Overview of SARNET Deployment and Progress

Thierry ALBIOL[1], Tim HASTE[2], Jean-Pierre VAN DORSSELAERE[1], Christophe JOURNEAU[3], Leonhard MEYER[4], Bernard CHAUMONT[1], Bal Raj SEHGAL[5], Bernd SCHWINGES[6], David BERAHA[6], Alessandro ANNUNZIATO[7], Roland ZEYEN[8]

1) Institut de Radioprotection et de Sûreté Nucléaire (IRSN), France
2) Paul Scherrer Institute (PSI), Switzerland
3) Commissariat à l'Energie Atomique (CEA)**,** France
4) Forschungszentrum Karlsruhe GmbH (FZK), Germany
5) Kungl Tekniska Högskolan (KTH), Sweden
6) Gesellschaft für Anlagen- und Reaktorsicherheit (GRS), Germany
7) Joint Research Centre (JRC) Ispra, Italy
8) Joint Research Centre (JRC) Petten - Cadarache, France

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SUMMARY

51 organizations network in ***SARNET*** (Severe Accident Research NETwork of Excellence) their capacities of research in order to resolve the most important remaining uncertainties for enhancing, in regard of Severe Accidents (SA), the safety of existing and future Nuclear Power Plants (NPPs). This project has been defined in order to optimise the use of the available means and to constitute sustainable research groups in Europe and in Canada. SARNET tackles the fragmentation that exists between the different R&D national programmes, in defining common research programmes and developing common computer tools and methodologies for safety assessment.

To reach these objectives, all the organizations networked in SARNET contribute to a so-called Joint Programme of Activities (JPA), which consists in:

- Implementing an advanced communication tool for accessing all project information, fostering exchange of information, and managing documents;
- Harmonizing and re-orienting the research programmes;
- Jointly analysing the experimental results provided by research programmes in order to elaborate a common understanding of relevant phenomena;
- Developing the integral computer code on severe accidents ASTEC, which capitalizes in terms of physical models the knowledge produced within SARNET;
- Developing Scientific Databases, in which all the results of research programmes are stored in a common format (DATANET);
- Developing a common methodology for Probabilistic Safety Assessment (PSA) of NPPs;
- Developing courses and writing a text book on SA for students and researchers;
- Promoting personnel mobility between various European organizations.

After the first period (2004-2008), co-funded by the European Commission (EC), the network will progressively evolve toward self-sustainability.

This paper presents the general organization of the Network, the main achievements, after three years of activities and the bases – still under discussion – for the follow-up of the SARNET activities.

A. BACKGROUND

The current Nuclear Power Plants existing in Europe are designed with the principle 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. In some low probability circumstances, some 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.

Remarkable achievements have been obtained in the field of Water Reactor Severe Accidents, thanks in particular to the numerous European actions undertaken within the 4^{th} and 5^{th} Framework Programmes (FP) of the European Commission. In spite of the accomplishments reached, in 2004 – start of the SARNET Project – a limited number of specific issues remained where research activities were still necessary in order to reduce further uncertainties that were considered of importance and to consolidate severe accident management plans: core reflooding, iodine chemistry, ex-vessel melt coolability, timing of base-mat failure are examples of remaining issues underlined by the Phenomena Identification and Ranking Table (PIRT) action conducted within the EURSAFE thematic network of the 5^{th} FP (Ref. [1]).

The best state of knowledge on severe accident phenomenology, qualified computer tools and appropriate methodology should be used uniformly throughout Europe – and ideally, worldwide – in order to evaluate the corresponding risks and update former evaluations, taking into account notably the inevitable evolutions in reactor operations (e.g. new types of fuel, higher burn-up, extension of plant life). Additional appropriate engineering devices and/or accident management measures may have then to be developed and implemented in order to reduce the risks to an acceptably low level.

Up to now, research programmes on SA were usually decided at national levels. Co-operation agreements are often concluded around these national programmes, but on a case by case basis. Facing the inevitable reduction of the national budgets in this field, it is necessary to coordinate better the national efforts to optimise the use of the available expertise and experimental facilities in order to resolve the remaining issues. This coordination will take benefits of, and strengthen, the existing complementarities between the different laboratories throughout Europe (corium / fission product chemistry experts, small-scale / large-scale testing, simulant / real materials, experimentalists / model developers / code developers).

