Emergency Management in Europe - Contribution of Euratom Research

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ABSTRACT

This paper summarises the contribution of EURATOM research to off-site emergency management in Europe over the past two decades. Effort initially focused on the development of methods and software that could be used to underpin the nature and extent of emergency management arrangements and policy. With time, and partially in response to accidents at TMI and Chernobyl, effort shifted to the development of a comprehensive decision support system that could find broad use in real time across Europe in order to better inform decisions on emergency management. The deployment of the developed system across Europe, largely so far at a pre-operational level, is described together with the opportunities this offers for more coherent response to any accident that may in future affect Europe and for better use of scarce resources, both human and otherwise. Indications are given of where further effort or initiatives should be directed with a view to ensuring that the major research achievements are fully and effectively exploited.

Keywords

Research, off-site emergency management, real time decision support systems

INTRODUCTION

Nuclear safety is built on three independent but complementary pillars: prevention, mitigation and off-site emergency management. The primary goal is to **prevent** the occurrence of an accident. Should one occur, engineering provisions are made to limit the extent to which it may progress (ie, **mitigation**), both to protect the capital investment in the plant and to minimise the risk of releasing radioactive material to the environment. **Off-site emergency management** is the third and final pillar and provides "defence in depth" for the potentially affected population should **prevention** and **mitigation** prove insufficient or fail.

This paper is concerned solely with the third pillar, off site emergency management and, in particular, the contribution EURATOM research has made to its improvement in Europe over the past two decades. The commercial use of nuclear energy suffered two major setbacks in the closing decades of the last century: firstly, the accident at Three Mile Island (TMI) in the US in 1979 followed by the accident at Chernobyl in 1986. Both accidents resulted in the severe degradation of the nuclear fuel and the release of substantial amounts of radioactive material from the reactor compartment. At TMI, the radioactive material was largely retained within the purpose built containment, with only a tiny fraction released to the environment. At Chernobyl, where the reactor was "uncontained", almost all of the more volatile content of the fuel was released directly into the environment with major health, social, environmental and economic consequences.

Both accidents had major impacts on emergency management in Europe, in particular Chernobyl. Improvements were made in response to these accidents at national, European and international levels, both in operational and policy contexts, and were supported by longer term research and development programmes. The contribution of EURATOM research to these improvements over the past two decades is summarised in this paper and is based largely on the personal views/reflections of the author. It is both timely and opportune to look backwards to assess the extent to which the expectations for this research have been met, in particular to learn from the past with a view to improving the future.

PRE- AND POST- TMI

The 1970s represented a major turning point for the commercial use of nuclear energy. In the early 1970s, installed

[1] The views expressed in this paper are those of the author and not necessarily those of the European Commission.

capacity was forecast to expand rapidly to 4,000 GW(e) by the end of the century with the extensive use of fast reactors and fuel reprocessing. Various oil crises reinforced and added credibility to these forecasts. In practice, installed capacity only reached about 400 GW(e) (ie, an order of magnitude lower), reprocessing was limited in scale and fast reactors failed to be implemented commercially.

The major expansion in the projected use of nuclear energy conditioned thinking on many issues in the early 1970s. Major considerations at that time were the health and environmental impact of such a large increase (especially in reprocessing) and criteria for siting and emergency arrangements, in particular as any major expansion would require the siting of nuclear installations in more populated areas than hitherto. The seminal US Reactor Safety Study (USNRC, 1975), which well characterised the risks presented by nuclear power reactors, was carried out in the early 1970s. This was followed by a comparable study in Germany (Deutsche Risikostudie, 1981) and by similar assessments for planned reactors in the UK (Kelly and Clarke, 1982). The European Commission, through EURATOM research, later capitalised on this German and British work and commissioned the development of software (COSYMA) applicable generally in Europe for assessing the risks (health, environmental and economic) presented by nuclear installations and for supporting studies on siting and emergency management (European Commission, 1985a; KfK and NRPB, 1991 and Jones et al, 1996). This software has found broad use in Europe for these purposes and remains a standard in this area. After a decade of more limited use, these methods are again the subject of renewed interest (European Commission and Nuclear Energy Agency, 2005), in particular in the context of promoting a more common and technically rational basis for establishing emergency plans. Some see opportunities in reducing the nature or extent of emergency plans or arrangements in keeping with ever improving safety provisions in both existing and new reactors. While well intentioned, these new studies are unlikely to bring any substantive change in existing plans or arrangements; the latter have broader origins in providing a robust approach to nuclear safety, not least in underpinning public confidence which is neither well, nor directly, correlated with narrower technical considerations. They will, however, through revisiting this issue, provide a fuller and shared understanding of the key issues and their interactions.

