

A joint approach to Safety, Security and Resilience using the Functional Resonance Analysis Method

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Knowledge for Tomorrow

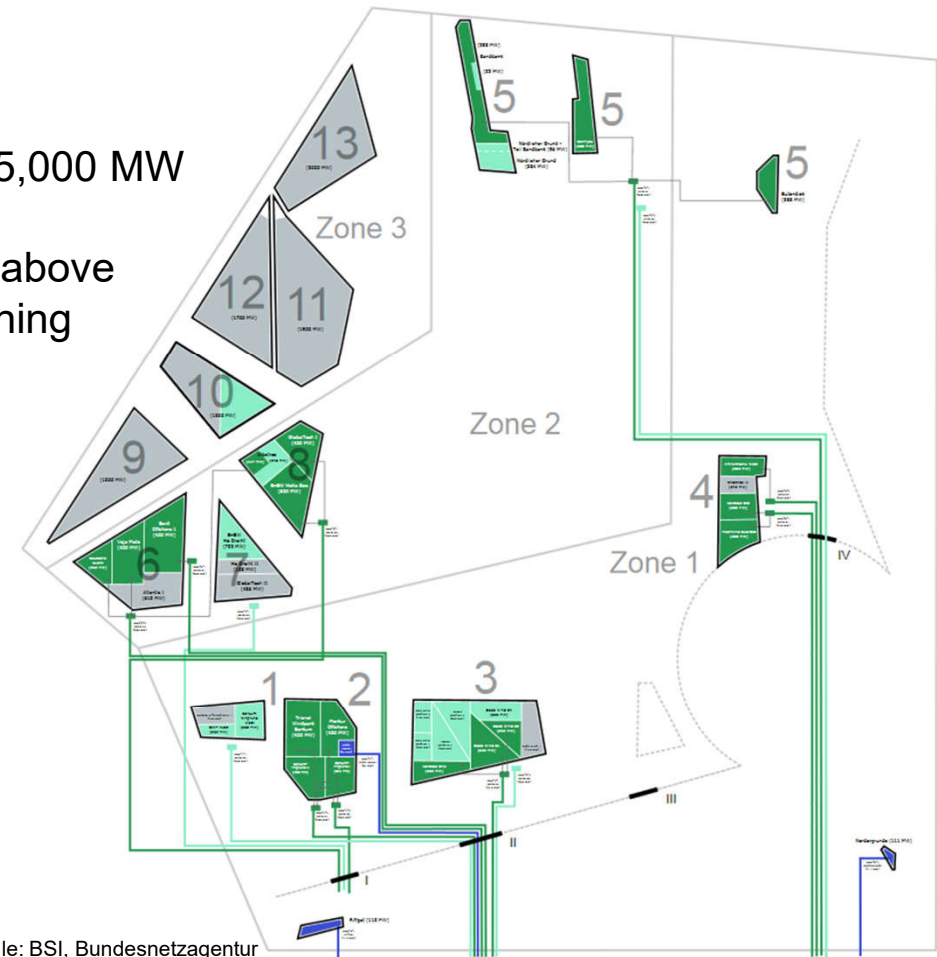


Motivation for this work

Power supply by wind farms is growing in Germany

→ 03/2019: 6,616 MW → 12/2020: 7,700 MW → 2030: 15,000 MW

Electricity generating units with a capacity of 420 MW and above becomes critical infrastructures and their seamless functioning should be protected



Project

KISS – Key performance Indicator (KPI)-based monitoring of the safety and security level of offshore wind farms (OWF) in real-time

- development of the system theoretical background for the description of safety/ security levels in the system OWF
- Elaboration of a practical concept to supervise safety/security in real-time

Quelle: flickr/Vattenfall



Safety, security and resilience (SSR)

Resilience

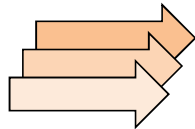
~ is considered as “the intrinsic ability of a system to adjust its functioning prior to, during, or following changes and disturbances, so that it can sustain required operations under both expected and unexpected conditions.

