Allocation of Safety Functions to Defence in Depth Levels

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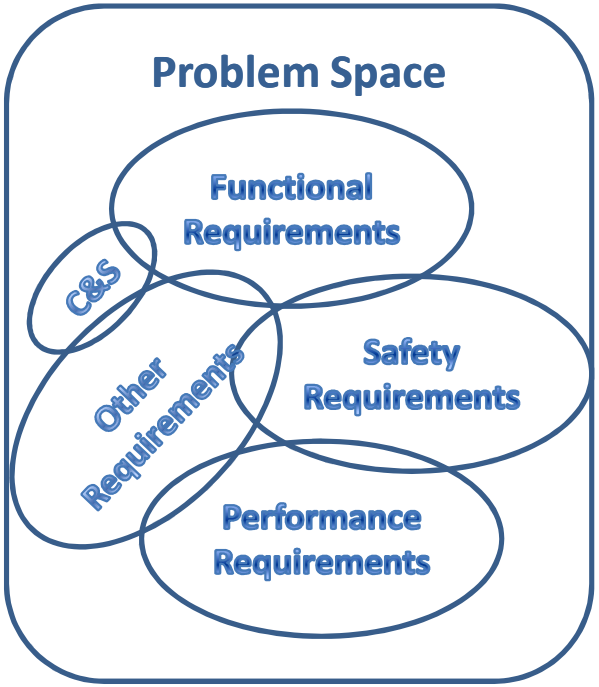
Content

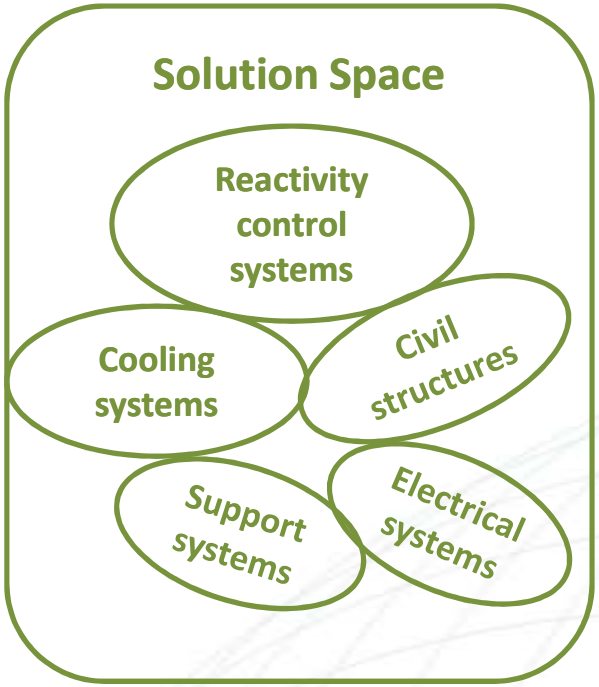
- A short introduction to System Engineering (SE) techniques on RRs projects
- An attempt to a identify a complete Safety Functions Breakdown Structure (SFBS)
- The DiD dimension
- Conclusions

SE in Research Reactors

- Why a SE approach for RRs?
  - Widely used in the industry
  - Provides evidence of an organised approach along the project stages
  - Difficult application in projects for one-of-a-kind facilities with limited budget

