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

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IARIA

Haytham B. Ali is employed as PhD research fellow and Assistant Professor at the University of South-Eastern Norway (USN). He is working on connecting engineering with science, focusing on mathematics. Haytham focuses on his PhD at using a combination of conceptual modeling and data analysis to enhance the early design phase in the product development process. He holds a Master of Science in Systems Engineering with Industrial Economics degree and a Bachelor's degree in Mechanical Engineering with a specialization in Product Development, both from USN.

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: https://www.usn.no/english/research/our-research/technology/norwegian-industrial-systems-engineering-research-group/h-seif-2/

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?

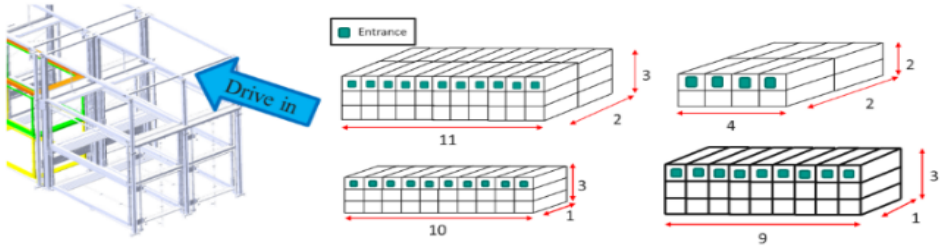
Conceptual modeling

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

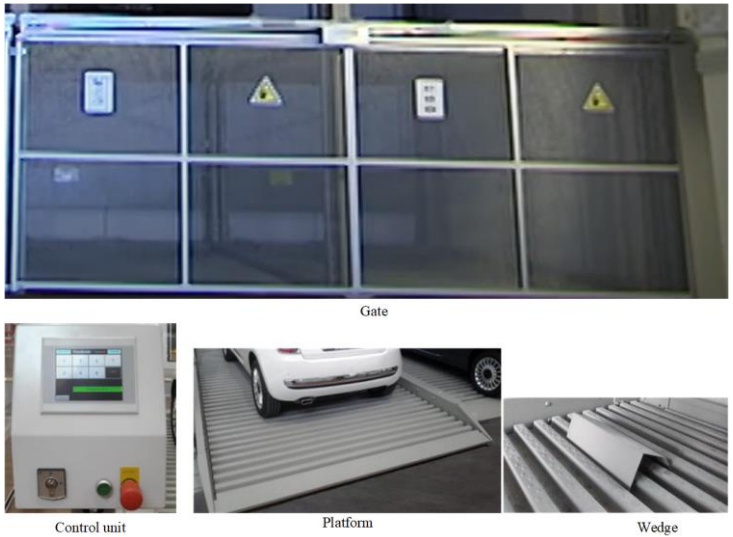
"Conceptual models are explicit representations of complex systems that help people understand and communicate the system and its behavior in its actual context."

(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)

