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EXPERT GROUP ON UNCERTAINTY ANALYSIS IN MODELLING

Mandate and Programme of Work

English - Or. English

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OECD/NEA Nuclear Science Committee

Expert Group on

Uncertainty Analysis in Modelling

Mandate and Programme of Work

Background

Following the presentation made by Prof. J. Aragonés at the 1-2 June 2006 meeting of the OECD/NEA Nuclear Science Committee of the results from the Uncertainty Analysis in Modelling UAM-2006 Workshop held from 28-29 April 2006 and hosted by the University of Pisa, Italy (see summary report NEA/NSC/DOC(2006)15), the setting up of an Expert Group on Uncertainty Analysis in Modelling (UAM) was endorsed. This Expert Group will report to the Working Party on Scientific issues in Reactor Systems (WPRS) and because it addresses multi-scale / multi-physics aspects of uncertainty analysis, it should work in close co-ordination with the benchmark groups on coupled neutronics-thermal-hydraulics and on coupled core-plant problems, and the CSNI Group on Analysis and Management of Accidents (GAMA).

Mandate

The Group has the following mandate:

1. To elaborate a state-of-the-art report on current status and needs of sensitivity and uncertainty analysis (SA/UA) in modelling, with emphasis on multi-physics (coupled) and multi-scale simulations.
2. To identify the opportunities for international co-operation in this area that would benefit from coordination by the NEA/NSC
3. To draw a roadmap for the development and validation of the methods and codes required for uncertainty analysis including the benchmarks adequate to meet those ends, the schedule and organization of its realisation

The proposed scope, objectives and general programme and background information is provided in the Annex, including the descriptions of the different steps that need to be carried out to produce the deliverables.

A fine structure of the programme will be elaborated in the coming months. It will consist of three Phases, each with specific deliverables. First results will be presented and discussed at the next workshop, scheduled for the week of 7-11 May 2007. This Workshop, UAM-2007, will be held in conjunction with the V1000CT5, BFBT4 workshops and will be hosted jointly by CEA and OECD/NEA.

ANNEX

OECD/NRC BENCHMARK PROPOSAL ON UNCERTAINTY ANALYSIS IN BEST ESTIMATE MODELLING (UAM) FOR DESIGN, OPERATION AND SAFETY ANALYSIS OF LWRS

OECD UAM-2006 Workshop
Pisa, 29 Apri 2006

Title: **Uncertainty Analysis in Modelling**
Coupled Multi-physics and Multi-scale LWR analysis.

Objective: To determine the uncertainty in LWR systems and processes in all stages of calculations

Reference systems and scenarios:
Reference systems and scenarios for coupled code analysis should be defined to study the uncertainty effects in all stages of calculations. Measured data from plant operation should be available for the chosen scenarios.

The already developed OECD/NEA/NSC coupled code transient benchmarks – such as BWR Turbine Trip (TT), PWR Main Steam Line Break (MSLB), VVER-1000 Coolant Transients (V1000CT) and BWR Full Bundle Test (BFBT) – will be used as a framework for uncertainty analysis in best estimate modelling for design and operation of LWRs. Such an approach will facilitate the proposed benchmark activities since many organisations have already developed input decks and tested their codes on the above mentioned coupled code benchmarks.

From these OECD LWR transient benchmark problems, the **Peach Bottom 2 BWR Turbine Trip** is chosen as the first reference system-scenario, although provisions will be made to address the other LWR systems and scenarios such as TMI-1 PWR MSLB, PWR-RIA-ATWS, BWR-CRDA-ATWS (with boron modelling), VVER-1000 CT, etc. The Peach Bottom 2 BWR Turbine Trip is well documented, not only in the OECD/NEA/NRC BWR TT benchmark specifications but also in a series of EPRI and PECo reports, which include design, operation and measured steady state and transient neutronics and thermal-hydraulics data. The presence of cycle depletion, steady state and transient measured data on both the integral parameter level and the local distribution level is a very important feature of the Peach Bottom 2 BWR Turbine Trip.

Interaction will be made with the OECD/NEA/NRC BWR Full Bundle Test (BFBT) benchmark and the uncertainty analysis exercises performed in its framework. The interaction will also be extended to the ongoing NEA/CSNI BEMUSE-3 benchmark through the NEA internal co-operation among the NSC and CSNI Committees.

The idea is: a) to subdivide the complex system/scenario into several steps (Exercises), b) to identify input, output and assumptions for each step, c) to calculate the uncertainty in each step; d) to propagate the uncertainty for the evaluation of the overall system/scenario.

