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# Challenges of a “Full-Scope” SA PIRT

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**SEAKNOT – 1<sup>st</sup> Open Workshop**

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**Oct. 2<sup>nd</sup>, 2025**



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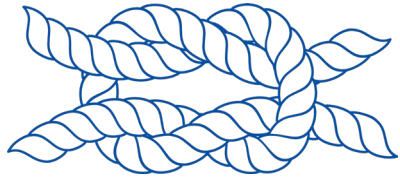
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# Background



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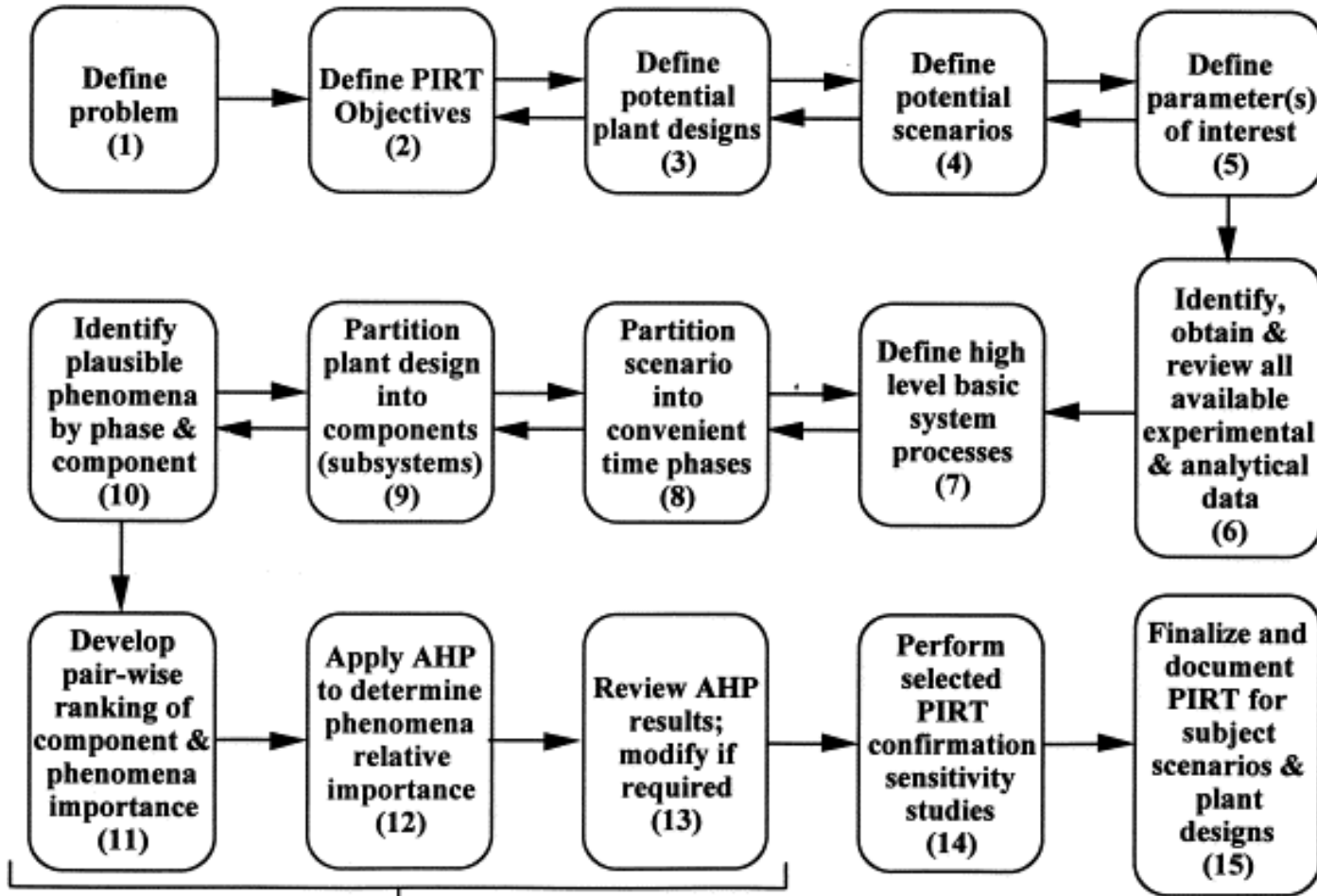
# The Origins

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- Step 3 in CSAU (Code Scaling, Applicability and Uncertainty) Method. (BEPU application in safety analysis; USNRC, 1988).
- A way to set technical basis for experimental programs.
- A means to establish computer codes phenomenological requirements.
- A methodology broadly used in SA (... but adaptation required!).
  - “Development of the source term PIRT based on findings during Fukushima Daiichi NPPs accident”, 2015.
  - “PIRT: R&D Priorities for Loss-of-Cooling and Loss-of-Coolant Accidents in Spent Nuclear Fuel Pools”, 2018.
  - “Elaboration of a PIRT for the modelling of In-Vessel Retention”, 2020.



