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SAMGs for German NPPs – Main Features and Implementation

Engineering & Projects (E&P)

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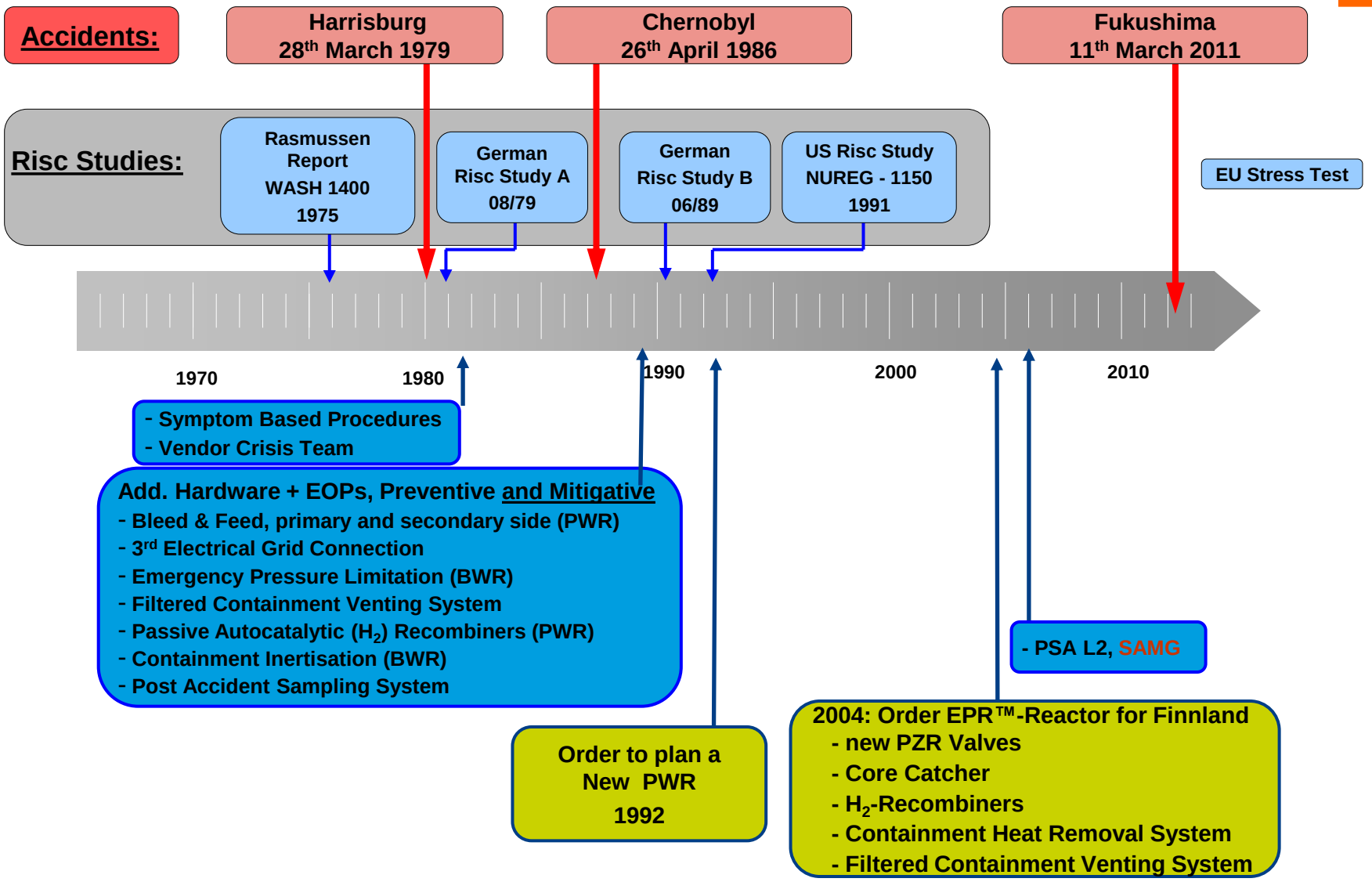
Content

- History
- Basic Approach
- Mitigative Measures and Strategies
- Verification and Validation
- Implementation
- Conclusions

History:
From DBA to Accident Measures at Core Melt



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Basis for the Development of SAMG

