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NUCLEAR SCIENCE COMMITTEE
and
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

OECD Benchmark for Uncertainty Analysis in Best-Estimate Modelling (UAM) for Design, Operation and Safety Analysis of LWRs (OECD LWR UAM Benchmark)

Summary Record of the First Workshop (UAM-1)
10-11 May 2007
NEA Headquarters, Issy-les-Moulineaux, France

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OECD Benchmark for Uncertainty Analysis in Best-Estimate Modelling (UAM) for Design, Operation and Safety Analysis of LWRs (OECD LWR UAM Benchmark)

Expert Group on Uncertainty Analysis

First Workshop (UAM-1)

OECD/NEA Headquarters, Issy-les-Moulineaux, France
10-11 May 2007

Hosted by the
NEA/OECD and CEA-Saclay

SUMMARY RECORD

Background and Purpose of the Workshop

In recent years there has been an increasing demand from nuclear research, industry, safety and regulation for best estimate predictions to be provided with their confidence bounds. Consequently an "in-depth" discussion on “Uncertainty Analysis in Modeling” was organized at the 2005 OECD/NEA Nuclear Science Committee (NSC) meetings, which led to a proposal for launching an Expert Group on "Uncertainty Analysis in Modeling" and endorsing holding a workshop with the aim of defining future actions and a program of work.

As a result the organization of the OECD/NEA Uncertainty Analysis in Modeling Workshop took place in Pisa, Italy on April 28-29, 2006 (UAM-2006). The major outcome of the workshop was to prepare a benchmark work program with steps (exercises) that would be needed to define the uncertainty and modeling task [1]. The other proposals made during the meeting were to be incorporated under the different steps (exercises) within the overall benchmark framework for the development of uncertainty analysis methodologies for multi-physics (coupled) and multi-scale simulations.

Following the results of the UAM-2006 Workshop the OECD/NEA Nuclear Science Committee at its June 2006 meeting endorsed the creation of an Expert Group on Uncertainty Analysis methods in Modeling [2]. This Expert Group will report to the Working Party on Scientific issues in Reactor Systems (WPRS). Since it addresses multi-scale / multi-physics aspects of uncertainty analysis, it will work in close co-ordination with the benchmark groups on coupled neutronics-thermal-hydraulics simulations and on coupled core-plant problems. The Expert Group will also coordinate its activities with the Group on Analysis and Management of Accidents (GAMA) of the Committee on Safety of Nuclear Installations (CSNI). The Expert 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 modeling, with emphasis on multi-physics (coupled) and multi-scale simulations.
2. To identify the opportunities for international co-operation in uncertainty analysis area that would benefit from coordination by the NEA/NSC.
3. To create a roadmap along with schedule and organization for the development and validation of methods and codes required for uncertainty analysis including the benchmarks adequate to meet those goals.

This activity as endorsed by the NEA/NSC, will be undertaken with the Pennsylvania State University (PSU) as the main coordinator and host with the assistance of the Scientific Board. The 40 participants (from 26 organizations in 16 countries representing industry, regulatory agencies, national laboratories and research institutions) in the UAM workshop in Pisa expressed interest in participating and contributing to this UAM Expert Group and proposed an uncertainty analysis benchmark activity.

To summarize, in addition to LWR best-estimate calculations for design and safety analysis, the different aspects of uncertainty analysis in modeling (UAM) are to be further developed and validated on scientific grounds in support of its performance. There is a need for efficient and powerful analysis methods suitable for such complex coupled multi-physics and multi-scale simulations. The proposed benchmark sequence will address this need by integrating the expertise in reactor physics, thermal-hydraulics and reactor system modeling as well as uncertainty and sensitivity analysis, and will contribute to the development and assessment of advanced/optimized uncertainty methods for use in best-estimate reactor simulations. Such an effort can be undertaken within the framework of a program of international co-operation that would benefit from the coordination of the NEA/NSC and all participants by interfacing with the CSNI activities.

