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IAEA Project: Multiunit Probabilistic Safety Assessment

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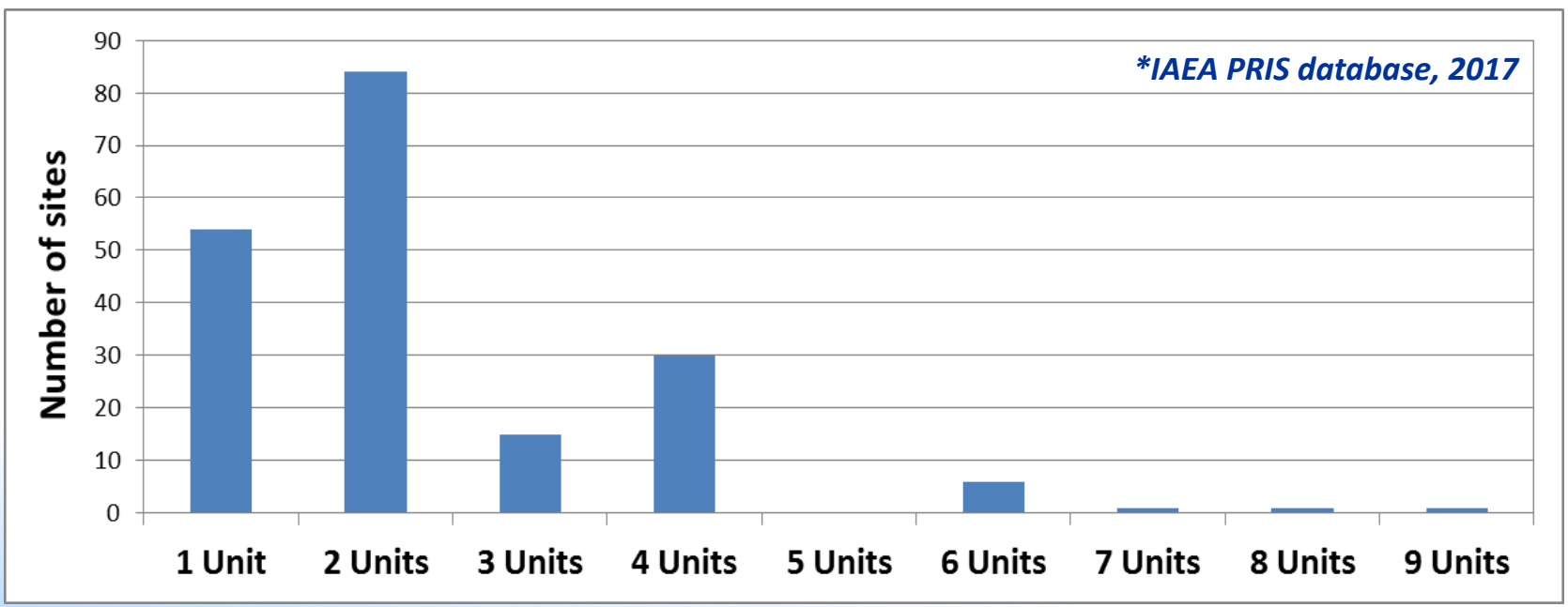
Single- vs Multiunit

- Safety assessment is based on analyses of single units
  - "one reactor at-a-time mind-set"
- Majority of nuclear sites have more than one unit (138 out of 192 NPP sites)



IAEA NSNI project on MUPSA

- Fukushima accident demonstrated importance of MU considerations
- Increasing interest among IAEA Member States
- GC resolutions on multiunit considerations
- Side Event during IAEA 61st GC (2017) “MUPSA – Challenges Related to Risk Assessment”

Challenges for risk assessment

- Definition of appropriate site wide risk metrics
- To address IEs that impact more than one unit
- Modelling of complex sequences involving MU plant response, mitigation, and core damage
- MU dependencies – CCF, fragilities, others
- HRA in the context of MU (accessibility issues, shared resources, etc.)
- Treatment of consequential (i.e. causal) failure probabilities (e.g. consequential loss of grid)

