:**
  - **‘Soft’ factors have to be taken into account**
  - **No adequate data are available**
  - **Complexity of problem context is high:**
    - **Many factors influence reliability**
    - **Many interactions play a role (product related, process related)**

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Reliability prediction and management method (I)

- **In order to cope with difficulties:**
  - **Include physical (‘hard’) as well as non-physical (‘soft’) factors**
  - **Usable early in and throughout the PDP**
  - **Incorporate uncertainty**
  - **Provide insights in how reliability is influenced in order to support decision making**

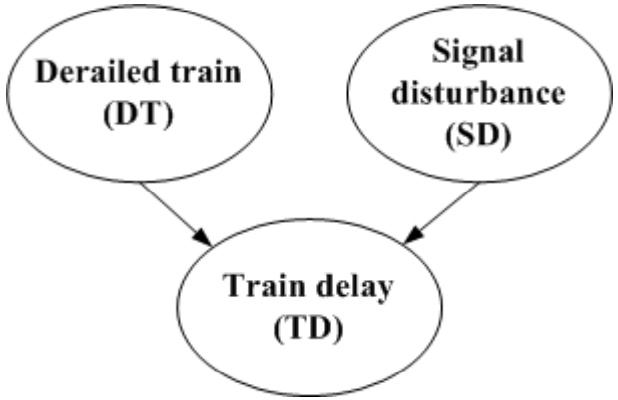
Reliability prediction and management method (II)

- **Traditional methods that give insights in reliability:**
  - **FMEA, testing, database methods**
- **Problems:**
  - **lack of insights in *how* reliability is influenced**
  - **methods are usable in later stages of the PDP (*testing can only be done with a finished product!*)**
- **Another approach:**
  - **Bayesian Belief Networks (BBNs)**

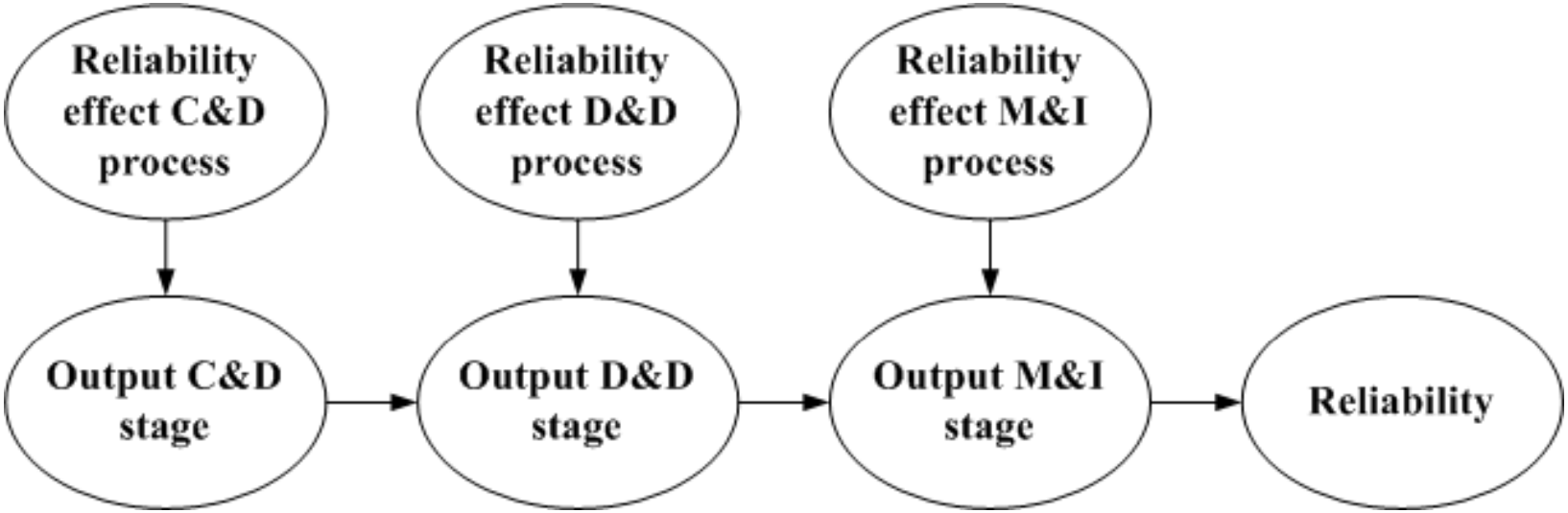
Bayesian Belief Networks (BBNs)

