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NUCLEAR ENERGY AGENCY
NUCLEAR SCIENCE COMMITTEE

Working Party on Scientific Issues of Reactor Systems

Third Workshop (C5G7-TD-3)

OECD/NEA Deterministic Time-Dependent Neutron Transport Benchmark without
Spatial Homogenization (C5G7-TD)

PROPOSED AGENDA

17-18 May 2018
Lucca, Italy

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**OECD Nuclear Energy Agency
Nuclear Science Committee**

**OECD/NEA Deterministic Time-Dependent Neutron Transport Benchmark without
Spatial Homogenization (C5G7-TD) – Third Workshop (C5G7-TD-3)**

**Lucca, Italy
May 17-18, 2018**

**in conjunction with BEPU-2018 conference on multi-physics and multi-scale simulations
with uncertainty**

**Hosted by NINE S.r.l.
Italy**

PROPOSED PROGRAMME

Sponsorship

The 3rd workshop for the OECD/NEA Deterministic Time-Dependent Neutron Transport Benchmark without Spatial Homogenization (C5G7-TD) – C5G7-TD-3 will be held on May 17-18, 2018 in Lucca, Italy in conjunction with BEPU-2018 conference in Lucca, Italy, hosted by NINE S.r.l., and is a follow up to the previous two workshops.

Increasing efforts have been made to the development of codes for transient calculations of nuclear reactors in recent years. In order to ensure reliable modelling of neutron physics within a state-of-the-art transient code, the neutron kinetics part of such a code should be based on the full-scale calculation of the space-time neutron kinetics equations without the use of the diffusion approximation and spatial homogenization. Such advanced approaches require the verification of neutron kinetics program modules through the cross-verification of codes, which are used to calculate thoroughly defined test cases, or the so-called benchmarks.

However, existing benchmark problems are not able to satisfy the demand for verifying codes/methods for performing the homogenization-free time-dependent transport calculations. On one hand, some of them are simplified diffusion benchmarks, in which the computational domain is composed of several homogeneous regions. On the other hand, some of them have a broad range of sources of uncertainties involved in the calculation, such as the nuclear data, group cross-section preparation procedure, and potentially other computational simplifications, making it difficult to reveal methodical errors of space-time neutron kinetics codes.

The main objective of this benchmark is to specify a series of space-time neutron kinetics test problems with heterogeneous domain description for solving the time-dependent group neutron transport equation. Physical materials in these benchmarks are described by transport macroscopic cross sections. Such benchmarks would allow carrying out verification of developed time-dependent heterogeneous transport deterministic and stochastic codes, and rigorously revealing methodical errors. Moreover, such benchmarks would allow studying possible inaccuracy of spatial homogenization and diffusion approximation in time-dependent cases.

This benchmark was proposed to the Expert Group on Radiation Transport and Shielding (EGRTS) and has been approved by Nuclear Science Committee (NSC) Working Party on Scientific Issues in Reactor Systems (WPRS) in the meeting in February 2015. The C5G7-TD benchmark is being carried out in 3 phases as follows:

- a) Phase I: Kinetics Phase – verification of methods/codes for heterogeneous time-dependent neutron transport calculations without feedback;
- b) Phase II: Dynamics Phase – verification of methods/codes for heterogeneous time-dependent neutron transport calculations with feedback;
- c) Phase III: High-fidelity Phase – uncertainty propagation in high-fidelity multi-physics calculations.

This workshop (C5G7-TD-3) will be held in conjunction with other meetings/workshops and the BEPU-2018 conference, in order to facilitate co-ordination and sharing of work. Seven other meetings are being held in Lucca, Italy during the same week in order to combine efforts in common areas such as neutronics, thermal-hydraulics, and multi-physics modelling and uncertainty analysis and to make the participation more efficient. The meetings/workshops concerned are:

- *May 14 – May 15, 2018* – Fourth OECD/NEA Sodium Fast Reactor (SFR) Uncertainty Analysis in Modelling (UAM) benchmark meeting (SFR-UAM-4);
- *May 14 – May 15 (morning), 2018* – Fifth COBRA-TF User's Group Meeting (CTF-5);
- *May 15 (afternoon), 2018* – Kick-off meeting on Blind benchmark on CANDU Thermal-hydraulics (CANDU T-H);
- *May 15 – May 16, 2018* – Competence Building Program for Embarking Countries workshop (CBPEC);
- *May 16 – May 17, 2018* – Twelfth OECD/NEA Light Water Reactor (LWR) Uncertainty Analysis in Modelling (UAM) benchmark meeting (UAM-12);
- *May 16 - May 17 (afternoon), 2018* – Kick-off meeting on Multi-Physics Pellet Clad Mechanical Interaction Validation benchmark (MPCMIV);
- *May 18, 2018* - Kick-off meeting on Rostov-2 VVER-1000 Multi-Physics benchmark (Rostov-2).

