Sixth COBRA-TF (CTF) User's Group Meeting - CTF-6

Oak Ridge, TN, USA
May 13-14, 2019

Hosted by Oak Ridge National Laboratory and Argonne National Laboratory
USA

Announcement and Proposed Program

Sponsorship

The sixth COBRA-TF (CTF) User's Group (UG) Meeting (CTF-6) will be held on May 13-14, 2019 in Oak Ridge National Laboratory (ORNL) and is a follow-up of the previous CTF UG meetings. The CTF-6 meeting will be held in conjunction with other meetings/workshops, in order to facilitate co-ordination and sharing of work. Six other meetings are being held in Oak Ridge, TN, USA 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 13 – May 14, 2019* – Fifth OECD/NEA Sodium Fast Reactor (SFR) Uncertainty Analysis in Modelling (UAM) benchmark meeting (SFR-UAM-5);
- *May 14 (afternoon), 2019* – First benchmark meeting on OECD/NEA PHWR Thermal-Hydraulics (PHWR-TH-1);
- *May 15 – May 16, 2019 – Thirteen OECD/NEA Light Water Reactor (LWR) Uncertainty Analysis in Modelling (UAM) benchmark meeting (LWR-UAM-13);*
- *May 15 - May 16 (morning), 2019* – First benchmark meeting on OECD/NEA Multi-Physics Pellet Clad Mechanical Interaction Validation benchmark (MPCMIV-1);
- *May 16 (afternoon) – May 17, 2019* - Fourth OECD/NEA Time-Dependent Neutron Transport (C5G7-TD) benchmark meeting (C5G7-TD-4);
- *May 17, 2019* - Kick-off meeting on OECD/NEA TVA Watts Bar 1 (WB1) Multi-Cycle Multi-Physics benchmark (TVA WB1).

In conjunction with the CTF-6 meeting a hands-on CTF training session will be conducted on Wednesday morning, May 15, 2019. CTF is a thermal-hydraulics subchannel and nuclear fuel modelling software package developed and maintained by Oak Ridge National Laboratory and North Carolina State University (NCSU). A hands-on training session will be provided to introduce users to its capabilities through a series of example application problems. Code access will be provided to students prior to the training by the Reactor and Fuel Management Group of NCSU. Instructions will be provided for installing the software on the student's personal computer. The course will instruct students how to build models of LWR geometry using the modernized CTF input. A portion of the training session will also be spent using the CTFFuel interface, which allows the user to model a single nuclear fuel rod and offers more control over fuel rod boundary conditions and modelling options. The training session will be performed with the latest code version CTF 4.0, which will be distributed by NCSU to the user group in advance of the training. The students will have to satisfy export control requirements to obtain the code. The code access will be handled by NCSU.

Tours of ORNL facilities will also be offered including:

- ORNL Reactors Tour including the historic Graphite Reactor, the world's first continuously operated nuclear reactor that is now a historical landmark as well as the High Flux Isotope Reactor (HFIR), the world's most powerful thermal neutron irradiation reactor.

- ORNL Irradiated Fuels Examination Laboratory with hot cells were active post irradiation examinations are ongoing for high burnup LWR fuel as well as TRISO fuel from the Advanced Gas Reactor campaign.
- ORNL Leadership Class Computing Facility including Summit, the world's most powerful supercomputer, as well as TITAN, formerly the world's most powerful, which is now ranked in 9th place. Participants will also visit state of the art data visualization facilities.

The weeklong events are sponsored by ORNL, especially through the ORNL Nuclear Resources – Analysis and Modelling Portfolio (ONRAMP) as well as the US Department of Energy, Office of Nuclear Energy. Bradley T. Rearden from ORNL is the local event host.

