

## Building the European Research Area in Nuclear Fission Pioneering Steps in Actinide Science

Hans Forsström

*DG Research, European Commission, B-1049 Brussels, Belgium  
Hans.forsstrom@cec.eu.int*

**Abstract** – *The concept of the European Research Area (ERA) aims at closer development of research policies in Europe and closer networking of research capacities, to reduce fragmentation of research in Europe. The goal is to make European research more effective and competitive. Several approaches are made to create ERA. The European Research Framework Programme is one tool in this context, with the introduction of the new instruments, Integrated Projects, Networks of Excellence and Integrated Infrastructure Initiatives. Actinide science is one area that could benefit from better coordination and more effective use of the research capacities, both human and physical. The European Commission is thus funding a Network of Excellence (ACTINET-6) and an Integrated Project (EUROPART) in this area within the sixth Euratom Framework Programme.*

### INTRODUCTION

Research on actinide science is fundamental for the development of nuclear technology and in the field of nuclear safety. It has been an important component of the research supported by the European Commission over the years in the fields of reactor safety, fuel development and spent fuel and radioactive waste management. But actinide science requires large and expensive infrastructure facilities. With the reduction in funding for nuclear research that is seen in several European countries, it is clear that it will be necessary to pool the resources effectively to ensure that the knowledge is maintained and that development can take place on a European scale. Initiatives to increase the collaboration between the different European laboratories in the area thus become very important.

### EUROPEAN RESEARCH AREA (ERA)

Several studies have shown that research in general in Europe is very fragmented and thus neither achieving the results nor using the results as effectively as could be wished. This is one reason why Commissioner Busquin in 2000 launched the concept of a European Research Area [1].

In March 2000 the Lisbon Summit agreed on a new strategic goal for the European Union: "Europe should become the most competitive and dynamic knowledge-based economy in the world by 2010". ERA is one component of this strategy. ERA aims at bringing the development of research policies of the different Member States closer together and a closer networking of

the research capacities in Europe. Another component is the agreement between the Member States to increase their investments in research to approach 3 % of GDP by 2010. Two-thirds of the research investments should be made by industry. A main challenge is thus to make R&D investment in Europe more attractive to industry, through a wide range of policies at regional, national and EU level.

The studies on the effectiveness of research have not specifically looked at the nuclear sector. Nevertheless, although much co-operation already exists in this sector, the co-operation can certainly be further improved.

The sixth Framework Programme (FP6) is one important tool to help create ERA. The main instruments provided by FP6 are the new instruments: integrated projects, networks of excellence and integrated infrastructure initiatives. FP6 also provides the possibility for closer co-ordination of national research policies.

FP6 is, however, only one tool. Several other initiatives are necessary to build ERA. Some examples are the need for facilitating the mobility of scientists in Europe, improving research infrastructures, simplifying patenting (Community patent), and improving electronic communication. ERA does not, however, mean that Europe should isolate itself in research. ERA must be open to the rest of the world. This openness should enable the EU to benefit from international cooperation and further develop relations between the EU and third countries.

## EURATOM SIXTH FRAMEWORK PROGRAMME

FP6 has the aim of closer integration of the research. The priorities for Euratom FP6 are fusion energy, radioactive waste management, radiation protection and other activities in nuclear fission, such as reactor safety, innovative reactors and education and training [2]. While the research on fusion energy can be seen as highly integrated at the European level and even at the international level, further integration is still needed in the other areas.

The fusion energy research aims at the preparation for ITER, but also at continued research into fusion physics and technologies, including study of other magnetic confinement formulas and operation of existing devices, e.g. JET.

The research on radioactive waste management has two main strands, geological disposal and partitioning and transmutation. For both these strands actinide science is important and the funding of support for actinide science is therefore a priority.

The main topic of the radiation protection priority is improved understanding of the risks associated with low and protracted exposures, through epidemiological studies and cellular and molecular biology research. Other topics in radiation protection are medical exposures, natural sources of radiation, protection of the environment and radioecology, risk and emergency management and protection of the work place.

