FIVE-YEAR ASSESSMENT OF THE SPECIFIC PROGRAMME: NUCLEAR ENERGY:
Nuclear Fission and Radiological Sciences

FINAL REPORT

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1 Introduction

In accordance with Article 5 of both Decisions on the EC and EURATOM Fifth Framework Programme, the Commission is required to have an external assessment into the implementation and achievements of Community activities during the period 1995-1999 before submitting its proposals for a Sixth Framework Programme. This document represents the Final Report of the Board engaged in this task in the Specific Programme (SP) of Nuclear Energy, and in particular the Key Action 2 "Nuclear Fission " and the Generic Research in Radiological Sciences.

Nuclear Energy continues to contribute approximately one third of The European Unions electricity supply. As such it represents a very large investment, both in physical plant and human resources. Nuclear technology is demanding in terms of knowledge and expertise and the public rightly demands that the highest levels of safety and competence be maintained. The EU research programmes have had this as an ultimate goal since the original EURATOM Treaty was signed in 1957. Then, as now, energy from nuclear fission has been seen as a contributor to a balanced energy supply strategy, and as a potential building block of a sustainable energy future. To fulfil this function, the demonstration of exceptionally high levels of safety for all aspects of the fuel cycle is paramount, as is public acceptability. Also included in this specific programme are projects from a wide ranging area of research in radiological protection aimed at optimising protection and reducing exposure of the public and workers to radiation from all sources, from naturally occurring radiation, to the medical and industrial uses of radiation. Underpinning it all is a programme of generic Research in Radiological Sciences, which investigates the fundamental actions of radiation on tissue. The contributions of this work over many years to the health and quality of life of the European Union’s population is well recognised.

The five-year period covered by this report includes the completion and appraisal of the Third Framework Programme (FP3) (1990-94), the completion and partial appraisal of the Fourth Framework Programme (FP4) (1994-1998) and the initiation of the Fifth Framework programme (FP5) (1998-2002). The reshaping of the Framework Programmes in the early 1990’s is described in the previous five years assessment. Eventhough this report overlaps in time to some extent with that report we do not repeat the steps that were reported there. However, the process continues and there was a quite considerable change in structure of FP5 from that of FP4. This was not limited to the specific programme, of course, but perhaps because of its long history and the recent changes between FP3 and FP4, lead to a good deal of confusion in the technical community as to the required emphasis and focus. Parts of the specific programme have been likened to a shopping list, not a strategic research plan.

The terms of reference for this review (Annex 1) require that it should be done in the structure of FP5. This is not easy, as there are significant differences between FP4 and FP5 in its basic structure. To facilitate our task we have used the "translation table" shown in Annex 2. If the structure of the FP has changed, the basic objectives have not. The table shown in Annex 3 summarises how the overall objectives have evolved with time.

FP5 comprises Key Action 2, Nuclear Fission with four sub-headings, and one Generic Research programme in Radiological Sciences. In addition the programme has an action on Support for Research Infrastructures. The aims of the different parts are summarised in the table in Annex 4.

Data for the number of projects funded, the number of partners (and the number of different member states represented) in each project, the size of the projects and the ratio of shared cost to concerted actions are all available. The trend over this period has been for a decrease in overall funding and some considerable internal re-focussing of research. This is summarised in Annex 5. We will comment on specific aspects below, but it is clear that in operational safety there has been a move away from severe accident research, which in some areas is reaching maturity, to issues related to materials ageing, plant life management and human factors. However, the inclusion in the area "safety of the fuel cycle" of Partitioning and Transmutation is something we have doubts about and discuss more fully below. The necessity to generate a separate "Generic Research" area caused much confusion in the radiation protection community and has lead to a rather unsatisfactory situation mid way through FP5.

Method of working: the Board received a large number of reports covering all aspects of the programme. A summary list is given in Annex 6. In addition interviews and visits were undertaken to give an opportunity for the Board to gather first hand views from those concerned in implementing the programme as well as with DG Research staff. More than 100 people were interviewed; their names and affiliations are given in Annex 7. Finally, the Board members and their backgrounds are given in Annex 8.

The Board wishes to express its particular thanks to members of DG Research staff who have made time available for interviews and have been very supportive in this task

2 Assessment of Implementation.

2.1 ASSESSING EFFICIENCY

2.1.1 THE ROLE OF ADVISORY GROUPS

The Nuclear Energy R&D Programme has advisory committees that reflect its EURATOM Treaty basis. The Scientific and Technical Committee (STC) has held the principal strategic advisory role for many years, with the Programme Committee[4] (CCE) also having been long established with an overview of the way in which the programme is managed. In addition for FP5, there is a new External Advisory Group (EAG), which has a mandate to comment on the content and programme planning of the FP5. We believe that there might be a role for all of these groups. However, there seems to be insufficient co-ordination between their activities and there needs to be a more effective and efficient management of the considerable expertise and knowledge available through them. Cross membership of the STC and EAG helps to some extent, but a more pro-active use of the groups would help. The technical committees (STC and EAG) in particular are made up of very experienced people who give their time voluntarily. It would be valuable to have an evaluation of the mandates and interfaces of these advisory groups. The STC continues to play an important role, especially in strategic matters and taking long term views. It has remained flexible to the changing needs of the Commission and the end users. A key element in the success of any of these groups is the information available to members. The Commission can do only so much and it is important that Members have appropriate networks/contacts nationally and internationally in order to contribute effectively. In addition, it is most important that they are brought into the process early enough to be useful. As a case in point, the timing of the preparation for FP5 meant that the new EAG did not get off to a good start.

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[4] In the case of the EURATOM programme, this is the Consultative Committee for EURATOM (Fission) (CCE Fission).

2.1.2 PROGRAMME MANAGEMENT.

In general terms we believe that the programme objectives have been pursued in a cost-effective manner. This, of course, is subject to a number of caveats and criticisms. The "transparency" of the management of the programme has been improved and the staff of DG Research have made significant contributions to its success. The process of calling for tenders and evaluating them remains very bureaucratic and heavy handed. Improvements have been made, e.g. by the extensive use of electronic means of communication. Nevertheless it remains a daunting task for a research manager to write a proposal, gather together an EU wide consortium and submit it for evaluation. Added to that is the very long time between submittal and acceptance. The annual monitoring reports have made suggestions as to how this process may be speeded up (e.g. by seeking input from other DG's in parallel with the proposal progress rather than in series) and we support those suggestions. Long delays can also add to problems of continuity for some players. However, as long as the demands for scientific excellence, transparency and auditability remain, it is inevitable that proper review and safeguards procedures must be in place and these will take time and effort. It is true that the evaluation process has been improved, but it still remains difficult to balance experience, independence and availability of suitably qualified people in what is a relatively small pool of experts in Europe.

Once projects have been awarded, there is a strong case for giving more authority to the project co-ordinators. They should be allowed to manage flexibly and to ensure that objectives and targets are met in the most efficient way; this means that changes must be possible once a project is underway. This should be accompanied by more assistance from Commission staff on strategic and networking matters. It has to be remembered that research is not always going to give foreseeable results and good researchers need to be able to make adjustments as knowledge is gained.

The projects in the specific programme of Key Action 2 and Generic Research in Radiological Sciences have historically had good, highly motivated scientific officers in the Commission. This has lead to the situation where much of the added value of the work comes from these few individuals. In recent times the number of personnel has been decreasing. This throws more emphasis on the need for a change in the nature of the programme management. In the area of radiation protection in particular recent sharp falls in staffing levels means that the number of personnel is now under the minimum critical mass. This is a very difficult position since during the past 10 years or so, the EU programmes have become world leaders in many aspects of basic radiological research. For example, the ICRP is now relying more on European research centres than those of the USA. Now is the time to consolidate that position, not withdraw from it.

The major divisions between the FP programme management and the JCR's have been a problem for a long time. Establishing appropriate connections is difficult, and depends largely on the management culture, and the motivation of individuals. We are assured that problems are recognised and are being tackled by the DG Research staff responsible. This effort needs strong support from higher management.

There have been many "structural" changes in the programme and this has led to some difficulties associated with the transitions between one FP to another. The most common complaint from project co-ordinators was the potential lack of continuity. In some cases (especially FP4-FP5) the delay in implementing the new programme meant that either work had to stop, or research bridging finance from the host Institute had to be found. For large national programmes, or Institutes with some degree of autonomy over their budgets this was not a big problem, but for smaller Institutes or privatised organisations it was intolerable. In addition, the change in programme structure for radiation protection from FP4 to FP5, i.e. the splitting between key action and Generic Research, lead to a transition that was too obscure. This, and the reduction of resources, caused many problems for potential contracts and for DG Research staff.

Finally, in terms of efficiency, we attempted to judge the value of the outputs of the research in terms of the resources used. This is a notoriously difficult process even for far down stream research. In some areas of research, some quantification is possible; for example, the research done under the ETHOS project has given practical information on how a population could safely resume living in a contaminated area. Other examples might include the resolution of the in-vessel steam explosion issue so that such events can be safely ignored in accident management procedures and for future reactor designs. In many cases, the Commission funds represent only a small fraction of the total investment. Examples include the PHEBUS experiments and underground laboratories for waste disposal experiments. Nevertheless, these resources are valuable in allowing other Member States to participate and in disseminating important knowledge widely amongst the European technical community. The main conclusions on "value for money" are summarised as;

- The quality of scientific research was given priority in letting contracts and this has ensured good quality output as a result.
- The "value" of bringing researchers together from many Member States (and now from Applicant Countries too) is not quantifiable, but is universally judged to be an important and necessary contribution to European Harmonisation.
- For some technical areas research is now mature and the resources which have been used can be seen to have contributed directly to problem solving applications.

2.2 ASSESSING EFFECTIVENESS.

In attempting to judge effectiveness, the Board has followed the guidelines given to it in Annex 1. This means that there is some overlap with comments above under the heading of Efficiency.

In judging whether the activities funded were of high scientific and technical quality and relevant to the objectives, the Board gives its specific views in the individual work areas. In general terms, the work that was supported has been of a consistently high quality. This is reflected in the publication of numerous papers in professionally reviewed journals, and in the use of the outputs of the work by Regulatory Authorities, international bodies such as the ICRP, in underpinning EU Directives, and, of course by the industry.