# The Process



Ranking approaches, other than AHP, are available

(1) Resources vs. efforts!

What problem must be solved to what level!

(2) Plant behavior!

Guidance

- Experimental

- Code development

- Code uncertainty

(3&4) Relative importance =  $f(\text{design}; \text{scenario})$

(5) Primary evaluation criteria!

(6) Collective knowledge of SOAR understanding.

(7) "Saving time".

(8&9) Need to accommodate to SA.

(10) Brainstorming ("What the team does not know").

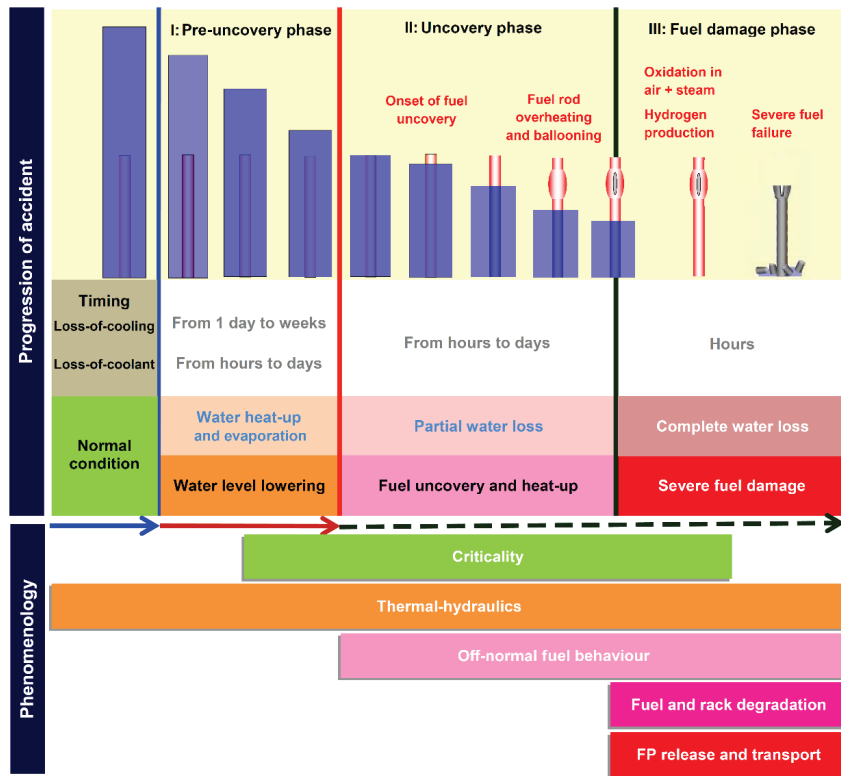
(11-13) Ranking – Focused on (5) using (2).

(14) Confirmation of validity!

(15) Documentation!



# Adaptation to SFP (NEA/CSNI/R(2017)18)



1. Define the problem(s) justifying the PIRT and the objectives of the work

(1)& (2)

2. Define the current knowledge base by collecting and reviewing available experimental data and analytical results

(6)

3. Define the SFP design, spent fuel inventory and accident scenario

(3)&(4)

4. Partition the accident scenario into suitable time phases with regard to the expected sequence of occurring phenomena

(9)

5. Identify and describe plausible phenomena for each time phase

(10)

6. Define evaluation criteria to be used for the importance ranking

(5)

7. Rank the importance of each phenomenon with regard to the selected evaluation criteria

(11)&(13)

