NC STATE UNIVERSITY
Department of Nuclear Engineering

Consortsium for Nuclear Power
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Eleventh COBRA-TF (CTF) User's Group Meeting and Training - CTF-11

3 July 2025

Trumpington Street, CB2 1PZ, Cambridge, United Kingdom

Hosted by the OECD Nuclear Energy Agency (NEA) and the Department of Engineering of the University of Cambridge in collaboration with the Cambridge Nuclear Energy Centre, University of Cambridge, United Kingdom

Announcement and Proposed Program

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Sponsorship

The eleventh COBRA-TF (CTF) User's Group (UG) Meeting and Training (CTF-11) will be held on July 3, 2025 (Track 3 morning and afternoon respectively) in Cambridge, UK, as part of the Benchmarks Workshops Event of the Working Party on Scientific Issues and Uncertainty of Reactor Systems (WPRS). This event with three parallel tracks combines benchmarking efforts in common areas such as neutronics, thermal-hydraulics, and multi-physics modelling and uncertainty analysis. The full schedule for the incoming WPRS Workshops, SINUS-3 school and CTF-11 Meeting and Training is given on the meeting web page: https://www.oecd-nea.org/jcms/pl_98752/wprs-benchmarks-workshops-2025

Executive Summary

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 the 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 storage, have been implemented. As a result, CTF has become a 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 becomes 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 Users' Group activities. CTF was also part 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 has 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 is 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 a unified and up-to-date code version, supplemented with an 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 interested parties.

The information for CTF UG is provided at https://www.ne.ncsu.edu/rdfmg/cobra-tf/

The CTF-11 meeting will involve all interested users with the objective to discuss on the progress in achieving a common version and reviewing the contributions from different organizations to the common version (including code development, improvement, verification and validation, uncertainty quantifications, and applications). CTF-11 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 to the verification and validation (V&V) matrix as well as the coverage matrix of CTF. Proposals for further expansion of the 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, LFRs, 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-11 meeting and to draw up the final program, etc. The members of the Program Committee are:

The members of the Program Committee are:

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

Maria Avramova – Co-Chair
North Carolina State University, USA

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

NEA WPRS 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 CTF-11 meeting is English.

Proceedings of the Meeting

A summary of the CTF-11 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 the participants' restricted area after the CTF-11 meeting.

Contacts and Registrations

Link to the registration page for the WPRS-related workshops and meetings (including CTF-11 registration) and the overall program.

https://www.oecd-nea.org/jcms/pl_98752/wprs-benchmarks-workshops-2025

Workshop Location

The meeting place/venue for the meetings/workshops during the week of 30 June to 4 July 2025 is the Department of Engineering of the University of Cambridge:

Trumpington Street, CB2 1PZ, Cambridge, United Kingdom.

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Annex 1:

Eleventh COBRA-TF User's Group Meeting (CTF-11)

PROPOSED PROGRAM

3 July 2025, Morning

CT00. CTF Training

3 July 2025, Afternoon

CT01. Introduction and opening remarks.

CT02. Review of the CTF User's Group activities after the CTF-10 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.
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CT05. Presentations on CTFFuel model developments and improvements/and 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.

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.

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.S