



**NARSIS**

**New Approach to Reactor Safety Improvements**

## **WP6: Dissemination and Communication activities**

**Del6.5 – Proceedings of an international scientific workshop related to the main outcomes of NARSIS WPs 1-4 (Poland)**



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



**Project Acronym:** NARSIS  
**Project Title:** New Approach to Reactor Safety Improvements  
**Deliverable:** Del6.5 – Proceedings of an international scientific workshop related to the main outcomes of NARSIS WPs 1-4 (Poland)  
**Month due:** M30                      **Month delivered:** M38  
**Leading Partner:** WUT  
**Version:** Final  
  
**Primary Author:** E. Foerster, F. Ragon (CEA), P. Mazgaj (WUT)  
**Other contributors:** All proceedings' authors

**Deliverable Review:**

- Reviewer #1:    **Date:**  
 - Reviewer #2:    **Date:**

Dissemination Level		
PU	Public	<b>X</b>
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

**Table of contents**

1 Executive Summary ..... 4

2 NARSIS Workshop Proceedings..... 5

## **1 Executive Summary**

This deliverable gives the table of contents of the 1<sup>st</sup> NARSIS international Workshop held at the Warsaw University of Technology (Poland) on September 2-5, 2019. The proceedings as well as the lectures and training materials can be found online at: <http://www.narsis.eu/page/warsaw-workshop-training-probabilistic-safety-assessment-nuclear-facilities>.

## 2 NARSIS Workshop Proceedings

As part of the NARSIS international Workshop (“Training on Probabilistic Safety Assessment for Nuclear Facilities”, <http://nuclear.itc.pw.edu.pl/narsis-workshop/>), held on September 2-5, 2019 at the Warsaw University of Technology (Poland), the NARSIS Partners have prepared education and training materials (cf. D6.16) as well as papers related to the workshop lectures gathered as proceedings. This report presents the detailed table of contents of the proceedings.

---

**Proceedings of the 1<sup>st</sup> NARSIS Workshop**  
**Training on Probabilistic Safety Assessment for Nuclear Facilities**  
**International Training Course**  
**Warsaw, Poland, September 2-5, 2019**

---

### TABLE OF CONTENTS

#### **Article I - Introduction to External Hazard Events: Background, Parameters and Interactions**

---

- I.1 Introduction**
- I.2 Background to possible event types**
  - I.2.1 Temporal Scales and Interactions
  - I.2.2 What NPPs could this impact?
- I.3 Geophysical Hazards**
  - I.3.1 The case of Kaikoura: knowledge as to what is possible
  - I.3.2 Earthquake Shaking
  - I.3.3 Tsunami
- I.4 Hydro meteorological Hazards**
  - I.4.1 Usual methodology for analysis of hydro meteorological hazards
  - I.4.2 Flood Modelling
  - I.4.3 Wind, Lightning and Tornado Modelling
- I.5 Conclusion**

#### **Article II - Modelling External Floodings – The quantification of the Extreme Sea Level according to the French flooding guide (ASN n°13) recommendations**

---

- II.1 External Flooding in the French guide for the Safety of Basic Nuclear Installations**
- II.2 Evaluation of the RFS “Sea Level and waves” according to the ASN guide principles**
  - II.2.1 Reference Flood Situations for Sea level and Waves defined in the French regulatory guide
  - II.2.2 Focus on a typical challenge in extreme hazard assessment: outliers in surges

II.2.3 Example of application: the case of La Rochelle

## **II.3 Conclusions**

### **Article III - Identification of Critical Elements within NPPs Screening and Ranking Methods**

---

**III.1 Introduction - Nuclear safety fundamentals**

**III.2 Deterministic classification of SSC**

**III.3 PSA description**

**III.4 Definition of RISC Categories and utilization for identification of NPP critical elements**

### **Article IV - Methods for the Derivation of Fragility Functions**

---

**IV.1 Introduction**

**IV.2 State-of-the-art of current methods**

IV.2.1 Theoretical framework

IV.2.2 The separation-of-variables method (safety factor method)

IV.2.3 Regression models from numerical simulations

IV.2.3.1 Regression on the IM-EDP cloud

IV.2.3.2 Regression using a binomial distribution

**IV.3 Selection of seismic intensity measures**

**IV.4 multi-variate fragility functions**

**IV.5 Concluding remarks**

### **Article V - Latent Weaknesses and Root Causes In The Feedback Of Operating Experience Programmes**

---

**V.1 Introduction**

**V.2 Latent Weaknesses**

V.2.1 Davis Besse Reactor Pressure Vessel Head Corrosion

**V.3 Event Investigation Methods**

V.3.1 Root Cause Analyses

V.3.1.1 Event and Causal factor Chart (E&CF Chart)

