First OECD/NEA EGMUP Task Force on Artificial Intelligence and Machine Learning Benchmark Meeting

Bologna, Italy
May 24, 2023 (Track 1 Afternoon)

Hosted by hosted by ENEA, Italy

Announcement and Proposed Program

Background and Purpose of 1st OECD/NEA EGMUP Task Force on AIML Benchmark Meeting

The first OECD/NEA EGMUP Task Force on Artificial Intelligence and Machine Learning Benchmark Meeting (TF-AIML-1) will be held on May 24, 2023, in Bologna, Italy. The TF-AIML-1 meeting will be held in conjunction with other OECD/NEA Working Party on scientific issues and uncertainty of Reactor Systems (WPRS) meetings/workshops to facilitate co-ordination and sharing of work. Nine other meetings are being held in two parallel tracks at Bologna, 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 22, 2023 (track 2 morning) – Ninth COBRA-TF (CTF) User's Group (UG) Meeting (CTF-9) followed by a hands-on CTF training sessions which will be conducted on Monday afternoon, May 22, 2023 and Tuesday morning, May 23, 2023 (track 2);
- May 22, 2023 (track 1 afternoon) – First Burst-Fission-Gas Release Benchmark (BFGR-1) workshop;
- May 23, 2023 (track 1) - Sixteen OECD/NEA Light Water Reactor (LWR) Uncertainty Analysis in Modelling (UAM) Benchmark (LWR-UAM-16) workshop;
- May 23, 2023 (track 2) – OECD/NEA HTGR-TH Benchmark introductory presentation and discussions;
- May 22-23 (track 3), 2023 – OECD/NEA International School on Simulation of Nuclear
- Reactor Systems (SINUS);
- May 24, 2023 (track 1 morning) - OECD/NEA Task Force on Doppler Effective Fuel Temperature meeting;
- May 24, 2023 (track 2 morning) – Fourth OECD/NEA McMaster Core Thermal-
- Hydraulics (CTH) Benchmark (CTH-4) workshop;
- May 24, 2023 (track 1 afternoon) – OECD/NEA Task Force Artificial Intelligence &
- Machine Learning meeting;
- May 24, 2023 (track 2 afternoon – LFR neutronics) – May 25, 2023 (track 2 morning – LFR Thermal-hydraulics) – Second OECD/NEA Lead Fast Reactor (LFR) Benchmark (LFR-2) workshop;
- May 24, 2023 (track 1 afternoon) – May 25, 2023 (track 1 morning) - Eight OECD/NEA Time-Dependent Neutron Transport (C5G7-TD) Benchmark (C5G7-TD-8) workshop;
- May 25, 2023 (track 2 afternoon) – Second Liquid Metal Fast Reactor (LMFR) Thermal-Hydraulics (T/H) Benchmark workshop (LMFR T/H-2);
- May 25, 2023 (track 1 afternoon) – May 26, 2023 (track 1 morning) - Third meeting on OECD/NEA TVA Watts Bar 1 (WB1) Multi-Physics Multi-Cycle Depletion Benchmark (TVA-WB1-3) workshop.
- May 26, 2023 (track 2) - Eight OECD/NEA Sodium Fast Reactor (SFR) UAM Benchmark workshop and First Liquid Metal Fast Reactor (LMFR) Thermal-Hydraulics (T/H) Benchmark workshop (SFR-UAM-8);
- May 26, 2023 (track 1 afternoon) – Fifth benchmark meeting on Rostov-2 VVER-1000 multi-physics transient benchmark (Rostov2-5).