Background and Purpose of the Benchmark Workshop

The objective of the work is to define, conduct, and summarise an OECD/NEA Time-Dependent Neutron Transport Benchmark without Spatial Homogenization benchmark – C5G7-TD. The benchmark model is based on the well-established steady-state C5G7 benchmark problems, which were developed to test the capabilities of radiation transport codes that do not utilize spatial homogenization above the fuel pin level. It is a miniature light water reactor (LWR) with sixteen fuel assemblies (mini-core): eight uranium oxide (UO₂) assemblies and eight mixed oxide (MOX) assemblies, surrounded by a water reflector. It features a quarter-core radial symmetry in the 2-dimensional (2-D) configuration.

There are two sets of kinetics exercises considered in Phase I of the benchmark. The first set, including 5 exercises, is focused on the 2-D configuration of the C5G7 core. The second set, including 3 exercises, is with regard to the 3-D C5G7 configuration extended to full axial length.

Specification document entitled “Time-Dependent Neutron Transport Benchmark without Spatial Homogenization (C5G7-TD)” for Phase I has been updated based on participants' comments.

The detailed perturbation law of each exercise is described in the specification. Two additional exercises focusing on the control rod ejection type of transient scenario have been proposed, preliminarily tested, and will be included in the next release of the specification, which is scheduled before the workshop. Draft specifications for Phase II has been updated also for discussion and feedback at the C5G7-TD-3 workshop. The motivation of Phase II is that with the completion of the proposed kinetics exercises, the benchmark to be extended to more realistic dynamics exercises, which will take into account the thermal-hydraulic feedback mechanisms.

Scope and Technical Content of the Benchmark Workshop

The technical topics to be addressed at the workshop include:

- a) Discussion on the final benchmark specifications for Phase I, as well as received comments, suggestions, and corrections;
- b) Discussion of final templates for submission of participants' results for Phase I;
- c) Discussion of deterministic and Monte Carlo kinetics modelling for Phase I cases;
- d) Comparative analysis of submitted results for Phase I;
- e) Discussion of reference results for benchmark cases for Phase I;
- f) Presentations on participants' experience and expertise in time-dependent neutron transport calculations;
- g) Discussion of draft specifications for Phase II - extension of kinetics benchmark cases to dynamics benchmark cases;
- h) Discussion of deterministic and Monte Carlo dynamics modelling for Phase II cases;
- i) Comparative analysis of submitted results for Phase II;
- j) Discussion of reference results for benchmark cases for Phase II;
- k) Presentations on participants' experience and expertise in high-fidelity dynamics calculations;
- l) Defining a work plan and schedule outlining actions to progress on the benchmark activities.

Organization of the Benchmark Workshop

The meeting is organised around the discussion in depth of the benchmark specifications, templates for submission of participants' results, reference solutions, and proposed work plan and time schedule for the OECD/NEA C5G7-TD benchmark activities. The participants are requested to present their modelling and results as well as their experience and expertise in time-dependent neutron transport analysis.

Participation in the Benchmark Workshop

For Benchmark Workshops sponsored by the Nuclear Science Committee (NSC), participation is restricted, for efficiency, to participants in this study and to experts (research laboratories, safety authorities, regulatory agencies, utilities, owners' groups, vendors, etc.) from OECD/NEA member countries nominated by Delegates to the Committee in consultation with official authorities concerned and with the assistance of members of the Nuclear Science Committee.

Organisation and Programme Committee of the Benchmark Workshop

An Organisation and Programme Committee has been nominated to make necessary arrangements for the 3rd Benchmark Workshop and to organize the Sessions, draw up the final programme, appoint Session Chairmen, etc. The members of the Programme Committee are:

Jason Hou – Co-Chair and Co-ordinator

North Carolina State University, USA

X - Local Co-Chair

NINE S.r.l., Italy

Victor F. Boyarinov - Co-ordinator

National Research Centre “Kurchatov Institute”, Russian Federation

Kostadin N. Ivanov - Co-ordinator

North Carolina State University, USA

Kiril Velkov

Gesellschaft fuer Anlagen und Reactorsicherheit mbH, Germany

Tom Downar

University of Michigan, USA

Andreas Pautz

Paul Scherrer Institut, Switzerland

Maria Avramova

North Carolina State University, USA

Secretariat: **Tatiana Ivanova**

Shuichi Tsuda

OECD/Nuclear Energy Agency, France

Proposed Programme of the Benchmark Workshop

The proposed programme for the 3rd OECD/NEA C5G7-TD Benchmark Workshop (C5G7-TD-3) was drawn-up by the Programme Committee and is enclosed as **Appendix 1**.

Language of the Benchmark Workshop

The official language of the C5G7-TD-3 Benchmark workshop is English.