- **Cause-consequence diagrams that represent the way in which factors influence the end result *(based on the belief of experts)***

- **Containing:**
  - **The *factors* that influence each other and the end result**
  - **The *relations* between factors**
  - ***Quantification of relations* using probabilities**



Case study:
BBNs applied in a reliability context



- **Separate models: different stages of the PDP**
- **Total model: PDP**

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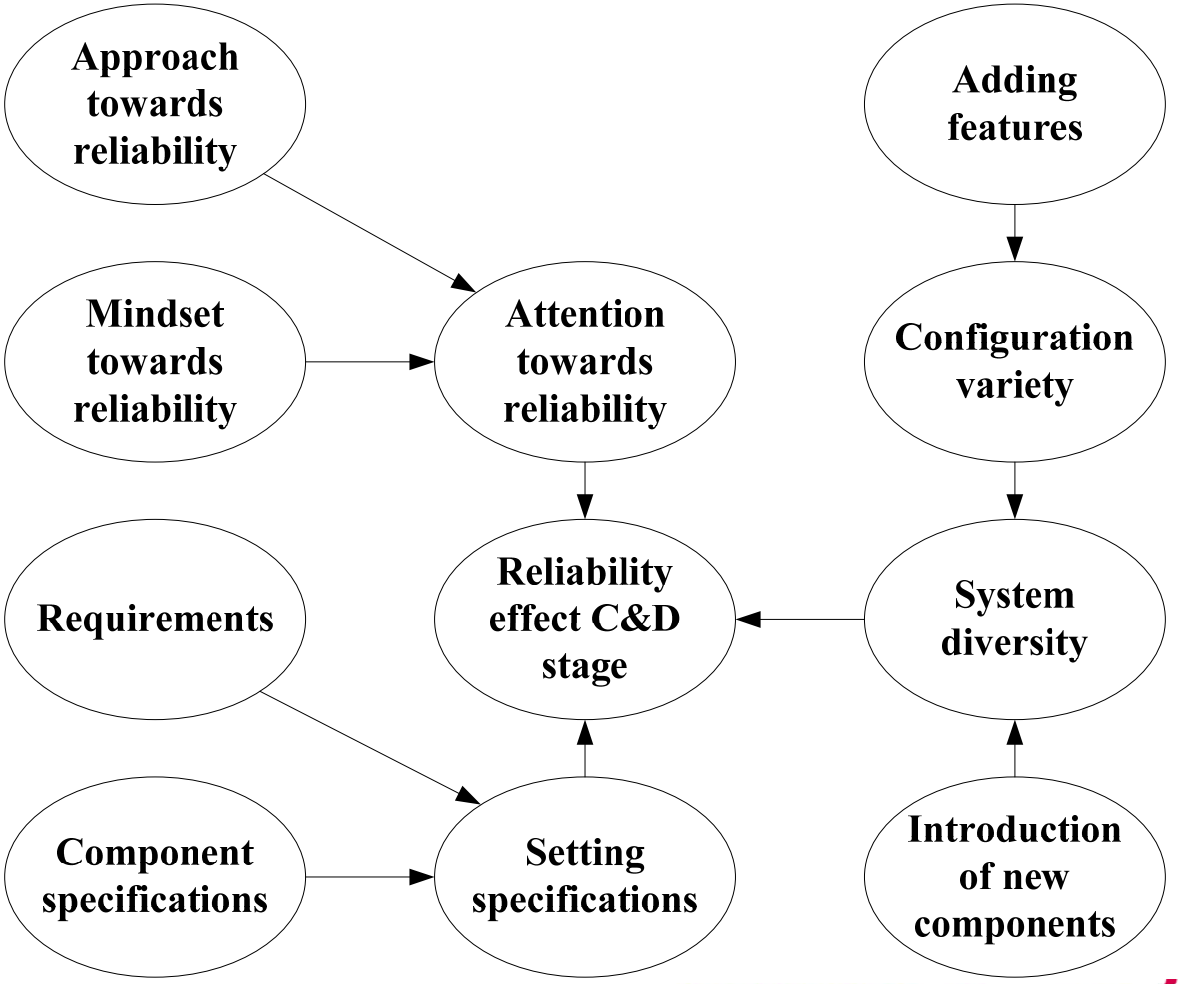
Case study results (I)
BBN C&D stage



