EUROPEAN COMMISSION
Community Research

SEVENTH FRAMEWORK PROGRAMME

SEVENTH FRAMEWORK PROGRAMME OF Euratom FOR NUCLEAR RESEARCH AND TRAINING ACTIVITIES (2007-2011)

THEME: NUCLEAR FISSION AND RADIATION PROTECTION

Grant agreement for: NETWORK OF EXCELLENCE

Annex I – "Description of Work"

Project acronym: SARNET2

Project full title: "Network of Excellence for a Sustainable Integration of European Research on Severe Accident Phenomenology and Management – Phase 2"

Grant agreement no.: **231747**

Date of preparation of Annex 1: March 11th, **2009**

Date of approval of Annex I by Commission: **2009**

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PART A

A.1 Overall budget breakdown of the project

The table below presents **"estimated"** values of the eligible costs for the whole duration of the network, as well as the corresponding requested EC funding contribution. The actual costs will be evaluated at the end of each period during the lifetime of the network.

A3.2: What it costs

Project Number [1]	231747	Project Acronym [2]	SARNET2

One Form per Project

Participant number in this project [3]	Participant short name	Estimated eligible costs (whole duration of the project)				Total receipts	Requested EC contribution
		RTD (A)	Management (B)	Other (C)	Total A+B+C		
1	IRSN	9,505,773.00	1,060,795.00	161,075.00	10,727,643.00	0.00	1,977,184.00
2	AEKI	199,000.00	0.00	32,000.00	231,000.00	0.00	45,904.00
3	AREVA NP GmbH	171,150.00	0.00	0.00	171,150.00	0.00	16,438.00
4	AREVA NP SAS	99,842.00	0.00	0.00	99,842.00	0.00	7,333.00
5	BME	23,600.00	0.00	0.00	23,600.00	0.00	9,429.00
6	CEA	7,070,908.00	2,500.00	89,022.00	7,162,430.00	0.00	1,051,869.00
7	CESI R	260,000.00	0.00	0.00	260,000.00	0.00	28,335.00
8	CHALMERS	103,334.00	0.00	0.00	103,334.00	0.00	20,295.00
9	CIEMAT	181,421.00	0.00	32,754.00	214,175.00	0.00	35,443.00
10	DEMOKRITOS	185,000.00	0.00	0.00	185,000.00	0.00	11,680.00
11	EDF	258,454.00	0.00	0.00	258,454.00	0.00	19,732.00
12	EI	54,000.00	0.00	0.00	54,000.00	0.00	24,477.00
13	ENEA	451,000.00	0.00	0.00	451,000.00	0.00	46,437.00
14	Jülich	74,736.00	0.00	0.00	74,736.00	0.00	15,398.00
15	FZK	4,648,300.00	1,500.00	44,000.00	4,693,800.00	0.00	670,552.00
16	GRS	1,518,520.00	0.00	192,000.00	1,710,520.00	0.00	287,680.00
17	INR	155,134.00	0.00	0.00	155,134.00	0.00	87,003.00
18	INRNE	154,800.00	0.00	0.00	154,800.00	0.00	77,223.00
19	IVS	142,200.00	0.00	0.00	142,200.00	0.00	50,303.00

A3.2: What it costs

Participant number in this project	Participant short name	Estimated eligible costs (whole duration of the project)				Total receipts	Requested EC contribution
		RTD (A)	Management (B)	Other (C)	Total A+B+C		
20	JSI	554,000.00	0.00	0.00	554,000.00	0.00	75,824.00
21	KTH	1,643,000.00	0.00	207,000.00	1,850,000.00	0.00	296,762.00
22	LEI	108,000.00	0.00	0.00	108,000.00	0.00	24,439.00
23	NNL	114,683.00	0.00	0.00	114,683.00	0.00	9,254.00
24	NRG	79,600.00	0.00	0.00	79,600.00	0.00	4,852.00
25	PSI	855,628.00	0.00	0.00	855,628.00	0.00	75,587.00
26	RUB	134,286.00	0.00	0.00	134,286.00	0.00	11,537.00
27	TRACTEBEL	47,016.00	0.00	0.00	47,016.00	0.00	11,524.00
28	THERMODATA	255,600.00	0.00	0.00	255,600.00	0.00	31,177.00
29	TUS	70,784.00	0.00	0.00	70,784.00	0.00	32,952.00
30	UJD SR	209,040.00	0.00	0.00	209,040.00	0.00	22,000.00
31	UJV	624,243.00	0.00	0.00	624,243.00	0.00	68,758.00
32	UNEW	112,683.00	0.00	0.00	112,683.00	0.00	13,881.00
33	UNIPI	657,802.00	0.00	25,454.00	683,256.00	0.00	71,746.00
34	USTUTT	2,113,984.00	0.00	0.00	2,113,984.00	0.00	220,276.00
35	VEIKI	520,112.00	0.00	0.00	520,112.00	0.00	77,359.00
36	VTT	1,031,404.00	0.00	11,596.00	1,043,000.00	0.00	108,731.00
37	VUJE	117,000.00	0.00	0.00	117,000.00	0.00	26,521.00
38	JRCs	307,840.00	144,123.00	39,974.00	491,937.00	0.00	84,105.00
39	AECL	400,000.00	0.00	0.00	400,000.00	0.00	0.00
40	KAERI	280,000.00	0.00	0.00	280,000.00	0.00	0.00
41	USNRC	1,400,000.00	0.00	0.00	1,400,000.00	0.00	0.00
TOTAL		36,893,877.00	1,208,918.00	834,875.00	38,937,670.00	0.00	5,750,000.00

A.2 Project Summary

Most of the actors involved in severe accident research in Europe, plus Canada, Korea and the United States (41 partners), will network in SARNET2 (Severe Accident Research NETwork of Excellence - Phase 2) their capacities of research in order to resolve important pending issues on postulated severe accidents of existing and future Nuclear Power Plants (NPPs). The project has been defined in order to optimise the use of the available means and to constitute a sustainable consortium in which common research programmes and a common computer tool to predict the NPP behaviour during a postulated severe accident (ASTEC integral code) are developed. With this aim, the SARNET2 partners contribute to a Joint Programme of Activities, which consists of:

- Maintaining and improving an advanced communication tool (developed during SARNET) for accessing all project information, fostering exchange of information, and managing documents;
- Harmonizing and re-orienting the research programmes, and defining new ones;
- Performing experimental programmes on high priority issues, defined during SARNET;
- Analyzing experimental results in order to elaborate a common understanding of relevant phenomena;
- Developing the ASTEC code (including its applicability to all types of European NPPs), which capitalizes in terms of physical models the knowledge produced within SARNET2;
- Developing Scientific Databases, in which all the results of research programmes are stored in a common format (DATANET);
- Developing education courses on severe accidents for students and researchers, and training courses for specialists;
- Promoting personnel mobility amongst various European organizations;
- Organizing yearly a large international conference on Severe Accident research (ERMSAR).

After the first phase (2004-2008), and the four-year proposed second phase, co-funded by the EC, the network will evolve toward self-sustainability: a legal entity will be created.

A.3 List of Beneficiaries

Benef. number	Beneficiary name	Beneficiary short name	Country	Date enter project	Date exit project
1	Institut de Radioprotection et de Sûreté Nucléaire	IRSN	France	1	48
2	KFKI Atomic Energy Research Institute	AEKI	Hungary	1	48
3	AREVA NP GmbH	AREVA NP GmbH	Germany	1	48
4	AREVA NP SAS	AREVA NP SAS	France	1	48
5	Budapest University of Technology and Economics	BME	Hungary	1	48
6	Commissariat à l'Energie Atomique	CEA	France	1	48
7	CESI RICERCA SpA	CESI R	Italy	1	48
8	Chalmers tekniska högskola AB	CHALMERS	Sweden	1	48
9	Centro de Investigaciones Energeticas Medio Ambientales y Tecnologicas	CIEMAT	Spain	1	48
10	National Centre for Scientific Research "DEMOKRITOS"	DEMOKRITOS	Greece	1	48
11	Electricité de France SA	EDF	France	1	48
12	Energy Institute JSC Sofia	EI	Bulgaria	1	48
13	Ente per le Nuove Tecnologie, l'Energia e l'Ambiente	ENEA	Italy	1	48
14	Forschungszentrum Juelich GmbH	JÜLICH	Germany	1	48
15	Forschungszentrum Karlsruhe GmbH	FZK	Germany	1	48
16	Gesellschaft für Anlagen- und Reaktorsicherheit mbH	GRS	Germany	1	48
17	National Autonomous Company for Nuclear Activities Nuclear Research Subsidiary Pitesti	INR	Romania	1	48
18	Institute for Nuclear Research and Nuclear Energy	INRNE	Bulgaria	1	48
19	Inzinierska Vypoctova Spolocnost Trnava s.r.o.	IVS	Slovakia	1	48
20	Jozef Stefan Institute	JSI	Slovenia	1	48
21	Kungl Tekniska Högskolan	KTH	Sweden	1	48
22	Lithuanian Energy Institute	LEI	Lithuania	1	48
23	National Nuclear Laboratory	NNL	UK	1	48
24	Nuclear Research & Consultancy Group v.o.f.	NRG	Netherlands	1	48
25	Paul Scherrer Institut	PSI	Switzerland	1	48
26	Ruhr-Universität Bochum	RUB	Germany	1	48
27	Suez-Tractebel SA	TRACTEBEL	Belgium	1	48
28	Thermodata	THERMODATA	France	1	48
29	Technical University of Sofia	TUS	Bulgaria	1	48
30	Urad Jadroveho Dozoru Slovenskej Republiky	UJD SR	Slovakia	1	48
31	Ustav Jaderneho Vyzkumu Rez a.s.	UJV	Czech Rep.	1	48
32	University of Newcastle upon Tyne	UNEW	UK	1	48
33	Dipartimento di Ingegneria Meccanica, Nucleare e della Produzione - Università di Pisa	UNIPI	Italy	1	48
34	Universität Stuttgart	USTUTT	Germany	1	48
35	VEIKI Institute for Electric Power Research Co.	VEIKI	Hungary	1	48
36	VTT Technical Research Centre of Finland	VTT	Finland	1	48
37	VUJE Trnava, a.s. – Inzinierska, Projektova a Vyskumna Organizacia	VUJE	Slovakia	1	48
38	Commission of the European Communities – Joint Research Centres[1]	JRCs	European Union	1	48
39	Atomic Energy Canada Limited[2]	AECL	Canada	1	48
40	Korea Atomic Energy Research Institute[2]	KAERI	Korea	1	48
41	United States Nuclear Regulatory Commission[2]	USNRC	USA	1	48

[1] EC funds will be directly allocated by the EC
[2] No EC funding requested

PART B

B.1 Concept and Objectives, Long Term Integration, Joint Programme of Activities

B1.1 Concept and project objectives

B1.1.1 Background

The current Nuclear Power Plants (NPPs) existing in Europe, excluding some old Russian design plants, are designed with the principles of defence in depth. In particular, they incorporate a strong containment and engineering systems to protect the public against radioactivity release for a series of postulated accidents. Nevertheless, in some very low probability circumstances, severe accident sequences may result in core melting and plant damage leading to dispersal of radioactive material into the environment and thus constituting a health hazard to the public well beyond the borders of the State where the damaged plant is located.

It is therefore crucial that the best state of knowledge on severe accident phenomenology, qualified computer tools and appropriate methodology should be used uniformly throughout Europe, in order to evaluate the corresponding risks and update former evaluations, taking into account notably the inevitable evolutions in reactor operations (e.g. new type of fuel, higher burn-up, extension of plant life, new generations of reactors). Additional appropriate engineering devices and/or accident management measures may have then to be developed and implemented in order to reduce even more the risks.

In 2004, facing and anticipating budget reductions and seizing an opportunity offered by the European Commission (EC) in the 6th Framework Programme (FP), 49 European organizations[3] involved in research on nuclear safety, have decided to join their efforts in a durable way to resolve outstanding severe accident safety issues for enhancing the safety of existing and future NPPs. Integrating their respective and complementary know-how and spreading out the gained knowledge was the main objective of the Severe Accident Research Network of Excellence SARNET from April 2004 to September 2008. Three more organizations, including a Canadian one joined the network in 2006.

On the one hand, in spite of many major achievements, a limited number of specific issues remain where research activities are still necessary to reduce further uncertainties that are considered of importance for nuclear reactor safety and to consolidate severe accident management plans. Starting from previous work performed in the 5th European FP, one of the achievements of SARNET consisted in obtaining a European consensus on six high priority issues on which research was still considered as necessary. These issues are:

- Core coolability during re-flooding and debris cooling;
- Ex-vessel melt pool configuration during Molten Corium Concrete Interaction (MCCI), ex-vessel corium coolability by top flooding;
- Melt relocation into water, ex-vessel Fuel Coolant Interaction (FCI);
- Hydrogen mixing and combustion in containment;
- Oxidising impact on source term (Ruthenium oxidising conditions/air ingress for High Burn-up and Mixed Oxide (MOX) fuel elements);
- Iodine chemistry in Reactor Coolant System (RCS) and in containment.

On the other hand, one aim of this previous network was to become self-sustainable, it is to say to be operational without EC funding. After four years and a half of operation, significant progress toward this self-sustainability have been achieved (courses, conferences, etc…), but, considering that industries have no real willingness in supporting this type of research which does not produce direct benefits, some more time is necessary before really reaching this self-sustainability.

[3] including research organizations, technical safety organizations (TSOs), industry, utilities and universities

The remaining research work to be performed and the time still necessary to reach a real self-sustainability of the network justify the present proposal of a SARNET follow-up for a four-year duration in the SARNET2 project.

B1.1.2 Objectives of SARNET2

The SARNET2 general objectives, in the streamline of the SARNET objectives, but with special emphasis on some specific points, are defined as follows:

- Tackle the fragmentation existing in defining/carrying out research programmes among the different countries;
- Spread more efficiently the knowledge to the stakeholders, especially in the new European Union (EU) countries more efficiently, and associate them to the definition and the conduct of the research programmes more closely;
- Bring together top scientists in severe accident research so as to be THE world leader in advanced computer tools for severe accident risk assessment in NPPs;
- Perform significant progress towards the closure of the remaining high priority research issues in the domain of severe accidents;
- Establish a self-sustaining organization in the field of severe accident research through activities in networking, integration, knowledge management, exchange of information, dissemination of results and training in order to keep the competence in severe accident management alive in Europe.

B1.1.3 Concepts of SARNET2

The SARNET2 Consortium will be constituted by most of the research capacities and expertise in severe accident from 41 organizations, coming from 17 EU Member States (Belgium, Bulgaria, Czech Republic, Finland, France, Germany, Greece, Hungary, Italy, Lithuania, the Netherlands, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom), from Switzerland, the United States, Canada, Korea, plus two Joint Research Centres of the European Commission (IE/Petten, ITU/Karlsruhe). The list of the participating organizations is provided in Table A.3. The active participation of the research community and users (industry and regulators) within the project will allow to better meet the objectives of the project.

SARNET2 will be organized in 8 work-packages (WPs) (see Chapter B1.3, Table 1) to fulfil its general objectives: Management, Spreading of Excellence, Information Systems, ASTEC, Corium and Debris Coolability, Molten Corium Concrete Interaction, Containment, Source Term.

Besides its role of direct link with the EC, for technical, administrative and financial matters, the network management will coordinate the knowledge generation through joint projects of research activities, monitoring integration in ASTEC, making sure that access rights are correctly implemented, disseminating appropriate information, preserving the knowledge in scientific databases, and identifying the missing knowledge. These actions will be decided and controlled by a Steering Committee of 10 SARNET2 representatives assisted by appropriate advisory capacities. In addition, an annual General Assembly will allow information and consultation of all the SARNET2 partners.

To be sure that the research conducted on severe accident is efficient and well focused, the SARNET Severe Accident Research priority (SARP) work will be updated, evaluating the most recent experimental results and taking into account the remaining safety issues, as those highlighted by Level 2 PSA studies as being of high priority for reducing uncertainties (link between SARNET2 and the ASAMPSA2 Project in FP7). These evaluation activities will be conducted in close relation with the work performed both in existing international organizations - mainly the OECD/NEA/CSNI Group on Analysis and Management of Accidents (GAMA) and the International Science and Technology Centre (ISTC) Projects – and in the Sustainable Nuclear Energy Technology Platform (SNE-TP). Close links will be kept with international programmes such as Phebus FP and the International Source Term Programme (ISTP), in particular through some joint interpretation circles with SARNET2.

In parallel, actions will be taken for training students and researchers in experimental techniques, in risk evaluation and in code mastering and assessment, and for facilitating their mobility into the corresponding teams. Periodic conferences will be organized too, in order to better share at the

international level, the knowledge gained through SARNET2. Also in this "education and training" field the activities will be conducted in close relation with existing European organizations as ENEN.

The extensive use of the "Advanced Communication Tool" and of the "DATANET" experimental database developed in SARNET to facilitate the capitalization and the diffusion of knowledge, and the joint execution of research activities together with reducing rapidly the number of meetings and amount of travels, will be pursued in SARNET2. The current external SARNET WEB site will be developed for an easier and more convivial use and public information outside of the SARNET2 community.

The integral severe accident analysis code ASTEC will provide the backbone of the integration. Indeed, the past efforts by IRSN and GRS on this code and the enhancement of these efforts thanks to its use by most of the SARNET participants have brought the code to an international acknowledgment level. In SARNET2, actions are proposed to continue to integrate into ASTEC the current and future knowledge. In addition, the code adaptation, including specific model validation, so as to be used for all types of existing water-cooled reactors in Europe will be pursued. IRSN and GRS will go on to provide the necessary capacity for maintenance, training and developments for satisfying the network users.

The scientific research will be organized in four WPs: Corium and Debris Coolability; Molten Corium Concrete Interaction; Containment; Source Term. These four WPs cover the six high level priorities issues as defined within the SARNET/SARP. In addition to the networking activities, experimental programmes to be developed and implemented in the frame of SARNET2 are proposed. Two major experimental programmes will tackle two key priority issues identified in SARNET/SARP: in-vessel degraded core coolability and/or ex-vessel corium coolability; corium interaction with concrete. More than half of the SARNET2 grant will be devoted to these research programmes. In the four WPs, interpretation and benchmarking activities will make the best use of existing and future experimental results, up to the development of models and their validation in the ASTEC simulation tool. The interpretation circles already working on the results of experimental programmes, in particular Phebus FP, International Source Term Programme (ISTP) and ISTC projects will be further integrated into the SARNET2 community.

To better ensure the self-sustainability of the network after the four-year period of the SARNET2 Project, the fund distribution to the partners will be managed on a strongly decreasing basis. About one third of the funds will be granted to the partners for the first year, reaching about one fifth of the funds for the last year.

Finally, note that the harmonization of the Probabilistic Safety Assessment of level 2 (PSA2) which was part of SARNET is not considered anymore in SARNET2 as a specific project (ASAMPSA2) has been put in place following the first call for proposals of the EC in the frame of the 7th FP. Direct links with this project will be maintained, mainly for contributing to the definition of the ASTEC code requirements and of the research priorities as regards PSA2 needs.

B1.2 Long Term Integration

The ultimate objective of the integration of the research is to form a "virtual centre of excellence" based on national resources, know-how and expertise, and having a strong coordinating structure. This centre of excellence will have the mission to carry out the commonly agreed research programmes in an optimised way in order to resolve remaining safety issues and produce highly validated and qualified tools for Level 2 PSA studies for any kind of NPP in Europe.

In the first step, already achieved in the frame of SARNET, the execution of the Joint Programme of Activities allowed a progressive re-orientation of the existing national programmes and contributed to launch new ones in a more coordinated way and in accordance with the research priorities identified by the network, eliminating duplications and developing complementarities. Thanks to the acknowledged weight of SARNET, this re-orientation of programmes already applies and will still apply within SARNET2 to programmes out of the European Union (Russian ISTC projects, OECD/NEA projects, etc…).

The complete integration of the experimental research capacities is necessarily more progressive. The main obstacle to the integration is the need to increase funding at national and extra-national levels in order to support the cost of the experimental programmes, notably in case of large ones. A clear policy in

terms of access rights to the experimental data produced within the network is proposed to preserve the interests of the different organizations. Progress reports on restricted experimental programmes were widely disseminated in the frame of SARNET in order to promote extension of existing collaborations within other members of the network. It will be done again in the frame of SARNET2.

Beyond the four-year duration of the SARNET2 project, the long-term duration of the network will be ensured by the creation of a legal entity which will allow to the partners to work together in a legally organised structure. The creation of this legal entity will constitute one of the major goals of SARNET2 at the Management (coordinator) and at the Steering Committee level. The foreseen steps – that will be more detailed after some months of operation of SARNET2 – are given in § B1.3.5 (description of WP1.3 in Management WP1).

Within this legal entity, the objective will be to reach the "virtual centre of excellence" where the strong coordinating structure for work orientation could be the follow-up of the SARNET2 Steering Committee. The availability of most severe accident competencies will in particular allow a progressive extension of the activities to the new Generation IV of reactors.

B1.3 Joint Programme of Activities

B1.3.1 Overall strategy and general description

In the streamline of SARNET, the SARNET2 activities will consist of:

- the R&D activities carried out by SARNET2 members in the frame of national or international programmes, contributing to the resolution of remaining issues identified in the SARNET Network of Excellence (NoE);
- a programme jointly carried out, called Joint Programme of Activities (JPA) aiming at:
  - pursuing the integration of the above national/international research programmes (already well improved by SARNET);
  - initiating and launching new programmes jointly carried out by sustainable research groups, including experimental work co-funded through SARNET2;
  - going on to jointly analyze and interpret the available experimental results and capitalize the acquired knowledge into the experimental DATANET database and into the integral simulation code ASTEC;
  - disseminating the knowledge.

This JPA will constitute the kernel of SARNET2. Such activities will give the orientations to be followed, in terms of research and work distribution among the SARNET2 members. They will build the necessary links between national programmes, facilitate the necessary transfers of information (inside and outside the network), and organize the work partition in order to make the best use of available competences and means.

The **Management** sub-work-packages are: Coordination, Administration and Budget; Integration Assessment; Severe Accident Research Priorities. So, the **assessment of progress and results** will be followed at the Management level. The R&D needs will be periodically updated and the objectives of future experiments will be defined taking into account the outcome of the R&D, of the risk studies (links with the PSA2 specialists) and the advices of the industry and utilities. In a continuity of what was done in SARNET, a consensus could be reached on closure of some further research issues and would allow redistributing again competence and manpower on the few open ones in concert with other international projects (e.g. ISTC, OECD…).

The Spreading of Excellence work-package will allow to disseminate the knowledge in the severe accident field to young researchers and students by an education and training programme and through mobility grants. It will allow the general spreading of the gained knowledge through the organisation of periodic ERMSAR conferences which are becoming the major worldwide conference on severe accident research.

The Information Systems work-package includes the external SARNET2 WEB site, the Advanced Communication Tool (ACT) and the Experimental Database. These tools are essential elements for giving information to the general public, for making easier the communication between the Coordinator and all

the participants and reducing the number of meetings, and for having a standard common experimental database system. So, it largely contributes both to the spreading of excellence, and to the integration of the research work.

The ASTEC code will remain the major integrating component and will be one of the repository places of the knowledge. Through its numerous users, it will contribute to the diffusion of this knowledge efficiently.

Concerning the last four research WPs, they have strong links with ASTEC, as it is one of their ultimate goals to provide physical models to be integrated into ASTEC. Furthermore, the exchange of information on the detailed models developed by the various experts through interpretation of experiments will lead at medium and long term to generic common models used first in the different detailed codes (e.g. ICARE/CATHARE and ATHLET-CD). Then, adequate models will be derived from these detailed models and they will be included into the common reference ASTEC code.

More generally, all the JPA elements are interlinked: for instance, experimental work and subsequent interpretation with models/codes in WPs 5 and 6, experimental database activity in WP3, ASTEC development in WP4 and dissemination of results through the ERMSAR Conferences in WP2. This will contribute to tighten the links between the different participants to these activities (horizontal integration).

The R&D activities surrounding the JPA and connected to it are mainly:
- the IRSN-GRS programme aiming at developing the integral code ASTEC and making it open and available for all SARNET2 partners,
- the diverse national research activities (experimental programmes, related interpretation and modelling activities on national basis or on specific international agreements, e.g. Phebus FP, ISTP, ISTC Projects, OECD Projects, etc…) that aim at resolving open issues identified as important and of common interest in SARNET/SARP conclusions.

These key programmes will be called associated programmes.

The JPA will clearly constitute the active link connecting all these associated programmes plus the experimental programmes (mainly on MCCI and Coolability) included in the SARNET2 JPA, and making, in a sustainable way, the whole system more and more efficient. It will be a priority task of the Consortium to define the way to associate or integrate these programmes and the involved teams, when they are in a position to complement in a sustainable way the competence and expertise of SARNET2 in domains of importance.

They are described below in order to give the boundary conditions of the JPA, main component of the present Project.

ASTEC

This code, which is jointly developed by IRSN and GRS, describes the complete behaviour of a NPP under severe accident conditions. It is intensively used by IRSN for Level 2 PSA. It will behave as the main integrator of knowledge in SARNET2 and contribute to disseminate it to all members.

A new series V2 of versions will be delivered from 2009. Three versions are today planned:
- Spring 2009: ASTEC V2.0, mainly characterized by the applicability to EPR and the ICARE2 advanced models for core degradation,
- Autumn 2010: ASTEC V2.1, mainly characterized by the full applicability to all situations in Gen.II or III NPPs (shutdown states, vessel external cooling, air ingress into the vessel),
- End of 2011: ASTEC V2.2, mainly characterized by the applicability to the major part of sequences in BWR and CANDU NPPs.

Research programmes

Such activities concern experimental programmes, interpretation work and/or modelling activities. SARNET/SARP highlighted 6 remaining important safety issues quoted in Chapter B1.1.1.

Current and future activities to be carried out by partners with the objective to solve these issues have been selected for SARNET2 associated programmes. More precisely, they consist of:

- performing new experimental work (separate-effect or integral tests) and preparing/interpreting it with models or codes;
- interpreting already performed experiments with models or codes;
- performing scenario sensitivity studies in reactor conditions with models/codes to target actual conditions in the experiments or to investigate the influence of various models or model options;
- modelling activities.

The list of these research activities is not detailed here, but the description of work associated to each WP (Chapter B1.3.5) indicates the links between the associated programmes and the JPA.

Note: Two major experimental programmes relevant to corium and debris coolability and MCCI (WP5 and WP6), plus some other experimental tasks on Containment and Source Term are directly co-funded through the present SARNET2 project and so, are full part of the JPA.

The SARNET2 project does not present any significant risk in terms of achievement of its main objectives. If we imagine that one of the major experiments fails, in such case the closure of the corresponding issue would become more difficult, or rather would be delayed, without jeopardizing the whole project.

B1.3.2 Timing of work packages and their components

Usually, a work-package is a "*major sub-division of the proposed project with a verifiable end-point - normally a deliverable or an important milestone in the overall project*". In the specific case of this Network of Excellence, the 8 WPs have no real end point, which is rather logical in the spirit of continuing the network on a self-sustainable way after the EC Grant Agreement. Nevertheless, major milestones and deliverables are mentioned in order to follow easily and efficiently the project progress and results.

As a result, no "Gantt chart, pert diagram or similar" is provided in this document, but strong links exist between the WPs, as it was the case in SARNET. As an example of these links, we can imagine a high priority pending issue, defined in the SARP group (**WP1**). A specific experiment may be undertaken in one of the **WPs 5 to 8**, then still in the same WP, the experimental results are analyzed in another task. In parallel the experimental results (and associated reports) are implemented in the DATANET database (**WP3**). The interpretation of the experimental results leads to a better understanding of the issue and to the development of a new (or improvement of an existing) model, which is then implemented in ASTEC (**WP4**), then assessed and finally used for reactor application and/or benchmarking (**WP4**). Finally, a presentation of the corresponding progress is presented in an ERMSAR Conference (**WP2**). Of course, all along the process an extensive use of the ACT (**WP3**) will have been done.

