The Institute for Systems, Informatics and Safety (ISIS) is one of eight institutes that constitute the European Commission’s Directorate-General Joint Research Centre (DG-JRC). Situated in Ispra, Northern Italy, ISIS supports EU policies with systems-oriented research in areas where the safety and security of the citizen are of concern. In particular, ISIS focuses on the following policy support themes: nuclear safeguards, non-proliferation and international humanitarian security; cyber-security, knowledge access and assessment, the fight against fraud; and natural and technological risks and emergencies.
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## RESOURCES

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## ISIS CONTACT POINTS
The year 2000 offered the Institute for Systems, Informatics and Safety (ISIS) not only the opportunity to refocus and concentrate its activities, but the possibility to strongly re-affirm its role in serving European Union policy makers.

In January 2000, the Communication Towards a European Research Area¹ (initiative of the European Commissioner for Research Mr. Philippe Busquin) outlined the JRC’s contribution to the European Research Area in terms of supporting the development of a scientific and technical reference area for policy support. In June 2000, A review of the Joint Research Centre by an independent High Level Panel, chaired by Viscount E. Davignon, outlined several priorities for non-nuclear research at the JRC: (1) security for the European citizen, including health, food, environment and privacy; (2) security for economic issues including new crimes related to the information society and intellectual and industrial property rights; (3) enlargement; and (4) the common foreign and security policy. With this in mind, the mission statement of ISIS focuses on supporting EU policies with systems-oriented research in areas where the safety and security of the citizen are of concern in the following policy support themes:

- nuclear safeguards, non-proliferation and international humanitarian security;
- cyber-security, knowledge access and assessment, the fight against fraud;
- natural and technological risks and emergencies.

To strengthen the Institute’s fulfilment of its new mission statement and to provide a better clustering of expertise, the humanitarian demining technologies work was transferred from the Space Applications Institute to ISIS in October 2000.

ISIS’s role is to provide a service to meet the requirements of its customers – other Directorates-General (DGs) and services of the European Commission – thereby providing a direct contribution to European policy processes. This service covers the full cycle of policy making from the conception of a new policy through support in its development and implementation to its monitoring and evaluation. Consistent with Commissioner Busquin’s project on the European Research Area, added benefit and value derives from ISIS being able to call upon the expertise of many research establishments, throughout the European Union, due to its extensive involvement in networks and collaborative actions, and from its independence of national and private interests as a European research organisation. In such a manner, ISIS brings a greater critical mass to bear on its support to policy making and provides a gateway to the world of science and technology for its DG customers.

David R. Wilkinson
Director
Institute for Systems, Informatics and Safety

MISSION STATEMENT OF ISIS

ISIS supports EU policies with systems-oriented research in areas where the safety and security of the citizen are of concern. The application areas include:

- nuclear safeguards, non-proliferation and international humanitarian security;
- cyber-security, knowledge access and assessment, the fight against fraud;
- natural and technological risks and emergencies.

Its prime objectives are to develop techniques for the assessment of risk in complex systems and to apply information, communication and engineering technologies for improving their reliability, safety and security. The strong cross-fertilisation between its nuclear and non-nuclear activities strengthens the expertise it can bring to the benefit of customers in both domains.


4 Foreword
The diagram reflects the organisational structure of ISIS and the main focus of the activities of each unit. Some overlap between the competencies may occur.
The Communication Towards a European Research Area (initiative of the European Commissioner for Research Mr. Philippe Busquin) embraces, in particular, the following: networking, improved use of infrastructures, training and mobility and the establishment of a common scientific and technical reference system for the implementation of policies – all of which involve partnerships, collaborations, the pooling of complementary expertise, information exchange, mutual learning and knowledge sharing. ISIS is not only active in promoting networks, operating several successful research infrastructures, providing research training for researchers and playing a role in developing a common scientific reference system, but it is also very dynamic in encouraging collaborations and partnerships and in creating a wider culture of research and innovation by earmarking a portion of its budget for exploratory research.

NETWORKING

ISIS currently utilises networking as the preferred formula when undertaking ambitious research activities. Up until now, ISIS’s networking has been mainly through competitive projects won in consortiums through the indirect actions of the Framework Programme. Many networks have been centred around infrastructures such as ELSA (European Laboratory for Structural Assessment). While ISIS continues to maintain a strong commitment to competitive work and facility-oriented networks, new mechanisms of networking will be explored in order to bring the expertise of the European scientific community to bear on specific problems that concern European policy. In this way the DGs and Services of the European Commission can access the world of science and technology by utilising ISIS as the gateway. As proposed in the Communication Towards a European Research Area, networks will be developed to serve as common scientific and technical reference systems for policy decision-making.

COLLABORATIONS

Collaborations and partnerships enable ISIS to provide an efficient and fast service to its customers on a wide spectrum of policy-based scientific and technological issues. Typical forms of collaboration include: shared-cost action collaborative projects under the Framework Programme; institutional collaborations without exchange of funds; sharing of experimental facilities; commercial services for third parties; sub-contracting; workshops; research networks; technology licences; and supplies and services contracted by the JRC. Participation in these collaborations enhances the scientific competence and scientific validity of ISIS, increases its visibility and is a means of attracting new researchers.

INFRASTRUCTURES

ISIS operates a number of unique experimental facilities, for example, PERLA (Performance Laboratory) for safeguards and verification techniques, TEMPEST (Thermal, Electromagnetic and Physical Equipment Stress Testing) laboratory, ELSA (European Laboratory for Structural Assessment), LDTF (Large Dynamic Test Facility), LISA (Linear Synthetic Aperture Radar facility), EMSL (European Microwave Signature Laboratory) and EGO (European Goniometric laboratory). As well as positioning ISIS at the forefront of international research, they attract users and customers from Member State and non-Member State laboratories, lend a visible European focus to research networks and provide the means to address sensitive issues. These facilities represent unique research infrastructures in Europe.

TRAINING AND MOBILITY

ISIS encourages scientists from other organisations to spend time working at the JRC and contributes to their scientific training and development by offering interdisciplinary research in an international environment with a good infrastructure, some unique installations and excellent networking opportunities. This has been achieved through various mechanisms including Marie Curie fellowships and other Community and national mobility initiatives. ISIS is committed to continuing and strengthening these arrangements and increasing the emphasis on hosting scientists from the Applicant Countries so as to speed up their integration into the EU.

EXPLORATORY RESEARCH

ISIS currently earmarks 6% of its institutional budget for exploratory research. The aim of this mechanism is to test out ideas of a more speculative nature to assist ISIS in shaping future actions. Exploratory research involves a bottom-up and top-down approach wherein projects are proposed by the scientific staff of ISIS, evaluated in a documented and transparent manner by a scientific committee on the basis of scientific innovation, feasibility, strategic value and cost, and then selected by a management committee comprising the director and unit heads.

In the period 1997-2000, 46 projects were approved. Nearly all yielded interesting results and peer-reviewed publications. While several projects were developed further in collaborative partnerships with competitive funds, others were amalgamated into the JRC’s institutional work programme either within ISIS or within other institutes.
**KNOWLEDGE MANAGEMENT**

ISIS is highly aware of the importance of pooling its skills and knowledge. At the level of the JRC, there is a corporate portal: a centralised home page with links to the various institutes (http://www.jrc.cec.eu.int/isis) and other items of information. At the level of ISIS, many Intranets exist that permit the storage of a core of knowledge.

**CUSTOMER RELATIONSHIPS**

For each policy support theme in ISIS: (1) nuclear safeguards, non-proliferation and international humanitarian security, (2) cyber-security, knowledge access and assessment, the fight against fraud and (3) natural and technological risks and emergencies, a number of customers can be identified. The main customers are identified in the table below.

During 2000, ISIS sent out customer opinion questionnaires to its institutional customers – various DGs and Services of the European Commission – in order to measure customer satisfaction and to evaluate ISIS’s responsiveness to its customers. The questionnaire included several questions covering the usefulness of the research results, scientific quality, project management, the administrative and financial interface of ISIS and pressing scientific or technical issues that need exploring for future policy needs. The response rate was 82 %. The results proved that ISIS offers a service that meets the requirements of its customers.

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<th>Nuclear safeguards, non-proliferation and international humanitarian security</th>
<th>Cyber-security, knowledge access and assessment, the fight against fraud</th>
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ISIS’s scientific and technological base is designed to support EU policies related to the general theme of enhancing the safety and security of the individual citizen and society. Participation in research, which is increasingly based on networks and collaborative projects with industry, universities, national laboratories and research organisations, forms the backbone of this base. Research in ISIS is based on three main themes, which support European policy processes: (1) nuclear safeguards, non-proliferation and international humanitarian security; 2) cyber-security, knowledge access and assessment, the fight against fraud; and 3) natural and technological risks and emergencies.

**Nuclear Safeguards, Non-proliferation and International Humanitarian Security:** With its well-established and universally recognised role as a reference centre for the technology of safeguarding fissile material and its growing presence as a European focus for initiatives to provide more efficient ways of reducing the threat from anti-personnel land mines, ISIS is able to provide a solid support to the EU’s efforts to develop an effective Common Foreign and Security Policy (CFSP). The customers include the inspectorates (ESO – Euratom Safeguards Office and IAEA – International Atomic Energy Agency), the External Relations DG, the Development DG, AIDCO (EuropeAid Co-operation Office), ECHO (Humanitarian Aid Office) and the Information Society DG.

**Cyber-security, Knowledge Access and Assessment, the Fight against Fraud:** The explosive growth of information and communication technology is bringing undoubted benefits to society. There are, however, fears about the risks of fraud and threats to privacy, concerns that a society that is increasingly dependent on global communications might be vulnerable to systematic malicious attacks on its infrastructure and worries that citizens who are poorly educated, disabled or monolingual might be excluded from the benefits of the Information Society. As well as supporting EU policy on these issues, ISIS has been supporting the European Commission’s efforts to increase the effectiveness of anti-fraud measures. In addition to exploring the application of new technologies – DNA analysis for livestock identification, intelligence gathering from open sources, language technology to analyse multilingual documents, satellite image interpretation – ISIS provides customers with an integration of knowledge that includes the entire cycle from data capture, data fusion, data mining through to visualisation and estimation. Furthermore, ISIS has been working to provide more accurate, more timely and more socially robust information to the policy process, e.g., by improving official statistics and by developing quality assurance methodology for scientific input to governance. Support is given to the Information Society DG, the Education and Culture DG, the Agriculture DG, the Fisheries DG, OLAF, the European Environment Agency, EUROSTAT and the European Investment Bank.

**Natural and Technological Risks and Emergencies:** ISIS has developed a considerable expertise in the management of natural and technological risks and, in a number of important areas, is the main adviser to those services of the European Commission responsible for managing these risks. ISIS’s work can be categorised into the following domains: harmonised European reporting systems - e.g., Major Accident Hazards Bureau (MAHB), Natural and Environmental Disaster Information System (NEDIES) and the European Co-ordination Centre for Aircraft mandatory Accident Reporting Systems (ECCAIRS), the application of structural mechanics to improve safety, transient structural dynamics and nuclear safety. Direct and impartial support is given to the Environment DG, the Regional Policy DG and the Enterprise DG.
# Nuclear Safeguards, Non-proliferation and International Humanitarian Security

## 1 Safeguards and Prevention of Proliferation of Nuclear Weapons

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### 1.2 Non-Destructive Assay (NDA)
- 1.2.1 Improvements in PERLA
- 1.2.2 Neutron Measurement Techniques and Calorimetry
- 1.2.3 Gamma Spectroscopy
- 1.2.4 Unattended Verification of Fresh Fuel Assemblies using UMS

### 1.3 Sealing and Identification Techniques

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- 1.5.2 Image Retrieval by Visual Examples
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### 2.4 Human Factors in Humanitarian Demining
OVERVIEW

A. Poucet

The mission of ISIS in the safeguards and non-proliferation area is to provide enabling research, technology, instruments, technical services and training for the verification of treaties relating to the non-proliferation of weapons of mass destruction:

- to Inspection Agencies;
- to States and operators establishing and operating accountability and control systems;
- as a support for the definition of a common EU non-proliferation policy.

Verification and control related to non-proliferation of nuclear materials is performed by the Euratom Safeguards Office (ESO) of the European Commission within the context of the Euratom treaty, and by the International Atomic Energy Agency (IAEA) within the context of the Non-Proliferation treaty. ISIS gives scientific, technical and training support to both these organisations.

ISIS also supports the Russian Federation and other Commonwealth of Independent State (CIS) countries in establishing a system of nuclear materials accountability and control, which is comparable with Western standards in terms of efficiency and effectiveness. In addition to states and agencies, ISIS also helps facility operators to meet their safeguards obligations in an efficient and cost-effective way.

To be able to provide state-of-the-art support to its customers, ISIS carries out underpinning research and development in a number of areas that are relevant to nuclear materials accountability and control and to other verification activities in the framework of non-proliferation of weapons of mass destruction. Such research is necessary to meet the demands for more cost efficient safeguards and to respond to new emerging needs due to changes in verification protocols in nuclear fuel cycle technology and materials.

1.1 MASS AND VOLUME MEASUREMENT TECHNIQUES (TAME LABORATORY)

B. Hunt

Safeguards support activities have been performed for the IAEA and ESO, and for the establishment of mass/volume and containment/surveillance infrastructure and training at the ULBA fuel fabrication plant in Kazakhstan (under the TACIS programme).

For the Joint Members Support Programme task to the IAEA (Independent Data Collection and Evaluation during the LASTAC Exercise) a joint draft document was produced on the conclusions and recommendations, which will be submitted to the JNFL (Japanese Nuclear Fuel Limited) by the IAEA [1.1]. The document concerns a safeguards system for the Rokkasho Reprocessing Plant in Japan. The joint members completed the draft on target for submission in October 2000 following meetings in January and September 2000 on the review of analyses and recommendations resulting from the experimental campaigns of 1999. IAEA personnel also participated in a mass/volume methodology training course in November 2000 and received special instruction on the JRC-ISIS’s Unattended Volume Measurement System (UVMS), which incidentally has been purchased by NMCC (Nuclear Materials Control Centre) of Japan and scheduled for delivery after ISIS verification, assembly, commissioning and test reporting in December 2000, with a view to application in Rokkasho in June 2001. Similarly, requests were received in December from the IAEA for the purchase of two UVMS systems for inspector application in the Rokkasho facility in 2001. This is currently being processed.

In the field of R&D, long-term comparison experiments have been and are continuing on both the PIMM (Pressure Instrument Measurement Module) prototype instrument and the commercially available digital pressure modules DPM 7885. Tank calibrations, long-term monitoring and sensitivity tests have been performed and are undergoing analyses [1.2].

For ESO support programme tasks, the planning made late 1999 with respect to the wishes of ESO regarding tank calibrations in La Hague, France was successfully carried out during 2000. In particular equipment was supplied and commissioned at the JRC prior to shipment to La Hague. Up to five man weeks of support on-site was also provided by ISIS personnel in July and August, in setting up the equipment, commissioning it and launching the first calibration campaigns, with ESO personnel in attendance for on the spot training in order to be able to continue with the rest of the campaign. The equipment is due to be shipped back to Ispra in January 2001 after the completion of the final tank calibration. Two training courses were carried out in both March and May 2000 in the Mass/Volume laboratory for ESO inspectors closely involved in the La Hague campaigns. Experience with the equipment destined to be utilized in La Hague was also included as part of the training course.

Regarding the TACIS work, an administrative arrangement [1.3] was set up with respect to support activities for the ULBA conversion and fabrication facility in Kazakhstan. On the basis of an analysis made on the situation in the ULBA conversion and fabrication lines, a priority was established to improve the following techniques:
• Mass/Volume determination of liquids in a large number of tanks (M/V techniques).
• Procedures for calibration and data evaluation for weighing scales (M/V techniques).
• Sealing and identification techniques (C/S techniques).
• Surveillance techniques (C/S techniques).

A visit to the ULBA facility in June 2000 allowed first hand knowledge and technical information of the plant to be gathered. Sub-contracts have been set up with the ULBA Metallurgical Plant and the project was defined with the aid of the Swedish consultancy firm, SKI. A detailed analysis of the plant [1.4] has been made allowing a clearer definition of priorities. Preparation of the training room will have priority together with training courses in Ispra and subsequently in the ULBA plant itself. For the mass/volume determinations, the design prototype of a fixed measurement station incorporating a micro-scanning valve system and a portable measurement station together with the informatics for data acquisition and management have been defined with components already purchased and under test. Similarly for containment surveillance, equipment has been purchased or ordered, such as hardware for the verification of metal cap seals, a market survey for the embedded computers in the camera housing of the surveillance system, plus the development of a software module for ambient tests of the embedded computer with TV. The latter is extremely important due to the yearly extremes of temperature, -50 ºC to +40 ºC. Preparation is underway for the technical specifications regarding the tender which forms 50% of the TACIS contract for equipment purchase.

For the TACIS 98 budget relating to Kazakhstan, the technical terms of reference are already underway with the completion of the administrative arrangement expected early 2001.

1.2 NON-DESTRUCTIVE ASSAY

1.2.1 Improvements in PERLA

P. Schillebeeckx

The nuclear safeguards activities, related to Non-Destructive Assay (NDA) of nuclear materials, are executed in the PERformance Laboratory (PERLA). PERLA is a unique facility within the EU, housing an extensive collection of well-characterised nuclear reference material and instrumentation. The activities are specifically oriented to the development, validation and implementation of nuclear NDA methods and techniques. The application fields cover calorimetry, gamma spectrometry, passive neutron assay and active neutron interrogation, used either individually or in integrated systems. Most of the activities are done in direct support to ESO and the IAEA. Over the last year the laboratory performance was significantly improved, with a view to accreditation as a European reference laboratory for NDA of nuclear material. Already during 2000 these improvements had a direct impact on the support to national and international nuclear safeguards authorities and the nuclear industry.

The performance of PERLA is based on three pillars: nuclear reference material, reference instrumentation and the experienced staff developing various methodologies for the NDA of nuclear material. The procurement scheme and characterisation of reference neutron sources, and the procedures for characterisation of neutron instrumentation were improved. This resulted in an enhanced use of the Monte Carlo simulation code MCNP-PTA and the neutron correlation technique based on Hage’s point model developed at ISIS.

References

1.1 Authors from IAEA, USDOE, NMCC Japan and JRC-Ispra. Joint MSSP Task A132, “Independent Data Collection and Evaluation during the LASTAC Exercise, – Conclusions and Recommendations”. Safeguards Confidential.
1.2 PERLA and its functions.

- Characterisation of neutron sources
  The characterisation and calibration procedures of neutron sources were updated and include neutron, gamma and heat measurements. This results in a determination of the total neutron emission rate, total activity and nuclide composition. The total neutron emission rate is obtained from measurements with neutron counters optimised for application of the neutron correlation technique. The counters are characterised and calibrated by both Monte Carlo simulations and measurements with reference neutron sources. The sources are certified for their neutron intensity and anisotropy by the National Physics Laboratory in the UK. Application of the neutron correlation technique allows the absolute determination of the emission rate for $^{252}$Cf(s.f.) sources and the verification of the degree of expected randomness for the $(\alpha,n)$ isotopic neutron sources. For $(\alpha,n)$ sources the total $^{241}$Am activity is deduced from measurements with an Anti-Compton spectrometer surrounding a Ge-telescope. This spectrometer is characterised by Monte Carlo simulations and calibrated by three independent laboratories. From the photon spectra the relative abundance of impurities (e.g. $^{154}$Eu, $^{239}$Np, $^{241}$Am, ...) is deduced. In addition the intensity of some Doppler broadened full energy photon peaks indicate the probability of $(\alpha,n)$ reactions and can be related to the neutron output. The total activity of the $(\alpha,n)$ sources is also determined by calorimetric measurements using the Small Sample Calorimeter (SSCAL). This calorimeter has an optimum operation region of between 5 – 80 mW and a 0.15% measurement precision.

- Methodology for calibration of neutron devices used for NDA
  The PERLA procedures for the characterisation and calibration of instruments, used for passive and active neutron assay, have been improved to include the use of new reference instrumentation and certified reference material and the use of our Monte Carlo simulation code MCNP-PTA. The complete process is optimised to allow a reliable determination of response functions by MCNP-PTA and a verification of the instrumental constraints for the application of Hage’s point model, for the application of passive neutron assay. The complete characterisation process results in the determination of the following instrumental parameters: high voltage plateau and optimum operating bias, system dead time, empirical dead time coefficients, detection efficiency for a $^{252}$Cf and a plutonium ”point source”, detection efficiency for various $(\alpha,n)$ neutron sources, radial and axial efficiency profile, and decay curve for a point source in different positions of the cavity.

Calibration measurements of PERLA NDA standards allow a comparison with the results of Monte Carlo simulations and/or the response of a reference instrument. For passive neutron instruments, the procedure includes measurements of a set of plutonium standards with a plutonium mass in the specific application range of the instruments. For active devices, used for the verification of fuel assemblies, the calibration report includes the response for typical BWR and PWR reference assemblies and MTR assemblies if required.

1.2.2 Neutron Measurement Techniques and Calorimetry

P. Schillebeeckx, M. Thornton

Active neutron interrogation is the most commonly applied Non-Destructive Assay (NDA) technique for the determination of the fissile content in uranium bearing samples. The verification of input powder and scrap material by ESO in Low Enriched Uranium (LEU) facilities is based largely on measurements with the Phonid device. The disadvantages of this instrument are the need for very extensive and expensive calibration campaigns and an interrogating neutron source. Together with the support group of ESO, a new measurement method, based on the detection of neutrons emitted after the spontaneous fission of $^{239}$U, is proposed. To investigate this technique, measurements with a commercially Active Well Coincidence Counter (AWCC) were performed in PERLA. Besides these measurements, various simulations using the MCNP-PTA code have commenced to confirm the proposed methodology and to design a device, optimised for in-field use in LEU fabrication facilities of the EU.

The Physical Inventory Verification (PIV) in LEU facilities during 2000 again indicated shortcomings for measurements on fuel assemblies with gadolinium loadings currently encountered. The calibration procedures for the verification of such assemblies should be re-evaluated. A re-evaluation, only based on experimental results, requires an enormous number of reference
Following the successful completion of the tests, the measurement times were reduced from in excess of 8 hours to 3 hours. To avoid such interventions, an analysis methodology was determined. Utilising this method enables measurement of the system and quality checking of the equipment prior to implementation. The significance of this feature was widely appreciated by ESO (and ISIS) as a means to reduce the number of inspections to the facility. For ISIS this allows remote monitoring of the system and quality checking of the measurements.

A new procedure for measurements of so-called “Rainbow cans”, which are difficult to characterise due to the heterogeneous nature of the plutonium within the can, has been validated in PERLA. Measurements of simulated rainbow cans were performed in PERLA using plutonium standards of mixed isotopic composition, a gamma spectroscopy system, and a calorimeter. An average isotopic composition was determined by rotating the cans, and moving the detector a sufficient distance from the source, to allow the whole can to be viewed. Off-line post analysis of collected calorimetry data enabled an improved prediction algorithm to be determined. Utilising this method enables measurement times to be reduced from in excess of 8 hours to 3 hours. Following the successful completion of the tests, a new measurement methodology is being recommended to ESO.

Support to ESO

The Drum Monitor, designed and manufactured at the JRC-Ispra, was successfully installed in the old Siemens MOX fuel fabrication plant in Hanau (Germany). The Drum Monitor is intended for the verification of Siemens’ declarations of the plutonium content in waste drums. The instrument will be operated jointly by ESO and IAEA inspectors. The plant, now known under the name of “Siemens AG Rückbauprojekte”, will over the next 24-36 months produce the last three thousand of a total of about eight thousand 220 litre radioactive waste drums. The content of all waste drums will eventually be compacted, cemented, and stored in a new storage facility on site. At this moment about half of all drums has been cemented. The waste includes components such as glove boxes and machine components used in the MOX fuel production as well as process waste such as clothing and gloves. The drums (cemented and not cemented) may contain from below one gram to about 30 grams of plutonium. Actinides other than plutonium present in the waste are uranium and americium in variable amounts.

The operator gave the permission for ESO (and ISIS) to access the Drum Monitor computer remotely via a dedicated telephone line. The significance of this feature was widely appreciated by ESO as a means to reduce the number of inspections to the facility. For ISIS this allows remote monitoring of the system and quality checking of the measurements.

Support to IAEA - verification of special nuclear material entering the civil fuel cycle

As part of a collaboration agreement with the IAEA, a series of measurements were performed to demonstrate the feasibility of using calorimetry in place of destructive analysis in the homogeneity testing of plutonium oxide from excess weapons material stored in the USA. The PERLA Small Sample Calorimeter (SSCAL) and nuclear reference material were used to validate the method prior to implementation in the field. The precision, accuracy, and linearity as a function of heat output were verified by a set of heat producing samples that both covered and exceeded the heat range of the instrument. If calorimetry is to replace destructive analysis, the final overall uncertainty on the heat output must be less than 0.2%. Although not certified for heat output, the plutonium is sufficiently well characterised to allow for its use as a calibration standard. The precision obtained with both the electrical and plutonium standards is better than 0.15% at 10 mW and, as such, exceeds the specification requested. It is envisaged that a reduction in the level of precision will be obtained.

Support to the Institut de Protection et de Sûreté Nucléaire (IPSN)

The improved quality procedures for the characterisation of neutron sources and NDA instrumentation resulted in a close collaboration with the Institut de Protection et de Sûreté Nucléaire (IPSN), the French national safeguards authority. During 2000 the first agreement has been made for several calibration campaigns in PERLA during 2001. IPSN will also use PERLA as the European independent reference laboratory to evaluate the performance of commercial instrumentation for the measurement of plutonium samples prior to procurement.

Support to the nuclear industry

Further to the IAEA task related to the performance comparison of codes for the determination of the isotopic composition, much interest has been generated within the nuclear industry. For example the gamma spectra library, created within the IAEA task activities, is used frequently by companies and international organisations as part of their quality control. At the request of several organisations it is planned to make the library available on the Internet.
1.2.3 Gamma Spectroscopy

*R. Berndt*

CdZnTe semiconductor detectors for gamma spectrometry have an increasing importance as a measurement tool for Euratom inspectors in the field of nuclear safeguards. Since they are small and handy they are as well helpful in the fight against illicit trafficking of nuclear or radioactive material. This rapidly developing detector type has found an application as a qualitative means for underwater measurements on spent nuclear fuel. Here, fission products or activation products need to be identified. A user code BE-VERIF has been developed [1.5].

On the other hand, this detector has shown that it has the potential to give also good quantitative results with the characterisation of the isotopic composition of radioactive samples. There is still however a drawback to overcome: the spectral responses of all individual detector specimens vary so strongly - (Figure 1.3) - that a uniform concept for the peak area determination results in errors of a factor of two. For this reason the individual characterisation of detectors was started according to a peak shape model with four components. Using the detector specific and energy dependent parameters, the uncertainties are dramatically reduced and it is possible to determine isotopic ratios in a reliable way. This work is aimed at user tools in the above mentioned fields.

During 1999, the UMS-2 was extensively tested at the ABB LEU fabrication facility at Västerås (Sweden). This was carried out under a collaboration contract between ABB and ESO. The objectives of the test were to see the impact of this safeguards approach on the production flow in real manufacturing conditions and to verify the precision and accuracy of the measurements. This testing period gave very satisfactory results. One feature of the test was that during operations both measurement data and operational status information could be accessed using a remote link to the ISIS laboratories. In the last quarter of 1999, the UMS-2 was used by ABB during production of three different types of PWR assemblies and the resulting experience was evaluated by ISIS, ESO and ABB. The data from these measurements were analysed by ISIS in order to quantify the measurement performance of the instrument.

In Figure 1.4, the UMS-2 measurement uncertainty for measurement campaigns of two different fuel assembly types is given. The data, originating from assemblies with and without neutron poison, show that the reproducibility is slightly more than 1 % (without counting statistical uncertainty).

References


1.2.4 Unattended Verification of Fresh Fuel Assemblies using UMS

*P. Schillebeeckx, J. Löschner, J.G.M. Gonçalves*

Under the support programme to ESO, ISIS has developed and tested unattended automated systems for the safeguards verification of fresh LEU and MOX assemblies in fabrication plants. The implementation of such systems will allow ESO to have 100% verification of fuel assemblies without inspector presence. The unattended verification includes video reading of the assembly identification number and a neutron collar measurement. The position and duration of the measurement can be configured according to the assembly type if the identity number of the assembly is known to the system. If the assembly characteristics are known to the system, it can carry out unattended data evaluation to confirm the declared characteristics. The verification is activated by the operator loading the assembly into the measurement station and no other intervention of the operator is required. The unattended measurement station (UMS) carries out its own monitoring of background and detection efficiency.

In Figure 1.4, the UMS-2 measurement uncertainty for measurement campaigns of two different fuel assembly types is given. The data, originating from assemblies with and without neutron poison, show that the reproducibility is slightly more than 1 % (without counting statistical uncertainty).
During 2000, discussions have taken place between ESO and the FBFC LEU fabrication facility in France (Romans sur Isère) to prepare the installation of two UMS systems on the production lines, which are being set up there. It is planned that the first of these lines should be functional in 2002 and the second in 2005. The first UMS system needs to be ready for installation in August 2002. Technical discussions involving FBFC, ESO and ISIS are ongoing in order to identify the technical modifications required for the features of the specific production lines. In this context, ISIS is investigating the applicability of triangulation-based laser striping for reading the characters that identify the assembly while it is in the UMS. ISIS is also investigating the integration of a vision-telephone system (web-based) so as to allow ESO inspectors have access to remote ISIS technical support during inspector visits to the UMS. The neutron collar measurement approach will remain as in the earlier versions.

1.3 SEALING AND IDENTIFICATION TECHNIQUES (CONTAINMENT SURVEILLANCE)

B.C. d’Agraives

The sealing and identification techniques laboratory (SLab) activities have essentially been an extension of the work done in 1999. SLab has been active in three domains and has progressed mainly in testing and installing new equipment to meet research needs. In addition, an important third party work contract has been advanced. SLab has specialised in developing ultrasonic sealing techniques as a support to, and on request of, the safeguards authorities such as the IAEA or ESO, which originally requested such systems for the control of nuclear storage containers, either in La Hague Cogema plant/France (MK-6 Sealing-Nuts) or in Sellafield BNFL plant/UK (MK-4 Sealing-Bolts).

In 2000, the activities focused around three main lines:

- **Support and Assistance:** to ESO and, to a lesser extent, to the IAEA, which jointly or separately use SLab sealing systems on storage containers at the above mentioned sites. The SLab team visited La Hague (France) and Sellafield (UK) sites several times and provided support to inspectors as well as replacement equipment. New orders for reading equipment and seals were prepared and delivered as well.

- **Research Activities:** work continued on the improvement of the sealing bolts’ mechanism to offer a safer item to inspectors. A large effort was also devoted to the specification and fabrication of special electronic cards to be installed on portable computers used for the verification of seals. On a principle similar to that for ultrasonic seals, SLab has also studied, developed and patented a new technique for the “unique identification” of sensitive structures such as PWR fuel bundles or any other kind of container, by incorporating specially marked metallic “disks” generating a digital code to be “uniquely” read by ultrasonic means. In the area of developing identification means, SLab has also studied, developed and filed a patent for a new “non-ultrasonic” technology, based on laser interferometry, which is aimed at the identification of sensitive items by using “speckle images” produced in certain conditions in a reproducible manner by their surface (Figure 1.5). SLab has worked and solved the main mechanical and electronic problems raised by a special “double way” ultrasonic reading-head, capable of reading two ultrasonic features (identity and integrity) or (identity and number) practically at once.

| 1.5 | New interferometric head for the identification of objects by “Speckle Effect”. |
| 1.6 | Production of parts for seals for MOX fuel bundles before assembly and laser welding. |
• **External collaboration:** SILab has conducted two kinds of external collaboration: (1) manufactured two reading units associated with two portable computers (which were to be used for demonstration purposes) and provided them to the TACIS programme, along with some ultrasonic seals specimens for the IPPE Obninsk Centre in Russia and (2) worked intensively on the 230,000 Euros contract signed last year with the Japanese Hitachi/Toshiba Fuel Makers (now JNF). This contract aims at offering a feasible solution to JNF fuel makers if they have to place ultrasonic seals on their future BWR MOX fuel bundles, which should come into production/be used in Japan within the next years. This work is based on an original skill, developed years ago, when SILab developed and tested a special “cap seal” for German BWR fuel bundles in Kahl (Germany). Several technical visits were made to Yokohama and Ispra. SILab came up with 5 different designs and series of prototypes, which were all assembled and tested mechanically. If the contract is not extended, it will end in March 2001.

1.4 **TRANSPONDER-BASED IDENTIFICATION**  

*C. Korn*

The transponder-based seal was further developed in 2000 to eliminate the need for an inspector to tie a knot in the wire. This new wire-locking system reduces installation problems and is less time-consuming. 3000 samples of this ISIS patented transponder seal (*Figure 1.8*) were delivered to the ESO for installation and evaluation. New readers for in-field identification are under evaluation in the TEMPEST laboratory – see Section 1.6. These readers combine a high reading range with a larger memory and better overall resistance.

Another batch of 300 seals has been installed in the Ispra decommissioning building to identify various types of containers. Special disk transponders have also been installed on the transport pallets for identification on entry to and exit from the various storage facilities. Specially designed stationary readers were studied and developed and are being installed to track the movements of the containers (*Figures 1.9 and 1.10*).
1.5 SURVEILLANCE AND MONITORING

1.5.1 Design Information Verification

V. Sequeira, J.G.M. Gonçalves, E. Wolfart

The objectives of design information verification (DIV) are threefold:

• to ensure that an installation has been built according to the approved design plans;
• to ensure that an installation has not been changed without authorisation;
• to track and document all the changes in successive inspections (continuity of knowledge).