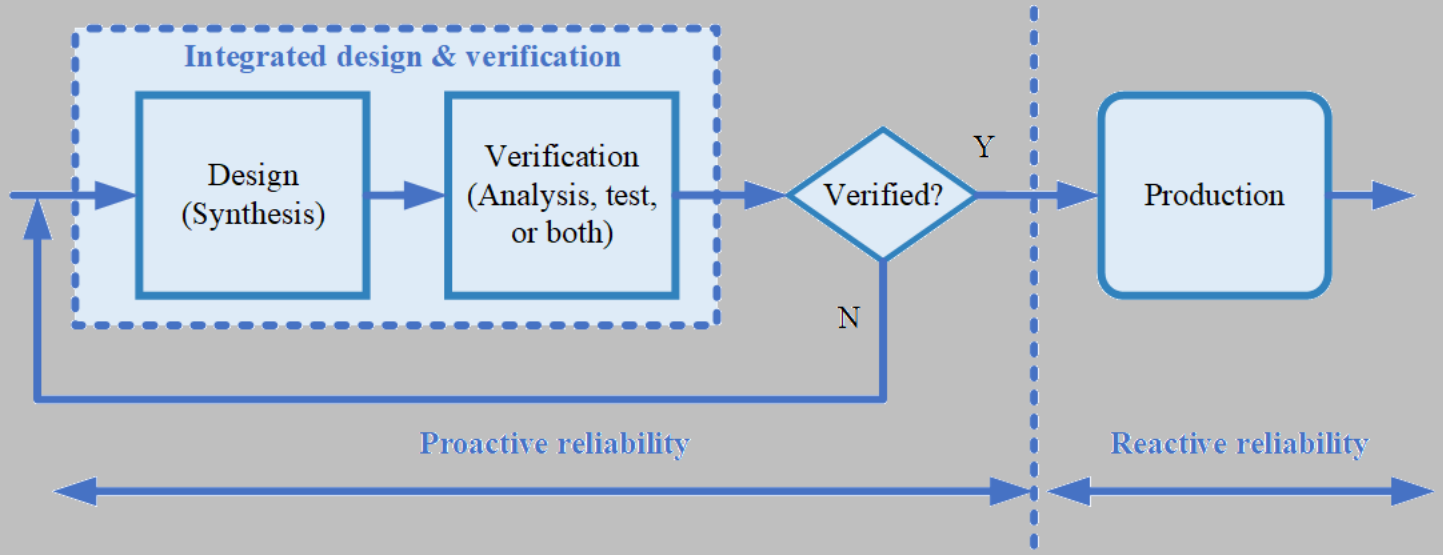


The System-Of-Interest (SOI): semi-automated parking system (left) and its configurations (right).



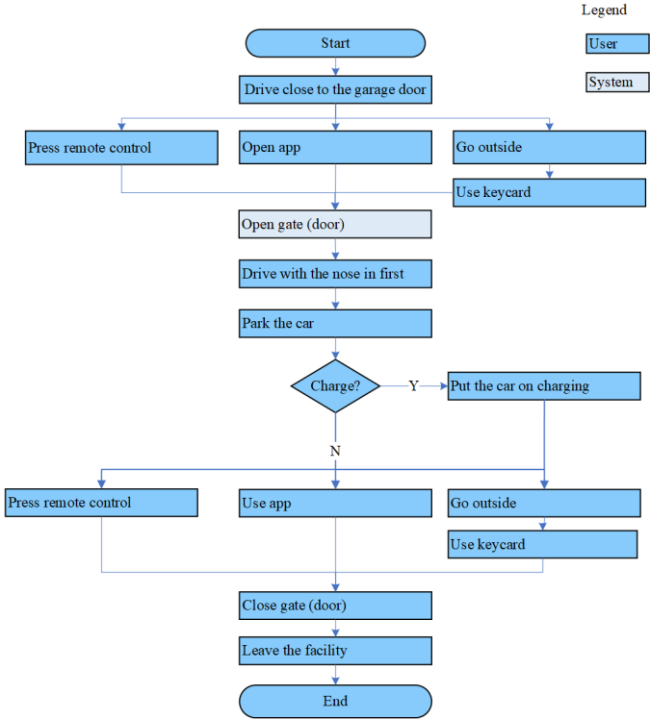
System-Of-Interest's main parts.