AI/ML have gained tremendous interest across all branches of nuclear engineering, driven by the increasing computing power, advancements in AI/ML algorithms, and the availability of user-friendly ML libraries. While it is widely acknowledged that AI/ML has great potential to enhance

data-driven scientific computing problems in nuclear engineering, its potential has not been fully realized due to several challenges. First, there are no guidelines on how to apply application-agnostic AI/ML algorithms to high-consequence nuclear systems. Second, there are no AI/ML benchmarks based on realistic nuclear reactor measurement data or numerical simulation data to compare and validate various ML algorithms. Third, there are significant gaps in the trustworthiness assessment of AI/ML models for nuclear applications. In May 2022, the OECD/NEA Working Party on Scientific Issues and Uncertainty Analysis of Reactor Systems (WPRS) endorsed at its annual Benchmark Workshops the creation of a task force on ``Artificial Intelligence and Machine Learning for Scientific Computing in Nuclear Engineering'' under the auspices of its Expert Group on Reactor System Multiphysics (EGMUP).

The goal of this task force is to develop benchmark exercises that aim at evaluating the performance of AI/ML in multi-physics M\&S of nuclear reactor systems. It will provide recommendations to the WPRS and the nuclear community on the scientific development needs (data, methods, and benchmark exercises) for trustworthy AI/ML applications in nuclear scientific computing problems. This benchmark will design and execute benchmark exercises on both single physics (reactor physics, thermal-hydraulics and fuel performance) and multi-physics coupled simulation problems. The exercises will target specific key challenges of each computational domain through interactions with the corresponding WPRS expert groups. A broad spectrum of AI/ML sub-domains will be explored, including supervised learning, unsupervised learning, reinforcement learning, deep generative learning, and probabilistic ML. In each benchmark exercise, the participants will use self-chosen AI/ML algorithms to perform tasks specified in the exercises. The development of the benchmark specifications will be conducted in two phases.

1. Phase I of the benchmark will focus on tasks related to regression, classification, dimensionality reduction and anomaly detection, and
2. Phase II of the benchmark will focus on tasks related to VVUQ, transfer learning, deep generative learning and deep reinforcement learning.

The first draft version of the Phase 1 specification is planned to be provided by early May 2023 to allow initial studies to be discussed during the WPRS Workshops in May 2023. Final specification for Phase 1 will be completed in December 2023. Once the Phase 1 final specification is released, the task force will supervise the gathering and analysis of the participants results up to the end of 2024. The Phase 1 final report will be approved by mid-2025. The Phase 2 draft specifications will be provided by February 2024 and the final specifications will be approved by the task force by the end of 2024. The task force will supervise gathering of results from the participants for Phase 2 up to the end of 2025 and approve the final Phase 2 report by mid-2026.

The information about the Task Force on AI/ML is provided at:

https://www.oecd-nea.org/jcms/pl_77779/task-force-on-artificial-intelligence-and-machine-learning-for-scientific-computing-in-nuclear-engineering

Scope and Technical Content of the Meeting

The topics to be addressed at the workshop include:

- Review and discussion of databases that will be used for evaluating the performance of AI/ML techniques in the benchmark exercises,

– Updates from the subgroup leads on the benchmark exercise development,

– Updates from the subgroup leads on the benchmark specification drafts for Phase I,

– Feedback and concerns of task force participants for the exercises and specifications,

– Discussion on the benchmark execution of Phase I in 2024,

– Discussion of templates for submitting participants' results for Phase I,

– Discussion on potential interaction of this Task Force with other relevant activities such as LWR-UAM and the Task Force on Doppler Effective Fuel Temperature, Working Party on Materials Science Issues in Nuclear Fuels and Structural Materials (WPFM) Expert Group on Fuel Materials (EGFM), and

– Defining a work plan, schedule and goals for the next year of the Task Force.

The proposed meeting program is attached as Annex 1.

Organization of the Meeting

The meeting is organized around the discussion of the benchmark exercises, benchmark specification preparation, TF participants' concerns, Phase I execution and other benchmark-related activities. The subgroup leads are requested to present their progress on benchmark exercise development and benchmark specification preparation.

Participation in the Meeting

Participation is restricted to individuals from OECD/NEA member country institutions.

