Regulatory Requirements and Monitoring and Assessment of the Implementation of Defence in Depth

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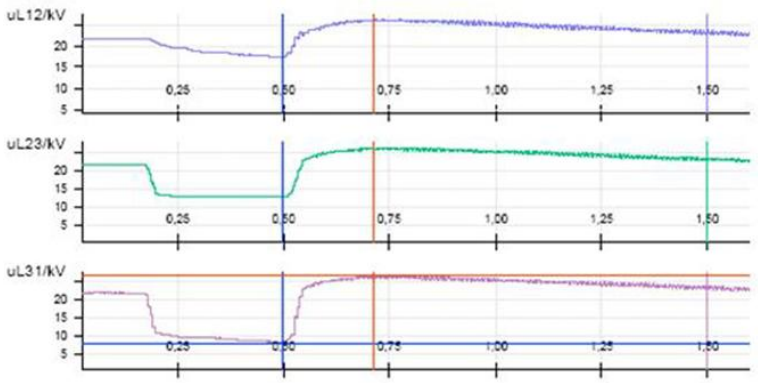
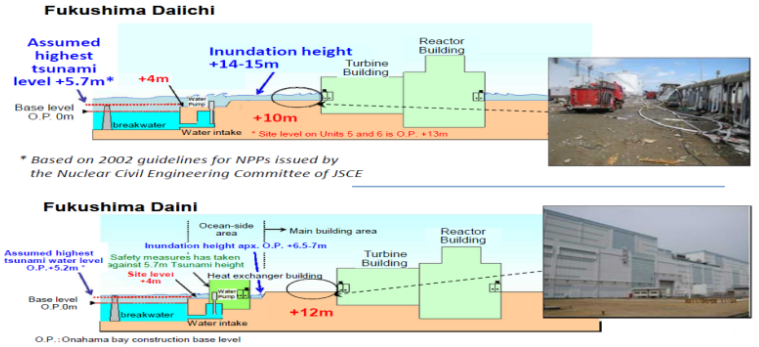
Content

- Defense in Depth in the light of recent experience
- Defense in Depth and Finnish safety regulations
- Experience with the implementation and oversight of Defense in Depth
- Conclusions

Recent Experience and Defense in Depth

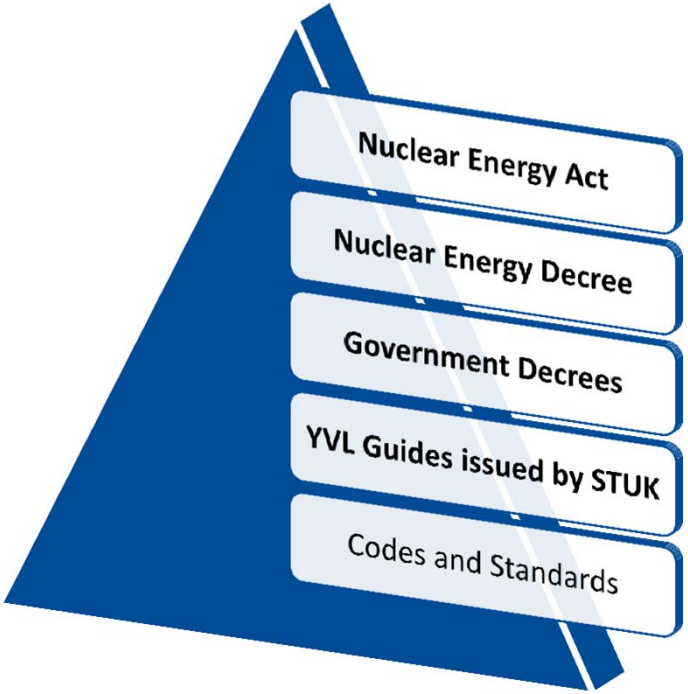
- Forsmark event 2006
  - Offsite grid disturbance resulted in voltage surge on the onsite power supply systems resulting in common cause failure in safety systems
  - Issues of generic nature (robustness of DiD Levels, Dependencies, Fail-safe design)
  - Didelsys Task Group report (NEA/CSNI/R(2009)10)
- Tepco Fukushima Daichi Accident 2011
  - Insufficient design basis against flooding resulted in common cause failure in safety systems
  - Issues with Fail-safe design, weaknesses in DiD levels as well as dependencies between DiD levels





Requirements for Defense in Depth in the Finnish Regulations and Guides

- Nuclear Energy Act
  - Section 7 b on Safety principle of defense-in-depth; safety of a nuclear facility shall be ensured by means of successive levels of protection independent of each other
- Government Decree on the Safety of Nuclear Power plants (2013) provides requirements for
  - functional safety with five levels of defense
  - independence between the levels
  - structural safety with barriers
  - application of redundancy, separation and diversity principles to ensure fulfillment of safety functions
- YVL B1 Safety design of a nuclear power plant (2013)
  - Detailed requirements for the application of DiD in the design of a NPP e.g. for DiD levels, independence of the levels, and strength of individual levels

