

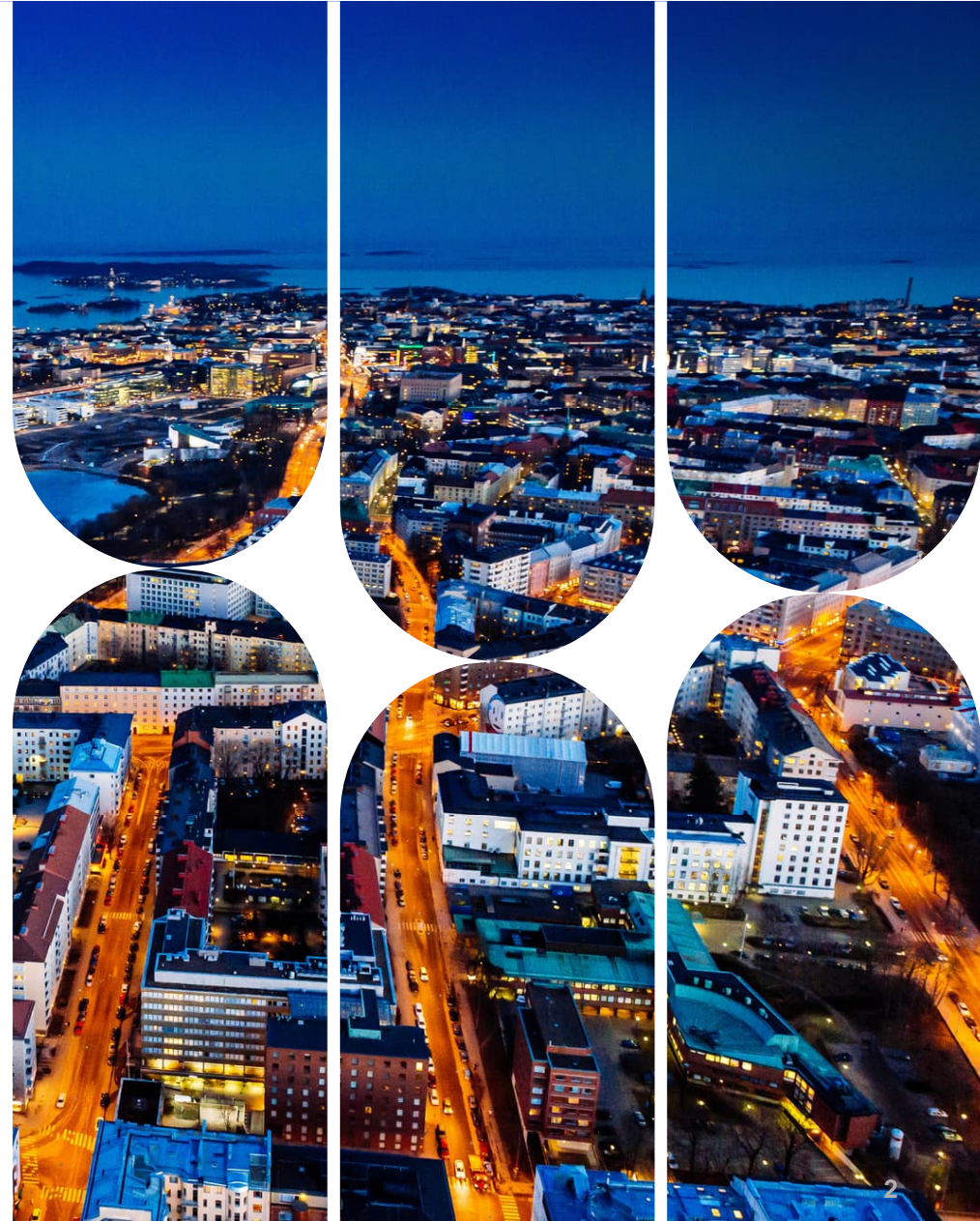
WP5: RAMS and HFE in H2 storage planning

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1/23/2026 VTT – beyond the obvious

RAMS and HFE processes in operation development

- Task goal: unified development program that holistically involves the RAMS and HFE viewpoints
- Recommendations during planning and operations



