



## International Conference on Topical Issues in Nuclear Installation Safety – Vienna 6-9 June 2017

### ***Enhanced Nuclear Engineering Simulators (ENES)*** ***Presented by Dr. Emanuele Negrenti - ENEA***

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- Engineering simulation of NPPs is a sophisticated **multi-purpose technology** allowing the users of the simulator to perform a variety of 'engineering' activities:
  - modifying' the plant lay-out and components
  - adjust a quantity of parameters,
  - test alternative design solutions,
  - perform calculations relevant for safety assessment.
- ENEA developed with Westinghouse one of the very first Eng. Simulators, that was validated in 1986
- Nowadays ES are used by industry, operators, TSOs in most countries w NPPs.

# PWR Engineering Simulator - 1986



**Westinghouse-ENEA ES-1000 (ENEA Casaccia – 1986-1990)**

# Example of current simple NPP Eng. Simulator



- **Launch of the idea : April 2014**

- **PROJECT idea full TITLE:**

Design of the development of Post Fukushima  
**EN**hanced **E**ngineering **S**imulators (ENES)

Current status : template 2 on NUGENIA web site  
NOIP system for consultation

# Project Idea 'ENES' - 2



- **Goal** : to **design in detail** the desirable improvements to the current generation of Engineering Simulators for NPP in order to arrive as soon as possible to a **new generation of Enhanced Nuclear Engineering Simulators (ENES)**
- These must respond adequately to the issues raised by the Fukushima Accident and in general those interesting the nuclear fission 'community'
- Testing of real sample cases (Demonstration) of those software tools (e.g., those representing extreme natural events) that are 'new' for ES platforms.

- **Easing the realisation of break-through engineering simulators featuring:**
  - Full 3D description of NPP and surroundings
  - Modelling interactions among Units
  - Modelling Extreme Natural Events and their interaction with the NPP
  - Better modelling impacts on environment and population deriving from accidents
  - Possibility of use for Design, Safety Analysis, and Plant Operation

# Project Idea 'ENES' – 3 – vs Nugenia



- **Strategy** : the design activity will be based on the systematic recognition and in depth discussion of the issues raised by Fukushima accident, and other issues relevant for industry, operators, safety authorities and linked TSOs, and the **NUGENIA community**.
- Current **NUGENIA road map** shows RTD topics within several Technical Areas (e.g. TA1 'Safety' ) where Enhanced ES can be part of the solution : ENES 'strategic' project will identify them and will describe in detail the solutions that future 'ENES' can offer



- **We expect ES improvements to be reached through :**
  - **Improvements in software models** that do not represent with adequate accuracy important phenomena **and/or in visualization and analysis (uncertainty?) tools**
  - **Addition of new models** for covering areas so far neglected
  - **Increasing the simulation speed (many times faster than real time)** (e.g. for using EES as Decision Support Tools (DST) in plant life when decisions can be eased by fast and accurate analysis of alternative actions consequences)
  - **Dealing with the necessary accuracy emerging issues such as the impacts of Extreme Natural Events on NPP, events affecting more Units, impacts of accidents on population and environment.**

# Project Idea 'ENES' – 5: Target partners



- Target partners for funded projects based on ENES are:
  - **Industry**, for their potential interest in having improved design support tools
  - **Operators**, for use in pre-training, as DST in plant life, communication activities and running of safety studies.
  - **Research Organizations and Academia**, as providers of technical solutions for simulation issues, and as users in high level education
  - **TSOs** (Technical Safety-Support Organizations) for their expected roles in defining new needs, identifying technical solutions, making use of future tools.
  - **Simulators vendors** : for their unique roles in identifying possible solutions to the emerging new requirements, and commercially exploiting the project outcomes

# NUGENIA Project Idea 'ENES' – 6 NUTEMA PLATFORM



- **ENES Project** can take benefit from the experience gained in the design, development and operation of **NUTEMA** (NUclear Power Plant TEchnology Knowledge MAnagement System), a facility located in the premises of the **University of Pisa**
- **NUTEMA** platform is candidate to host in future the implementation of the prototype of the **Enhanced Engineering Simulator**
- **NUTEMA** could be used in **ENES** as a testing platform for the new software tools to be integrated in the enhanced simulator architecture
- **NUTEMA** already used for support of safety analysis of Atucha-2 NPP (Argentina)

