**Kick-off Meeting of the WGAMA Task Group on MCCI State-of-the-Art Report**  
*10 April 2012, NEA Headquarters, Issy-les-Moulineaux*

**A. Welcome, opening remarks**

The Task Group Chairman, Jean-Michel Bonnet of IRSN, welcomed the participants for this kick-off meeting and invited them to introduce themselves.

**B. Approval of the Agenda**

The proposed agenda (see Appendix 1) was agreed upon without changes.

**C. MCCI SOAR Task Description**

Jean-Michel Bonnet provided an update on the MCCI SOAR task which was approved by CSNI as WGAMA task in December 2011. He addressed its objectives, scope, justifications and its safety significance as well as the outline of the report and the milestones associated to its preparation.

Jean-Michel Bonnet explained the reasons for delaying the kick-off meeting (as compared to the date given in the CAPS) and noted that JAEA and JNES are interested to join the task; he underscored that the participation is of course open to other organizations who would like to contribute.

To a question whether the report would be restricted or public, the NEA Secretary answered that all CSNI reports are public and as such the MCCI SOAR will be publicly available. Further, the participants discussed the availability of the experimental results. It was noted that the results of the MCCI Project will be public by the time of publication of the SOAR but the question has to be addressed for the results of European tests that has not been yet published. Regarding the ongoing CCI-7 test, Kresna Atkhen noted that this would be a matter of discussion between the partners of this program and did not exclude that the test or at least the main results would be opened.

**D. Presentation of existing documents**

Jean-Michel Bonnet recalled the 1995 European MCCI State-of-the-Art Report which summarized the work performed between 1990 and 1994 in the frame work of Nuclear Fission Safety Project 5 “Molten corium/concrete interaction”. The report included two parts dedicated to (i) Molten Corium Concrete Interaction and (ii) Ex-Vessel Corium Coolability and Core Retention Devices (See Appendix 3). Jean-Michel Bonnet underscored the importance of this document as providing the history of the MCCI issue and its treatment from the 1980’s to the middle of the 1990’s.

Further on, Michel Cranga updated the participants on the status of the ongoing SARNET MCCI State-of-The-Art Report. He noted that the work is being performed within SARNET 2, 2009-2013, Work package 6. It was noted that most of the authors of the report belong to the WGAMA Task Group on MCCI SOAR. Michel Cranga presented in detail the content of the SARNET MCCI SOAR as well as the Chapter coordinators and the Section authors. He noted that the report is being completed and that a first complete draft should be available at the end of April 2012.
**E. Discussion on the WGAMA MCCI SOAR content**

The participants discussed the initial content of the WGAMA MCCI SOAR in terms of additional information to include as compared to the existing documents mentioned above, clarification of section area and level of detail expected, and review and approval of the document.

The initial outline of the report consists of two main parts:

- The first part includes the following sections (1) a description of the accident phenomenology and introduction to the main phenomena involved; (2) significant outcome of major corium concrete interaction experiments performed in the world since the 1980s, including ex-vessel molten core coolability experiments; (3) major simulation tools currently used in the world focusing on models currently applied to describe the main phenomena involved; (4) status of model and code validations produced by recent activities, evaluation of model uncertainties.

- The second part includes the following sections (5) plant application in dry cavity situation focusing on the assessment of basemat melt-through; (6) Plant application in wet cavity situation focusing on the assessment of melt coolability as a containment failure risk mitigation perspectives for Gen III but also as back-fit, as appropriate and applicable, for Gen II; (7) open issues, conclusions and recommendations.

Regarding the items to be considered or discarded, the participants agreed on how to consider the experiments, the models, the simulation tools and the reactor applications as described in the Appendix 4 as result of this discussion. In particular, they discussed the scaling issue which is very important for AREVA, noting that emphasis may be put on specific items according the information availability. Regarding the models, Christophe Journeau advised to justify why we are using 0D models and why CFD models are not widely used. It was also clarified that PSA Level 2 tools would not be discussed in details within the reactor application. In addition, Sudhamay Basu suggested to discuss melt fragmentation and also to consider fission product release during MCCI. For reactor applications Jean-Michel Bonnet recalled the importance underlined by WGAMA to provide guidelines to apply simulations tools not only for ideal cases but also for different real plant geometries including the possibility for example to have partial spreading in adjacent rooms as a consequence of a fast radial ablation. Jean-Michel Bonnet suggested to revisit these topics during the preparation of the report according to the material available.