There has been considerable EU added value[5] throughout these projects. Much of this arises from the multi-national approach through consortia drawn from different Member Sates to perform the research. There are a number of common problems that benefit from

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[5] It is surprising to the Board that there is no generally agreed definition of "European Added Value". It is surprising because it is a central plank of the FP5, and all potential bidders for work are asked to identify where their proposal contributes to it. We understand that a study is underway at the moment, but will not be available before the deadline for submittal of this document. Therefore, for clarity we offer the following as "our working definition".

A Research project has European Added Value if it offers one or more of the following;

- Increases the availability of Research data and knowledge throughout the Union (and Applicant Countries).
- Addresses a problem that is common to several Member States.
- Engenders closer collaboration between Research Institutes and research workers in the Union.
- Generates scientific consensus on key issues for regulation and in publicly sensitive areas of scientific and industrial policy.
- Increases efficient use of resources for example
    - By allowing the Union to speak with one voice internationally.
    - By making expensive or unique facilities commonly available
    - By creating the necessary knowledge base.

a common solution, not least to ensure consistency of regulation and interpretation throughout the Union. Having an EU wide S&T consensus is also very important in sensitive areas such as the requirements to protect people from sources of radiation, both man made and natural or such as the management of radio-active waste.

This description of European added value also applies to the contribution of the specific programme to social objectives. The contribution is essentially derivative. That is it underpins other activities that are more directly involved. For example, in terms of employment, clearly an active industry requires stable and cheap energy supplies. In terms of quality of life and health, much of the programme in radiation protection is aimed directly at ensuring that people are both protected from harmful radiation and that benefits through medical applications are used effectively. Should there be a large nuclear accident, then the programme is also aimed at providing the common warning, protection and recovery procedures.

In terms of contributions to the harmonious and sustainable development of the Community, we would reiterate that public confidence is absolutely vital. The research programme has helped to engender that by improving the knowledge base, whilst recognising that societal interactions and values represent complex problems which also need attention. Sustainability, in terms of energy supplies, is a key issues and far too complex for a simple response here. However, it is clear that a safe and efficient nuclear fission programme for electricity production can offer decision-makers policy choices in the future if sustainability conditions are fulfilled.

The research integrates the spectrum of activities and disciplines that are needed for achieving the objectives of the Programme through a considerable degree of multi-disciplinary projects. There are many examples where scientific activities (measurement, computer modelling etc) are complimented by engineering solutions. For example in plant life management, it is necessary to provide a holistic approach to all the relevant materials and plant performance issues. It is also the case in aspects of land restoration that many multi-disciplinary facets must be taken into account, including socio-psychological issues.

3 Indications of Significant Achievements.

3.1 KEY ACTION 2: OPERATIONAL SAFETY OF EXISTING INSTALLATIONS.

This area of research is characterised by a significant shift from developing the necessary understanding of the phenomenology of severe accidents in FP3 and FP4 to the use of this information in accident management and to the increasingly important issues relating to plant and materials ageing in FP5. Many of the earlier results are being used directly in the new programme. In many areas the research has reached a point of "maturity[6]".

Under FP4 the work was focussed into clusters. These combined projects with similar technical interest for managing and reporting purposes. With the key actions structure of FP5 it is not so clear how such clusters may be formed. However, we believe that the added value found from most cluster activity in FP4 makes it worthwhile to follow this up in FP5, along with the additional networking envisaged.

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[6] We use mature in a very loose meaning. It is recognised that there will always be further avenues of research even for the most highly developed areas, however, it is a matter of judgement and priority as to whether "fitness for purpose" has been reached. We use the term mature to mean the latter.

3.1.1 PLANT LIFE EXTENSION.

This area was not identified separately in FP4, although a number of projects were carried out in the "AGE" cluster. There was a very close collaboration with the established "AMES[7]" network that was managed by the JRC Petten. The increasing importance of this technical area is reflected in the weight given to it in FP5. As it concerns a mature Industry the Commission should maintain a balance between industrial and regulatory needs. Much of the background of the technical state of the art was provided by earlier projects. Significant achievements include;

- An overall appreciation of the many interacting aspects of materials performance through life which have to be drawn together to optimise plant life management.
- A comprehensive study of methods for assessing stress corrosion cracking in dissimilar welds has produced a series of recommendations on methods of testing.
- A major study (through concerted action) with the AMES network of non-destructive techniques for examining aged material has laid the groundwork for a next phase of qualification and industrial validation at the European level.
- A major state of the art report on modelling requirements to follow ageing processes has been produced.

3.1.2 SEVERE ACCIDENT MANAGEMENT.

The area of severe accident research has been receiving major international attention for more than 20 years. The achievements now emerging from the recent work have to be seen in the context of this large effort made by many countries. A number of significant achievements have been made under the general heading of severe accident research in the EU RTD programmes which have paved the way to the change in FP5 towards problem solving rather than basic research. The following gives a breakdown by the sub-topic areas of FP4.

IN and EX vessel corium phenomena. This work represents the culmination of many years of activity, nationally and multi-nationally to establish the physical behaviour of molten core material (corium) both in and ex vessel during the progress of a severe accident. Specific achievements include:

- It has been established that an in-vessel steam explosion (energetic molten-fuel coolant interaction) of sufficient size to threaten the reactor pressure vessel (RPV), especially the upper head can now be ruled out. This closes a long running, albeit low probability, initiation of major RPV failure.
- It has been shown that for core powers of up to 600MWe, and possibly up to 1000MWe, a molten core can be retained inside the RPV using external cooling. This provides important guidance for the design of new reactors and for Severe Accident Management (SAM) in many existing designs.
- A series of experiments has established that large amounts of corium are coolable when spread out in containment. This is important for design and SAM of larger reactor designs where RPV melt through cannot be ruled out. It also demonstrated that expensive ceramic materials were not necessary to achieve this.
- A smaller, but still important, example of problem solving in FP4 is the development of SAM procedures for preventing re-criticality events in Boiling Water Reactors (BWRs).

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[7] The European Network on Ageing Materials Evaluation and Studies (AMES) is one of a number of networks in this area organised by the Institute for Advanced Studies (IAM) of the Joint Research Centre at Petten. The success of these networks has been instrumental in the focus on this mechanism for co-operation adopted for FP5.

Containment: This area has focused on the threats to containment from molten core material released from the RPV and from Deflagration or Detonation of Hydrogen gas produced as a result of oxidation of the Zircalloy and steel core components.

- Significant information is now available concerning the control of hydrogen, by ignition or recombination, sufficient for design and SAM solutions
- The threat to containment from Delayed Containment Heating[8] (DCH) has been shown to be very small.
- The leak rate through micro cracks in concrete has been shown to be very much reduced by water condensing in the cracks.

A significant new development has been the application of very sophisticated state of the art Computational Fluid Dynamics (CFD) codes to the complicated 3D problems in containment. The future development of these codes is important in this and many other areas of such work and represents a significant challenge to the "horizontal" co-ordination of EC activities.

Source Term: The many physical and chemical conditions and the number of different chemically active species involved has always made the fundamental calculation of the amounts of material which may be released in a severe accident, i.e. the "source term", very difficult. This is a very well co-ordinated programme with much bi-lateral as well as EU and other multi-lateral added value. Significant achievements include the demonstration that silver (from control rod material) has been shown to "fix" radioiodine and acts as a natural stabiliser, reducing the amount available for transport and release. Considerable progress has been made in producing models and codes that are detailed enough, and quick enough. Nevertheless there is still some way to go before this area could be considered to be mature. In this context, the planned future major tests in the PHEBUS[9] facility represent a continuing and important contribution. The contribution of the FPs to this project have been relatively small compared to the overall costs, but good added value has been obtained through collaborative activities both between EU Member States and particularly in the wider international scene. The series of tests has taken longer than originally planned, but this reflects the extreme experimental difficulties and the caution that must be exercised whenever experiments involving large amounts of radioactive material are undertaken. Progress towards the eventual goal of validating large fission product migration and release computer codes is being achieved. The Board noted that financial control of the EU funding has recently passed from JRC Ispra to DG Research. Eventhough there is no anticipated change to the funding for the FP contribution, this move will help bring the EU funded activities into the overall frame of the relevant activities under FP5, and possibly FP6.

Additional items. The mainstream research activity has been supplemented by a number of useful concerted actions. Examples include

- A survey of regulators to find their attitudes and needs from severe accident research.
- A benchmark for the use of engineering judgement, identifying the "rules" which should be applied.
- The generation of a database for Probabilistic Safety Assessments of severe accidents, including the availability of software platforms so that they can access the large amount of data now available.

Concerted actions such as this provide excellent value for money in giving overviews and strategic information on the mainstream research activities.

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[8] Delayed containment heating arises from the possible distribution of an aerosol made up from hot core debris directly into the atmosphere of the containment.

[9] PHEBUS is a large reactor based installation at Cadarache in France capable of melting fuel and monitoring the transport and deposition of fission products in scale model containment. It can be decontaminated between experiments and is in the middle of a series of tests investigating fission product migration and transport.

3.1.3 EVOLUTIONARY CONCEPTS.

This was not identified as a programme area in FP4 and the results relevant to it are summarised in the severe accident management section above, particularly the information relating to design data for ex-vessel core cooling. It also overlaps with the key action "safety and efficiency of future systems" which is discussed in section 4.3 below. In general terms we would say that future work in this area needs to be carefully considered as it is in danger of becoming very far "downstream" and therefore more appropriate to Industry funding either directly, or through safety research programmes deemed necessary by the regulatory authorities.

3.1.4 SUMMARY AND RECOMMENDATIONS.

Much has been achieved in giving a comprehensive underpinning knowledge for future problem solving applications. Data is available for the generation of SAM that will significantly improve safety margins. The results of earlier programmes have helped to crystallise the key phenomena so that future research will be better focused in risk significant areas. Although not a part of this assessment, the work of the JRCs also contributes in this technical area. Although this activity (so-called direct action) has its own review process, there is little evidence in the past that sufficient care has been taken to ensure consistency and a full exchange of information. There is evidence that with the change in structure following the introduction of FP5, and some changes in personnel this sorry state of affairs is changing. It is very important that any research performed by the JRCs is, and is seen to be, entirely consonant with that of the main FP.

Recommendations.

