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EU Research in Reactor Safety, with Emphasis on Severe Accident Management

RESULTS OF THE 5th EURATOM FRAMEWORK PROGRAMME 1998-2002 AND PROSPECTS FOR THE FUTURE

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ABSTRACT

This paper deals with the European Union (EU) research activities, conducted through multi-partner scientific co-operation programmes, in the area of reactor safety with the scope to contribute to risk reduction in the nuclear installations, in particular, under severe accident conditions. Ensuring the safety of nuclear installations and of the entire fuel cycle becomes particularly demanding in countries where large-scale evacuation and land contamination subsequent to an accident are "practically" prohibited because of high population density.

An overview is given of the most important achievements of research programmes in NUCLEAR FISSION cofinanced by the European Union (EU) from the end-users point of view (i.e. the contracting organisations : utilities, regulatory bodies, manufacturing and service industry and the Commission itself). The objectives from the various end-users are discussed and a number of Community projects are selected to demonstrate to what extent these objectives were met.

INTRODUCTION

The fundamental safety objective for nuclear power plants (NPPs) consists in protecting the public and the environment from the harmful effects resulting from ionising radiations. Traditionally the technological problems of nuclear reactor safety are related to the 3 basic safety functions, namely: controlling the power, cooling the fuel and confining the radioactive material. In the relevant Euratom research programmes, the emphasis was put until now on these technological problems, leaving man-machine and organisational problems to national (plant dependent) research.

Maintaining the fission product boundaries intact under all conceivable reactor conditions is the main purpose of the preventive measures, but this might no longer be possible in the highly hypothetical case when severe core damage has begun. Therefore, the most recent research and technological developments in reactor safety have been focusing on accident management strategies, based not only on advanced prevention techniques but also on mitigation strategies for accidents consequences. Mitigation measures may consist in engineered dedicated safety systems added to the reactor or in severe accident management guidelines proposed to the operators responsible for accident management.

Besides reactor safety research (including severe accident management research), EC co-sponsored research is also conducted in areas such as "Safety of the fuel cycle" (including waste management, partitioning and transmutation), "Safety and efficiency of future systems" (including innovative concepts for fuels and reactors, such as high temperature reactors), and "Radiation protection" (including off-site emergency management). Interaction between all these research activities is ensured through a series of research and training networks, aimed at discussing and harmonising the scientific/technical base for plant safety improvements and more generally contributing to maintaining nuclear fission energy as an acceptable option in the mix of energy sources available for future needs.

From an industrial and regulatory point of view, most of the technological problems seem to have received a standard solution. Despite the historical safety record of NPPs of Western design, the key players believe, however, that research is still needed to further increase both the safety and the performances of these power plants in line with the steadily growing pressure of regulatory and market forces as well as of the public opinion. Research is still needed, both at the plant dependent level (short-term results expected) and at the generic level (medium- and long-term results expected). The time period corresponding to medium- and long-term is as follows : medium is in the order of 4 years and long is twice as much. The EU research activities discussed here are usually of the generic type and are more specifically related to an additional level, let us say, of the defence-in-depth in line with the increasingly stringent safety requirements.

What is usually looked for by participants in EU research programmes in reactor safety, besides S/T discussions, is an international « neutral » platform, bringing together players who are not used to discuss in a co-operative way (e.g. industrial competitors across Europe or regulators versus utilities in their own country). Another benefit of the participating organisations, particularly appreciated in the current deregulated electricity market, is to hear about each others safety culture and technical implementation of international safety regulations (socio-economic aspects).

OBJECTIVES OF THE END-USERS

As far as the above-mentioned additional level of defense-in-depth is concerned (i.e. mitigation), a cluster called **SAM** ("Severe Accident Management"), is focusing on the following items: assessment of severe accident risks; severe accident management measures. Most of this research is of the regulatory type (or confirmatory) : no wonder then that **regulatory bodies (in particular, their associated technical safety organisations)** – primarily interested in plant safety - are taking most profit from this type of Community research, whenever the issues treated are not requiring a prompt solution (medium-term results expected). What regulatory bodies are primarily looking for in participating in this type of confirmatory Community research, seems to be a common platform for exchange of scientific knowledge and experimental facilities, with a twofold aim :

- network and integrate the many existing national RTD programmes (in the sense of the European Research Area) in order to share the RTD costs needed to improve the knowledge necessary, in particular, to get an international confirmation to consolidate their views on some specific safety issues
- keep informed amongst regulators and industries about S/T breakthroughs and practical applications of relevant EU policies throughout Europe (in particular, whenever plant management practices might be affected with consequences on regulatory strategies).

