PSAM 18 Conference

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CNEA

Probabilistic Modelling Approach for Human Actions in Emergency Management at an SMR Multi-Unit Site

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1. Research motivation
2. Objectives and Methodology
3. Identification of Human Actions for the On-site Emergency Management Plan
4. Probabilistic Modelling of HAs and HFEs
5. Application case: Results
6. Conclusions

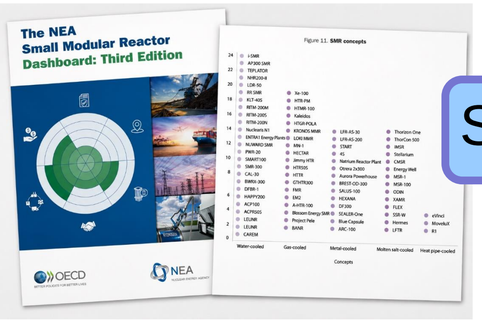
Figure 1: Bariloche Atomic Center – CNEA - location.

1. Research motivation

New nuclear power plant designs

New challenges!

Small Modular Reactors (SMRs)



Human Factors Engineering (HFEN)

Multi-unit or multi-module sites

Figure 2: Image extracted from The Fukushima Daiichi Accident, IAEA, 2015

On-site Emergency Management Plan

HUMAN ACTIONS (HAs)

2. Objectives and Methodology

Objectives

1. To define a structure of HAs involved in emergency plan management for a multi-unit site with SMR units.

2. To define guidelines for modelling HAs within a dynamic probabilistic model that supports emergency management plan development

Methodology

- Literature reviews → No references regarding HA identification and modelling in on-site emergency management
  Literature reviews → Thematic descomposition
- Propose of methodological approaches
- Application case: Hypotethical multi-unit site with two i-PWR SMRs.

3. Identification of Human Actions for On-site Emergency Management Plan

HA identification

HFEN → Task analysis (Hierarchical Task Analysis)

HRA perspective

HFEN → Staffing organization

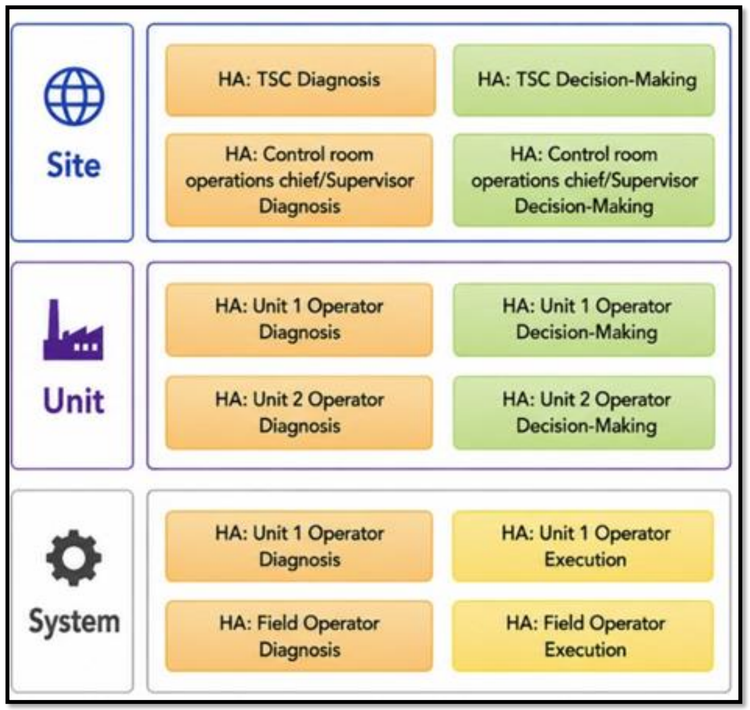


Figure: HA structure for on-site emergency management.

