CONSEJO DE SEGURIDAD NUCLEAR

Use of computerized tools for combined deterministic/probabilistic analysis

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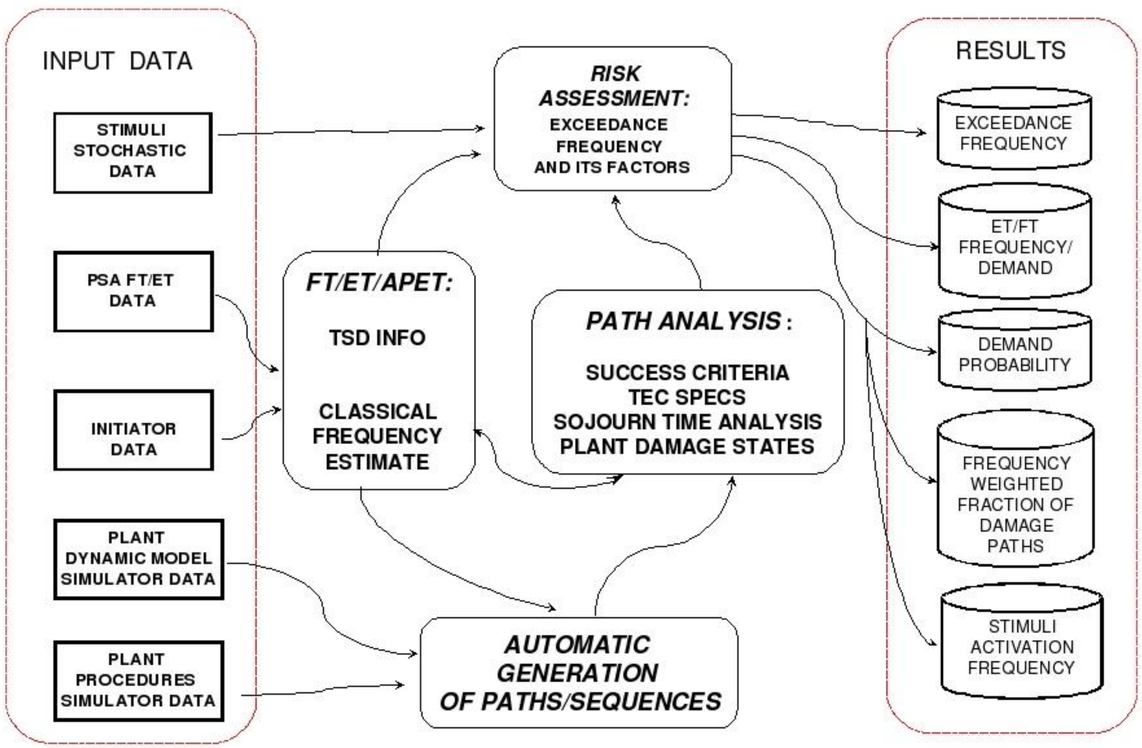
INTRODUCTION

Need for risk-based disgnostic 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 and 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.

The CSN-MOSI approach to ISA

- The CSN branch of Modeling and Simulation (MOSI) has developed an ISA system supported by the TSD mathematical framework