Reliability Engineering

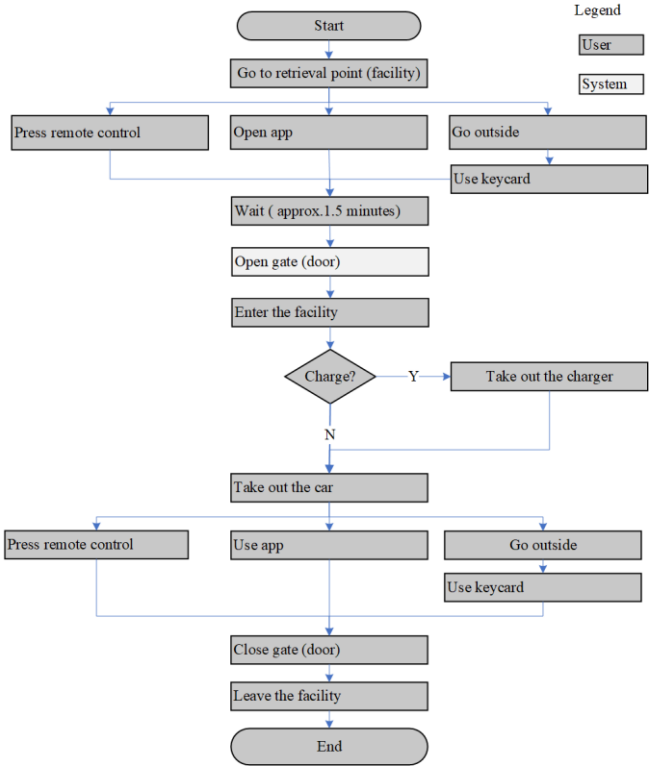


Proactive and reactive reliability engineering within the product lifecycle, including the new product development (NPD) process

Workflow for car entry & for car retrieval from the SOI



Workflow for car entry to the SOI.

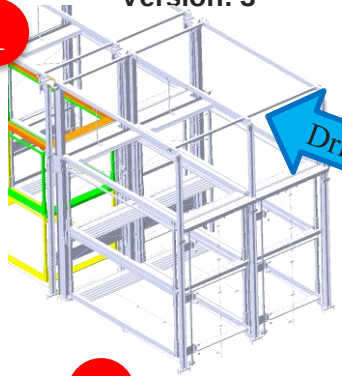


Workflow for car retrieval from the SOI.

Version: 3

A3 Architecture Overviews (A3AO) – Condition-based maintenance (CBM)

1



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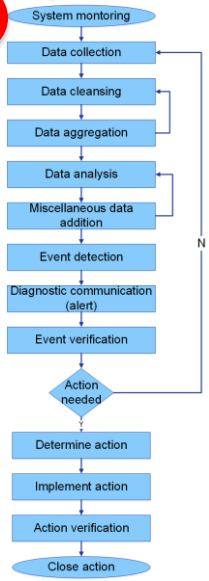

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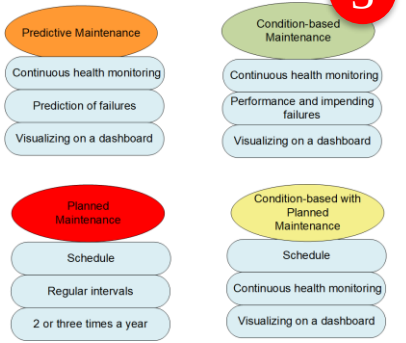

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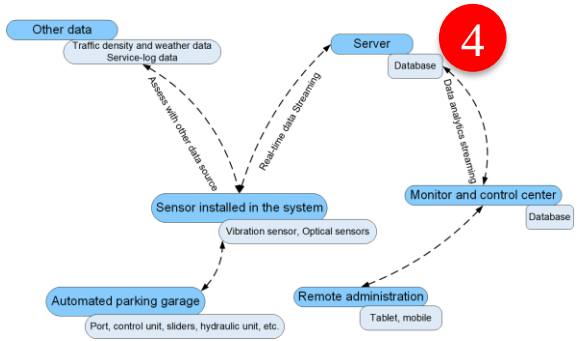