B1.3.3 Work package list / overview

The JPA is broken down into 8 WPs as shown in the Table 1.

Table 1: SARNET2 Work package list

Work-package No	Work package title (and short title)	Type of activity	Lead beneficiary No	Person-months	Start month	End month
WP1	Management (MANAG)	MGT	1 - IRSN	75	1	48
WP2	Spreading of Excellence (SE)	OTHER	21 - KTH	14,5	1	48
WP3	Information Systems (IS)	OTHER	16 - GRS	39	1	48
WP4	ASTEC (ASTEC)	RTD	1 - IRSN	451	1	48
WP5	Corium and Debris Coolability (COOL)	RTD	15 - FZK	340	1	48
WP6	Molten Corium Concrete Interaction (MCCI)	RTD	6 - CEA	319	1	48
WP7	Containment (CONT)	RTD	20 - JSI	183,9	1	48
WP8	Source Term (ST)	RTD	36 - VTT	283,2	1	48
	TOTAL			1705,6		

WARNING: The lead participants identified in the Table may change during the execution of the four-year JPA.

B1.3.4 Deliverables list

The key outputs of the WPs, plus the formally requested progress reports will be reported in deliverables as defined in Table 2. Other technical notes, reports, minutes of meetings, etc.., will be issued as necessary; they will have a specific SARNET2 numbering and will be stored using ACT.

Table 2: SARNET2 Deliverables

Del. no.	Deliverable name	WP no.	Lead beneficiary	Estimated indicative person. months	Nature	Dissem. level[4]	Delivery date
1.1 *	Project Presentation	1	1	2	R	PU	3
1.2 *	Communication Action Plan	1	1	2	R	PU	6
1.3 *	First Periodic SARNET2 Report (months 1-12)	1	1	6	R	CO	14
1.4 *	First Periodic Integration Assessment Report (months 1-12)	1	1	2	R	CO	14
1.5 *	Updated version of SARNET SARP conclusions and proposals	1	16	10	R	PU	28
1.6 *	Second Periodic SARNET2 Report (months 13-30)	1	1	6	R	CO	32
1.7 *	Second Periodic Integration Assessment Report (months 13-30)	1	1	2	R	CO	32
1.8 *	Final Report on the Distribution on the Community's Contribution (months 31-48)	1	1	2	R	CO	49
1.9 *	Final Integration Assessment Report (months 31-48)	1	1	2	R	CO	50
1.10 *	Final SARNET2 report	1	1	10	R	PU	50
2.1	4th ERMSAR conference	2	-	2	O	PU	12
2.2	Course on Severe Accidents	2	-	2	O	PU	15
2.3	5th ERMSAR conference	2	-	2	O	PU	24
2.4	Course on Severe Accidents	2	-	2	O	PU	30
2.5	6th ERMSAR conference	2	-	2	O	PU	36

[4] Please indicate the dissemination level using one of the following codes:
PU = Public
PP = Restricted to other programme participants (including the Commission Services).
RE = Restricted to a group specified by the consortium (including the Commission Services).
CO = Confidential, only for members of the consortium (including the Commission Services).
CR = Confidential, parts of the reports only for members of working on the same subject (including the Commission Services)

Del. no.	Deliverable name	WP no.	Lead beneficiary	Estimated indicative person. months	Nature	Dissem. level[4]	Delivery date
2.6	Course on Severe Accidents	2	-	2	O	PU	45
2.7	7th ERMSAR conference	2	-	2	O	PU	48
4.1	First periodic progress report on ASTEC (months 1-12)	4	1	5	R	CO	13
4.2	Progress report on ASTEC adaptation to BWR and CANDU	4	1 - 16	5	R	CO	18
4.3 *	Synthesis of ASTEC V2.0 assessment	4	1	20	R	CO	18
4.4	Second periodic progress report on ASTEC (months 13-30)	4	1	5	R	CO	31
4.5 *	Final synthesis report on ASTEC	4	1	12	R	CO	49
5.1	First periodic progress report on Corium and Debris Coolability (months 1-12)	5	15	5	R	CO	13
5.2	Benchmark on models for ex-vessel debris formation and cooling	5	34	5	R	CO	25
5.3	Second periodic progress report on Corium and Debris Coolability (months 13-30)	5	15	5	R	CO	31
5.4	Benchmark on models of reflooding and cooling of a degraded core	5	34	5	R	CO	37
5.5 *	Final synthesis report on Corium and Debris Coolability	5	15	9	R	CO	49
6.1	First periodic progress report on MCCI (months 1-12)	6	6	5	R	CO	13
6.2	Report on the first VULCANO SARNET experiment	6	6	3	R	CR	18
6.3	Report on simulant material tests on 2D ablation	6	1	3	R	CR	25
6.4	Second periodic progress report on MCCI (months 13-30)	6	6	5	R	CO	31
6.5	Benchmark on reactor scale MCCI	6	18	3	R	RE	46
6.6 *	Final synthesis report on MCCI	6	6	9	R	CO	49
7.1	First periodic progress report on Containment (months 1-12)	7	20	5	R	CO	13
7.2	Second periodic progress report on Containment (months 13-30)	7	20	5	R	CO	31

Del. no.	Deliverable name	WP no.	Lead beneficiary	Estimated indicative person. months	Nature	Dissem. level[4]	Delivery date
7.3	Comparison report on simulations of containment spray experiments	7	1	5	R	CO	43
7.4	Description of generic containment CFD models and performed simulations	7	14	3	R	CO	49
7.5	Analytical interpretation of SERENA experiments	7	1	3	R	CR	49
7.6	Report on experiments on hydrogen combustion in the course of direct containment heating	7	15	3	R	CO	49
7.7 *	Final synthesis report on Containment	7	20	9	R	CO	49
8.1	First periodic progress report on Source Term (months 1-12)	8	25	5	R	CO	13
8.2	Final report on ThAI benchmark	8	16	3	R	CO	24
8.3	Second periodic progress report on Source Term (months 13-30)	8	25	5	R	CO	31
8.4	Final report on FPT2 benchmark	8	1	3	R	CO	33
8.5	Final report on FPT3 benchmark	8	1	3	R	CO	48
8.6	Final report on TMI2 benchmark	8	41	3	R	CO	48
8.7	Data Book on Ruthenium	8	36	3	R	CO	48
8.8 *	Final synthesis report on Source Term	8	25	9	R	CO	49
			TOTAL	229			

* These Deliverables need to be formally approved by the Commission.

B1.3.5 Work package descriptions

The SARNET2 Joint programme of Activities can be described as a function of the 8 WPs as mentioned in Table 1.

Note on the following tables: All the figures expressed in person.months are given for the full duration of the project, i.e. 4 years.

Work package number	1	**Start date or starting event:**	1
Work package title	Management (MANAG)		
Activity Type	MGT (+RTD)*		

* WP1-1 corresponds to Management activities (52 person.months) while WP1-2 and WP1-3 correspond to RTD activities (23 person.months).

Participant number	**1**	3	9	11	15	16	21	25	29	36
Participant short name	**IRSN**	AR G	CEA	EDF	FZK	GRS	KTH	PSI	TUS	VTT
Person-months	**52**	2	2	1	2	4	2	2	2	2
Participant number	38									
Participant short name	JRCs									
Person-months	4									

Objectives

Coordination, Administration and Budget

Coordinate the JPA technically, administratively and financially.

Prepare the long term self-sustainability of the network by the creation of a legal entity.

Integration Assessment

Monitor the progress of the network and propose corrective actions in order to reach the SARNET objectives.

Severe Accident Research Priorities

Prioritise the research to be performed in the field of severe accident phenomena and management, notably using the results of SARNET/SARP, of SARNET2 ASTEC, Coolability, MCCI, Containment and Source Term WPs, of Level 2 PSAs performed in national projects (risk oriented approach, direct link with the ASAMPSA2 FP7 project), and of international programmes (OECD/NEA, ISTC, etc…) to provide the Steering Committee of SARNET2 with guidelines for defining the orientations to be given to the Joint Programme Activities (JPA) in terms of joint activities for research of common interest and high priority.

Description of work

WP1-1: Coordination, Administration and Budget (COOR)

This activity involves the Coordinator (IRSN) helped by an assistant (JRC/IE) who will in particular assure the secretary of the meetings of the Management Team and the General Assembly.

- Monitor progress of JPA
- Check release of deliverables and survey milestones
- Organize technical reviews when necessary
- Anticipate and examine possible difficulties in JPA execution
- Make periodic syntheses for JPA update (no longer required by the EC) for the Steering Committee approval, plus other formal deliverables at the Management level for the EC (with contributions from WP leaders)
- Elaborate and update budgets
- Gather, control and forward to the EC the partners' costs statements and distribute community funds as decided in the Consortium Agreement (and approved by the Steering Committee and the EC)
- Organize bi-annual meetings of the Steering Committee and of the Management Team and the annual General Assembly
- Set-up a Quality Management System, and verify that it is respected
- Prepare the long term self-sustainability of the network by the creation of a legal entity:

  From discussion with lawyers from various partners' organisations, propose to the Steering Committee the type of legal entity to be created (six months after the project beginning),

After approval by the Steering Committee (at the latest one year after the project beginning), proceed to the necessary steps (still under the Steering Committee control): writing the necessary description of the legal entity (objectives, organisation, budgets, rules for joining the entity, etc), gathering (in link with the Coordinator's lawyers) the necessary administrative documents, up to the formal deposit of the request for creation to the ad-hoc Administrative Authority,

In link with Steering Committee, launching the operational phase of the legal entity.

WP1-2: Integration Assessment (IA)

Task periodically carried out by the Coordinator and WP leaders. The work consists in:

- Collecting the information necessary to measure the evolution of several performance indicators,

- Analysing the results, and proposing if necessary JPA corrective actions.

Note: In SARNET the following 16 indicators were used for monitoring the following aspects:

- Success of the electronic communication system: number of SARNET member accesses to the SARNET Web site per month; number of collaborative documents elaborated and/or stored using ACT per year ;
- Success in using ASTEC and PSA methodology: number of ASTEC users in SARNET; number of organisations using ASTEC for its own applications (reactor studies or test analyses); number of industrial applications per year using ASTEC; number of Level 2 PSAs using methodology/recommendations developed by SARNET;
- Success of developing collaboration in research activities: number of access rights granted by contractors for applications in the frame of SARNET, or new partnerships with ISTC, VVER research programmes and advanced reactor research programmes related to Severe Accidents; fraction (in part of budgets) of research projects carried out in Europe that have been set-up under the aegis of SARNET per year; maximum number of associated organisations in a joint project ; number of issues closed;
- Scientific quality in collaborative research: number of joint publications per year;
- Success of the Education and Training activities and of the mobility plan: number of attendees to SARNET courses or training sessions; number of researcher detachments ;
- Success of the dissemination of public knowledge: number of presentation of SARNET activities in conferences; number of hours devoted to updating the SARNET web site for diffusing information outside SARNET; number of accesses to the Website from outside the Network.

For SARNET2, taking into account the SARNET feedback, these indicators will be slightly modified.

WP1-3: Severe Accident Research Priorities (SARP)

Work commonly performed by 10 partners (IRSN, AREVA NP GmbH, CEA, EDF, FZK, GRS, KTH, PSI, TUS, VTT) and led by GRS.

- Agree on updated assessment methodology

- Review issues resulting from SARNET SARP which are not appropriately covered by SARNET2

- Analyse R&D progresses and results from Level 2 PSA studies

- Reassess issues ranking and eventually reorient priorities

- Identify potential experimental and theoretical programmes to address these issues (including estimated costs and duration)

- Make recommendations for R&D programme revision

- Agree on further issues to be considered as closed

Deliverables

10 deliverables (cf. Table 2).

Work package number	2	**Start date or starting event:**	1
Work package title	Spreading of Excellence (SE)		
Activity Type	OTHER		

Participant number	1	**21**	33							
Participant short name	IRSN*	**KTH**	UNIPI							
Person-months	3,5	**9**	2							

* Attributed initially to IRSN that will distribute them to the partners (to be defined) that will prepare, host and co-organise on one hand the ERMSAR conferences and on the other hand the Education and Training courses. For the latter courses, in continuity of SARNET, CEA and IRSN in particular should be involved for their preparation.

Objectives

Organize three courses on Severe Accidents, as well for students and young researcher (education purpose) as for people already involved in the Severe Accident Field (training purpose).

Organize annual ERMSAR conferences to disseminate the results gained within SARNET2 and more generally within the whole Severe Accident Research Community. ERMSAR should become the major worldwide conference on severe accident research.

Organize the dissemination of information.

Implement a Mobility Programme for students and researchers (mainly, but not only, from Central and Eastern European Countries to Western European Countries) to form real teams of researchers by enhancing the exchanges and the dissemination of knowledge. An objective of 8 granted mobilities per period is fixed.

Description of work

WP2-1: Education and Training (ET)

The Education and Training programme in SARNET2, coordinated by UNIPI, is focusing on raising the competence level of the university students (Master and PhD) and researchers engaged in severe accident research. Towards this purpose, in the streamline of what was done for SARNET, education courses will be developed on the phenomenology of the various areas of severe accidents. For their preparation, CEA and IRSN in particular should be involved. The teaching will not be a survey but an in-depth treatment so that the students and researchers will be able to (a) understand (b) develop the methodology in the topics further and (c) use analysis tools (e.g. ASTEC) more effectively for any type of European NPP. The description of the scenarios with event trees and of the failure rates with fault trees will be demonstrated and efforts will be made to determine the probabilities of the various events occurring. The analysis of the consequences, performed using codes like ASTEC, MELCOR, MAAP, and their phenomenology will be explained. In particular, the models in the ASTEC code will be explained. The best-estimate analysis will be supplemented with an uncertainty analysis. It will be used to demonstrate the margins that are available in the NPP designs and operations. Links with the European ENEN association will be maintained and strengthened. Besides, training courses for plant operators and interested researchers in the severe accident management procedures will be proposed. Here, the emphasis should be in identifying what these procedures are based on and why they are effective. Finally, a course (or “information day”) more targeted to NPP managers will be organized.

The final review and the editing of the text book on SA phenomenology that was written in the SARNET frame will be performed in 2009.

WP2-2: ERMSAR conferences (ERMSAR)

The work will aim at organizing an annual ERMSAR Conference (during SARNET the periodicity was 15 to 18 months) gathering more than 100 participants and showing the major achievements in the Severe Accident research field. This European Conference should become the major worldwide conference on severe accident research.

A second task will consist in organizing the dissemination of information through for example newsletters or participation to public events.

WP2-3: MOBility programme (MOB)

The work consists in organizing a programme, coordinated by KTH, under which university students and researchers could go to different laboratories for education and training in the severe accident area. One element is the summer internship programme under which a student spends a summer at another University (than his own) to learn about the severe accident work ongoing there or the funding of stages for master thesis in the severe accident field to be performed in the ENEN framework to obtain the 20 credits (ECTS) necessary for the achievement of the European EMSNE (European Master of Science in Nuclear Engineering) quality label. The second element is the development of the deputation programme in which a researcher from one laboratory will spend several months at another European Laboratory where he / she would participate in an area of the severe accident research ongoing there. In this mobility programme, the long term goal is to build and strengthen teams which would engage together in a certain activity of the NoE.

Deliverables

3 Courses (plus one “Information Day”)

4 ERMSAR yearly conferences

Work package number	3	**Start date or starting event:**	1
Work package title	Information Systems (IS)		
Activity Type	OTHER		

Participant number	1	2	6	9	15	**16**	21	36	38	
Participant short name	IRSN	AEKI	CEA	CIEM	FZK	**GRS**	KTH	VTT	JRC	
Person-months	4	4	4	4	4	**12**	4	1	2	

Objectives

Develop the existing public SARNET WEB site in order to make it more attractive and providing more information on the severe accident research field to the general public.
Maintain and improve the Advanced Communication Tool (ACT) and the DATANET database to foster collaborative works amongst network members while decreasing meetings, and to make easier access to scientific data on severe accident research. The long term objective of the database consists in gathering and maintaining in a standardized format all the available data (including comprehensive experimental reports) on Severe Accident Research that SARNET partners are willing to share with the other partners in the network. So, preservation and easy access for code users will be ensured. The data of concern are both existing experimental data and all new data to be produced within SARNET2.

Description of work

Note that most partners of SARNET2 will only be ACT users and will be involved in specifications and or in the assessment of the tool through their feedback. This participation is not mentioned in the worktable above which includes only GRS as the WP leader, in charge of the WEB and of the ACT maintenance and development, JRC/IE as the DATANET leader charged of the Database maintenance and development, and the partners which implement data in DATANET.

WP3-1: Web site (WEB)

Development of the current public SARNET Web Site with the direct participation of the Coordinator and of all the WP leaders to have a clean, periodically updated and attractive page per important Severe Accident issue.

WP3-2: Advanced Communication Tool (ACT)

Development of ACT modules consistent with the SARNET2 organization.

Development of “knowledge mapping”, in the continuation of what was done in SARNET, for an easier use of the ACT and for a better storage of relevant data and reports.

Maintenance, users’ support and upgrades of the ACT tool.

Attribution and periodic updates of the access rights, in link with the WP leaders.

WP3-3: Experimental Database (ED)

Creation of local STRESA nodes for the newcomers.

Maintenance, users’ support and upgrades of the STRESA tool.

Organisation of training sessions for newcomers when necessary.

Support for establishing the links with the Advanced Communication Tool.

Attribution and periodic updates of the access rights, in link with the WP leaders. The protection of confidential data is an important feature to be taken into account as the informatic security of the database.

Deliverables

No specific deliverables for this WP, but several SARNET2 Performance Indicators will be linked to this WP (e.g.: monthly number of accesses to the WEB site, monthly number of accesses to the ACT, monthly number of researchers accessing to the ACT, number of items stored in ACT, monthly number of accesses to DATANET, monthly number of researchers accessing to DATANET, number of test results and associated documents stored in the DATANET).

Work package number	4	**Start date or starting event:**	1
Work package title	ASTEC (ASTEC)		
Activity Type	RTD		

Participant number	**1**	3	4	5	6	9	11	12	13	15
Participant short name	**IRSN**	AR G	AR S	BME	CEA	CIEM	EDF	EI	ENEA	FZK
Person-months	**52**	7	7	9	1	1	5	9	17	1
Participant number	16	17	18	19	20	21	22	26	27	29
Participant short name	GRS	INR	INRNE	IVS	JSI	KTH	LEI	RUB	TRACT	TUS
Person-months	34	57	23	23	1	35	11	1	11	5
Participant number	30	31	33	34	35	37	39	40		
Participant short name	UJD	UJV	UNIPI	USTU	VEIKI	VUJE	AECL	KAERI		
Person-months	21	1	1	62	23	23	5	5		

Objectives

Distribute the code versions to the code users, and provide them with a support.

Organize information exchange between ASTEC users, in particular for collection of users' requirements.

Capitalize the knowledge by integration of models proposed in the WPs 5 to 8.

Assess the code capability to simulate reactor accident scenarios in all types of European NPPs, and the corresponding physical models.

Description of work

Twenty-eight organizations (including IRSN and GRS) will continue to collaborate on the development and assessment of the successive ASTEC versions. The development will account for the inputs provided by the different Work-Packages of the JPA.

WP4.1: Users' Support and Integration (USI)

- Delivery of code versions and documentation by IRSN and GRS to the code users: ASTEC V2.0 in April 2009; V2.1 in Autumn 2010 and V2.2 end of 2011.

- Support to code users. Analysis and solution of users' requests (error corrections, minor developments).

- Maintenance of the ASTEC Web site on ACT.

- Users Club meetings (in average every 15 to 18 months): 4th one planned in Spring 2010, with participation of all code users' organizations.

- Workshops on ASTEC use for beginners or experienced users. Set up of e-learning on the ASTEC Web site.

- Analysis of users' requirements for further code evolutions.

WP4.2 : ASTEC Code ASsesment (ACAS)

This activity will mainly consist in covering a broad matrix of ASTEC reactor applications, aiming at the most important accident scenarios for 4 types of reactors (PWR, BWR, VVER and CANDU). Parametric and sensitivity calculations will be performed in order to demonstrate the reliability and consistency of the ASTEC calculations, as well on reactor applications than on some selected reference experiments. Although not the prime objective, partners may benchmark ASTEC with other reference codes that they master, such as the integral codes MELCOR and MAAP and detailed codes such as ICARE/CATHARE, ATHLET-CD, SCDAP/RELAP5, COCOSYS, TONUS…

In complement to these reactor applications, ASTEC assessment will continue through calculations of integral experiments such as Phebus FP and on real plant accidents such as TMI2.

As a secondary objective, depending on the validation needs, a limited number of validation tasks against experiments may be performed either for phenomena not addressed in WP5 to 8 or on some selected reference experiments as indicated above.

As a last objective, an important task of the ASTEC development is the creation of a deterministic code suitable for PSA level 2. This will be demonstrated e.g. by running ASTEC in a coupling mode with dynamic PSA2 methods (in continuity of the work done in SARNET).

For the longer term, this WP4.2 activity will continue taking into account code evolution and new reactor concepts or SAM procedures.

The work will focus on ASTEC V2.0 assessment in the first 18 months. Then it will switch on the following versions. This activity will be shared between 19 organisations:

- For Western PWR (including TMI-2): EDF, ENEA, AREVA NP, AREVA GmbH, GRS, IRSN, KAERI, TRACTEBEL, USTUTT and LEI (the latter on coupling with dynamic PSA2 tools),
- For BWR: GRS, USTUTT, KTH
- For VVER-440: BME, IVS, UJD, VEIKI, VUJE
- For VVER-1000: EI, INRNE, TUS
- For CANDU: INR.

WP4.3: ASTEC Model EXtension (AMEX)

Contribution to the model developments to simulate SA sequences in BWR and CANDU reactors: specifications and prototyping (in very close collaboration with the IRSN-GRS developer team), and finally validation against adequate experiments.

In a second stage of SARNET2 project, some benchmarks with other codes on BWR and CANDU plant applications will be performed in the WP4.2.

The involved partners (outside of IRSN and GRS) will be:

- For BWR: USTUTT, KTH,
- For CANDU: INR, AECL.

Remark: Work on ASTEC in WP5 to 8

Some partners participate with 1 person.month only to this WP4. As a matter of fact, they will apply ASTEC in the WPs 5 to 8 (ASTEC validation on experimental data, model proposals for further integration in ASTEC, possibly some plant applications). This low level participation in WP4 corresponds only to their participation to the ASTEC Users' Club and on discussion about the code evolution.

Deliverables	
First periodic progress report on ASTEC	Month 13
Progress report on ASTEC adaptation to BWR and CANDU	Month 18
Synthesis of ASTEC V2.0 assessment	Month 18
Second periodic progress report on ASTEC	Month 31
Synthesis report on ASTEC	Month 49

Work package number	5	**Start date or starting event:**	1
Work package title	Corium and Debris Coolability (COOL)		
Activity Type	RTD		

Participant number	1	2	6	7	13	**15**	16	18	19	21
Participant short name	IRSN	AEKI	CEA	CESI	ENEA	**FZK**	GRS	INRNE	IVS	KTH
Person-months	20	6	20	4	12	**52**	20	8	18	34
Participant number	22	25	26	28	29	31	34	35	36	39
Participant short name	LEI	PSI	RUB	THERM	TUS	UJV	USTU	VEIKI	VTT	AECL
Person-months	8	34	8	16	4	4	32	24	12	4

Objectives

The major motivation is to reduce or possibly solve the remaining uncertainties on the possibility of cooling structures and materials during severe accidents, either in the core or the vessel bottom head or in the reactor cavity, so as to limit the progression of the accident. This could be achieved either by ensuring corium retention within the vessel or at least a slow corium progression and small flow rates of corium release into the cavity. These issues are to be covered within the scope of accident management for current reactors, and also within the scope of the design and safety evaluation of future reactors. Increased understanding was reached with the help of computer codes such as MAAP, MELCOR, SCDAP/RELAP, ICARE/CATHARE, ATHLET-CD and ASTEC being under European development. Nevertheless, as the required status of validation and partly modelling of these codes are not yet fully achieved and as a convincing PSA depends on the quality of prediction of the analytical tools used, current PSA level 2 studies still show very large uncertainties in the results of the reflooding phase.

The different actions of the “Corium and debris coolability” WP have to improve our understanding of the phenomena associated with reflooding and allow the integration of validated models applicable to reactor conditions into the severe accident codes, in particular the ASTEC integral code, with the final aim of reducing the uncertainties on the evaluation of in- or ex-vessel coolability, during the different phases of the severe accident. Three key situations and processes are considered for coolability and retention, leading to four tasks, including a general one on application to reactor, addressed in sub-work packages.

WP5.1 - Reflooding and coolability of a degraded core: The focus will be on the phase after boil-off during the accident. Heating and melting may produce a severely damaged, partly molten core with relocated material and partly broken parts. If quenched at such a stage by water injection, even increased fragmentation of material, molten and solid, can be expected, the hot solid parts being broken because of large thermal stresses with the result of the formation of a debris bed. Quenching of this hot, degraded core is the main issue here.

WP5.2 - Remelting of debris, melt pool formation and coolability: If core cooling fails, a melt pool will form in the core and melt might flow down into remaining water in the lower head. The TMI accident indicated that even though coolability of the core is not attained, a coolable configuration may result from break-up of the melt in the water of the lower head. If cooling in the core and in the lower head is not possible, the development of a melt pool in the lower head has to be analysed and whether a melt pool can be kept in-vessel due to external vessel cooling or the timing and modes of vessel failure have to be considered. The modes of vessel failure concern location and size of the failure. Due to the similarity of the processes under ex-vessel conditions, the related coolability questions are to be investigated in conjunction with the ex-vessel case.

WP5.3 - Ex-vessel debris formation and coolability: A porous debris bed can be formed in a water pool of the reactor cavity due to the fragmentation of the molten corium jet ejected from the lower head of the vessel. The water pool is available through cavity flooding (e.g. SAMS in Swedish and Finnish BWRs) or water accumulation in the sump of a PWR due to LOCA conditions or containment spray. This is a similar process to the in-vessel situation, when melt relocates from the core to a water filled lower head. Deep water pools in BWRs yield additional effects.

WP5.4 - Bringing research results into reactor application: A general view on coolability shall be reached based on available modelling and derivation of conclusions for adequate modelling in ASTEC. This requires further studies and evaluations focusing on the major accident situations described above. The emphasis will be on validation with use experimental results, code to code comparisons and joint reactor applications.

Description of work

During the three different key situations two main aspects are important to investigate the coolability of the materials:

- The geometrical characteristics of the "porous media" like damaged rods with molten materials or debris bed in the core, debris bed in the lower head or in the cavity (ex-vessel),
- The thermal-hydraulic phenomena in these porous media.

Due to the similarity of some processes in the three keys situations, some experiments and modelling tasks will be useful for any porous media. All partners will be engaged in joint work to conclude from the experiments and calculations on improved, validated modelling and to propose simplified models for ASTEC based on the elaborated major processes and evaluation results.