The process of DIV can be divided into two main steps: acquire raw data from the plant and compare the “as-built” and target models. The objective of this work is to develop a prototype that accepts multi-sensory data as input and is multi-scale. This last feature allows for different acquisition systems and algorithms according to the size of the objects/buildings to be modelled. Indeed, a building, large tanks or small pipes require different equipment and modelling algorithms. The system will provide semi-automated tools to compare the acquired “as-built” and the approved design models. Figure 1.11 shows a short-range laser scanner as well as a snapshot of the 3D model of a real pipe scene. Safeguards relevant distance measurements can be automatically extracted.

1.5.2 Image Retrieval by Visual Examples

E. Stringa, J.G.M. Gonçalves, P. Meylemans

Surveillance cameras installed in nuclear plants provide valuable safeguards information. A major problem is the number of images to be analysed by inspectors. A first reduction, typically 95%, can be obtained by using scene-change detectors, but this is still not enough. The goal of this research is to design and develop a system capable of identifying all safeguards relevant images as a support to inspectors in the analysis of surveillance images.

Image retrieval systems aim at extracting from an image database all the images similar to a specific, user-defined example. This is achieved by characterising each image (i.e., indexing) with a set of numerical features (related to shape, colour, texture and other properties). The retrieval phase uses a subset of features to rank the images by decreasing degree of similarity. The user queries the database by selecting a visual example (an example image) and the interesting pictures are extracted by matching the content of the example to one of the images in the database (Figure 1.12). Preliminary tests indicate the suitability of image retrieval techniques [1.6-1.10] to extracting all safeguard relevant images from a surveillance database.
1.5.3 Machine Learning Techniques for Data Reduction of Surveillance Images

J. del R. Millán, M. Franzé, J. Mouriño, C. Versino

In available image retrieval systems, the user must manually select those numerical features that better describe the relevant images. This work explores machine learning techniques for the automatic selection and tuning of relevant features to retrieve safeguard relevant images.

The result of a preliminary study indicates that a promising approach is to combine feature selection and induction – i.e., the process of learning the appropriate classifier that differentiates between safeguards relevant and irrelevant images – in an interactive system where the inspector gives qualitative feedback on a limited number of images. Briefly, by giving two initial sets of relevant and irrelevant images, the system selects those features for which the classifier better discriminates between the two classes. Then, the system applies the learned classifier over new images and presents a few significant images to the inspector for feedback who labels them as relevant or irrelevant. After a few iterations the initial sets of images expand and the learning of the appropriate classifiers is tuned gradually.

1.5.4 Visualisation Techniques for Training of Inspectors

J. del R. Millán, M. Franzé, J. Mouriño, C. Versino

Advanced multimedia and visualisation techniques provide a major contribution to the realism required in any safeguards training package, considering that an object (e.g., an instrument) or remote location (e.g., nuclear plant) is represented by different types of data: text, photographs, animations, videos, sound, 3D, etc. (Figure 1.13).

A visual panorama is a 360° Internet compatible picture obtained by stitching together a sequence of adjacent photos. Several visual panoramas can be connected to create a virtual tour – an interactive visit to all relevant locations of a plant. This provides a good perception of space, i.e., the “feeling of being there”. Specific regions, i.e., “hot-spots”, can be easily linked to other sources of information. It is thus possible to link a large installation to its contents, inventory information or detailed explanations on how to use/maintain the equipment. Recently, these techniques have been demonstrated for the creation of safeguards training tools.

1.5.5 Electronic Agenda

V. Sequeira, S. Carelli, C. Korn, J.G.M. Gonçalves

Recent developments in information and communication technologies are changing the way professionals work. This is particularly true for people working away from headquarters, as is the case for safeguards inspectors. Three technologies are instrumental in this change:

• Miniaturised computer equipment (e.g., palmtops, pocket PCs or wearable devices);
• Wireless communications both short (e.g., Bluetooth or IEEE 802.11b) and long range (e.g., GSM);
• Position technologies (e.g., GPS or transponder-based identification).

The combination of the above technologies enables the development of a new family of field equipment to support safeguards inspectors when away from headquarters. The objective of this work is to identify the most suitable technologies, which allow for easy and secure remote access to safeguards information (e.g., manuals, maintenance instructions, measurement databases, etc.). In a second phase some working proto-

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1.7 COMPASS: http://compass.itc.it/index.html
1.8 QBIC: http://www.qbic.almeden.ibm.com/
1.9 SURFIMAGE: http://www-rocq.inria.fr/cgi-bin/imedia/surfimage.cgi/
1.10 IMATCH: http://www.mwlabs.de/
types based on commercial off-the-shelf components will be built to test the validity and usability of the new equipment. Figure 1.14 shows a subset of today's components that can be already employed by safeguards inspectors in the field.

1.5.6 Remote Inspection and Tele-operation for Advanced Storage Areas

E. Ruiz Morales

After the dismantling of nuclear weapons and their probable release under international verification regimes, unmanned, highly automated and secured environments may be required for the storage of strategic materials. In view of this technological emergence, ISIS is developing an advanced prototype and demonstration system for the automated control of storage areas. This system also aims at being a training platform for inspectors and a test-bed for TACIS projects in nuclear safeguards.

The RIALTO tele-operation laboratory includes a prototype robotics system, and associated tools such as the GENERIS robotics controller, the graphical computer simulation for real-time monitoring and the inspector’s interface. Further, a variety of sensors were investigated in order to provide autonomy to the robotics equipment during the material inspection phases. As a result, a vision system and tactile force/torque sensors were successfully integrated (Figure 1.15). In addition, the design of a novel tele-operation concept including a mobile platform and special guidance equipment for enhanced flexibility was recently initiated.

1.6 ENVIRONMENTAL TESTING (TEMPEST LABORATORY)

C. Korn

The TEMPEST (Thermal, ElectroMagnetic and Physical Equipment Stress Testing) laboratory extended its activities in terms of electromagnetic compatibility immunity and measurement testing (such as harmonics measurements, conducted perturbations measurements, etc.) as well as in the field of mechanical shocks and low frequency vibrations, installing new generators and measurement instruments to be able to perform tests based on new international standards.

The accreditation of the TEMPEST laboratory according to quality standard EN 45001 was confirmed in December 2000 with an external COFRAC (Comité Français d’Accréditation) surveillance audit and a new test bench was recognised: immunity of conducted disturbances induced by radio-frequency fields (according to IEC 1000-4-6 standard). The TEMPEST laboratory remains the only thermal and electromagnetic test laboratory, which is recognised world-wide under the EN 45001 quality standard.

During 2000, the activities of the TEMPEST laboratory, increased in terms of the number of safeguards equipment and devices tested mainly in support to the IAEA, for example, electromagnetic (radiated and conducted immunity and emission) tests conducted on IAEA's DCM-M3 [1.11], ALIS Pacpro [1.12] and Portable Alis [1.13] surveillance systems, as well as thermal, humidity and mechanical tests conducted on the portable reader for the IRC passive transponder seal [1.14] used by the ESO as well as on the IAEA’s Alis Pacpro [1.15] surveillance system.
In order to be able to match the laboratory tests as closely as possible to the real equipment operation conditions, the TEMPEST laboratory, as a support to the ESO, developed a specific portable environmental parameters recording unit. (Figure 1.16). This recording unit, transported and installed where ESO surveillance systems and/or seals and measurement instruments are located, is able to record the following parameters: temperature, humidity, light intensity, radiated electric fields, radiated magnetic fields and main network perturbations (voltage variations, harmonics, surge etc.). A special training course was held in the TEMPEST laboratory for ESO experts in order to manage the system, which will be used to correlate in the best possible way in-field operation conditions of ESO equipment with the test levels conducted in the TEMPEST laboratory. This will result in the development of a new test procedure for safeguards equipment, based on in-field measurements and IEC standards. 

The TEMPEST laboratory began a new activity of support to the Energy and Transport DG within the framework of the new recording equipment for road transport. The role of the TEMPEST laboratory is defined as follows:

- development of specific test procedures and test benches for interoperability tests between on-board control equipment, sensors and tachograph cards;
- interoperability tests;
- certification of public keys for the security of the systems.

The TEMPEST laboratory has prepared the design of the various test benches as well as the overall organisation. Preliminary tests will be run in 2001.

1.7 INFORMATION SYSTEMS

1.7.1 Satellite Imagery and Geographical Information Systems

A. Poucet

ISIS started to investigate the benefits and cost of using high-resolution satellite images as a means for providing independent information on layout and characteristics of nuclear sites. High-resolution satellite images, with ground sampling distance of a few metres – until recently the domain of military satellites – are now becoming available on a commercial basis and can provide useful information to verify site declarations.

It was realised early on that a promising approach was to integrate satellite images with other geo-referenced information (Figure 1.17). Therefore a start was made with the development of an “inspector workstation” based on Geographical Information Systems (GIS) technology. In this approach satellite pictures are corroborated with other information such as site maps and other geographically related information to enable a “cadastral survey” on existing nuclear sites.

A prototype, called SIT (Site Investigation Tool), is under development with the objective of integrating as much as possible site related information from declarations and from open sources in a single environment. SIT is an integrated platform for collecting, managing and analysing data from declarations and from a variety of other sources to support verification of completeness and correctness of states’ declarations. The architec-
ture of SIT allows the integration of information from facility attachments and other data provided in the context of the traditional safeguards declarations, as well as information provided under the new additional protocol. Besides verification, SIT may also support inspection planning and training. A study was started to investigate the use of SIT in combination with dispersion modelling to support planning of activities and interpretation of results related with wide area sampling.

1.7.2 Information Centre on Non-proliferation

L.V. Bril, F. Mousty

Support to the definition of a common EU non-proliferation policy as included in the mission statement of the JRC is a very important task. The non-proliferation issue not only addresses nuclear activities, but also includes chemical and biological material and in general, Weapons of Mass Destruction (WMD). First, a database is being established to allow for fast answers to requests coming from the political world. However, this database cannot be considered as a simple “bank” because many governmental organisations (GOs) and non-governmental organisations (NGOs) have already information available on the web. It has been conceived as a dynamic system, which analyses and validates information, and it will describe and analyse the present and future various material cycles (nuclear fuel cycle, chemical industry etc.). It should, from these investigations, foresee the consequences for Non-Proliferation (NP) and Verification Regimes. Above all, it is conceived as an impartial and independent tool at the service of the EU i.e., independent of external pressure. The tasks of the Information Centre can be identified as follows:

- Establishment of a first information set concerning Treaties, Agreements, Regulations and the various GOs involved in the implementation. A second set will concern the NGOs. This task is currently well advanced.
- Establishment of a competence centre on present and future material cycles (nuclear fuel cycles, chemical and biological industries, technologies, developments, etc) and world-wide monitoring of activities (NP, disarmament and WMDs). This task is under development.
- Establishment of a continuously updated database and analysis and validation of the data collected. Part of the information should be available to the public through the web or other information means. Furthermore, by using the information on the database, country profiles can be established and analysed. This task has begun and some preliminary documents have been produced.
- As a function of technological improvements, evaluation of the consequences on NPs, verification regimes and disarmament.

1.8 INSPECTOR TRAINING

M. Franklin, S. Guardini

Training in nuclear safeguards is expensive for a variety of reasons. It requires specialised laboratories with an extensive range of instrumentation and nuclear samples. It also involves the time spent by specialists in giving courses and preparing manuals. For the past several years at ISIS, training and calibration laboratories like PERLA and TAME have been created, with the aim of simulating as close as possible field conditions.

ISIS nuclear activities play an important role in providing training in the techniques of auditing of accountability for plutonium and uranium in nuclear facilities. This auditing ensures that the nuclear material is properly accounted for. The major client for this training service is ESO. The ISIS training course menu includes about 15 courses covering, for example, passive and active neutron measurement methods, gamma spectrometry techniques for isotopic composition, calorimetry, mass and volume measurements for liquids in accountability tanks as well as courses dealing with the practical procedures of verifying an inventory and subsequent data processing. In most of the courses for ESO, the instruction is a combined effort from ISIS specialists and experienced staff from ESO itself. ESO is not, however, the only client of these training courses as some of the ISIS courses for ESO are also attended by the IAEA inspectors, mainly oriented to solution monitoring in the TAME facility. During 2000, ISIS gave a total of ten different types of courses for ESO and IAEA participants.
A special training course led by personnel from the Los Alamos National Laboratory and supported by our staff was held in PERLA. Staff from ESO and the IAEA attended the course. During the course, the attendees gained an intimate knowledge of the functioning of the Advanced Multiplicity Shift Register, used for the determination of the mass of fissile material. The course benefited from the expertise, infrastructure, and in particular, the nuclear reference material of the PERLA laboratory which was used extensively. This equipment will be deployed world-wide to assist inspectors in their day-to-day job of monitoring nuclear material to avoid the proliferation of nuclear weapons.

The emerging technologies of computer based learning can meet some of these needs in an appropriate way. For this reason ISIS has an on-going project of development of multimedia modules for ESO inspectors. This development is an active collaboration between ISIS and the training personnel in ESO and uses external software companies as much as possible. These multimedia modules will be made available via network.

The available modules cover active and passive neutron measurements, gamma spectrometry, as well as concepts of measurement uncertainty and measurement quality control. The content covers the practical setting up of the instrumentation, use of software, theory of the measurement methods, problem solving, etc.

In the framework of ISIS's support to the development of similar training in Russia, courses are also organised for Russian participants who will be instructors in the Russian training centres. During the year 2000, ISIS provided three courses for Russian participants. These covered K-edge/X-ray densitometry of liquid phase nuclear materials, Non-Destructive Assay (NDA), Statistics and Nuclear Material Accountancy and Characterisation of NDA Reference Materials (together with US-DOE).

1.9 TECHNICAL ASSISTANCE TO THE COMMONWEALTH OF INDEPENDENT STATES (TACIS)

Co-operation with Russia and Kazakstan is performed in the framework of the various TACIS projects that are coordinated by ISIS. The following projects are under way:
- Russian Methodology and Training Centre (RMTC Obninsk) in co-operation with the Institute for Physics and Power Engineering (IPPE).
- Instrument development (in co-operation with the Institute for Automation - VNIIA).
- Ural Siberian Methodology and Training Centre (UrSiMTC Snezhinsk) in co-operation with the All Russian Institute for Technical Physics (VNIITF).
- Development of NMAC (Nuclear Material Accountancy and Control) systems for fuel fabrication plant in Ulba (Kazakhstan).
- Development of NMAC systems NPP Kursk and Kalinin (in co-operation with Rosenergoatom - REA).

1.9.1 RMTC (Obninsk) and URSIMTC (Snezhinsk)

In recent years one of the interesting spin-offs that has emerged from the European Commission’s activities in nuclear safeguards is the fact that it has become a resource for transferring EU experience of nuclear materials management to the Russian Federation, which is involved in upgrading its own accountancy and control of nuclear material. Among its support activities under the TACIS programme, ISIS has assisted the Russian Federation in setting up a training centre at the Institute of Physics and Power Engineering at Obninsk – similar to the PERLA training centre at ISIS. The support has included: provision of instrumentation; provision of nuclear material standards; modification of laboratories; training; participation in training courses and workshops at Obninsk and making available ISIS training documentation.

In a second project, work has begun in identifying the detailed needs for a second training centre in the Ural region. This centre, UrSiMTC (Ural Siberian Methodology and Training Centre) will focus on the back end of the fuel cycle. A first laboratory to be implemented will address the NMAC aspects related to plutonium storage. The detailed specifications for this laboratory have been worked out.
1.9.2 Instrument Development
This project is supporting the development of Russian produced instrumentation for NMAC. The main activity in 2000 involved:

• a study to identify needs and priorities for the Russian’s own production of measurement equipment (instrumentation needs, development priorities, review of commercial instruments, QC requirements, etc.),
• specification, development of testing procedures and procurement of instrumentation to measure uranium and plutonium.

1.9.3 NMAC at the ULBA facility
(Further details can be found under section 1.1: Mass and Volume Measurement Techniques.)
The objective of this project “Computerised NMAC system at Russian nuclear power plants” is to implement a computerised system for NMAC at two Russian nuclear power plants and then to extend such a system to all Russian nuclear power plants. In 2000, an in-depth analysis was made of the situation with regard to nuclear material management at the Kursk nuclear power plant (RBMK type) and at the Kalinin nuclear power plant (VVER type).

1.10 ESARDA
The European Safeguards Research and Development Association (ESARDA) remains the most important cornerstone of cooperation with other organisations in Europe. In 2000, ESARDA organised its 22nd Annual Meeting [1.16] in Dresden. This meeting focused on the strengthening of safeguards and how to integrate traditional verification with the new regime (Additional Protocol). The 3rd Joint ESARDA-INMM Workshop was held in Tokyo. This was the third in a series of workshops on “Science and Modern Technology for Safeguards”.

References
Humanitarian De-mining

OVERVIEW

I. Shepherd

1999 was the first year in which ISIS’s institutional work supported EU policies on humanitarian de-mining. Several projects were started to better understand the nature of the problem and to identify how best the European Commission should focus its efforts in order to be most effective. In the second year, 2000, many of these studies were completed, reports were prepared and delivered to customers. These included a number of experimental and analytic studies on new detection methods – electronic noses, electrostatic and infra-red sensors – as well as algorithms for fusing together information from different sensors and the use of computer-aided design packages to distinguish between different types of mine. A study was completed on the potential transfer of ISIS’s knowledge on human factors in aviation safety to the training of deminers. The second year also led to a rationalisation of efforts. This was prompted first by insights gained in this work, secondly by requests from the External Relations DG, which co-ordinate the European Commission’s efforts on land mines, and thirdly by the arrival in ISIS in October which co-ordinate the European Commission’s efforts secondly by requests from the External Relations DG, was prompted first by insights gained in this work, second year also led to a rationalisation of efforts. This was prompted first by insights gained in this work, secondly by requests from the External Relations DG, which co-ordinate the European Commission’s efforts on land mines, and thirdly by the arrival in ISIS in October 2000 of the “Detection and Positioning Technologies” unit from JRC’s Space Applications Institute (SAI). The improvement and assessment of demining technologies became the responsibility of the ex-SAI unit and the work on information systems began to concentrate on improving the transparency, visibility and effectiveness of EU mine action operations.


2.1 IMPROVING TRANSPARENCY, VISIBILITY AND EFFECTIVENESS OF EU MINE ACTIONS

I. Shepherd, R. Peckham
http://eu-mine-actions.jrc.cec.eu.int/

In view of the enormous nature of the problem, effort is focusing on South-East Europe. This has two objectives – first to contribute towards the European Commission’s road map for the region and secondly to develop methodologies and tools that can be applied more widely. ISIS continued to maintain its web-site and on-line database of EU mine actions. Progressively its accuracy and level of detail improved as information from the different services of the Commission involved – the External Relations DG, Common Service for External Relations (now AIDCO – EuropeAid Co-Operation Office), ECHO and the Development DG – were cross-checked and correlated. An on-line geographical information system was completed.

A major effort was made to harmonise information in the South-East Europe region. A preliminary workshop in Ispra in March 2000 was followed by another, in September 2000 at the Bosnia-Herzegovina Mine Action Centre (BHMAC), Sarajevo. Participants included representatives of Mine Action Centres in Albania, Croatia, Bosnia Herzegovina and Kosovo. Intensive discussions led to the definition of standard terminology for the contents and formats of reports describing infected areas (type, position, estimated area, numbers and types of ordnance). The approach used was to keep the reports as simple as possible to begin with and restrict these transfers to information which could be placed in the public domain. The contents and formats for reports describing incidents and accidents were also discussed and agreed following similar lines.

A six-monthly reporting interval was agreed. In 2000, the first deliveries of information were made by the Mine Action Centres to the JRC. Information was received from Bosnia-Herzegovina, Croatia and Kosovo. This information is being fed into a decision support system linked to a geographical information system with the primary aim of helping developers of new technology understand the operational requirements. That there is a need for such technology is not in doubt. The backwardness of present equipment – prodders, metal detectors, dogs, mechanical means – meant that during 2000 only about 10 km² out of a suspected 4,500 km² was cleared in Croatia. The decision support system merges the mine-field information with information originating in JRC on landcover, slope, population density, climate, soil type, etc. A database is being set up to make this merged information available over the Internet.

The system is intended as a building block for the regional information system or “headquarters module” wanted by the External Relations DG. This might have security applications beyond only mine clearance. In the spring of 2000, ISIS participated in a Council of Europe task force mission to Kosovo whose objective was to ease the transformation of the former Kosovo Liberation Army from a military body to a civil protection force. The first step was to prepare an assessment of risks in Kosovo – floods, fire, seismic, landmines – that might need an intervention from such a body. The JRC contributed its general risk assessment expertise as well as a more specific expertise in landmines and acted as editors of the final report.
2.2 REMOTELY CONTROLLED MECHANICAL EQUIPMENT

F. LITTMANN

The methods in use today in humanitarian demining are slow, dangerous and expensive. To develop realistic techniques and procedures that will truly enhance the process of mine clearance (faster, safer and cheaper means), two important factors must be considered:

- Mines: the threat presented by the extensive variety of mines themselves and the ways in which they are used. One of the main threats is from bounding fragmentation mines and associated tripwires.
- Minefields: the limitations imposed by the real minefield environment, where the terrain often rules out whole categories of techniques and equipment. One of the main difficulties is the vegetation, which creates a physical access problem (clearing vegetation takes up to 70% of the deminer’s time), but also makes it difficult to spot fragmentation mines and tripwires.

Heavy mechanical devices could be the solution, but they are often derived from military equipment fulfilling breaching requirements (high speed, clearance rate around 80% etc), consequently they are heavy (between 10 and 60 t), cause soil erosion, destroy all the trees or crops and their transport, mobility, spare parts and associated logistics are often not affordable for most non-governmental organisations. Light mechanical demining vehicles (between 1 and 5 t) are used in humanitarian demining, mainly for vegetation cutting and tripwire clearance. They are remotely controlled, offer a high mobility, are easy to transport and are affordable for most operations. A preliminary survey of light and remotely controlled mechanical equipment has provided information on several potential already existing candidates.

2.3 PILOT CAD DATABASE FOR THE CLOSE-IN DETECTION OF LANDMINES

F. ANDRITSOΣ, F. LITTMANN, I. VAKALIS

One of the major issues in landmine detection is the very high false alarm rate associated with the high sensitivity metal detectors needed for the detection of the modern minimum metal mines, coupled with the usually high debris soil contamination. At present, each metal detector alarm can only be confirmed by manual probing and digging to visually identify the suspect object.

The work performed at ISIS aims at using 3D Computer Aided Design (CAD) models of mines for a pilot multi-sensor data-fusion application. CAD feature extraction coupled with multi-sensor data fusion algorithms is expected to help in identifying the cause of many metal detector alarms, thus saving a lot of manual work and enhancing the demining process significantly.

Continuing the work started in 1999, staff members were trained to use the CAD software tool, which had been chosen as being the most suitable for the envisaged work and several CAD models of anti-personnel and antitank mines were done.

2.4 HUMAN FACTORS IN HUMANITARIAN DE-MINING

P.C. CACCIABUE

Despite the amount of research conducted in order to identify new technologies to support clearance operations in humanitarian de-mining, detection and clearance are still performed manually using metal detectors and probes. The human being is the main actor in field operations.

A pilot research started in early 2000 helped in identifying performance indicators and professional competence of deminers [2.1]. These results, in turn, define the training needs in terms of objectives and contents to be developed and emphasised in a training course on non-technical issues, i.e., human factors. The most important findings of this pilot research can be summarised in the definition of two levels of interventions: risk management and individual-organisational factors (Figure 2.3). At risk management level, the main factors which have an impact on de-miners’ behaviour

2.1 A few examples of remotely controlled light mechanical equipment.

2.2 PMA2 CAD model and real anti-personnel mine.

2.3 Pilot CAD database for the close-in detection of landmines.
are related to attention, risk perception, national/safety culture, mental and physical fatigue (normal duration of a single prodding task should not exceed 20 minutes). In particular:

- The level of attention of de-miners decreases strongly with routine and complacency and this causes “poor” or unsafe results.
- Risk perception, decreased by routine as well as the high rate of false alarms (100-1000 false alarms for each real mine detected), further increases “over-confidence bias” in detection and inspection tasks, as well as “invulnerable” and “macho” attitudes.
- National/safety culture determines the way in which Standard Operational Procedures and safety equipment are applied and used. For example, in some cultures, wearing protective equipment is seen as a sign of weakness.
- Fatigue can strongly affect performance during prodding and de-miners can normally carry out this task for 20 minutes before requiring a rest.

The most important individual and organisational factors that may be the objective of training are:

- Teamwork, highlighting the role of good communication among team members, team building, and interdependence.
- The features of successful leadership.
- National culture as way of communication and relationship with the local population.
- Co-ordination and co-operation within the organisation and among the different institutions dealing with demining in the same area.

In the future, the research work will focus on the long-term objective of developing guidelines for the design (objectives, contents, and methodology) of human factors training for personnel working in the field of humanitarian de-mining.

In the framework of humanitarian de-mining, a collaboration with the University of Padua and the University of Turin focused on the study of professional competence of experts in manual clearance operations. In particular, the Naturalistic Decision Making (NDM) movement, initiated in the United States in 1989, addresses the study of how people use their experience to take decisions in the field setting. NDM research has been mainly applied in two main domains: pilots (aviation) and fire-fighting brigades. The collaboration with the Department of General Psychology of the University of Padua showed that the NDM paradigm and methodologies can be applied for the evaluation of the metal processes of typical experts in the humanitarian demining domain. Consequently it can be exploited for the selection processes and for the development of training [2.2].

A pilot research was planned and carried out in collaboration with the University of Turin – Department of Psychology – and the Italian Non-Government Organisation (NGO) Intersos. The pilot research aimed at identifying elements of professional competence of experts working in the demining field. Different methodologies were taken into consideration and some were immediately rejected, for instance observation and “think aloud”, due to the specific type of competence and the difficulty in their application in the field during clearance operations. Finally, three different techniques based on verbal interactions were selected and applied: instructions for one’s double, behavioural event interview and story telling. According to the preliminary results obtained, the research highlighted some major areas of professional competencies, namely: social/interpersonal and cultural dimension (relationship with the team-members, the local population and local organisations/institutions); and cognitive dimension (in particular, decision making competencies) [2.3-2.4]. These data will guide the second part of the research, which will be conducted in collaboration with the Italian Army involved in humanitarian de-mining. The final results will lead to the identification of the elements of professional competence, which should be trained in order to increase efficiency and safety of de-mining operations.

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2.4 Donato, E. – Contributing to the qualification of deminers by an investigation on the development of competence – Graduation Thesis in Psychology (in Italian), Università di Torino, Italy (2000).
The explosive worldwide growth of the Internet, its vulnerabilities and the lack of clear legal rules in international electronic commerce (e-commerce) have raised a legitimate concern with respect to the adequacy of security and consumer protection measures. The research during 2000 addressed key concerns in the areas of consumer trust and confidence in cross-border electronic commerce, safeguarding privacy in the on-line environment and protecting critical information infrastructures from vulnerabilities and cybercrime. ISIS has so far concentrated its support activities in the cybersecurity area with the Information Society DG. However, the impact of electronic technologies is so great that a wide range of policy-making DGs also needs expert technical advice in defining their policies and recommendations. These include the Health and Consumer Protection DG, Internal Market DG and the Enterprise DG. Similarly the European Parliament has shown interest in impartial advice regarding technical constraints and implications of proposed legislation. In the Europe Action Plan endorsed at the Feira European Council meeting in June 2000, the EU underlined the importance of building up consumer confidence on the Internet (eConfidence) in order to accelerate growth in business towards consumer e-commerce.

3.1 CREATING CONSUMER CONFIDENCE IN E-COMMERCE BY MEANS OF EFFECTIVE REDRESS MECHANISMS

M. Wilikens
http://econfidence.jrc.it/

Whilst e-commerce has many qualities that consumers find attractive, it also has properties that facilitate fraud and make prosecution in the judicial system difficult. Business to consumer e-commerce is characterised by a large volume of relatively low value transactions carried out across borders. Thus, the relevance and effectiveness of courts for resolving problems may be limited. Alternative dispute settlement mechanisms for providing consumer redress are therefore needed. New web-based technologies offer new possibilities, features and dimensions to dispute settlement. A successful workshop in March 2000 (in collaboration with other Commission DGs, industry and consumer organisations) explored technical concepts and criteria for on-line dispute settlement systems that are fair, effective and secure for resolving cross-border consumer disputes at a pan-European level. As a direct consequence of the workshop, an on-line eConfidence forum (http://econfidence.jrc.it/) was developed to facilitate information exchange and discussions on eConfidence. A new project to develop a demonstrator platform for testing components, business models and software applied to on-line consumer dispute settlement was launched later during 2000.

3.2 ON-LINE PRIVACY

T. Jackson
http://dsa-isis.jrc.it/Privacy/

The Internet and the World Wide Web have made it possible for an individual’s activities to be monitored, tracked and profiled closer than ever before. In Europe, efforts have been made to create a legal framework to protect the privacy of personal data collected or stored on-line. Nevertheless, legislation can only play a partial role in securing data privacy. To overcome this, ISIS is conducting a project for the Information Society DG on how technology can support European data protection directives. The project is investigating the state-of-the-art in privacy technologies for consumer and corporate deployment, and identifying privacy threats inherent in new and emerging technologies such as mobile code (software agents), biometrics, e-money and mobile telecommunications. In support of these activities a study and a workshop entitled “The Role of Technology in Facilitating On-line Privacy” was held in Brussels during May 2000. Consequently, a Privacy Hub (http://dsa-isis.jrc.it/Privacy/) was set up. Reference implementations of the Platform for Privacy Preferences (P3P) standard for privacy management will be tested in the TRINIDAD laboratory.

3.3 CHILDREN AND THE INTERNET

T. Jackson
http://efilter.jrc.it/

Effective filtering techniques and web tools for use by parents and teachers are a means to allow controlled access to high quality educational material and to avoid access to defamatory content. Nevertheless, the performance of these tools, both in terms of usability and effectiveness, is variable, and often does not meet the requirements of the individual users. ISIS has commenced a study, including laboratory tests, to foster a better understanding of the process of benchmarking filtering software and services used to protect children from harmful or undesirable content on the Internet. In particular the study seeks to define the evaluation
criteria that might be employed in specific benchmarking exercises. The project is intended to further the activities of the European Commission’s Safer Internet Action Plan, in particular action line 2 (developing filtering and rating systems) and to contribute to the definition of the EU research agenda in this area.

3.4 SECURITY OF CRITICAL INFORMATION INFRASTRUCTURES

M. Masera
http://deppy.jrc.it/

Society is increasingly dependent on the proper functioning of critical large-scale information infrastructures that underpin e-commerce, education, health care, etc. These infrastructures are vulnerable to malfunctions, attacks and cybercrime and are very complex due to extensive interdependencies. Initial technical discussions on possible transatlantic collaborations on the issue were organised by ISIS for the Information Society DG in 1999. Subsequently, an exploratory study was performed on “Dependability and Complexity: Exploring ideas for studying large unbounded systems”. A number of industrial sectors representing utilities, telecommunications and health care contributed to this work. An electronic forum was developed to foster information exchange and networked collaboration on this important societal issue.

3.5 DRIVE (DRUG IN VIRTUAL ENTERPRISE)

M. Wilikens
http://dsa-isis.jrc.it/

The Drive project is a shared-cost action research project under the Information Society Technologies programme, which commenced in July 2000. It seeks to develop a secure information-sharing infrastructure to improve the exchange of drug-related information between pharmaceutical companies and the various departments in hospitals concerned with therapy administration to patients. The objective is to increase patient safety by reducing drug-related errors by means of appropriate integrity checking of the information and identification of the people involved, whilst protecting privacy contemporaneously (Figure 3.2).

3.6 TRINIDAD TEST LABORATORY FOR INFORMATION SECURITY

L. Breitenbach
ISIS is further developing the TRINIDAD (Trial Infrastructure for Dependable Applications Deployment) laboratory for testing and assessing information security solutions that increase business and consumer trust in information society applications. TRINIDAD is an open infrastructure based on open computing and communications standards (TCP/IP, WWW, Java, Open Source, etc) to ensure platform independence of the tested solutions. The tested solutions include newly developed technologies, best practices as well as reference implementations of emerging standards (e.g., P3P standard for privacy management). Demonstrators have been developed on TRINIDAD using European Java-based technology. One demonstrator concerns a kiosk for the secure retrieval by patients of medical documents. Another is a Java-based smart card test platform for web-centric applications. The platform will amongst others be used for evaluating electronic authentication and identification techniques in the DRIVE project (section 3.5). Furthermore, TRINIDAD is being equipped to perform benchmarks of web filtering tools to protect against harmful Internet content (section 3.3).

Suggested Further Reading


### 4.1 WEB TECHNOLOGIES

**C. Best**

An important impact of the web on society is the new possibility for large-scale distance education and training. In a fast changing world, the need for lifelong learning, the development of educational technologies and measures to combat social exclusion are all recognised as major EU policies. During the year 2000, the research carried out in ISIS supported EU policies in the area of web-based education and training in the following main areas:

- Technical co-ordination of the PROMoting Multimedia access to Education and Training in European Society (PROMETEUS) network — a European Commission initiative encouraging collaboration and standardisation between over 400 companies and organisations in developing educational multimedia for Europe (http://prometeus.org/).
- Development and prototyping of the Gateway to European Learning Area.
- Technology observatory: To provide technical advice to the Information Society DG in developing their policies in education and training through hands on prototyping.