1. In order to capture the knowledge generated in the already completed research a continuing activity is required. This is to gather up data, results of experiments, models and codes and store them in databases in an intelligent and recoverable way for the future.
2. Some techniques currently being developed in the nuclear safety field have applications beyond their immediate purposes. An example mentioned above is that of CFD. It also includes topics such as the reliability of software based control systems and many aspects of human performance and man/machine interfaces. The horizontal links in FP5 could be put to good use in making these state of the art methods more widely available.
3. The general tightening of resources is strongly felt in this research area, where expensive major facilities are required. Some means for rationalising their availability in the future needs to be addressed and we will suggest that consideration be given to some combined EU actions in the future, perhaps through identified "centres of excellence".
4. The shift in emphasis towards plant life management and ageing issues is a prudent investment protection programme for European Industry and the needs of the Regulators.
5. The creation of networks as a means for increasing co-operation and dissemination of information is strongly encouraged. The area of plant life management already has a well-developed network system and this should be nurtured and encouraged rather than trying to set up new networks. Successful networks depend on the motivation of their members, any proposals for establishing networks should be preceded by "market research" which determines the need.
6. Although there has been a change in emphasis, some of the "traditional" areas of research need continuing development and support. Amongst these is thermohydraulics, where major computer code development remains a priority for underpinning future safety justifications.

7. The question of fission product migration and release is not closed and it is important that the key role of the PHEBUS experiments, and the supporting research aspects continue to receive support in the future.

3.2 KEY ACTION 2: SAFETY OF THE FUEL CYCLE.

The title of this section could be misleading as it only addresses some aspects of the fuel cycle and not only safety issues. The core of this part of the programme is nuclear waste management; concentrating mainly on the disposal of the important highly active and long lived waste. It also contains part of the decommissioning of nuclear installations and a long-term innovative development for the fuel cycle, that is P&T. Many operational safety and environmental issues related to the transport of nuclear materials, reprocessing and low and medium level waste management were not covered in FP4 and/or FP5 but were addressed mainly by national programmes. Fusion waste management and waste implications of new reactor and fuel concepts were also not covered here and should be addressed by the relevant programmes in a co-ordinated way. As can be seen in Annexes 2&5, the budget was halved for waste management in FP4, while P&T was transferred from the work area "Exploring Innovative Approaches and New Reactor Concepts" in FP4 to this area in FP5, with an increase in funding.

3.2.1 WASTE AND SPENT FUEL MANAGEMENT AND DISPOSAL

This part of the programme focuses on HLW disposal and has contributed to a successful international collaboration with a substantial input from new Member States. The budgetary constraints and new priorities made it difficult to maintain continuity in some key long-term projects and left little margin in FP5 for new projects and broader challenges in nuclear waste management. The new structure of FP5 makes it particularly difficult to follow the evolution of the sub-areas. The EC nuclear waste management research programme represents a relatively small contribution to research compared with national programmes. Because of the differing needs of these national programmes, it seems difficult to establish a clear strategy at the European level. An improved co-ordination with other DGs, more involvement of regulatory bodies and transdisciplinary studies could create progress towards the public acceptance objective.

Management Strategies. A project in FP3 on technical feasibility of retrievability in various host rocks continued as a concerted action in FP4. This yielded an inventory of views in 8 countries throughout different phases in disposal and helped the mutual understanding of different disciplines. A clear difference was illustrated between retrievability during operation and after closure. Implications were identified for repository design, technology, safety, monitoring and safeguard aspects and at the socio-political level. Retrievability is considered as an opportunity to gain public confidence but must not compromise safety. Further dedicated studies are needed to include retrievability scenarios in risk assessments and performance analysis and to better understand the identified limiting factors such as cost. A step by step reversible approach with sustained transdisciplinary R&D efforts integrating social and economic sciences in technology and risk assessment could offer perspectives for consensus and solve crucial problems of waste in future.

There were no proposals on waste management strategies from the first call for FP5. Discussions with project co-ordinators indicated that this was due to the call being too broad. Commission staff intend to rectify this in the second call through a re-focusing of the objectives.

During the five years covered by this assessment, there has been little work done on economic aspects of waste management strategy. This makes it difficult to assess competitivity aspects. Research projects in future could be more balanced by the inclusion of a wider participation of stakeholders, especially regulators. This could also improve the process of setting standards and criteria to make it more transparent and amenable to public debate.

Quality Checking of waste packages. A European network was initiated in 1992 to promote European collaboration in the quality checking of radioactive waste packages (Non-destructive methods, Destructive methods and QA/QC procedures). The Round Robin Test for non-destructive assays of radioactive waste packages was aimed at improving the accuracy of techniques across Europe. The results of the non-fissile tests were good, while the fissile tests were not so satisfactory. A system for the detection of non-uniform hot spot activity remains necessary.

A network forum on destructive methods is editing a guidebook. Inter-laboratory comparisons will be needed to validate the methodologies, which would then be accredited by member states.

The network working group on QA and QC procedures moved forward towards a draft report on low and medium level waste packages in order to increase confidence in the waste management systems and to harmonise procedures in the community. The global network can be considered as a success by creating valuable fora for exchange of information and has led to improved identification of R&D projects.

This is an important research area. If international QA/QC could be based on reliable measurement techniques, validated by international comparison and referring to internationally harmonised standards, controversy over international transport might be reduced. The EC reduced funding in FP5 due to budgetary constraints. Work continues under the (non-supported) European Network for QA/QC labs. For NDA of large volume packages from decommissioning a project was approved.

Repository Technology. The CLUSTER network[10] of underground research labs (URLs) with 24 contracting parties in FP4 can be considered as the core of this key area. The feasibility of repository concepts has been demonstrated with large field tests of the behaviour of components such as the engineered barriers. At the same time measuring the impact of the heat and radiation, with particular attention to backfilling and sealing in situ barrier studies under disposal conditions. The projects FEBEX (in collaboration with NAGRA (Grimsel granite), BAMBUS (Asse salt) and RESEAL (Mol clay)) were a successful synergy of near real scale in-situ tests, modelling, laboratory tests and fundamental studies with performance assessment (PA) feedback, whilst at the same time creating opportunities for confidence building. The high costs and long time scales of such experiments made them an appropriate focus for international co-operation. The increased common understanding of backfill behaviour of bentonite in most URL’s is a European added value. In these experiments the thermo-hydro-mechanical (THM) processes in the near field are being monitored successfully with numerous sensors both in clay and crushed salt as backfill. The rather good correspondence between modelled and observed behaviour increased confidence and common understanding of backfill materials. The three projects were approved for continuation in FP5 with particular attention to the dismantling (semi real retrieval) and post mortem analysis after 9 years of heating in BAMBUS, which is considered as a final project on salt backfill behaviour. As handling of real waste underground was limited up to now and considering the problem of transferability of results obtained, a clear need for testing of components under real disposal conditions arose.

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[10] Club of Underground Storage, Testing and Research facilities

Future activities in URLs have to integrate all the successive actions to be undertaken in repository development at a specific site, such as the Prototype Repository project at Äspö in Sweden, approved for FP5. The need for better dissemination of knowledge could be satisfied in FP5 by the thematic network CROP, a proposal selected for the research infrastructure area, to constitute a forum for pooling and assessing experiences from various URL's.

Performance assessment of repository systems. PA is a very complex activity covering a large set of disciplines and this means that there are many uncertainties that have to be accounted for. The underground site studies have offered unique opportunities to refine PA tools through successful international collaboration and scientific understanding. PA approaches and tools have been further developed during the last 5 years.

The SPA-project in FP4 covered the elements needed to come to a total system analysis of spent fuel disposal in various host rock formations (clay, crystalline rocks and salt formations). Progress was made with regard to the various source term models adopted by the participants, engineered barrier behaviour, the possible effects of an excavation damaged zone, scenario and biosphere definition and deterministic and probabilistic calculation methods. The importance of optimal selection of engineered barriers was illustrated.

A new method for global sensitivity analysis and a conceptual framework to account for all sources of uncertainty in simulation problems of complex systems was developed through the Gesamac project. An important message from the study is that the PA of complex systems needs to take into account scenario, structure, parametric and predictive uncertainties, but that scenario uncertainties dominate.

The geoprospective studies regarding the evolution of earlier climate to predict future hydrogeology was succesfully coordinated. It yielded important feedback for PA by gaining insight in uncertainties over 10^4- 10^5year periods, through changes in hydrogeology effected by climatic changes.

Major achievements were realised linking laboratory work, field experiments and modelling. This exposed more clearly remaining deficiencies in knowledge and challenges for strategies. These include; does P&T make sense from the point of view of waste management? How well are the varieties of potential source terms defined? How well do we have to define the biosphere? Natural analogues, closer integration of laboratory work, in situ tests, modelling of a real site and basic studies in migration in open geosphere systems will help to clarify some of these issues. Selected proposals in FP5 include future climate change simulation and the SPIN project which aims to identify, test and evaluate safety indicators such as biosphere releases of radionuclides, looking for less abstract indicators for robustness than potential small doses.

Long term behaviour of repository systems. This proactive program on basic phenomena focuses on natural analogues, migration and a thermodynamic database for environmental monitoring (JETDEM CA). Natural analogue studies were very successful. These studies covered a broad spectrum of important phenomena. The project at Palmottu (Finland), amongst other things, focused on hydrogeological behaviour characterising a (post) -glacial period. Results will help to estimate future behaviour of geology and to update future climate scenarios and their potential effect on technical barriers under changing hydrogeological conditions.

Important studies on the interaction between waste forms, container and repository materials were continued. In the CORALUS case, experiments in FP4&5 analyse in situ corrosion of active glass samples in clay, through migration profiles of leached radionuclides. Real exposure conditions of high dose and temperature will be applied on three interacting materials such as bentonite. International laboratory collaboration was successful and the local safety authorities accepted the design.

Another subject concerns better knowledge of the spent fuel source term, which is more complex than uranium dioxide in its near field interactions. The spent fuel characteristics are affected by the trend to high burn-up in reactors. It was surprising, considering the potential impact on long-term safety, that one of the important projects has not yet been included in FP5.

The role of a number of key issues in the radionuclide transport and retardation processes deserves further investigations. The characterisation and modelling of flow and transport through fractured rock is not fully understood. Clear progress was made on gas formation. Projects were grouped in the cluster PEGASUS on gas generation and transport through clay, fractured rock and salt. Gas research should be continued for particular waste forms such as containing organic fractions.