V.3.1.2 ASSET/PROSPER

V.3.1.3 HPES – Human Performance Enhancement System

V.3.1.4 MORT – Management Oversight and Risk Tree

V.3.2 Probabilistic Precursor Analyses

V.3.3 Deterministic transient analyses

**V.4 Conclusions**

---

**Article VI - Uncertainties and Risk Integration**

---

**VI.1 Introduction****VI.2 Setting for uncertainty quantification**

VI.2.1 Uncertainty classification

VI.2.2 Treatment setting

VI.2.2.1 Step 1: Problem definition

VI.2.2.2 Step 2: Uncertainty representation

VI.2.2.3 Step 3: Uncertainty propagation and sensitivity analysis

**VI.3 Bayesian-network as an integrative tool**

VI.3.1 Introduction to Bayesian Network

VI.3.2 Uncertainty representation

VI.3.3 Uncertainty propagation

VI.3.4 Sensitivity analysis and probability updating

**VI.4 Concluding remarks**

---

**Article VII - Risk Assessment Using Bayesian Approach: Risk Informed Validation Framework and Multi-Hazard Risk Assessment**

---

**VII.1 Multi-Hazard Risk Assessment Frameworks**

VII.1.1 Earthquake Induced External Flooding Hazards =

VII.1.2 Future Work Recommendations

**VII.2 Risk Informed Validation Framework****VII.3 Illustration/Case Study: Flooding**

VII.3.1 Event Tree / Fault Tree Logic

VII.3.2 Fragility Estimates

VII.3.3 Critical Events

VII.3.4 Validation Metric

VII.3.5 Additional Data - Updating

**VII.4 Summary and Conclusions**

---

**Article VIII - Metamodels for Reducing Computational Costs in Probabilistic Safety Analyses**

---

**VIII.1 Introduction****VIII.2 Procedure**

VIII.2.1 Principles

VIII.2.2 Step 1: setting the training data

VIII.2.3 Step 2: construction of the meta-model

VIII.2.4 Step 3: validation of the meta-model

VIII.2.5 Step 4: use of the meta-model

**VIII.3 Case study**

## **VIII.4 Concluding remarks**

### **Article IX - Severe Accident Assessment with Uncertainty and Sensitivity Analysis**

---

- IX.1 Introduction**
- IX.2 Severe Accident Simulation**
- IX.3 Uncertainty Analysis**
- IX.4 Sensitivity Analysis**
- IX.5 Summary and Conclusions**

### **Article X - Severe Accident Phenomenology and Management**

---

- X.1 Introduction to severe accidents**
- X.2 phenomenology of severe accidents**
  - X.2.1 In-vessel phase
    - X.2.1.1 Steam explosions
    - X.2.1.2 Corium relocation
  - X.2.2 Ex-vessel phase
    - X.2.2.1 High pressure melt ejection
    - X.2.2.2 Low pressure melt release
    - X.2.2.3 Molten Core-Concrete Interactions
    - X.2.2.4 Creep failure
  - X.2.3 Containment response
    - X.2.3.1 Hydrogen combustion
- X.3 basic scenarios of severe accidents**
  - X.3.1 High RCS pressure sequence (e.g. SBO)
  - X.3.2 Low RCS pressure sequence (e.g. LB LOCA)
- X.4 severe accidents management guidelines (SAMG)**
  - X.4.1 Diagnostic Flow Chart (DFC)
  - X.4.2 Severe Challenge Status Tree
  - X.4.3 Severe Accident Control Room Guidelines
  - X.4.4 Severe Accident TSC Guidelines
    - X.4.4.1 Inject into the Steam Generators
    - X.4.4.2 Depressurize the RCS
    - X.4.4.3 Inject into the RCS

### **Article XI - Probabilistic Safety Analysis (PSA): Main Elements and Role in the Process of Safety Assessment and Verification**

---

- XI.1 Introduction**
- XI.2 Risk Curve**



- XI.3 Safety Management (Risk Management)**
- XI.4 Overview of PSA and its main technical elements**
- XI.5 Combined use of DSA and PSA in design verification**

## **Article XII - Principles Of Severe Accident Risk Analysis**

---

- XII.1 Introduction**
- XII.2 Accident progression logic model**
  - XII.2.1 Principles for Characterization of Plant Damage States (PDS)
  - XII.2.2 Principles of Containment Event Tree, Accident Progression and Quantification
  - XII.2.3 Principle characterization of Release Categories (RC)
- XII.3 Severe accident progression and degrees of severity**
- XII.4 Types of decision and strategies/actions performed in severe accident management**
- XII.5 Attributes for Use in Decision-Making**
- XII.6 Summary**