As for the restriction on the scope and in particular for the phenomenology and models, the participants agreed that (i) existing core catcher designs will be described but not all the relevant phenomena detailed; (ii) for model description : report will focus on corium concrete interaction and corium coolability mechanisms (direct contact between corium and coolant…); (iii) phenomenology for corium spreading, aerosol fission product release and behavior or two phase flow (debris coolability, vessel – plate - tube CHF…) would not be detailed; (iv) for reactor applications different NPP types with different pit geometries and accident scenarios would be considered.

In general, it was agreed that the material prepared within SARNET would be provided and considered in the preparation of the present report.
In Section 2, a specific item on AREVA experiments focused on the behavior of refractory material during MCCI will be included. Also a sub-section addressing experiments dedicated to physical and chemical properties measurements will be added. In addition, it was agreed to consider as much as feasible an exhaustive list of real material and for simulant material to focus on experiments currently used for model validation.

In Section 3, it was recalled to add a sub-section justifying why we are using 0D models and why CFD models are not widely used. In addition, it was agreed to add a sub-section on thermo-physical and thermodynamic material properties.

In Section 4, the issue of scaling was again discussed in terms of extrapolation of correlations obtained at small scale to reactor scale; it was agreed to address it also in this section. Furthermore, the participants agreed to add also a sub-section on “Properties” and finally discussed whether code validation could be merged within Section 3. However, the risk of unbalanced report sections should be considered in this case.

The last 3 sections have been discussed more rapidly as they will be considered in a second time.

Section 5 is dedicated to plant application focusing on the assessment of basemat melt-through. It was recommended to address in this section not only dry situation but both initially dry and initially wet cavities to consider the different geometries and accident management procedures that we can find for existing plants. Also, Sections 5 and 6 may be considered all together later in the first draft.

In Section 6, it was agreed to address plant application focusing on the assessment of melt coolability as a containment failure risk mitigation perspectives for Gen III but also as a back-fit, as appropriate and applicable, for Gen II. Core catcher concept as well as the way to consider simultaneous refractory material- / concrete-corium interaction will be considered in this Section.

It was agreed that the NEA Secretariat would create a Task Group web page, password protected, in order to allow the task members to exchange and to follow the progress of the activity.

F. Distribution of the work

The distribution of the coordination and writing of the different sections as well as the deadlines were discussed with focus on Sections 1 through 4. However, the participants anticipated and addressed also the last three sections expected to be prepared between November 2012 and May 2013.

- Section 1 will be coordinated by Fernando Robledo, with contributions from Christophe Journeau, Mitchell Farmer, Sudhamay Basu and Kresna Atkhen (SAMG safety issues). The deadline is first week of September 2012.

- Section 2 will be coordinated by Mitchell Farmer, with contributions from Christophe Journeau, (contribution from SARNET by early May 2012), André Fargette and JAEA for COTELS, Sudhamay Basu and Kresna Atkhen (SAMG safety issues). The deadline is first week of September 2012.
- Section 3 will be coordinated by Michel Cranga, with contributions from Claus Spengler (ASTECD-MEDICIS), André Fargette and Manfred Fischer (on specific COSACO model), Sudhamay Basu (for US contribution MELCOR-CORCON and CORQUENCH), Jerzy Foit (WECHSL). Christophe Journeau (for TOLBIAC) and JNES/JAEA (for COCO). The possibility to consider a Russian MCCI module of SOCRATE has to be checked. A template will be provided by Mitchell Farmer and will be followed by the authors of this section. The deadline is first week of September 2012.

- Section 4 will be coordinated by Claus Spengler (to be confirmed), with contributions of Christophe Journeau on the properties, AREVA on the scaling issue, Sudhamay Basu (US contribution) and Michel Cranga on the interface model. A validation matrix template will be provided by the Coordinator and will be followed by the authors of this section. The deadline is first week of September 2012.

- Section 5 will be coordinated by Kresna Atkhen, with contributions from Michel Cranga, Sudhamay Basu, Fernando Robledo, AREVA, Sudhamay Basu, Mitchell Farmer, Claus Spengler, Jerzy Foit and JNES/JAEA. The deadline is May 2013.

- Section 6 will be coordinated by Manfred Fischer or by Jerzy Foit (to be confirmed), with contributions from Kresna Atkhen, Michel Cranga, Mitchell Farmer and Fernando Robledo (based on Raj Sehgal’s material). The deadline is tentatively fixed at May 2013.

- Section 7 will be coordinated by coordinated by Jean-Michel Bonnet with Sudhamay Basu’s support and contribution by all the participants. This section will be written after the second and third meetings, i.e., after May 2013.