KTA 1203
Requirements
to the EOM

RSK-Recommendations

SSK-Recommendations

BMU – Announcement
“Reactor Safety Handbook“

International

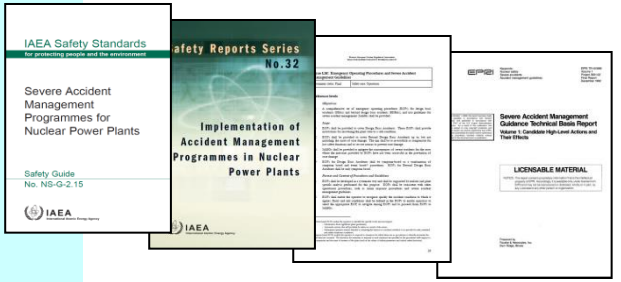
IAEA Standards

e.g. NS-G-2.15

Safety Report No.32

WENRA Issue LM

EPRI TBR



Safety Requirements
for NPPs
(BMU Module 7)

BMU –
Backfitting
Requirements

Germany

Development of a Guide Book (SAM-M) for the ERT
to mitigate the consequences of a severe accident and its implementation
into the Operation Regulations – PWR + BWR

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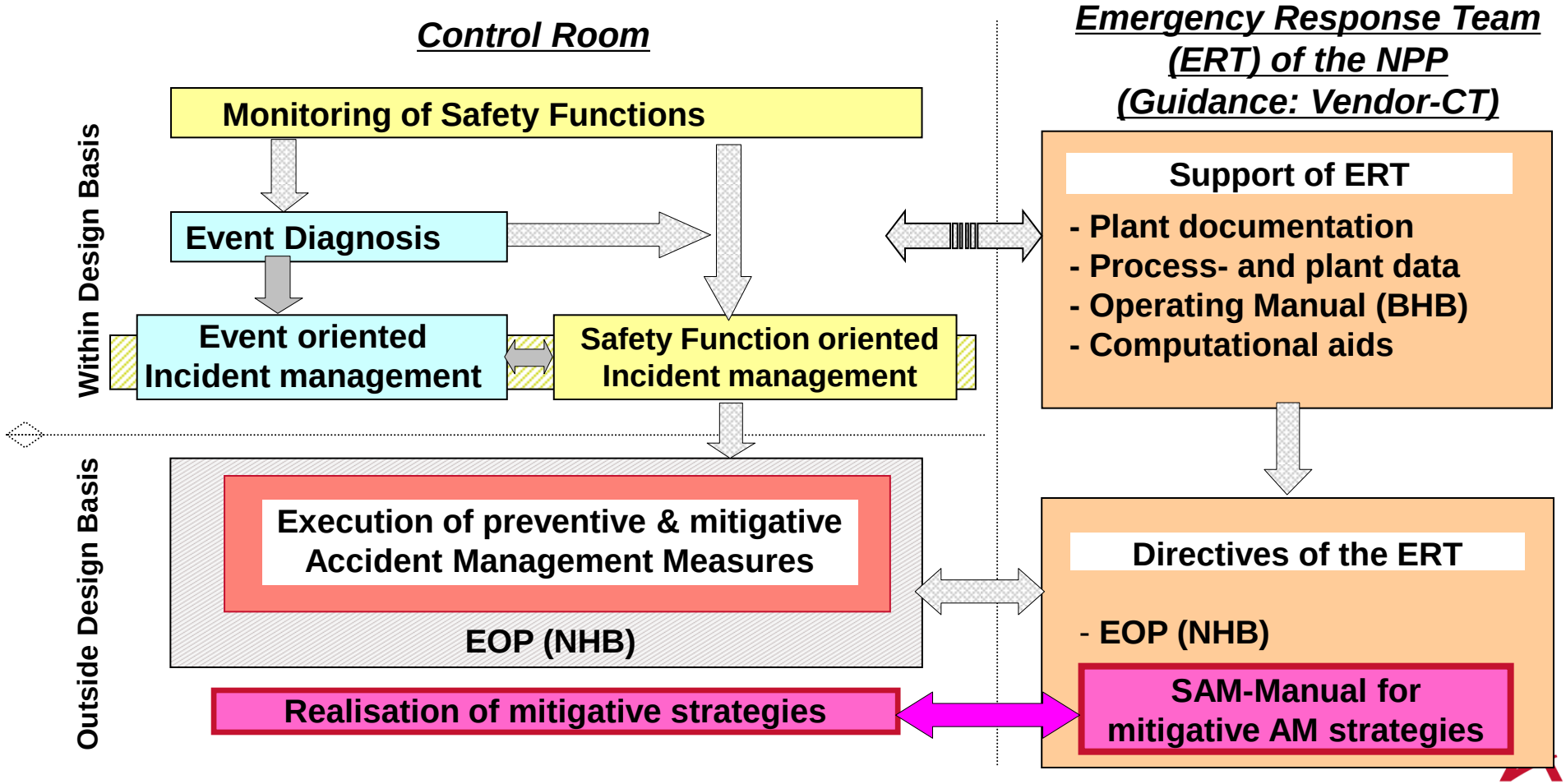
Accident Management Principle after Introduction of SAMG