The prospects for nuclear energy in many but not all parts of the world declined through the late 1970s, not least because of commercial, proliferation and political considerations. The accident at Three Mile Island (TMI) in the US in 1979 was a further major blow which led to moratoria or postponement of future build in several countries. Within Europe, the response to the TMI accident largely focused on improving plant safety and management, in particular on reducing the probability of core melt and developing better methods for in-plant severe accident management. By comparison, off-site emergency management received only modest attention, a consequence largely of TMI having minimal off-site radiological impact.

TMI did, however, stimulate increased interest in the development of decision support systems (DSS) for use in managing the off-site consequences of an actual emergency in real time. The earliest of these systems did little more than "computerise" the calculations that would be made by hand/calculator in the event of an accident or would be extracted from pre-prepared manuals or nomograms. As such they were seen as beneficial in freeing up technical personnel from more mundane tasks, thereby affording them more time to "think". Other systems were derived from codes/software that had been developed in the 1970s for safety assessment or supporting studies on siting or emergency planning (eg, precursors of the COSYMA software) and the advent of personal computers acted as a further stimulant. The outcome was a plethora of DSS of widely varying scope and content, many of which found their way into emergency centres of utilities and regional/ national authorities, albeit often limited to complementing existing procedures. In many cases these systems promised much more than they could deliver, suffering from limited robustness, reliability and comprehensiveness. However, they did provide a useful foundation for later developments.

In response to these developments, the European Commission in 1985 organised the first of a series of Workshops on Decision Support Systems for Emergency Management (European Commission, 1985b; Kelly G N and Fraser, G, 1993; Baverstam, U, Fraser G and Kelly G N, 1997; Hohenberg J-K and Kelly G N, 2004). The first workshop provided a timely (ie, in the context of the Chernobyl accident which occurred in the following year) and important opportunity to bring together and exchange experience among the many developers, most of whom were working autonomously and largely with national support. The most striking outcomes of the workshop were the almost singular focus on atmospheric dispersion modelling (to the exclusion of other equally if not more important issues), the similarity of developments in many countries and the opportunity for resource savings that could be achieved by collaboration. However, the timing was not opportune for the latter, not least due to a wish in many quarters to preserve national autonomy in this area and to a surfeit of national funding for such activities post TMI. The capabilities of many of these systems were to be seriously challenged in the following year.

CHERNOBYL – A WATERSHED

The Chernobyl accident in 1986 was a watershed for emergency management in Europe and elsewhere. The accident drew stark attention to the limitations/failings of existing arrangements, in particular in responding to a large accident with trans-boundary implications. Notwithstanding safety studies and broad recognition that large accidents could occur, detailed emergency planning in most countries was based on a reference, or design basis, accident of relatively modest size – albeit the plans were capable of expansion if necessary. The scale and extent of the Chernobyl accident far exceeded anything that had been planned for (at least in a detailed manner) and led to widespread problems not only in those countries directly affected but, internationally, through disruption in international trade, etc. Lack of coherence in response across national and regional boundaries was a major source of public concern which led to a loss of trust and confidence in authorities, some of which persists today.

As is common in the aftermath of any accident, nuclear or otherwise, there was some degree of over-reaction. Resources which hitherto were scarce or not available suddenly become available to remedy identified failings and public concerns. Most European countries initiated extensive reviews of their emergency arrangements in the aftermath of the Chernobyl accident and major improvements (eg, early notification of accidents, foodstuff restrictions in international trade, mutual assistance, extensive national monitoring networks, more exercises, etc) resulted at national, regional and international levels. Support for research on off-site emergency management increased dramatically but has since declined as memories of the accident and political interest fade.

A number of initiatives were taken by the European Commission in response to the accident both in research and in the legislative field. Regulations (Council Regulation, 1987) were established to control the import and marketing of contaminated foodstuffs within Europe and a system (Council Decision, 1987) was established for early notification of any future accident – both important for public confidence and reassurance and for the proper operation of a Common Market. Ongoing research in radiation protection was supplemented by a post-Chernobyl research action with additional funding. It provided an important focus for integration and exchange of information with national research activities initiated in the aftermath of Chernobyl, in particular in identifying and minimising unnecessary duplication.