Therefore, a number of European R&D organizations, including technical support organizations of the safety authorities (TSOs), industries, utilities and universities, decided to seize the opportunity offered by the European Commission in the framework of the 6^{th} Framework Programme to network in SARNET (Severe Accident Research NETwork of Excellence) their capacities of research in the severe accident area in a durable way in order to resolve outstanding issues for enhancing the safety of existing and future NPPs.

The general objectives of SARNET are to:

- Tackle the fragmentation that exists between the different R&D organizations, notably in defining research programmes and developing/qualifying computer tools;
- Harmonize the methodologies applied for assessing risk and improve Level 2 PSA tools;
- Diffuse the knowledge to Newcomers to the European Union more efficiently and associate them with the definition and the conduct of the European research programmes more closely;

- Bring together top scientists in severe accident research to constitute a world leadership in advanced computer tools for severe accident risk assessment.

In overall 51 organizations are now in the project, coming from 18 Member States of the European Union (Austria, Belgium, Bulgaria, Czech Republic, Finland, France, Germany, Greece, Hungary, Italy, Lithuania, the Netherlands, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom), Switzerland, Canada and the Joint Research Centres of the European Commission (Fig. 1). The network started its activity on April 1st, 2004 for a four-year period (duration of the contract with the European Commission) and is coordinated by IRSN (Ref. [2]). Then, the network will progressively evolve toward self-sustainability. The bases for such an evolution, still under discussion, are presented in the last part of the paper.

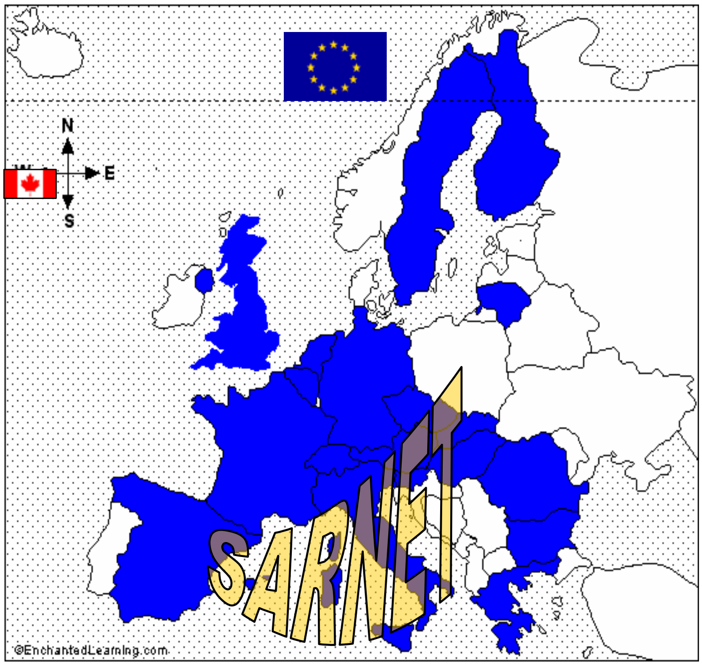

Fig 1. SARNET partners countries

B. ORGANIZATION

The SARNET Network is organised on the basis of a two-level structure. On the first level, a Governing Board involving all members is in charge of strategic decisions and is advised by an Advisory Committee. On the second level, a Management Team is entrusted with the task of the day-to-day management of the Network.

B.1 The Governing Board

SARNET is steered by a Governing Board. It reviews the progress made by the Network, in particular in terms of progressive integration, and makes recommendations on future orientations. It decides upon the allocation of the financial contribution of the European Commission and approves the programme of activities. The Governing Board is composed of one member designated by each Contractor, plus the representative of the Commission as observer.

Members are in general of high management level and may commit the resources of their organization for performing activities decided by the Governing Board.

B.2 The Advisory Committee

The Advisory Committee involves managers of end-user organizations (belonging or not to the SARNET Consortium and appointed by the Governing Board), including Vendors, Utilities and Regulatory Bodies. Its role is to provide the Governing Board with advices on strategic orientations of the research activities of SARNET, as seen by the end-users which really have to apply the outcomes of these research activities.

