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SAFETY ASSESSMENTS OF NUCLEAR POWER PLANTS I&C SYSTEMS ARCHITECTURE

PSAM14 Conference

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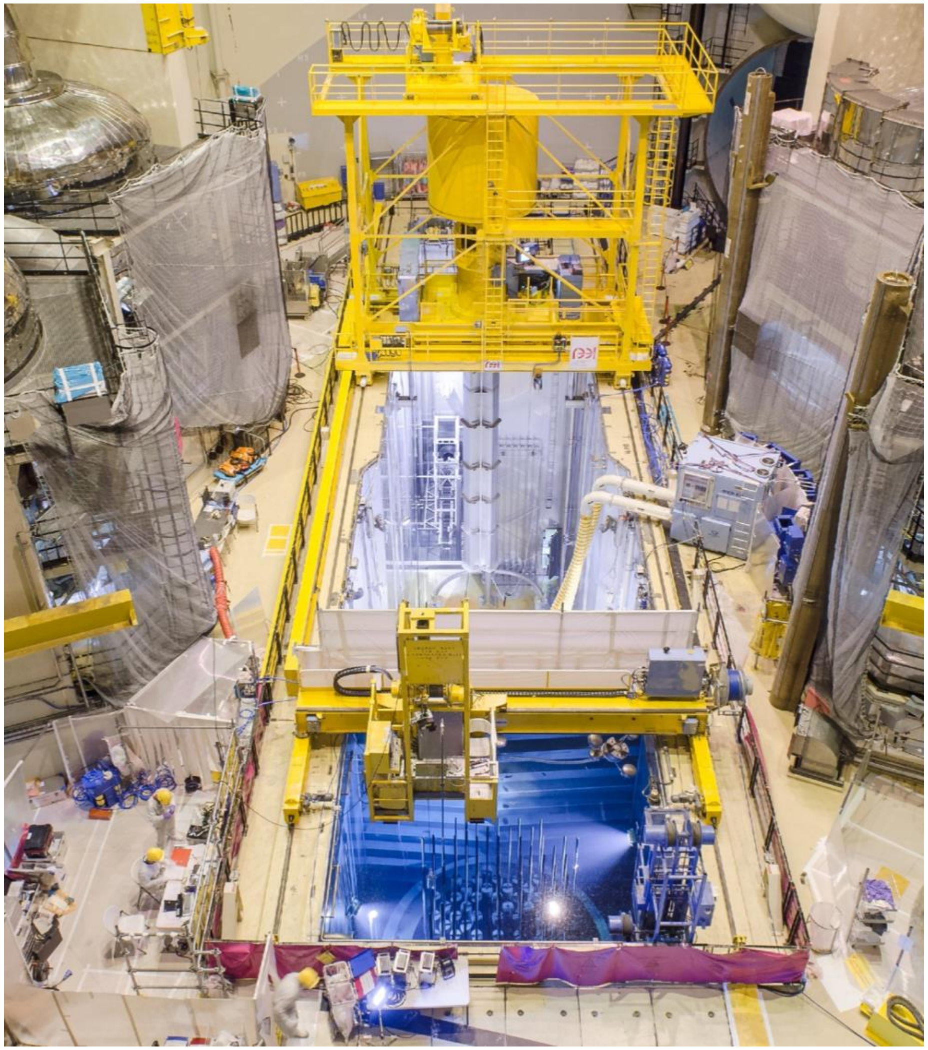
External public presentation

1. ABOUT FRAMATOME

About Framatome



- Framatome (formerly AREVA NP) is a major international player in the nuclear energy market.
- The company designs, manufactures, and installs components and fuel for nuclear power plants and offers a full range of reactor services.
- Framatome is owned by the EDF Group (75.5%), Mitsubishi Heavy Industries (MHI – 19.5%) and Assystem (5%).

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Framatome Key figures *(July, 2018)*


Finland, Olkiluoto unit 3 - EPR Reactor

14,000 employees worldwide

3,3 billions annual revenue

58 locations

14 billions backlog

- **June 29, 2018, Taishan Nuclear Power Plant Unit 1 has been successfully connected to the Chinese grid.**
- **This is the first EPR reactor worldwide to be producing electricity.**


China, Taishan units 1&2 - EPR Reactor

2. SAFETY ASSESSMENTS OF NUCLEAR POWER PLANTS I&C SYSTEMS ARCHITECTURE

Introduction

- **Major importance of I&C systems in the design of NPPs and in particular in their safe and reliable operation**
- **Switch from analog I&C to digital I&C = opportunity**
  - Easier to maintain
  - Easier implementation of modifications during the whole plant lifetime
  - More ergonomic HMIs with great human reliability advantages
- **But additional questions linked to digitalization, software development and implementation…raised**
  - Many safety analyses linked to I&C designs in order to check probabilistic/ deterministic safety requirements and targets are met

Context

- **Framatome works on various projects where these kinds of analyses are needed**
  - New build projects, e.g EPR projects
  - Modernization of I&C systems of existing NPPs so that digital I&C and LTO can be introduced and obsolete technologies replaced

Methods

- **Experience with these studies and implementation of their conclusions in the design => more efficient process**
- **Better quality**
- **Optimized schedule**
  - Despite very large scope and need for exhaustiveness
  - One major challenge = ability to mutualize without missing safety insights
- **Better interface with I&C designers**
  - Very important to be able to give relevant recommendations to designers during all design stages
  - Goal = ensure that safety requirements and targets will be met with high confidence, and an adequate level of margin will exist throughout the life cycle of the plant

Methods

- **Justification of defense in depth**

First line of defense: to control the main plant parameters within their expected operating range

Second line of defense: to detect and intercept deviations from normal operational states in order to prevent anticipated operational occurrences from escalating to accident conditions

Third level of defense:
Actuation of engineered safety features that are capable of leading the plant first to a controlled state, and subsequently to a safe shutdown state, and maintaining at least one barrier for the confinement of radioactive material.