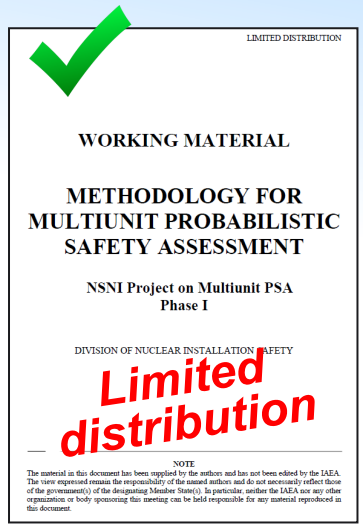
IAEA NSNI project on MUPSA

- NSNI MUPSA project was initiated in 2016 (joint EESS & SAS)
- Kick off Meeting held 14-16 December 2016
- 39 experts, from 29 organisations, 13 MSs
- Belgium, Canada, Czech Republic, France, Germany, Hungary, Japan, Korea, Romania, Russia, Slovakia, UK, USA

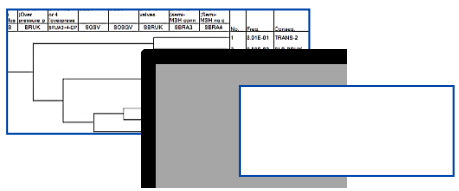
4th Consultancy Meeting on MUPSA
IAEA, Vienna, 16-18 October 2017

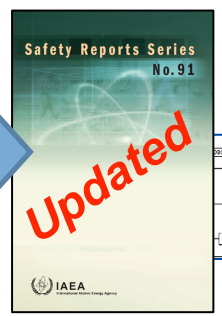
IAEA NSNI project on MUPSA

No	Activity	Outcome	Month 1	2	3	4	5	6	7	8	9	10	11	12
Phase 1 - Develop MUPSA methodology (2017)														
1	Kick off Meting (2016)	Detailed WP												
2	Develop TS for external experts	SSA												
3	Conclude SSA	Start contracts												
4	Drafting the document	Developed methodological document												
4	First CS Meeting	Progress Review												
5	Second CS meeting	Review Draft 0												
6	External Review	Final Draft												
7	Internal NSNI Review	QA check												
8	Send to PC	Sent to Publication												
9	Develop TS for the Case Study	TS for the Case study												
Phase 2 - Develop Case Study (2018)														
10	Conclude SSA (2018)	Start Contracts												
11	Kick off Meeting Phase 2	Detailed WP												
12	Development of the Case Study	MUPSA model & report												
13	Second CS Meeting	Progress Review												
14	Third CS Meeting (Large Group)	Discussion of results & feedback to the SG												
15	Forth CS Meeting	Final Draft												
16	Internal NSNI Review	Case Study final report												
Phase 3 Update the MUPSA methodology based on the feedback from the Case Study (2019)														
17	DPP development & approval	DPP												
18	Kick off Meeting Phase 3	Detailed WP												
19	Conclude SSA (2018)	Start contracts												
20	Development of the updated MUPSA methodology	Final Draft of MUPSA methodology												
20	External Review	Review comments												
21	First CS Meeting	Progress Review												
22	Technical Meeting	Comments & ideas to improve methodology												
23	Second CS Meeting	Approve final Draft												
24	NSNI Internal Review	QA check												
25	Sent to PC	Sent to Publication												