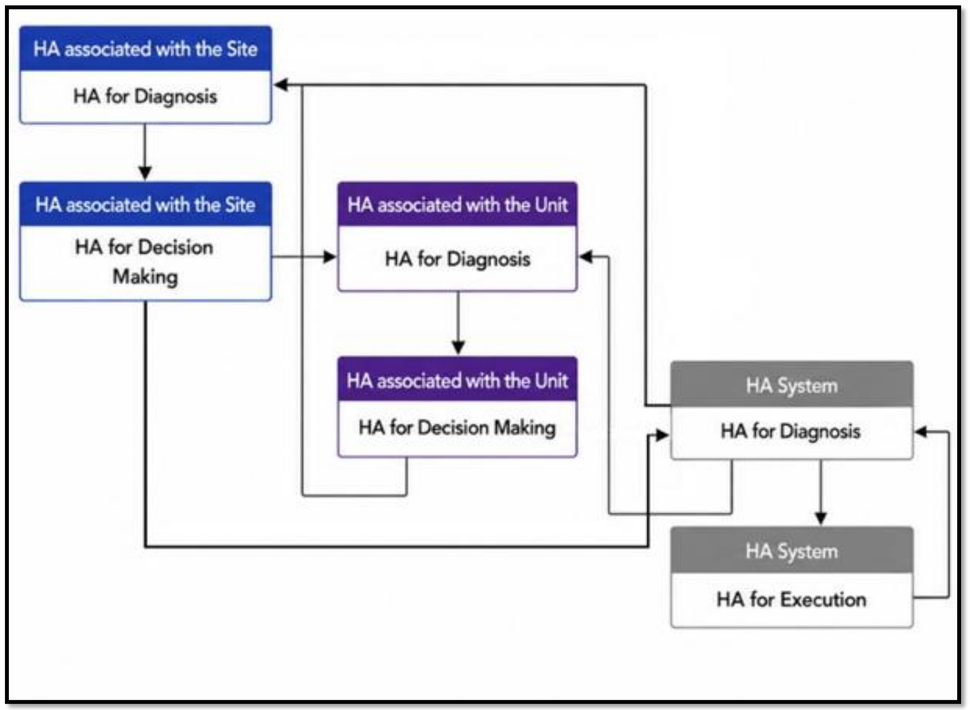


Figure 3: Relationships among HAs for on-site emergency management.

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4. Probabilistic Modelling of HAs and Human Failure Events

Framework

- Probabilistic model to support design on-site emergency management plan →Dynamic probabilistic model

Type of human action

- Post-initiated HAs
- Strategies: Control of Initiating event, FLEX, Severe accident management

Methods & tools

- SPAR-H (RiskSpectrum HRA)
- EMRALD

Scope

- Static Permormance Shaping Factors (PSF) →standarized by type of HA
- No delays considered in HA
- Dependences: First approach→ only information transfer among organizational structure. Definition of Dependency types. Evaluated according to SPAR-H.

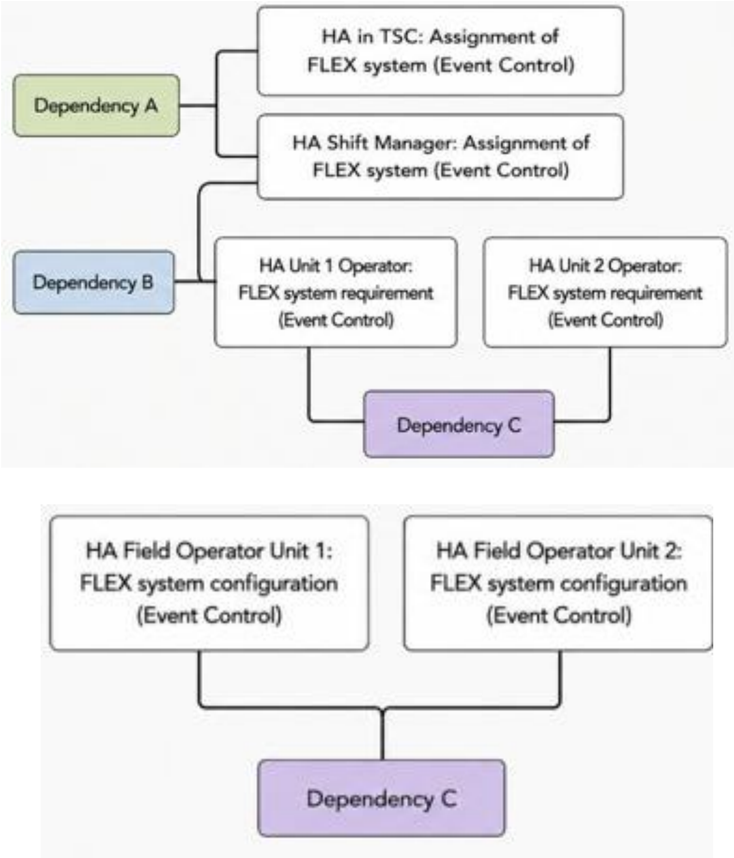

Figure 4: Proposed dependency types.