Reactor safety research deals primarily with material ageing, severe accident management, and numerical simulation. Innovative systems that are considered include High Temperature Reactors, Gas-Cooled Fast Reactors and Supercritical Water-cooled Reactors.

Education and training should be an important component in all integrated projects and networks of excellence. Specific support is also given to integration of education efforts on a European scale.

### Instruments in FP6

One important purpose of the Framework Programmes has always been to increase the co-operation between the researchers in the Member

States. Thus for the last Framework Programmes only projects with partners from several Member States have been funded. The co-operation has, however, primarily been between researchers. In FP6 the emphasis will be on co-operation between organisations in larger projects. The main new instruments for the research support are Integrated Projects, Networks of Excellence and Integrated Infrastructure Initiatives. In addition the "old" instruments like Specific Targeted Research Projects and Co-ordination Actions are kept, as well as the important training activities like fellowships, grants and special training courses. However, about 80 % of the funding is expected to be used for the new instruments.

*Integrated Projects* are designed to achieve ambitious, clearly defined scientific and technological objectives by integrating the critical mass of activities and resources needed. The key words here are ambitious and integrated. They should integrate and steer the research needed to achieve the ambitious objectives. By mobilising a critical mass of resources, Integrated Projects will also have a structuring effect on the fabric of European research. The Integrated Projects are normally quite large, with a typical budget of 10 - 20 M€, of which 5-10 M€ from the Commission, but they could also be larger.

*Network of Excellence* is the really innovative instrument in FP6. It is designed to strengthen Europe's excellence on particular research topics by tackling the fragmentation of European research. It should lead to a close and durable integration of the involved research organisations. The Commission's funding (typically 5 - 10 M€) should primarily be used for activities that will overcome the barriers to integration, not research per se. It is foreseen that after the period of funding the establishment of a Network of Excellence, the NoE should not receive further funding for networking. The success of a Network of Excellence is thus not measured in terms of scientific results, but by the extent to which the social fabric for researchers and research organisations has changed due to the project, and the extent to which the existing capacities become more effective as a result of this change.

*Integrated Infrastructure Initiatives* are similar to Networks of Excellence but are restricted to the infrastructures. The objective is to support

the integrated provision of infrastructure services to the research community at a European level. It includes networking, transnational access to research facilities and joint research activities to develop the infrastructures.

### **ACTINIDE SCIENCE IN THE FRAMEWORK PROGRAMMES**

Research involving actinide sciences have been included in several areas of earlier Framework Programmes. This has concerned reprocessing technology and waste treatment, partitioning and transmutation, geological disposal and fuel investigations.

#### **Fifth Framework Programme**

In FP5 three projects were dedicated to partitioning. Two of them, PARTNEW and CALIXPART dealt with the development of solvent extraction processes for minor actinides from the acidic high level liquid. In the third project, PYROREP, the flow sheets for pyrometallurgical processing of spent fuels and targets were assessed [3].

Two other projects, CONFIRM and FUTURE, looked at new fuels for transmutation based on uranium-free nitride fuel and actinide-based oxide fuels respectively [4].

In geological disposal several projects dealt with the transport of actinides and other radionuclides in the bedrock. ACTAF dealt with the chemistry and thermodynamics of actinides and fission products in natural aquatic systems, TRANCOM-II addressed the migration behaviour in reducing clay environment, with special emphasis on the role of organic matter. HUPA quantified the impact of humic colloid mediated actinide transport on the long-term safety of nuclear waste disposal. IN-CAN PROCESSES and SFS examined the processes involved in spent fuel dissolution under relevant geological disposal conditions [5, 6].

Actinide science is also involved in the different projects connected to severe accident management, in particular concerning the behaviour of the molten reactor core and the radiological source term.

In a late phase of FP5 a thematic network was launched to prepare a European-wide network structure for advanced research on actinide

sciences for the further development of the nuclear fuel cycle, including the safe disposal of nuclear waste [7]. This was the start of the work that has led to the ACTINET-6 Network of Excellence that is funded in FP6, and will be described in more detail below. The background to the initiative was the observed trend towards reduced basic research on actinide science in Europe and the concentration of the work in a few national research institutions and the European Commission's Joint Research Centre (JRC).