# NUGENIA - Project Idea 'ENES' - 7 NUTEMA PLATFORM



# EURATOM Project Proposal 'ENES'



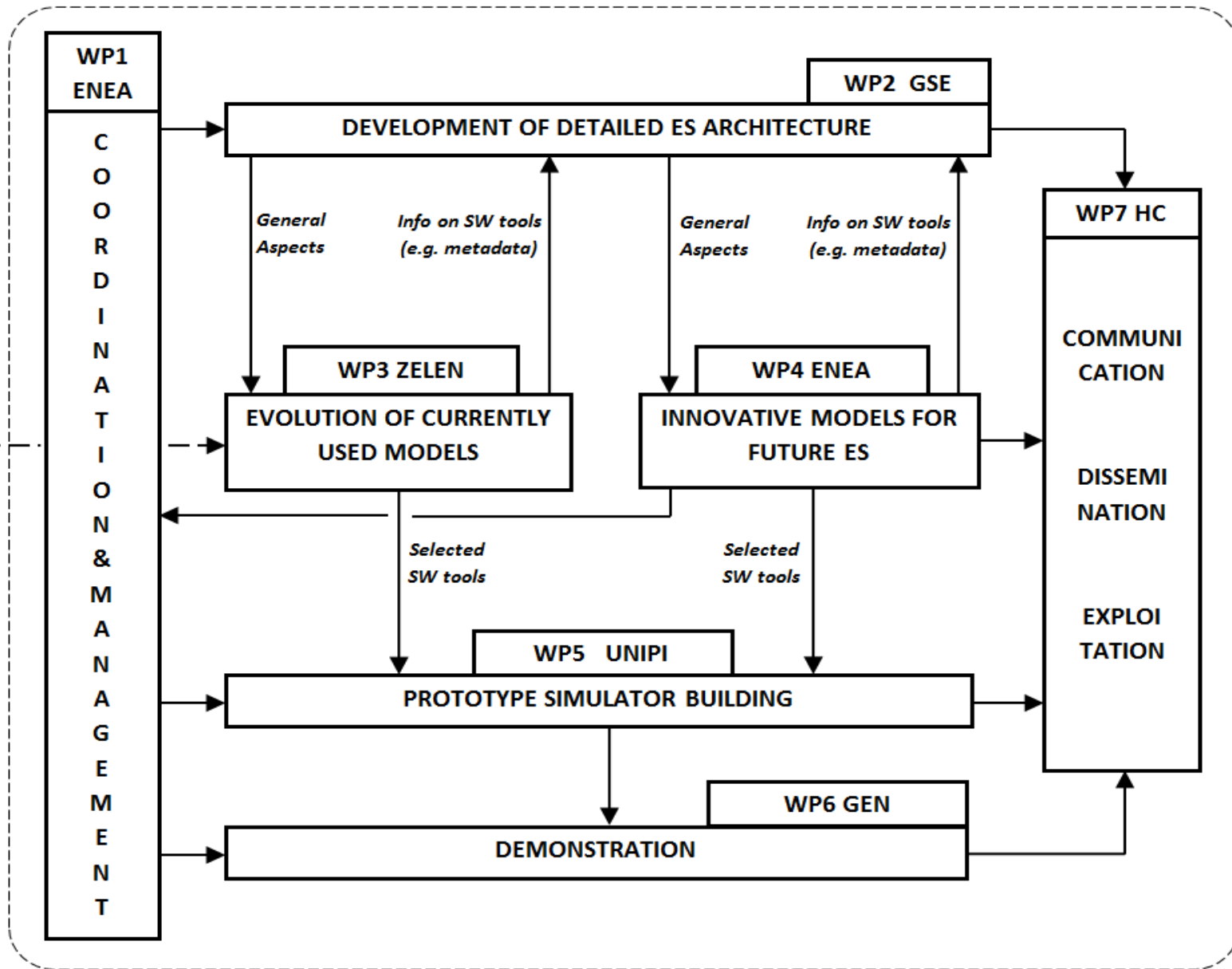
- **Proposal sent 5th October 2016**
- **Partners : ENEA, Pisa Univ., NINE (Italy), Gen-Energija & ZEL-EN (Slovenia), HC (Germany), GSE-Systems (Sweden)**
- **ENES Advisory Board : AREVA (D), ANSALDO-N (I), L3-Mapps (Can), UJV (Cz)**
- **Focus on enhanced architecture, alternative models in each simulation area, use of NUTEMA and ENEA HPC CRESCO, Demo study on Krsko NPP.**
- **Evaluation : 4+4+3.5 >>> 11.5/15 (not bad .. But not funded)**
- **Criticalities: too fast proposal writing, very high competition (45 proposals for 12-15 contracts )**