B.3 The Management Team

The Management Team is in charge, on behalf of the Governing Board, of the day-to-day administration of SARNET.

Based on the general SARNET organization, the Management Team is composed of the SARNET Coordinator heading the Team, the Advanced Communication Tool Leader, the ASTEC code Coordinator, the PSA2 Leader, the Experimental Database Leader, the Severe Accident Research Priorities Leader, the three Scientific Coordinators (corium, containment and source term domains), the Excellence Spreading Coordinator and a Secretary.

The Management Team monitors the progress made in the different activities, analyses any difficulty which may arise and launches with the corresponding project leaders the actions to overcome them, examines the new projects, promotes collaborations both within the Network and with external organizations (OECD, ISTC, IAEA, etc), makes proposals to the Governing Board for updating the programme of activity, manages the communication system and the databases of the Network, organises the training and education activities, and disseminates information inside and outside the network, in particular by organizing periodic conferences and topical seminars, and by periodically updating the public SARNET Web site: *http://www.sar-net.org/*.

The Coordinator acts under the control of the Governing Board, and reports to it on his duty. He provides the Governing Board with technical and financial reports and implements its decisions, notably by updating the programme of activity. Furthermore, he is responsible for the relations with the European Commission, which, yearly, organises a review of the progress of the project by a panel of independent experts.

C. THE JOINT PROGRAMME OF ACTIVITIES

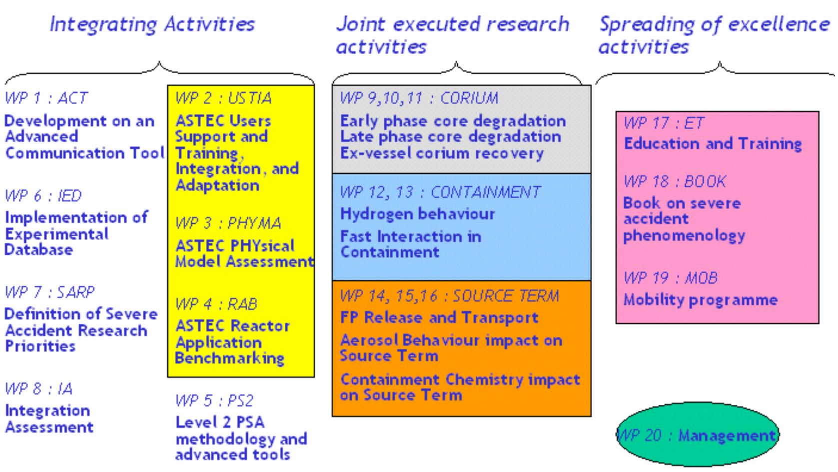

Fig. 2: SARNET Joint Programme of Activities

To achieve the objectives of SARNET a Joint Programme of Activities (JPA) has been defined and is yearly updated. All the organizations networked in SARNET contribute to the JPA, which can be, beyond management activities, broken down into three elements (Fig. 2):

- Integrating activities to strengthen links between organizations;
- Joint research activities to resolve remaining outstanding issues;
- Spreading of excellence activities.

The integral code ASTEC (Ref. [3]), jointly developed by IRSN and GRS, is the main integrating component and contributes efficiently to the diffusion of the knowledge. Activities linked to ASTEC thus appear as "Integrating Activities". Furthermore, most of the "Joint Research Activities" are linked to ASTEC as one of their ultimate goals is to provide physical models to be integrated in ASTEC. The exchange of information on the detailed models developed by the various experts through interpretation of experiments is progressively leading to generic common models in the different detailed codes (example of ICARE/CATHARE and ATHLET-CD for core degradation). Then, improved models for ASTEC itself are derived from these ones and included in this common reference code.

The R&D needs are periodically updated and the objectives of future experiments are defined taking into account the outcome of the collaborative work on risk studies. A consensus has already been reached on the "closure" of some issues and will allow redistribution of competence and manpower on open issues in concert with other international projects (e.g. OECD projects).

D. MAIN ACHIEVEMENTS

Main achievements, which are described below, correspond to the current status of the Project after three years of operation.

