CSN CONSEJO DE SEGURIDAD NUCLEAR

On the evolution of Dynamic PSA tools and methodology: applications of the OPSA-MEF at CSN

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CSN

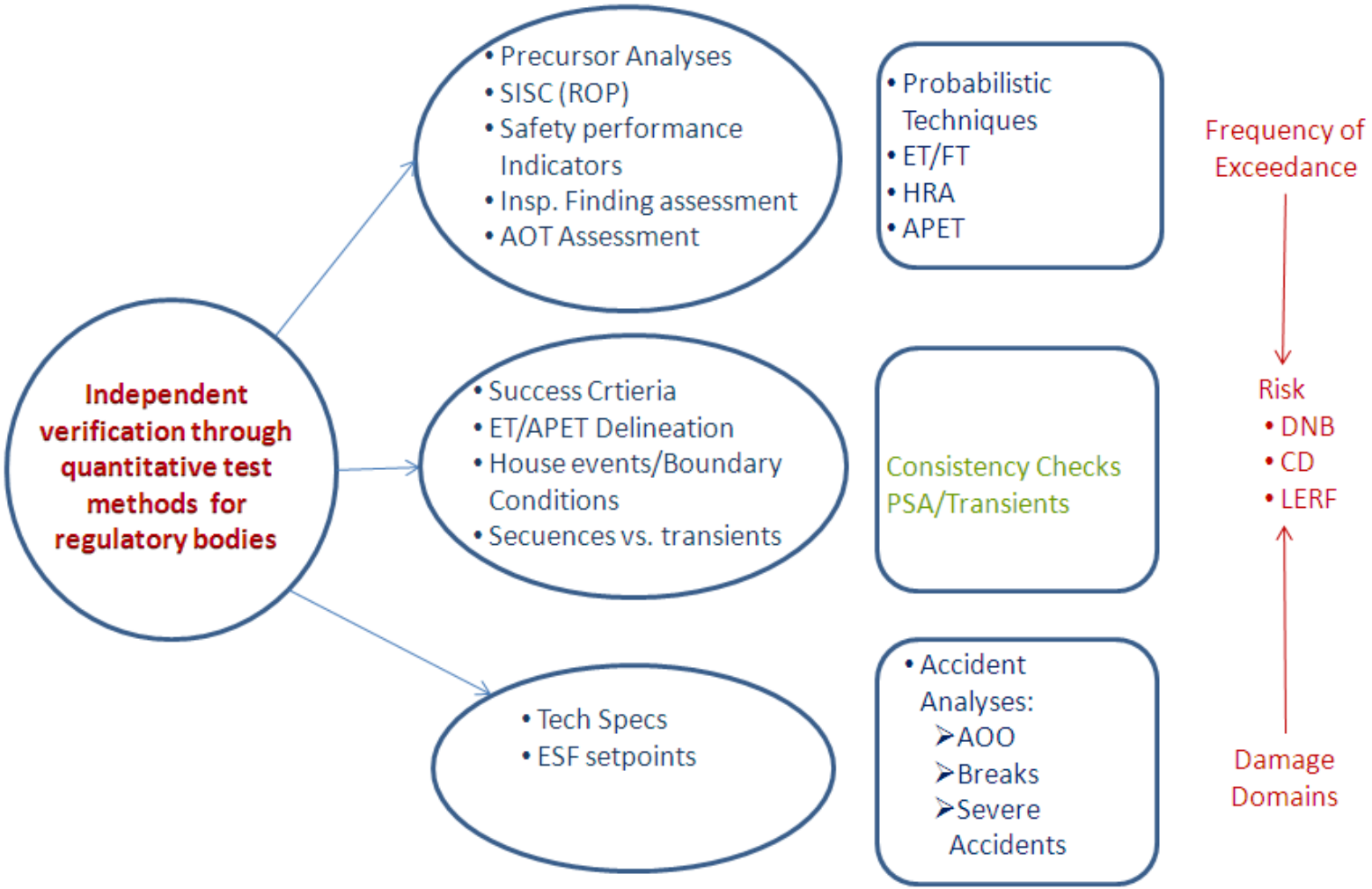
Regulators' Role

Risk based diagnostic tools

- Most often, industry safety analyses have to rely on computational tools for simulation of transients and accidents and probabilistic safety assessments, among others.
- Increasing trend towards Risk-Informed Regulation and technology independent methods also contribute to the need of computerized tools.
- This generates in regulatory bodies a parallel need for specific diagnostic tools able to support: review & approval of methods and results of licensees independent analyses and calculations to verify the quality and the conclusions of industry analyses.
- The regulatory approach and tools shall include a sound combination of deterministic and probabilistic checks as pieces of an Integrated Safety Assessment (ISA) methodology.
- Focus the objective of the regulatory process: review for gaps

Regulators' Role

Regulators and TSO



Integration of Deterministic and Probabilistic Approaches

Origin

- Licensing of NPPs: Deterministic methodologies in the 70s
  - However, probabilistic considerations in the deterministic approach
- Probabilistic approaches: WASH-1400, post-TMI, NUREG-1150:
  - Their evolution currently used for licensing and oversight
- CSN has long-standing research and applications activities to bring coherence into the use of probabilistic and deterministic approaches
- Coherence of the process: Integration of methodologies

