Tenth COBRA-TF (CTF) User's Group Meeting and Training - CTF-10

Lucca, Italy
Sunday, May 19 2024
In conjunction with the BEPU 2024 Conference

Hosted by N.IN.E. (Nuclear and Industrial Engineering), Italy

Announcement and Proposed Program

Sponsorship

The tenth COBRA-TF (CTF) User's Group (UG) Meeting (CTF-10) will be held on May 19, 2024 in Lucca, Italy in conjunction with the 2024 Best-Estimate Plus Uncertainty (BEPU-2024) international conference as well as with the Organization for Economic Cooperation and Development (OECD)/Nuclear Energy Agency (NEA) Working Party on scientific issues and uncertainty of Reactor Systems (WPRS) workshops, in order to facilitate co-ordination and share work, to combine efforts in common areas such as neutronics, thermal-hydraulics, multi-physics modelling and uncertainty analysis, and to make the participation more efficient. The OECD/NEA WPRS meetings/workshops/school concerned are:

- *May 20, 2024 (track 1 morning)* – Third OECD/NEA Lead Fast Reactor (LFR) benchmark (LFR-3) workshop – LFR Thermal-Hydraulic (T/H) Stage
- *May 20, 2024 (track 2 morning)* - Third OECD/NEA Fluoride High Temperature (FHR) Reactor Benchmark (FHR-3) workshop
- *May 20, 2024 (track 1 afternoon)* – Third OECD/NEA Lead Fast Reactor (LFR) benchmark (LFR-3) workshop – LFR Neutronics Stage
- *May 20, 2024 (track 2 afternoon)* - Sixth benchmark meeting on Rostov-2 VVER-1000 multi-physics transient benchmark (Rostov2-6)
- *May 21, 2024 (track 1)* - Ninth OECD/NEA Sodium Fast Reactor (SFR) UAM Benchmark workshop (SFR-UAM-9)
- *May 21, 2024 (track 2 morning)* - Ninth OECD/NEA Time-Dependent Neutron Transport (C5G7-TD) Benchmark (C5G7-TD-9) workshop
- *May 21, 2024 (track 2 afternoon)* – Fifth Multi-Physics Pellet Cladding Mechanical Interaction Validation Benchmark (MPCMIV-5) workshop
- *May 20*-21 (track 3), 2024 – 2nd OECD/NEA International School on Simulation of Nuclear Reactor Systems (SINUS)
- *May 22, 2024 (track 1)* - Seventeen OECD/NEA Light Water Reactor (LWR) Uncertainty Analysis in Modelling (UAM) Benchmark (LWR-UAM-17) workshop including OECD/NEA Task Force on Doppler Effective Fuel Temperature meeting
- *May 22, 2024 (track 2 morning)* – Fourth Liquid Metal Fast Reactor (LMFR) Thermal-Hydraulics (T/H) Benchmark workshop (LMFR T/H-4)
- May 22, 2023 (track 2 afternoon) – First OECD/NEA HTGR-TH Benchmark (Based on HTTF Data) workshop (HTGR-TH-1)
- *May 23, 2024 (track 1)* – Fourth OECD/NEA TVA Watts Bar 1 (WB1) Multi-Physics Multi-Cycle Depletion Benchmark (TVA-WB1-4) workshop
- *May 23, 2024 (track 2 morning)* - Summary session with presentations of recently concluded benchmarks: OECD/NEA First Burst-Fission-Gas Release Benchmark (BFGR) and OECD/NEA McMaster Core Thermal-Hydraulics (CTH) Benchmark
- *May 23, 2024 (track 2 afternoon)* – OECD/NEA Task Force Artificial Intelligence & Machine Learning meeting

In conjunction with the CTF-10 meeting, which will take place on Sunday afternoon, May 19, 2024, a hands-on CTF training session will be conducted on Sunday morning, May 19, 2024.