WP5-1: Reflooding and Coolability of a degraded core (RefCool)

Experiments: New QUENCH experiments (FZK) and CODEX experiments (AEKI) are foreseen, analysing the relocation of cladding and fuel and the formation and cooling of in-core debris beds to gain information on the characteristics of the created particles. The main objective of these tests is the investigation of these processes under prototypical boundary conditions for a whole bundle. POMECO (KTH) and DEBRIS (USTUTT) analytical tests with debris beds will be performed to support the quantification of basic laws and coolability behaviour. Top and bottom flooding (quenching) of hot debris (up to 900 °C) can be investigated in the DEBRIS facility, also at elevated pressures. New POMECO test facilities are designed and constructed at KTH to perform isothermal and boiling two-phase flow tests with better instrumentation and flexibility for variations to accommodate various prototypical conditions. POMECO aims at analyses under boil-off conditions with emphasis on basic laws and specific 2D effects (down-comers) more oriented at lower head or ex-vessel situations but also addressing basically the situation in the degrading core. Both, DEBRIS and POMECO, deal with irregular particles aiming at realistic debris.

IRSN is planning a larger quenching experiment with 2D porous media allowing multi-dimensional progression of the quench front. This PEARL programme will simulate the reflooding of a debris bed, characteristic of an in-core debris bed, surrounded by a more permeable medium (such as intact structures and rods). PEARL goes beyond DEBRIS quenching analyses by the larger facility (60 cm diameter vs. 15 cm in DEBRIS) and thus the possibility to perform extended analyses on multidimensional effects. It will also provide a general basis for the assessment of the overall behaviour described in the codes (both in- and ex-vessel phenomena).

Modelling, model validation and implementation in ASTEC: Concerning the coolability of porous media, analyses have indicated the importance of multi-dimensional effects. E.g., quenching analyses performed in SARNET showed agreement concerning a strongly favoured coolability by inflow of water from lateral water-filled regions of the core with higher porosities. Since lateral water inflow, especially via lower regions, strongly improves coolability, in general the coolability is much better than concluded from 1D analyses with top flooding, and 2D / 3D computer codes including adequate descriptions of constitutive laws are required to analyse the real coolability situation. Also, it is necessary to improve the modelling on the formation of porous media in the core. Alternatively, for assumed configurations, degradation and melting, pool formation and melt release have to be analysed taking into account water supply, in order to reveal major trends (cooling vs. melt pool formation). A final objective is to improve mechanistic models (ATHLET-CD/WABE, ICARE/CATHARE) and propose an adequate model for ASTEC.

WP5-2: Remelting of debris, Melt Pool Formation and coolability (MPF)

Experiments: The LIVE facility (FZK) provides in a first phase further experiments for validation with emphasis on the pool build-up. In the second phase, LIVE will provide data about the whole sequence of events from core melting, melt accumulation in the core, core failure, melt inflow into the lower plenum,

particulate debris formation with water in the lower plenum, and also of direct (without water) melt pool formation and its behaviour. Experiments at the CNU facility (CEA) dedicated to the study of two-phase flow with steam production around a heated hemispherical geometry will be performed. New data will be available for the validation of models for the external vessel cooling in conditions more representative for the reactor case in 3D geometry, which will serve for integration in ASTEC.

Modelling, model validation and implementation in ASTEC: In the frame of ATHLET-CD, the VECO module allows in principle to calculate the whole development from melt release from the core until melt pool formation in the lower head. Thermo-chemical equilibrium calculations will serve to validate melt pool configurations and their extrapolation to reactor conditions. States of a melt pool inside a particulate debris as well as its growth by inflow of melt from the core or in a final state are calculated (as for the core region) by a simplified model. This model is based on the FLUXBAIN code (CEA), also applied in ICARE and is similar to the ECCM (Effective Conductivity - Convectivity Model) in MVITA code, developed by KTH. New models are under development at KTH for simulating melt pool formation and behaviour in the lower plenum. The models are implemented in the FLUENT code, and applied to the complex geometry of a BWR lower head for in-vessel coolability analysis in the case of having the cooling system of control rod guide tubes (CRGTs) available. Concerning the coolability aspect, analyses are to be continued for better evaluating the quenching and cooling processes in the lower head. Since this task is partly similar to the above for the core, validation can also use the above experiments.

WP5-3: EX-vessel debris formation and COOLability (EXCOOL)

Experiments: To date, there is no conclusion from the existing research of the definition of a prototypical debris bed, which is strongly related to the attempt to solve the coolability problem. While there exists a large number of experimental and analytical (computational) studies on molten fuel-coolant interactions (e.g. jet break-up, melt droplet fragmentation, premixing), very little data and virtually no significant insights are available on the debris bed formation itself. From the DEFOR experiments (KTH), answers about realistic debris formation and resulting structure (particle sizes and local composition, porosities, and heap-like shape of debris bed) are expected.

New STYX experiments (VTT) are planned to investigate the effect of water penetration from the sides. In these experiments, debris bed formation in deep ex-vessel water pools concerning the SAMS in BWRs is specifically addressed. Due to the similarity of basic processes in the three key situations, the POMECO (KTH), DEBRIS (USTUTT), and LIVE (FZK) test facilities, described before, will also be used for the ex-vessel coolability aspect. POMECO tests will use debris from the DEFOR experiments. An emphasis in the new DEBRIS experiments will also be on stepwise going to realistic debris (mixtures of spherical particles, then of non-spherical ones, finally taking debris from melt breakup experiments, e.g. PREMIX of FZK).

Modelling, model validation and implementation in ASTEC: More efforts need to be focused on modelling of particle settling and packaging, under the prototypical conditions. The tools have to be developed to encompass the capabilities to analyze all aspects of a possible prototypical debris bed on coolability. As in the case of core quenching, multi-dimensional effects are expected to be decisive for the coolability of the debris beds in the cavity, based on previous analyses. Further exploration of the coolability potential is required, especially in deep water pools (SAMS).

WP5-4: Bringing research results into Reactor Application (COOL-RA)

For the reflooding and coolability of a degraded core, the emphasis will be on the analysis of formation and quenching of hot heterogeneous beds under the influence of lateral modes of water inflow. For the remelting of debris, melt pool formation and coolability issue, the calculations for reactor conditions shall serve to further check the relevance of mechanisms during remelting of debris and pool formation with influence of water supply and to investigate the remaining chances of cooling and thermal loads to the vessel and their consequences. In the case of ex-vessel debris formation and coolability, the approach is to identify in a first step the melt boundary conditions (e.g. melt discharge mass) and parameter ranges through in-vessel simulations of selected severe accident scenarios of risk significance. In a second step the coolability has to be studied taking into account the derived debris beds or melt configurations formed using available data from the existing test facilities or new test set-up designs for ex-vessel coolability studies. Overall, the coolability options and chances are to be explored during the whole accident development, which is also influenced by the cooling measures, and applied to the different reactor types.

Workshops

Periodic workshops will be organized open to all partners to demonstrate the progress made in this work package and to clearly identify and adjust the objectives for the following period. These workshops will serve as well for the interaction between the different work packages, especially with the WP6 MCCI, where several topics have common interests.

Deliverables	
First periodic progress report on Corium and Debris Coolability	Month 13
Benchmark exercise on models for ex-vessel debris formation and cooling	Month 25
Second periodic progress report on Corium and Debris Coolability	Month 31
Benchmark exercise on models of reflooding and cooling of a degraded core	Month 37
Final synthesis report on Corium and Debris Coolability	Month 49

Work package number	6	**Start date or starting event:**	1
Work package title	Molten Corium Concrete Interaction (MCCI)		
Activity Type	RTD		

Participant number	1	**6**	7	11	12	15	16	18	21	28
Participant short name	IRSN	**CEA**	CESI	EDF	EI	FZK	GRS	INRNE	KTH	THERM
Person-months	36	**108**	12	1	12	28	10	26	16	12
Participant number	29	31	34	35	36	38	40			
Participant short name	TUS	UJV	USTU	VEIKI	VTT	JRCs	KAERI			
Person-months	6	6	16	10	12	4	4			

Objectives

In the case of a severe accident with vessel melt-through, the containment is the ultimate barrier between the corium and the environment. The present WP is addressing the situation where the reactor pit is initially dry but water injection may occur later during MCCI. This issue has been ranked by the SARNET SARP (Severe Accident research Priorities) group with high priority. The case of a pit flooded prior corium ejection is out of the scope of this WP, since it is treated by the WP5 COOL focussed on the general item of corium coolability.

The impact of cavity flooding after MCCI onset and possibly using new coolability concepts will be nevertheless investigated in the present work package, since it is closely related to the MCCI phenomenology in dry conditions.

This proposal is towards providing new data and understanding of corium-concrete interaction, by using innovative approaches to address more prototypical phenomena with the view of closing the issue at the end of the project or, at least, significant progress toward this issue closure will be very significant. It has been designed to ensure complementarity with the ongoing MCCI project of the OECD-NEA.

When SARNET started (2004), the MCCI codes were quite able to compute the available 1D oxide tests (e.g. ACE, MACE, SURC). Recent 2D tests have provided new results that questioned the reliability of these models and their extrapolation to reactor conditions. As an example, it becomes clear that new effects have to be taken into account to be able to describe the ablation anisotropy observed in case of silica-rich concrete and the different behaviour of Limestone Common Sand (LCS) concrete. This anisotropy was also present in the ablation of Chernobyl silica-rich concrete. The intention during SARNET2 is to gain sufficient experimental data in order to determine which phenomenon(a) is(are) responsible for the observed isotropy/anistropy of the concrete ablation. Then it shall be modelled and implemented in codes. The issue will be closed if, when these models are implemented in codes, the codes become predictive in 2D configurations with and without stratification, within a satisfactory uncertainty to be determined in contact with end-users.

Concerning the oxide/metal configuration, only few experimental programmes were conducted with stratified pools using simulant melts. Among them the large-scale 2D BETA test series (FZK, Germany) with a large test matrix. Together with a series of COMET (FZK, Germany) experiments, which were performed in alumina thermite within the LACOMERA programme, a valuable database on a long-term melt-concrete interaction for various initial and boundary conditions (wide power input range: low, intermediate and high; Zr content in the metallic phase; cooling by surface flooding) was obtained. CEA has recently engaged a programme in prototypic material to address the issue of 2D MCCI with oxide + metal pool, which has the unique characteristics of providing heat to the oxide layer, as in reactor case. At present time there has been two tests performed in the VULCANO facility, one test with a small fraction of metal within the MCCI-OECD programme as well as two metal/concrete interaction tests at HECLA and more data are clearly required to improve our knowledge in these configurations.

Water-cooling is main available mean to terminate the concrete ablation. It is mainly studied within the OECD MCCI programme. Recently, interest has been interest to pursue R&D on concepts that could be used to provide bottom-cooling in the pit of current reactors.

The complementarities with the ongoing MCCI programme of the OECD-NEA and the potential large-scale experiment within ISTC are the following:

- The SARNET MCCI programme will concentrate on separate-effect tests on the effects of concrete nature on 2D ablation, in view of achieving predictive modelling of the partition between horizontal and vertical ablation.
- The VULCANO facility can handle significant fractions of steel during long term tests (several hours), while the CCI tests are limited to small masses of metal during that must rapidly be oxidised.
- The ISTC Large Scale experiment (when it overcomes its technical challenges) will be devoted to demonstration experiments and is intrinsically limited in terms of experiment duration.
- The work on water cooling is focused on joint interpretation of OECD tests and on research of potential back-fitting options, which are out of the scope of the OECD programme.
- Reactor scale applications *(PWR, BWR, VVER)* will be part of the joint activities and benchmarks will be organised on generic reactor configurations.

Description of work

The current results of 2D MCCI tests with oxide or with oxide + metal pool show that several phenomena are still not well understood and require further R&D. This WP is divided into four sub-WPs, each one addressing a specific issue:

- **WP6-1 Effect of the concrete nature on 2D Ablation Profiles (AbProf), led by IRSN**
- **WP6-2 Role of Metallic Layer on the MCCI (MetLay), led by FZK**
- **WP6-3 Efficiency of Late Water Cooling (LWC), led by KTH**
- **WP6-4 Bringing research results into Reactor Application (MCCI-RA) led by INRNE**

The experimental programme comprises 6 VULCANO experiments at CEA, small scale prototypic corium experiments at UJV and JRC/ITU aiming at improving the thermodynamic modelling of corium-concrete mixtures, a high temperature simulant test at FZK, low temperature separate-effect tests at CEA and FZK. VTT will provide the results of its HECLA experiments and CEA will provide the results of past VULCANO VB-U5 and U6 tests.

These experiments will be jointly analyzed and models will be proposed to improve European codes, in particular MEDICIS, WEX and WECHSL that are part of SARNET. Interactions between modelling and reactor applications will be guaranteed by the activities of task 4. Links with WP5 COOL and WP 4 (ASTEC) will be achieved thanks to information exchanges and invitations to workshops and meetings.

It is planned to have at least 3 PhDs in relation to the WP6 activities.

Workshops

In the view of favouring the exchange of information on MCCI experimental and modelling results, periodic workshops on MCCI are planned. Some sessions will be restricted to the partners in the WP. The joint programme for the following period will be presented and commented during this workshop.

Deliverables	
First periodic progress report on MCCI	Month 13
Report on the first VULCANO SARNET experiment	Month 18
Report on simulant material tests on 2D ablation	Month 25
Second periodic progress report on MCCI	Month 31
Benchmark on reactor scale MCCI	Month 46
Final synthesis report on MCCI	Month 49

Work package number	7	Start date or starting event:	1
Work package title	Containment (CONT)		
Activity Type	RTD		

Participant number	1	3	6	10	11	13	14	15	16	18
Participant short name	IRSN	AR G	CEA	DEM	EDF	ENEA	JULICH	FZK	GRS	INRNE
Person-months	20.7	2.3	10.9	2.3	5	6.9	6.6	8.1	13.5	2.3
Participant number	**20**	21	22	24	26	29	31	33	34	35
Participant short name	**JSI**	KTH	LEI	NRG	RUB	TUS	UJV	UNIPI	USTU	VEIKI
Person-months	**38.9**	4	4.6	4.6	2.3	4.6	4.6	10.4	4	6.9
Participant number	36	37	39	40						
Participant short name	VTT	VUJE	AECL	KAERI						
Person-months	2	2.3	8.1	8						

Objectives

The issue considered in the WP7 is the threat to the containment integrity, due to two types of highly energetic phenomena: steam explosions and hydrogen combustion. Steam explosions may be caused by ex-vessel fuel-coolant interaction due to a reactor pressure vessel failure and pouring of the reactor core melt in the flooded reactor cavity. Hydrogen combustion (deflagration and detonation) may be caused by ignition of a gas mixture with high local hydrogen concentrations, which may be due to the imperfect mixing of the containment atmosphere. Phenomena linked to these threats will be considered as well. Essential insights and results from this research should be applicable to actual NPPs.

Three sub-work packages, including a general one on application to European NPPs, will be considered.

WP7.1 - Ex-vessel Fuel Coolant Interaction

Ex-vessel fuel-coolant interaction (FCI) may lead to steam explosions. The corium ejected in the reactor cavity after RPV failure may lead to high-pressure loads on the containment or vital components in case of FCI. The work performed in the frame of SARNET and SERENA-1 (OECD project) allowed the identification of the major uncertainties that make it difficult to quantify containment safety margins to an ex-vessel steam explosion. These uncertainties mainly concern the level of void in the pre-mixing phase and the role of material properties on explosion energetics. A new OECD programme (SERENA-2) has been launched in October 2007 to resolve these uncertainties by performing a limited number of well-designed tests with advanced instrumentation reflecting a large spectrum of ex-vessel melt compositions and conditions in the KROTOS (CEA) and TROI (KAERI) facilities, and the required analytical work to bring the code predictive capabilities to a sufficient level for use in reactor analyses. The main objective of the WP7-1 will be to further review and debate the progress made in the OECD SERENA-2 programme, and to propose and perform any activity that might be needed to complement (and possibly have positive feedback on) the work performed in SERENA-2, with the help of data produced in SARNET out of SERENA (such as MISTEE, DEFOR and DROP experiments)[5].

WP7.2 - Hydrogen mixing and combustion in containment

Phenomena that are linked to the hydrogen-in-containment issue, which is still today of highest priority, are addressed. As a result, the containment thermal-hydraulics, including the hydrogen distribution, different hydrogen combustion regimes, their impact on containment structures and measures to prevent (severe) combustion processes or at least to mitigate their consequences with specific devices like passive autocatalytic recombiners (PAR) or with accident management measures, like containment sprays, are covered by this issue.

[5] To respect the property rights of the SERENA2 results, the participation in the WP7-1 will be open only to the organisations, from countries already partners of the SERENA2 Project, which is currently the case.

WP7.3 - Bringing research results into Reactor Application

The objective of this sub-work package is to achieve a comprehensive understanding of the experimental and theoretical work performed on the threats on the containment integrity of steam explosions and hydrogen combustions on containment integrity, to make use of it in a harmonized manner, and to apply the acquired knowledge to safety analyses of actual NPPs.

Workshops

In the view of favouring the exchange of information on the experimental and modelling results, periodic workshops are planned. They will be used too for preparing the joint programme of activities for the following period.

Description of work

This WP is divided into three sub-work packages.

WP7-1: Ex-vessel Fuel Coolant Interaction (FCI)

Task 1: Clarification of basic phenomena: melt jet fragmentation, void generation, fine fragmentation,…

Task 2: Evaluation of the range of applications and strength of the conclusions.

Task 3: Comparisons and analyses of the SERENA experimental data with European codes (MC3D, IKEJET/IKEMIX, IDEMO-2D, FRADEMO) and experiments (MISTEE and DEFOR experiments of KTH).

WP7-2: Hydrogen mixing and combustion in containment (H2)

Task 1: Modelling of containment sprays (leader: IRSN)

As a conclusion of the SARNET activities in this area, the level of validation obtained is encouraging for the use of water spray modelling for risk analysis. However, it is not sufficient and more investigations are needed in order to reach the level of validation that has been reached on gas distribution in containment applications during the OECD/CSNI ISP-47 project. Further activities on this topic are well encouraged: numerical benchmarks, in order to evaluate the influence of different parameters in the modelling, as well as benchmarks based on separate-effect tests.

The objective for SARNET2 is to go further with the code qualification, in particular for ASTEC, on analytical experiments concerning phenomena involved in containment analysis with spray systems. Two steps are planned:

– A global step, where some TOSQAN spray tests could be made available for the benchmarking, such as a TOSQAN test similar to TOSQAN 101 (analyzed in SARNET) but with addition of helium gas.

– A separate-effect step, where specific laboratory IRSN experiments designed for separate effects that occur with sprays systems are proposed in order to study influent parameters in spray models, modelling of experiments on the droplet coalescence, or other parts of the modelling.

Task 2: Condensation modelling in CFD codes (leader: University of Pisa)

Concerning the subject of the condensation modelling, simulations of experiments performed at the University of Pisa CONAN facility will be further carried out using Computational Fluid Dynamics (CFD) tools. Namely, many different approaches are currently being used in simulation of containment atmosphere behaviour in severe accident conditions, and the overall picture should be clarified. During SARNET2 project, the issue of condensation modelling in containment using CFD codes will eventually be closed, in the sense that:

– a comprehensive assessment of different existing models will be performed,

– some models will be eventually improved,

– consistent guidelines will be set up about adequate approaches for condensation modelling in CFD simulation of the containment thermal-hydraulics.

Task 3: Benchmark for flame acceleration and deflagration-to-detonation transition (leader: AECL)

The work planned in this proposed contribution aims at better understanding of the phenomena Flame Acceleration (FA) and Deflagration-to-Detonation Transition (DDT), that are of major interest for containment related research. Currently, criteria for FA and DDT in homogeneous mixtures with complete confinement are used in numerical accident analyses. However, the practical work for real plant applications in the recent years has shown that in accident simulations, predominantly stratified mixtures with concentration gradients and only partial enclosure of the burnable mixtures occur.

AECL is offering experiments as in-kind contribution dealing with partly stratified hydrogen-air mixtures, which may allow to derive less conservative criteria for flame acceleration and deflagration-to-detonation transition in homogeneous and inhomogeneous H_2-air-mixtures. AECL also tries to incorporate tests for partly-vented geometries. Benchmark calculations based on some AECL tests and their careful analysis may contribute to close an issue of high safety relevance. In addition, complementary data could be made available by IRSN to extend the benchmark activity to study the impact of diluents on the flame velocity.

Task 4: Hydrogen combustion in the course of DCH (leader: FZK)

An important outcome of the research activities in the domain "Direct Containment Heating (DCH)" within SARNET was the realization, that the combustion of hydrogen produced by oxidation during melt ejection from the reactor pressure vessel as well as the hydrogen initially present in the containment can be the dominant phenomenon for the containment pressurization. It turned out that the uncertainty in the combustion rate under these conditions was too large for the assessment of containment integrity for some reactors. Dedicated combustion codes (e.g. COM3D) are presently not capable to reproduce the results obtained in a first series of experiments with hydrogen release conducted in the DISCO facility at FZK. Combustion models and heat loss models need further improvements. As experiments at a single scale are not sufficient to reach this goal, additional tests at different scales should be performed. FZK will conduct hydrogen combustion experiments under DCH conditions at a large scale (220 m^3) and apply the CFD code COM3D for the analysis of these experiments. The final objective is to obtain parameters for combustion rates under DCH conditions at the reactor scale, to be used in lumped-parameter codes such as ASTEC.

WP7-3: Bringing research results into Reactor Application (CONT-RA)

One outcome of the OECD ISP-47 on containment thermal-hydraulics (on TOSQAN, MISTRA and ThAI facilities) was the recommendation to elaborate a generic containment (for benchmarking purposes) including all important components and allowing analyses being performed with lumped-parameter codes as well as with CFD codes. In this task, such a generic containment should be designed, the input decks for various codes should be prepared, first calculations should be performed (e.g. for passive autocatalytic recombiner behaviour with CFD codes under realistic accident conditions), and the calculations results should be compared. After the partners have defined the generic containment, which should be rather simple at the beginning, the input decks have to be prepared and benchmark calculation may start. In further steps, this containment can be completed with geometries and components of specifics interests. This work package is strongly linked to the other ones of the WP7 as it is a kind of necessary analytical scaling step from test facilities to real plant dimensions.

Task 1: Ex-vessel FCI reactor application (leader: to be defined)

An ex-vessel reactor exercise is scheduled at the end of the SERENA-2 phase. This exercise will serve to demonstrate the progress made as compared with Phase-1. The exercise should be concluded well before the end of SARNET-2. In line with the objective of FCI activities, the exercise results will be further analysed and discussed in the frame of SARNET2. If required, complementary calculations (e.g., sensibility calculations, different geometry…) will be also performed.

Task 2: Detailed evaluation of important experiments (leader: JSI)

Within the topic of atmosphere mixing, some experiments that have already been simulated in the past (such as, for example, the ISP-47 experiments) will be simulated again, with the additional knowledge and experience gained from the work performed in the meantime. Also, as the ultimate goal of investigations is the prediction of the behaviour of the containment atmosphere in actual NPPs, the issue of scaling of experimental and simulation results from experimental facilities to actual containments will be addressed.

Task 3: Preparation of input decks and test application (leader: Jülich)

Preparation of the input deck of the generic containment for lumped-parameter and CFD codes, followed by a calculation of a theoretical containment case based on a test examined in the first step (e.g. formation and deformation of a stratified atmosphere, including the influence of jets and plumes).

Task 4: Analyzing PAR modelling (leader: GRS)

The issue of PAR-atmosphere interaction is one of the most important issues of the interaction between the containment atmosphere and the hydrogen mitigation systems. However, not much theoretical work on this topic has been performed so far. Benchmark calculations using models for the behaviour of PARs will be performed. Additional information will be generated to dispose PARs in a highly effective manner.

Deliverables

The research will be carried out continuously during the 4-year period. Intermediate results will be presented in the periodic progress reports. The most important final results will be presented in detail in specific reports, mostly at the end of the 4-year period. A general overview of the work and the results of the 4-year period will be presented in the final Synthesis report, in which other results that have not been presented in specific reports but only in progress reports will also be described in more detail.

Progress and final reports:

First periodic progress report on Containment	Month 13
Second periodic progress report on Containment	Month 31
Final synthesis report on Containment: status of progress made towards issue resolution and impact of the remaining uncertainties	Month 49

Specific reports:

Comparison report on simulations of containment spray experiments	Month 43
Description of generic containment CFD models and performed simulations	Month 49
Analytical interpretation of the SERENA experiments	Month 49
Report on experiments on hydrogen combustion in the course of direct containment heating	Month 49

Work package number	8	**Start date or starting event:**	1
Work package title	Source Term (ST)		
Activity Type	RTD		

Participant number	1	2	3	6	7	8	9	10	11	13
Participant short name	IRSN	AEKI	AR G	CEA	CESI	CHAL	CIEM	DEM	EDF	ENEA
Person-months	23	12	4	20	8	8	18	8	6	8
Participant number	15	16	17	23	25	29	32	33	35	**36**
Participant short name	FZK	GRS	INR	NNL	PSI	TUS	UNEW	UNIPI	VEIKI	**VTT**
Person-months	20	20	12	8	20	8	12	8	8	**26**
Participant number	38	39	41							
Participant short name	JRCs	AECL	NRC							
Person-months	8	12	6.2							

Objectives

The overall objective of the programme is to reduce the uncertainties associated with calculating the potential release of radiotoxic fission products (FPs) to the environment that may occur during a severe accident in water-cooled nuclear reactors. It concentrates on iodine and ruthenium, given their high radio-toxicity, noting that the release of ruthenium is enhanced in oxidising atmospheres, such as those that may follow air ingress into the reactor coolant system (RCS). The research treats the transport of these elements through the primary circuit, including consideration of the steam generator for PWRs, and their behaviour in the containment. Of particular importance there is the prediction of volatile iodine and ruthenium species in the containment atmosphere, forms that are hard to remove by containment sprays, or by filtration while venting the containment. For ruthenium, the enhanced release from the fuel in oxidising conditions is also studied. The current understanding is distilled in the European severe accident sequence code ASTEC; this will be improved through performance of relevant experiments, interpretation of results, and coordinated model development / assessment. The results are relevant to PSA level 2 studies and development of severe accident management guidelines. To summarise, the aims would be:

- To address effectively these remaining high priority issues; and
- To distil the results in the form of validated models for ASTEC so that the gain in knowledge can be exploited in plant safety analysis.

The studies are thus divided into 3 tasks, reflected in the sub-packages:

- Oxidising influence on source term, considering ruthenium in particular;
- Iodine chemistry in the reactor coolant system and containment;
- Bringing the research results to reactor safety analysis.

Full advantage will be taken of cooperation with international programmes such as Phebus FP, the International Source Term Programme (ISTP), the International Science and Technology Centre (ISTC) concerning collaboration with Russia, and the programmes of the OECD/CSNI Group on Analysis and Management of Accidents (GAMA), to avoid duplication of experiments, to help coherency of the programmes and to identify remaining needs.

Description of work

WP8-1: OXidizing impact on source term (OX)

The technical work concentrates on areas where the main phenomena are not understood or not investigated at all, following the ruthenium source term from the fuel to the behaviour in-containment in particular:

- *FP release from fuel*: release from HBU and MOX fuels; role of fuel cladding, i.e. the competition between cladding oxidation, UO_2 oxidation and FP release; FP release under mixed steam-air conditions, which are more realistic than 100% air conditions in accident situations;
- *Ruthenium transport in RCS*: thermodynamic behaviour of ruthenium oxides; reactivity with surfaces and other chemical compounds such as caesium;
- *Ruthenium behaviour in containment:* behaviour of ruthenium oxides as aerosols in the containment, and their potential conversion to volatile forms; thermodynamic behaviour of ruthenium species in liquid phase and potential volatilization.

On the first of these items, experimental work on FP release and transport will be performed by CEA in VERDON facility under ISTP, and also in MERARG, with provision of similar data by AECL and also from the ISTC VERONIKA project if realised. The FIPRED programme at INR will provide further data on FP release from debris beds along with data on fuel pellet self-disintegration.