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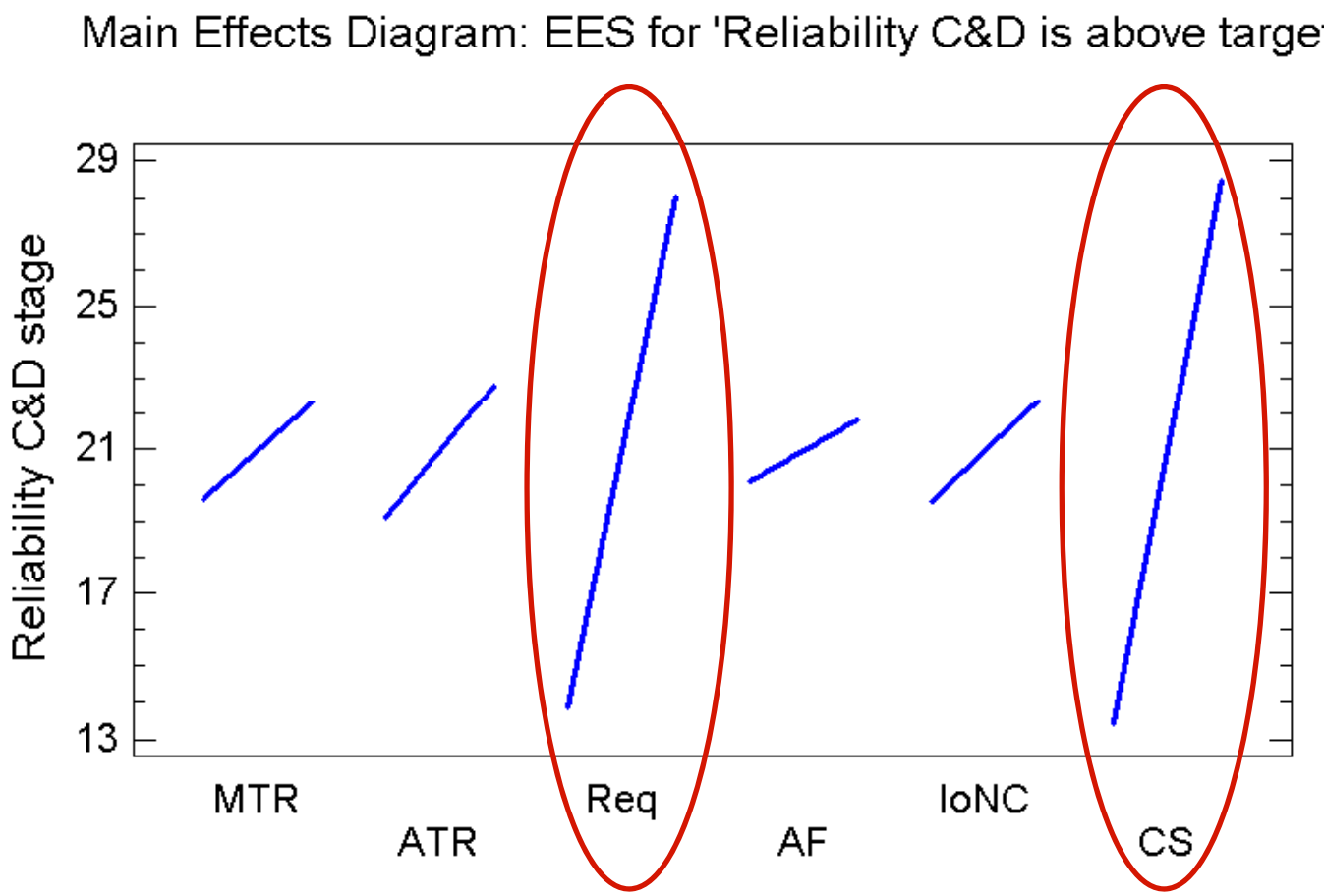
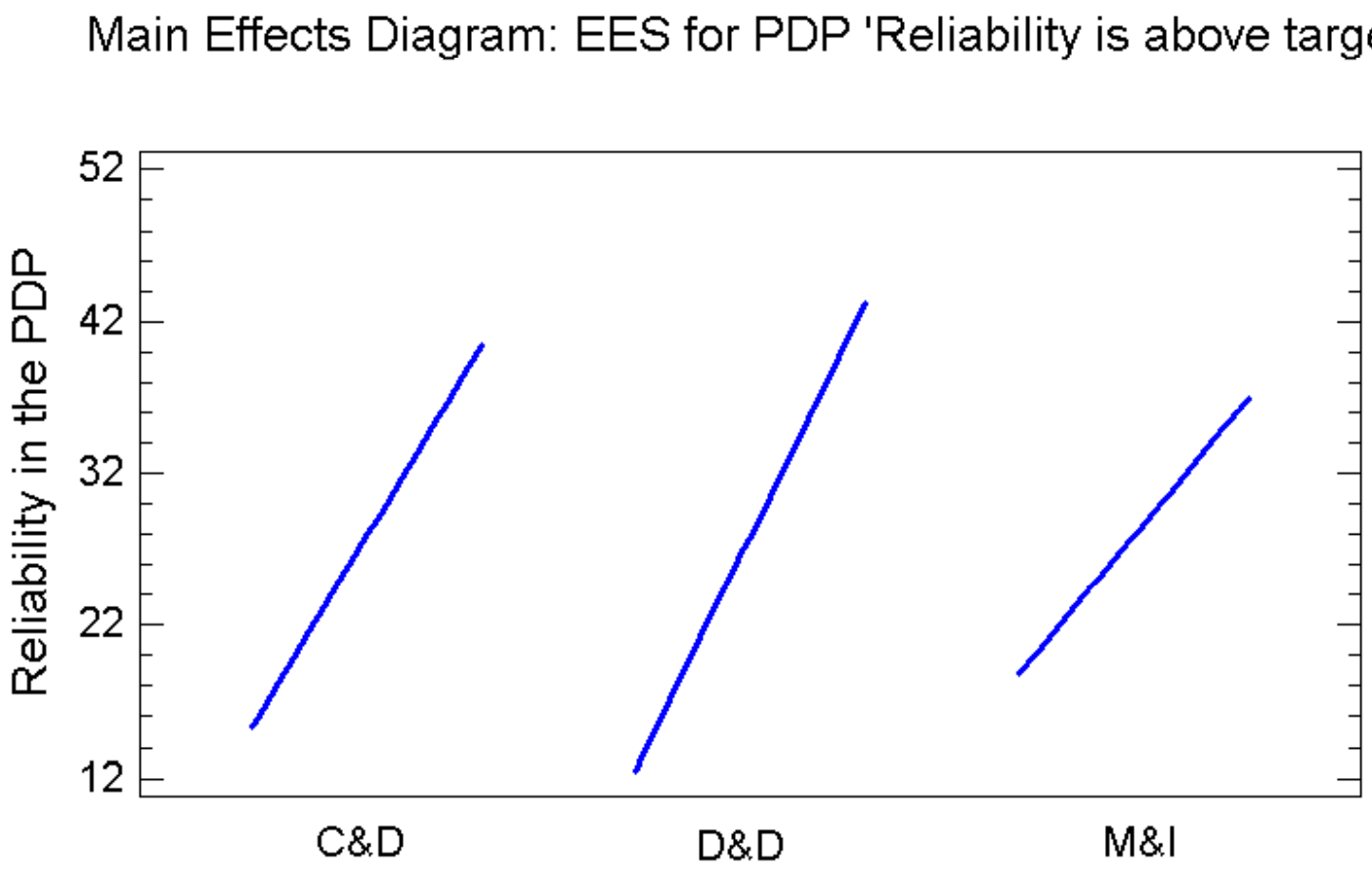
Case study results (II)
MEA: C&D stage 'Reliability above target'



Case study results (III)
Main effects analysis (MEA): PDP



Reflection on research

- **BBNs as a tool for reliability prediction and management**
  - **+ Estimate, upfront, the evolution of reliability throughout the PDP**
  - **+ Identifying the most important influencing factors**
    - **Steering on the most important factors**
    - **Supporting compromising when resources are scarce**
  - **- Validation of the model is difficult**
  - **- Quantification of the model is difficult**

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Why do BBNs help? (I)

- **BBN's take a more holistic approach to reliability management, taking into account that:**
  - **Highly complex systems are more than a collection of components**
  - **Reliability of such systems is determined by both systems factors as well as factors in the organization and PDP process**
  - **Uncertainty is an essential characteristic of some (if not most) of these factors**
  - **The collective knowledge and experience of an (development) organization can be used to better manage reliability**

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Why do BBNs help? (II)

- **The constructed BBN can be used to further determine where improvements need to be made for future developments, when we need to obtain even higher reliability requirements**