Hollnagel, E.; Paries, J.; Woods, DD.; Wreathall, J.; (2019) Prologue: The scope of Resilience Engineering

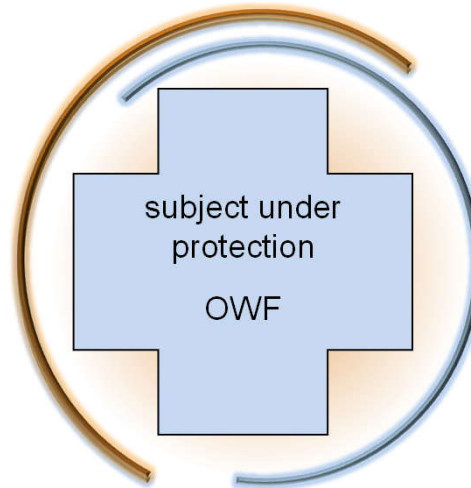
Safety aspects

~ unintended disturbances and threats 1...N in relation to diversity of safety goals

- random events
- carelessness
- inabilities



flanks of vulnerability and brittleness

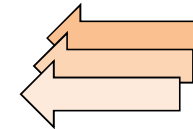


barriers, defence and mitigation means, recovery mechanism, incident management...

Security aspects

~ intended disturbances and threats 1...M in relation to security goals

- vandalism and attacks as purpose
- criminal and terroristic attacks as mean



Diversity of objectives of OWF stakeholders

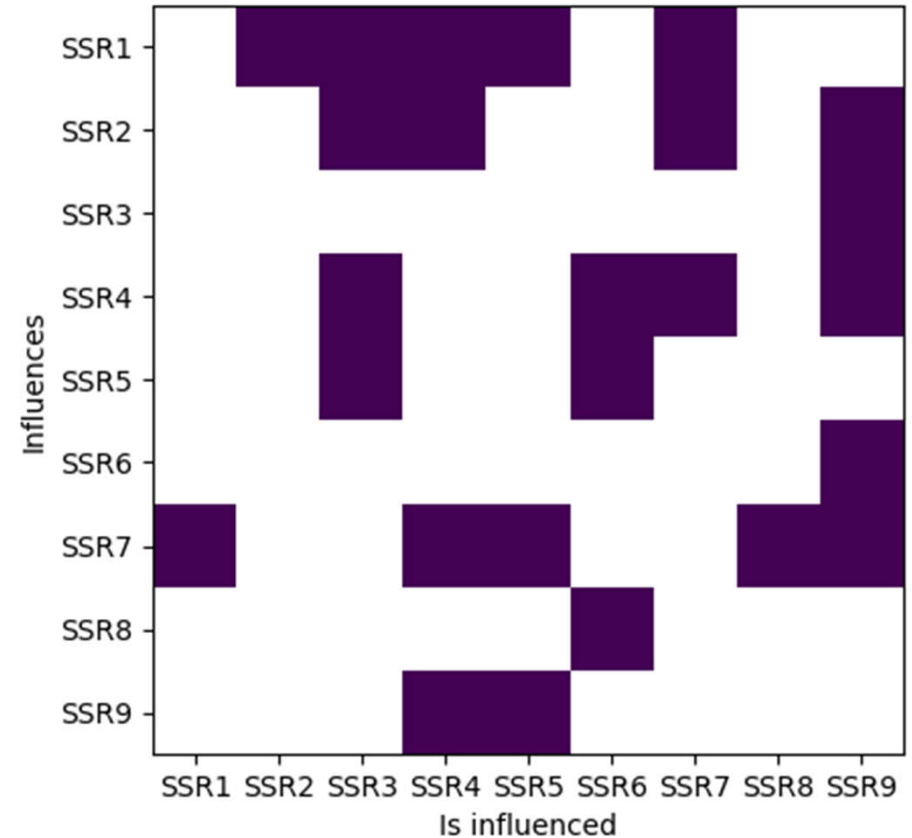
stakeholder	objectives →	accident prevention	security	occupational safety	compliance	environmental protection	reputation	plant safety	finance	supply reliability
	owner	✓	✓	✓	✓	✓	✓	✓	✓	✓
operator	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
maintenance provider	✓	✓	✓	✓	✓		✓	✓		
logistics company	✓			✓	✓					
⋮										
coast guard	✓		✓	✓	✓				✓	
rescue forces	✓			✓	✓					
vessel traffic services	✓		✓	✓	✓					
⋮										
fisheries					✓	✓			✓	
investors			✓	✓	✓	✓	✓	✓	✓	✓