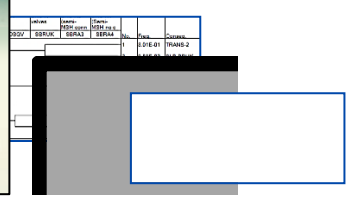


CASE STUDY



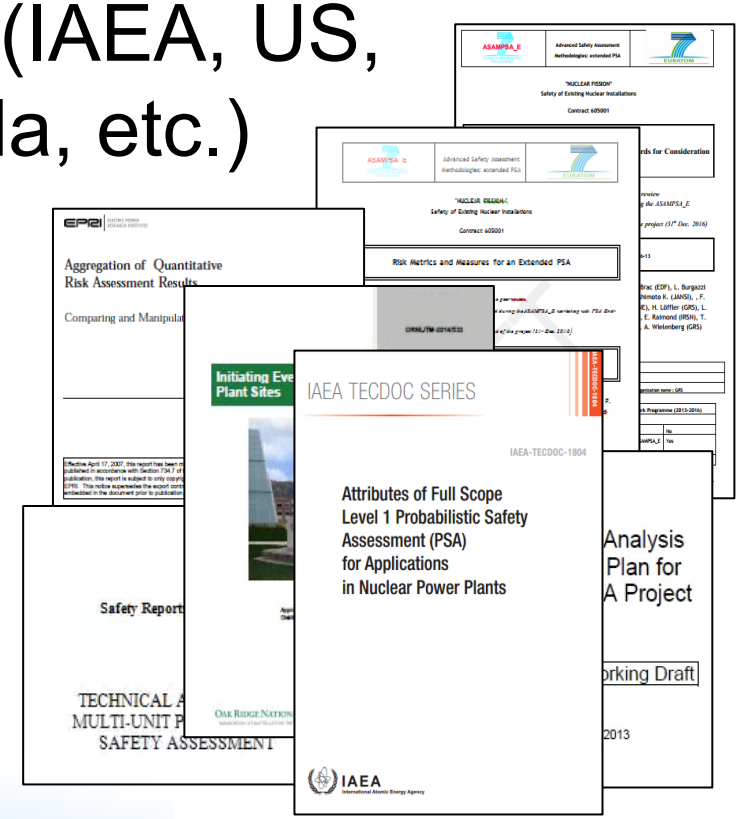


+ CASE STUDY



MUPSA state of the art review

- State of the art review performed by IAEA
- The objective of the review was to describe the available technical basis on MUPSA
- Sources of information used (IAEA, US, ASAMPSA_E project, Canada, etc.)
- Main observations
  - Limited MUPSA experience
  - No harmonized approaches
  - SUPSA used as a prerequisite
  - Ideas on MU risk metrics
  - Guidance on IE screening