General scheme of the ISA methodology

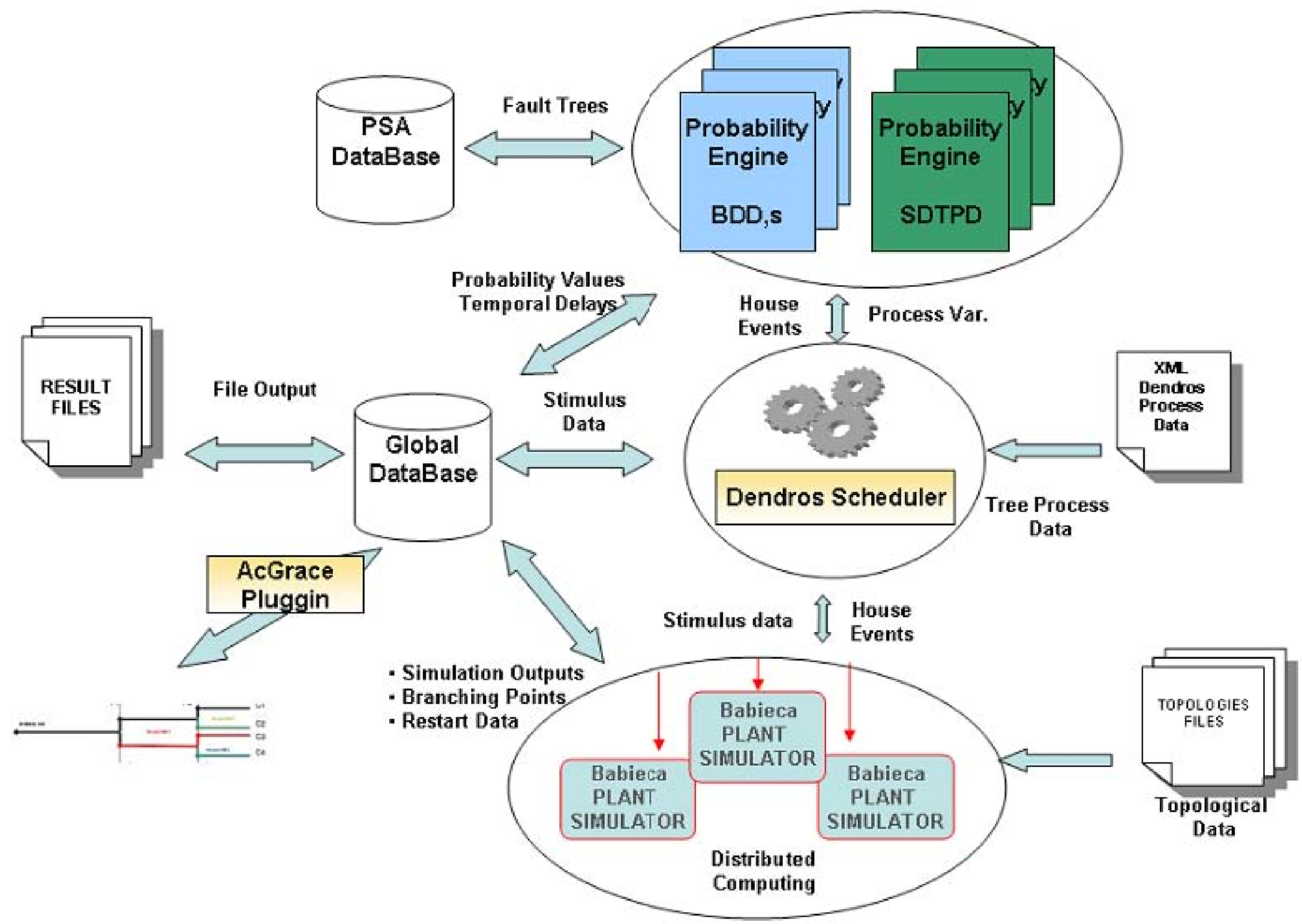
The SCAIS package

- A suitable **software package** called **SCAIS** has been developed with the capability of coupling:
  - Simulation of **nuclear accident sequences** from normal operation to severe degradations.
  - 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**.