This workshop (UAM-1) was held in conjunction with other meetings, in order to facilitate co-ordination and sharing of work during the same week and to combine efforts in common areas such as computational fluid dynamics (CFD) modelling and uncertainty analysis thus making participation more efficient. The meetings concerned are the fifth workshop for the OECD/DOE/CEA VVER-1000 Coolant Transient (V1000CT) benchmark – V1000CT-5 which took place on 7 May 2007, and the fourth workshop for OECD/NRC Benchmark based on NUPEC BWR Full-size Fine-mesh Bundle Tests (BFBT) – Fourth Workshop (BFBT-4), which was held on 8 and 9 May 2007. In parallel with the BFBT-4 workshop the annual meeting of the Working Group D involved in VVER reactor dynamics and safety research was also held at the same premises. For further details concerning this meeting please contact Soeren Kliem at s.kliem@fzd.de.

Scope and Technical Content of the Workshop

In summary, the objective of the benchmark activity is to define, conduct, and summarize an OECD benchmark for uncertainty analysis in best-estimate coupled code calculations for design, operation, and safety analysis of LWRs. The title of this benchmark is: “OECD UAM LWR Benchmark”. Reference systems and scenarios for coupled code analysis are defined to study the uncertainty effects for all stages of the system calculations. Measured data from plant operation are available for the chosen scenarios.

The proposed technical approach is to establish a benchmark for uncertainty analysis in best-estimate modeling and coupled multi-physics and multi-scale LWR analysis, using as bases a series of well defined problems with complete sets of input specifications and reference experimental data. The objective is to determine the uncertainty in LWR system calculations at all stages of coupled reactor physics/thermal hydraulics calculation. The full chain of uncertainty propagation from basic data, engineering uncertainties, across different scales (multi-scale), and physics phenomena (multi-physics) are tested on a number of

benchmark exercises for which experimental data are available and for which the power plant details have been released. The principal idea is: a) to subdivide the complex system/scenario into several steps or Exercises, each of which can contribute to the total uncertainty of the final coupled system calculation, b) to identify input, output, and assumptions for each step, c) to calculate the resulting uncertainty in each step; d) to propagate the uncertainties in an integral systems simulation for which high quality plant experimental data exists for the total assessment of the overall computer code uncertainty.

The main scope covers uncertainty (and sensitivity) analysis (SA/UA) in best estimate modelling for design and operation of LWRs, including methods that are used for safety evaluations. The meeting was organized around the discussion of the draft of General Benchmark Specifications on the 3 Phases of the UAM LWR benchmark, the draft of a detailed specification on Phase I of UAM LWR benchmark relative to sensitivity and uncertainties for the neutronics calculations, and the proposed time schedule for the UAM LWR benchmark activities. The participants were requested to present their experience and expertise in uncertainty and sensitivity analysis of LWRs.

The technical topics addressed at the workshop included:

1. Review of benchmark activities after the UAM-2006 Workshop
2. Discussion of the draft of the General Specification for the 3 Phases of the UAM LWR benchmark
3. Discussion of the proposed time schedule for the UAM LWR benchmark activities
4. Discussion of the draft of a detailed specification on Phase I of UAM LWR benchmark relative to sensitivity and uncertainties for the neutronics calculations
5. Integrate feedback from participants into both specifications
6. Presentations on participants' experience and expertise in uncertainty and sensitivity analysis of LWRs
7. Defining a work plan and schedule outlining actions to progress the two phases of the benchmark activities

Organization and Programme Committee of the Benchmark Workshop

An Organization and Programme Committee has made the necessary arrangements for the first Benchmark Workshop, organized the Sessions, and prepared the final program. The general chair was Eric Royer (CEA-Saclay). The other members were José Aragonés (UPM), representing the NSC, Francesco D'Auria (UP), representing CSNI, D. Cacuci (CEA-Scalay), S. Langenbuch (GRS), M. Zimmermann (PSI), T. Downar (PU), S. Kliem (FZR), L. Hochreiter (PSU), H. Utsuno (JNES), A. Hotta (TEPSYS), Y. Hassan (TAMU), M. Williams (ORNL), and K. Ivanov (PSU), representing the UAM scientific board, and E. Sartori from OECD/NEA Secretariat, who hosted the meeting.