The activities dealing with evolutionary concepts are put together in the cluster called **EVOL** ("Evolutionary Concepts"), focusing on the following items: evolutionary safety concepts (using, for example, passive safety systems for decay heat removal); advanced fuel technologies such as high burn-up and MOX fuel. Most of this research is of the promotional type (or exploratory) : no wonder then that **industry (in particular, manufacturers and services)** – primarily interested in plant innovation - are taking most profit from this type of Community research, especially when it comes to design new concepts far away from the market (long-term results expected). It is clear that this type of reactor safety research is appropriate only for technical problems that can wait « ten years » to get a solution. What industry is primarily looking for in participating in this type of exploratory Community research, seems to be a common platform for exchange of scientific knowledge and experimental facilities with a twofold aim :

- build up new common national/industrial RTD programmes (in the sense of the European Research Area) in order to share the RTD costs for acquiring new knowledge of common interest and developing demonstration products or services
- keep informed amongst partners/competitors about potential S/T breakthroughs and potential practical applications of relevant EU policies throughout Europe (in particular, whenever this might affect market opportunities in the far future).

As far as the first level of defense-in-depth (i.e. prevention) is concerned, another cluster called **PLEM** ("Plant Life Extension and Management"), is focusing on the following items: integrity of equipment and structure; on-line monitoring and maintenance; organisation and management of safety. Most of this research is of the operational type: no wonder then that **industry (in particular, the utilities)** – primarily interested in plant performance - is taking most profit from this type of Community research, whenever the issues treated are not requiring a prompt solution (medium-term results expected). It is clear that this type of reactor safety research is not appropriate for technical problems requiring a quick solution - remember the well known slogan: « Industry is interested in good solutions in one year and not in excellent solutions in ten years ». Community research is not aimed at providing « good solutions in one year », not only because of the inherent inertia of international organisations but also because this type of operational problem is usually plant dependent and commercially sensitive in nature. Neither is Community research aimed at providing « excellent solutions in ten years », unless when it is related to advanced innovative (as opposed to evolutionary) technologies.

What utilities are primarily looking for in participating in this type of operational Community research, seems to be a common platform for exchange of scientific knowledge and experimental facilities with a twofold aim :

- de-fragment and integrate the many existing national/industrial RTD programmes (in the sense of the European Research Area) in order to share the RTD costs needed to improve knowledge and practices of common interest for plant efficiency (« value for money »)
- keep informed amongst partners/competitors about S/T breakthroughs and practical applications of relevant EU policies throughout Europe (in particular, whenever industrial practices and commercial strategies might be affected).

The **Commission** interests, so to say, (reflected in the Commission policy for RTD programme management and the associated implementation tools for FP-6) are primarily to create the conditions for a the construction of a European (nuclear) Research and Innovation Area (ERA). Therefore the EU financial contribution is expected to favor RTD project proposals demonstrating at best two qualities :

- a European added value (to be achieved, for example, by networking fragmented RTD activities and disseminating their results) following the subsidiarity principle, and
- a (preferably durable) integration at various levels (for example, cross-disciplinary work programme, mix of governmental and industrial budgets, consortium comprising all key players, contribution to EU policies such as enlargement, internal market, protection of man and environment, etc).

In this paper, a number of projects is selected out of the clusters SAM and EVOL for discussion from the end-users point of view (i.e. the contracting organisations : utilities, regulatory bodies, manufacturing and service industry and the Commission itself). Some practical applications are given in connection with the (medium and/or long-term) needs of these end-users, be it from a technological or a socio-economic nature.

SEVERE ACCIDENT MANAGEMENT (CLUSTER SAM)

The fission products constitute the principal health hazard to the public, resulting from a severe accident. Therefore, the amounts and physico-chemical forms of those materials released from the reactor (the radiological source term) are of great safety significance. As a result, the regulatory authorities in some EU countries are requiring to take into consideration as much as possible the very unlikely severe beyond design-basis accidents (BDBAs). In the German licensing process, for example, BDBA evaluations are necessary since 1 January 1994 to ensure that even extremely unlikely events involving core melt-down would not require radical actions to ensure protection against the damaging effects of ionising radiations outside the fence of the installation site. BDBAs are also a concern expressed by the utilities and by the designers/vendors, as it is shown in the discussions around the European Utility Requirements (EUR Document, last release in April 2001) and in the European MICHELANGELO initiative (dealing with Generation IV reactors).