The investigation of uncertainty effects is undertaken for each step of calculation and therefore it is proposed to have a sequence of Exercises as described below:

1. Derivation of the multi-group microscopic cross-section libraries (nuclear data, selection of multi-group structure, etc.).
2. Derivation of the few-group macroscopic cross-section libraries (energy collapsing, spatial homogenisation, etc.).
3. Criticality (steady state) stand-alone neutronics calculations (k_{eff} calculations, diffusion approximation, etc.).
4. Fuel thermal properties relevant for transients performance.
5. Neutron kinetics stand-alone performance (kinetics data, space-time dependence treatment, etc.) in PWR rod ejection and BWR control rod drop accidents.
6. Thermal-hydraulic fuel bundle performance – interaction with the OECD/NRC BFBT benchmark and the available experimental data as well as the Uncertainty Analysis Exercises being performed in the framework of the BFBT benchmark.
7. Coupled neutronics/thermal-hydraulics core performance (coupled steady state, coupled depletion, and coupled core transient with boundary conditions) – interaction with the Peach Bottom Cycles 1, 2 and 3 operating and measured data.
8. Thermal-hydraulics BWR system performance – interaction with the Peach Bottom Turbine Trip and BEMUSE-3 experimental data.
9. Coupled neutronics kinetics thermal-hydraulic core/thermal-hydraulic system BWR performance - interaction with the Peach Bottom Turbine Trip experimental data and Peach Bottom stability performance – interaction with EOC2 and EOC3 experimental data.

It is recommended to use experimental data as much as possible (two “interactions” with ‘known’ experimental data are indicated above but others can be added). The Host Institution shall identify Input (I), Output (O) or target of the analysis, as well as assumptions for each step and target uncertainty parameters (U). The uncertainty from one step should be propagated to the others (as much as feasible and realistic).

The above described approach based on the introduction of 9 steps (Exercises) will allow to develop a benchmark framework which mixes information from the available integral facility and NPP experimental data with analytical and numerical benchmarking. Such an approach will compare and assess the current uncertainty methods on representative applications and simultaneously will benefit from different approaches to arrive at recommendations and guidelines.

These 9 steps (Exercises) will be carried out in 3 phases each covering a two-year period. The first phase will include the first 3 Exercises (neutronics), with the final Specifications to be discussed and adopted at a first workshop, planned for May 2007 in Paris (NEA or Saclay).

Scientific Board and Co-ordination

Name	***Organisation***	***Country***	***Role***
Kostadin IVANOV	PSU	USA	Co-ordination and host
Thomas DOWNAR	U-Purdue	USA	Member
Jess GEHIN	ORNL	USA	Member
Martin ZIMMERMANN	PSI	Switzerland	Member
José ARAGONÉS	UP-Madrid	Spain	NSC member, rapporteur
Akitoshi HOTTA	TEPSYS	Japan	Member
Francesco D'AURIA	U-Pisa	Italy	Member
Dan G. CACUCI	U-Karlsruhe	Germany	Member
Siegfried LANGENBUCH	GRS	Germany	Member
Eric ROYER	CEA	France	Member
Enrico SARTORI	OECD/NEA		Secretariat

Prof. K. Ivanov, with the support of US-NRC and assistance of the Scientific Board will undertake the role of main co-ordinator and host after the endorsement of the NEA/NSC. The 40 participants (from 26 organizations in 16 countries) in the first UAM workshop in Pisa showed interest in contributing to this UAM Expert Group. The Group would be open to the experts designated by the NSC members.

The work of the group will address mainly the scientific aspects of the methodologies being developed and demonstrate their validity. This work will interface with the activities of the CSNI who would later address any licensing issues.

To summarise, uncertainty analysis in modelling (UAM) is to be further developed and validated on scientific grounds in support of its performance, in addition to LWR best-estimate calculations for design and safety analysis. There is a need for efficient and powerful analysis methods suitable for such complex coupled multi-physics and multi-scale simulations. The proposed sequence of benchmarks will address this need by combining the expertise in reactor physics, thermal-hydraulics etc. and uncertainty and sensitivity analysis, and will contribute to the introduction of advanced/optimised uncertainty methods in best-estimate reactor simulations. Such a task can only be undertaken within the framework of a programme of international co-operation that would benefit from the coordination of the NEA/NSC and the US-NRC and from interfacing with the CSNI activities.