Important migration issues have been successfully coordinated by the EC at world level since 1983 with MIRAGE, covering 80 multinational and interdisciplinary research projects. This action was continued more specifically on the influence of colloids and humic substances in FP4. The HUMICS project in FP4 has indicated potential consequences for actinide transport assessment. Specifically, in the case of environmental release to the aquifer from a geological barrier, humic colloid mediated actinide transport could lead to an unhindered transport of part of the actinide ions. The project on the influence of humic substances under natural aquatic conditions was considered too ambitious and not approved in FP5.

TRANCOM, a success but not an end-point in FP4, improved the understanding of the role of the organic matter for radionuclide transport in a reducing clay environment.

Aquatic Chemistry and Thermodynamics (ACTAF) could provide new experimental data in FP5 about the behaviour of actinides and fission products in natural aquatic systems that will help to close gaps in the thermodynamic database.

BORIS (financed by DG Environment) addresses new and innovative aspects of how to assess migration and retention behaviour in two Russian liquid waste injection sites.

The last three projects will contribute to the assessment of the function of the geological barrier.

Public Attitudes and involvement. Little attention has been given up to now at EC level to public attitudes and involvement. There is one project and a concerted action in FP5 concerning the evaluation of transparency in decision making, but there are no activities such as consensus conferences or public discussions of safety criteria. There is a need to incorporate different aspects through work packages integrated into projects, and especially to involve social sciences.

Recommendations.

1. To account for uncertainties, to be able to consolidate scientific assessment, and to gain the confidence of the public, continued research at an international level with sufficient resources is needed in radioactive waste management, including basic studies
2. Research should also be supported to maintain the advanced knowledge, skills and research capacity in nuclear waste management, irrespective of nuclear energy options taken.
3. The implementation of a repository surveillance strategy is suggested as a concerted action for extending the retrievability action.
4. More harmonisation is needed of waste characterisation activities for some types of waste packages The suitability of various available techniques for waste package quality checking should be demonstrated.
5. Safeguarding and monitoring of repository sites with attention to long term operationally sustainable monitoring instrumentation is an important issue for the future and one where co-ordination with the JRC could increase.

6. As all nuclear waste is mixed, chemotoxic aspects should be integrated in a general way thereby giving rise to potential horizontal FP connections
7. Because of the continuing interest in the influence of microbiological activity, it is suggested that the Commission consider setting up a network in this area.

3.2.2 PARTITIONING AND TRANSMUTATION (P&T)

The aim of Partitioning and Transmutation is to separate long lived wastes and transmute them into shorter lived species so as to reduce long term radio-active waste disposal problems. Interest has been renewed during the 1990's in systems to achieve this driven by, for example, the Japanese Omega project started in the late 1980's, the new French law on nuclear waste research in 1991 and the developments in accelerator technology during the 1980's. The motivation of the proponents of P&T has been strengthened by the delays in siting and construction of repositories for spent fuel and/or high level waste. This is reflected in the increase of funding over FP3, 4 and 5. I.e. 4.8-5.8-17.3 MEUR[11] respectively. Such an increase is in line with the recommendations of the previous five years assessment Board. Recent studies in Europe and the USA have shown that the very optimistic claims made by some proponents of P&T in the early 1990's were not justified. The development of a P&T system will take a long time, many decades, and furthermore, will have to be operated for very much longer, perhaps more than a century, in order to substantially reduce the amount of transuranic elements produced by current power reactors (or alternatively reach an equilibrium level of actinides in any new fuel cycle). There are also concerns over the potential radiological impact of P&T systems as these systems involve the active control and destruction of the long lived nuclear wastes and will require the complex recycling of large amounts of very radioactive material. The risks from such an active and complex system have to be compared to the relatively robust system for geological disposal. In addition to the projects supported by DG Research under the FP, a number of projects are funded by the EU (and also jointly by partners) within the ISTC and ISTU[12]. These projects have close informal contacts with FP funded projects.

National programmes in member states dominate the projects within this part of the programme. There is a clear dichotomy of views, some experts question the increase in funding in FP5, whilst others believe that the resources made available are too limited. There is no coherent set of national programmes on P&T in the EU, reflecting mainly the lack of a coherent fuel cycle policy between Member States. The trend away from reprocessing towards a once through cycle is another reason why P&T is less favoured. Despite this there is a strong will to participate in European collaboration. Even organisations fully committed to the once through fuel cycle find it prudent to support limited efforts on research in P&T in order to be able to evaluate the concept and compare it to direct disposal. Likewise, organisations committed to recycling wish to investigate any possible complementary technologies to present reprocessing and recycling systems. There are also pressures brought about by political lobbying for the exploitation of the P&T concept. All of these issues have made it possible to create the current will for a co-operative programme in some of the key research areas in P&T.

This is an area where international co-operation has become widespread, with many partners being involved. This has many advantages, but it has to be recognised that it is also considerably increasing the burden of project co-ordinators.

Work done under the FP4 has yielded some very promising result. In particular, progress has been made in the separation of tri-valent actinides (americium and curium) from

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[11] Note that this is the amount actually awarded in the first call of FP5. The total available is approximately 26 MEUR.

[12] The Institute for Science and Technology (ISTC) was set up in Moscow specifically to help Russian weapons scientists. The ISTU is the corresponding institute for Ukraine.

lanthanides. The results suggest that it may be possible to develop a process with a single cycle allowing direct extraction of the minor actinides from the very acid high level liquid waste from reprocessing. This research is being followed up in FP5.

The projects concerning transmutation in FP5 have a clear tendency towards ADS. However, there have been no projects selected on design and evaluation of transmutation systems, nor on the important topic of the safety features of such systems. Additionally, some research to provide the basis for comparing the radiological risks from alternative P&T is needed. The staff of DG Research is aware of this and this is reflected in the priorities for the second call for proposals.

Although the present focus of the P&T proponents is for a European facility based on an accelerator driven system (ADS), it is not clear to us that this route will be easier than the liquid metal cooled (LMR) fast reactors which were persued so vigorously during the period 1960 - 1985. The clear message from that experience is for caution and a thorough basic development before entering into any large-scale demonstration programme. This should be the aim of near term research and, in that context the FP5 programme objectives and the EU projects awarded in P&T seem reasonably well chosen.

Recommendations.

1. In FP5 P&T is included in the category "Safety of the Fuel Cycle". Recent studies have clearly shown that any successful development will need a long time before any industrial application is possible. Furthermore P&T will not eliminate the need for deep repositories; it will only change the properties of the waste that has to be disposed of. Finally, the transmutation of substantial parts of the waste for the current nuclear power programme would require a very long time indeed. It would therefore seem logical to us that further research on P&T systems should be evaluated and grouped in the category "Safety and Efficiency of Future Systems".
2. Projects concerning conceptual design and evaluation (including safety properties and waste issues taken in the broadest sense) of ADS systems should be given priority in future calls for proposals.
3. The concept of P&T is under development and its technical realisation undergoes frequent changes. Strategic studies of the complex system(s) for P&T need to be done and to be frequently updated to justify and support any long-term efforts.

3.2.3 DECOMMISSIONING OF NUCLEAR INSTALLATIONS

The EC has been conducting research into decommissioning of nuclear installations since 1979. The research may be considered mature and new techniques, for example in innovative remote handling and manipulation have been produced. The previous five years assessment pointed to some of the principal achievements, including particularly the publication of the "Handbook on Decommissioning of Nuclear Installations". However, the research area cannot be considered closed because no commercial nuclear structure has yet been fully dismantled.

The programme in FP4 followed the lines previously suggested, that is of generating data bases for various aspects of the dismantling process (the projects TOOL and COST), the development of a common methodology on decision making strategies and management of nuclear decommissioning projects and the further development of selected innovative cutting techniques (laser, plasma arc and water jet)

The current programme is reduced in size and focuses on transfer of knowledge for future decommissioning projects, the development of common strategies and the maintenance and accessibility of relevant databases. The main European Added Value is seen in speeding up the decommissioning process, maintaining a cutting edge capability in relevant fields via international collaboration and increasing confidence in the EU that decommissioning is well understood and can be tackled economically with minimal radiation risk to workers and the public. One aspect that has not been considered so far is research needs associated with decommissioning many potentially activated installations, such as research accelerators. There may be a large number of these in the Member States that will require attention.

3.2.4 RECOMMENDATION.

The current focus of this small research area is seen as appropriate, and the continued support of networks and data and knowledge sharing is underwritten.

3.3 KEY ACTION 2: SAFETY AND EFFICIENCY OF FUTURE SYSTEMS.

This is a newly identified research area for FP5 with the objectives of assessing new or previously discarded reactor concepts that would offer advantages in terms of safety, economy, sustainability, waste generation and diversion. Relevant work had been undertaken in previous programmes, particularly in severe accident phenomenology and severe accident management. This is reported in section 4.1.2. That work has laid the foundation in terms of the necessary understanding of the physical and chemical processes of severe accidents so that a well-founded appreciation of future designs is now available.

In response to the first call for proposals in FP5 in June 1999, six projects and one concerted action were selected. For the later calls, the EAG has indicated that proposals for state of the art studies of applications of nuclear power other than electricity generation, such as heat production, desalination and hydrogen production, should be sought in order to maintain an overview of current developments. In addition, attention should be given to a more holistic approach to innovative design, integrating licensability and public acceptance at the outset.

There is an issue over projects concerning high temperature gas cooled reactor systems as they dominate the projects already awarded. These systems were vigorously developed through the 1960's and 1970's but then abandoned. There is renewed interest in other parts of the world and developments in technology means that there is a need to re-consider their potential for deployment later on in Europe. However, a full development programme will require a large, fairly long - term effort which seems rather unlikely in the present climate.

Recommendation

The development of evolutionary reactor designs should be driven by commercial considerations. There is a justification and need for common programmes concerning the longer-term development of innovative reactor designs.

3.4 KEY ACTION 2: RADIATION PROTECTION.

The legal basis for radiation protection regulation and research in the European Commission is laid down in the EURATOM Treaty of 1957. In particular it gives the Commission the responsibility to establish uniform "basic standards for the protection of the health of workers and the general public against the dangers arising from ionising radiation and ensure that they are applied". Regarding the research supporting this responsibility the Treaty states it should be a "study of the harmful effects of radiation on living organisms". The Treaty has a very broad coverage and provides the underpinning rationale for the research in this area. The objectives of the Key Action Area are specified as follows. To help operators and regulatory authorities to protect workers and the public during operations in the nuclear fuel cycle, to manage nuclear accidents and radiological emergencies, to restore contaminated environments and to improve competence in this area through training. These are therefore seen as being specifically end user oriented. It is important to note that the generic research in radiological sciences (section 4.5) covers the essential foundations of radiation protection and is fundamental to the activities in the key action area.

