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# New trends in Multihazards Probabilistic Safety Assessment for nuclear installations: the H2020-NARSIS Project


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*This project has received funding from the Euratom research and training programme 2014-2018 under Grant Agreement No. 755439.*

# Outline

- **Overview of the project**
  - Main objectives
  - Organization
- **Some on-going works**
  - A multi-hazard framework tool
  - A multi-risk model for nuclear installations

# Overview of the project
## *Main objectives*

- **NARSIS mainly aims at:**
  - **Identifying gaps between practice and needs in existing Probabilistic Safety Assessment (PSA) methodologies for external events and multi-hazard analyses (R&D)**
  - **Improving parts of these methodologies, based on & complementing other recent projects, e.g.:**

ASAMPSA_E
SEVENTH FRAMEWORK PROGRAMME
*Advanced Safety Assessment Level 2 PSA*

INFRARISK
*Novel indicators for identifying critical INFRAstructure at RISK from Natural Hazards*

SEVENTH FRAMEWORK PROGRAMME MATRIX
*New Multi-Hazard and Multi-Risk Assessment Methods for Europe*

  - **4 main primary hazards and their related secondary effects / combinations, will be considered in NARSIS:**
    - Earthquake & secondary effects (excluding tsunamis),
    - Riverine and coastal flooding (e.g. storm surge)
    - Extreme meteorological hazards (high winds, rainfall, droughts)
    - Tsunamis

# Overview of the project
## *Organization*

- **Proposed improvements:**
  - **Better characterization of selected hazards, including their combinations, as well as of their impacts**
  - **Fragility evaluation of the main critical SSCs of NPPs** to account for conjunct effects (including ageing effects) and interdependencies under single or multiple external aggressions.
  - **Better risk integration combined with uncertainty characterization and quantification**, to allow risks comparison and account for risk interactions (combined events) and cascade effects
  - **Better processing and integration of expert-based information within PSA:** investigating the applicability and the benefits of using modern uncertainty theories both to represent in flexible manner experts' judgments and to aggregate them to be used in a comprehensive manner.

# Overview of the project
## *Main objectives*

- **Main results expected:**

⇒ An integrated multi-risk framework for safety analyses

- **Scenarios with combined or cascade external hazards** (earthquake, flooding, extreme weather, tsunamis)
- **Physical & operating fragilities and interdependencies**
- **Human factors**