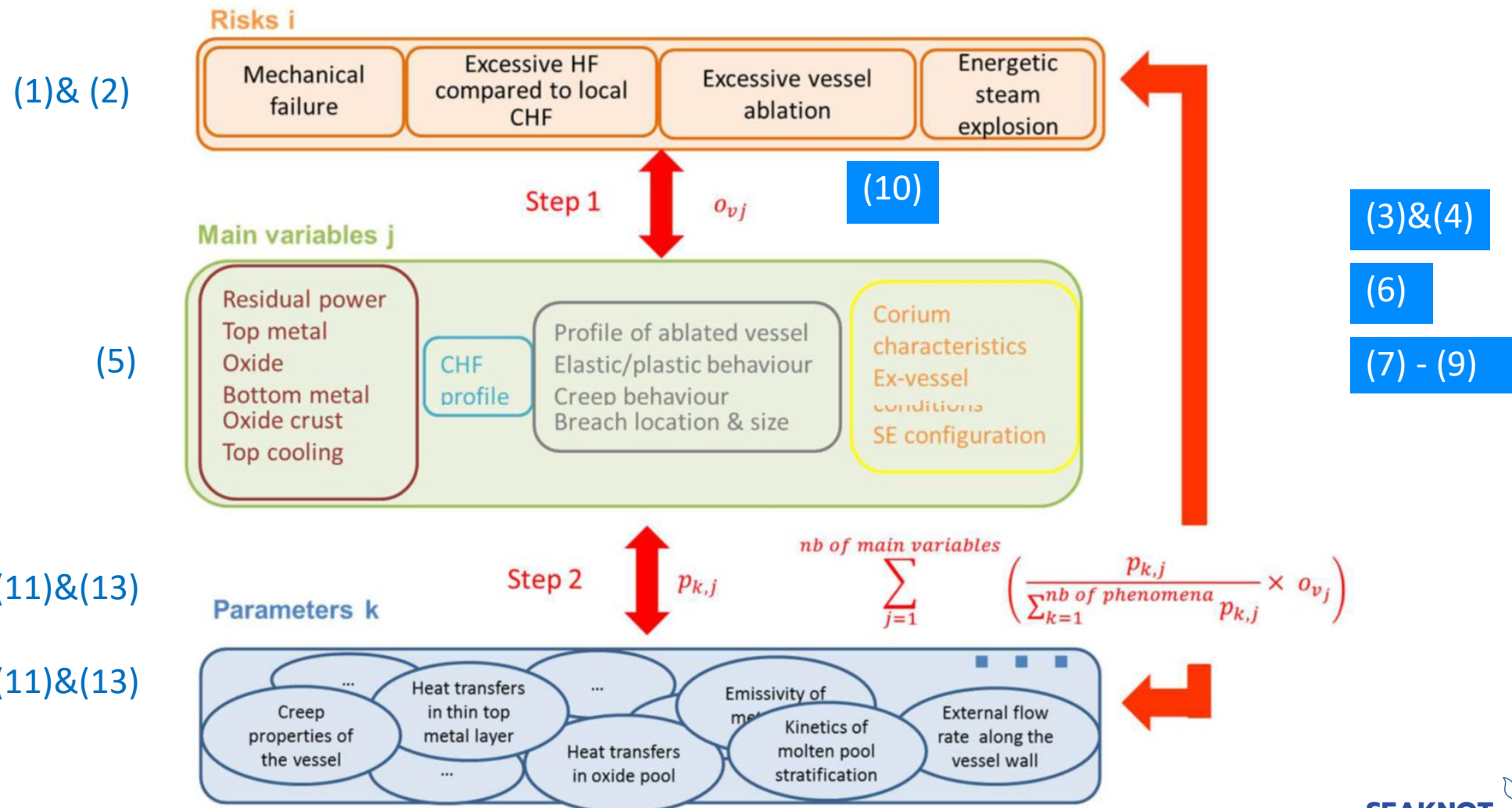
8. Assess the current level of knowledge for each phenomenon

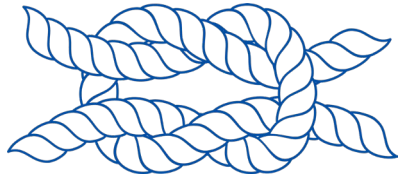
(11)&(13)

9. Document the PIRT process and the results, including the technical rationale for the ranking

(15)

# Adaptation to IVMR (j.anucene.2020.197617)





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# **SEAKNOT Adaptation**



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# Step-by-step

**(1) Definition: SA Research to be done in the coming 10 years.**

- Prevention & mitigation.
- Reducton of uncertainties (practical elimination; decision-making; ...).
- From the SOARS, PIRTs and SARPs + input from recent projects