SE root concept

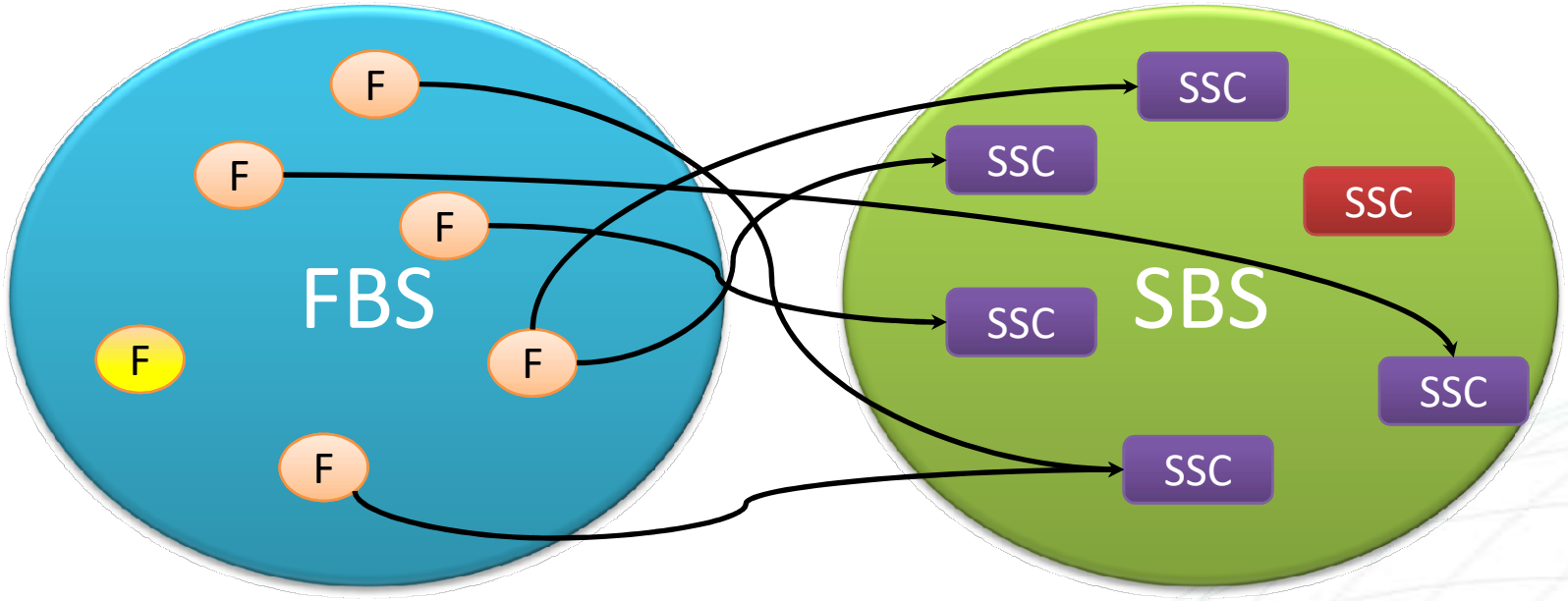




FBS and SBS

- The solution space is organised by:
  - Arranging the SSCs into a System Breakdown Structure (SBS)
- The problem space is organised by:
  - Organising requirements into different levels
  - Developing structured trees for functional requirements (FBS) mainly related with the operation of the facility
  - Gathering safety functions from:
    - Guidelines (such as IAEA SSR-3)
    - Previous experience

Pairing FBS with SBS



Orphan Function → New SSC required
Orphan SSC → Is this SSC really needed?