Opening Session – Introduction and opening remarks

Eric Royer welcomed participants on behalf of CEA-Saclay, co-hosting the workshop with OECD/NEA. José Aragonés, representing the NSC, and Francesco D'Auria, representing CSNI, provided the background. In this project, for the first time, uncertainties are propagated through the whole process from microscopic cross-sections to plant transients on a unified benchmark framework to provide credible coupled code predictions with defensible uncertainty estimations of safety margins at the full core/system level. The OECD LWR UAM benchmark framework is expected to help formulating recommendations and guidelines on how to utilize advanced and optimized sensitivity analysis and uncertainty analysis (SA/UA) methods in "best estimate" reactor simulations in licensing practices

The agenda was approved with minor amendments (see Annex I).

Participants introduced themselves. The workshop was attended by 50 participants from 31 organizations in 15 countries. The list of participants is given in Annex II. The group of participants in this benchmark includes experts from different fields namely in thermal-hydraulics, neutronics and uncertainty analysis. Several expert groups had been formed previously, each addressing specific benchmark problems and now they are to combine this long term effort aimed at establishing best-estimate simulation methods with systematic uncertainty analysis across different phenomena (multi-physics) and different scales (multi-scales).

E. Sartori presented Nuclear Science and Data Bank support to OECD/NEA activities.

K. Ivanov on behalf of the benchmark team made a presentation giving an overview and status of the UAM benchmark activities.

Technical Sessions on General Specification for the Three Phases

Sessions 1, 2 and 5 were devoted to discussion of the General Specification for the Three Phases. The benchmark team presented the draft of the General Specification for the 3 Phases of the UAM LWR benchmark and made a review of existing OECD benchmarks, available data, and conclusions. The existing OECD/NEA/NSC coupled code transient benchmarks – such as BWR Turbine Trip (TT) [3], PWR Main Steam Line Break (MSLB) [4], VVER-1000 Coolant Transients (V1000CT) [5], and BWR Full Bundle Test (BFBT) [6] are used as part of the framework for adding uncertainty analysis methodologies in the best estimate modeling for design and operation of LWRs. Such an approach facilitates the proposed benchmark activities since many organizations 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 (PB-2) BWR Turbine Trip (TT) is proposed as the first reference system-scenario, although provisions are made to address the other LWR systems and scenarios such as TMI-1 PWR MSLB, PWR-RIA-ATWS, BWR-CRDA-ATWS (with boron modeling), 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 [4] but also in a series of EPRI [7, 8] and PECo reports [9], which include design, operation, and measured steady state, and transient neutronics and thermal-hydraulics data. The fuel cycle depletion, steady state and transient measured data, available at the integral parameter level and the local distribution level, are very important features of the Peach Bottom 2 BWR Turbine Trip benchmark.

Integration of the OECD/NEA/NRC BWR Full Bundle Test (BFBT) benchmark with the uncertainty analysis exercises performed in its framework is planned. The integration of the PB-2 BWR turbine trip is extended to the ongoing NEA/CSNI BEMUSE-3 benchmark through the NEA internal co-operation among the NSC and CSNI Committees.

Discussion of interactions with BWR stability performance and provision to address a PWR system and scenario and available data were also discussed by the benchmark team. GRS and RRC KI made a proposal in their presentation to include NPP Kalinin-3 measured data in the provision for VVER system and scenario in addition to Kozloduy -5, 6 NPP benchmark data (VVER-1000 CT benchmark).

The general frame of the OECD LWR UAM benchmark was discussed and agreed on. It will consist of three phases with three exercises for each phase. The scheduled duration is six years, on a basis of two years per phase (some overlapping is possible between consecutive phases) as follows:

Phase I (Neutronics Phase)

- Exercise I-1: Derivation of the multi-group microscopic cross-section libraries (nuclear data + covariance data, selection of multi-group structure, etc.)

- Exercise I-2: Derivation of the few-group macroscopic cross-section libraries (energy collapsing, spatial homogenization of cross-sections and covariance data, etc.)

- Exercise I-3: Criticality (steady state) stand-alone neutronics calculations with confidence bounds (k_{eff} calculations, diffusion approximation, etc.)

Phase II (Core Phase)

- Exercise II-1: Fuel thermal properties relevant for transient performance

- Exercise II-2: Neutron kinetics stand-alone performance (kinetics data, space-time dependence treatment, etc.)