#### **Sixth Framework Programme**

As already stated, one objective of the sixth Framework Programme is to help structure the research fabric in Europe and to take steps towards the European Research Area. In this spirit a Network of Excellence, ACTINET-6, has been created in the area of actinide sciences. The ambition is to create a long-lasting "virtual" institute for this research in Europe. Actinide science research is and will be a part of several current and future Integrated Projects, where the purpose is to provide the scientific understanding and input necessary for achieving the objectives of those projects.

#### **ACTINET-6, the first Network of Excellence**

ACTINET-6 is a pioneering effort within the EURATOM programme. Together with EC-SARNET (Severe accident research) they are the first Networks of Excellence in the programme and will therefore be test beds for these new approaches to research funding in the Euratom programme..

The objective of ACTINET-6 is to take steps to bring together both research infrastructures and human expertise in Europe to guarantee an adequate performance level in the fields of physics and chemistry of actinides. This objective has three parts related to research infrastructures, research programmes and training [8].

ACTINET-6 has gathered 27 institutions from 14 European countries (incl. JRC). The members of the network range from large national laboratories to university departments, thus bringing together the major experimental facilities, training experience, and academic and applied research capacities. It is organised around a Core Group providing the main

experimental facilities. The core group consists of CEA (France), Forschungszentrum Karlsruhe (Germany), SCK-CEN (Belgium) and the ITU (part of the Joint Research Centre).

At the origin of this project is the need for a European-wide research *infrastructure* policy in this field. Currently, research facilities are scattered among several institutes, some of them are redundant, while others are either not available or difficult to gain access to by academic researchers. The intention is to pool selected parts of the major facilities of a few large institutes, for the benefit of a joint programme of research involving all members of the Network. The pooled facilities are provided by the Core Group. The objective of ACTINET-6 will be to operate the pooled facilities as a "multi-site user facility", and make it accessible to all members through a selection procedure overseen by a Scientific Advisory Committee. Several prior steps will be necessary to make this possible, e.g. implementing improved regulations and procedures to allow ease of access, clarifying issues of confidentiality, provide necessary training and not least implement an economic model.

ACTINET-6 may also include networking of theoretical expertise for the modelling of systems containing actinides around the ACTINET "Theoretical User Lab", which will use the expertise and computing infrastructures within the member organisations, e.g. access to supercomputers provided by CEA.

To use effectively the resources in the network it will be necessary to define shared ambitious *research programmes* and to improve the mobility between the involved institutions. The research activities to be supported by ACTINET-6 cover three scientific areas: the chemistry of actinides in solution and solid phases, the geochemistry of actinides and the physics and chemistry of irradiated actinide materials. An impressive list of research activities has been prepared within these areas. Support will be provided through ACTINET-6 for selected projects proposed by the members and evaluated by the Scientific Advisory Committee. The evaluation will take into account scientific excellence, potential impact on integration, and potential impact on issues of importance for nuclear energy. The support using the EU grant will not cover the full cost of the research, but only the costs specifically associated with the

integration aspect of the project and the costs for performing the research in the pooled facilities. Other funding will also be needed, e.g. to cover personnel costs.

The third important component of ACTINET-6 concerns *education and training*. The teaching activities in actinide sciences have decreased over the last twenty years. Several universities are still delivering courses, but difficulties are encountered in renewing equipment, increasing staff and maintaining availability of courses. Through ACTINET-6 activities will be initiated to improve this situation. These include a stronger participation of the core members in education and training at the universities. Specialists will be offered to give advanced courses, a specific ACTINET course might also be considered, and an ACTINET Summer School will be established. Also the increased mobility and the participation in joint research projects will increase the training aspect, at the same time providing good contacts between the core institutes and the students.

With ACTINET-6 an important step is taken towards ensuring the continued availability of expertise and research capacity in actinide sciences in Europe. It will serve the dual purpose of ensuring an inflow of new human expertise through universities and other academic institutions and the widened possibility to perform advanced actinide research in the small group of dedicated laboratories in Europe.

