NARSIS

New Approach to Reactor Safety ImprovementS

Newsletter # 5

Edito

Welcome!

Evelyne** Foerster NARSIS **project coordinator

Dear reader
A warm welcome to the this issue of NARSIS Newsletter!

As you well know now, the NARSIS project coordinates the research efforts of eighteen partners among leading universities, research institutes, technical support organizations (TSO), nuclear power producers and suppliers, reactor designers and operators from ten countries. The project aims at making significant scientific updates of some elements required for the Probabilistic Safety Assessment (PSA), focusing on external natural events such as earthquake, tsunami, flooding, high-speed winds etc.

Among the objectives of the NARSIS project, the dissemination of research results to a wide community as well as training have a special place. The production of knowledge and its transfer to younger generations are essential to ensure the safe use of the nuclear energy of the today and tomorrow.

In this frame, and with this newsletter, we would like to announce a second NARSIS training workshop. Unlike the first workshop, held in Warsaw (September 2-5, 2019), in collaboration with the European Nuclear Education Network (ENEN) through their European project ENEN+, and due to the still on-going Covid-19 situation, this new workshop will be held virtually, proposing online dedicated materials (presentations, tools, etc.) on the NARSIS web site (www.narsis.eu), as well as four Questions & Answers sessions, to foster interactions between the NARSIS teams and workshop participants.

We hope that this unusual format will help to broaden the circle and share the outcomes of our project with larger audience.

We will be happy to receive your comments and suggestions. Please feel free to communicate your feedback to Prof. Behrooz Bazargan Sabet (b.bazargan-sabet@brgm.fr) for inclusion in our forthcoming issues. We would also like you to help us disseminate this fifth newsletter to your network.

We look forward to hearing from you!

EVENT

NARSIS Workshop
TRAINING ON PROBABILISTIC SAFETY ASSESSMENT FOR NUCLEAR FACILITIES

April 9 & 12, 2021

Online Questions & Answers sessions

Registrations now open!

Please visit also the NARSIS web site (www.narsis.eu) for regular information and updates!

WP
Event outline

WP1: Characterization of potential physical threats due to different external hazards and scenarios

James Daniell
KIT

T*his WP is devoted to the development of methods to characterize some external hazards of interests, as identified as priorities by the PSA End-Users community in the EU ASAMPSA_E project. We update individual hazard characterization and secondary effects by introducing new approaches derived from latest researches and develop framework for combined hazards (multi-hazards) and screening analysis to select relevant scenarios for safety assessment. The training proposed in the frame of WP1 is outlined hereafter.*

Multi-hazard assessments have been undertaken as part of the NARSIS project for various decommissioned NPP sites around Europe. The selection of hazards, hazard combinations and their parameters, is often difficult due to much uncertainty along each component of the chain.

A matrix multi-level approach is used to define key hazards, and concurrent hazards in terms of their operational time windows are explored.

Depending on the damage thresholds for various NPP components, the component failure return periods can be computed for combinations of independent hazards. The extension to dependent hazards is also discussed. As part of the exercise, an interactive demonstration in the open source NARSIS-MHE will be made. (https://github.com/a-schaefer/NARSIS-MHE).

To explore a key concept of modelling hazards for a singular site such as a NPP, a practical demonstration is also made as part of the session. This presentation discusses the main concepts of multivariate extreme value theory necessary to calculate the probability of the joint occurrence of extreme hazards. It applies these results to several meteorological cases.

physical and functional fragility assessment of main critical NPPs' SSC. Indeed, a considerable source of epistemic uncertainty is present in the construction of fragility curves, due to usual consideration of estimated damages caused by single IM parameters. Recent works have shown that the use of more than one IM leads to a better prediction of the damage states with significant reduction in the uncertainty. We improve fragility models by accounting for cumulative effects, soil-structure interactions and ageing mechanisms. Regarding these latter, structural degradations due to plants' ageing is expected to be among key factors to be assessed in order to obtain a realistic evaluation of the reactor safety, especially when extreme environmental demands, such as large earthquakes or tsunamis are considered. The training proposed in the frame of WP2 is outlined hereafter.

Fragility functions for NPP components and sub-systems are being developed in the NARSIS project. Special care has been devoted to the treatment of uncertainties, and specifically the record-to-record

WP
Event outline

WP2: Fragility assessment of main NPPs critical elements

Pierre Gehl

BRGM

***T**his WP defines the theoretical framework for considering combined aggressions. New methods are introduced to define improved functions for*

Following a critical appraisal of current approaches for the derivation of fragility functions for structures, systems and components, a practical demonstration on a hypothetical IM-EDP dataset (Intensity Measure / Engineering Demand Parameter) is proposed, with the following goals:

- Quantitative analysis of the most suitable Intensity Measures, via different criteria and indicators;
- Application of different statistical methods for the fragility derivation, such as

regression in the log-log space or generalized linear models;

- Use of two intensity measures as predictors in a vector-based fragility function, in order to reduce the inherent dispersion in the fragility function.