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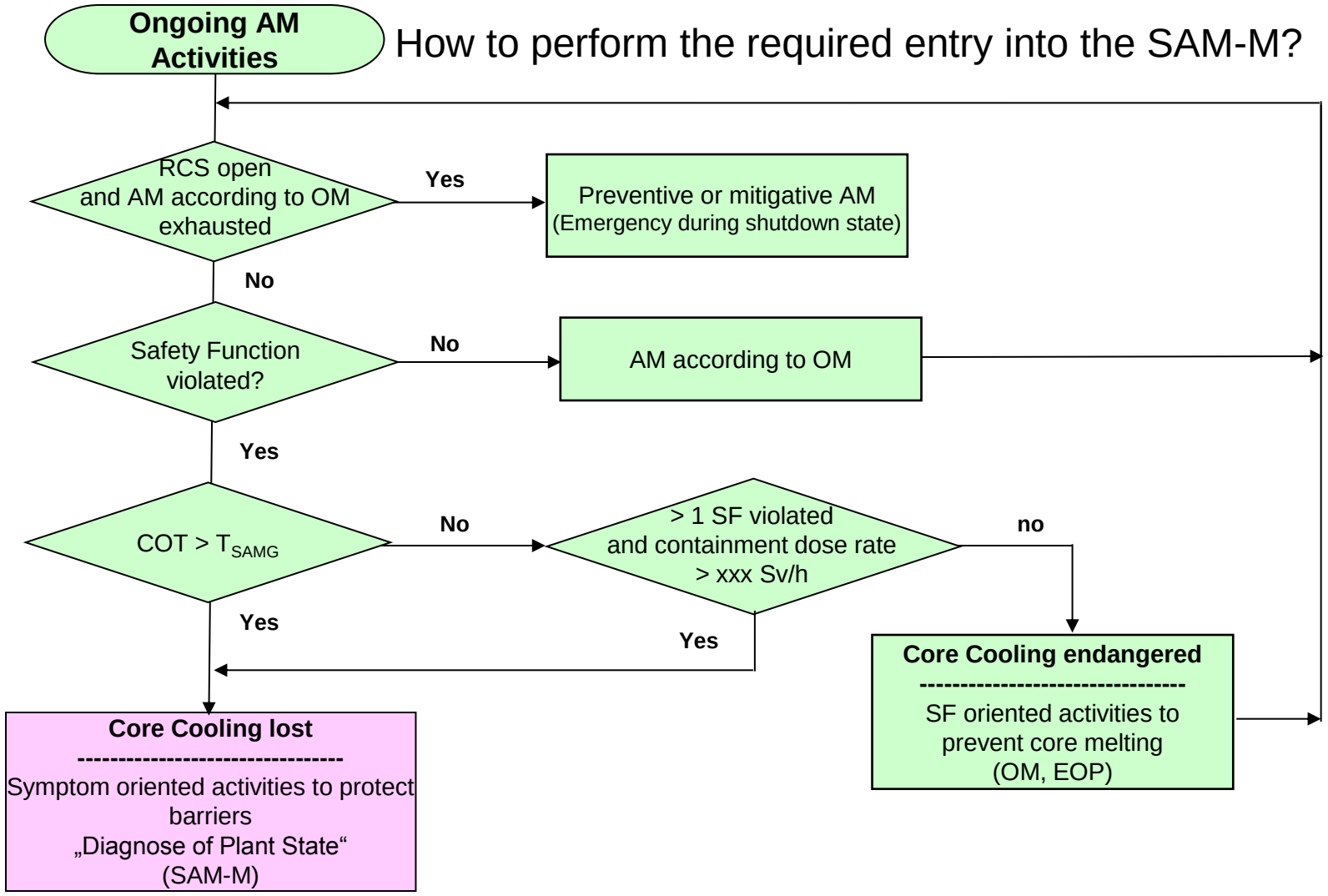
Steps to Use an Appropriate SAM Strategy

What are the steps to use an appropriate strategy?