- Exercise II-3: Thermal-hydraulic fuel bundle performance

Phase III (System Phase)

- Exercise III-1: Coupled neutronics/thermal-hydraulics core performance (coupled steady state, coupled depletion, and coupled core transient with boundary conditions)

- Exercise III-2: Thermal-hydraulics system performance

- Exercise III-3: Coupled neutronics kinetics thermal-hydraulic core/thermal-hydraulic system performance

Technical Sessions on Phase I

Sessions 3 and 4 were devoted to discussions of the draft of a detailed specification on Phase I of UAM LWR benchmark relative to sensitivity and uncertainties for the neutronics calculations.

Phase 1, focused on stand-alone neutronics, and was discussed in more detail. Exercise 1 propagates the uncertainties in evaluated nuclear libraries data files (microscopic point-wise cross sections) into multi-group microscopic cross-sections used as input by the lattice physics codes. Exercise 2 determines the overall uncertainties in few-group macroscopic cross-sections used for core calculations. Finally Exercise 3 computes uncertainties at core level. For this phase, simple numerical benchmarks will be designed at pin-cell, assembly and core levels, and experimental data will be utilized for critical mock-ups or cold core conditions.

In order to finalize the draft Specifications for Phase I, the participants have agreed to the following technical points:

- Covariance data: two sources are proposed to be used (ZZ-COV-15GROUP and the 44 groups covariances from SCALE-5.1). In addition to the covariance matrices, the ZZ-COV-15GROUP

package contains a utility program for interpolating or collapsing from a given group structure (e.g. 15 energy groups) to another one.

- Nuclear Data Libraries: the three main libraries (ENDF, JEFF, JENDL) are possible candidates.
- Energy group structure: no specific group structure is specified. Participants can choose any standard (e.g. 44, 172…) according to the input requirements of their lattice code to be utilized.
- Transport solver: any type of lattice solver can be used, either deterministic or stochastic. In this latter case, Monte-Carlo may provide reference solutions.
- Core applications: three main LWR types are selected, based on previous benchmark experiences and available data:
    - PWR (TMI-1)
    - BWR (Peach Bottom-2)
    - VVER-1000 (Kozloduy-6, Kalinin-3)

Sessions 6 and 7 were devoted to the participants' presentations on their experience and expertise in uncertainty and sensitivity analysis of LWRs.

In the final discussion the following suggestions and recommendations were accepted by the participants in the workshop. This project is challenging and responds to needs of estimating confidence bounds for results from simulations and analysis in real applications. It will create the favorable environment for the development of these methods and their use and become a standard. In order to achieve this, the UAM scientific board members recommended that research organizations and institutions reserve the necessary funds to support this activity and that an uncertainty analysis culture is developed in nuclear engineering. Specifications will be prepared in order to allow participation in the full Phase or only in a subset of the Exercises. Boundary conditions and necessary input information will be provided by the benchmark team. Each organization interested in the UAM benchmark has to identify its own objectives and priorities. In particular for the preparation of Phases 2 and 3, it might be necessary to rank the priorities between the reactor types or the transients to be analyzed.

Conclusions, Actions and Schedule

In summary at the UAM-1 workshop the benchmark team presented in total 18 presentations supplemented by 12 presentations from participants. The action items and schedule of benchmark activities were discussed. They are provided in the following list:

List of Agreed Actions

1. The UAM-1 workshop summary will be prepared by the benchmark team and reviewed by the scientific board
    a) Additional feedback from participants are expected by the end of May, 2007
    b) Distribution of summary by June 15th, 2007

2. Draft Specifications for Phase 1 will be prepared by Penn State and reviewed by the scientific board

    a) One volume for the three exercises will be issued

    b) Review will be made by the "scientific board" in July and August, 2007

    c) Distribution is scheduled for September, 2007

3. Participants have to provide their feedback on the Specifications through the UAM mailing list and to prepare their preliminary results for exercises I-1 to I-3 by the end of February 2008.

4. A sub-group, led by F. D'Auria, member of CSNI, will be responsible for defining the objectives, the impact and benefit of the UAM for safety and licensing (For details see: Technology Relevance of the "Uncertainty Analysis In Modelling" Project for Nuclear Reactor Safety, NEA/NSC/DOC(2007)15).

5. The second workshop (UAM-2) will be held from 2 to 4 April 2008 and hosted by Gesellschaft für Anlagen und Reaktorsicherheit (GRS), Garching, Germany.

