



NPP Failure Analyses in Finland

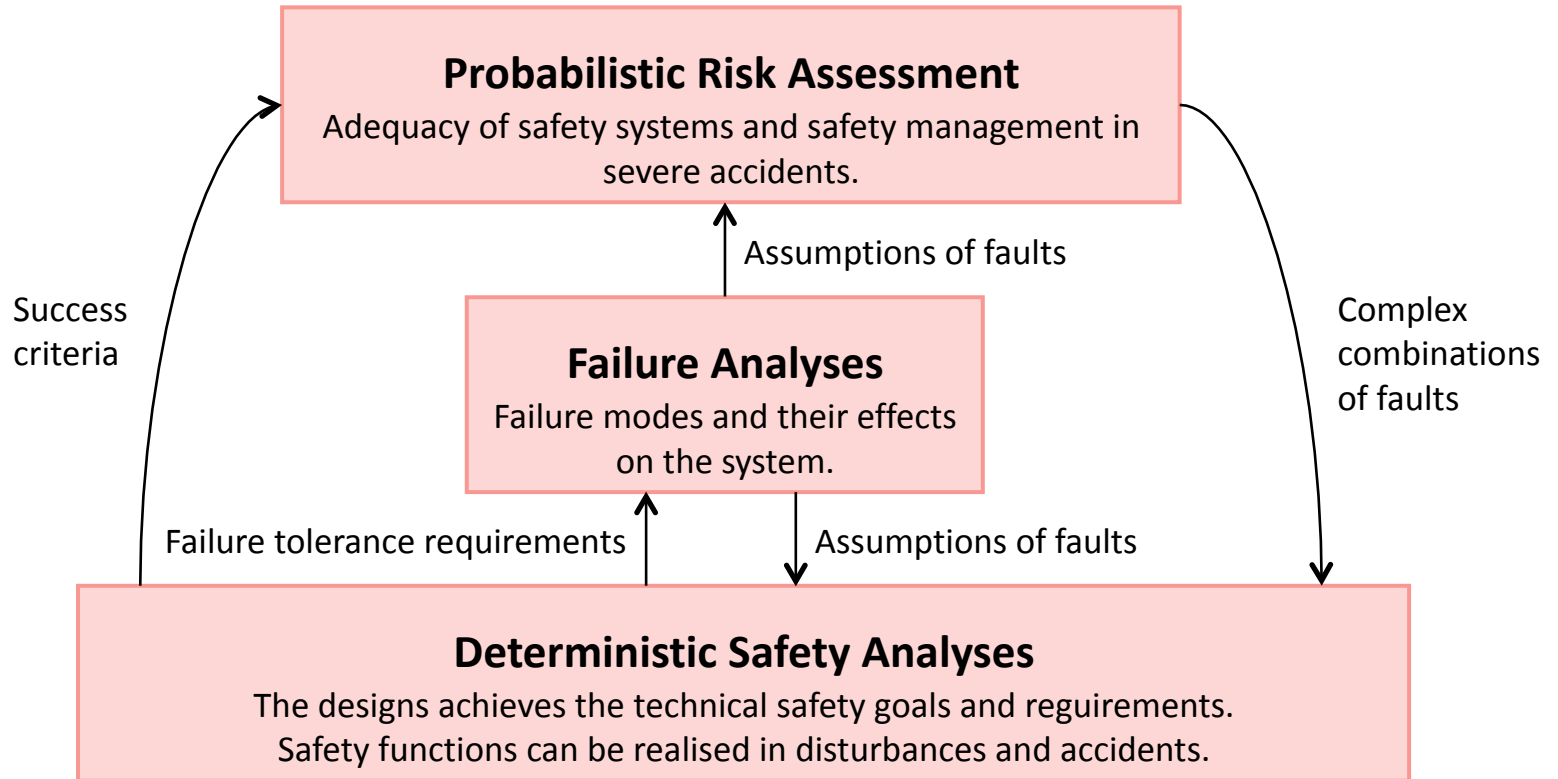
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Contents

Motivation and development of structured set of failure analyses

- ...to recognize failures modes and describe their effects
- ...to demonstrate redundancy, diversity and separation of safety functions
- ...to support PRA and improve the coverage of analyses scope.

Relations Between Analyses



Challenges in Integrating Analyses Types

- Analyses of failures and failure tolerance, PRA, Deterministic Safety Analyses did not cooperate optimally.
- Regulatory requirements focused on individual technical disciplines.
 - General plant level impression of failure tolerance was not considered.
- Development of failure analyses as a regulatory concept:
 - To outline the compiled *failure analyses* set to reach traceability and sufficient coverage of analyses.
 - To define '*Failure Tolerance Analysis*'.
 - To clarify the target for these.
 - To reduce overlapping work.

Failure Tolerance Analysis in YVL Guides

- Finnish Regulatory Guides (YVL Guides) was updated 2013.
- New requirements of usage of *Failure Tolerance Analysis* set to demonstrate the redundancy, diversity and separation of safety functions and systems.
- Paying attention to the whole function instead of single systems.
- The purpose is to demonstrate acceptability of consequences of failures.