3.4.1 RISK ASSESSMENT AND MANAGEMENT

The basic radiation protection principles, such as justification, dose constraints and ALARA assume the establishment of a framework for assessing, managing and optimising safety; that means risk governance for all activities where workers or members of the public are, or might be exposed to ionising radiation. This area covers research projects aimed at underpinning such a framework. A number of computer codes have been developed for predicting the consequences of nuclear accidents and to assist in emergency management. The COSYMA code has been widely distributed inside and outside the EU. Continuing efforts to co-ordinate users' efforts and to maintain the code as state of the art are being made. This widely used code will continue to be supported under FP5 as an accompanying measure. The major RODOS code system is discussed separately under the heading "Off-site emergency management" in section 4.4.3.

It has become clear that a better quantification of risk and risk comparison has had only a limited impact on judgements as to risk acceptability. Social trust is now recognised as a pre-condition for any activity to be considered acceptable. The TRUSTNET concerted action has addressed risk governance through interdisciplinary activities at a European level aimed at understanding social organisation of risk taking and the preconditions for social trust. This work will continue in FP5.

Several social-psychological projects were carried out in the aftermath of the Chernobyl accident but, whilst scientifically very successful, did not help with the practical problems of the affected population in the re-establishment of safe living conditions. The ETHOS project offered an alternative approach to the centralised one, used by the authorities. It requires a strong involvement of the local population in the rehabilitation process; its success may be judged from the fact that the Belarussian authorities are to apply the approach widely. Lessons for Western European conditions are being considered in the EURETHOS project.

3.4.2 MONITORING AND ASSESSMENT OF OCCUPATIONAL EXPOSURE

Optimisation of all types of occupational exposure and dissemination of good ALARA practices within all sectors of the European industry and research involving ionising radiation is an essential part of risk governance. Important results of the work include recommendations on the implementation of ALARA in decommissioning strategies and operations and in the non-nuclear industry and research sector. These recommendations have resulted in specific actions in DG Environment, e.g. the organisation of workshops on "Good Radiation Protection Practices in Industry and Research" and on "Managing Internal Exposure". The ALARA-Newsletter has proven to be a very useful way to disseminate practical information and needs to be continued in future eventhough funds for it have not been identified in FP5.

3.4.3 OFF-SITE EMERGENCY MANAGEMENT

Experience gained after the Chernobyl accident clearly demonstrated the importance of improving administrative, organisational and technical emergency management arrangements in Europe. A lack of coherence contributed to the loss of public confidence. A key element in the research support to this EC need has been the development of the RODOS (Real Time On-line Decision Support for off-site emergency management) project. This has been under development for some time and the first pilot version for test operation was issued at the end of FP3. It has been further developed during FP4 to the point where it can now be implemented for operational use. 40 institutes from 20 countries in the East and the West have been involved in the project and some countries have already decided to install RODOS as a decision support tool in their national emergency centres.

RODOS offers a platform to share the development of a comprehensive decision support system applicable across Europe. It is vital that the users are fully involved in future development of the overall scheme, as well as individual components. It is important to note here that the users are likely to be experts on radiation safety related matters and not the real end-users, i.e. authorities and political decision-makers. The needs and expectations of these real end-users need more attention in future by means of e.g. exercises. There is also a need to ensure that the radioecology research community is involved in particular in the requirements for long term countermeasures.

For FP5 three projects have been approved; better decision support tools, better methods for assimilating information and handling uncertainty and managing disparate forecasts of medium/long range atmospheric dispersion. Economic and social questions still need more attention, as do environmental monitoring strategies that have not yet received sufficient attention.

3.4.4 RESTORATION AND LONG-TERM MANAGEMENT OF CONTAMINATED ENVIRONMENTS.

Much of the R&D in FP4 was conceived under the influence of Chernobyl and other situations of radiological significance in the former Soviet Union. It complements activities by DG Environment and work funded under the TACIS and PHARE programmes.

Radioecological research has been utilised more effectively in studies on restoration of radioactive contaminated areas than in the off-site emergency preparedness area above. Models have been developed to identify areas with high radio-caesium transfer because of specific uses of the environment. The emphasis in the projects has been varied; for example covering the self-help capacity of affected populations (RESTORE) and environmental and socio-economic responses to counter measures (CESER). The development of more holistic countermeasures strategies has made significant progress by integrating many aspects into the countermeasures selection process. Multi-attribute utility analysis has been used to rank restoration options at contaminated sites (RESRTAT) and additionally research has helped develop a management tool to assist decision making for restoration strategies for a range of urban, agricultural, semi-natural and forest environments taking into account the secondary effects and the produced waste (TEMAS). The further development of the model depends on the progress in radioecology, dosimetry and technical information on countermeasures. There is now a need to synthesise all relevant EC and national information for use in guides and supporting documents, and develop the models to be of more direct support to the decision-makers.

Recommendations

1. Global risk governance i.e. how to cope with different types of risk simultaneously, will continue to be important.
2. The handling of social and economic factors and innovative management techniques in decision-making processes needs further development and in particular to crisis management.
3. Monitoring, operational dosimetry, optimisation (ALARA) and case studies of internal exposure need more attention both in nuclear fuel cycle facilities (e.g. decommissioning), and in other industries such as those using Naturally Occurring Radioactive Materials (NORM), the radio-pharmaceutical industry and nuclear medicine services in hospitals.

3.5 GENERIC RESEARCH IN RADIOLOGICAL SCIENCES

3.5.1 RADIATION PROTECTION AND HEALTH

Estimates of the risks from exposure to ionising radiation are the basis of all radiation protection and they have to cover the extremely wide range of radiation types and exposure conditions in the natural environment, the workplace and the clinic to be of practical value.

Cancers and heredity effects have been studied in both FP3 and FP4. The emphasis in FP4 has been given to the development of a coherent approach combining the biophysics of energy deposition and induction of damage in DNA with the molecular biological investigation of the process involved in the repair of DNA damage. It also includes the cellular effects that mis-repair can cause and molecular biological analysis of the early events leading to the induction of cancer. This has given a deeper understanding of the mechanisms by which radiation exposure leads to the induction of cancer, and particularly to pre-disposition. As a final step the development of mechanistic models of the carcinogenesis process will be used to interpret epidemiological data.

Progress has also been made in the field of hereditary risk estimation as the result of the incorporation of advances in human molecular biology into the framework of genetic risk estimation.

Recent developments in gene research, molecular biology, irradiation techniques (single cell irradiation by soft energy microbeams without disturbing surrounding cells) and computer modelling provide exciting new possibilities to improve our knowledge of the dose-effect relationship at low doses where neither direct measurements nor epidemiological studies are applicable. More attention was paid to the promotion phase of the cancer process, where the role of suppresser genes in between two mutational steps was confirmed by molecular biology.

Understanding the mechanisms and modelling of the entire path from exposure to carcinogenesis has been developing fast and the models now have a good biological basis. Quantitative data suitable for modelling have been provided. Integration of experimental radiobiological work and theoretical approaches to develop mechanistic models of carcinogenesis has been successful. The experimental studies on the mechanisms underlying variation in DNA damage response and tumorigenic development were well represented in the FP4.

The post-radiotherapy second cancers in some inbred human populations were identified as a principal source of concern regarding genetic susceptibility. In particular, high dose medical irradiation at young ages may pose the greatest risk to such genetic cases. The question of the need for genetic testing for cancer susceptibility in the context of occupational exposures has also risen. The acquisition of knowledge on genetically determined radiation risk will be of significant importance in the further development of radiological protection standards. The whole area of DNA damage response and genetic susceptibility to radiation needs to continue in FP5.

New information on the neutron dose to the Japanese survivors has been obtained; specifically a possible underestimation of the neutron doses in the low dose region. The expected resolution of the neutron contribution to dose in Hiroshima is of crucial importance for radiation risk estimates and assessment of the current LNT (Linear-Non-Threshold)-model.

A better understanding of the mechanisms of radiation action at low doses and dose rates has been achieved through comprehensive mechanistic models for the induction by radiation of somatic late effects. The ultimate aim of these mechanistic models is to serve as a basis for extrapolation of epidemiological data to low doses and dose rates. The models are very promising for mechanistic understanding and improved dose extrapolation methods.

Important studies on childhood thyroid cancer were started in FP3 and this underlines the essential elements of continuity which characterise this area, especially as there is a need for follow up studies which will have to be organised 15 years after the exposure. This of course is provided that the material continues to be available.

The bone marrow transplantation approach that was unsuccessful in previous accidents is being replaced by methods currently under further development which involve growth factor treatment to facilitate the reconstitution of blood cell production and immune functions. It was demonstrated in these studies that thrombopoietin, if immediately administered, strongly counteracts radiation induced bone marrow damage by promoting reconstitution of immature stem cells and their direct progeny thereby making possible the response to other growth factors, and prevent profound thrombocytopenia and anaemia.

In FP5 the attention remains essentially focused on cancer. Five projects are funded concerning induction and repair of DNA damage, five projects addressing health effects of genome damage and predisposition to cancer and four projects addressing epidemiology and modelling of cancer.

Communication between researchers and the Article 31 group at joint seminars is welcomed and should be further developed as an excellent possibility of two-way communication. During the past ten years Europe, thanks to EC programmes has became the leader in many sections of basic radiological research with effective communication to the ICRP.

Well co-ordinated research groups and naturally grown networks were of great value for the effectiveness of the research in this area. Co-operation with the general health area in quality of life programmes could be beneficial. However, the type of co-operation and the benefits need to be carefully evaluated first.

Typical of this area of research presently is the very high speed of progress and therefore intense competition, so a rigid idea of concentrating all research in ”centres of excellence” may not be productive if the need of extremely expensive facilities does not require it.

3.5.2 ENVIRONMENTAL TRANSFER OF RADIOACTIVE MATERIAL

The strong impact of the special Chernobyl projects on the radioecological research in the regular FP3 programme highlighted the need to solve practical problems. In addition the complexity of the contamination situation forced the research groups into more interdisciplinary activities. It also showed that socio-economic and ecological consequences had to be considered alongside the radiological aspects.