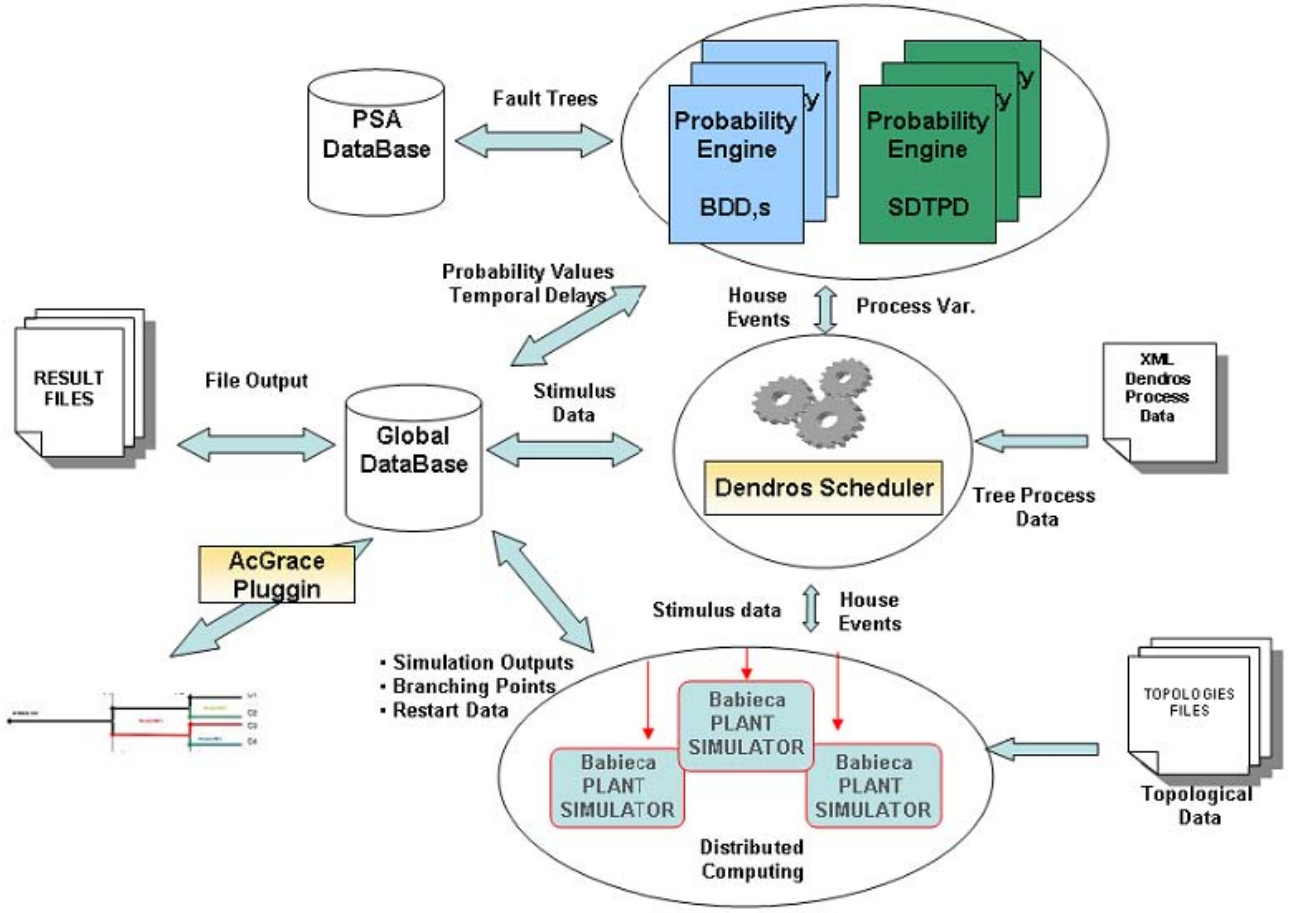
Assessment Tools

SCAIS

- A suitable software package called SCAIS has been developed with the capability of coupling:
  - Simulation of nuclear accident sequences from normal operation to severe degradation.
  - Simulation of operating procedures and severe accident management guides.
  - Automatic delineation (with no a-priori assumptions) of event and phenomena trees.
  - Probabilistic quantification of fault trees and sequences
  - Integration of results and statistic treatment of risk metrics.
- Two main features should be mentioned:
  - Capability to perform tree simulations.
  - Use of external codes, coupled through a standard interface, as SCAIS modules.

Assessment Tools

SCAIS architecture: current status



Assessment Tools

Scheduler

- Capability to perform tree simulations
- Automatic delineation (with no a-priori assumptions) of event and phenomena trees
- Parallel processing
- Management of branch opening and delays
- Storage facilities to allow for probabilistic analysis

Assessment Tools

Dynamic models

- Plant
  - Through simplified, home-made models
  - Linkage with industry fast accident analysis tools: MAAP, MELCOR
  - Linkage with detailed tools: RELAP, TRACE
- Operator
  - Built-in through the simulator input model
  - Linkage to external tools: SIMPROC

Assessment Tools

Probabilistic quantification and Risk Integration

- Current theory distinguishes Paths (transients with the same plant status but different actuation timing) and Sequences (sets of paths)
- Frequency results depend on the frequency of the simulation paths that lead to core damage
- The frequency for each sequence depends on the success/fail of the systems involved, including its configurations
- The quantification considers the uncertainty in the timing of the human actions
- Damage Domain: region of space of uncertain parameters (in particular, operator actions timing) where the damage criteria are exceeded
- Frequency of exceedance: integral over the damage domain

Assessment Tools

Failure of systems/trains

- Needed to calculate each sequence frequency, using models and data from PSA
- Need to modify the Fault Trees to consider configurations rather than success criteria, in order to model
- Need to extract the HRA modeling to account for time uncertainties

SCAIS Input Data and Software Specification

- Input data to all the SCAIS components are XML files.
- External codes maintain their own format for input data.
- SCAIS components do not need to run always together. Only the necessary components are used for each possible type of analysis.
- SCAIS has been developed with an object oriented architecture using only Open-source standards.
- Input to to the probabilistic calculation tools are foreseen to be in the Opsa-MEF format