- Check whether an entry criterion is met
- Determination of the core degradation and confinement state (power states) or
  Recording the phase of shutdown
- Selection of an adequate strategy
- Working through the prioritized measures of a dedicated strategy
- Evaluate consequences – positive and negative – of each measure
- Decision to perform / no perform the candidate measure
- Checking of the plant state regularly

General Accident Management Flow Chart
Entry into the SAM-M



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Strategies[1] based on Plant States – Core Damage and Confinement States

- The basic principle of the German SAMG concept is the prioritization of CHLAs by strategies, which are assigned to relevant plant damage states
- The selected core damage and confinement states are practically the same as proposed in the EPRI TBR
- In addition, the confinement states reflect the relevant FP release paths of the PSA Level 2

EPRI TBR

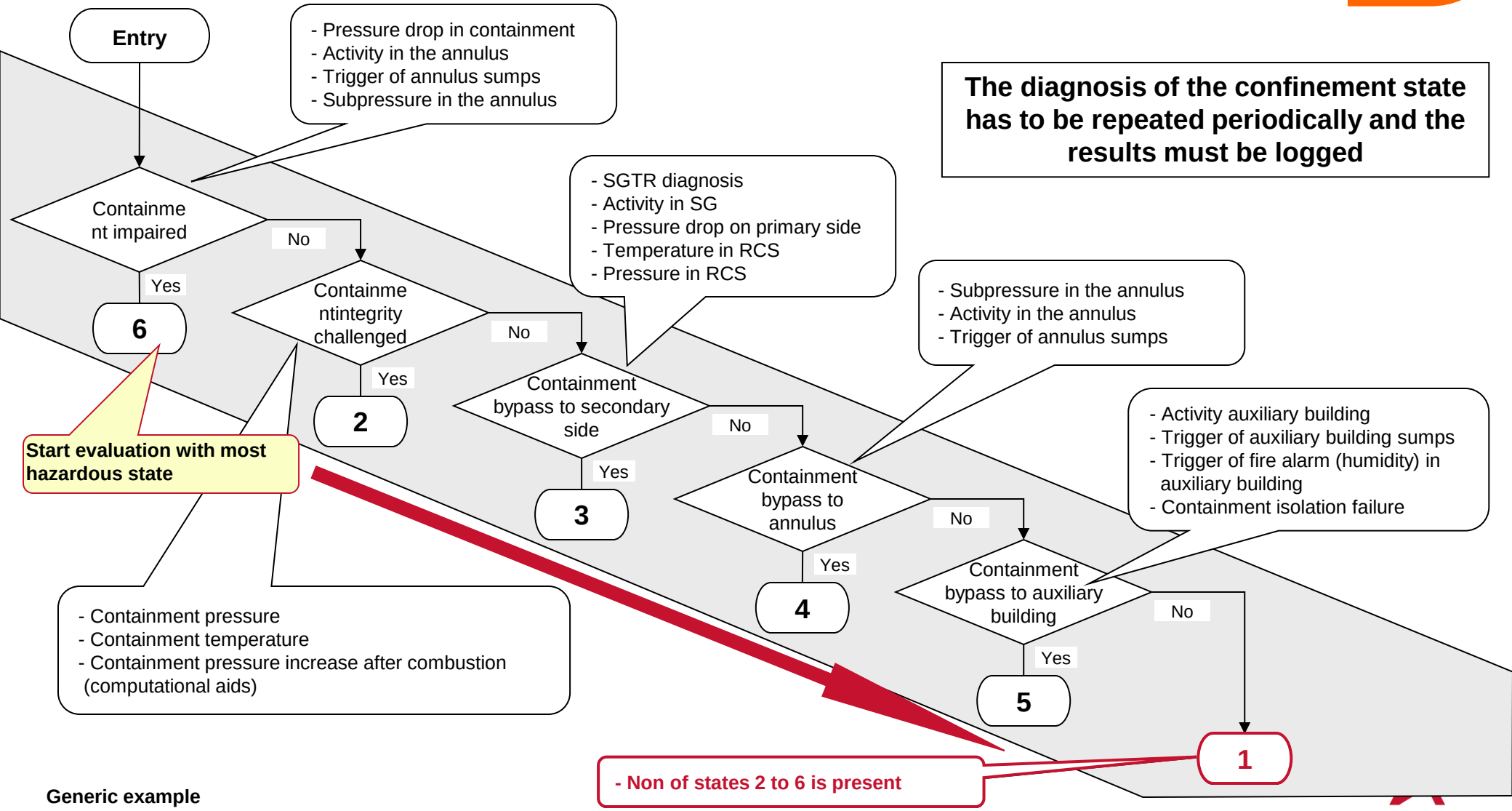
Core	
OX	Oxidized
BD	Badly Damaged
EX	Ex Vessel
Containment	
CC	Cooled and Isolation Complete
CH	Challenged
B	Bypassed
I	Impaired

