A N N U A L · R E P O R T · 92

Institute
FOR
Systems
Engineering
AND
Informatics

JOINT RESEARCH CENTRE

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COMMISSION OF THE EUROPEAN COMMUNITIES

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CONTENTS

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1 EXECUTIVE SUMMARY

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INTRODUCTION TO THE INSTITUTE

The **Institute for Systems Engineering and Informatics (ISEI)** is one of 8 Institutes which constitute the Joint Research Centre of the European Communities, situated in 5 different sites in Europe (Ispra in Italy, Karlsruhe in Germany, Geel in Belgium, Petten in the Netherlands and Brussells in Belgium).

The Joint Research Centre is part of the Directorate General for Science, Research and Development (DG XII) in the Commission of the European Communities as shown in the organigramme below *(fig. 1.1)*.

PRESENTED OF THE COMMISSION
17 COMMISSIONERS

Vice President P.M. Pandolfi
With special responsibility for
Science, Research and Development

DG XII Director General **P. Fasella**	**DG XIII** Director General **M. Carpentier**

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Director
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P. Bonnaure | Ispra Site
Environment Institute
Director
F. Geiss | Ispra Site
Institute for Remote Sensing Applications
Director
R. Klersy | Ispra Site
Safety Technology Institute
Director
H. Holtbecker |

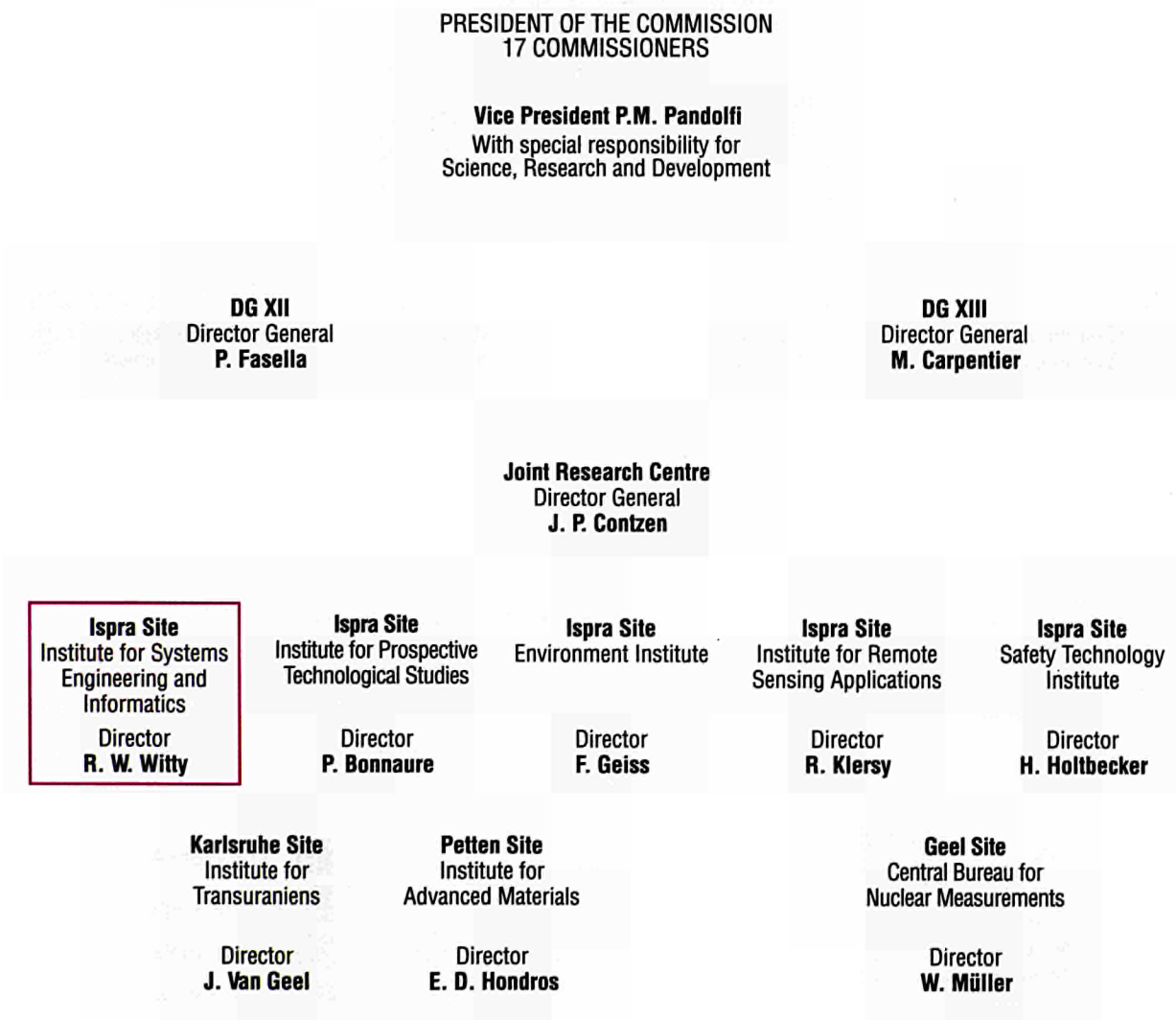| Karlsruhe Site
Institute for Transuraniens
Director
J. Van Geel | Petten Site
Institute for Advanced Materials
Director
E. D. Hondros | Geel Site
Central Bureau for Nuclear Measurements
Director
W. Müller |

Fig. 1.1. The Joint Research Centre in the Organisation of the Commission of the European Communities

ISEI is devided into 8 units *(fig. 1.2)*. One is in charge of the administrative management support, two are informatics services (corporate and distributed) and five are research units for Industry Environment, Non-Nu-clear Energies, Nuclear Safeguards, Electronics & Sensor Based Applications and Energy Environment Interaction.

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                  ┌─────────────────┐
                  │ Director of the │
                  │   Institute     │
                  │                 │
                  │   R. W. Witty   │
                  └─────────────────┘
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Industry Environment	Non-Nuclear Energies	Safeguards	Management Support

Electronics and Sensor Based Applications	Corporate Informatics Services	Distributed Informatics Services	Energy Environment Interaction

Fig. 1.2. Structure of the Institute

The Institute is engaged in four main types of activities:
– Research in the framework of the EC Multiannual Framework Programme
– Exploratory Research
– Support to the Community Policies
– Contract research.

Furthermore ISEI is a partner in collaborative projects and associations with other research organisations and laboratories as well as in an EUREKA project.

At the end of 1992 the Institute had 220 permanent staff, which is about 75% of total staff, 8 detached

Permanent S/T		189
Permanent Adm.		31
Auxiliary Agents		5
Detached Experts		6
Visiting Scientists		2
Grant Holders		23
Stagiaires		36
Total Staff		**292**

12,3%
7,9%
0,7%
2,1%
1,7%
10,6%
64,7%
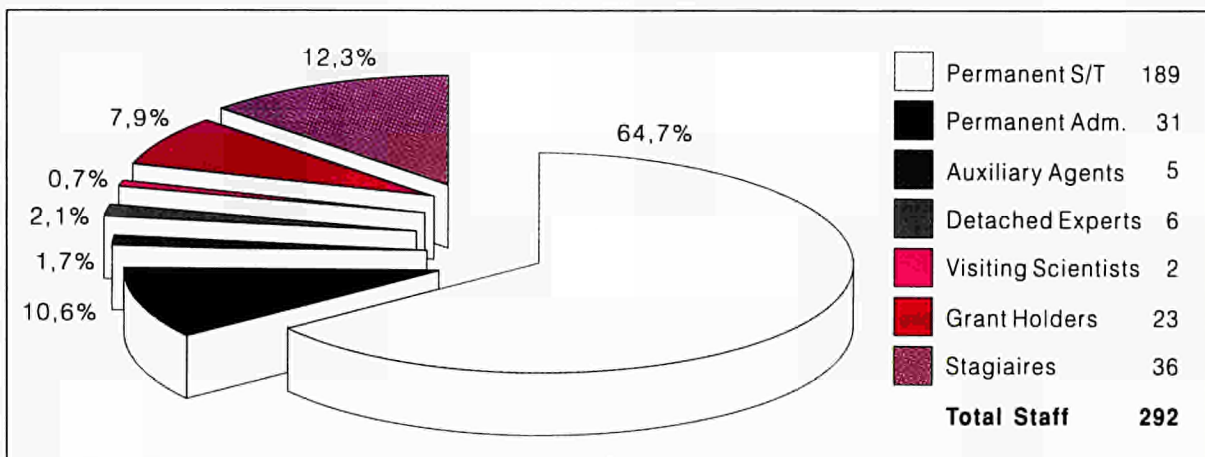
Fig. 1.3. Human Resources 31.12.1992

experts or visiting scientists, 23 grantholders, 36 stagiares and 5 auxiliary agents for a total of 292 *(fig. 1.3)*.

In 1992 ISEI had a research budget of 20.69 million ECU of which 38% were funds for the Commission Special Project and 18.5% for research in the context of the Framework Programme. 3.3% was money earned through contract research and Inter Institute contracts, while 10.5% was support to the Community Policies for other Directorate Generals of the Commission of the EC *(fig. 1.4)*.

	in MECU	
☐	FWP incl. Expl. Res.	3.82
■	Informatics Services	5.47
■	Admin.	0.48
■	Inter Inst. Contracts	0.52
■	Spec. Project	7.87
■	TPW	0.37
▨	Supp. Com.	2.16

Pie chart values: 38,0% · 2,5% · 2,3% · (CIS + DIS) 26,4% · 1,8% · 10,5% · 18,5%

Fig. 1.4. Financial Resources 1992 - Research Credits

SUMMARY OF THE ACTIVITIES

Specific Programmes
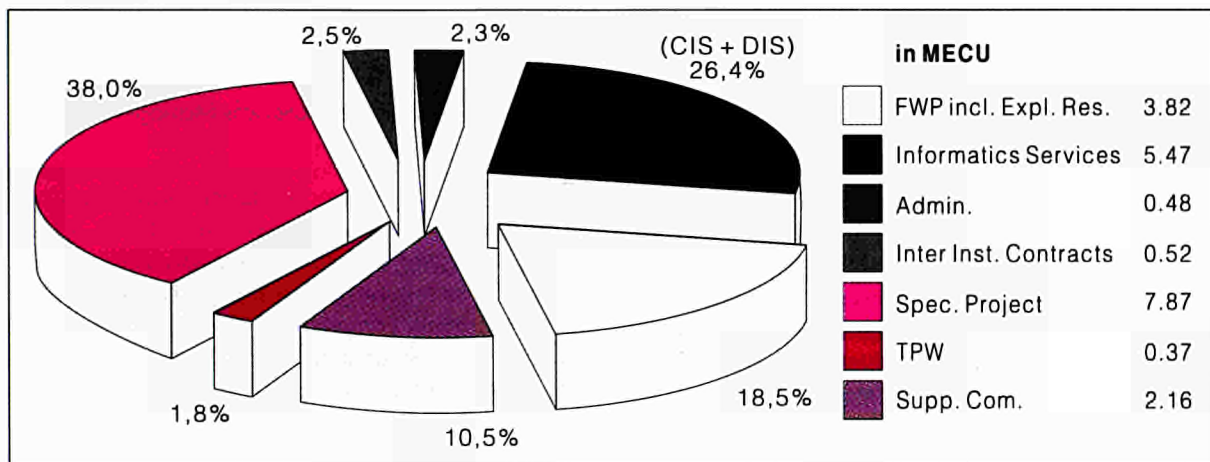
Fission Reactor Safety

The objective of the work was the development of methods to control the level of safety of power plants over their life. The main activities have been:

Knowledge Based Systems (KBS) oriented to Probabilistic Safety Assessment (PSA)

The approach is based on the restructuring of the information contained in the PSA into an explicit declarative plant model which can be easily accessed and on the use of the model by KBS to deduce information on the plant's safety state. A first application is being made where the plant model is the backbone of a tool that provides the safety analyst with a dynamic picture of how the calculated risk evolves during the lifetime of the plant.

Statistical Analysis of Data on Plant Operating Experience

The "Intelligent Selection" method has been applied to define the taxonomy of a reliability data book for electric motors.

Dynamic reliability analysis

A computer model, DYLAM, which represents a user-friendly environment for the development of plant simulation models, has been developed. Results from DYLAM have been compared with success to those obtained by the Fault-Tree Technique. The code has been also coupled with the TRETA (Transient Response Therma-Hydraulic Analysis) package.

Re-ordering of CEDB (Component Event Data Bank)

After the end of its operation as a centralised system, the Data Bank has been reordered and an improved version for the PC has been built.

Structural Reliability

The second campaign of repeated tests on a nozzle corner with thermal and pressure transients where an artificial crack was produced by electro-erosion, has been completed and analysed. During the tests no significant propagation of the crack was oberved, in agreement with the theoretical predictions. A Knowledge-Based System named BOSS (Backtracking and Overviewing for Structural Safety) has been developed, interfaced with the Data Acquisition System and coupled with various structural reliabilty software packages.

Safeguards and Fissile Materials Management

Surveillance

The main effort was directed to the exploration and demonstration of the use of mobile robotics for the remote verification of a fissile materials storage area, i.e. remote inspection and inventory. The system consists of two main components: a vehicle carrying on board a manipulator arm and sensors (TV cameras, laser range finder and ultrasonic sensors), and the system's operator console. The system's functional modules are built on top of a sensor oriented kernel in communication with the vehicle and the manipulator arm. The existing modules include the following functions: navigation, vision system, position monitoring and calibration, arm control, position authentication. Other surveillance techniques under development are digital storage in real time, integration of information from different safeguards devices and a new system combining scene change detection with the automatic positionning and zooming of a TV camera.

Industrial Hazards

Various aspects have been investigated, namely: working environment, environmental emergencies, safety and reliability assessments, decision support systems.

Working Environment

The activity was focused on various interactive topics. Cognitive ergonomics and organisational factors with the focus on human factors. In particular, the effects of stress on the cognitive activities of air traffic controllers have been analysed.

New technologies and safety at work with the emphasis on the impact of Information Technology on the design of control systems and accident management procedures.

Process diagnostics for early fault detection and diagnosis in accident management, with the focus on plant components and instrumentation. The cognitive model COSIMO has been fully documented and a first set of

field studies has been carried out for the development of a model of "stress" and of "temporal reasoning" affecting decision making. A prototype of a System Response Generator aiming to analyse human decision-making during accidents has been set-up. Two pilot studies, based on the System Response Analyser concept, have been carried out.

Environmental Emergencies

This activity concerns initial studies of the environmental impact of technological systems, in particular with regard to the definition and implementation of environmental indicators and the definition of the architecture of an Informatic System for Integrated Environmental Studies (INES). The ISEI software package set up for reliability analyses using personal computers has been distributed to about 40 organizations.

Safety and Reliability Assessments

The STARS project (Software Tool for Analysis of Reliability and Safety), started in 1989, was formally closed at the end of 1992. In the last period a toolkit was developed that consists of a kernel plus Knowledge Bases and related tools used to build the plant model, as well as a set of safety and reliability analysis tools. A new graphical interface has been also set-up to access the Knowledge Bases and to create hierarchical object oriented representations of the plant under analysis. In parallel have been developed other tools supporting computer aided design at the system level, namely a fault-tree construction expert system, a fault-tree editor and a module for determining the cut-sets and performing a time dependent quantitative analysis.

Decision Support Systems

The work focused on the definition and selection of the appropriate criteria used in Decision Support Systems. Various approaches to generate alternative sets have been investigated. Among them, one of the most promising is the integration of a Decision Support System with a Geographical Information System (GIS). A method has been devised to generate alternatives for facilities siting using genetic alghoritms. (GENET). A prototype GIS for the Ispra ECOCENTRE project has also been set-up, as well as the extension of the GIS named GEOSCOPE, developed for waste management in Lombardia, to European Statistical Regions (EUROSCOPE).

The computer package XTRIM, dealing with evaluation of the work due to the transport of dangerous goods, has been adopted to estimate risks associated with transport by rail and road. The code has been applied to investigate the case of Denmark. Meanwhile the code was validated by comparison with real accidents and with traditional risk assessment approaches, as reported in the literature. A pilot study of accidents during marine transport was also made on the basis of about 150 case histories.

Cross-national risk communication research in Italy and England has been undertaken as a part of the implementation of the Seveso Directive on Major Hazards together with a study of the long term consequences of the Seveso dioxin leak.

Reference Methods for Non Nuclear Energies

This activity is concentrated on pre-normative research on photovoltaic devices, as a part of the ESTI (European Solar Test Installation) mission.

Basic studies have dealt with the comparison of the reflectivities of Al and Ag deposited on Si by screen printing and by vacuum evaporation, in particular as far as their ability to produce good quality Si-metal contacts. The code developed in 1991 for 1D numerical simulations of solar cells in steady state conditions has been generalised and extended to include transient regimes.

A new reference cell for Monitoring of Photovoltaic plant performance, named ESTIsensor, has been developed. It is a precision solar radiation sensor based on a silicon solar cell, optimised for low cost, long lifetime and easy use. Although designed mainly for monitoring purposes, it may be also used as a primary reference cell for indoor use. A new calibration procedure has been also set up both for irradiance and for the temperature signal utilising the light decay of a commercial large area pulse solar simulator.

Qualification test sequences of Si-modules, based on light soaking and annealing, have been pursued with improved techniques. The results of the light exposure at low temperature indicate that one might save considerable testing time when decreasing the ambient temperature. However more statistical evidence has still to be obtained in order to generate an acceptable standards proposal.

Reliability of Structures

Materials and Structural Damage Measurements

Various inspection techniques have been applied to the detection of defects in materials and components. Laser holographic interferometry has been used to analyse specimens of composites and to investigate service induced damage on aircraft fuselages. The work on acoustic emission was conducted within the frame of a Bench Mark exercise by the laboratories constituting the

EAMA (Acoustic Emission for Aeronautical Materials). The research in the field of adiabatic thermal emission has been continued by testing virgin and impact damaged composites. The results are encouraging but further studies are needed before ensuring the validitity of the method for deformation analysis.

An electronic speckle pattern interferometer with an endoscopic imaging system has been developed for non-destructive measurements in hidden or difficult-to-reach zones. The whole system is very flexible and the fields of application can range from industrial to medical diagnostics. The feasibility of using a digital speckle pattern interferometer with optical fibres for non destructive testing of art work has been investigated. First results are encouraging.

Various techniques for surface characterisation and profiling by laser methods are under study, namely the two-refractive-index holografic contouring, the white light interferometric contouring and the triangularisation system with laser light line projection, and speckle decorrelation measurements applied to the study of deterioration mechanisms in stones. The last technique may constitute a substantial improvement in diagnosis of monuments for their protection and restoration.

The problem of the fatigue limit in metal components subjected to multiaxial, non proportional cyclic loads was also investigated. A new methodology, based on a microscopic approach, is under development.

Fusion Technology and Safety

Fusion activities at JRC are part of the European Fusion Programme. Contributions have been given to the Next Step and Long Term actions as well as support to the Joint European Torus (JET).

Structural Integrity during Disruption Events

The computer 3D model TRIFOU for analysis of transient magneto-mechanical coupling effects in reactor vessel structures has been improved. A number of investigations by various methods to evaluate accidental plasma disruption effects on the mechanical structures of the internal Next Step components have been carried out. The feasibility of an attachment lock on blanket segments has been assessed. The ELBA facility for transient mechanical tests and validation studies has been installed and the implementation of the measurement systems is in progress.

Remote Handling

This activity is oriented towards computer simulation and experimental validation of Next Step in-vessel components operation. In 1992 a Remote Handling computer simulator package of the remote operation of blanket segments has been developed. It uses the Medusa-CAD system, through an appropriate visual simulation model, based on the inverse kinematic approach. Meanwhile a Remote Handling Workstation for the control of the equipment and tools envisaged for the handling of the blanket segments has been set-up. The experimental validation was carried out using the ROBERTINO facility, a large gantry robot intended to test a 1/3 mock-up of a blanket module. A detailed characterisation of the facility has been carried out in order to know its behaviour under different loading conditions and trajectories, and then helping to design the various types of attachment locks.

Accident Analysis

The evaluation of the consequences of the so-called Envelope Loss-of-Coolant Accident in ITER has been carried out by the computer package developed in the previous year at Ispra. "Envelope" conditions correspond to an instantaneous complete and permanent loss of active cooling. The time evolution of the temperature in the various components of the reactor plant has been calculated up to three months after the accident, in order to investigate its capability for passive safety.

JET Support

The reliability of the transport articulated boom of JET has been assessed and a Plant Definition Document for the software of the local boom controller has been produced.

Low Activation Materials

The neutron induced radioactivity in Silicon Carbide composites (ceramic matrix/ceramic fibre), identified as SiC/SiC, has been analysed. The purpose was that of controlling the compliance to the radioactivity limits with Low Activation Criteria developed in 1991. The results were that SiC/SiC in the first wall of a commercial power reactor satisfies the criteria related to accident safety and to maintenance. The long term activation rules-out the possibility of "hands on" recycling, but SiC/SiC could be recycled by remote handling.

Activated Waste

A classification of fusion activated wastes, based on limits on the contact dose and on the decay heat per unit volume, has been proposed. Three classes of wastes, Low, Medium and High Level, have been identified. This classification was applied to the waste from three fusion machine designs.

Breeding blanket

The conceptual design of a Lithium-Lead, Water cooled breeding blanket with circular channels for breeder containment, intended for a demonstration power reactor, was completed in view of its comparison with an alternative solution developed at the French CEA involving boxes for the breeder containement.

Environment

A feasibility study of the Centre for Earth Observation (CEO), a project collaboration between JRC and ESA, has been pursued. The objective of the CEO is that of setting up a distributed international network for earth observation and related environmental information, linking data centres of expertise and data users. The feasibility study of the project is foreseen to be completed by summer 1993.

Support has been given to various Remote Sensing projects in the area of data visualisation, namely a world mapping software, a 3-D visualisation system and a 3-D topography display.

Exploratory Research

High Sensitivity Interferometric Sensors

The 1992 activity was devoted to the characterisation of the two sensors discovered the year before, namely:

- a sensor for temperature variation measurements (non-contact), capable to detect temperature gradients much lower than 10^{-3}°C. Calibration of the device is made by image processing techniques
- an all optical interferometric modulator, with high sensitivity and low response time, suited for opto-electronics applications.

An optical transducer extremely sensitive to small variations and to gravitational interactions between masses in movement, has been also developed. Theoretical evaluations indicate that this transducer is capable to detect micromovements of the optical table where it is placed having amplitudes of the order of 10^{-20} times.

Neural Networks

Image Classification for Land Cover Mapping

Some tests were performed to see if improvements in classification accuracy could be achieved by using hybrid classifiers based on a combination of the multilayer perceptron model (MLP) with other methods. MLP networks were combined with Kohonen Learning Vector Quantization networks (LVQ). The results show that the prior use of the MLP network to pre-set class separation surfaces in feature space makes it easier for the LVQ method to adapt its own model of the image class characteristics.

A collaboration was established with the National Remote Sensing Centre Limited, UK, for the commercial exploitation of the neural network techniques to remote sensing.

Robot Path Finding and Navigation

One approach to controlling robots is to generate feasible paths to a target destination in real time by means of a reinforcement-based reactive system, whose main component is a neural network. Tests on a prototype have shown that this robot learns extremely quickly, exhibits good generalisation capabilities, copes with dynamic environments and adapts itself easily to new environments.

The data integration capabilities of neural networks are an important asset to take advantage of the ultrasound sensor spatial redundancy and overlapping, in order to obtain better environment descriptions or to guide the robot among obstacles. Simulation tools have been installed and tested in different computing environments.

Signal Detection in Information Sequences

The objective of this research is to develop methods for the production of atlases of signals in information sequences.

Two types of information sequences have been selected, genetic sequences and abnormal event sequences observed and recorded in nuclear power plants.

The detection of repeat singnals has been formulated as a statistical hypothesis testing and the estimation problem has been adressed by the likelihood ratio principle. The approach has been applied in the aminoacid sequence of one of the structural proteins of Antherea Poliphemus to produce an atlas of the repeat signal realisations in the sequence.

Development of a similar approch to event sequence has started by taking data of an Abnormal Occurences Reporting System designed and managed in the past at Ispra.

Co-Evolution in Computer-Supported Scientific Team Work

The aim of the project is to set up a workbench capable of enhancing the co-evolutive capabilities of distributed work performed by a scientific team. During the year various preparatory actions have been undertaken, namely the analysis of four JRC research projects, that of work processes of an Organisation outside the JRC and the identification of available groupware adapted to R&D work processes and mapping the selected groupware to the requirements for co-evolution in order to assemble the workbench.

Support to the Community Policies

Industrial Policy (DG-III)

World Shipbuilding Data Bank
The data system has been modified and upgraded from the mainframe to a Unix environment. The annual statistics data production has been pursued.

Transport Policy (DG-VII)

Aircraft Incident Data Base
The specifications of a prototype of the European Coordination Centre for the mandatory Aircraft Incident Reporting Systems (ECC-AIRS) have been developed and a functioning prototype solution is under development.

Environmental Policy (DG-XI)

Major Accident Hazards
The Community Documentation Centre on Industrial Risk (CDCIR) is now well established. It diffuses information on safety regulations and reports on accident investigation, analysis of chemical emergencies and comparisons of safety regulations and standards. A computer data base to supply to the public information on the CDCIR activity is under testing. The Major Accidents Reporting System (MARS) has been redesigned since the notification procedures have been modified.

Biotechnology Hazards
An activity has started to technically support the implementation of two Directives on the contained use and on the deliberate release into the environment of genetically modified organisms. Similar support is given as for the Major Accidents through a Biotechnology Information Centre and by registration of Biotechnology Accidents with a structure similar to that of MARS.

Civil Protection
The construction and demonstration of specific workpackages of a Pilot Communication and Information System for civil protection was completed early in the year. After installation in eight end-user sites, specifically in the civil protection national Centres of the member States, the system has been in pilot operation for a period of nine months.
A workshop on Emergency Management was organised at Ispra in June in view of the preparation of a Conference on Natural Disasters to be held in October 1993.

Telecommunications, Information and Industrial Innovation policy (DG-XIII)

Advanced Networking
Support work has been performed in framework of the planning for the successor of the IXI X.25 backbone network connecting the national academic networks and in conjunction with the European Consultative Forum of research networks. The definition of a pilot satellite network capable of connecting the JRC sites to other sites involved in remote sensing and environmental activities has been worked out in collaboration with ESA and industry.

Parallel Computing Applications
Several enhancements of the 3-D image ray-tracing techniques and radiosity software have been implemented on the T-Node and CUBI 9000 parallel computer systems. Work is also in progress to implement on the same computers the SPACE software, intended to visualise NOAA satellite images on high resolution peripheral devices and to perform all the necessary corrections needed for users exploitation, in particular in the agricultural field.

Image Processing and Synthesis for Holograms
Image Synthesis and Processing Techniques applied to the synthesis of holograms to reconstruct real scenes are under development. The image synthesis software, already implemented in the T-Node computers, was transferred to the CUBI System. For the hologram synthesis a number of mathematical formulations, based on the fast transform principle, have been developed. Various techniques have been used for image compres-

sion up to a reduction factor of 1000 without any significant loss in the released information.

Energy (DG-XVII)

Renewable Energies and Energy Saving

THERMIE PROGRAMME

The JRC support to the Commission for the demonstration projects within the THERMIE programme concerns Solar Photovoltaic/Thermal Systems, Buildings and Transport Sectors.

During 1992 monitoring data from over 20 photovoltaic demostration projects have been analysed and presented in more than 60 intermediate and final performance reports. The data are stored online on the ESTI Sunsparc-10 computer; they constitute the world's largest data base on photovoltaic operational data. Also evolution of the technical part of new proposals, analysis of progress reports and updating of the SESAMO data bank has been performed.

A Tele-Monitoring System which allows remote interrogation of the data emerging from individual active and passive solar systems has been developed, in order to provide contractors with a common approach to the storage/monitoring data and programme managers with a direct way to judge the correctness of a project without visiting the site.

Guidelines for the presentation of intermediate and final project reports have been also prepared.

RESEARCH ON BUILDING PARAMETER IDENTIFICATION METHODS

Building Parameters Identification methods are being investigated by experiments conducted on four occupied multi-appartment buildings in Varese. The 1992 campain was devoted to investigating the problems related to the non-linear relationship between the input energy and the useful energy supplied to the building's wall in particular those associated to the effect on the internal temperature of the sensor position when the heat distribution between floors is not well balanced. A calculation model has also been set up to check the measurement results and to assess the effects of the internal temperature distribution and free gains on internal parameters. The heating plant of one of the buildings was monitored with a time step resolution of one minute. Results have shown that inertial effects associated with transient periods are signficant. Comparison with the theoretical models indicate a coherence in the trends but large deviations in single points. The internal temperature of all the thermal zones was calculated by the TRNSYS code. The results of the

comparison with the measured data are satisfactory. The programme MRQT was used as an identification tool. From the identified parameters it was found that large errors can occur.

APPLICATION OF IDENTIFICATION METHODS TO SOLAR TEST CELLS

In the frame of the PASSYS project, mathematical tools using identification techniques for the assessment of thermal parameters of solar thermal cells have been set up. The intention is to promote together with other techniques and design guidelines, the application of passive heating and cooling.

SAVE PROGRAMME

In the frame of the activities to promote processes capable of generating options, demand-side management measures and purchase/sales that enable a utility to meet society's energy needs at the lowest overall cost (Least Cost Planning), the American data base code on Energy Efficiency Programmes DEEP was analysed and comparison made between European and American demand-side management conditions.

EURATOM Safeguards

Various systems have been developed in the field of optical surveillance.

COMPUTER AIDED VIDEO SURVEILLANCE (CAVIS)

The first single rack version of CAVIS-2S has been installed in the field and it is operating in routine use. CAVIS provides an unique combination of video recording and logging of relevant events into a data file.

COMPUTER AIDED REVIEW STATION (CARES)

A dedicated station for reviewing video tapes recorded by the CAVIS 2 systems has been developed. The CARES system is designed for operation outside the plant and consists of two light weight table-top racks.

REVIEW STATION WITH DIGITAL STORAGE

This development is preparing the next generation of systems for safeguards review of video pictures. It is based on a digital storage unit with image compression and decompression. A scene change detection system will trigger the storage unit to dump alarm scenes.

Community Statistical Office

Statistical Applications of neural networks

Applications of neural networks have been made in the fields of automatic classification and unsupervised

clustering. A connectionist model called Kohonen Map, has been used and enhanced for the purpose of achieving a reduction in the complexity of data sets of socio-economic feature vectors. Another application was that of estimating missing data in yearly foreign trade statistics. Other theoretical studies have been carried-out, where the neural network model called Multilayer Perceptron is viewed as a nonlinear regression model.

Secretariat-General

Management of the Parliamentary Petitions
An ORACLE data base for the management of petitions to the Parliament was set-up in 1991 and designed to run in a multi-server environment. This data base has been revised during the year to satisfy the User Service and installed in Brussels for implementation and operation in 1993.

Anti-Fraud Work Programme
Following the revision of the Anti-fraud Documentation Data Base (DAF) and first experiments with the DAF collection exercise, a number of work packages have been analysed to produce a formal document model for each document type and a set of authoring conventions so as to enable an automatic conversion of word-processed files and drawings into structured text and graphics files.

Third Party Work

Non Nuclear Energy

Several contracts have been gained in the solar components area, by exploiting the capability of the ISEI-Solar Test Facility (ESTI). Most revenue came from photovoltaic module qualification tests for industrial companies and from calibration of reference devices.

Environmental and Industrial Risk

The following contract services have been performed:
- Critical review of models to describe the environmental impact and the risk consequences of accidents in the process industry (ISPEL, Italy).
- Use of laser holographic interferometric and acoustic emission on a section of aircraft fuselage undergoing fatigue damage (Agusta-SIAI Marchetti, Italy).
- Statisical Analysis of data stored in the Component

Event Data Bank of an electric power station (ENEL, Italy).
- Decision Support Systems application for the management of planning and control of the cleaning up of the river Po (Italian Ministry of the Environment).
- Decision Support System application for the rational management of toxic and noxious industrial waste on regional scale (Italian Ministry of the Environment).
- Qualitative evaluation of the risk related to rail transport of propylene (Himont, Italy).
- Risk of road transport of dangerous goods (CINEAS, Italy).

Computer Aided Engineering

- Application of Computer Aided Engineering design for various industrial Companies.

Participation to EUREKA Projects

Formentor

This project is developing realtime decisions support systems to help operators of complex hazardous plants. ISEI is one of the partners of the project. During 1992 the activity was mainly concentrated in one of the pilot applications of the project, the Petrochemical Application, involving the development of a multilayered functional model of the target plant, a Butadiene extractive distillation plant in the UK. Major software integration and tests have been completed. Another FORMENTOR pilot system was finished during the year. The system was developed as a case study to test different formalisms for system modelling and different systems architectures. The first version of the FORMENTOR toolkit was also developed, as well as the finalisation of the first version of the FORMENTOR Handbook.

Special Commission Projects

Euro-Quebec Hydro-Hydrogen Pilot Project

The 100-Mw pilot project is intended to demonstrate the provision of a clean and renewable primary energy in the form of hydropower, converted via electrolysis into hydrogen and shipped to Europe, where it is stored and used in different ways, as electricity/heat

cogeneration, fuel cell operation, power/drinking water generation, steel fabrication, public transport and aviation propulsion. The energy vector is liquid hydrogen LH_2. The project is sponsored by the Commission and the Governement of Quebec, Canada. The JRC is in charge of the coordination of the project which is carried out through contracts to industrial firms and institutions. The present phase concerns the design specification of the system and the implementation of the hydrogen application demonstration sub-projects.

During 1992 a number of contracts on the operation of components have been finalised in the areas of public transport, aviation propulsion, steel fabrication, cogeneration and storage technology. New contracts have been launched for improvement of a fuel cell boat for inland navigation, and an LH_2-fuelled cogeneration unit with fuel cells. Study contracts investigated the feasibility of Shanno (Ireland) as an European Centre for the reception of clean energy, improvement of hydrogen liquefaction and vaporisation, an environmentally neutral fuel production road transportation concept (methanol), operational management system for hydrogen buses and transatlantic power beaming with a satellite system.
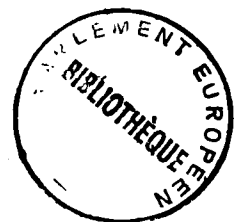
2 SPECIFIC PROGRAMMES

Reactor Safety

Safeguards and Fissile Materials Management

Industrial Hazards

Reference Methods for Non-Nuclear Energies

Reliability for Structures

Fusion Technology and Safety

Environment

Working Environment

2 SPECIFIC PROGRAMMES

REACTOR SAFETY

The general objective of the work is the development and/or assessment of methods to control the level of safety of a Nuclear Power Plant (NPP) over its life. The work is based on the use of probabilistic approaches. It aims at extending and strengthening the so-called "Living Probabilistic Safety Assessment" (PSA) approach.

Three aspects of plant safety are considered, as single contributors and in their interactions: the engineering systems, the structures and the control and management. The grounds for this are the growing importance of the PSA approach for the NPP design and optimisation of plant operation, human and organisational factors in safety management, and the impact of aging of components and structures on plant safety margins. The final target of the research is the development of an integrated set of software tools, capable of dealing with the three mentioned contributing elements to plant safety.

Research activities related to reactor safety are the following:
- Knowledge Based Systems (KBS) oriented to living PSA, to support safety and reliability management
- Statistical analysis of data on plant operating experience
- Man-Machine Interface simulation tools and dynamic process studies
- Realisation/up-dating of databases related to safety and reliability evaluations
- Structural Reliability.

Research activities are performed in collaboration with national research centres, safety bodies and industry.

Knowledge Based Systems oriented to living PSA, to support Safety and Reliability Management

The objective of this activity is to study how information in a Probabilistic Safety Assessment (PSA) could be restructured and complemented with other safety related information, e.g. feedback from experience, monitoring of the evolution of risk over the plant life and support to risk management or reliability management related decisions (e.g. backfits or maintenance planning).

The approach is based on:
- the restructuring of the information contained in a PSA into an explicit declarative plant model that can be easily accessed and updated
- the use of the model by Knowledge Based Systems to deduce information on the plant's safety state.

The activity builds upon experience gained in two major projects: the European Reliability Data System project - in which the Component Event Data Bank (CEDB) and the Abnormal Occurrences Reporting System (AORS) were developed - and the STARS project, a research project on the use of KBS in safety and reliability analysis.

The plant model

Much of the effort spent until now in the research project was devoted to the question of how to represent in a structured way the complex information contained in a PSA or reliability analysis. The solution adopted was to subdivide this information into a functional model, a structural model and an operational experience feedback model. All three models are implemented as sets of objects in three corresponding Knowledge Bases (KB's). The overall architecture of the plant model and its creation and accesses are shown in *fig. 2.1.*
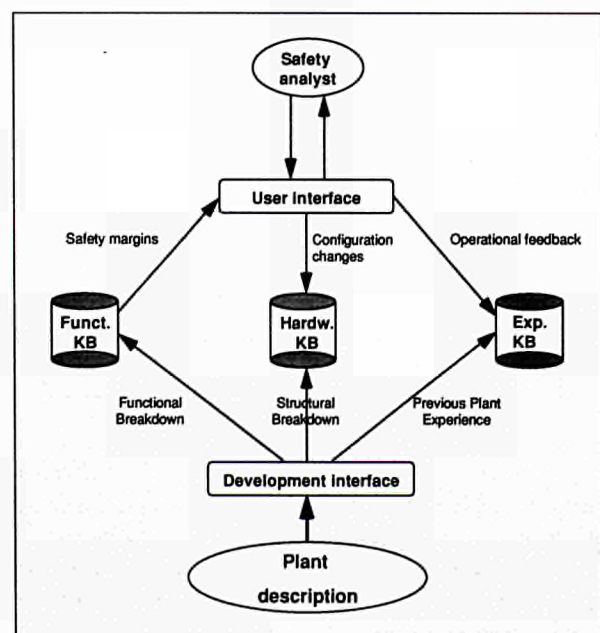

Fig. 2.1. Overall Architecture

The functional model represents the (safety) functions in the plant and gives information about which functions are required under different scenarios, which systems perform the function in a given scenario and which are the success requirements to these systems.

The structural model represents the hardware breakdown of the plant. It follows the hierarchy:
1. plant
2. unit
3. system
4. subsystem (optional)
5. aggregate
6. component
7. piece-part (optional)

Events that occur during the life of the plant can be stored in the plant experience KB. This KB is different from a conventional reliability data bank in that it collects events at the various levels identified in the hardware breakdown, and models how a specific event is "seen" by each of the levels concerned /1/2/.

Use of the plant model

A first application is being studied /3/ (see fig. 2.2) in which the plant model is the backbone of a tool that provides the safety analyst with a dynamic picture of
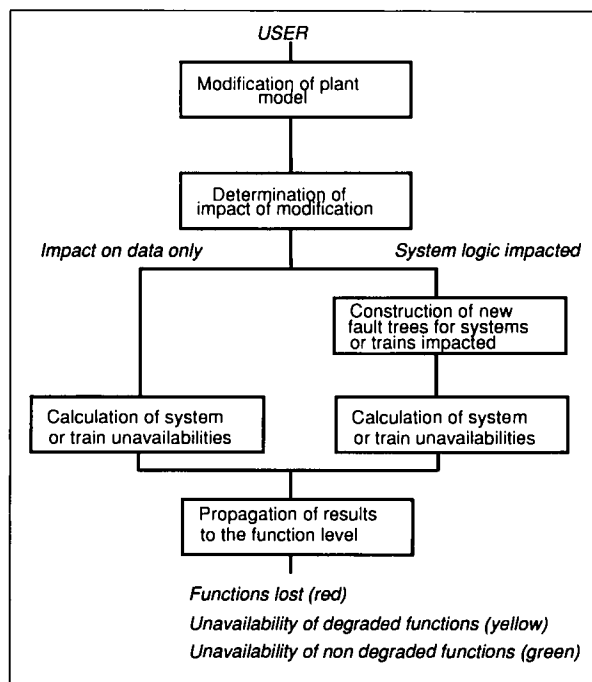

Fig. 2.2. Risk Monitoring

how the calculated risk evolves during the lifetime of the plant, given that the plant undergoes modifications and given that more and more plant specific evidence becomes available. Some of the STARS modules are used to create the plant model, to interface with it and to update the reliability models and the calculations of the (un)availabilities of safety functions in case of modifications or new evidence.

The approach is currently being implemented in a prototype that runs on workstations. The prototype will be tested on a pilot application representing a simplified plant with a limited set of safety functions and simplified system diagrams.

A first validation of some of the tools was made by using information contained in the Surry PSA. This validation also demonstrated the potential of some of these tools to be used for quality control and formal certification of safety assessments.

In another application, the model together with RAMS (Reliability, Availability, Maintainability, Safety) analysis tools will be used to support RCM (Reliability Centred Maintenance) techniques.

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Statistical Analysis of Data on Plant Operating Experience

The major difficulty in the use of raw reliability data for purposes of estimation and/or testing for heterogeneities between different component populations (data suppliers, component types, etc) arises from sparsity in the data. Sparsity is due to two sources: the high detail in which events are recorded and the rarity of events observed, due to the high reliability of components.

"Intelligent selections" (IS) eliminate most of mostly empty codes (or combinations of codes) for variables (or

combinations of variables) in order to dispense with heterogeneities caused by rare codes. /1/ presents in summary the application of IS to define the taxonomy of a reliability data-book for electric motors.

So far, (IEEE Std 500-1984, the T-Book, OREDA) data available and accessible in databases have not been exploited to define taxonomies which have instead been specified solely on the basis of opinions of experts and prior to data collection. IS may be considered by statisticians as suggested by the data themselves. In applications, they have been accepted eagerly by subject matter experts on the basis of subject matter considerations.

In the classical and parametric framework, failure rates of groups of components are assumed to be equal (homogeneity assumption within each group). This assumption is difficult to accept a priori and it has been seen /2/ that in the presence of heterogeneity, it produces a dramatic underestimation of the mean failure rate in the group. Population variability can be modelled by the compound model. Failure rates of components are assumed to be independently sampled from a distribution that Bayesians may prefer to call prior but that has a sampling interpretation. A failure rate is sampled for each component from this prior. Given the failure rate for each component, the number of failures in the hours the component operated is assumed to be a Poisson variable. In the context of this model, for the observed failure times of a group of components, two estimation problems are posed: the estimation of the average population failure rate and the estimation of the failure rate of individual components given the operating experience of other components in the group.

The first problem has been addressed by the minimum variance unbiased estimation approach (MVUE). We have derived MVU estimators of the population mean of the failure rate based on classical individual component estimates. The estimators are derived by Lagrange multipliers and are carried out in two stages, the first stage based on preliminary estimates of the mean and variance of the population failure rate. Two different choices for the preliminary estimates have been derived, one of them being the OREDA estimator /2/.

For the second estimation problem, the optimal estimator in the mean square error sense is what would be the Bayes estimator if the population distribution of the reliability parameters (the prior) were known. As there is very little basis to make a choices for the prior distribution, the empirical bayes (EB) approach has been taken

and new implicit EB estimators for individual components have been derived. They are based either on the application of the method of Robbins or to the expansion on a fraction of Laplace integrals /3/.

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Man-Machine Interaction and Dynamic Processes Study

At the beginning of the year 1992 the activity relating to the System Response Analyser project, developed during the years 1989-1991 and dedicated to the integrated study of man-machine systems was concluded. A rather comprehensive application of the SRA concept to the analysis of the Chemical and Volume Control System of a PWR was issued /1/. Fig. 2.3 presents the schema of the system analysed.