Projects (e.g. PEACE, SAVE, SEMINAT, LANDSCAPE, ARMARA) dealing with the dynamics and migration of radionuclides, mainly caesium and strontium, and ecological models in different types of environments including agricultural, semi-natural, fresh water and Arctic marine environments, have been progressing well. Special success stories have been the models of radionuclide transfer from various types of soil to plants, based on deposition and soil characteristics, including soil solutions. The ability to model the dominating processes facilitates the prediction of caesium flux in an accident situation.

For FP5 two projects were approved concerning radionuclide behaviour in soils and one concerning aquatic ecosystems, namely re-mobilisation processes in marine sediments. Co-operation between modellers and experimentalists has been good, for example in the successful work on fresh water modelling (ECOPRAC, MOIRA). The overall objective of this work is the development of a mechanistically based, generally applicable whole-ecosystem model that can be applied in support of chemical and hydrological countermeasures mainly concerning caesium contamination.

Radioecology is moving more and more towards modelling the phenomena and the entire ecosystems. It is essential that models (and parameter values) are adapted to the local conditions and tested in the types of environments where they are expected to be used. The national end-users have to develop confidence in the models. The experience from the Chernobyl accident was not only the lack of models, but also the use of inappropriate models, e.g. not considering the impact of rainfall.

Notwithstanding the successes in the programme, a holistic approach to environmental radiation protection is still lacking. Other environmental non-nuclear contaminants, such as heavy metals, can be present together with radionuclides. Furthermore, only limited attention has been paid to NORM and no attention has yet been paid to the impact of radiation on other organisms. On the latter, it is important to be prepared to find a reasonable solution for the present social requirements to be able to demonstrate that other species, not only man, are sufficiently protected against ionising radiation. In FP5 one project has now been accepted for funding, that addresses the protection of non-human species.

It is essential in the future to synthesise the information gained in the Chernobyl and related radioecological studies and make it generally available. All of the end-user groups need to be taken into account carefully while making syntheses of the results and guidance based on them.

Experimental and field studies in radioecology are the best way to maintain preparedness in know how and measuring capabilities for accidental situations.

3.5.3 INDUSTRIAL AND MEDICAL USES AND NATURAL SOURCES OF RADIATION

FP4 focussed on medical uses and natural radiation; the industrial use was restricted to nuclear energy. The Basic Safety Standards require application in the non-nuclear energy sector where significant radiation protection issues occur. An example of this is in phosphate industry. However no projects have covered this topic to date. The Patient Directive 97/43/EURATOM legally requires the use of optimisation in diagnostic radiology. The work in the recent programmes has concentrated successfully on optimisation in radiography (intervention radiography (IR), paediatrics, Computer Assisted Tomography (CT), and fluoroscopy) as well as addressing image quality criteria.

The population is exposed to higher levels of exposure from medical radiology than from any other man-made source of ionising radiation. The revised EC Patient Directive introduces a number of new and extremely relevant requirements into the legal framework of radiation protection of persons who undergo medical exposures. As children are substantially more sensitive to adverse effects of radiation than adults a number of studies were carried out in order to develop guidance on paediatric radiology which resulted in European Guidelines on Quality Criteria for Diagnostic Radiographic Images in Paediatrics. These included both patient dose and image quality criteria. Also Quality Criteria for Computed Tomography were developed for adults in a previous FP but not for children. The work continued in FP4 by extending the quality criteria to a selection of common fluoroscopic and CT examinations on children and provided a practical methodology for defining image quality and patient dose criteria. Two draft quality criteria documents have been prepared which could be used as draft working documents and further developed into more complete European Guidelines in the FP5.

Computed Tomography is contributing up to 40% of the collective effective dose from diagnostic radiology in some EU countries and use of it is expanding. Therefore, a revised version of European Guidelines on Quality Criteria for Computed Tomography has been developed and delivered to the EC for printing. Funds for publication of some guidelines has been a problem and needs to be solved in future in order to fully exploit the results.

New devices and developments in interventional radiology and vascular brachytherapy tend on the one hand to increasing radiation doses, and yet on the other imaging is faster. Therefore it is important to continue efforts at optimisation. An important conclusion is that improved risk-related dose quantities are required for routine application in diagnostic radiology.

Only two projects were accepted for funding in FP5 on medical applications, one concerning clinical requirements for x-ray imaging and another to underpin the Patient Exposure Directive in relation to justification, optimisation and reference levels. In addition one concerted action on optimisation of CT practices was approved.

Radon is the largest contributor to the radiation dose to the public. However, the question of risk from in-door exposure to radon has not yet been resolved. The basis for current risk estimates are from underground miners and these are obtained in conditions very different from those in dwellings. Pooling of European and USA epidemiological studies in dwellings is important. In FP3 and FP4, extensive studies were carried out with good results in lung modelling, aerosol behaviour, retrospective dosimetry, epidemiology and intercomparison of passive radon detectors as well as techniques for reduction of radon exposure. It is important that the work on radon risk is continued in FP5 and beyond to find a satisfactory solution. And we note that in FP5 only a conference was approved. However, the identified need for further work concerning radon risks should not be allowed to delay European policy decisions on protection against radon.

3.5.4 INTERNAL AND EXTERNAL DOSIMETRY.

Radiation protection and the effective use of radiation in medical applications requires the capability to accurately quantify the characteristics and extent of radiation exposure so that appropriate assessments of the potential health consequences and risks can be formulated. The International Commission on Radiation Units and Measurements (ICRU) is making international recommendations on these quantities and how to deal with various measuring problems. The work is partially based on EC projects on these subjects. During FP4 work has covered dosimetry of external beta rays, conversion coefficients for photons, neutrons and electrons, proton dosimetry and nuclear data for neutron and proton beam therapy etc.

Assessment of the radiation doses and risks associated with exposure to air born radionuclides requires quantitative information on the deposition of inhaled material in each region of the human respiratory tract and on the pathways of clearance. The ICRP Human Respiratory Track Model (HRTM) has been used to calculate dose coefficients for inhalation of radionuclides that have been adopted into the BSS Directive. However, important uncertainties remained in the assumptions made in the HRTM and this work continued in the FP4 and will have to continue in the future. In FP4 specific progress was made e.g. regarding the particle deposition in the lungs and the clearance from the respiratory tract.

An extensive database of dose coefficients was published to meet the demands of health physics practitioners and researchers in radiological protection and the database was adopted by ICRP.

Computer codes have been developed to calculate bioassay data for acute and chronic exposures for the use in assessing intakes. Because of the free movement of people in Europe it is important to have a common standard for monitoring with personal dosimeters and monitoring for internal doses, as well as the same requirements defined by the BSS Directive and Patient Directive.

To improve the dosimetry of low energy photon radiation, beta radiation and mixed photon and neutron fields several new dosimeters were developed either to prototype or to commercial level. A real breakthrough was achieved in mixed neutron detection that has important commercial possibilities (proportional counters and cheap solid state pin diodes), although the size of the potential market is small.

The implementation of BSS to air crew exposed to cosmic radiation (which is specified as occupational exposure), posed a practical radiation protection problem because of the complex radiation field. This work has been a good example of multidisciplinary co-operation that resulted in a practical solution for worker dose control in the implementation of the BSS. This work will continue in FP5 addressing the exposure of aircrews during solar maxima.

Recommendations.

1. Quantification of radiation effects is still of vital importance and therefore requires a continuing research effort.
2. Genome projects, involving both human and animal studies, genetic susceptibility in particular in high dose areas and epidemiological studies with appropriate available groups should continue.
3. Possible fingerprints of the origin of cancer cells would be valuable.
4. Existing exposed groups e.g. for thyroid cancer need to be followed for sufficient time.

   Retrospective dosimetry should be improved in order that epidemiology can be successfully interpreted.
5. The concept of dose as a means of reflecting risk is not ideal, and efforts need to be made to improve the concept and the measuring instrumentation accordingly.
6. A holistic approach to environmental protection is still missing and needs further work to cover both non-human species and non-nuclear and nuclear contaminants in the same framework.
7. Societies' expectation for further reductions in the releases of radionuclides into the environment requires a balance between various aspects (health protection, technical, social, economic, and different sectors of the environment) in order not to do more harm than good. Preparing for the implementation of the OSPAR (Oslo-Paris) convention is one such example.
8. Co-operation with the general health area in quality of life could be beneficial as long as potential contributions can identify added value.
9. In the medical field optimisation of exposure of patients and medical staff should be developed in order to reduce risk, in particular with relation to new technical developments.

3.6 KEY ACTION 2: SUPPORT FOR RESEARCH INFRASTRUCTURE.

This is a new activity in FP5. Its objectives are to enhance access to and improve the consistency of the nuclear research fabric within the Community so that optimal use can be made of the available resources to the competitive advantage of European industry, and to continue ensuring the safe and acceptable exploitation of nuclear technologies. Three priority areas are identified in the programme: large scale facilities, networking and databases and tissue banks.

Proposals so far received have focused solely on networking and data bases/tissue banks. The absence of proposals on access to large-scale facilities was surprising but was probably a result of this topic not having featured in previous Euratom programmes (albeit featuring in previous EC programmes). With the maturity of nuclear energy and its limited market prospects, many large scale nuclear research facilities are being decommissioned, both in Europe and elsewhere; access to those remaining will, therefore, become increasingly important and this topic should be given greater prominence.

Networking remains a key feature of the programme. A better distinction needs, to be made between networking generally (i.e., thematic networks) and that under the section of the programme concerned with support for research infrastructure; this was a source of some confusion in the first calls for FP5. The importance of effective networking for the success of the programme as a whole cannot be over-stated and its role and importance should, therefore be reinforced. In particular it should be aimed at:

- providing better co-ordination of Commission and nationally sponsored research and training
- promoting more effective collaboration and feedback between the research and user (industry and regulatory authorities) communities
- achieving consensus or convergence of views on key issues with industrial, public acceptance and/or European policy implications
- strengthening and stimulating an efficient European nuclear research infrastructure
- exploiting strategic research carried out in Europe
- promoting more effective cross-discipline research
- providing better access to and making more effective use of important or unique nuclear facilities

The scope and nature of networks supported by the programme will, however, be largely determined by what is proposed by the research community. This may be insufficient, in either scope or content, to secure the programme objectives. In these cases, the Commission Services may need to be more pro-active (without, however, compromising the principle of equity of opportunity for those making proposals) and take additional steps to achieve the required level and quality of networking. This may take various forms. At an informal level, potentially interested organisations or groups of organisations may be encouraged to take initiatives in a particular area or areas; in some cases a more formal approach may be needed, for example a dedicated call for networking in particular areas or networking of particular types.