As a result, it is envisaged by design to "practically eliminate" situations and phenomena which could lead to early failure of the containment system and subsequent uncontrolled large releases of fission products into the environment. Examples of such situations are high-pressure ejection of molten core (possibly leading to direct containment heating) and energetic in-vessel core debris interactions with water (possibly leading to hydrogen generation). For example, for such situations in the containment, a hydrogen strategy is proposed, based principally on passive autocatalytic recombiners (PARs) aimed at keeping the hydrogen concentration far from the critical deflagration-to-detonation transition (DDT) conditions. Other situations, then, such as low pressure core melt, should be dealt with – or "controlled" – by ensuring in the design that the decay heat of the molten core can be removed and that the vessel or containment can withstand the associated loads.

To better understand the radiological source term behaviour and to develop efficient prevention and mitigation measures, appropriate research is needed which combines experimental investigations and numerical modelling activities, supported by a robust scaling up strategy to extrapolate from simulant to prototypical materials and from small-scale laboratory to full-scale reactor conditions. Historically, since the accidents of TMI-2 (March 1979) and Chernobyl-4 (April 1986), many international RTD programmes have been focusing on the development of a kind of 4^{th} level to be added to the 3 "standard" levels of the defence-in-depth strategy, as it has been mentioned in the Introduction. The international PHEBUS FP programme, in particular, that was launched by IRSN (France) and is co-sponsored by the EC and other partners, is the largest and most successful in-pile experimental programme devoted to the source term behaviour: it is aimed at bringing essential contributions to the knowledge on melt progression and fission product release. Based on a series of integral in-pile experiments using real core materials, the PHEBUS FP programme evaluates the amount and nature of radioactive products that could be released into the environment by occurrence of a core melt-down accident.

In the projects belonging to the cluster SAM ("Severe Accident Management"), the emphasis is on the development of mitigative measures for defence-in-depth in the very remote case of severe accidents (BDBAs). Under FP-4 a particular effort was devoted to the understanding of BDBAs through the 45 projects of the 5 clusters INV (= IN-Vessel core degradation), EXV(= EX-Vessel accident progression), ST (= radiological Source Term), CONT (= accident progression in the CONTainment building) and AMM (= Accident Management Measures). This effort on severe accident analysis is continued under FP-5 in the cluster SAM.

Under FP-5, the following two key issues have been identified:

- (1) core degradation, corium formation in the reactor pressure vessel and its behaviour inside and outside the vessel (in particular upon a core-catcher). Research is needed with the aim of evaluating the coolability of the melt and ensuring the containment integrity. Criteria for deflagration and detonation processes in hydrogen/air/steam/dust mixtures also are needed to improve engineered safety systems and to better understand the capabilities of structures to withstand dynamic loads. Finally, understanding the release of radioactive materials from a degrading core into the cooling circuits and the containment, using in particular the PHEBUS-FP results, will enable to optimise mitigation measures and to better predict the source term. The above issues are the subject of the section "Assessment of Severe Accident Risks" further down.

- (2) improved methods and tools for severe accident management and operator training that make use of modern information and control systems and can handle uncertainties associated with man-machine interfaces in a structured way. Research is needed to develop safety systems for present and future reactors, which enable to extend the grace period, i.e. the period during a severe accident when no active intervention is needed. The above issues are the subject of section "Severe Accident Management Measures" further down.

No wonder that the important actors in the area "severe accident management" are the European technical safety organisations, working for the national regulatory bodies, that is principally: IRSN in France; GRS in Germany; universities and CSN in Spain; NNC and HSE in the UK, SCK-CEN and AVN in Belgium, universities and SKI in Sweden and VTT in Finland.

Generally, the results obtained from severe accident (SA) experimental investigations and analytical studies contribute firstly to improve the phenomena understanding (e.g. corium behaviour, hydrogen explosions or radiological releases) and to validate SA models and integral codes, whose use has a direct repercussion on deterministic safety assessments and PSA studies as well. Such improved phenomena understanding also contributes to reduce uncertainties in safety margins quantification – very relevant for regulatory considerations - and to maintain the readiness to respond to emerging issues or to properly assess specific scenarios.