These activities were continued with EURATOM support in a dedicated research programme on Chernobyl and in subsequent multi-annual research Framework Programmes. The Chernobyl research was carried out under the auspices of a political agreement between the Commission and the Chernobyl Ministries in Belarus, Russian Federation and Ukraine. This provided an effective framework for prioritising research needs and minimising duplication with other bi-lateral activities between the Former Soviet Union countries and others (eg, US, individual European countries, Japan, etc) which were commonplace at that time. The co-ordinating or integrating role of the Commission was further facilitated by the relatively rapid decline in national resources allocated to this issue by most European and other countries. The research supported by the Commission in response to Chernobyl was wide ranging and included off-site emergency management; remediation and long term management of contaminated territories; environmental, health and social impacts and their reduction; identification and treatment of thyroid cancer, treatment of early injuries, etc. Only one of these topics, emergency management, is addressed further here.

DEVELOPMENT OF A COMMON DECISION SUPPORT SYSTEM FOR USE IN EUROPE

Two important weaknesses or failings were evident in developments within Europe on off-site emergency management in the 1980s. These were:

- the considerable waste of scarce resources resulting from parallel and largely independent/autonomous developments in many European countries
- difficulties in ensuring a coherent response to any future accident that might affect Europe due to the development and use of disparate technical tools for supporting off-site emergency management in each country

The benefits to be gained from closer collaboration in Europe are self evident – in particular in an area such as off-site emergency management where capability and preparedness must be avidly maintained but is rarely, if ever, used. Achieving these benefits is not easy, not least because of pressures (both technical and political) to preserve national autonomy on these matters. Without in any way impinging on national prerogatives, the EURATOM research in this area had, from the outset, an underlying or implicit goal of promoting European collaboration on emergency management – essentially using research as one, albeit indirect, mechanism for this purpose. This was achieved through making the development of a common decision support system (DSS) the main focus of, or basis for, research in this area. This focus had three major benefits: firstly, it provided a framework to identify and differentiate between competing priorities, the criterion being the extent to which further research would result in tangible improvements in practical emergency management (as opposed to improvements within a narrower research area per se); secondly, it provided an integrating mechanism through which significant research outcomes could be effectively exploited and brought rapidly to practical effect; and, thirdly, it facilitated the identification and avoidance of duplication in both EURATOM and nationally supported programmes. Much has been achieved in the last decade or so but more needs to be done to fully exploit and consolidate the major achievements of, and opportunities offered by, the EURATOM research programmes. Political initiative will be imperative but will need to be supplemented by technical developments, in particular to further enhance the case for the deployment and use of a common DSS across the whole of Europe or on a more limited basis in specific regions.

The vision of developing a common and comprehensive DSS that could find broad use in Europe crystallised in the early 1990s and has been the focus of support ever since, albeit with some change in emphasis from one Framework Programme to another. This vision was not only shared in the Union but also in Belarus, the Russian Federation and the Ukraine, countries who, following Chernobyl, became acutely aware of the need and benefits of such a system. The main protagonists or developers of the common DSS recognised that the scale of the issues to be addressed far exceeded those available in any one country and that collaborative action was needed – more so given the decline in funding that was expected to occur as the memories of Chernobyl faded and political support diminished.

Translation of the vision of a common DSS for broad use in Europe into practical reality began in the EURATOM research programme 1990-91 and was consolidated in the 1992-95 programme which ran in parallel with the separate, but complementary, Chernobyl research programme (Kelly, Ehrhardt and Shershakov, 1996). By the mid 1990s some 30 European institutes (about 20 from the EU and the rest from FSU countries) were participating in the development of a common DSS for broad use in Europe. The bringing together and effective management of such a diverse group of participants in pursuit of a common goal was in itself a considerable achievement - Community support was instrumental in creating the necessary focus but progress would not have been achieved without the interest and commitment of all those concerned.

This collaboration was further intensified in the 4th Framework Programme (1994-1998) with the active involvement of institutes from Central and Eastern Europe under the auspices of the PECO programme and was continued in the 5th Framework Programme (1998-2002). In these periods some 40 institutes from more than 20 European countries (about half from the Union and the rest from CEE and FSU countries) were involved in the development. Indeed, the management arrangements in the 4th Framework Programme were a precursor or an embryo of Integrated Projects in the 6th Framework Programme. Some seven separate projects in the 4th Framework Programme, while contractually independent, were fully integrated through informal management arrangements into a coherent whole, with benefits for all concerned and the resulting outcome (Ehrhardt and Weis, 2000).