SCAIS description

SCAIS architecture: current status



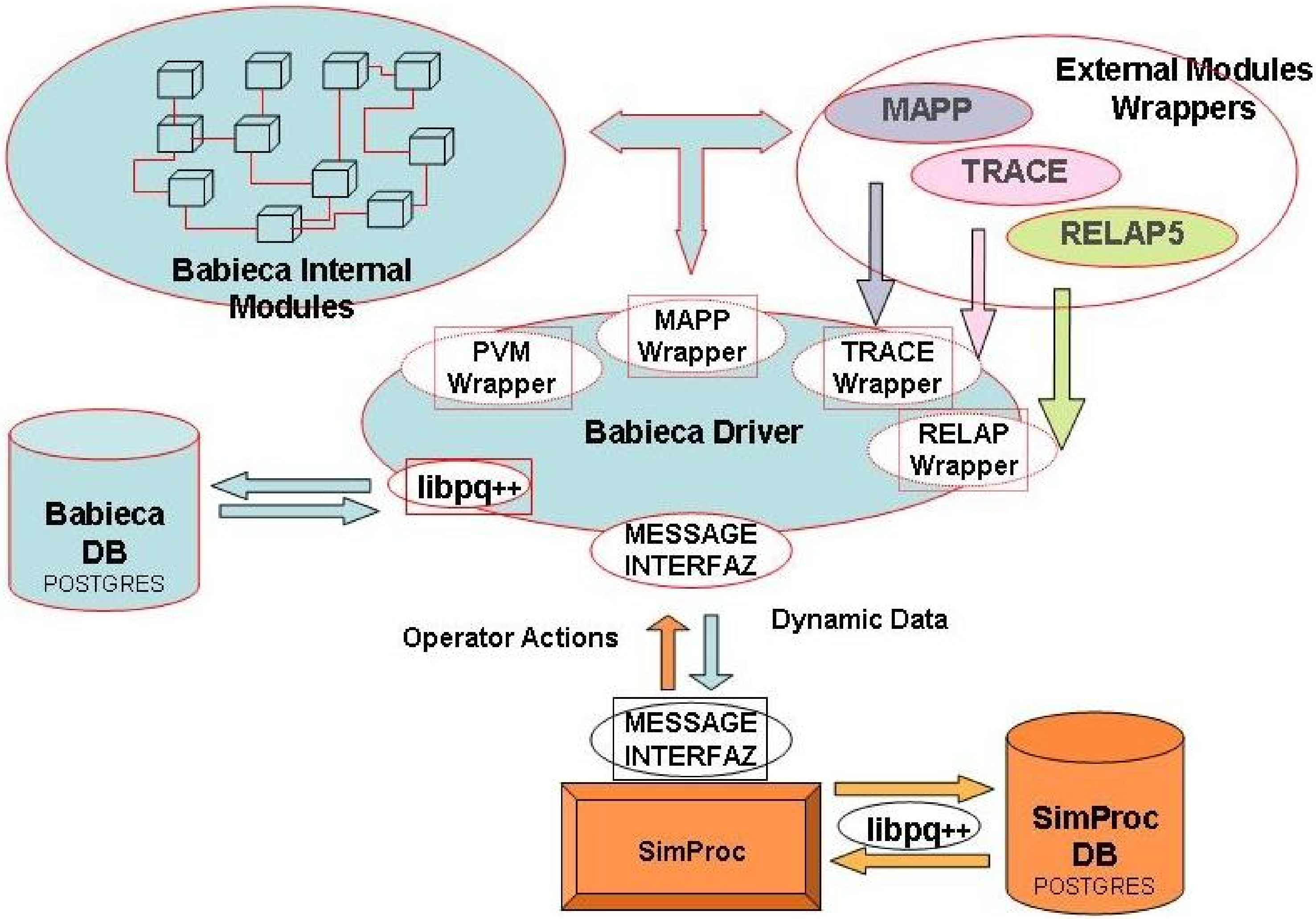
SCAIS description

The simulation driver BABIECA

- Solves topologies of simulation modules, represented as block diagrams.
- Topology levels: a topology can be a module of a higher level topology
- High connectivity: external codes can be used as BABIECA modules using a standardized linkage method based on PVM.
- Connectivity includes BABIECA-BABIECA coupling allowing for distributed parallel simulation
- Two types of coupling:
  - Initial conditions
  - Boundary conditions
- Connection with the procedure simulator SIMPROC is non-standard.

SCAIS description

BABIECA architecture



SCAIS description

Procedure Simulator SIMPROC

- Aimed at allowing for a better integration of HR issues in accident sequence analysis.

- Provides capability to
  - Evaluate the adequacy of emergency procedures for preventing the degradation of accidental situations.
  - Improve the probabilistic evaluation of human actions through a better treatment of their associated uncertainties.