Interrelation between objectives

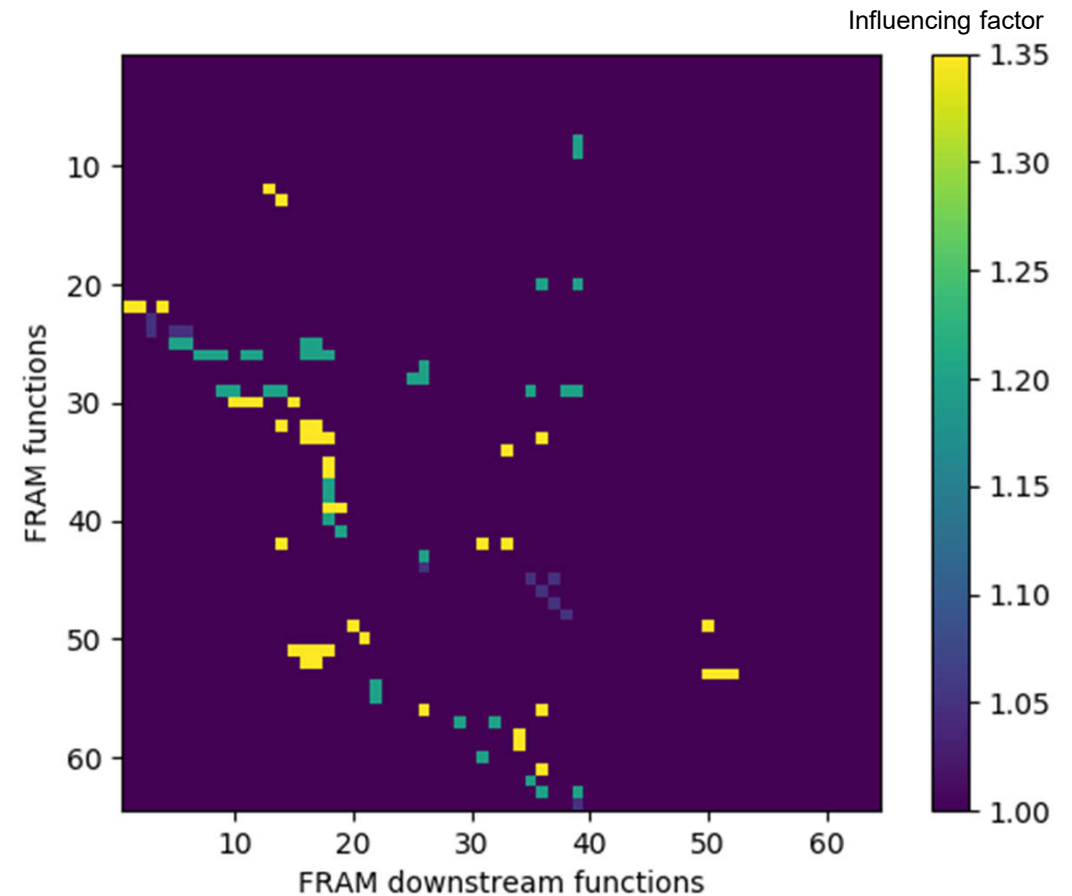
Nine general objectives (SSR goals) are derived and prioritized:

- 1) Accident prevention
- 2) Security
- 3) Compliance
- 4) Occupational safety
- 5) Environmental protection
- 6) Reputation
- 7) Plant safety
- 8) Supply reliability
- 9) Finance