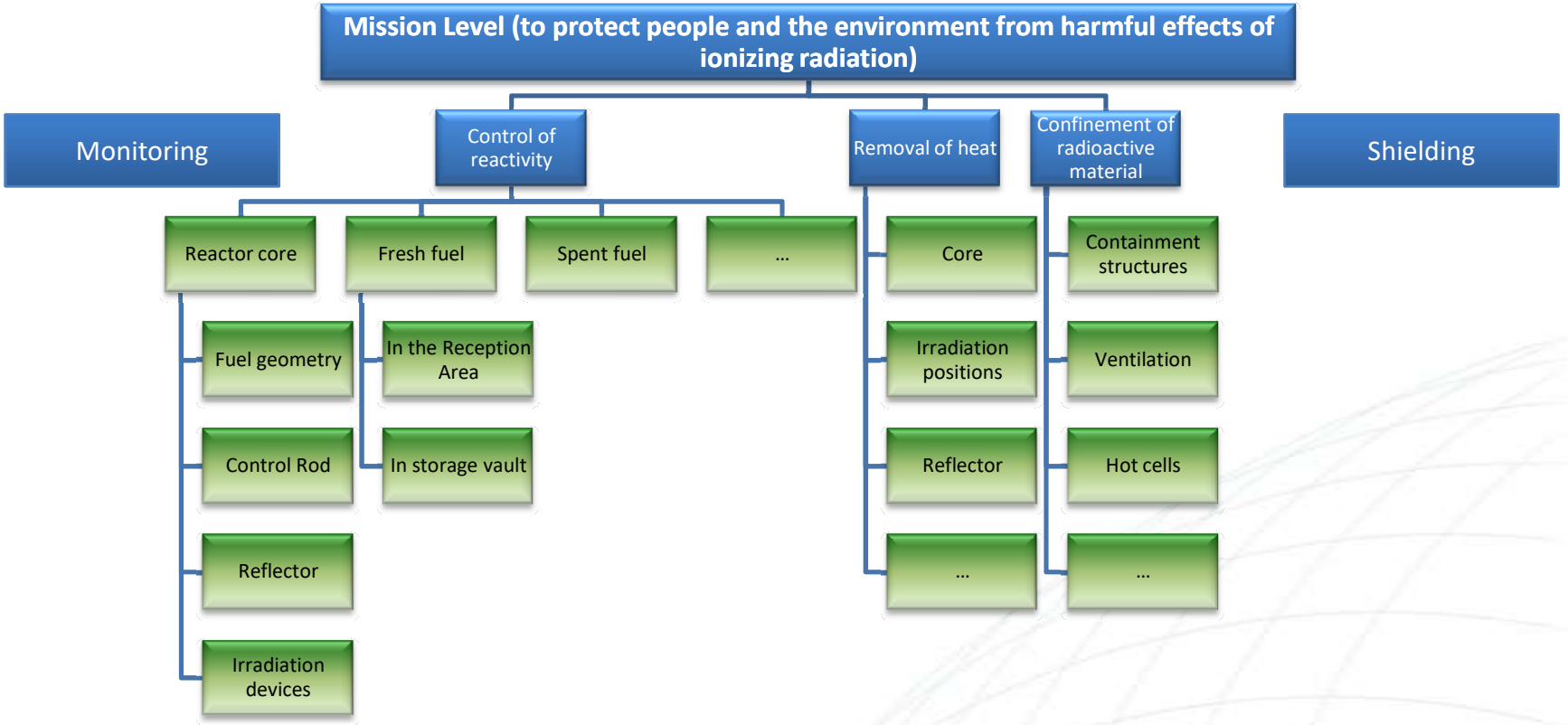
Safety Functions

TABLE I–1. SELECTED SAFETY FUNCTIONS FOR RESEARCH REACTORS

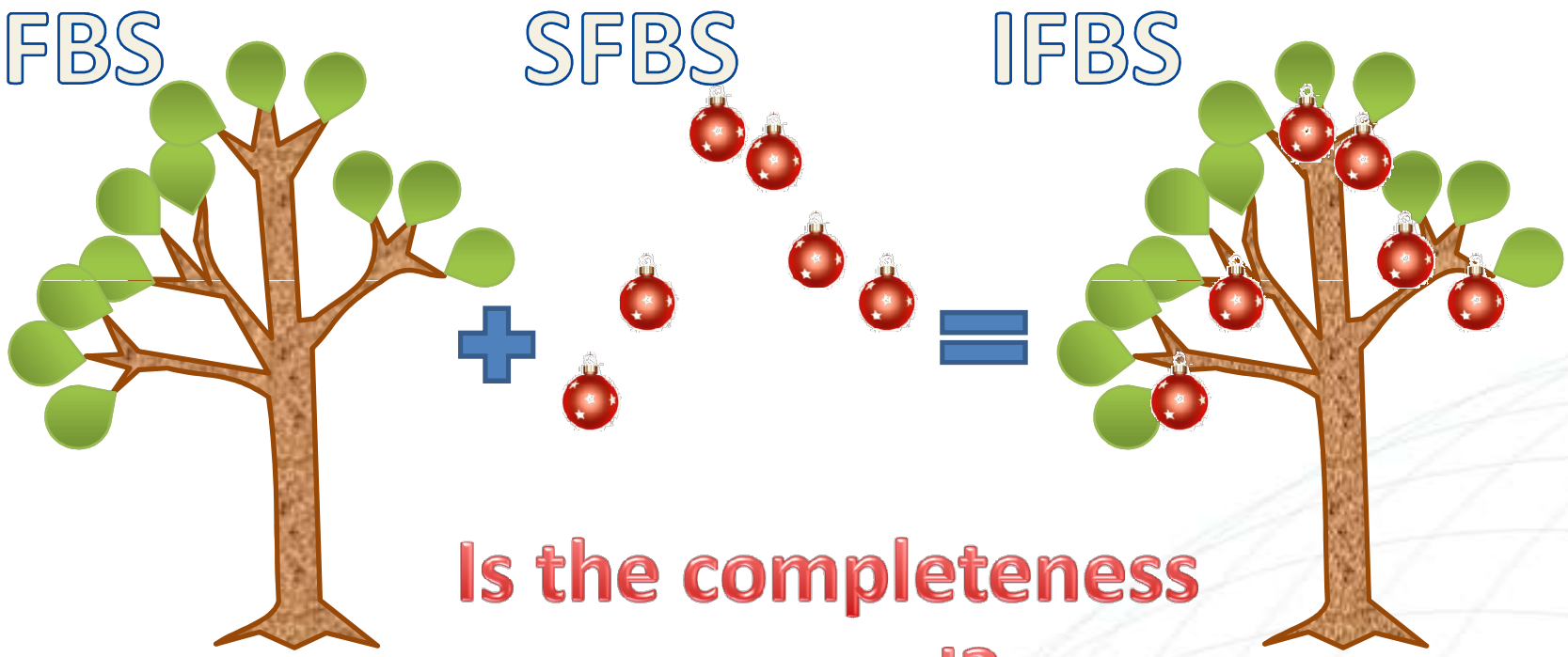
Items important to safety	Safety functions
Buildings and structures	To form a barrier to the uncontrolled release of radioactive material to the environment
	To provide protection against external and internal events for the enclosed safety systems
	To provide shielding against radiation
Reactor core	To maintain the fuel geometry and the necessary coolant flow path so as to ensure the possibility of shutdown and heat removal in all operational states of the reactor and in design basis accidents
	To provide negative feedback of reactivity
	To provide a means of moderating and controlling neutron fluxes
Fuel matrix and cladding	To form a barrier to the release of fission products and other radioactive material from the fuel
	To provide a coolable fuel configuration
Reactivity control system (including the reactor shutdown system)	To control the reactivity of the reactor core to ensure that the reactor can be safely shut down and to ensure that the fuel design limits and other limits will not be exceeded in any operational state of the reactor or in design basis accidents