AREVA GmbH SAM-M

Core	
A	Core Oxidized
B	Badly Damaged, RPV Intact
C	Core mostly Outside of RPV, RPV Failed
Confinement	
1	Integrity Secured, Isolation Complete
2	Integrity Challenged
3	Bypass to the SG (SGTR)
4	Bypass to the Reactor Building Annulus
5	Bypass to Reactor Auxiliary Building or Isolation Failure
6	Impaired, Very High Leakage

[1] Prioritization of Candidate High Level Actions (CHLA)

Confinement State Determination Flowchart



Generic example

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Selection of an Adequate Strategy
Step 1: Diagnosis of the Plant State

▶ Step 1: Diagnosis of the Plant State

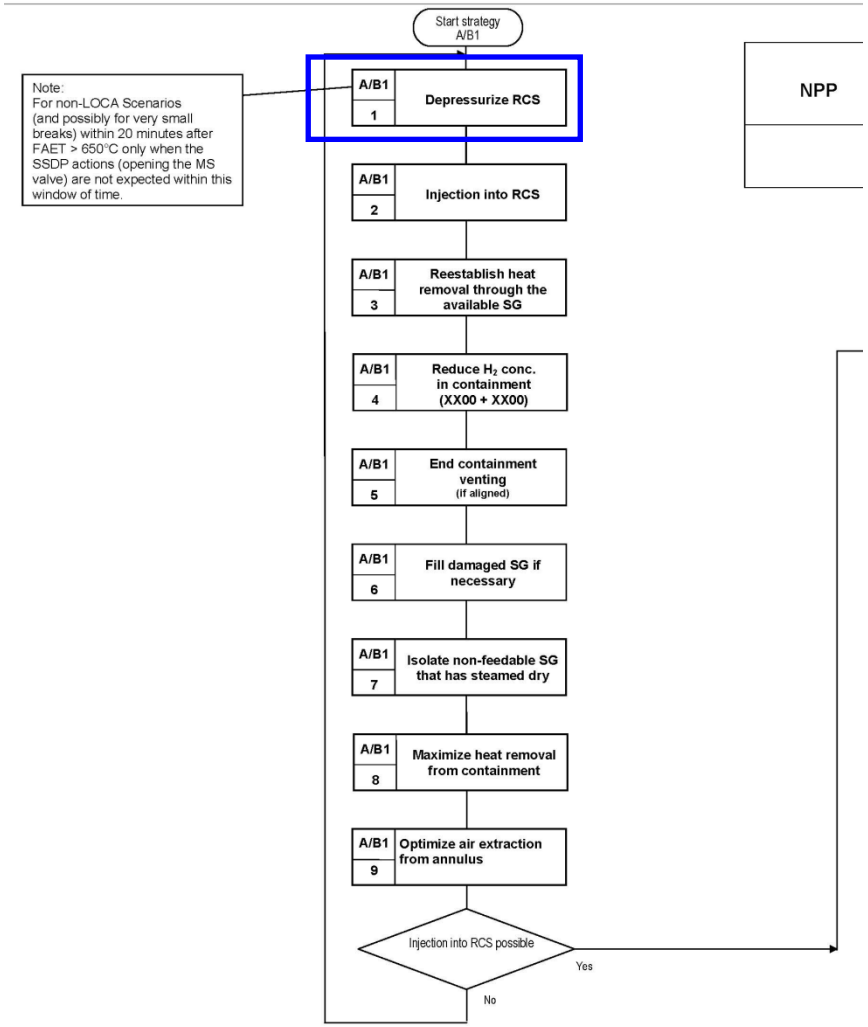
- based on instrumentation and computational aids (CA)
- specific strategy flow chart for each plant state
- periodical re-diagnosis and documentation of the plant state