Organization and Program Committee of the Meeting

An Organization and Program Committee has been nominated to make the necessary arrangements for the TF-AIML-1 benchmark meeting and to draw up the final program, etc.

The members of the Program Committee are:

> **Xu Wu** - *Principal Investigator and Chair*
> North Carolina State University, USA

> **Gregory Delipei** - *Co-Chair*
> North Carolina State University, USA

> **Giacomo Grasso –** *Co-Chair, and Local Host*
> ENEA, Italy

Secretariat: **Oliver Buss**
OECD/Nuclear Energy Agency, France

Proposed Program of the Meeting

The proposed program was drawn up by the Program Committee and is enclosed as Annex 1.

Language of the Benchmark Workshop

The official language of the TF-AIML-1 meeting is English.

Proceedings of the Meeting

A summary of the TF-AIML-1 meeting will be published by the program committee after the meeting. The summary will be distributed free of charge to the participants in the meeting. The presentations will be available free of charge to the participants to download from participants' restricted area after the TF-AIML-1 meeting.

Contacts and Registrations

The annual benchmark workshops/meetings of the [Working Party on Scientific Issues and Uncertainty Analysis of Reactor Systems (WPRS)](#) and TF-AIML-1 Meeting will be hosted by ENEA in Bologna (Italy). The meetings will take place in two tracks in parallel during the week of 22 May to 26 May 2023 to exchange results and lessons learned for the different WPRS benchmark activities and to discuss future activities.

The link to registration page for the WPRS-related workshops/meetings (including TF-AIML-1), overall program, and local information for transportation and hotels is:

https://www.oecd-nea.org/jcms/pl_71612/wprs-benchmarks-workshop-2023

Workshop Location

The meeting place for the ten meetings/workshops during the week of May 22 – 26, 2023, in three tracks is at the Zanhotel Europa, Bologna, Italy (in-person meeting). As mentioned above the local information for transportation and hotels is given at:

https://www.oecd-nea.org/jcms/pl_71612/wprs-benchmarks-workshop-2023

The program and schedule of the meetings is shown below:

	Track 1	**Track 2**	**Track 3**
Monday, May 22	Morning: MPCMIV Afternoon: Burst Fission Gas Release	Morning: CTF UG Afternoon: CTF Training	Morning: SINUS Afternoon: SINUS
Tuesday, May 23	Morning: LWR UAM Afternoon: LWR UAM	Morning: HTGR-TH Afternoon: HTGR-TH	Morning: SINUS Afternoon: CTF Training
Wednesday, May 24	Morning: Task Force on Doppler Effective Fuel Temperature Afternoon: Task Force on AI & ML	Morning: McMaster CTH Afternoon: LFR Neutronics	
Thursday, May 25	Morning: C5G7-TD Afternoon: TVA-WB1	Morning: LFR TH Afternoon: LMFR TH	
Friday, May 26	Morning: TVA-WB1 Afternoon: Rostov-2	Morning: SFR-UAM Afternoon: SFR-UAM	

ANNEX 1

The First OECD/NEA EGMUP Task Force on Artificial Intelligence and Machine Learning Benchmark Meeting (TF-AIML-1)

Host Organization

Hosted by ENEA

Bologna, Italy

May 24, 2023

PROPOSED PROGRAM

TA01-10: Session codes

Day 1: May 24, 2023

TA01. Introduction and opening remarks

TA02. Overview of Task Force activities and current status

TA03. Updates from the subgroup leads on the benchmark exercise development

TA04. Updates from the subgroup leads on the benchmark specification drafts for Phase I

TA05. Feedback and concerns of Task Force participants for the exercises and specifications,

TA06. Discussion on the benchmark execution of Phase I in 2024

TA07. Discussion of templates for submitting participants' results for Phase I

TA08. Discussion on potential interaction of this Task Force with other relevant activities

TA09. Action items, schedule and goals for the next workshop (TF-AIMI-2)

TA10. Conclusions and closing remarks