Concerning ruthenium transport in circuits, exploitation of data from new experiments by VTT and AEKI (RUSET) allows the building of a transport model, which is presently the missing link between the fuel release model and that for ruthenium behaviour in the containment. This would be enhanced by insights gained in the USNRC programme. This step is crucially important to obtain a predictive model to simulate the source term from the fuel through to the environment.

Concerning ruthenium behaviour in the containment, the current experimental and analytical work performed in the ISTP EPICUR programme and that concluded at Chalmers University concerning production of volatile ruthenium species under irradiation would be reviewed in the first period, also relevant insights from US work, and the need for any further work identified. Proposals would be made for any further small-scale experimental work and coordinated modelling/assessment studies as required, then execution of such work as appropriate.

WP8-2: IODine chemistry in RCS and in containment (IOD)

A similar approach will be adopted in the iodine area, under the following headings:

- *Iodine transport in circuits:* kinetic of gaseous phase reactions; speciation of revaporised iodine, and of other FPs; development of a databank from plant iodine spiking data supplying and associated development of a correlation type model covering some steam generator tube rupture (SGTR) events, volatile iodine mass transfers and adsorption/deposition in secondary side of a steam generator (SG) in case of a SGTR event;
- *Iodine behaviour in containment:* mechanisms of iodine association with painted surfaces (adsorption of iodine from particulate iodides deposited on 'wetted' surfaces); subsequent volatile iodine formation from iodine-loaded paint; radiolytic destruction of gaseous iodine species to form nucleate particles and subsequent behaviour of these particulate iodine oxides; iodine binding on sump materials and in sump screen blockages; the effect of passive autocatalytic recombiners (PARs) on iodine on the source term.

Much relevant experimental work is ongoing in ISTP, particularly concerning the kinetics of iodine chemistry in the circuit (CHIP facility), and in the containment under irradiation (EPICUR facility), while a new facility at VTT is devoted to speciation of revaporised FPs. Full exploitation of these data will allow the building of a kinetic and thermodynamic transport model, which is presently the missing link between the fuel release model and that for behaviour in the containment. Also relevant are the ISTC EVAN project and possible follow-on, the CSNI Behaviour of Iodine (BIP) project that includes data from AECL and VTT, and the CSNI ThAI project.

A review in the first period would identify any remaining experimental needs not covered in the international programmes so far, and proposing new experiments that could be performed to fill gaps in the database,

noting the need to avoid duplication. As for ruthenium, small-scale experiments would be conducted and analysed as needed. The data from existing and new experiments would be used for coordinated model development and assessment, as above.

WP8-3: Bringing research results into Reactor Application (ST-RA)

The objective of this package would be to benefit safety analysis from all the research performed in the source term area in recent years, in other words, to bring safety analysis to the current state-of-the-art of existing knowledge. A number of activities are foreseen:

- *Integral plant scenario calculations* to assess the impact of including recent research results in the area of source term;
- *Benchmarking of available codes* against integral experiments;
- *Maintenance of data books* where existing, such as for iodine, and *development,* such as for ruthenium;
- *Critical assessment* of severe accident management guidelines.

Benchmarks will be based on Phebus FPT2 (PWR control rod, period of steam starvation), Phebus FPT3 (boron carbide control rod, similar conditions to FPT2), concentrating on iodine behaviour in the circuit and containment, and also the multi-compartment ThAI-Iod-11 and Iod-12 tests; these will enable iodine models to be assessed in an integral context, for system-level codes such as ASTEC and possibly for more detailed treatments based for example on CFD tools. Advantage would be taken of OECD International Standard Problem (ISP) 46 performed on the basis of Phebus FPT1 data (PWR control rod, steam-rich conditions) and on the ThAI-Iod9 benchmark successfully performed in SARNET. The scope of the previous OECD TMI2-based benchmark exercise to the circuit and containment will be increased to cover FP release and containment behaviour, with suitable adjustment of the boundary conditions. This gives transposition to full reactor scale without possible proprietary-related issues, and takes advantage of the fact that TMI-2 nodalisations already exist for most major codes. Finally, in the view of bringing these research results into safety analysis, and to preserve the knowledge gained, it is envisaged to maintain data books at least for ruthenium and iodine, possibly extended to such topics as the effect of aerosol behaviour on FP transport, and to make a reassessment of severe accident management guidelines in the light of SARNET source term results. This activity will encourage and stimulate technical exchange amongst partners.

Workshops

Workshops will be held towards the end of each reporting period of the project, to review the technical progress over the whole of the WP and to decide the programme for the following period, taking into account the lessons learnt so far. The proceedings from these workshops will form the basis for the progress reporting foreseen below. They will also serve as opportunities for collaboration with other relevant WPs, for example in the corium area. Following the successful experience in SARNET, each WP will be organised into specialist technical circles that will progress their work in a cooperative manner, meeting where appropriate to help coordinate their activities, and feeding their results into the WP as a whole.

Deliverables	
First periodic progress report on Source Term	Month 13
Final report on ThAI benchmark	Month 24
Second periodic progress report on Source Term	Month 31
Final report on FPT2 benchmark	Month 33
Final report on FPT3 benchmark	Month 48
Final report on TMI2 benchmark	Month 48
Data Book on Ruthenium	Month 48
Final synthesis report on Source Term	Month 49

B1.3.6 Efforts for the full duration of the project

Table 3: Project Effort Form 1 - Indicative efforts per beneficiary per WP

Project number (acronym): 231747 (SARNET2)

Workpackage[6]	**WP1**	**WP2**	**WP3**	**WP4**	**WP5**	**WP6**	**WP7**	**WP8**	**TOTAL per Beneficiary**
IRSN	52,0	3,5*	4,0	53,0	20,0	36,0	20,7	23,0	211,2
AEKI	0,0	0,0	4,0	0,0	6,0	0,0	0,0	12,0	22,0
AREVA NP GmbH	2,0	0,0	0,0	7,0	0,0	0,0	2,3	4,0	15,3
AREVA NP SAS	0,0	0,0	0,0	7,0	0,0	0,0	0,0	0,0	7,0
BME	0,0	0,0	0,0	9,0	0,0	0,0	0,0	0,0	9,0
CEA	2,0	0,0	4,0	1,0	20,0	108,0	10,9	20,0	165,9
CESI R	0,0	0,0	0,0	0,0	4,0	12,0	0,0	8,0	24,0
CHALMERS	0,0	0,0	0,0	0,0	0,0	0,0	0,0	8,0	8,0
CIEMAT	0,0	0,0	4,0	1,0	0,0	0,0	0,0	18,0	23,0
DEMOKRITOS	0,0	0,0	0,0	0,0	0,0	0,0	2,3	8,0	10,3
EDF	1,0	0,0	0,0	5,0	0,0	1,0	5,0	6,0	18,0
EI	0,0	0,0	0,0	9,0	0,0	12,0	0,0	0,0	21,0
ENEA	0,0	0,0	0,0	17,0	12,0	0,0	6,9	8,0	43,9
JÜLICH	0,0	0,0	0,0	0,0	0,0	0,0	6,6	0,0	6,6
FZK	2,0	0,0	4,0	1,0	52,0	28,0	8,1	20,0	115,1
GRS	4,0	0,0	12,0	33,0	20,0	10,0	13,5	20,0	112,5
INR	0,0	0,0	0,0	57,0	0,0	0,0	0,0	12,0	69,0
INRNE	0,0	0,0	0,0	23,0	8,0	26,0	2,3	0,0	59,3
IVS	0,0	0,0	0,0	23,0	18,0	0,0	0,0	0,0	41,0
JSI	0,0	0,0	0,0	1,0	0,0	0,0	38,9	0,0	39,9

*3,5 person.months have been affected in WP2 to the IRSN partner, as a reserve, in order to cover the organisation of the ERMSAR conferences and the education and training courses. They will be distributed later on to each partner (to be defined) that will host and co-organise them.

[6] Please indicate in the table the number of person months over the whole duration for the planned work , for each work package by each beneficiary

Workpackage[7]	WP1	WP2	WP3	WP4	WP5	WP6	WP7	WP8	TOTAL per Beneficiary
KTH	2,0	**9,0**	4,0	35,0	34,0	16,0	4,0	0,0	104,0
LEI	0,0	0,0	0,0	11,0	8,0	0,0	4,6	0,0	23,6
NNL	0,0	0,0	0,0	0,0	0,0	0,0	0,0	8,0	8,0
NRG	0,0	0,0	0,0	0,0	0,0	0,0	4,6	0,0	4,6
PSI	2,0	0,0	0,0	0,0	34,0	0,0	0,0	20,0	56,0
RUB	0,0	0,0	0,0	1,0	8,0	0,0	2,3	0,0	11,3
TRACTEBEL	0,0	0,0	0,0	11,0	0,0	0,0	0,0	0,0	11,0
THERMODATA	0,0	0,0	0,0	0,0	16,0	12,0	0,0	0,0	28,0
TUS	2,0	0,0	0,0	5,0	4,0	6,0	4,6	8,0	29,6
UJD SR	0,0	0,0	0,0	21,0	0,0	0,0	0,0	0,0	21,0
UJV	0,0	0,0	0,0	1,0	4,0	6,0	4,6	0,0	15,6
UNEW	0,0	0,0	0,0	0,0	0,0	0,0	0,0	12,0	12,0
UNIPI	0,0	2,0	0,0	1,0	0,0	0,0	10,4	8,0	21,4
USTUTT	0,0	0,0	0,0	62,0	32,0	16,0	4,0	0,0	114,0
VEIKI	0,0	0,0	0,0	23,0	24,0	10,0	6,9	8,0	71,9
VTT	2,0	0,0	1,0	0,0	12,0	12,0	2,0	**26,0**	55,0
VUJE	0,0	0,0	0,0	23,0	0,0	0,0	2,3	0,0	25,3
JRCs	4,0	0,0	2,0	0,0	0,0	4,0	0,0	8,0	18,0
AECL	0,0	0,0	0,0	5,0	4,0	0,0	8,1	12,0	29,1
KAERI	0,0	0,0	0,0	5,0	0,0	4,0	8,0	0,0	17,0
USNRC	0,0	0,0	0,0	0,0	0,0	0,0	0,0	6,2	6,2
TOTAL	75,0	14,5	39,0	451,0	340,0	319,0	183,9	283,2	1705,6

[7] Please indicate in the table the number of person months over the whole duration for the planned work, for each work package by each beneficiary

Table 4: Project Effort Form 2 - Indicative efforts per activity type per beneficiary

Project number (acronym): 231747 (SARNET2)

Activity Type	IRSN	AEKI	AREVA NP GmbH	AREVA NP SAS	BME	CEA	CESI R
RTD/Innovation activities							
WP1	4		2			2	
WP2							
WP3							
WP4	53		7	7	9	1	
WP5	20	6				20	4
WP6	36					108	12
WP7	20,7		2,3			10,9	
WP8	23	12	4			20	8
Total 'research'	156,7	18	15,3	7	9	161,9	24
Consortium management activities							
WP1	48						
WP2							
WP3							
WP4							
WP5							
WP6							
WP7							
WP8							
Total ' management'	48						
Other activities							
WP1							
WP2	3,5						
WP3	4	4				4	
WP4							
WP5							
WP6							
WP7							
WP8							
Total 'other'	7,5	4				4	
TOTAL BENEFICIARIES	212,2	22	15,3	7	9	165,9	24

Activity Type	CHALMERS	CIEMAT	DEMOKRITOS	EDF	EI	ENEA	JULICH
RTD/Innovation activities							
WP1				1			
WP2							
WP3							
WP4		1		5	9	17	
WP5						12	
WP6				1	12		
WP7			2,3	5		6,9	6,6
WP8	8	18	8	6		8	
Total 'research'	8	19	10,3	18	21	43,9	6,6
Consortium management activities							
WP1							
WP2							
WP3							
WP4							
WP5							
WP6							
WP7							
WP8							
Total ' management'							
Other activities							
WP1							
WP2							
WP3		4					
WP4							
WP5							
WP6							
WP7							
WP8							
Total 'other'		4					
TOTAL BENEFICIARIES	8	23	10,3	18	21	43,9	6,6

Activity Type	FZK	GRS	INR	INRNE	IVS	JSI	KTH
RTD/Innovation activities							
WP1	2	4					2
WP2							
WP3							
WP4	1	33	57	23	23	1	35
WP5	52	20		8	18		34
WP6	28	10		26			16
WP7	8,1	13,5		2,3		38,9	4
WP8	20	20	12				
Total 'research'	111,1	100,5	69	59,3	41	39,9	91
Consortium management activities							
WP1							
WP2							
WP3							
WP4							
WP5							
WP6							
WP7							
WP8							
Total ' management'							
Other activities							
WP1							
WP2							9
WP3	4	12					4
WP4							
WP5							
WP6							
WP7							
WP8							
Total 'other'	4	12					13
TOTAL BENEFICIARIES	115,1	112,5	69	59,3	41	39,9	104

Activity Type	LEI	NNL	NRG	PSI	RUB	TRACTEBEL	THERMODATA
RTD/Innovation activities							
WP1				2			
WP2							
WP3							
WP4	11				1	11	
WP5	8			34	8		16
WP6							12
WP7	4,6		4,6		2,3		
WP8		8		20			
Total 'research'	23,6	8	4,6	56	11,3	11	28
Consortium management activities							
WP1							
WP2							
WP3							
WP4							
WP5							
WP6							
WP7							
WP8							
Total ' management'							
Other activities							
WP1							
WP2							
WP3							
WP4							
WP5							
WP6							
WP7							
WP8							
Total 'other'							
TOTAL BENEFICIARIES	23,6	8	4,6	56	11,3	11	28

Activity Type	TUS	UJD SR	UJV	UNEW	UNIPI	USTUTT	VEIKI
RTD/Innovation activities							
WP1	2						
WP2							
WP3							
WP4	5	21	1		1	62	23
WP5	4		4			32	24
WP6	6		6			16	10
WP7	4,6		4,6		10,4	4	6,9
WP8	8			12	8		8
Total 'research'	29,6	21	15,6	12	19,4	114	71,9
Consortium management activities							
WP1							
WP2							
WP3							
WP4							
WP5							
WP6							
WP7							
WP8							
Total ' management'							
Other activities							
WP1							
WP2					2		
WP3							
WP4							
WP5							
WP6							
WP7							
WP8							
Total 'other'							
TOTAL BENEFICIARIES	29,6	21	15,6	12	21,4	114	71,9

Activity Type	VTT	VUJE	JRCs	AECL	KAERI	USNRC	TOTAL ACTIVITIES
RTD/Innovation activities							
WP1	2						23
WP2							0
WP3							0
WP4		23		5	5		451
WP5	12			4			340
WP6	12		4		4		319
WP7	2	2,3		8,1	8		183,9
WP8	26		8	12		6,2	283,2
Total 'research'	54	25,3	12	29,1	17	6,2	1600,1
Consortium management activities							
WP1			4				52
WP2							0
WP3							0
WP4							0
WP5							0
WP6							0
WP7							0
WP8							0
Total ' management'			4				52
Other activities							
WP1							0
WP2							14,5
WP3	1		2				39
WP4							0
WP5							0
WP6							0
WP7							0
WP8							0
Total 'other'	1		2				53,5
TOTAL BENEFICIARIES	55	25,3	18	29,1	17	6,2	1705,6

B1.3.7 List of milestones

The major milestones of the project are listed in Table 5 here-under.

Table 5 : SARNET2 milestones

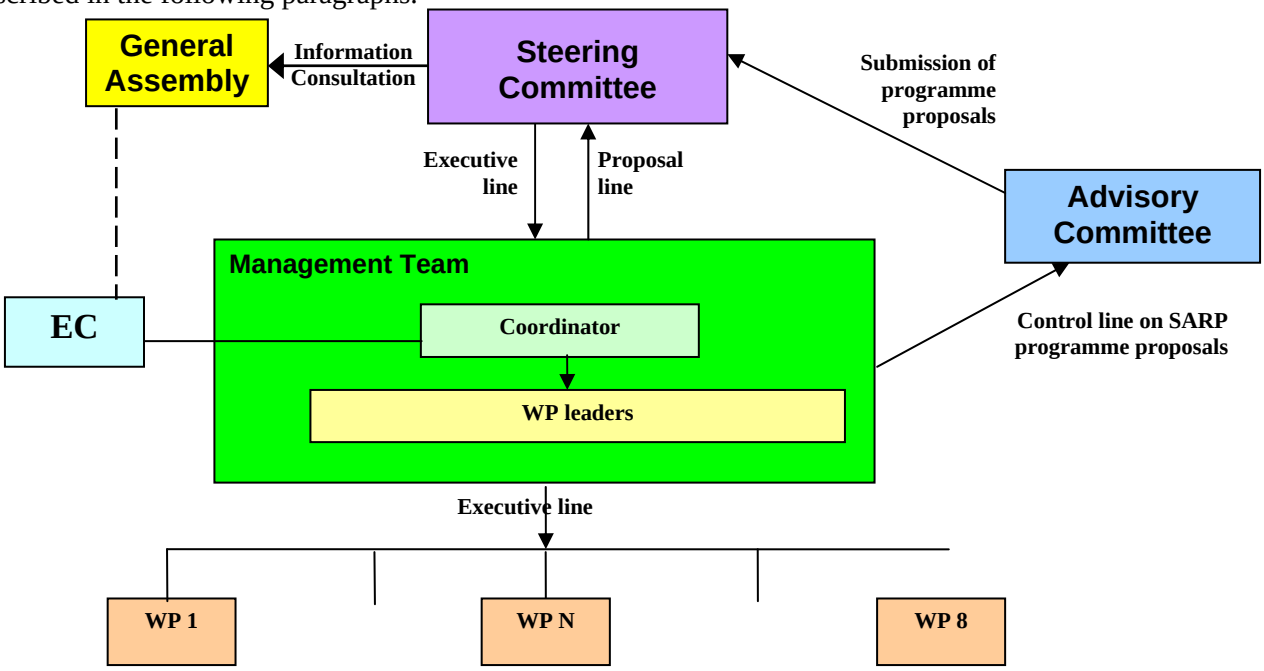
Milestone n°	Milestone name	WP(s) involved	Expected date (months)	Means of verification
M1	Decision on the type of legal entity to be created after the SARNET2 Contract and assessment of the viability of the durable integration structure proposed for the network (sources of funding, etc…)	**Steering Committee** and **WP1**	12	Dedicated review. Decision reported in a document (e.g. meeting minutes)
M2	First VULCANO SARNET2 experiment	**WP6**	12	Experiment performed
M3	Synthesis of ASTEC V2.0 assessment	**WP4**	18	Report issued
M4	Updated version of SARNET SARP conclusions and proposals	**WP1**, 4, 5, 6, 7, 8	28	Report issued
M5	Development of generic containment model	**WP7**	30	Report issued
M6	Major progress on corium and debris coolability	**WP5**	30	Progress on model validation and implementation in ASTEC*
M7	Proposal of improved MCCI models for ASTEC	**WP6**	36	Report issued
M8	Release of ASTEC V2.2 version (improved for BWR and CANDU NPPs)	**WP4**	36	Version released to code users
M9	Conclusions on corium and debris coolability	**WP5**	48	Report issued and proposals for model implementation in ASTEC
M10	Data Book on Ruthenium	**WP8**	48	Book edited
M11	Creation of a legal entity and self-sustainability of the NoE	**Steering Committee**, All WPs	48	Status of the legal entity
M12	Final Synthesis SARNET2 Report	**WP1**, and all	49	Report issued

* This milestone corresponds to expected major progress on corium and debris coolability. Nevertheless, the models will be periodically updated all along the SARNET2 duration.

B.2 Implementation

B2.1 Management Structure and Procedures

The global management structure of SARNET2 project is represented by the following scheme and described in the following paragraphs.



B2.1.1 The Steering Committee

SARNET will be steered by a Steering Committee.

This Steering Committee will be constituted of 10 members:

- 6 representatives of the partners already involved in the SARNET Follow-up Working Group: IRSN, CEA, FZK, GRS, KTH, PSI,
- 1 representative of utilities: EDF,
- 1 representative of vendors: AREVA NP GmbH,
- 2 representatives of other partners (to be elected by the General Assembly).

The Steering Committee will be in charge of strategic decisions. It will meet twice a year. In case of specific problems to be solved urgently, a specific meeting may be held (possibly by video-conference) or a decision may be taken from e-mail exchanges between the Steering Committee members. It will inform and consult all the Consortium Contractors, plus the EC representative, through an annual General Assembly where all the partners will be invited. The Steering Committee will be advised by an Advisory Committee.

The Steering Committee will review the progress made by the network, in particular in terms of general management, of integration, of spreading of excellence and of ranking of research priorities. It will make recommendations on future orientations to be taken regarding missing knowledge, from the work of the research priority team, taking into account the advice of end-user representatives through the Advisory Committee.

One major mission of the Steering Committee will consist, from proposals of the Management Team, to take the decision on the type of legal entity which will be created before the end of the four-year period, including a dedicated review to assess the viability of the durable integration structure proposed, together with the practical steps for achieving it: see Milestone M1 in B1.3.7 with the deadline one year after the project beginning. It will carefully follow the steps of the creation of this legal entity to be sure of the

setting-up and the operability of this legal entity in due time, to ensure the long term self-sustainability of the network (see Chapter B1.3.5 on the WP1 Management for more details).

The members of the Steering Committee shall be of high management level in their organization in order to be able to commit the resources of their organisation for performing research activities decided by the network. These activities will be proposed by the Management Team (periodic JPA for the coming period that will serve as Detailed Implementation Plan, no longer required by the EC) and will be approved (or amended) by the Steering Committee.

The Steering Committee will elect a Chairperson among its members. A Deputy coming from another Contractor located in a different State will assist the Chairperson.

The Chairperson may invite any expert or qualified person to attend meetings of the Steering Committee with a role of advisor. The Coordinator shall attend the Steering Committee meetings, both to report the activities of the network and in an advisory capacity. The chairperson of the Advisory Committee will be also invited to attend the Steering Committee meetings in an advisory capacity.

The Steering Committee, as the Consortium's decision-making and arbitration body, shall notably:

- Define the strategic orientations of SARNET2, in particular in promoting jointly executed research activities and programmes for disseminating excellence,
- Set up objectives for knowledge management and organize knowledge assessment,
- Approve the periodic JPA proposed by the Management Team, and monitor its implementation,
- Decide on the allocation of the financial contribution of the Commission,
- Be informed by the Contractors or by the Management Team of any difficulty that a Contractor may have to face in implementing the JPA and examine the actions to be taken to overcome them,
- Decide on any inclusion, exclusion or withdrawal of Contractors,
- Ensure the long term self-sustainability of the network through the creation of a legal entity.

The Steering Committee will endeavour to reach its decisions on a consensual basis. However, in case a consensus could not be reached, the decisions will be taken by vote. Details concerning the voting process will be defined in the Consortium Agreement.

B2.1.2 The Advisory Committee

The Advisory Committee will be constituted by managers of end-user organisations (belonging or not to the SARNET2 Consortium), including Vendors, Utilities and Regulatory Bodies.

The role of the Advisory Committee will be to provide the Steering Committee with advice on strategic orientations of the research activities of SARNET2, with the ultimate goal of a better prevention and mitigation of severe accidents in European NPPs.

The Steering Committee will appoint the Advisory Committee members. The Advisory Committee members will elect a Chairperson and will meet yearly.

B2.1.3 The General Assembly

The General Assembly will be constituted by one representative of each Consortium Contractor, plus the EC representative.

It will be called yearly in order to inform and consult all the Consortium Contractors. The progress of the network activities, the JPA and the decisions taken by the Steering Committee will be reported by the SARNET2 Coordinator and by the Chairperson of the Steering Committee.

In addition to the General Assembly, all the Consortium members will be periodically informed of major progress and events by the Coordinator.

B2.1.4 The Management Team

The Management Team will be entrusted on behalf of the Steering Committee with the operational tasks for the day-to-day management of the network.

The SARNET2 Coordinator heads the Management team. He will be in charge of the relations with the European Commission and of the overall coordination of the network. He will be helped by an assistant.

The Management Team is composed of the Coordinator heading the team, plus the seven Work-package leaders (WPs 2 to 8).

The Management Team shall notably:
- Monitor the progress made in the JPA,
- Promote collaborative work,
- Examine any difficulty that may arise and examine with the corresponding task leaders the possible actions to overcome them,
- Examine the new proposals of work, promote collaborations and make proposals to the Steering Committee for updating the JPA,
- Manage the communication system of the network,
- Manage the experimental database of the network,
- Manage knowledge and make sure that the access rights stipulated in the Consortium Agreement are fully respected,
- Organise the training and education activities,
- Disseminate information inside and outside the network, in particular by organizing conferences and topical seminars, and by maintaining updated information on the Web site.

The Coordinator acts under the control of the Steering Committee, and reports to it on his duty, by:
- Providing technical and financial reports,
- Coordinating the periodic JPA updates for approval by the Steering Committee,
- Implementing the decisions of the Steering Committee, notably on the JPA content.

The Coordinator is responsible for the relations with the Commission. In particular, he will be in charge of:
- Transmission of all information related to SARNET2 to the Commission,
- Reception of all payments made by the Commission,
- Administration of the Community's contribution, in particular distribution of the funds between Contractors in accordance with the Consortium Agreement and with decisions taken by the Steering Committee. The Coordinator shall ensure that the appropriate payments are made to Contractors without unjustified delays.
- Keeping accounts making it possible to determine at any time what portion of the Community funds has been allocated to each Contractor for the purpose of the network so as to inform the Commission of the distribution of funds and the date of transfers to the Contractors on a periodic basis.

IRSN will act as the SARNET2 Coordinator for the duration of the Project with the Commission. Beyond this period, a legal entity will be created to ensure the continuation of the network on a self-sustainable basis.

The Management Team will regularly report to the Commission and the Steering Committee on the technical progress made in the JPA and on the financial status.

A large part of the management activities will also be devoted to the dissemination of information and knowledge inside and outside of the network:
- Information on the progress made in the JPA;
- Information on main outcomes of the JPA;
- Information exchange between participants on their activities and specificities;
- Promotion of joint publications in open literature;
- Participation to the organization of ERMSAR conferences.

Beyond these tasks a large effort will be produced to prepare the creation of a legal entity which will ensure the continuation of the network after the EC Grant Agreement on a self-sustainable basis. Currently several possibilities are envisaged for this legal entity (Association in the framework of the "French law of 1901" or equivalent Belgium system, Research Foundation, non-profit European Economic Interest Grouping (EEIG)…). Advantages and drawbacks of these possibilities will be studied in depth by the Coordinator and lawyers in order to choose the most adequate solution.

B2.2 Beneficiaries

Participant number 1: Institut de Radioprotection et de Sûreté Nucléaire (IRSN, France)

IRSN groups together more than 1 500 experts and researchers. IRSN carries out research, analysis and work within the fields of nuclear safety, protection against ionising rays, the control and protection of nuclear materials and protection against acts of malevolence. IRSN plays an active role in providing information to the public within its fields of expertise: nuclear and radiological risks.

In the domain of severe accidents IRSN has more than 20 years of experience. It carried several kinds of R&D activities: in-pile testing (PHEBUS), separate-effects testing, interpretation and modelling, code development (ICARE/CATHARE, ASTEC, TONUS, MC3D), and PSA. Its domains of competence involve fission product chemistry, core degradation, corium modelling, and containment modelling, including hydrogen behaviour and containment thermal hydraulics. It has a large experience in managing international collaborations (PHEBUS, CABRI, ICARE/CATHARE, ASTEC) and EU projects (CIT, COLOSS, ENTHALPY, EVITA, EURSAFE, THENPHEBISP… and SARNET).

The key persons involved are:
L. Bellenfant, A. Bentaib, P.Chatelard, B. Clément, M. Cranga, F.Fichot, J. Fleurot, N. Girault, G. Guillard, J. Malet, R. Meignen, E. Primet, E.Raimond, B. Simondi-Teisseire, N. Stenne, A. Tenaud, J.P. Van Dorsselaere.