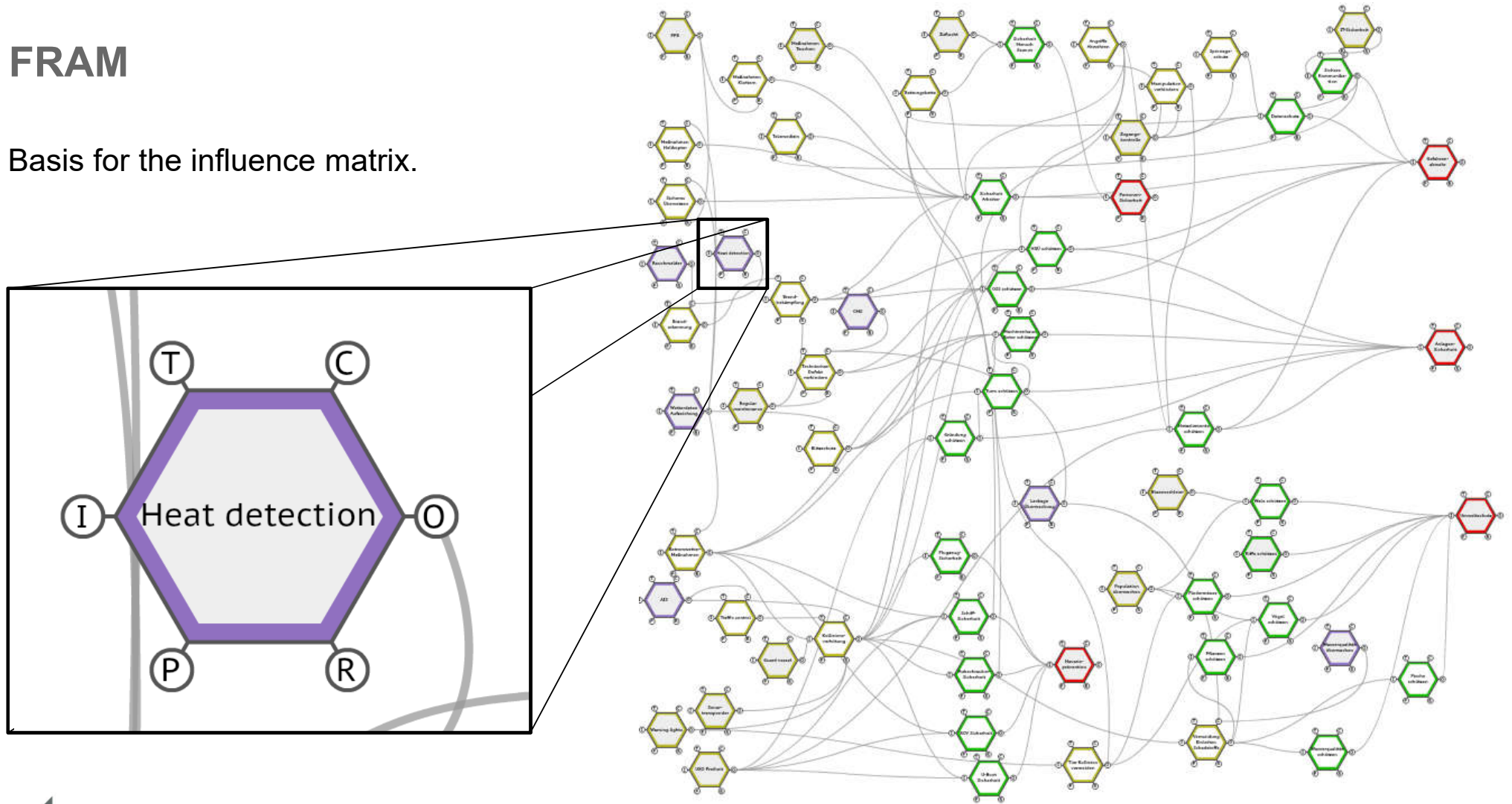
Mapping of objectives on functions

- Five prioritized overall objectives are represented by 64 functions of an arbitrary OWF e.g. fire detection, safe helicopter, or safe information.
- The 64 function may be classified regarding their main responsibility:
 - functions to protect specific components and processes
 - functions to perform/manage the maintenance of safety
 - functions to gather safety-relevant information (status, trends, conditions)
- Resilience analysis matrix (RAM)