D.1 Integrating Activities

The integrating elements of the programme are considered of highest importance and remain the key elements of the JPA as regards the SARNET general objective.

One integrating element is the implementation of an Advanced Communication Tool (ACT) for aiding information exchange. ACT is a key concept to achieve SARNET goals; it provides unified support for efficient communication within the network, concerning:

- Access, search, publication of documents and codes (concept of knowledge storage);
- Contact and communication with partners (interactive and collaborative services);
- Joint co-ordination of actions/programmes (co-operative management of the network);
- List of links to satellite community projects (R&D projects, related sites).

A platform has been developed and deployed. Access is given by Web Browsers, enabling access from any Internet connection. After three years, around 250 users of SARNET have been granted access to this tool and the ACT, on which more than 6000 items are posted, is used intensively (more than 2000 accesses per month on the last six months) and efficiently.

A major integrating activity is the development, assessment and maintenance of the SA integral analysis code ASTEC. Twenty-nine organizations collaborate with IRSN and GRS on the development and assessment of this code. It describes the behaviour of a whole NPP under SA conditions, including Severe Accident Management (SAM) engineering systems and procedures. It is intensively used by IRSN for Level 2 PSAs for 900 and 1300 MWe PWRs, and due to large improvements on its robustness and on its computation time, more and more partners use it for complete accident scenario calculations. It is the main integrator of knowledge in SARNET.

A close and efficient collaboration between ASTEC users and developers has been set up using ACT and the MARCUS tool for code maintenance. Several training courses were organized. Three code versions were released to the SARNET partners: V1.1 mid-04, V1.2 mid-05 and V1.3 end of 2006. Two ASTEC Users' Club meetings, held in February 05 and in June 2006, allowed fruitful direct discussion between users and developers.

Model developments are under way by CEA, in close collaboration with IRSN, on in-vessel late-phase of core degradation (already implemented in V1.3) and on vessel external cooling. Other developments proposed by the source term Topic will be implemented in 2007. Concerning other reactor types than PWRs, only minor modifications were needed for adapting the code to VVER-440 and VVER-1000. For BWR, RBMK and CANDU, specifications of model adaptations are underway along with exploratory calculations.

Extensive validation has also been carried out. The code has been applied to more than 35 experiments (analytical and integral ones). Generally, the results were ranked as good, and even very good for thermal-hydraulics, core degradation and aerosol behaviour. Partners, independent from the developers, confirmed IRSN-GRS results on several OECD/CSNI International Standard Problems (44, 45, 46, 47) and on the PHEBUS FPT0/1 tests. After some adaptations, FZK is now using the code to prepare and analyse its experiments (QUENCH and LIVE tests). Several plant applications are also underway on various NPPs (PWR, VVER-440, VVER-1000, CANDU), including benchmarks with other codes (MELCOR, MAAP4, …). All users' requirements on ASTEC evolution are now taken into account by IRSN and GRS for the specifications of the new series of versions ASTEC V2.

Harmonization of Level 2 PSA methodology and development of advanced tools is also an integrating activity. Level 2 PSA is a powerful tool to assess plant-specific vulnerability regarding NPP SA. It evaluates possible SA scenarios in terms of frequency, loss of containment integrity and radioactive release into the environment and quantifies the contribution of prevention and mitigation measures in terms of risk reduction. Different approaches are used in Europe, derived more or less from what has been implemented in the USA. A description and comparison of the main elements of methods used by the different partners to develop their PSA has been written. A questionnaire has been set up and the answers have been analyzed in order to define next steps of harmonization, this word having different meanings depending on the various experts. Harmonization of level 2 PSA issues is going on and feasibility case studies on hydrogen combustion, iodine chemistry and melt corium concrete interaction (MCCI) are well advanced while work has been initiated on other issues such as large early releases and reactor end states definitions. A State-of-the-Art Report on Dynamic Reliability methods has been produced and the limitations of classical methods, which could be exceeded using these reliability methods, were identified. Examination of the benefit of one of the possible methods (Monte Carlo Dynamic Event Tree – MCDET) has been achieved on station blackout situation. A benchmark exercise to compare dynamic reliability methods with classical ones has been organized in two steps (without then with uncertainties assessment) and is now achieved. The exercise dealt with hydrogen distribution and combustion issues and considered the possibilities of ignition when physically possible, core reflooding and spray system operating at any time.