Participant number 2: Hungarian Academy of Sciences KFKI Atomic Energy Research Institute (AEKI, Hungary)

AEKI is a research institute of the Hungarian Academy of Sciences mainly active in the field of basic and applied research related to nuclear energy. Practical applications are essential as well. The activities of the institute started in the fifties, that time AEKI was part of the Central Research Institute for Physics (KFKI). AEKI became independent on January 1, 1992.

AEKI has almost 200 employees, among them about 100 scientists. The main research areas of AEKI are reactor physics, thermal hydraulics, fuel behaviour studies, material sciences, related aspects of informatics (simulators, core monitoring, etc), health physics, environmental investigations, nuclear electronics and chemistry. Most of these activities started in the fifties and sixties, providing the experts of the institute with remarkable background.

Experimental work has always been emphasized. Experiments were performed from the fifties to the eighties on several critical assemblies. Experiments on a thermohydraulic loop started in the seventies and are still running. The CODEX (COre Degradation EXperiment) integral tests and small scale experiments on severe accidents are running since the early nineties. The institute operates the 10 MW Budapest Research Reactor, providing the scientific community of Europe with research possibility for neutron physics and applications and Hungary with radioactive isotopes, mainly used by medical applications.

AEKI proposes different experimental series for SARNET-2 corium and source term activities.

The key persons involved are:
Dr. Zoltán Hózer is a senior research scientist at the Hungarian Academy of Sciences KFKI Atomic Energy Research Institute, working in the area of fuel and reactor materials experimental and analytical studies. He is heading the Fuel Department of AEKI
Nóra Vér is a research scientist at the Hungarian Academy of Sciences KFKI Atomic Energy Research Institute, working at the area of high temperature reactions of cladding materials and of ruthenium oxidation and release. She is responsible for running the RUSET experimental programme
Imre Nagy is a research scientist at the Hungarian Academy of Sciences KFKI Atomic Energy Research Institute. He is involved in experimental programmes devoted to the investigation of reactor core materials under extreme conditions. Imre Nagy is responsible for the maintenance of the STRESA node of AEKI and plays leading role in the execution of CODEX tests.

Participant number 3: AREVA NP GmbH (AREVA NP GmbH, Germany)

A description of AREVA NP is provided in the next part: AREVA NP SAS participant.

The key person involved is:
J. Eyink

Participant number 4: AREVA NP SAS (AREVA NP SAS, France)

AREVA NP is an AREVA group company dedicated to the design and construction of nuclear power plants and research reactors, engineering, instrumentation & control, modernization, maintenance and repair services, components manufacture and supply of nuclear fuel.

Headquartered in Paris (Areva NP SAS) with regional subsidiaries in the U.S. (Areva NP Inc) and Germany (Areva NP GmbH), AREVA NP has a total workforce of 14,200 employees and is active in Eastern and Western Europe, North and South America, Asia and Africa. In the company, AREVA has a 66% stake and Siemens 34%.

As a committed leader in the development and growth of nuclear power, AREVA NP offers experience, R&D, and unparalleled innovation and expertise in engineering, major project management, fuel, equipment and services supply for all reactors technologies, primarily for PWRs and BWRs.

Serving as Original Equipment Manufacturer (OEM), AREVA NP has built about 100 nuclear plants in 11 countries that provide about 30% of the world's total installed nuclear power capacity and its experienced resources remain focused on the local needs of individual clients, wherever in the world they may be.

AREVA NP's priority is to provide the best solutions to meet challenges faced by electrical utilities worldwide. The company further improves plant performance, reduces operating costs and extends plant lifetime and thus helps customers power the world with safe, clean and cost-effective nuclear energy.

AREVA NP SAS has a large expertise in severe accidents analysis for PWR, FBR, to enhance the safety level of existing and future plants, in the design approach to mitigate consequences of a severe accident, as for EPR, in PSA level 2 analysis, in operating strategies.

AREVA NP SAS is particularly involved in integral codes improvements and reactor applications to study the core melt scenarios, mainly with MAAP, but also with other codes as ICARE/CATHARE.

In SARNET2, AREVA SAS mainly aims to participate in Reactor applications with ASTEC code and benchmarking in the frame of WP4: to evaluate and improve the capability of ASTEC to simulate reactor transients, and compare it to other integral codes as MAAP.

The key person involved is:
Pascal Gandrille, Senior Engineer with more than 15 years experience in severe accident codes analysis.

Participant number 5: Budapest University of Technology and Economics (BME, Hungary)

The Institute of Nuclear Techniques (INT) of the Budapest University of Technology and Economics (BME) is part of the Faculty of Natural Sciences. The Institute constitutes of two units: the Department of Nuclear Techniques organises the educational tasks of the Institute, whereas the Department of Nuclear Energy operates the Nuclear Training Reactor. However, every member of the academic staff of the Institute has his/her own tasks as well in the education and training as in the reactor operation.

The Institute of Nuclear Techniques - because of the high value Training Reactor - has been declared as "interuniversity institution". Its main task is to educate the undergraduate, graduate and PhD students of the BME and other Hungarian universities and higher education institutions in the field of nuclear techniques. The Institute of Nuclear Techniques plays an important role in several fields of the education:

- Leads and organises a specialisation module - the module of Nuclear Techniques - of the 5 years engineering-physics formation. (This type of formation runs out with the introduction of the Bologna system in Hungary)
- Helds lectures and laboratories for the undergraduate students of Physics BSc, who choose the specialisation "Applied Physics" with nuclear orientation

- Leads and organises the "Nuclear Energy" specialisation of the "Energy Engineering BSc"
- Leads and organises the specialisation "Nuclear Techniques" of the Physics MSc programme, which is scheduled to start in 2009
- Leads and organises the programme of the specialisation "Nuclear Energy" of the "Energy Engineering MSc" programme
- Organises regularly the postgraduate continuing education programme "Reactor techniques"
- Regularly offers research possibilities for undergraduate and graduate students
- Announces diploma works for undergraduate and graduate students
- Contributes to the PhD programme of the BME with announcing research possibilities for PhD theses in the nuclear field
- Organises and participates in the international "Eugene Wigner Course for Reactor Physics Experiments" ENEN exchange course (in English)

Students from abroad can also study in the Institute of Nuclear Techniques. Group of graduate students of the Slovak Technical University Bratislava and the Czech Technical University Prague come here regularly and perform laboratory experiments. A few students of the University of Rennes INSA (France) have prepared their diploma work here, and we received PhD students form Delft University (The Netherlands) as well. Every year there is a common project work done by a group of students of the Ecole de Mines de Nantes (France) and Hungarian students. Following the request of the International Atomic Energy Agency (IAEA) Vienna the staff of the Institute of Nuclear Techniques has organised technical courses of different duration - from 6 weeks to 3 months - for professionals of developing countries about the utilisation of research reactors. We also regularly train individual young professionals with the fellowship of the IAEA.

The educational and research activity of the Institute is centred around the Training Reactor, but it is accompanied by other theoretical fields of the nuclear techniques. An internationally accredited radiochemistry laboratory is working here as well. The Training Reactor can be visited by all students of the Budapest University of Technology and Economics, but also by external visitors.

The Budapest University of Technology and Economics will participate to SARNET through its Institute of Nuclear Techniques and apply to severe accidents its expertise in thermal hydraulics and CFD codes.

The key persons involved are:
Dr. Attila Aszódi, Gábor Paitz

Participant number 6: Commissariat à l'Energie Atomique (CEA, France)

CEA/DEN is the Nuclear Energy Directorate of the French Atomic Energy Commission. Within this directorate, about 5000 staff work on R&D for all the aspects of nuclear energy. For a long time, the CEA teams have worked on severe accidents, firstly for breeder reactors, then for PWRs. From these studies, a broad expertise has been acquired which can be detailed as follows:

- Long-term experience on operating highly qualified research facilities with different technological background amongst them: small-scale/large-scale, basic phenomena, demonstration of overall processes, real / simulant corium materials… At the present time, CEA operates the largest real material platform in Europe (PLINIUS), with the VULCANO facility for MCCI study and KROTOS facility for FCI experiments (CEA is the operating agent of the OECD SERENA 2 project on FCI).
- Expertise on measurement technique.
- Expertise on the physico-chemistry and thermal-hydraulics coupled phenomena.
- Know-how on microanalysis and metallographic investigations.
- Expertise in modelling of the investigated phenomena using different approaches.
- Expertise in code development related to severe accident.
- Knowledge on the boundary conditions for real reactor application in existing as well as future reactor plants being currently designed.

Besides these competencies in physics, through the participation in several EC projects from more than 10 years and the coordination of some of them (CSC, EUROCORE, CORIUM EUROCOURSE, PLINIUS…), the CEA severe accident team has now a long-term expertise on organizing and leading multi-partner consortiums for international research programmes.

CEA will be mostly involved in WP 6 activities (Molten Corium Concrete Interaction). CEA will also contribute in WP 5 (Corium and debris Coolability, WP7 (Containment) and WP8 (Source Term) activities.

The key persons involved are:

Dr. J.M. Seiler, CEA Research Director, is more particularly in charge of the analysis of PWR severe accident studies. He is member of OECD/CSNI MASCA Steering Committee and contributed to the review for the US DOE of the AP 600 core retention report. He has a 25-year experience in nuclear safety started with a PhD thesis on sodium boiling and ranging from safety of nuclear material transport to EPR severe accidents. He is one of the promoters of the coupled approach between physico-chemistry and thermal-hydraulics.

Dr. G. Ducros, CEA Research Director, is in charge of fission product studies. He conducted the VERCORS programme in Grenoble in close cooperation with the IRSN experts. Within this programme, he studied the release of fission products from degraded fuel in various conditions including some tests with MOX.

Dr. C. Journeau, CEA Senior Expert, has a 15-year experience in instrumentation and in the analysis of complex experiments. His current field of research is the coupling between heat transfer, physico-chemistry and fluid dynamics and corium properties. He stayed one year at JRC Ispra to work on the FARO facility, in which 300 kg of prototypic corium could be melted by direct electrical heating. He is currently the PLINIUS platform scientific officer. He authored 44 peer-reviewed publications and communications. Strong experience on experiments (COLIMA, participation to OECD-MASCA) and modelling on prototypic corium molten pool and debris bed behaviour. Previously strongly involved in CIT, CSC, ENTHALPY, ECOSTAR, EUROCORE, EURSAFE,...), he has co-ordinated the corium domain in the phase 1 of SARNET.

Dr. P. Piluso, CEA Senior Expert, Engineer (graduated from Ecole Nationale Supérieure de Céramiques Industrielles) and Doctor in Material Sciences (graduated from Université Pierre et Marie Curie / Ecole Supérieure de Physique et de Chimie Industrielles de Paris), works on Thermophysical properties of corium : measurements and data bases. He acts as the Material Science officer of the experimental PLINIUS Platform, and he was the main organizer of two out of the three SARNET Courses on Severe accident (France and Hungary).

Participant number 7: CESI RICERCA S.p.A. (CESI R, Italy)

CESI RICERCA S.p.A. was established at the end of 2005 and has been operating since 1st January 2006 with the mission to develop research activities funded at the national and international level in the electricity and energy field. CESI RICERCA S.p.A. is a publicly-controlled Company: ENEA, the "Italian National Agency for New Technologies, Energy and the Environment", holds 51% of its shares and CESI, the "Italian Electrotechnical Centre of Experiences Giacinto Motta" S.p.A., holds the remaining 49%. The combined participation of the public and private sector guarantees that the objectives of CESI RICERCA are in agreement with the Country's energy strategy and the needs of the operators of the electricity sector.

The mission of CESI RICERCA is to develop research projects of general interest to the national electricity system, focusing on applied research and with a system-oriented approach. The activity is aimed at innovating and improving the performance of the system from the point of view of economics, safety and environmental compatibility. Other major purposes are a wide activity of dissemination of the results, and the in-depth discussion of electro-energetic and environmental issues.

The know-how of CESI RICERCA covers all stages of power system life cycle. Feasibility studies, analysis of industrial processes, development of innovative measurement systems and computer models are part of its job. CESI RICERCA labs are located in Milan, Bergamo and Piacenza. They employ about 400 people and operate several experimental and demonstration plants.

In the NoE, CESI RICERCA is in charge of modelling in the field of aerosol transport and corium coolability.

The key persons involved are:

Dr. Flavio Parozzi. He got a university degree in Nuclear Engineering at Politecnico of Milano, Italy, in 1978. He is team leader of nuclear power researches and directly manages the safety studies and the development of new thermal-hydraulic and physic-chemical simulation tools in cooperation with utilities,

research organizations and universities. He has been working on nuclear safety theoretical and experimental activities since early Eighties at ENEL, joining international specialist groups and developing original computer models for severe accident analyses, with particular attention to the fission product transport aspects and the containment phenomenologies. As an expert of severe accident modelling, he cooperated with the European Commission both as evaluator of research proposals and as coordinator of international research projects on nuclear safety.

Dr. Franco Polidoro. He graduated as nuclear engineer at Politecnico di Milano in 1989, started his career at CISE as a researcher, studying problems related to the neutronic and thermal-hydraulic analysis of nuclear power plants. He joined the Hydraulic and Structural Centre of ENEL in 1998, carrying out consulting activity in the simulation of fast transient dynamic events in fluid-structure interaction systems and in the field of structural safety. He has acquired significant experience in safety analysis and assessment of industrial power plants with reference to fire and explosion risks. He is presently involved in the safety problematics of the nuclear power evolution and, in particular, to the Generation IV requirements.

Dr. Lidia Ferravante. She graduated in Nuclear Engineering at Politecnico of Milan, Italy in 1991, started her working activity at CISE as experimental researcher in the field of material processing related to power plants. Then, she dealt modelling activity in the electricity market. At present, she is working in data mining and modelling of nuclear severe accidents consequences.

Participant number 8: Chalmers tekniska högskola AB (Chalmers, Sweden)

Chalmers University of Technology was founded in 1829 following a donation by William Chalmers and was transformed into an independent foundation in 1994. Chalmers' annual turnover is approximately 2 billion SEK (appr. 220 million EUR), out of which two-thirds are related to research. More than 11000 people, including over 8000 undergraduates, work and study in some of Chalmers' departments and divisions.

The university offers PhD and Licentiate programmes as well as MScEng, MArch, BEng and nautical programmes. There are around 8,600 students taking undergraduate programmes leading to 1,300 Master's degrees annually. More than 1,000 students are involved in graduate and doctoral programmes leading to around 340 PhD and Licentiate of Technology degrees each year. Chalmers is involved in approximately 140 industrial and educational projects within the EU programmes.

Nuclear Chemistry/Industrial Recycling at Chalmers has been working for more than 50 years in the development of solvent extraction processes. During the last 30 years research has been made in many different areas but the main fields have been:

- Partitioning and transmutation,
- Chemistry related to deep geological disposal,
- Chemical modelling and associated uncertainty and sensitivity analysis,
- Thermo dynamical data,
- Recovery of precious metals from different waste streams.

We have been actively participating in about 10 EU-frame work programmes on various topics. Over the years more than 70 publications concerning the special chemistry of the lanthanides have been published.

The key persons involved are:

Prof. Christian Ekberg made his PhD in 1999 and is currently working as Stenas professor in Industrial Materials Recycling with supervision work in nuclear chemistry He is the author of more than 60 refereed papers and about 30 reports.

Dr. Henrik Glänneskog made his dissertation at Chalmers in 2006 and is currently working at the Ringhals NPP in Sweden and part time as supervisor at Chalmers.

M.Sc. Joachim Holm is working at Chalmers as PhD student since 2007.

Participant number 9: Centro de Investigaciones Energeticas Medio Ambientales y Tecnologicas (CIEMAT, Spain)

Background

Since mid eighties, CIEMAT has been involved in several domestic and international projects within the field of nuclear safety. Since the very beginning CIEMAT set up an analytical group in charge of accident simulation by means of using computer codes available at the moment (i.e., CONTAIN, IODE, SPARC, etc.). As a part of their activities they participated in programmes such as OECD-LOFT, LACE, ACE, PHEBUS-CSD, PHEBUS-FP, and others. In the earliest 90's CIEMAT enlarged their capabilities to experimental aspects, and built up an experimental rig where thermal, aerodynamic and aerosol studies are feasible (Laboratory for Analysis of Safety Systems, LASS). Since then several research programmes have been undertaken, most of them addressing phenomena involved in cleaning up particle-laden gases, and other facilities have been constructed (i.e., RECA for H2 recombination studies and GIRS for gaseous iodine removal by sprays).

In the last 4 years CIEMAT have been participating in two main projects within the severe accident field: ARTIST and SARNET. In the ARTIST project, CIEMAT has been heavily involved in the phase II (dry break stage), where their studies have encompassed a diverse set of activities: from aerodynamic tests and CFD simulation to aerosol experiments and modelling. In SARNET, CIEMAT has been involved in several activities: ASTEC validation against experiments, Source Term studies and Education and training. As for ASTEC validation, several model of the ASTEC code have been tested, particularly against the PHEBUS-FP data made available at the time. Concerning Source Term, CIEMAT has coordinated the work packages on aerosol behaviour and in-containment iodine chemistry; additionally, CIEMAT has carried out several tasks in several of the interpretation circles set-up within both work packages. Finally, in the education and training, CIEMAT has taken an extensive participation: CIEMAT detached a scientist to PSI for aerosol studies on SGTR sequences and always sent a member of their team to the courses organised in the SARNET frame; additionally, CIEMAT contributed by lecturing on Source Term when requested and, no less important, CIEMAT is also participating in the Severe Accident book that is being prepared.

Current proposal

CIEMAT plans to take part in the SARNET2 Project by continuing their contribution mainly in the ASTEC validation and Source Term. As in the previous SARNET project, CIEMAT will collaborate in the Education and Training activities as requested. CIEMAT has accepted the coordination of the Work Package devoted to the research results to safety analysis that is included in the Source Term area, where CIEMAT will also participate as a contributor. CIEMAT will be also involved in the Iodine Chemistry studies.

The key persons involved are:

Joan Fontanet, Mónica Vela, B.Otero and Luis E. Herranz. The first three will be involved in the ASTEC and the iodine chemistry studies, respectively, whereas the latter will scientifically supervise the whole CIEMAT work and take over the coordination of the work package mentioned above. Their experience in severe accident research ranges from 5 to more than 20 years and is, particularly, related to Severe Accident analysis and Source Term.

Participant number 10: National Centre for Scientific Research "DEMOKRITOS" (DEMOKRITOS, Greece)

The NCSR "Demokritos" is the oldest and largest research facility (public) in Greece. It covers a wide gamut of scientific research from nuclear physics and nuclear technology to microelectronics, information technology, material science and biology. Demokritos has about 750 employees and an R&D expenditure of the order of 35 MEuros each year. The Institute of Nuclear Technology and Radiation Protection (INTRP) operates a 5 MW research reactor. In parallel, research is carried out in the areas of thermal-hydraulics, environmental radioactivity, system's reliability, environmental research, and energy research. The Thermal-Hydraulics and Multiphase Flow Laboratory (THEMLAB) of INTRP conducts basic and applied research in the areas of aerosol science technology and thermal hydraulics (CFD) modelling. The activity, besides serving externally funded projects, is carried out in support to the needs of the national

"Nuclear Technology Programme" conducted in INTRP. THEMLAB disposes extensive expertise in physical modelling and computer simulation matters, and has a well-established position in the European R&D. The laboratory is equipped with advanced computer infrastructure consisted of an IBM computer cluster (CPU farm) permitting about 100 parallel processes, which is connected to the grid.

The key person involved is:

Dr Christos Housiadas (Dipl. Mech. Eng., National Technical University of Athens, 1983; PhD in Mechanics, Institut National Polytechnique de Grenoble, 1984). He is a recognized expert on aerosol flows. He has written the standard text on aerosols in the new CRC Press Handbook of Multiphase Flows, and has published more than 80 papers in peer-reviewed journals and international conferences. Currently is Research Director and Head of the Thermal-Hydraulics & Multiphase Flow Laboratory. He has an extensive experience of 20 years in research and project management in the areas of aerosol flows, scientific computing, transport phenomena, multiphase systems, and nuclear engineering. He has worked at European Commission's Joint Research Centre, Ispra for 6½ years and the French CEA for 4 years. Dr Housiadas has been actively involved as principal investigator in many European and National research programmes with participation of industry. He has been awarded an honourable distinction by the Greek Scholarship Foundation (IKY), and a fellowship by the European Commission for graduate studies. He has an excellent command of three foreign languages (English, French, Italian) and a rich international professional experience, including training and teaching in international courses. Also, he has expert consulting activities and significant involvement in R&D policy making and evaluation committees both at national and international level.

Participant number 11: Electricité de France (EDF, France)

COMPANY PROFILE. The EDF Group, one of the leaders in the energy market in Europe, is an integrated energy company active in all the businesses: production, transport, distribution, energy selling and trading. The Group is the leading electricity producer in Europe. In France, it has mainly nuclear and hydraulic production facilities where 95% of the electricity output involves no CO_2 emissions. EDF operates 1,200,000 km of low and medium voltage overhead and underground electricity lines and around 100,000 km of high and very high voltage networks. The Group is involved in supplying energy and services to more than 40 million customers around the world, including more than 28 million in France. The Group generated consolidated sales of € 58.9 billion (of which 42% in Europe excluding France) and net income from ordinary operations of € 4.2 billion in 2006. EDF is listed on the Paris Stock Exchange and is a member of the CAC 40 index.

EDF R&D. The aim of the EDF's R&D Division is to keep electricity costs competitive, prepare the generating facilities of the future, enhance the quality of supply while preserving the environment, as well as to develop innovative solutions with the customer in mind. The variety of these objectives has led EDF to set up a strong R&D function, including multidisciplinary knowledge, and with a balance between basic research and industrial applications. Figures for EDF's R&D activities in 2005:

- 1329 researchers of whom 27% women,
- 96 teaching researchers, 55 PhD candidates,
- Participating in 53 FP6 projects (7 coordinated by EDF),
- 4 main research sites: Clamart (France), Chatou (France), Les Renardières (France), Karlsruhe (Germany).

SPECIFIC EDF's ACTIVITIES IN RELATION TO THE PROJECT. As EDF operates 58 nuclear reactors, a large part of the R&D programmes is devoted to nuclear reactors (safety, fuel, fuel cycle, environment, reactors lifetime, …). The R&D division is divided into 15 branches, each being focused on a scientific domain (for example fluid mechanics and heat transfer, materials, neutronics and information science, …). It develops methods and tools for the engineering and operation needs, and has a strong history in modelling and developing computer software. It has a strong collaboration with the CEA, and also, in the field of nuclear safety, with IRSN, but also many collaborations with foreign institutes and universities.

In the field of severe accidents, EDF has research programmes in collaboration with the CEA and IRSN on several topics: corium behaviour, core degradation, source term assessment, participates in OECD programmes (MCCI, SETH2, …), or has its own research programmes (hydrogen risk or vessel

integrity for example). EDF also developed a Level-2 PSA. EDF was involved in the 4th and 5th European programmes (CIT, COLOSS, ENTHALPY, EVITA…). EDF also has a strong competency in thermal hydraulics and core degradation modelling (CATHARE, MAAP), and finally, a strong experience in plant applications with severe accident integral codes (MAAP4). EDF is of course member of the NoE SARNET.

The key persons involved are:

Thierry Daguse, head of the SA section of EDF engineering division: WP 1 (on severe accidents research priorities).

Armelle Bretault, senior research engineer, with thirty years of experience on thermal-hydraulics, neutronics and SA simulation: WP 4 (on ASTEC assessment).

Kresna Atkhen, expert in corium behaviour (coolability, MCCI), with 10 years of experience on this subject, EDF representative in the management board of MCCI of OECD project: WP6 (on molten core concrete interaction).

Stéphane Mimouni, expert in thermal hydraulics, with 15 years of experience on one and two phase flows and CFD simulation: WP 7 (on hydrogen mixing and combustion).

Jean-Sylvestre Lamy, head of the SA research project, expert in SA, with 8 years of experience on this domain, contact expert group of the EC for ISTC project assessment (who will also supervise EDF contribution to SARNET2) and Emilie Bezet, PhD student since January 2008: WP 8 (source term).

Gerard Labadie, nuclear safety and radiation protection R&D programmes director: contact person for SARNET2.

Participant number 12: Energy Institute JSC Sofia (EI, Bulgaria)

EI is a private engineering company working in the field of nuclear and thermal energy.

The main activities cover a large spectrum of nuclear energy: nuclear safety, designing, ageing mechanisms of structural materials, irradiation technologies. EI has experience in Design Basis Accidents (DBA) and Beyond Design Basis Accidents (BDBA) safety analysis and has a strong experience in the development and assessment of VVER-440 and -1000 databases.

In the field of severe accident, EI works in association with TUS and has significant experience regarding VVER safety analysis and studies, Environmental Impact Assessment of NPP, etc. EI collected an experience in the severe accident research in the frame of 5th FP Projects PHEBEN2 and RMPS, experimental programme PLINIUS, etc. Since 2002, TUS participated with EI in the PHEBUS FP Programme in the frame of the SARNET project.

The key person involved is:

Dr. Boris Kalchev Head of Nuclear Energy Department

Participant number 13: Ente per le Nuove tecnologie, l'Energia e l'Ambiente (ENEA, Italy)

ENEA is a public Italian Organisation responsible of supporting government initiatives toward competitivity and sustainable development in the domains of energy, environment and technology innovation.

In the domain of nuclear applications, it has the responsibility of preserving the scientific and technological knowledge, contributing in the development of innovative systems and in the reduction of the risk associated with nuclear wastes. Since 1998, ENEA is involved in a research programme to study the physics and to develop the technologies needed to design an Accelerator Driven System for nuclear waste transmutation, carrying out experimental programmes in Pb/Pb-Bi loops addressed to resolve open technological issues of key-components and systems. ENEA maintains a limited but qualified partnership in several International initiatives on nuclear safety, with specific co-operation agreements (e.g. with IRSN in PHEBUS) or participating in programmes promoted by International Organisations (NEA, IAEA, USNRC). Activities are aimed at maintaining the knowledge on the most relevant methods, solutions and themes related to nuclear fission safety and an adequate domestic capability of evaluating nuclear accident sequences and related risks.

The key persons involved are:

Dr. Felice De Rosa (contact person), Dr. Giacomino Bandini, Dr. Nora Davidovich, Dr. Stefano Ederli, Dr. Sandro Tirini.

Dr. De Rosa and Dr. Bandini have a multi-annual experience in participating in International Organisation activities (NEA-CSNI WGs) and European Projects (from 3th FWP on). Dr. Davidovich, Dr. Ederli and Dr. Tirini have developed specific competences in severe accident phenomenology analysis, through a direct participation, from the beginning, in the PHEBUS FP test preparation and evaluation.

Participant number 14: Forschungszentrum Juelich GmbH (Jülich, Germany)

Forschungszentrum Jülich GmbH is one of the 15 Helmholtz Research Centres in Germany (Helmholtz Community of German Research Centers, HGF). Organised in 8 Institutes, a staff of 4400 work on a broad spectrum of research topics in the fields of Health, Energy & Environment, Information, and Key Technologies. The research and development programme is guided by the research policy goals of the two partners, the Federal Republic of Germany and the state of North Rhine-Westphalia.

In the area of nuclear safety research the research programme of Jülich addresses the safety issues of devices for control of hydrogen in light water reactors focusing on the application of passive autocatalytic recombiners (PAR). The scientific programme includes both experimental and theoretical investigations, thus providing a data base for model validation and enhancement of the PAR assessment in severe accident situations. The hydrogen laboratory with several small and medium scale facilities provides excellent possibilities for testing and investigating recombiners.