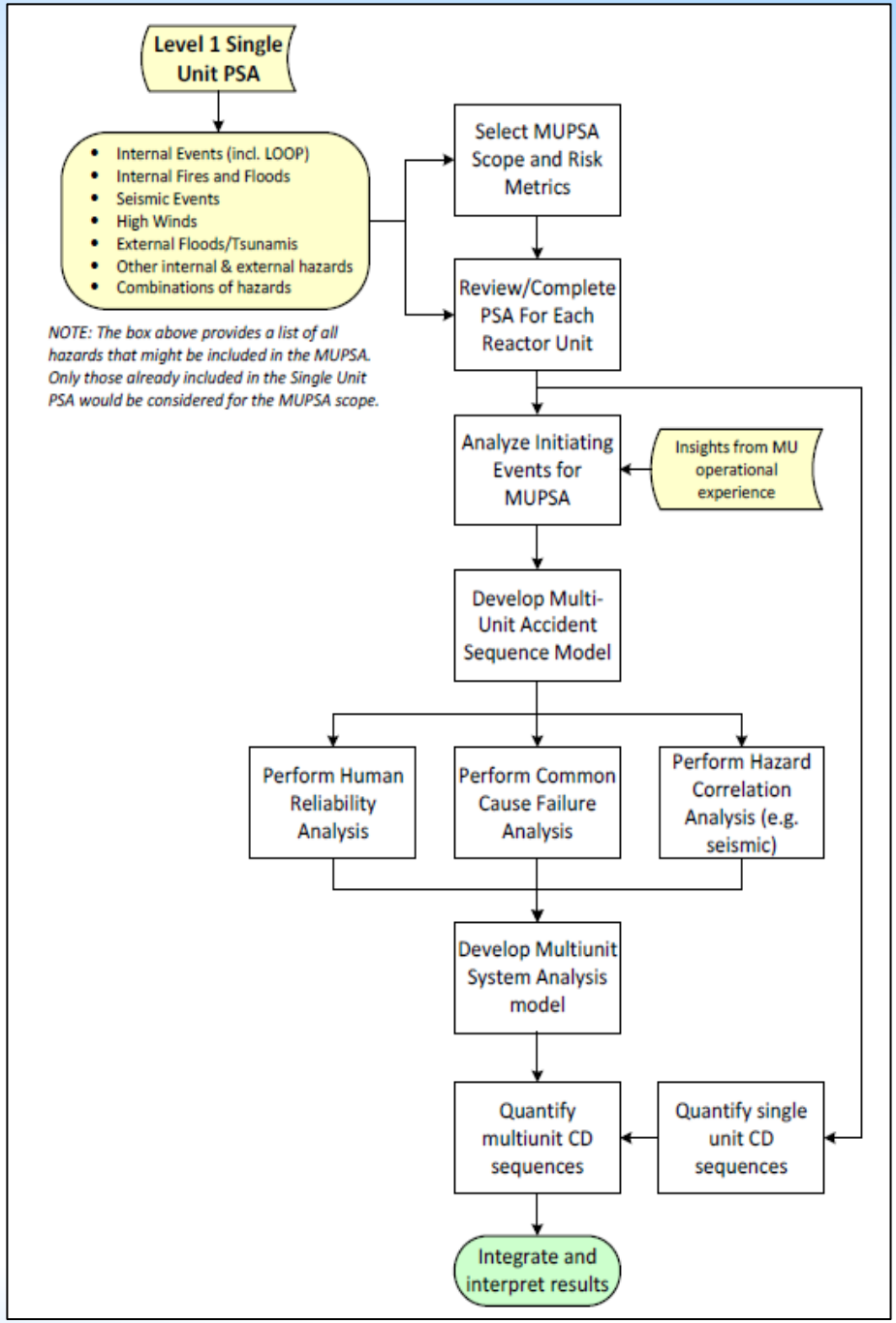


Principles

- Methodology is complementary to single unit PSA
- Methodology is applicable for site with a large number of units
- Methodology should be able to identify and rank MU risk contributors
- The SFP will be considered (in Level 1) mainly for the impact on resources allocation (e.g. human and technical resources)
- Methodology should be sufficiently detailed in implementation level to support the case study

Main assumptions

- Administrative shutdowns
- Modelling of multiunit combinations “k-of-n”
- Inter-unit CCF and seismic correlations
- Inter-unit CCF, “n-of-n” model
- Single unit PSA available with sufficient quality