Mid way through the 4th Framework Programme the first version of the RODOS (Real time On line DecisiOn Support system) DSS, suitable for pre-operational use, was released and tested in national emergency centres. RODOS was progressively improved and extended in the remainder of the 4th Framework Programme and during the 5th Framework Programme with new versions released periodically. The system is undergoing further development in the 6th Framework Programme (2002-2006) where the emphasis has shifted to demonstration as opposed to development (EURANOS, 2004). Here is not the place to describe the technical content and capabilities of the system nor the scope and nature of the research carried out; this can be found elsewhere (eg, Ehrhardt and Weis, 2000; Kelly and Rojas-Palma, 2004; European Commission, 2002). Suffice to say that the system is comprehensive (applicable to all stages of, and times after, an accident), applicable across Europe and comprises the following main elements:

- inputs
  - predicted or actual release of radioactive material
  - local and regional meteorological/hydrological data
  - environmental measurements

- modules/data bases
  - prediction of the distribution of radioactive material in the atmosphere and terrestrial and aquatic environments
  - predictions of health and environmental impact
  - data bases (eg, land use, population, topography, agricultural production, etc)
  - models for simulation, evaluation and ranking of countermeasures

- outputs
  - analysis and prediction of the radiological impact

- simulation of countermeasures and quantification of their pros and cons
- evaluation of countermeasures

In parallel with the research programme, the Commission through its PHARE and TACIS programmes, promoted the implementation of state of the art DSS in the Central and Eastern European (CEE) and Former Soviet Union (FSU) countries. In the early 1990s major programmes were implemented to improve the safety of nuclear reactors in Eastern Europe. Improvements were made to safety systems, the management of safety and its regulation, etc, and some of the older reactors were closed. Deficiencies were also present in off-site emergency arrangements and assistance was provided in four main areas: early warning systems; exchange of information both nationally and with neighbouring countries; decision support systems to process information and monitoring results and better inform decisions; iodine prophylaxis, emergency clothing and monitoring equipment; and training.

For early warning systems the policy objective was to have in place a ring of gamma detectors (minimum of twelve) around each nuclear power plant (NPP) with automatic links to the NPP and the local/regional/national emergency centre/s. With a few exceptions, this policy goal has been achieved. For DSS, the goal was to install a state of the art system in national emergency centres in each CEE and FSU country in Europe. Again, with a few exceptions, this goal has also been achieved or will be within the next couple of years. The RODOS DSS is installed for pre-operational use in the Czech Republic, Hungary, Poland, Slovakia, Slovenia and Ukraine and is foreseen for installation in Bulgaria and Russia in 2006. Installation in Romania and Croatia is under consideration. The ARGOS[2] system has been installed in Estonia, Latvia and Lithuania by Denmark and is now receiving further support from the PHARE programme with sustainability and operational use being the objectives. In each country, the DSS are in pre-operational use in the national emergency centres and the key challenge is to bring them into full operational and routine use.

These DSS are also finding increasing use in the EU. RODOS has been installed in Germany and is in operational use at State and Federal levels. It is in pre-operational use or under evaluation in several other countries including, Austria, Belgium, Finland, Greece, Luxembourg, Netherlands, Spain, Switzerland and Portugal. ARGOS is installed in Denmark, Ireland and Norway and under evaluation in Sweden. The extent to which these DSS have been installed across Europe is illustrated in Figure 1 and this augurs well for a more coherent response to any accident that may affect Europe in future.