The objective of DATANET, the SARNET experimental database network, is to develop and maintain an instrument that ensures preservation, exchange and processing of SA experimental data, including all related documentation. The data are both existing experimental data that SARNET partners are willing to share within the network and all new data produced within SARNET. DATANET is based on the STRESA tool developed by JRC

Ispra and consists of a network with several local databases (or nodes). From the central database, it is possible to connect with other local databases. Direct connections to the local databases are also possible, which increases the potential and the power of this type of system. After three years, DATANET is fully operational and comprises eight nodes: the central one at JRC Ispra, and local ones at FZK, IRSN, CEA, CIEMAT, FORTUM, AEKI and KTH. Now, GRS is planning to open a ninth node. Training weeks are periodically organized at JRC-Ispra. The results of about 100 experiments from 20 experimental facilities have been implemented so far.

Research priority assessment is a major integrating activity. It identifies research priorities and intends to re-orientate progressively the existing national programmes, to contribute to launch new ones in a coordinated way, eliminating duplications and developing complementarities. This activity was initiated during the second SARNET year, with close collaboration amongst participants (those mainly involved in the PIRT carried out in EURSAFE (Ref. [1])), representing TSOs, industry and utilities. The whole spectrum of SA situations, extending from core uncovery to long-term corium stabilization, long term containment integrity, and fission product release to the environment was considered in order to reassess the priority ranking of the EURSAFE issues due to new progress on research and to potential evolution of the needs. Currently, although some discussions are going on, among the 21 high priority issues from EURSAFE, six issues only are regarded to be investigated further in the EC framework with high priority (core and debris coolability; ex-vessel melt pool configuration during MCCI and ex-vessel corium coolability by top flooding; melt relocation on lower head and ex-vessel Fuel Coolant interaction (FCI); hydrogen in containment; ruthenium oxidation and release; iodine chemistry). For five issues the current knowledge is considered as sufficient assessing both the state and progress of knowledge and the risk and safety relevance and taking into account ongoing activities: these issues can be considered as “closed” at the present time. Other issues are expected to be treated as planned (programmes already launched for instance).

D.2 Jointly Executed Research Activities

These activities constitute the R&D basis of the network. In spite of the accomplishments reached in SA research, the assessment of research priorities shows that efforts are still needed on some issues to reduce uncertainties considered important and to consolidate SA management plans. Joint research activities in SARNET are executed to help to resolve these remaining issues. They are split into three areas: corium behaviour, containment integrity and source term.

In all three areas, the same method has been adopted: review and selection of available relevant experiments; synthesis of analyses and interpretation of data from these experiments; model review, synthesis and proposals of new or improved models for ASTEC.

The corium behaviour topic ranges from early phase of core degradation to late phase core degradation and ex-vessel corium stabilization. A major effort is also underway on the development and improvement of the corium thermodynamic and material physical property databases. Joint activities have been deployed, such as the contribution to the definition and the interpretation of OECD-CCI tests around the MCCI programme, with benchmark exercises and associated model improvement, and a contribution to the definition and interpretation of PLINIUS and LACOMERA tests: QUENCH-10 on air ingress in bundle geometry, QUENCH-11 on boil-down and quench, QUENCH-12 with VVER bundle, COMET-L1 and L2 to study MCCI in 2D geometry, LIVE or VULCANO-COMET tests. Similar activities have been carried out for ongoing and new projects from the International

Scientific and Technical Centre (ISTC): PARAMETER project on core top flooding models, METCOR on the impact of thermo-mechanical interaction on the vessel behaviour, CORPHAD on the corium thermodynamic (improvement of the NUCLEA database).

As major achievements in the corium behaviour domain, after three years of SARNET, we can quote:

- Understanding of the oxidation phenomena in steam and in air, validation of oxidation correlation;
- Collection of experimental data on B_4C oxidation allowing common interpretation of PHEBUS FPT3 integral test;
- Successful launching of Late-In-Vessel tests LIVE (first two tests performed);
- Common understanding of the OECD OLHF-1 test on the vessel failure by creep rupture.
- Increased coolability for inhomogeneous 2D debris bed structures as compared to 1D particle beds demonstrated;
- Unexpected results – ablation anisotropy for silica-rich materials to be interpreted – on 2D MCCI tests;
- Progress on core catcher modelling.