⇒ A support decision-making tool (demonstration) for nuclear facility management

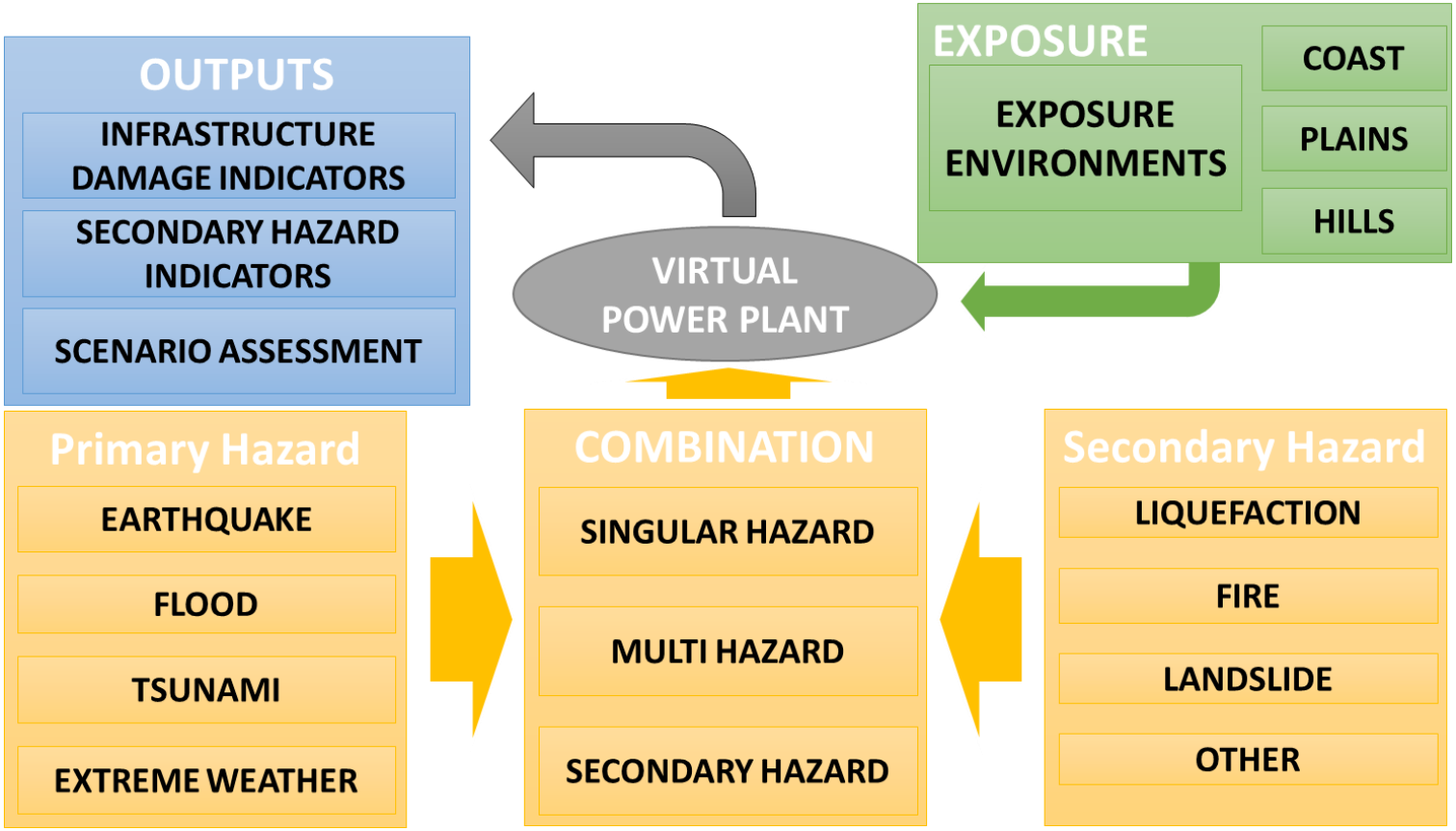
- **Normal** conditions
- **Severe Accident** due to external natural events

# Overview of the project
## *Organization*

- **A threefold methodology**
  - **Theoretical improvements** in natural multihazard assessment, evaluation of consequences and uncertainties
  - **Validation in the frame of the safety assessment** through adequate model reduction and simulations on a virtual (simplified) NPP.
  - **Demonstration of the applicability of the proposed improvements in PSA process (virtual & real NPP cases)**

# A multi-hazard framework tool

➢ *See D2114 | EGU2020-8829 for details*



# A multi-risk model for nuclear installations

## ➢ Challenges of integration:

- ❑ Multiple hazards and vulnerabilities
- ❑ Cascading effects
- ❑ Low probability events
- ❑ Complex systems (often dynamic)
- ❑ Expert judgement
- ❑ Human and organisational factors
- ❑ Multiple uncertainties

# A multi-risk model for nuclear installations

- **A Dynamic Bayesian Networks (DBN) model has been adopted in NARSIS for multi-risk integration**
- **DBN Model:** ***see D2112 | EGU2020-21036 for details***
  - Built from existing Fault/Event Trees for nuclear plants
  - Considering probability distributions of random variables (RVs) varying over time, to model components or facets of each system for a given timeline
  - Useful for forward (causes) as well as backward (diagnostics) analyses, allowing to our understanding of causality between the RVs
  - Structured through various sub-networks related to technical, human & organizational aspects

# A multi-risk model for nuclear installations

- **One key challenge: integration of detailed sub-networks (SNs) with larger BN for accident scenarios**
  - **Selection of the relevant RVs** for each SN, which has to be modelled in details allowing to the studied scenario:
    - Hazard events (e.g earthquake, flooding, extreme weather such as drought, tornado etc.)
    - Related secondary hazards (e.g. flood defence structure failure after an earthquake)
    - On-site features at the time of external event occurrence (e.g. availability of safety equipment, functionality states of emergency power supply, etc.)
    - Human/Organisational BN (e.g. human performance shaping factors, maintenance activities, decision-making during severe accident management, etc.)
    - …
  - Methodology developed for integration of SN results into larger BN

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