4. Probabilistic Modelling of HAs and Human Failure Events: EMRALD

EMRALD modules

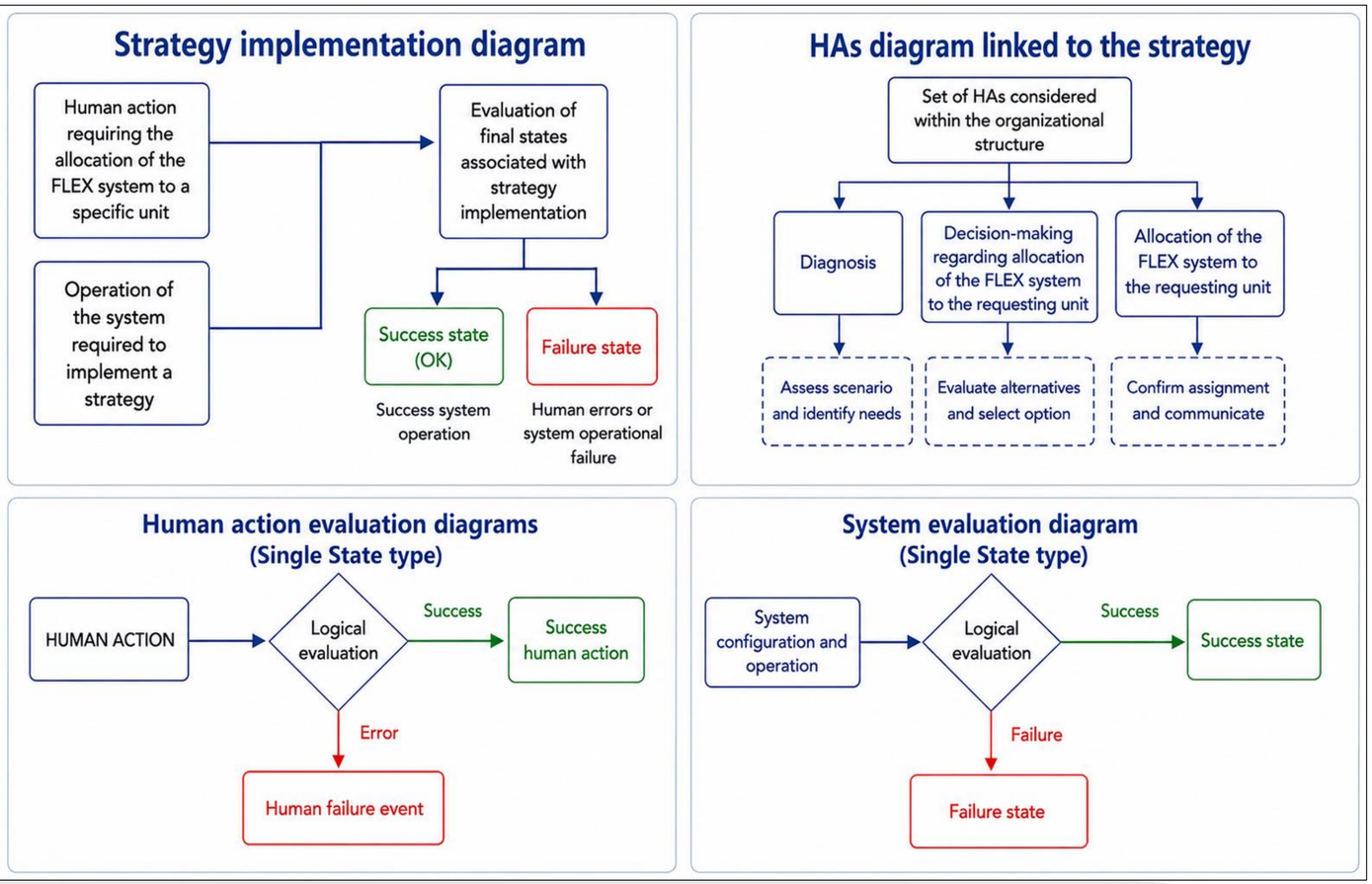

Figure: Proposed modules for the EMRALD model.