The leading theme of the 1992-1994 FWP on Reactor Safety is the safety of aging plants and the development of methodologies oriented to living PSA. Within these guidelines, the contribution of the MMI (Man-Machine Interaction) sector to the 1992-1994 FWP is focused on the valorisation of the experience acquired in the past and on the development of two main themes of research in the domain of dynamic reliability methodologies for a) the analysis of systems and b) the analysis of operational and emergency procedures and human errors. Both activities are based on the use of the DYLAM code, for the dynamic reliability analysis of systems.

In the course of 1992 the manual of the new version of the code, namely DYLAM-3, has been issued /2/. The validation of the DYLAM methodology and the comparison with the classic tools existing for the reliability analysis of systems has continued. The investigations, that DYLAM permits, have been compared in detail with the results obtained using the Fault-Tree Technique /3/. Concerning the methodological aspects, it appears that

Monte Carlo sampling techniques coupled with the physical simulation of the system looks also a promising way to address the problem of dynamic reliability analysis /6/.

The coupling of the DYLAM programme with the TRETA (Transient REsponse Thermal-hydraulic Analysis) package for the simulation of systems, has been finalised /5/. This work started in 1991 in the frame of an established cooperation between ISEI and the Consejo de Seguridad Nuclear, the Spanish Nuclear Safety Authority that developed TRETA. The DYLAM-TRETA package permits the use of the DYLAM code for the analysis of real complex systems with the simulations that can be easily developed with TRETA routines. In particu-

lar, the application of the DYLAM-TRETA package to the analysis of a Steam Generator Tube Rupture (SGTR) incident in a PWR has been initiated. This kind of initiating events is particularly severe for some existing old plants that do not have redundant configurations of steam generators. The SGTR study with the DYLAM-TRETA package will continue at least for the whole year 1993.

Finally, some more methodological problems connected to the DYLAM-TRETA project and, in general, to the application of dynamic reliability techniques at plant level for the automatic generation of dynamic event trees, have been addressed /4/. The study will also include the analysis of human factors in an integrated way.
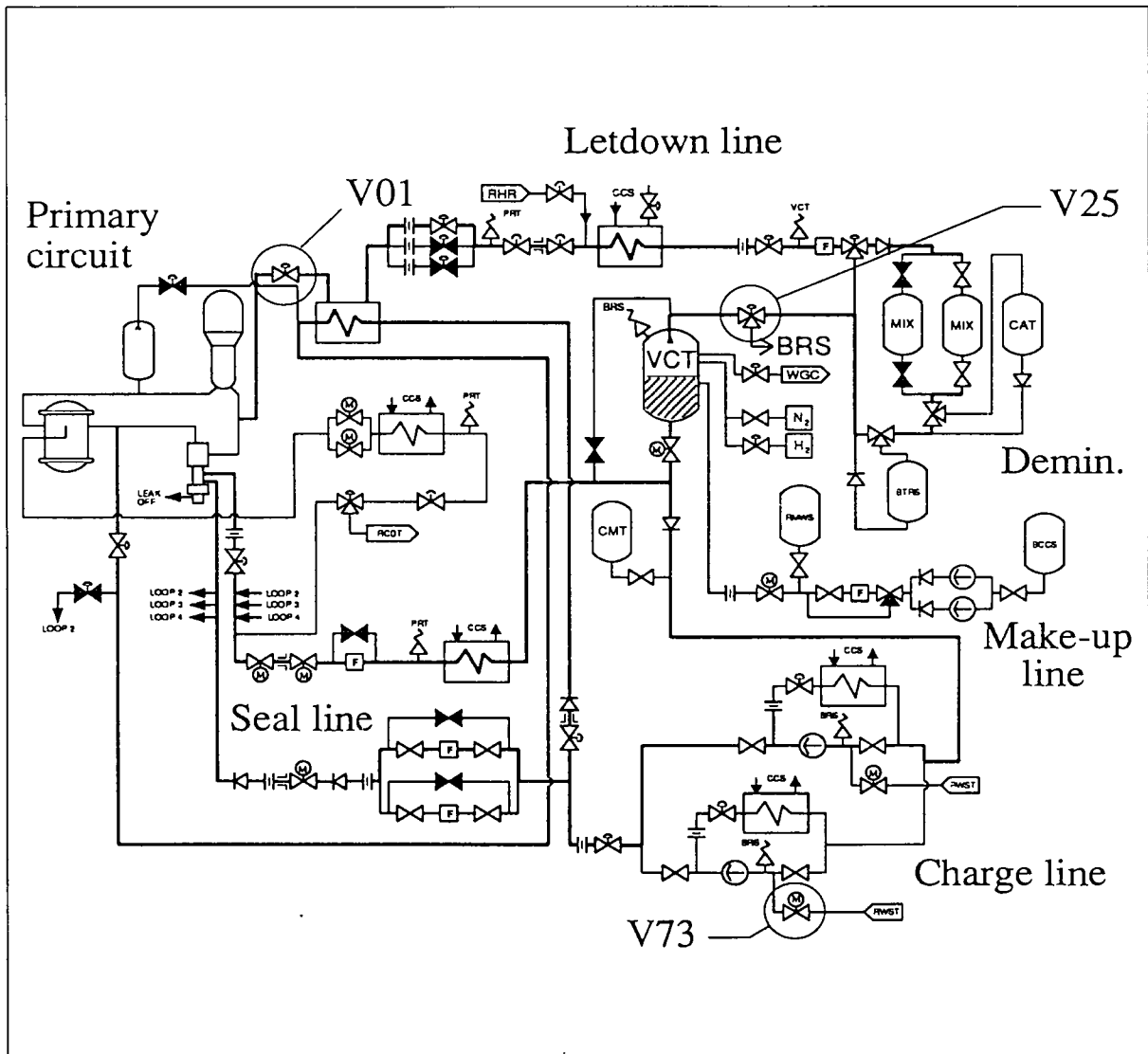

Fig. 2.3. Scheme of the Chemical and Volume Control System of a PWR

References

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Realisation/Maintenance of Databases related to Safety and Reliability Evaluations

Re-ordering of CEDB after the end of its operation as a centralised data bank

The CEDB (Component Event Data Bank) is a data bank storing data on component failure events, collected in various European NPP's. As of December 31st, 1991, it stored 6323 failures, related to 7709 components, for a total observation time corresponding to 43584 comp.years. From January 1st, 1992, the operation of the Component Event Data Bank - CEDB, as a centralised Data bank, is no longer supported by the Commission under its 92-94 Framework Programme. In addition, the JRC Mainframe Amdahl, on which the CEDB was running, has been phased out of use. The Amdahl ceased operation as of 30th June 1992.

In 1991 a question was raised concerning the conservation and use of the existing data sets. During the 9th Meeting of the CEDB Steering Committee, held on 18-19th November 1991 at the JRC Ispra, the following agreement was reached:

– The JRC will distribute to all members of the CEDB Steering Committee (S.C.) a copy of the data files stored in CEDB at the end of 1991. The use of these data files is bound to the confidentiality rules of the document "Rules for CEDB operation". No commercial use is allowed.

– The JRC will continue, in the frame of its 1992-94 programme, to perform prototypical analyses of the data sets in order to estimate average reliability parameters. The results will be distributed to the S.C. Members. Analyses are expected to be performed also by the other Members; the results of these analyses will be communicated to all parties.

– All data have been copied from the Mainframe Amdahl into the SUN Server of the MMI Sector /1/ /2/. Data can be accessed by authorised members of ISEI only. These data will be used by ISEI to support its research activity, e.g. the development of methods for the estimation of component reliability parameters.

According to the above mentioned agreement, a copy of the CEDB database has already been distributed to the following Members of the CEDB Steering Committee: Vattenfall-ATV (S), EdF-DER (F), ENEL-CRTN (I), KEMA (NL), Nuclear Electric (UK) and UNESA (E).

In the framework of these actions aimed at re-ordering all the CEDB situation, the transcoding into the CEDB format of a set of data on complete failures (observation period 1983-1989), supplied by SRDF-EdF (Systhème de Recueil de Données de Fiabilité - Electricité de France) during the period 1990-91, was performed. According the CEDB definition, a complete failure is defined as "a failure of the component which causes its contemporary unavailability and total loss of its main function, due either to a spontaneous failure of component part (s), or because of the automatic intervention (shutdown) of the component protective system, or because of the manual shutdown of the component (performing outside of its specifications) to avoid a more serious damage to the item". According to the importance, for system/plant safety, of the function performed by the component in a specified system/plant state, a complete failure can possibly be regarded as a "critical" failure, from the safety point of view. All this taken into account, it was considered of interest to the safety analyst to have available a database storing data on a remarkable number of complete failures. This database, named CEDBC, was realised by putting together part of the CEDB content (the part related to the characterisation of components that had complete failures, the description of their complete failures, their annual operating time/cycles) and the above mentioned transcoded data set.

The CEDBC, as the CEDB, has been stored into the Server of the MMI Sector, with the same restrictions on access /3/4/. A copy of the database was sent to the above mentioned members of the Steering Committee.

Realisation of an improved version of CEDB for PC

In the framework of a collaboration contract with ENEL-CRTN (Member of the former CEDB Steering Committee), some support is being given to CISE/ENEL in the design of a first version of CEDB for PC. ISEI made available all the programmes related to CEDB running on Amdahl and is giving assistance to ENEL-CRTN. The latter takes care of the design and implementation. This first version for PC will have the same features of the CEDB for Amdahl. The following step will be the revision of all the CEDB structure, e.g. to make it capable of storing information related to preventive maintenance, and the data analysis programmes presently included in the query procedure.

Maintenance of various Databases related to NPP safety and reliability

Copy of the following databases is made available to the members of JRC staff:
- Incident Reporting System (IRS by OECD) (Balestreri, Carnevali, 1992) /5/,
- Nuclear Computerised Library for Assessing Reactor Reliability (NUCLAAR by INEL),
- Power Reactor Information System (MicroPRIS by IAEA),
- Significant- Event Compilation Tree (SECT by OECD),
- Nuclear Power Plant Data Collection Scheme (NPPDCS by OECD).

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Structural Reliability

Experimentation

In the first semester of 1992, phase 2 of Pressurised Thermal Shock Experimentation has been completed. During this phase, 500 thermal transients (heating up to 300°C, quick cooling by injecting 10°C water; varying internal pressure from 3 to 0 MPa) have been performed. The main difference between phase 2 and the previous phase 1 of the experiment, lies in the different way in which the internal pressure of the vessel was applied. In phase 1, the internal pressure was maintained at a constant value during the thermal transient, whereas in phase 2, the internal pressure was varying during each thermal shock. The variation of the pressure permitted an increase of the Stress Intensity Factor Range VK, applied at the crack that had been artificially (by electroerosion) introduced at the nozzle corner. At the end of phase 2, non destructive techniques of inspection (ultrasonic measurements) showed that, as clearly foreseen by predictive analysis, no significant propagation of the artificial crack had occurred. This can be attributed to two factors:

- the sharpness of the front of the artificial crack was not as high as that of real fatigue cracks, so that some hundreds of thermal transients were necessary to initialise propagation;

- the material of our test piece did not undergo any irradiation embrittlement; consequently its fracture toughness remained higher than the applied Stress Intensity Factor (caused by the combined action of the thermal shock and the internal pressure at the nozzle corner). Results of phase 2 confirm that thermal shocks are not dangerous in case of volumetric defects and low irradiation. Phase 3 of the experimentation has been designed to reach critical conditions at crack front by means of two actions:

- a special device (heavy actuator) has been designed and manufactured during the second semester of 1992. This actuator, placed inside the vessel in a position orthogonal to the nozzle, is able to produce high mechanical straining at the nozzle corner crack. It is being used, in a preliminary step of planned phase 3, to submit the vessel to cyclic mechanical loading alone, to produce, from the existing artificial crack, a fatigue crack of suitable dimension and sharp front. The monitoring of this experimental step is performed by 24 strain gauges and 2 crack gauges and by acoustic emission sensors.

- In parallel with the activities described above, a study has been performed for the simulation of irradiation effect on fracture toughness by shifting the thermal shock temperature range towards negative values. The fracture toughness being an increasing function of temperature, lower values of temperature induce lower values of fracture toughness. To this end, a small experimental device has been manufactured to check, on a spare nozzle, the feasibility of a cooling device based on liquid nitrogen. The results obtained showed that the temperature at the depth of the crack front was approximately −100°C with a very steep temperature gradient through a surface layer of 5mm. Since these values induce a high straining and a fracture toughness low enough to obtain critical crack growth of the nozzle corner crack, phase 3 of the experimentation will be performed in this temperature range.

The results obtained, in collaboration with ENEL-CISE, on modelling of environmentally assisted fatigue crack propagation on pressure vessels, have been presented in a specialised conference /1/.

The knowledge based system BOSS (Backtracking and Overviewing for Structural Safety)

The installation and check of hardware (Sun Workstation Spark II) and software (Nexpert Object; PVWAVE) necessary for the development of BOSS, have been completed. The development of the interface with the Data Acquisition System and of the pre-elaboration software (for low level control and display) has been basically done, using existing software for PVWAVE, too. Some programming efforts are still necessary for the dynamic visualisation of the structure on Sun Workstation display (completion expected for the spring of 1993). Integration between KBS and standard engineering software: the state of the art is characterised by implementations based on shallow coupling, i.e. coupling architectures enabling only a fixed scheme of interaction.

Our efforts are towards an integration architecture allowing a deep coupling, i.e. giving the KBS the capability of modifying the interaction scheme. Some software packages relevant to structural reliability (namely COVASTOL, RELIEF, FITPAR, FORM-SORM) are being coupled with KBS BOSS.
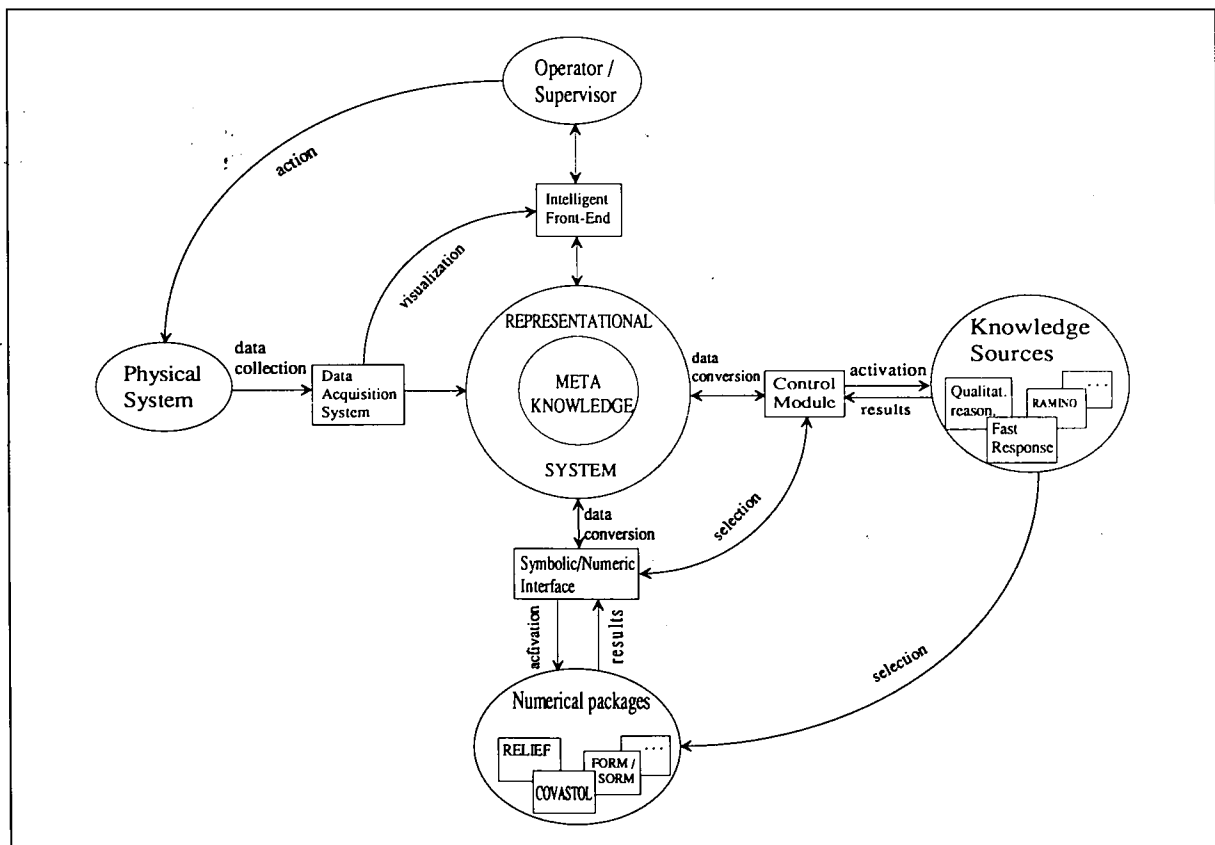

Fig. 2.4. The architecture of BOSS

The activity on knowledge representation has been aimed at evaluating the feasibility of a meta-knowledge base to be shared by all the modules of BOSS. The deep coupling architecture mentioned above may be seen as a first trial of implementing a meta-knowledge base. The state of art of qualitative representation of knowledge and qualitative logic has been reviewed and their use foreseen for coping with situations needing a fast answer from BOSS. A sample case is being implemented based on PTS testing facility. (The architecture of BOSS is shown in *fig 2.4*).

The results on the development of the expert system ARTIC ,for creep damage assessment and lifetime prediction, have been presented in /2/.

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SAFEGUARDS AND FISSILE MATERIALS MANAGEMENT

Integration of Safeguards Techniques

The activities performed in this research area are oriented towards two directions: one is the development of tools for the evaluation of the nuclear fuel cycle, the trend of safeguards R/D activities and the management of ESARDA which is a wide ranging R/D association in EC. The second direction concerns the planning and evaluation of experiments for evaluating performances of mass and volume measurement in liquids.

Data Base on Nuclear Fuel Cycle and R/D Activities

The establishment of the nuclear fuel cycle data base on existing facilities in EC has been continued. After the review of the data on power reactors, the effort has been concentrated on introducing the description of bulk handling facilities.

Concerning the EC safeguards R/D data base, ESARDA partners have continued to supply the required data for the 1992 updating.

Furthermore an analysis has been conducted with the ESARDA partners on the R/D activities related to destructive and non-destructive techniques and the results of this analysis are to be published in the ESARDA bulletin.

Management of ESARDA

The management of the European Safeguards Research and Development Association was performed through the general secretariat, held by ISEI staff. In particular, support was provided to the organisation of the internal meeting held on May 5-8, 1992, at Salamanca (Spain). This meeting, which was attended by aproximately 110 persons, discussed two important subjects, namely:

– Containment and surveillance safeguards techniques applicable to the intermediate and long term storage of irradiated fuels
– Non-destructive assay techniques applicable to safeguarding nuclear materials in waste

Mass and Volume Measurements

The construction of the Tank Measurement (TAME) facility has been continued and is oriented to cover a wide range of tanks used in nuclear reprocessing plants. The mechanical set up of the annular tank ($15m^3$) has been completed as well as the hydraulic circuitry. The instrumentation for the remote operation of the facility and for the measurements of different parameters (e.g. temperature, water flow, dip tube pressure) are in the final phase of installation. The TAME project is a joint project executed between the Institutes of Safety Technology (IST) and of Systems Engineering and Informatics (ISEI). On March 25-27, 1992, an expert meeting was organised at Ispra on "R/D for Volume and Mass Determinations in Liquids". This meeting was intended to review the needs of the nuclear industry in this particular technology area, to collect suggestions on the possible activities of TAME and to explore the feasibility of bilateral and/or multilateral collaborations. The meeting was attended by representatives of all present technology holders of reprocessing plants in EC and Japan, EURATOM and IAEA safeguards Inspectorates, R/D laboratories in EC, Japan and US, which have development programmes in liquid mass and volume measurements.

Containment and Surveillance

The research area of Containment and Surveillance includes in this report two types of activities namely:
– Surveillance and Teleoperations
– Containment and Surveillance Performance Evaluation.

Surveillance and Teleoperation

The objective of the work is the development of surveillance techniques for safeguards requirements and mobile robotics remote verification.

Computer Aided Teleoperation for remote verification
The objective of this project is to explore and demonstrate the use of mobile robotics technologies for the remote verification of a fissile material storage area, i.e., remote inspection and inventory. The system consists of two main components: a vehicle carrying on board a manipulator arm and sensors (TV cameras, laser range finder and ultrasound sensors), and the system's operator console. Special attention has been

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given to safeguards considerations, as well as to the man-machine interface /1/2/.

A major goal of the man-machine interface is to integrate into a single screen all the information needed by the operator. This information can assume different forms: control panels, visual and graphical. A second goal is the provision of tools to help the operator during routine operations.

System's Architecture and Functional Modules
The architecture of the system is illustrated in *fig. 2.5*. It represents the system's operator console, actually a graphical workstation, the vehicle's and manipulator's computers, and the different sensors transported on board of the vehicle. Also represented are the two computer controlled pan and tilt units, as well as the computer controlled zoom and focus lens. The two remote computers run a realtime operating system, supporting the different low level sensor oriented tasks.

Fig. 2.6 represents the system's functional modules /3/. These modules are application oriented and are built on top of a sensor oriented kernel. Communications with both the vehicle and the manipulator arm are achieved via a serial link, managed by a local communications server.

The existing modules are classified according to their functionality :

- Navigation : steering (GUIDE) and mapping (MAP2D and MAP3D)
- Vision System
- Position Monitoring and Calibration
- Arm Control
- Position Authentication.

Vehicle Navigation
The GUIDE module enables the manual steering of the vehicle. Three user interfaces are implemented, two of them more adapted to manoeuvring.

Environment representation is achieved by the MAP2D and MAP3D modules. These modules display 2D and 3D realtime animated views of the environment. Different display options can be selected, such as : view as "seen" from the vehicle, or as "seen" from an arbitrary user-selected point. *Fig. 2.7* shows these tools in an integrated screen.

Vision System
The vision system consists of two TV cameras with computer controlled zoom and focus lenses, mounted on top of computer controlled pan-and-tilt units.
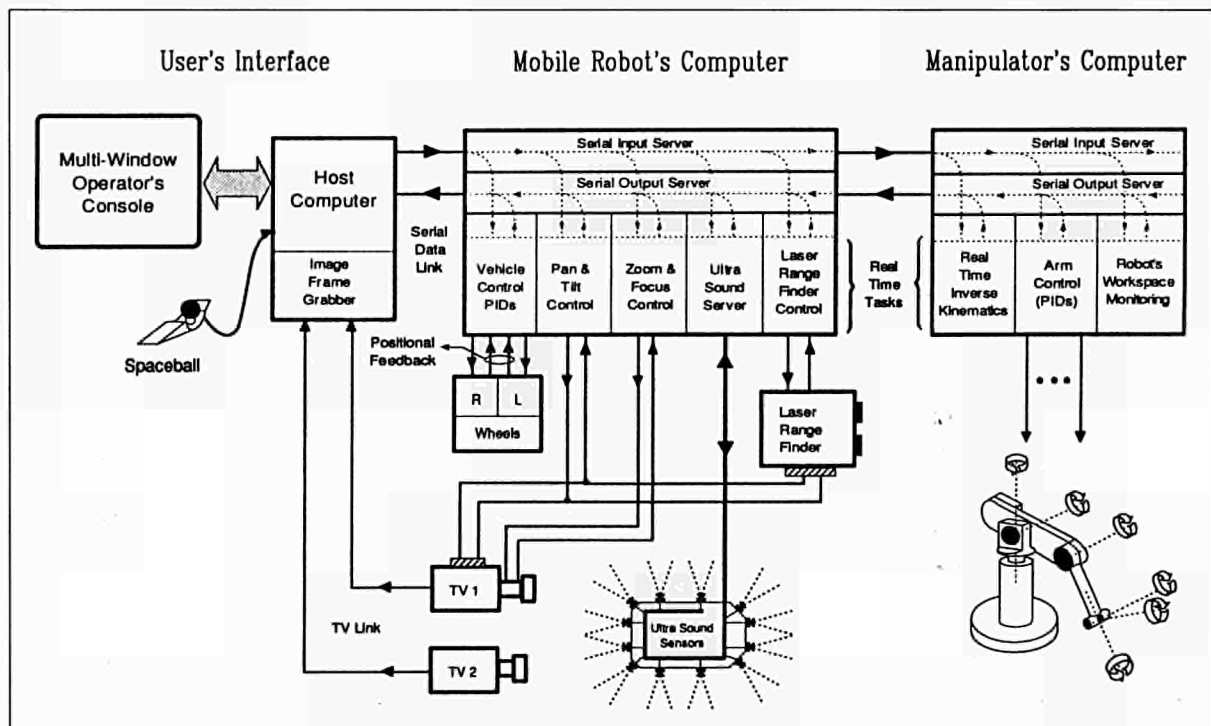

Fig. 2.5. System's architecture

A graphical panel allows the display of up to two quasi-live TV images on the operator's console. Some utilities available are realtime brightness and contrast enhancement as well as remote zoom and focus control.

A computer controlled permanent auto focusing system /4/ has been implemented, relieving the operator from manual focus adjustments while guiding the vehicle.

Position Monitoring and Calibration

Position monitoring is necessary to ascertain the compatibility between the vehicle's real position and orientation, and the values measured by the odometers located at the vehicle's wheels. Several factors contribute to cumulative errors in positional data, e.g. sharp manoeuvres or a rough ground surface.

Two methods are being investigated for position monitoring :

- analysis of geometrical inconsistencies between the environment and the vehicle's representations.
- analysis of range data, provided by the ultrasound sensors.

After detecting position discrepancies, position calibration is mandatory. This module computes the exact position of the vehicle inside the storage area. It relies on a horizontal profile of distances between the vehicle and its environment. This distance profile is measured by the laser range finder /5/. This approach is totally self-contained, i.e. it does not rely on pre-installed active or passive beacons or on local illumination.
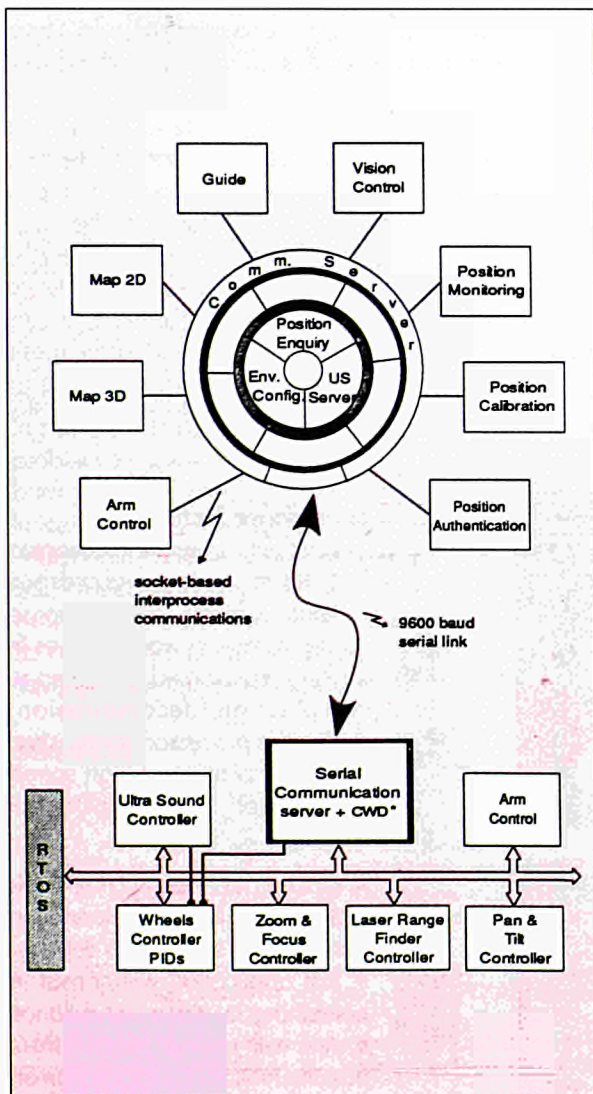

Fig. 2.7. Integration of visual and graphical information into a single screen.

Control of the Manipulator Arm

The operator controls the manipulator arm by means of the Spaceball input device. This device is connected to the workstation via a serial link, and is basically a six degrees of freedom joystick: three for translation and three for rotation.

The workstation sends the positional commands to the computer of the manipulator arm. These commands are input to an inverse kinematics task, which computes in realtime the displacements at each joint axis that correspond to the desired end-effector motion. The joint displacements are then input to the embedded PID controllers that actuate the motors and force the required displacements.

A graphical tool was implemented to provide a 3D representation of the arm /6/. Also implemented is the

Fig. 2.6. Functional modules and software implementation

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arm control panel, from which the operator can set the required motion parameters. An integrated screen of the manipulator arm is shown in *fig. 2.8*. A workspace monitoring task was also implemented. This task performs a direct kinematics computation and checks whether the manipulator is approaching its physical spatial limits. If this is so, the movements of the arm are stopped and the operator is informed.

Position Authentication

The motivation for this work originated from the security measures that are foreseen in a safeguards environment. The objective is to explore the capabilities of the laser range finder, in terms of the authentication of a particular piece of environment.

Range images are acquired from the environment using successive horizontal laser scans. These images are then analysed, and geometric features are extracted. Two approaches have been pursued :
- regions from edges (a region is characterised by delimiting edges)
- edges from regions (an edge is the intersection of two neighbouring regions).

This latter approach made possible the identification of planar regions in the range image. This is shown in *fig. 2.9*, where four faces of an office scene (office, door, cupboard and a file cabinet) have been identified. Image analysis is based on the Split and Merge paradigm. The algorithm starts by dividing the image into planar homogeneous regions, and then finds the final surfaces by an iteratively region merging procedure. The implementation of the algorithm is based on quad-tree structures.

Systems Integration

This has constituted a major component of the work, considering that each sensor requires its own hardware, software and timing characteristics. Furthermore, there is a clear need to separate logically the functional aspects (application oriented) from the sensor aspects (hardware oriented). A major guideline in this project is the use of an Opens Systems philosophy, enabling portability aspects. The system's operator console is built around a graphical workstation running some industry standard software, such as Unix, X-Windows, Motif, etc..

The combination of these multi-processor architecture, part dedicated to the functional aspects, and part dedicated to sensors' interface, proved to be quite flexible allowing for a modular approach at all levels. This is an important aspect since it leaves room for future modifications and/or extensions. Furthermore, an important aspect that cannot be forgotten is that the user's interface must be designed to include the human operator in the loop.

Surveillance Techniques

Several techniques are investigated for a future use in safeguards surveillance systems. They comprise digital storage of video pictures in realtime associated with image compression/decompression, dedicated processors for processing video pictures at high speed and infrared image capture devices.

A second development line deals with the integration of information from different safeguards devices. A first application will consist in combining a video surveillance system with nuclear measurement instrumentation. Collaboration on this item started inside JRC with STI and outside JRC with CEA. A
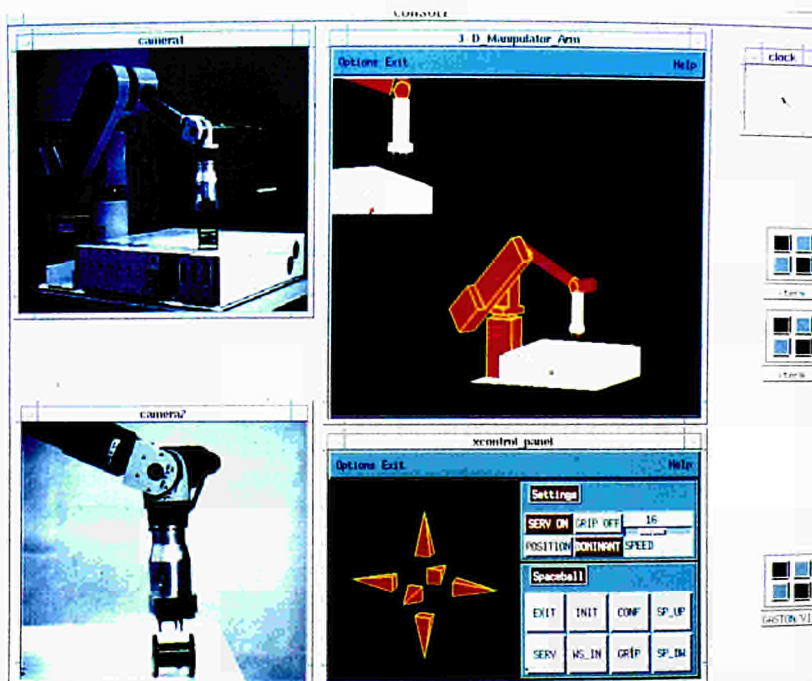

Fig. 2.8. Integration of visual and graphical information for controlling the manipulator arm.
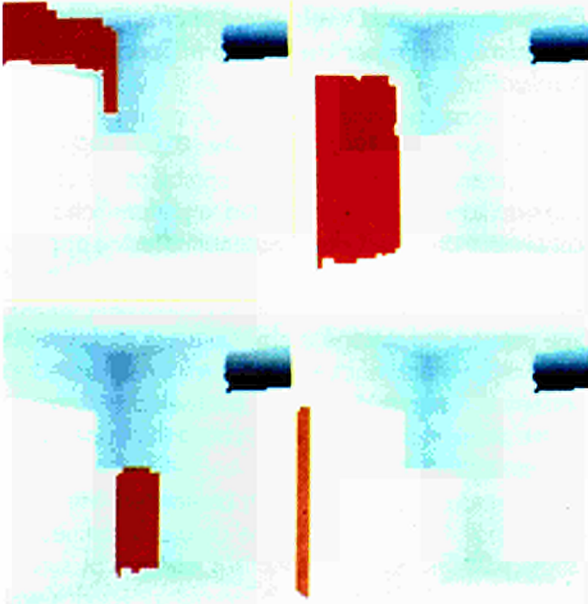
Fig. 2.9. Identification of planar surfaces in an office environment using laser range images

more general solution will require a dedicated network with high tamper resistance and authentication capability. Contacts for a joint development work is going on with Sandia Laboratories.

The development of a new surveillance system combining scene change detection with the automatic positioning and zooming of a TV camera started in 92. The problem to solve is the poor object resolution in the background of pictures taken by wide-angle surveillance cameras. The idea is to use two cameras, one wide-angle and one camera with motorised pan and tilt unit. If the control computer detects scene changes in the wide-angle picture, the second camera is pointed to the zone of interest and automatic zooming is performed to have the best image resolution.

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Containment and Surveillance Performance Evaluation

There is a large increase of the utilisation by safeguards inspectors of containment and surveillance devices and systems in large bulk handling facilities and reactors. In order to technically support this utilisation, the LaSCo laboratory (Laboratory for Surveillance and Containment) has been established with the following objectives:

- Performance assessment of C/S devices and systems
- Demonstration and development of effective procedures for proper use of C/S in specific applications
- Training of users for the application of different C/S techniques

Performance Assessment of C/S Devices and Systems

In order to evaluate the performances, including the reliability and the fitness for the purpose from C/S systems, a part of LaSCo's laboratory has been equipped for testing C/S components under thermal, humidity and mechanical stresses. Two zones were created:

- A Thermal Test Area which is composed of two climatic chambers operating between −30 and 150°C in temperature and 20 to 98% in humidity. A specific software was developed, running on a PC and using Lab Window software, to drive both climatic chambers in order to generate complex thermal and humidity cycles. A third climatic chamber, operating from −65° to +150°C, will be installed in 1993 in LaSCo, which will permit testing at very low temperatures.

- A Mechanical Test Area which is equipped with a vibration unit which permits sinus vibration generation in a range of 1 to 6000 Hz; the capacity of the vibration pot is about vibrating 2 Kg at 19 g's. This unit is used for testing components such as seals, electronic cards, video cameras under vibrations, generated for instance during transportation. A second vibration unit will be installed during 1993, which will permit to make sinus and random vibrations on components of about 30 Kg at 9 g's: entire racks may then be tested. During 1993, both vibration units will be driven by a computer in order to generate complex vibration profiles (random), to be as close as possible to the transport vibration profiles given by the various international standards.

- A second equipment installed in this area is a free fall machine which permits drops of components up to

a height of 3 meters, in order to determine if the test item is capable of withstanding the transit drops normally induced by loading and unloading. For testing small components such as seals under important shocks, a comparison shock calibrator has been installed, which permits to generate shock waves from 30 g's and up with a very high repeatability. To generate shocks on bigger equipments such as racks, measurement devices, LaSCo will be equipped, in the near future with a Shock Generator System which will be connected to the vibration pots described before.

During this year, a number of test protocols have been defined and specific tests on items have been performed on:

– MOS TRU transmitter of the Neumann surveillance system. This transmitter was tested to determine its performances at different temperature levels.

– Two electronic cards produced by French industry: an electronic filter and a voltage/current transformer. These cards were tested under standard thermal, humidity and mechanical stresses in order to determine their performances.

LaSCo's programme of tests foreseen for 1993:

– Vibrations tests on an inclinometer used on trucks. These tests are requested by a French company.

– Thermal and mechanical tests on a video camera used for surveillance.

– COSMOS compact surveillance system for which detailed protocol of thermal and mechanical tests was prepared and submitted to IAEA.

– Study of the performances under thermal and mechanical stresses of a second production of TITUS ultrasonic seal.

– Environmental tests on the IRUSS ultrasonic reading device.

Demonstration and Development of Effective Procedures for Proper Use of C/S in Specific Applications

The Advanced Storage Area in LaSCo will provide the opportunity to study and demonstrate the application of C/S systems based on different combinations of new and traditional C/S devices, and to perform long term test of these devices. Different scenarios for the application of C/S are envisaged, including the control at the level of individual nuclear material containers, of storage units and of storage areas. One has to define the tasks or functions each C/S device is supposed to perform in a particular situation and select a device or a combination of devices which have the appropriate performance profile.

A multi-sensor system has been assembled within the LaSCo hall for the surveillance of areas defined as "strategic". This system comprises an optical surveillance unit called CAVIS-IIs (Computer Aided Video System) developed at JRC-ISEI and which is now being used by EURATOM Safeguards Inspectors in several bulk handling facilities. Presently seven cameras are connected to CAVIS. A selection of sensors will also be connected to that unit in the near future.

In the Advanced Storage Area eight real size storage units (typically used for PuO2 storage) have been mounted and are now being equipped. Each unit comprises four cavities, which may include two cans each. Every operation to open the cells and to handle the cans is remote controlled. The trails supporting the cans, in a horizontal position, are activated by a stepping motor, which enables to have access to the front or the rear positioned container. The opening of the doors is remote commanded by a pneumatic system. The lay-out of this storage area includes also a mock-up of the upper part of vertical storage, which comprises four pits of 38 cm diameter and is used, for instance, for fuel assemblies. Each sensor will be tested for its reliability and its specific technical and operational characteristics and functions will be described. The final system will be a combination of the appropriate sensors in order to meet the safeguards requirements and cost effectiveness criteria. After studying the best combination sensors, the ones which are selected, will be connected to CAVIS in a "C/S integrated system".

INDUSTRIAL HAZARD

Environmental Emergencies

The activities linked with the management of emergencies are strongly connected with the actions in support of the Commission Environmental Policy. Therefore this section describes the activities directed to study the environmental impact of technological systems and accident preventive measures. These can be subdivided into two main items: Environmental Systems Analysis, which can be considered as a newly starting project, and Risk Analysis, which is the follow up of a well consolidated project.

Environmental Impact Assessment

The growing need of knowledge and transparency in the management of environmental problems calls for an increasing research activity in the environmental field, particularly in the analysis of environmental systems. The Council Directive on the assessment of the effects of certain public and private projects on the environment (Directive 85/337/EEC) and the Council Regulation on ECO-audit, which is expected to be adopted very soon, ask detailed studies that require accurate methods and sophisticated tools to be performed at the convenient quality level. In fact, the quality level of the EIA performed to fulfil the requirements of the directive 85/337/EEC is generally lower than expected by the authority, in all the EC countries. The activity here discussed is intended to help to reduce the gap between the quality of the available methods to be used for environmental systems analysis and the real needs. It mainly concerns environmental indicators and indices, environmental models, methods and tools.

Environmental indicators and indices: The proceedings of the Workshop on "Environmental Indicators" held at JRC Ispra, 2 December 1991, in collaboration with the Italian Association of the Environmental Analysts, were issued /1/. The contributions deal with the following topics: fundamentals of environmental indicators and environmental standards, limits of the "objectivity" of the environmental standards, role of the environmental standards in the environmental policy, choice of the statistical parameters to be used as reference in defining environmental standards. The proceedings also contain the synthesis of the concluding Round Table devoted to a critical analysis of the available environmental standards. The need of a common language to improve the understanding among the experts in the various fields and the lack of clear reference criteria are underlined.

A synthetic index to evaluate the quality of the water of a river has been developed /2/. The aim was to define a simple index, based on a limited number of parameters, to be used for routine monitoring. The index includes six parameters: dissolved oxygen, BOD5, COD, ammonium, total phosphorus and faecal coliforms. The quality of the water is defined according to range of values of each parameter. The index was applied to the river Po. Two collaborations started. The first one, with the University of Pisa (I), concerns time and space variability of environmental indicators. The second one, with the University of Marburg (D), concerns distributional aspects of environmental indices.

Environmental models, methods and tools: Models describing the aversion-dispersion of pollutants in rivers and groundwaters were reviewed. The review addresses the following problems: aversion-dispersion of pollutants in rivers under normal and abnormal (i.e. accidental) conditions, thermal pollution of water courses due to discharge of hot water during normal operation and aversion-dispersion of pollutants in groundwater from diffuse and point sources /3/.

The book "Environmental Impact Assessment" was issued /4/. It is based on the contributions presented at the Eurocourse on Environmental Impact Assessment held at JRC Ispra, 30 Sept. - 4 Oct. 1991. It includes seventeen papers. Five of them are authored by JRC Ispra/ISEI people. A comparative study on the implementation of the EIA directive in the EC Member States was performed /5/. The architecture of an informatic system for "Integrated Environmental Studies" (INES) has been defined. The system is mainly designed to support EIA. Nevertheless, it is intended that it be used for other environmental analyses also, like feasibility studies of industrial installations and environmental audit. *Fig. 2.10* outlines the system INES (inputs, controls, processors and output). In *fig. 2.11* the structure of INES, with reference to EIA, is given.