The main achievements were:

- Successful running and maintenance of the PROMETEUS web service and 12 mailing lists used by the special interest groups (SIGs).
- Generic Information Server Toolkit (GIST) software releases V1.04, 1.05 and 1.06.
- Gateway demonstrator (http://learningeurope.org/) was developed and demonstrated at an intergovernmental conference in Lisbon and at the Hannover trade fair.
- Knowledge Management System was developed as a simple fast but powerful community forum and web-site. It was demonstrated to an inter-DG workshop on Knowledge Management (figure 4.1).

- Development of a virtual live meeting system — Powercomm — and an operational web-casting system, which were demonstrated to the Education and Culture DG and the Information Society DG at a joint workshop.

#### 4.1.1 European Technology Transfer Network (ETTN)

**C. Segre**

http://ettn.jrc.it/

ETTN was a European Commission initiative designed to make technical research and expertise widely available to European industry. The aim of ETTN was to improve the process of technology transfer by encouraging the exchange of information and the setting up of an effective network of services. The technical management of the project was performed by ISIS on behalf of the Information Society DG and the Enterprise DG and was completed in September 2000.

ETTN facilitated technology transfer among Small Medium Enterprises (SMEs) belonging to information technology and environment sectors using a demand-oriented approach supported by a wide use of web-based communication tools. More than 370 SMEs belonging to 14 clusters, and technology brokers with an extensive knowledge of local industry tried to match technology requests and technology proposals exchanged throughout Europe using a web-based communication system. This new web-based system (a combination of GIST and CIRCA software) was specifically developed for the project. At the end of the project, 233 technology requests and 171 technology proposals had been introduced in the system. 27 ETTN case studies (i.e., actual contractual agreements between trans-national partners) have been published. Many organisations, announcements, innovations, events, news, services and products dealing with SMEs and technology transfer have been introduced in the ETTN web-site to facilitate the information exchange between SMEs.

#### 4.1.2 Information Highways and New Technologies

**P. Loekkemyhr**

http://vesl.jrc.it/

EUROSTAT recognised early on that the rapidly growing Internet and the wealth of new and emerging technologies associated with it represented an unprecedented opportunity for improving access to, interchange and visualisation of statistics related information. This project aimed at reviewing some of these new and emerging technologies, selecting promising contenders and developing and evaluating possible implementations in the form of demonstrator systems. ISIS has, in collaboration with other institutes in the JRC, namely, the Environment Institute (EI) and the Space Applications Institute (SAI), investigated a range of technolo-
gies: desktop video-conferencing; streaming video on the Internet (figure 4.2); tools for virtual meetings; interactive visualisation of urban land use in virtual reality (SAI); visualisation of geo-referenced data (EI); and web-based Geographical Information Systems (EI). Prototype systems have been developed to identify useful features and possible applications. Results from surveys and experiments have been used to produce guidelines for efficient implementation of information systems employing these technologies. The results and technologies from the project will be fed into the technology transfer activities that ISIS runs in collaboration with EUROSTAT (see section 6.1).

4.1.3 Virtual European Statistical Laboratory

P. LOEKKEMYHR
http://time-series.jrc.it/

The Virtual European Statistical Laboratory (VESL) is a project undertaken by ISIS for EUROSTAT. The goal for the first half of the project was to design and implement a community-style Internet service for research and training in official statistics. The service was put into operation in April 2000. The service contains directories of people and organisations, libraries for software and documents and interactive services, which enable users to announce events and share software, data and documents with the community. Maintenance of the service is mainly done in a decentralised manner by the users themselves; VESL is an open self-populating web-site. The service is built using Generic Information Server Toolkit (GIST) technology (figure 4.3).

Towards the end of 2000, the project continued to pursue objectives related to demonstration, dissemination and technology transfer by broadening the scope to include some results from the Information Highways and New Technologies project (section 4.1.2). The project will continue until the middle of 2001 and the project results will be fed into the technology transfer activities that ISIS runs in collaboration with EUROSTAT (see section 6.1).

4.1.4 European Treasury Browser (ETB)

A. REGGIORI
http://etb.jrc.it/
http://rdfstore.jrc.it/
http://mda07.jrc.it/
http://xml.jrc.it:8080/

The European Treasury Browser (ETB) is the European Schoolnet’s web-based educational resource infrastructure for schools in Europe and will provide a European-wide clearing house for educational resources. The project started in February 2000. ETB is based on a distributed metadata network connecting repositories of educational web resources across Europe. The ETB architecture is designed to provide high quality information submitted from each agency. To support publishing and access to high-quality educational resources, the envisaged components for ETB are as follows:

- A web-enabled multilingual educational subject classification and thesaurus to aid accessing and providing content.
- An intelligent data-entry system for the end-user including a metadata authoring tool with gateways to existing metadata systems and a quality assurance procedure.
- A dynamic metadata network to allow the flow of information across the Internet.
- A metadata registry with an intuitive search interface.
- A full set of measures of harmonisation and normalisation addressing different layers.

4.2 Streaming video on the Internet was one of the topics of the project. The final presentation, live video and presentation screen of the project was webcast live in November 2000 to ten viewers in different European countries.

4.3 Example page from the web-service used to support research and training in the area of time-series in statistics.

4.4 ETB system architecture – an educational metadata network for European schools.
4.1.5 ParlEuNet – European Parliament Network:
a student’s parliament via educational multimedia learning

A. Reggiori
http://pen.jrc.it
http://parleunet.jrc.it

The ParlEuNet project began in January 1998 and officially terminated in June 2000. The ParlEuNet project was the first European initiative to permit secondary school students to use state-of-the-art networks and multimedia resources to learn about and undertake collaborative projects on the European Parliament. Internet connections, videoconferencing and a web-space containing a well-structured updateable multimedia database of educationally relevant materials was used by students to access information on the Parliament, create their own projects, and exchange information and views with members of Parliament and students in other countries.

The ParlEuNet system provided a multimedia database on the Internet, which was accessed by 12 schools from 7 European countries. The theme of the database has been the history, institutions and functions of the European Parliament and the "The world of work". The system can handle two types of information: reference material and dynamic educational material. ISIS developed a highly fast and efficient dynamic database to store, browse and retrieve such multimedia information. Cutting-edge technologies were deployed and investigated to actually implement the final product: XML data modelling; custom built, fast DBMS server using BerkeleyDB files; HTTP state-fullness and caching; live HTML document editing; user profile and individual session management; Apache, mod_perl and MsqI; and UNIX FreeBSD 100Mbit interconnecting fabric.

4.1.6 Solar Radiation Databases

M. Kleih, C. Best
http://soda.jrc.it/
http://opengis.jrc.it/

The project Solar Radiation Databases (SoDa) answers the needs of industry and research for information on solar radiation data. ISIS has developed a prototype JAVA tool for creating maps from multiple web servers. This is the first stage in creating an “Intelligent System” that should be able to process user from professional and non-professional solar radiation data users over the Internet. The ISIS JAVA tool implements the Interoperable Web Mapping Testbed (WMT) standard from the OpenGIS Consortium (http://opengis.jrc.it/). This standard defines how map servers respond to requests. The data can be distributed over the Internet and is accessed through HTTP requests (URLs). For ordering the geographical databases, another protocol developed by ISIS, the “HTTP-based geotemporal Search” (HGS) was used. This protocol allows one to define a hierarchical structuring of databases whereby the definition of the structure can be distributed. It also enables the participating institutes to maintain their own branch in the database hierarchy. To simplify participating data to the Geographic Map Request Tool (GMRT), another system was developed to upload and/or register geographic data. (http://soda.jrc.it/) All registered databases appear automatically as WMT servers. In the future a distributed processing system will be incorporated, which will permit users to run algorithms to further process solar radiation data.
4.1.7 Support to Improving Human Potential Programme

_C. Best, P. Henshaw, P. Shiels_

http://improving.jrc.it/
http://locin.jrc.it/

ISIS has implemented the main web database systems for the Improving Human Potential Programme in support of the Research DG. These dynamic web databases allow users to search for opportunities, networks, vacancies, conferences etc. and for remote managers to add and modify the content all through a web interface. The main services provided are as follows: research networks and vacancies; targeted socio-economic research; Marie Curie fellowships; access to research infrastructure; and high level scientific conferences. A large new system was released in December 2000 to present the database on “Local Initiatives to Combat Social Exclusion” (LOCIN). All these systems have been built using the JRC’s Generic Information Server Toolkit (GIST) technology, which has a proved robust and reliable framework for this type of dynamic website and offers users sophisticated search interfaces.

The project contributes to social policies by guaranteeing a high level of social security related services throughout the community. Such activities strongly motivate human mobility, which is endorsed by all European policies. ISIS’s role in the project is that of a multidisciplinary research centre, which, independent of commercial or other interests, contributes to the user requirements; lays down the functional requirements of the system as well as the acceptance criteria based on the user requirements; presides over the validation committee (medical and VR experts and Parkinson’s disease patients external to the project); and prepares for an eventual certification procedure. A rapid prototype of the PARREHA VR training tool has shown impressive results in bringing a person suffering from Parkinson’s disease from the “off-state” to the “on-state”.

4.2 SUPPORT FOR THE DISABLED

4.2.1 Rehabilitation IT Aid for the Parkinsonians (PARREHA)

_F. Andritsos, I. Vakalis_

http://www.parreha.com/

Parkinson’s disease is a dysfunction at the level of motor planning. Recently, scientists have shown that visual stimulation of Parkinson’s disease patients with “virtual” obstacles and auditory stimulation with rhythmical sounds can significantly improve the efficacy of traditional rehabilitation schemes. The project aims at the design and development of a system for:

- the assessment of motor performance,
- design and performance of training programmes for patients suffering from Parkinson’s disease by incorporating virtual reality (VR) visual stimulation, auditory biofeedback and interactive video conference technologies to conventional kinematics analysis and rehabilitation exercise protocols.

4.2.2 Adaptive Brain Interfaces

_J. del R. Millán, J. Mourriño, M. Franzé_

http://sta.jrc.it/abi/

The Adaptive Brain Interfaces (ABI) project has developed a portable brain-computer interface based on the analysis of electroencephalogram (EEG) signals. ABI makes it possible for people to interact with computer-based systems through conscious control of their thoughts after a short training period [4.1-4.2]. The portable brain interface has an embedded neural network that recognises which mental task the wearer is concentrating on. It does so by analysing continuous variations of EEG rhythms over several cortical areas of the brain. The approach is based on a mutual learning process where the user and the ABI interface are coupled together and adapt to each other. Interaction is quite natural as the user can make spontaneous and self-paced decisions without having to wait for, or respond to, external cues. The user can also concentrate on a wide range of mental tasks, from motor-related (e.g., imagination of physical movements) to cognitive tasks (e.g., completing mental operations involving awareness and judgement). Analysis of learned EEG patterns confirms that for a subject to operate satisfactorily his/her personal ABI, the latter must fit the individual features of the former. Briefly, there are hardly any features shared by subjects [4.3]. Building individual interfaces greatly increases the likelihood of success, as demonstrated for all subjects we have worked with despite the short training time of most of them.
During 2000, several applications were developed that illustrate the wide range of systems that ABI can be linked to. Thus, ABI augments disabled people’s communication capabilities through the use of a virtual keyboard, provides new forms of education and entertainment (Figure 4.8), and also enables the operation of physical devices such as wheelchairs (see section 4.2.3). The brain-operated virtual keyboard was presented publicly at a workshop on “Biosignal-based Human-Computer Interaction” held in Helsinki on 16 May 2000. During a live demonstration, a member of our team wrote a sentence correctly (suggested by the public) in a few minutes. This was recorded by Finnish television and shown on the news that evening (Figure 4.9).

The virtual keyboard and the computer game were also shown during the IST 2000 Exhibition in Nice on 6-8 November 2000 (this is the European conference of the information society community organised by the Information Society DG). In addition to live demos carried out by members of the project, several visitors tried ABI and achieved rather good performances in less than 1 hour of training. In December 2000, the BBC (British Broadcasting Corporation) invited our team to London to work with a disabled person who had volunteered to validate ABI as part of a service about our project. After a few hours of training, he mastered two tasks very well. At the end of the session, the journalists asked him for his opinion, and what he said rewarded the team more than anything else: “this is the first technology I have tried (including voice recognition) that made me feel independent and empowered”.

4.2.3 SMART-2

J. del R. Millán, L. Bort, S. Chiappa

This research network aims at training promising young researchers in the broad field of robotics technologies. ISIS’s participation focused on two topics:

• the use of ISIS’s Adaptive Brain Interface (ABI) to control a mobile robot: user’s mental states are associated to high-level commands autonomously executed by the robot. The robot relies on reactive strategies to move in the desired direction in a safe (avoiding collisions) and smooth way.

• Application of mathematical tools to analyse ABI when used for human-robot interaction. The analysis provides a more solid formulation and understanding of the learning paradigm, thus improving ABI’s performance and reliability.

This work demonstrates that it is possible for a physically disabled person to operate a motorised wheelchair without external assistance provided the wheelchair has some on-board sensory capabilities. Figure 4.10 shows how ABI enables the operation of physical devices, such as a mobile robot that closely mimics the

References


operation of a wheelchair. In this case, the user gives high-level commands (i.e., move forward, stop, turn left, turn right) and all the low-level details are handled separately. All high-level commands are sent to a reactive controller for execution. In this kind of controller, on-board sensors are constantly read and determine the next action, i.e., change the speed of the wheel motors.

4.2.4 VOICE: Giving a Voice to the Deaf

G. Pirelli
http://voice.jrc.it/

A significant number of Europeans suffer from hearing difficulties. They gain no benefit from telephone, non-subtitled television broadcasts or oral presentations. ISIS is encouraging the development of new equipment and attempting to raise awareness among the hearing population.

The project VOICE demonstrates how speech recognition systems in conversation, conferences and school lessons can translate voice into PC screen messages, taking into account the requirements of citizens with hearing impairments. In order to develop awareness among users, systems producers and services providers, ISIS has organised and presented VOICE at a large number of international workshops and congresses to approximately 5,000 participants, from industry, academia, broadcasting organisations, as well as final users. The prototype demonstrator has been used in several languages to generate live subtitling of these events, as an important means of validation in the field. A workshop has demonstrated the possibilities of the system to RAI (Radio Televisione Italiana) and other television broadcasters considering the best use of this technology. RAI broadcast information on the event and on the prototype’s tests in the schools. The users feel encouraged and helped by the VOICE team in their contacts with the producers and the service providers. For instance, RAI started subtitling the Evening News as an answer to impaired users’ requests (supported also by means of this project). ISIS has performed an overview of television subtitling in Europe and extended it to Canada. It has also investigated the use of this technology in subtitling telephone communication and has held a few meetings using subtitled video-conference sections.

VOICE was initiated as an ISIS exploratory research project and then sponsored by the Information Society DG’s Telematics Applications Programme (TAP). The project involves the active participation of several associations of people with hearing impairments, from different European countries, exchanging information via a multilingual VOICE Web Forum at http://voice.jrc.it/ for spreading results and best practices. The presentation follows the current recommendations for creating Internet contents that are accessible by people with visual impairment or reduced mobility, as an example of a web-site designed following the rules of “web-accessibility for all”. A hearing impaired auxiliary staff and a visually impaired student contributed to the web-site’s development.

Suggested Further Reading


4.2.5 ACCESS to Education for People with Disabilities

G. Pirelli
http://voice.jrc.it/access/
http://voice.jrc.it/moise/

The project ACCESS investigates the development of multimedia applications for helping people with disabilities in accessing the Information Society in their education and training. The aim is that of improving the quality of life by trying to include a portion of the population that is currently, at least partially, excluded. The research will facilitate the integration of people with special needs, including the elderly and immigrants. Owing to a “design for all” approach, everyone will benefit from this advance.

ACCESS is extending the VOICE project’s basic idea that the Internet is also the written voice of a teacher or a friend for those who cannot hear the spoken voice. The idea is even larger, in the sense, that also people with visual impairment may read the spoken web pages via text-to-voice synthesis of the written web pages. Workshops, videoconferences, tele-education sessions, Net-meetings and an ACCESS Web Forum offer opportunities for sharing common experiences and the dissemination of new ideas on the adaptation of multimedia systems to specific needs.

Collaboration with the Education and Culture DG has started in the MOISE (Modello Organizzativo Internazionale di Servizi per bisogni Educativi speciali – International Organization Model for persons with Special Educational needs) project on education and disability. ISIS is helping a group of schools in the use of new information technology tools. After validation by the final users, examples of best practices and design recommendations are selected and loaded onto the Internet in a format that can be accessed by all, irrespective of the required human-computer interface.

The team participates in an Inter-Service Group on Disability where it helps identify user needs and translates them into recommendations and technical specifications.

4.2.6 Multimedia Simulation System for the Disabled

P.C. Cacciabue

A scientific collaboration between ISIS and Istituto di Ricovero e Cura a Carattere Scientifico (IRCCS) “Eugenio Medea” was set up in order to promote a research programme aiming at a better integration of mentally disabled people in SMEs. The difficulty to recognise and react to our own errors is a common experience. In particular, this holds true for mentally disabled subjects because of their low projective capabilities, their attention deficit and the rigidity with which they apply resolutive schemes. Usually, during training they are taught how to operate machines by simple automatic sequences.

In order to devise a new training methodology and an innovative way to deal with errors a quite innovative approach was taken.

A two-year project (1999-2001), financed by the Italian Ministry of Health, was set up focusing on the development of a multimedia simulation system for improving error diagnostic skills in mentally disabled people. The starting point of the research was the development from scratch of a new classification for the analysis of human-machine interaction hazards in the context of mental disabilities [4.4]. The following step was the development of a simulation device that reproduces the normal and abnormal (i.e., failures) functioning of real craft machines. The simulator will be embedded into a Computer Based Tool (CBT) and will be used for training purposes (Figure 4.13). In the second year of the project, likely scenarios to be played by the simu-
lation system and guidelines for the design of the user interface of the CBT were developed [4.5]. In particular, the latter subject was tackled in the context of a graduation thesis carried out in collaboration with the University of Turin - Department of Psychology.

4.2.7 Improvement of Error Diagnostic Skills in the Disabled

P.C. Cacciabue

A graduation thesis [4.6] has been developed with the aim of studying and improving error diagnostic-skills in young, mild mentally disabled people, in order to enhance their interaction with craft machines. This research activity is part of the collaboration with Istituto di Ricovero e Cura a Carattere Scientifico (IRCCS) “Eugenio Medea”.

A Computer Based Tool (CBT) has been developed and will be dedicated to the professional preparation of these people; the CBT being part of a new training course. The analysis of users’ needs (teachers and pupils) allowed the definition of the software characteristics of the CBT. According to these needs, the CBT user interface was designed as a series of “logical environments”, that are mutually interconnected, each one fulfilling specific users’ goals. Five milieux have been conceived within which the user interaction takes place (Figure 4.14). Such a tool could be used within a training course for a preparation to be held in a didactical laboratory, before the direct experience on the real machines – the idea includes multiple appeals. Principally, it provides a solution for safety-related problems and, as a consequence, it allows pupils to experiment with unusual situations, by stimulating at the same time the development of their problem solving skills and producing beneficial effects on their motivation and self-esteem. In addition, the use of software in a laboratory allows the collection of information to investigate error modalities, through the possibility of systematic observations in a “controlled” environment.

It is important to point out that the main objective of the simulator training is not to transfer a specific and precise competence, but rather to stimulate the development of disabled people’s reasoning skills. These can be applied across different situations within the machine interaction such as in other areas in everyday life. Hence, the most important objective in the development of this software is not to create an exhaustive code capable of accurately reproducing reality, but to design a functional tool for teaching a behavioural style.

References


Activities within advanced integrated optical systems concentrate on the technologies needed for the applications using 3D real time colour holographic synthesis. Diffractive optics (holograms, holographic optical elements, computer generated holograms, diffractive gratings) differ from classical optics in the way that coherent light waves are simulated and used. Instead of using incoherent light technology that handles large complex images (e.g., in computer visualisation) new active diffractive systems work with thousands of real or simulated coherent light waves; each system carrying much more limited information, but in the end, the recombination of the original real or simulated optical wave gives a full 3D information. The diffraction phenomenon has become the primary tool for designing the new passive or active optical systems, which can be controlled almost in real time. This active real time control is a fundamental advantage compared with the conventional optics and instruments that depend on entirely passive means.

The research concentrates on developing improved and up-to-date mathematical packages to simulate the synthesis of true real colour holograms for realistic 3D active optical components and 3D reconstruction of scenes, and for studying natural vision. Software has been designed to carry out multi-stage progressive and sequential 3D-hologram reconstruction whilst maintaining very good optical quality. A large number of applications (displays, storage, image synthesis and processing, etc.) can now be implemented using this advanced software. Since thin and volume holograms are mainly used for 2D and 3D static and dynamic recordings, the first application and the most useful is the 3D real time display, but other applications like interconnects, memory data storage or optical correlators are equally important. Potential uses cover new active optical sensors; security and authentication products; real-time holography and active holographic optical elements; advanced diffractive grating DOE; real time holographic interferometry; active and passive holographic optics; active and passive integrated optics; optical interconnects; opto-electronic devices used in advanced informatics, passive optical elements, basic elements used in hard disk for data storage, RAM, DRAM memories, flash memories, new CD-ROM and DVD technologies.

5.1 MOVING FROM 2D DATA TO REAL 3D MEDICAL IMAGING

ISIS provides scientific support in validating and testing medical and health telematic systems and applications, in particular concerning 2D and 3D imaging. In this context, common reference image sets and derived image libraries have been acquired and are available to test and validate medical image algorithms and software applications. Starting from original and segmented images of the Visible Human Dataset, a reference library of 3D models of human anatomical structures and organs has been generated using the Visualization Toolkit. To give a real 3D perception of the created models an innovative auto-stereoscopic prototype screen is used. User-friendly generation of solid 3D anatomical models is addressed as well.

5.1 Fourier and Fresnel Holograms Synthesis
Real-time Holographic Visualisation
Holographic Optical Element (HOE) Synthesis
Diffractive Optical Element (DOE) Synthesis
Innovative Holographic Flat Liquid Crystal Display
LCD Chip Design
Real-time Spatial Light Modulator (SLM)
Holographic Security & Authentication

5.2 Artefact example: some pixels belonging to the abdominal aorta have been considered as belonging to the bone tissues.
5.2 SCIENTIFIC AND TECHNICAL SUPPORT FOR MEDICAL IMAGES AND SYSTEMS
ISIS provides a coherent scientific and technical support to explore the conception and implementation of European initiatives in the field of medical imaging and media interchange communication under the European Health Policy. The objectives of the project are to study, develop and promote a European scientific and technical framework for testing specific medical imaging and media communication systems in consultation with relevant parties from the public and private sectors at the European and national levels. In this context, a feasibility study of the research project called Image Guided Orthopedic Surgery (IGOS) has been done. IGOS is a specific application of IOS (Image Guided Surgery) in field orthopedic surgery. This field of surgery deals mainly with bones, spine and maxillofacial surgery.

Main functionalities
• Make a 3D cephalometry
• Compute maxilla displacement
• Integrate mandible displacement
• Visualisation of maxilla and mandible displacement
• Export both displacements

Accidental trauma, dysmorphosys from birth maxilla or mandible deformities.

5.3 Simultaneous rendering of bones, articulations and cartilaginous tissues of the Visible Human Male.

5.4 Image Guided Orthopaedic Surgery application.
OVERVIEW
A. Saltelli

The focus at ISIS is in the domain of technology transfer for official statistics in support to EUROSTAT. Another major commitment is devoted to user-driven methodological support for economic and financial analysis, and the competence being offered is in the domain of applied statistics and econometrics. This work supports the European Investment Bank (EIB), the European Central Bank (ECB) and the Economic and Financial Affairs DG.

6.1 NETWORK BUILDING IN COLLABORATION WITH EUROSTAT
A. Saltelli, R. Girardi

http://europa.eu.int/comm/eurostat/research/
http://www.jrc.cec.eu.int/uasa/prj-amrads.asp/

ISIS has an excellent collaboration with EUROSTAT. The main joint effort is in network building and technology transfer. The technologies of interest are all those potentially relevant for official statistics. ISIS stimulates the creation of thematic networks and consortia on themes such as time series, confidentiality, metadata and others, and collaborates with EUROSTAT in the organisation of international technology conferences. In this context ISIS also participates in the AMRADS project, an accompanying measure to build networks in official statistics. Further more specific support is offered to EUROSTAT in the domain of time series analysis (section 6.4).

6.2 CONVERGENCE OF EMU ECONOMIES
C. Planas, G. Fiorentini, G. Teyssiere

http://www.jrc.cec.eu.int/uasa/prj-busy.asp/

One of the most important achievements of the EU has been the adoption of the Euro. Besides insuring stability of exchange rates within the Monetary Union, the monetary policy conducted by the European Central Bank (ECB) for the 11 States of the Monetary Union is a strong support for the co-ordination of the macroeconomic policy. It is thus an important matter to measure the convergence of the Monetary Union economies (Figure 6.1). ISIS contributes to this issue with its ongoing work for the standardisation of business cycle analysis tools in Europe (BUSY project). BUSY is a 3-year collaborative project (2000-2002) of the Fifth Framework Programme. It is supervised by EUROSTAT and aims at making an organised set of tools for the statistical analysis of business cycles available to European economic and financial institutions. For this project, ISIS coordinates a consortium including the Spanish, the French and the Italian statistical offices. An interest group has been set up for this activity that includes the Economic and Financial Affairs DG, the ECB, EUROSTAT, national statistical institutes and central banks. A major conference on the convergence of the EU economies (Good Statistics for Good EU Governance) is foreseen for the autumn of 2001, which will be jointly organised by the Economic and Financial Affairs DG, EUROSTAT and ISIS.

6.3 SHORT-TERM ECONOMIC INDICATORS
A. Rossi

http://www.jrc.cec.eu.int/uasa/prj-flash.asp/

There is a crucial need for rapid estimates of the main Quarterly National Account aggregates of the European Economic and Monetary Union and of the European Union. The target delay is 40-45 days after the end of the reference period. What central banks and the ECB need is a coherent system that is able to help them to conduct short-term economic analyses and to take monetary policy decisions. This would avoid the shortcomings associated with the delays in availability of the official quarterly figures. ISIS is active in this area and is collaborating with the German Institute of Economic Research, the Italian national statistical institute, the British NIESR and the National Bank of Belgium.

6.1 Recent advances in information technology now make it possible to access in real time a large number of economic time series. This allows the derivation of short-term leading indicators that are crucial for public and private economic decision making.

Temporal Evolution of Economic Activities
Short-Term Indicators

Example of policy choice to raise/reduce interest rate
6.4 ECONOMIC TIME SERIES RELEVANT TO EMU AND EU AREAS

Economic time series present themselves as time dependent jigsaws. These signals embody irregularities (e.g., an outlier due to strike) and yearly movements (e.g., Christmas spending frenzy, summer or Easter holidays), which hide the underlying long-term path (e.g., the trend of the economy). For monetary policy making, it is important for Central Banks to have a clear picture of the dynamic behaviour of these movements. In particular, extracting the long-term trend in consumer prices is crucial for the monitoring of inflation. ISIS contributes to this activity with its expertise on time series analysis in collaboration with EUROSTAT.

A methodological study was performed in 2000 for the ECB on the seasonality in the European Industrial Production Indexes aggregated at the European Monetary Union level. An ongoing study for the Economic and Financial Affairs DG is in the modelling of GDP and inflation through estimation of Potential Output models. A comparison of EUROSTAT and ECB policy recommendations for seasonal adjustment has been produced at the request of EUROSTAT as well as a proposal for a quality report on seasonal adjustment. On the same topic a handbook jointly written by EUROSTAT and ISIS is in preparation. ISIS also operates a web-based Help Desk for statisticians involved in time series analysis and held a course on the subject on the premises of the ECB in Frankfurt in November 2000. According to EUROSTAT-A (Director P. Nanopoulos), from 2001 most of EUROSTAT’s methodological activities of application of time series analysis to official statistics will be delegated to ISIS.

6.5 ANALYSIS OF FINANCIAL RISK

Managing risk is a major concern for financial institutions worldwide, as shown by the very existence of the Basle Committee. As a major financing arm of the EU, the European Investment Bank (EIB) must excel in its financial risk evaluation procedures in line with best market standards. Mathematical models are developed to evaluate the financial transactions that the EIB performs daily and to construct a portfolio minimising the risk (be it market or credit risk). ISIS has discussed potential areas of co-operation with the EIB both on model building and model assessment via uncertainty and sensitivity analysis. Uncertainty and sensitivity analysis are valuable tools in the practice of financial risk assessment as they quantify the maximum risk incurred by a bank and identify what factors mostly contribute to such a risk. In the perspective of European integration, balanced development, economic and social cohesion of the Member States, and in the view of the enlargement of the EU, managing sophisticated financial risk is a priority for the European financing institution. Two major results have been achieved in 2000:

- The identification of concrete settings where uncertainty and sensitivity analysis can be successfully applied to manage financial risk.
- The assistance provided to EIB for model building, e.g. the Hull and White one factor interest rate model has been studied and an implementation has been provided to the EIB, in addition to the interface with the EIB’s operating environment.

6.6 ENVIRONMENTAL MODELS AND INDICATORS

The sector also operates a number of activities relevant to sustainable growth and environmental policy, in the context of a growing support of ISIS to the European Environment Agency (EEA). These studies are underpinned by ISIS’s combined experience in uncertainty and sensitivity analysis, and modelling and indicators building. The “Dashboard of Sustainability”, developed in co-operation with the International Institute for Sustainable Development (IISD) and the EEA, aims at communicating complex sets of indicators in a format that is accessible to decision-makers, stake-holders and the general public. ISIS focuses on the theory of aggregating economic, environmental and social indicators to a Policy Performance Index (PPI), and of analysing the linkages between these indicators. The main objective of the “Dashboard” is to establish the “missing link” between detailed indicator sets and non-expert users without losing the information on the underlying indicators, like for example, for the approximate 60 SD indicators promoted by the United Nations Commission for Sustainable Development and used by EUROSTAT. This project is also an important input for the Environment DG in their preparation of Rio+10.

ARTEMIS is an international project financed by the Energy and Transport DG where the experience from different emission calculation models is combined to build a harmonised methodology for transport emission estimates, which serves to support EU air quality policies. ISIS is one of the 34 partner institutions in the project and its task is to make quantitative statements about uncertainties in emission estimates, which result from complex error chains, and to make them available to policy-makers, by considering the impact of different scenarios, framing assumptions, and the effects of different transport options. A first application was addressed to the Fréjus Tunnel area. COPERT-III (Computer Programme to calculate Emission from Road Transport) was extended to take into account uncertainties that...
derive from meteorological data, fleet composition and other model parameters. NOx, CO2, VOC and PM10 pollutant emissions have been estimated for 2000 and 2010.

IMPACT is a project financed by the Information Society DG. Natural fluctuations in the state of the environment can often overshadow the human impact. This makes tools aimed at extracting anthropogenic signals from more or less noisy data highly relevant for environmental assessment and policy making. The main objective of IMPACT is to introduce new analytical tools (e.g., global sensitivity analysis) that can facilitate assessment of human impacts on the environment in the presence of natural fluctuations in meteorological, hydrological and other conditions. Test cases worked so far include air pollution and eutrophication problems at a regional/European scale.

The demand of industry in terms of complex problem solving has resulted in ISIS engaging in applied statistical work that targets specific industrial needs. A collaboration has been established between AGIP and ISIS aimed at applying ISIS’s expertise in the conceptual and computational environment used by engineers for the analysis of the oil-potential of sedimentary basins. The objective of the work is to improve the success rate of drilling by combining petroleum system modelling (AGIP) with global uncertainty and sensitivity analysis (ISIS).

6.7 DISSEMINATION

A. Saltelli, F. Clement

http://time-series.jrc.cec.eu.int/
http://sensitivity-analysis.jrc.cec.eu.int/
http://europa.eu.int/comm/eurostat/research/

2000 was an intense year of dissemination for the sector. The Help Desk forum TSAOS for time series analysis was launched as well as a forum for sensitivity analysis. The publishers John Wiley & Sons published ISIS’s book on sensitivity analysis (Figure 6.2). A seminar was held in Brussels in June to communicate to the EIB, the ECB, the Economic and Financial Affairs DG and others the most recent activity of the group, especially in short term analysis (BUSY, FLASH) and financial modelling. Altogether the sector maintains approximately 100 pages of web material related to its work and is moving into the field of XML technology.

6.2 “Too often modellers do not realise that sensitivity analysis is an essential part of the model building process. This volume has a didactical value showing how sensitivity analysis is often useful – and sometimes essential – to complete the model building process and to interpret results properly. It guides the reader through an array of different approaches, illustrating in a generally clear fashion the specificity of the different techniques to different problem-settings” (Amazon.com review).
Suggested Further Reading

Girardi R. – Introduction to sensitivity analysis of conditional forecasting, a variance based application to econometrics – EEA 2000-6, Istituto di Economia Politica, Studi e Quaderni, Serie di Econometria applicata, Università Bocconi, Milano, Italy.
7.1 SCIENCE AND GOVERNANCE
http://alba.jrc.it/science-governance.html

The many recent debates on science-related issues (for instance, technological and environmental risks) show that the reliability of policy-relevant scientific information can no longer be assumed. Unlike most other processes and products, scientific information does not have an established quality assurance programme, beyond the informal practice of scientific peer review and refereeing of basic research and project proposals. Increasing attention is being paid to scientific aspects of policy or administrative decisions taken at European levels. Certain features of the process, including the potentially irreversible consequences of decisions, the uncertainties involved and the pressure on scientists to produce a particular result, indicate the need for a new relationship between science and governance. This should incorporate greater openness and more participation in the process from stakeholders.