Jülich will contribute to the activities in the field of 'Hydrogen mixing and combustion in containment' aiming at enhancing the numerical models for simulating the operational behaviour of recombiners in severe accidents and their interaction with the containment atmosphere. Experimental data from the REKO facilities will be opened to the network partners for code validation.

The key persons involved are:

Dr. Ernst-Arndt Reinecke. Scientist, since 1996 working in the field of experimental and theoretical studies on hydrogen control in nuclear power plants at Jülich, since 2007 leader of the experimental department, Institute of Energy Research (IEF-6).

Prof. Hans-Josef Allelein. Head of the Institute of Energy Research - Safety Research and Reactor Technology (IEF-6) since 2008, simultaneously Chair Professor of the Institute of Reactor Safety and Reactor Technology at RWTH Aachen University, prior to this 21 years at GRS, Germany, responsible for COCOSYS and ASTEC code development until 2002, recently head of the department 'Barrier Effectiveness'.

Participant number 15: Forschungszentrum Karlsruhe (FZK, Germany)

Forschungszentrum Karlsruhe (FZK) is one of the largest science and engineering research institutions in Europe, funded jointly by the Federal Republic of Germany and the State of Baden-Württemberg. Its research and development programme concentrates on five research areas: Energy, Structure of Matter, Earth and Environment, Health, and Key Technologies.

The Programme Nuclear Safety Research (NUKLEAR) is recognized as a long-term, provident research activity, studying scientific aspects of reactor safety and the safety of nuclear waste disposal. The results are applied in the public interest domain in order to contribute to the continuous improvement of the high safety standards of German nuclear installations and to provide the scientific and technical tools for the long-term safe nuclear waste disposal, including Partitioning and Transmutation. The scientific research work is performed in seven academic Institutes, the strategy and co-ordination work is performed by the Programme Management.

In the area "Safety Research for Nuclear Reactors", those accident phenomena are investigated which could lead to the loss of integrity of the reactor containment in the case of a severe accident in a Light Water Reactor. These are especially hydrogen generation, distribution and combustion, in- and ex-vessel corium behaviour, and corium interaction with structural materials. The aim is the development of measures, which effectively control the accident progression and limit release of radioactive materials to the environment to negligible levels.

The Programme Nuclear Safety Research is specialised in the operation of large and mostly unique experimental facilities, supported by analytical and modelling activities. It participated successfully with its experienced research teams in numerous projects in the former EC Framework Programmes. It further co-operates with many organisations worldwide. It is therefore well positioned to provide significant contributions to the European research activities in the severe accident field in the frame of SARNET2 Network of Excellence.

The key persons involved are:
Wolfgang Breitung, Leonhard Meyer, Alexei Miassoedov, Martin Steinbrück, Th. Walter Tromm.

Participant number 16: Gesellschaft für Anlagen- und Reaktorsicherheit mbH (GRS, Germany)

GRS is a scientific-technical expert and research organisation. It provides interdisciplinary knowledge, advanced methods and qualified data for assessing and improving the safety of technical facilities and for further developing the protection of man and the environment from the technical hazards and risks involved in such facilities. GRS activities are mainly focused on the area of nuclear safety and waste management, where it is Germany's leading expert institution. GRS is a member of the European TSO network (ETSON).

GRS has around 400 employees (excluding the subsidiaries). Around 300 of them are highly qualified technical and scientific experts, among them 250 engineers from different fields of engineering, physics, chemistry, geochemistry, geology, geo-ecology, geophysics, mathematics, computer science, biology, jurisprudence, and meteorology.

GRS is a non-profit company. Its assessments are solely bound by the principles of science and technology. They are mainly based on the knowledge and experience gained from the company's own research and development activities, detailed prototype safety analyses, the in-depth evaluation of operating experience, and many years of international co-operation.

The expertise of GRS in the field of severe accidents is a result of the continuous participation in international organisations, working groups and code benchmarks, the successful development and validation of well-known codes like ATHLET/ATHLET-CD, COCOSYS and ASTEC (together with IRSN), and an active role in related research activities in Germany. GRS has specific experience in thermal hydraulics and core degradation modelling steam explosion, hydrogen risk and Level 2 PSAs for PWRs and BWRs

The key persons involved are:
Mr. Siegfried Arndt, Dr. Henrique Austregesilo, Dr. David Beraha, Mr. Wolfgang Luther, Dr. Christoph Müller, Dr. Nils Reinke, Mr. Bernd Schwinges, Dr. Claus Spengler, Dr. Klaus Trambauer, Dr. Gunter Weber.

Participant number 17: Institute for Nuclear Research (INR, Romania)

The Institute for Nuclear Research (INR) is the main nuclear power R&D organization in Romania with over 30 years of activity in the nuclear energy field, deeply involved in the management and execution of the R&D National Nuclear Power Programme.

The main activities cover a large spectrum of nuclear energy: nuclear safety, designing, manufacturing and testing of nuclear fuels, ageing mechanisms of structural materials, irradiation technologies and radioisotopes production in a TRIGA 14MW research reactor, instrumentation and control, environmental protection, radioactive waste and spent fuel management.

Nuclear safety research is one of the most important technical areas covered by the Institute. It includes the development and application of models and computer codes for deterministic accident analysis, probabilistic safety assessment, reactor physics, nuclear fuel and reactor components behaviour in accident conditions, mainly devoted to CANDU PHWR nuclear power plant.

INR will participate in the ASTEC (#4) and Source Term (#8) work packages. The SARNET2 team consists of senior researchers involved in both analytical and experimental activities. The analytical experience includes using severe accident codes (ASTEC, ICARE/CATHARE, SCDAP/RELAP5) to simulate both experiments and reactor accidents scenarios. The experimental work consisted mainly in

oxidation studies on UO_2 fuel pellets and Zircaloy-4 samples. Two members of the SARNET2 team had the opportunity to work at IRSN/DPAM in the frame of the SARNET Mobility Programme, dealing with ICARE/CATHARE and ASTEC validation.

The key persons involved are:

Mr. Ilie TURCU, Scientific Director; works in Computer Science, Reactor Physics and PSA for 30 years

Dr. Dumitru OHAI, Head of the Nuclear Materials Dept; works in material testing and corrosion for 30 years; INR Source Term team leader

Dr. Marin CONSTANTIN, Head of the Reactor Physics and Nuclear Safety Dept; works in computer code development, reactor physics and safety analysis for 25 years; INR ASTEC team leader

Ms. Gabriela RADU, Senior Researcher, Reactor Physics and Nuclear Safety Dept; works in PSA for 20 years

Mr. Andrei RIZOIU, Senior Researcher, Reactor Physics and Nuclear Safety Dept works in computer code development, reactor physics and and safety analysis for 20 years; INR SARNET2 team leader

Participant number 18: Institute for Nuclear Research and Nuclear Energy (INRNE, Bulgaria)

The Institute for Nuclear Research and Nuclear Energy (INRNE) of the Bulgarian Academy of Sciences is founded in 1972 carrying the main part of activities of the former Institute of Physics with Atomic Research Centre. INRNE is the leading Bulgarian Institute for fundamental and applied researches in the field of elementary particles and nuclear physics, high energy physics and nuclear energy, radiochemistry, radioactive wastes treatment, monitoring of the environment, nuclear instruments development and soon. The Institute's staff of about 350 (150 of them are scientific researchers) works in more than 30 research groups. Five basic installations are commissioned at the INRNE.

Experience: DBA and BDBA safety analysis. Strong experience in the development and assessment of VVER-440 and VVER-1000 databases.

INRNE will work in the following WPs in SARNET2:

- WP4: ASTEC VVER1000 plant application.
- WP5: Emphasis on quenching of a degraded core: applications of ASTEC and comparison with MELCOR for QUENCH experiments at FZK.
- WP6: Role of the metallic on MCCI: Interpretation work of the Large-scale transient MCCI tests in KIT including improvements in ASTEC/MEDICIS code, comprise blind calculation and post-test calculation as well as Interpretation work of the VULCANO Oxide-Metal test in oxide/metal configuration in the frame of SARNET including MCCI model improvements in ASTEC/MEDICIS code including performance of blind calculation, post-test calculation and analysis of PTE and Transposition of R&D results to the reactor scale: Co-ordination activity of this task, co-ordinator: Dr. P. Groudev and Contribution to benchmark activities.
- WP7: Atmosphere: Atmosphere mixing, PAR-atmosphere interaction; Hydrogen combustion: Benchmark for a Generic Containment.

The key persons involved are:

Dr. Pavlin Groudev. University: Moscow Power Technical University (1981 –1987). PhD: Moscow Power Technical University (1991-1995). Further Position: Engineer, INRNE-BAS (1987-1990). Researcher III degree, Head of a Laboratory "NPP Safety Analysis" at INRNE-BAS (1990-1997). Researcher I degree, Head of a Laboratory "NPP Safety Analysis" at INRNE-BAS (1997-2004). Assoc. Prof. Head of a Laboratory "NPP Safety Analysis" at INRNE-BAS (2003-2004). Current Position: Assoc Prof., Head of a Laboratory "NPP Safety Analysis" and Deputy Director of INRNE-BAS (2004 till now).

Antoaneta Stefanova. University: Technical University, Sofia (1993–1998). PhD student: INRNE-BAS (2007 to now). Further Position: Engineer, INRNE-BAS (2000-2004). Researcher III degree, INRNE-BAS (2004 –2007). Current Position: Researcher II degree, INRNE-BAS (2008 till now).

Boryana Atanasova. University: Technical University, Sofia (1987-1994). Further Position: Engineer, INRNE-BAS Nuclear Research and Nuclear Energy (2000-2008).

Emilia Georgieva. University: Sofia University (2003-2007). Further Position: Physicist - Engineer, INRNE-BAS (2007 till now).

Participant number 19: Inzinierska Vypoctova Spolocnost Trnava s.r.o. (IVS, Slovakia)

Inzinierska vypoctova spolocnost Trnava, s.r.o. (Company for Engineering Calculations Trnava, Ltd) is a company working in the field of computational modelling of DBA and BDBA of VVER reactors. Main computational tools used are RELAP5, MAAP4-VVER and ASTEC V1.3 codes. Recent activities relevant to SARNET 2 project were as follows:

- involvement in 5th Framework Programme (projects EVITA, IMPAM-VVER, VERSAFE);
- involvement in 6th Framework Programme (project SARNET);
- support analysis for the SAMG preparation devoted to hydrogen production and hydrogen management during severe accidents of VVER-440/V213;
- feasibility studies devoted to application of in-vessel corium retention concept via reactor cavity flooding for VVER-440/V213 units;
- involvement in the IAEA activities devoted to accident analysis of VVER NPPs, co-ordinated research projects, benchmark activities;
- bilateral co-operation with IRSN on ASTEC assessment (TMI-2, Super Moby-Dick, Patricia GV1 and GV2, plant applications);
- participation in the OECD/NEA activities (Gama TMI-2 alternative benchmark, OECD-IAEA Paks Fuel Project);
- support analysis for the source term estimation for VVER-440/V213.

In the frame of SARNET project, main activities were devoted to ASTEC validation (e.g. analysis of PACTEL ISP-33 and T2.1 experiments), plant applications (analyses of blackout and LOCA scenarios) and in-vessel corium retention activities (applications of DIVA stand alone module for VVER-440/V213, comparison with prediction of other codes).

In SARNET2 main involvement should be in WP4 and WP5 activities. Within WP4 it is assumed to perform ASTEC code validation and benchmarking and VVER-440/V213 plant applications (including severe accident management and plant upgrading). Within WP5 main activities should be focused on in-vessel corium retention for VVER-440/V213 reactors (ASTEC benchmarking for in-vessel retention, analysis of LIVE L1 experiment, estimation of thermal loads acting on reactor wall, cooling of outer surface, etc.).

The key persons involved are:

Peter Matejovic (PhD), Miroslav Barnak (PhD). Strong experience of VVER-440 type reactors and of ASTEC use. Have actively participated to the EVITA project of the 5th framework programme and SARNET of the 6th framework programme.

Participant number 20: Jožef Stefan Institute (JSI, Slovenia)

The Jožef Stefan Institute is an internationally highly regarded institution in the fields of natural and technical sciences. The staff of around 800 specializes in research in physics, chemistry and biochemistry, electronics and information science, nuclear technology, energy utilization and environmental science. The Department of Reactor Engineering is engaged in basic and applied research in the fields of nuclear engineering and safety. Topics include modelling of basic thermal-hydrodynamic phenomena, thermal-hydraulic safety analyses of design-basis and severe accidents, structural safety analyses and probabilistic safety assessment. Most research activities are part of international cooperation programmes. In the field of severe accidents, researchers from the department are being actively involved in the modelling and analysis of experiments performed in the PHEBUS, KROTOS, TROI, QUENCH, QUEOS, KAEVER, TOSQAN, MISTRA, ThAI, PANDA, LACE and CONAN facilities. They are participating in the OECD/NEA programmes SETH-2 and SERENA-2. The computer codes MC3D, ASTEC, MELCOR and CONTAIN are used for the investigation of severe accident phenomena and for safety analyses of the Krsko (Slovenia) 2-loop Westinghouse PWR NPP.

The JSI will be mainly involved in the Containment work-packages WP7-1 Ex-Vessel Fuel Coolant Interaction and WP7-2 Hydrogen Mixing and Combustion in Containment. In WP7-1, we will be involved in all foreseen tasks, with the objective to further review and evaluate the progress made in the SERENA-2 programme and to propose and perform any activities that might be needed to complement the work performed in SERENA-2. These activities include clarification about basic phenomena, range of applications and resulting strength of conclusions, and more specific comparisons and analyses with the

code MC3D. In WP7-2, we plan to continue the research on the modelling of hydrogen mixing in the containment, including interaction between containment atmosphere and mitigation systems (Passive Autocatalytic Recombiners and containment sprays). The research may include investigations of separate phenomena, such as steam condensation on surfaces and water droplets. In SARNET, JSI was involved in the following work-packages: WP2: ASTEC Development, User Support and Training, WP3: ASTEC Physical Model Assessment, WP12-2: Containment Atmosphere Mixing, WP13-1: Fuel-Coolant Interaction

The key persons involved are:

Prof. Borut Mavko is the Head of the Reactor Engineering Division, JSI, and the Leader of the Graduate Programme of Nuclear Engineering at the Faculty for Mathematics and Physics, University of Ljubljana. He has more than 40 years of experience in nuclear safety and published more than 100 articles in SCI journals. He is a member of the JSI Scientific Council, the NPP Krško Safety Committee, the Board of NPP Operator Licensing at the Slovenian Nuclear Safety Administration and the representative of Slovenia in the Committee on the Safety of Nuclear Installations at OECD/NEA.

Dr. Matjaž Leskovar (contact person) has nearly 15 years of experience in the field of severe accidents, focusing on fuel-coolant interaction. He defended his Ph.D. thesis in the year 2000 at the Graduate Programme of Nuclear Engineering, Faculty for Mathematics and Physics, University of Ljubljana. He has published 14 articles in SCI journals and was/is the JSI leader of a number of national and international research projects (i.e. OECD/NEA SERENA-2, ISP-45, ISP-46; 5.FP EU: KROTOS/PLINUS; 6.FP EU: SARNET, THENPHEBISP; NRC CSARP; PHEBUS).

Dr. Ivo Kljenak has been involved in various topics of nuclear engineering and safety, including severe accidents, since joining JSI in 1995. He has or is currently participating in a number of international projects (OECD NEA International Standard Problems No. 44 KAEVER, No. 46 PHEBUS and No. 47 TOSQAN-MISTRA-ThAI, Phebus FP Agreement, OECD SETH-2). In SARNET, he was Task leader of WP12-2 Containment Atmosphere Mixing from November 2006. He has co-authored 8 papers in international journals and more than 70 papers at international conferences.

Mag. Mitja Uršič, Ph.D. student at the Graduate Programme of Nuclear Engineering, Faculty for Mathematics and Physics, University of Ljubljana. Employed at JSI since 2007. Field of work: Fuel-coolant interactions.

Participant number 21: Kungliga Tekniska Högskolan / Royal Institute of Technology (KTH, Sweden)

Kungliga Tekniska Högskolan (Royal Institute of Technology), KTH, is responsible for one-third of Sweden's capacity for engineering studies and technical research at post-secondary level. The university has over 11,000 undergraduate students, 1,500 active postgraduate students and a staff of 3,100 people. KTH conducts top-notch education and research of a broad spectrum – from natural science to all branches of technology, including architecture, industrial economics, urban planning, work science and environmental technology. Apart from research performed at its departments, a large number of competence centres are housed at KTH. Strategic research foundations are funding other research programmes or graduate schools. Continuing education is also an important part of its activities.

Regarding severe accident study, KTH has a strong experience on experiments with simulant materials (SIMECO, FOREVER, POMECO, DEFOR, MISTEE) and modelling on corium molten pool and debris bed coolability, as well as vessel mechanical failure.

KTH will participate in Work-Packages 2, 3, 4, 5 and 6 of SARNET2, with main involvement in Education and Mobility programmes, Experimental Database (providing data), extension of ASTEC code to BWRs, analytical support of MCCI tests, and experimental and analytical studies on corium (melt pool or debris bed) coolability. KTH is also the coordinators of WP5-2 and WP6-3.

The key persons involved are:

Prof. Bal Raj Sehgal was engineering from University of Delhi in 1955, and received his M.S. and Ph.D degrees in Engineering Sciences from University of California, Berkeley in 1957 and 1961, respectively. He took various positions in the United States. During 1991-2004 he was Chair Professor of Nuclear Power Safety Division at the Royal Institute of Technology, Stockholm, Sweden. He developed the

research division on reactor safety in Sweden, and was Swedish delegate to various international organizations and projects, and consultant to numerous international organizations.

Dr. Weimin Ma received his PhD in Mechanical Engineering from Xi'an Jiaotong University (Xi'an, China) in 1996. During 1998-2000 he was working as an Associate Professor at Southeast University (Nanjing, China). He joined in KTH in 2001 and is currently a Senior Research Scientist and the leader of the group on Severe Accident Risk Assessment and Management (SARAM) at the Division of Nuclear Power Safety, Royal Institute of Technology, Stockholm, Sweden. His current research focuses on heat and mass transfer, multiphase flow, nuclear power safety.

Participant number 22: Lithuanian Energy Institute (LEI, Lithuania)

The Lithuanian Energy Institute (LEI) was established in 1956. In January 1992 the Government of the Republic of Lithuania granted a state science institution status to the Institute, which became independent from the Academy of Sciences. The LEI is a technical research centre dealing with nuclear safety of Ignalina NPP, energy related research in thermal physics and fluid mechanics, structural integrity assessment of components and structures, development of energy planning methods, analysis of security of energy supply, research of safety and reliability of power plants and their effects on thermal behaviour of cooling pools, studies of refectories and chemically resistant materials, simulation of complex energy systems. LEI have 303 persons of staff. Among them there are 16 Dr. Habilitus, 72 Ph.D., 30 researchers with B.Sc. and M.Sc. and 23 Ph.D. Candidates. Institute has an extensive experience in international projects: IAEA, FP5, FP6, Phare, Intelligent Energy Europe, COST, Eureka, Leonardo da Vinci, INTERREG III, Nordic Energy Research Programme.

The main research areas, related to the nuclear energy are: thermal-hydraulic analysis of accidents and operational transients in reactor cooling circuit and confinement of Ignalina NPP (RBMK-1500); simulation of aerosols and Fission Products transport in the compartments of RBMK-1500; assessment of RBMK-1500 reactor core modifications and analysis of postulated reactivity accidents; structural analysis of NPP buildings, components and piping; Level 1 and Level 2 Probabilistic Safety Assessment of Ignalina NPP; sensitivity and uncertainty analysis of modelling parameters and results; safety analysis of thermonuclear synthesis reactors; analysis of new generation nuclear reactors. There are no experimental investigations related to severe accident research. Numerical simulations using the codes ASTEC, RELAP/SCDAPSIM, ATHLET-CD, COCOSYS are carried out. LEI specialists participate in PHEBUS-FP research programme using RELAP/SCDAPSIM and COCOSYS codes for simulation of core degradation processes and containment processes.

In the frame of new SARNET2 Lithuanian Energy Institute would like to contribute to CORIUM, ASTEC and CONTAINMENT work packages. In CORIUM contribution would be related to interpretation of QUENCH and DEBRIS experiments. ASTEC code will be used for the analysis. As well this work contribute to validation of ASTEC code models. In CONTAINMENT work package contribution to solution of gas mixing problem in containments and to investigations of safety systems interaction with containment atmosphere is suggested. In ASTEC work package the work will be devoted to the demonstration of the ASTEC capability to run in a coupled mode with dynamic PSA2 methods.

The key persons involved are:

Official representative (GB member) – Mr. Eugenijus Uspuras (Prof. Dr. Habilitus in Technology Sciences) Director of Lithuanian Energy Institute).

Technical/administrative/financial correspondent – Mr. Algirdas Kaliatka (Dr. Habilitus in Technology Sciences) has more than 15 years experience in thermal hydraulic analysis of processes in reactor cooling circuit, last 5 years working in area of severe accident analysis.

Technical representatives of WPs:

Mr. Egidijus Urbonavicius (Dr. in Technology Sciences) has 10 years experience in thermal hydraulic analysis of processes in reactor confinement, hydrogen, radionuclides and aerosols transport in the compartments.

Mr. Mindaugas Vaisnoras (Dr. in Technology Sciences) has more than 15 years experience in thermal hydraulic analysis of processes in reactor cooling circuit.

Mr. Virginijus Vileiniskis (Dr. in Technology Sciences), has 12 years experience in thermal hydraulic analysis of processes in reactor cooling circuit, last 5 years working in area of severe accident analysis.

Participant number 23: National Nuclear Laboratory (NNL, United Kingdom)

In July 2008, the UK Government announced the launch of a National Nuclear Laboratory (NNL) for the UK, with the responsibility of supporting the UK's strategic nuclear research and development requirements, by safeguarding and enhancing key skills, and by operating strategic facilities. National Nuclear Laboratory Ltd was formally established in November 2008, and is led by the former Nexia Solutions Ltd, which was itself established as a separate legal entity within the BNFL Group on 1st April 2005. Nexia was established out of the former BNFL Nuclear Sciences and Technology Services, which in turn was formed from the Research and Technology division of BNFL and encompassed the Research and Technology activities of BNFL, Magnox Electric and the Nuclear Science business of AEA Technology, acquired in 2003.

NNL is a unique resource constituting the bulk of the UK's remaining national nuclear research capability and all of the civil nuclear research facilities. The company comprises approximately 800 staff based at six locations around the United Kingdom, operates both active and non-active research facilities and provides specialist technical and consulting services to a range of customers including NDA, MoD, AWE, UKAEA, Sellafield Ltd and other commercial organisations (both in the UK and overseas).

NNL provides a range of independent technology services to support operating nuclear plants as well as decommissioning and clean-up activities and scientific research organisations. These services include the ability to accommodate and conduct both active and inactive work at its facilities.

NNLwill be involved in the Source Term work package (WP8) in the area of Iodine Chemistry in the Containment. Their contribution will comprise:

a) Assessment and analysis of results from international programmes and comparison with mechanistic INSPECT modelling;

b) Contribution of Sizewell B data to data bank on iodine activities in PWR coolant for proposed SGTR activity;

c) Participation in a benchmark exercise on one Phebus-FP test;

d) Maintenance of Iodine Data Book reviews prepared under the SARNET programme.

NNL staff have extensive experience in the area of iodine chemistry, and have coordinated several projects in the 4th and 5th Framework Programmes.

The key person involved is:

Shirley Dickinson. Shirley is a Senior Technology Manager with over 25 years' experience within the nuclear industry. She has extensive knowledge of chemical issues related to the nuclear power industry, in particular in coolant chemistry, fission product behaviour in reactor accidents and waste management. She has played a key role in providing consultancy support on chemical issues to a range of customers, and has coordinated several European Framework Projects.

Participant number 24: Nuclear Research & Consultancy Group v.o.f. (NRG, The Netherlands)

The Nuclear Research and consultancy Group (NRG) was established as a Partnership Firm in 1998 through the merger of ECN's and KEMA's business activities in the nuclear fields. In a later stage, TNO-CSD (national person dosimetry centre) was taken-over by the Group. The successive mergers have created a Centre of Excellence for the nuclear technology, integrating all relevant disciplines.

The mission of NRG is to enable sustainable applications of nuclear technology for energy, health and environment. For these purposes, NRG provides a complete set of services and products for various sectors of industry as well as governmental bodies with a dedicated staff of more than 300. NRG is also a service provider also for non-nuclear businesses like the chemical, oil and gas industry and the medical sectors. Furthermore, NRG is the main producer of radionuclides for the medical sectors in Europe.

NRG has a complete set of nuclear facilities like a 45 MW research reactor (the HFR), hot-cell labs (HCL), laboratories for research and analyses, decontamination facilities and the radio-isotope production facilities.

With regard to the field of severe accidents NRG has done a lot of things in the past, ranging from implementation of severe accident management guidelines at the Borssele nuclear power plant to

performing containment analyses with MELCOR, MAAP, and our own developed code SPECTRA. In the framework programmes NRG has participated in the TEMPEST, SGTR, LISSAC and SARNET projects.

In SARNET2 NRG will be involved in the containment WP, mainly in the simulation of containment mixing phenomena with CFD codes. Continuation of the CONAN and PARIS2 benchmarks and analyse separate and combined phenomena.

The key persons involved are:
Ir. P. Wakker. Pieter Wakker has been working on systems thermal-hydraulics and severe accidents for over ten years. Mr. Wakker is involved in the development of the in-house thermal hydraulics Spectra code. Currently Mr. Wakker is team manager Thermal Hydraulics & Fuel Management. Mr. Wakker holds an M.Sc. in Mechanical Engineering.
Ir. M. Houkema. Michiel Houkema has been working with NRG for almost ten years. He has performed many projects on the design of innovative systems for energy generation and energy regeneration, including thermal acoustic cooling and Stirling engines and projects for the nuclear industry on hydrogen combustion reactor safety issues. His current main field of activity is CFD modelling of containment mixing. Mr. Houkema holds an M.Sc. in Applied Physics.

Participant number 25: Paul Scherrer Institut (PSI, Switzerland)

The Paul Scherrer Institut is multi-disciplinary research centre for natural sciences and technology. In national and international collaboration with universities, other research institutes and industry, PSI is active in solid state physics, material sciences, elementary particle physics, life sciences, nuclear and non-nuclear energy research, and energy-related ecology. The institute's priorities lie in areas of basic and applied research. PSI has acquired a large experience in the domain of nuclear reactor safety, in particular through aerosol and iodine separate-effect testing, modelling, severe accident codes (SCDAP/RELAP5 and MELCOR) validation and plant (BWR and PWR) applications. PSI has actively contributed to plant applications in many different international and national projects. Model development in the area of cladding oxidation, iodine and aerosol behaviour are main activities in parallel with experiment studies associated with aerosol behaviour in complex structures.

The key persons involved are:
Salih Güntay, Jon Birchley, Bernd Jaeckel.

Participant number 26: Ruhr-Universität Bochum (RUB, Germany)

RUB-LEE (Ruhr-Universität Bochum/Ruhr-Universaet Bochum (RUB), Lehrstuhl für Energiesysteme und Energiewirtschaft/Energy Systems and Energy Economics (LEE)).

The Reactor Simulation and Safety Division of RUB-LEE has considerable experience in reactor safety related research. Since 1988 projects sponsored by the industry, the German government and the EU in the field of reactor safety were carried out, and therefore a significant amount of knowledge and experience has been built-up.

The focus in the field of nuclear safety research is on modelling (e.g. source term, aerosols, corium behaviour, containment thermal hydraulics) connected with code development activities, code validation/interpretation (e.g. ASTEC, COCOSYS, ATHLET-CD) and benchmarking. Furthermore, own CFD tools have been developed and commercial tools are used intensively on simulations for various tasks and applications.