### **EUROPART, an integrated project on partitioning techniques**

In FP5 partitioning techniques were studied in three separate projects, which were informally clustered together. In FP6 one Integrated Project has been created, EUROPART. The research will include both hydrometallurgy and pyrometallurgy and will largely be a continuation of the FP5 research. The selected elements for partitioning of the high active waste from reprocessing of spent fuel (high burn-up UOX and multi-recycled MOX) are the minor actinides. The research also includes the partitioning of waste from dedicated fuels and targets for transmutation.

After separation the actinides will either be transformed into short-lived or stable nuclides through nuclear transmutation or conditioned into dedicated solid matrices

The specific objectives for the research related to hydrometallurgy are: i) definition of processes for the joint partitioning of trivalent actinides (from Am to Cf) from highly active raffinates and/or highly active concentrates, ii) definition of processes for the individual separation of the trivalent Am/Cm/Bk/Cf ions from the product generated by the first process, iii) definition of reprocessing processes for spent fuel or targets for transmutation (eg Accelerator Driven Systems, ADS) that will permit co-extraction of the actinides at the +VI (U,Np, Pu), +IV (Np, Pu) and +III (Am-Cf) oxidation states, and iv) definition of methods for the co-conversion of actinides for fuel or target preparation.

For pyrometallurgy the objectives are: i) determination of the basic properties of actinides in molten halides (chlorides and fluorides), ii) definition of the partitioning process of actinides from high level waste from reprocessing by the PUREX process, iii) definition of reprocessing processes for advanced dedicated fuel cycles (such as those of ADS), iv) definition of conditioning methods for the wastes generated by the pyrochemical process, and v) definition of the overall organisation of the methods to be implemented for pyrometallurgical partitioning processes.

The research in EUROPART will integrate all aspects of the partitioning process development. It will include fundamental research to improve the knowledge of the chemistry of the actinide elements in solution in various media and their reaction properties with ligands, process definition (including testing of extraction devices and modelling of the separations) and cold tests, and preliminary hot tests of the selected processes. There will also be a strong link to the research that will be performed in FP6 on transmutation, and in particular to the development work for the fuels and targets.

The EUROPART consortium includes 24 partners. Most of them are also members of the ACTINET-6 network. EUROPART is thus an example of how specific financial support can be given for goal oriented research performed by members of a Network of Excellence.

Training and dissemination are also important components of EUROPART. It has been decided that special training sessions open to a wider audience will be arranged in connection with important project meetings.

Given the size of the project it is clear that the management capacity of the project has had to be strengthened compared with the smaller projects in FP5. This provides for a clearer responsibility for the project and also more flexibility. This added flexibility is especially necessary in the planning for the project, and has been provided for as an integral part of the new instruments in FP6. The planning will be based on a rolling 18-months plan that is revised and discussed within the consortium and with the Commission each year.

Although EUROPART is a European project, contacts have been established with non-European work in the area. These includes the possible participation in the project of a Japanese partner, preparations for close collaboration with research supported by the US DOE and close co-operation with partitioning projects in Russia and Ukraine, supported through the International Science and Technology Center (ISTC) and the Science and Technology Centre in Ukraine (STCU).

#### **Actinide science in other FP6 projects**

In the area of *geological disposal* an Integrated Project, NF-PRO, has recently been selected that will improve the understanding and numerical modelling of the key processes in the near-field and their coupling for different host rocks and repository strategies. One important component of this project is the processes for dissolution of the waste matrix and the release of radionuclides from the waste matrix and their transport through the near-field.

In addition, a call for proposal has recently been held for a complementary Integrated Project to improve the understanding and numerical modelling of the key processes for radionuclide migration through the geological environment for different repository host rocks.

In the area of *partitioning and transmutation* the same call for proposals requested an Integrated Project for transmutation of high-level nuclear waste in an Accelerator Driven System, including studies of advanced fuels and targets. Subject to successful selection and evaluation by independent experts, it is hoped that both these projects will be able to start in 2005.

Concerning *innovative systems*, studies of new fuels will be included in proposals for an integrated project on high/very high temperature reactors, and also for other new reactor concepts.

In *reactor safety*, a Network of Excellence on severe accidents, SARNET, has been created.

