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Severe Accident Diagnosis and Prognosis in European Nuclear Power Plants

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European Commission

The Goal

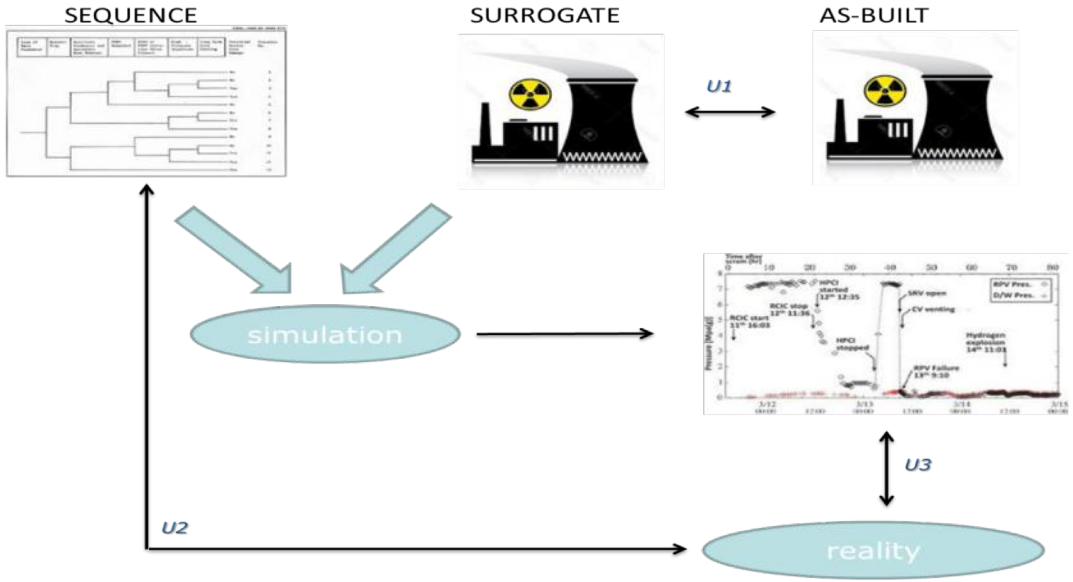
To Predict & Diagnose Nuclear Severe Accidents affecting European Countries

The Tool

Accident sequence simulations with the MAAP code
Deterministic & Probabilistic Approach
NPP-Specific
Best-Estimate (non-conservative calculation)
Pre-Calculated Scenarios: Database
On-Line Scenarios after the onset of the Emergency

Sources of Uncertainty

PLANT: as-built vs surrogate model
SEQUENCE: real vs pre-determined sequence
PHENOMENA: real vs modelled phenomena evolution



Phases and Duration of the Project

1st phase:

Set up the methodology
Pilot project (limited implementation of U2)
Benchmarking

2nd phase:

Build up a European SA NPP database

3rd phase:

Address U1 (PLANT uncertainties)
Fully Address U2 (SEQUENCE uncertainties)
Address U3 (PHENOMENA uncertainties)

4th Phase:

Radiological Meteorological Dispersion

Output variables of interest

Inner variables

1. SG depletion time
2. Core uncovery time
3. Core melting time
4. RPV failure time
5. Ex-vessel debris quenching time
6. Cavity basemat erosion
7. Containment [H2+CO] > LFL
8. Containment failure type
9. Containment failure time
10. Source term characterization

Outcome variables

1. Core melting time
2. RPV failure time
3. Containment failure
4. Source term characterization
   - 65 most important radioisotopes
   - Dose radiation map
5. Safe Stable State expected time:
   - [H2+CO] > LFL
   - Steady RCS & Cont. P/T
   - Releases under limits and decreasing

Reference plants (Rx)

PWRs

1. Westinghouse Large-Dry Cont.
2. Babcock & Wilcox Large-Dry Cont.
3. Westinghouse Ice-Condenser Cont.
4. VVER440 (213 and 230)

BWRs

1. MARK I BWR/4
2. MARK II BWR/5
3. MARK III BWR/6
4. Oskarshamn I (ABB-Atom)
5. Oskarshamn II (ABB-Atom)
6. Oskarshamn III/Forsmark III (ABB-Atom)
7. Ringhals I (ABB-Atom)
8. Forsmark I/II, TVO I/II