- Detailed or simplified plant procedures are coded as XML files which are used as input data for SIMPROC

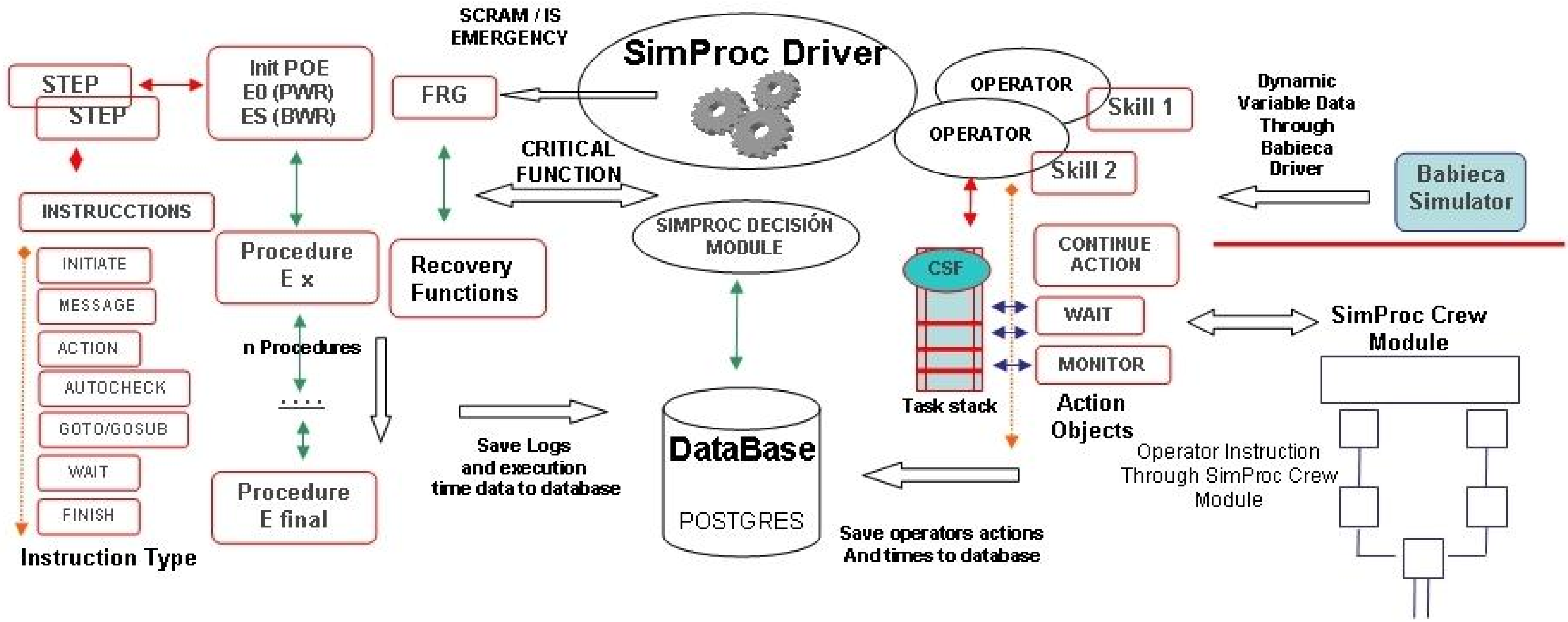
- Procedures are built from a reduced catalogue of elementary instructions: ACTION, AUTOCHECK, INITIATE, FINISH, GOSUB, GOTO, MONITOR, RETURN, WAIT.

SIMPROC working process

- SIMPROC receives from the plant simulator information on process variables and component states.
- It generates the orders for actions specified in operating procedures and sends these orders to the simulator.
- SIMPROC is not an operator model but implements different skill profiles (e.g., reactor or turbine operator) used for task assignment.
- At the beginning of the simulation, SIMPROC monitors the variables needed to identify initiation conditions of procedures
- SIMPROC regularly communicates with the plant simulator to get process information and send action requests
- The execution speed is controlled by two attributes of instructions: *execution time* and *task load*.

SCAIS description

SIMPROC architecture



SCAIS description

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 posible type of analysis.
- SCAIS has beed developed with an object oriented architecture using only Open-source standards.

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SCAIS description

Ongoing developments

The capability of SCAIS as a TSD/ISA tool is being completed with the development of two new components:

- **Path Assessment** module:
  - Supports transient identification in sequences with time uncertainties.
  - In connection with DENDROS it implements sampling methods, systematic or aleatory.
  - It is able to identify damage domains.
  - It extracts from each simulated transient all the necessary unformation to calculate its probability density.
- **Risk Assessment** module:
  - Takes the information generated by the Path Assessment and calculates the required risk metrics.
  - It is being designed to work both on-line during the simulation or off-line with data stored in the data base.

The high complexity of these modules makes that only experimental versions have been developed so far.