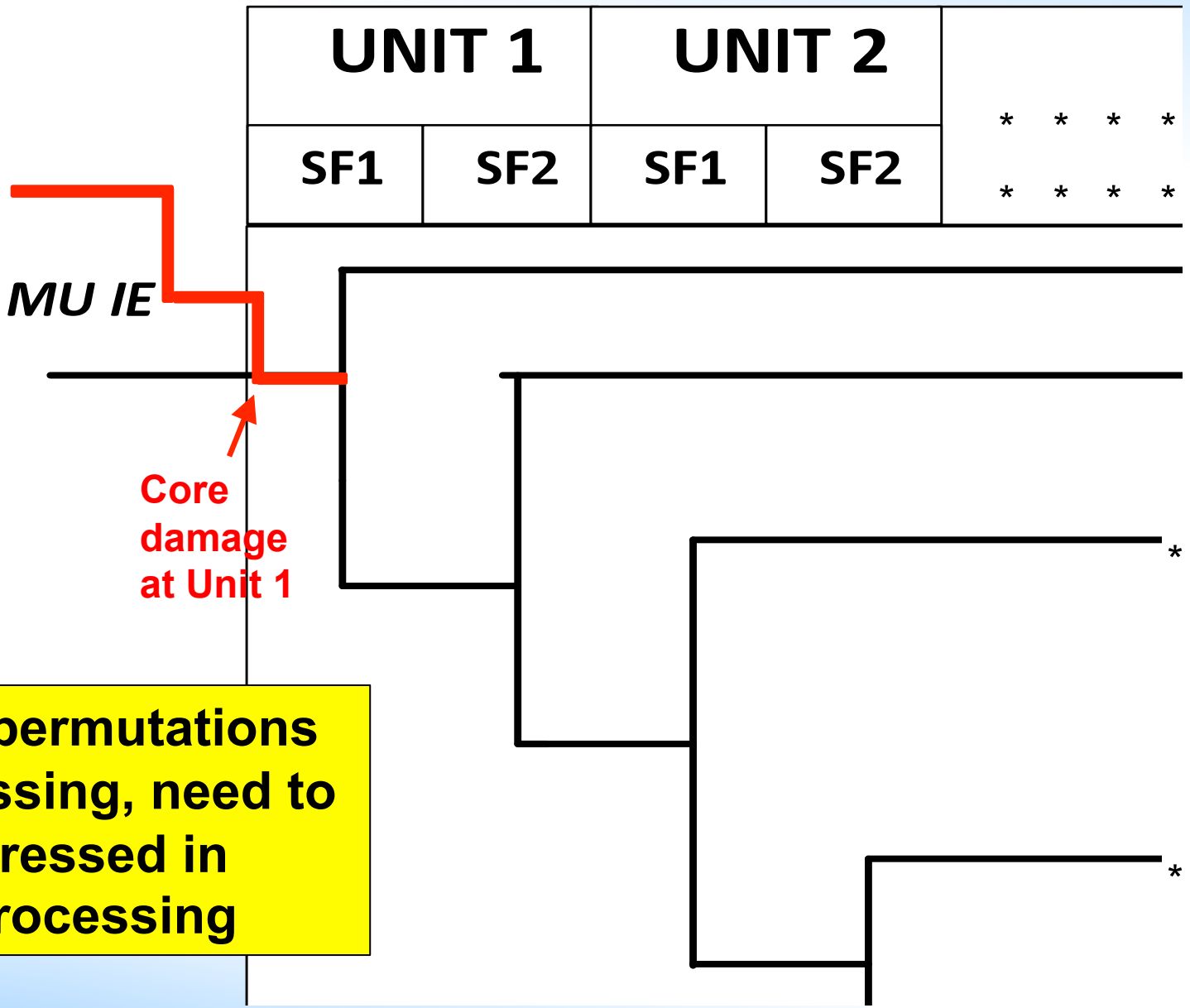
Initiating events analysis

- Typical categories of IIEs (PWR):
  - a) ~~Spurious reactor trips~~
  - b) ~~Reactivity induced accidents (boron dilution, control rod ejection, etc.)~~
  - c) ~~Decrease of reactor coolant flow (e.g. trip of the reactor coolant pump~~)
  - d) ~~Increase of reactor coolant inventory (e.g. inadvertent actuation of the emergency core cooling system)~~
  - e) ~~Decrease of reactor coolant inventory~~ (ISLOCA could be a MU issue)
  - f) Increase of heat removal by the secondary side (e.g. steam line breaks)
  - g) Decrease of heat removal by the secon ruptures)
  - h) Loss of offsite power (modelled as an in
  - i) Support systems failures (e.g. loss of se