CTF is an advanced thermal-hydraulics subchannel and nuclear fuel modelling software package developed and maintained by North Carolina State University (NCSU) in collaboration with Oak Ridge National Laboratory (ORNL). A hands-on training session will be provided to introduce users to its capabilities through a series of example application problems.

Background and Purpose of 10th CTF User's Group Meeting

CTF is a version of COBRA-TF. COBRA-TF is a thermal-hydraulic simulation code designed for Light Water Reactor (LWR) vessel and core analysis. It uses a two-fluid (hence the "TF" designation), three-field modeling approach. The original COBRA-TF code was developed as a thermal-hydraulic rod-bundle analysis code in 1980 by Pacific Northwest Laboratory under sponsorship of the Nuclear Regulatory Commission. It was subsequently implemented in the COBRA-TRAC code system and further validated and refined as part of the FLECHT-SEASET 163-Rod Blocked Bundle Test and analysis program. Over the past several decades, the COBRA series of codes has been used extensively throughout the nuclear industry, resulting in many variants of the code being created and validated.

CTF is the shortened name given to the version of COBRA-TF being developed and improved by the Reactor Dynamics and Fuel Modeling Group (RDFMG) initially at the Pennsylvania State University (PSU), and currently at NCSU in cooperation with ORNL. In the last decade, CTF has been extensively validated for Pressurized Water Reactor (PWR), Boiling Water Reactor (BWR), Water-Water Energetic Reactor (VVER), Small Modular Reactor (SMR), and research reactor applications. Improvements have included development of models, enhancing computational efficiency, as well as improving software quality and associated Quality Assurance procedures and documentation. CTF is now NQA-1 certified software package. Modifications and validation of CTF to analyze advanced reactors such as Molten Salt Reactor (MSR) designs and Liquid Metal Fast Reactor (LMFR) designs (sodium and lead-bismuth cooled designs) as well as spent fuel pools and dry storages have been implemented. As a result, CTF has become state-of-the-art subchannel code for reactor bundle and core thermal-hydraulics analysis.

The CTF was included in two large projects – U.S. Department of Energy (DOE) Consortium for Advanced LWR Simulation (CASL) (as the basic thermal-hydraulic core feedback model) and European Commission (EC) NUclear REactor SAFEty simulation platform (NURESAFE) (as a BWR, PWR and VVER core thermal-hydraulic transient analysis tool). Within CASL, CTF become an important component of VERA, a "Virtual Environment for Reactor Applications", Core Simulator (CS) – VERA-CS. CTF is a part of the DOE Nuclear Energy Advanced Modeling and Simulation (NEAMS) program for LWR applications and VERA User's Group activities. CTF was part also of DOE sponsored Advanced Nuclear Technology Project entitled "Modeling and Analysis of Exelon BWRs for Eigenvalue & Thermal Limits Predictability", which involved further high-fidelity development and application of VERA-CS, including CTF, to BWRs.

CTF have been distributed under code licenses to different organizations, which resulted in further improvements, modifications, verification & validation activities, and applications. In order to leverage and combine all non-proprietary developments, improvements, modifications and error fixes as well as the available verification and validation database and application experience of CTF from different organizations and activities, it was decided to establish a CTF User Group (UG) under the leadership of RDFMG/NCSU in order to provide and maintain the so-called "gold-standard" of CTF. RDFMG/NCSU is the keeper of the gold-standard CTF and taking on the responsibility of maintaining and merging all developments and modifications. RDFMG/NCSU

works to bridge the gap between different programs and activities related to CTF. Such unified and up-to-date code version, supplemented with extended verification and validation suite and application guidelines based on previous documented experience, will be useful to all CTF users in the future. RDFMG works to implement non-proprietary features developed in different projects in a single, gold-standard, and state-of-the-art version of CTF for the entire nuclear industry to benefit. The gold-standard version of CTF uses GIT source control and is hosted on RDFMG GitLab server to be accessible by all members of CTF UG. The code can be run in serial or parallel modes and is distributed via a code agreement/license to interesting parties. The information for CTF UG is provided at https://www.ne.ncsu.edu/rdfmg/cobra-tf/.