Background and Purpose of 6th CTF User's Group Meeting

COBRA-TF is a thermal-hydraulic simulation code designed for 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 (NRC). 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 the North Carolina State University (NCSU) in cooperation with ORNL. In the last decade, CTF has been extensively validated for Pressurized Water Reactor (PWR), Boiling Water Reactor (BWR), 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 (Q&A) procedures and documentation of CTF. Modifications and validation of CTF to analyze advanced reactors such as Molten Salt Reactor (MSR) designs and Sodium Fast Reactor (SFR) designs as well as spent fuel pools and dry storages is underway. As a result, CTF has become state-of-the-art sub-channel code for reactor thermal-hydraulics bundle and core analysis.

CTF have been distributed under code and collaboration agreements/licenses to different organizations, which resulted in further improvements, modifications, verification & validation activities and applications. The CTF has been 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). As part of the CASL program CTF is being jointly developed by ORNL and NCSU. CASL mission is to provide leading edge modeling and simulation capabilities to improve the performance of currently operating LWRs. Within CASL, CTF has become an important component of VERA, a "Virtual Environment for Reactor Applications", Core Simulator (CS) – VERA-CS. Recently one of the U.S. Department of Energy (DOE) Awards for U.S. Advanced Nuclear Technology Projects entitled "Modeling and Analysis of Exelon Boiling Water Reactors (BWRs) for Eigenvalue & Thermal Limits Predictability" involves further development and application of VERA-CS, including CTF, to BWRs.

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 Prof. M. Avramova, 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 the CASL program, the NURESAFE program and other activities (from other organizations) 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 GITHUB to be accessible by all members of CTF UG. The code can be run in serial or parallel modes and is being 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-6 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). The meeting will be conducted following the agreements reached at the CTF-1 meeting to have one annual meeting of the CTF UG to present, discuss and coordinate activities related to CTF.

Scope and Technical Content of the Meeting

The topics to be addressed at the workshop include:

- Review of the CTF UG activities after the CTF-5 meeting;
- Discussion of status and recent additions to the CTF UG – activities, coordination, code agreements/licenses, export control requirements, code distribution, etc.;
- Discussion on updates of the common CTF version, GITHUB access, source control, maintenance, testing, etc.;
- Discussion on updates of coding guidelines and Software Quality Assurance Requirements for CTF;
- 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 CTF model improvements/additions;
- Discussions of using high-fidelity models to inform low-fidelity models in CTF;
- Overview of CASL activities with CTF;
- Overview of EC activities with 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;
- Discussion of multi-physics and multi-scale activities involving CTF;
- 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

The participation in the meeting is open to all former, current and future developers and users of COBRA-TF (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-6 meeting and to draw up the final program, etc. The members of the Program Committee are:

Robert Salko – *Co-Chair, Local Host, and Coordinator of CASL CTF activities*
Oak Ridge National Laboratory

Maria Avramova – *Co-Chair and Coordinator of CTF UG*
North Carolina State University, USA

Alessandro Petruzzi
NINE S.r.l., Italy

Oak Ridge National Laboratory, 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-6 meeting is English.

Proceedings of the Meeting

A summary of the CTF-6 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-6 meeting.

Contacts and Registrations

A common registrations webpage is made available for the participants of the SFR-UAM-5, CTF-6, PHWR-TH-1, LWR-UAM-13, MPCMIV-1, C5G7-TD-4, and TVA WB1 workshops:

https://onrampmeetings.ornl.gov

Inquiries about registrations can be directed to:

Brad Rearden
ORNL
reardenb@ornl.gov

Robert Salko
ORNL
salkork@ornl.gov

Please send the titles and authors of your presentations for CTF-6 meeting to Maria Avramova – mnavramo@ncsu.edu

For registration in CTF hands-on training session on Wednesday morning - May 15, 2019 please contact Maria Avramova – mnavramo@ncsu.edu and Robert Salko - salkork@ornl.gov

Workshops' Location

The meeting place for the seven workshops during the week of May 13-17, 2019 is the ORNL Conference Canter at ORNL.