Furthermore, the associated risks to those better understood phenomena can be reduced by means of appropriate SAM strategies. Such measures have a clear impact on the nuclear industry and could be implemented through design improvements of new power plants (e.g. ex-vessel core catchers), through the development for existing plants of both, backfitting measures or engineered systems (e.g. techniques for removing the hydrogen risk in the containment or mitigation processes against radiological releases) and implementation or optimisation of SAM guidelines or operating emergency procedures. It is therefore demonstrated that there is a long way from phenomenological research towards final reactor application.

Under FP-5, the total EU budget to be spent for the 23 projects in the cluster SAM amounts approximately to EUR 15.3 million, which represents roughly half of the total value of these projects (EUR 28.2 million). The 23 projects of the SAM cluster are listed in the summary Table 1. This might be compared to the total EU budget spent under FP-4 for the 45 projects in the clusters INV, EXV, ST, CONT and AMM, which was EUR 29 million.

TABLE 1 : Severe Accident Management Research Projects under FP-5 (cluster SAM)

	Assessment of SA Risk		SAM Measures
Corium	***COLOSS*** ***ENTHALPY*** PLINIUS LACOMERA	ECOSTAR	EUROCORE
RPV	LISSAC	ARVI	
Source Term	***LPP*** ***THENPHEBISP*** ***ASTERISM II***	***ICHEMM***	
Hydrogen / Containment	HYCOM	SCACEX	THINCAT ***PARSOAR***
By-Pass Sequences		***SGTR***	OPTSAM
Code Development	***PHEBEN 2***	***EVITA***	SAMOS

EURSAFE — VERSAFE — ***Phébus FP Programme*** — **Cluster SAM**

Assessment of Severe Accident Risks

Core degradation processes in the presence of high burn-up and MOX fuel are investigated in a project with emphasis on core degradation knowledge of PWR, BWR and VVER for implementation in the various severe accident codes, including in particular tests on high burn-up and MOX dissolution, clad rupture, oxidation of U-O-Zr mixtures, and bundle experiments concerning B_4C control rod degradation and oxidation. Comprehensive phase diagrams of the elements and systems present in both, in- and ex-vessel corium, are developed by another project, based on one unique thermodynamic database and its coupling with severe accident codes.

The experimental demonstration of the technical feasibility of ex-vessel mitigation measures (core-catcher approach) and the validation of spreading codes are addressed in a specific project. Those experimental activities are addressing issues related to melt dispersion, jet erosion, large-scale spreading, corium solidification, interaction with structural materials and coolability approaches as top and bottom flooding.

Damage models and failure strain criteria of essential reactor components are examined in another project, with emphasis on the ultimate deformation capacity by applying uniaxial and biaxial static and dynamic loads. The creep behaviour of prototypic reactor vessels, timing and modes of its failure with and without penetrations, as well as the effects of the melt pool stratification are investigated in another specific project.

The hydrogen combustion behaviour and the corresponding loads in complex multi-compartment geometries are investigated in a project, using the large experimental programme in the Russian RUT facility, with combustion modes ranging from slow to fast turbulent deflagration.

A common code validation strategy for the integral code ASTEC is developed by a project with the aim to optimise SAM strategies in a variety of NPPs: as a result, accident management measures are optimised, such as filtered venting systems to limit the pressure in the containment and/or PARs to reduce the hydrogen concentration.

The long-term behaviour of a solidified core immersed in a water pool is examined by a project, which provides useful kinetics data concerning the release of fission products and core materials from in- and ex-vessel molten corium.

There is also an expert network which has as the main objective to establish within the EU an ample consensus on SA issues where large uncertainties still subsist, and to propose a structured approach to address them by appropriate R&D.

Finally, there is an action on research infrastructures, with the main objective to provide support for EU researchers to conduct experiments with prototypic corium in a platform composed of a series of facilities.

Severe Accident Management Measures

The scope is to contribute to the development of techniques, for example, to “practically eliminate” some of the severe accident phenomena or to develop mitigation strategies to “control” some of them. In addition, the progress in numerical techniques as well as the availability of powerful and cost-effective information technology systems will assure more reliable information and will help to improve the diagnostic means as well as the implementation of some accident management measures.

Further assessment of various retention concepts, i.e. the pros and cons of internal and external reactor vessel cooling, is the subject of a concerted action aimed at achieving consensus on feasible and reliable industrial corium recovery concepts connected to in-vessel retention, the corium-concrete interaction with water addition and ex-vessel spreading techniques.