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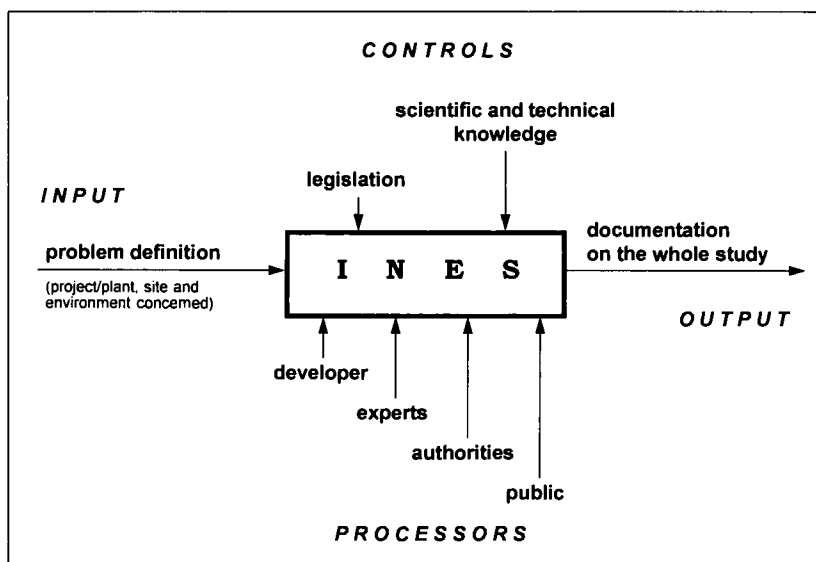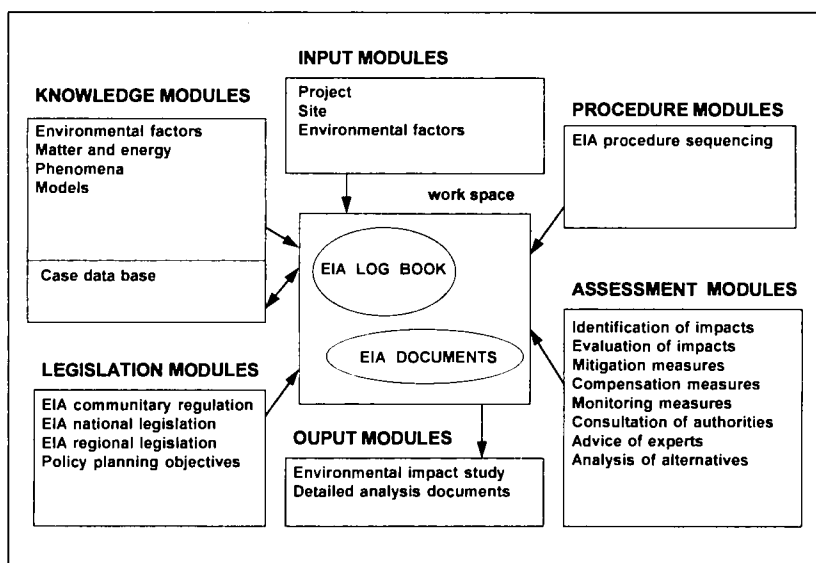
Fig. 2.10. Activity Diagram of INES

Fig. 2.11. Block Diagram of INES

/2/ CHITOTTI O., A synthetic index to evaluate the quality of the water of a river: Application to the river Po, Thesis of Laurea in Natural Sciences (in Italian), University of Milano, March 1992.

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/5/ COLOMBO A.G., "The EEC Directive on EIA and its implementation in the EC Member States", in: Proceedings of the Specialisation Course in Environmental Impact Assessment (in Italian), Polelli M., Segole A., Sorlini C. and Vighi M. (eds.), University of Milano, November 1992.

Risk Analysis

The objective of this activity is the development of procedures and models for risk analysis of chemical installations /1/ as well as the study of accidents consequences and of preventive measures.

The computer code ISPRA-FTA /2/ has been successfully distributed to about 40 organisations, and is one of the first example at JRC of a tool developed for a scientific purpose and then commercialised. A new version in C language is under development.

A model for the evaluation of the behaviour of tanks subject to nearby fires and for the assessment of the corresponding mitigating measures has been developed. It will be the subject of a PhD thesis at the university of Thessaloniki /3/.

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/3/ KOURNETA, P., ZIOMAS, I., DROGARIS, G, CONTINI, S.: Assessment of Mitigation Measures Effectiveness for Minimising DOMINO Type Accident Propagation in Storage Tanks. In Proceedings of the ESRA conference, RNL, 10-12 June 1992, Copenhagen, Elsevier Appl. Science.

Knowledge Based Systems for Safety and Reliability Assessment: the STARS Project

STARS was started in 1989 as a collaborative project with the objective of developing a methodology and a software structure that provides knowledge based support to different phases in safety and reliability assessment. The project was formally closed in 1992.

The project has produced a set of methods and

software tools that help safety and reliability analysts to /1/2/:

- collect the information needed for the analysis and structure this information in an object oriented model of the plant,
- identify potential hazardous events and event scenarios making use of precompiled knowledge about typical process plant units, chemical substances and chemical reactions,
- model and analyse causes of undesired events making use of precompiled knowledge about typical components and their behaviour

The STARS methodology and tools have been designed to offer:

- a structured approach improving consistency and traceability,
- a full integration with knowledge and data bases that can be used for capturing the general domain expertise of safety and reliability analysts,
- the possibility to incorporate plant experience as well as knowledge and experience deriving from other analyses and other plants,
- an computer-based explicit documentation of the analysis, its underlying models and assumptions,
- a user friendly and flexible environment for rapid updating in case of modifications to the plant description, new evidence from the plant or changes in the assumptions underlying the analysis.

A STARS toolkit was developed that consists of:

- a kernel with the Knowledge Bases (KB's) and the KB related tools that are used to build the plant model,
- a set of safety and reliability analysis tools that use the plant model to derive RAMS (Reliability, Availability, Maintainability, Safety) results.

Generic knowledge bases in STARS are designed to contain general domain knowledge and expertise:

- the plant/unit KB contains characteristics, failure events and hazards associated with process units and typical plant systems,
- the component KB has information on component characteristics, failure modes, generic reliability parameters and contains rules on the behaviour of components,
- the substance KB contains physical and chemical properties of substances and related hazards,
- the chemical reactions KB has knowledge about characteristics and hazards of typical chemical reactions, and some conservative estimates of potential hazards involved with unintended reactions.

A graphics based environment has been developed to access the knowledge bases and to create hierarchical object oriented representations of the plant under analysis (see *fig. 2.12*). The user can create, modify and access this object oriented plant description by drawing diagrams or interacting with those on a CAD-like interface /3/.

The JRC developed a set of tools supporting computer aided analysis at system level: a fault tree construction expert system, a fault tree editor and a module for determining the cut sets and performing a time dependent quantitative analysis have been developed. These tools support reasoning on a detailed plant representation (Piping and Instrumentation Diagram) and use the generic knowledge of the component KB.

The fault tree construction expert system (*fig. 2.13*) has been validated by applications on offshore systems and on nuclear safety systems. It has shown to have an interesting potential for formal certification purposes. A study was performed on the use of physical models and simulation during system modelling. A prototype was developed of a tool that is able to use simulation as a support to automatic fault tree construction. This tool allows to qualify an undesired event like "high temperature in line x" by a physical constraint (e.g. temp. higher than 400K) and to propagate this constraint by using physical models and local simulation so as to come to a more qualified statement about the possible causes modelled in the fault tree.

The other partners in the project focused on:

- development of a prototype tool for qualitative hazard identification /4/ and analysis based on reasoning on a process flow diagram and using the plant/unit substance and reaction KB's (RISOE - DK and VTT - SF in collaboration with NESTE)
- specification of an interface to include consequence tools within the STARS toolkit (TECSA, I) and vulnerability tools (TNO - NL).

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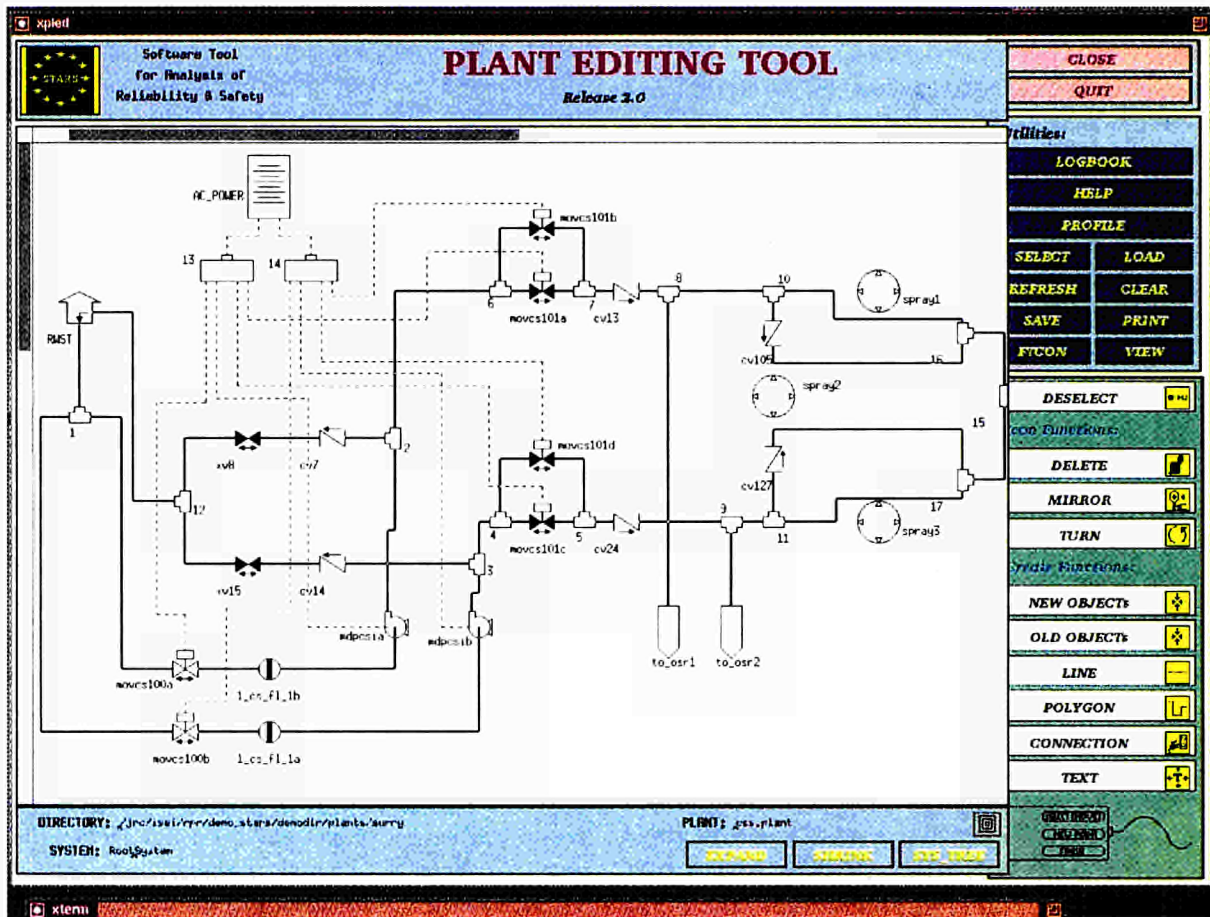
Fig. 2.12. STARS-Plant editing tool

Decision Support Systems for Environmental Management

This activity is oriented to the development of Decision Support Systems (DSS) which can be used to address problems of Environmental Management. The methods developed are based on the use of clearly specified (formal) models, or sets of models, implemented using suitable information technology, and the resulting information systems are designed to be integrated within, and to improve upon, existing decision making processes. A major feature of the systems developed is that they incorporate techniques from the field of Multi-Criteria Decision Aid (MCDA).

In the first stage of any decision process the analyst seeks to define alternatives and criteria, taking into account all the relevant aspects of the problem. The decision aid system aims at establishing comparisons between the alternatives on the basis of their quantitative evaluation with respect to the chosen criteria. For the

development of a Decision Support System the definition of the set of feasible alternatives and the selection of the appropriate criteria is a very important part of the scientific work which requires great care, especially in decision processes which arise in the field of Environmental Management.

The activity of the sector in 1992 has addressed the key phase of the definition of the set alternatives, aiming to improve on the rational ideal model which simply assumes the existence of such a set. This has been done by the examination of techniques used in different real cases, and by studying various approaches. The main problem is one of selecting a reduced set of concrete, promising alternatives for presentation to the decision maker. The guiding principle for doing this is usually that of the efficiency, taken from classical operational research, i.e. the reduced set of promising alternatives is determined by screening according to efficiency.

Different ways of understanding and hence implementing the efficiency concept have been explored; the
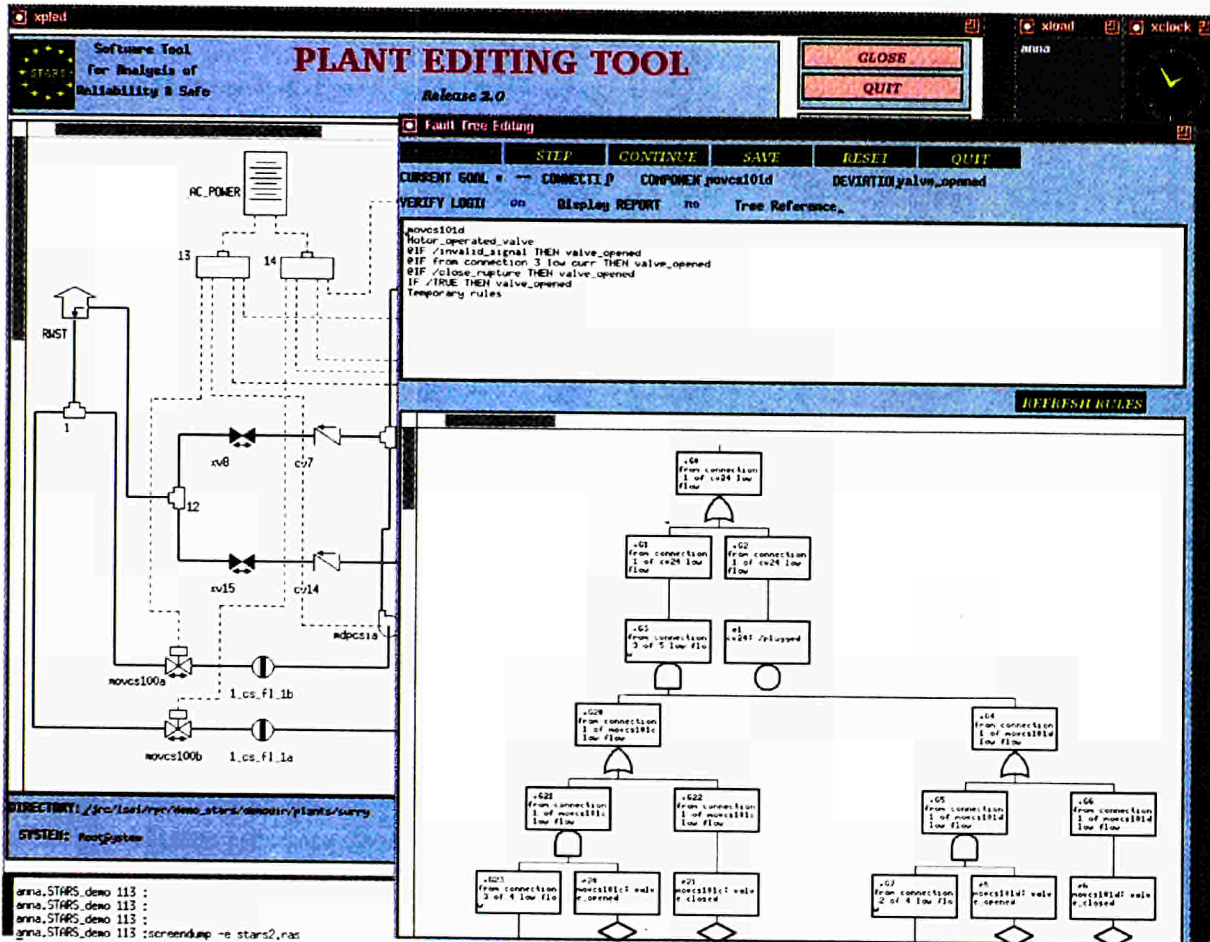
Fig. 2.13. STARS-Fault tree constructor

approaches differ in their assumptions regarding the information which is available for use in the system, and communicated from the decision maker to the analyst. The choice of approach is accomplished by studying the decision-maker's behaviour in previous or, more frequently, fictitious contexts, or by otherwise interrogating him or guiding his self-examination. This method has been used in the development of several DSS: the most recent one being RITO, a system to support the management of industrial wastes on regional scale. (See "Work for Third Parties"). In this system a number of different scenario generation techniques were implemented. These were all based on the choice of a set of points, (in fact sites for waste disposal plants), selected from a finite set of candidate points, in order to minimise a parameter which characterised the spatial distribution of the "plant" points by quantifying their distances from another set of "customer" points.

During the year other possibilities for generation of alternatives were also studied. One of the most promis-

ing is the integration of DSS with GIS (Geographic Information Systems). Taking for example a decision problem for the siting of a plant, the area screening techniques available in GIS could be used to identify all the potentially feasible areas in which to look for sites.

This can be achieved by overlaying relevant siting factors, such as population, geology, and height, to select the areas which simultaneously satisfy required values. This brings a reduction from a large and indefinite number of alternatives to a smaller and more manageable set. Standard GIS based routines are normally well suited to this kind of analysis and can determine those areas in which all the specified criteria are met. In DSS terminology they could define the relevant subset of efficient alternatives. GIS routines also allow quick comparative evaluations, based on selected criteria, and their easy modification to meet particular requirements. A good example of this technique has been given by Carver (S. J. Carver, 1991) for the siting of a nuclear facility.

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Another procedure for the generation of alternatives has also been analysed. In this procedure the project is first split into a number of constitutive elements, each of which will be a component of one or more project alternatives. For example, alternative road projects can be generated by putting together different combinations of possible short road segments. A costitutive element of the alternatives is however not necessarily physical. One can imagine different rules for building a complete alternative from the constitutive elements. It is also possible, using a combinatorial procedure, to build all possible alternatives.

Finally it is worth mentioning the activity for the use of genetic algorithms to generate alternatives (described in detail in the following section), and the use of an approach based on knowledge representation of the problem space by means of an expert system (see section on MAPO project).

Transportation of Dangerous Goods

Road Transport

In 1992 one of the major projects concerning risk from transport of dangerous goods was finalised, namely the prototype version of the risk management programme XTRIM.

XTRIM stands for an X-windows programming version of the Transport Risk Management programme. The background for developing this programme was that a collection of accidents from open literature sources showed that transport accidents form a significant fraction of accidents involving dangerous substances; namely 729 transport accidents (40%) out of 1801 accidents for both fixed installations and transport. Further study of this accident data showed that transport accidents and accidents at fixed installations have equal probabilities of escalating once they have happened.
The work of collecting transport accidents, executed in connection with the XTRIM project, was finalised in the form of an EUR report containing a list of the transport accidents. The accidents are divided into groups according to the mode of transport: pipeline, road, rail, inland waterways, marine and some accidents during loading/unloading.

A risk assessment for transport of dangerous goods for an entire country, or a selected area, requires informa-

tion concerning volumes of dangerous goods transported. The study has shown that such information currently has to be based on (uncertain) assumptions, the main reason for this being that the transporters are not registered in public or central registers. However it is expected that more detailed information will be available in the future, as transport risk receives more attention.

The purpose of the study was to develop a model able to provide reliable estimates of the risk associated with transport of dangerous goods by road and rail. These estimates should be sufficiently detailed to make the model an adequate help for decision makers when selecting a specific transportation route among the available options. Further, the model should provide the possibility of estimating the risk from transport of dangerous goods in entire communities or countries.

With XTRIM it is possible to answer the question: "What is the risk of transporting a given substance in a specific tank, using a specific route between two towns?" More complex risk assessments are possible by finding the solutions one by one and subsequent addition of these. The approach adopted for answering the question involves the assessment of three parameters:

1. The traffic accident frequencies, including a description of the types of accidents included in the frequency.
2. The probability of having a release, given the traffic accident.
3. The consequences of a release of the transported substance.

Contacts already established with Danish institutions lead to clear advantages of choosing Denmark as the area to be implemented in the XTRIM prototype.

The traffic accident frequencies were estimated for Denmark, for the three road types: urban, semi-urban (industrial), and rural areas, extracting the information from the exhaustive traffic accident database managed by the Road Directorate of Denmark. The traffic accident frequencies were estimated as a function of the road type and the traffic load, and ranged from 4 to 100 per 100 million kilometers travelled. The percentage of collisions, types of collision parties, and the speed distribution of the vehicles involved were estimated on the basis of 17645 accidents involving heavy vehicles. The resulting distributions classified in three road types according to the Danish speed limits: 50, 80 and 100 km/h, were used as input data for an event tree analysis of tank rupture, in order to estimate the conditional probability of release.

Rail traffic accidents were analysed using Danish accident data from 1969-1989, and the accident frequencies for stations and links connecting stations were found.

The consequences of a release were defined as losses of human lives. A consequence model for chlorine and ammonia (later extended to LPG, gasoline and diesel fuel) based on a fatality index approach was developed. The model is in effect, a parameter model. The parameters of the model were estimated from historical accident data. The parameters were estimated for three different population classes: rural, semi urban (or industrial) and urban. The distribution of the number of fatalities relative to the estimated average number of fatalities was found to approach an S-shaped distribution function. A simple distribution function gives, however, results comparable to the more complex form.

These three elements of the risk assessment model were implemented in the prototype computer package, XTRIM, which was used for an assessment of the risk from transporting dangerous goods by truck in Denmark. The estimate is uncertain, partly due to the uncertainty of the models used and partly due to the necessary assumptions concerning the flow of dangerous goods in Denmark. XTRIM in its current version illustrates the use of the software as a risk management tool concerning detailed routing problems.

Road transport of dangerous goods in Denmark was assumed to be represented by transport of 10 million tons/year of gasoline, diesel fuel and domestic fuel (by trucks travelling 24-34 million kilometres) and of 300.000 tons/year of ammonia and LPG respectively. For the defined corridors, 6 to 15 traffic accidents per year are expected. Further the frequency of accidents resulting in 10 or more fatalities is expected to be once every 100 years if the shortest paths are chosen. Selecting safer paths may reduce the frequency to once every 500 years.

Comparisons between road and rail transport of specified corridors was not attempted due to the considerable difference in detail (and assumed accuracy) of the models for the two transport modes.

In the risk assessment of gasoline, diesel fuel and domestic fuel transport in Denmark a figure of approximately 0.5 major releases per year was estimated. This corresponds well to the actual 8 major releases observed in 13 years.

XTRIM was validated by comparison with both real accident experiences and with traditional risk assessments reported in the literature. For the case of assessing the risk of transportation of chlorine by rail in the USA the

fatality index model seems to be less conservative, and closer to empirical observations than the traditional models.

The risk assessments for flammable liquids, LPG and ammonia transport in Denmark were compared with similar assessments recently made for the UK. Considering the differences in the volumes transported in the two countries the results are, for all three substances, very similar. This indicates that the release frequency estimates are similar. More important is, however, the validation of the consequence model, which is seen to give results close to those of much more complicated models which are generally accepted for consequence estimation.

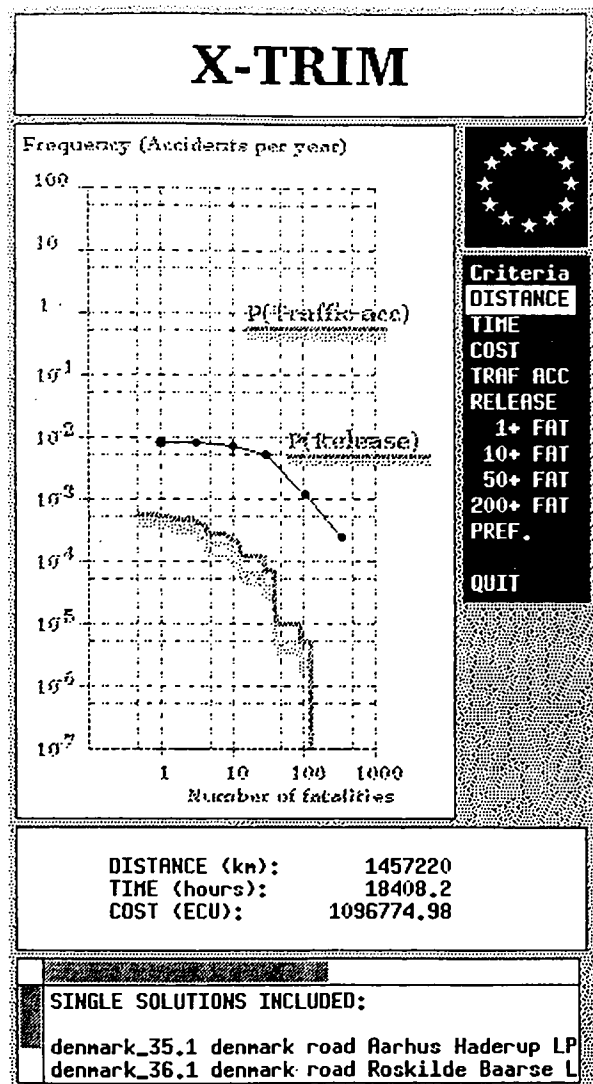In fig. 2.14, the results of the risk assessment of the

Fig. 2.14. XTRIM output for the risk assessment of road transport of LPG travelling 1.5 million kilometers.

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transport of 300.000 tons of LPG by road, with the trucks travelling 1.5 million kilometers is shown.

As seen from the figure, the frequency of accidents with fatalities from the transport of petrol is estimated to be approximately once per 100 years, with a frequency of once every 1000 years for an accident with more than 100 fatalities. As in the previous figure, the black line shows the results of a traditional risk assessment made by the Health and Safety Executive of the United Kingdom. The curve corresponds to the transport of 32 million tons of motor spirit, travelling 82 million kilometers. As can be seen the frequency estimate in the HSE case is 3 to 4 times higher than for Denmark, for a situation where the petrol is transported 3 times the distance. Also in this case, there is very satisfying agreement between the models.

Marine Transport of Dangerous Goods

A pilot study of accidents during marine transport was made on the basis of 151 accident case histories. For the different accident types collision, grounding, fire/explosion and structural damage accident frequencies were estimated, and the range was $1 * 10(-3)$ to $2 * 10(-2)$. Further estimates of the probabilities of spillage of at least 100 tons of cargo and/or fatalities in connection with the accidents were made. The consequences, measured as number of fatalities, were compared for the cargo types oils and chemicals, and it was shown that accidents involving oils were twice as frequent as accidents involving chemicals. However, the distribution of the number of fatalities seemed to be similar for the two types of goods. Concerning the local surroundings: port, coastal waters and open sea, it was shown that most accidents, whether with minor or major consequences, happen in coastal waters. The sizes of the spills were modelled by linear regression based on accident type and the size of the ship. Fairly good correlation between the spill size and the size of the tanker was shown for grounding, fire/explosion and structural damage.

Risk Communication of Transport Risks

An exploratory study has also been conducted on risk communication and the transport of dangerous goods. The research was devoted to exploring the possibility of extending experience from fixed installations processing or storing hazardous chemicals gained through the application in the EC of the Seveso directive concerning the major accident hazards of certain industrial activities

(Directive 82/501/EEC and following amendments). The study identified a number of similarities and differences between fixed installations and transport, including scientific, technical, organisational and juridical aspects. As to the type and magnitude of accidents to be considered, similar problems and uncertainties exist in both cases, which influence risk communication policies. However, the Seveso directive clearly establishes duties and responsibilities for the management of fixed installations, including the obligation of risk communication. These are further specified by the Member States which identify specific individuals and organisations to whom specific tasks are assigned. The situation for transport is instead similar to that existing for fixed installations before the implementation of community legislations, characterised by high overall uncertainty even with respect to responsibilities and duties.

GENET - A method to Generate Alternatives for Facilities Siting using Genetic Algorithms

The process of generating alternatives has been given little attention by decision makers as part of the whole process of decision.

Regarding facilities siting, often aspects other than geographic or ecological underlie the selection of a site, or a set of sites, to subject to further detailed analysis. Indeed, economical aspects are the most common objective factors taken into consideration by the proponents of a project when proposing sites. In this way, sites that are more appropriate than the current candidates being considered may be missed by the decision maker.

It is believed that a fundamental step in the structuring of a siting problem is the generation of alternatives. This task should occur at the beginning of a decision process, giving a preliminary insight into the feasibility of the project in the area of concern by identifying a manageable number of feasible alternatives for careful review and consideration. Indeed, an option generation stage avoids the analysis of inadequate alternatives, and reduces the risk that none of the considered alternatives is satisfactory at the end of the process.

The purpose of this project is to present a methodology aimed at generating alternatives for siting of facilities taking into account a number of environmental factors. This is carried out by applying genetic algorithms (GAs) which are natural phenomena based algorithms for optimisation and random search procedures. GAs provide probabilistic convergence.

The mechanisms that link a GA to the problem it is solving are two: a way of encoding solutions to the problem (chromosomes - to mimic natural phenomena) and an evaluation (fitness - also to mimic natural phenomena) function that returns the worth of any chromosome in the problem context. In this study, GAs carry out simulated evolution on populations of strings of binary digits.

The methodology being developed can be described as a random search process through a discrete space whose points have a certain value according to their environmental quality (fitness). The search space is a representation of a territory whose characteristics are stored by means of a Geographic Information System (GIS). Several layers of information are stored in the GIS and each layer represents an attribute.

The attributes analysed within the study are of two types:
- mappable attributes which are of environmental nature (e.g. geology, land use, etc.) and
- continuous attributes which are not mapped and are manipulated directly by the algorithm (e.g. distance to a certain point in space).

Both types are evaluated by means of rules of the type if ...then, $c_i(x,y)$ is the fitness associated with each attribute.

The resulting values assigned to the x,y point are combined into an evaluation function for the total fitness, which reflects both the weight of each criterion and its priority. At the end of the process an optimum set of alternatives is obtained according to the examined criteria, the weights and the priority schemes.

The methodology is currently being developed for facilities described by points, and it will be extended for facilities described by trajectories (concatenations of points).

GENET is an automatic method to generate alternatives for facilities siting linked with the GIS GRASS (Geographic Resources Analysis Support System). It is possible to run the algorithm within GRASS. In this way the necessary information is provided by this system in the most convenient format and the same systems tools are used for displaying and storing the results, i. e. the generated alternatives and their characteristics are avail-able for further analysis, viz. environmental impact assessment, cost/ benefit analysis, risk analysis, etc.

Data storage and visualisation

Significant progress has been made in data visualisation software in 1992. Expertise in this area has been developed by a small group within ISEI. Software already written by this group is being applied by experimental and modelling groups inside JRC.

Data Visualisation of Reacting Gas Flows

A software package TURCOM has been written during 1992 /1/ to visualise the results of 2-d fluid dynamics modelling on non structured grids. The work has been performed under an inter-institute contract with STI. The phenomena being studied are the modelling of chemical explosions, and shock wave propagation in confined or semi-confined environments.
The calculations are performed on non-structured grids in 2 dimensions.

ISEIs contribution has been to manage the storage and visualisation of results for this project. Data are stored in the EDF (Experiment Data Files) database /2/ and visualised with TURCOM. All software has been written inside ISEI. New methods of visualising scaler and vector fields have been developed, together with a sophisticated user interface. TURCOM is in daily use in STI. *Fig. 2.15* and *2.16* show some example displays of pressure and gas velocity, taken from the workstation displays.
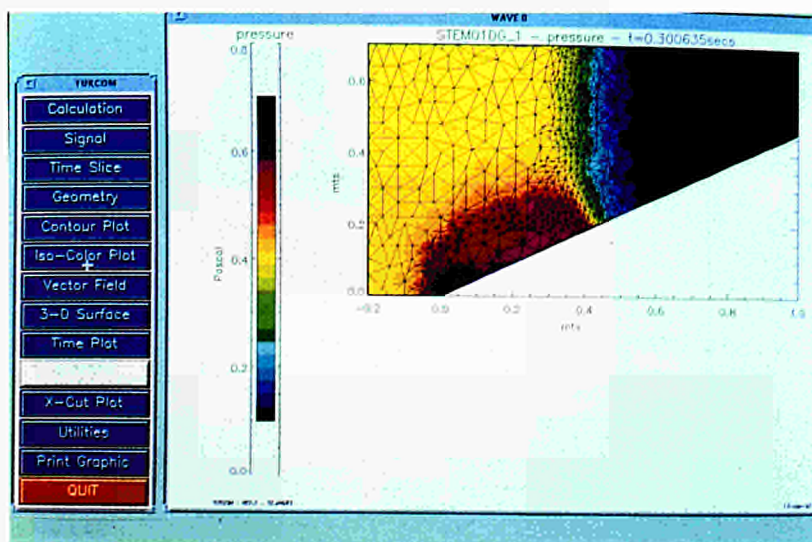

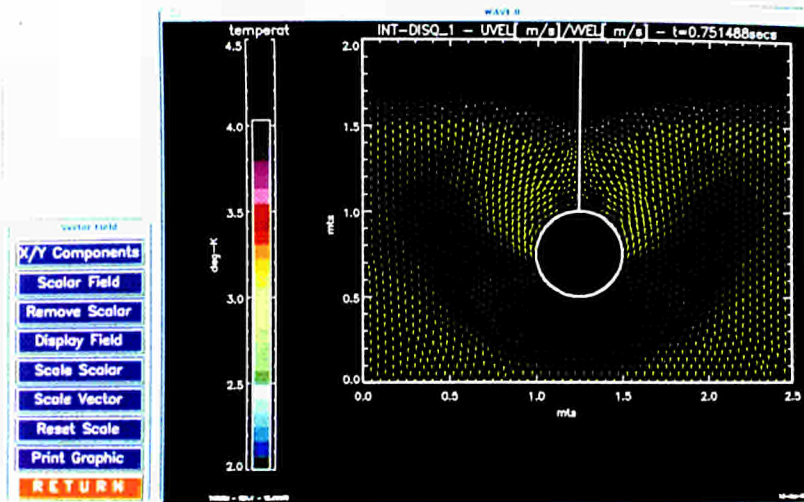**Fig. 2.15.** Gas pressure distribution within a closed vessel

Fig. 2.16. Gas velocity field during an explosion

A project was started to develop general software to visualise such volume data /3/. This software is already able to view data using three methods: iso-surfaces, contour slices, and image slices. *Fig. 2.17* shows an iso-surface plot using data supplied by the sea modelling group of STI.

Informatics support to Safety Technology Institute

During 1992, a reorganisation of informatics systems within the Process Engineering Division of STI has taken place. The work has been performed by staff from STI and ISEI (under an inter-institute contract). This successful reorganisation has resulted in improved systems, print, software, and file services.

Visualising signals defined in 3-dimensions (Volumes)

It is often the case that measurements or calculations are performed within a volume of some medium. An example of this is the measurement of sea temperatures as a function of latitude, longitude and depth. The sea modelling group within STI also produces model calculations within a volume of ocean, and requires means to easily visualise their results.
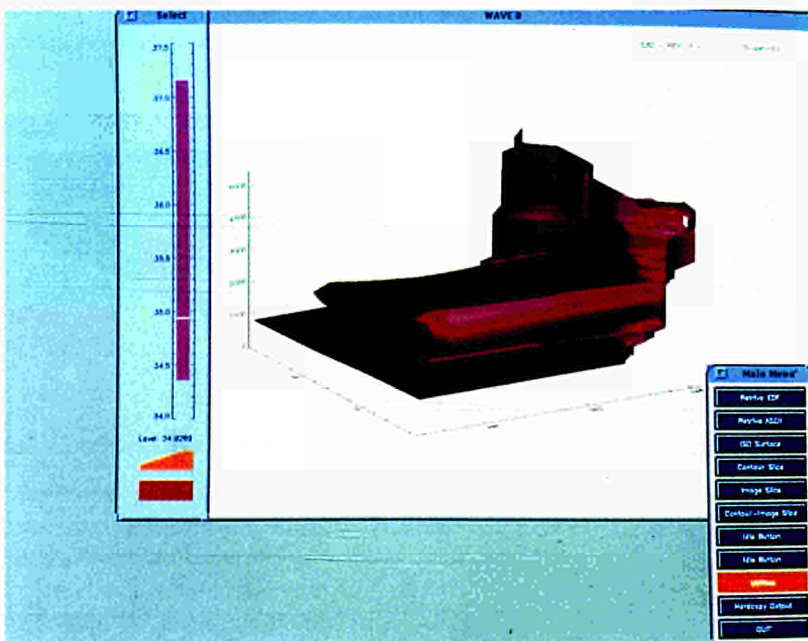
One of the major successes has been the setting up of an automatic heterogeneous backup of Unix workstations within STI. All the system software for this was developed jointly by ISEI and STI /4/. Currently 16 Unix workstations are backed up nightly onto a central fileserver. It has already proved invaluable in protecting data from accidental loss.

Support to FIRES experiment

Throughout 1992 informatics support has been given to the FIRES experiment. A second micro-Vax computer has been linked to the data acquisition system and ISEI developed data analysis and graphic software used to process the results of various experiments of the facility performed in 1992.

EDF database for FARO

The FARO experiment of STI has been interfaced to the EDF database during 1992. This now allows access to FARO data by other groups of STI using the various analysis and graphic tools already developed for EDF data, for example SPLASH /5/.

Fig. 2.17. Iso-surface of sea-modelling data

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/1/ TURCOM, Visualisation of Reacting Gas Flows on Non-Structured Grids, Tech. Note No. I.92.136, C. Best & D. Roebbelen

/2/ BEST C. Experiment data files, a general system for storing data from experiments - Technical Note N.I.90.96 October 1990

/3/ VOLPLOT, Visualising data defined in 3 dimensions, Tech. Note to be published, M. Scarin, C. Best & D. Roebbelen

/4/ An automatic backup system for UNIX Workstations, Tech. Note I.92.29, C. BEST & F. BOSSI

/5/ SPLASH - A PV-wave Application Interfaced Directly to the EDF database. Technical Note I.91.143, C. BEST & D. ROEBBELEN

REFERENCE METHODS FOR NON NUCLEAR ENERGIES

Basic Research on Physics of PV Devices

In the context of the scientific collaboration that ESTI (European Solar Test Instllation) maintains with the photovoltaic research group of the university of Ferrara, a comparative study on the reflectivities of Al and Ag deposited on silicon by screen printing and by vacuum evaporation has been concluded /1/. These two deposition methods are now compared for their ability to produce good quality Si-metal contacts. This study aims at an improvement of the cell efficiency through a reduction of the series resistance and is still in progress.

The code developed in 1991 for the monodimensional numerical simulation of solar cells in steady state has been generalised and extended to include the transient regime. Several iterative schemes proposed in the literature as suitable for electronic devices have been tried showing, however, extremely slow convergence when applied to solar cells. A stable solution to the time dependent problem could only be obtained by a simultaneous solution of the Poisson and the two carrier continuity equations. The actual code is adapted for the simulation of any kind of transient conditions driven by combinations of voltage, current and light excitations.

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/1/ M.C. CAROTTA, L. PASSARI, D. PALMERI, G. MARTINELLI and R. VAN STEENWINKEL: Effect of thickness and surface treatment on silicon wafer reflectance. Solar Energy Material and Solar Cells, 27, 265-272 (1992)

Calibration of PV Devices

The ESTIsensor - A New Reference Cell for Monitoring of PV Plant Performance

Measuring solar irradiance is of major interest in all solar energy applications. Traditionally, thermopile sensors as e.g. pyranometers are used for this purpose. The increasing number of photovoltaic solar energy applications requires a new type of solar sensor which matches the particular needs of these installations /1/. The ESTIsensor is a precision solar radiation sensor based on a silicon solar cell, optimised for low cost, long lifetime and ease of use. Being designed mainly for monitoring purposes, it may also be used as primary reference cell for indoor use according to /2/. Special attention has been paid in order to ensure a long lifetime in an outdoor environment (fig. 2.18).

A special feature of the new sensor is its ability to determine its own temperature without requiring an additional temperature sensor.

The ESTIsensor is based on a single-crystal silicon solar cell packed in a glass-EVA-PVF laminate similar to commercial photovoltaic modules. The cell is cut by means of a diamond saw in two halves, one is connected to a precision shunt and caters for the irradiance signal; the other remains at open circuit and serves as temperature monitor /3/. As the open-circuit voltage of a solar cell depends on temperature and irradiance, the temperature can be calculated from the signals of both cells (fig. 2.19). The method of encapsulation guarantees a similar performance as commercial PV modules; in fact, the ESTIsensor passes the Specification 503 for crystalline PV Modules /4/.

ESTI has developed a new calibration procedure both for the irradiance and the temperature signal utilising the light decay of a commercial large area pulsed solar simulator. The procedure aims at high volume calibration at low cost, but maintains a high accuracy and reproducibility. A spin-
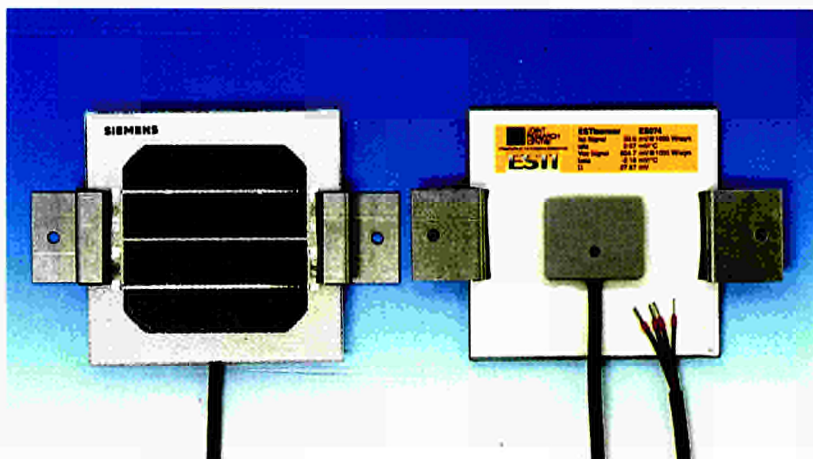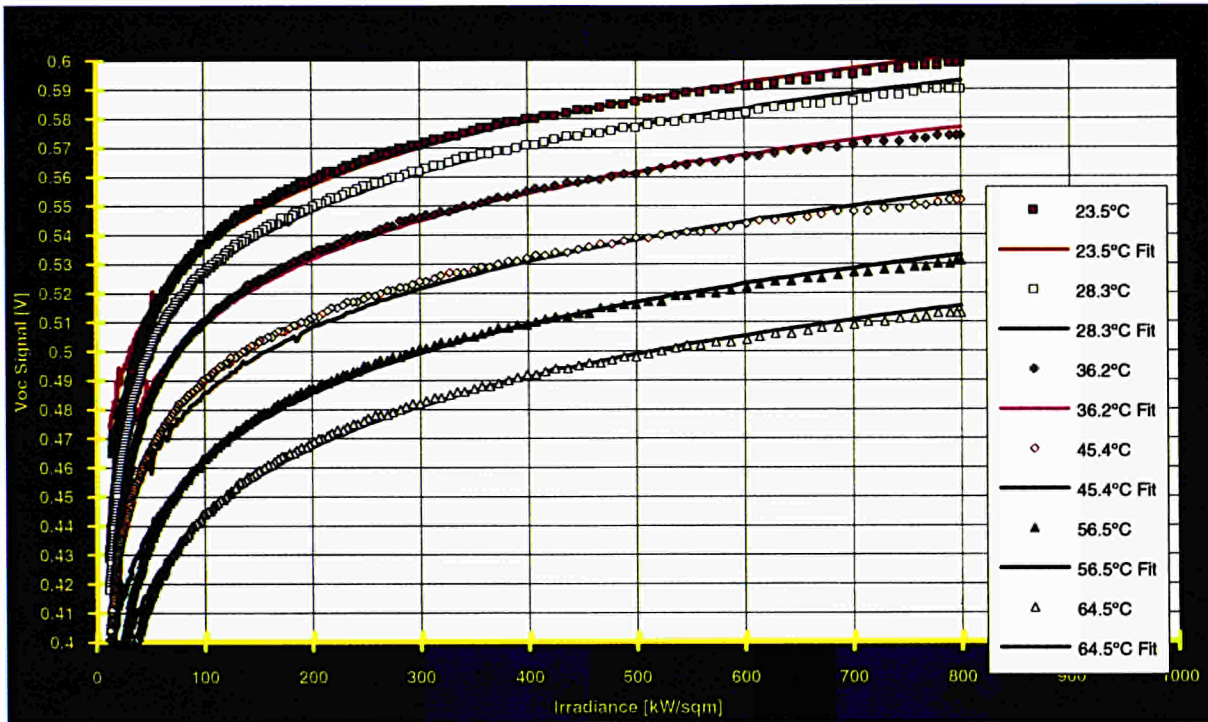

Fig. 2.18. The ESTIsensor

Fig. 2.19. One-diode model fit to the Voc signal as function of the irradiance. The resulting formula is used together with the temperature coefficient of Voc to determine the sensor temperature. Note that the irradiance is measured down to 15 W/m2.

off of the calibration method is the extremely precise (+/– 0.5%) determination of cell model parameters as the diode quality factor, dark saturation current and their temperature coefficients.