Assessment Tools

Use of OPSA-MEF

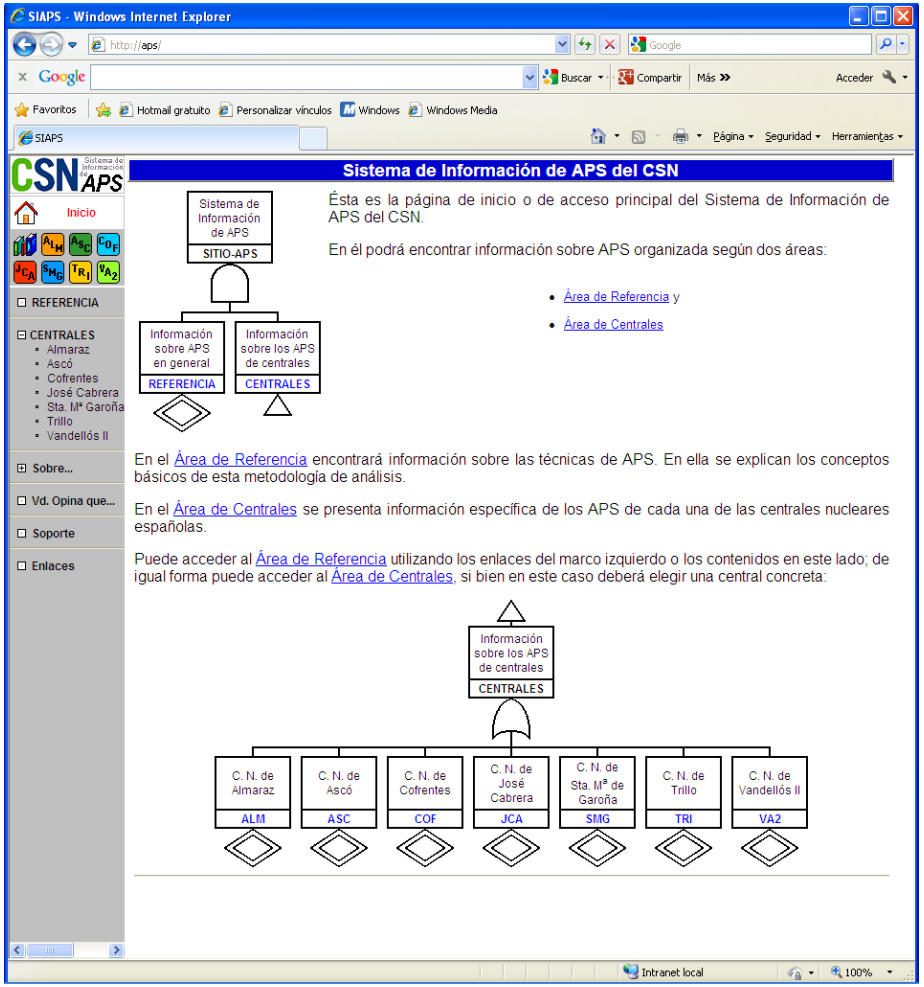
- Input to the probabilistic quantification part of SCAIS
- Allow for easy reading of the Fault Tree/Event Tree structure to obtain the reliability models
- Although event Trees are built on-line, functional event information may be used to define the analyses
- Outputs may be rendered comparable
- Opsa-MEF allows for easy manipulation through XML libraries