Experience = Complete set of Safety Functions

Safety Functional Tree

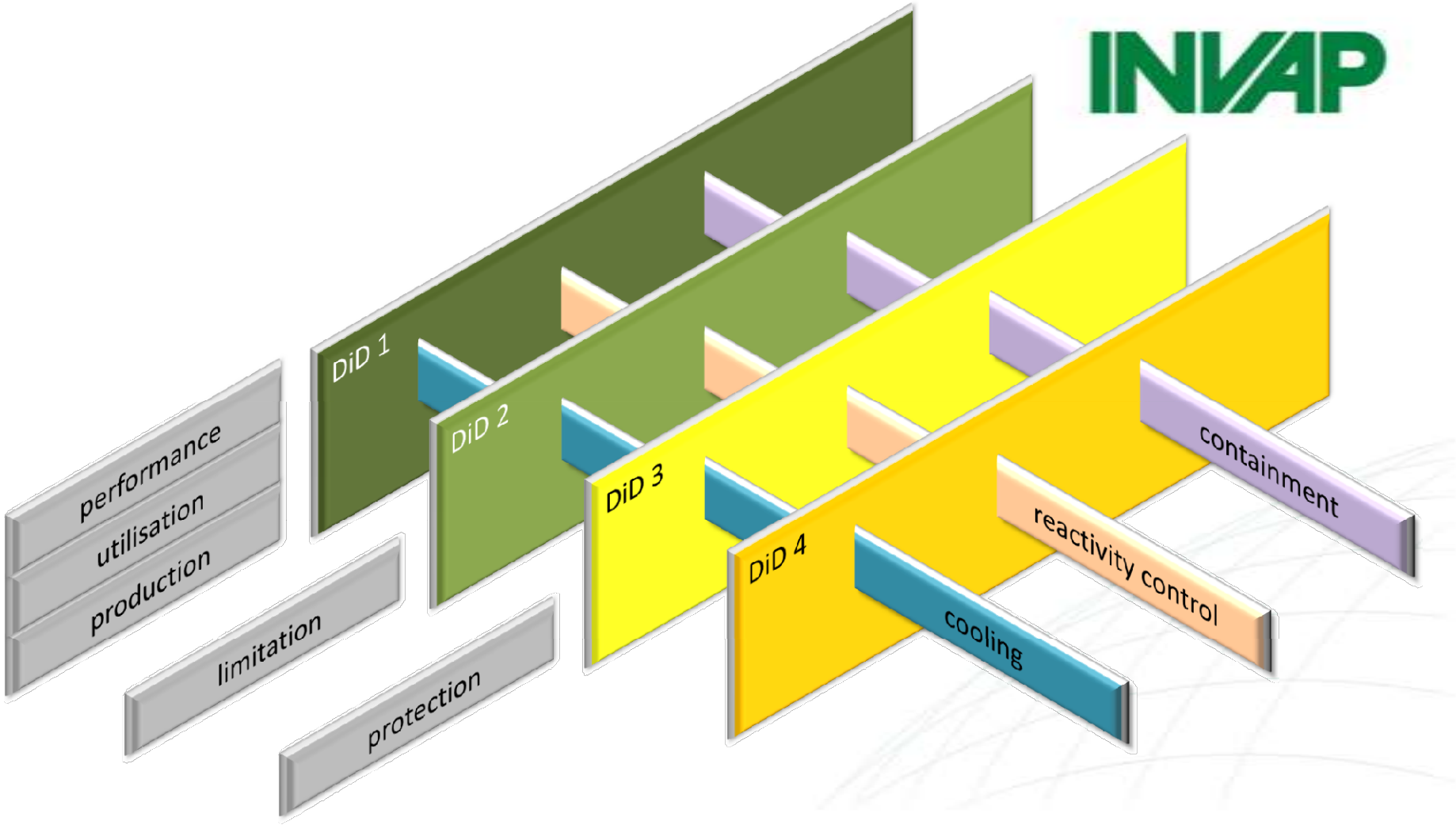


Integrated functional tree



Introducing DiD dimension

Levels of DiD	Objective	Reactor Status
1	Prevention of abnormal operation and failures	Normal and nominal operation
2	Control of abnormal operation and detection of failures	Anticipated deviations from normal and nominal conditions
3	Control of accidents within the design basis	Response to Postulated Initiating Events
4	Control of severe plant conditions, including prevention of accident progression and mitigation of the consequences of severe accidents	Controlling accidental scenarios
5	Mitigation of radiological consequences of significant releases of radioactive materials	There are no systems in RR design (may be for the site) for off-site measures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DiD 1
DiD 2
DiD 3
DiD 4
performance
utilisation
production
limitation
protection
containment
reactivity control
cooling

Conclusions

- The approach seems to be providing a more structured identification of functions.
- Application to high performance designs is completed
- Grading to small RRs uncertain.
- Including C&S may trigger another complexity.

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Thank you!

Questions ?

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