The ESTIsensor is a new irradiance sensor which guarantees a lifetime similar to commercial crystalline modules when used outdoors. The encapsulation technique and the calibration procedure proposed allows costs for the sensor to be considerable below pyranometers.

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/1/ H.Ossenbrink, G.Beer, S.Guastella, M.S.Imamura, "Recent Advances in Solar Irradiance Monitoring Devices and Calibration Methods", Int. J.Solar Energy, 1991, Vol. 10, pp 161-173

/2/ Requirements for Reference Solar Devices, International Electrotechnical Commission, Technical Committee 82, Central Office 11, Geneva

/3/ Determination of the Equivalent Cell Temperature " (Draft), International Electrotechnical Commission, Technical Committee 82, WG2 ,(Secretary 162)

/4/ H.Ossenbrink, E.Rossi; "Qualification Test Procedures for Crystalline Silicon PV Modules", CEC JRC , EUR 13897EN

Development of Thin Film Qualification Tests

Light Soaking and Annealing of a-Si Modules for Qualification Test Purposes

ESTI as test laboratory for Photovoltaic (PV) devices is since 1989 elaborating a preliminary qualification test proposal for a-Si PV modules. At a certain stage the proposal was published as Specification 701/1/, and brought as study document to IEC/TC82/WG2 for discussion. Meanwhile, the test sequence was applied to commercial a-Si modules in order to gain experience for coming standards.

The qualification test sequence for a-Si modules as described in /1/ foresees an initial light-soaking and annealing cycle before the subsequent tests. The purpose is to have a stabilised module before the UV and Outdoor Exposure test, and an annealed module before the environmental tests which imply high temperature exposure. The light-soaking test is performed in a climatic chamber with a built-in, large area light source and the modules are exposed for 500h to an irradiance of 800 W/sqm. The chamber houses 8 modules with an area of total 3 x 4 sqm; the IV-characteristics of all

modules can be measured at any moment throughout the test period. The ambient temperature of the climatic chamber has been kept controlled at 25°C, rising the module temperature to about 62°C.

The annealing of the modules has been performed at 65°C in an heated chamber, equipped with a glass window so as to allow continuous measurement of the IV-characteristics by a large-area flash simulator.

The light soaking has been stopped after the efficiency of the modules did not vary more than +/−2% within 48h, which was the case after about 350h of irradiation. In order to assess the possibility of reduced test time, the climatic chamber was than cooled to 0°C (module temperature 25°C), and the soaking was continued for another 150h. It was observed that a further degradation of power output was achievable, with a much faster rate of power decrease (*fig. 2.20*).

The annealing was carried out until the module efficiency remained constant within +/−2% in a 48h period. It was not possible to fully anneal the modules; the final power output remained about 5% below the initial, as measured before the light soaking tests.

Light soaking and subsequent annealing is a necessary requirement in the qualification of a-Si modules. The results of the light exposure at low temperature indicates that one may save considerable testing time when decreasing the ambient temperature. More statistical evidence has still to be brought in order to establish the equilibrium between light soaking and annealing, and to conclude on an agreeable standards proposal.

Reference

/1/ H.Ossenbrink, Specification 701, V2.1,"Recommended Qualification Test Procedures for Thin-Film Photovoltaic Modules", EUR Report, CEC JRC Ispra, May 1990
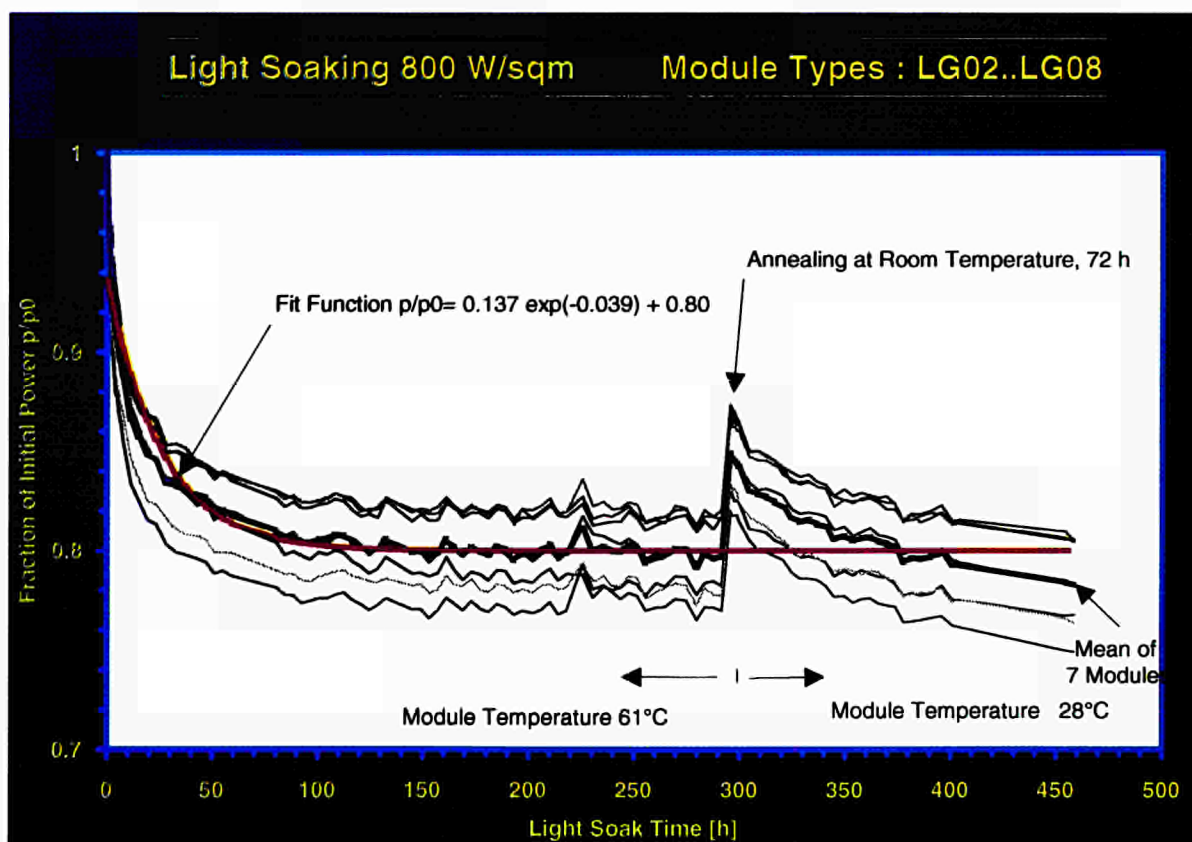

Fig. 2.20. Relative power output of LG-type modules during light-soaking; note that in the last 150h the module temperature was decreased, and that after a 72h break of the test the modules started to anneal.

RELIABILITY OF STRUCTURES

Material and Structural Damage Measurement

The objective in this area is the development and application of diagnostic tools for the detection of defects in materials and components, and the assessment of their degree of damage. Major effort has been dedicated to composite materials, and in particular those with continuous carbon fibres and epoxy matrix. Three inspection techniques have been extensively employed: Laser Holographic Interferometry, Acoustic Emission, and Adiabatic Thermal Emission.

The method of laser holographic interferometry has been applied for the detection of impact induced damage and marvels in specimens of composites and of service induced damage on aircraft fuselage. Because a major part of the last work has been carried out for an aircraft manufacturer, its report is in the chapter on Work for Third Parties.

Realtime and two-reference-beam interferometry were implemented while the specimens were thermally strained by the heat of a lamp and constrained at their ends. For small temperature increases (2°C) irregular fringe patterns were immediately observed where structural anomalies or defects were present. In particular:
- For the impacted specimens closed shape fringes begin to form at the impacted areas, and the more damaged the specimen, the sooner their appearance and their extent. The technique further reveals damage even in the non impacted side.
- For the specimen containing the marvels the fringes appear very wavy. It should also be mentioned that this type of defects escapes detection by ultrasonics.

In both cases pseudo three-dimensional images of the deformed surfaces are obtained which provide a very clear picture of the effect of the defect, and further yield accurate quantitative results /1/2/3/.

The work with Acoustic Emission was conducted within the frame of a Bench Mark exercise by the laboratories constituting the EAMA (Acoustic Emission for Aeronautical Materials) group in Italy. It aimed primarily at identifying and investigating the variability in the AE measurements and their interpretation, even when working with identical specimens and under conditions conforming to the appropriate standards /4/.

Unflawed 0° and 90° unidirectional composite laminates were tested in tension. Their material was carbon fibre-5245C resin matrix. All participants employed similar type of instrumentation. It is worth noting that the participating laboratories had different degrees of expertise in the use of the AE method. Thus several general conclusions were drawn from this exercise. Among them the following:
- the "count rate vs. load" plots seem to be the most sensitive indicators of the damage processes and their variance from one laboratory to another was relatively small.
- the interpretation of the AE activity is influenced not only by the acquisition parameters, but also by the analysis and presentation parameters. This means that results apparently different may derive from very similar primary information sets.

The research in the field of adiabatic thermal emission has been continued with the testing of virgin and impact damaged composites. Considerable differences in their thermal responses to deformation have been observed. The approach could thus be seen to hold considerable merits to develop into a non-destructive technique /2/5/. However, further studies are necessary because theoretical analyses have shown that the surface temperature depends strongly on the stacking sequence of the composite. The contact type point temperature measurements (by thermistors) pose also a serious limitation /6/.

For an automatic running of these experiments a computer program named DITE (Damage Investigation using Thermal Emission) has been completed and successfully tested on the Zwick Universal Test Machine.

Deformation Analysis by Laser Methods

ESPI (Electronic Speckle Pattern Interferometry) for Micro-Deformation Analysis
Electronic speckle pattern interferometry (ESPI) enables micrometric static and dynamic surface displacements to be measured with an accuracy of ± 0.1 μm, less than the wavelength of visible light. ESPI is an interesting alternative to conventional holographic interferometry: it has the added advantage that, since it uses a video-electronic system for detection and processing, meas-

urements can be made in real time and detection of micrometric deformation evolution can be easily performed. Tests have been carried out to define clearly advantages and limits of this technique.

Endoscopic System for ESPI

An electronic speckle pattern interferometer with an endoscopic imaging system has been developed for non-destructive measurements in hidden or difficult to reach zones. The whole system is very flexible and the fields of application can range from industrial survey to medical diagnostics /7/.

Application to Artwork Diagnostics

The possibility of employing a Digital Speckle Pattern Interferometer with optical fibres for non destructive testing of artwork has been investigated. A simple and accurate fibre optic interferometer, able to perform realtime measurement in hostile environment, has been realised with a minimum of optical components and adjustments. As a result, the deformation map of wooden panel paintings or mural frescoes under thermal stresses may be depicted. Preliminary tests were carried out in laboratory, further measurements on ancient painted surfaces and on monuments were performed in situ. Out-of-plane and in-plane deformation maps allowed the detection of cracks, delamination, and voids in the support layers of the inspected artifacts /8/. *Fig. 2.21* shows a surface detachment detected, in the wooden panel of a painting, by ESPI and suitable processing of the original interferogram (above left).

Surface Characterisation and Profiling by Laser Methods

The activity on surface profiling was started in 1991. Several techniques such as: grating projection, ESPI compensation, Moiri fringes and two wavelength holography have been applied and compared. The use of Phase Shifting and Fourier Transform methods did allow the passage from purely qualitative to quantitative results. Among the results obtained in 1992, it is worth mentioning:

Two refractive-index holographic contouring

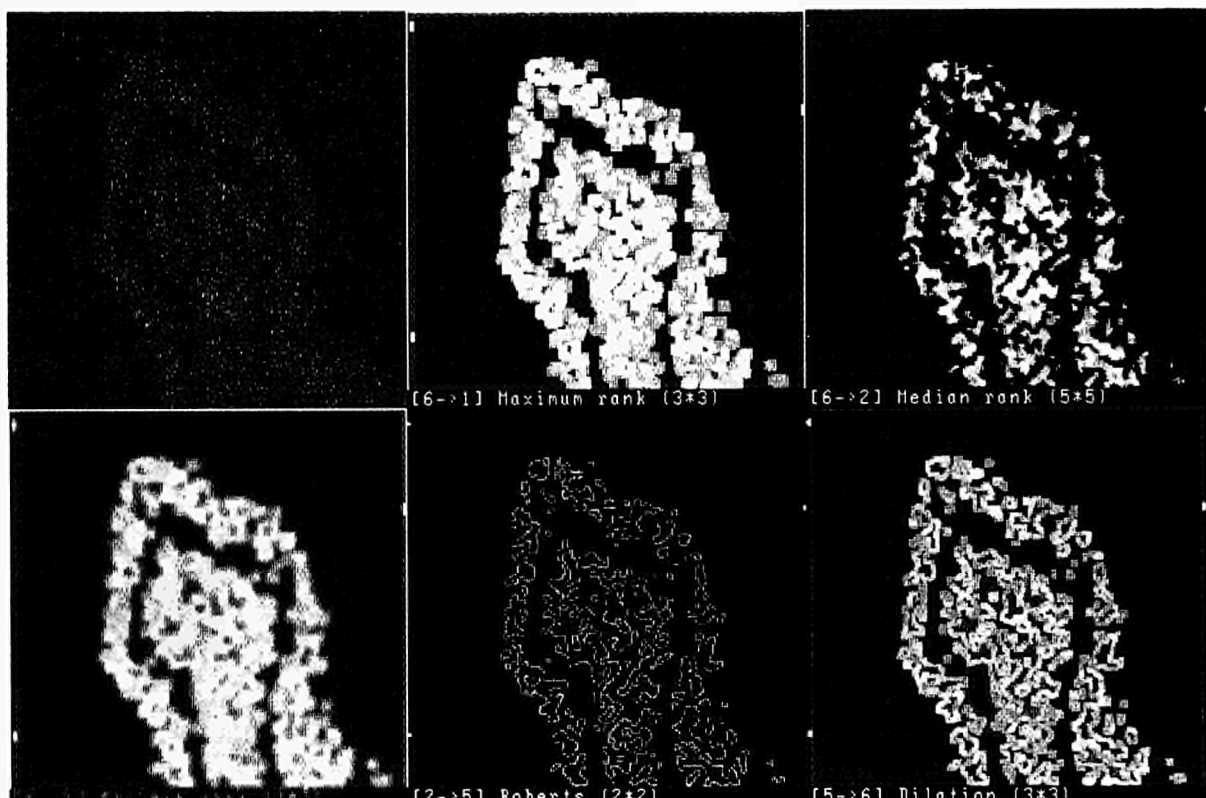The object, whose 3D shape has to be extracted, is

Fig. 2.21. Use of ESPI (Electronic Speckle Pattern Interferometry) and proper image processing for the detection of a surface detachment in the wooden panel of a painting (above left: original interferogram; below right: final image).

placed in a cell with a glass window and imaged by a telecentric telescopic system. In the first stage of the experiment the hologram of the object is recorded on a thermoplastic plate with the cell filled with a liquid of refractive index η_1. In the second stage the liquid is replaced with another having a refractive index η_2. Viewing both the reconstructed image through the hologram and the object in the new liquid, realtime depth contours can be observed on the object surface. The contour spacing is: $(\lambda/2)/|\mu_1-\eta_2|$, which allows a variable resolution in the range 1μm-1mm. Applying phase-shifting techniques, the 3D shape of the object can be retrieved using phase unwrapping algorithms on four digitised images of the fringe pattern acquired by means of a CCD camera. This technique is quite interesting for high resolution, measurements on objects

movable to lab, but cannot operate in daylight. The need to operate in laboratory is also due to the sensitivity to external vibrations and thermal drifts.

White light interferometric contouring (Coherence radar)

Exploiting the short coherence length ($\approx$3μm) of a white light source we can extract the contour map of an object. A typical Michelson interferometer with the object at the one end and a mirror at the other was used. The interfering surface points are recorded as the surface is scanned by the axial motion of the mirror. The depth resolution is 10 μm. Metallic surfaces have been mapped out. The work for improving the performances and the range of application of the coherence radar is planned as an Exploratory Research in 1993.
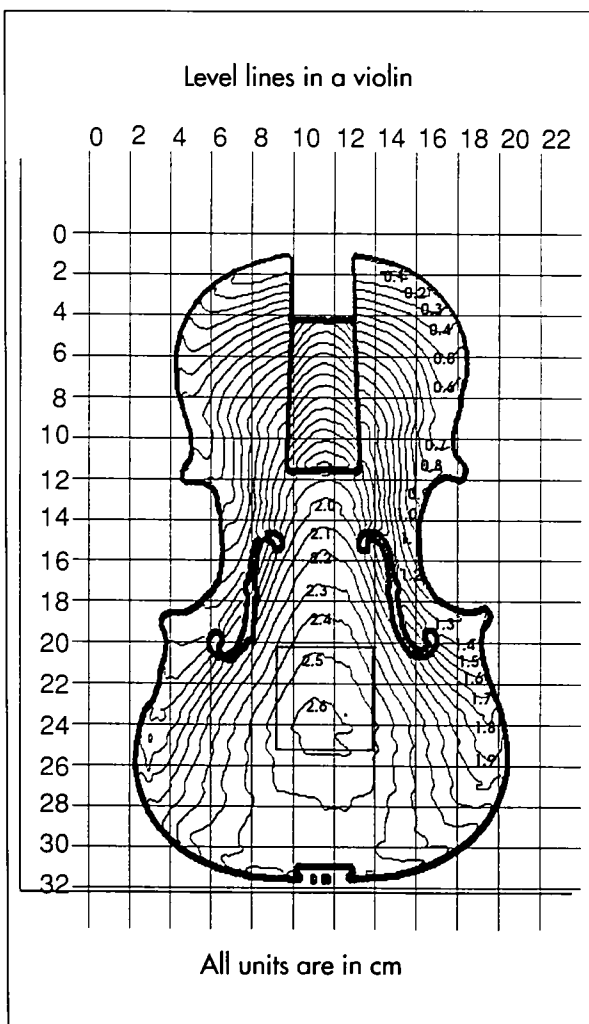
Fig. 2.22. Surface contouring, by triangulation with laser light line projection, on a violin (collaboration with Istituto Internazionale per l'Artigianato del Legno e della Liuteria-Cremona)
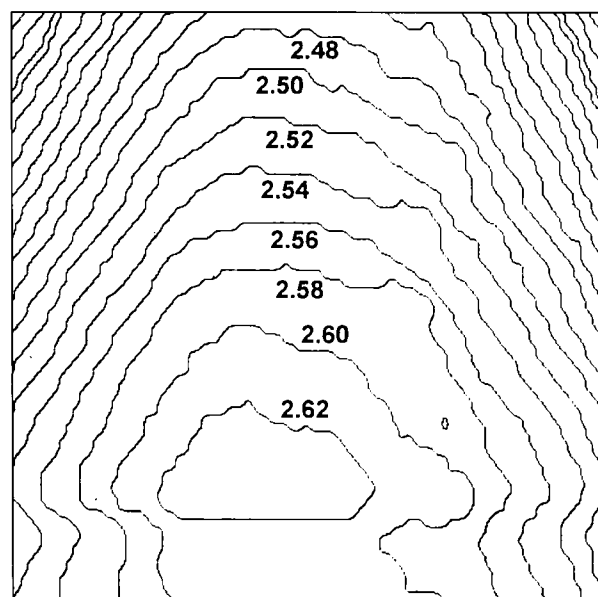
Fig. 2.23. Surface contouring as in fig. 2.22 on a smaller region of the violin and with higher resolution (0.2 mm.).

Triangulation System

Many efforts have been put in the development of a triangulation system based on laser line projection. Sub-pixel techniques lead to a typical depth resolution of 0.1 mm.

The system, almost completely automatic, is useful to evaluate the profile of different kinds of surfaces starting from entire facades of buildings down to musical instruments or smaller objects. The portability of the equipment is high, daylight operation is possible and mechanical micro-vibrations seem to have no effect on the measurements. *Fig.2.22* shows the level lines,
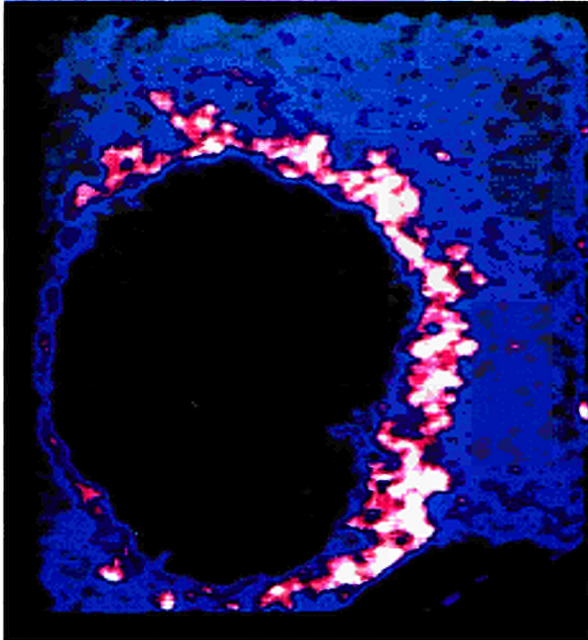
Fig. 2.24. False colour image obtained, by laser speckle decorrelation measurements, on a stone specimen for early detection of the formation of salt efflorescence. (Collaboration with Centre G.Bozza for Conservation of Works of Art, Milano).

surface where salt crystallisation has just occurred. Real time analysis offers the possibility to measure the speed of the process. The technique may constitute a substantial improvement in diagnosis of monuments for their protection and restauration. *Fig.2.24* shows the false colour image of laser speckle decorrelation in a sand stone specimen during evaporation of a salt solution. Pink & white pixels correspond to areas of strong decorrelation and allow a very early detection of the presence of salt efflorescences. (Collaboration with Centre G.Bozza for the conservation of works of art, Milano).

Further information on the use of optical diagnostic methods are reported in /9/ and /10/, while /11/ deals with image enhancement and noise filtering methods, whose role is essential for obtaining clear information from our images.

One result of proper image processing can be seen in *fig.2.28*, while *fig.2.31* shows the final result of the processing of a double exposure interferogram to obtain a 3D deformation map *(fig. 2.25)*.

obtained by this system, on a violin (collaboration with Istituto Internazionale per l'Artigianato del Legno e della Liuteria-Cremona). *Fig.2.23* shows the same type of representation but for a smaller region of the violin and higher resolution.

Speckle decorrelation measurements applied to the study of deterioration mechanisms in stone.

The aim of this work is to characterise the formation mechanism of salt efflorescences in stones exposed to salt weathering. The inspected samples of stone undergo a set of aging cycles to accelerate the process. Speckle techniques monitor the evaporation of a salt solution, previously absorbed by the stone sample, and efflorescence formation on the surface. In particular, decorrelation measurements of the speckle pattern at two different times indicate the zones of the
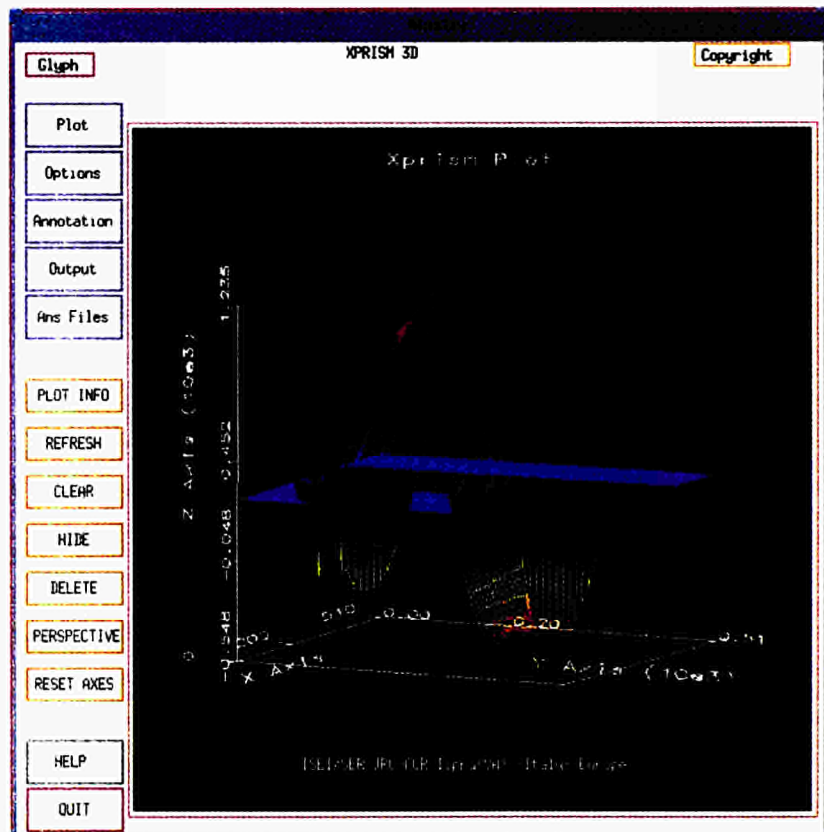

Fig. 2.25. Use of double exposure holographic interferometry and image enhancement and representation methods: deformation map of a specimen in composite material for aeronautical applications

High-Cycle Fatigue Behaviour of Metals

The problem of the fatigue limit is of very high industrial interest. In fact, its knowledge allows the distinction of a damaging cyclic loading from a non damaging one. The work performed during 1992 was focused on the problem of the fatigue limit of metal components subjected to multiaxial non-proportional cyclic loading. A new methodology, based on the microscopic approach, first introduced in metal fatigue by Egon Orovan in the early thirties, has been developed. With the help of this method, the local stresses and strains at the scale of the metal grain can be evaluated. In our approach, the fatigue limit is then interpreted as a bound applied to the plastic micro-strain accumulated by a cyclic loading. This new theory has been tested on the basis of a considerable amount of experimental data found in the scientific literature. It has been found that the performance of the developed approach is very satisfactory over the entire range of multiaxial high-cycle fatigue, and overall much more consistent than that of older theories. The main results of this work have been presented at the EUROMECH 297 colloquium on fatigue /12/. Some studies concerning the numerical implementation of our methodology have also been performed. A simplified version of the new approach is already used as a basis for the development of a specific software. This software is mainly a post-processor that analyses the results of finite elements calculations. Some applications have been presented at the EUROMECH colloquium mentioned before /13/. Automotive industries (Renault, Peugeot, Fiat, Rover) have expressed their interest for this work. The set up of a collaboration scheme is at present under consideration.

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/6/ MELVIN, A.D., "Thermal response analysis", Contract 4373-91-06 ED ISP GB, Final Report.

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/9/ A.C. LUCIA "Structural diagnostics by laser techniques" Second Int.Conf.on Optics Within Life Sciences (OWLS II), Optics for Protection of Man and Environment against Natural and Technological Disasters, M_nster (Germany) 4-9 October 1992

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/11/ D.ALBRECHT, P.ZANETTA, M.FACCHINI, C.GIANIKAS, "Holographic Interferograms Filtering by the Bidimensional Fast Fourier Method", Tech.Note No.I.92.96 ISEI/IE/2330/92

/12/ PAPADOPOULOS, I.V. "Fatigue Limit of Metals under Multiaxial Stress Conditions: A Literature Survey and a New Proposal", EUROMECH 297 - Fatigue Analysis in the Context of Mechanical Design, Lozari, France, September 1992.

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FUSION TECHNOLOGY AND SAFETY

In compliance with the JRC mission, the fusion-related activities carried out at the ISEI aim at assessing the feasibility and acceptability of thermonuclear fusion as controlled energy source.

The main subjects of the ISEI activities are:
- Integrity and reliability of Fusion Reactors stuctures in off-normal conditions
- Operational Safety during maintenance
- Safety and environmental impact assessments.

These activities are complementary to the other fusion activities performed at the JRC, which are:
- Safety aspects of tritium technology (IST, Institute for Safety Technology)
- Development of materials for fusion applications (IAM, Institute for Advanced Materials).

They are fully integrated into the European Fusion Programme.

More specifically, fusion activities at the ISEI pertain to the following main research areas:
- Structural Integrity Assessment during Disruption Events
- Remote Handling
- Envelope Analysis of Loss of Cooling Accidents
- Low Activation Materials and Activated Waste Management
- Safety Related Aspects of Blanket Design,

and are related to three chapters of the European Fusion Programme, as:

- "Nex Step Activities"   concerning the experimental reactors NET and ITER
- "JET Support"   concerning reliability studies for JET Remote Handling Transporters
- "Long Term Studies"   concerning Demo and commercial reactors.

The 1992 achievements of the various actions are described in the following sections, under the corresponding research areas, with the indication of the related tasks of the European Fusion Programme.

Structural Integrity Assessment during Disruption Events

One of the major items in fusion with magnetic confinement is the study of electromagnetic (EM) forces caused by variation of magnetic fields in the conducting structures surrounding the plasma. The design of the plasma-facing components (PFCs), the related vessel interfaces and the vacuum vessel itself are strongly affected by the necessity of maintaining the stresses caused by rapid and abnormal magnetic field variations, e.g. during disruptions, within acceptable limits, in order to avoid damages (e.g. permanent deformations and vacuum losses). ISEI is working, both theoretically and experimentally, in this field.

ISEI has the experience and the tools (an integrated computer-aided-engineering (CAE) system and a validation laboratory (TESLA) for ensuring the support to the Design, Analysis and combined Validation in the context of the Tokamak Structural Integrity Assessment.

In particular, the proposed Attachment Locking (AL) Systems, designed to support the blanket segments and to transmit huge reaction forces at the level of the vacuum vessel (VV), must also satisfy Remote Handling (RH) Requirements of an easy dismountability. Many AL concepts have been investigated but a final solution has not yet been obtained due to unresolved feasibility and reliability problems. Specific studies and tests in transient conditions are needed with the aim to choose a reference solution and to attain a design optimisation.

Feasibility Study on Blanket Segments Attachment Locking System:Evolution of the Toroidal Belt Concept (Next Step Activity - NET Design Support Task)
The original concept, called the "twin belt concept" and proposed by the JRC ISPRA, for the Attachment Locking (AL) System of the First-Wall Blanket Segments (FWBSs) to the Vacuum Vessel (VV), was developed in the frame of a NET support task and has been recognized as one of the reference solutions for the inboard region of the reactor. ABAQUS, PATRAN and CAD/MEDUSA were extensively applied.

Results of the recent 3D structural dynamic analysis (see fig. 2.26) have shown that the high values of the

induced EM loads and the shape of the elongated modules still pose structural problems difficult to solve with only two belt bars /1/. Therefore, an upgraded solution for the "toroidal belt concept" has been developed, considering an increased number of bars symmetrically arranged around the equatorial plane. The thermal expansions which are mainly in vertical direction due to the shape of the inboard FWBS are allowed by the free vertical movement of the modules, without the need of any rotation. The modules are still fastened by the upper belt, while the other belts react to horizontal loads, leaving free the vertical expansions. The subdivision of the belts in separated modules has been investigated. The advantage is that they could be radially assembled together with the VV sectors and then mechanically joined through electrical insulations. A report describing the present evolution of the concept is in preparation.

Modelling, Analysis and Validation Studies on the Transient Magneto-mechanical Coupling Effects (Next Step Activity)

The coupled 3D electromagnetic-mechanical study of a system of bodies has been successfully implemented in the Trifou Code from EdF solving simultaneously each of the following problems /2/:
- The mechanical problem which results in the kinematical computation of the system with the knowledge of all the electromagnetic and mechanical forces.
- The electromagnetic problem that means, from the kinematics of the bodies, inferring the eddy-currents and the electromagnetic forces.

The investigations into the real impact of the accidental events of plasma disruptions on the mechanical design

BOX-TYPE   **INBOARD BLANKET**

MISES VALUE

    + 1.04E+00
    + 2.06E+00
    + 3.09E+00
    + 4.11E+00
    + 5.14E+00
    + 6.17E+00
    + 7.19E+00
    + 8.22E+00
    + 9.24E+00
    + 1.02E+01
    + 1.13E+01
    + 1.23E+01

MAG. FACTOR = +1.0E+02

TIME COMPLETED IN THIS STEP +1000E+00
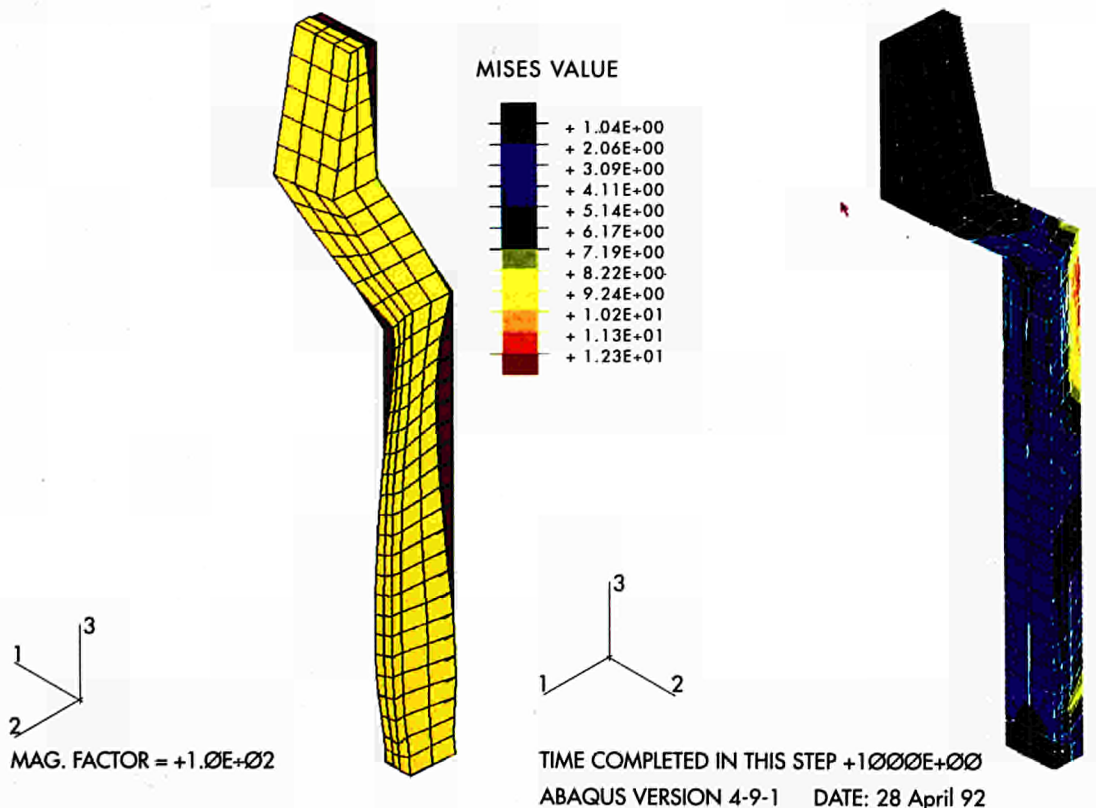ABAQUS VERSION 4-9-1   DATE: 28 April 92

Fig. 2.26. Results of Structural Dynamic Analysis of Blanket Modules.

of the internal Reactor components, with the contribution of numerical modelling and Computer Simulations, have been pursued in the TESLA Laboratory (Structural Transients Simulation Laboratory in Electromagnetics & Thermo-Mechanics). The applied Computer tools were CARIDDI, TRIFOU, ABAQUS and PATRAN.

In particular, during 1992, computational strategies in coupled transient magneto-mechanical analysis have been applied to a box-like FWBS in order to investigate correctly the real effect of the magnetic damping.

In the context of the TEAM (Testing Electromagnetic Analysis Methods) Workshops, the new TEAM Problem 16, a coupled electromagnetic-mechanical benchmark case of a plate in torsion, has been successfully solved /3/.

The ELBA test-rig for experimental validation studies has been designed, built by Ansaldo and finally installed in the TESLA Laboratory /4/. The identification of the optical instruments for measurements has been made /5/. The development of a data base acquisition system and the definition of clean validation experiments, to be carried out during 1993, have been undertaken.

References

/1/ Y. CRUTZEN, F. FARFALETTI-CASALI, A. INZAGHI, S. PAPADOPOULOS, J. SCHNEIDER, N. RICHARD, "Transient Electromagnetical Analysis of the In-Vessel Region During Off-Normal Conditions", Proceedings of the 17th SOFT.

/2/ N. RICHARD, S. PAPADOPOULOS, Y. CRUTZEN, "Recent Developments in Coupled Transient Magnetomechanics ", Int. Workshop on Electric & Magnetic Fields (Liege).

/3/ R. ALBANESE, E COCCORESE, Y. CRUTZEN, P. MOLFINO, Proceedings of the Int. '91 T E A M Workshop, Editors EUR Report 14137 EN, CEC-JRC Ispra, Jan 92.

/4/ Y. CRUTZEN, F.FARFALETTI-CASALI, S. PAPADOPOULOS, F. VAN PAEMEL, P. ALBERTELLI, A. PERFUMO, E. PICCO, "Integration of Validation Studies in Magnetomechanical Analysis", Int. Workshop on Electromagnetic Forces..."KfK (Karlsruhe).

/5/ Y. CRUTZEN, S. PAPADOPOULOS,F. VAN PAEMEL, "The ELBA Experiment", Technical Note No 1.92.141 (ISEI / IE 2370 /92), 1992.

Remote Handling

The Fusion Reactors will become radioactive during operation to such an extent that they will not permit any human intervention and will require, during maintenance, tight containment of tritium and activated dust. Moreover, the dimensions (up to 20m) and weights (up to 150 tons) of the internal components (such as first wall

blanket modules), to be removed with precisions of few mm, pose unresolved problems. If a Remote Handling Device fails within the reactor, it can damage the internals and cannot be repaired or removed by humans. If an exceptional disruption event damages the PFCs, they must be substituted remotely. If the containment of the activated products leaks during maintenance, it can have severe consequences on the environment.

This means that the reliability of Remote Handling devices and operations, and the containment during maintenance are key problems for the design, in order to demonstrate that a Fusion Reactor can be remotely operated, maintained and decommissioned in a safe way. Because of the requirements to work in such a radioactive environment on huge heavy components, neither the conventional industrial robotics technology nor the "in space" technology are adequate.

It follows that specific studies and tests are needed to achieve operational safety during maintenance. ISEI has the experience and the tools (an advanced CAE System and a Teleoperation Laboratory TELEMAC) for ensuring a support to the design, reliability analysis and testing of maintenance equipments and operations, which could satisfy the previous requirements.

The engineering support to the Remote Handling problems is provided by Computer Simulation, Experimental Validation on Mock-ups in scale and Reliability Analysis. TELEMAC Laboratory allows validation tests to be performed on mock-ups of whole complex systems in a scale big enough to give, at an acceptable cost, significant indications of the behaviour of the full-scale systems and prototype equipments.

Development and application of a Remote Handling Simulator (Next Step Activity - Task RHB 1-1)

The purpose of this activity is to develop an integrated system, the ISPRA-Simulator, supporting the design of remote handling systems for the assembly and maintenance of a nuclear fusion plant. The support provided by the system is based on simulation techniques: kinematic, dynamic and visual simulation. The system accepts design models of remote handling equipments and environment and supports the assembly of the robot.

The ISPRA-Simulator has been originally developed starting from the MEDUSA CAD System, through an

appropriate visual simulation module. An assembly module has been implemented to allow the creation of hierarchical data structure of the robot system. A visual simulation module, based on the direct kinematic approach was also implemented.

The Inverse Kinematic module provides a numerical system necessary for the visual simulation and the interactive planning of the task of the robot arm. The user is able to control interactively the position and orientation of a reference frame attached to the end effector. Three different algorithms have been implemented to solve the inverse kinematic problem, depending on the constraints and objectives of one task.

The User interface module connects and integrates all the modules of the system in a consistent environment, where the user will be allowed to execute the necessary operations for designing, planning and verifying via visual simulation a robotic arm.

A Collision Detection module has also been developed and integrated into the system. Finally an Inverse Dynamic module allows to solve the problems of determining, for a given trajectory and operation, forces and torques which have to be provided by the robot actuators.

Future work on the ISPRA-Simulator will concern the possibility of using models taken from the CATIA CAD System and the link of the package with the experimental facilities of the TELEMAC (Teleoperation) Laboratory.

In parallel to the activity of development of a new simulator, a collaboration with KfK - Karlsruhe was undertaken in the frame of the European Fusion Technology Programme, with the aim of choosing the most appropriate Remote Handling Simulator for use in the Fusion field. As a consequence the KISMET Simulation package, developed by KfK, has been also installed and tested.

In view of the final choice, a joint Requirements Definition Document was produced and agreed /1/. An agreement on candidates selection for simulator packages was also reached. The testing procedures and the choice decision criteria have been defined.

Reference

/1/ U. G. Kuhnapfel, M. Becquet, "RHB 1-1 / 3D Kinematic Simulator Requirements Definition Document", Document IRE 534. NET 92.TEXT (RDD 1) KfK Karlsruhe, November 3rd, 1992.

Development of a Remote Handling Workstation (Next Step Activity - Task RHB 1-2)

The purpose of this activity is to develop a Remote Handling Workstation (RHW) for the control of the RH equipments and tools envisaged for the operation and maintenance of the Next Step Fusion Reactor. This task is carried out in collaboration with KfK - Karlsruhe, in the frame of the European Fusion Technology Programme. The activity benefits from the Control Station of the ROBERTINO facility inside the TELEMAC Laboratory and from the improvements which will be applied to this Control System.

A first Requirements Definition Document concerning a general Remote Handling Workstation has been produced in collaboration with KfK. In particular a contribution concerning the Safety and Reliability Requirements has been integrated into the document. An example of a Remote Handling procedure for blanket handling has been also defined showing the high level operator support needed and the importance of the man-machine interface aspects. This activity will give the opportunity of defining and integrating a prototype Workstation on the ROBERTINO experimental facility and of applying and testing the Remote Handling simulation packages.

Studies for Remote Handling of first wall/blanket modules (Next Step Activity - Task RHI 1-2)

This activity provides support to the design of the Blanket Handling Device (BHD) full-scale prototype, which will be used, in case of damage, for the replacement of the First Wall/Blanket modules of the Next Step Reactor, with reference to the NET/ITER design. This task is carried out in collaboration with ENEA, in the frame of the European Fusion Technology Programme. The activity has been pursued, as in 1991, along two main lines, namely computer simulation and experimental validation on a reduced scale mock-up of one NET/ITER sector, by using the ROBERTINO facility (see fig. 2) inside the TELEMAC (Teleoperation) Laboratory. In parallel, the reliability analysis of BHD has been also pursued.

Computer Simulation Studies
The CATIA CAD System, which will replace the MEDUSA, has been installed and it is being used to prepare the 3-D models of the ROBERTINO test facility and of the 1/3 scale mock-ups, which are used for the experimental validation. A structural analysis has been performed on the inboard blanket models by using ABAQUS code.

A first dynamic analysis of the ROBERTINO behaviour during operation has been performed by using the ADAMS code.

Simulation packages (KISMET from KfK and ISPRA-SIMULATOR) have been installed and tested by performing the first kinematic simulations of the ROBERTINO operation. They will be linked to the Personal Computer for ROBERTINO control.