Some documents and a python code with an example will be provided on the NARSIS web site.

avoid cliff-edge effects. Improvements of flexible approaches and procedures relying on expert-based information, as well as the identification and prioritization of the most influential sources of uncertainty are considered. This will help constraining their impact on modelling results before integration within the BN. The proposed treatment of uncertainty and particularly the quantitative approach help to reduce conservatism in favor of evidence-based approaches. The training proposed in the frame of WP3 is outlined hereafter.

NPP probabilistic safety assessments (PSA) is being studied within the NARSIS project. Both traditional fault tree-type analyses and Bayesian Networks are considered. Bayesian Networks are probabilistic graphical models that have many advantages in risk analysis. Specifically, their application in estimating system reliability is explored and comparisons are made with existing PSA methods. In this course, both fault tree PSA and BNs are considered.

WP Event outline

WP3: Integration and safety analysis

Phil Vardon
TU Delft

W*P3 treats one of the major pillars of the NARSIS project that is the development and use of an approach relying on the Bayesian Networks (BN). Another part of the WP is dedicated to developing an "Extended Best Estimate plus Uncertainty" (E-BEPU) analysis, which enables to combine insights from probabilistic and deterministic safety analysis, in order to provide adequate safety margins and to*

Event and fault trees from existing PSA data are used and converted to Bayesian networks to compare various aspects such as:

- Top event probability estimation
- Failure diagnostics
- Importance measures
- Multi-state variables
- Statistical dependencies
- External multiple hazards

Further, the modelling of common cause failures (CCFs) within Bayesian networks is studied.

Representation of existing methods such as the Multiple Greek Letter (MGL) model is demonstrated. Participants will carry out exercises using BNs to highlight the major features and allow participants to explore the behaviour of BNs.

This WP develops a tool to support decision-making (DM) in the severe accident management at NPP and emergency plan implementation procedures, relying on the PSA techniques, hence extending the results, insights and conclusions in the form of structured logic models of progression of hazard-induced accident sequences. Induced hazard damage states are postulated as initial conditions (in a similar fashion as for the stress testing purposes). The assessment of the induced hazard damage states considers the type and intensity of the hazard or combinations of hazards resulting in a given plant damage state. The PSA application then focuses on estimating the conditional probabilities for (further) accident progression and, ultimately, conditional probabilities ranges of release categories / source terms. The training proposed in the frame of WP5 is outlined hereafter.

The Severa decision-support tool is being developed in the NARSIS project. The tool is capable of recognizing the status of the core and containment, based on key parameters.

WP
Event outline

WP5: Supporting Tool for Severe Accident Management

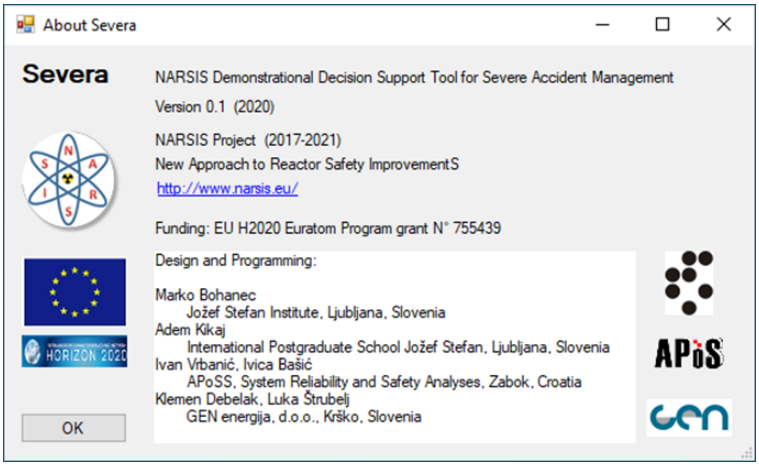
Luka Štrubelj
Gen Energija

These measurements are qualified for severe accidents (high temperature and radiation) and include:

- core exit temperature,
- reactor pressure vessel water level,
- reactor coolant pressure,
- containment temperature,
- containment pressure,
- hydrogen concentration in containment, and
- water level in steam generator.

In the first phase the diagnostic of key parameters is performed and the state of barriers (reactor coolant system, containment system) is identified.

Next the accident progression is predicted and possible recovery actions are identified. Then the feasibility of these actions are assessed. The consequences of these actions are predicted and assessed. The best action is suggested, based on core damage frequency or large and early release frequency. The Severa decision-support tool will be described in more detail and usage demonstrated to the participants.



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