7.2 QUALITY ASSURANCE OF POLICY-RELATED RESEARCH
http://alba.jrc.it/pedigree.html

In the appraisal of strategic policy issues, scientific information is but one of the inputs. It is supplemented and interpreted by knowledge of local contexts, as filtered through political processes. The analytical work needs to proceed in recognition of social controversy, uncertainties, and plurality of decision criteria. The appropriate methods include multi-criteria aids, institutional analysis and deliberative techniques. Information technology plays an essential role in the design and development of appropriate tools that capture the complexity of policy and decision exercises. Their power enables them to avoid an exclusive dependence on quantification: they permit the construction of “spaces of negotiation” where all the stakeholders can see their concerns expressed and where potential compromises can be explored.

Moreover, a programme of knowledge assessment is essential when information that is used as an input to policy making is complex – deriving from several sources or evaluated by several criteria – uncertain and even disputed. There is a need for an agreed and credible set of procedures or guidelines by which the reliability of information can be assessed, and also assert established among all stakeholders in this process. In particular NUSAP and Pedigree schemes can provide elements on quality, legitimacy and reliability of several levels of information processing for policy making. Thus the Pedigree scheme has been conceived as an exploring tool through which three main elements of decision-making processes – the information, the decision tool and the role of the analyst – can be assessed. The community involved in the decision-making process such as experts, politicians and citizens defines criteria and attributes implemented during this exploration. The Pedigree scheme has been recently implemented in a case study of environmental planning dealing with atmospheric pollution issues.

7.3 INFORMATION TECHNOLOGIES AND KNOWLEDGE ASSESSMENT

Information technologies have a great and growing power to provide information, quickly, cheaply, in large quantities to many users and to integrate different types and sources of knowledge that characterise many complex problems. Nevertheless, the technologies themselves do not guarantee the quality of that information. The development of a sustainable information society requires public trust in the technology and the information it provides. Many issues must be resolved by the providers and the users and regulators of the technologies. These include the reliability of the information, the protection of the privacy, security and civil liberties of its users, and its accessibility by all sectors of society, as well as the openness, transparency and legitimacy of the technology and its governing institutions. Then the information technologies will realise their promise as the means for providing a forum for broad and effective citizens’ participation, enabling the growth of a sustainable information society.
The application of a knowledge assessment approach enables the systematic analysis, appraisal and assessment of the use and reliability of appropriate knowledge for policy processes. It is essential to explore ways to make that information available in a transparent, open and reliable way; this has to be done with the audiences for whom the information is intended. Of particular relevance here is the development of Internet-based interactive multi-media information technology and the creation of tuning contexts by means of deliberative procedures and other knowledge assessment mechanisms, so that the final design of these systems and pitfalls of usage are fully understood by all concerned.

7.4 VISIONS - INTEGRATED VISIONS FOR A SUSTAINABLE EUROPE
http://alba.jrc.it/visions.html

The VISIONS project has been implemented in 3 different regions in Europe; the JRC/ISIS being responsible for the Venice region. The set of four images of the future of Venice in 2025 was prepared by means of multimedia materials, providing insights into systemic interactions amongst different dimensions of sustainability with connections to European scale scenarios being developed by the co-ordinator of the project, thus showing in an interactive way, the unfolding of the imagined visions of the future. These scenarios have been proposed through a social process to stakeholders and citizens in Venice. Early versions of the scenarios were tuned for their contents – put into context – and visualisation by taking into account the opinions of the participants in the social process. Later, the scenarios were proposed to the participants to explore them as tools to engage the society in a debate about policy options, empowerment, responsibility and governance issues to attain desired futures.

7.5 GAS - GREENHOUSE GASES METER, SCENARIO EXPLORER AND DAY PLANNER
http://alba.jrc.it/gas.html

GAS is much more than a simple software implementation project of a tool that relates lifestyles with greenhouse gas emissions and possibly with climate change: this tool embeds new concepts of the communication of science to non-scientific audiences and therefore it reflects concerns on a number of quality issues: (1) information: reliability of sources, data uncertainty and ignorance; (2) calculation core: uncertainty of model ling, transparency, assumptions; and (3) user interface to scientific issues: intuitive interface, “vocabulary”, tangible, transparency.

GAS is an example of the sort of new tool that is being deployed by an information society that tries to engage all citizens in the problems that affect us all. Its aim is the empowerment of all citizens about a global issue and their assuming responsibility for it in order to enhance the processes of governance. The validation of the software was financially supported by the Enterprise DG and consisted not only of the scientific basis of the calculation core, but also of the appropriateness of the interface to be used by non-specialised users. The final version of GAS is available for 5 different countries in Europe: France, Italy, Portugal, Spain and the UK including data for each of those countries. GAS is distributed as a stand-alone tool in the form of a CD-ROM.

7.6 GOUVERNe
http://alba.jrc.it/gouverne.html

The project GOUVERNe (Guidelines for the Organisation, Use and Validation of Information Systems for Evaluating aquifer Resources and Needs) aims at the development and pilot implementation of a user-based and scientifically validated Decision Support System (DSS) for the improved management of underground water resources at the catchment and sub-catchment levels. The role of the envisaged DSS is not to generate a “best” or “optimal” management choice in a technocratic fashion, but rather to furnish a validated scientific support for debate and deliberation by decision-makers, stakeholders and citizens allowing for compromises, generation of novel options and, to the greatest extent possible, co-operative conflict resolution. The emphasis in GOUVERNe is on a process of stakeholder-based appraisal and management means that decision support is understood not only as the acquisition, scientific validation and organisation of the information, but also as procedures for effective exploitation of this information by users. This is another case of creating quality assured interfaces between science and society. ISIS is involved not only in the creation of the actual multi-media interface between the modelling deployed by the DSS but also in the knowledge assessment process, i.e., the scientific quality assurance and the creation of a tuning context where these tools are evaluated for their fitness by end-users.
8.1 ANTI-FRAUD INFORMATION MANAGEMENT

Overview

T. Barbas

Work in information technologies during 2000 focused primarily on improving our early warning capacity and on developing new open source intelligence capabilities, including new developments in the area of information extraction from texts. This is expected to imply advances in both strategic and operational intelligence capacities for our customers and partners. At the same time, our effort to raise awareness about fraud control techniques among participants in anti-fraud networks was significantly intensified. As in previous years, mixed funding, internal and external, was used to finance the activities. While the primary beneficiary of our work was the European Anti-Fraud Office (OLAF), other beneficiaries included the Agriculture DG and Member State specialist agencies. Finally, a strategic collaboration with the Regional Policy DG was launched in the area of information technologies applied to financial management for the Structural Funds.

8.1.1 Early Warning Analysis

T. Barbas, C. Moussas, A. Burger, A. Varfis

In early warning, analysis of relevant data sources continued from previous years. This included a study to integrate IRENE (reported frauds and irregularities database of OLAF) fraud case data into a generalized architecture for sectorial data marts of particular interest to OLAF’s intelligence and operational strategy department [8.1]. In December 2000, we concluded work in data modelling, transformation and harmonisation work aimed at the development of a data warehouse for export refunds. The beneficiary of this work was Clearance of Accounts of the Agriculture DG. The tools used for data navigation, visualization and reports were BusinessObjects and WebIntelligence (of BusinessObjects, France). We also invested some effort in migrating existing consolidated import trade data for textiles (the result of previous years’ work) to a web-compatible environment using SAS/IntrNet software (of SAS Institute, USA). Finally, a commitment was made with the External Relations DG’s financial management department for a strategic study of relevant information technologies to be applied to the management of payment data, both at the aggregate and the detailed accounting levels.

Again in the area of early warning, the software application EWS-GIS (Early Warning System for Transit) was finally handed over to the customer (OLAF) [8.2]. Results achieved in 2000 included usability and functionality improvements, as well as a prototype for web-based access of maps visualized by the system. The system was actually field-tested during the Joint Customs Surveillance Operation WAMBA in Alicante (1-16 June 2000) and was also used for training participants in new analysis techniques in a special preparatory meeting for the same operation in Toledo.

The Neural Networks and Machine Learning (NNML) Laboratory of ISIS supported this line of activities through the continued development of a software prototype to detect outliers in large databases. As a result of the latest enhancements, the software is now also of interest to domain or problem experts with no particular programming or computer skills.

References

8.1 Moussas C., Barbas T. – Integrating IRENE Data into OLAF’s Data Warehouses – Technical Note No. 1.00.54, April 2000.

8.1.2 Name Data Cleaning and Information Portals

T. Barbas, A. Garg

Two important projects were carried over from 1999. Both were financed by OLAF, at least in part. The first is DOCTUM-V2, a powerful, completely rewritten version of an earlier prototype for cleaning structured data inside files or databases – like names and addresses of companies, or locations [8.3-8.4]. DOCTUM-V2, like its predecessor, uses a number of approximate matching techniques. With respect to the prototype, the software can now export directly clean data into third party software for visualisation or (network) analysis. In addition, the operations necessary to group similar information items together became more powerful and the user interface was significantly improved. It should be added, however, that DOCTUM-V2’s matching power, as defined by the set of methods and algorithms it contains, remained unchanged with respect to the earlier prototype.

The second important project carried over from 1999 is IIIMS-V2 [8.3]. More than an information portal in anti-fraud, IIIMS-V2 is meant to be a kind of knowledge base, a virtual forum where investigators and analysts can share, assess and exchange their knowledge about good sources of information. The system’s true power will only be revealed if the user population is extended to include national partners over an anti-fraud network (linked via an Extranet or similar mechanism). With respect to its predecessor (IIIMS), IIIMS-V2 runs as a web server and also includes facilities for personalised information capture and filtering from the web. At the time of writing of this report, development of IIIMS-V2 is 80% complete.
8.1.3 Open Source Intelligence

J. Perdigao, A. Garg, T. Barbas

In the area of open source intelligence capabilities, after a first-level requirements' analysis and technology review [8.5], our work focused on the development of a software prototype intended to improve current monitoring capacity for the movements of containers, based on information available over the Internet. One context where this is useful is when customs investigators are looking for evidence involving past activity of specific containers (itineraries, loading or unloading events etc.). Another context is pro-active risk analysis to better target physical inspections. Technology-wise, this development combines web engineering for gathering and filtering information, with data warehousing for transformations and consolidation of data and, finally, data analysis and visualisation. The validity and relevance of the approach was confirmed by many members of European maritime customs intelligence forums during a number of presentations by JRC-ISIS staff. A decision will be taken in early 2001 as to whether to proceed with a pilot project.

References

8.5 Garg A. – Automatic Intelligence gathering from the web: Pre-Analysis, (interim project report) – May 2000, Technical Note No. I-00.137.
In 2000, ISIS continued work on a number of data analysis and risk analysis issues pertaining to the exploitation of data on irregularities and frauds committed against the budget of the EU and reported by Member States to the European Commission. This work was conducted on a recent complete download of the IRENE database in which the cases are stored. IRENE is a database of OLAF, which is the primary customer of the project.

In 1999, an examination of cases reported by Member States against the European Agricultural Guidance and Guarantee Fund (EAGGF) had been done at the request of OLAF, on the basis of subject matter knowledge to differentiate between frauds and irregularities. In 2000, this work was extended to cases reported against the traditional own resources and the Structural funds [8.16]. Descriptive statistics on the number of cases and amounts established were calculated and tabulated by Member States and robust statistical tests were applied to bring out Member States reporting significantly large or small cases. Zero amounts established appear in the data surprisingly frequently: 23% of the cases against the EAGGF and 20% of the cases against traditional own resources. The sector developed and applied a procedure of data-mining two-way contingency tables and characterised such cases by Member State, and status variables for the case. The grouping of all types of irregularity into two categories (frauds and other irregularities) is meaningful when cases are characterised appropriately. To take into account possible heterogeneities in reporting practices, [8.10] also derives and tabulates signals either in the frequency of reporting cases or in the amounts established for combinations of Member States and types of irregularity.

In order to carry out the work reported in [8.16], extensive referencing had to be done to data stored in fields not previously retrieved from the cases downloaded. This included a study of the structure of the templates in which the cases are stored. IRENE is a database of data on irregularities and frauds committed against the budget of the EU and reported by Member States to the European Commission. This work was conducted on a recent complete download of the IRENE database in which the cases are stored. IRENE is a database of OLAF, which is the primary customer of the project.

The numerous tables of signals on two-way categorical tables presented in [8.16] were produced in two stages, first programming in SAS and then processing SAS outputs in VBA (see Figure 8.2). This is one of a number of similar SAS-VBA batches for presentation of knowledge extracted from databases by using statistical methods. Such batches are expected to simplify very laborious, cumbersome and repetitive tasks and make presentation of results aesthetically appealing.

8.1.5 Dissemination
T. Barbès, J. Perdigao, R. Steinberger, A. Garg, S. Scheer, J. Hagman

There were many occasions this year where project results were disseminated to anti-fraud partners, going beyond the usual presentations of results to customers. For example, in addition to the Joint Customs Surveillance Operation already mentioned above, ISIS presented work in automatic intelligence gathering to technical meetings of Marinfo-North and Marinfo-South (maritime customs intelligence forums), as well as the Open Source workshop of EUFIS (the European Forum for Intelligence Specialists). As for work in Language Technology, ISIS presented its findings also in academic conferences like [8.14-8.15].

References
8.3 ADVANCED STATISTICS FOR THE CLEARANCE OF ACCOUNTS

S. Arsenis, A. Karvounaraki, T. Vogiatzi

2000 was the second year of execution of the Advanced Statistics for the Clearance of Accounts project. The project aims to provide a valid scientific basis for the choice of appropriate sampling plans and estimation methods to be adopted and practised in conducting audits for payments made to beneficiaries of the Common Agricultural Policy (CAP) in order to estimate overpayment in payment populations. The primary customer for the project is the Agriculture DG and the secondary customer is the European Anti-Fraud Office (OLAF).

After having examined payment and audit data for a compliance audit conducted by the Clearance of Accounts unit and having reported on such data and proposed a new estimator for overpayment [8.18], the project team focused on the current state of practice of controls conducted by the certifying bodies in the Member States. The reports of two certifying bodies on two paying agencies were studied with an interest in the extent to which previous auditing experience can be of use in current audits. As a result of the study, the sector concluded that particular emphasis has to be placed on how to standardise the control work and the presentation of results deriving from it, the choice of control parameters, i.e., audit risk, materiality and expected error to define sample size, the estimation and testing procedures used, and the definition of errors. Another issue of importance is the extension of methods and techniques applied meaningfully by one certifying body and in one budgetary line to other paying agencies. Finally, we quantified the extent to which beneficiaries confirmed by the certifying bodies to have been involved in irregularities or frauds were independently known to have been associated with similar practices in the past. Results of this work were presented in a seminar to customer staff. The final report [8.19] incorporates input and comments from the participants in the seminar.

In order to formulate the present state of knowledge on overpayment errors, the project team scanned all financial clearance decisions and compliance decision 200/216/EC under the reformed Clearance of Accounts procedure and compiled a four-way table of corrections done per Member State, sector, budgetary position and year [8.20]. In the future, amounts corrected will also presented as fractions of advances paid. This work will cover the five remaining compliance decisions to maintain updated summaries of the present state of corrections.

References

The highest quality audit data on payments made to beneficiaries of the CAP are those obtained by the Court of Auditors DAS (Déclaration d’assurance) annual exercises. The project team has looked into the characteristics of the tainting populations and expects to obtain access to the complete samples.

Reports [8.18-8.19] contain partially confidential data and will not be disseminated freely.

**References**


### 8.4 IDEA (IDENTIFICATION ELECTRONIQUE DES ANIMAUX)

**C. Korn, O. Ribó**

The objective of the project IDEA (Identification Electronique des Animaux) [8.21-8.23] is to assess the feasibility of electronic identification for farm animals and to validate identification systems in real field conditions (Figure 8.3). Approximately one million animals from three species (440,000 cattle, 490,000 sheep, 30,000 goats) in six EU Member States (France, Germany, Italy, The Netherlands, Portugal and Spain) are to be identified by applying three different types of electronic tags: injectable transponder, ruminal bolus and ear tag (Figure 8.4). The performance of electronic identification devices and the necessary organisational structure in a real EU livestock scenario are to be evaluated. The analysis will determine whether electronic identification is a feasible system to trace animals individually from birth to the slaughterhouse. It is important to identify the appropriate technologies for electronic tags and reader types for full-scale implementation in EU livestock.

The IDEA project (1998-2000) was launched by the Agriculture DG and has been recently extended until the end of 2001 in accordance with the current Regulation 1760/2000 on the identification and registration of bovine animals, which states in article 4 that not later than 31 December 2001, the Council shall decide on the possibility of introducing the electronic identification system in the EU livestock. ISIS is responsible for the technical and scientific support, the testing and certification of electronic identification devices, quality control of equipment, definition and establishment of the central database, data transmission and recording during the project, and global evaluation of results obtained.

The design and development of the IDEA Central Database was finished in 1999. The JRC IDEA database was implemented and tested and has been operational since the beginning of 2000, when the data stream from the IDEA participants to ISIS started. During 2000, all participants finished the test phase of the data transmission and some IDEA participants began to send real data, which was analysed at a syntactic and semantic level, validated and entered into the IDEA database. A document, which defines the statistical analysis to be performed with the IDEA data, was prepared. The software programming of the statistical tools to analyse the IDEA data commenced at the end of 2000. During 2000, six new electronic identification devices (electronic tags, and portable and static readers) were certified in the TEMPEST (Thermal, Electromagnetic and Physical Equipment Stress Testing) laboratory. Thus, since 1996, 82 pieces of equipment have been certified and 343 certificate updates have been produced.

Complementary research was conducted to study the influence of various parameters such as animal speed, electromagnetic interferences, etc. on the reading efficiency of the tags. Quality control of the tags used by the participants also started in 2000 and 8 samplings were conducted with 8 different participants in order:

- to check that all tags used by the contractors have the Laboratory Acceptance Certificate and correspond exactly with the reference tags described in the certificate.
• to check the performances of the tags used by the contractors (in real conditions) for the IDEA project. A comparison between normal production units versus laboratory-tested samples for certification was also carried out.

The electronic identification of animals within the IDEA project began in September 1998. During 2000, IDEA participants supplied data from 275,000 cattle, 400,000 sheep and 25,000 goats electronically identified applying ruminal bolus (n=525,000), electronic eartags (n=150,000) and injectable (n= 25,000), which represent 75% of these animals in the IDEA project. It is expected that in 2001 this will reach a total of 1 million animals to be identified within the IDEA project.

A preliminary analysis of the results indicates that electronic eartags and ruminal bolus presented the lowest mean percentages of losses compared to injectable transponders. The retaining rates of ruminal bolus and electronic eartags are higher than commonly observed retaining rates in plastic eartags. These preliminary results appear to indicate that electronic tagging using ruminal boluses and electronic eartags seems to be an efficient and reliable method for livestock identification. However, this conclusion is drawn only from a fraction of the data to be collected. Detailed data on loss, breakage, electronic failures by animal type, tagging and reading data, equipment, people, etc. shall be taken into consideration when further analyses will be performed with more data.

References

8.21 Korn Chr. – List of Certificates of Laboratory Acceptance for the IDEA Project – Version 2.0 of 15/03/00. Sa-Ve-Tech Unit, ISIS Institute, JRC Ispra (I), Technical Note no. I.00.45, March 2000.


8.4 (a) Injectable transponder; (b) ruminal bolus; and (c) electronic eartag.
8.5 NEW TECHNOLOGIES FOR MONITORING FISHING VESSELS
I. SHEPHERD, N. KOURTI

http://intelligence.jrc.cec.eu.int/fish/index.htm

The European Union’s Common Fisheries Policy manages fisheries for the long-term benefit of fishing communities and consumers. The objective is to regulate the amount of fish taken from the sea so that young fish can reproduce. Management measures include:
- total allowable catches (TACs) which limit the total amount of a species that can be caught in a given area in a given time;
- quotas which determine how much of a given TAC is allocated to each country;
- technical measures which might restrict the type of fishing gear to be used or the season in which fishing is permitted in order to protect young or non-targeted fish.

Regulations to monitor and check these measures are decided at an EU level and implemented by the Member States. These regulations include the obligation for all vessels more than 24 metres in length – over 4,000 vessels in the EU – to install satellite-based navigation and communication equipment. The position of the vessel is then transmitted on an hourly or two-hourly basis to a Fisheries Monitoring Centre in its flag state. The flag state then sends it on to an equivalent centre in the coastal state. The system is at present still being implemented – the transmission from vessel to flag state works well in a number of Member States, but there is some work to do for the re-transmission to the coastal state. Clearly vessels that do not carry this onboard equipment or whose on-board equipment is not working cannot be monitored in this way.

ISIS has been helping the Fisheries DG assess the possibilities of using space-borne Synthetic Aperture Radar (SAR) to detect and possibly identify these vessels. The study has covered three test areas:
- The Flemish Cap – in international waters in the North West Atlantic (summer 1999).
- The North Sea (spring 2000).
- The Azores (spring 2000).

In general, the challenge is to detect targets against an ocean background. The noise from the background is lowest, and therefore the detection easiest, if the SAR beam is polarised horizontally and if it has a large incidence angle, i.e., the satellite is low on the horizon. There is a trade-off between fine resolution and large area coverage. Of the commercial satellites currently in operation, the Canadian RADARSAT satellite offers the most appropriate options. In the studies it was found that its SCANSAR mode, although relatively coarse in resolution, was best for vessel detection because it covered a large sea area – 300 x 300 km. Most operational vessel detection systems rely on a human operator examining an image, but ISIS felt that an operational system would need a more automatic system and developed a PC-based software including land-masking and fast geo-referencing.

The Flemish Cap studies showed that nearly all the vessels could be detected on the images – only on very rare occasions were the sea conditions such that the background noise was too high. The detected positions were then compared against VMS reports obtained from the Icelandic, Norwegian, Portuguese and Spanish fisheries inspectorates. It was found that 72% of the vessels whose position was given in the VMS reports could be identified – the reason for non-identification usually being a too infrequent reporting interval for VMS and the resulting uncertainty in the vessel’s position at the acquisition time. The average discrepancy between positions determined from the image and positions determined from VMS was 0.3 nautical miles. This was considered an outstanding result considering all the potential inaccuracies – georeferencing, VMS uncertainties and doppler shifts due to vessel velocity. A report was delivered to the Fisheries DG and the results summarised at meetings of EU Fisheries inspectors.

The studies in the North Sea and Azores were in collaboration with the UK’s Defence Research Evaluation Agency (DERA) who run a satellite ground station at West Freugh in Scotland. VMS positions were supplied by the Dutch, Danish (for the North Sea) and Portuguese (for the Azores) authorities. The aims were to examine the potential of SAR imagery in areas of heavy maritime traffic (North Sea) and in remote areas where control is difficult and to determine whether the results could be given to inspectors in real time. In a number of trial runs, times of 2.5 hours were obtained from image acquisition to completion of the analysis. The limiting factors were the processing at the ground station and the transmission of the 140Mb processed image from the ground station to the analysis centre. Options for improving the speeds were examined and costed. A number of new difficulties was highlighted – the real-time images are not so well geo-referenced as those processed some days later because of inherent orbit uncertainties and small vessels requiring lower threshold parameters, which may give some false alarms. Based on these results an outline design for an operational system was developed. The vessel identification rate in the North Sea was found to be about 90%, while in the Azores it was less than 10% – the reason being that the Azores fishing vessels are made of fibreglass with different backscattering properties to those of steel.
Some effort was started to see whether the new high-resolution satellite, IKONOS, could provide useful information for vessel identification. Both panchromatic and multi-spectral images of an area in the Adriatic Sea were analysed. Although effectiveness may be limited by the small area covered and the disturbance of clouds, the ability of this satellite to provide evidence for fishing activity should not be underestimated. Further studies are required to find a methodology to couple IKONOS imagery with other monitoring and control tools to fully exploit its possibilities. IKONOS imagery as well as other optical imagery can be used in areas such as the Mediterranean where the majority of the vessels are below 24 m and mainly made of fibreglass or wood.

No one method or technology can provide all the information that authorities need under all circumstances. It has become clear that what is needed is an integration of information of tools and technologies to provide knowledge. Work is continuing on behalf of the Fisheries DG, and in close collaboration with authorities in the Member States and their suppliers of advanced monitoring and communications technology, first to further develop and assess these tools and technology and secondly to help with their integration into complete packages.
9. **Safety and Emergency Management of Man-made and Natural Hazards**

9.1 Major Accident Hazards Bureau (MAHB)

9.2 Natural and Environmental Disaster Information Exchange System (NEDIES)

9.3 Management of Natural and Technological Hazards in Pre-accession Countries

9.4 Competitive Activities and the Major Accident Hazards Bureau

9.4.1 Assessment of the Uncertainties in Risk Analysis of Chemical Establishments

9.4.2 Safety Management Systems for Major Accident Hazards in Small and Medium Enterprises

9.4.3 Network on Hazard Assessment of Highly Reactive Systems

9.5 Risk Monitoring and Emergency Management

9.6 Software Package for Civil Protection Emergency Planning and Management

9.7 Safety of Industrial Processes and Human Factors

9.8 Thematic Network on Safety Assessment in Waterborne Transport

9.9 Automotive Collision Avoidance System

9.10 Monitoring of Landslides

9.11 Detection of Oilspills

10. **Decision Support for Risk and Emergency Planning**

10.1 Enhancing Scientific Underpinning to Agri-environment Policies

10.2 MATADOR

10.3 UTOPIA

10.4 The CommonGIS Project

10.5 The MURST project

11. **Aviation Safety**

11.1 European Co-ordination Centre for Aviation Incident Reporting Systems (ECCAIRS)

11.2 Human Factors in Accident Databases

11.3 Competitive Activities on Human Factors in Aviation Safety

11.3.1 Aircraft Dispatch and Maintenance Safety (ADAMS)

11.3.2 Development of a Method for Air Transport Safety Improvement through Quantitative Risk Evaluation (DESIRE)

11.3.3 Advanced Cross-Communication Environment providing Support Services to Dispersed Maintenance and Technical Support Engineers (ACCESS-maints)

11.3.4 Advanced Integrated Training in Aeronautics Maintenance (AITRAM)

11.3.5 Aviation Safety Targets for Effective Regulation (ASTER)

11.3.6 Collaborations

12. **Seismic Protection for Civil and Cultural Heritage**

12.1 Seismic Protection for Civil and Cultural Heritage

12.2 Activities concerning Fibre Reinforced Composites (FRC)

12.2.1 Upgrading and Repair of Reinforced Concrete Elements

12.2.2 Application of Composites to Seismic Resistance of Reinforced Concrete Buildings

12.3 Seismic Assessment of Masonry Structures

12.4 Further Developments in Dynamic Control of Earthquake Engineering Facilities

12.5 Active and Semi-Active Control in Civil Engineering (ACE and CASCO)

12.6 Vulnerability Assessment of Bridges (VAB)

12.7 Anchorages in Concrete under Dynamic Loading

12.8 The ICONS and SAFERR Research Networks

12.9 Project LADIB (Laboratorio Dinamico Industriale della Basilicata)

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Overview

A.C. Lucia

In this cluster of projects (a cluster that also includes the projects presented in Chapters 10 and 11) the JRC is acting as a centre dedicated to the development and validation of scientific advice at the EU level and to the establishment of a scientific and technical reference in the development of a system approach to the management of natural and technological hazards. The projects support the implementation of policies aimed at the protection of individuals, infrastructures and society and are in accordance with the guidelines expressed by the European Research Area initiative.

The new attention paid by citizens to decisions that may have consequences on their health, safety, quality of life or the state of the environment, the ever increasing complexity of technological systems and extension of highly industrialized areas and the still unsatisfying degree of preparedness to face disasters and mitigate consequences are the main driving forces of these activities.

ISIS efforts are focused on:
- Accident reporting and analysis, which is done at the European scale with the necessary independence from national and private interests and which assures that experience is shared among all Member States and data kept confidential when required;
- Support to the conception, preparation and implementation of European directives;
- Use of up-to-date information and communication technologies offering reliable and powerful means for collection, assessment, dissemination and correct and timely exploitation of data, information and knowledge;
- Helping candidate countries align more quickly with the European Union’s “acquis communautaire” in fields reflecting pre-accession process priority needs.
- Methodological developments, validation and applications, mainly performed in the framework of large international projects (typically shared-cost actions) and third party works for national or regional authorities (such as the SIMAGE project for the Italian Ministry for the Environment).

9.1 MAJOR ACCIDENT HAZARDS BUREAU (MAHB)

J.S. Duffield, A.C. Lucia, N. Mitchison, C. Kirchsteiger, M. Christou
http://mahbsrv.jrc.it

The process industry covering the petrochemical, chemical, agrochemical and pharmaceutical industries is a major economic force, which employs millions of people and generates billions of Euros in shareholder value and tax revenues. It is more than twice the size of the global market for telecommunications equipment and services and accounts for 7% of global income and 9% of global trade. The safety and public acceptance of this industry is therefore of paramount importance to our society.

The Major Accident Hazards Bureau (MAHB) gives independent scientific and technical support to the European Commission in the field of EU policy on the control of major hazards involving dangerous substances and the prevention and mitigation of major accidents. This most notably concerns the successful implementation and monitoring of the “Seveso II” Directive 96/82/EC for the control of major hazards in fixed installations. Furthermore, in order to fulfil its information exchange obligations towards the Member States, the Commission established the Major Accident Reporting System (MARS) and the Community Documentation Centre on Industrial Risks (CDCIR), which are managed and maintained by MAHB.

The principal customers of MAHB are the European Commission, particularly the Environment DG, and all players concerned with process plant safety including the legislative and regulatory process – these customers include national and local authorities, industry, research organisations, safety consultants and trade unions.

Although the transposition of the “Seveso II” Directive into Member States’ national law should have taken place by February 1999, many Member States encountered difficulties in achieving this goal, due in no small part to the fact that this was a completely new directive. The directive introduced significant changes to policy related to the control of major hazards, such as safety management systems, formalised risk assessment, land-use planning etc., and it is these changes and their consequences which were the focus of much of MAHB’s work in 2000.

One of the major activities of MAHB results from the fact that Member States are legally obliged to notify the occurrence of major accidents to the European Commission, and significant effort is devoted to the analysis of these accidents and to the extraction and distribution of lessons learnt. To this end, MAHB operates and maintains an accident reporting system called MARS. Using this system, Member State authorities have a local data logging system, which they use to prepare accident reports. These reports are then submitted in electronic form to the central MARS system run by MAHB where advanced analysis tools have been developed to facilitate in-depth analysis of the accidents notified. To enhance transparency and to fulfil our obligation regarding information to the public much of this data is made available through the MAHB...
website. Furthermore, in recognition of the value and usefulness of our accident reporting system MAHB has been approached by the OECD and the UN/ECE organisations with a request to design and manage similar accident reporting systems for their purposes. Collaboration agreements have been drawn up between ISIS and the two international organisations, and during 2000 pilot versions of the OECD and the UN/ECE MARS versions were completed. In this way MAHB has become probably the world centre for major accident reporting, and furthermore by having a uniform data structure for the information reported it will greatly facilitate the analysis of the root causes of accidents. Closely coupled to the accident reporting system and forming an integral part of the software is a GIS-based application in which the geographical component of risk associated with industrial plant is developed. This windows-based application, the “Seveso Plant Information Retrieval System” (SPIRS) has the goal of containing all relevant data on industrial plant throughout Europe which has to comply with the directive. It will enable the Commission to perform hazard potential and risk categorisation assessments on a uniform basis. Complementing the MARS/SPIRS software is a dangerous substances data management system (DMDMS) which holds specific information, such as physical properties and qualifying quantities on all the named substances and generic categories in the directive.

The Community Documentation Centre on Industrial Risk (CDCIR) now holds over 3,700 documents and is a very important source of knowledge on process safety and industrial risk. This library holds, in addition to documents conventionally published, a wide range of “grey literature”, such as company reports, codes of practice, accident reports, safety studies, etc. A new web-based facility has been extended in the year 2000 to holding indexing information, abstracts, authors, keywords etc., for all these documents thereby enabling on-line access to the CDCIR through the MAHB website.

MAHB, in close collaboration with the Environment DG, runs a number of Technical Working Groups (TWGs). In most cases the primary objective of these groups is to develop guidance to ensure a coherent and correct implementation of the Seveso II Directive. It was a major achievement that, as a compendium to the directive and prior to the transposition of the directive into Member States’ national law, a full set of “guidance” documents was completed, published and widely distributed by MAHB. All these documents can be viewed and downloaded from the MAHB website. During 2000, TWG7 “Substances Dangerous to the Environment” and TWG8 “Carcinogenic Substances” have completed their work. These two working groups were set up at the request of the European Parliament and Council to investigate the appropriate threshold limits for substances classified as being dangerous to the aquatic environment, and to identify substances and the appropriate threshold limits for substances that can cause cancers from a single exposure, such as that following a major accident. The recommendations of the working groups have been published [9.1-9.2] and they will be used as the scientific basis for a future amendment to the directive.

In an attempt to promote good practice and seek a unified implementation of the directive, MAHB and the Environment DG have initiated a “Mutual Joint Visits Programme” (MJV). This activity aims at facilitating information exchange among the Member State inspectors by allowing a host country to present and discuss their inspection systems with fellow inspectors from other Member States. This has proven to be very successful and to date visits have taken place in the Netherlands, Ireland, Germany, Finland and the UK.