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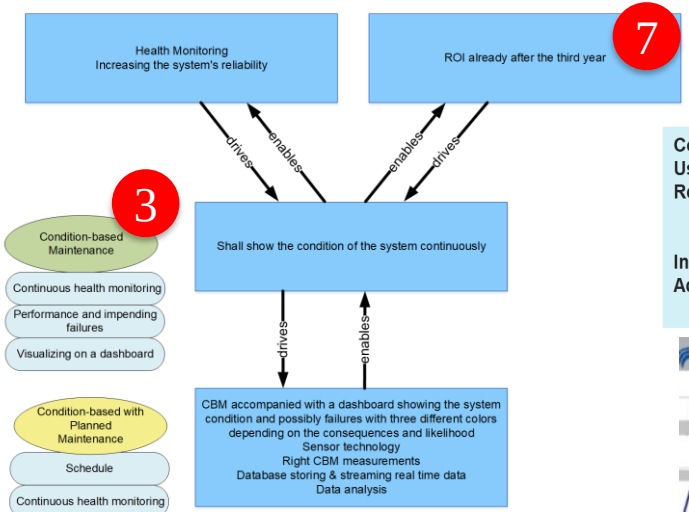
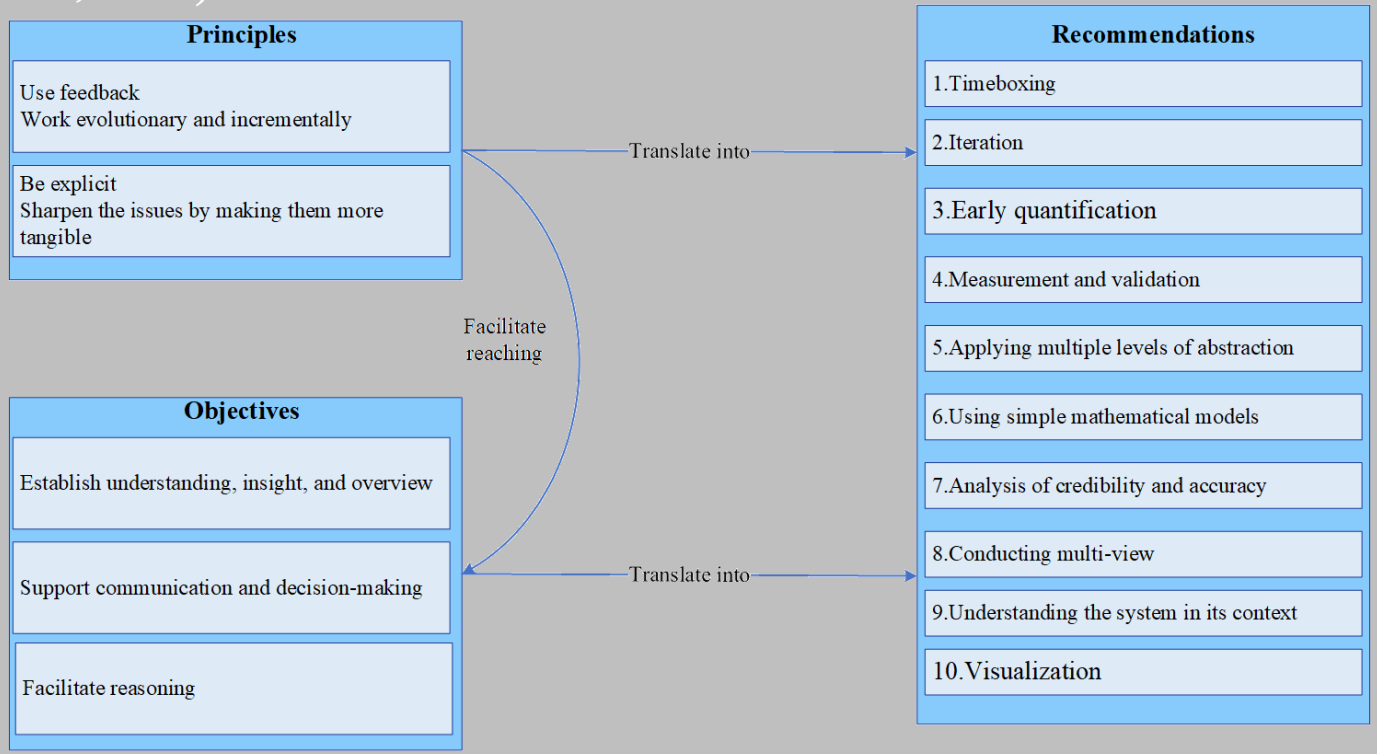
Cost: 3MNOK
Usability: 15 minutes
Reliability: false positive 1/100,
false negative 1/1000,
system failure 1/1000
Interoperability: at least 5 share points
Adaptability: data storage capacity 20T,
data frequency 3 minutes