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

https://onrampmeetings.ornl.gov/lodging/

The programme and schedule of the meetings is shown below:

	Monday May 13			Tuesday May 14			Wednesday May 15			Thursday May 16			Friday May 17	
Location/ Time	TN A	TN B	Tours	TN A	TN B	Tours	TN A	TN B	Tours	TN A	TN B	Tours	TN A	TN B
8:30 AM	Opening Plenary			SFR-UAM-5	CTF-6		LWR-UAM-13	MPCMIV-1		LWR-UAM-13	MPCMIV-1		TVA WB1	C5G7-TD-4
9:00 AM	SFR-UAM-5	CTF-6												
10:30 AM	Coffee Break													
10:45 AM	SFR-UAM-5	CTF-6	IFEL	SFR-UAM-5	CTF-6	IFEL	LWR-UAM-13	MPCMIV-1	IFEL	LWR-UAM-13	MPCMIV-1	IFEL	TVA WB1	C5G7-TD-4
12:00 PM – 1:00 PM	Lunch													
1:00 PM	SFR-UAM-5	CTF-6	Reactors	SFR-UAM-5	PHWR-TH-1	OLCF	LWR-UAM-13	MPCMIV-1	Reactors	LWR-UAM-13	C5G7-TD-4	OLCF	TVA WB1	C5G7-TD-4
2:30 PM	Coffee Break													
2:45 PM	SFR-UAM-5	CTF-6	Reactors	SFR-UAM-5	PHWR-TH-1		LWR-UAM-13	MPCMIV-1	Reactors	LWR-UAM-13	C5G7-TD-4		TVA WB1	C5G7-TD-4
6:00 PM - 9:00 PM	Welcome Reception													

IFEL: ORNL Irradiation Fuels Examination Laboratory

OLCF: ORNL Leadership Computing Facility

Reactors: Historic Graphite Reactor and High Flux Isotope Reactor

Please note that the CTF hands-on training session will be conducted on Wednesday morning - May 15, 2019.

ANNEX 1

Sixth COBRA-TF User's Group Meeting (CTF-6)

Host Organization
Oak Ridge National Laboratory (ORNL)
Oak Ridge, TN, USA

May 13-14, 2019

PROPOSED PROGRAM

CT01-27: Session code

Day 1: May 13, 2019

CT01. Introduction and opening remarks

CT02. Review of the CTF User's Group activities after the CTF-5 meeting – M. Avramova, NCSU

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

CT04. CTF CASL updates – R. Salko

CT05. Implementation of two-phase species transport modeling into CTF for modeling of MSRs – Z. Taylor

CT06. Hi2Lo reconstruction models and capabilities in CTF and CTFFuel

CT07. Updates on residual formulation implementation in CTF and associated verification studies.

CT08. Presentations on recent uncertainty quantification studies of CTF.

CT09 Implementation of a transient DNB model into CTF – X. Zhao

CT10 Applications of physics-informed machine learning for predictions of CHF - X. Zhao

CT11. Other presentations on CTF model developments and improvements/additions.

CT12. Presentations on coupling CTF with system thermal-hydraulics models.

CT13. Presentations on CFD informed models for CTF.

CT14. Improvements to CTFFuel for modeling depletions in VERA – J. Hu

CT15 Other presentations on CTFFuel

CT16. Summary of GRS activities with CTF – Y. Perin, GRS

Day 2: May 14, 2019

CT17. CTF modifications and applications to PWRs.

CT18. CTF modifications and applications to BWRs.

CT19. CTF modifications and applications to VVERs.

CT20. CTF modifications and applications to SMRs.

CT21. CTF modifications and applications to research reactors.

CT22. CTF modifications and applications to SFRs and MSRs.

CT23. Presentations on CTF applications to solving industry challenge problems.

CT24. Presentations on multi-physics and multi-scale activities involving CTF.

CT25. Presentations on CTF efficiency improvements and parallelization.

CT26. 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 as well as design and safety applications.

CT27. Defining a work plan and schedule for CTF UG activities.