Hypothetical case study

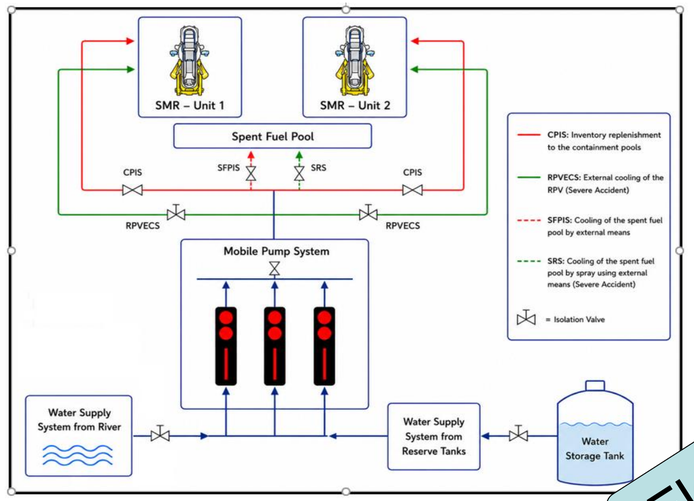

Figure 5: Hypothetical case study.

Flex strategy

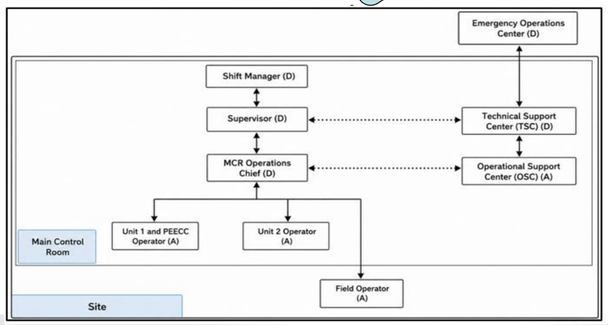

Figure 6: Organizational structure for emergency management in the hypothetical case study.

5. Application case: Results

HA identification	• HA identification for FLEX strategy according to HAs structure.
Modelling of identified HAs	• Modelling of HAs required for complex actions required for assigning a shared system in a multi-unit site (Site HA, Unit HA, System HA).
Evaluation of Human Error Probabilities (HEP)	• HFE asociated to each HA • Selected PSF: Available time, Complexity, Stress/stressors, Ergonomics/HMI • Dependency: Moderate (based in hypotheses) • HEP ~ 4x10-1 (Flex strategy)
EMRALD Model	• Proposed an structure of modules. • Definition of methodological aspects (eg. Variable definitions). • Coherent results for application case.

Figure 7: EMRALD model. HAs linked to strategy.

Final States → Coherent results!

6. Conclusions

Proposed structure of HAs linked to the organisational structure involved in on-site emergency management plan

Identification of HA requiered for on-site emergency management plan (Design stage)

Methodological guidelines to develop HA probabilistic model

* Application of SPAR-H to model HAs for on-site emergency management plan (PSFs and dependencies).

* Building of modules for EMRALD model.

Future work

HA modelling:

- To analyze PSF values, particularly for HAs related to FLEX and severe accident strategies.
- To incorporate delays and uncertainties for HAs.
- To analyze other dependency sources related to organizational factors and how to incorporate them into the model.

Development of a dynamic probabilistic model to support development of the on-site emergency management plan

Identification of critical HAs (HFEN, NUREG-0711)
Development of documentation for emergency management planning (Emergency operating procedures, FLEX procedures, Severe Accident Management Guidelines)

Thank you for your attention!