The methodologies and the packages used for the Simulation of the ROBERTINO operation can be directly applied to the simulation of the procedures for replacement of the blanket modules in the Next Step design, by using the full scale Blanket Handling Device.

Experimental Validation Activity

The purpose of this activity is to validate the results of the simulation activity on a 1/3 scale mock-up. The choice of the scale has been done, on the basis of an appropriate analysis, to perform, at an acceptable cost, validation tests with reliable indications of the behaviour of the full scale components, by taking into account some relevant mechanical aspects such as deformations under weight, impact of gaps, etc.

The facility used, ROBERTINO (fig. 2.27), is a large gantry robot, whose purpose is to test the replacement of the blanket modules mock-ups from the mock-up of one sector of a Fusion Reactor. After the first commissioning and operation of the robot, two mechanical improvements were planned to increase dynamic performances, one by adding a vertical guide on the Z axis motion and the other by installing a second screw drive unit on axis X. The first improvement has already be done and effect on the system verified.

Experience gained with reliability analysis has already permitted to improve the ROBERTINO control system in adding an extra limit in some special circumstances

Other additional equipments and mock-ups, as the structure of the cryostat above the vessel mock-up and the racks for blanket modules storage, have been completed and assembled. An original design and prototype of temporary attaching locks for the inboard segments and a temporary rigid gripping system were produced and tested successfully, by performing the first trials of automatic insertion and removal of the inboard segments skeleton structures (bare skeleton structures with reduced weights).

The connections of the outboard blanket modules to the temporary gripper and to the vessel are also under construction and will be assembled as soon as possible, in order to undertake the first trials of automatic insertion and removal for the outboard modules. Video cameras were installed inside the test bed to provide information during operation. A first part of the instrumentation (strain-gauges, proximity sensors, verticality sensors, acceleration sensors) foreseen on the gripper and on the facility has been installed and a data acquisition system has been integrated on the Personal Computer devoted to the ROBERTINO control.
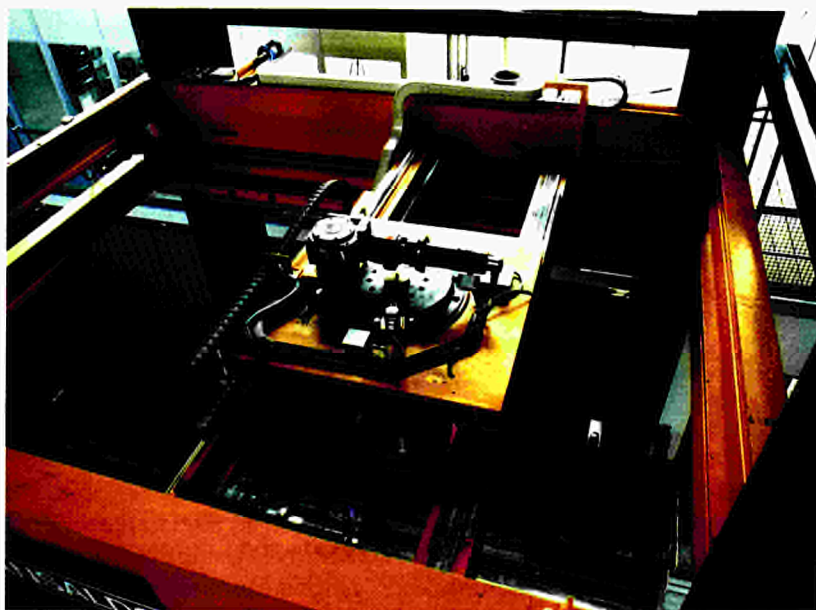
Fig. 2.27. ROBERTINO Facility

A detailed characterisation of the ROBERTINO facility has been carried out by using the installed instrumentation, in order to know the behaviour of the facility (precision and repeatability of positioning, vibrations during movements, etc.) for various loading conditions and trajectories. This characterisation will help in designing the various types of attachment locks and grippers which will be tested.

A detailed planning is in preparation, in accordance with the ITER Home Team, to define the tests which have to be carried out on the temporary gripper and attaching locks, for the removal and insertion of the inboard and outboard modules, which will be used before as

bare skeleton structures and then as mock-ups with real shape and increased weight.

The study of a new control system for improving the ROBERTINO performances has been undertaken. The new control system will be an up-graded open system with the possibility of including in the control loop sensors and supervisors.

Reliability studies

The FMECA analysis of ROBERTINO facility has been undertaken in detail. The results will be used for improving the reliability of both the ROBERTINO testing facility and the Blanket Handling Device full-scale prototype design.

Reliability Assessment of JET RH Transporters - JET Support Task

This task, whose objective is presently that of contributing to the improvement of the overall reliability of the Articulated Boom of JET, has been pursued in close link with the JET RH Laboratory, through the direct participation of an engineer on the JET site for six months.

As a result of the joint work, a test Plan Definition Document for the Software of the new Local Boom Controller has been produced. Moreover, a document concerning test cases specifications has been published at JET /1/. At the same time, a first analysis of the Articulated Boom behaviour has been performed by using the ADAMS code.

Reference

/1/ E. Ruiz, "Test cases specifications for diagnostic tasks", Tech. Note of JET Joint
Undertaking, Fus. Tech. Division, Remote Handling Group, N° U/BM/T007 Dec. 92

Envelope Analysis of Loss of Cooling Accidents

During its normal operation, Fusion Reactors structural materials (especially those near the plasma) are subjected to a high energy neutron flux and are thus activated. One of the consequences of the activation is the volumetric production of heat, called decay heat (or afterheat). Due to the very efficient thermal isolation of the reactor, in conditions of absence of active cooling,

the redistribution of the initial temperatures (at short term) and the decay heat (at medium and long term) can cause a substantial increase of the temperature of some components, leading even to their structural failure.

The demonstration that no significant thermally induced damage can be done to the containment, even in these "envelope" conditions (i.e. instantaneous, completed and permanent loss of all active cooling), is a significant contribution to demonstrate the passive safety of a Fusion Reactor. Moreover, a reliable prediction of such an "envelope" temperature history is important because many safety related processes (such as oxidation rates, tritium release rates etc.) are temperature dependent.

Such envelope calculations are extremely complex, not only because of the complicate lay-out of a Fusion Reactor but also because of the complexity of the physical phenomena involved. These calculations were undertaken at the Design Analysis lab of the General Design Office (BEG). For the last 3 years, a wealth of Numerical Analysis Computer codes, were tailored to work together with the task of modelling the post accident temperature transient of the whole Fusion Reactor for as long as 3 months after the accident. Results were tested extensively by independent parties.

As result of this and other activities, the Engineering Design Analysis lab at BEG has acquired a significant experience in complex non-linear thermomechanical calculations. Computer codes that are available at EDA/BEG include: PATRAN (FEA), P-Thermal (F. Diff.), ABAQUS (FEA Struct.), Fispact and ANITA (Activation). In parallel to that exists a considerable expertise in CAD, both 2D drafting and 3D modelling.

Envelope Accident Analysis of Loss of Cooling for NET/ITER (Next Step Activity - Task SEA 3.4)

The modelling of the complete Fusion Reactor under envelope post accident conditions involved extensive neutronic and thermal calculations, which have been done, in the context of the NET/ITER SEA tasks (3.4, former 3.8), at the Engineering Design Analysis lab. of the General Design Office (BEG). This work led to a comprehensive model of a complete 11°15' sector (including inboard and outboard components with poloidal conducting links) of the NET/ITER midplane. The codes that were used to build this model are validated and most of them are commercially available. The results of the model /1/2/3/4/5/, for the ITER CDA (Conceptual Design Activity) parameters, have been

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extensively checked against calculations performed independently with different codes /4/. The use of this model has already been requested for the Power Reactor Safety studies (Safety Environment Assessment of Fusion Power - SEAFP-A tasks).

On the basis of the past experience, a new parametric model will be developed. This model will basically be axisymmetric but it will incorporate some information about the geometrical variations along the tangential coordinate as well. It is expected that the new model will be able to adapt to the new ITER EDA as well as to the SEAFP parameters, following the designs as they evolve.

The above activity has already been proposed by the NET Team as an ITER Task. This work could produce very soon results useful in implementing additional passive safety features in the ITER EDA and SEAFP designs. In the future ,it can also be of a great use in the demonstration of the passive safety of the devices and furnish a wealth of data useful for the licensing procedure.

References

/1/ F. ANDRITSOS, M. ZUCCHETTI, "Post Accident Afterheat dissipation in the ITER", presented at the 1st National Congress on Computational Mechanics (NCCM), Athens, Greece, Sept. 1992.

/2/ F. ANDRITSOS, "Post LOCA Temperature Transient of ITER Inboard and Outboard, Draft Intermediate Report for subtask 3.4", Technical Note No I.92.30.

/3/ F. ANDRITSOS, M. ZUCCHETTI, "A Study of the total Loss of Coolant Accident in ITER", Fusion Thecnology, ANS, Vol. 21, No 3, part 2B, pp 2046-2050, May 1992, Illinois, USA (presented at the 10th Topical Meeting on the Technology of Fusion Energy, American Nuclear Society, Boston, USA, June 1992).

/4/ CH. KONRAD, H.W. Bartels, F. Andritsos, "Passive Removal of the Afterheat in the Next Step Fusion Device", presented at the 17" SOFT, Rome, Sept. 14-18,1992.

/5/ F. ANDRITSOS, "Post Accidental Envelope Temperature Transient of the NET/ITER with the European Shielding Blanket", Technical Note No I.92.81.

Envelope Accident Analysis of Loss of Cooling for Long Term Studies of Power Reactors. (Long Term Studies - SEAFP Task A2)

It has been seen that the envelope calculations done in the frame of the NET/ITER SEA tasks would be useful also for the Long Term Reactor Studies. Some preliminary calculations have already been done, based on the CDA design of ITER but using Manet instead of AISI 316 steel and extrapolating the Neutron fluxes /1/.

The activity proposed for the NET/ITER Loss of Cooling Envelope Safety Analysis is already one of the SEAFP sub-tasks. Calculations will start as soon as the neces-

sary design and neutronic data about the Power Reactor become available. Proposals or possible alternatives for specific device components (i.e. various blanket designs) can be easily integrated in the model and checked in "envelope" post accidental conditions. Steps in that direction have been taken in collaboration with CEA (France).

Reference

/1/ F. ANDRITSOS, "Post Accidental Envelope Temperature Transient of the NET/ITER design with MANET steel-Preliminary Results", Technical Note No I.92.84.

Low Activation Materials and Activated Waste Management

The large dimensions of the tokamak fusion reactors and the high ratio of fast neutrons per power produced will give rise to large amounts of activated materials. As a consequence, from the beginning of fusion studies, attempts were made:

a) to adopt as simple as possible waste disposal strategies, e.g. the near surface burial of the waste. The US Regulations 10CFR61 on "Shallow Land Burial" (SLB) were the term of reference commonly adopted.

b) to reduce, or completely eliminate the activated waste stream by recycling, i. e., the re-use of the materials in other nuclear facilities.

In order to comply with a) and b), novel materials are being developed that, beside a proper thermo-mechanical behaviour in the fusion environment, have present long term radioactivity levels (i.e., after 50-100 years of cooling) substantially lower than those of conventional materials. These "Low Activation Materials" (LAMs), which, more properly could be called "Materials with reduced long-term activation", are mainly steels, obtained by substituting selected alloying elements (Ni, Mo, Nb. . .) and by controlling certain impurities (Ag, Eu, Tb, Sm), both producing long-lived radioactivity.

In the last years, the goals indicated in a) and b) have been partially modified. In fact:

- Ideal novel materials for fusion should have improved radioactive behaviour at all cooling times. In this way the radioactivity-related safety aspects would be improved in all phases of fusion energy.

These considerations explain the investigations of the radioactive behaviour of SiC, which are described in a following section.

- The applicability of 10CFR61, developed for fission waste, to define SLB for fusion waste is criticised also in the USA, as the "credits" for the waste form and dilution, used to evaluate the maximum allowable concentrations of the various radioisotopes, are different in the two cases.

In Europe the norms on near-surface burial differ site by site and are more restrictive than 10CFR61. The trend is toward the geological disposal of the radioactive waste which cannot be recycled. The investigations on the activated fusion waste management described in a next section follow the concept of the geological disposal when the alternative solution of recycling is not applicable.

Two topics have been investigated:
- Analysis of the low-activation characteristics of Silicon Carbide
- Development of a classification of fusion activated waste aiming at reducing the tecnical requirements of the waste repositories and/or allowing the re-employ of irradiated materials (recycling).

The computer code used for the radioactive inventory evaluations was ANITA (JRC), which will be complemented by FISPACT (AERE Harwell) in the next evaluations.

Low Activation Properties of Silicon Carbide (Long Term Studies)

The neutron induced radioactivity in the Silicon Carbide composite (ceramic matrix/ceramic fibre), identified as SiC/SiC, has been analysed /1/. Short- and long-term issues have been taken into account, i.e. safety in accidental conditions, maintenance operations in the plasma chamber and waste management. The purpose was to control the compliance to the radioactivity limits of the Low Activation Criteria developed previously (see Annual Report 1991).

First wall and blanket irradiation conditions of a power reactor were examined, i.e., a first wall load of 4.15 MW/m² for 2.5 years. The impurity concentrations were assumed to be those of the material investigated at present at JRC Ispra. These concentrations are likely to be reduced in the future, provided that the most troublesome impurities are identified.

The results were the following:

- SiC/SiC in first wall conditions complies with the radioactivity limits for LAMs related to accident safety, and maintenance, which are, respectively:
  - an early dose to the most exposed individual of the public of less than 50 mSv for an atmospheric release (with pessimistic assumptions) of 100 kg of material,
  - a dose rate in the plasma chamber one day after the shut down of less than 10^4Gy/h.

The proposed radioactivity limit for MLW (Medium Level Waste, see the next section on Activated Waste Classification), settled as 20 mSv/h of contact dose after 50 years of cooling, can be fulfilled if the concentration of cobalt impurity in the material is less than 2 wppm. This impurity level is attained at present. The long-term activation of SiC/SiC rules out the possibility of "hands-on" recycling, since the contact dose after 100 years of cooling is about 0.4 mSv/h, that is, more than one order of magnitude higher than the 25 microSv/h limit. SiC/SiC could be recycled by remote handling, but the recycling of ceramic matrix composites presents difficult technological aspects.

- The blanket irradiations conditions examined are those of the blanket outboard zone, with a total neutron flux about one order of magnitude lower and also much softer than that in the first wall. SiC / SiC, largely complies with all radioactivity limits of the LAMs criteria.

Reference

/1/ P. ROCCO, M. ZUCCHETTI, "A Reference Manual for Low-Activation Materials Development and the Silicon Carbide Case Study", EUR 14805 EN (1992).

Proposal of a Classification for Fusion Activated Waste (Long Term Studies)

Timely and appropriate solutions of the waste management aspects will contribute to the acceptability of fusion as an environmentally benign energy source. Management of fusion activated waste has been analysed /1/. Taking into account the difficulties indicated in the introductory remarks, to adopt the near surface burial, the waste disposal in geological repositories seems to be the option to be investigated as alternative to recycling.

A classification of activated waste is proposed accordingly /1/, based on the two parameters affecting the waste handling and the requirements of the geological repository: the contact dose D and the decay heat per

unit volume H, after 50 years of cooling (i.e. after a period of interim storage).

Three classes of waste are proposed:

- Low Level Waste (LLW): a waste with D and H lower than 2 mSv/h and 1 W/m^3 respectively. It can be handled with the same procedures used for radioactive shipments (where the allowed contact dose rate of the package is 2 mSv/h). The low heat release does not require particular care for the heat transfer.

- A High Level Waste (HLW) has D and H greater than 20 mSv/h and 10W/m^3. Handling this waste requires substantial shielding and the repository must have adequate heat transfer capabilities.

- A Medium Level Waste (MLW) can be defined for the intermediate cases, namely for D between 2 and 20 mSv/h and H between 1 and 10 W/m^3. Shielding and heat transfer requirements are less demanding than those of HLW.

It can be stated that:

- HLW and MLW will be disposed into geological repositories. MLW disposal will have less demanding technical requirements (heat dissipation, shielding) than HLW disposal, with a greater availability of suitable sites.

- LLW, which will constitute the main fraction of fusion activated waste, can be recycled eventually, taking into account that recycling procedures have been proposed for waste having contact doses more than 2 orders of magnitude higher than the dose limit for hands-on operation, which is 25 10^6 Sv.

This classification has been applied to the activated waste of 3 fusion designs, with the following results:

- IGNITOR, a compact D-T burning machine, produces LLW only,

- ITER, an experimental reactor with AISI 316 as structural material produces HLW in the zones near the plasma chamber, all other zones are MLW or LLW,

- EEF, a power producing reactor, has a waste characterization near to that of ITER, if conventional materials are used for the structures; an advanced version of EEF, where LAMs are used instead shows a disappearance of HLW and a general improvement of the other waste (from MLW to LLW).

Reference

/1/ P. ROCCO, M. ZUCCHETTI, "A General Approach for the Management and Disposal of Activated Fusion Waste", Technical Committee Meeting on Methodologies for the Assessment and Comparison of the Environmental Impacts of Wastes Generated from Nuclear and Other Energy Sources, I.A.E.A., Vienna, 14-17 December 1992.

Safety Related Aspects of Blanket Design

ISEI had for many years, the competences and the tools for carrying on the conceptual studies and the design optimisation of Plasma Facing Components (PFC$_s$) and Vacuum Vessel with particular regard to the safety and reliability aspects.

Breeding Blanket Design Studies (Long Term Study)

The design of a tritium breeding blanket for a Fusion Demonstration Power Reactor "DEMO" /1/ has been continued. It is operated with liquid Pb 17 Li as a breeder and H$_2$O as coolant. Essential guidelines of the design were safety and reliability aspects and ease of fabrication.

Compared with former studies an improvement of the over all coverage could be achieved by the extension of the breeding blanket behind the divertor plates on the inboard side of the plasma and a better packing density of the blanket units on the outboard side.

Thermal hydraulic, thermal mechanic, and neutronic analysis demonstrated the feasibility of the design and the possibility to achieve a full tritium supply for the reactor by means of the breeding capacity of the proposed blanket.

Reference

/1/ M. RIEGER, "Design of a Modular Tritium Breeding Blanket with Pb 17 Li as Breeder and H$_2$O as Coolant for a Fusion Demonstration Power Reactor", Technical Note No. 1.92.108.

ENVIRONMENT

CEO - Centre for Earth Observation

The necessity of accessing accurate, long term and compatible data on the status of the environment is now worldwide recognised: policy makers need this information to make objective decisions, researchers need this information to understand the environment and predict its evolution, operational users are to rely on it for real time interactions.

Data derived from Earth Observation sensors have been proven to be an essential source of such information; it is therefore essential that within Europe considerable effort be given to the establishment of an environmental data network that promotes the standardisation and integration of data derived from Earth Observation sensors and thus makes available to the wider community data sets of both European and global importance.

CEC and ESA have combined these requirements in a common European initiative for the Global Environment Data Network (GEDN), that would thus link parallel initiatives in the USA and Japan.
The JRC, together with ESA, in the over all frame of these EO activities, has recently proposed a further major initiative: the Centre for Earth Observation (CEO) project.

The Centre for Earth Observation - CEO - project

The over all objective of the CEO is to ensure the long term supply and maintenance of compatible EO and derived environmental data to users. The main issue being not just the data collection per se, rather than the maximum utilisation and exploitation of existing and new environmental data, and thus the set up of enabling technologies for the accomplishment of this goal.

CEO is therefore intended to be an European data facility, composed of a decentralised distributed international network, linking data centres, centres of expertise and data users, through information, cooperation and communication modules.

In developing the CEO, JRC and ESA have complementary roles: whilst ESA's primary mission is to develop and launch the spaceborne sensors, and to acquire and distribute the data generated by them, the JRC will ensure that maximum utilisation, harmonisation and integration of EO data is undertaken. A full user oriented approach is therefore acknowledged in the JRC action.

The concept of CEO originated actually in the frame of the CEC/ESA Environment and Earth Observation Working Group early in 1991; a project outline was thus worked out and presented to a meeting of national experts (nominated by the Joint Research Centres Board of Governors) on the 13th November 1991. This meeting recommended to establish a Steering Committee to progress in the proposal for the Centre for Earth Observation; the Steering Committee was formed with observers from ESA and EFTA countries; it has since monitored and guided the development of the project and in particular the establishment of the specifications for the Feasibility Study.

The Steering Committee met twice, the first time in Brussels on the 1st July 1992, the second time in Frascati (ESRIN premises) on the 15th of October 1992; this second meeting coincided with the start of the Feasibility Study.

The next meeting of the Steering Committee will take place in conjunction with the CEO Workshop, on 11 and 12 February 1993, in London.

Meanwhile ESA has terminated the GENIUS study (Global Environmental space Network Information and User System): this study has defined a ground segment capable of handling payload data generated by present and near future EO systems. In so doing GENIUS has addressed a number of objectives ranging from data gathering/archiving to cataloguing/processing and data distribution issues.

The intention of the JRC, in the first phase of the CEO project - the Feasibility Phase - is to complement and build on the results of the GENIUS study; focus will be exercised on data application oriented problems and on user requirement analysis.
In order to achieve this, the JRC has already started two tasks:

- to define the scope of the CEO in a top down, flexible manner by investigating the range of applications that it should address, and to begin to define the product requirements through the carry over of a Feasibility Study,

– to undertake two Feasibility Demonstrators which, by exploiting existing applications, will provide models for the Pathfinder Studies to be undertaken in the second phase of the CEO project.

While the first task has made the object of an outside contract to a consortium lead by NRSC (UK), to which also Telespazio (I), Scot Conseil (F), Matra Marconi (F) and DLR (Germany) belong, the second task has been implemented through two in-house activities: the TREES project and the Dimethylsulphide (DMS) project (these activities are performed by the IRSA and EI Institutes of the JRC).

In the following some details of the Feasibility Study are given.

The CEO Feasibility Study

The study which began in November 1992, is divided into two phases which are split by a workshop designed to allow users to refine their requirements prior to the freezing of the concepts being used by the study team.

In the first stage of the study detailed data is gathered on the various institutes, agencies and programmes which used space based data, together with the detailed analysis of the structure and content of typical data sets. This permits also to perform an initial survey of national centres of excellence which could later form part of the CEO's decentralised network. In parallel with this, the sources of data are identified from national, international and non-space data capture and processing centres.

Using this information, a number of possible architectures can be developed and tested against conjectural models of what functions the CEO might usefully perform in furthering the aims of JRC towards the dissemination and use of remotely sensed data in Europe.

At the end of this first phase a workshop of technical experts will be held to agree the criteria which should be used to judge the attributes of the various architectures and to expand on any area of the horizontal and vertical definition of the user requirements which may not have been fully defined. The workshop is actually scheduled for 11 and 12 of February 1993, in London, UK.

In the second phase after the workshop, the study will incorporate the new details and complete the development of the various concepts needed to show the

feasibility and the constraints of the CEO concept. A number of "Pathfinder Studies" will be identified to carry the concept forward and reduce the risk of further stages of any programme.

A presentation will be made to the JRC Board of Governors in June 1993 of the final outline findings of the Feasibility Study and of the Feasibility Demonstrators, with a confirmation report being presented in September 1993; a decision of the Board is required for the continuation of the CEO project.

CEO Guiding Principles

Although it is too early to present results from the Feasibility Phase of CEO, it is anyway important to record few principles which are embodied in the CEO concept and strategy:

– CEO as a decentralized distributed network involving and integrating national centres of expertise (data acquisition centres, data processing centres, thematic data centres), other European initiatives (European Environmental Agency, European Space Agency etc., etc.) and the users;

– subsidiarity principle in defining the function of the coordination node of the network;

– adding value to the system, by designing added services such as interdisciplinarity in the production and use of data, and cooperation and communication in the operation of the system;

– involvement of the users in the design of the system and of the services;

– flexibility of the system architecture to cope with dynamic user requirements and with the evolution of sensor and information technologies;

– addressing research operational and commercial user domains across all relevant disciplines (physical, natural and social/human sciences);

– improving visibility of existing data regimes, through early implementation of meta-data systems;

– necessity of harmonising the user requirements for data production and processing, and the user interfaces;

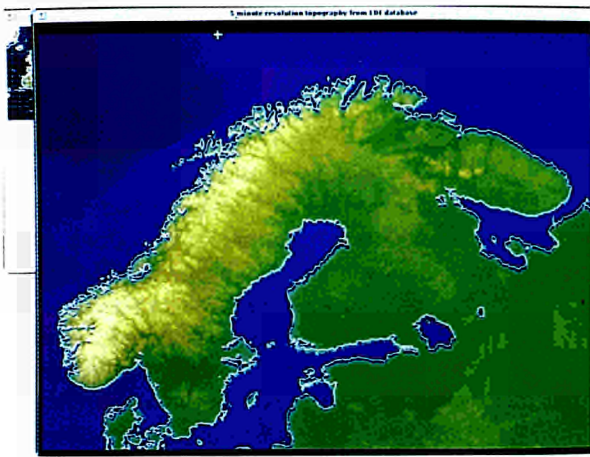– improving the networking infrastructures in Europe.

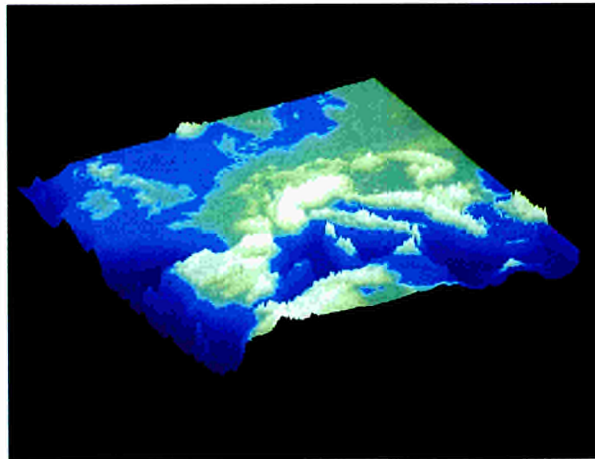**Fig. 2.28.** Topographic Image of Scandinavia

Fig. 2.29. 3-d surface topography of Europe

Remote Sensing

In the area of data visualisation the following projects have been realised in support of the JRC's Remote Sensing programme.

World mapping software "Xmap"

A computer generated mapping system based on a 5 min world topography dataset has been developed by ISEI. This software is based on the IDL visualisation package using widgets. The 5min topography data has been stored in the EDF database /1/. Topographic images are generated using as input only digital height information. The Xmap programme /2/ allows users to select any spatial zone of the globe.

The data can be displayed in various ways, and in various projections. Topography data can also be stored to a file for input to other programmes. Any geophysical data (such as sea temperature) can be overlaid onto such maps. *Fig. 2.28* and *2.29* show some example images.

3-D visualisation "S3PLOT"

A modified version of the D3PLOT programme /3/ is being used extensively to display the results of sea modelling calculations. This

programme -S3PLOT shades land areas while displaying contours in the sea of various oceanographic parameters. *Fig. 2.30* shows surface salinity of the world's oceans. The programme can just as easily handle vertical slices in the ocean. Ocean temperature and salinity data are stored in EDF database.

3-d topography display

A mathematical model of the earth's topography in a 3-D spherical coordinate system has been developed. Software has been written which uses Z-buffer tech-
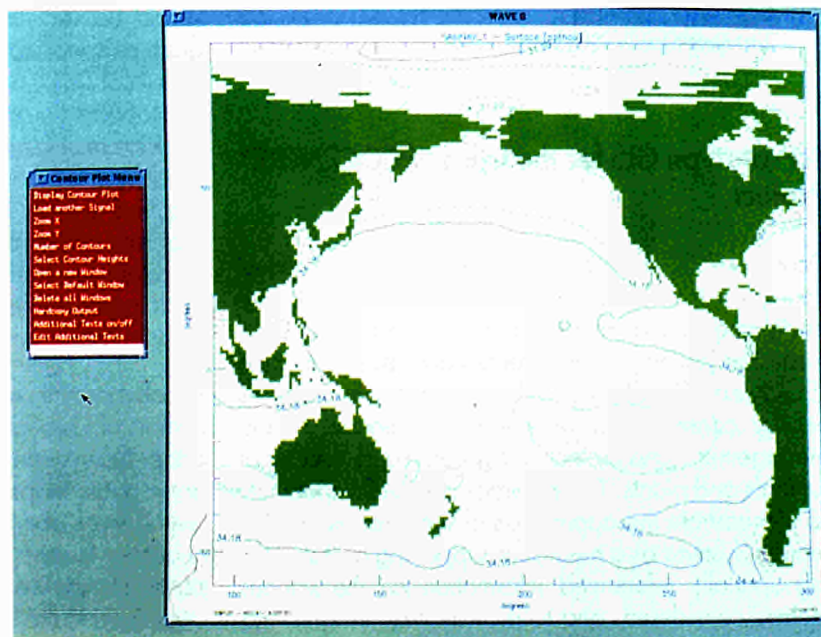

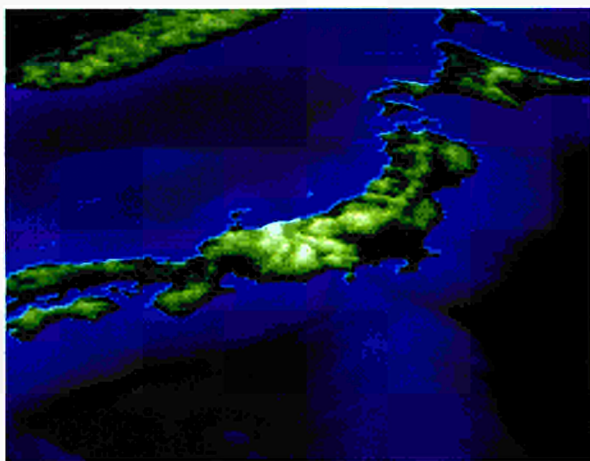**Fig. 2.30.** Surface salinity of the world's oceans

Fig. 2.31. Computer generated view of Japan from satellite

niques to visualise this model from any imaginary viewpoint, at any height and in any direction. *Figure 2.31.* shows the computer generated view of Japan from a satellite 300 kilometres above the earth. The future development of this work will be in animating global physical phenomena.

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/2/ BEST C. Xmap a geographic display tool - Technical Note to be published.

/3/ ROEBBELEN D., BEST C. D3PLOT - 3-D data visualisation Technical Note. I.92.33 April 1992.

A Prototype GIS for the Ispra "ECOCENTRE" Project

During 1992, the JRC Ispra developed a proposal under which it would use its site to demonstrate more environmentally oriented approaches to site management. The project, since accepted and given the name "ECOCENTRE ISPRA", will address issues such as energy conservation, recycling of materials, waste management, and protection of people and species of animals and plants. This provides an ideal opportunity to demonstrate the application of Geographical Information Systems as a means for supporting and structuring spatially referenced information on the various themes considered, and to provide new insights into environmental problems by the use of spatial analysis. In order to illustrate some of the possibilities, and to

develop further competence for use in the development of decision support systems for environmental management, a prototype demonstration system for the JRC site was implemented.

The PC version of "Intergraph Microstation" was used, linked to the database "dBASEIV". An existing digitised map of the JRC site was imported to Microstation and adapted for the chosen themes which were "Buildings" and "Storage of wastes and toxic materials". The information compiled for buildings included their use, number of persons present, floor area, volume, height and construction type. For the storage of toxic materials the database contained a description of the materials present, the quantities, toxicity indices, and type of final disposal. The information was compiled for a small number of example buildings. The records in the data base were linked to the appropriate graphical elements in the JRC site map, enabling map-based query of the information. This can already be used as an aid to management and planning, but the inclusion of further thematic maps and data in the future will enrich the possibilities. Preliminary work on the creation of a three dimensional model of the JRC site was also initiated.

Euroscope

Following the successful application of the Geographical Information System "GeoScope" to a project on waste management in Lombardy, it was decided that it would be very useful to have a version of this programme specifically configured for use with European Statistical Data, and ready prepared with maps of the appropriate European Statistical Regions (NUTS - Nomenclature of Territorial Units for Statistics - regions). This would permit the rapid creation of the GIS support required to build decision support systems to address problems on European scale, with easy manipulation of Eurostat statistical data referenced to the NUTS regions. Such a system was also foreseen to be potentially of use in many other areas of the Institute's work.

A collaboration agreement was established with the authors of GeoScope to make the necessary software adaptations for this GIS to be named "EuroScope". The appropriate maps of the 12 countries down to NUTS level 2 were obtained and converted into the required quadtree format. A number of tables of example statistical data were taken from the Regio publications, introduced to the system and linked to the corresponding NUTS regions.

The example data introduced at NUTS level 1 included

data on population, unemployment, private car ownership, deaths from traffic accidents, deaths from diseases of the circulatory system, agricultural output and wheat production (mostly for the year 1987). Wheat production for 1987 was also introduced at the more detailed NUTS-2 level.

Calculations can easily be performed on these example data using the spreadsheet programme "Excel", and transferred directly to "EuroScope" where results remain referenced to the appropriate European Regions. New maps can be generated using the "classify" function to classify and colour regions according computed results. *Figure 2.32* shows an example of NUTS-1 regions classified according to deaths from traffic accidents per head of population. The first "Beta" version of EuroScope is now available for use throughout the ISEI.
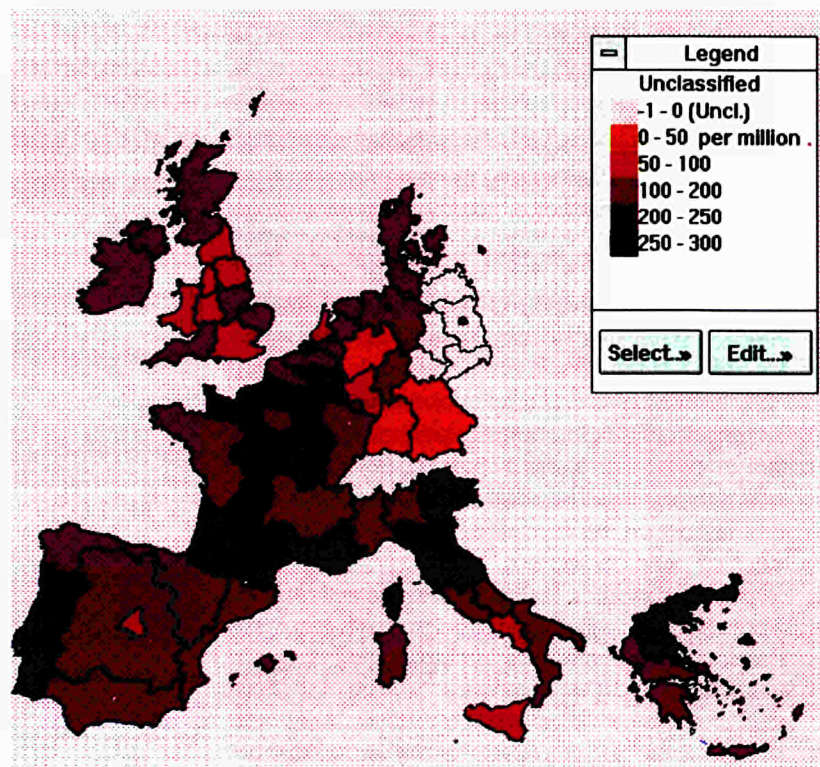

Fig. 2.32. NUTS-1 regions classified according to deaths from traffic accidents per head of population

WORKING ENVIRONMENT

The activity in the Working Environment (WE) has developed within a Laboratory of Man-Machine Systems, where four interactive topics of research are carried out:

– Cognitive ergonomics and organisational factors effecting safety, with focus on the human element of the WE.
– New technologies and safety at work, with focus on the impact of Information Technology (IT) on the design of control systems and accident management procedures. The study of human factors and their impact on the probabilistic safety assessment has also been carried out.
– Process diagnostics for early fault detection and diagnosis in accident management, with focus on the plant components and instrumentation.
– Information and Documentation Service, for data collection of accidents involving human errors as well as norms and standards for the assessment of the safety at work.

Cognitive Ergonomics and Organisational Factors

The research in the area of cognitive ergonomics has covered different field researches in Working Environments performed partly within the Working Environment Framework Programme and partly as Contract Research. The experimental research activity within the laboratory of Man-Machine Interaction has been developed in particular application of advanced analysis methods of Human-Computer Interactions (HCI) and Exploratory Sequential Data Analysis (ESDA) such as video analysis, verbal protocol analysis, interaction analysis and conversation analysis have been performed. These techniques were in particular used to further analyse recordings of operators interacting with a nuclear power plant, the Steam Generating Heavy Water Reactor (SGHWR). The results allowed to provide better description, explanation and prediction on operators problem solving and strategies in specified and in unspecified incidents.

Analysis and Modelling of the Effects of Stress on Cognitive Activities in Air Traffic Control

The goal of the research, partly funded by the CNR Roma, Italy, is (a) to analyse the causes and the effect of stress on controllers' cognitive activities in Air Traffic Control (ATC) environment; (b) to develop a model based on the results obtained of the relationship between stress and cognitive activities; (c) to improve the design of computer-based tools by providing a stronger scientific basis for the analysis of design specifications. The choice of the ATC domain was motivated by the increase of traffic these last five years and therefore the necessity to evaluate whether this increase has an effect on controllers' workload and whether current decision support systems (radar screen, flight strips and audio equipment) are appropriate. Important questions /1/ are - how does stress affect cognitive mechanism and, ultimately, performance - what are strategies used by ATC controllers when coping with stress and what cognitive activities do these involve?

The study focused on approach control (departures and arrival). A mission analysis allowed a sequential description of controllers' strategies and cognitive activities. Data were collected during the execution of the task in variable workload moments (high, medium and low workload) by:
– observing controllers when performing their task,
– recording of realtime radar,
– video recording controllers,
– audio recording of ATC controllers and pilots interaction,
– auto-confrontation of controllers to the video recording and
– rating scale on subjective stress.

New technologies and safety at work

The activities in the area "New Technologies and Safety at Work" have concentrated on:
– STEP Project 83 System Response Generator,
– Interactive Planning for Integrated Supervision and Control in Complex Plants,
– Human factors study.

System Response Generator

The purpose of the System Response Generator project is to develop and implement a software tool which can be used to analyse the interactions between an operator and a process, in particular the influence of human decision making and action in the way in which incidents in complex systems evolve /5/.

Specific uses of the SRG are:

- to explore the ways in which a scenario can evolve, by systematically examining all the possible combinations of conditions and events,
- to identify potential problem areas, i.e., the parts of the task and the Man-Machine Interaction where problems are likely to occur,
- to evaluate the effects of specific modifications to the system (of e.g. procedures, information presentation, level of automation, or control options), and
- to provide quantitative data as input to more formal types of analysis.

The System Response Generator architecture consists of a number of software modules (see fig. 2.33). The system mediates, supervises, and controls a simulation of human decision making and action, and a simulator of the process. A first version of the System Response Generator has been implemented and successfully tested in the avionics domain. The specification of the Operator Simulator has resulted in the design of a Contextual Control Model. The Operator Simulator is a continuation of the already existing activity on the cognitive simulation model, called COSIMO /3/. Experiments have been conducted and analysed on the application of cognitive models in a system of cooperating agents /6/.

Two demonstrations of the SRG have been implemented: the control of a simple water tank and the control of an aircraft. For the latter application a simulation of an Airbus has been used (see fig. 2.34), with a representation of a pilot following the procedures for auto pilot based maneuvers. The aircraft application has been used to analyse the consistence and robustness of procedures for nominal flight and emergency procedures.

Interactive Planning for Integrated Supervision and Control in Complex Plants

The overall purpose of the project is to demonstrate the application of models of plant goals and functions in a planning task for the systematic integration of human supervisory functions with the automated control systems.

The study has the following three main objectives:

- To develop a demonstrator for a start-up planning task in a conventional coal fired power plant boiler. The system will enable the operator to participate in the planning process and to carry out his own strategies within a task envelope maintained by a planning support system. The task envelope is maintained on the basis of plant models representing plant design knowledge.
- To propose extensions to the demonstrator comprising fault management tasks involved in an Auxiliary Feed Water System (AFWS) simulator.
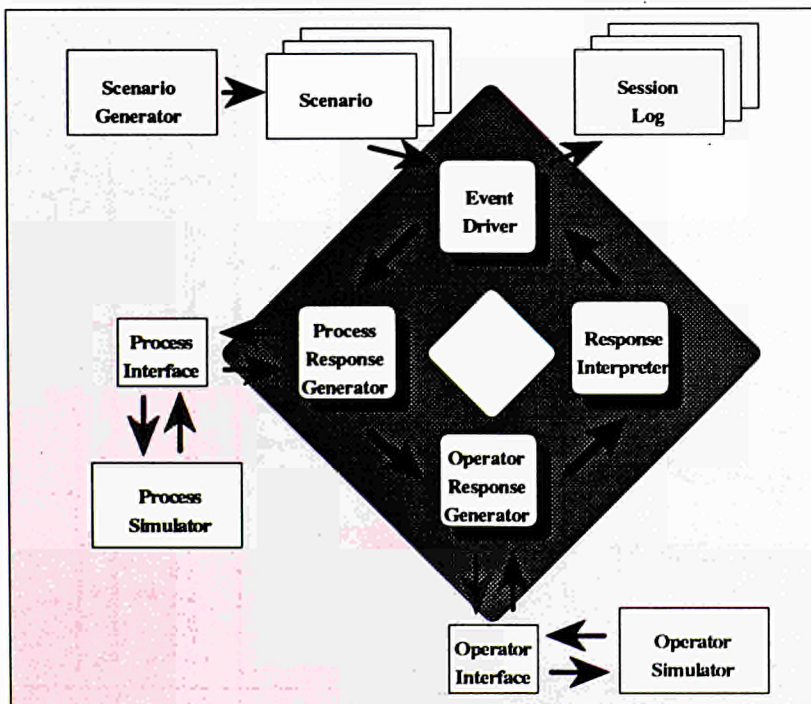- To investigate the use of means-end and part-whole concepts for modelling of the planning tasks.

The system architecture has been defined and the appropriate knowl-

Fig. 2.33. General architecture of the System Response Generator

edge to support an operator interactively during a start-up of a coal fired power plant has been established. The physical structure and component description have been defined and formalised. The functions of the power plant have been identified and modelled using the Multilevel Flow Modelling (MFM) technique (fig. 2.35). The procedures for start-up have been analysed and coupled with the structural and functional models.

Human Factors Studies

The activity relating to the analysis of procedures and of human errors with dynamic methods has been developed in connection to the research conducted in the same domain in the reactor safety area /4/. In particular, a study of the pilot-airplane interaction of a Boeing 747 type like aircraft, during the approach to landing phase, has been developed /2/. A classic human reliability technique, THERP (Technique for Human Error Probability), has been employed as reference in order to present the advantages derived from the use of a dynamic human reliability analysis. It has been shown that, given certain initial conditions of the system, the

study of the sequence with a dynamic technique for human reliability, based on the simulation of the man-machine system, may turn in failures success sequences obtained with the simpler THERP analysis. *Fig. 2.36* shows the human error dynamic event tree resulting from a man-machine simulation, with the enhanced failed sequences which are evaluated as successes in a THERP analysis.