Consequential loss of offsite power, administrative shutdowns

Accident sequence analysis

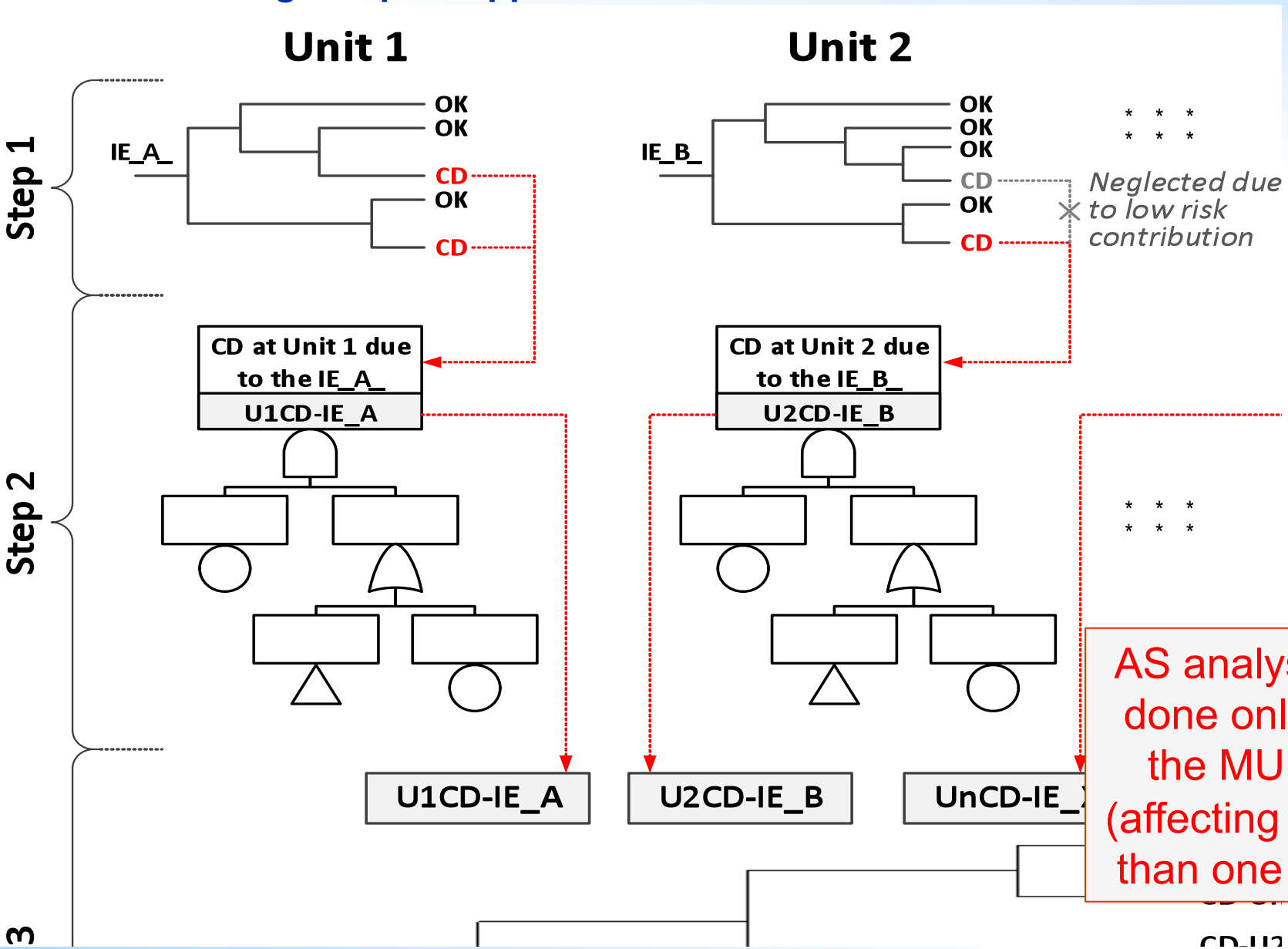
Method 1 – Master ET approach



Some permutations are missing, need to be addressed in post-processing

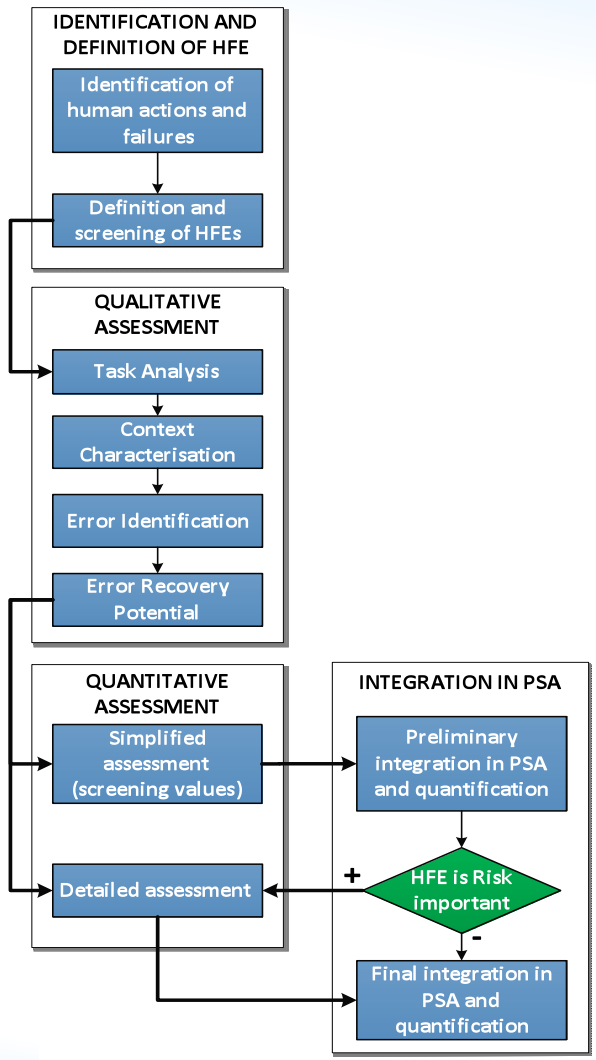
Accident sequence analysis

Method 2 – Single Top FT approach



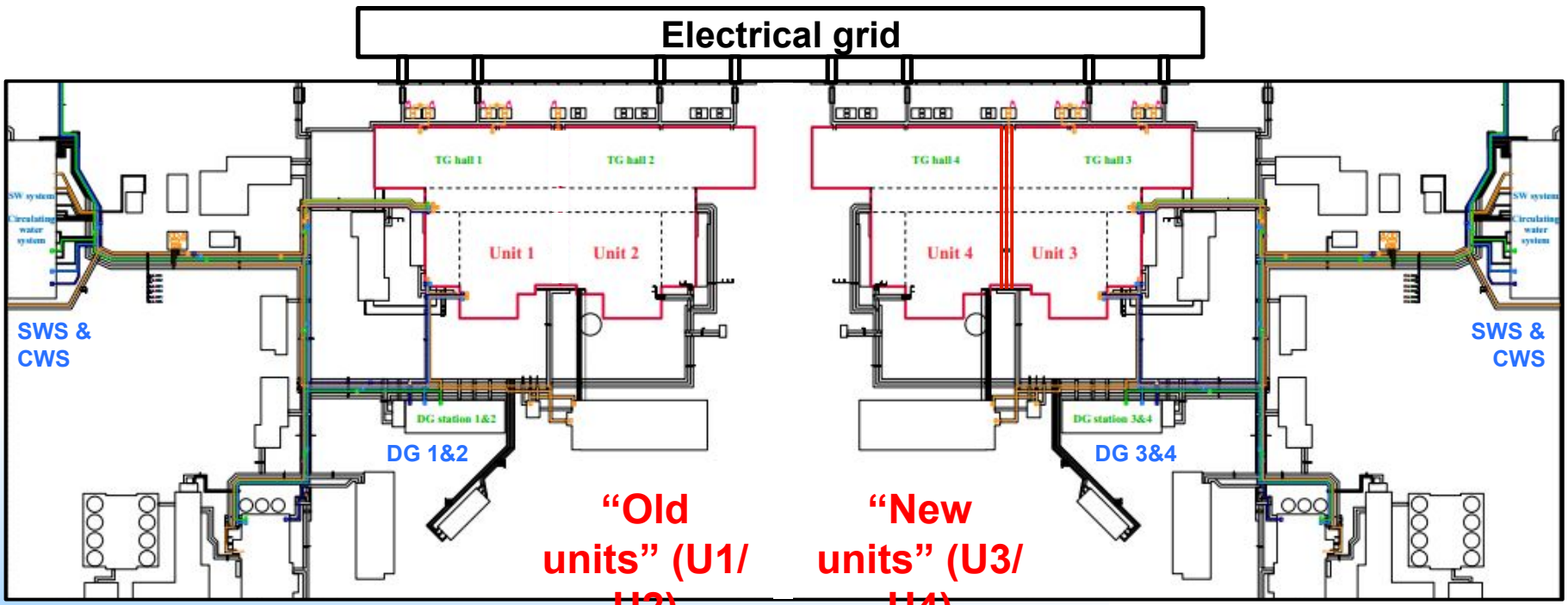
Human reliability analysis

- Unique features in MU context: accessibility issues, shared staff among units
- Context characteristics
  - Resources might be insufficient
  - Time windows
  - Stress level and other PSF
  - Coordination of activities (e.g. procedures, priorities)
  - Inter-unit dependencies
  - Radioactive release on site
  - Dynamic interactions



MUPSA Case study

- Real PWR PSA model
- Full power operation, MUCDF
- 5 scenarios: Steam line break, Fire in TH, LOOP, Seismic, *Special case:* Release at U1



Summary

- Increasing interest on MU considerations
- IAEA/NSNI MUPSA project is ongoing:
  - Phase 1 – completed
  - Phase 2 – ongoing, to be finalized in 2018
  - Phase 3 – planned for 2019, feedback from the case study, TECDOC/Safety Report, TM is planned
- Preliminary insights from the Case Study: Methodology is applicable for MUPSA, requires more elaboration in specific areas
- Main challenges: Inter-unit CCF, Inter-unit HRA dependencies, inter-unit hazard correlations

Acknowledgements

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Thank you!