Recommendations:

1. To give greater prominence to this part of FP5.
2. Networking is a potentially important future direction for Commission activities. It should be followed up vigorously, but with the specific requirements of thematic and facility based networks clarified. The Commission staff should be more pro-active in both explaining the rationale for networks and in kick-starting particular networks.

4 The current situation concerning FP5

In the specific programme nuclear fission safety, the objectives are very broad and as we have shown in the introduction have not changed significantly for some years. We can therefore say that some objectives are still relevant even if not all of them can be addressed by a programme that is resource limited. The current position for FP5 is that a first set of calls was made in June and October 1999 and about 60% of the funding for the whole programme was utilised. As a result some 130 projects have been selected. Two further calls are envisaged (January 2001 and 2002). This allows for a reorientation of the programme in response to analysis of the responses to the first call (i.e. how well they covered the objectives of the programme), and to take into account recent S&T developments and social demands.

The response to the first call was patchy. As we have said, the change in structure has lead to some confusion, and the research community did not properly understand the inclusion of new actions such as Support to Research Infrastructure. Not surprisingly, responses in those areas were disappointing. In radiation protection particularly the split between key action and generic Research caused considerable problems which were exacerbated by staff reductions. However, we welcome that many of these issues have been picked up by the EAG in its review of the work programme for the second call.

5 Recommendations from the previous 5 years assessment.

The previous assessment made a number of recommendations, both general (10 in all) and in the specific Research areas (27 in all). We cover the specific Research areas in the relevant sections above, and here give some overall observations concerning the previous recommendations.

In general terms, the previous recommendations are reflected in the way in which FP5 was developed. This is certainly true for the detailed scientific aspects. It is clear that many important questions have been brought close to their solution and that FP5 is providing a closure pathway in many cases. It is also clear that the "problem solving" nature of the research characterising FP5 goes a long way to implementing the previous recommendations in this context. The involvement of other end users, such as DG's Environment and Energy is an on-going requirement

The question of closure criteria, however, remains. This Board believes that closure criteria should be treated with caution, as they vary from discipline to discipline and each aspect should be judged on its merits and on the prevailing situation of the research in that field at the time.

It is recognised that scientific quality must remain a priority, given, of course, that it must be paralleled by fully professional project management and leadership. The Annual Monitoring Reports have continued to emphasise this point. The new arrangements for evaluating proposals against scientific quality as well as programme objectives are an important contribution to this continuing quest for scientific excellence.

The relationship between the SP "nuclear fission" and the research activities carried out in the same field by the JRCs has remained opaque. This too has been reflected in the

Annual Monitoring reports from the intervening years. There are some indications that changes in structure in DG Research and the overall management of the JRCs are leading to greater transparency, but the Board believes that much more is needed to be able to demonstrate that obvious co-ordination and common goals are well established. The recent closure of the FARO facility is a case in point. The new JRC in Seville should be encouraged to take up technical developments relevant to this SP and in addition it could assist DG Research in implementing the social and economic aspects of the programme.

The recommendation to make greater use of association agreements has been overtaken by the decision that they are no longer allowed. This does not detract from the spirit of the recommendation and we recommend a greater devolution of authority (technical and financial) to project co-ordinators, especially in the light of many concerns expressed to us about the shortage of manpower in DG Research.

The continuation of 100% funding for Universities and Hospitals has been achieved, but the whole question of the level of contribution from EU funds needs to be reconsidered in the light of the principles espoused in the "European Research Area" concept. The use of concerted actions as a means of both information gathering and strategic planning by DG Research staff is to be encouraged.

The recommendation on the need to peer review periodic reports has not been implemented and we make our own recommendations concerning review and "valorisation" of projects both during their implementation and post-job.

The need to pay particular attention to dissemination and communication is well recognised by DG staff, nevertheless, whilst scientific dissemination is generally excellent, communicating the value and context of the work to decision-makers and the public is less so. It needs to be recognised that communicating sometimes difficult scientific and technical research results to non-technical recipients is a professional task and some fraction of the resources should be made available to "add value" to work done by making it more accessible.

Greater co-operation is being achieved with high level scientific institutions outside the EU, principally through the internationalisation of large-scale projects. In some areas this could be improved, and in particular, a better-formalised relationship with the USA in radiation protection and waste management would be valuable. Many EU Member States and EU funded experimental facilities are identified in the recent OECD/NEA study on Safety Research facilities and capabilities worldwide (SESAR/FAP). Interaction with CEEC countries is now assured through the many activities associated with accession.

6 Overall Conclusions and Recommendations

This section summarises the overall conclusions and recommendations of the Board. Detailed conclusions and recommendations concerning the individual topic areas are given at the end of the respective sections.

1. The overall objectives of the Commissions Specific Programme of Research and Training in "Nuclear Fission" have been met by the programmes implemented in the FP3 and FP4 and are likely to be met by the current programme FP5. The evolution of these programmes has shown that the research performed has been flexible enough to respond to changing needs, whilst at the same time providing a degree of continuity and support for research efforts requiring time to deliver results. However we must say that the trend of reducing support to these

programmes during the period covered has put constraints on its capability to meet all of the objectives. In conclusion, we believe that a forward programme of Research into FP6 and beyond would be cost effective and a prudent investment given the overall objectives of Commission funded research.

2. The fact that radiation protection is covered by two separate parts of the programme caused confusion. We therefore suggest that Radiation Protection be grouped with Generic Research in Radiological Sciences separately from Nuclear Fission.
3. To improve the coherence and effectiveness of the programme in future it is necessary to develop a "vision" for European Research in the SP of Nuclear Fission and Radiological Sciences, and to back this up with a strategic approach which is transparent and widely supported by the technical community and decision makers. The staff of DG Research should be given a much more pro-active role in developing and implementing such a strategy. Calls for proposals in future should strongly reflect the needs of research to implement that strategy.
4. We recommend that the needs for training (in the broadest sense) should be given a higher priority in future. This should begin with a clear statement of the strategic aims of such activities. The well being and safety of the nuclear activities in Europe depend upon a continuing supply of well-trained and highly motivated scientist and technologists.
5. The Board supports the concept of "European Centres of Excellence". These should be identified in the areas of competence of the nuclear fission specific programme and, wherever appropriate, should build on existing centres in EU Member States (including Applicant Countries). However, it may have serious drawbacks in building monopolies, reducing competition and possibly reducing national interests in financing research. The concept must, therefore be implemented with great caution and only in specific areas where the advantages clearly dominate.
6. The creation and support of networks as a means of increasing co-operation and dissemination of information is strongly encouraged. It has already been successfully implemented in a number of areas of the programme with good effect.
7. The Advisory Committees (STC, CCE and EAG) each have their place, but more needs to be done to encourage communication between them and to optimise the use of the large pool of experience and knowledge available through them.
8. A number of new research tools have been developed in this specific programme which are either clearly more widely useful, or have even been developed in parallel elsewhere. DG Research should first identify common areas of Commission funded programmes and second, perhaps by sub-contracting, ascertain more widely distributed opportunities. A policy of "joined up research" should be an important aim for the future.
9. Continued vigilance is required to maintain the current often generally excellent dissemination of results in the scientific community. Communicating the value of the research, and its context in supporting Commission objectives is a job for professional communicators and more use needs to be made of them in getting the message to decision-makers and the public.
10. Where large projects are let, the project co-ordinators need to be given clearly defined responsibilities and sufficient freedom and resources to manage them, subject to an appropriate level of audit.
11. Insufficient attention is given to post job evaluation and to the consolidation of research output into a coherent body of information supporting end users in the

field. In addition, a larger fraction of resources should be devoted to the storage/data banking and general husbanding of hard won research results.

12. We recognise that this research programme is paid for by taxpayers in the Union and that in consequence it must be subjected to audit and scrutiny. However, we believe that there is a significant danger of "assessment overload". The advisory committees review progress and strategy, there is an annual monitoring activity and this 5-year assessment. In addition, there are numerous scientific and technical evaluations available in the different areas. It would be reassuring to see an assessment of the system of reviews, perhaps conducted by the STC to ensure that the most efficient process is undertaken.
13. Further Research on P&T-systems should be evaluated and grouped in the category "Safety and efficiency of Future Systems".
14. A common theme emerging from many of the research areas is risk governance, That is how to manage activities where the overall risk is made up of contributions from many factors, including both technical and social. Developing an understanding of such complex systems is not limited to nuclear activities and we recommend that very broad inter and multi disciplinary studies are undertaken by the Commission as a horizontal activity.

ANNEX 1

Terms of Reference

ANNEX 2

Conversion Table for FP4 to FP5

. The panel is requested to comment on the outputs of the previous programmes, but in the structure of FP5. Therefore we have used the following table to show the link between the programme headings of FP4 and FP5 in Nuclear Fission Safety. We have not attempted to include headings from FP3 as these have already been subsumed into the FP4 format.

FP5 Key Actions	**FP4 Programme Areas**
Operational safety of existing installations. 1. Plant life extension 2. Severe accident management 3. Evolutionarily concepts.	A. Exploring innovative Approaches Conceptual reactor safety features B. Reactor Safety In-vessel core degradation and coolability Ex-vessel corium behaviour and coolability Source term Containment performance Energetic containment threats
Safety of the fuel Cycle Waste and spent fuel management and disposal Partitioning and transmutation Decommissioning of nuclear installations	A. Exploring innovative Approaches Partitioning and transmutation C. Radioactive Waste management and Disposal and Decommissioning Safety aspects of waste disposal Underground research laboratories Research on basic phenomena Decommissioning of nuclear installations.
Safety and Efficiency of future systems 1. Innovative systems 2. Revisited systems	A. Exploring Innovative Approaches Partitioning and Transmutation
Radiation Protection 1. Risk assessment and management 2. Monitoring and assessment of occupational exposure 3. Off-site emergency management 4. Restoration and long-term management of contaminated environments.	D. In part E. Mastering Events of the Past Recognition and amelioration of health effects Restoration of severely contaminated territories Management and disposal of radioactive waste Emergency management approaches Data management Public information.
Generic Research in Radiological Sciences	**FP4 Programme Areas**

1. Radiation protection and health 2. Environmental transfer of radioactive material 3. Industrial and medical uses and natural sources of radiation 4. Internal and external dosimetry.	D Radiological Impact on Man and the Environment Understanding radiation mechanisms and epidemiology Evaluation of radiation risks Reduction of exposures. E. In part
Support for Research Infrastructure	**No equivalent in FP4**

Table showing the relationship between the key action areas of FP5 and the programme areas of FP4. It is difficult to give a one to one correlation for all of these areas, but the ongoing themes of the research are seen to be maintained, even though the structure of the programme is different.