In *radiation protection*, topics concerning transport of radionuclides in the environment are included.

## CONCLUSIONS

The Sixth Framework Programme has been designed to contribute to the creation of the European Research Area, which should improve the effectiveness and competitiveness of European research. The main task is to reduce the fragmentation of research. The main tools provided by the Framework Programme are the new instruments, Networks of Excellence, Integrated Projects and Integrated Infrastructure Initiatives. These will serve to foster a closer co-operation between the research organisations in Europe.

This paper describes how the concept of the European Research Area has been taken up within the specific area of actinide sciences. It has been recognised for some time that there is a clear need for better co-operation to ensure the future availability of human expertise and research capacities in this area. Thanks to the initiative by many people involved in the research, a concept for a Network of Excellence has been developed. This will utilise the important research facilities at a few large laboratories and network the expertise at these laboratories with the broad expertise available at universities. In parallel, this expertise has also been included in specific research activities within Integrated Projects.

The trend over time for the Framework Programmes has been to further increase the collaboration amongst research partners. In early programmes, support was given to individual research groups. For more than 15 years now, support has only been given to collaborative projects involving researchers from several member states. In FP6, a further step has been taken to increase the collaboration between research institutes at the management level. For future research programmes considerations are going even one step further and introducing the

concept of technology platforms for pan-European public/private research co-operation on very ambitious new projects, e.g. the hydrogen society.

## REFERENCES

1. "Towards a European research area, Communication from the Commission to the Council, the European Parliament, the Economic and Social Committee and the Committee of the Regions", Office for Official Publications of the European Communities (2000).
2. Council Decision concerning the sixth framework programme of the European Atomic Energy Community (Euratom) for nuclear research and training activities, also contributing to the creation of the European Research Area (2002 to 2006), *Official Journal of the European Communities*, **L232**, p. 34, 29.8.2002.
3. C. MADIC et al, "Advanced Chemical Separations of Minor Actinides from High Active Nuclear Wastes", *EURADWASTE'04 -Radioactive waste management. Community policy and research initiatives*, Proceedings of the sixth EC Conference, Luxembourg 29 March - 1 April 2004, ", Office for Official Publications of the European Communities (In press)
4. D.HAAS et al, "European Transmutation Fuels Projects", *EURADWASTE'04 - Radioactive waste management. Community policy and research initiatives*, Proceedings of the sixth EC Conference, Luxembourg 29 March - 1 April 2004, ", Office for Official Publications of the European Communities (In press)
5. G.BUCKAU et al, "Geochemical Behaviour and Migration of Radionuclides: Major Achievements of the Projects ACTAF, HUPA and TRANCOM-IIAdvanced Chemical Separations of Minor Actinides from High Active Nuclear Wastes", *EURADWASTE'04 -Radioactive waste management. Community policy and research initiatives*, Proceedings of the sixth EC Conference, Luxembourg 29 March - 1 April 2004, ", Office for Official Publications of the European Communities (In press)
6. J.M.CAVEDON et al, "Development of Radionuclides Source Term for Spent Fuel in Geological Disposal. Major Outcomes of the European Projects 'In Can Proc' and

- 'Spent Fuel Stability' ", *EURADWASTE'04 - Radioactive waste management. Community policy and research initiatives*, Proceedings of the sixth EC Conference, Luxembourg 29 March - 1 April 2004, ", Office for Official Publications of the European Communities (In press)
7. R.KLEUZE et al, "Establishment of a Network of Excellence for Actinide Sciences (ACTINET-5)", *EURADWASTE'04 -Radioactive waste management. Community policy and research initiatives*, Proceedings of the sixth EC Conference, Luxembourg 29 March - 1 April 2004, ", Office for Official Publications of the European Communities (In press)
  8. P.CHAIX et al, "ACTINET Thematic Network: Establishment of a Network of Excellence for Actinide Sciences ", *EURADWASTE'04 -Radioactive waste management. Community policy and research initiatives*, Proceedings of the sixth EC Conference, Luxembourg 29 March - 1 April 2004, ", Office for Official Publications of the European Communities (In press)