In this area of research, another project is being carried out in collaboration with other European research institutions and industries: HEAT (Human Error Analytical Taxonomy) (Project STEP-CT 90-0089). This project is dedicated to the development of a method for the data collection and organisation of accidents related to human factors and it contains a new type of protocol essentially oriented to the socio-technical aspects of the working environment in which the accident has been generated. A first set of field data have been analysed and a number of more methodological factors, relative to the data collection software have been studied (STEP-PROJECT HEAT - Interim Report, 1992). The software has been further developed at JRC and it is presently being revised and tested for the final release and description.
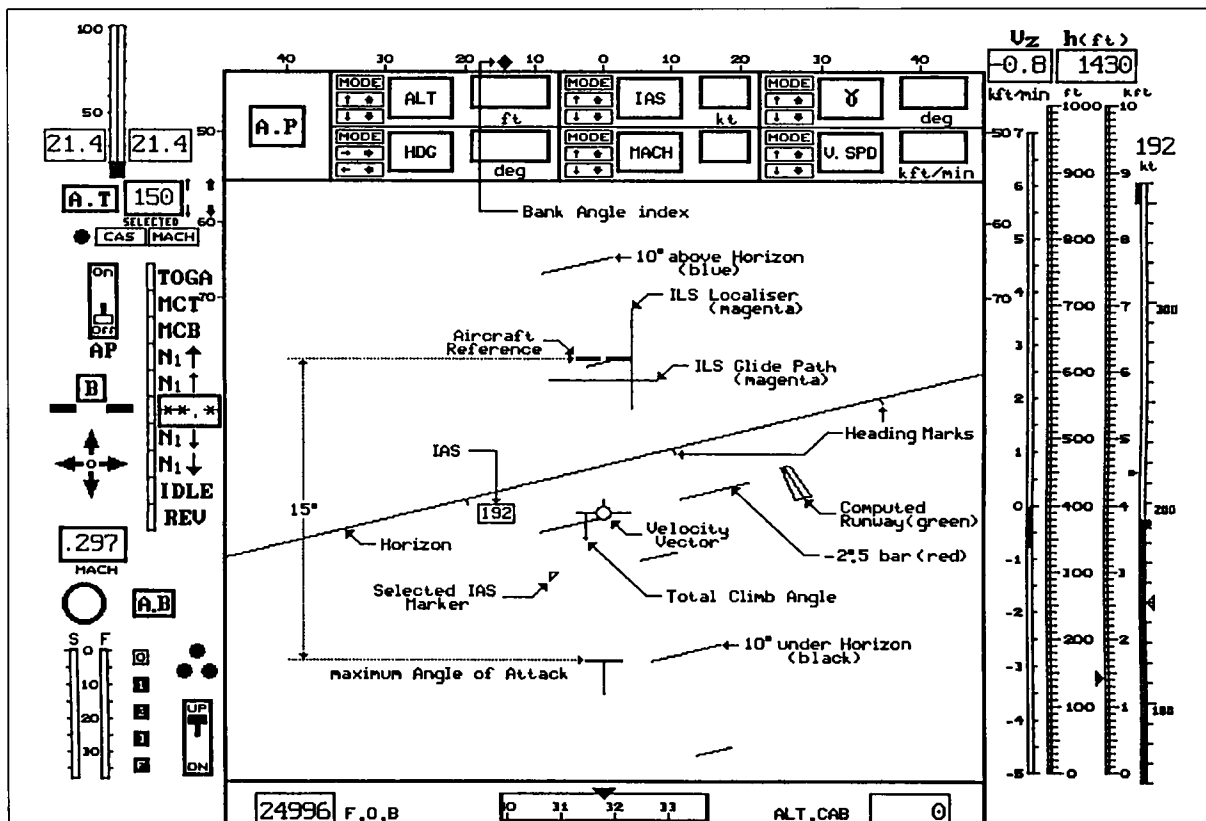

Fig. 2.34. Airbus Flight Simulator

Process diagnostics

The work deals with "statistical diagnostics" of systems suitably modelled within a linear stochastic pattern and refers to the management of installations, where a continuous, or quasi continuous, monitoring of the working operations is practicable.

The ultimate aim of the research is to provide the human operators with automatic diagnostics devices of control and supervision for an integrated diagnostics methodology in the Man Machine Interaction /8/.

In particular, the integration of stochastic modelling and simulation with cognitive engineering techniques is, at the present, an open problem.

Methodology

Recursive Estimation: The choice of the estimation procedure is an important key for the interpretation of the data. The recursive estimation procedure offers, with respect to Maximum Likelihood techniques, several advantages: robustness to loss of whiteness in the error distribution and allows, because of its on line character, updating of estimates and verification of velocity of convergence. For this reason in this context, suitable criteria of optimality, e.g. the "criterion of actual identifiability", for a careful selection of the possible trajectories of reference have been studied and implemented. In fact, only estimates derived from satisfactory trajectories can be considered as satisfactory estimates, because in these cases the physical system is closer to conditions of optimal identifiability. Nevertheless, even
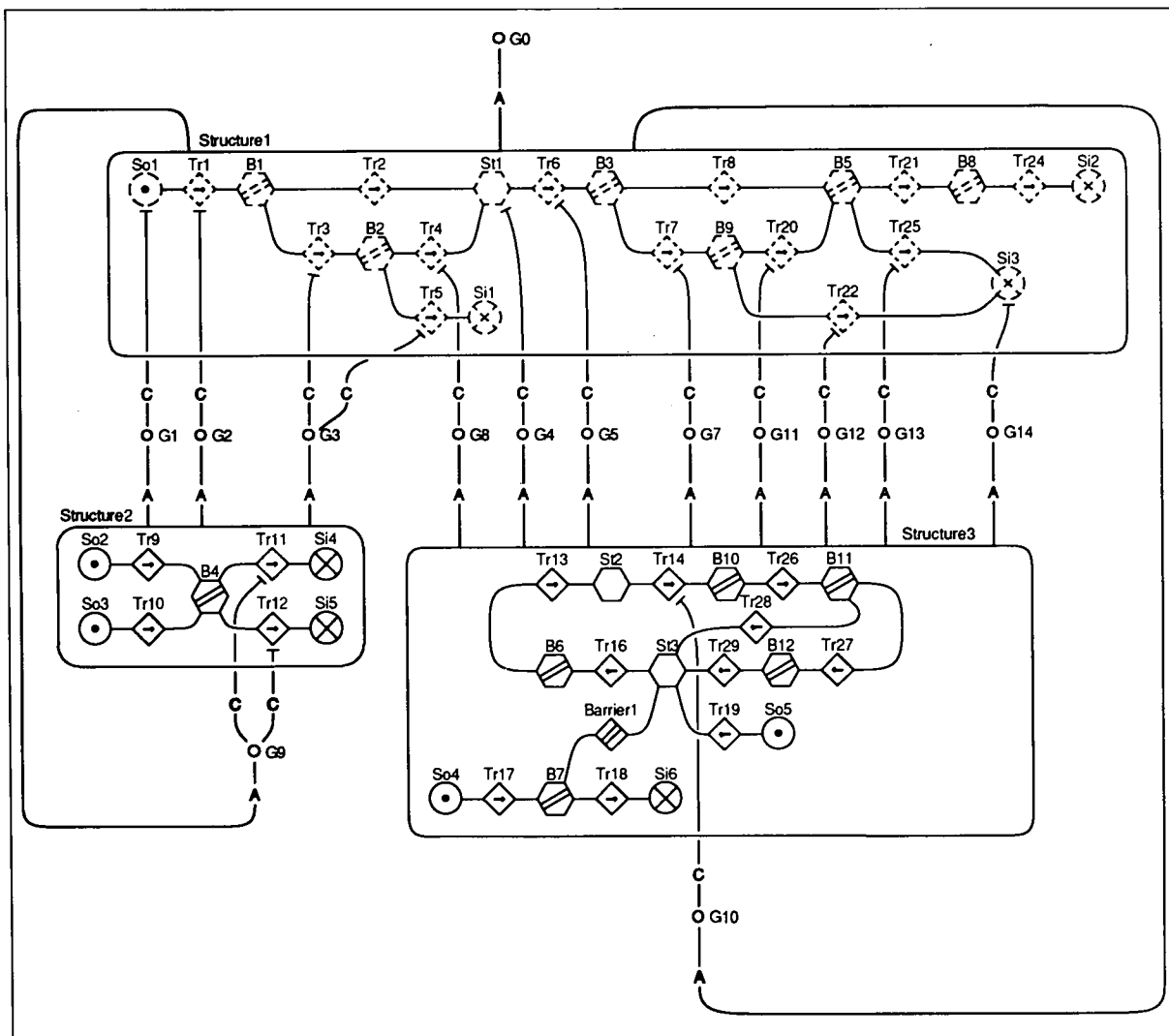

Fig. 2.35. Multilevel Flow Model of coal fired power plant.

75

156
251
282
301 **306**
(S) **F F₁** **F**

154

157   **157**

245
276
F

202   **202**   **241**   **241**

295   **300**

262 **254** **255** **247** **255** **255** **249** **249**

352 **F 342** **F 345** **F 337** **F 342** **F 341** **F 338** **F 337** **F 335** **333** **334** **333**

S **S** **F** **F** **S** **F** **F** **F** **S** **S** **F** **F** **S** **F** **F** **F** **F₂** **F** **F** **F F₃** **F** **F** **F**

F1: Flaps to position 1.
F5: Flaps to position 5.
F10: Flaps to position 10.
CA: Calibration of altimeter on QNH.
LV:Llevel the flight on 4000 ft.
CL: Execute the approach check list.

* The enhanced sequences
would result in success
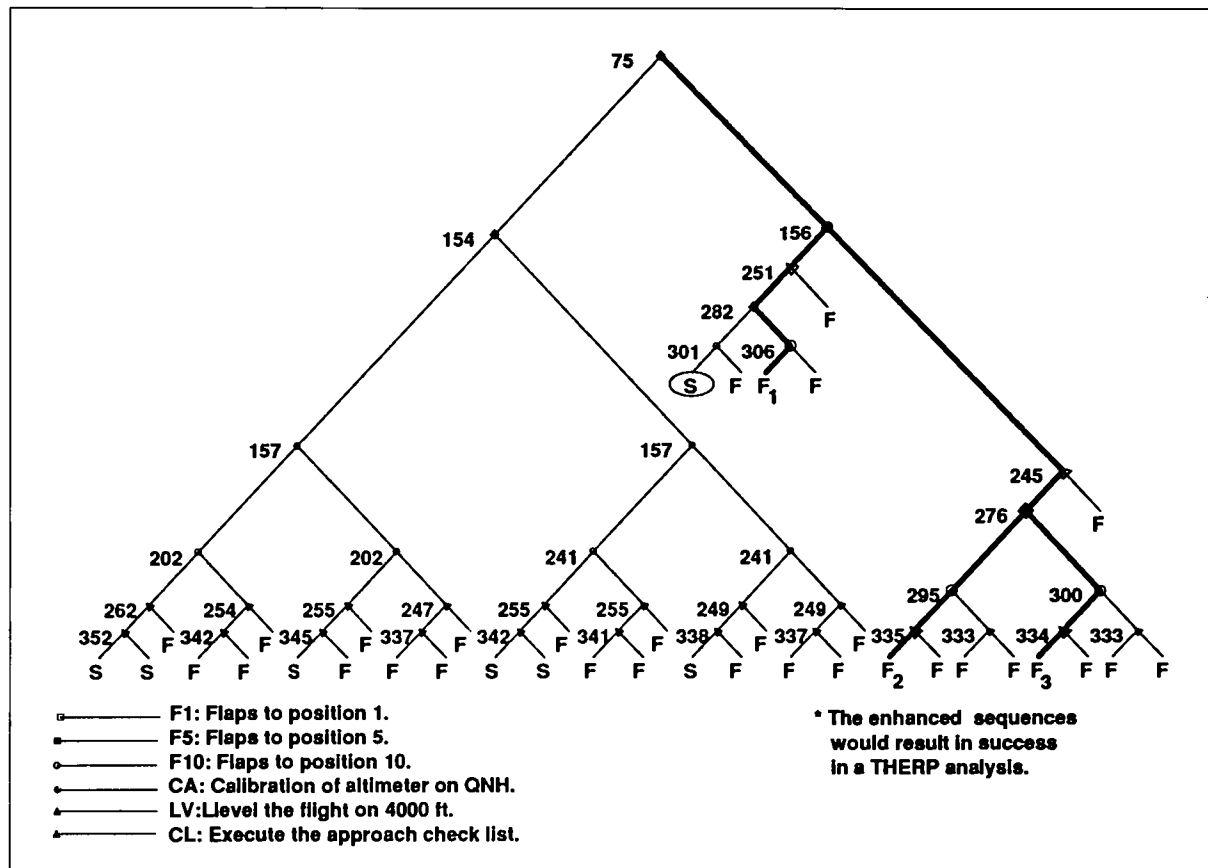in a THERP analysis.

Fig. 2.36. Example of human error dynamic event tree.

if the constraints imposed by the rules of theoretical identifiability are respected, when the number of observations in a trajectory has not reached the sufficient information content to assure the parameter estimation, the velocity of convergence is unsatisfactory. The results obtained enable a criterion of actual identifiability to be defined and, in practice, one can decide whether the coefficient estimates can be accepted and considered as convergent estimations of the model parameters, or refused.

Handbook for Process Diagnostics: The software has been tested and the results are very satisfactory. The handbook can be considered accomplished and available to the market. The documentation has been published in the form of a technical note /8/.

Applications

Experiment Facilities for Process Diagnostics: The methodology for fault detection and diagnosis in systems

engineering, up to now tested only in a simulation environment, needs a proper validation. To this aim, a Lab experiment of identification of an electromechanical system as a black box generator of signal trajectories has been chosen. It is expected to receive the first results of on line process parameter estimation by Spring 1993. The experiment is performed in collaboration with the "Istituto di Elettrotecnica Industriale Università degli Studi di Bologna" and "Dipartimento di Statistica, Universita` di Padova".

Diagnostics for a combustion boiler: The experiment regards the identifiability, within a diagnostics project, of the combustion process in the combustion boiler of a thermoelectric power station of an industrial plant of Enichem-Anic in Ravenna. Data provided, concern two observation sets of one hour duration each at two different running conditions. Two output variables are of importance: the whole air provided to the combustion chamber and the residual oxygen at chimney. Each single set of data has been submitted to the check of actual identifiability and convergence velocity, then,

identified by the ordinary recursive procedure and fitted on a 2-AR (1) model at a sampling rate of 5 seconds. This rate assures a good convergence. The coefficients have been obtained by recursive identification procedure.

Information and Documentation Service

In view of the creation of an Information and Documentation Service, contacts have been taken with some European Organisations active in the field of Occupational Accident Prevention and Management such as: Health and Safety Executive (HSE - UK), Institute National de Recherche et de Securite' (INRS - F) and the Istituto Superiore Prevenzione e Sicurezza del Lavoro (ISPESL - I). ISPESL agreed on our request to access in 1993 their data system S.I.PRE (when the system will be operative). Further contacts should be taken with INRS to establish a line of collaboration.

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3 EXPLORATORY RESEARCH

3 EXPLORATORY RESEARCH

HIGH SENSITIVITY INTERFEROMETRIC SENSORS

Objective: Development and characterisation of high sensitivity interferometric sensors.

The 1992 activity was essentially devoted to study, improve, characterise the two sensors discovered the year before within the FWP Measurement and Testing.

The first device is for temperature variation measurements (non-contact). By comparison with performances of thermistor, it can be estimated that the interferometric sensor is able to detect temperature gradients much lower than 10^{-3} °C. Calibration of the device and correct quantitative interpretation of the measurements is a goal which is pursued by image processing techniques (the response of the sensor to temperature variation is in fact constituted by a modification of a field of interferometric fringes).

A sensor of similar configuration has furthermore been set up which is able to detect extremely low variations of pressure. The high sensitivity and the fast response of this detector may lead to a number of different applications in fundamental physics and industry as well.

The second device is an all optical interferometric modulator. The device has similarities to a nonlinear optical material in the sense that it is possible to modulate a laser beam by another laser beam. The system has equivalent properties to an optical switch and also presents bistable or multistable behaviour. The high sensitivity and the low response time of the system seem quite suitable for opto-electronics applications, for example optical computers, optical telecommunications etc.

A third device has been developed in 1992. It is an optical transducer which is extremely sensitive to small vibrations and to gravitational interactions between masses in movement. The transducer is placed on a massive optical table (300 kg) with pneumatic support (isolation from vibrations) acting like an antenna. The transducer is for example able to detect the microvibration induced onto the table by a small mass (1 kg) slowly rotating outside the laboratory.

The theoretical calculations estimate that the sensor detects the micromovements of the optical table having amplitudes of the order of 10^{20}. The device, should its performances be confirmed by further investigations and tests, could be very useful in applications such as: passive radar; studies of microvibrations; study of microseismicity, etc.

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NEURAL NETWORK RESEARCH

Neural Network Image Classification for Land Cover Mapping

This project is a more focused extension of a previous exploratory research project on "Neural Networks for Remote Sensing Images", which covered the application of neural networks to remote sensing in general. The main purpose of this activity, which is done in collaboration with the IRSA institute, is to develop to a very high level the possibility of operationally using neural networks in mapping land cover from space over large regions (e.g. 10.000 sq. km.). This includes continued improvement of image classification for land cover mapping, which has been performed through the development of hybrid connectionist classifiers.

Hybrid Neural Network Classifier

A number of studies undertaken both in the Joint Research Centre and elsewhere have demonstrated the power of multilayer perceptron (MLP) networks in performing image classification /1/.

Such networks are supervised pattern recognition systems and have been found to give good results, eventually achieving of the order of 80% accuracy with 20 or more classes /2/.

Since a number of alternative neural network models exist for supervised pattern recognition some experiments were performed to see if improvements in classification accuracy could be achieved by using hybrid classifiers based on a combination of the multilayer perceptron model with other methods /3/.

MLP networks were combined with Kohonen Learning Vector Quantization networks (LVQ). In this hybrid procedure, outputs from the second hidden layer of neurons of an MLP net were fed in parallel both to the output layer of the MLP and also to the inputs of a LVQ network. The LVQ network was then trained with the data fed from the hidden layer of the MLP. Afterwards the classification performance was compared by examining the results derived at the outputs of the MLP network and at the LVQ network output. Interestingly the experiments demonstrated that the use of the LVQ method to replace the final layer of the MLP network gave increased total classification accuracy of the order of 1 - 2%. The MLP network is essentially a method for learning hyper-planes in pattern feature space to separate the classes in the data. The LVQ method is based on the learning of prototype pattern feature vectors to represent the separate classes. The results showed that the prior use of the MLP network to pre-set class separation surfaces in feature space makes it easier for the LVQ method to adapt its own model of the image class characteristics.

Commercial Development of the Neural Network Technique

A collaboration was established in 1992 with the National Remote Sensing Centre Limited (NRSC, UK) for the commercial exploitation of the neural network technique in remote sensing. NRSC Ltd has entered into a partnership with JRC to develop the technique for the market. Also NRSC Ltd. undertook some evaluation studies in which the connectionist method was found to be particularly useful in discriminating land cover and forest classes in a water collecting area from Landsat-TM imagery.

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A Reinforcement Connectionist Approach For Robot Path Finding

This research aims at building autonomous mobile robots able to generate feasible paths to a target destination in real time. A path is defined as feasible when it is sufficiently short and, at the same time, it has a wide clearance to the obstacles. Concern is also given to mobile robots that have to perform their tasks in environments that are partially unknown, are perceived inaccurately (due to sensors limitations), and are dynamic. Finally, mobile robots should tackle continuous domains. If the set of robot configurations and robot actions are discrete, then some feasible solutions may be lost and, on the contrary, some unfeasible solutions may be accepted as correct up to the resolution of the representation.

These features make unapplicable classical teleoperation approaches as well as planning techniques. Our approach is to control the robot by means of a reinforcement-based reactive system, whose main component is a neural network. In this framework, the robot must learn to produce a suitable action for every perceived sensory situation from a limited experience. In order to solve this learning task, the robot simply tries different actions for every situation it finds when experiencing the environment and selects the most useful ones as measured by a reinforcement or performance feedback signal. A second benefit of learning in this way is that the robot can improve its behaviour continuously and can adapt itself to new environments. /3/ discusses how to build autonomous mobile robots through reinforcement connectionist learning. /1/ reviews the work we have done.

During this year 1992, an initial prototype developed at the end of 1991 was improved. The new prototype is intended for a cylindrical mobile robot of the Nomad 200 family with 16 analog infrared sensors and 16 analog sonar sensors evenly placed around its perimeter. /4/ describes in depth the first prototype and /5/ reports the most important results.

The new prototype has been tested in simulation before implementing it onto the real robot. These simulations show that the robot learns extremely quickly, exhibits good generalisation capabilities, copes with dynamic environments and adapts easily to new environments. /2/ describes partially the second prototype and reports first results.

The first experiments with the real mobile robot that have been carried out seem to prove the feasibility of our approach.

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Neural Networks for Navigation of an Autonomous Robot

The objective of this work is to investigate the use of artificial neural networks for mobile robot navigation. The mobile robot includes a belt of 24 ultrasound sensors, as well as other sensing devices, e.g. TV cameras and laser range finder. Ultrasound sensors are cheap sensors, and provide accurate range measurements when used in optimum conditions. these conditions are difficult to obtain in real operations. The data integration capabilities of neural networks seem an important asset to take advantage of the ultrasound spatial redundancy and overlapping, in order to obtain better environment descriptions, or to guide the vehicle among obstacles.

An early study has identified some neural network architectures and topologies suited to this particular application /1/. At the same time, some neural network simulating tools have been installed and tested in different computing environments.

Developments were made in what concerns ultrasound data acquisition and its fast transmission to a central workstation. This made possible the implementation of a realtime visualisation tool for ultrasound range data, as shown in fig. 3.1. Current work deals with the construction of ultrasound perception maps, i.e., the spatial environment representation by means of appropriated occupancy grids /2/.
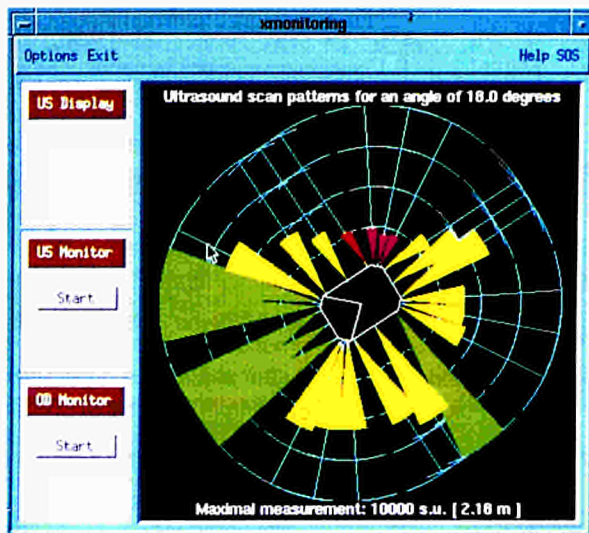
Fig. 3.1. Ultrasound Range Data Visualisation

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SIGNAL DETECTION IN INFORMATION SEQUENCES

The objective of this research activity is to develop methods for the production of atlases of signals in informational sequences. Two types of informational sequences have been selected for the development and testing of such methods: genetic sequences and abnormal event sequences observed and recorded in nuclear power plants. These two types of informational sequences share very different characteristics. Genetic sequences are error free, with codes established independently of data collection, of a small size and of a low dimension. Event sequence data are very much dependent on specific data collecting schemes which provide for many variables with many categories each. Hence, informational sequences of the former type are ready for processing whereas the detection of patterns in the latter prerequires the transcription of the sequence data into alphabets tractable (relatively small in size) and imposing no information loss in the transcription.

The detection of repeat signals in informational sequences has been formulated and posed as a statistical hypothesis testing and estimation problem addressed by the likelihood ratio principle (LRP). For genetic sequences, the presence of signals in sequences is formulated as the concatenation of noise to string pairs of unknown location and unknown match/mismatch probabilities appropriately constrained. Likelihood maximisation has been carried out as a convex programming problem. The significance of repeat signals is assessed by simulation. The above approach has been applied in the amino acid sequence of one of the structural proteins of Antherea polyphemus to produce an atlas of the repeat signal realisations in the sequence. The signals are in concordance to those reported in the literature and detected by visual, subjective, less efficient and less objective procedures /1/.

In order to investigate on the development of similar approaches to event sequences, data of the Abnormal Occurrences Reporting System (AORS) - a data base designed and managed by the JRC in the past - have been exported from ADABAS into SAS libraries. An examination of AORS data has been carried out with a view towards variable duplications and data validation /2/.

The dimension of abnormal event sequences will be reduced by transcribing sequences data into alphabets of smaller sizes, in a reduced number of variables and at no large loss of information. It is expected that such reductions will be made feasible by a comparison of entropy estimations of joint and marginal distributions of the variables examined in the raw data /2/3/. The application of LRP on the transcribed data is expected to yield statistically significant of repeat and precursor patterns in the data.

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CO-EVOLUTION IN COMPUTER-SUPPORTED SCIENTIFIC TEAM WORK

The exploratory research project entitled "Co-evolution in Computer-Supported Scientific Team Work" was started in January 1992 for a period of two years. It has been performed during 1992 in collaboration with various laboratories, particularly with RSO, University of Milano and Tecnomare.

This project aims to specify and design (prototype) a Computer-Supported Co-Evolutive Work (CSCEW) workbench enhancing the co-evolutive capabilities of distributed work performed by a scientific team. This workbench should assure that the outcome of the collaborative work of a team, connected by e-mail and a file exchanging network, results from co-evolution of knowledge and does not correspond to simple juxtaposition of knowledge.

Within the Institute for Systems Engineering and Informatics, from 1989 onwards particular attention has been given to the impact of communication, by computer networks, on scientific work performed in parallel by a large number of scientists, constituting a team.

In this field, a joint effort with the laboratory of Ricerca Sistemi Organisativi (RSO) lead to a workshop entitled Cooperative Work in Research Laboratories in December 1989. Then, electronic mail provided the opportunity to start some generalised experiments and a presentation was made at the "Get-Together" of the Second European Workshop on Computer-Supported Cooperative Work in September 1991 /1/.

Particular consideration has been paid to knowledge co-evolution as the modality, enhanced by computer-supported communication, which makes cooperative work in a scientific team more efficient and effective, as it enhances collective creativity. Two co-evolution modalities in computer-supported communication have been recognised by other laboratories (e.g. Tecnopolis) with whom we are collaborating. These modalities are also important for the effectiveness of Distant Learning systems.

During the seminal works, the conceptual link between the co-evolution process and the emergence of meaning process, due to Henri Atlan, has been recognised /2/. Based on this background, it seems reasonable to conceive a structured research programme aiming at qualifying the co-evolution modalities obtained by networking, and to design a workbench, to add to a

computer network system, that could enhance these modalities as far as they are useful for the purpose of networking.

Four phases have characterised the work on the CSCEW workbench during 1992. They are:

– Analysis of four of JRC's research projects (AIRS, DAF, FORMENTOR and RITO projects) for identifying their quality indicators and dissatisfaction indicators (terminology taken from Fernando Flores). From these analyses indicators of co-evolution and the project needs regarding tools for co-evolution are deduced /3/.

– Timed analysis of work processes of an R & D Engineering organisation external to the JRC (Tecnomare) for measuring the correlation between SQA (Sistemi di Qualita Aziendale) project quality factors and their parameters of dissatisfaction /4/.

– Identification of available groupware adapted to R & D work processes and mapping the selected groupware to the requirements for co-evolution in order to assemble the CSCEW workbench /3/.

Modelling of Co-authoring Work Processes by Petri nets

While these studies were analysed, a global model for co-evolution has emerged. An extension of the exploratory research will allow a detailed specification of the model for co-evolution and guidelines for its realisation, including the choice of suitable tools according to the type of work processes.

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4 SUPPORT TO COMMUNITY POLICIES

Support to International Cooperation (DG I)

Support to the Community Industrial
Policy (DG III)

Support to the Community Transport
Policy (DG VII)

Support to the Community Environmental
Policy (DG XI)

Support to the Community
Telecommunications, Information and
Industrial Innovation Policy (DG XIII)

Support to the Community Energy
Policy (DG XVII)

Support to the Community Statistical Office

Support to the Secretariat-General
of the Commission of the EC

4 SUPPORT TO COMMUNITY POLICIES

SUPPORT TO INTERNATIONAL COOPERATION (DG I)

Support to DG I/IAEA

The cooperative support programme to IAEA safeguards comprises a number of specific tasks covering a wide range of scientific disciplines. These tasks are performed in the Institutes of CBNM, ISEI, IST and ITU. The overall coordination of the programme in respect to IAEA is performed by ISEI. In particular ISEI performs activities in the area of safeguards information systems, surveillance techniques, sealing/identification techniques and studies on volume/mass determination in liquids. The highlights for these last activities are presented below.

Safeguards Information Systems

The activities were mainly concentrated on the design and implementation of a knowledge based system for transit matching and on the review and upgrading of the Safeguards Equipment Information Systems.

One of the responsibilities of the IAEA is to confirm the receipt of international and domestic shipments of nuclear material by matching shipments reported by one Member State against receipts reported by another Member State. This activity requires considerable human effort and expertise to study and judge lists of declarations. An expert system, Computer Assisted Human Matching (CAHM) has been designed and implemented to reduce substantially the manpower required in the phase of Human Transit Matching. This new system is integrated within the IAEA safeguards Information System (ISIS) and has completely replaced the previous manual matching system for NPT. The extension of the application of the CAHM system to declarations made according to different rules has been made. In this framework the following approach was followed:
- generation of the required knowledge base
- development of a customized rules interpreter
- design of an interactive multifunctional editor for the problem selection and review of the resulting automating matching.

The purpose of the Safeguards Equipment Information System (EQUIS) is to provide an automated system to inventory safeguard's equipment and to provide com-

prehensive information on each piece of equipment inventoried. The information stored in the data base identifies each equipment item, including in some cases information on the individual sub-assemblies of equipment, when it was purchased, how much it costs, by whom it was manufactured, a description of the item and how it is used. The data base also includes a history of where and when the equipment is and was used. Moreover, the Division, Section and Staff member responsible for the equipment item is recorded.

The first version or the EQUIS system was installed on the IAEA Vienna Computer in May 1992 and has replaced the old batch-oriented system.
EQUIS data can now be updated with an easy to use on-line data entry system and consulted with a query system and with an optional hardcopy output.

Sealing and Identification Techniques

Ultrasonic sealing techniques are being applied by IAEA mainly for two applications, namely for the sealing of CANDU spent fuel stacks and of Multi Element Bottles (MEB) for LWR spent fuel storage, used at Sellafield. For this reason JRC, SNL (US) and AECB/AECL (Canada) have actively proceeded with the In Situ Readable Ultrasonic Seal System (IRUSS) project, aiming to develop a single instrumentation for reading both types of sealing systems. Based on the recent experience gained at JRC Ispra, on the replacement of separate ultrasonic pieces of reading equipment by ultrasonic boards, new technical specificatons were studied and jointly defined.
Much exchange of information took place between JRC and AECL laboratories to compare their respective technology used for the ultrasonic reading devices and a one week technical seminar was organised at Ispra in November for demonstration exercises and for developing a common workplan.

On request of the IAEA the first prototype of a Seal Interface Unit, capable of reading both systems, should be delivered by January 1994. Furthermore the IAEA ordered 50 seals to be applied on MEB's which are to be delivered in 1993. These sealing bolts are used jointly with those applied by the EURATOM Safeguards Directorate.

Solution Mass Verification Technology

The Mini TAME laboratory, transferred from IAEA Vienna to LaSCo last year, is a small scale model of a mass and volume measuring system of liquids used in bulk handling facilities. The lay-out of this facility may be subdivided in the following parts: the tank, the hydraulic lines, the pneumatic lines, the measurement instrumentation. *Fig. 4.1* provides a flow diagram of the different parts.

The Tank

A 150 litres circular stainless steel tank is equipped with a mouvable mounting panel with three dip tubes, a thermocouple to measure the water temperature, a TDR (Time Domain Reflectometer) probe, a sampling line and at about half of the height a 2 litres internal pot. This tank is also equipped with an air sparging system. With the combination of three dip tubes, density and level are measured. The difference of height between the level and the density probe is 357 mm. The small squared

internal pot is used as a "signature" of the stainless steel tank during calibrations and recalibrations.

Hydraulic lines

In Mini TAME the calibration liquid presently used is water. There are two lines:
- a calibration line, from the feed line to the tank, through a 30 litres prover where the increments of liquid are measured with a weighing scale
- a direct line, used during continuous re-calibrations, equipped with a flow meter.

The amount of liquid in the 150 litres tank can also be measured with a load cell. The temperature of the feed water is measured in the prover with a thermal gage connected to a data logger.

Pneumatic lines

The flow of the three lines used during these experiments is regulated by three rotometers for a flow of ca. 7 l/h of nitrogen. From these rotometers the pneumatic tubing is teeing to the dip tubes, to the pressure sensors and to the pneumatic scanner.
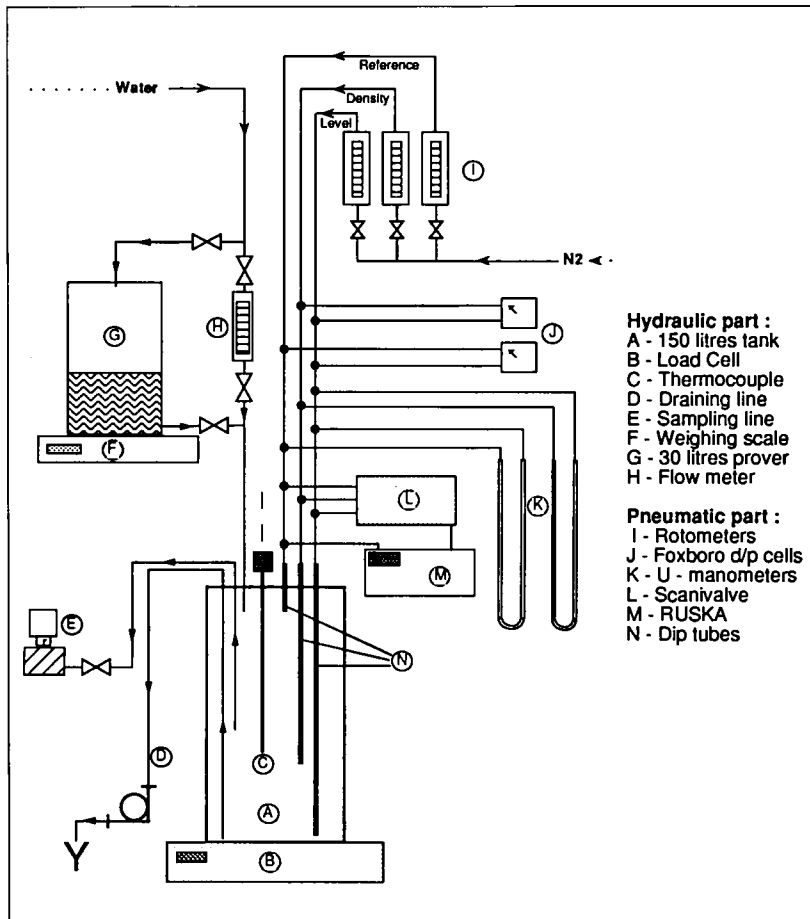
Measurement Instrumentation

Three types of instruments for level and density measurements are installed:
- two Foxboro differential pressure (d/p) cell transmitters, with dial indicators and with the possibility to read values on a strip chart recorder, are mounted on the utility post next to the tank,
- two U-tube liquid manometers are also installed next to the tank. The level manometer is filled with water and the density tube with Marian oil,
- an electromanometer system (RUSKA) complete of pneumatic scanner, solenoid controller, ICS 488 interface, digital voltmeter and electronic scanner is being used for the real calibration exercise and during further re-calibrations. The sensitivity of this systems allows to detect a variation of 10 ml of water in an existing volume of 100 litres.

Hydraulic part :
A - 150 litres tank
B - Load Cell
C - Thermocouple
D - Draining line
E - Sampling line
F - Weighing scale
G - 30 litres prover
H - Flow meter

Pneumatic part :
I - Rotometers
J - Foxboro d/p cells
K - U - manometers
L - Scanivalve
M - RUSKA
N - Dip tubes

Fig. 4.1. Diagram of the hydraulic and pneumatic parts

The data acquisition and the interpretation software which were running on a HP 9845 computer, after translation are now running on a DOS computer. The value of humidity, room temperature, atmospheric pressure are read on a data logger. For the next upgrading of the acquisition software, a LabView application, these data and the water temperature will be collected automatically by the PC.

The mini TAME laboratory will be mainly used for basic laboratory training in tank measurement methods, as was done in the past at the IAEA headquarters. A video tape for training purposes was prepared by IAEA staff in co-operation with the JRC and a course manual is now in the final phase of preparation. This facility which is very flexible to be operated (small volume and easy access to sensors), is also to be used for feasibility studies of methods, tests of new instruments like for i.e. Time Domain Reflectometer, various kinds of electromanometers, etc.

CALDEX

The results of weight and volume measurements performed during the CALDEX Exercise were critically analyzed. A report is in preparation. Problems related to the operation of the ANTARES tank were analysed and supplementary specifications were given to IST for improving its capabilities. The internal geometrical arrangement of the tank was measured. A sensitivity study of thermal effects in volume/mass measurements in tanks was completed.

SUPPORT TO THE COMMUNITY INDUSTRIAL POLICY (DG III)

World Shipbuilding Databank

The objective of the work is the production of statistical tables (quarterly, annual and historical) on world shipbuilding production, by ship type, size and flag. The aim is to supply this information to DG III, independent of national bodies, to be used for all preparation of an annual report from the Commission to the Council of Ministers.

In 1992 the work has involved the modification and upgrading of the system from the mainframe version to a version which works in a Unix environment. This is only seen as a holding measure which will (during 1993) be replaced by a workstation/Personal Computer version of the system with added functionality. During this new development work, the existing system has continued to be used for production of quarterly and annual statistics. Interactive access has been replaced by an indirect query system following the closure of the scientific mainframe service.

SUPPORT TO THE COMMUNITY TRANSPORT POLICY (DG VII)

Aircraft Incident Data Base (ECC-AIRS)

Objective: Set up of a European Coordination Centre for the mandatory Aircraft Incident Reporting Systems (ECC-AIRS)

Around 1990 a number of studies in the field of accident investigation and incident reporting systems were carried out on behalf of the European Commission (DGVII: Transport). Among the conclusions of a study entitled "Community Air Safety Information System" performed by IFALPA (International Federation of Airline Pilots Association), it was deemed beneficial for air safety to bring together the knowledge derived from the collection of incident reports in various member states.

The study recommended to set up a European Coordination Centre for the mandatory Aircraft Incident Reporting Systems (ECC-AIRS). ISEI was given the task to generate a proposal, including a functioning prototype solution, for a system that is able to logically connect the various systems related to aircraft incident reporting in the different member states.

During 1992 ISEI produced the proposal containing the specifications for the implementation of a prototype of the ECC-AIRS (fig. 4.2 shows its logo). The main objectives of this prototype are to:

- provide all the information necessary, to make a decision on whether or not it is desirable to implement a permanent coordination activity at European level,

- evaluate the applicability of the Central European system, possibly in an adapted form, as a technical solution for those member states that actually do not have an automated incident reporting system running.

A review of the ISEI proposal, by DGVII and the participating Member States (Belgium, Denmark, France, Germany, Italy, Portugal and the United Kingdom) resulted in a formal agreement between the JRC and DGVII to start the pilot project.

The last quarter of 1992 was used to purchase and install the systems hardware and basic software environment and to allocate the necessary resources during the projects life cycle. At the end of the year the laboratory

has been completed allowing the actual development work to start in 1993.
It is foreseen that the project will take another two years to finish. At the end of 1994, apart from completing the technical implementation and related functional tests, all involved partners (DGVII and the Member States) will have evaluated the pilot implementation of ECC-AIRS in order for the project to meet it's major objectives.

Fig. 4.2. Logo of the European Coordination Centre for Aircraft Incidents Reporting Systems (ECC-AIRS)
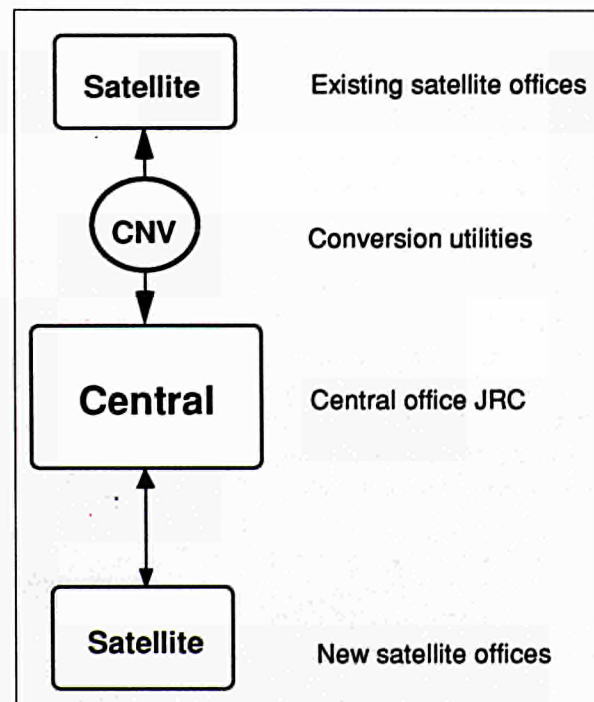

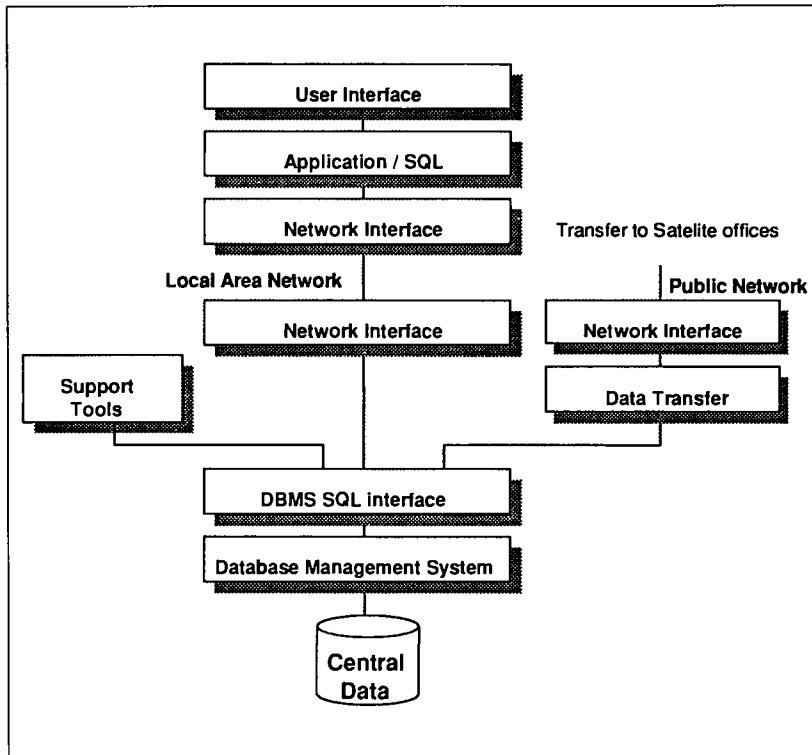Fig. 4.3. Block diagram of the global architecture of ECC-AIRS

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Fig. 4.4. Block diagram of the architecture of the Central Office of ECC-AIRS

result hopefully in data compatibility, and thus data interchange, at an even larger scale.

The central system has logical links to existing national incident databases via conversion utilities, and direct links to new national systems which are based on the technology used in the central office and thus already compatible. *Fig. 4.3* shows the the global architecture of ECC-AIRS.