The objectives of the next workshop (UAM-2) will be the following:

    a) Discussion of preliminary results of Phase 1

    b) Output parameters and format for Phase 2

    c) Priorities for Phases 2 and 3.

References

1. "Uncertainty Analysis in Modeling UAM-2006 Workshop", Summary Record, NEA/NSC/DOC(2006)15.
2. "Expert Group on Uncertainty Analysis in Modeling", Mandate and Programme of Work, NEA/NSC/DOC(2006)17.
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4. J. Solis, K. Ivanov, B. Sarikaya, A. Olson, and K. Hunt, "BWR TT Benchmark. Volume I: Final Specifications", NEA/NSC/DOC(2001)1.
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6. B. Neykov, F. Aydogan, L. Hochreiter, K. Ivanov (PSU), H. Utsuno, F. Kasahara (JNES), E.Sartori (OECD/NEA), M. Martin (CEA), "OECD-NEA/US-NRC/NUPEC BWR Full-size Fine-mesh Bundle Test (BFBT) Benchmark", Volume I: Specifications, © OECD 2006, NEA No. 6212, NEA/NSC/DOC(2005)5
7. "Core Design and Operating Data for Cycles 1 and 2 of Peach Bottom 2", EPRI NP-563, June 1978.
8. "Transient and Stability Tests at Peach Bottom Atomic Power Station Unit 2 at End of Cycle 2", EPRI NP-564, June 1978.
9. A. M. Olson, "Methods for Performing BWR System Transient Analysis", Philadelphia Electric Company, Topical Report PECo-FMS-0004-A (1988).

Annex I

OECD Benchmark for Uncertainty Analysis in Best-Estimate Modelling (UAM) for Design, Operation and Safety Analysis of LWRs - First Workshop (UAM-1)

Hosted by
OECD/ NEA and CEA-Saclay,
10-11 May 2007

PROPOSED PROGRAMME [U101]
(*Unnn identifiers relate to file identification on the DVD)*

Day 1: 10 May 2007

Opening Session - Chair Eric Royer

9:00 - 9:15 Introduction opening remarks, participants [U102] – E. Royer, J. Aragones, F. D'Auria

9:15 - 9:30 Overview and status of benchmark activities – K. Ivanov [U103]

Technical Sessions on General Specification for the 3 Phases

Session I - Chair Eric Royer

9:30 - 10:00 Presentations on draft of the General Specification for the 3 Phases of the UAM LWR benchmark - K. Ivanov [U104]

Review of existing OECD benchmark, available data, and conclusions:

10:00 - 10:20 Review of OECD/NRC BWR TT Benchmark and its utilization for the UAM LWR Benchmark - B. Ivanov [U105]

10:20 - 10:40 Review of OECD/NRC PWR MSLB Benchmark and its utilization for the UAM LWR Benchmark - B. Ivanov [U106]

10:40 - 10:55 Coffee Break

Session II - Chair – S. Langenbuch

10:55 - 11:15 VVER-1000 Cooling Transients – Review and possible utilization in UAM – E. Royer [U107]

11:15 11:35 Review of the BWR Full Bundle Test (BFBT) benchmark and its utilization for the UAM LWR benchmark. – E. Royer [U108]

11:35 -11:55 The BEMUSE Programme: Synthesis of the Results of Phase 3: Uncertainty and Sensitivity Analysis of LOFT L2-5- Agnes de Crecy [U109]

11:55 - 12:35 Basic Reference System Scenario – PB-2 BWR TT and Available Data. – K. Ivanov [U110]

12:35 - 14:00 Lunch

Technical Sessions on Phase1 – Discussions of the draft of a detailed specification on Phase I of UAM LWR benchmark relative to sensitivity and uncertainties for the neutronics calculations

Session III - Chair M. Zimmermann

14:00 - 4:30 Draft Specification for Exercise I-1 of the UAM LWR Benchmark - Derivation of the multi-group microscopic cross-section libraries (nuclear data, selection of multi-group structure, etc.).- K. Ivanov [U111-112]

14:30 - 14:50 Review of experimental and evaluated data along with covariance information from existing data libraries from national laboratories, OECD, and literature – K. Ivanov [U111-112]