In addition to its institutional activity, MAHB has been involved in a number of competitive activities. During 2000, these have included the ASSURANCE shared-cost action project that focuses on assessing the uncertainties associated with the most commonly used risk analysis methodologies for assessing major industrial hazards and the SMMARTEN shared-cost action project that focuses on safety management systems for small and medium sized enterprises and the HARSNET thematic network that focuses on hazard assessment of highly reactive systems.

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References


MAHB has a long tradition in organising international seminars on themes related to industrial risk. In 2000, in view of the transposition of the Seveso II Directive, an important international conference was organised in London entitled “The Implementation of Seveso II”, in which delegates from competent authorities, industry research organisations and academia were able to present their views on the worth, practicalities and functioning of the directive. Following the firework accident in Enschede, (Figure 9.1) in which 21 people were killed and 944 were injured, a more restricted seminar was organised in Marseille, linked to the committee meeting of the competent authorities. The results from this meeting together with a follow-up meeting in 2001 will form the basis for an additional amendment to the directive.

Risk assessment plays a central role in the directive and MAHB together with the nuclear safety unit of ISIS organised an international workshop on “Promotion of Technical Harmonisation on Risk-Based Decision Making” [9.3] where experts drawn from all types of activities and industries discussed the possible need and perspectives of developing an internationally accepted generic “standard” for risk-based decision making.

The growing importance of the Internet has been recognised and MAHB maintains an active and dedicated website ([http://mahbsrv.jrc.it/](http://mahbsrv.jrc.it/)) from which documentation, software tools, MAHB publications and relevant information can be readily downloaded by interested parties. A selected list of MAHB publications for 2000 is given in [9.4-9.12].

9.2 NATURAL AND ENVIRONMENTAL DISASTER INFORMATION EXCHANGE SYSTEM (NEDIES)

A.G. COLOMBO, A.C. LUCIA, C. THEOFILI

http://nedies.jrc.it/

NEDIES (Natural and Environmental Disaster Information Exchange System) is a project concerned with the analysis of natural and environmental disasters that have occurred in the EU Member States. It has been promoted by the Environment DG and is under development at ISIS.

The main aim of the project is to produce “lessons learnt reports” by type of disaster. Lessons learnt reports enable the interested organisations in the Member States to gain from the analyses of the experiences in other countries. Moreover, it is expected that Member States can take into consideration this beneficial information for planning future activities so as to mitigate the harmful consequences of disasters. The process involves the following steps:
• identification of the disasters to be analysed and collection of the relevant documentation (usually through an ad-hoc meeting);
• analysis of the information collected and production of a lessons learnt report;
• dissemination of the documents produced.

The disasters to be considered in the analysis are selected according to their relevance, taking also into account the availability of the needed endorsed information. The analysis is structured according to the management phases of a disaster: prediction, prevention, preparedness and response. Particular consideration is given to the information supplied to the public before, during and after the event. The role of mitigation in the three phases is investigated.

In 2000, five lessons learnt reports have been completed, which deal with avalanche disasters, flood disasters, catastrophic earthquakes, train accidents and tunnel accidents, respectively.

• Avalanches: six events were considered, four of which occurred in 1999: Gargellen (Austria), northern part of the Swiss Alps (Switzerland), Chamonix (France) and Aosta Valley (Italy), and two occurred in 1995, in the west fjords of Iceland. The main lessons learnt from those disasters are reported in [9.13].

• Floods: three flood disasters were selected for the analysis. They are: the 1993 flood in Limburg (Belgium), the 1995 high water emergency in the Netherlands and the 1997 summer flooding of the Oder in Germany. The lessons learnt from those floods are discussed in [9.14].

• Earthquakes: the analysis concerned four events, which occurred in Greece: the earthquake in the Attica area (2000) that caused more than one hundred and forty fatalities, and the earthquakes in Kalamata (1986), Grevena - Kozani (1995) and Egio (1995). The related lessons learnt are reported in [9.15].

• Train accidents: six accidents were investigated. These include the ICE train disaster in Eschende (Germany), which occurred in 1998 and caused more than one hundred fatalities, the 1999 accident in the Paddington (UK) railway station and the 1991 crash in the railway station at Melun (France). The ammonia derailment in Kävlinge (Sweden) that resulted in the evacuation of 9,000 people for twenty-four hours, the 1995 train accident, which occurred in Klostertal Mason Valley (Austria) and the 1993 train accident in Naestved (Denmark) were also considered in the analysis. The main lessons learnt from these accidents are presented in [9.16].

• Tunnel accidents: nine accidents were examined. These consist of the 1999 fire in the Mont Blanc tunnel between France and Italy that caused 38 fatalities; two accidents that occurred in Austria of the same year (Tauern tunnel and Pfänder tunnel), which also caused several fatalities; the fire in the Channel tunnel between UK and France, which occurred in 1996; and another five accidents that, fortunately, did not provoke the loss of lives. Lessons learnt from these nine accidents are reported in [9.17].

To collect and store the endorsed information on natural and environmental disasters, and to disseminate the information collected and produced, a website (http://nedies.jrc.it/) has been designed and implemented (homepage shown in Figure 9.2). The information contained in the website is arranged into two parts: “Open Information” and “Password-Protected Information”. Non-registered users are able to read the “Open Information” that consists of a short description of the background of the project and the main contents and achievements of the two phases. They are also able to read and download the main reports issued by the project team. Authorised users can put into the database, protected information on disasters and read all the information stored. A password is required, however. Authorised experts are able to search for disasters, specific documents (i.e., documents related to a specific disaster input in the system) and generic documents (i.e., documents containing generic information on natural disasters and their management), and report generic documents. Nominated representatives are able to report and search for disasters and both types of documents (generic and specific).

References

9.3 MANAGEMENT OF NATURAL AND TECHNOLOGICAL HAZARDS IN CANDIDATE COUNTRIES
A.C. Lucia, J.S. Duffield, N. Mitchison

This activity started in the second half of 2000, in the context of the JRC Enlargement Programme, on the grounds of the experience acquired and the tools developed in the institutional project described in sections 9.1 and 9.2. Its main objective is the design and creation of compatible regional and national central information systems for supporting authorities in the management of risk and emergency situations due to natural and technological hazards and to the existence of heavily polluted land sites. Candidate (Central and Eastern Europe) countries have to face challenges and problems of a large dimension and complexity arising from a wide range of natural and technological hazards. Furthermore, quite a serious threat to the safety and health of citizen is constituted by the existence of land polluted by industrial spoil, military activities and improper handling of hazardous wastes: actions for land recovery or for reduction of risk have to be undertaken.

The envisaged steps of the activity are:

1. Creation of a collaboration structure in the countries concerned.
2. Collection of data and information on
   • sites that are potential sources of major accident hazards;
   • sites that are potential sources of environmental pollution;
   • sites where there is soil or groundwater pollution (from current or past activities);
   • past accidents and events and related reports and lessons learnt;
   and creation of the relevant geo-referenced databases and information systems.
3. Creation of risk maps.
4. Development and application of methods for the risk-based screening of sites and installations and for the prioritisation of the interventions.

The year 2000 activity (started after the summer) has been devoted to the identification of official key contact persons in the 10 pre-accession countries, through contacts with the embassies and ministries, and to the creation of a network of technically involved persons. A second part of the activity has been the preparation, organisation and planning of an international workshop “Management of Natural and Technological Hazards” to be held in Ispra on 14th-16th March 2001, with the participation of delegates from these countries.

9.4 COMPETITIVE ACTIVITIES AND THE MAJOR ACCIDENT HAZARDS BUREAU
J.S. Duffield, M. Christou, A. Mengolini, M. Fiori

9.4.1 ASSESSment of the Uncertainties in Risk Analysis of Chemical Establishments (ASSURANCE)

The ASSURANCE project began in 1998 and will be completed in the spring of 2001. It aims to improve the understanding of the uncertainties associated with the risk analysis of major industrial hazards by assessing these uncertainties and the way that they can affect the final outcome of risk studies. This is achieved by assessing the state-of-the-art (including approaches, techniques, models, and assumptions) of risk analysis in the European Union; analysing the sources of uncertainty present in risk assessment and their contribution to the uncertainty and variability of the overall results; and comparing the approaches used to deal with these uncertainties. The method adopted was that a reference installation was analysed by different teams independently of each other and the results compared. Special exercises/case-studies (with well-defined common assumptions and based on the reference installation) were carried out and intermediate results from each phase of the risk assessment procedure are being collected and compared to identify which phase – and which source – contributes most to the variation of the overall results. The implications of these uncertainties in policy issues, such as land-use planning, are also being examined. Seven teams from throughout Europe have performed these case studies and ISIS, as technical co-ordinator, is evaluating these results.

9.4.2 Safety Management Systems for Major Accident Hazards in Small and Medium Enterprises (SMMARTEN)

The SMMARTEN project recognises the specific needs of small and medium sized enterprises (SMEs) working with dangerous substances in their efforts to fulfil their legislative obligations. It is a project funded under the CRAFT programme and was the first of its type for the JRC. The main objective of the project was to bring together a number of companies with research organisations and to identify priority issues among the several elements of a safety management system (SMS) where guidance and support to SMEs is most needed. Recognising the limited resources that SMEs possess to formalise the way they manage safety, a central feature of the project was to develop an easy-to-use methodology to support the companies in the implementation of an effective safety management system (a major requirement of the Seveso II Directive). In addition, the project consortium has tried to identify the functional characteristics of a dedicated SME network, which will establish contacts between those enterprises interested
in improving their approach to safety management systems and interested service and knowledge providers. This network is expected to provide support on risk management and control issues to a wider range of SMEs operating in the European Union.

9.4.3 Network on Hazard Assessment of Highly Reactive Systems (HARSNET)

HARSNET is a Brite-Euram thematic network on Hazard assessment of Highly Reactive Systems – it has over 35 members that are drawn from the major industrial, academic and research organisations throughout Europe. The main objective of the network is to transfer the safety knowledge, procedures and best available practices from large companies and research centres to small and medium sized chemical industries. It follows the urgent need to introduce hazard assessment techniques for reactive chemicals into the normal working procedures of SMEs. Most of the expensive and specialised experimental techniques commonly employed in such studies are not usually easily available to such concerns, and with this in mind, new guidelines are being produced including a step-by-step assessment procedure based on a literature survey, simple predictive calculations and laboratory based testing in readily available equipment. Such procedures are being incorporated into a software package (HarsMeth) which is designed to reveal the occasions (typically 5%-10% of all reactions) where more sophisticated tests should be performed by external laboratories or specialised experts.

Other activities of the network include the production of HarsBook, which is based on the accumulated and shared experience of the partners and describes the best methods currently available for predicting, assessing and minimising exothermic reaction hazards. HarsBase is also being developed, which is a collection of databases and links to chemical reaction safety related data that can be easily be accessed by SMEs through the Internet. Finally, an important spin-off from the network is the formulation and promotion of new research projects to support the methodologies underpinning HARSNET. In this context, a shared-cost action project (AWARD) has recently been granted that concentrates on the early detection of runaway reactions using chaos theory and the safe disposal of reaction products. ISIS is playing an active role.

9.5 RISK MONITORING AND EMERGENCY MANAGEMENT

J.P. Nordvik, A.C. Lucia, D. Chavaudra

This was the first year of the 3-year framework agreement with the Italian Ministry for the Environment for the establishment (at the national level) of an integrated system for environmental monitoring, risk management, and environmental and technological emergency management. The major objectives of the project, called SIMAGE (Sistema Integrato per il Monitoraggio Ambientale e la Gestione del rischio industriale e delle Emergenze), are:

• the creation of harmonized air-quality networks for the industrial areas of Brindisi and Taranto, including the integration and optimisation of existing air-quality networks, the installation of new monitoring stations and air pollutants instruments and the definition of quality-control procedures and associated control laboratories;
• the design and establishment of a national co-ordination centre for environmental information exchange concerning air, water and soil quality, networked with the major existing Italian risk areas, in particular, the areas of Brindisi, Taranto, Porto Marghera, Priolo-Augusta, Gela, Milazzo, Genova, Ravenna and Livorno-Piombino;
• the development of a pilot system for the monitoring and control of the transportation of dangerous substances via road, railway and sea, including a benchmark exercise of tracking and mobile communication technologies, and the realization of local systems in Brindisi, Taranto and Porto Marghera for traffic control and emergency management;

9.3 One major objective of the Framework Agreement called SIMAGE established between the JRC and the Italian Ministry for the Environment is the development of an integrated information exchange network that covers the main existing Italian risk areas.
SIMAGE started in Autumn 1999 with ISIS being in charge of the design, realisation and effective establishment of the integrated system, as well as of the overall project co-ordination. Results in 2000 included the activities of:

- identification and preparation of user requirements at national and local levels;
- high-level design and architecture definition of the Brindisi and Taranto air-quality monitoring networks, of the national overall environmental information exchange network, and of the pilot system for the monitoring and control of the transportation of dangerous substances;
- organisation and running of the major call for tender related to air-quality monitoring networks and associated systems.

ISIS also continued to manage the monitoring systems that it installed during the previous years in the three major industrial risk areas of Sicily, and further extended these networks with new network management systems.

### 9.6 SOFTWARE PACKAGE FOR CIVIL PROTECTION EMERGENCY PLANNING & MANAGEMENT

**J.P. Nordvik, M. Delaval**

A software package (EPMS) has been developed to support the activities of civil protection authorities related to planning and management of emergencies. Computer tools have been developed to support the collection and diffusion of all civil protection related information, their organisation into ready-to-use emergency plans and procedures, and their exploitation during real emergencies to support the different aspects of the management of the crisis including in particular co-operation with all players involved in the crisis.

The product is sub-divided into two main software logical units: emergency planning and emergency management applications. The former is concerned with the preparation of the emergency plans and procedures of civil protection, with the possibility of geo-referencing this information on the territory. It also concerns the management, updating, sharing and diffusion of this information and of the emergency procedures concerning local, provincial or regional end-users. The latter offers to the operator of an emergency room a software environment to support the management of the crisis. Pre-defined procedures of intervention are available for immediate use by the operator. A “logbook feature” is available to trace all actions performed by the operator for post-emergency analysis or emergency training procedures. The product will be validated through a realistic test case involving all the players concerned during an emergency, i.e., local, provincial, regional administrations and operative structures of the civil protection and other technical structures. Data, modules (forms), procedures and alarms are the most important entities that will concern the users.

The Oracle server 8.0 and a first prototype version of the EPMS software have been installed at ISIS for demonstration and for a first assessment. A typical user-interface interaction is shown in Figure 9.4.

### 9.7 SAFETY OF INDUSTRIAL PROCESSES AND HUMAN FACTORS

**P.C. Cacciabue**

A research activity, performed in collaboration with the Politecnico di Milano, focused on the importance of combining macro and micro approaches in the analysis of accidents and incidents in complex systems such as those involving production and distribution of energy. A new formalism was proposed, providing a working frame for showing the complex interconnections between external and internal causes leading to the manifestation of erroneous behaviours [9.18].

The impact of human factors and in particular the question of safety-related effects have been investigated and are recognised as the most important issues for the future development of technology. Improving the safety of systems implies improving the design, implementation, evaluation and management of the associated human factors and human-machine interfaces. In several technological domains, the recognition of this crucial issue and the outcome of related research in human factors, has already led to the introduction of standardised methods in the design and development of automated systems, in safety assessment and in training [9.19-9.20].

In other domains, the contribution of human factors to the development of systems and working environments still remains underestimated. For these reasons, the human factors issue needs to be further considered by regulatory bodies and developed at the technical level.
Moreover, as this subject spreads throughout the whole of Europe (and the world), the question of safety becomes a trans-national one, demanding the use of internationally accepted means and methods. In this respect, ISIS has organised and hosted the XIX European Conference on Human Decision-Making and Manual Control [9.21] and [http://humanfactors.jrc.it/EAM2000.html/].

9.8 THEMATIC NETWORK ON SAFETY ASSESSMENT IN WATERBORNE TRANSPORT (THEMES)
P.C. Cacciabue

The objective of THEMES is to improve shipping safety and marine environmental protection by establishing a common knowledge base and a framework of safety assessment/management for waterborne transport.

This is met by:
- describing the state-of-the-art for aspects related to safety assessment including human factor issues;
- establishing a common framework for safety assessment based on present standards;
- describing requirements and implementation strategies for improved knowledge on risk factors;
- identifying knowledge gaps and proposing further research to be carried out;
- making available and disseminating present knowledge for safety assessments.

This network is co-ordinated by Det Norske Veritas and about 30 organisations, ranging from industry to academia, are involved.

9.9 AUTOMOTIVE COLLISION AVOIDANCE SYSTEM
P.C. Cacciabue, D. Petraccone

The activity, performed in collaboration with Politecnico di Milano [9.22], focused on the development of a prototype for a collision avoidance system (CAS) to be installed in a car, according to the human-centred design philosophy. Particular emphasis was put on the driver’s interface. In this study the leading idea was also to take advantage of the know-how gained in the aerospace domain and see whether it is possible, and to which extent, transfer the principles of human-centred automation from aviation to automotive domains. The system architecture was sketched together with the design of a head-up display (HUD). A demonstrator for the HUD has been developed to show the main features of the interface, the automation issues in different situations, i.e., nominal and abnormal conditions (poor visibility, mechanical failure, and wet road) – (Figure 9.5).

References

9.5 Screen shots of the demonstrator of the CAS.

References
9.10 MONITORING OF LANDSLIDES

D. TARCHI

Synthetic Aperture Radar Interferometry (D-InSAR) using ERS 1-2 and RADARSAT data has currently generated more and more interest in the scientific community. In the field of earth sciences, particular interest is related to the construction of precise digital elevation models and new applications such as displacement detection of earthquakes, landslides and subsidence phenomena have been approached and validated.

ISIS has developed a specific methodology for the application of such a technique to the monitoring of landslides based on the use of ground based imaging radar instrumentation. This approach combines the well-known advantages of radar imaging techniques, such as remote action, day and night operability, non-invasiveness, with a maximum flexibility in terms of viewing geometry, frequency of observation, polarimetric capabilities and temporal coverage.

The instrument, called LISA (Linear Synthetic Aperture Radar), is capable of performing measurements on areas extending from a few metres to a few kilometres thus providing also close-in views of portions of particular interest (Figure 9.6). The frequency of observation can be selected in the range from 500 MHz to 18 GHz with full polarimetric capabilities. Attainable spatial resolutions are in the range from tenths of centimetres to a few metres while the accuracy in the measurement of displacements is in the millimetre range. Different versions of this instrument are available, which are suitable for medium and long term monitoring but which can also be operated in case of adverse environmental conditions or during emergencies when flexibility and minimum time for installation are required.

During 2000, several experimental campaigns have been carried out with the system, aimed at validating the approach. Sites for the experiments have been selected in order to be representative of typical environmental conditions and characteristic of the phenomenon being monitored. Figure 9.7 shows a picture of a test area – the Tessina landslides near Belluno, Italy. In Figures 9.8 and 9.9, a whole series are shown. They have been obtained by comparing pairs of images acquired at time intervals of 12 and 24 minutes, respectively. Colours, coded according to the scale, represent the relative displacement along the line of sight of the system of the different portions of the area with respect to the reference acquisition. Negative displacements indicate displacements towards the observer. As confirmed by the network of traditional optical devices installed on the site the area was undergoing a quite rapid and complex pattern of displacements due to intense rainfall in the previous days. In both interferograms, two main areas of movements are recognisable. The left bottom side shows the most rapid displacement. After only 12 minutes the relative displacement exceeds half of the wavelength of the radiation employed, i.e., 9 mm, producing a fringe in the resulting interferogram. This common effect, sometime misleading in the interpretation of the results, can be easily fixed by applying appropriate unwrapping algorithms. Increasing displacements are recognisable in the second interferogram, corresponding to a longer time interval, where additional fringes are present. All the data acquired during the experimental campaign have been carefully analysed and compared to ground truth data coming from traditional monitoring devices. Correlation has been found in all cases leading to a full validation of the proposed approach as a valid complement to the existing tools commonly employed in monitoring operations.

Further activities have been already scheduled. Two additional aspects will be approached. The first will investigate the potential of the combined use of ground based SAR platforms and spaceborne imagery in the field of regional scale geological risk assessment. The second originates from the interest for the technique manifested by different Civil Protection Authorities and will aim at validating the approach in real emergency situations.
ISIS is also active in the field of innovative SAR sensors and concept development and testing such as noise radar technology and parasitic SAR system. The latter concept in particular, due to the absence of electromagnetic emissions, is suited for long term monitoring of subsidence phenomena in urban areas. An operational prototype is almost ready and will be tested in real conditions in 2001.

9.11 DETECTION OF OIL SPILLS

D. Tarchi, P. Pavlakis

The MARPOL 73/78 convention, recognising the specific oceanographic and ecological sensitivity of a number of regional seas, identifies them as “Special Seas Areas”. Within such areas, discharges of oil or oily mixtures from vessels are virtually prohibited. All the European regional seas are accorded with such a status. Key elements, however, for the success of any international environmental agreement, are monitoring and intervention. In the case of deliberate pollution, monitoring is effective only when supported by perpetual airborne surveillance. It is, however, neither technically nor economically possible to employ airborne surveillance possibilities over all the European seas. Thus, spaceborne surveillance means need to be exploited, especially SAR (Synthetic Aperture Radar) sensors, which are independent of sunlight or cloud coverage and are capable of providing wide-area reconnaissance. As a support to the European Commission’s effort to ensure an optimum level of protection for the European marine and coastal environment, ISIS performs systematic work around such a quest. Through the best available techniques and methodologies and an established expertise, ISIS provides comprehensive information on vessel pollution at the regional level.

9.8 Displacements pattern (with respect to a reference condition) after a time interval of 12 minutes.

9.9 Displacements pattern (with respect to a reference condition) after a time interval of 24 minutes.

9.10 Spills detected on ERS-1/2 SAR images during 1999 in the Mediterranean Sea. Shape and radar backscattering elements of the spills, stored together with auxiliary environmental information, help to reconstruct the spilling scenario and associate the spill with ship tracks detected in the pollution zone.
Decision Support for Risk and Emergency Planning

OVERVIEW
D. Bain

Changes in research priorities within ISIS meant that 2000 was a year of transition within the Decision Support activity area. 1999 had already witnessed a change of focus from exclusive concern with environmental management projects towards sustainable mobility. This experience in transferring competencies now proves invaluable in making the further transition to risk and emergency management decision support.

As in the past, ISIS derives its expertise in the decision support area from the tools and techniques which it has developed and from the cumulative experience gained in building customised Decision Support Systems (DSS) for specific real-life projects. Much effort during 2000 was devoted to maintaining, upgrading and developing the various decision support tools and to ensuring continued capability in their use. Specific outputs in the area of risk and emergency planning are therefore planned for later years.

Outputs in 2000 included a number of case studies involving use of Multi-Criteria Decision Aids (MCDA) in areas such as water resource management and solid urban waste management. In addition, a new software tool, known as MARPA (Multi-criteria Analysis using the Reference Point Approach) was developed as a web-friendly addition to the existing tool box. Work also continued on enhancing scientific support to agri-environmental policies (section 10.1).

Parallel to preparation for the new tasks, work has continued on a number of competitive actions. Although none of these is specifically related to the risk and emergency management theme, the various decision support tools developed or under development have illustrated important lessons, which will prove invaluable in future projects. The projects in question include two shared-cost actions – MATADOR and UTOPIA (both now completed) – in the area of sustainable mobility and CommonGIS, which advances the use of spatial analysis techniques. There is also an on-going third party work project called MURST, which deals with flood protection.

10.1 ENHANCING SCIENTIFIC UNDERPINNING TO AGRI-ENVIRONMENT POLICIES
D.H.A. Al-Khudhairy, C. Leemhuis, V. Hoffmann, J.M. Terres, R. Calaon, I.M. Shepherd

Agriculture is the biggest land user in the European Union (occupying approximately 40 % of its territory). Over the centuries, European agriculture has given rise to unique European landscapes with a rich variety of semi-natural habitats and species. However, in the last few decades European agriculture has also been viewed as a major source of pollution and a driving force behind the disappearance and degradation of Europe’s landscape and wetlands. This is because European agriculture has changed notably in the last four decades. It has become a complex “high-tech” industry that has increased agricultural production, thanks to rapid application of new technology and the encouragement of generous support under the Common Agricultural Policy (CAP), by rates that far exceed those in other industries. Moreover, because of the high level of agricultural land in and around remaining European ecosystems of special biodiversity and wildlife interest, their future is strongly linked with changes in agricultural practices and intensity, and thus in reforms in agri-environmental policies.

The extent of environmental problems linked with European agriculture and the lack of information available to meet the demand of agri-environmental policymakers, the farmers, the scientific community, and the general public to understand agri-environmental relationships, and to analyse the environmental impacts of reforms in agri-environmental policies has resulted in the considerable global interest shown today in developing and incorporating appropriate indicators into agri-environment and agricultural policies. As part of the remits of the SHYLOC project1 and the JRC agri-environment cluster2, computer-based models, remote sensing based software, and specific agri-environment indicators have been developed to provide scientific underpinning to agri-environment and agricultural policy development, monitoring and analysis.

The computer-based model is an advanced wetland model that will enhance the design and implementation of agri-environment programmes for maintaining, protecting, or restoring wildlife habitats in agricultural landscapes [10.1]. The remote sensing based software,

1 SHYLOC (System for HYdrology using Land Observation for model Calibration) is a pilot project that started in November 1997 and ended in October 2000. The project was partly funded by the European Commission, led by ISIS-JRC, and had partners in England (University College London), Denmark (DHI Water & Environment) and Greece (University of Thessaloniki & Greek Biotope/Wetland Centre).

2 The agri-environment cluster comprises several JRC institutes including ISIS, SAI, EI and IPTS, and interfaces with the Environment DG, the Health and Consumer Protection DG, the Energy and Transport DG, EUROSTAT and the European Environmental Agency, through participating and providing support in the working group on “Indicators Integration in the CAP”.
SHYLOC [10.2], was developed by ISIS and validated against ground-measurements provided by SHYLOC partners to provide information on specific environmental pressure-state indicators by means of monitoring (a) surface water levels in areas of water management/abstraction issues where farmers receive payments to maintain high water levels in ditches and dykes to maintain and enhance wildlife conservation values of wetlands and (b) water level requirements of wetland flora and fauna in ditches for which farmers receive payments to manage and maintain high ditch water levels. Finally, the framework and methodologies for structuring and analysing a set of specific agri-environmental indicators and related environmental links that the JRC can provide in the short, medium and long term have been established, and are reported in [10.3].

The afore-mentioned models, remote-sensing based software, and agri-environment indicators form part of the mission of the JRC as a service of the European Commission to foster sound EU agri-environment and agricultural policies through credible scientific and technological underpinning, and hence to contribute towards the long-term protection of the environment.

References

Integrating satellite-derived information with ground measurements provides scientific support to assessing the environmental effects of EU policies, such as agriculture, on areas of special biodiversity/nature interest, and to monitoring the conformity of the environmental objectives of such policies to environmental targets.
10.2 MATADOR

D. Bain, F. Mazzeo Rinaldi, R. Wolfler Calvo, L. Trovelli

The use of non-conventional vehicle drive-line technologies (electric, gas, hybrid, etc.) is an increasingly live option for fleet operators in areas as diverse as carhire, bus services and road haulage. Occasionally the initiative for considering such options may come from fleet managers themselves. More frequently, however, the pressure to examine such alternatives will come from other sources, including environment and health legislation, local access regulations, incentives offered by state agencies or from other parts of the organisation keen on improving the corporate image.

As fleet managers will readily testify, the introduction of new technologies is generally a highly complex operation, with issues such as maintenance, reliability, range, refuelling structures, driver acceptance, staff training, vehicle behaviour, re-sale values and availability of spares as important as the headline characteristics such as fuel costs per kilometre and environmental impacts. Comparative information on all these matters may be difficult to obtain.

The MATADOR project (Management Tool for the Assessment of Drive-line Technologies and Research) seeks to provide fleet operators (and others interested in commercial introduction of new propulsion technologies) with a wide range of information, much of it collected for the first time. The software tool that guides this process is known as MIG (MATADOR Interactive Guide). As its name implies, MIG help users to access the MATADOR information base and will also give them the possibility of making a multi-criteria comparison of various new drive-line options, relative not only to each other but also to conventional vehicles.

Exploring the details of the different vehicle types available allows the user to appreciate both positive and negative attributes and the impact of these on a range of different decision criteria. While single criteria may be sufficient to discard particular options it is extremely rare that they can form the basis of acceptance. MIG incorporates a decision enhancement capability based on Multi-Criteria Analysis (MCA) to assist fleet operators to take a range of vehicle characteristics into account before making any decision to proceed.

The software structure of the MIG has been designed in terms of software modules, module interactions, functionalities, general information contents and rules for the delivery of inputs in terms of models, data and documentation.

10.3 UTOPIA

D. Bain, F. Mazzeo Rinaldi, R. Wolfler Calvo, L. Trovelli

http://utopia.jrc.it

Most Europeans live in cities and even most of those who do not are to some degree dependent on cities for employment, education, entertainment and other services. How cities work, the quality and dynamism of the urban system are therefore of vital importance to the vast majority of European citizens. While it is, of course, people who are the key element in determining the relative success of cities, physical aspects have a crucial shaping influence. Most elements of this – housing, sanitation, lighting, shops, offices, etc. – have improved dramatically over the last century. The one area where there has been a marked deterioration, for a large proportion of European cities, has been in transport.

This has come about through an explosion of mechanically-assisted mobility, particularly the vast growth in the numbers of private cars entering and using the urban space. The problems that these raise have led to widespread calls for radical change. Among the solutions proposed are physical or financial disincentives to use cars, encouragement of other travel modes such as public transport or cycling and walking, promotion of virtual mobility using advanced information technology, and the adoption of new propulsion systems.

UTOPIA focuses on this last option. It considers the wide range of new and improved propulsion systems currently coming on stream and draws together findings from a wide range of disciplines to address the complex issue of how to ensure successful market entry of new transport technologies. Although the main driver of the introduction of such technologies is concern for the environment they will also have a wide range of impacts on many other aspects of society. These additional impacts need to be understood and given due weight by decision-makers – apart from their intrinsic
importance they also affect the likelihood of market take-up. UTOPIA draws on practical experience derived from previous case studies in Europe, giving guidance on how these can best be applied to specific urban situations and providing tools to understand what the effects might be.

NAVIGATE UTOPIA is a software tool which has been developed to allow local decision-makers to explore and evaluate the numerous new transport technology options already available or on the point of entering the market. Getting urban transport “right” is a challenging task for decision-makers, given the number of policy areas affected, the large range of stake-holders and the high political sensitivity of almost any option adopted (including “do nothing”). Ultimately any decision must rest with the skills and informed judgement of the decision-maker or decision college. It remains difficult. NAVIGATE UTOPIA can help, however, by providing structured access to a large quantity of information and experience, allowing systematic balancing of a wide range of options and consequences and allowing serious “what if?” speculation.

10.4 THE COMMONGIS PROJECT
R.J. PECKHAM, S. MAFFULLI

ISIS continued its participation in the CommonGIS, a shared-cost action project funded by the ESPRIT programme. The aim is to develop the means for the dissemination of geo-referenced information to a broad cross section of the public via the World Wide Web. It delivers map-based visualisations of statistical data through an Internet browser, together with user friendly methods for interactively adjusting the displays. The Internet is increasingly being used as a means of disseminating information not only among specialists and professionals, but also for the general public. In many areas of decision-making presentation of the information on maps is a powerful aid to perception of the phenomena concerned and is essential to understanding spatially distributed phenomena.

The project has proceeded through the development of a first prototype, user studies and evaluations, and then a second prototype incorporating the feedback and suggestions from the trial users. The project consortium included partners from Germany, the Netherlands, Portugal and Italy. ISIS contributes to the project management, to application development, and information management, as well as standardisation and dissemination activities.

The system developed includes facilities for automatic generation of visualisation instruments such as colour-shaded areas, bar charts and pie charts superimposed on maps within a web browser. Intelligent, knowledge based methods are used to automate the generation of visualisations and to minimize the inputs required from the user. Once they have been generated the visualisations can be interactively adjusted using familiar controls to aid exploration and understanding the data.

The system has many potential applications and during 2000, ISIS has set up two prototype applications on forest fires and earthquakes. The forest fires demonstrator shows on a map the mean duration of fires, the mean delay between the alarm and the intervention and the total surface burned, referred to the provinces of Spain. In the earthquake application, data from a European catalogue of historical earthquakes are used to illustrate the basic attributes of the events (magnitude, intensity and radius) using symbols with graduated colours. The user can interactively adjust a reference value above and below which the symbols are displayed in different colours. Alternatively a single event can be chosen as the reference and events with parameter values higher and lower than this can be rapidly visualized. The events can also be displayed as bars with variable colours and heights, again with user friendly tools for adjusting the visualisation.
Tools of this kind can be effective aids to decision making, and when implemented over the Internet they can facilitate access to, and understanding of, geo-referenced statistical information by a broad spread of interested stakeholders and managers. However it is a significant challenge to make these tools sufficiently user friendly and intuitive to be used by non-specialists. The user studies carried in the CommonGIS project have helped to make progress in this area.

