#### Applying Conceptual Modeling and Failure Data Analysis for "Actual Need" Exploration Case Study for an Automated Parking System

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## Aims of Our Study as Part of a Large Research Project

#### • In our study, we aimed at:

Applying conceptual modeling and failure data analysis to explore an industry's "actual need" through a case study for a medium-sized company that delivers Automated Parking Systems (APS). Company plans the introduction of Condition-Based Maintenance (CBM). Conceptual modeling facilitated the exploration of the Company's actual need behind the plan, which is increasing APS reliability. We collected failure data to understand APS reliability in this context. We find that the combination of conceptual modeling and data analysis facilitates exploring and understanding the Company's actual need. The conceptual modeling supports communication and understanding, while the data analysis guides the modeling. This study concludes with suggestions regarding using a combination of data analysis and conceptual modeling as a short-term vision to increase the system's reliability. On the other hand, this short-term vision may support the CBM as a long-term vision.

#### • Research project

 This study is part of a larger research project, the second iteration of the Human Systems Engineering Innovation Framework (HSEIF-2), funded by The Research Council of Norway (Project number 317862). For more information, please visit the research website at: <u>https://www.usn.no/english/research/our-research/technology/norwegian-industrial-systemsengineering-research-group/h-seif-2/</u>

### **Research questions**

- RQ1: How can conceptual models help the different stakeholders within a sociotechnical research project to formulate a shared understating of the Company's request and its consequences?
- RQ2: How can shared understanding support reasoning and decision-making about options for solving the actual problem?
- RQ3: How can data support common understanding, reasoning, communicating, and decision-making for the actual problem?

### **Conceptual modeling**

Conceptual models are a combination of empirical and first-principle models.

"Conceptual models are explicit representations of complex systems that help people understand and communicate the system and its behavior in its actual context." (Vrenne, T., Syverud, E., & Muller, G. (2021, July). Conceptual modeling of energy storage systems. In INCOSE International Symposium (Vol. 31, No. 1, pp. 31-46).)

### System-Of-Interest (SOI)



*The System-Of-Interest (SOI): semi-automated parking system (left) and its configurations (right).* 

System-Of-Interest's main parts.

## **Reliability Engineering**



Proactive and reactive reliability engineering within the product lifecycle, including the new product development (NPD) process



#### Workflow for car entry & for car retrieval from the SOI



Workflow for car entry to the SOI.







Workflow for car retrieval from the SOI.



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## Recommendations, accompanied with its principles and objectives, modified from (Muller, 2015)





#### Failure data: maintenance record data

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Column	Description
Dato (Date)	The date of the event (fault occurring)
Klokkeslett (Time)	Time of the event
Telefon	Telephone number
Brikke	Tag access number
Bilnr	Car registration number
Plassnr	Car place number
Årsak (Cause)	Description of the fault and comments by the maintenance personnel
Fakturerbar Ja/Nei	Invoice yes/no



#### **Failure data Analysis**



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#### **Failure data Analysis**



Mean Time Between Failures (MTBF) for 6 years period for the gate.



Gate failure events versus time of day (hour).

## Conclusion

- The combination of conceptual modeling and failure data analysis facilitated exploring and understanding the Company's actual need
- The conceptual modeling lifts customer value and business value on the one hand. On the other hand, conceptual modeling implementation encourages concrete, specific solutions and technologies
- conceptual modeling aided in communicating and sharing understanding of analysis of the value proposition of the Company's proposed system, CBM, which is formulated as a need.
- Actual need is increasing the system's reliability

# Thank You