ANNEX 3

Evolution of Programme Objectives from FP3 - 4 - 5

Framework Programme	Summary of basic objectives.
FP3 (1990-1994)	The aim of this section (nuclear fission safety) is to continue the common endeavour to support Member States in the fulfilment of their responsibilities for regulating and protecting the environment. Community action will foster a harmonised approach to safety by bringing together all the parties involved, this reinforcing the prenormative dimension of research. A new impulse will be given by concentrating research on reactor safety with greater attention to passive technologies, radioactive waste management, decommissioning operations, intervention in a hostile environment, fuel elements, actinides and control of fissile materials. Radiation protection research will cover radiation from natural and medical sources, a better definition of the risks of low radiation doses and new technologies to assess quickly the radiological consequences of nuclear accidents.
FP4 (1994-1998)	The objective is to ensure the safety of all nuclear activities whatever they are, the production of electricity from fission, the use of radioactivity or ionising radiation, or the presence of natural radioactivity. In spite of the progress achieved by the electricity industry, the accident at Chernobyl has highlighted the need for research on specific topics in collaboration with the nuclear safety community in central and eastern Europe. It is necessary to consolidate the nuclear option by showing our ability to control in all areas of application. This demonstration of a full nuclear safety capability will be made through four priority areas; • The development of a dynamic approach to nuclear safety contributing to the consolidation of a safety culture on a world scale. • The joint use of the large European facilities to arrive at a better understanding of the crucial phenomena linked to the nuclear fuel cycle and waste. • Pursuing the development of nuclear safeguard techniques. • The integration of radiological protection into a global system for the protection of man and the environment.
FP5 (1998-2002)	To enhance the safety of Europe's nuclear installations, to improve the competitiveness of Europe's industry, to ensure the protection of workers and the public from radiation and to help solve waste management and disposal problems. To consolidate and advance, through generic research, European knowledge and competence in several areas concerning radiological protection and health.

ANNEX 4

Summary of Basic Objectives of FP 5 Specific Area: Nuclear Fission and Generic Research in Radiological Sciences

FP5 Key Action 2	**Summary of basic objectives**
Operational Safety of Existing Installations	To provide improved and innovative tools and methods for maintaining and enhancing the safety of existing installations, for achieving evolutionary improvements in their design and operation and for improving the competitiveness of Europe's nuclear industry.
Safety of the Fuel Cycle	To develop a sound basis for policy choices on the management and disposal of spent fuel and high-level and long lived radioactive wastes and on decommissioning and to build a common understanding and consensus on the key issues.
Safety and Efficiency of Future Systems	Investigate and evaluate new or revisited concepts for nuclear energy that offer potential longer term benefits in terms of cost, safety, waste management, use of fissile materials, less risk of diversion and sustainability.
Radiation Protection	To help operators and safety authorities to protect workers, the public and the environment during operations in the nuclear fuel cycle, to manage nuclear accidents and radiological emergencies and to restore contaminated environments.
Support for Research Infrastructure	To make optimal use of, enhance access to and improve the consistency of the European research fabric of infrastructures (large facilities, networks of distributed facilities, infrastructural centres of competence) to the extent that such measures are not undertaken by other aspects of the framework programme. To this end, measures are envisaged to help researchers with trans-national access to infrastructures that are of Community wide interest on account of their rarity and/or specialisation.
Generic Research in Radiological Sciences	The emphasis is on understanding and awareness of the hazards related to ionising radiation and radioactivity. More especially the effects of low-dose radiation, particularly on humans, and including epidemiology studies. On the environmental transfer of radioactivity, enhancing the safety and efficacy of medical and industrial uses of radiation and better assessment of exposures from sources of natural radiation, and to improvements in internal and external dosimetry.

ANNEX 5

Overall trends in funding from FP3 to FP4 to FP5

Topic Area	FP3 (89-94)	FP4 (94-98)	FP5 (98-02)
Operational safety of existing installations.	15.3	42.4	37.0
Safety of the Fuel Cycle			
Waste Management	71.7	32.5	31.0
Partitioning and Transmutation	4.8	5.8	26.0
Decommissioning	39.6	3.7	2.0
Teleman Project	23.9	-	-
Safety and Efficiency of Future Systems	-	4.8	12.0
Radiation Protection and Generic Research in Radiological sciences	62.4	57.0	49.0
Support to Infrastructure	-	-	9.0
Total	217.7	146.2	166.0

Note that these figures are derived from information from the various programmes that are made on different bases due to changes in the structure of the programme. In particular we should note

1. Reactor safety includes 13 MEuro for the PHEBUS experiment in FP4, even though this was administered through the JRC programme. In FP5 this is 4 MEuro.
2. Partitioning and transmutation is included in innovative approaches in FP4 and in Safety of the Fuel Cycle in FP5. In FP5 this amounts to 26 MEuro. This means that the trend in funding for this area over the three programmes has been 116.1 - 37.2 - 31.0 MEuro. This includes decommissioning activities that were previously identified separately.
3. Not included here are 23 MEuro for Radiation Protection projects directly related to the Chernobyl accident, which were outside the framework programmes.
4. In FP 4, there has been some funding of researchers in the from the INCO-COPERNICUS programme of about 9 MEuro.

ANNEX 6

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[13] Note, not all members of the panel have read all of the referenced documents. In addition to the documents referenced, many summaries of final reports and project descriptions were received.

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In addition to the reports distributed to the entire Panel, 63 summaries of final reports and publications were received on Radiation Protection matters:

ANNEX 7

List of Experts interviewed by the Assessment Panel

L.Baetsle	Chairman OECD/NEA Expert group on P&T 1996-1998	Belgium
G.Colard	SCK.CEN, Mol	Belgium
C. Desaintes	SCK.CEN	Belgium
P. Jacquet	SCK.CEN	Belgium
J.Marivoet	SCK.CEN	Belgium
B.Neerdael	SCK.CEN	Belgium
S. Pilate	Belgonucleaire/EDF	Belgium/France
A. Poffijn	RUG/DBIS	Belgium
M.Put	SCK.CEN	Belgium
P. De Saint-Georges	SCK.CEN	Belgium
P. Van Iseghem	SCK.CEN	Belgium
H. Vandenhove	SCK.CEN	Belgium
Mr. Vanmarcke	SCK.CEN	Belgium
G. Volckaert	SCK.CEN	Belgium
A. Wambersie	UCL Woluwe. ICRU	Belgium
H. Zeevaert	SEK.CEN, Mol	Belgium
M. Annanmaki	STUK	Finland
L. Mattila	VTT	Finland
T. Jaakkola	University of Helsinki	Finland
T. Rahola	STUK	Finland
K. Sinkko	STUK	Finland
M. Tapiovaara	STUK	Finland
H. Tuomisto	FORTUM, Vantaa	Finland
T. Turtiainen	STUK	Finland
B. Wahlstrom	VTT	Finland
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H. Boussier	CEA, Marcoule	France
Mr. Brechignac	IPSN	France
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C. Broeders	FZK	Germany
T. Bucherl	Technical University of Munich	Germany
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Mr. Harrison	GSF	Germany
Mr. Heidenreich	GSF	Germany
E. Hicken	FZJ Julich	Germany
Mr. Jacob	GSF	Germany
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R. Storck	GRS	Germany
W. Von Lensa	FZJ. Julich	Germany
Mr. Verner	GSF	Germany
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V. Frid	SKI	Sweden
W. Gudowski	RIT Stockholm	Sweden
O Olsson	SKB	Sweden
B, Raj Sehgal	RIT Stockholm	Sweden
C Svemar	SKB	Sweden
P. Wikberg	SKB	Sweden
B. Bowsher	AEA Technology Winfrith	UK
R. Clarke	NRPB Chilton , Chairman ICRP	UK
R.Cox	NRPB Chilton	UK
A. Edwards	NRPB Chilton	UK
M. Gardiner	AEA Technology Harwell	UK
D. Lloyd	NRPB Chilton	UK
J.C.H. Miles	NRPB Chilton	UK
C. Muirhead	NRPB Chilton	UK
D. Pooley	Former Chairman STC	UK
W. Rodwell	AEA Technology Harwell	UK
J. Simmonds	NRPB Chilton	UK
B. Stather	NRPB Chilton	UK
B. Wall	NRPB Chilton	UK
M. Williams	AEA Technology Harwell	UK
W. Kickmaier	NAGRA	Switzerland
P. Zuidema	NAGRA	Switzerland

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R. Konings	JRC-ITU
J. Magill	JRC-ITU
B.Sätmark	JRC-ITU
R. Schenkel	JRC-ITU

ANNEX 8

Panel Members

Panel Member	**Background**
Louis Patarin. Chairman	Former R&D Director COGEMA. Former Director Chemistry Division CEA. Professor, National Institute for Nuclear sciences and Techniques.
Michael R Hayns. Rapporteur and Reactor Safety	Formally Director Advanced Systems and Safety. AEA Technology Formally POWERGEN Professor Aston University. Visiting Professor University College London Former Chairman CGC5 (CCE) Member of the External Advisory Group on Nuclear Fission Safety.
Anneli Salo. Radiation Protection	Formerly Director of the Surveillance Department STUK Finland. Formerly Section head of the Radiation Protection Section in IAEA. Member of National Council for Nuclear Waste,Sweden President Nordic Society for Radiation Protection.
Per-Eric Ahlstrom. Partitioning and Transformation	Retired in 1997, Vice-President of SKB 1993-1997, Research Director of SKB 1984-1993. Now senior consultant for SKB. Over 43 years of professional experience in the nuclear power industry - reactor physics, nuclear engineering, reactor safety and nuclear waste management.
Gilbert Eggermont. Radio active Waste.	Advisor to the Board and Programme Manager of SCK.CEN,Mol, visiting Professor at the University of Brussels(VUB), former Vice-President of the Board of NIRAS.ONDRAF.