Experimental activities are developed by another project to generate experimental data and to validate transport models to support accident management interventions in steam generator tube rupture sequences leading to severe accident conditions in PWRs and VVER-440. A better exploitation of volatile iodine mitigation processes is investigated by a specific project, which provides useful kinetics data for destruction and transmutation reactions of volatile forms of iodine.

The feasibility and reliability of PARs from an industrial prospect are examined in a concerted action, which is comparing qualification tests and licensing procedures, relevant to the hydrogen risk, under various severe accident conditions.

The radiological source term for operating reactors across Europe is examined in a project, with the aim to evaluate qualitatively the impact of various SAM strategies on radiological effects, and to establish a technical basis for the definition of realistic source terms.

Finally there is a thematic network to investigate the feasibility of a computerised operator supporting tool for elements in SA scenarios (e.g. severe accident management guidelines).

EVOLUTIONARY CONCEPTS (CLUSTER EVOL)

It is worth recalling that there are currently 20 reactor units in construction in Eastern Europe and in the Russian Federation, and 25 reactor units in construction in the rest of the world, with total planned capacities of 16 and 21 net GWe, respectively. Some of these reactor units are of the evolutionary type, i.e. with emphasis on design simplification and enhanced man-machine interface, with the aim to further reduce any (severe) accident risk. In evolutionary LWR designs, with their emphasis on design simplification and enhanced man-machine interface, the severe accident risk will be further reduced. Some of the innovative reactors rely mainly on passive prevention and mitigation features and systems.

Part of EC co-sponsored research is devoted to the investigation of phenomena associated with the use of passive systems in some evolutionary LWR designs for decay heat removal (from the core region and from the containment building) and for other safety measures (e.g. depressurisation and injection). The potential advantages of passive safety systems (e.g. independence from external energy sources, simpler design, less complex instrumentation and control) should be weighted against their potential disadvantages (e.g. reliance on small driving forces, limited operational flexibility, reduced in-service testing capability, difficult diagnosis of status, etc). In addition, the coupling of different neutronics and thermal-hydraulics computer codes, needed for this purpose, enables to improve and/or validate the numerical models used in the existing thermal-hydraulics computer codes, and to extrapolate the results of the small-scale experiments towards full-scale reactor conditions.

No wonder that the important actors in the area "evolutionary concepts" are the European vendors and manufacturers.

As far as passive safety systems in evolutionary LWRs are concerned, the emphasis is on understanding decay heat removal processes (both from the core region and from the containment building) and developing safety measures (e.g. depressurisation and injection).

Under FP-5, the total EU budget to be spent for the 17 projects in the cluster EVOL amounts to approximately EUR 10 million, which represents roughly half of the total value of these projects (EUR 21.8 million). The 17 projects of the EVOL cluster are listed in the summary Table 2. This might be compared to the total EU budget spent under FP-4 for the 11 projects in the INNO cluster, which was EUR 4.8 million.

TABLE 2 : Evolutionary Concepts Research Projects under FP-5 (cluster EVOL)

	Evolutionary Safety Concepts	Nuclear Fuel (High Burn-up / MOX)	
Analytical Tools *(codes, methodologies)*	ASTAR - ECORA RMPS - VALCO - CRISSUE-S TEMPEST - ITEM	EXTRA - SIRENA	Cluster EVOL
Operational Practices and Design Improvement	NACUSP DEEPSSI FABIS	MICROMOX OMICO	
Databases and Education & Training	CERTA EUROFASTNET *JSRI* ENEN	VALMOX	

The shared cost projects in this area have all a strong "numerical" flavor as progress in numerical modelling, especially CFD (computational fluid dynamics) codes, is needed to catch up with the progress made recently in experimental investigations, especially for passive systems. The further use, improvement and applications of CFD codes for a wide range of conditions were highly recommended in the conclusions of some final reports of FP-4.

Four projects are strongly related to the use, development and improvement of three-dimensional (3-D) and CFD codes. There is a project aiming at the development of advanced numerical methods for 3-D two-phase flow simulation tools that might lay the scientific and technical basis for a new generation of thermo-hydraulics codes. This should improve the modelling of safety relevant phenomena related to the next generation of evolutionary LWRs. The expected outcome of another project is a comprehensive evaluation of CFD software for applications in the primary system and the containment of nuclear reactors, resulting in recommendations for Best Practice Guidelines and for necessary CFD software improvements. The project aims also at establishing a Network of European Centres of competence for applications of CFD codes to reactor safety. In a concerted action, a critical assessment is made of the needs, in nuclear engineering, for thermal-hydraulics R&D, with emphasis on a coherent balance between advanced CFD modelling and experimental validation using innovative instrumentation.