Forth line of defense:
to address severe accidents in which the design basis may be exceeded and to ensure that radioactive releases are kept as low as practicable.

- **Justification of safety classification**

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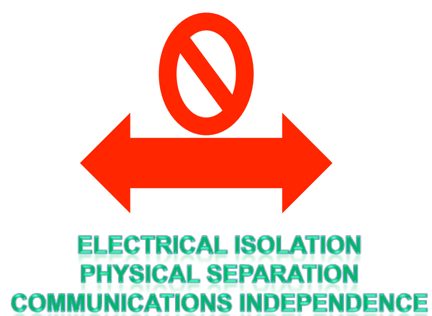
PSAM 14
16-21 September 2018
Probabilistic Safety Assessment and Management

Methods

FMEAs/Justification of single failure criterion

Component	Component function	Failure mode	Failure consequence		Function loss	Detection mean
			local	Functional		
Power supply module	Supplies the power	Supply has default number FMxx	Identified by internal detection features	Voting logic is degraded to 1/2	No	Self-test

Independence analyses



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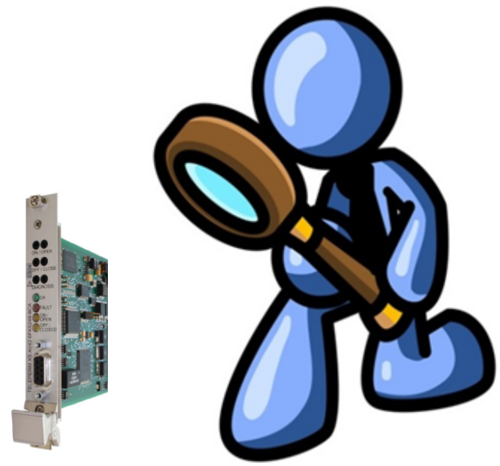
Methods

- **CCF analyses**
  - Backup system?
  - Which PIEs?

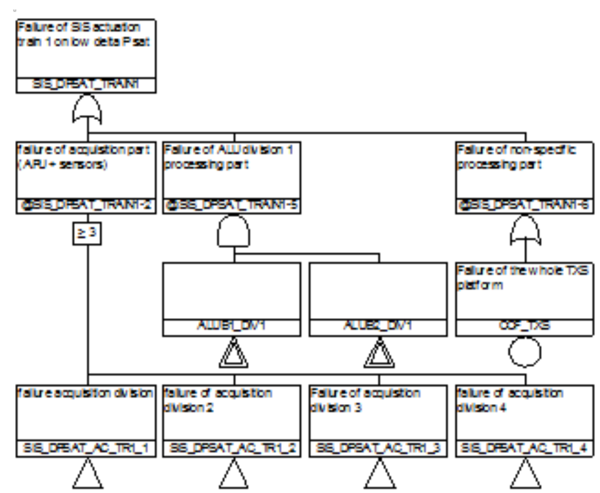


Need for diversity?

- **Robustness of I&C architectures with regards to internal hazards**
  - Fire
  - Flooding

Methods

- **Reliability and availability analyses**
  - Probability of failure
    - Per demand
    - Per hour
  - Frequency of spurious actuation



- **Inclusion of I&C in PSA**

Roles in the safety demonstration

<table>
<tr><th></th><th>Overall I&C justification</th><th>I&C system justification</th><th>Probabilistic demonstration</th><th>Deterministic demonstration</th></tr>
<tr><td>Justification of defense in depth</td><td>X</td><td></td><td></td><td>X</td></tr>
<tr><td>Justification of safety classification</td><td></td><td>X</td><td></td><td>X</td></tr>
<tr><td>FMEAs/Justification of single failure criterion</td><td></td><td>X</td><td></td><td>X</td></tr>
<tr><td>Independence analyses</td><td>X</td><td>X</td><td></td><td>X</td></tr>
<tr><td>CCF analysis</td><td>X</td><td></td><td colspan="2">X</td></tr>
<tr><td>Robustness of I&C architecture with regards to internal hazards</td><td>(X)</td><td>X</td><td></td><td>X</td></tr>
<tr><td>Reliability analyses</td><td></td><td>X</td><td>X</td><td></td></tr>
<tr><td>Inclusion of I&C in PSA</td><td>X</td><td></td><td>X</td><td></td></tr>
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Links between methods

	Justification of safety classification	FMEAs / Justification of single failure criterion	Independence analyses	CCF analysis	Robustness of I&C architecture with regards to internal hazards	Reliability analyses	Inclusion of I&C in PSA
Justification of defence in depth	No	No	Yes	Yes	Sometimes	No	No
Justification of safety classification		No	Yes	No	No	No	No
FMEAs / Justification of single failure criterion			Partially	No	Yes	Yes	Yes
Independence analyses				No	Sometimes	No	Yes
CCF analysis					No	Yes	Yes
Robustness of I&C architecture with regards to internal hazards						No	Yes
Reliability analyses							Yes

3. CONCLUSION

Conclusion

- **Picture of safety methods and issues dealing with I&C systems**

- **Acquired knowledge is used to improve in a continuous manner the process for better safety and efficiency!**


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Questions ?
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