# ENES Euratom Proposal Oct. 2016 – WPs



## ENES PROJECT DIAGRAM

NEW EXPERIMENTAL DATA

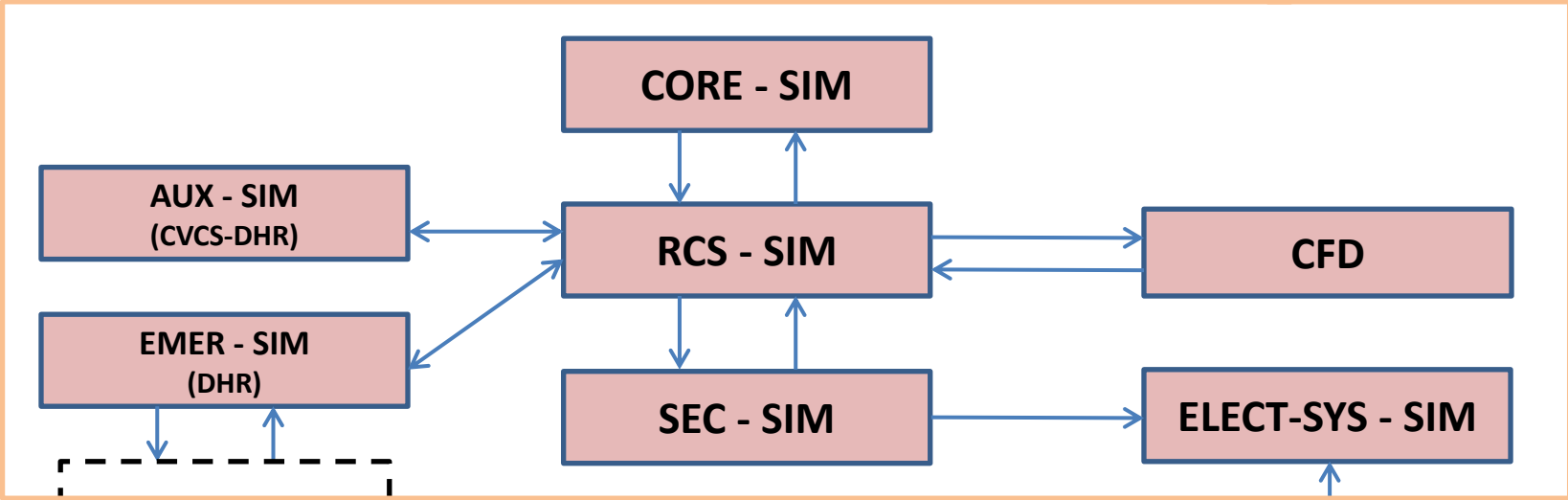


# ENES TENTATIVE ARCHITECTURE

**SIM.EXE**  
(manager of all sw tools)



**I&C - SIM**



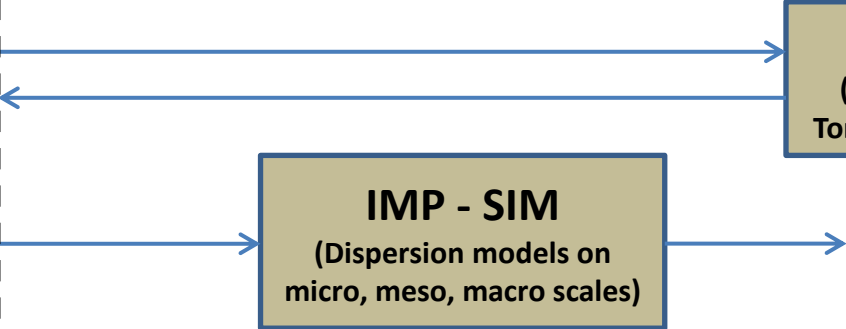
**SA - SIM**



**CONT - SIM**

**EXTEVE - SIM**  
(Tsunami, Hurricane, Tornado, Flooding, Fires)

**IMP - SIM**  
(Dispersion models on micro, meso, macro scales)



- a) Sound concept and methodology (criterion 1)**
- b) Innovation potential clearly visible (c1)**
- c) Needs of end-users properly addressed (c1)**
- d) Addresses important issues raised by Fukushima and widens the scope of engineering simulators covering extreme events (c2)**
- e) Can address the demand for simulators companies to grow (c2)**
- f) Dissemination properly addressed (c2)**
- g) Management structure and board are appropriate (c3)**



## ... and ENES Evaluation 'not OKs'

- 1) interface w ongoing research should be stronger (c1, c2)
- 2) lack of details in the working program (c1)
- 3) it seems some tasks require relocation of resources (c3)
- 4) time allocation for several tasks seems optimistic....  
'rather short overall project duration' (42 months) (c3)

# Conclusions



- **ENES Project Idea launched and developed under NUGENIA since 2014**
- **Euratom NFRP1 Proposal in October 2016, with encouraging results**
- **Next : Analysis of Proposal 2016 Evaluation (among all partners, issue by issue >>> draw an 'Upgrade Road-Map')**
- **Key Goal: Strengthening Consortium and Advisory Board, build more links with synergic projects and contexts**
- **Upgraded Reproposition in 2018 ?**

# Finally ...

- Thanks a lot for your attention
- If you wish to know more about ENES project or being involved in future initiatives... please contact:

>>>>>

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