The research efforts on energetic phenomena that could potentially threaten containment integrity concern hydrogen behaviour and fast interactions in the containment.

For the former, the hydrogen combustion and associated risk mitigation is studied, concentrating on the formation of combustible gas mixtures, local gas composition and potential combustion modes, including reaction kinetics inside catalytic recombiners. Hydrogen distribution within the containment is studied to assess the risk of high concentrations. Experimental programmes on combustion with gradients (ENACCEF) and recombiner kinetics (REKO-3) are ongoing. Benchmarks are ongoing on ENACCEF experimental results, on interaction of sprays with containment atmosphere, on condensation issues and on interactions between Passive Autocatalytic Recombiners (PARs) and containment atmosphere. The PROCO combustion model, improved using the first experimental results, has been transferred to ASTEC and testing is still underway. In ISP-47, data from the TOSQAN, MISTRA and ThAI facilities were used for further validation of lumped-parameter and CFD codes. Limitations of CFD codes (especially commercial codes) were identified with respect to wall condensation modelling and saturation conditions. Specific topics such as mitigation system modelling, sprays and recombiners have been identified as future tasks.

Concerning fast interactions, fuel-coolant interaction is studied to increase the knowledge of parameters affecting steam explosion energetics during corium relocation into water, and determine the risk of vessel or containment failure by investigation of specific processes like premixing, melt fragmentation and particle heat transfer mode. The KROTOS facility is now under operation and a KROTOS-PLINIUS test (K-101) was performed, leading to a limited quantity of melt (300g). This test has been repeated. Post-test calculations by various partners are ongoing. In the OECD programme SERENA, reactor case calculations were performed and progress towards synthesis of experiment interpretations achieved. Direct Containment Heating (DCH) processes are studied, including melt dispersion into various reactor compartments, heat transfer and chemical processes such as production and combustion of hydrogen. A DISCO experiment with the geometry of a French reactor was performed in the EC-LACOMERA programme, which was used as a benchmark for lumped parameter code calculations. It has been documented in four reports. A report on LACOMERA-L2 test with VVER-1000 geometry has also been issued.

As major achievements in the containment integrity domain, after three years of SARNET, we can mention that:

- Three issues can be considered as closed: very fast hydrogen explosions; hydrogen explosions with no hydrogen gradients; hydrogen explosions with hydrogen gradients on small scale;
- More work is necessary on four issues: scaling of hydrogen explosions with concentration gradients; self-ignition of recombiners; coupling between dispersion and combustion (taking recombiners into consideration); combustion of hydrogen jets ejected into reactor rooms with different hydrogen concentrations in connection with DCH.

In the Source Term area, the main safety-related issues addressed are the effect of air ingress, iodine volatility in the primary circuit, containment by-pass in the case of steam generator tube rupture, aerosol retention in containment cracks, aerosol remobilization, and aerosol and iodine behaviour in the containment. These are dealt with in several work packages where technical discussion 'circles' clustering participants around specific issues are highlighted, bringing experimentalists and modellers closer together.

The main achievements have been detailed by Haste (Ref. [4]). A large part of the activity is devoted to the definition / preparation of the so-called International Source Term Programme launched by IRSN, CEA and EDF with the support of the European Commission (Ref [5]). Concerning Fission Products (notably ruthenium) release from irradiated fuel under very oxidising conditions, a large effort has been devoted to the interpretation of available AECL and of RUSET (AEKI) data. It has been concluded that ruthenium release occurs in oxide form after an incubation period during which full oxidation of fuel and cladding occurs. From RUSET and VTT tests, it has been noticed that oxide forms can stay volatile enough in lower temperature regions to be transported to the reactor containment. It has been emphasized that water vapour likely suppresses decomposition of RuO_4 on stainless steel. This result is of major importance for source term as it shows that depending on conditions, some ruthenium may reach the containment in a stable volatile form. Further data are required. They are provided through the current RUSET and VTT tests and future VERDON tests. In cooperation with the ISTC, the VERONIKA experiment proposal on fission product release from highly irradiated VVER fuel was reviewed and the SARNET team proposed interesting modifications to the test matrix which were taken into consideration; this followed a similar exercise with EVAN on iodine chemistry (this project is now under way).