RAMS and HFE lifecycle processes in H2 storage planning

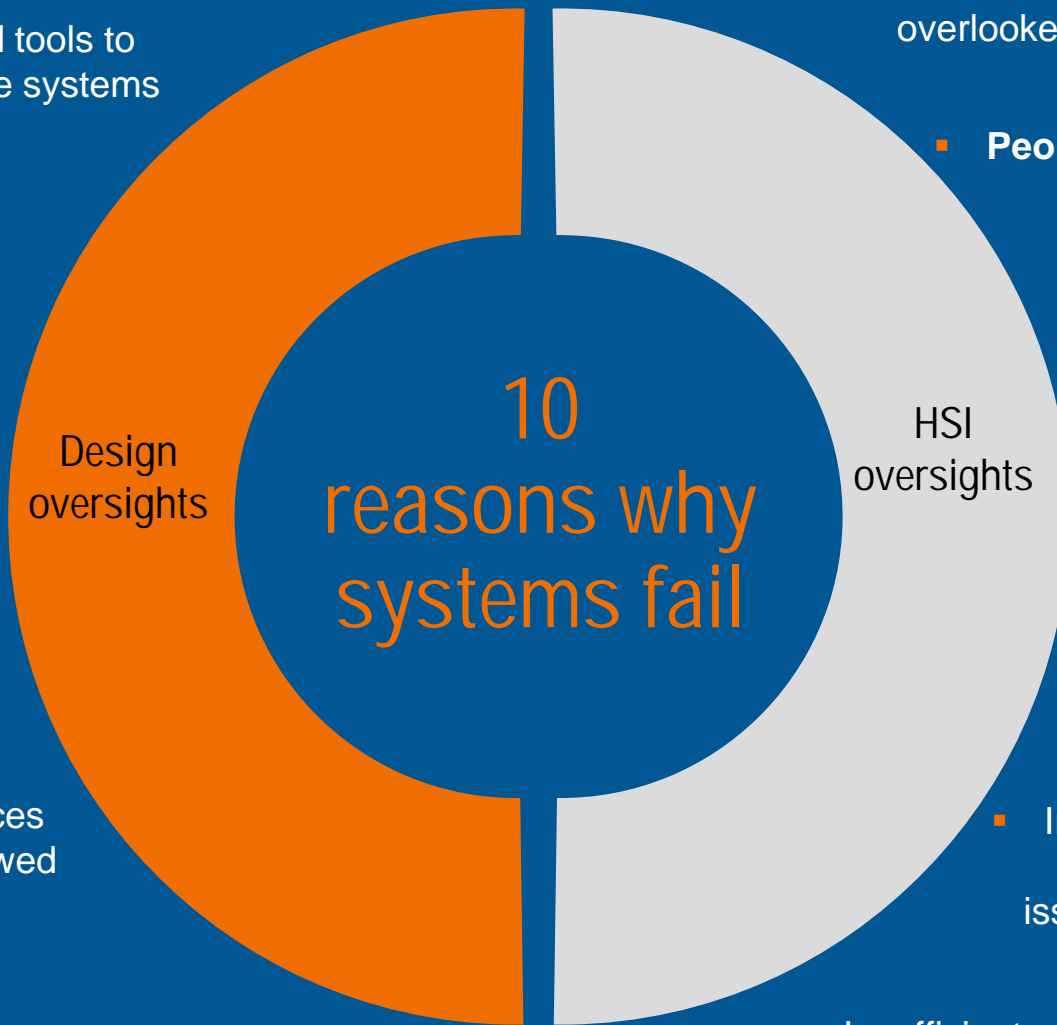
RAMS: Reliability – Availability – Maintainability - Safety

- Reliability: design/operational reliability; *the probability for failure-free operation* during any given interval
- Availability: system/component availability during any given interval
- Maintainability: maintenance outage durations, maintenance action time requirements and constraints (incl. servicing, inspections, repairs, modifications)
 - A key maintainability figure of merit is the mean time to repair (MTTR) and a limit for the maximum repair time.
- Safety: acceptable levels of risk in the system state, lifecycle, or at any given interval

HFE: Human Factors Engineering

- Systematic integration of human capabilities, limitations, and behavior into the design of technologies, systems, and work processes to ensure safe, efficient, and seamless operation
- Human error, skills, productivity, system availability, safety, health and comfort
- Human physical, psychological and cognitive abilities and restrictions
- **Human-system interaction (HSI)**

- Lack of effective methods and tools to predict in complex, large-scale systems early in design process
- Bridging research and practical application remains limited, hindering knowledge growth.
- Conflicting requirements of various stakeholders in the system development process
 - Established best practices and standards not followed