There is also a project proposing a specific methodology to assess the thermal-hydraulic reliability of passive systems. The main activities are the identification and quantification of the sources of uncertainties, the propagation of the uncertainties through the thermal-hydraulics models and the introduction of passive systems unreliability in the accident sequence analysis.

KNOWLEDGE MANAGEMENT

Improving knowledge or acquiring new one, as it has been discussed above, is naturally inherent in each FP-5 project. From a programme management point of view, however, this basic objective requires nowadays what is called a knowledge management strategy. It is worth presenting first of all three FP-5 projects of general interest that are somehow dealing with nuclear knowledge management (KM), stretching across the three clusters PLEM, SAM and EVOL, thereby contributing to the conservation of the nuclear expertise. Unfortunately, there is not yet a global Community strategy for nuclear KM.

The principal end-users of these three projects are the decision makers interested in knowing who in Europe is doing what in reactor safety research, the academic community concerned with the decrease of education resources and the developers of numerical simulation tools interested in virtual laboratories (e-science).

- **JSRI** (Joint Safety Research Index), a concerted action for the dissemination of information about the European reactor safety research programmes (i.e. the so-called « centres of excellence ») and their main achievements in the areas covered by PLEM, SAM and EVOL (see homepage http://w2ksrvx.ike.uni-stuttgart.de/jsri/). More than 1350 projects from 16 EU and CEE countries (+ DG JRC) are described, covering the period 1998 – 2003, and the names and addresses of numerous experts are listed. This is a management tool for decision makers interested in the most recent RTD developments.
- **ENEN** (European Nuclear Education Network), an accompanying measure to pioneer the European area of higher education in nuclear engineering, using the instruments proposed by the Bologna declaration (1999). It is proposing a global strategy for quality control and mutual accreditation of masters grades in nuclear engineering and performing pilot education sessions to test the proposed scheme (see homepage http://www3.sckcen.be/enen). A durable legal structure is proposed, comprising more than 22 universities representative of EU and CEE countries.
- **CERTA,** a thematic network for the preservation of the integral system experimental data bases for reactor thermal-hydraulic safety analysis acquired by institutional and industrial research organizations throughout the EU and CEE countries (see homepage http://lunar.jrc.it/stresaWebSite/). This web-based informatics platform is a e-tool that can be extended to drive the exchanges of large datafiles needed for any joint distributed numerical development, avoiding the stiffness of the static traditional centralised databank systems.

It is clear, however, that a real nuclear knowledge management strategy at the Community level is still missing, i.e. a coherent durable EU approach and the appropriate implementation instruments for activities related to identification, acquisition, development, disssemination, use and preservation of knowledge. To optimise dissemination, for example, a thorough discussion with the owners of scientific data and knowhow is still needed, in particular to agree on access rights for using the results of Community research activities after the contractual period (exploitation and further research).

CONCLUSION

Research on plant modernisation, in particular when it is related to the phenomenology and management of severe accidents, is contributing to improvements and a better harmonisation of safety practices throughout the EU and the candidate CEE countries. It has also been shown that severe accident research results in a better evaluation of these very unlikely events: the uncertainties are better quantified and subsequently the risks related to corium behaviour, hydrogen explosions and/or radiological releases are reduced. Some interesting evolutionary safety concepts and innovative numerical tools have been discussed. Further exploitation of the results of this innovative research will help the nuclear industry achieve the scope of reducing even further the risks of both design basis and severe accidents.

Besides technological requirements, socio-economic aspects are becoming increasingly important due to the level of public and political acceptance and to the economic pressure of deregulated electricity markets. It has been shown that research conducted in the Euratom framework could contribute to meet these requirements, thereby maintaining nuclear power as a competitive and sustainable option for the energy policy of the European Union.

In the future, Community research in nuclear fission will continue to contribute to offer a response to some of the main concerns raised by the key stakeholders and by the European citizens at large in line with the European Research Area concept (ERA). The new challenge to Euratom research will be to reorganise itself using the implementation instruments proposed for the next 6th framework programme (2002-2006), as they are described on the website of the European Commisssion Directorate General "Research", namely: http://www.cordis.lu/fp6/nuctech.htm.