The system is implemented using several functional modules, stacked upon each other in a layered architecture. This approach guarantees an 'open' architecture which allows portability to other hardware and software platforms (see in *fig. 4.4*, the diagram of the central office as an example). The development environment for the ECC-AIRS system consists of a relational database supporting standard SQL running on a powerful UNIX RISC system. Access to this system is allowed via the Local Area Network and via the Public Networks. User-interfaces will be implemented on a low cost platform (like a PC) on top of a graphical environment, and have to support all the languages of the European Community.

It is noteworthy that during the last months of 1992 contacts have been made with Canadian and Australian authorities, as well as with the ICAO (International Civil Aviation Organisation) which resulted in an intention for cooperation in the ECC-AIRS project. This will

SUPPORT TO THE COMMUNITY ENVIRONMENTAL POLICY (DG XI)

Scientific and Technical Support for the Implementation of Directive 82/501/EEC on Major Accident Hazards

The Community Documentation Centre on Industrial Risk (CDCIR) is now well established :

- on the one hand, by its extensive collection of documents it allows diffusion of information on safety regulations, codes of good practice, accidents investigations and other relevant material, to authorities, industry and research organisations (the regular publication of bulletins has been insured);
- on the other hand, it is publishing the results of studies performed by JRC or sponsored by JRC to exchange information on national experiences.

Such reports have interested a wide number of customers. They can be classified into different categories:

Accidents Investigation:

1. Major Accident Reporting System. Lessons Learned from Accidents Notified (EUR 13385 EN. 1.)
2. Major Accident Reporting System. Lessons Learned from Accidents Notified. Volume 2 (EUR In printing)
3. Review of Environmental Accidents and Incidents (EUR 14002 EN)
4. Review of Accidents Involving Chlorine (EUR 14444 EN).
5. Review of Accidents Involving Ammonia (EUR 14633 EN).
6. Review of Accidents Involving Unexpected Runaway Reactions (EUR 14634 EN).

Analysis of Chemical Emergencies:

7. Lessons Learnt from Emergencies after Accidents in the UK involving Dangerous Substances. (EUR 13322 EN)
8. Lessons Learned from Emergencies after Accidents in the FRG involving Dangerous Substances. SP-I.91.23.
9. Lessons Learnt from Emergencies after Accidents in France involving Dangerous Substances. (EUR in printing)

(On demand of the Competent Authorities the studies on emergencies have been extended to the other member countries: for Italy, Greece, Ireland, Denmark and the Netherlands the studies are already in progress; whereas for Belgium and Luxembourg, Spain and Portugal the corresponding study contracts are being established)

Comparison of safety regulations and standards:

10. National Approaches to the Safety Report. A Comparison (S.P.-I.91.07)
11. Comparison of LPG Related Regulations. (EUR 13699 EN)
12. Comparison of selected LPG Related Codes and Standards. (EUR 14636 EN).

Information of the Public:

13. Empirical Evaluation of Public Information around Major Hazards Sites (EUR 14443 EN).

Because of the success and hence increasing number of customers of the CDCIR service, it was found to be an advantage to design and implement a data base, which is able to supply the information in the bulletins on an Informatics Medium. Firstly floppy disks may distributed on request and when the number of data increases distribution on CD-ROM is foreseen. The database system is now in a test phase.

The Major Accidents Reporting System (MARS), 10 years after the issue of the Directive, has required a new design (see *fig. 4.5*) since the notification procedures have been modified according to the experience gathered so far from the accidents notified and the corresponding analyses. Such change is also linked to the fundamental revision of the Directive (foreseen to be proposed during 1993) where a clearer definition of notifiable accidents is given.

Furthermore cooperation has been given to the works of the revision of the Directive, for drafting guidelines for information of the public about hazardous installations and advice has been given to the relevant technical working groups for the implementation of the Directive.

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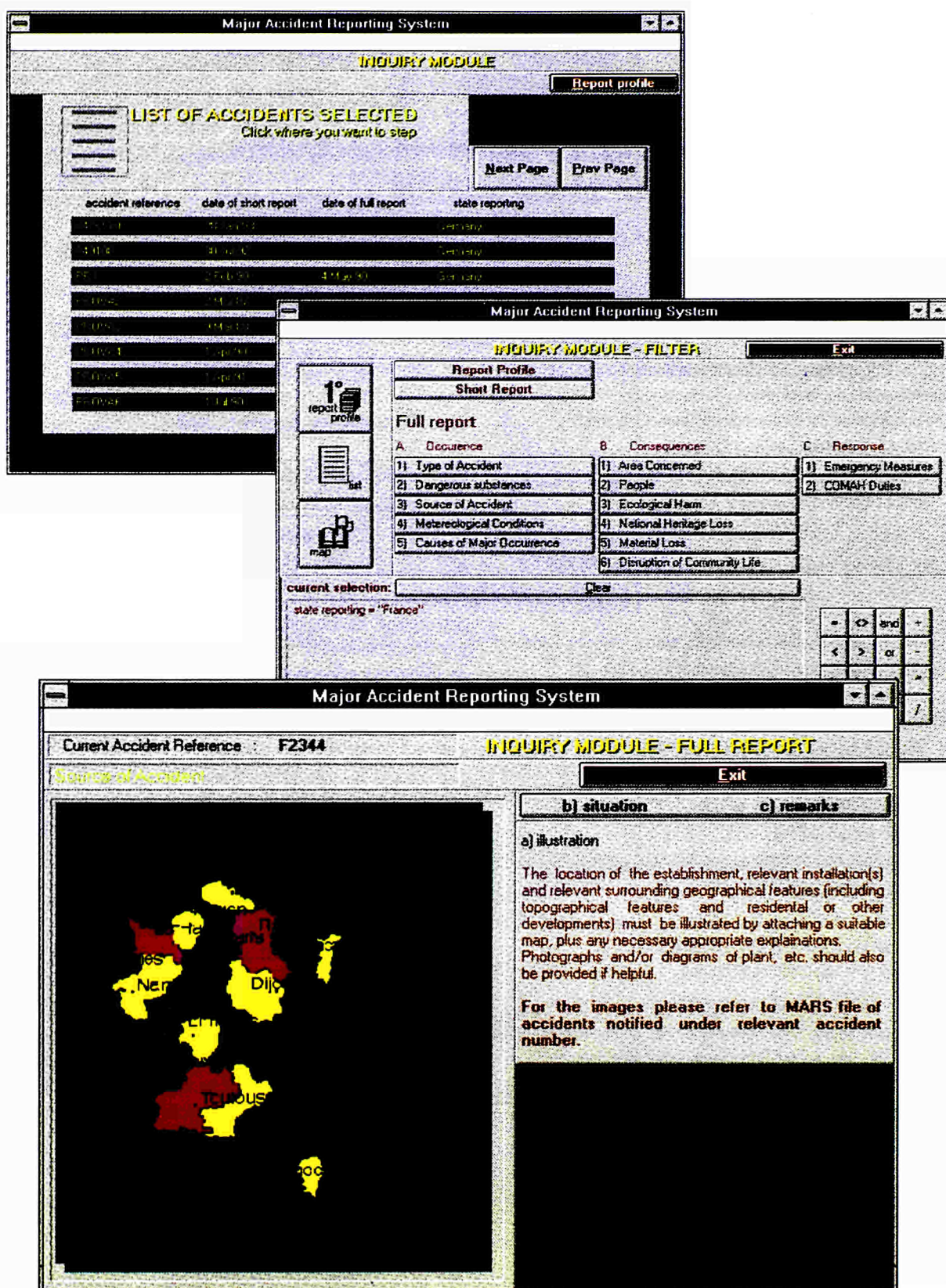
Fig. 4.5. Examples of MARS windows

/3/ A. AMENDOLA: Implementation of Art.8: Information of the public. 10th Anniversary of the Seveso Directive" Seminar organised by CEC and the French Ministry of Environment. Cayenne 21-25 Sept.1992
/4/ K. RASMUSSEN: Accidents with Hazardous Materials initiated by Natural Events Seminar organised by CEC and the French Ministry of Environment. Cayenne 21-25 Sept.1992

Risk Communication

Technical Guidelines for the Content of Information to the Public were developed in order to address the Council Resolution of 16th October 1898 (89/C273/01) which invites the Commission to draft a practical guide to facilitate implementation of Council Directive 88/610 /EEC amending Directive 82/501/EEC on the major-accident hazards of certain industrial activities (Seveso Directive). General guidelines were prepared to be submitted to the National Competent Authorities for their consideration and comment. The guidelines developed on previous research work in support to the Commission and were based on relevant information and materials obtained by the Member States. Each item listed in Annex VII to Directive 88/610/EEC was examined in detail and headings were provided for a fuller specification of the information to be provided. Other general guidelines were suggested in order to guarantee that all the stakeholders participate in the information process.

Cross-national research was undertaken in Italy and England on "The management of uncertainty in the communication of major hazards" (collaboration with RMC Ltd, London). Its main objective was to explore how key institutional actors in a major hazard situation manage the uncertainties in their assessment of risk, both scientific and situational. The project was organised in several phases, alternating between theoretical development and empirical research. Interviews were conducted with leading responsible persons in relevant fields of emergency planning and management in both countries, as well as with persons from the media and relevant areas of research. The main product of the study is a checklist "Uncertainty and Communication" which can be used as a diagnostic tool apt to identify similarities and differences among cases and among institutional cultures in relation to uncertainties in the communication of hazards, also suggesting ideal types. Furthermore a research on long term consequences of the Seveso dioxin leak has been conducted: main purpose was to highlight the major problems faced by the community. Particular attention was paid to methodological issues related to the epidemiological studies conceived after the events. Interviews were conducted with people who held positions of responsibility at the time of accident and in its aftermath.

Scientific and Technical Support for the Implementation of Directive 90/219/EEC and of Directive 90/220/EEC

This activity concerns the scientific and technical support for the implementation of the Directive 90/219/EEC on the contained use of genetically modified micro-organisms (GMMs) and of the Directive 90/220/EEC on the deliberate release into the environment of genetically modified organisms (GMOs) /2/.

The S/T support has been organised in a way very similar to the actions on the Major Accident Project. Indeed the customer is the same DGXI service and the activities can be assisted by very similar informatics tools.

As a service to the Competent Authorities, ISEI acts as an information centre where they can obtain assistance for specific safety related questions. In addition, a mandate was given to collect relevant information on safety and regulatory issues in a biotechnology documentation centre. The content of it was reviewed in a bulletin, the "European Community Documentation Centre on Biotechnology Safety and Information" (fig. 4.6) which has been widely distributed and which will be produced on a regular basis /1/. The structure of the bulletin and the data base is very similar to that of the previously described CDCIR.

Since a mandate was received to hold a register of biotechnology accidents, notified under Directive 90/219/EEC, a database was developed to accommodate these notifications according to a form agreed upon in the Committee of Competent Authorities. Again a structure very similar to MARS has been adopted. ISEI has further assisted DG XI in international fora and has participated in the EC-US bilateral environmental consultations (the permanent technical working group on biotechnology and the environment) and in the OECD meetings with the Group of National Experts in Biotechnology.

References

/1/ Community Documentation Centre on Biotechnology Safety and Regulation - Bulletin No. 1, G. Van den Eede (editor) - SP-1.92.31, November 1992.
/2/ G . VAN DEN EEDE and F. CAMPAGNARI, 1992. Protection of human health within the framework of EC biotechnology regulation. in E. Melonio (Ed.) "Proceedings of the first World Conference on Health Emergencies in Technological Disasters", in press.
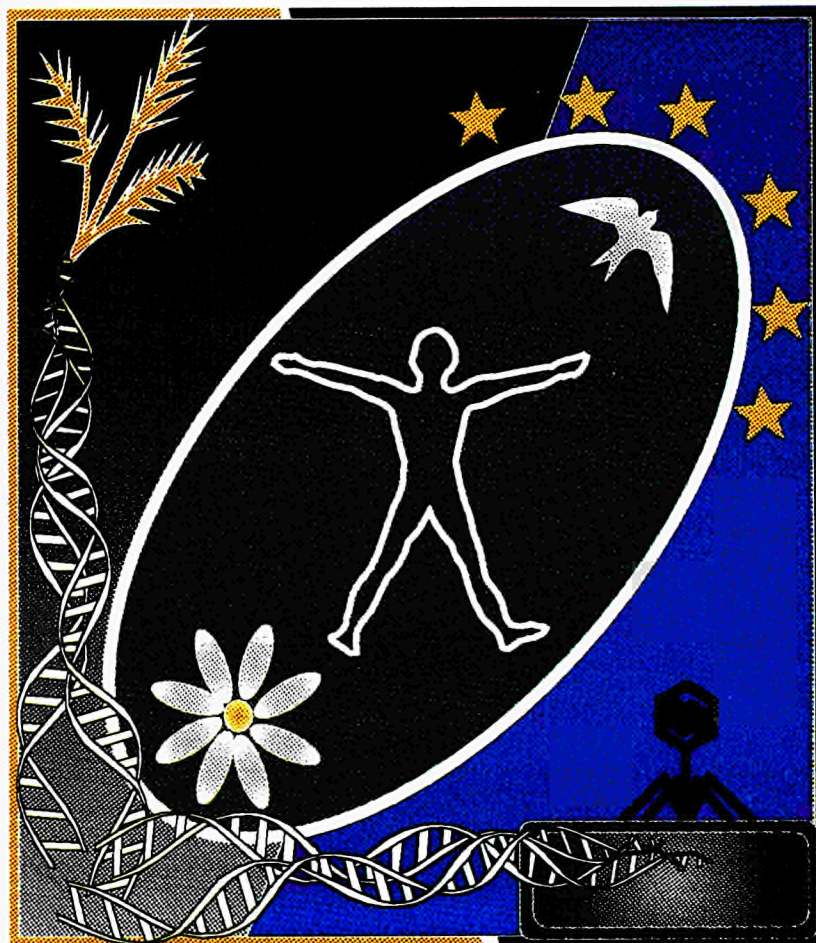
Fig. 4.6. Cover of the first issue of the bulletin on "European Community Documentation Centre for Biotechnology Safety and Regulation

contact points).

Installation and training of the pilot system at 8 end-user sites (at the national operational centres of the member states) were completed by the end of June 1992.

Starting in July 1992, for a period of 9 months, the system has been in pilot operation. ISEI has been managing a maintenance and help-desk contract. The contract covers user and system support via a help desk, system enhancements, and a number of on-site visits (at the national civil protection agencies) to ensure additional installations and extraordinary maintenance.

Exploration of the desirability and the feasibility of the creation of a European 'Observatory' on natural disasters

In 1992 DGXI has asked ISEI to explore the desirability and the feasibility of the creation of a European 'Observatory' on natural disasters. At this purpose ISEI is planning a conference to be organised for October 1993, in cooperation with both DGXI and DGXII.

Support to the Civil Protection Policy

Pilot Communication and Information System for Civil Protection

Technical advice to DG XI.A.5 and supervision of contracts related to the construction and demonstration of specific work packages of the pilot system (including communications facilities and the development of local databases) terminated in January 1992. A demonstration of the deliverables of the project took place in January 1992 during the meeting of the national civil protection correspondents in Brussels. The functions demonstrated included the common user interface, the gateway access to external databases, the electronic mail and bulletin-board, and a number of local online databases (including the civil protection Vademecum, the inventory of existing information systems in the civil protection domain, and access data about the national

As a preparation to the conference a workshop on Emergency Management was organised at Ispra, on 23 -24 June 1992 /1/ which opened a trans-disciplinary and cross-cultural debate among experts of different disciplines.

Among the main items emerging from the discussions as worthy of deep attention, the following are encouraging towards the prosecution of the activity:

- Unified framework for natural and technological disasters (benefits of the "Seveso Directive" for risk management of chemical installations) /4/,
- Subsidiarity: added value from the comparison of national experiences,
- Risk management whole cycle: prevention (land use planning, technology state of art), event monitoring and forecasting, preparedness & response, risk communication at each step /2/3/,

- Organisational learning as an open environment (organisation has no memory...),
- Interest for the proposed observatory and usefulness of the planned conference if organised in a way that would allow a constructive debate among all involved parties among priorities for a possible common action.

References

/1/ A. AMENDOLA and B. DE MARCHI (eds.) "proceedings of the workshop on Emergency Management, Ispra 23 -24 June 1993" EUR report (in press)

/2/ B. DE MARCHI,"Emergency Management and Risk Communication" in (A. Amendola ond B. De Marchi editors) "proceedings of the workshop Emergency Management, Ispro 23 -24 June 1993" EUR report (in press)

/3/ B. DE MARCHI "Una comunicazione efficace per la prevenzione e la gestione delle emergenze" in G. Luongo (ed.) Prevenzione dei disastri naturali,qualita' ambientale, sviluppo sostenibile, Osservatorio Vesuviono e Istituto di Studi Filosofici, Napoli (in press).

/4/ A. AMENDOLA "Le relazioni tra rischi naturali e rischi tecnologici" in G. Luongo (ed.) Prevenzione dei disastri naturali, qualita' ambientale, sviluppo sostenibile, Osservatorio Vesuviano e Istituto di Studi Filosofici, Napoli (in press).

Support to the European Environment Agency Task Force

During 1992, the TA sector was involved in continued support to the EEA task force, in relation to informatics requirements.

Though only limited work was carried out in 1992, a pre-analysis study of the EEA Informatics Requirements was produced, which was used by the EEA task force as a base document for a meeting of scientific experts.

After the meeting various tests of electronic information exchange were carried out, and actually by the end of 1992, the EEA task force and the JRC had exchanged electronic messages.

SUPPORT TO THE COMMUNITY TELECOMMUNICATIONS, INFORMATION AND INDUSTRIAL INNOVATION POLICY (DG XIII)

Advanced Networking Support

The objective of this activity is to provide technical and organisational support to networks for the European R&D community, promote user groups exploiting pan-European services and pilot products from industry for multidisciplinary applications, and provide technical advise for planning.

In 1992, work has been performed in the framework of:
- the planning for the successor of the IXI X25 backbone network connecting all national academic networks. The initiative sees the coordination of a number of relevant actions: the EBONE backbone for production level IP and ISO-CNLS services, the 2 Mbps X25 pilot fast private network available for a limited time under favourable conditions by an international service provider, the extension of IXI to central and eastern Europe, and the European fast multiprotocol backbone to which finally all other initiatives are expected to converge.
- the European Consultative Forum of research networks (ECFRN) is a group of high-level officials responsible for R/D networks in Europe. The evolution of research networking beyond the end of the COSINE-EUREKA project is addressed with a view to define improved technical and organisational structures. The 'Computer networking for European Researchers - The Challenge Ahead' planning document was produced and circulated to the relevant National Authorities. It identifies an urgent need for better coordination, a central management and increased connectivity and capacity. The proposal takes into account work carried out in the context of the DARPA/ESPRIT/NSF joint exploratory workshop on IT and the 'Rubbia' task forces on High Performance Computing and Communication.
- the technical secretariat of ERCOFTAC European Association on flow, turbulence and combustion.

Recently, a collaboration between ESA, European industries and JRC has allowed the definition of a pilot satellite network experiment capable of connecting the JRC sites and possibly other partners involved in joint R/D ventures.
The technical and organisational aspects of this pilot network have been analysed in detail.

Parallel Computing Applications

To contribute to the valorisation of ESPRIT results with particular reference to the SUPERNODE computers (ESPRIT Basic Research), it was decided to create a critical research and reference point for advanced computing including the introduction of parallel computing into the JRC specific application domains. A multiannual inter-DG agreement has been initiated. Furthermore an inter-Institute IRSA-ISEI agreement has been pursued within the framework of the Agriculture Project using the NOAA Satellite results.

The following achievements have been accomplished:

- In collaboration with the VALUE Programme, many enhancements of the 3D Image Ray-tracing and radiosity software have now been implemented and the extension to the animation aspects in real-time have been fully tested.

- The implementation and the tests of this complex software have been done on the SUPERNODE T.NODE 64 Transputer Parallel Machine and on the CUBI 9000 Parallel System.

- As regards the Agriculture Project, within the framework of the inter-Institute collaboration, a special effort has still been dedicated to the SPACE software /2/. The objective of this system is to visualise NOAA satellite images on high resolution peripheral devices and to perform all the necessary corrections of these raw data in order to be used by end users, specially for agriculture interpretation and/or global change research studies. The implementation of the complete SPACE software has been done on the SUPERNODE T.NODE 64 Transputer Parallel Machine.

The present results have been demonstrated on Transputer SUPERNODE Parallel Machines /1/ during the "SUPERCOMPUTING MEETING Europe" (fig. 4.7). Such software is intended to be used for production since this first parallel release has extensively been tested and the enhancements included have demonstrated that a speed factor of about 15 has been reached /1/ and /2/.
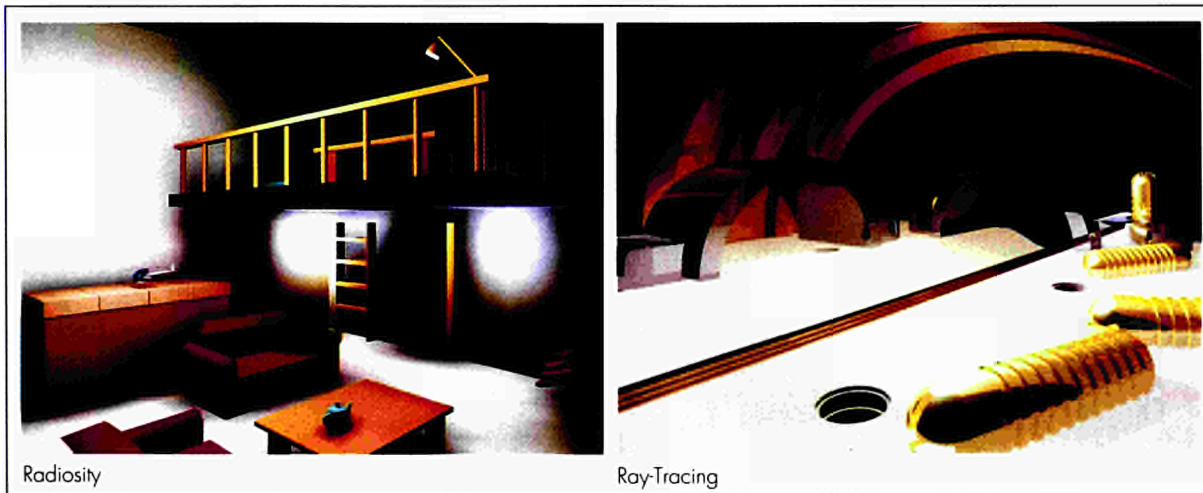
Radiosity   Ray-Tracing

Fig. 4.7. Image Synthesis obtained on the SUPERNODE Parallel System

References

/1/ D. HEIDRICH: Logiciel de Télédétection SPACE - Aspects Systèmes pour la Mise en Oeuvre sur Réseaux de Transputers, Technical Note No.1.92.107 ISE/IE 2348/92

/2/ C. SILBER: Recherche d'Algorithmes de Parallélisation et Implémentation du Logiciel "SPACE" sur Machine Parallèle SUPERNODE (T.NODE 64 Transputers), EUR Report No. 1407 FR 1992

Image Processing and Synthesis and Holographic Processing and Synthesis

The Image Processing and Synthesis techniques are applied to the synthesis of holograms in such a way that one can reconstruct real three dimensional scenes. The developments are based on optical phenomena that were discovered in the JRC 3-D Image Processing Laboratory. The main objectives of the work is to develop a mathematical package to simulate this discovery and thus realise an industrial European prototype for image compaction and 3-D restitution on advanced parallel computers.

The following achievements have been accomplished:

– Theoretical developments on basic Ray tracing and radiosity techniques, initiated one year ago, have been pursued.

– The complete new image synthesis software implemented on parallel SUPERNODE T-NODE computers, has been transposed on the CUBI 9000 real-time parallel system /1/ and /3/.

– Concerning the holographic synthesis, theoretical developments have been pursued and the implementations on SUPERNODE T.NODE 64 parallel machine of the first release have been accomplished. Comparison with experimental data have been initiated on simple 3D scenes. Experimental setup for holograms in true colours are going to be studied.

– Hologram synthesis has to use a set of basic numerical tools, based on the fast transform principle, thus FOURIER, HADAMARD, WALSCH, PALEY and HAAR's transformations and WAVELET techniques have been modified and the enhancements constitute an advanced software package. The applications of such a package needed by many research domains, have been applied to image compaction techniques and holographic techniques.

PALEY, HAAR's and WAVELET techniques associated with the JPEG (Joint Photographic Expert Group) world ISO standard have been used for image compression.

The special implementation realised in the laboratory demonstrated that image compression can be achieved by a factor of 10 up to 1000 without any significant loss of information /2/.

These very important fundamental results will be protected by patents and copyrights. In particular original studies are under development in order to be applied to medical and satellite images *fig. 4.8* and *4.9*).
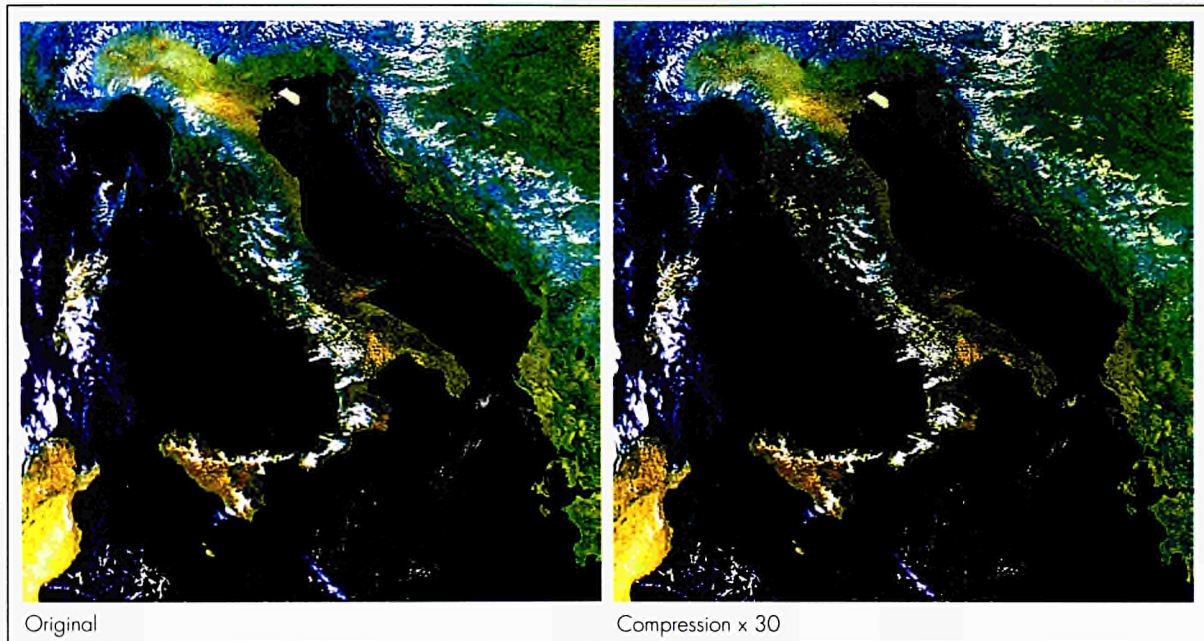
Original   Compression x 30

Fig. 4.8. JRC Image Compression Techniques applied to Satellite Images

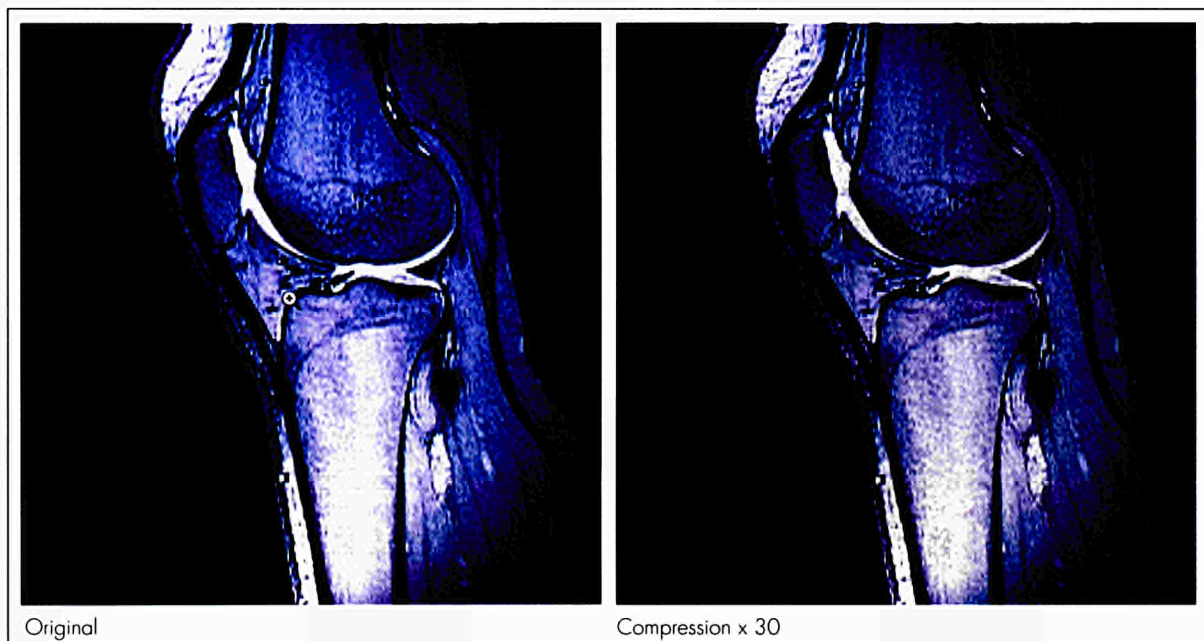
Original   Compression x 30

Fig. 4.9. JRC Image Compression Techniques applied to Medical Results

References

/1/ J.C. Grossetie, D. Arques, G. Maffeis, S. Michelin, Image Synthesis with the Radiosity Method Using a New Expression of the Form Factor Implemented on a Transputer Parallel Machine, EUR Report No.14506 EN 1992

/2/ C. GROSSETIE, M. HOHENADEL, J.C. FRANCESCATTI, First Studies on Image Compression for Philips Medical Systems, Note Technique No. 1.92.143, 1992

/3/ J.C. GROSSETIE, S. MICHELIN, G. MAFFEIS, D. ARQUES, Radiosity Technique in Image Synthesis: a New Expression in the Form Factor with Parallel Implementations, MICAD Congrés, Paris, 1993

Support to Training Course

The objective of this work is to organise training and summer schools in order to contribute to the dissemination of ESPRIT results.

In 1992 no specific training course or workshop was held. However, planning and study activities have been performed. These have been aimed at ascertaining the training/workshop activities which would be relevant to persons working and researching in the areas of Safety Critical Computer Systems and Safety Related Systems. The results of these study activities performed in 1992 will lead to targeted training/workshop activities in 1993 and beyond.

SUPPORT TO THE COMMUNITY ENERGY POLICY (DG XVII)

Support to the THERMIE Demonstration Programme

Under an agreement with the Directorate General for Energy (DGXVII), the Non-Nuclear Energies unit (NNE) of ISEI performs a variety of tasks that can be divided into three categories:
- regular activities, specific requests, and own initiatives.

THERMIE Proposals

Regular activities principally concern the THERMIE programme through which the Commission supports energy saving projects in a number of sectors. The NNE's activities are in the Solar, Buildings, and Transport sectors. In 1992 these projects were of two types:- "Innovative" and "Dissemination", although plans were drawn up for a third category "Targeted" to be launched in 1993. Innovative projects receive a grant of 40% and Dissemination projects 35% of the eligible costs.

The annual THERMIE cycle begins with the preparation of a "Call for Proposals" which lays down the rules and specifies the areas to be supported. These vary from time to time and NNE staff advises on their definition. The next phase is the assessment of proposals, of which there have recently been around 60 in the Buildings sector and 35 each in the Solar Thermal and Transport

sectors. The NNE staff has over ten years experience in the assessment of proposals for DGXVII. On the technical side, the final phase is the selection of projects to be supported. This selection is made only after consultation with official representatives of the Member States. NNE staff takes part in these discussions, explaining the reasons for the Commission's ranking of the proposals.

In 1992, an analysis of the proposals submitted showed (fig. 4.10) that, in the buildings sector, the cost of energy saved was greatest for projects involving new buildings and lowest for the renovation of existing buildings. Once the selected projects are under way, their progress has to be followed through Intermediate Technical Reports and site visits. This is another area in which the NNE staff supports the THERMIE Programme.

Guidelines for the Presentation of Intermediate and Final Reports

A specific request received in 1992 was for the preparation of "Guidelines for the Presentation of Intermediate and Final Reports". These are intended to help contractors and to ensure that reports are complete and easy to read. The "Guidelines" consist of a general section for all contractors and a separately bound set of 36 "Format Sheets" for projects in the Buildings sector. The sheets cover all types of building projects and contractors are expected to copy and use only those which apply to their particular projects. Copies of these publications will be available for all contractors from 1993 onwards /1/2/.

The Tele-Monitoring of Active and Passive Solar Projects

On its own initiative, the NNE unit has been developing a tele-monitoring system which allows remote interrogation of the data emerging from individual THERMIE projects. It is a condition of the THERMIE Programme that all projects must provide for detailed performance monitoring of their installations.

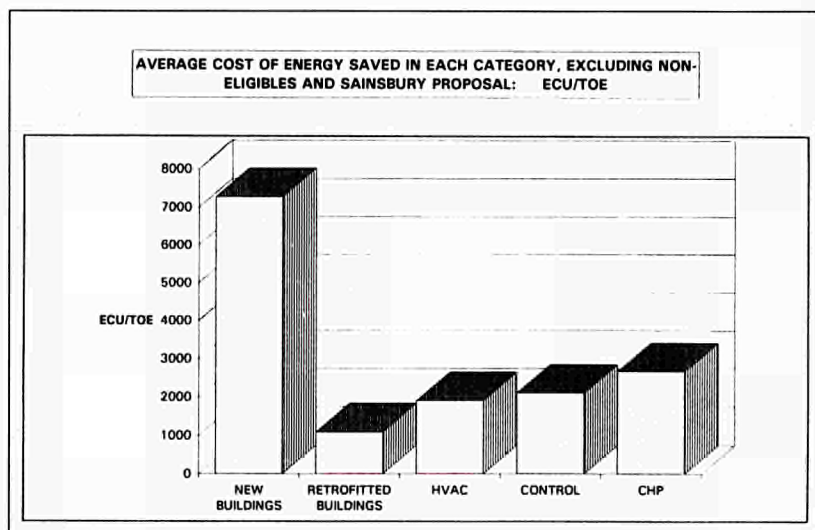AVERAGE COST OF ENERGY SAVED IN EACH CATEGORY, EXCLUDING NON-ELIGIBLES AND SAINSBURY PROPOSAL: ECU/TOE

Fig. 4.10. Average Cost of Energy saved in each Category of Buildings

These data have to be presented in Intermediate and Final Reports and should be made available to Commission representatives during site visits. The Tele-Monitoring system, however, makes the most important data available at all times, to anyone having a PC, a modem, and a telephone line. The data will generally be collected by a Data Acquisition System (DAS) but there are many types of DAS and each has its own specific software. It is not usually possible, therefore, to transfer data to a third party that is not equipped with the appropriate software. The Tele-monitoring guidelines developed by NNE have two main objectives:

–   To provide contractors with a common approach to the storage of monitoring data, which will make their results rapidly available to third parties, whilst ensuring that they remain responsible for quality control and the release of data.

–   To provide programme managers with a direct means of establishing whether or not a project is working correctly, without having to visit the site or wait for a progress report. (This facility may also be of use to project managers themselves.)

The overall concept of tele-monitoring is shown in fig. 4.11, which illustrates the following key features:

–   Each project is fitted with monitoring sensors, which supply data to its DAS.

–   Each DAS is connected to either a "Project-PC" or a "Central-PC" where the data are processed and stored in a standardised set of files.

–   Each "Project-PC" or "Central-PC" is permanently connected to a modem and hence to the public telephone network.

–   An authorised inquirer connects his or her "Inquirer-PC, via its modem, to the public telephone network and obtains access to the data.

The inquirer is then able to:

–   See data records on the PC screen

–   Down load selected data files

–   Receive messages from the Project-PC or Central-PC

–   Deliver messages or other technical information to the Project-PC or Central-PC.

The tele-monitoring system has been described in a number of publications /3/4/5/ and several workshops have been held to demonstrate it to potential users.

Research on Building Parameter Identification Methods

The inclusion of Building Energy Certification in the building norms of various European countries has increased the need for advanced and reliable measurement methods. The technique of building thermal parameter identification is very promising but until quite recently, experience of its application was limited to test cells or small houses. Several problems have to be overcome before it can be widely applied to inhabited buildings. The JRC, in cooperation with the Ecole des Mines de Paris, is investigating these problems with
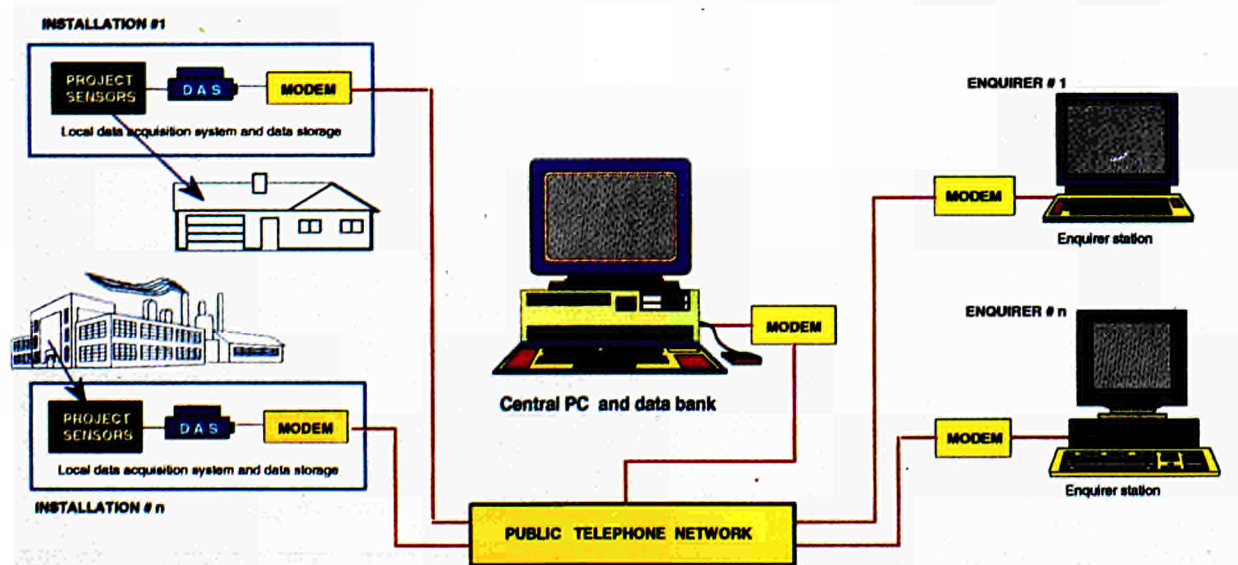

Fig. 4.11. Data Acquisition System with Tele-monitoring Procedure

experiments it is conducting on four occupied, multi-apartment buildings in Varese. The study, which should continue until 1994, concentrates on dynamic models, since these are capable of providing results in the shortest possible measurement time (e.g. a couple of weeks).

The application of identification techniques to large, occupied buildings is complicated by the fact that the sets of measured data are rather "dirty", that is they contain a number of biasing effects, which must be removed by "cleaning" procedures. The most important biasing effects are:

a) the non-linear relationship between the input energy and the useful energy supplied to the building, resulting from the variation of boiler efficiency with load (this effect does not arise with electrically heated houses) and from the thermal inertia of the heating system.

b) the value of the internal temperature can be affected by the sensor position, particularly if the heat distribution between floors is not well balanced.

c) non-constant incidental internal gains over the heating season, due to occupant behaviour; e.g. window opening habits, which alter the constancy of parameters.

d) non-constant solar gains over the heating season, due to the changing position of the sun with respect to the building; this is particularly important if obstructions are present, and the building has large south-facing glazed areas.

The monitoring campaigns of 1991-92 were devoted to investigating the problems associated with points a) and b) above. It was also decided to complement the experimental activity with a detailed simulation of one of the buildings in order to check the measured data with calculated ones. The simulation makes it possible to assess the effects of the internal temperature distribution and free gains on the identified parameters. Moreover, it can provide data sets for different configurations of the building and plant system which can be fed as input to the identification models. In this way, additional expensive and time-consuming measuring campaigns can be avoided.
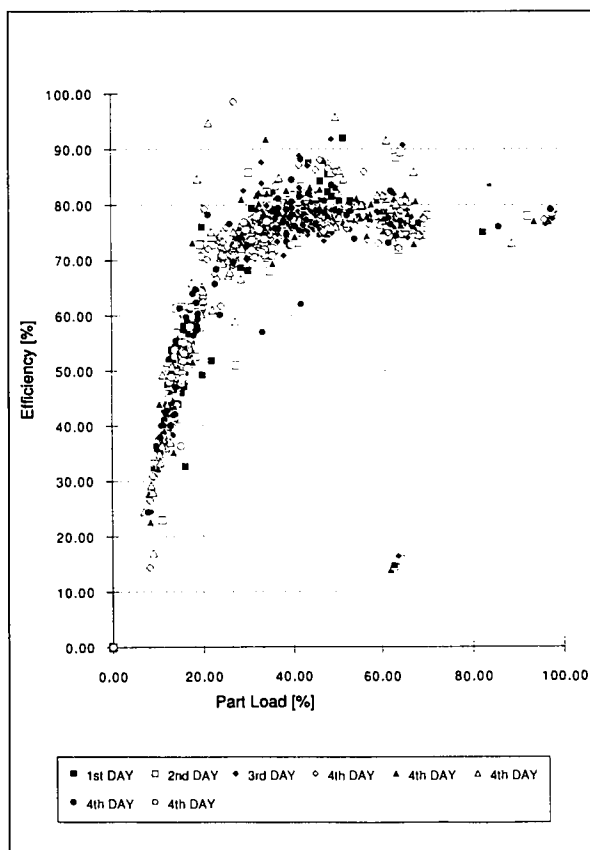
Heating Plant Efficiency Measurement

Usually, the input energy to the building's heating plant is obtained by measuring (on an hourly basis) the burner operation times and the fuel energy fed to the burner nozzle. In order to obtain the useful energy to the building envelope it is necessary to multiply the input energy by plant efficiency. Various formulae (Diettriech, Anglesio, Gini) have been investigated but considerable differences have been found on comparing measured values with theoretical ones. The heating plant of one building was, therefore, monitored, during the 1991-92 measurement campaign with a time step resolution of one-minute. This resolution was chosen in order to consider transient periods and to try to validate complex formulae containing frequency terms. Experimental results have shown that inertial effects associated with transient periods are significant. On the other hand, the characteristic curves of boiler efficiency vs load factor (fig. 4.12) derived from experimental data on each burner cycle (a cycle is taken to be the time between two successive burner-on signals) also include many points from transient periods which are not in agreement with steady state values.

Comparison of these results with theoretical curves based on the above three formulae (fig. 4.13) shows that the trends of the theoretical curves are coherent

Fig. 4.12. Efficiency vs Part Load, Experimental Results

although single data may deviate widely from the theoretical values and cause large errors.

This means that the plant behaviour has to be identified by a more complex model which takes into account the boiler transient periods. If these are ignored, the burner-"on" time cannot be used as a direct measurement of useful energy supplied to the building. An alternative would be direct measurement of the useful energy supplied to the distribution system but this is more expensive and not always feasible. Research on heating plant identification models will continue.