RUB-LEE participated in several EU projects and Concerted Actions of the 3rd, 4th, 5th and 6th Framework Programme.

Planned contributions in SARNET2:

- WP 4 ASTEC: Installation of ASTEC, Participation at the ASTEC Users Clubs, ASTEC code assessment is purpose of WP 5 and WP 7.

- WP 5 COOL: RUB-LEE propose to perform analyses of physical models of the severe accident codes ATHLET-CD and ASTEC. For the analyses of the current modelling the QUENCH and PHEBUS test series will be considered. The results of theses analyses should be used for the improvement of the modelling and the implementation of the modelling into SA codes especially into ASTEC by the code

developers. Additionally, the results of the model improvement might be used in reactor applications. RUB-LEE is also interested in the analysis and interpretation of severe accident experiments using the USTUTT codes WABE and/or MEWA within joint activities.

- WP 7 CONT: The main aims of RUB-LEE activities are to investigate the simulation of thermal hydraulic phenomena like atmospheric stratification processes, the modelling of atmospheric jets and their entrainment as well as aerosol deposition processes with Lumped-Parameter Codes like ASTEC and COCOSYS. Besides nodalisation influences, the implemented physical models will be analysed. This work will be based on experiments in the ThAI and BMC test facilities. The results of theses analyses should be used for the improvement of modelling in severe accident analysis codes by the code developers.

The key persons involved are:
Prof. Dr.-Ing. Marco K. Koch (Head of Reactor Simulation and Safety Division of RUB-LEE),
Dipl.-Ing. Jörg Burkhardt,
Mr Thimo Brähler,
Mr Philipp Kruse,
Dipl.-Ing. Thorsten Hollands,
Dipl.-Ing. Miriam Klöcker.

Participant number 27: SUEZ – TRACTEBEL ENGINEERING (TRACTEBEL, Belgium)

Tractebel Engineering, division of SUEZ-Tractebel SA, headquartered in Brussels, Belgium, is 2,400 multidisciplinary experts and consultants worldwide who offer life-cycle consultancy and engineering services for power, nuclear, gas, industry and infrastructure installations from feasibility studies to engineering, procurement and construction contracts, including operational support services and consultancy in the domains of fossil-fired power generation plants, nuclear power stations and installations, power networks and energy services.

Tractebel Engineering has built up a very substantial track record in the nuclear power sector, providing project management and technical services to utilities, research centres, agencies and suppliers around the world. Tractebel Engineering is the architect engineer for all 7 Belgian nuclear power plants and is responsible for permanent engineering support to those units including backfitting, accident and transient analysis, licensing, probabilistic safety assessment, nuclear fuel procurement and fuel cycle improvement, operation and maintenance support, plant upgrades and modifications simulator development, operator training.

The bulk of TE’s severe accident expertise resides with experienced graduate engineers involved in severe accident analysis both in support of PSA level 2 studies and in support of the development of accident management strategies. TE’s experience is not limited to handling the tools used for severe accident analysis but also includes the application of the analysis results in developing accident management measures. On behalf of the Belgian Utility (Electrabel) TE examined in detail specific severe accident topics and provided the Utility with several measures that have been implemented to reduce the risk associated with beyond-design accidents (hydrogen mitigation system, severe accident management guidelines, cavity flooding feasibility).

TE will be mainly involved in WP4-1(USI) and WP4-2 (ACAS) continuing the efforts already performed during SARNET aiming at evaluating the predictive capabilities of the reference code ASTEC in comparison with MELCOR code for a Westinghouse 1000 type NPP.

The key persons involved are:
Mrs Michèle Auglaire has a master degree in Electromechanical Engineering and has acquired extensive experience in the field of severe accident. Since 1990, she has been involved in all severe accident projects for Belgian Nuclear Power Plants like implementation of catalytic recombiners, development of severe accident management guidelines, training of staff personal, severe accident analysis using STCP and MELCOR. She was the technical coordinator for the development of the Belgian PSA level 2 model. She was also in charge of developing severe accident strategies for Russian VVER-1000 type. Actually she is leading the Thermalhydraulics and Severe Accident Section of the Nuclear

Department in Tractebel Engineering and she is the technical coordinator for the update of the Belgian PSA level 2 models.

Mr Antonio Cipollaro has a Master of Science Degree in Nuclear Engineering, specialization "Innovative nuclear power plants" - University of Pisa (Italy). As a Design Engineer in TRACTEBEL ENGINEERING (Nuclear Department - Safety Assessment & Operation Service- Thermal Hydraulics and Severe Accident section) he participates to the validation of Severe Accident Management Guidelines for the Belgian units, to the Reactor Application Benchmark activities within the Severe Accident Research Network (SARNET), and the update of level 2 PSA for the Belgian Power Plants. He is also providing SAM training to NPP staff personnel of Belgian Nuclear Power Plants. Other field of expertise concern the application of Westinghouse LBLOCA Best Estimate Methodology ASTRUM, Two-Phase Flow Water Hammer Transients and Induced Loads on Materials and Structures of Nuclear Power Plants, Safety studies for the European Fusion Power Plant Conceptual Study by means of various engineering tools such as MELCOR, ASTEC, ATLAS, RELAP5, WCOBRA-TRAC, COCO, SNAP, WAHA.

Participant number 28: THERMODATA (THERMODATA, France)

Since 1974, THERMODATA is working on generating thermodynamic databanks and software tools for thermochemistry. The objective is to make thermodynamic calculations fast and easy and to allow chemist and materials engineer to carry out global thermochemical approach of their complex problems. For a long time (14 years), THERMODATA is engaged in the critical compilation and assessment of thermodynamic data for inorganic and metallurgical substances involved in nuclear materials, and has a unique experience and expertise in the evaluation of data for solution phases and thermochemical equilibrium calculations. The use of the database NUCLEA, initially developed in the frame of the ENTHALPY project of the 5th FWP, already gave really encouraging results confirmed by experimental results (FP release, solidus/liquidus, viscosity, etc...). The CALPHAD technique used is adopted by the majority of the thermochemicists in the world and then the data produced can be easily incorporated in many calculation codes. THERMODATA is member of SGTE (GIE) with 12 other international laboratories engaged in thermodynamic data assessment and cooperates in a broader international effort to unify thermodynamic data and assessment methods.

The key persons involved are:
Dr. Bertrand CHEYNET, Evelyne FISCHER.

Participant number 29: Technical University of Sofia (TUS, Bulgaria)

TUS is the biggest higher technical educational and research complex in the fields of thermal- nuclear- and electrical power engineering, computer science and technologies, communications, etc. with close contacts and cooperation with governmental energy and environment institutions and the nuclear regulatory body, and with national role for the distribution of safety engineering knowledge, and for development of the Nuclear Energy Research Area in Bulgaria.

Safety and Environmental Engineering Laboratory (SEEL) by the Electrical Power Department at TUS, together with involved experts from Kozloduy NPP plc, Belene NPP project, etc. has significant experience regarding VVER safety analysis and studies, Environmental Impact Assessment of NPP, post test analysis, ASTEC benchmark calculations, etc. TUS, in particular SEEL collected an experience in the nuclear and severe accident research in the frame of FP5 Projects - PHEBEN2 and RMPS, and 6FP Projects - SARNET, COVERS and NEPTUNO. SEEL was initiator for preparation and implementation joint with CEA and FZK teams different experiments for VVER conditions in experimental programme PLINIUS - COLIMA tests and in LACOMERA platform – COMET-1 (MCCI), DISCO-L2 (DCH) and LIVE-L1 tests, etc. Since 2002 TUS participates in the PHEBUS FP Programme.

The key persons involved are:
Ivan Ivanov, Petar Kaleychev, Salih Kisyoski, Dimitar Popov

Participant number 30: Urad Jadroveho Dozoru SR (UJD, Slovakia)

UJD is a central administrative state office of the Slovak Republic responsible for the nuclear regulatory activities. An official representative of UJD is a chairperson – Mrs. Marta Ziakova. To the main responsibilities of the Department of Safety Analyses and Technical Support belongs:

- independent safety assessments of the present status and proposed upgrade of the nuclear facilities;
- independent analyses of accidents and operational events;
- preparation of the scenarios for emergency exercises with prediction of courses and consequences of nuclear accidents.

The team of this Department has an experience with computational analyses of accident scenarios including severe accidents with various codes, focusing on VVER-440 reactors. The team has been actively participating in various projects, e.g. PHARE P/TS/03, PR/TS/17, EVITA, SARNET and has a strong knowledge of specificities of VVER-type reactor, and of ASTEC use (has actively contributed to the EVITA project of FP5 and SARNET project FP6). The involvement of the team in SARNET2 is planned within ASTEC topic – i.e. validation and benchmarking activities (WP4.1 and WP4.2).

The key persons involved are:
Ms. Lubica Kubisova, Ms. Stanislava Stubnova

Participant number 31: Ustav Jaderneho Vyzkumu Rez a.s. (UJV, Czech Republic)

Nuclear Research Institute Rez plc (UJV Rez a.s.) is one of the Czech Republic's largest companies in the nuclear sector. Institute staff comprises over 900 employees, around of them are 450 university graduates and highly qualified scientific experts. One of the important tasks of the Institute is R&D and technical support of activities related to the long-term strategy of power supply, and especially to nuclear power development, nuclear safety, nuclear waste management and practical utilisation of ionising radiation. Institute closely cooperates with the industry and plays a key role in research and development in all areas of nuclear technologies and offers services for the safe and reliable operation of nuclear power plants including design and engineering services and manufacturing of special products and equipment.

An important part of Institute's R&D activities is its participation in the EU, especially EURATOM Framework Programmes. In 2006 Institute answered the last call for projects of 6th EURATOM FP in the field of nuclear fission, and the total number of 6th projects with Institute's participation reached 31. UJV activities in the area of severe accident R&D are focused on the validation of physical models, validation and qualification of computer codes for severe accident analyses, experimental studies of UO_2-ZrO_2-Fe_2O_3 and UO_2-SiO_2 systems, analyses of severe accidents, development of guidelines and strategies of severe accident management and development of PSA-2 studies for VVER type reactors.

UJV will contribute to:
- WP5 - calculations of LOFT LP-FP2 and Quench tests, pre- and post test calculations of Quench-Debris test;
- WP6 - experiments and studies of physical and chemical properties of U-Fe-O, UO_2-ZrO_2-Fe_2O_3 and UO_2-SiO_2systems, post test calculations of CCI-4 and VULCANO VB-U experiments;
- WP7 - calculations of TOSQAN, MISTRA, THAI and CONAN experiments, calculations of generic containment.

The key persons involved are:
Jan Jakab, Jiri Duspiva, Monika Kiselova, Bohumir Kujal, Zbynek Parduba

Participant number 32: University of Newcastle (UNEW, United Kingdom)

The University of Newcastle UK is one of the UK's leading R&D universities. Nuclear safety studies are carried out in the Multiphase Flow / Thermal Systems Group in the School of Mechanical & Systems Engineering. This is a newly formed group involved with the measurement, modelling and simulation of industrial, environmental and biological multiphase flows. Specialist areas include two-fluid modelling of dispersed flows and CFD multiphase flow. Computation and simulation studies have been considerably widened with the setting up of a CFD lab and the installation of a 20 Opteron 2.4 Ghz Blade Sever allows the group to perform LES and DNS calculations of agglomeration, and transport of particles in turbulent flows. Measurement techniques for two phase flow application include PIV, and particle tracking using high speed digital cameras which form an integral part of a new Fluids Lab. Current nuclear safety research involves the modelling and measurement of aerosol release, transport and agglomeration in a PWR Steam Generator Tube Rupture (sponsored by the Paul Scherrer Institute, Switzerland); modelling of multilayer resuspension of aerosol particles under nuclear severe accident conditions (in collaboration and

sponsored by IRSN); the computation and modelling of fission product transport in advanced gas–cooled reactors with special emphasis on iodine attached to dust particles (sponsored by British Energy UK).

The University of Newcastle will participate in the Source Term activities of SARNET2, more especially on Iodine chemistry in RCS and Containment with the development of a model of iodine transport using CFD methods with droplet tracking.

The key persons involved are:

Prof. Michael Reeks (Professor in Multiphase Flow) has over 30 years of experience of working in the nuclear industry first with CEGB/ Magnox Electric (25 years) and latterly at the European Joint Research Centre ISPRA in nuclear safety unit. He has worked exclusively on nuclear aerosols and fissions product Transport. He was formerly head of the aerosol and containment thermal hydraulics group at Magnox Electric, and chairman of the scientific committee of the STORM experiment and has had an active involvement in the PHEBUS FP transport experiments. He is currently an editor of the Journal of Turbulence and Combustion.

Dr. Ian Potts has many years of experience in both experimental and computational thermal fluid research. His key expertise is in Computational Fluid Dynamics where he has developed his own research codes as well as being fully conversant with a number of commercial CFD codes particularly FLUENT where he is familiar with the underlying source codes and has implemented a number of changes. He is current Principal Investigator for the British Energy Sponsored programme on Fission Product transport in Gas-Cooled Reactors.

Dr David Swailes is a lecturer at Newcastle University in the School of Mechanical & Systems Engineering and, prior to that, in the Department of Engineering Mathematics. His primary research interest has been in the development and analysis of transport models for disperses two-phase flows some of which has been directly funded by British Energy. He has been an active member of SARNET and participated in a number of severe accident workshops and symposia.

Participant number 33: Department of Mechanical, Nuclear and Production Engineering (DIMNP) of the University of Pisa (UNIPI, Italy)

The Department of Mechanical, Nuclear and Production Engineering (DIMNP) is a research structure of the University of Pisa (UNIPI), with more than 70 academic and research staff members. Since its institution, UPI has been characterised by a strong orientation towards collaborations with Italian and European Industries in applicative research projects with wide scientific and technological significance.

Professors and researchers belonging to the Nuclear Engineering Area are traditionally involved in research and teaching activities related to peaceful applications of nuclear energy, with main emphasis on plant design and safety, radiation measurements and nuclear reactor physics. The Nuclear Engineering group is continuously involved in researches carried out in cooperation with prestigious international organisations, thus preserving and updating its knowledge and capabilities in the nuclear field, even in a period of nuclear moratoria in the Country.

The UPI, trough the Italian CIRTEN Consortium, is an effective member of the European Nuclear Education Network (ENEN) Association, a non-profit international organization under the French law. ENEN's mission is the preservation and the further development of higher nuclear education and expertise.

The Severe Accident group of UNIPI has a long experience in the field of thermal-hydraulic (both primary system and containment analysis) and on severe accidents analysis. This experience has been gained with autonomous activities and with the participation to different OECD/CSNI International Standard Problems and EU Projects in past years.

Within SARNET2, UNIPI is offering to contribute to the WP 2, 4, 7 and 8. In WP2 it will participate initially on the WP2-1 ET, also considering its strong link with ENEN. In WP 4, UNIPI will only participate to WP4.1 USI to maintain the knowledge about the ASTEC code, being an experienced user of other source term codes as MELCOR, SCDAP/RELAP and ECART. In WP7.2, UNIPI mainly will contribute with new CONAN experiments on condensation in severe accident conditions inside the containment and with the coordination of the follow-up of the benchmark on condensation models for CFD tools (Task 2). In WP 8, UNIPI main interest is in benchmarking activities during WP8.3 “Bringing research results into safety analysis”.

The key persons involved are:

Prof. Francesco Oriolo is full professor in Nuclear Engineering and teacher in the PhD course in Nuclear and Industrial Safety. His research activity is documented by more than 150 publications, mainly related to heat and mass transfer phenomena in LWRs and to requirements and numerical modelling of source term. Since 1970, his main research interest has been in computational and experimental thermal-hydraulics, focused on incondensable gas and steam distribution in nuclear containment systems. He cooperated with IAEA for "special services" at Atomic Energy Institute of China and at CNEA of Argentina and participated in several OECD-CSNI Task Group and IAEA Technical Committee Meetings as well as in the STORM Scientific Committee. He is member of the Contact Expert Group on Corium Management (CEG-CM) of EC & International Science and Technology Centre (ISTC).

Prof. Sandro Paci is associate professor in Nuclear Plants and teacher in the PhD course in Nuclear and Industrial Safety. He has more than twenty-five years experience in development and application of numerical models and codes, especially in the field of containment thermal-hydraulics. At present, he is involved in the area of thermal-hydraulics and fission products analysis for severe accidents, regarding both in-vessel and ex-vessel scenarios, also for innovative LWRs and fusion reactors. He was a member of the STORM Scientific Committee and responsible for UNIPI of two EU contracts (PHEBEN and ISP46 Thematic Network). Now he is involved in various national and international research groups, as the European MELCOR Users Group, on different aspects of nuclear plant safety.

Prof. Walter Ambrosini is associate professor in Nuclear Plants and teacher in the PhD course in Nuclear and Industrial Safety. His research interests involve: a) thermal-hydraulic system codes application and development for the analysis of the dynamic behaviour of nuclear reactor systems; b) experiments on heat and mass transfer problems (namely, film-wise condensation and falling film evaporation) and experiments and modelling of natural circulation phenomena; c) development and application of numerical methods for heat transfer and fluid flow problems. He took active part in different EU projects related to relevant aspects of heat and mass transfer (e.g., DABASCO, INCON, SCACEX) running both experimental and theoretical research activities.

Participant number 34: Universität Stuttgart (USTUTT, Germany)

Founded in 1829 as a polytechnic school, the University of Stuttgart nowadays is one of Germany's top ranked research universities with a focus on Engineering and the Natural Sciences. The staffs comprise about 4400 full-time employees and about 19500 students are presently enrolled at 10 faculties. The University provides an international range of study programmes, including 7 Master's courses taught in English.

Education and research at the University in the field of nuclear energy is mainly concentrated at the Institute for Nuclear Energy and Energy Systems (IKE). IKE has more than 35 years of expertise and active experience in theoretical and experimental research, especially in the fields of reactor physics, heat transfer and nuclear reactor safety. IKE has carried out numerous research projects sponsored by the industry, the German government and the EU in the field of severe reactor accidents. Main areas of research presently are related to core degradation, to corium coolability under both in- and ex-vessel situations and to steam explosions. IKE is developing models and codes (like the WABE and MEWA modules which are developed for implementation in the German system code ATHLET-CD) and is carrying out experiments for model validation (DEBRIS experiments). IKE has been an important and reliable partner in various projects of the past Framework Programmes of the EU (e.g. the EVITA, ECOSTAR, ARVI and COLOSS projects of the 5th and the SARNET project of the 6th Framework Programme).

Within SARNET2, IKE is offering to contribute to the Work Packages 4 (ASTEC), 5 (corium and debris coolability), 6 (molten corium concrete interaction) and 7 (Containment/FCI). In WP 4, IKE will especially contribute to the ASTEC extension for BWR, with emphasis on modelling of BWR-specific core components and of corium slumping into a water filled cavity. IKE has large experience from similar modelling work in the context of the ATHLET-CD development. IKE is also an experienced user of the ASTEC code and has contributed to validation and reactor application benchmarking in the EVITA and SARNET projects.

In WP 5, IKE will contribute with new DEBRIS experiments, joint interpretation of experiments within the project (DEFOR, PEARL, LIVE), model improvements based on the joint analysis of the analytical and semi-integral experiments in the project and contributions to joint analyses of plant scenarios. IKE has long-standing experience in the research on coolability and has coordinated the debris coolability WP 11.1 in SARNET. The DEBRIS facility operated at IKE provides an important database for the development and validation of models related to coolability and quenching of porous debris. Models and codes being developed at IKE have been successfully applied for the analysis of experiments and reactor conditions, also by external users (e.g. KTH and VTT) which have obtained the codes through the cooperation in SARNET.

In WP 6, IKE will contribute by developing a model for the coolability of melt layers, taking into account porosity formation as the major mechanism, either due to bottom injection as in the COMET core catcher concept or due to volcano-like eruptions in the case of top flooding. IKE has contributed with modelling on bottom injection (COMET core catcher concept) and related validation already in the ECOSTAR project of the 5th FP and in SARNET (VULCANO-COMET experiment).

In WP 7, IKE will participate in the FCI work package with contributions to joint analysis of experiments, model development and reactor scale applications. IKE has a long-standing experience in the field of steam explosion research and has developed models and codes (IKEJET/IKEMIX, IDEMO) that were successfully applied e.g. in the SERENA-1 project of the OECD. IKE has been a major contributor to previous MFCI projects of the EU and to the WP13.1 in SARNET and is also a partner in the SERENA-2 project of the OECD.

The key persons involved are:

Manfred Bürger. He is the head of the Severe Accident Research Group at IKE. He has more than 30 years of experience in the field and has carried out and managed many severe reactor accident research activities. The results of his research have been published in more than 100 articles, conference proceedings and reports. He coordinated the debris coolability WP 11.1 in SARNET.

Michael Buck. He has more than 15 year experience in the field of severe accident research and has been strongly involved in the ASTEC, CORIUM and CONTAINMENT topics in SARNET. He is responsible for the development of core degradation models for ATHLET-CD. He has more than 40 publications in journals, proceedings and reports.

Participant number 35: VEIKI Institute for Electric Power Research Co. (VEIKI, Hungary)

VEIKI has experience in analysis of containment phenomena, in using simulation codes and in assessment of calculation results with experimental data. Strong knowledge of specific features of VVER-type reactors and of ASTEC use. Has actively contributed to the EVITA project of the 5th framework programme

At present the research and development activity of VEIKI is related to the following main fields:

- safety assessment of nuclear power plants,
- combustion technology,
- mechanical and power engineering technology,
- systems of control engineering and telemechanics.

Activities of the Nuclear Engineering Division extend from the probabilistic safety assessment to containment analysis and severe accident analysis and management. Project team activities are being continuously monitored, in addition periodic quality assurance audits are performed.

VEIKI participated in the AGNES project for reassessment of the safety of Paks NPP in 1991 - 1994 and was responsible for the severe accident analyses and probabilistic safety analyses (PSA). A part of the analyses addressed interventions to stop the development of the accident phenomena or to mitigate the consequences (accident management).

Since the accomplishment of the AGNES Project VEIKI participated in the PHARE 4.2.7a Project entitled VVER-440/213 Beyond Design Basis Accident Analysis and Accident Management project. Among key domestic projects the Level 2 PSA project for Paks NPP should be noted. Currently, VEIKI is participating in an ongoing severe accident management guidelines (SAMG) implementation project for Paks NPP.

VEIKI participated in three work packages of the SARNET NoE between 2004 and 2008.

The key persons involved are:

Dr. Zs. Téchy has more than 20 years of experience in nuclear safety calculations. He served as project manager of the severe accident analysis team in the domestic AGNES project for the safety reassessment of the Paks NPP. The project addressed accident management strategy definition for the plant. Later, he was project manager of the PHARE 4.2.7.a Beyond Design Basis Accident Analysis and Accident Management project and coordinated MAAP calculations to define an accident management framework for the VVER-440/213 containment.

Dr. G. Lajtha has 10 years experience in severe accident analysis. In 1992 he spent 6 month in Cadarache to learn the use of ESCADRE code. He worked two years (1995-96) in Cadarache (IPSN) where he participated in the development of the SOPHAEROS code to include vapour chemistry. He has experience in code calculations, and in analysing experiments (DEMONA, LACE, FALCON, STORM).

P. Kostka has 4 years of experience in the field of VVER-440 severe accident analyses. He was involved in a number of national and international projects concerning accident analysis and accident management. He participated in the project of DBA hydrogen removal from the containment of Paks NPP, Unit 3., the PHARE 4.2.7a "VVER 440/213 Beyond design Basis Accident Analysis and Accident Management During Severe Accidents" projects.

Dr. G.L. Horvath has 12 years experience in fission product transport issues. In 1995-96 he was attached to Brookhaven National Laboratory and worked on the development of MELCOR input for VVER-440 reactors. He participated in the PHARE 4.2.7.a "Beyond Design Basis Accident Analysis and Accident Management" and the PHARE 2.06 "Filtered Venting of the Containment" projects. Acted as Visiting Scientist at JRC, Ispra. He also took part in the development of the SPRINT software, which is the subject of demonstration in this project.

Participant number 36: VTT Technical Research Centre of Finland (VTT, Finland)

VTT Technical Research Centre of Finland is a contract research organization involved in many international assignments. With its 3000 employees, VTT provide a wide range of technologies and applied research services for its clients, private companies, institutions and the public sector. VTT has a large experience in assessment of severe accident phenomena in BWR and VVER 440; within this domain, VTT's own experimental research has focussed on aerosol behaviour in the containment and reactor coolant system and in ex-vessel coolability of particulate debris beds; this work has also involved the development of analytical tools.

The key persons involved are:
Ms. Ilona Lindholm (in WP1-3, WP5, WP6, WP7-1)
Ms. Eveliina Takasuo (in WP5, WP7-2 and WP7-3)
Mr. Tuomo Sevón (in WP6)
Mr. Ari Auvinen (in WP8)
Mr. Teemu Kärkelä (in WP8)

Participant number 37: VUJE Trnava, a.s (VUJE, Slovakia)

VUJE has over 30 years of experience in NPP operation support and research in the field of nuclear industry and provides full scope of tasks for the NPPs in Slovakia. The work is focused onto VVER440/213 reactor units. VUJE possesses perfect knowledge of specificities of VVER440 reactors.

Main projects:
-Modernization of the two V2 units with VVER440/V213 reactors
- Design work and implementation of the Republic Repository of Radioactive Waste in Mochovce
- Gradual reconstruction of V1 units (VVER440/V230) in cooperation with SIEMENS
- Preparation of power uprate of Bohunice and Mochovce units
- Support to SAMG development and application in cooperation with Westinghouse
- Design of Bohunice and Mochovce units upgrade (including strengthening against severe accidents)

WP4-2 ACAS (ASTEC)

Planned activity: Application of ASTEC code to VVER440/V213 reactors, benchmarking and verification of the analyses, code-to-code comparison to other integral codes.

Experience: Cooperation with IRSN on ASTEC code assessment for many years. Active contribution to the EVITA, SARNET, PHEBUS projects.

Experience in ASTEC code application, input deck development, code assessment.

WP7-2 H2 (CONT)

Planned activity: The course of participation will focus onto passive autocatalytic recombiners and hydrogen igniters. Measures including PARs and igniters are needed to cope with hydrogen risk during severe accidents, as there is very low margin to containment failure pressure of VVER440/V213 NPP units during a severe accident involving hydrogen combustion. The predominant interest is in "application" work for the package (involving integral codes; analyses of PAR installation, numbers, types, PAR abilities to ignite atmosphere …).

Experience: VUJE participated in preparation of Mochovce 3,4 NPP project modification also in the area of strengthening of the units against severe accidents with emphasis given onto in-vessel retention and hydrogen control. VUJE prepared design of measures for mitigation of severe accidents for VVER440 units in operation.

Key persons involved are:
Juraj Jancovic - VUJE - responsible for severe accident analyses (safety reports, PSA L2, research, support of NPP modifications...).
Albert Bujan - VUJE - responsible for severe accident analyses (source term, radiological consequences, ASTEC code/input deck development). JRC Petten, participated in ASTEC/SOPHAEROS calculations and development.
Jozef Slaby - VUJE - responsible for ASTEC calculations, verification and interpretation.

Participant number 38: EURATOM Joint Research Centres (JRCs, European Union)

JRC has a wide-ranging experience in development and maintenance of the scientific database STRESA as well as the training of its use. Moreover it has an excellent experimental knowledge of core material interactions with irradiated fuel (dissolution and melting points). The JRC has been heavily involved in post-test examinations of Phebus bundle degradation (JRC Karlsruhe - ITU) and in the interpretation of these tests (JRC Ispra - IE). All relevant processes on core degradation, the behaviour of fission products and aerosols as well as the FP chemistry in the containment are analysed using SA codes – mainly with ASTEC. In addition the JRC 's (especially ITU & IE above) have accumulated considerable experience on the modelling of hydrogen combustion and fuel dissolution, on uncertainty and sensitivity analysis and statistical data analysis in PSA where the JRC was involved in all the EU shared cost actions in these research activities. These are detailed below:

JRC ISPRA: Development, maintenance and training of the STRESA database.