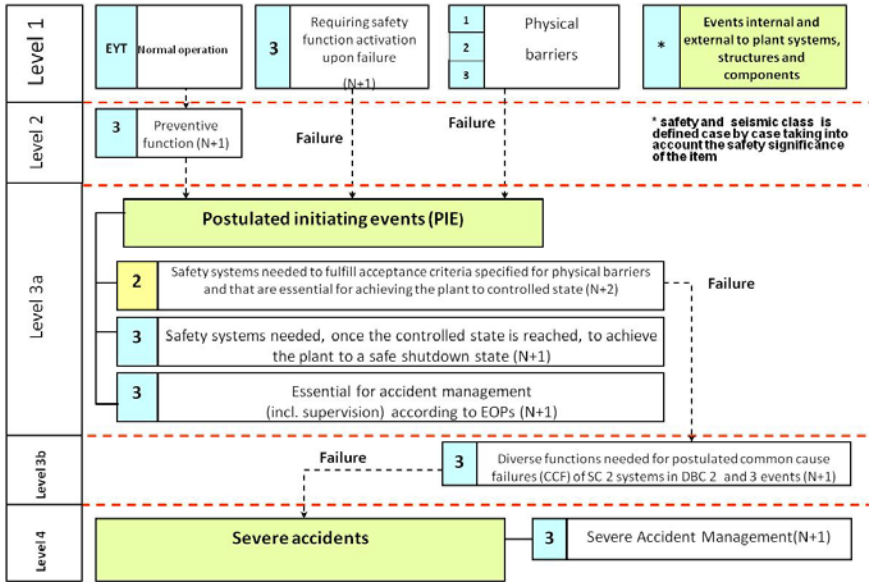


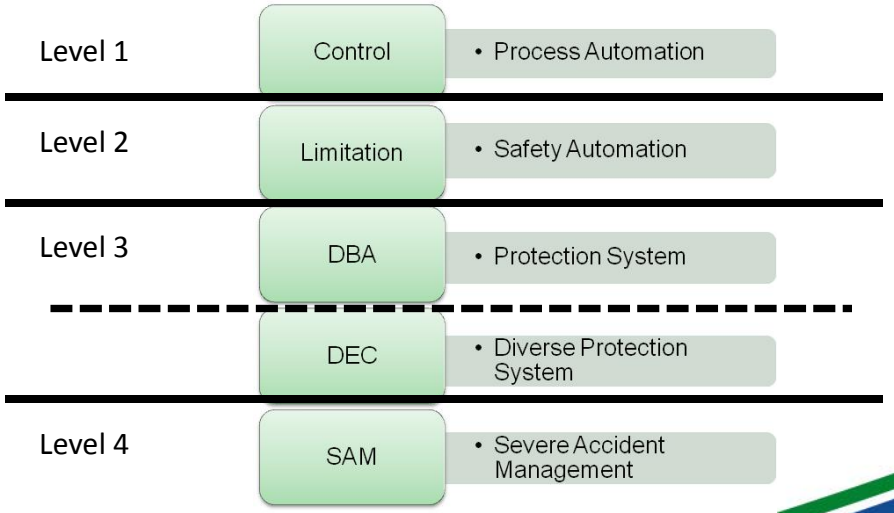
DiD Levels, Event Categories and Frequencies

Level 1	Normal operation (DBC 1)	
Level 2	Anticipated operational occurrences (DBC 2)	$f > 10^{-2}/a$
Level 3a	Postulated accidents Class 1 (DBC 3)	$10^{-2}/a > f > 10^{-3}/a$
	Postulated accidents Class 2 (DBC 4)	$f < 10^{-3}/a$
Level 3b	Design extension conditions (DEC)	**DEC A – CCF combined with DBC2 / DBC3** **DEC B – Probable failure combinations** **DEC C – Rare external events**
Level 4	Severe accidents (SA)	Safety goals **CDF $<10^{-5}/a$; LRF $< 5\times10^{-7}/a$**
Level 5		

Implementing and overseeing DiD

- Operating NPPs and current DiD requirements
  - In particular robustness against extreme external hazards
  - In general robustness of levels and independence between levels
  - Redundancy, Diversity, Separation/Isolation within or(/and) between levels
- Consistent implementation of DiD in different technical disciplines e.g. Digital I&C
- Clarification of applied concepts with e.g. quantitative goals
  - e.g. practical elimination, reasonably achievable/practicable
- Regulatory inspection and assessment approaches and their focus on DiD, use of different analysis tools, PSRs)





Conclusions

- Defense in Depth has been and continues to be the key concept for safety of nuclear power plants – But needs to be reinforced (e.g. against external events, loss of power systems, malfunction or loss of I&C, loss of heat sink, spent fuel pools)
- Needs to be regulated – Requirements for the implementation of Defense in Depth are set in the Finnish regulations and regulatory guides
- For harmonizing Defense in Depth approaches and in particular the implementation of DiD, practical guidance is be needed (e.g. extreme external hazards)
- Role of operators and regulators in ensuring DiD is also maintained and improved when necessary during the lifetime of the NPP – use of deterministic and probabilistic tools, PSRs