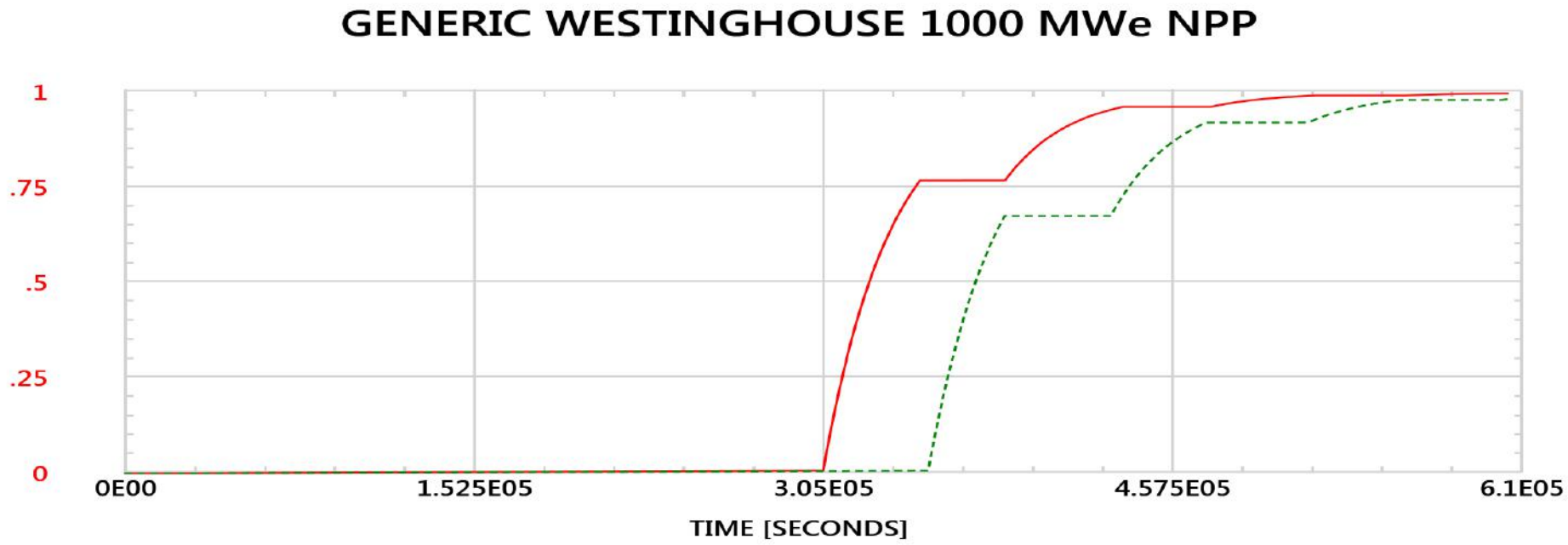
Benchmarking results (1/4)

Results for LBLOCA, SBLOCA, SBO and SGTR:

Uncertainty Bands	Core Uncovery	CET	RPV Failure	1st Venting
Negative Bound	9.62%	14.32%	21.50%	21.73%
Positive Bound	0.00%	-0.74%	-27.37%	-9.73%

Benchmarking results (2/4)

Results for SBO releases of Noble Gases:

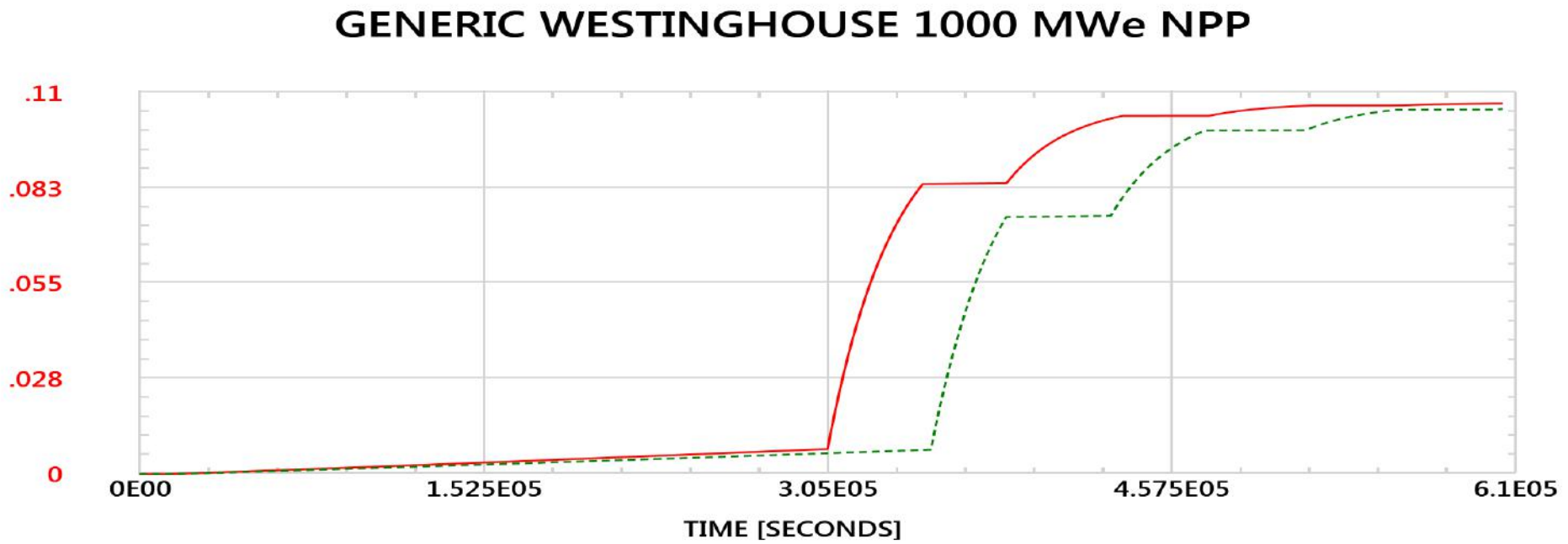


Benchmarking results (3/4)

Results for SBO releases of Elemental Iodine:

Benchmarking results (4/4)

Results for SBO releases of Organic Iodine:



Wrap-Up Results and Conclusions

The European Commission is embarked in a project aimed at making a P&D of Nuclear SAs in Europe

The results of the benchmarking exercise confirms the feasibility of the D&P tool

Currently, the SA NPP database is being filled in

Phase 3 (full account of uncertainties) and 4 (radiological meteorological dispersion) will be addressed next year