Concerning Iodine Chemistry in the Circuit IRSN has provided an overall interpretation of iodine chemistry in the circuit. Under reducing conditions, and without absorber material, iodine chemistry seems relatively straightforward, the iodine being transported predominantly as caesium (and rubidium) iodide. In oxidizing conditions the picture is more complicated since Cs take up in forms other than CsI affects iodine chemistry. Hence, iodine can either still be principally CsI or tend to form other metal iodides such as with control rod materials or, if these are not present, conditions become conducive to HI formation. These statements still need to be confirmed. This is the role of the CHIP programme (Ref [5]) which is starting to provide kinetic and thermodynamic data on iodine transport to primary circuit breaks under severe accident conditions.

Regarding Radioactive Aerosols Issues, three scenarios are being addressed: steam generator tube rupture (SGTR) sequences, remobilisation from Reactor Cooling System deposits and transport of aerosols through containment cracks.

Several facilities have investigated aspects of the aerosol retention within the steam generator (SG) under SGTR conditions: PSAERO/HORIZON, PECA/SGTR and ARTIST.

PSAERO/HORIZON tests have shown that resuspension is important in aerosol retention within horizontal tubes and that sudden velocity changes enhance resuspension. A model has been developed for retention in a flooded secondary side of a SG. High decontamination factors are observed in these circumstances if the break is not too near the top water level. There is some retention for a dry secondary side, though lower (ARTIST/5FP and PECA/SGTR tests). New activities concern investigation of physical resuspension using data from the EU/JRC Ispra STORM project.

Revolatilisation tests are being performed in the small-scale REVAP facility where samples from PHEBUS are being tested under different conditions. These tests show that the extent of Cs revaporisation is very high (~95%) on flat metallic substrates. During slow temperature ramps under flowing steam, it starts at 550°C and is rapid until 750°C; it continues to 1000°C but it is practically finished by then. Radiotracer testing confirms that CsOH deposits on stainless steel have the same behaviour as that of the PHEBUS sample deposits. Further data are needed to achieve a correlation of results; use of AECL results is being investigated.

Aerosol retention in concrete containment cracks can be effective, particularly with steam present (SIMIBE tests). More data are needed to support the theoretical developments underway. A proposal has recently been made for experiments in COLIMA under the PLINIUS platform, to investigate retention using concrete samples and prototypic aerosols.

The experimental facilities involved in Containment Chemistry are: PHEBUS FP, CAIMAN, SISYPHE, the Chalmers facilities, PARIS and EPICUR (Ref [5]).

Waste Management Technology (once part of AEA Technology) has issued an Iodine Data Book, whose six volumes cover inorganic chemistry, organic chemistry, surface reactions, mass transfer, gaseous chemistry, and large scale experiments/modelling. Particular attention is being given to the interpretation of some PHEBUS observations. The CAIMAN programme gave also some interesting results: in the presence of paints, irradiation and high temperature, organic iodide can be the dominant form of volatile iodine; in alkaline conditions, gaseous iodine concentrations decrease by several orders of magnitude. The nature of mass transfer regime between sump and gas has been specifically addressed in SISYPHE. The two main effects of evaporating conditions are to increase the kinetics of transfer from the liquid to the gaseous phase and to change the steady state iodine concentrations, the sump iodine concentration being reduced. The well-known two-film model has been modified to extend it to this type of conditions.

The effect of radiation on the nature of containment atmosphere and the effect of metallic impurities in the sump have been investigated in the PARIS and Chalmers experimental programmes, respectively. The organic iodine formation models are based on a simultaneous consideration of thermal and radiolytic mechanisms both in gas and liquid phases. There are however discrepancies in the aqueous modelling, essentially concerning the organic sources. Data from the EPICUR programme are suitable for validation of these models. To complete the picture, ruthenium behaviour in the containment is now studied experimentally and theoretically, as is the effect of recombiners on fission product behaviour (particularly the potential to increase iodine volatility through FP decomposition), and finally cooperative evaluation of the ThAI-Iod9 integral test is under way. Use of AECL data (RTF tests) is also under investigation.