G. Validation of milestones and next steps

The next steps were agreed as follows:

- Status report to WGAMA in September 2012;

- Second meeting after preparation of the 4 first sections the 8 (or 9) November 2012 in connection with SERENA seminar (5-6-7 of November);

- Third meeting after the 3 last sections, end of May 2013;

- Distribution to WGAMA members for review and comments by early September 2013; presentation to WGAMA and request for external review;

- External review from October 2013 to December 2013;

- Revision and edition of the final version; March 2014;

- Submission to PRG/CSNI in April/June 2014.

K. Closure of the meeting

The Chairman closed the meeting 6:30 p.m. and thanked the participants for their active participation and valuable input.
Appendix 1

WGAMA Task Group Kick-off Meeting on MCCI SOAR

10 April 2012

NEA Headquarters, Meeting Room A, 12, Boulevard des Iles, 92130 Issy-les-Moulineaux

Tentative Agenda

10 April 2012 - Meeting Start at 13:30

1. Opening:
   1.1 Welcome by the report coordinator and NEA secretary
   1.2 Approval of the Agenda

2. MCCI SOAR description
   2.1 Objectives and rationales
   2.2 Description of the main sections
   2.3 Milestones

3. Presentation of existing documents
   3.1 Recall of 1995 European MCCI state of the art report
   3.2 Status of ongoing SARNET MCCI state of the art report

30 minutes for coffee break

4. Discussion on report content
   4.1 What additional information when we compared with existing documents?
   4.2 Clarification of section area and level of detail expected
   4.3 Approbation of document content

5. Distribution of writing activities
   3.1 Focus on the first 4 sections (phenomenology, experiments, simulation tools, status of models and codes validation): April 2012 - October 2012
   3.2 Needs for anticipation regarding the last 4 sections (plant applications for wet and dry cavities, open issues and recommendations): Nov. 2012 – May 2013

6. Validation of milestones

7. Closure of the meeting around 18:30
Appendix 2
List of participants

FRANCE

Mr. Kresna ATKHEN
EDR - R&D
MFEE – 181
6 Quai Watier
78401 CHATOU
Tel: +33 (0)1 30 87 91 29
Fax: Email: kresna.atkhen@edf.fr

Mr. Jean-Michel BONNET
Head of Severe Accident Department
IRSN/PSN/SAG
BP3, Centre de Cadarache, bat 702
13115 St Paul-lez-Durance CEDEX
Tel: +33 (0)4 42 19 94 96
Fax: +33 (0)4 42 19 91 67
Email: jean-michel.bonnet@irsn.fr

Mr. Michel CRANGA
Severe Accident Department
IRSN/PSN/SAG
Centre de Cadarache - Bâtiment 702
B.P. 3
F-13115 ST. PAUL LEZ DURANCE CEDEX
Tel: +33 (0)4 42 19 94 96
Fax: +33 (0)4 42 19 91 67
Email: Michel.cranga@irsn.fr

Mr. Christophe JOURNEAU
CEA Cadarache
DTN/STRI/LMA
F-13108 St Paul les Durance
Tel: +33 (0)4 42 25 41 21
Fax: +33 (0)4 42 25 77 88
Email: christophe.journeau@cea.fr

GERMANY

Mr. André FARGETTE
AREVA NP GmbH
Paul-Gosson Strasse 100,
D-91052 Erlangen
Tel: +49 9131 900 93348
Fax: Email: andre.fargette@areva.com

Spain

Mr. Fernando ROBLED0
Senior Expert on Severe Accident
Consejo de Seguridad Nuclear
CL. Pedro Justo Dorado Dellsmans 11
E-28040 Madrid
Tel: +34 91346 0249
Fax: +34 91346 0496
Email: frs@csn.es
USA

Mr. Sudhamay Basu
U.S. Nuclear Regulatory Commission
11545 Rockville Pike
Rockville, Maryland 20852
Tel: +1 301 251 7521
Fax: +1 301 415 5160
Email: sudhamay.basu@nrc.gov

Mr. Mitchell FARMER
Reactor Engineering Division
Argonne National Laboratory
NE Building 206
9700 S. Cass Avenue
Argonne, IL 60439
Tel: +1 630 252 4539 / 4758
Fax: +1 630 252 6080
Email: farmer@anl.gov

INTERNATIONAL ORGANISATIONS

OECD/NEA

Mr. Abdallah AMRI
OECD-NEA / Nuclear Safety Division
Le Seine St-Germain
12 bd des Iles
F-92130 ISSY-LES-MOULINEAUX
Tel: +33 1 45 24 10 54
Fax: +33 1 45 24 11 29
Email: abdallah.amri@oecd.org
Appendix 3