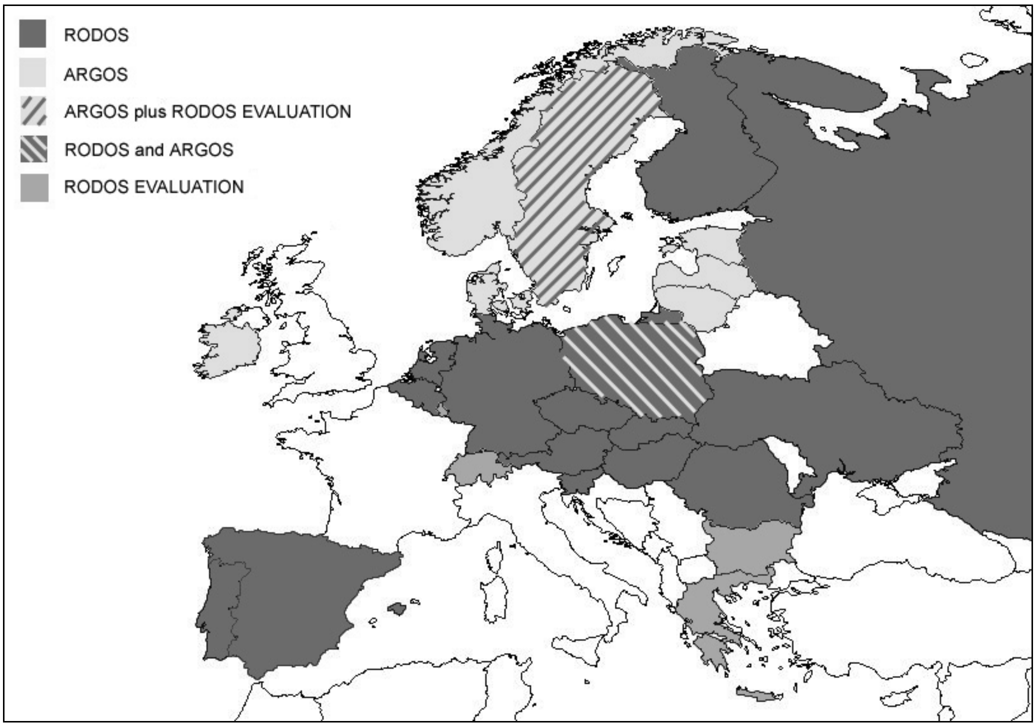

Figure 1 Deployment of RODOS and ARGOS in Europe

[2] The ARGOS DSS was initially designed with limited functionality, essentially to receive environmental monitoring data and process them to display the impact of an accident in support of decision making. In collaboration with RODOS developers, its functionality has been, and is in the process of being, extended with the progressive integration of RODOS products (transfer of radionuclides through the food chain, countermeasure models, multi-attribute decision techniques, etc).

The increasing installation of RODOS in many countries is also acting as a stimulus for related policy initiatives and fostering closer and more effective interaction on emergency management in general. A regional cooperation agreement on emergency preparedness in Central Europe was signed in late 2003, initially between the Czech Republic, Germany, Hungary, Slovakia, Slovenia and Austria with the intent to extend it in due course to Poland and Switzerland (Kelly, Jones, Crick, Weiss, Morrey, Lochard and French, 2004). This cooperation will be established around two main axes: operationally, through use of the RODOS system as a common platform for decision support and exchange of information within this region; and, in a research context, through their active participation in the EURANOS project (EURANOS 2004) on emergency management. A similar approach, albeit without the formality of an agreement, has been adopted between the Benelux countries which will take part in the demonstration activities of the EURANOS project. Given the obvious benefits of such regional cooperation, both in terms of resource utilization and more coherent emergency management, they may prove to be useful models for collaboration elsewhere in Europe and on a broader range of topics relevant to emergency management.

BUILDING ON SUCCESS

Considerable progress has been made in achieving the two main goals underlying EURATOM research in this area – the development and exploitation of a common DSS across much of Europe (with a view to a more coherent response to any future accident) and the better use of European resources (through their effective integration in pursuit of a common goal and avoiding unnecessary duplication). Making the development of a common and broadly applicable DSS the focus of EURATOM research in this area has been the key to the success achieved. It provided an essential framework for prioritising and integrating research activities and was also the vehicle for the timely and effective exploitation of significant research outcomes (ie, practical improvements in emergency management). In judging the success of this research, undue attention is often given to the technical content of the DSS and its functionality. While this is undoubtedly important, such a narrow view is mistaken. Of even greater importance are the, albeit less tangible, benefits of the integration that has been achieved as a result of these programmes, both in research and operational emergency management – without this the emergency management “scene” in Europe would look very different from what it is today.

Notwithstanding this undoubted success, complacency would be misplaced and further effort is needed to consolidate and further exploit what has been achieved. This effort would be most profitably directed towards the following goals or tasks:

- continue to use the development and deployment of a common DSS as a mechanism or focus for achieving sustainable integration in all aspects of emergency management in Europe
- promote a change in “ownership” of the developed DSS from the research to the operational community/ies (both technically and financially)
- optimise the DSS for operational use (ie, currently still largely and overly research oriented)
- put in place administrative/financial mechanisms for maintaining and further developing the DSS – with the onus on the users
- promote the merits (ie, cost and resource savings, more coherent response across national borders) of supra-national or regional approaches to emergency management and encourage political initiatives in this respect
- establish a road map for the longer term maintenance of the DSS including its re-engineering, if necessary, at an appropriate time
- fully demonstrate efficacy in operational environments
- make better use of DSS for training and exercising, in particular for senior personnel and decision makers
- interface DSS better with decision makers
- remain abreast and take advantage of emerging informatics and communications technologies (eg, exploit earth observation systems in real time, secure and reliable communications, etc)
- integrate nuclear emergency management within emergency management more generally, with a view to cost savings and making better use of resources, both human and otherwise

In summary, a platform to support effective and coherent emergency management has been established as a result of EURATOM research. It behoves the user and political communities to profit from this development and use it as a framework for achieving sustainable integration of all aspects of emergency management in Europe.

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