10.5 THE MURST PROJECT

F. Mazzeo Rinaldi, R. Wolfler Calvo

The project is a third-party work financed by the Ministero dell’ Università e della Ricerca Scientifica e Tecnologica (MURST). The task of ISIS is to develop a multi-criteria decision support system for flood protection. The application addresses flood damage prevention and comprises a Geographical Information System (GIS) together with three models to simulate the behaviour of the rivers and streams in flood (a distributed hydrological model, a semi-distributed model and a model of flood propagation along riverbeds) and a multi-criteria module.

The goal of the decision support system, called DEFF (Decision Framework for Flood Protection), is to support decision-makers in finding a compromise solution among a set of possible actions aimed to achieve an optimal use of the territory, the safety of people and a reduction of the damages caused by critical flood events. DEFF will be applied to a case study in the Liri Garigliano watersheds. The Liri Garigliano watershed is one of the most important in the south of Italy and extends over the territory of three regions (Abruzzi, Lazio and Campania) and five provinces (L’Aquila, Frosinone, Latina, Roma, Caserta). It takes water from a large section of the south-western Appennines and discharges it in the Tirreno sea.

The basin’s environmental system, as produced by centuries of close interaction between natural evolution and human-made changes, now appears to a large extent compromised. The strong land modification by infrastructure of the last 30 years, coupled with the natural vulnerability of the basin landscape, has caused damage, some of which is irreversible. Basin authorities have initiated preliminary studies to better plan future actions to protect the Liri Garigliano watershed. Bad land management is the main cause: on the one side congested urban and industrial areas overcharge rivers with polluting discharges and, on the other, in marginal and abandoned rural areas the loss of population and of traditional activity makes lands vulnerable to erosion and destabilisation.

A publication of the Liri Garigliano basin authority highlights the following emergencies and critical points:

- pollution and overuse of waters, with critical values at Fucino, Sacco, Melfa and at the mouth of Garigliano;
- destabilisation of slopes;
- flooding, with particularly high risk in the middle Liri valley and Sora plain, along the greatest part of the Sacco stream and in the low Garigliano area;
- land degradation, with critical areas in the high Sacco valley, at the Cosa inflow in Sacco and in Liri Valley between Sacco and Melfa down to Cassino.

<table>
<thead>
<tr>
<th>Region</th>
<th>Province</th>
<th>Surface</th>
<th>Surface falling in the watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abruzzo</td>
<td>L’Aquila</td>
<td>5034 km²</td>
<td>1242 km²</td>
</tr>
<tr>
<td>Lazio</td>
<td>Frosinone</td>
<td>3239 km²</td>
<td>2835 km²</td>
</tr>
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<td>Latina</td>
<td>2251 km²</td>
<td>296 km²</td>
</tr>
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<td>Lazio</td>
<td>Roma</td>
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<td>474 km²</td>
</tr>
<tr>
<td>Campania</td>
<td>Caserta</td>
<td>2639 km²</td>
<td>287 km²</td>
</tr>
</tbody>
</table>

10.4 Watershed view.
In order to improve the present situation, several alternatives can be proposed. In the choice of a better solution major help is given by multi-criteria methodologies: alternatives are compared by means of criteria that can be satisfied at various levels. This case of a decision support system for mitigation and prevention of damages due to floods comprises four families of criteria: environmental, economical, social and technological. Each alternative involves an integration of structural interventions that tend to reduce the probability of the critical event and non-structural interventions such as regulation in the possible use of a certain area, the organisation of monitoring of rivers and assistance to the people during emergencies. Risk = 0 is impossible to achieve, hence it is necessary to limit the comparison of alternatives amongst those which can reduce the risk to an acceptable level.

**Suggested Further Reading**

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Cavallet A., Malucelli F., Wolfler Calvo R.
OVERVIEW
A.C. Lucia

The projects presented in this chapter are part of the JRC effort supporting the implementation of policies aimed at the protection of individuals, infrastructures and society against natural and technological hazards. The core activity in aviation safety is constituted by the institutional project on the European Co-ordination Centre for Aviation Incident Reporting Systems (ECCAIRS), supporting the Energy and Transport DG in the establishment of a common European reporting system for in-flight incidents, including analysis of the influence of human error. The Energy and Transport DG has recently prepared a proposal for a Council Directive “Establishing a co-ordinated system of national mandatory occurrence reporting schemes”. The proposal is based on the conviction that the establishment at the Community level of a mandatory aviation incident reporting system is feasible and that a suitable tool (ECCAIRS) is available to those Member States that do not want to develop their own system. A centralised database facilitates the exchange of information between all Member States.

Several synergistic competitive activities are also ongoing, focusing mainly on human factors, which contribute to keeping and updating ISIS’s expertise in this field. Based on the results obtained in 1999 and 2000, the priority activity development lines for the future have been identified. They include: maintaining, updating and further developing ECCAIRS as well as providing support to the implementation of the relevant Directive; supporting pre-accession countries and facilitating their gradual involvement in ECCAIRS; strengthening data analysis activities by a co-ordination effort at the European level; and starting a risk analysis activity on some priority aspects (at present under discussion with the Energy and Transport DG) of aviation safety.

11.1 EUROPEAN CO-ORDINATION CENTRE FOR AVIATION INCIDENT REPORTING SYSTEMS (ECCAIRS)
W. Post
http://eccairs-www.jrc.it/

All safety experts recognise that the global rate of aviation accidents is stabilising and, as a consequence, the growth in air traffic, if nothing is done to improve it, will lead to an increase in the absolute number of incidents and accidents per year. For that reason the European Commission (the Energy and Transport DG) proposed to create the necessary framework to collect and disseminate information on aviation incidents, at the widest scale, so that all parties involved in aviation can learn from mishaps and improve their performances to produce a safer system.

The related directive1 “Proposal for a directive of the European Parliament and of the Council on occurrence reporting in civil aviation”, prepared by the Energy and Transport DG in December 2000, will address both mandatory and confidential reporting of incidents, defects or malfunctions, which may constitute a hazard for civil aviation operations (called under the generic term of “occurrences”). Since accidents are usually preceded by a number of these “precursors”, a better knowledge of occurrences may help to eliminate some of the causal factors leading to an accident and therefore prevent it.

The ECCAIRS project provides support to the Energy and Transport DG for the setting-up and implementation of the framework described. ECCAIRS is a network of collaborating EU aviation authorities, set-up by JRC-ISIS over the last 5 years, whose objective is to exchange, collect and assess aviation incident and accident information provided by EU aviation authorities. The project’s objective is to have all Member States participating actively in the network by the end of the Fifth Framework Programme (2002) when, most likely, the European Commission’s directive will have been adopted.

In 2000, the ECCAIRS steering committee, in which representatives of all EU Member States and others like the Energy and Transport DG, ICAO2 and Eurocontrol3 have a seat, had its second annual meeting in Ispra. At the meeting the steering committee decided to implement in the year 2000 an enhanced version of the ECCAIRS 3.3 reporting system, a tool already widely used by many countries (Ireland, Denmark, France, Greece, Germany and Italy) and under test or evaluation by most other EU aviation authorities. In December 2000, the development of this new version, Release 3.4 has been completed. The French Civil Aviation Authority (CAA) developed, using tools provided by the JRC, a French version of the ECCAIRS application for this release, which is now being used locally. The data collected, apart from narratives, remains completely compatible with the English version and can be exchanged without problems. The German AIB has prototyped a similar German version to be completed in the first months of 2001.

Also during 2000 the preparation and prototype development of a completely new, but backwards compatible

2 International Civil Aviation Organisation, part of the United Nations.
3 The pan-European organisation responsible for co-ordinating Air Traffic Management.
version of the reporting system (Release 4, see Figure 11.1) has been started and resulted in a second beta-version made available to the authorities in September. A very close collaboration with ICAO, Eurocontrol, Deutsche Flug Sicherung (DFS) and the Swedish Civil Aviation Authority finally resulted in a proposal for a new data classification scheme to be used in ECCAIRS. The scheme is also highly compatible with Eurocontrol’s standardisation efforts for Air Traffic Management (ATM) related occurrences. The result is that there is an increasing chance that the ECCAIRS reporting system will not only be used by EU civil aviation authorities but also by organisations at an international level (ICAO and non-EU authorities) or in related areas like ATM (Eurocontrol and DFS) and others.

**11.2 HUMAN FACTORS IN ACCIDENT DATABASES**

P.C. Cacciabue

Following the research actions oriented towards accident analysis, safety assessment and human behaviour studies, ISIS has been involved in the development of the new Accident Classification scheme (ADREP-2000) proposed by ICAO. In order to assess advantages and open issues associated with ADREP-2000, especially in relation to human factors, an extended study was started in 1999 and continued throughout the year 2000 within the project ECCAIRS. This study has shown the ability of ADREP-2000 in representing, in a condensed and formal way, the findings of an accident, including cognitive and organisational aspects. In addition, the new classification scheme was shown to incorporate the most modern theories of human factors and human errors. However, the classification process with ADREP-2000 remains quite complex and cumbersome to complete, especially for the part related to human factors, and the risk of generating inappropriate coding remains quite high. For this reason it is necessary to develop a support tool that provides appropriate guidance in the application of the taxonomy.

A number of other considerations has resulted from the study [11.1]. First, considering that accidents in the domain of aviation are very rare, the contribution of the insight contained in mandatory reporting databases is too scarce and dispersed to offer a real contribution in terms of information and data. This implies that from a database on accidents it is not possible to identify real indicators of incipient failures of defences or conditions of latent errors. Other data collection systems, e.g., voluntary reporting systems on near-misses and incidents, are much more appropriate for this purpose and richer in information content as long as the collected information is properly analysed.

Secondly, for the same reason as above, i.e., the scarcity of data, a database only focused on mandatory type of events, such as ADREP, does not offer a sufficient amount of data to derive probabilities or failure rates for risk assessment and risk management methods [11.2]. As an example, Figure 11.2 shows a comparison between the old ADREP-87 classification and ADREP-2000 based on 6671 accidents codified with the two taxonomies. It is quite obvious how the probabilities that can be associated to each type of error are only broadly evaluated by making substantial assumptions about behavioural and cognitive functions. Moreover, these data are dependent probabilities on the occurrence and therefore have a very limited range of generality.
In conclusion, although ADREP-2000 is able to describe the accident from an organisational and socio-technical point of view, it is largely insufficient in offering an in-depth insight and is useless in promoting important changes and improvements. It does not offer a solid base for the definition of “safety indicators” within an organisation, and is not able to represent a consolidated set of data for risk and reliability assessment. Only by coupling accident data with findings from other sources of investigation and information such as voluntary reporting, task analysis and regular assessments of work and safety practices is it possible to obtain real and effective insights into human factors for improving safety levels and preventing future occurrences.

A complementary activity, in the framework of the common research programme with the Politecnico di Torino (Aerospace Department), focuses on human reliability methods, accident investigation methods and related data collection and analysis. The aim of this research in the domain of aviation is to support the evaluation of the new classification schemes being developed within the ICAO. In the year 2000, the taxonomy and classification system was analysed with respect to its ability to generate human reliability data for probabilistic safety studies. The most relevant conclusion of this research was that, while ADREP-2000 level of detail is fine and permits the reconstruction of an accident for many aspects, especially related to human interactions, its ability to support reliability data definition is presently questionable [11.3].

<table>
<thead>
<tr>
<th>Code</th>
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<td>11</td>
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<td>illusions</td>
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References


11.3 COMPETITIVE ACTIVITIES ON HUMAN FACTORS IN AVIATION SAFETY

P.C. Cacciabue, M. Pedrali, M. Bacchi, D. Baranzini, A. Trasi

11.3.1 Aircraft Dispatch and Maintenance Safety (ADAMS)

The project ADAMS aimed at the study and design of an integrated human factors safety system for aircraft maintenance and dispatch. The following partners took part in the project: Defence Evaluation and Research Agency (United Kingdom), Netherlands National Aerospace Laboratory, Trinity College Dublin (Ireland), Sabena (Belgium), Scandinavian Airlines System, Aer Lingus-TEAM and the Joint Research Centre (ISIS).

The project ended in early 2000. A “Human Factor Guide” was finally published by the consortium titled “Human Centred Management for Aircraft Maintenance”. This guide is devoted to the industry and contains user-focused practices for managing human factors in aviation maintenance. The guide (on CD-ROM) and the ADAMS outputs were presented to industries and European Aviation institutions during a dissemination day entitled “Human Factors: Beyond JAR Compliance – creating effectiveness in Aircraft Maintenance”, held in Amsterdam on the 28th February, 2000.
The objective of the project was to develop and evaluate Avionique (France), Marsh (UK) and Airclaims (UK). Joint Research Centre (ISIS), Airbus Industrie, Sextant National Aerospace Laboratory NLR (the Netherlands), of 2000. The following partners took part in the project: The 3-year project DESIRE was completed by the end of 2000. The following partners took part in the project: National Aerospace Laboratory NLR (the Netherlands), Joint Research Centre (ISIS), Airbus Industrie, Sextant Avionique (France), Marsh (UK) and Airclaims (UK).

The objective of the project was to develop and evaluate a quantitative risk assessment model of air transport safety, which allows the cost-benefit analysis of safety measures. The project started with an assessment of the factors that govern the need to improve aviation safety. New pressures on aviation safety, such as airport congestion, declining financial resources, ageing aircraft, insufficient safety oversight in some parts of the world were identified. Safety assessment techniques that are currently being used were evaluated and developments in risk-based regulation were reviewed. The role of cost/benefit criteria used by decision-makers in the aviation system was discussed in the perspective of current safety assessment techniques.

It was believed that by placing accidents into a limited number of broad groups, based on the sequence of events and the likely severity of their outcome in terms of physical damage and deaths and injuries, a model could be derived allowing predictions for “typical” groups of accidents. Hence, the model architecture was centred on the “single-consequence” concept, at the end of a chain of events. The consequence is defined as “the event in the accident sequence that resulted in the most damage and/or deaths and injuries”. Detailed analyses of the expected outcome in terms of aircraft damage and the death of the occupants were carried out for each of the defined consequences.

A classification of causal factors in aviation accidents and incidents was developed, which enabled the description of the chain of events that can lead to a particular consequence. The classification provides a set of categories for the creation of an accident scenario, in which both the events (i.e., factual information – the “whats”) and the causal factors (i.e., causal information – the “whys”) related to a consequence are highlighted. For each of the categories, an attempt was made to quantify their frequency of occurrence in normal operations [11.4].

In order to allow a cost benefit analysis, a classification of cost factors was also developed. Both direct cost factors, such as those related to passenger deaths and injuries and aircraft physical damage, as well as indirect cost factors, such as airline loss of reputation, were considered. Financial data for a large sample of some 1,000 accidents were reviewed in order to produce a cost profile for each “consequence”. The cost-side of the model is not intended to predict the costs of individual accidents but rather to provide an indication of broad average costs, which may arise from accidents falling into typical groups.

Although considerable care was taken in selecting the factors, the interconnections, the probabilities and the financial equations and data, it is expected that users will make their own choices to tailor the model to their specific situation. The model describes “average” accidents, both on the causal side as well as on the cost side. In reality, each individual accident may have its own peculiarities. The model should not be used to justify cuts in the safety budget. It should be used as one of the many tools that can help to determine how to spend the safety budget in the most efficient manner.

11.3.2 Development of a Method for Air Transport Safety Improvement through Quantitative Risk Evaluation (DESIRE)

The 3-year project DESIRE was completed by the end of 2000. The following partners took part in the project: National Aerospace Laboratory NLR (the Netherlands), Joint Research Centre (ISIS), Airbus Industrie, Sextant Avionique (France), Marsh (UK) and Airclaims (UK). The following partners are taking part in the project: National Aerospace Laboratory NLR (the Netherlands), Joint Research Centre (ISIS), Airbus Industrie, Sextant Avionique (France), Marsh (UK) and Airclaims (UK).

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References


11.3.3 Advanced Cross-Communication Environment providing Support Services to Dispersed Maintenance and Technical Support Engineers (ACCESS-maints) http://www.metriqs.it/accessmaints/index.htm/
The main objective of the project, started in February 2000, is the implementation of a Corporate Knowledge (CK) Management and Delivery Platform that will permit experienced technicians and young professionals to receive appropriate support for their engineering activity. A second objective is the definition of methodologies, rules and tools that will permit the collection and the sharing of those parts of CK having direct impacts on the specific industrial areas. The CK does not belong to one company but it is usually distributed throughout the full chain provider-integrator-client. The following partners are taking part in the project: SIA-Società Italiana Avionica (Italy), MQS (Italy), MPL (Italy), Politecnico di Torino (Italy), CISI (Italy), CS (France), CASAS (Spain), GTD (Spain), ISPASAT (Spain) and the Joint Research Centre (ISIS).

The IT basis of the ACCESS project consists of the implementation of a communication and server platform enabling transfer of corporate knowledge between remote sites: the ACCESS Server Platform (ASP) and network infrastructures, that range from public switched...
Telecom networks to Internet and private networks using if possible high speed satellite links. The ASP includes a database containing CK, which may be updated under the control of experts from a given company.

The standpoint of the project is the definition of CK as “the set of values, beliefs, assumptions, symbols and behaviour that identify an organisation in relation with other organisations and govern the ways in which relationships, business and practices are carried out”. The project started with the identification of the real needs of users to manage, represent, store, transmit and share parts of the CK and on the practices adopted to access this knowledge.

In the first year of work, the technical aspects of the ASP, i.e., the IT structure on which the knowledge is stored and through which it is transferred and the basic mechanisms of CK transfer have been studied. In particular the key figures in knowledge management, i.e., the knowledge holder, knowledge broker and knowledge seeker, have been identified and correlated with the ASP structure.

### 11.3.4 Advanced Integrated Training in Aeronautics Maintenance (AITRAM)

http://www.aitram.de/

The project aims to contribute to the improvement of the learning process by developing an advanced training system for aeronautical maintenance technicians. This training will address both technical and human factors issues and will be based on innovative concepts, new cognitive approaches and simulation technologies such as Virtual Reality. The project started in May 2000.

The following partners are participating in the project: Fraunhofer Gesellschaft Institut Fabrikbetrieb und Automatisierung (Germany), Trinity College Dublin - TCD (Ireland), SR Technics (Switzerland), FLS Aerospace (Ireland), AirEurope (Italy) and Joint Research Centre (ISIS).

During 2000, ISIS was involved in the collection of user needs through on the job observations and the application of the Aircraft Maintenance Attitudes Survey questionnaire, developed within the ADAMS project and adapted for AITRAM purposes. Afterwards, ISIS developed an integrated training concept in collaboration with TCD, based on user needs assessment, the latest results of the ADAMS project, and the state-of-the-art of training means (STAMINA course). Internal to the AITRAM project, the collaboration with TCD has been established in order to develop new models of aviation maintenance training systems focusing on a progressive integration of human factors with technical training elements by the use of Virtual Environment devices. A survey has also been conducted across the three end-users of the AITRAM project to identify human factors and technical needs to be considered for implementation. The use of a new version of the Aircraft Maintenance Attitudes Survey served this purpose [11.5].

From this perspective, a preliminary integration of technical and human factor (HF) training elements has been centred upon the development of a new competence model for the Aircraft Maintenance technician. This model will integrate HF and technical competency requirements in order to satisfy those HF and technical training objectives, which are most frequently applied as separate elements in aviation maintenance domain. The AITRAM training system approach will be illustrated through the analysis of three different maintenance scenarios: aileron servo-control removal/installation, integrated drive generator removal/installation and nose landing gear seals removal/installation.

### References


### 11.3.5 Aviation Safety Targets for Effective Regulation (ASTER)

The ASTER consortium brings together: National Aerospace Laboratory – NLR and the Netherlands Economic Institute (the Netherlands), Meridiana (Italy) Airclaims (UK), Israel Aircraft Industries (Israel), Eurocontrol (France) and the Joint Research Centre (ISIS). The main objective is the development of a means to enable safety targets to be set and optimised for each of the participants in the air transport system (ATS) in order to reach the optimum level of safety for the system as a whole. To achieve that it is necessary to identify the elements within the ATS (i.e., airports, air traffic management, airworthiness of “products” and operations) and the causal factors that might jeopardise the safety of each element. Afterwards, a target level of safety (TLS) of the ATS can be established with which to compare the current one. Through the collection and analysis of data on occurrences it will be possible to quantify the safety per element and check consistency against this TLS, leading to the identification of the best safety practice or measure to be adopted to “fill this gap”.

A classification, derived from the DESIRE project, supports the identification of causal factors. A functional model of the ATS, derived from a NLR study for the
Dutch Civil Aviation Authority, supports the identification of the relationships between causal factors. The protocol helps in the identification of the causal factors for a specific accident/incident scenario and it will also show the affected elements in the ATS.

11.3.6 Collaborations

• Trinity College Dublin

The collaboration with Trinity College Dublin (TCD), in the framework of the Leonardo Project “STAMINA” (Safety Training For Aircraft Maintenance Industry), lead to development of a specific “module” of the overall STAMINA training course. The module was specifically designed for team-related human factors issues for aircraft maintenance personnel.

Specifically, the delivery and exploitation of STAMINA training courses has now moved beyond the analysis and assessment by end-users and partners involved in the project. A Welsh consortium called WATAG (Wales Aerospace Training Advisory Group), interested in the exploitation of Stamina products, has made STAMINA work outside the boundaries of the project itself. As such, a joint effort between TCD and ISIS is still maintained throughout STAMINA training delivery and exploitation across other European maintenance organisations.

• Politecnico di Milano

Since 1992, an extensive research programme is being carried out in collaboration with the Aerospace Department with the objective of developing and implementing into a simulation frame an integrated model of a flight crew, an aircraft, and the surrounding environment. The main purpose is to make available an exploratory tool for conducting qualitative and quantitative analyses of normal and critical flight conditions. The latest improvements to this exploratory tool focused on:

the Crew Model

In the previous versions of the tool, the simulation considered either only one pilot or the same model was used for the two/three crew members of the B747. In the latest improvement of the crew model two kinds of paradigms for the human were considered and merged. This permitted certain aspects related to both single aircraft handling and co-operation and communications between (three) crew members to be considered. The results show that without the use of a dynamic approach, i.e., simulation modelling, a static analysis of these procedures would not have permitted the detection of weak points [11.6-11.9] (Figures 11.3 and 11.4).

the Airborne Collision Avoidance Systems - ACAS

The work focused on alarms emitted by ACAS and analysed conflict situations between two aircraft equipped with this system. A multi-aircraft simulator - MAS - allows the dynamic reproduction of the trajectories of two aircrafts: the first one simulated during the approach to landing phase and the second one invading either the caution or the warning area of the former. The potential risk of collision has been analysed through an exhaustive collection of case studies.

The conclusions drawn are that anti-collision systems are not always the ideal solution. Indeed, less rarely than expected, they turn out to be far from perfect devices and can generate additional risk rather that improve safety.

References

OVERVIEW
M. Gérardin, V. Renda

The European Commission is strongly engaged in research and development for the protection of the European population against the consequences of natural and man-made hazards. A significant effort is carried out in the field of safety in structural mechanics with reference to buildings and bridges, means of transport (chapter 13) and protection of cultural heritage. The activities are performed at ISIS and take advantage of the unique facility in Europe – the European Laboratory for Structural Assessment (ELSA). Full/large scale tests are performed at ELSA to assess the behaviour of structures of civil and architectural interest stricken by strong earthquakes. The work related to the protection of cultural heritage includes the development of technologies for structural diagnostics and techniques for strengthening/repair of the structures validated through full/large scale seismic tests performed at ELSA. All these activities are complemented by sophisticated numerical modelling and analyses.

12.1 SEISMIC PROTECTION FOR CIVIL AND CULTURAL HERITAGE
A. Pinto

Earthquakes are by far the most deadly natural disasters in the world. In the last 15 years, more than 5,000 people have died in earthquakes occurring in the European Union, in 1980, a terrible earthquake struck southern Italy, killing 4,580 people and leaving 250,000 homeless. More recently, in 1997, an earthquake in Assisi and in Athens (1999) caused extensive damage and human suffering. The death toll in Turkey (1999) was estimated to be 40,000 and more than 200,000 housing units will have to be built. There is however an important reduction in the relative number of casualties (causalties/inhabitants), but the cost of damage is escalating with very negative impacts (including financial) on society. In fact, in spite of the important efforts and investments made in earthquake protection, the damage seems greater today for two reasons: countries are more densely populated, including those at risk; and, there are new industrial infrastructures that may be vulnerable in the event of an earthquake: gas and oil pipelines, chemical factories, communication networks, etc.

How should we approach the problem? We must use all our creative skills and energy and act in four main areas: 1) to develop and qualify appropriate design and re-design methods, incorporate new technologies and materials with improved performance in construction and retrofitting of existing vulnerable buildings and infrastructures; 2) to provide a complete set of regulatory documents including the most recent research and technical achievements as well as a more rational and accurate quantification of the earthquake actions; 3) to progress towards more effective preparedness and earthquake mitigation programmes including also civil protection and educational aspects; 4) to involve, assist and co-ordinate the efforts of all concerned regional, national and European authorities and institutions for a more rational definition and development of earthquake risk mitigation programmes as well as to promote international collaboration.

ELSA is acting along these lines. Specifically, there is the on-going research project on earthquake assessment and retrofitting of structures, which covers three main topics: 1) ordinary constructions (buildings and bridges), 2) masonry and built cultural heritage and 3) active, semi-active and passive systems and techniques for structures subjected to dynamic loading (earthquake, wind, etc.). Substantial progress was made on all three topics with special emphasis on masonry structures for which a specific sub-project was set-up and developed during 2000 as described hereafter. Topics 1 and 2 were also undertaken joining the efforts and synergies between the institutional project (entitled “Research in support to the implementation and validation of the EUROCODES; Research for structural vulnerability assessment, strengthening/repair techniques for civil and cultural heritage structure under earthquakes”) and several competitive projects. Examples are the work on assessment and retrofitting of existing constructions (buildings – ICONS and SAFERR research networks, bridges – VAB project) and on active control (ACE and CASCO projects) are worth mentioning.

Furthermore, ELSA organized in November 2000 an international workshop on “Mitigation of Seismic Risk” to support recently affected European countries. The workshop aimed at a better co-ordination of the efforts for the mitigation of seismic risks in Europe. Support came from the Environment DG – Civil Protection; the Research DG; the Enterprise DG – Construction; patronage from the European Parliament; Commissioner Busquin; Commissioner Wallström; and several European governments. Conclusions and recommendations from this workshop will certainly assist national authorities and the Commission, in particular, to define their mitigation programmes. It is believed that the Sixth Framework Programme should reflect the views and strategic actions as discussed in the workshop, which are fully in line with Commission policies and specifically with the recently adopted European Research Area project.
12.2 ACTIVITIES CONCERNING FIBRE REINFORCED COMPOSITES

ELSA has extended its on-going research programme concerning the use of fibre reinforced composites (FRCs) in civil engineering by studying two different applications. One concerns the generic rehabilitation of degraded reinforced concrete columns and the other looks at how the seismic protection of damaged reinforced concrete buildings may be increased by wrapping carbon fabric around critical elements.

12.2.1 Upgrading and Repair of Reinforced Concrete Elements

E. Gutiérrez, W. Johansen, D. Tirelli

A growing problem in the housing sector in Europe is the poor manner in which many reinforced concrete buildings built in the housing booms after the Second World War have aged. At the time of their construction it was thought that concrete was an inert material—not prone to corrosion. Unfortunately this has not proved so and, at present, throughout all the Member States, many EU citizens have directly (or indirectly as tenants of local housing authorities) inherited a housing stock, of which a significant proportion is in need of major structural repair. This scenario is not as dramatic as the structural destruction of housing caused by earthquakes or other natural disasters, but it does have a pervasive cost both socially and economically.

In the context of our institutional research, and in collaboration with construction companies and composite manufacturers involved in the repair of degraded buildings, and in order to gain first hand experience of the types of rehabilitation required and the standard repair methods used at present, ISIS has conducted field trips to construction sites where extensive rehabilitation work was being carried out on low-income housing areas. In view of the structural degradation pathologies that resulted in the reduction of the load-carrying capacity of the main columns, ISIS has conducted an experimental campaign with the aim of studying repair techniques using FRC pre-fabricated confining shells. The scope of the research was to determine if this repair technique (which is known to work well for circular section columns) could be applied successfully to square and rectangular cross-sections.

Three types of reinforcing material (carbon, aramid and glass fibre) were selected and tested on rectangular prisms of plain concrete. Also, given that the angle of the reinforcing fibre is a fundamental parameter in the confinement capacity of the FRC shell, various types of fibre lay-up (cross-ply, unidirectional and woven fabric) were selected and compared. Another parameter studied was the effect of the geometry of the corner radius on the confining capacity of the shell.

Examples of the test set-up, showing two column cores confined with shells made from aramid (Figure 12.1) and carbon (Figure 12.2) fabrics, give an impression of how the experiments were conducted within a 360 ton hydraulic press. The experiments consisted of monitoring the forces and the volumetric expansion/contraction of the column sections as the load was applied at the ends of the concrete prisms.

Our findings suggest that FRC pre-formed shells can be used effectively to confine concrete cores and increase the load carrying capacity by a factor of three. However, to obtain the best results the cavity between the concrete core and the confining shells should be pressure grouted with a cement filler. Moreover, in order to increase the confining resistance of the shells, and in analogy to pressure vessel design, the corner radius is increased (Figure 12.1) in order to reduce the secondary bending stresses at the corner (Figure 12.2) that would otherwise generate premature delamination failure.
12.2.2 Application of Composites to Seismic Resistance of Reinforced Concrete Buildings

P. Negro, A. Colombo

The improved confining capacity of composite materials described above for the generic case of vertical loading has been exploited to enhance the seismic response of non-ductile reinforced concrete structures. A reinforced concrete structure damaged by previous experimental activities has been used to assess the effectiveness of the wet lay-up application of carbon fibre-reinforced polymers (CFRP) as a repairing technique (Figure 12.3). The investigation, carried out in close collaboration with industry, aimed at verifying the efficiency and the feasibility of this intervention on a structure as a whole.

The anisotropic properties of CFRP have been exploited in repairing the different type/s of damage characterising the critical zones of the building. After the injection of all cracks with epoxy resin, mono-directional carbon fibre wraps were glued around all the member (beams and columns) ends. The shear walls were wrapped throughout the height of the building using quasi-isotropic (fibres oriented at 0, 90 and ±45 degrees) wraps. After the intervention, the frame was subjected to the same input motion applied during the previous experimental campaign. A preliminary analysis of the results seems to demonstrate that, because of the intervention, the loss in strength caused by the damage suffered during the previous tests was recovered. In addition, the capacity of the frame to behave in a ductile fashion appears to have improved.

12.3 SEISMIC ASSESSMENT OF MASONRY STRUCTURES

P. Pegon, Y. Le Pape

This activity is intended (1) to allow the calibration/development of advanced numerical models for masonry with particular emphasis on the in-plane cyclic behaviour and (2) to provide accurate guidelines for retrofitting interventions after a seismic event by assessing the efficiency of traditional and innovative repair strengthening techniques. Connected numerical and experimental works have been carried out. The objective of the numerical work is to provide a complete study of the in-plane behaviour of masonry walls for various mechanical scales. It is heavily connected with the experimental work. Three scales are considered: microscopic, macroscopic and structural with particular emphasis on the existing connections between the corresponding modelling strategies. Indeed, the modelling of masonry generally falls between two distinct classes:

- the micro-mechanical models (sometimes referred to as discrete models) accounting for the morphology of masonry;
- the macro-mechanical models (also called homogeneous or continuous models) account for the behaviour of a typical relevant unit cell by establishing a direct constitutive law between the average stresses and strains states.

The micro-mechanical approach is seen as the best modelling scale to understand the salient features of the in-plane behaviour of masonry panels. The introduction of a tensile cut-off within the joint model has been proved to be a key point in the modelling of masonry. The ratio of tensile strength with respect to the cohesive is a factor of great influence upon the behaviour of a shear wall. Nevertheless, such modelling cannot reasonably be applied to deal with a structure larger than a single wall. For instance, the modelling of complete infilled-storey buildings definitely requires adopting another standpoint at a macro-scale level.

The macro-mechanical models shall be obtained by either adopting a phenomenological standpoint assuming the masonry as a “no-tension material”, or using homogenisation techniques. Obtaining a consistent continuous anisotropic inelastic model has been proved to be a difficult task due to the materials intrinsic properties and the lack of comprehensive experimental results. Therefore, one of the objectives of the institutional project is to complete an accurate database obtained both by numerical and experimental means, so as to provide information about the mechanical behaviour at different scales.

12.3 Wet lay-up application of a quasi-isotropic carbon FRP on the shear walls of a reinforced concrete dual frame.
Three types of numerical tests are considered (Figure 12.4): (a) at the structural level, in-plane cyclic behaviour of a shear wall, (b) at a “mesoscale”, large assemblages, also called “wallettes”, with inclined bed-joints are tested under biaxial loading conditions, and finally, (c) at the lowest scale, the behaviour of a basic cell under the assumptions of periodic medium is also studied with a view to deriving the mechanical global constitutive law through the homogenisation techniques. It should be noted that (c) can only be tested by numerical means due to the impossibility of making an adequate testing rig capable of reproducing the periodic conditions. Tests (b) - Figure 12.5 - and (a) - Figure 12.6 - are also performed by experimental means thanks to ELSA’s full-scale testing facilities. The multi-scale approach proposed in the numerical framework requires collecting experimental data for every studied scale. Up to now a single test of each kind has been performed.

Some future experimental tests will be performed so as to provide a significant feedback to the numerical modelling of unreinforced masonry.