**(2) Objectives: External radiological impact (Source Term)**

- FP release
- Barriers

$$J_i(t) = \underbrace{\int_0^{t_f} e(t) \cdot dt}_{\text{Leak function}} \cdot \underbrace{I \cdot F \cdot F_i \cdot \int_0^t s(t') \cdot dt'}_{\text{Release mode}} \cdot \underbrace{\exp \left[ - \int_{t'}^t \varepsilon(t'') \cdot dt'' \right]}_{\text{Probability of remaining airborne}}$$

(High complexity: Eng. Judg. + multi-parameter sensitivity studies! (12))

# Step-by-step

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**(3) Plant designs: PWR-W/VVER/BWR/WC-SMRs (SASPAM-Types I, II)**  
(ATFs – near term; cross cutting considerations; high Bup & enrich.)

**(4) Scenarios:** Approach to phenomena: phenomena → Key scenarios (prf).  
Proven “risk-contributing” scenarios!



# Step-by-step

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**(5) Parameters:** Main RN in terms of RC ( $I^{131}$ ;  $I^{132}$ ;  $Cs^{137}$ ;  $Ru^{106}$ ;  $Te^{132}$ ;  $Kr-88$ ;  $Xe-133$ ;  $Xe-135$ ).  
Onset time; release activity rates; amount & composition.

**(6) Data:** Collective expertise (6) – deep on subject; broad in approach (exp; mod; ap.)  
AB&EUG – Supplementary role (feedback).



# Step-by-step

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**(7) High level features:** Bifurcation/disruption of accident progress.  
(Phasing / AMgmt).

**(8) Accident phases:** Alternate to domains ... In-V + containment + Source Term  
Ex-V + containment & Source Term

**(9) Partition in components:** Attention in accidents phasing.  
Ex. Ex-V Containment

- Sprays
- Spools
- PARs
- Fan coolers
- FCVS

# Step-by-step

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## **(10) Phenomena identification:**

Based on “team satisfaction”  
from SOARs+PIRTS+Projects; plausibility!

## **(11) Phenomena ranking:**

Collective expertise (6)  
AB&EUGs – Supplementary role (feedback).  
“Model”: integral code model-type (3D/CFD).  
Barriers integrity!

## **(12) Sensitivity studies:**

Inspiration for long-term mobility grants.

## **(13) Documentation:**

Full traceability: defensible/scrutinizable/complete.  
Feedback from AB&EUG highly recommended.



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# The Key Element



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# PIRT Ranking

- **Safety significance** – Referred to the primary parameters of interest (5)  
Three levels: L/M/H  
L: Low  
M: Medium  
H: High
- **Knowledge/Understanding** – Data/Models/Uncertainties
  - a. Data: Existing & QVD (H); Existing, but no direct application VD (M); Non-existing (L)
  - b. Models: Existing in codes (H); Existing but highly uncertain (M); Non-existing (L)

# Knowledge Ranking

		DAT		
		L	A M	H
MODEL	L	L (Unknown)	L (Qualitative understanding)	M (Bases for "known" set)
	M	L (Uncertain approximation)	M (Qualitatively assessed app.)	M (Soundly assessed app.)
	H	L (Uncertain model)	M (Qualitatively assessed model)	H (Known)

# Final Ranking

		SAFETY		
		L	M	H
KNOWLEDGE	L	L	M <sub>2</sub>	H
	M	L	M <sub>3</sub>	M <sub>1</sub>
	H	L	L	L