D.3 Spreading of Excellence Activities

The third major type of activity concerns spreading of excellence.

The more experienced organizations have started to contribute diffusing the excellence by preparing an educational course on SA phenomenology addressing PhD students and young researchers, which was given in January 2006, over 5 days. A training course on "Accident progression (data, analysis and uncertainties)", addressing instead more experienced nuclear safety specialists was given in March 2007, over 5 days. Besides this, the content of a text book on SA phenomenology has been set up. This book covers historical aspects of Light Water Reactor (LWR) safety and principles, phenomena concerning in-vessel accident progression, both early and late containment failure, fission products (FP) release and transport; it contains a description of analysis tools or codes, of management and termination of SA, as well as environmental management. It also gives elements on Generation 3 LWRs. The partners who have agreed to work together in preparing the first course and writing this book are universities, TSOs, national laboratories and industrial organizations that share their great talent and experience within SARNET.

These spreading of excellence activities are complemented by a mobility programme under which students and researchers can go to different laboratories of SARNET partners for training. Nine delegations were initiated during the first two SARNET years, twelve during the third SARNET year, and twelve are expected for the fourth year.

E. SARNET FOLLOW-UP

The current SARNET contract with the EC was defined for a four-year period from April 2004 to March 2008. Due to a rigorous management of the EC funding, an extension of about 6 months, at constant budget, will be negotiated with the EC.

The initial idea was to tend to self-sustainability of the network. It is with this main consideration that a SARNET follow-up is currently under preparation, based on the work of a specific working group composed of 9 representatives of the Governing Board.

Indeed, in this field of Severe Accidents on NPPs, where no industries are strongly interested in terms of potential direct benefits, the self-sustainability is rather difficult to reach. So, it is planned to ask again for EC co-funding, for a certain duration, in the 7th Framework Programme, but with a reduction in the SARNET perimeter. The general structure would remain as it is, but the Project would be more focused on high-level integrating actions consisting in defining jointly agreed research priorities and in analysing, selecting and promoting R&D programme proposals that would be granted a SARNET label according to the defined priorities.

The other key integrating activities would be pursued: integration of acquired knowledge in ASTEC, work on PSA2 methodologies, spreading the knowledge (public SARNET Web site and Advanced Communication Tool (ACT), organization of education and training courses, encouragement of exchange of students and researchers, organization of conferences and seminars), etc. Topics could also be extended toward crisis management and new generations of reactor, cooperating with the Sustainable Nuclear Fission Technology Platform.

Beyond the requested funding for the SARNET network, R&D programmes that would be promoted by SARNET would also require EC funding. These programmes would be "satellite" programmes of the Network of Excellence.

F. CONCLUSION

The four-year SARNET Network of Excellence started in April 2004 with the ambitious but highly important objective to provide an appropriate frame for achieving within a couple of years a sustainable integration of the European severe accident research capacities.

By capitalizing the acquired knowledge in the ASTEC code and in the DATANET database, SARNET is really producing conditions necessary for preserving the knowledge produced by thousands of person-years of research, and diffusing it to a large number of end-users. The ASTEC code, which is really becoming a reference code in the SA field, is being actively used as well as DATANET.

By fostering collaborative work in the PSA2 domain, SARNET has started to create the necessary conditions for harmonizing the approaches and making Europe a leader in SA computer code and risk assessment methodology.

Through an education and training programme (organization of courses, writing a text book addressing young scientists), SARNET is developing synergies with educational institutions to keep attractive this domain of activity for young people. This is reinforced by an efficient mobility programme which allows fruitful exchanges between European laboratories for young students and researchers.

By fostering collaborative R&D work in the domains of corium behaviour, containment integrity and source term, SARNET is progressing to resolve remaining outstanding issues and to provide ASTEC with modelling recommendations. Proposals have been elaborated for various ASTEC models and their implementation is under way.

Finally, SARNET is clearly becoming a reference, in terms of research priorities in the field of SA, having impact on national programmes and associated budgets. Progressively all the research activities in this field will become coordinated by the Network, which contributes to an optimised use of European resources.

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