

# WP2

# HOLISTIC VIEW ON UHS ECOSYSTEM RISKS

---

SOTEC framework and technical risks

Nadezhda Gotcheva and Tero Välisalo, VTT

22 January 2026

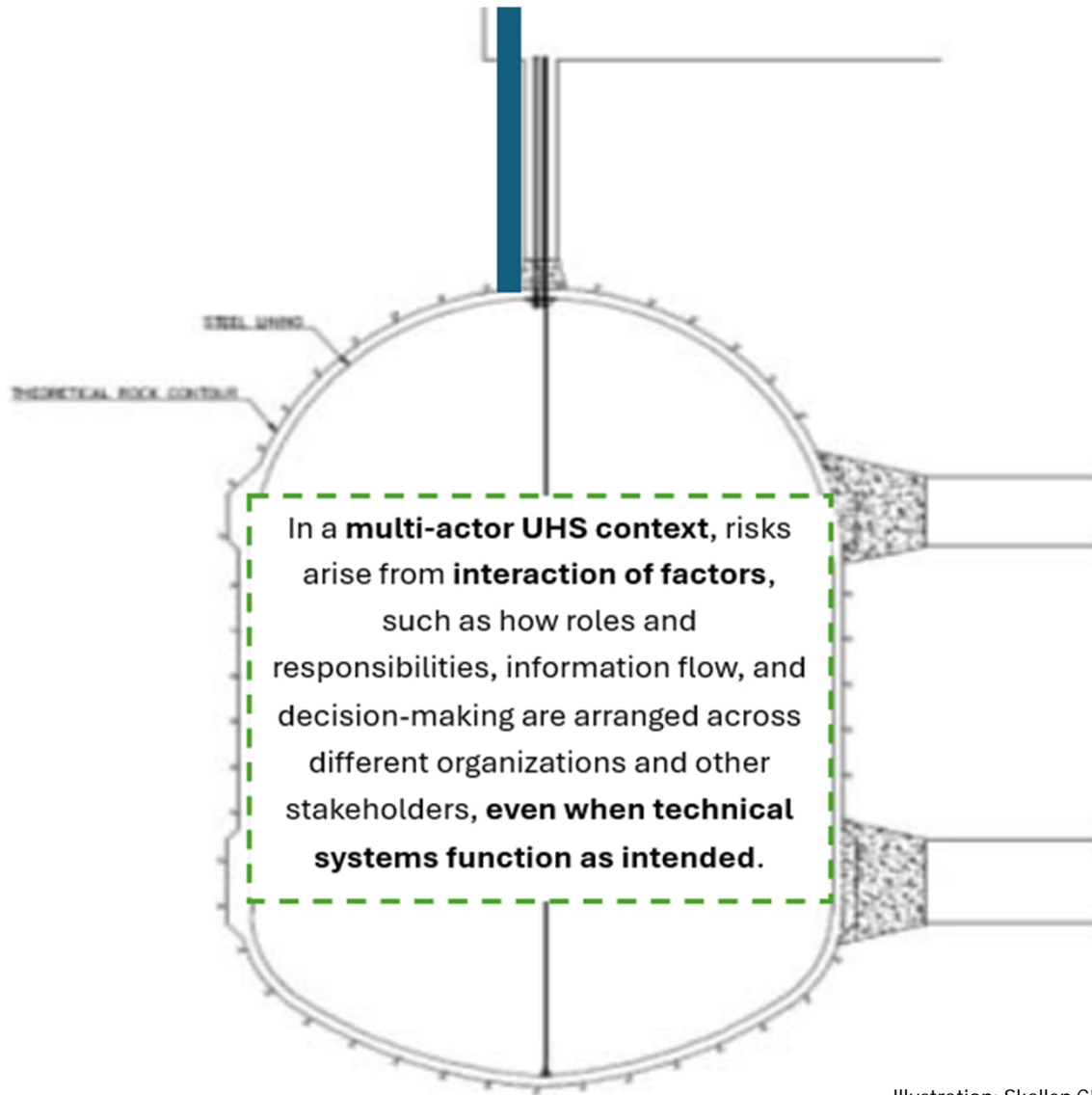
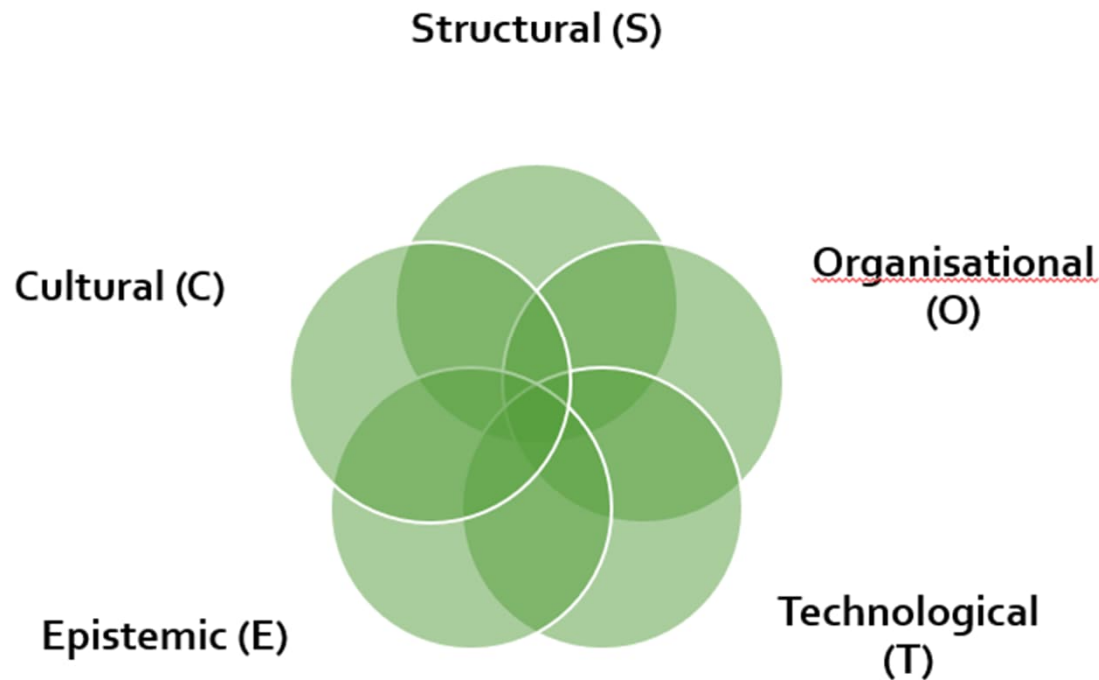