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# Practicalities



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# Ranking Phasing

## In-V (In-V+CONT+ST) & Ex-V (Ex-V+CONT+ST)

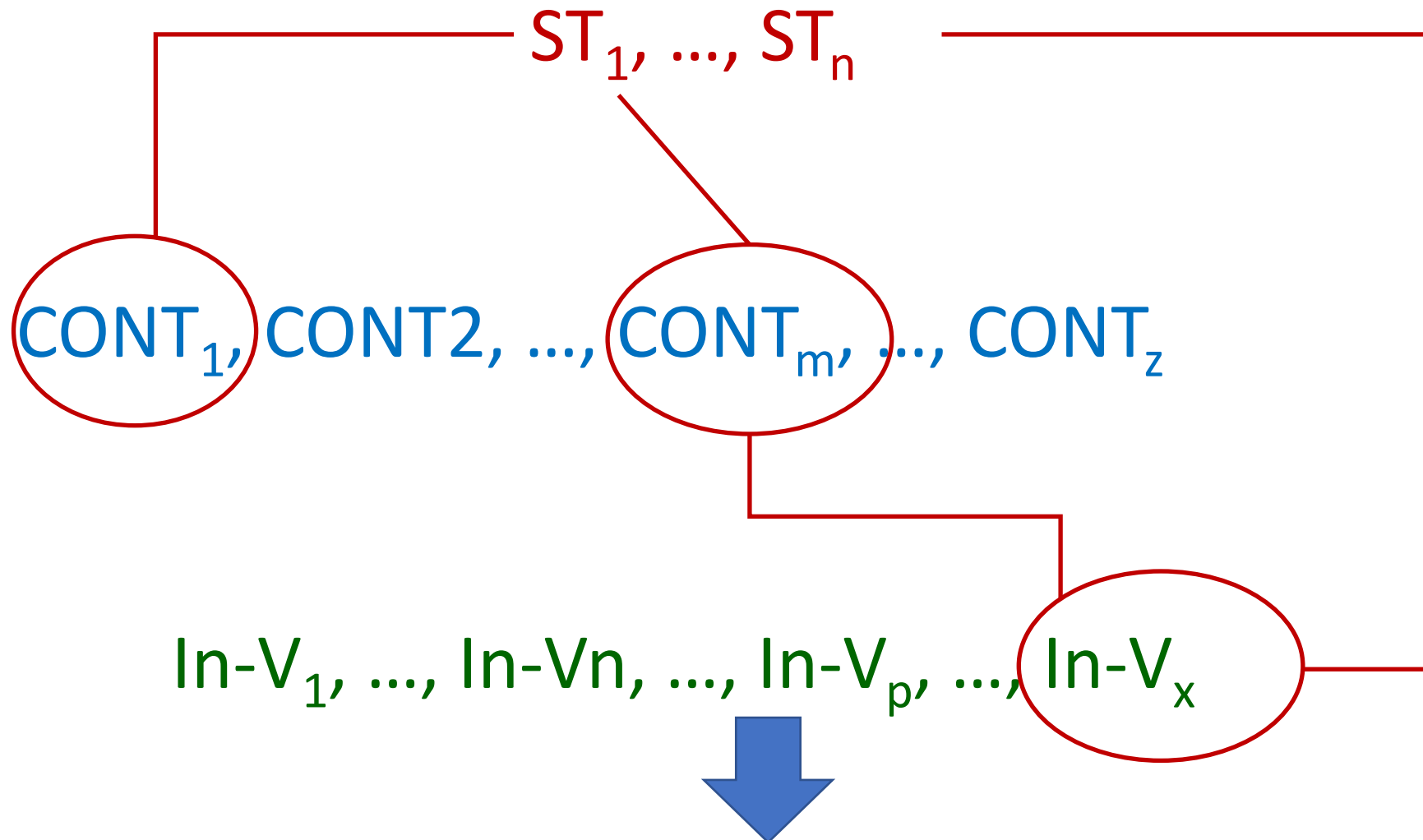
- I. Individual ranking (In-V/Ex-V; CONT+ST).
- II. CONT & ST should split their ranking into In-V & Ex-V.
  - ≠ phenomena
  - = phenomena; ≠ BCs

III. Joint ranking – Focus on high priority issues.

		SAFETY		
		L	M	H
KNOWLEDGE	L	L	M <sub>2</sub>	H
	M	L	M <sub>3</sub>	M <sub>1</sub>
	H	L	L	L

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# Ranking Phasing



ST<sub>1</sub>, ..., ST<sub>n</sub>, CONT<sub>1</sub>, CONT<sub>m</sub>, In-V<sub>x</sub>


# Documentation of “Hot” Issues

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Phase PIRT Template
Phenomenon name:
Accident phase:
Accurate description (2-5 lines)
Domain ranking statistics
Specific information missing (refs. mandatory)
Connection with Source Term (refs. mandatory)
Safety significance (refs. Mandatory)
List of supporting references given in previous boxes

# AB Feedback integration

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- In case of AB specific disagreements with PIRT:
  - a. Phenomenon identification
    - a1. Missing
    - a2. Considered
  - b. Phenomenon evaluation
    - a1. Undervalued
    - a2. Overvalued
  - Identification of the phenomenon.
  - Short description.
  - Rationale.
  - Supporting references.

(1-page template to be prepared)
- SEAKNOT (WP1 + ExB) assessment of the feedback.
- SEAKNOT decision making and COO reporting back to AB.