12.4 Scales of modelling

12.5 Large assemblage/“wallette” test set-up - structural behaviour.

12.6 Shear wall test set-up - structural behaviour.
12.4 FURTHER DEVELOPMENTS IN DYNAMIC CONTROL OF EARTHQUAKE ENGINEERING FACILITIES (FUDIDCOEEF)
G. MAGONETTE

The Continuous Pseudo-Dynamic (PsD) testing method used at ELSA is implemented by means of a synchronous process with short control period (1 ms) and small integration time step. This introduces some challenging difficulties for the implementation of the sub-structuring technique because if the analytical structure is complex, the analytical process is unable to perform even an elastic computation during a control period of the experimental process. Different time steps must be used by the two processes. To face this problem an improved inter-field integration scheme has been developed. This scheme, denoted as “inter-field with correction in force and in displacement”, uses different time steps for the analytical and experimental processes and provides a better solution by doubling the integration process to solve the analytical part [12.1-12.2].

Several experimental tests have been carried out on a simple structure to validate an implementation including the explicit CD scheme in the experimental process and the implicit trapezoidal integration rule in the analytical process. Further tests are in preparation on a large steel structure (Figure 12.7).

12.5 ACTIVE AND SEMI-ACTIVE CONTROL IN CIVIL ENGINEERING (ACE AND CASCO)
G. MAGONETTE

An active control system is one in which an external source powers control actuator(s) that apply forces to a structure in a prescribed manner. These forces can be used to either add or dissipate energy in the structure. The methodology considered in the ACE project is based on active tendons in which the damping is induced by the control of the displacement of the cable anchor point. This concept developed at the Université Libre de Bruxelles has a strong physical support and its effectiveness has been fully confirmed experimentally by numerous tests performed on a large-scale model of a cable-stayed bridge [12.3-12.5]. As an alternative to actively controlled actuators, semi-active (S-A) devices offer some attractive properties: unconditional stability, low power requirements (which is of great importance in case of an earthquake) and efficiency comparable to active devices. The two concepts are compared in Figures 12.8 and 12.9. The particularity of S-A control comes from the fact that it is not possible to directly command the S-A damper to generate a specified force \( f \), because the response of the damper not only depends on the input command (valve stroke for a variable-orifice device, applied magnetic field for a magneto-rheological damper), but also on the instantaneous motion of the piston. However, the force produced by the S-A damper may be increased or decreased by adjusting the value of the input command. An important limitation comes from the fact that only dissipative control forces can be generated. So, most often, the S-A strategy consists of a modified active control law, illustrated in Figure 12.9, where the S-A input command is determined by “clipping” the active control strategy.

The work currently carried out in the CASCO project aims at adapting the active system presented above into a S-A system. Therefore, some important technological issues have to be addressed: (i) dealing with a static load in the S-A damper, (ii) limitation of the internal friction, (iii) minimum required stroke for the S-A device to be efficient.

References
ISIS is participating in the VAB (Advanced Methods for Assessing the Seismic Vulnerability of Existing Motorway Bridges) project as the major partner for the testing activity. Four large-scale models of typical bridge piers with different span ratios were constructed and will be tested at ELSA using non-linear substructuring techniques, which allow the online numerical simulation of the behaviour of part of the bridge piers, combining this numerical simulation with the physical testing of the most critical piers.

Insufficient consideration for seismic risk in bridge design has resulted in inadequate detailing of confining steel and insufficient shear reinforcement in the bridge piers, insufficient seat length of bearings, and inadequate design of the bridge abutments. There are many open questions concerning the ductile behaviour of large bridge piers, in particular those with a rectangular hollow cross-section commonly used in Europe.

The VAB project aims at contributing to the solution of most of these aspects, in particular, by identifying methods to assess vulnerability of existing bridges and by developing appropriate retrofitting solutions and techniques for bridge piers with a rectangular-hollow cross-section.

Further development of the non-linear substructuring to be used in the online control of the experiments was achieved in 2000, combining this test technique with the continuous pseudo-dynamic testing technique, which allows for more accurate experiments. Final definition and design of the testing and measuring systems and devices were carried out and the instrumentation plans were proposed to the project partners. A discussion was launched on the seismic retrofitting solutions and techniques for bridge piers with a rectangular hollow cross-section, which will assist the retrofit of one squat pier to be tested at ELSA.
12.7 ANCHORAGES IN CONCRETE UNDER DYNAMIC LOADING

G. SOLOMOS

Anchorage systems in the concrete construction industry are given special attention, which is justified by the following global trends: increased interest in earthquake retrofitting world-wide; increased interest in preservation of the historical built environment and in the re-use and rehabilitation of existing structures, particularly in Europe; increasing use of pre-fabricated structural elements; other special anchorage demands (offshore construction, road safety barriers, nuclear power plants etc.).

Understanding of the anchorage response, principally to dynamic loads, is the principal objective of this activity. New materials design of high performance concrete (with steel fibres), materials modelling (including the strain rate dependence of the stress-strain curve of concrete and its softening branch) and numerical simulation tools have been pursued. An extensive experimental programme has supported all theoretical developments. Central to this high strain-rate testing activity, has been the employment of various Hopkinson bar techniques (mainly the Large Dynamic Test Facility - LDTF), particularly suited for precision pull-out tests.

Specimens have been made of normal and high performance concrete and include: plain cubic specimens [12.9], rebars (cast-in-place and post-installed) and anchors (of chemical, undercut and headed stud type) – Figure 12.10. A large number of tests has been performed at the LDTF and interesting results have been obtained for the dynamic behaviour of 20 mm diameter rebars and anchors of diameters of up to 16 mm – Figure 12.11. Parallel material modelling work is carried out for concrete along the lines of the lattice, microplane and strain gradient plasticity models.

The big part of this activity [12.10] is performed within the framework of the project ANCHR "Anchorages in Normal and High Performance Concretes subjected to Medium and High Strain Rates". Other partners include: DENSIT a/s (Denmark), HILTI (Lichtenstein), ENEL-CRIS (Italy), Politecnico di Milano (Italy), University of Patras (Greece) and Bekaert (Belgium).

References


12.11 Characteristic force-displacement curves of M16 headed studs under quasi-static, low-dynamic and higher-dynamic pull-out testing.

12.8 THE ICONS AND SAFERR RESEARCH NETWORKS

A. PINTO

ISIS is participating very actively in the training programmes of the European Commission. Since 1994, ELSA has been involved in a) the “Access to Large-scale Facilities” programme by opening its doors to external researchers, b) in research training networks with research topics focused on earthquake engineering and also c) in Marie Curie fellowships by hosting a few young researchers who have developed their research projects at the facility.

Recently, ELSA was considered a European Marie Curie training site, which enhances the key role of ELSA in the European earthquake engineering community. Furthermore, ELSA was considered and financed as a large-scale research infrastructure integrating the European Consortium for Large Earthquake and Dynamic Engineering Research (ECOLEADER) [12.11] and a new grant was awarded for the continuation of its participation in the SAFERR research training network [12.12]. There is a very important feature that makes these
The ICONS (Innovative Seismic Design Concepts for New and Existing Structures) project covered five research topics, namely: 1) Advanced methods for the quantification of the seismic action; 2) Assessment, retrofit and repair of existing buildings; 3) New deformation-based design (DBD) methods; 4) Composite structures, and; 5) Shear-wall structures. Important achievements are summarised as follow: a) A new set of displacement spectra to be included in EC8, which allow application of DBD methods; b) Calibrated rapid screening methods for seismic assessment and qualification of strengthening solutions and techniques supporting calibration of EC8 - part 1.4 - “Repair and Strengthening”; c) Development of DBD methods and procedures for design and re-design of structures in earthquake prone zones. A promising, truly European, method was developed under ICONS and proposed to the international scientific community; d) Research under composite structures allowed the inclusion of the corresponding annex of EC8 as a normative part; e) Research on shear-wall structures led to several tests on U-shaped walls carried out on a shaking-table (CEA-Saclay) and cyclic tests at ELSA, which constitute a unique set of data for design of non-rectangular shear walls and for model calibration.

The SAFERR (Safety Assessment for Earthquake Risk Reduction) project intends to continue to enhance the earthquake engineering research in Europe following an approach based on three underlying themes [12.13], which are: advancement, application and dissemination of measures for reducing seismic risk in Europe. Thus, emphasis has been placed on advancing the state-of-the-art in assessment of hazard (exposure) through task 1 “Characterisation of Seismic Hazard”. The perpetual problem of how to design and build safely and economically in areas of low seismic exposure (which covers a large proportion of Europe) and where taking no precautions may lead to extensive losses in small-to-medium earthquakes is dealt with in task 2 “Design and Assessment in Low Seismicity Regions”. Whilst appreciating the value of developing new methods of design for new constructions, the existing infrastructure stock remains highly vulnerable in many parts of Europe. Therefore, task 3 addresses “Strategies and Techniques for Vulnerability Reduction”, which deals with a selected number of sub-topics in assessment and retrofitting of buildings, bridges and their foundations. Finally, integrating the above hazard-related and vulnerability-related activities in a usable “risk” framework is undertaken in task 4 “Risk Assessment Systems”.

References


As a part of the contractual activities for the Basilicata region, ELSA was given the task of providing reference experimental results of pseudo-dynamic tests to be used in the commissioning of the new structural mechanics laboratory at Potenza, Italy. Two complete structures were built and are being tested. The first is a reduced scale model of a steel building with moment-resisting welded connection (Figure 12.13). This will allow differing pseudo-dynamic tests to be conducted, both in the elastic and non-linear ranges, to be reproduced in the new laboratory in Potenza. The comparisons will be extended to the real-time dynamic tests conducted at the ISMES shaking table on a similar structure as a part of the STEELQUAKE project [12.14].

The second structure is a three-storey reinforced concrete building designed according to old seismic design practice. Beside the data needed for the commissioning of the new laboratory, the tests on this structure will throw light on the behaviour of flat-slab structures, for which many design principles enforced by the current design codes are violated.

The objective of the Tunnelling project [12.15] was to develop a monitoring system, based on a novel fibre-optics technology, to detect the onset and progression of damage in the concrete lining of transportation tunnels. During the first phase, ELSA produced the experimental results needed for the definition of an energy-based damage model for these structures. In 2000, tests were conducted to assess the performances of the fibre-optic system and of the damage evaluation model. The fibre-optic sensors were mounted on the surface of the specimen, and interfaced by multiplexed connection to the optical acquisition unit. The specimen (Figure 12.14) underwent a deformation time-history representative of the seismic action during an earthquake, and the measurements were compared with those made by means of traditional sensors (Figure 12.15). Finally, the damage assessments made by the energy-based damage model were compared with the observed damage states.

References


In the last years, ISIS has increased its expertise in 3D reconstruction by collaborating in competitive projects. The objective of 3D Reconstruction is to build a 3D photorealistic computer model of an environment “as-built”, i.e., with all its visual and spatial characteristics. This technique applied to culture heritage results in visually appealing 3D models to make the cultural site accessible over the Internet (Virtual Heritage), as well as for accurate 3D measurements for documentation and conservation purposes (Cultural Conservation).

The RESOLV project aimed at the development of the basic 3D reconstruction technologies, whereas INFOBOY was more application oriented, specifically for advertising old farmhouses in rural tourism. Figure 12.16 displays the 3D model of a heritage farmhouse. The models are inserted inside a virtual sphere “painted” with the surrounding photographs. This technique constitutes an effective way to provide spatial context to models of buildings and monuments.

At the end of 2000, BBC (British Broadcasting Corporation) invited the JRC to model the “Sala dello Scrutinio” (45m x 15m x 10m) at the Doges Palace, in Venice, Italy. It took four hours to scan the room, which is normally closed to the public and contains major paintings such as “Giudizio Universale” by Palma il Giovane. Figure 12.17 shows some snapshots of the model illustrating details of the room as well as BBC’s Peter Snow in two versions: photograph and 3D avatar.
13

Safety in Transient Structural Dynamics

OVERVIEW

M. Gérardin

The experimental work achieved in the field of safety in transient structural dynamics consists of impact and crash tests on material samples and structural components. The large-scale tests are performed at the Large Dynamic Test Facility (LDTF), a unique facility in Europe. The smaller scale tests are performed in the Dynamic Material Testing Laboratory. All these tests are complemented by sophisticated numerical modelling and analyses, which are indispensable to assess the structural integrity of a large variety of systems and installations. In particular, during 2000:

• An important effort has been made in the numerical simulation of fast transient dynamic phenomena occurring in complex fluid-structure systems submitted to impulsive loading. For this purpose, the collaboration with CEA (Commissariat à l’Energie Atomique) has been intensified to integrate the latest expertise of both research teams in the common software platform EUROPLEXUS. This collaboration is also being extended to other European partners.
• The experimental activity dealing with certain passive safety aspects in the field of transport, where crash and impact are involved, has been particularly intense. This work has been planned and is intended to provide support to the Enterprise DG in terms of the Commission’s normative action policies. The aspects concerned are: frontal impact of vehicles and associated crashworthiness, road safety barriers and pedestrian friendliness of car fronts.
• An in-depth study of constitutive models of various materials subjected to impact loading was also started with the objective of bringing the constitutive modelling activities up to the state-of-the-art level in modern material modelling. The numerical simulation of notched specimens subjected to transient loading has been started.

13.1 NUMERICAL MODELLING - EUROPLEXUS

F. Casadei, T. Dyngeland, J.P. Halleux

ISIS’s activities regarding the numerical simulation of fast transient dynamic phenomena occurring in complex fluid-structure systems submitted to impulsive loading have now evolved into a large scale action aiming at bringing together similar research work performed elsewhere. In this respect, CEA and the JRC have already launched a five-year collaboration agreement effort for the setting-up of a new computer code, EUROPLEXUS, which effectively replaces the former codes CASTEM-PLEXUS and PLEXIS-3C. EUROPLEXUS is expected to offer features, both in terms of actual computational mechanics models and software tools, attractive enough to convince others to join in this common development effort. In order to ensure an effective usage of such research efforts, in particular at the industrial level, commercialisation through an internationally recognised finite element software vendor is currently being negotiated.

A collaboration agreement between ISIS and EDF (Electricité de France) was established in October, which will run for 16 months to the end of January 2002. The topic of the collaboration is “Fast Dynamics and Impacted RC-Structures” and includes one seconded person from EDF working at ISIS for the full period of 16 months. The collaboration project is well under way with the first main topic related to the development of a global reinforced concrete model for finite shell elements. At the end of December, a document describing the integration principles for two different integration methods was finished. Furthermore, the two integration methods have been implemented in EUROPLEXUS and are now being tested. The material model involved in the work is based upon a global moment-curvature law and with uncoupled membrane and bending effects at this level of development.

13.1.1 Industrialisation of FEM Advanced Software

for Large-scale Fluid-structure Transient Dynamics Applications

The EUROPLEXUS documentation has been arranged in a CD-ROM for easy presentation and access to the user manual and various articles, reports, slides, etc. that are available for the EUROPLEXUS software. ISIS's contractor, Socotec Industrie, has forwarded a final version of the CD-ROM and the product is currently under evaluation at ISIS.

A prototype version of the EUROPLEXUS preference software (user interface based on Samtec/Design) has been developed by Socotec Industrie in collaboration with Samtec and is now being evaluated. The part of the EUROPLEXUS preference software that should deal with the post-treatment of the numerical results is not developed yet. A meeting next January/February 2001 will set the path for finalising the last part of this software. The prototype version is developed for the Windows NT operating system for PCs.

13.1.2 Report on Phase 1 of the EUROPLEXUS Agreement with CEA

The EUROPLEXUS project (between CEA and JRC, signed in December 1999) consists of two phases: (1) creation of the initial version of the code by suitably merging its two ancestors CASTEM-PLEXUS (CEA) and PLEXIS-3C and (2) further common development. Phase 1 was started at the beginning of 2000 and may be considered complete. The major achievements obtained during this phase are briefly described hereafter.
• **Common software development environment**

The merging activity has been performed by means of a new common software development environment that allows synchronised and harmonious evolution of the code (including its source, benchmark tests and basic documentation) by several development teams, located at geographically distinct sites, and using different computer platforms. The environment is based upon communication through the World Wide Web, and guarantees that the same, common and unique version of the code (version under development) can be used at all development sites ("mirror sites"). The collection, testing and distribution of the evolution packages is performed by a “central site”, which is accessible through the web. This environment is entirely based upon public domain software utilities and is readily extendible according to user needs [13.1-13.3]. Its development has been active since January 2000 and has proven to be useful and effective for the purpose.

• **Code merging**

The two EUROPLEXUS ancestors, CASTEM-PLEXUS and PLEXIS-3C, were “frozen” in their status of December 1999. Then, the first version of EUROPLEXUS was prepared by gradually merging all features and models from PLEXIS-3C into CASTEM-PLEXUS.

• **User’s manual**

The EUROPLEXUS manual is part of the common software development environment and is constantly developed together with the code. The English language and the LaTeX format have been adopted. Various formats are automatically produced by the evolution procedure: DVI and PDF formats (suitable for exchange and on-screen visualization), PostScript format (suitable for printing), and HTML format (for on-line browsing).

• **Source code**

The merging of the source code has been completed so that the current version (as of end December 2000) may be considered to be the initial version of EUROPLEXUS. It contains virtually all the models and features of both its ancestors. During the merging activity, many obsolescent and old-fashioned code parts have been cleaned up. The programme source currently consists of 325,000 code lines collected into more than 2,000 source files.

*Figures 13.1, 13.2 and 13.3 present some novel applications that are now possible thanks to the EUROPLEXUS collaboration with CEA, namely crash analysis, high-speed impact with fragmentation and fluid structure analysis of pipelines.*
13.1.3 Benchmark Tests
Another essential component of the EUROPLEXUS system is the benchmark tests suite. These tests are aimed at ensuring that code modifications do not conflict with previous models ("non-regression tests") and are an essential component of Quality Assurance. While CASTEM-PLEXUS was already endowed with a series of such tests, these did not exist in the PLEXIS-3C environment, therefore many new tests have been set up in order to cover as broad a spectrum as possible of the new features inherited from PLEXIS-3C. Over 150 tests have now been implemented and have been executed at each code evolution.

13.1.4 Documentation
The re-organisation of the available technical documentation concerning EUROPLEXUS and its ancestors has also been started. To date, over 80 documents (technical notes, reports, papers, etc.) are available in PDF format and may be consulted on-line via the EUROPLEXUS development environment.

13.1.5 Data Structure Modernisation
An important aspect of the EUROPLEXUS project is the modernisation of code programming aspects. Ancestors were essentially written in Fortran 77. While new developments are of course expected to be directly implemented in Fortran 90, it is also foreseen to gradually convert the whole code to the new standard. This will allow substantial improvements in, for example, the elimination of dimensioning directives, the optimisation of data structures and algorithms, etc.

Some preliminary considerations and guidelines have been defined [13.4]. As a practical exercise, conversion of the materials data structure has been already started [13.5]. This activity is a long-term one and will most probably require several years to complete.

Central to this activity has been the development and employment of the “energy flow transducers”, whose underlying principle has been extensively tested on single car components, like longitudinal beams [13.7]. In Figure 13.4, these transducers are represented schematically by the elements 1, 2, …7. They are aluminium bars and they have been selected according to structural details concerning their cross-sectional area. Matching of acoustical impedances is a crucial factor in this case [13.8]. The cutting section of the “body-in-white” has been selected slightly distant from the foot-well. This position presents certain advantages for the experiments, as the structural components of the car take a more linear form in that region, and thus favour a predominantly uniaxial wave propagation pattern. These components are: two A-pillars with a small roof section, two side-members under the floor, two sills, and the tunnel. A view of the actual experimental set-up is shown in Figure 13.5, where further details of the structural specimen and of the input and output (energy transducer) bars are seen [13.9]. All experiments have been performed with an impactor speed of approximately 15m/s. In order to obtain this

References

velocity, a pretensioning of the LDTF cables of 260 tons was applied. In addition to the strain gauge measurements, a fast speed camera was employed at a rate of 4,000 frames per second. A total of three tests were performed under the same loading conditions and with satisfactory repeatability (Figure 13.6).

The curve of Figure 13.7 shows the force at the end of the incident bar at the joint with the impactor versus the impactor displacement. This is in principle the force-shortening diagram of the car “body-in-white” front. There is a first peak of approximately 140 tons followed by peaks/troughs, which correspond to successive collapse mechanisms of the front structure. The Finite Element (FEM) code RADIOSS has been used by RENAULT for the numerical simulations. The existing FEM model of the Clio car has been adapted to the needs of the ISIS experiment by introducing appropriate initial and boundary conditions.

- Comparison of the experimental and simulation results is conducted on the basis of the force-time curves determined for each of the structural members examined. An overall satisfactory agreement has been observed. Both the trends of the corresponding curves and their numerical values are very close (Figures 13.8 and 13.9).
- This is a significant and encouraging outcome and justifies the approach followed. It shows that numerical codes, properly validated, can deliver reliable results in the crash design problem. It further demonstrates that numerical simulations and precision experiments can help each other in complex structural problems.

**References**


13.2.2 Road Barrier Deformation Tests

Safety barriers are designed to restrain and redirect errant vehicles, according to specified performance levels of containment, for the benefit of both the occupants and of other road users. The requirements that these road barriers have to meet for certification purposes are set in the relevant standards, e.g. EN 1371-1-2, prepared recently by the Technical Committee CEN/TC226. Full-scale tests involving barriers as well as vehicles are prescribed in them. A significant impediment to developing new road barrier systems is the high cost of performing these full-scale tests. While some full-scale crash tests will always be needed to demonstrate that the devices work correctly, it is highly desirable that numerical computer simulations enable engineers to reliably evaluate alternative designs more quickly and at less cost. This can help to drastically reduce the number of crash tests and enhance designers’ understanding of the performance of the barrier.

The research initiated aims to tackle exactly this aspect of road barrier design by validating numerical approaches and codes with precision testing at the LDTF. Experiments are in preparation, which will reliably represent the main parameters of full-scale tests. A big part of the project is supported by the Enterprise DG. Within this framework, there is close collaboration with the Spanish Technological Centre LABEIN in the area of modelling and numerical simulations with Finite Element techniques, and with the French L.I.E.R. (Laboratoire d’essais Inrets Equipments de la Route) for conducting some standard full-scale tests, necessary for assessing the equivalence of the two approaches. Two producers (one French and one Italian) of deformable road barriers have been contacted for the procurement of the specimens.

The actual tests at the LDTF have experienced some delay. Two barrier manufacturers have delivered the necessary testing material and the necessary adaptations of the machine are in progress. The impactors have been constructed and the small specimens for the mechanical characterisation of the barrier material under impact conditions have been fabricated. The first results produced by the two partners are currently being assessed: LIER has performed the two tests with the barriers from the French manufacturer and LABEIN, using the code ABAQUS/Explicit, has attempted to implement a model for the LDTF tests and some preliminary numerical simulations have been run.
13.2.3 Pedestrian Safety

The European Commission has been preparing a proposal concerning new technical requirements for cars with the aim of reducing the number of fatalities and the seriousness of injuries in accidents involving pedestrians. The major contribution to this effort has been provided by the EEVC (European Enhanced Vehicle-Safety Committee), which has drafted a document, where four basic component tests are recommended for assessing the pedestrian-friendliness of a car. These are: child head-form against bonnet, adult head-form against bonnet, lower leg-form against bumper, and upper leg-form against bonnet leading edge. However, the ACEA (Association des Constructeurs Européens d’Automobiles) has raised considerable doubts about the validity of parameter values in these tests, and has instead counter-proposed others. In the absence of agreement between the two proposals, the Enterprise DG has requested the expertise of ISIS on transient dynamics.

Despite the tight time constraints, the JRC/ISIS evaluation team reviewed and assessed a lot of material collected from the relevant literature provided by EEVC and ACEA. In the report prepared [13.10], test conditions and reference values of parameters have been proposed. Particular attention and priority has been given to the head-form against bonnet test. Open questions have been pointed out and the approach of a mild introduction for these tests is being advocated.

References

At present, some 30% of the total electricity generated in the EU and Candidate Countries is generated by nuclear power plants. With the pressing need to meet the Kyoto targets on reduced atmospheric emissions, it must be expected that over the next 10 to 20 years there will be little or no reduction in nuclear energy production. Indeed, considerable international discussion focuses on the next generation of nuclear reactors with enhanced performance and safety features. For the European Commission, therefore, nuclear safety will remain a political priority issue, particularly in view of the enlargement process, the assurance of adequate safety levels in ageing nuclear installations, and the licensing of advanced and innovative new reactor systems.

A recent IAEA (International Atomic Energy Agency) report on nuclear safety declares that “Nuclear power plant safety requires a continuing quest for excellence. All individuals concerned need constantly to be alert to opportunities to reduce risks to the lowest practicable level. The quest, however, is most likely to be fruitful if it is based on an understanding of the underlying objectives and principles of nuclear safety and the way in which its aspects are interrelated”. This statement echoes the belief that safety in general can be enhanced most effectively through an improved understanding of the physicochemical processes involved – a tacit endorsement of the need for continued advancements in nuclear science.

Incidents, and especially accidents, within any of the existing nuclear installations could lead, if not properly mitigated, to serious consequences for the plant or, worse, for the public and the environment. The continued availability of nuclear energy as a secure and reliable resource will also impact upon Europe’s economic and competitive well-being. Therefore common safety practices, rooted in a comprehensive safety culture operating at all levels, are highly desirable ingredients of any communal EU policies on nuclear safety.

Concerns have been expressed recently by the Davignon panel-of-experts over the possibility of dwindling competencies in the field of nuclear technology within Europe. In recognition of these concerns, the JRC is striving to reinforce its own activities in nuclear safety and to seek counter-measures to maintain a high level of expertise in nuclear technology and reactor safety. The JRC is therefore emphasizing the importance of nuclear safety by directing policy-related activities along three lines. First, the integration of the Candidate Countries (and the New Independent States) must progress towards a common safety level and safety culture. Secondly, to provide assurance that the high safety levels of Western plants will be maintained, particularly in relation to the ageing of plant components and nuclear fuels at high burn-up rates, and to further improve and validate accident management procedures. Thirdly, provision of the needed competence for new innovative reactor concepts (with the potential to dispose of plutonium) must be maintained to keep the nuclear energy option open.

The approach to nuclear safety in the Candidate Countries is subtly different to that of the West and cannot draw on equally broad safety investigations and research. A transfer of the achievements and knowledge to these countries, covering all key safety issues, is therefore an essential step towards improving the safety of their plants and to promoting their integration within a common safety level and safety culture. Indeed, it is seen as a prerequisite to their joining the EU. To achieve these aims, the JRC, with its long-standing involvement in a variety of nuclear safety-related activities, will continue to give direct and impartial support to the Commission Services responsible for nuclear safety and civil protection.

The main focus of the unit is on the development of methods, interpretation of experiments, and code validation for severe accidents, covering important topics such as melt-coolant interactions, structural integrity, hydrogen risk, and source term (fission products). The unit also develops innovative models for plant thermal-hydraulics. A growing activity is the evaluation of the safety of new reactor designs, which complements the more general activity on harmonisation of safety approaches and safety assessment methodology. Dissemination of data and collaboration, particularly with enlargement countries, are highlighted in the JRC’s policy support role. Finally, the unit is a leader in ISIS in modelling and technological innovation, and a number of spin-off activities have been supported in 2000, both via exploratory research and competitive funding.

14.1 SEVERE ACCIDENTS

A. Annunziato, C. Addabbo

The research activities carried out in the accident simulation and analysis sector were mainly aimed at the evaluation of the test results obtained in the performed FARO/KROTOS experimental programmes and at the further development/assessment of the JRC melt-coolant-interaction safety analysis code COMETA. High priority has been given to the development and implementation of the STRESA web-based informatics platform for the management of the FARO/KROTOS and LOBI experimental databases. Collaborative activities with Central Eastern European Countries (CEEC) and the New Independent States (NIS) research organisations have been promoted within the provisions of the EU enlargement agenda in the field of reactor safety research. In line with the rationales of the prospected European Research Area, the CERTA thematic network (see section 14.5.1) has been established under the EC Nuclear Safety FP-5 assembling 10 major European research organisations to consolidate and archive the experimental databases acquired in European reactor safety integral system effect thermal-hydraulic test facilities.

14.1.1 Melt Coolant Interaction

A. Annunziato, C. Addabbo

A comprehensive research programme dedicated to the identification and/or verification of melt-coolant-interaction phenomenologies in water coolant reactors severe accident conditions has been conducted at JRC Ispra in the framework of the Euratom reactor safety research programme. The overall research activities have included 1) design, construction and operation of the FARO and KROTOS test facilities to investigate melt-coolant-interaction as well as melt spreading phenomenologies under realistic melt composition (UO2-ZrO2-Zr) and 2) development and application of the COMETA (Core Melt Thermal-Hydraulic Analysis) code for test design and pre- as well as post-test analysis of the results.

The progression of severe accidents in water-cooled reactors is characterised by complex multi-phase, multi-component processes which include the interaction of a variety of reactor materials under a wide range of parametric conditions. Relevant phenomena with potential safety implications comprise core degradation and melt-down, melt relocation into the reactor pressure vessel lower plenum and potential interaction with the residual coolant which could lead to quenching or to energetic escalation with a violent heat transfer from the melt to the coolant. This in turn could result in rapid vaporization with conversion of thermal energy into disruptive mechanical loads.

Objectives of the STRESA Database

Large scale experimental programmes have been executed at JRC-Ispra during the past two decades to support development and assessment of system codes used in reactor safety analysis.

STRESA has been developed to provide a web-based informatic platform for the preservation of the acquired experimental data bases and the maintenance of the supporting information and documentation.

Experimental data bases currently included in STRESA-JRC:

- LOBI MOD1 and MOD2: Loss of Coolant Accidents and Transients in PWRs
- FARO: Melt Coolant Interaction and Quenching
- KROTOS: Steam Explosion

14.1 Web-based information platform STRESA.
Following the completion of the FARO/KROTOS experimental programmes, analytical activities have been focused on the evaluation and documentation of relevant test results with inclusion of supporting post-test prediction calculation performed with the COMETA (Core Melt Thermal-Hydraulic Analysis) safety analysis code [14.1-14.2].

Studies on scaling aspects relevant to the application of the COMETA code to a full size reactor geometry have been conducted in the framework of an university degree dissertation grant through the application of the code to the analysis of the TMI accident sequences [14.3]. A synopsis of the COMETA predictive capabilities benchmarked against FARO test data have been reported in [14.4].

In order to ensure storage and retrieval of the experimental data acquired in the execution of the FARO/KROTOS as well as of the LOBI experimental programmes, the web-based informatic platform STRESA (Storage of Reactor Safety Analysis Data) has been developed to facilitate dissemination and access to the data within and outside the European Union (Figure 14.1).

14.1.2 Structural Integrity of Reactor Vessel in Severe Accidents

G. Solomos

The problems of the impact of a slug of molten corium and debris on the upper reactor vessel head as well as the dynamic pressure loading in the lower part of the reactor vessel due to steam explosion are of concern. Reliable modelling and simulations require the knowledge of the material deformation and failure processes. Strain rate and temperature must be correctly included and size effects should be examined in order to assure the transferability of the small specimen results to the real structure.

References
14.1 Annunziato A. et al. – Quick Look Report of FARO Test L-33 - TN.I.00.111
14.4 Technical Exchange Agreement between EC-JRC and the Electrogorsk Research and Engineering Centre (EREC); Electrogorsk, Moscow Region, Russian Federation.

14.2 The ø2.4mm, ø7.2mm and ø24mm nuclear steel notched specimens used in the investigation for studying possible size effects.

14.3 Trends of the nominal strength versus size curves for several strain rate and temperature conditions.

ISIS has carried out dynamic tests for material characterisation, employing principally the Large Dynamic Test Facility (LDTF), Uniaxial and biaxial tension tests have been performed on the materials used for the pressure vessel and its internal structures. These include: ferritic steel 20MnMoNi55 (vessel head), austenitic steel X6CrNiNb1810 (Upper Internal Structure), ferritic steel 26NiCr Mo146 (bolting). Geometrically similar smooth cylindrical tension specimens of diameters 3 mm, 9 mm and 30 mm have been tested at room and higher temperatures (400°C-600°C), and at strain rates ranging from quasi-static (10^3/sec) to dynamic (200/sec) conditions. Notched cylindrical tension specimens of minimum diameter 2.4 mm, 7.2 mm and 2.4 mm have also been tested under the same conditions (Figure 14.2). Strain rate and temperature effects have been adequately assessed through the stress-strain diagrams obtained [14.5]. The size effect issue has demonstrated to be more sensitive. For the smooth specimens it appeared to be minor with respect to resistances and concentrated mainly to local deformation parameters near fracture, such as the area reduction, the meridional radius of curvature etc. [14.6]. The tests with the notched specimens, where strain gradient effects and local phenomena are more accentuat-
ed, tend to confirm better these size effect trends. Further, for the notched specimens the nominal strength (maximum force over minimum initial cross-sectional area) seems to have some size influence (Figure 14.3). Possible positional effects are examined for explaining this behaviour [14.7].

The above activity has been carried out within the framework of two EU projects in the Nuclear Fission Safety/Reactor Safety programme. They are: (a) RPVSA “Behaviour of the Reactor Pressure Vessel under Mechanical and Thermal Loadings caused by Core Melt-Down and Steam Explosion Accidents”, and (b) REVISA “Reactor Vessel Integrity in Severe Accidents”. A third project is currently in progress: LISSAC “Limit Strains for Severe Accident Conditions”. The objective is to study whether larger structural deformations should be allowed for severe accidents. Thus, failure strains of essential reactor components are investigated. The experimental work includes testing under different temperatures, and static and dynamic loading conditions for a wide range of specimen sizes.