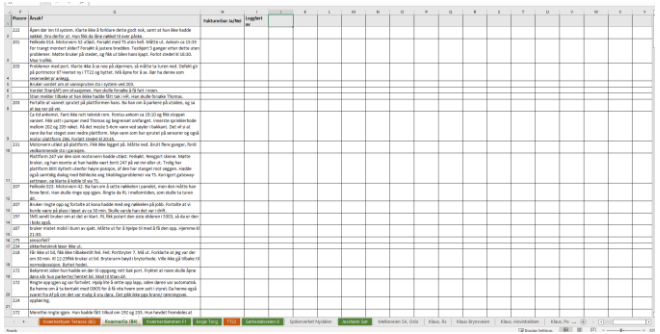
7



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

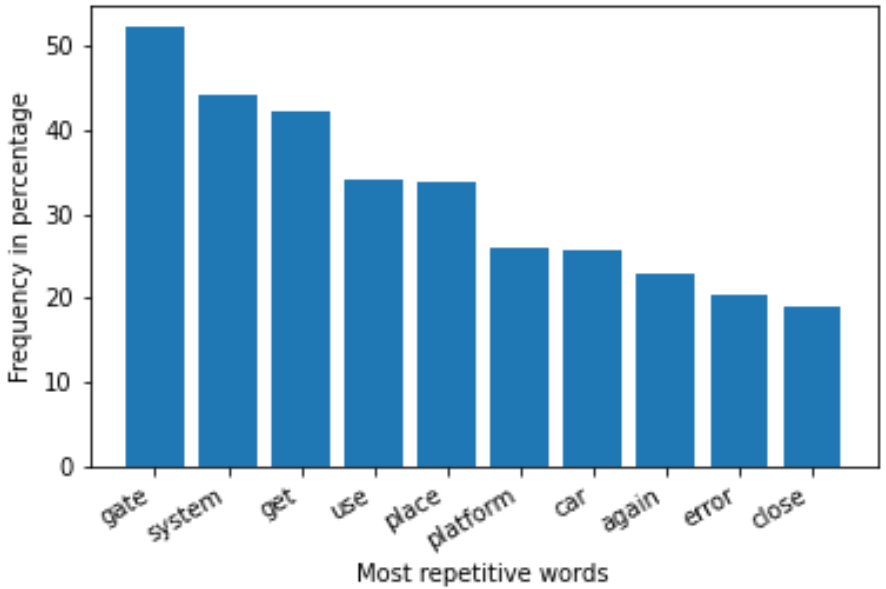


Failure data: maintenance record data



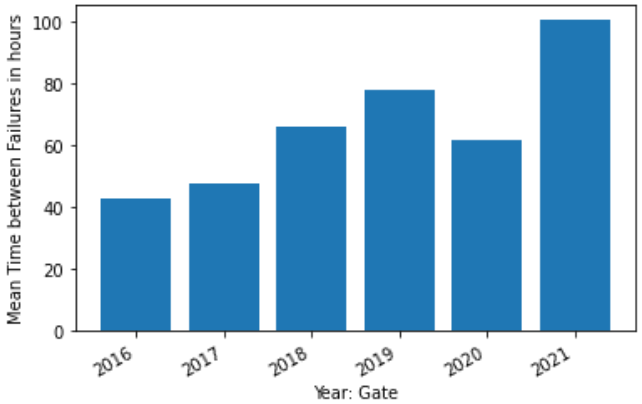
Column	Description
Dato (Date)	The date of the event (fault occurring)
Klokkeslett (Time)	Time of the event
Telefon	Telephone number
Brikke	Tag access number
Bilnr	Car registration number
Plassnr	Car place number
Årsak (Cause)	Description of the fault and comments by the maintenance personnel
Fakturerbar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

Failure data Analysis

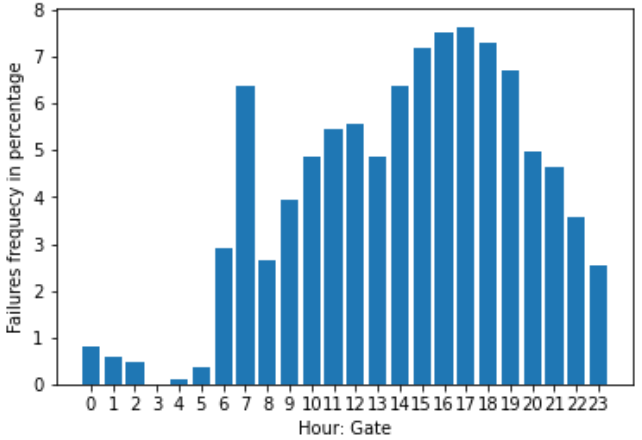


Percentages for most-repeated words for failure events.

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

Q & A