Content of 1995 European MCCI State-of-the-Art Report

Part A: Molten Corium Concrete Interaction
- Main Objectives of MCCI for NPP Safety Analysis: PWR and BWR traditional and advanced
- Review of Experiments on Dry Corium Concrete Interaction
  - BETA, SANDIA Large Scale Experiments (TURC, FRAG, HSS, SURC SWISS, WETCOR), ACE/MACE (M0, M1B)
  - Specific Small Scale experiments (AEA fuel jet on concrete), intermixing of metallic and oxidic melts (Gonzalez, Greene) and Solidus/liquidus Temperatures of Core-Concrete mixtures (Roche experiments)
- Thermal Hydraulic Codes: WECHSL and CORCON Characteristics and validation
- Plant Applications of CORCON/WECHSL: PWR and BWR
- Fission Product Release During MCCI
- Influence of Water: crust formation and debris coolability
- Each chapter includes conclusions and references

Part B: Ex-Vessel Corium Coolability and Core Retention Devices
- Requirements for Reactor Application
- Main Features of Proposed Concepts and Patents
- Corium-Coolant Interaction (FCI) in Corium Retention Systems
- Controlling Debris Dispersal and Fission Product Release
- Advantages and Drawbacks of Some Typical Concepts: flooding the reactor cavity, UO₂/ThO₂ flooded pebble bed, SCORE, Staggered-Pans, Dry Multi-Crucible, COMET, EPR corium spreading, Dry Spreading, multi-layer, COMSORS
- R&D Needs and Recommendations
- Conclusion
- References
- Appendix: Core Catcher Patent List
Appendix 4
Content of the WGAMA MCCI SOAR after discussion

Executive Summary

Section 1
Description of the accident phenomenology and introduction to the main phenomena involved
- 1.1: Pouring phase and debris formation (debris bed – cake => corium pool)
- 1.2: Corium concrete interaction
- 1.3: Melt stabilization
- 1.4: Safety and accident management issues: containment failure (melt through, dynamic loading), source term

Section 2
Significant outcome of major corium concrete interaction experiments performed in the world since the 1980s, including ex-vessel molten core coolability experiments
- List of experiments: Exhaustive list to be considered real material may be but for simulant material just focus on experiment currently used for model validation
- 2.1: Prototypic experiments including also simultaneous refractory-Concrete and corium interactions
- 2.2: Simulant experiments
- 2.3: Learning from technological point of view (heating, measurements…)

In appendix or included with facility description…
Scaling issues volume/surface thickness crust anchoring time ratio… / artefacts identification
- Sub sections: Dry \ wet homogeneous \ stratified pool…
- Experiment dedicated to physical and chemical properties measurements
- Use of templates based on SARNET existing ones to provide synthesis tables

Section 3
Major simulation tools currently used in the world focusing on models currently used to describe the main phenomena involved
- List of codes: CORCON, CORQUENCH, COSACO, MEDICIS, TOLBIAC, WECHSL, COCO, MAAP (DECOMP), SOCRATE (MCCI?)
- 3.0: Why 0D is currently used … / CFD, DNS
- 3.1: General description of codes
- 3.2: Thermal hydraulics models
- 3.3: Models to describe interface or boundary conditions (including refractory behaviour)
- 3.4: Models to describe cooling mechanisms
- Thermo physical properties and thermo dynamic properties
- Use of templates based on SARNET existing ones to provide synthesis tables

Section 4
Status of model and code validations produced by recent activities, evaluation of model uncertainties
- 4.1: Thermal hydraulic
- 4.2: Interface conditions
- 4.3: Cooling mechanisms
- 4.4: Properties
Possibility to consider validation within section 3
Address here the scaling issue way to use correlations obtained at small scale to reactor application (connection to scaling issue in section 2)
Risk $\Rightarrow$ non well balance sections..

Section 5
Plant application in initially dry or wet cavity situation focussing on the assessment of basemat melt-through.
- 5.1 :
- 5.2 :
- 5.3 :
- We could consider section 5 and 6 all together, to be considered later with the first writing
- Or modification of section 5 and 6 perimeters as suggested here

Section 6
Plant application focusing on the assessment of melt coolability as a containment failure risk mitigation perspectives for Gen III but also as a back-fit, as appropriate and applicable, for Gen II
- 6.1 :
- 6.2 :
- 6.3 :
- Section 6 evolution about Gen III, GEN II back-fit and core catcher concept
- Output of simultaneous refractory-concrete corium interaction experiment to be consider here

Section 7
Open issues and recommendations
- 7.1 :
- 7.2 :
- 7.3 :