JRC ITU: ITU Hot Cells have a wide range of equipment combined with in-depth experience with irradiated fuel. They have carried out extensive experimental work on core material interactions (dissolution investigations and corium melting point determinations). Previous investigations under Shared Cost Actions include irradiated fuel testing under the CIT and COLOSS projects. Furthermore, ITU has had long and extensive connections with the international Phebus FP project and carried out post-irradiation examinations of the degraded Phebus bundles as well as examining fission product deposits in the Phebus circuits.

JRC PETTEN: Strong experience on core degradation, on the behaviour of fission products and aerosols, on hydrogen combustion as well as on uncertainty and sensitivity analysis and statistical data analysis in PSA. Having a very good knowledge of ASTEC, JRC Petten has participated actively to the EVITA project of the 5th FP. It currently chairs the Bundle Interpretation Circle of the Phebus programme. Involved in the PHEBEN-2, COLOSS, ICHEMM, HYCOM projects.

The key persons involved are:
R. Zeyen (JRC-IE-Cadarache). He has 20 years experience in a wide range of activities and areas such as fission product behaviour and in–pile experimental techniques gained in his work in various positions within the Phebus FP team and in co-ordinating various scientific committees. He is currently chairing

the Bundle Interpretation Circle, Scientific and Analysis Working Groups and the Phebus Steering Committees.

U. Von Estorff (JRC-IE-Petten)

D. Bottomley (JRC-ITU-Karlsruhe). Following a PhD in UMIST, Manchester and several post-doctoral projects in France and Holland in High Temperature Corrosion and Electrochemistry, he came to ITU to work in ITU's Hot Cells in 1987. Since then he has accumulated 20 years experience in irradiated material experimentation. He has been active in a broad range of projects in severe accident field and has been responsible for co-ordinating ITU's investigations for the Phebus FP project: e.g. PIE investigations of FPT0, FPT1 and FPT2 bundles as well as the corresponding fission products analyses and testing. Other experience in this field includes fuel dissolution of molten cladding and high temperature interactions under the EC COLOSS and CIT projects but also fission product volatility studies under the REVAPORISATION project. He has also lead the ITU investigations of the TMI-2 material examined under the OECD project.

Participant number 39: Atomic Energy Canada Limited (AECL, Canada)

Atomic Energy of Canada Limited (AECL) is a fully integrated nuclear technology and services company providing services to nuclear utilities worldwide. Its 4,000 employees are dedicated to delivering leading edge nuclear services, R&D support, design and engineering, construction management, specialized technology and waste management and decommissioning in support of CANDU reactor products.

AECL is committed to supporting its Canadian and international customers in all aspects of nuclear power technology management. It provides on-site expertise, closely supported by its nuclear science laboratories, testing capability and engineering facilities. CANDU reactors supply about 16% of Canada’s electricity and are an important component of clean-air energy programs on four continents. AECL is a crown corporation that was established in 1952 to develop peaceful applications of nuclear energy.

AECL’s nuclear platform research and development program maintains and enhances the CANDU safety, licensing and design basis. In addition, it supports public policy for nuclear technology, develops pre-commercial CANDU technology and preserves the capability and expertise needed to address future issues.

AECL’s expertise also supports improvements in plant performance and licensing for CANDU utilities. Generic support, part of the safety, licensing and design basis, is provided through cost-shared programs with the CANDU Owners Group.

AECL continues to advance its research vision of providing components, systems and technology that will ensure CANDU’s long-term safety and performance competitiveness in global markets.

AECL has strong research and development (R&D) programs that keep us at the leading edge of nuclear technology. Through these activities, AECL is continuing to enhance the design of CANDU power reactors, advance MAPLE research reactor technology, and explore continuous improvements in all our products and services.

Its scientific and engineering staff is committed to understanding and meeting the current and future needs of our customers. AECL focus on eight key technologies:

- safety and in particular severe accident situations, AECL is a partner of the ISTP carried out in France by IRSN and CEA;
- fuel and fuel cycles;
- fuel channels;
- components and systems;
- heavy water production and processing;
- environment, emissions and waste management;
- control and information;
- and constructability.

The R&D programs include underlying work, which is needed to ensure that CANDU technology has a solid technical base, through to applied programs that result in qualification of equipment, processes and systems for power and research reactors.

Participant number 40: Korea Atomic Energy Research Institute (KAERI, Korea)

Founded in 1959, KAERI (Korea Atomic Energy Research Institute), as the sole national nuclear R&D research institution, has greatly contributed to strengthening the competitive edge of the nation's science and technology by achieving technological self-reliance in nuclear technology and expanding its research activities to other related areas. KAERI has built a reputation in various fields at the forefront of the national R&D in science and technology and as the first to be established as a government-supported research institution in Korea. Especially, to resolve outstanding issues in an efficient manner, the international collaborations have been pursued in severe accident programs such as CSARP (Cooperative Severe Accident Research Program), OECD-MCCI (Molten Core Concrete Interaction), OECD-SERENA (Steam Explosion REsolution of Nuclear Applications), OECD-MASCA (MAterial SCAling), OECD-THAI(Thermal-hydraulics, Hydrogen, Aerosol and Iodine), and MUG (MAAP User's Group).

The work-packages and main tasks for SARNET2 (over the whole duration of the planned work) are:

1. WP7-1 (on Ex-vessel FCI) participation with 4 p.m.
2. WP7-2 (on H2 mixing/combustion in containment) with 4 p.m.
3. WP6-3 (on MCCI) participation with 4 p.m.
4. WP4-2 (on ASTEC assessment) with 5 p.m.
5. WP8-3 (on ST research results to reactor application) with 2 p.m.

The key persons involved are:

Dr.Hong Seong-Wan has a 20-year experience in the experiment and analysis of severe accidents. His current field of research is focused on experiments and analysis for the corium coolability in the reactor vessel, the fuel coolant interaction (OECD/NEA SERENA P-2) and the corium coolability in the reactor cavity. Specially, he leads the experiment and analysis for the OECD/NEA SERENA program in Korea and plays a role of PRG (program review group) member in this program. His qualified specializations are:

- Experiment and analysis of the fuel coolant interaction research using prototypic reactor materials in TROI facility,
- Code improvement for severe accident related thermal-hydraulics and accident management,
- Development of severe accident managements,
- Experiment and analysis of hydrogen combustion,
- Severe accident code (STCP, CONTAIN, etc.) proficiencies.

Dr. Kim Sang-Bak has a 25-year experience in thermal-hydraulics and severe accident research. His current field of research is focused on the hydrogen mixing and combustion in the reactor containment during severe accident. He is a leader of the evaluation project of the hydrogen issues in evolutionary PWR plants for licensing and also a member of PRG in OECD-THAI project. His qualified specializations are:

- Containment analysis of thermal-hydraulic and severe accident,
- Debris bed coolability and In-vessel corium retention,
- Evaluation of in-vessel and ex-vessel SAMG (severe accident management guideline) strategy.

Mr. Song Yong-Mann has a 20-year experience in Level 2 PSA and in the analysis of severe accidents. His current field of research is to develop an integrated optimal accident management system via an effort to minimize a level-2 PSA uncertainty and to add risk information to a previous DSA (Deterministic Safety Analysis) frame. He is a leader of the development project of the Level 2 risk optimal assessment and application technology. His qualified specializations are:

- Probabilistic safety assessment (Level-2 PSA) application for PWR/PHWR,
- Containment performance analysis for PWR/PHWR,
- Severe accident code (STCP, MAAP, MELCOR, XSOR, MELTSPREAD etc.) proficiencies,
- Code development for severe accident related thermal-hydraulics and accident management,
- Development of source term analysis methodologies and source term evaluation under severe accidents.

Participant number 41: U.S. Nuclear Regulatory Commission (USNRC, United States of America)

The U.S. Nuclear Regulatory Commission (NRC) was created as an independent agency by Congress in 1974 to enable the nation to safely use radioactive materials for beneficial civilian purposes while ensuring that people and the environment are protected. The NRC regulates commercial nuclear power plants and other uses of nuclear materials, such as in nuclear medicine, through licensing, inspection and enforcement of its requirements. It is essential to the mission of the NRC that it possesses, among many, expertise on severe accident phenomenological behaviour and a quantitative predictive capability for simulating the response of nuclear power systems to severe accidents. Towards this end, the NRC has created a repository of severe accident knowledge in the MELCOR computer code. To maintain this code validated at the current state of knowledge, to increase understanding in critical areas which remain uncertain, and to add the capability for predicting accidents for advanced reactor designs and new fuel compositions as these become imminent, the NRC conducts research programs covering a broad range of severe accident phenomena and collaborates in international severe accident experimental research programs.

The key persons involved are:
Dr. Richard Lee, Dr. Dana Powers (Sandia National Laboratories), Dr. Michael Salay

B2.3 Consortium as a whole

The SARNET2 Consortium will gather 41 organizations. Practically, all the European actors in research on nuclear energy, including Research organizations and Universities, are participating actively to SARNET2 project. As the end-products developed by the network (ASTEC, scientific databases) may be used not only for R&D activities but also for other purposes, under conditions that are defined in the Consortium Agreement, several organizations from the Industry (EDF, TRACTEBEL SUEZ, AREVA NP) are directly contributing to SARNET2. In return, the end-products of the network that will capitalize the large amount of knowledge acquired in this area will contribute to the improvement of safety of existing and future NPPs. In addition, most of the Technical Safety Organisations to the Regulatory Authorities are also actively participating in SARNET2. An Advisory Committee, comprising managers of end-user organisations, including Vendors, Utilities and Regulatory Bodies from Western and Central Europe, will provide the Steering Committee and the General Assembly with advices on strategic orientations of the research activities of SARNET2, with the ultimate goal of a better prevention and mitigation of severe accidents in European NPPs. Finally, three non-European major partners (AECL, KAERI and USNRC) complement the span of organizations to cover even more efficiently all the domains of the research in severe accident. Besides, they provide a wider view in terms of needs.

The “Education and Training” of young researchers and engineers, necessary to maintain existing nuclear knowledge, is another product of the Consortium. This trained work force will in part also provide future qualified staff to Europe’s nuclear industrial sector to accompany the development of the sector in the next decades.

A few SARNET2 partners are covering a wide range of competence though not complete, whereas others are specialized in very specific areas and thus complementarities are developing. Overall, it is estimated that the critical mass of competence for performing experiments needed in the severe accident domain, analysing them, developing models and integrating them in the ASTEC code is met for all types of NPPs in Europe. New European Union Countries are appropriately associated to most projects. Furthermore, SARNET2 will also maintain strong links with other European projects (ASAM-PSA2, SNE-TP, ENEN…), with the ISTC projects, with the ISTP (in particular the Phebus.FP programme), and with international organisations (OECD/NEA, mainly the CSNI/GAMA Group …).

Thus SARNET2 will be the crucible for a horizontal type of integration of a vast range of multidisciplinary activities with its main end-product: the integral code ASTEC. The knowledge gained by the network will be integrated into ASTEC through improved models so that it will be capitalized and will be applicable to all types of NPPs in Europe (… and worldwide).

B2.3.1 Subcontracting

The activity consisting in the first-level support of ASTEC users will be sub-contracted by IRSN. The reason is that experts in the ASTEC IRSN and GRS teams will be mostly involved in tasks aiming at improving and assessing the code. The company that is contractually in charge of on-line supporting ASTEC users will carry the corresponding activity (this company has been selected after a call for tenders set by IRSN in 2008 for a 4-year duration). IRSN will be responsible for the subcontracting, the amount of the sub-contract is around 130 k€/year.

The maintenance, the development and the users’ support of the public Web site and of the ACT will also require a sub-contract. GRS will be responsible for the subcontracting, the amount of the sub-contract is around 6 k€/year. The same tool as in SARNET will be used but with an improved version. The utilization of the procedures which have been well established and practiced in SARNET by the same subcontractor will allow a rapid and smooth transition to the communication tools in SARNET2, and result in minimization of transition time and costs.

B2.3.2 Third parties

Not applicable.

B2.3.3 Non European Countries

Three partners are from non European countries: AECL (Canada), KAERI (Korea) and USNRC (United States). These three major partners in the field of Severe Accident Research will provide very valuable contributions to the network. Nevertheless, they will not require any funding from the EC. This positive attitude is an evidence of the interest in joining the network even without EC funding and is a very encouraging sign for the future self-sustainability of the network.

B2.4 Resources to be committed

For the first JPA, four kinds of expenses are considered:

- Manpower, stated in person-months (one full time working year equals twelve person-months or p-m), with a lump average value of the person-year cost (132000€/year),
- Expenses for attendance of meetings (travel, accommodation….),
- Experimental costs,
- Other expenses related to (with the estimated value in parentheses):
  - Sub-contract for support to the ASTEC users (130000€),
  - Sub-contract for maintenance of the ACT and the WEB site (6000€),
  - Preparation of the ERMSAR-2010 Conference (it will be held in the first month of the 2nd period),
  - Mobility of students or young researchers (15000€). This will cover a partial contribution to their living expenses in the receiving organisation.

The following amount of the high-level integrating activities has been evaluated as follows:

- For the general coordination of SARNET2: 12 p-m/y,
- For the scientific coordination of the WP:
  - WP1, 2 and 3: 1 p-m/y,
  - WP4, 7 and 8: 2 p-m/y,
  - WP5 and 6: 3 p-m/y.
- For the scientific coordination of the sub-WP (except the WP 1-1):
  - Sub-WP containing major experiments (i.e. WP 5-1, 5-2, 6-1 and 6-2): 1 p-m/y,
  - Sub-WP not containing major experiments (i.e. the other ones): 0,5 p-m/y.
- For ASTEC user support and training: 8 p-m/y,
- For the excellence spreading activities: 3,5 p-m/y.

The Table 6 hereunder describes the resources needed to carry out the work for the total duration of the project. The same kinds of expenses than above should be considered. The following assumption has been made for excellence spreading activities: a total of 4 ERMSAR conferences and 3 Education/Training courses.

The IRSN requested contribution is mentioned as 1977183 €. Indeed, it covers 1871616 € currently calculated for IRSN, plus 105567 € to be dispatched to various WP2 (Spreading of Excellence) partners, still to be determined, for the organization of courses and of ERMSAR Conferences (the dispatching will depend on the volunteer partners for organizing them) and for the mobility programme (the dispatching will depend on the partners delegating and hosting students and/or researchers).

As indicated in Table 1, the total personnel to perform the four-year JPA is foreseen at 1705,6 person.months. This value does not take into account the experimentalist person-months, as the cost of experiments has been determined as a global value (including researcher and technician manpower, consumables, etc...) by each partner providing experimental results.

These global experimental costs are estimated as:

- 7290000 € for WP5,
- 5532000 € for WP6,
- 691000 € for WP7,
- 600000 € for WP8.

As described elsewhere in the document, one of the main objective of SARNET2, in continuation of SARNET, consists in optimizing these total resources at the European (and even worldwide) scale, by a large integration process. This integration progress avoids useless duplication of efforts and allows covering all the remaining important pending issues in the Severe Accident research field.

In this context, the EC contribution is seen as a bonus to encourage the Consortium Contractors to progress more quickly on this general integration process.

As already mentioned in Chapter B1.1.3, to better ensure the self-sustainability of the network after the four-year period of the SARNET2 Project, the fund distribution to the partners will be managed on a strongly decreasing basis. About one third of the funds will be granted to the partners for the first year, and then this amount will decrease in the following periods as shown by the figures below (roughly an equivalent grant of one fifth of the funds for the last year). The requested EC contribution per SARNET2 period will be:

- 1875000 € for the 1st period of duration 12 months,
- 2225000 € for the 2nd period of duration 18 months (i.e. 1483330 € in average per year),
- 1650000 € for the 3rd period of duration 18 months (i.e. 1100000 € in average per year).

Then the creation of a legal entity will ensure a continuation of the network on a self-sustainable basis.

The Table 6 below presents a more detailed repartition of the estimations of actual foreseen costs, as declared by the partners in Form A3.2 in § A.1, between the different categories and types of expenses. It shows that the total cost of the project comes around 3900000 €. Based on EC funding of 5750000 €, it means that more than around 33000000 € are coming from the SARNET2 partners' own budgets.

Table 6: Full SARNET2 cost for the total duration (48 months)

		RTD				Management		Others		
Benef. N°	Beneficiary short name	Personnel costs (€]	Exp. costs * (€)	Other costs (travels…) (€)	Sub-contracting (€)	Personnel costs + travels (€]	Audit certificates (€)	Personnel costs + travels (€)	Sub-contracting (€)	Spreading (courses, mobility…)(€)
1	IRSN	5355773	3600000	30000	520000	933795	127000			
2	AEKI	49000	145000	5000				32000		
3	AREVA NP GmbH	153150	0	18000						
4	AREVA NP SAS	94903	0	4939						
5	BUTE INT	17600	0	6000						
6	CEA	2370908	4680000	20000			2500	89022		
7	CESI R	220000	0	40000						
8	CHALMERS	23334	70000	10000						
9	CIEMAT	155581	0	25840				32754		
10	DEMOKRITOS	171000	0	14000						
11	EDF	248454	0	10000						
12	EI	49000	0	5000						
13	ENEA	416000	0	35000						
14	Jülich	74736	0	0						
15	FZK	1357300	3281000	10000			1500	44000		
16	GRS	1407000	0	111520				168000	24000	
17	INR	50134	85000	20000						
18	INRNE	152800	0	2000						
19	IVS	135700	0	6500						
20	JSI	414000	0	140000						
21	KTH	963000	660000	20000				207000		
22	LEI	92000	0	16000						
23	NNL	106105	0	8578						
24	NRG	74600	0	5000						
25	PSI	816628	0	39000						
26	RUB	122286	0	12000						
27	TRACTEBEL	39116	0	7900						
28	THERMODATA	250600	0	5000						
29	TUS	69328	0	1456						
30	UJD SR	202840	0	6200						
31	UJV	303243	306000	15000						
32	UNEW	72915	0	39768						
33	UNIPI	557002	90800	10000				25454		
34	USTUTT	1437984	660000	16000						
35	VEIKI	500112	0	20000						
36	VTT	651404	360000	20000				11596		
37	VUJE	102400	0	14600						
38	JRCs	250840	42000	15000		144123		39974		
39	AECL	250000	0	150000						
40	KAERI	280000	0	0						
41	USNRC	1000000	0	400000						
	To be defined							66075		95000
	Total (€)	21058776	13979800	1335301	520000	1077918	131000	715875	24000	95000

TOTAL COST (€)	38937670

* “Exp. costs”: global value including researcher and technician manpower, equipments, consumables, etc...

B.3 Potential impact

B3.1 Strategic impact

A very large amount of knowledge has already been obtained in the field of Water Reactor Severe Accident research for the last 30 years. However, if no action is taken, this knowledge may be used only partly and furthermore only by a few teams. It may very well disappear if not preserved appropriately for the next generation. The proposed long-term SARNET2 activity, in continuity of SARNET, of permanently capitalizing knowledge in the integral computer code ASTEC as well as in scientific databases will provide the necessary conditions for preserving this knowledge and disseminating it to a large number of current and future end-users throughout Europe. To achieve successfully this objective, it is necessary to gather in a federative structure and in a durable way the available technical and scientific excellence in severe accident phenomena and management in Europe and have them sharing and working on the same computer code.

Thanks to SARNET, the tendency of European end-users to use integral computer codes developed in the United States (resulting in a strong dependence on the US decisions about code maintenance and development) is now evolving, with more and more ASTEC users. The efforts must really be pursued in order to assess ASTEC as a really powerful tool to be used by end-users.

One of the SARNET achievements consisted in obtaining a European consensus on 6 high priority issues on which research was still considered as necessary (see Chapter B1.1.1). SARNET2 (WP5 to WP8) will contribute to make considerable progress towards the closure of these pending issues. Furthermore, the integration due to common work within the SARNET2 Consortium will allow a better coordination of the national efforts to optimise the use of the available expertise and experimental facilities in view of the future reductions of the national budgets on these issues.

By providing an appropriate forum of exchange of technical and scientific information among experts in various fields and by its strong coordination structure involving management high-level representatives, SARNET2, in continuation of SARNET, will contribute to prioritise the needed research, to favour co-programming amongst organizations, to optimise the use of the available research capacities and to promote the co-operation between the different members. This will be done by taking benefits of and strengthening the existing complementarities between the different laboratories: e.g. experimental activities using “simulating” materials and experimental activities using real materials; small-scale analytical tests and large-scale integral tests; experts in corium behaviour, experts in containment behaviour and experts in fission product chemistry; physical model developers and code developers…

Thus, SARNET2 will continue the modification of the landscape of research on severe accident in Europe, already well advanced by SARNET. Indeed, SARNET has become a reference in terms of research priorities in the field of severe accident having impact on national programmes and fund allocations. The research activities in this field have become more and more coordinated by the network and ASTEC has progressively become a federative tool thereby contributing to integrate, preserve and disseminate knowledge. SARNET2 will allow consolidating these evolutions in a durable way, including the transmission of the present knowledge to the next generation of researchers.

In addition, the SARNET research activities have contributed efficiently to keeping competence and expertise in the area of severe accident management for all types of European water cooled reactors, including those of Russian design (cf. ASTEC developments), and also for future nuclear reactor designs. To reach this objective SARNET has developed various partnerships (particularly with ISTC programmes). This will be continued through SARNET2 and reinforced for the future (GEN IV) plant designs, by links with the European Sustainable Nuclear Energy Technological Platform (SNE-TP), in which SARNET2 already contributes to the Strategic Research Agenda.

Then, after the end of this second Project with the Commission, as agreed upon by the organisation representatives (see the Consortium Agreement, currently under preparation and which will be signed before the beginning of the Project) the creation of a legal entity will ensure the continuation of these networking activities in a durable and self-sustainable way. The type of legal entity to be created will be

decided during the first year after the beginning of the Project, from a specific analysis of advantages and drawbacks of the diverse possibilities by the Steering Committee and the Coordinator, helped by a team of lawyers.

B3.2 Spreading Excellence, Exploiting results, Disseminating Knowledge

As for SARNET, an education and training programme is set up to disseminate the excellence and knowledge in the severe accident area, including out of the SARNET2 Consortium perimeter. It is intended to be an in-depth treatment so that the university students and researchers will be able to (a) understand (b) develop the methodology in the topics further and (c) use analysis tools (e.g. ASTEC) more effectively. The preparation of the Education and Training courses should involve in particular CEA and IRSN partners, in the continuity of the work done in SARNET.

A mobility programme under which students (including students from European Universities out of the SARNET2 Consortium perimeter) and researchers will be able to go into different laboratories of SARNET2 partners for training will complete this education and training programme to develop a common safety culture throughout Europe.

Many SARNET2 organisations will contribute to spread the excellence by providing lecturers for the courses and by welcoming foreign students and researchers in their research laboratories.

The Advanced Communication Tool, developed in the SARNET frame, will be maintained and improved to make easier any collaborative work within a large number of laboratories and save travel costs. The system is used to make easier the access to scientific databases and foster information dissemination.

In addition, a large Conference (ERMSAR) will be organised yearly on the progress made in SARNET2, and more widely on the progress made in the severe accident research field. The audience will be international and this conference should become the international reference on research on severe accidents.

A WEB site advertising the work performed in SARNET and the knowledge acquired, giving access to information open to the public, was put in place with SARNET. Large efforts will be done through SARNET2 to improve this open WEB site.

As the main obstacle to integration of most of the experimental programmes is the need to raise funding at national and extra-national levels, a clear policy in terms of knowledge management, notably regarding access rights to experimental data produced within the network, is proposed to preserve the interests of the different organizations. For instance, data reports on “protected” experimental programmes will only be distributed to those members who need them to perform their part of the Joint Programme of Activities. Generally speaking, these members are already partners as co-funders in these programmes. In addition, it is planned to issue progress reports on these “protected” programmes, so as to provide any member with the opportunity to negotiate with the owners of these programmes the access to the data to participate to the joint research activities around them, or to use the knowledge in application out of SARNET2; moreover, the Consortium members commit to grant the access rights for use outside of SARNET2 on fair and non-discriminatory conditions. In any case, the outcome of these programmes will be models to be implemented in ASTEC or will be validated databases thereby contributing to spread the knowledge to the members.

The dissemination will result from the activities of excellence spreading and from the efforts made by the organisations producing basic knowledge to open data to other organisations, especially organisations coming from new European countries.

The dissemination of knowledge will result also from other activities:

- Distribution of ASTEC by IRSN and GRS to the users, including the end-users, under conditions defined in a specific software agreement,
- Publications and participations to conferences based on the various SARNET2 activities,
- Publication of the Book on Severe Accidents.

Knowledge management is a key activity of the Management Team. In complement of what is written in Chapter B2.1.4, it will have the mission to:

- Coordinate the knowledge generation through joint proposals of research activities,
- Monitor the knowledge integration in ASTEC,
- Make sure that the access rights and use rights as stipulated in the Consortium Agreement are correctly implemented,
- Disseminate appropriate information on the knowledge by using electronic communication links and by organizing conferences/workshops,
- Preserve the knowledge in scientific databases with long-term maintenance capacities,
- Identify the missing knowledge (continuation of SARNET/SARP action).

Actors outside the research community (end-users and general public) will be contacted with the aim of organizing dissemination to more-general, non-specialist audiences of the information on the nature of SARNET2 activities and their benefits to society and the general public. It is expected that synergies with educational institutions (mainly universities) will be especially effective in this respect. It is noted, in particular, that:

- Each partner organization already individually committed to the objective of communicating information, as far as reasonably possible, to a wide public,
- The network will not only encourage such dissemination efforts but intends, when judged constructive to do so, to coordinate them,
- The network will also engage in raising the general perception of its results by participating in events open to the public (e.g. the “Journées de la Science” in France) and exploring means of communication through popular-science reviews (magazines, radio programmes, etc.).

B.4Ethical Issues

	YES	PAGE
Informed Consent		
• Does the proposal involve children?		
• Does the proposal involve patients or persons not able to give consent?		
• Does the proposal involve adult healthy volunteers?		
• Does the proposal involve Human Genetic Material?		
• Does the proposal involve Human biological samples?		
• Does the proposal involve Human data collection?		
Research on Human embryo/foetus		
• Does the proposal involve Human Embryos?		
• Does the proposal involve Human Foetal Tissue / Cells?		
• Does the proposal involve Human Embryonic Stem Cells?		
Privacy		
• Does the proposal involve processing of genetic information or personal data (e.g. health, sexual lifestyle, ethnicity, political opinion, religious or philosophical conviction)		
• Does the proposal involve tracking the location or observation of people?		
Research on Animals		
• Does the proposal involve research on animals?		
• Are those animals transgenic small laboratory animals?		
• Are those animals transgenic farm animals?		
• Are those animals cloned farm animals?		
• Are those animals non-human primates?		
Research Involving Developing Countries		
• Use of local resources (genetic, animal, plant etc)		
• Impact on local community		
Dual Use		
• Research having direct military application		
• Research having the potential for terrorist abuse		
I CONFIRM THAT NONE OF THE ABOVE ISSUES APPLY TO MY PROPOSAL	Yes	

B.5 Consideration of Gender Aspects

There are fewer women scientists than men in SARNET2 (~15%, figure to be checked later on), which reflect a global state in this research field. Participation of women will be encouraged at least in the mobility plan (that in SARNET implied 50% of women) and in the presentation of the work performed by scientist women in the ERMSAR conferences.