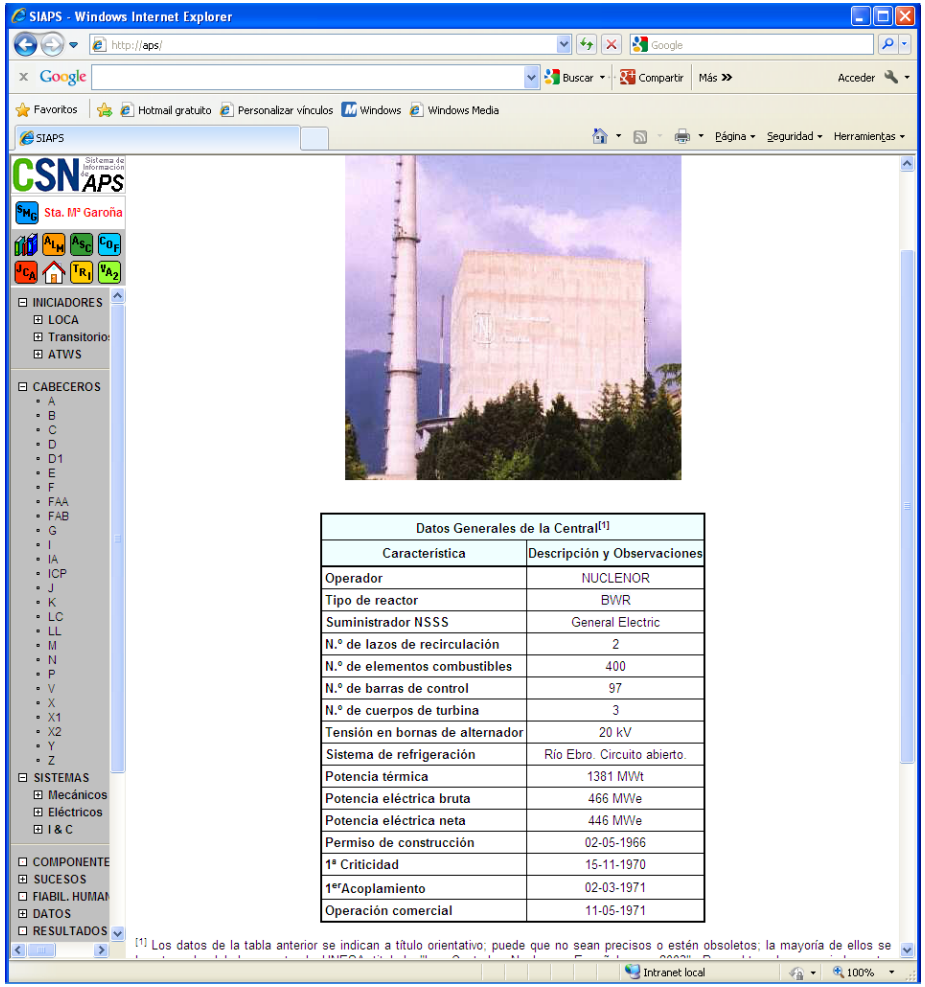
Information System for PSA

- The current regulatory approach makes heavy use of PSA in the determination of the consequences of licensee performance
- Whenever applicable,
  - Inspection scope is driven by PSA importance, and
  - Inspection results are assessed by PSA quantification
- PSA information needs to be disseminated throughout the organization: a PSA information system has been brought up

Information Tools

Information System for PSA





Datos Generales de la Central[1]	
Característica	Descripción y Observaciones
Operador	NUCLENOR
Tipo de reactor	BWR
Suministrador NSSS	General Electric
N.º de lazos de recirculación	2
N.º de elementos combustibles	400
N.º de barras de control	97
N.º de cuerpos de turbina	3
Tensión en bornas de alternador	20 kV
Sistema de refrigeración	Río Ebro. Circuito abierto.
Potencia térmica	1381 MWt
Potencia eléctrica bruta	466 MWe
Potencia eléctrica neta	446 MWe
Permiso de construcción	02-05-1966
1ª Criticidad	15-11-1970
1erAcoplamiento	02-03-1971
Operación comercial	11-05-1971

[1] Los datos de la tabla anterior se indican a título orientativo; puede que no sean precisos o estén obsoletos; la mayoría de ellos se

Information System for PSA

- Current foreseen scope of PSA models include at-power and shutdown, levels 1 and 2, internal and external (fires, floods), plus spent fuel pool as a source of radiation contamination
- Licensees are required to update their PSAs on a per-refueling outage basis
- This flow of new models needs to be handled and incorporate into the information system
- An automatic treatment of information is needed, implemented using Opsa-MEF "ideas"

Integrated Deterministic-Probabilistic Safety Analysis Initiative

- Compliance with evolving regulatory requirements will require innovative deterministic and probabilistic approaches of safety assessment for existing nuclear power plants
- There is also a need to combine the use of both methodologies for safety assessment
- Goals of IDPSA:
  1. to develop further IDPSA methods and for joint application with PSA and DSA in practice of safety analysis
  2. to assess advantages and present limitations of joint application of IDPSA with state-of-the-art PSA and DSA methods based on experience from a set of pilot realistic applications

Integrated Deterministic-Probabilistic Safety Analysis Initiative

- Dynamic PSA is considered one of the methodologies for integration
- Outcomes:
  1. New and improved IDPSA methods
  2. Recommendations and guidelines for joint applications of IDPSA, PSA and DSA
  3. Summaries of experience of addressing pilot realistic applications with IDPSA, PSA and DSA
  4. Increased awareness of the research, utility and regulator communities about advantages and current limitations of the new approaches to safety analysis which tightly combine deterministic and probabilistic methods.