Illustration: Skallen CNG storage

# WHY WE NEED A HOLISTIC VIEW ON UHS ECOSYSTEM RISKS?

# UHS is a sociotechnical system: SOTEC framework of sociotechnical risks



- Macrae (2022) developed the SOTEC framework through analysis of the fatal 2018 Uber self-driving crash to examine sociotechnical risk in autonomous and intelligent systems. The framework has recently been applied to energy transition context in Australia (Hayes & Maslen, 2025).
- The SOTEC framework integrates structural, organizational, technological, epistemic, and cultural sources of risk.
- The framework provides a structured approach to identify, assess, and manage sociotechnical risks, ensuring a holistic and effective risk management process.

# SOTEC: Five categories of risk



Structural – risks arising from interdependencies and dynamic interactions across technical and social structures.



Organizational – risks arising from social processes, organizing activities, human and contextual factors (e.g., planning, roles, incentives, procedures).



Technological – risks arising from capabilities, constraints, affordances “inscribed into” the engineered system.



Epistemic – risks arising from how individual and organizational knowledge and ignorance are constructed.



Cultural – risks arising from collective values, norms, beliefs, and practices that shape assumptions, priorities and behaviors.



# Example questions to address different risk categories

- Structural: Where do we have interdependence that could turn small problems into major consequences (regulators - operators; supply chain structures)?
- Organizational: What organizational conditions create challenges for work to be done with high quality (insufficient resources, unclear accountabilities)?
- Technological: What new constraints or affordances does the technology introduce that changes how work is done in practice?
- Epistemic: Where are we operating at the edge of knowledge, and how do we detect overconfidence?
- Cultural: What norms are being reinforced (e.g., production pressure, “cannot happen here” shared beliefs), and how do they impact decisions?

# Challenges and opportunities for using SOTEC

Security or geopolitical risks are not explicitly included in the SOTEC framework, but where to draw the line? There is an opportunity for new theoretical and methodological development with practical implications.

The SOTEC framework helps identify interrelations and vulnerabilities of different nature, which allows emerging risks to be recognized and addressed. Such holistic view helps to imagine what may go wrong and how to ensure safety.

The framework provides a comprehensive picture of risk, but it requires a multidisciplinary approach and expertise to analyze risks holistically. There is a need to integrate SOTEC into existing risk analysis processes.

# References

- Macrae, C. (2022), Learning from the Failure of Autonomous and Intelligent Systems: Accidents, Safety, and Sociotechnical Sources of Risk. Risk Analysis, 42: 1999-2025. <https://doi.org/10.1111/risa.13850>
- Hayes, J. and Maslen, S. (2025), Preparing for Public Safety Assurance in the Energy Transition, Future Fuels CRC, Australian Government.