FRAM

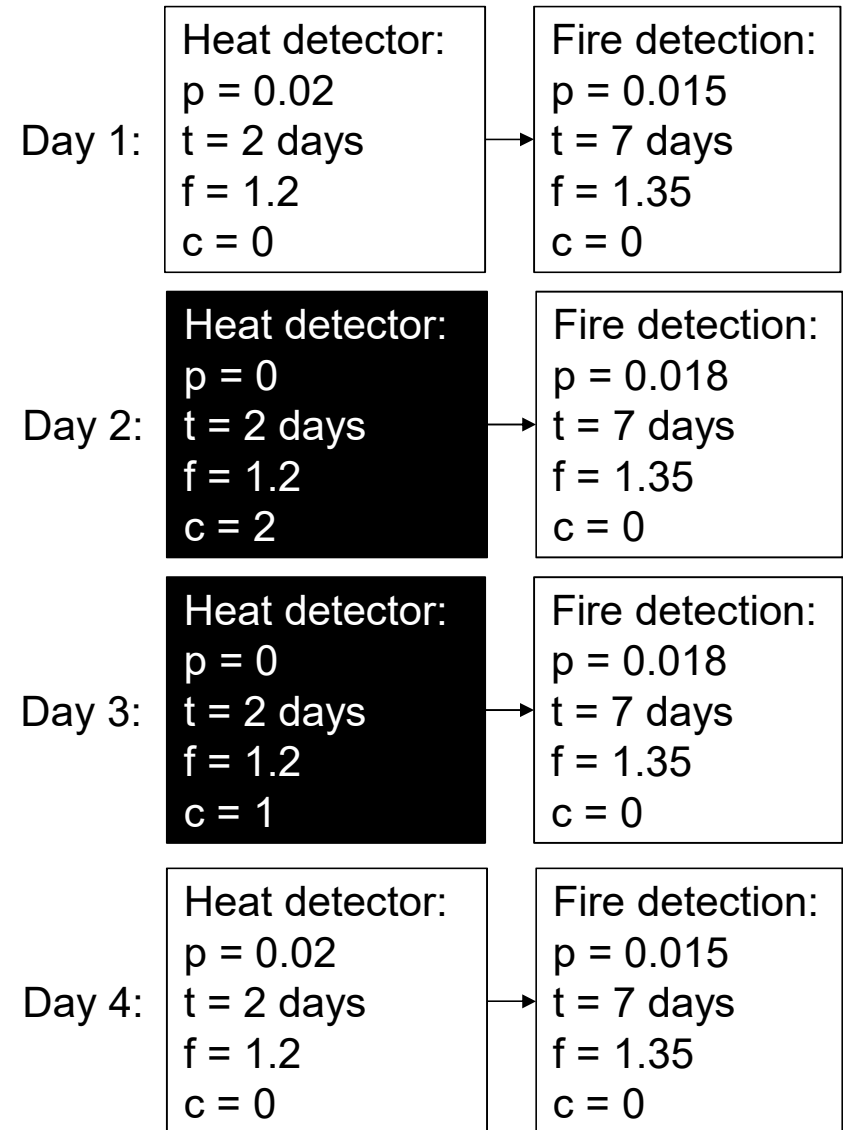
Basis for the influence matrix.