Failure Tolerance Analysis in YVL Guides

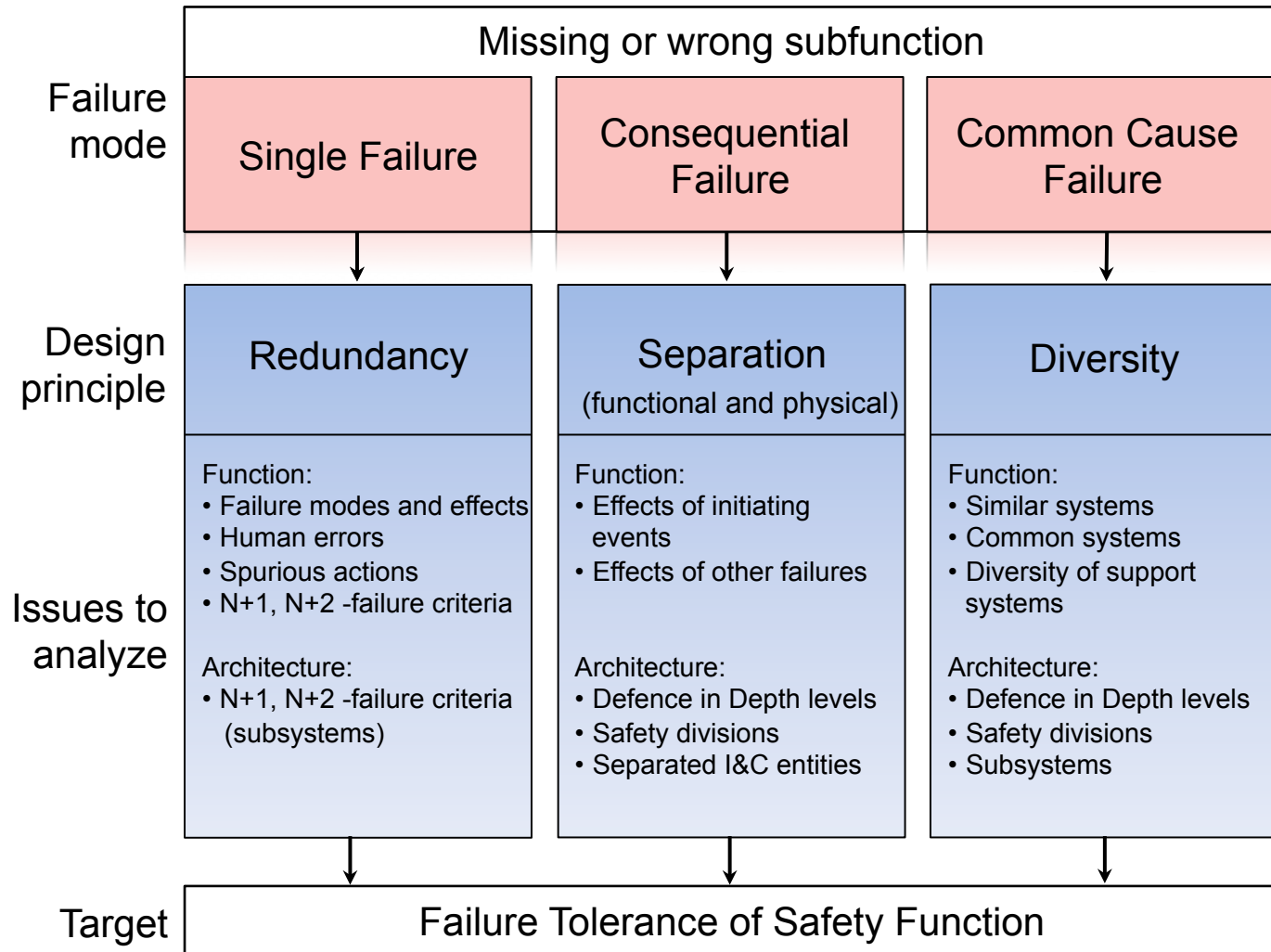
“Failure tolerance analyses shall be carried out to demonstrate that -- all systems performing safety functions and their auxiliary systems satisfy the failure criteria specified in section 4.3 of this Guide --” [YVL B.1 351]

“A failure tolerance analysis shall assess one functional complex at a time, with due regard both to the system that performs a safety function and its auxiliary systems. The analysis shall address each component that, in the event of a failure, may affect the successful execution of the safety function performed by the system following a specific initiating event --” [YVL B.1 352]

“A common cause failure analysis shall be drawn up for initiating events in design basis categories DBC 2 and DBC 3 -- The analysis shall address the common cause failures of all components whose common cause failures or spurious actuation may affect the performance of the safety function. --” [YVL B.1 353]

Reference: Radiation and Nuclear Safety Authority (STUK). “Safety design of a nuclear power plant”, Regulatory Guide YVL B.1, 15.11.2013, Helsinki. <https://www.stuklex.fi/en/ohje/YVLB-1>

Analyzing Failure Tolerance of a Function



Failure Analyses

Analyses used to recognize consequences of potential failures of systems and components.

In Finland, failure analyses have already been used to demonstrate tolerance against:

- Single failures (N+1)
 - Double failures (N+2)
 - Common cause failures
 - Fires, floods
 - Failures of entire I&C systems
- } *Failure Mode and Effects Analysis FMEA, redundancy analysis, human error analysis, initiating events analysis*
- } *CCF and diversity analysis*
- } *Safety divisions, separation analysis, hazard analysis*
- } *Analysis of active failures of separated I&C entities*

Failure Analyses

Analyses used to recognize consequences of potential failures of systems and components.

Failure Tolerance Analysis

Specified collection of *failure analyses*. Analyses demonstrate that the plant is tolerant to failures and its safety is confirmed also with defined failures.

Individual *failure analyses* are tools for *Failure Tolerance Analysis*.

Examples:

Failure Mode and Effects Analysis FMEA, redundancy analysis, human error analysis, initiating events analysis

CCF and diversity analysis

Safety divisions, separation analysis, hazard analysis

Analysis of active failures of separated I&C entities

Conclusions

- Failure analyses are a systematic and effective way to analyze amount of failure potentials.
- Failure analyses, Deterministic Safety Analyses and PRA support each other.
- Comparing of results of different analyses types raise evidence to question the validity or conclusions of analyses.
- Paying attention to relations between analyses helps to ensure a plant level coverage of analyses.