The CTF-10 meeting will involve all interested users with objective to discuss on the progress in achieving a common version and to review the contributions from different organizations to the common version (including code development, improvement, verification and validation, uncertainty quantifications, and applications). CTF-10 will be conducted following the agreements reached at the first CTF UG meeting to have annual meetings to present, discuss and coordinate CTF related activities.

Scope and Technical Content of the Meeting

The topics to be addressed at the workshop include:
- Review of the CTF UG activities
- Advances in reactor core thermal-hydraulics modeling
- Discussion of status and recent additions to the CTF UG
- Presentations and discussions on CTF/CTFFuel developments
- CTF-Residual (CTF-R) updates
- Presentations on multi-scale and multi-physics activities with CTF/CTFFuel
- Discussion of updates of verification and validation (V&V) matrix as well as coverage matrix of CTF. Proposals for further expansion of V&V matrix and coverage matrix
- Discussion of recent uncertainty quantification studies of CTF
- Discussions of using high-fidelity models to inform low-fidelity models in CTF
- CTF modifications and applications to PWRs
- CTF modifications and applications to BWRs
- CTF modifications and applications to VVERs
- CTF modifications and applications to SMRs
- CTF modifications and applications to research reactors
- CTF modifications and applications to SFRs and MSRs
- Discussions of transient applications of CTF;
- Presentations on other activities with CTF as well as experience and expertise of different organizations in CTF model developments, efficiency improvements, verification and validation efforts and applications
- Defining a work plan and schedule for CTF UG activities

The proposed meeting program is attached as Annex 1.

Organization of the Meeting

The meeting is organized around the discussion of CTF UG and its activities. The participants are requested to present their expertise and experience in CTF developments, improvements, verification and validation, uncertainty quantification and applications.

Participation in the Meeting

Participation in the meeting is open to all former, current and future developers and users of CTF for different applications.

Organization and Program Committee of the Meeting

An Organization and Program Committee has been nominated to make the necessary arrangements for the CTF-10 meeting and to draw up the final program, etc. The members of the Program Committee are:

Alessandro Petruzzi – *Co-Chair, and Local Host*
NINE S.r.l., Italy

Agustin Abarca – *Co-Chair*
North Carolina State University, USA

Maria Avramova
North Carolina State University, USA

Yann Perin - *Coordinator of EC CTF activities*
Gesellschaft fuer Anlagen und Reaktorsicherheit (GRS) mbH, Germany

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 CTF-10 meeting is English.

Proceedings of the Meeting

A summary of the CTF-10 meeting will be published by the RDFMG/NCSU 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 CTF-10 meeting.

Contacts and Registrations

The annual benchmark workshops/meetings of the [Working Party on Scientific Issues and Uncertainty Analysis of Reactor Systems](#) (WPRS) and CTF UG Meeting and Training will be hosted by NINE S.r.l. in Lucca (Italy). The meetings will take place in three tracks in parallel during the week of May 19 to May 23, 2024 to exchange our 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 CTF-10 registration, and overall program is

https://www.oecd-nea.org/jcms/pl_89133/wprs-benchmarks-workshops-2024

In addition, there is a link to registration form for the CTF-10 UG Meeting and Training is at NCSU/RDFMG website:

https://www.ne.ncsu.edu/rdfmg/cobra-tf/tenth-ctf-user-group-ug-meeting-and-training/

<u>Workshops' Location</u>

The meeting place/venue for the BEPU-2024 conference and the eleven meetings/workshops during the week of May 19 to May 23, 2024 is the Real Collegio, which is located inside the city walls of Lucca. The local information for transportation and hotels is given at:

https://www.nineeng.com/bepu2024/index.php/conference-info/about-the-conference

The schedule for the incoming WPRS Workshops, SINUS-2 school and CTF-10 Meeting and Training is given in the table below (all times in CEST):