Monte Carlo simulation

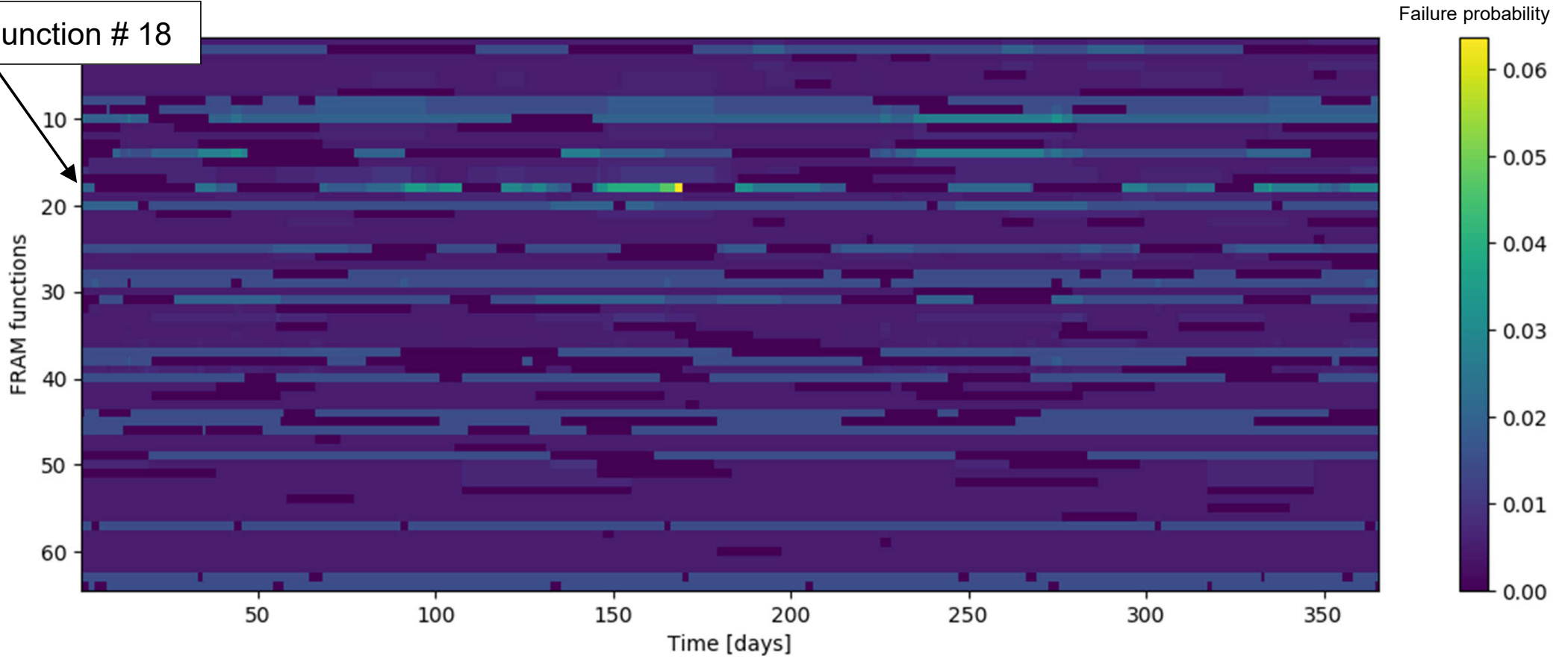


- Every function has three main properties:
 - Failure probability p
 - Time to restore/repair t
 - Influencing factor f
- Simulation over one year:
 - Every day uniform random numbers are generated.
 - Some functions fail and influence the downstream functions.
 - Some functions are restored (countdown $c = 0$)