Proceedings of the Workshop

A summary of the workshop will be published by the OECD/NEA after the meeting. The summary will be distributed free of charge to the participants in the Workshop and to Delegates of the NSC. The programme committee and the session Chairmen will prepare a summary report on the main results of the meeting for presentation to the NSC. Presentations will be available free of charge to the participants to download from participants' restricted area after the workshop.

Contacts and Registrations

The eight meetings/workshops to be held in conjunction with the BEPU-2018 conference are named WPRS Workshops and include: SFR-UAM-4, CTF-5, CANDU T-H, CBPEC, LWR-UAM-12, MPCMIV,

C5G7-TD-3, and Rostov-2. There is an established process by which those wishing to attend only the WPRS workshops/meetings (i.e. not participating in or presenting at the concurrent BEPU conference) should register to this event.

These instructions should be followed, in order to register without a conference package.

Please be aware and respect the following regarding this format of registration:

- **Dinners and lunches are not included**, and must be bought separately as desired by the individual. Coffee breaks, however, will kindly be made available to all;
- This option **precludes access to any of the BEPU conference rooms**;
- For those attendees to the WPRS workshops who have also **submitted a paper to the BEPU conference, attendance of the conference, and hence purchase of a conference package is necessary**. This is in order to publish the paper, to have access to the conference rooms and furthermore to be provided with the final conference proceedings.

At the initial sign-up page <http://www.nineeng.com/bepu/index.php/register>

1. Answer "Yes" to the question "Do you want to attend ONLY WPRS Workshops?"
2. Type as the 'WPRS code' the following: "wprs2018lucca" (all lower case)

Do you want to attend ONLY WPRS Workshops? ☒ Yes ☐ No ★

If YES, please type your WPRS code

Do you need an invoice? ☐ Yes ☒ No ★

3. Once logged in, use the registration system to add the intended workshops to your cart. At this time you may also purchase, additional dinners, lunches and technical / guided tours.



Should you have any question, please do not hesitate to contact the NEA wprs@oecd-nea.org or the Organizing Committee <http://www.nineeng.com/bepu/index.php/contact>.

Please send titles and authors of your presentations for C5G7-TD-3 to Jason Hou (jason.hou@ncsu.edu).

Workshops' Location

The meeting place for the eight workshops during the week of May 14-18, 2018 is the same as for the BEPU-2018 conference – the Real Collegio, which is located inside the city walls of Lucca:

<http://www.nineeng.com/bepu/index.php/venue/the-real-collegio>

The information for transportation and hotels are provided at the links below:

<http://www.nineeng.com/bepu/index.php/conference-info/transportation>

<http://www.nineeng.com/bepu/index.php/conference-info/hotel-reservations>

The programme and schedule of the meetings is shown below:

	Morning 08:30 - 12:30 (1 coffee break)	L U N C H	Afternoon 14:00 - 18:00 (1 coffee break)
MONDAY	SFR-UAM-4		SFR-UAM-4
	CTF-5		CTF-5
TUESDAY	SFR-UAM-4		SFR-UAM-4
	CTF-5		CANDU T-H
	CBPEC		CBPEC
WEDNESDAY	LWR-UAM-12		LWR-UAM-12
	MPCMIV		MPCMIV
	CBPEC		CBPEC
THURSDAY	LWR-UAM-12		LWR-UAM-12
	MPCMIV		C5G7-TD-3
FRIDAY	ROSTOV-2		ROSTOV-2
	C5G7-TD-3		C5G7-TD-3

Appendix 1**OECD/NEA Deterministic Time-Dependent Neutron Transport Benchmark without Spatial Homogenization (C5G7-TD) – Third Workshop (C5G7-TD-3)****Host Organization**

NINE S.r.l.
Lucca, Italy

May 17-18, 2018**PROPOSED PROGRAMME****C1-16: Session code**

- C1. Introduction and opening remarks
- C2. Overview of benchmark activities
- C3. Presentations on related activities
- C4. Discussion of the final Specifications for Phase I
- C5. Discussion of the added rod ejection type test problems and requested output for Phase I
- C6. Comparative analysis of submitted participants' results for Phase I
- C7. Participants' presentations on their modelling and results for time-dependent neutron transport calculations
- C8. Discussion of cross-section sets and libraries prepared with SCALE-6.2 for Phases I and II
- C9. Discussion of drafting the final report of Phase I
- C10. Discussion of the draft Specifications for Phase II
- C11. Discussion of the selected dynamics test problems and requested output for Phase II
- C12. Discussion of reference solutions for Phases II
- C13. Comparative analysis of submitted participants' results for Phase II
- C14. Participants' presentations on their expertise and experience in high-fidelity dynamics modelling and results
- C15. Action items and schedule of benchmark activities - next workshop (C5G7-TD-4) and plans
- C16. Conclusions and closing remarks