		Track 1	Track 2	Track 3 (SINUS)
Sunday, 19 May 2024	<u>9:00-13:00</u>	CTF UG Training		
	<u>14:00-18:00</u>	CTF UG Meeting		
	<u>Starting at 18:00</u>	Registration & informal networking		
Monday, 20 May 2024	<u>Starting at 8:00</u>	Registration		
	<u>9:00-13:00</u>	Lead-cooled Fast Reactor Benchmark (LFR) - T/H Stage	FHR - Fluoride High Temperature Reactor Benchmark	OECD NEA International School on Simulation of Nuclear Reactor Systems (SINUS)
	<u>14:00-18:00</u>	Lead-cooled Fast Reactor Benchmark (LFR) - Neutronics Stage	Rostov-2 VVER-1000 Benchmark	SINUS
Tuesday, 21 May 2024	<u>9:00-13:00</u>	Uncertainty Analysis in Modelling (UAM) for Design, Operation and Safety Analysis of Sodium-cooled Fast Reactors (SFR-UAM)	C5G7-TD: The Deterministic Time-Dependent Neutron Transport Benchmark C5G7-TD without Spatial Homogenization	SINUS
	<u>14:00-18:00</u>	SFR UAM	Multi-physics Pellet Cladding Mechanical Interaction Validation (MPCMIV) Benchmark	SINUS

		Track 1	Track 2
Wednesday, 22 May 2024	9:00-13:00	Benchmark for Uncertainty Analysis in Best-Estimate Modelling for Design, Operation and Safety Analysis of Light Water Reactors (LWR-UAM)	Liquid Metal Fast Reactor Core Thermal-Hydraulics Benchmark (LMFR T/H)
	14:00-18:00	LWR UAM including session on EGMUP Task Force on Doppler effective fuel temperature	HTGR T/H Benchmark based on HTTF Data
Thursday, 23 May 2023	9:00-13:00	TVA Watts Bar Unit 1 Multi-Physics Benchmark	9:00-11:00 Summary presentations of recently concluded benchmarks: - Burst Fission Gas Release (1h) - McMaster CTH (1h)
			11:00-13:00 EGMUP Task Force Artificial Intelligence & Machine Learning
	14:00-18:00	TVA Watts Bar Unit 1 Multi-Physics Benchmark	EGMUP Task Force Artificial Intelligence & Machine Learning

ANNEX 1

Tenth COBRA-TF User's Group Meeting (CTF-10)

Host Organization
Hosted by N.IN.E. (Nuclear and Industrial Engineering), Italy
Lucca, Italy

May 19, 2024
Afternoon

PROPOSED PROGRAM

CT01-18: Session code

CT01. Introduction and opening remarks.

CT02. Review of the CTF User's Group activities after the CTF-9 meeting.

CT03. Discussion of status and recent additions to the CTF User's Group – activities, coordination, agreements/licenses, distribution, etc.

CT04. CTF Version updates including CTF model developments and improvements/additions.

CT05. Presentations on CTFFuel model developments and improvements/additions.

CT06. Hi2Lo reconstruction models and capabilities in CTF and CTFFuel.

CT07. Updates on residual formulation implementation in CTF.

CT08. Presentations on recent verification, validation, and uncertainty quantification studies of CTF.

CT09. Presentations on recent verification, validation, and uncertainty quantification studies of CTFFuel.

CT09   Applications of machine learning techniques and artificial intelligence.

CT11. Presentations on coupling CTF with system thermal-hydraulics models.

CT12. Presentations on CFD informed models for CTF.

CT13. CTF modifications and applications to PWRs, BWRs, VVERs, SMRs, research reactors, SFRs, and MSRs.

CT14. Presentations on CTF applications to solve industry challenge problems.

CT15. Presentations on multi-physics and multi-scale activities involving CTF.

CT16. Presentations on CTF efficiency improvements and parallelization.

CT17. Presentations on other activities with CTF as well as experience and expertise of different organizations in CTF design and safety applications.

CT18. Defining a work plan and schedule for CTF UG activities.