14:50 - 15:10 Progress on proposal of a Benchmark for Stochastic and Deterministic Analyses of Nuclear Data Sensitivities and Uncertainties - V. Mastrangelo, I. Kodeli, E. Sartori [U113]

15:10 - 15:30 Sensitivity and Uncertainty Methods at Oak Ridge National Laboratory - Mark Williams, Brad Rearden, Jess Gehin, presented by K. Ivanov [U114]

15:30 -15:45 Coffee Break

Session IV - Chair S. Kliem

15:45 - 16:10 Draft Specification for Exercise I-2 of the UAM LWR Benchmark - Derivation of the few-group macroscopic cross-section libraries (energy collapsing, spatial homogenization, etc.) - K. Ivanov [U115-16]

16:10 – 16:30 Review of different techniques for the cross section energy collapsing, self-shielding treatment and spatial homogenization techniques and associated uncertainties including evaluation of the influence of energy collapsing of the covariance data on the final uncertainty estimation.- K. Ivanov [U115-16]

16:30 - 16:50 Draft Specification for Exercise I-3 of the UAM LWR Benchmark - Criticality (steady state) stand-alone neutronics calculations (k_{eff} calculations, diffusion approximation, etc.) - K. Ivanov [U117-18-19]

16:50 - 17:10 Review of different approximations for solving neutron balance equation and spatial discretization schemes and associated uncertainties in core calculations – K. Ivanov [U117-18-19]

17:10 - 17:30 Review of the available criticality experimental data and how they can be utilized for Exercise I-3 - K. Ivanov [U117-18-19]

<u>Day 2: 11 May 2007</u>

Session V - Chair H. Ikeda

9:00 - 9:20 Discussion on Phase 1

9:20 - 9:40 Discussion of interactions with BWR stability performance - K. Ivanov [U120]

9:40 - 10:00 Discussion of a provision to address a PWR system and scenario and available data - K. Ivanov [U121]

10:00 - 10:20 S.Langenbuch, A.Kolychev, S.Nikonov, K.Velkov: Proposal of a coupled code benchmark including uncertainty analysis on the base of measured data of VVER-1000 NPP Kalinin Unit 3. [U122]

10:20 - 10:40 Discussion on General Specifications for the 3 phases of UAM LWR benchmark

10:40 - 10:55 Coffee Break

Session VI - Chair K. Ivanov

Participants' presentations on their experience and expertise in uncertainty and sensitivity analysis of LWRs.

10:55 - 11:15 H. Ikeda et al.: RETRAN-3D/SIMULATE-3K Linkage Simulation and Sensitivity Study on Peach Bottom 2 Turbine Trip Tests [U123]

11:15 - 11:35 R. Bolado-Lavín. JRC-IE expertise in Uncertainty and Sensitivity Analysis Methods for LWR's. Recent developments [U124]

11:35 - 11:55 Dan Gabriel Cacuci: NURESIM SP4 (Uncertainty Analysis) [U125]

11:55 - 12:15 J. Macek, R.Meca: Uncertainty and Best estimate methodology of VVER reactors for licensing, (Methods of uncertainty, sensitivity analysis, practical application on MSLB, LOCA, PRISE accidents) [U126]

12:15- 12:35 Siegfried Langenbuch: Update on the GRS method for uncertainty and sensitivity analysis" [U127]

12:35- 14:00 Lunch

Session VII - Chair J .Macek

14:00 - 14:20 Rafael Macián Juan*, Paolo Vinai presented by Martin A. Zimmermann: Overview on uncertainty analysis at PSI [U128]

14:20 - 14:40 S. Kliem, A. Bousbia Salah, U. Rohde, F. d'Auria: Application of the SUSA and CIAU methods to the calculation of a NPP start-up experiment using a coupled code system [U129]

15:40 - 15:00 Enrique Vela: CSN Licensing and I+D projects involving Uncertainty Evaluation Methodologies [U130]

15:00 - 15:20 Discussion of the proposed time schedule for the UAM LWR benchmark activities – tentative summary - K. Ivanov [U131]

Coffee Break

16:00 - 16:20 Action items and schedule of benchmark activities - K. Ivanov

16:20 - 16:30 Next workshop (UAM-2) and plans - E. Sartori

16:30 - 16:40 Conclusions and closing remarks - E. Sartori

Annex II

List of Participants

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