References


14.1.3 Hydrogen Risk

T. Huld, H. Wilkening

One of the potential hazards during a severe accident in a nuclear reactor is the formation of hydrogen from the interaction of the hot core melt with the cooling water. An ignition of the hydrogen cloud may trigger a serious explosion that could damage the reactor containment. Due to the large-scale complex phenomena involved, studies of these explosions necessarily involve numerical simulations. For this task, the REACFLOW code has been under development for several years in ISIS, and has been applied successfully to a number of small-to-medium scale problems relevant to attaining a better understanding of the underlying phenomena.

During 2000 a number of new developments and improvements have been implemented in REACFLOW, including large-eddy-simulation (LES) turbulence modelling, improved diagnostics, and completion of the incompressible 3D solver with grid adaptation. This will extend the capabilities of the code to low-speed flows with possible application for hydrogen distribution problems.

Work started on a new shared-cost-action project HYCOM, in collaboration with the Forschungszentrum Karlsruhe and the Kurchatov Institute, Moscow, and others. The aim of this project is to assess the capabilities of hydrogen combustion codes to predict the consequences of hydrogen combustion events on a large scale, including a full-size nuclear reactor enclosure. For this project a number of blind predictive calculations have been carried out for comparison with experiments performed in the large-scale RUT explosion facility in Russia.

Work on another shared-cost-action project EIHP, to study the safety aspects of using hydrogen for vehicle propulsion, was brought to a successful close. This work involved a collaboration with a number of partners from industry (BMW, Renault, Air Liquide, Volvo, Messer Griesheim and others) and research institutions (Demokritos National Laboratory, Greece). A follow-up to this project, EIHP-2, has been proposed and accepted during 2000. The scope of this project will be to study a broader class of safety issues related to the use of hydrogen for vehicles, in particular regarding the safety of fuelling stations and distribution networks.

14.1.4 Source Term

14.1.4.1 Phébus Experimental Programme

R. Zeyen

Under the Phébus international in-pile Fission Product (FP) release programme, five in-pile bundle degradation experiments have been performed with special emphasis on fission product releases from degraded corium, transport and deposition in the coolant circuit and containment. FP chemistry, particularly iodine in the isolated containment is then a primary objective of this global severe accident research programme. While 1999 was marked by the successful performance of the debris bed test FPT4, with a large amount of data on the melt processes of a highly irradiated fuel mixture debris bed (UO2 + ZrO2), this year was specially highlighted by the running of the full bundle test FPT2 on 12 October, 2000.

FPT2 is the third bundle test with the main characteristic that the fuel degradation process will be carried out in “steam starved” or partially-hydriding conditions. Boric acid is introduced into the steam cooling to participate in complicated chemical reactions with fission products and structural materials from the fuel bundle.
Several preliminary conclusions can already be drawn from this test:

- The fuel degradation happened at higher temperatures and higher reactor power.
- An extended full hydrogen release period could be noticed (as expected).
- A substantial amount of gaseous iodine from the circuit arrived into the containment, less iodine retention in the sump due to the absence of silver from the control rod material in the melting process.
- High aerosol releases from the fuel into the containment followed by fast settling.

Fuel and test section tomography reveals, through density shadings, the different relocation zones and degradation mechanisms and, from post-test-examinations, local corium melting temperatures.

FP samplers are now being extracted remotely from the circuit for subsequent analysis in a number of specialised European hot laboratories. The Institute for Transuranium Elements (ITU) Karlsruhe is the most well-equipped and well-trained laboratory in this field. The final data report is not expected before 2002. The final interpretation reports will come out 6 or 7 years after the test performance.

Hydrogen recombiners were also tested against potential poisoning by real fission products. A holding device was designed to introduce, during a given time interval, coupons from all major world recombiner manufacturers. Unfortunately this device, after several trials, could not be introduced into the aggressive atmosphere of the simulated containment, such that we will have to wait for several years before this missing recombiner qualification can be performed.

The next test will be FPT3, now called the boron carbide test and scheduled for March 2003. Here the Ag, In, Cd control rod will be replaced by the B₄C, more typical for BWRs but also for more modern French PWRs. Finally, not before 2005, the FPT5 test will probably be a bundle degradation test including an air ingress phase.

ISIS’s Nuclear Safety unit is, as before, present as a co-leading agent in all executive working groups and steering committee meetings, as well as by its presence in day-to-day management of a number of technical and organisational matters in this important programme. International contributions to the Phébus programme from different countries are directly managed by ISIS scientific personnel. The Phébus Steering Committee in 2000 decided the conditions for test FPT2, including the testing of recombiner coupons, and approved a preliminary specification of the next test, FPT3. JRC experts have continued to support the Research DG by reviewing the experimental reports produced by IPSN, a considerable task in 2000. The Preliminary Report of test FPT4, and the Quick Look Report of test FPT2 have both been reviewed by the JRC. For the Final Report of test FPT1 additional reviewing effort was enlisted from volunteer experts from AEA Technology, FZK, CIEMAT and Chalmers University (Sweden), and a large number of pertinent comments were collected, helping to produce a much improved final version of the report.
14.1.4.2 Phébus Network

ISIS continues to contribute to the interpretation of the Phébus FP test results, the preparation of future tests, and the validation of LWR severe accident computer codes and models against Phébus data. Phenomena concerned are core degradation and fission product release and source term issues of fission product transport in the reactor circuit, aerosol removal in the containment, and both short-term and long-term fission product chemistry. It also promotes European and international co-operation on these themes through the Phébus “scientific analysis working group” (SAWG) and its interpretation focuses on degradation/release, aerosols and chemistry. These groups, which not only serve the Phébus project but also act as a focus for severe accident research across Europe, met twice in 2000.

The results from related shared-cost action projects where the JRC is a participant [14.8] are also factored into the activities, known generically as PhébusNet. One product in 2000 has been a status report on core quenching for the OECD, written in collaboration with GRS [14.9]. A well-attended Phébus Workshop, held in Marseilles (jointly with IPSN) in February 2000, included JRC papers on the state of understanding of bundle degradation, hydrogen generation and fission product behaviour in the Phébus FP tests performed so far [14.10-14.12]. Also presented was a paper on the application of Phébus results to plant analysis in Europe, the outcome of a survey of 14 safety authorities, designers and technical support organisations in 7 European countries [14.13]. Respondents identified several specific applications of Phébus data, including code validation and well-identified safety issues. They were unanimous in expressing appreciation for the way in which Phébus supports a holistic view of severe accident phenomena, and for the cooperative spirit engendered by the team approach adopted to test interpretation and analysis. French take-up of Phébus results was the subject of a separate paper.

Within PhébusNet, ISIS has made and applied some significant model developments in 2000. Regarding aerosols, progress has been made in the theory of particle formation [14.14], and analytical or semi-analytical approaches have been developed to heat transfer and particle deposition in tubes [14.15-14.18] which improve predictions for fission product retention in the reactor steam generator compared with current codes. In addition, an advanced random-walk simulation study was made of thermophoretic deposition in turbulent boundary layers [14.19]. Concerning aerosol resuspension, the JRC’s CAESAR code was assessed against STORM experiments [14.20], and a more general survey has been made of kinetic resuspension models [14.21]. In a collaboration with GRS and with VEIKI (Hungary) a visiting scientist is validating the latest version of the COCOSYS code against containment thermal-hydraulics and aerosols information from the Phébus test FPT0.

Chemistry strongly affects the mobility of fission products and is subject to considerable uncertainty in Phébus. A collaboration with IPSN has continued on the kinetic model for circuit chemistry, described in the 1999 Annual Report. Recently developed models for silver-iodine interactions and for organic iodide formation have been applied in a prediction of containment behaviour in the very recent test FPT2, where the degradation and release took place in steam-poor conditions [14.22]. Low iodine concentrations in the containment atmosphere were predicted, a result which seems to be confirmed by on-line measurements. Further work on iodine chemistry has been undertaken under the shared-cost action project ICHEMM.

Early in 2001 the Final Interpretation Report of test FPT0 should be completed, and the Intermediate Interpretation Report of FPT1 is scheduled for the latter half of the year. Precalculations for the ground-breaking test FPT3 should also begin.

14.5 The FPT2 ultrasonic thermometers performed extremely well and indicated temperatures higher than 2500°C.

Also the 100% hydrogen phase, lasting about 18 minutes can be well recognised.

14.6 FPT0 steam-generator deposition with new model versus experimental data and predictions from other codes.
14.1.4.3 PHEBEN2

A.V. JONES

The shared-cost action project PHEBEN2 stimulates the application of both detailed and integral (system-level) codes in use in the EU to the analysis of Phébus FP results, taking advantage of the existing structure of PhébusNet. Its other objectives are to validate the codes against the Phébus data and to develop and apply assessment criteria for integral codes as used in the analysis of real plants. In the first year of the project the 13 partners have contributed to the FPT0 Final Interpretation Report and performed analyses of FPT1 data using both types of code, and a compendium of summary descriptions of the integral codes in use by the partners, ASTEC, ECART, MAAP and MELCOR, has been drafted. In 2001 integral code assessment will play a larger role in the project’s activities. Synergy with the planned OECD ISP 46 on the integral analysis of Phébus test FPT1 is expected.

14.1.4.4 EVITA

A.V. JONES, K. MUELLER

In the frame of the shared-cost action project EVITA, the code ASTEC V0.3 developed by IPSN and GRS was installed on a SUN as well as on an ALPHA VX workstation. The aim of this ongoing code development is to provide the end-users like utilities, vendors and licensing authorities with a fairly well validated European Integral Code for the simulation of severe accident sequences. Different reactor test cases were recalculated in order to check the installation and to obtain first experience in code handling. To apply the implemented fission transport module SOPHAEROS V2.0 to the Phébus-FP experiments, an input deck for the steam generator tube (SGT) was generated. The first preliminary results indicate that the retention in the SGT was greater as a previous calculation showed. Also in this calculation a significant overestimation of the measured data was obtained, i.e. the model of thermophoretic deposition which is the dominant process has to be improved. Therefore the development of a separate particle tracking model was started. For code benchmarking using the SGT the fission product release and transport code VICTORIA 2.0 was installed. Future benchmark calculations will also be performed with these codes using selected STORM experiments.

14.1.4.5 ICHEMM

Y. DROSSINOS, E. KRAUSMANN

The objective of the shared-cost action project ICHEMM “Iodine Chemistry and Mitigation Mechanisms” is to study, both experimentally and theoretically, aspects of iodine chemistry that are currently poorly understood, especially for BWR conditions. In particular, some processes that lead to the destruction of volatile forms of iodine are not well quantified. An improved

References

The shared-cost actions ASTERISM II, COLOSS, PHEBEN2, EVITA, ICHEMM are described separately.


Krausmann, E. – Phébus FP: An IMPAIR3 Pre-test Calculation of the Phébus FPT2 Test – JRC Tech Note JRC TN I.00.112 (September 2000).
knowledge of these destruction rates will allow their importance to be assessed in terms of natural mitigation processes and accident management interventions. Moreover, the effect of certain materials and conditions specific to BWR systems on iodine behaviour are not known. During the first year, a state-of-the-art report on “iodine chemistry and related mitigation mechanisms” [14.23] was completed. Furthermore, iodine behaviour in the Phebus-FPTo experiment was calculated with an improved IMPAIR code; new models for heterogeneous organic iodide formation were included. The results showed better agreement with experimental data.

14.2 THERMAL HYDRAULICS
H. Städtke, B. Worth, G. Franchello

Model development in fluid dynamics continues to be an active research topic within the ISIS nuclear safety area, and computational fluid dynamics (CFD) is widely used for the simulation of generic thermal-hydraulic flow processes. At the JRC, a continuous effort in the evolution of basic two-phase flow theory has resulted in the development of new and innovative methodologies, providing a mathematical basis for future code development in this field [14.24-14.26]. These methods take advantage of high-resolution “up-winding” techniques now widely used in aerodynamics and compressible gas dynamics. They are developed specifically to capture the fine detail of discontinuous flow processes, such as shock wave propagation or, as in the case of nuclear reactors, the dynamic motion of two-phase mixture levels formed in the primary circuit during loss-of-coolant accidents.

The “Advanced Two-Phase Flow” (ATPF) pilot code being developed within ISIS provides one such approach for the numerical simulation of transient multi-dimensional two-phase flow processes. This work is supported partly through EC-funded competitive shared-cost activities. The ATPF code is based on a fully-hyperbolic “two-fluid” model for the simulation of non-equilibrium inhomogeneous two-phase flow using separated conservation equations for each of the two (coupled) phases. A mathematical approach based on the existence of real eigenvalues (characteristic velocities) and a complete set of independent eigenvectors allows the fluxes to be calculated from the wave propagation characteristics (eigenstructure) of the flow. This facilitates the implementation of stable “upwind” numerical schemes based on approximate Riemann Solvers, which combine signal propagation along characteristic lines to ensure conservation of mass, momentum and energy. A second-order finite volume interpolation technique provides high-resolution simulation of two-phase flow with very low inherent numerical viscosity. Real fluid viscosity can be included to give a physically-based simulation of viscous Navier-Stokes type flow problems.

The ATPF code has been successfully used for studying a large number of problems typical of those in the nuclear and process engineering industries. Of particular relevance to PWR safety is the simulation of steam-water mixture levels in a reactor pressure vessel during depressurization (“blowdown”) transients resulting from loss-of-coolant accidents. These situations can lead to rapid core uncover, dryout of the fuel rod bundle and possible (but extremely improbable) “melt-down” events. An accurate prediction of in-core temperature variation can be made only if the wetted regions of the core can be described from knowledge of the two-phase mixture levels. Resolving this problem with existing integral systems codes (e.g. RELAP5, CATHARE2, ATHLET) requires relatively fine discretization of the core, leading to very lengthy computation times. Other problems of interest include the accurate treatment of critical two-phase “choked” flow with steep pressure gradients and thermal non-equilibrium, fast depressurization and “flashing”, slow gravity-induced phase separation and the simulation of two-phase flow processes with low driving heads, such as natural convection processes.
The capabilities of the JRC ATPF code in simulating such problems are indicated in the ROSA-1 vessel blowdown problem (Figure 14.8 and 14.9). In this case, two cylindrical vessels (treated as pseudo 3-dimensional about a plane of symmetry) are connected by a horizontal (1-dimensional) pipe in which an orifice is located to restrict the flow. Initially, one vessel is partially filled with hot saturated water at 10 bar pressure whilst the other is filled with pure saturated steam at 1 bar. A transient event is initiated by rupturing a bursting disk at the outlet of the high-pressure vessel (Figure 14.8 left), causing rapid boiling with the discharge of two-phase fluid from the tank. Measured and predicted pressures, and residual mass inventory, as functions of time, are shown in Figure 14.8 for two different orifice sizes. Figure 14.9 shows the predicted volume fraction for liquid (dark blue) and vapour (light blue) in the left-hand vessel at four different times after initiating the transient. Some interesting flow patterns, easily identifiable in the prediction, include: rapid swelling of the mixture level due to fast evaporation in the liquid pool, transition from single phase vapour to two-phase flow and “choking” in the interconnecting pipe, jet formation in the low pressure vessel and jet impingement at the right-hand vessel wall (not shown), strong recirculating flow patterns, gravity-induced phase separation, liquid collapse and a wave-like “sloshing” of residual liquid pools in the two vessels.

14.2.1 ASTAR

H. Städtke, G. Franchello, B. Worth

The main objectives of the ASTAR (Advanced 3-D Two-Phase Flow Simulation Tool for Application to Reactor Safety) shared-cost action project, which started in 2000, are to establish the scientific and mathematical basis for a new generation of thermal-hydraulic (TH) codes for reactor safety studies. This activity aims at substantially improving the multi-dimensional prediction capabilities as well as enhancing those capabilities in the present generation of system codes, for safety-relevant phenomena in existing and future innovative Light Water Reactors. As a competitive activity, the ASTAR project involves partners from seven European organisations including the French partners CEA and EdF (Electricité de France), the European Commission, GRS (Germany), Manchester Metropolitan University (UK), the Von Karman Institute for Fluid Dynamics (Belgium) and the Paul Scherrer Institute (Switzerland).

The basis for the development of improved two-phase flow simulation is the 3-D “two-fluid model” coupled to the transport equations for interfacial area and turbulent kinetic energy and dissipation rate, for which new experiments are being planned to permit the development and validation of new physical models. High-resolution numerical schemes with very low artificial dissipation will be further developed and their improved accuracy will be assessed by extensive benchmarking on safety-relevant flow problems, and by comparing with prediction capabilities of existing TH codes. The development and verification of new 3-D TH code modules components are expected to overcome many of the deficiencies and limitations of present TH-systems codes like CATHARE, ATHLET, TRAC or RELAP5. These component modules could form the development basis for a new generation of advanced TH-codes having a highly modular structure, making them easily adaptable to coupling with existing European TH-codes in the near future.
14.3 SAFETY OF NEW DESIGNS

H.U. Wider, J. Karlsson, A.V. Jones

The main task of this exploratory research activity was to gather information on heavy-metal-cooled critical reactors, now receiving much attention worldwide. ISIS has also contributed to this debate [14.27-14.28]. At the ICONE8 conference in Baltimore in April 2000, two sessions were dedicated to Lead Bismuth Eutectic (LBE) – cooled critical reactors. An interesting design presented by ANL is a 300 MWe pool-type modular reactor with a secondary loop wherein water is superheated in the heat exchangers located in the upper part of the downcomer. This configuration makes the reactor compact and therefore cheaper, but a leak in the heat exchangers would lead to pressurisation of the vessel. The first ANL design featured natural circulation but jet pumps have since been added, in series with the heat exchangers, to maintain good natural circulation flow. Smaller designs by University of Berkeley feature cooling of the LBE via a corrugated inner vessel wall by superheated water, all surrounded by a strong external vessel. The whole core can be removed like a battery. This design would thus be a very proliferation-safe system. A design from MIT proposes the bubbling of (superheated) water though the riser of the core. The problem of this elegant looking approach is the \( \alpha \)-radioactivity of the LBE coolant. At the Generation IV meeting in Washington (May 2000), key criteria such as low capital cost (i.e., less than 1000 \$$/kW installed), demonstrable safety, low waste production and high proliferation resistance were identified as desirable design features. An LBE-cooled modular reactor is a Generation IV candidate in the US.

Minatom of Russia announced, in July, the starting of the BREST-300 project. This should lead within 10 years to a 300 MWe lead-cooled critical reactor and an integrated reprocessing facility for multiple recycling of the mixture of plutonium and minor actinides as well as the water-soluble long-lived fission products. The BREST-300 reactor is claimed to be cost-competitive, inherently and ecologically safe as well as proliferation-proof since no breeding blankets will be used and the plutonium will not be separated from the minor actinides. Obninsk in Russia, however, is proposing the smaller SVBR-75 LBE-cooled reactor based on their 80-reactor years experience with submarine reactors of this type.

The Tokyo Institute of Technology has for a long time proposed small and transportable super-safe LBE-cooled reactors with fuel lifetimes of 12 years. South Korea is proposing the LBE-cooled PEACER reactor that should meet the Generation IV criteria. Since there is no research yet in the EU on this reactor type, ISIS started an initiative for a concerted action considering the BREST-300 reactor and the different LBE-cooled designs. The main objectives are to determine whether to propose an EU co-operation with BREST-300 and to determine whether this type of reactor could be considered acceptable in the EU. A proposal has been submitted involving experts from Russia (RDIPE and Obninsk), six EU countries, Switzerland, Japan and Korea.

14.4 HARMONISATION

Overview

G. Cojazzi

ISIS promotes harmonisation on nuclear safety aspects by providing technical support to the relevant European Commission DGs by participating in international activities such as those of the OECD and IAEA through networking laboratories, by organising benchmark exercises and performing focused research on safety critical issues and risk-assessment methods.

ISIS supports the Nuclear Safety and Civil Protection Directorate of the Environment DG, in the implementation of the two Council Resolutions (C128-75, C172/2-92) dealing with reactor safety. The activity performed within the Commission permanent advisory group (the Nuclear Regulator Working Group (NRWG)), which networks the Nuclear Regulatory bodies of EU Member States, have been closely followed. Support in this sensitive area will continue with the Energy and Transport DG to which the nuclear safety matters in EU Member States have been transferred during the course of the year.

One of the main concerns among EU citizens and stakeholders is the safety of nuclear power plants of Eastern design. In order to improve the safety of these installations, the Commission has devoted considerable resources to technical assistance programmes. As a spin-off of the competencies acquired in reactor safety, JRC-ISIS together with JRC-ITU, JRC-IAM and JRC-DISI continued in 2000 to support the technical implementation of the Commission’s TACIS and PHARE assistance/co-operation programmes with CIS and CEEC [14.29]. ISIS’s contribution focuses on its areas of competence, namely thermal-hydraulics, design basis and beyond design basis accidents, severe accidents,

References


risk assessment, structural dynamics and integrity. Support has been given to the Common Service for External Relations (now EuropeAid Co-operation Office – AIDCDO), for “design safety” projects, in the drafting of contract Terms of Reference, in the selection and evaluation of project offers, in the follow-up and in the review of intermediate and final project reports. ISIS has also provided technical assistance, to the Environment DG, in the review and evaluation of project reports related to strengthening Eastern Technical Support Organisations (TSO) [14.30-14.31].

14.4.1 Probabilistic Safety Assessment
Probabilistic Safety Assessment (PSA) is one important area in which ISIS has developed knowledge and competence over many years. The subject and related important area in which ISIS has developed knowledge and competence over many years. The subject and related methods are of relevance also with respect to the general trend of developing and using risk-informed methods in support of decision making.

One of the main projects performed dealt with the problem of “expert judgement”. This involves how judgements derived from experts about safety-relevant issues, together with the relative uncertainties, can be collected from experts in a disciplined way, properly documented and, if necessary, suitably aggregated in order to provide the uncertainty quantification of the relevant issues in a PSA study. ISIS designed and coordinated an international benchmark exercise in order to collect information about the use of structured expert judgement techniques among level-2 PSA researchers and practitioners and to compare methods. The problems considered were fuel coolant interactions and the event of hydrogen deflagration/detonation in a pressurised water reactor system of evolutionary design. In the course of 2000, the analysis and valorisation of the results of the overall benchmark project has been carried out [14.32-14.39].

The development of the JRC-ISIS code ASTRA for reliability analysis, based on a binary decision diagram technique, has been continued in synergy with other research lines of ISIS and a module for event tree analysis has been added.

An emerging topic in the safety of nuclear power plants is related to the development and spreading of digital technologies and to their use in safety critical and safety related systems within NPP, leading to the so-called “safety critical software issue”. The subject is of relevance for both existing installations, due to the change from analogue to digital control systems, and for new installations which will make full use of digital technologies. In the course of the year 2000, an international benchmark study has been designed and accepted for funding as an action of the Research DG within the Fifth Framework Programme for comparison of methods for assessing the dependability of safety critical software. Partners of ISIS include GRS (Germany), STUK (Finland), VTT (Finland), SIEMENS (Germany), and IPSN (France) [14.40].

A workshop on “Technical Harmonisation of Risk-Based Decision-Making” was organized in collaboration with the Risk Management and Decision Support unit of ISIS and was attended by 120 participants. The workshop was a first step in launching an international initiative to promote the development of a generic standard for risk assessment to be applicable to different domains and industries [14.41-14.42].

References


References


14-5 DISSEMINATION AND COLLABORATION

14.5.1 CERTA

C. Addabbo, A. Annunziato

The safety evaluation of existing and, in perspective, of evolutionary or innovative reactor concepts, is generally supported by a wide spectrum of experimental and analytical activities. These are aimed at: 1) the acquisition of representative experimental databases in integral system effect and/or separate effect test facilities, and 2) the development of computer codes to provide realistic predictions of system and/or component response and the efficiency of related emergency safety systems under a variety of postulated accident and transient conditions.

In the past few decades, a considerable amount of resources has been devoted at the international level to the establishment and conduction of experimental programmes relevant to water-cooled reactor safety analysis. The extent to which the acquired experimental databases are preserved and can be eventually accessed and retrieved is an issue often debated in the nuclear community. In addition to the progressive loss of skilled human resources with lack of adequate replacement under the current constraints, a complicating problem is given by the continuous advancement of computer hardware and software technologies. This is making several of the traditional storage methods rapidly obsolete and access/retrieval of data is practically impaired.

The programmatic objective of the European thematic network CERTA (Consolidation of the Integral System Experimental Data Bases for Reactor Thermal-Hydraulic Safety Analysis) is thus aimed at providing a consolidated framework for the preservation of the integral system experimental databases acquired in the context of the water reactor safety research programmes carried out by European industrial and institutional research organisations.

JRC contributes to the CERTA network with the LOBI experimental database which has been acquired and developed at the JRC Ispra in the framework of previous reactor safety research programmes and under contractual agreement with the former BMFT, Germany. The LOBI database comprises 70 experiments covering mainly thermal-hydraulic phenomenologies relevant to Design Basis Accidents (DBA) and Transients as well as emergency operating procedures and accident management strategies. The LOBI test facility consisted in a scaled full-power, full-pressure integral system test facility representing a 1:700 scale model of a 1300 MWe PWR of Siemens-KWU design. As structured, CERTA includes experimental programs relevant to reactors in operation in the EU member countries (i.e., PWRs and

14.10 The European thematic network CERTA.
BWRs) as well as in the EU Enlargement countries (i.e., VVERs). The CERTA network, which includes 10 major European research organizations, has been promoted and is being coordinated by ISIS (Figure 14.10).

14.5.2 ASTERISM2
A.V. Jones, M. Delaval

The objective of this concerted action project is to improve the software developed by ISIS during the Fourth Framework Programme (FP4) in order to produce an effective and user-friendly database for the results of research programmes. A trial version of the software is now available on CD-ROM, charged with data from the N Research DG-funded nuclear fission safety projects of FP4 concerned with source term phenomena. A user guide is provided as well as a (paper and on-screen) catalogue of the database contents, and the suppliers of the original data are now testing the database thoroughly. For each project one may view the final report and final summary report, tables of results, graphs and other graphics, and pieces of software where appropriate. The software is so documented that it can be readily reused in other applications. The remainder of the project will examine extension to other nuclear safety projects and links with existing databases of severe accident data, as well as make any necessary corrections to the database.

14.5.3 Enlargement
C. Addabbo, A. Annunziato

Taking into account that the safety aspects connected with the reactors in operation in the Central and Eastern European Countries (CEEC) and in the New Independent States (NIS) are at the forefront of the EU enlargement agenda, exchange of information with CEEC and NIS research organizations has been pursued. As part of the technical exchange agreement concluded with the Electrogorsk Research and Engineering Centre (EREC) of the Russian Federation, it has been envisaged to benchmark the predictive capabilities of the EREC melt coolant interaction code VAPEX against the test results of FARO L-33 test results. L-33 has been the last test performed in the FARO test facility under extreme adverse conditions in order to trigger with an external explosive impulse (trigger) an energetic interaction. The results from test L-33 are rather unique calling for a deep and exhaustive analysis. This study will provide an opportunity to share and transfer best practices in reactor severe accident safety analysis at the European level through the appraisal of the predictive capabilities of the VAPEX code developed for VVER safety analysis and their comparison with the results of the JRC COMETA calculated results.

Within the long standing collaborative agreement between JRC and the KFKI Atomic Energy Research Institute of Hungary, it has been agreed to carry out a study to identify and apply multivariable signature analysis methodologies to discriminate accidents and transients in PWRs and VVERs. This study will use as a test bench the experimental results acquired in the JRC LOBI and in the KFKI PMK test facilities.

14.6 SPIN-OFF ACTIVITIES
14.6.1 Project Epsilon
B. Worth

This exploratory research builds upon theoretical developments in the area of two-phase flow and on a previous shared-cost action project related to improvements in the design of chemical reactors. Recognising that two-phase natural convection is a very important mechanism for heat removal from a partially-voided nuclear reactor core during accident conditions, Project Epsilon is looking into the application of “spin-enhanced natural circulation” also for non-nuclear process intensification.

The main objectives of Project Epsilon are to study the application of strong centrifugal force for enhancing electrochemical reactions in a multiphase mixture, particularly for the generation of “clean energy” in an electrochemical cell. Theoretical studies indicate that many multiphase processes which depend upon interfacial mixing for mass and energy transfer, as well as chemical and/or electrochemical reactions at a catalytic boundary surface, are often diffusion-limited processes. Gas generation or absorption at the surface of an electrode or within a porous bed in contact with liquid electrolyte, for example, depends on a combination of fluid flow parameters generally controlled by the interphase buoyancy term. In natural convection processes, this depends crucially on the density difference between two or more fluid phases (often a liquid and a gas), as well as on the local acceleration due to gravity. For a given fluid mixture, the interphase buoyancy force can be increased substantially by the application of centrifugal forces, as occurs for example in a centrifuge. Spin-enhanced natural circulation can be used to greatly increase the thermodynamic efficiency of many multiphase flow reaction processes, leading to compact and hence cheaper designs of reactors, as well as offering many advantages in terms of safety over conventional fuel cell systems.

Project Epsilon is using the techniques of process intensification to design and construct an innovative prototype centrifugal fuel cell for the clean generation of electricity. It has important links with nuclear energy in respect to the fuel cycle of electropositive metals such as zinc and aluminium. With several patents pending in Europe and elsewhere, it is hoped that this activity will open up new avenues of EU research into innovative renewable energy systems.
14.6.2 SUB-AERO

Y. Drossinos

The objective of this three-year, university-based shared-cost action project is the investigation of subgrid (local) variability on ozone and fine particulate matter in the Mediterranean area. As a first step towards understanding the effect of local variability on new particle formation, the effect of translational invariance on classical homogeneous nucleation theory was investigated. This was done by proposing a connection between field-theoretic descriptions of condensation and density-functional theories of nucleation [14.43]. The connection was obtained starting from a quantum mechanical Hamiltonian and using methods developed in the context of studies of Bose-Einstein condensation [14.44].

14.6.3 LUNG

A.V. Jones, M. Reeks

The LUNG exploratory research project has the objective of applying existing expertise in aerosol transport to improve understanding of particulate deposition in the human respiratory system and hence of the hazard arising from airborne particulates. A comprehensive deposition model which is frequently employed as a benchmark has been published by the International Committee for Radiation Protection, and a critical review has been made of the modelling of aerosol deposition in the various components (especially the bronchial region and alveolar interstitial regions) [14.45]. It was concluded that the modelling is relatively crude as regards the prediction of local surface concentrations of deposits e.g. at junctions, which are thought to play an important role in the toxicology. A CFD/particle tracking study has begun to examine deposition in such regions, using detailed calculations of the (normally laminar) flow field to drive the particle motion. Important for fine particles is Brownian motion, which is simulated by a Langevin term with a time scale on the order of 1% of the particle Stokes relaxation time.

The expertise acquired in LUNG has attracted interest from proposers of environmental and health-related shared-cost action projects. The contract for a project on urban aerosol generation, transport and health impact is ready for signature, and negotiations are in progress for a shared-cost action proposal on atmospheric particles and asthma.

14.6.4 Predicting Internet Traffic

Y. Drossinos

The objective of this exploratory research project was to study and model the self-similar (non-Poissonian) structure of information flow in the Internet. Statistical analyses of Internet traffic have shown that conventional assumptions based on Poissonian statistics do not reproduce the observed traffic flow. The associated time series (expressed, for example, as bytes per second passing through a server) have long-range correlations and they appear unchanged under different levels of aggregation: they are self-similar [14.46]. The results of a statistical analysis of access data of a JRC web server (ARI FP4) are shown in Figure 14.11. The log-log figure shows that times between successful URL requests (inactive periods) are distributed according to an algebraic distribution. The modelling work concentrated on relating the power spectrum of a characteristic time series of packet traffic to the probability distributions of active (ON) and inactive (OFF) periods. As shown in the figure, the inactive periods have a heavy tailed (Pareto-like) distribution; previous analyses of the active periods resulted in similar distributions [14.46].

The exponent characterising the low-frequency divergence of the power spectrum was related to properties of these distributions. Based on this relation an analytic expression for the Hurst exponent, a quantity that characterises persistence of correlations, was obtained [14.47].

![Figure 14.11 Statistical analysis of time periods between successful URL requests for a JRC web server (ARI FP4).](image-url)

References

RESOURCES

STAFF

Staff breakdown at the end of 2000.

- Temporary Agents (maximum 3 years): 18
- Temporary Agents (5 years or indeterminate): 95
- Officials: 131
- Auxiliaries: 46
- Grantholders: 32
- Visiting Scientists: 7
- Seconded National Experts: 2

BUDGET

ISIS obtains about 20% of its funding from sources outside the direct actions of the Framework Programme (i.e., institutional funding). These sources of complementary funding can be classified as:

- Competitive support to the Commission – was a mechanism employed during the Fourth Framework Programme whereby a part of the JRC’s budget was put out to tender on projects selected by the Commission DGs. This ended with the beginning of the Fifth Framework Programme so income from this source is zero for 2000.
- Other competitive activities – include projects paid by the DGs and Services of the European Commission directly from their budget lines.
- Shared-cost actions – where the JRC pays 50% of the costs from its own budget although some concerted actions and supplementary measures are fully paid.
- Training and mobility of researchers – include individual fellowships from the Marie-Curie scheme and networks organised around facilities such as ELSA.
- Third party work – includes work done for third parties.

Tables I, II and III below show details of income and work executed.

Table I: Contracts signed.

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<td>Shared-cost actions*</td>
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<td>Training and mobility of researchers</td>
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<td>Third-party work</td>
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Table II: Competitive work.

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Table III: Institutional work (direct actions of the Framework Programme)

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* includes JRC matching funds.
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