Core State \ Confinement State		1	2	3	4	5	6
		integrity assured	integrity challenged	bypass sec. side	bypass annulus	bypass aux. bldg. or isol. failure	impaired (leak or rupture)
A/B	Core damaged / degraded RPV still intact	A/B1	A/B2	A/B3	A/B4	A/B5	A/B6
C	RPV failure	C1	C2	C3	C4	C5	C6

Strategy Flow Chart

▶ Step 2: Processing of the Flow Chart

- **the measures are prioritized according to their efficiency to mitigate the accident**
  - strategies are based on extensive accident simulations, PSA level 2, and literature
- **sequential process**
- **simple (yes/no) decision boxes**
- **actions are carried forward as long as there is no advice to terminate**
- **detailed sheet for each CHLA (measures)**



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Candidate High Level Actions

▶ Step 3: Check the CHLA Sheet

One-page information sheet for each CHLA:

- description and objective
- initiation and termination criteria
- required systems/resources
- estimated plant response
- supporting information
  - positive and potential negative consequences
  - useful background information
- reference to applicable EOPs, CAs
- actions are continued until it is advised to stop them

plant state A/B1 CHLA-1

NPP	Severe Accident Management Manual (SAM-M)	SAM-M Part: A Page: 14 Revision -
	3. Accident during Power Operation 3.1 Possible core melt, RPV still intact 3.1.1 Containment intact	

A/B1	Depressurize RCS
1	

Description and Objective	
Additional Initiation Criteria	
Termination Crite-ria	
Required Systems / Actions	
Indications of effectiveness / Plant response	
Important Notes	
Applicable OM / EOM	
Available Resources	

Verification

- **Potential CHLAs and measures were assessed by dedicated parameter and efficiency studies**
- **Development at AREVA performed by two teams**
  - **Plant-specific MELCOR models**
  - **Deterministic scenario calculations, including parametric and efficiency studies**
  - **Interpretation of results**
  - **Periodically exchange of results and conclusions between the two teams**
- **Strong involvement of Utilities**
  - **led to several QA-loops**
- **Information exchange between different Utilities**

Training and Validation

- **Pilot trainings performed in each NPP on**
  - **Relevant phenomena**
  - **Behavior of the NPP in case of representative severe accident scenarios**
  - **Potential fission product release paths**
  - **General mitigation approaches for considered NPP**
  - **Application of the SAM-M**
- **Validation steps:**
  - **Simulation exercises using an engineering simulator**
  - **Exercises based on pre-calculated severe accident scenarios**
  - **Update of the draft SAM-M based on the feedback from trainings and exercises**
  - **Final full scope exercise, based on pre-calculated severe accident scenarios, including the impact of CHLAs that will be probably performed by the ERT**
- **Feedback from different NPPs used for improvement of SAM-Ms**

Implementation and Future Steps

- The SAM-M were implemented by end of 2013
- Revisions will be implemented by end of 2014, including
  - Feedbacks from trainings and exercises performed in all NPPs
  - Feedbacks from external information exchange
- Proposed actions beyond 2014
  - Performance of plant-specific yearly refresher trainings, including full scope exercises (up to 1 day)
  - Initial trainings for new personnel (2 days)
  - Review and potential update of the SAM-M based on the regularly performed safety assessments according to the accident management system of the NPPs and the Utilities
- Feedback from different NPPs used for best practise harmonization of SAM-Ms

Summary

- As German NPPs had already comprehensive preventive and mitigative EOPs,
  - the SAM-M has been developed as a structured guideline for the ERT and the AREVA crisis team
  - Basically, there is no need to modify the OM/EOP
- International developments, PSA Level 2 for German NPPs and plant-specific deterministic analyses supported the SAMG development essentially
- The SAMGs have been developed and validated in close cooperation with the Utilities
- Feedback from training and full-scope exercises performed in all NPPs supported the final version of the SAM-M
- Impact of the Fukushima Daiichi Accident:
  - no essential modifications of the SAM-M required but
  - besides SAMG preventive measures are introduced to enhance the robustness against external hazards

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End of presentation

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