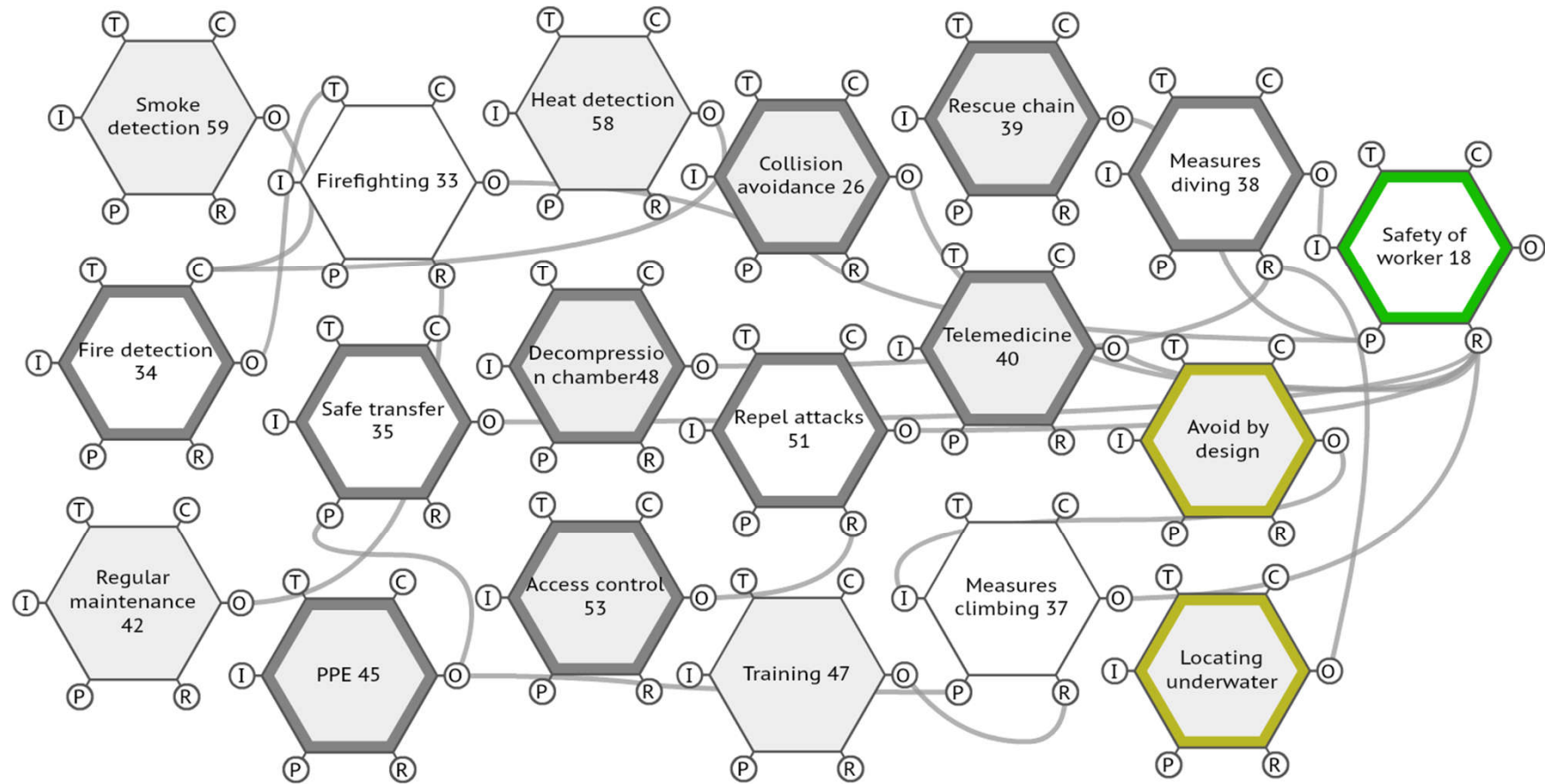


Failure probabilities over one year

Function # 18

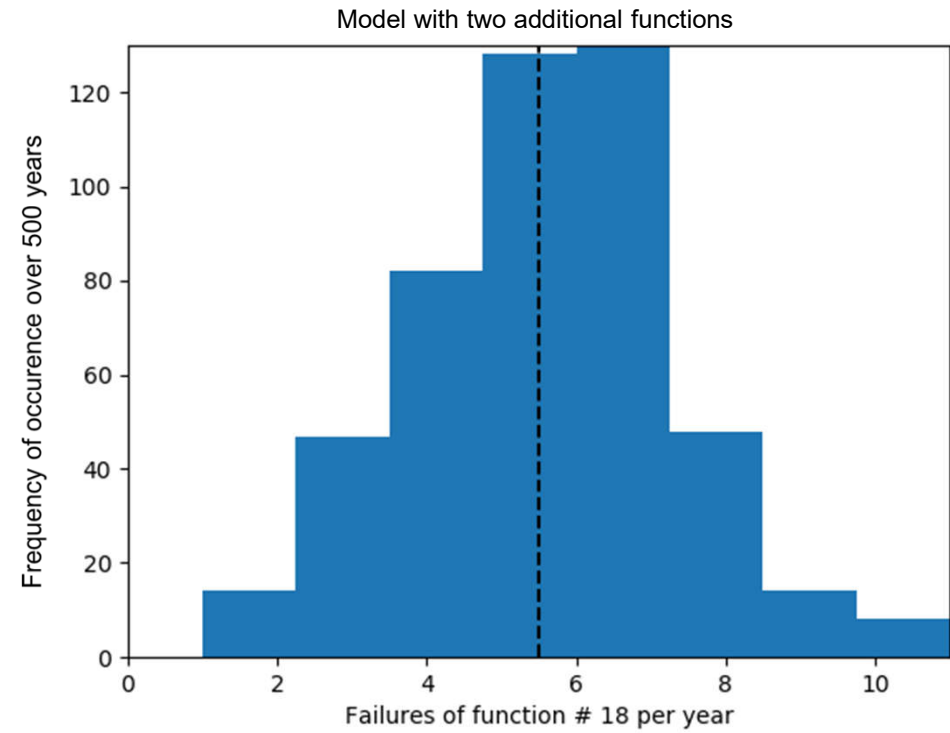
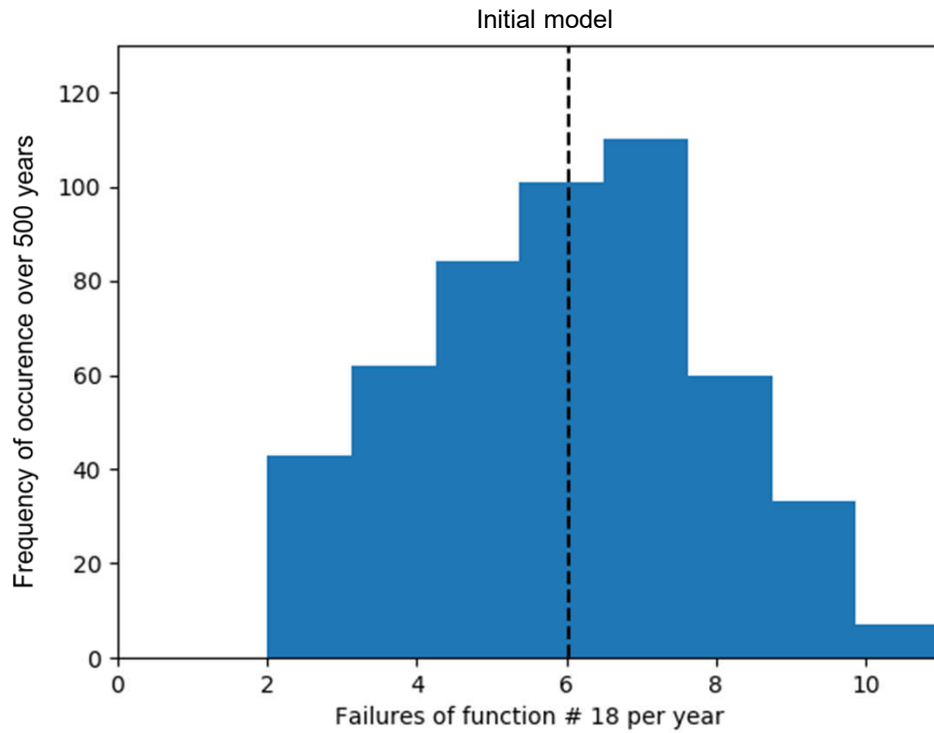


What is wrong with function # 18?



Impact of safety measures

Introducing two new measures reduces the number of work accidents per year.



Summary and outlook

Summary

- Simulation approach to propagate function failures through a FRAM model
- Conceptual identification of critical functions in infrastructures
- Quantitative evaluation method for additional safety measures

Critical review

- Safety II still needs to be implemented, performance can be degraded
- Model and risk assessment need to be validated

Outlook

- Automate re-evaluation after implementing a new measure
- Analysis of the slope of function failure probability to predict failures