- Human factors considerations overlooked early in system design
- **People frequently seen as liabilities rather than key contributors to system resilience**
 - Costs and resource allocation for HSI are hard to explicitly justify → lack of necessary resources due to a lack of awareness
- Metrics, data, and tools to support Human Systems Integration (HSI) insufficient or underused
- Inadequate education and training of system developers on HSI issues, and limited opportunities for training specialists
- Insufficient advocacy for HSI considerations at top organizational levels

Laux, L. (2009). Trends in HFE Methods and Tools and Their Applicability to Safety Reviews. <https://doi.org/10.2172/1013433>

UHS lifecycle

RAMS

- Decision-making point (Go / No-Go) for progressing
 - e.g. sufficient level of safety
- Design objectives clarification
- Results → input to implementation and validation
- Definition of separate sub-systems providers (subcontractors)

Concept

HFE

- Identify user objectives
- Operating experience analysis
- Plan HFE activities
- Understand user needs
- Define HFE requirements

RAMS

- Objectives and requirements of reliability, safety and cost-effectiveness
- Producing the control of RAMS elements

Development

HFE

- Prelim function allocation & task analysis
- Staffing & qualification analysis
- Understanding maintenance needs
- Test prototypes with users
- Human-oriented design assessment (usability)

RAMS

- Fulfilling previously settled RAMS requirements
- Fulfilling RAMS requirements allocated to subcontractors
- Producing coherent quality
- Achieving the targeted performance level

Realization / Commission

HFE

- Skills training
- Health & safety awareness
- Formal usability testing of full systems
- Ensure Regulatory compliance

RAMS

- The realization of RAMS requirements in practice, safe use of the machine
- Constant development of the operations

Utilization

HFE

- Operation/maintenance records
- Usability testing of procedures
- Corrective/preventive actions
- Incident reporting

RAMS

- Streamlining procedures in order to improve:
 - operational efficiency
 - obsolescence management

Enhancement

HFE

- Human performance monitoring
- Process improvements
- Recommendations for design changes

RAMS

- Confirming safety and environmental protection
- Apply chosen R-strategy (e.g. reuse, remanufacturing, recycle)

Retirement

HFE

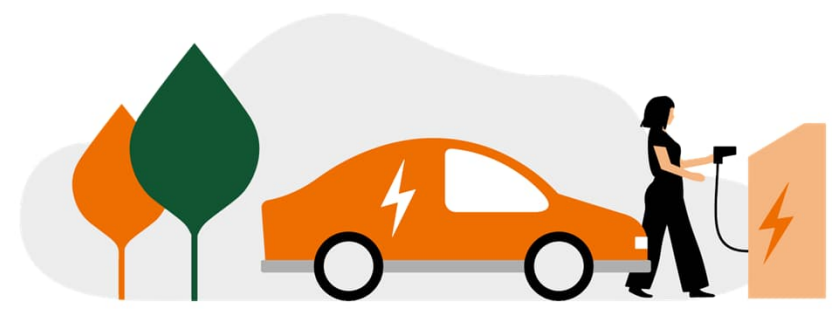
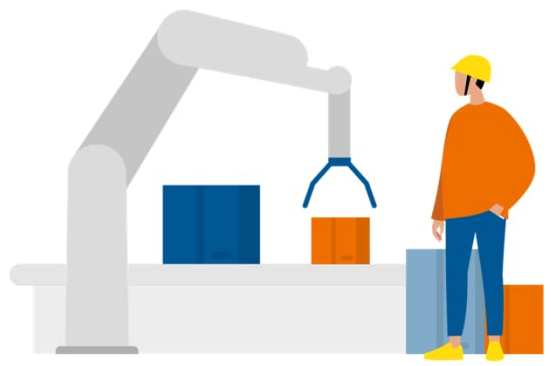
- HF issues related to disposals, recycling and reuse

UHS lifecycle



HFE

RAMS



In order to run
this...



...this needs to be
considered

HFE

RAMS



Questions for the design of any planned system:

1. Who's going to run it?
2. What does it take to run it?
3. How is the fulfilment of the requirements for running going to be monitored?
4. What are the personnel's capabilities **to respond to unexpected events?**
5. How adaptive is the system?

Next steps

**Operational
information needs**

By domain
By frequency

**UHS Monitoring
solution/
framework**

Whiteboard

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Thank you!

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