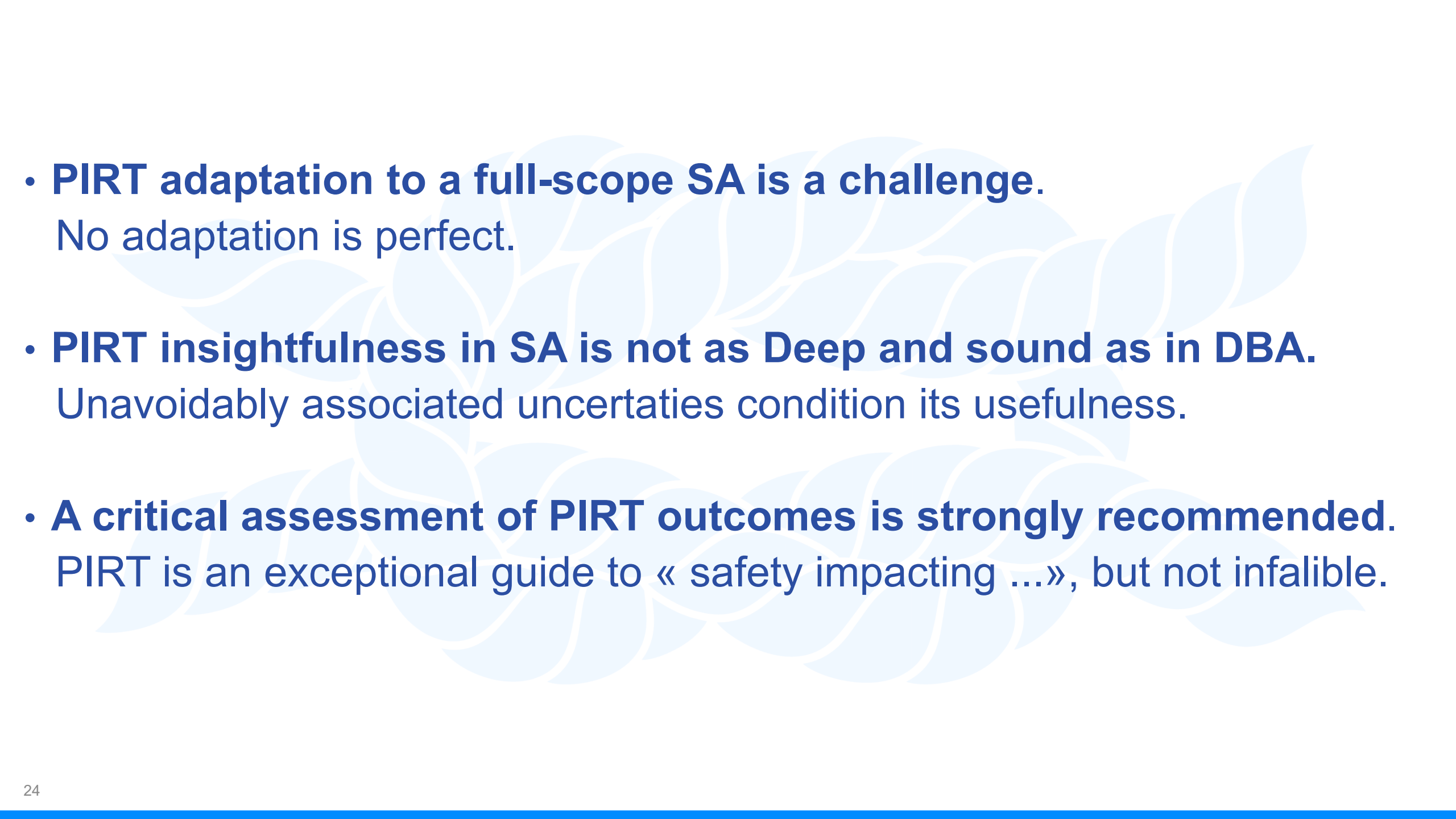


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# Final Remarks



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- **PIRT adaptation to a full-scope SA is a challenge.**  
No adaptation is perfect.
  - **PIRT insightfulness in SA is not as Deep and sound as in DBA.**  
Unavoidably associated uncertainties condition its usefulness.
  - **A critical assessment of PIRT outcomes is strongly recommended.**  
PIRT is an exceptional guide to « safety impacting ...», but not infalible.

# THANK YOU!

## Get in touch for more information

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All of the reports of the project will be available for download on the SEAKNOT website: **[www.seaknot-project.eu](http://www.seaknot-project.eu)**



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