Averaging Techniques of the Building's Internal Temperature

In order to assess the effect of internal temperature sensor positioning and of the averaging procedures, it was decided to make use of a simulation model for calculating the internal temperature of all the thermal zones into which the building had been subdivided. The output results of the simulation (that is the internal temperatures and the useful heat) were used as input data to the identification model.

This procedure has the advantage of allowing a more extended investigation, not only of the internal temperature distribution but also of several other effects. The simulation tool chosen was the program, TRNSYS (version 13.1) which is known world-wide and has been extensively tested. The multi-apartment building chosen for simulation was subdivided into 18 thermal zones, each corresponding to a single apartment. The results of the simulation are in satisfactory agreement with the measured data, although some further refinement is underway. *Fig. 4.14* shows the comparison of the calculated and measured useful heat to the building.
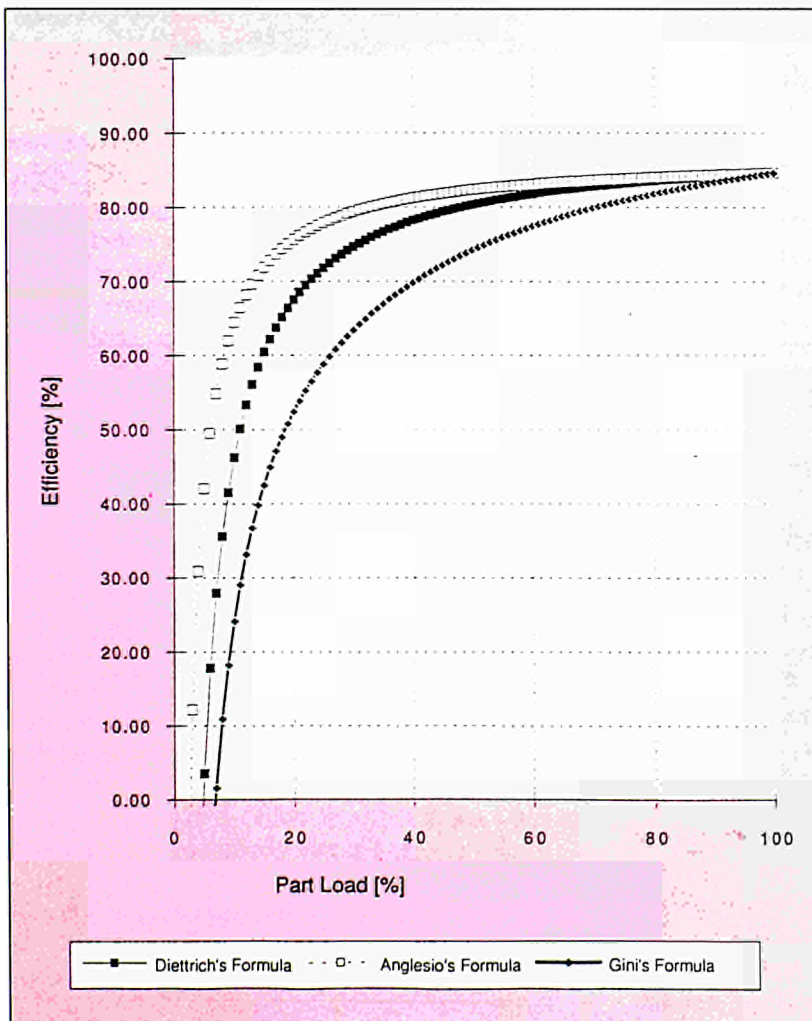
The programme MRQT (version 4.0) was used as an identification tool. Four simulation runs, corresponding to four 20 day measurement periods, from February till the end of April, provided input data for the identification. A four-parameter model was employed in MRQT. The values of the internal temperature T_i for the identification model were derived by 6 different averaging procedures over the 18 apartment temperatures. The values obtained for the identified parameters (*fig. 4.15* shows the results for the heat loss coefficient UA) show that, depending on the positions of the internal temperature sensors and on the averaging procedure used, very large errors can occur. As expected, the positioning of the temperature sensor in a central apartment is less sensitive to the high frequency effects that may produce unwanted bias on the identification. The use of only one sensor does not give a reliable measurement and is not advisable.

On the basis of these preliminary results, further research will be carried out during 1993 in order
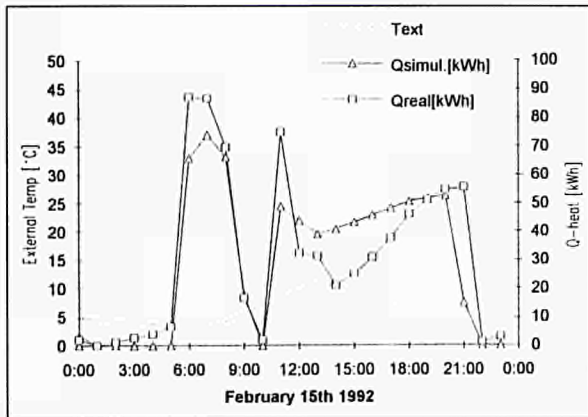

Fig. 4.13. Efficiency vs Par Load, Theroretical Calculation

Fig. 4.14. Comparison between Real and Simulated Heating System Performances

to improve the quality of data and to establish reliable data collection procedures /6/7/8/9/.

Application of Identification Methods to Solar Test Cells

This activity complements the work on occupied buildings described above and is carried out under DGXII's PASSYS project. It develops mathematical tools, using identification techniques, for the assessment of thermal parameters. These, together with other techniques and

design guidelines are intended to promote the application of passive heating and cooling. The integration of topics such as, ventilation, indoor air quality, daylighting, shading factors, and the seasonal influence of the solar aperture are also subjects of the research. A separate study has been made of the modification of the ISO standard on "in-situ measurements of the thermal resistance of insulating materials" and a second workshop organised on specific problem areas in the use of identification methodology. The title of the workshop was "Parameter Identification Methods and Physical Reality" /10/.

These activities will be continued under DGXII's new and recently started Energy Savings and Solar Heating projects.

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/2/ Format sheets for the Presentation of the Results of Building Projects: R.COLOMBO, F.CONTI, D.GILLIAERT, G.A.HELCKE, and A. LANDABASO. SP-I.93.01

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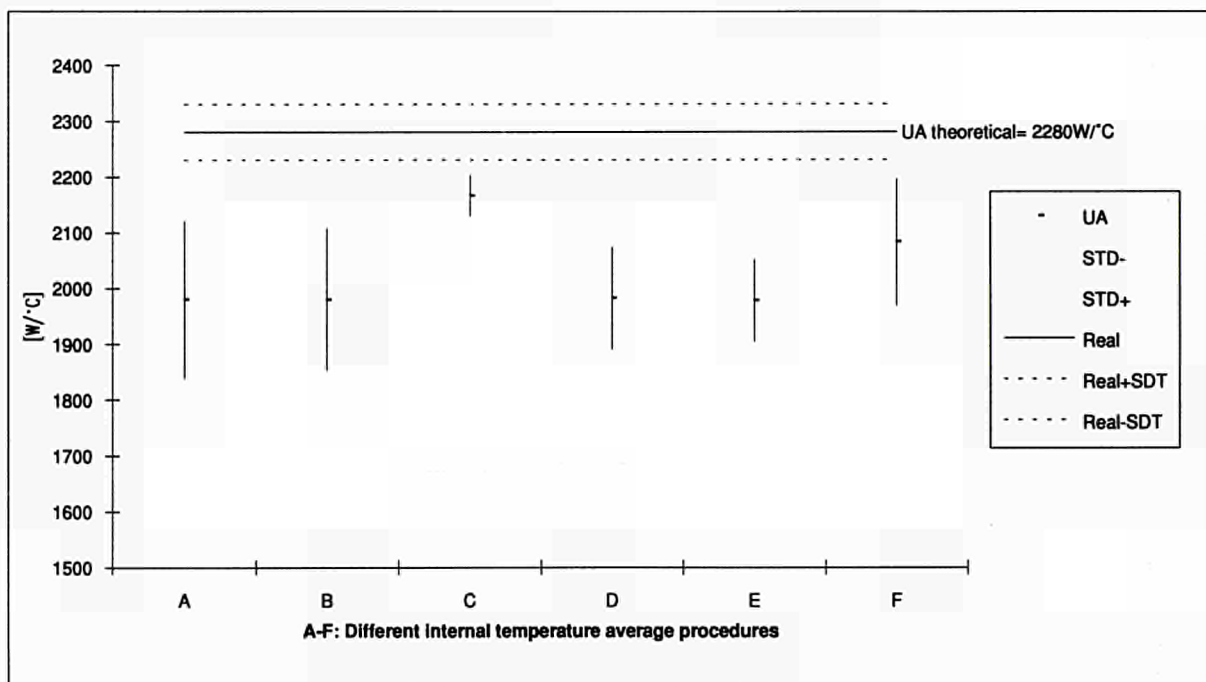
Fig. 4.15. UA-global Overall Conductance Parameter Identification Results

/5/ Guide-lines for Tele-Monitoring: Proceedings of the Meeting of the European Group on Solar Thermal Plan Monitoring, Espinho - Porto, Portugal, September 1992. R. COLOMBO, E. MALDONADO. SP-I.92.42.

/6/ Experimental Research on the Applicability of Thermal Parameter Identification Techniques to Building Energy Certification: F. CONTI et al., EUR 13238 IT 1990

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/9/ Experimental Research on Parameter Identification Methods on Four Italian Apartment Buildings: B. DANIOTTI, F. CONTI. Ibid.

/10/ Proceedings of the Workshop on "Parameter Identification Methods and Physical Reality", Ed. J.J. BLOEM, EUR 14863 EN

Monitoring of PV Demonstration Projects

The objective of this activity is to provide technical assistance to contract management and project performance evaluation in the PV part of THERMIE (European Technologies for Energy Management), which is the follow-up programme (1990 - 1994) of the DG XVII Energy Demonstration Programme (1979 - 1989).

During 1991 monitoring data from over 20 projects have been analysed and presented in more than 60 monthly, intermediate and final performance reports. (6 intermediate and final reports have been written for installations with analytical monitoring, 11 for installations with global monitoring) The data are stored online on the SUN SPARC-10 computer of NNE/ESTI; they constitute the world's largest data base on PV operational data. They are accessible for research purposes by all authorised persons using the European computer network or just the standard telephone line (via modem connection).

Another significant contribution to the DG XVII THERMIE programme consists in the evaluation of the technical part of new proposals for PV projects, the analysis of the progress reports and the corresponding updating of the PV part of the SESAME data bank (30 new proposals were evaluated, 73 SESAME sheets have been updated and 18 new sheets introduced).

Two on-site inspections were carried out to PV installations at Cansano and near Pisa, with discussions with the contractants (Italenergy, Italsolar, SEI).

New data acquisition equipment is under test in the ESTI laboratory, including very compact data loggers, and

recommendations on their suitability for field use are provided to the contractors.

The 1992 meeting of the European Working Group on PV Plant Monitoring was organised on the island of Vulcano in cooperation with ENEL (which operates several important PV projects on the Eolian islands). Documents B of the "Guidelines for the Assessment of PV Plants" concerning "Analysis and Presentation of Monitoring Data" was updated and newly issued. New monitoring procedures specific for grid-connected systems were discussed in detail.

A new issue of the European PV Plant Monitoring Newsletter was issued.

The highlights of these activities in the field of PV plant monitoring were presented at the 11th E.C. Photovoltaic Solar Energy Conference in Montreux /1/. A summary of the results obtained during the last 6 years by this cooperation with DGXVII was given at the PV EUROMED workshop in Istanbul which was organised by DGXVII.

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/1/ Review of Recent Results and Experience from CEC PV Demonstration and Thermie Programmes, by G. BLAESSER, W.B. GILLETT, W. KAUT, D.K. MUNRO, G. RIESCH (Proc. 11th E.C. Photovoltaic Solar Energy Conference, Montreux, Oct.1992)

SAVE programme

Demand Side Management

In recent years, the European Community has set some important objectives in the fields of energy saving and environment. The first target, set in 1986, was to achieve a 20% reduction in EC energy intensity by 1995 (with respect to 1985). The second objective is to keep energy pollutant emissions in the year 2000 at the same level as 1990. In order to cope with these objectives the EC has launched various programmes, one of which is SAVE. Among the actions underway within the SAVE framework, is the promotion of Least Cost Planning (LCP) or Integrated Resource Planning (IRP) as it is sometimes known in Europe. This action is intended to contribute a 3% reduction of total pollutant emission by the year 2000.

Least Cost Planning (LCP) is the process of selecting the mix of generating options, demand-side management

(DSM) measures, purchases and sales that enable a utility to meet society's energy needs at the lowest overall cost, subject to a variety of constraints, such as minimizing economic and environmental risks. LCP is a new, logical way of integrating load management and energy conservation into energy planning on an equal basis with supply options. The technique is enforced by legislation in many American States and US utilities have set up over 1000 residential and 750 commercial and industrial building energy saving programmes.

The Lawrence Berkeley Laboratory (LBL), of the Univ. of California, is developing a database to store the most interesting features of all these Demand Side Management (DSM) programmes, with funding from DOE and other public organisations. This database, is known by the acronym DEEP which stands for Database on Energy Efficiency Programs. In the EC, DG XVII would like to join the LBL project in order to have a similar tool ready for the time when new legislation will compel European utilities to adopt LCP. Information will then be needed on how to design, promote and evaluate suitable energy saving programmes. DG XVII has asked the JRC/ISEI to work with LBL in the transfer to Europe of the DEEP database.

While LBL is developing the US version, an international version (DEEP) will be the object of an ad hoc IEA Task forming part of a new Implementing Agreement created during 1992. The main DEEP project activities are:
– review of current data collection efforts in USA
– construction of the database and data collection instrument (DCI)
– pre-testing of the database and of DCI
– data entry and preparation of reports.

It will, first of all, be necessary to define the database field contents, then to collect the information from a sufficiently large number of energy conservation programmes in various fields (residential, commercial, industry), and finally to analyse it critically for consistency with field definitions, before loading it into the database. This work is already underway at LBL.

Work executed by the JRC/ISEI during 1992 focused on the collection of information on the DEEP project and on the preparation of an interim report, in which the main differences between US and European conditions for DSM programmes were considered and discussed. Visits to some European utilities were made in order to determine their interest in LCP and to understand the main problems connected with the implementation of DSM projects.

From this preliminary activity, some critical points have been identified.

a) The implementation of LCP in Europe requires the urgent modification of tariff regulation mechanisms. The more similar these are in the European Member States, the more useful the transfer of information and the availability of a common database will be;

b) A considerable prenormative effort will also be necessary to define the energy savings, the capacity reduction, the cost, and the environmental benefits of each DSM programme. The JRC could contribute to this activity.

c) Due to different institutional, normative, and energy situations, additional information is required for adapting the US database to European conditions. This will be one of the first tasks to be tackled during 1993.

d) Environmental externalities are one of the key problems of DSM programmes that have not yet been solved in the USA. A joint effort, aimed at better quantifying such social costs could be another important research topic for international collaboration.

e) If it is true that specific energy consumption is lower in Europe than in the USA, so that energy saving is easier in the latter, it is also possible that this situation has prevented more careful research into more effective DSM actions.

Passive Solar Test Site

The Passive Solar Test Site is part of the European test facility for the outdoor testing of building components and four test cells are maintained in operation for experimental work. Scientific work during this period was performed within DGXII's PASSYS programme.

An inspection, regarding quality aspects, of the 12 European test facilities was carried out in 1991 and 1992, at the request of the project coordinator and a final report was prepared /1/.

Energy Saving and Indoor Environment

Pilot studies were started recently on the use of specific sensors for the assesssment of indoor air quality in relation to energy demand in buildings. Experimental procedures are under development, in collaboration with the SIB (Sweden). The work will be extended in the coming year.

During the year, 5 students carried out scientific work in the Solar Thermal and Energy Conservation Sector as a part of their studies. They came from several universities, in different countries, (departments of physics or mathematics) and have learned how to apply the various identification techniques. Results have been reported at the appropriate meetings and conferences.

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Support to EURATOM Safeguards - Video Surveillance

Six collaboration tasks have been carried out for the EURATOM Safeguards Directory in Luxembourg. The activity consists in developing dedicated systems, hardware and software, in the the field of optical surveillance. The main projects are:

Computer Aided Video Surveillance (CAVIS)

After the positive tests of the prototype CAVIS-2 /1/2/ EURATOM asked JRC to realise five systems for installation in European nuclear plants. These systems provide computer aided video recording and reviewing in multi-camera applications (16 video channels). The control computer monitors the recording process and the environment through analog and digital I/O lines. CAVIS provides a unique combination of video recording and logging of relevant events into a data file. Self-checking feature and inspector interface with help functions are available. The first single rack version CAVIS-2S /3/ has been installed in field and is operated in routine use.

Computer Aided Review Station CARES

A dedicated station for reviewing video tapes recorded by the CAVIS 2 systems has been developed (fig. 4.16). The CARES system /4/ is foreseen for operation outside the plant and consists of two light table-top racks. The software performs the safeguards review of surveillance tapes with the unique possibility to correlate data stored in the log-file with the recorded video scenes. Two systems have been requested; one has been completed and installed in field.

Fig. 4.16. Review station CARES for safeguards video surveillance

Review Station with Digital Storage

This development prepares the next generation of systems for safeguards review of video pictures. It is based on a digital storage unit with image compression and decompression. A scene change detection system based on the Polyline method will trigger the storage unit for dumping alarm scenes. The system design and the communication protocol between both units have been defined.

A similar system configuration can be used for front-end data reduction in video surveillance. In this application only relevant camera pictures are recorded digitally. The front-end data reduction eases considerably the effort of safeguards reviewing process afterwards.

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/2/ Mol M., "CAVIS-2 Software Reference Manual", technical note I.91.91, July 1991

/3/ BETTENDROFFER E., COLZANI S., MOL M., "CAVIS-2S Computer Aided Video Surveillance System, Single recorder, single rack version", technical note I.92.116, November 1992

/4/ BETTENDROFFER E., MOL M., "CAVIS-2 and CARES: Systems for computer-aided video recording and reviewing in multi-camera applications", Proc. INMM, Orlando/USA, July 1992

Scientific and Technical Support to EURATOM Safeguards

Safeguards Information Systems

Several information systems have been designed and implemented at Luxembourg Headquarters. They concern sample and transport data base, a training course data base and a material accountancy system, briefly described hereafter.

The MADES (Material Accountancy Data Evaluation System) has been developed to support the Euratom Safeguards Directorate. The system is a multiuser program developed by using ADABAS as Data Base Management System, while Natural V2.1 and PL/1 have been used as programming languages. Two MADES versions are actually available:

MADES as mainframe version for MUF analysis MADES 3 pc (interactive part of MADES as PC version) which is implemented on a Toshiba 5200/100 under OS/2.

MADES Mainframe Version

The mainframe version is the code for MUF (Material Unaccounted For) analysis which can be operated through a Siemens terminal or through PC Siemens emulation via LAN (local area network).

MADES consists of 3 modules. MADES 1 validates and updates the masterfile data. MADES 2 selects the material categories of interest, marks the correlations, establishes the INPUT file(s) and transfers them into the DABAS. MADES 3 supports data review, stratification and variance calculation with temporary or stored schemes.

The first two modules are operated in batch mode; module 3 may be operated either in batch or in interactive mode.

MADES PC Version

The MADES 3 module has been implemented on a Toshiba portable PC under NATURAL OS/2. This module is operated in iteractive mode and allows the user to define the stratification schemes, the Operator's Measurement System and the MUF analysis with the relative variance analysis.

The required data files (3 ADABAS files per material category) are prepared by the Siemens mainframe (MADES 1-2), transferred via LAN to a standard ESD PC and then transferred through floppy to the Toshiba.

New stratification parameters (such batch name) and modification within the parallel batch runs for element and isotope data are included in the new PC version.

Sealing Identification Techniques

In 1991-1992 extensive field tests were conducted for the sealing of multielement bottles (MEB), which are special containers for the transport to and storage in storage ponds of spent fuel LWR elements at a reprocessing plant. The sealing system is based on the replacement of one of the existing closing bolts on the cover of the MEB by a special designed sealing bolt. The identification and integrity of the sealing bolt is performed by ultrasonic techniques. On the basis of the succesful results obtained for the application of 50 sealing bolts, the EURATOM Safeguards Directorate decided to implement this technique for inspection purposes. A set of 50 new sealing bolts and a complete ultrasonic reading system were supplied. At present the main emphasis is put on the optimisation of the industrial production of the seal and on the implementation of adequate and handy software and associated procedures to be used by inspectors on site or at HQ.

SUPPORT TO THE COMMUNITY STATISTICAL OFFICE

Statistical Applications of Artificial Neural Networks

The objective of this support activity consists of developing connectionist tools for statistical applications, and to implement the new techniques for solving various problems selected by the Statistical Office (SO, or EUROSTAT). The range of problems that may be addressed by a neural network approach is wide, and the collaboration agreement lists many potential topics including clustering, classification, discriminant analysis, regression techniques, time-series forecasting and definition of methodological frameworks. The policy of the Neural Network Laboratory (NNL) is to adapt to the current priorities of the SO whenever an application is recognised as being suitable for a connectionist approach.

The main achievements for 1992 pertain to the field of automatic classification or unsupervised clustering, both from the applicative and theoretical point of view. Some additional theoretical results have also been obtained for connectionist regression techniques.

Unsupervised Clustering with Kohonen Maps

Data sets of socio-economic feature vectors often involve a large number of high dimensional samples. In order to exhibit manageable representations and to extract useful information from these data, some preliminary reduction of the complexity may be required. A connectionist model called Kohonen Map has been used and enhanced for this purpose. It maps the feature space onto a two-dimensional lattice, while attempting to preserve substantial topological properties of the original samples. The results obtained on two problems selected by the SO have demonstrated that the connectionist approach provides an alternative to traditional techniques for unsupervised data analysis which is definitively well worth considering. It deals easily with missing data, has a wide applicability range, and provides a data representation that has no counterpart amongst the traditional statistical methods.

The data set for the first study consisted of 227 European Statistical Territorial Units (STU) described by 14 socio-economic variables, like unemployment rate, population density, activity rates and so on, with many missing values. The request was to find groups of STU's that have similar feature vectors.

On the way to the connectionist solution /1/, generic problems stemming from the non-deterministic behaviour of the algorithm have been overcome, to produce a reliable Kohonen Map /2/. Then, accounting for the little knowledge available about the ensuing interpretation phase from a statistical point of view - the Kohonen Map approach may be criticised for its lack of theoretical foundation -, the study was carried on with the goal of defining tools for gaining more insight into the data representation. The algorithm has been interpreted in terms of gradient descent along a potential function and the overall approach has been successfully compared with traditional techniques /3/.

For this specific problem, each STU is associated to a European geographic area. Then, Kohonen Maps may yield an interesting data representation tool to be integrated in Geographic Information Systems (GIS). By superimposing a "smooth" colour palette over Kohonen's grid, thereby associating neighbouring colours to similar regions, it is possible to summarise on a coloured European map the STU similarities. *Fig. 4.17* displays such a map for 62 European Regions.

The second task deals with the estimation of missing data in yearly foreign trade statistics. The data set consists of import/export data for about 200 countries, 10 product groups, and about 20 years. The study is still under way, but the early steps of the project have led to further theoretical progress, with two novel results about the quantization properties of the Kohonen Map model /4/ /5/.

Multilayer Perceptrons and Regression Techniques

Two additional theoretical studies have been carried out, where the neural network model called Multilayer Perceptron (MLP) is viewed as a nonlinear regression model.

The first study deals with the problem of estimating the expected generalisation mean squared error of a trained MLP. The estimator is based only on the observed learning set error, thus avoiding the use of a supplementary (and data consuming) test set to validate the model /6/.

The second study deals with adaptive learning for MLP. Dealing with a non-stationary process requires quick adaptation of the model's parameters, while at the
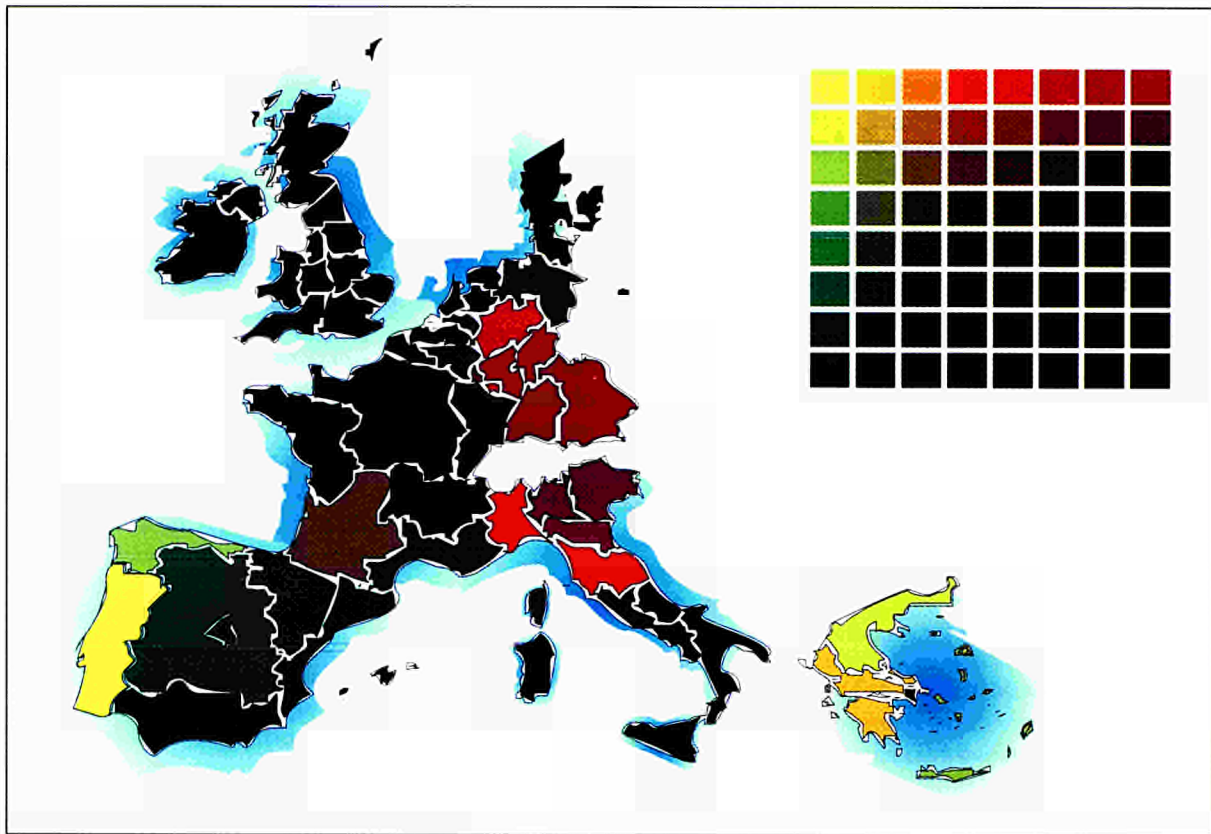
Fig. 4.17. Display of a Map for 62 European Regions

same time catastrophic forgetting of experience should be avoided. A neural learning technique, which satisfies these requirements without sacrificing the benefits of distributed representations, has been derived /7/.

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/2/ VARFIS, A., VERSINO C. Selecting Reliable Kohonen Maps for Data Analysis. ARTIFICIAL NEURAL NETWORKS II: Proceedings of the International Conference on Artificial Neural Networks - ICANN 92 - Brighton, United Kingdom, September 4-7, 1992, 1583-1586. Edited by I. Aleksander and J. Taylor.

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SUPPORT TO THE SECRETARIAT-GENERAL OF THE COMMISSION OF THE EC

Development of a Database for the Management of the Parliamentary Petitions

In the framework of support to Directorate E of the Secretariat-General, the Petitions database was designed and developed in 1991. It is an ORACLE database and designed to run in a multi-user environment. The first complete version of the database was demonstrated to members of the User Service in January 1992. As a result of significant changes in the user requirement since the database was first designed, it was decided that a second enhanced version of the database would be necessary before the definitive installation at the User Service premises. The second version was installed and demonstrated in Brussels in September 1992 and became fully operative by December 1992.

Support to the Commission Anti-Fraud Work Programme

Following revision of the DAF (the Anti-fraud Documentation database) feasibility document /2/ in November 1991 and first experiences with the DAF data collection exercise, a number of work packages were specified in early 1992. These included: i) analysis of data input requirements for DAF report authors, ii) development of a full authoring system based on standard word-processing software, but enhanced with special facilities to link or embed text from a source document to any number of destination documents, iii) analysis of facilities for conversion and import of data from free text into hypertext structure, iv) a market survey of suitable commercial software tools for the development and operation of the DAF end-user system, and v) detailed system specifications for the DAF system. Work for these work packages was completed by July 1992.

Starting in June 1992, detailed document analysis work was initiated for major document types in DAF. The objective was to produce a formal document model (in technical terms, a Document Type Definition) for each document type and a set of authoring conventions so as to enable the automatic conversion of word-processed files and drawings into structured text-and-graphics files with standard SGML markup. The overall objective was to specify a master database of all DAF documents coded in SGML, as well as to understand the intermediate stages involved for getting from word-processed files and drawings into SGML. The advantage of the SGML approach is the increased portability of DAF documents across heterogeneous computer platforms, but also the adding of structure (and intellectual value) to free text. In addition to SGML related analysis, in-house tests of candidate hypertext software for the implementation of the DAF end-user system were undertaken. The above work was completed by October 1992.

Owing to significant delays with the DAF data collection exercise, a call-for-tender for the design, construction and operation of the DAF information system did not take place in autumn 1992 as planned. Instead, all available resources were spent giving support to the work of DAF report authors and editors. This support included the in-house development of enhancements to the DAF authoring system, the extensive training of DAF authors and editors (at UCLAF in Brussels and the European University Institute in Florence), the analysis of language translation and version control problems, and the continuous monitoring of progress and revision of planning for the overall project. This support activity concerns points 14 and 28 of the Anti-fraud Policy/ Commission Work Programme /1/.

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/1/ "The Fight Against Fraud, Work Report 1991", CEC, SEC(92) 943 final

/2/ "DAF - A feasibility study for a text database containing descriptions of national anti-fraud management systems in the EEC", T. BARBAS, COM 4418, 1992

5 WORK FOR THIRD PARTIES

Non Nuclear Energy

Environmental and Industrial Risk

Computer Aided Engineering

5 WORK FOR THIRD PARTIES

NON NUCLEAR ENERGY

Photovoltaics

Work for Third Parties, i.e. industry and public organisations, against payment is an important part of ISEI's European Solar Test Installation (ESTI) activities. The following diagram (*fig. 5. 1*)shows the evolution in TPW since its start in 1988:

ESTI has a number of advantages which enable it to provide services to industrial clients. Foremost is the neutrality afforded by its status as an organisation of the European Commission. This, coupled with the policy of strict confidentiality maintained by ESTI, has encouraged all sectors of the photovoltaic industry to use ESTI.

Module qualification tests provide the largest fraction of third party work revenues. In the second half of 1992, ESTI reached its limits on throughput, caused by constraints in manpower.

The second largest contribution to ESTI's third party revenues comes from the calibration of reference

devices. These may be single cells or complete modules. ESTI is the only laboratory equipped to calibrate complete modules.

The calibrated devices are extremely important to manufacturers assessing the quality of their device production and to plant operators monitoring the performance of complete systems. There is an increasing trend for requests for module calibration, caused by a strong competition between manufacturers.
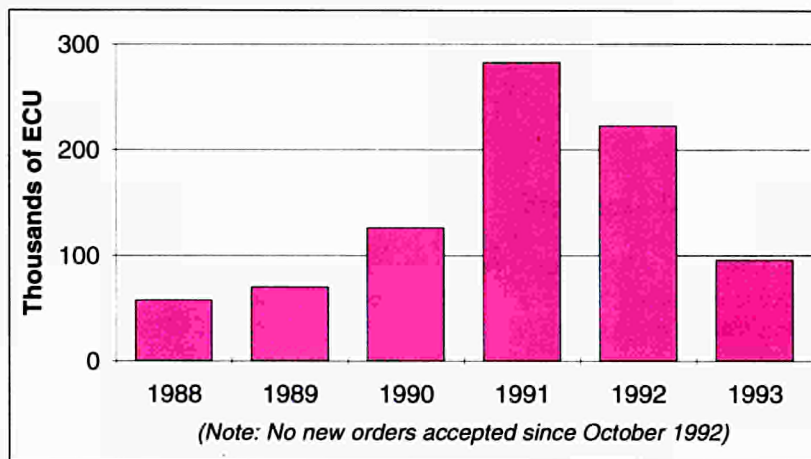

(Note: No new orders accepted since October 1992)

Fig. 5.1. Evolution of Third Party Work at ESTI

ENVIRONMENTAL AND INDUSTRIAL RISK

ISPESL: Accident Consequence Models

In 1992 the study for ISPESL (Italy) has been completed concerning a critical review on models to describe the environmental impact and the risky consequences of accidents in the process industry (Contini, Rasmussen, Sola).

Regione Emilia Romagna

Furthermore scientific advice has been given for the completion of the area risk study of Ravenna (ARIPAR project, organised by the Regione Emilia Romagna and the Italian Ministry for the civil protection).

Agusta-SIAI Marchetti

Objective: use of laser holographic interferometry and acoustic emission on a trunk of aircraft fuselage undergoing fatigue damage /1/.

The second campaign of holographic interferometric measurements has been carried out, in Sesto Calende (Italy), with ISEI's pulsed wave ruby laser. The use of the pulsed wave laser entailed the solution of non trivial problems of laser reassembling and re-alignement after its transportation, but did allow to get rid of the disturbances due to environmental parasite vibrations /2/. The detailed results of the measurements are confidential, but it is possible to say that the technique turned out to be effective. The use of double exposure holographic interferometry with thermally induced stresses allowed the identification of regions where the previous loading process induced structural damage /3/. In fig. 5.2 the behaviour of the fringes show the presence of a local decohesion between cylindrical shell and the internal frame element. The diagnosis is easier if fig. 5.2 is compared to fig. 5.4, showing the interferometric fringes in a region structurally integer.

The Acoustic Emission method has been used for monitoring the damage process during fatigue loading and final pressure test. The results of the measurements can be summarised as follows /4/.

Fatigue cycling

AE monitoring was performed three times; at 75000 cycles, at 78000 cycles and at 90000 cycles. Each time the AE activity during a 40 cycle period was recorded. The objective of this approach was to compare the relative AE activity. Changes in this activity pattern could have been caused by changes in the structure, i.e. damage. It was shown by the analysis of AE signals that no considerable changes in the number of hits, amplitude range etc. had taken place. A slight increase in the AE activity towards the end of the cycling might be indicative of some damage initiation.

Final Pressurisation Tests

Two consecutive pressurisations were performed. The rising phase of these pressurisations was monitored and it was observed that:

Fig. 5.2. Structural damage (decohesion between cylindrical shell and internal frame) revealed by pulsed laser holographic interferometry.
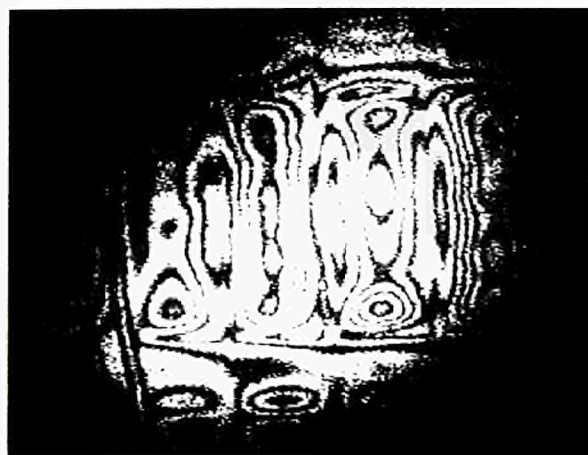
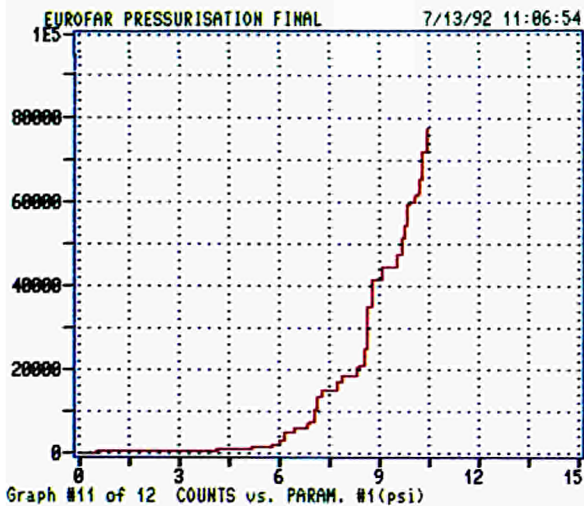**Fig. 5.3.** Interferometric fringes in a region structurally integer of fuselage

Fig. 5.4. Acoustic emission cumulative curve vs pressure: the many events at the pressure hold (around 8.5 psi) and their exponential increase reveals the existence of structural damage

— there were plenty of AE events of significant amplitude during the load holds (see *fig. 5.4*), which are signs of structural damage;
— indications of local structural debondings were revealed from the behaviour of the curve "cumulative counts vs. pressure".

The results of AE measurements are in agreement with that of laser interferometry.

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/4/ SOLOMOS, G., CARETTA, A. and LUCIA, A., "Misure di emissione acustica effettuate su tronco di fusoliera in composito presso la Agusta-SIAI Marchetti di Sesto Calende, SIAI-Test 1.2", Report ISEI-IE 2364/92 (Confidential)

Statistical Analysis of ENEL Data Stored in the Component Event Data Bank and Comparison with Analogous Data Related to other European plants

ISEI has undertaken under contract No 3842-89-11 TG ISP I to carry out research and applications activities to compare the performance of ENEL components to that of other data suppliers for data stored in the CEDB (the component event reliability data base designed and managed by ISEI). The components compared are electric motors. The methodology of "intelligent selections" has been applied to define strata where the comparison of component performance is meaningful and parametric and non-parametric comparisons between data suppliers have been implemented in each stratum.

As the observation periods of data suppliers and components are different and many of the components observed have suffered from no failures, the application of non-parametric methods has called for the development of empirical bayes estimates of the failure rates of components. These have been derived /1/ and are being applied in the last phase of the contract.

Reference

/1/ ARSENIS, S. P. (1992). "Empirical Bayes Estimation of the Mean Failure Rate of Components with Particular Reference to Reliable Components." ISEI/SER/2248/92

PETROBRAS, Petroleo Brasileiro S.A.

The Institute offered a consulting service to PETROBRAS on the development of the company's databank for the collection and storage of failure events on components operating on their offshore platforms. This consulting was done on the premises of PETROBRAS in Brazil.

The MAPO project

The initials MAPO indicate a decision support system for the management of planning and control of the cleaning up of the river Po. The project is financed by the Italian Ministry of the Environment and by the JRC. The basin which is the subject of the study is the largest in the country.

Most of the work related to the MAPO project was carried out in 1991, and in 1992 the final report was written and delivery of the software was undertaken (for further details about the project, see the annual report of 1991, EUR 14755 EN).

In 1992 the resulting prototype was also demonstrated to the client and to other relevant authorities. These

presentations of the work went very well, and there are high hopes that the work may continue under a new agreement with the Ministry.

Work was initiated in 1992, to document and publish the scientific results obtained during the project, especially related to the integration of multi criteria decision support systems and expert systems.

RITO

RITO is a decision support system for the rational management of toxic and noxious industrial waste on regional scale, which has been developed as a third party contract for the Italian Ministry of the Environment. The system is a decision aid which should help to reduce as much as possible, the overall impacts (on man, the environment and the economy), associated with the installation of the necessary waste disposal and treatment facilities in the reference region. During 1992 the development of the system was completed.

The RITO system consists of a Personal Computer workstation equipped with data bases, a geographical information system, various specialist programmes and a user interface connecting all system components and facilitating user interaction. The most important activities accomplished this year were the system analysis and design for the integration of the complete system, the development of the user interface, and the use of the system for a case study.

The user interface programme performs the integration between all specialist modules in the system, and links the system with the Geographical Information System (GIS). It supplies user-friendly and consistent communication between the user and the different modules, and produces numerical results and tables, coloured graphs and thematic maps. The results can also be printed out on paper. These facilities, together with the programming language adopted, are consistent with the project specifications.

Communication between the user interface and the other specialist modules is provided by a common memory area, which has the structure of information nodes. These nodes represent the module's external interfaces.

From the functional point of view the user interface is window based, the windows being the real vehicle of the dialogue between RITO and the user. The windows

manage five components: static messages, dynamic messages, dialogue boxes, graphics and menus. These components assume Windows 3 style. The system operation diagram shows the information flows between the various modules which form it (see fig. 5.5).

As already stated the system includes a GIS that processes and structures all the spatially referenced data required. On user request, these data may be shown on the screen or printed as tables and graphs by the GIS itself. Following any restructuring activity the data bases are updated.

In this decision support system an alternative is a scenario for the disposal of the region's wastes. It is described by a particular combination of locations of disposal and treatment facilities and by the description of their user basins. The user basin of a facility is described by the list of all its users (municipalities).

The scenario construction module sets up a number of alternative scenarios, using the module heuristics, the data concerning the offer and the demand for waste disposal, and details of the communication network between the various municipalities. It can also receive other input on the user's initiative. These input data mainly modify the original disposal offer and demand data, allowing the creation of scenarios different from those automatically generated by the module heuristics. Having generated some alternative scenarios the control can then be passed to the specialist evaluation modules. These make use of different area information depending on the calculations to be performed, as well as information on scenario definitions. The specialist modules available offer the possibility of evaluating for each of the alternative scenarios, indices for the associated cost, environmental impact, transportation risk and site severe accident probability. These indices represent the decision criteria required for choosing among the different alternative scenarios. On completion of the evaluation of the scenarios by the specialist modules the decisional matrix, which is the main input argument to the decision module, is constructed.

All the information traffic is guided by the user interface module, which transfers control to the user (by means of the menu) when required. The realisation of the information flows described makes use of ASCII files in some cases, to store the information which does not change with time.

In the case study, based on real information gathered from Lombardy Region, four alternative scenarios, which were generated by the system on the basis of different

heuristics, were considered. For the four scenarios examined the modules calculated the following aggregate parameters: a standard global scenario index which quantifies the risk of major accident; an investment cost index which quantifies the overall economic cost of a scenario in millions of Italian lire; two non-dimensional overall quantification indices of the environmental impact: an absolute index which supplies the general impact calculated on the common basis and a relative index which gives the maximum impact of those calculated for all the scenario plants. Naturally the specialist modules give the scenario evaluation parameters in more depth, depending on the accuracy considered adequate by the user. As an example, to evaluate the plant accident risk, instead of just one aggregate parameter which becomes the only risk criterion, as in the example, the system can keep the various parameters involved in the risk evaluation separate.

Moreover, instead of aggregating the different technologies, they can be kept separate, maintaining their independent values as decision criteria for risk. In the case study we have opted for simplicity, aiming first to

understand the system behaviour. The decision criteria have thus been limited to four. The results produced recommend the concentration of the disposal and treatment of toxic-noxious industrial waste in a few large-capacity plants.

The RITO system is now operational and, as it has been developed under a third party work contract, it will soon be delivered to the customer.

A Study of the Risk of Rail Transport of Propylene for Himont

This study was made for the Italian chemical company Himont in the period March to August 1992 and it concerned a qualitative evaluation of the risk related to rail transport of propylene. A study of this type provided an opportunity to apply the on-going research into transport and accident patterns of hazardous materials.

The study consisted of four parts: 1) a literature survey of preceding studies, 2) analysis of accidents involving
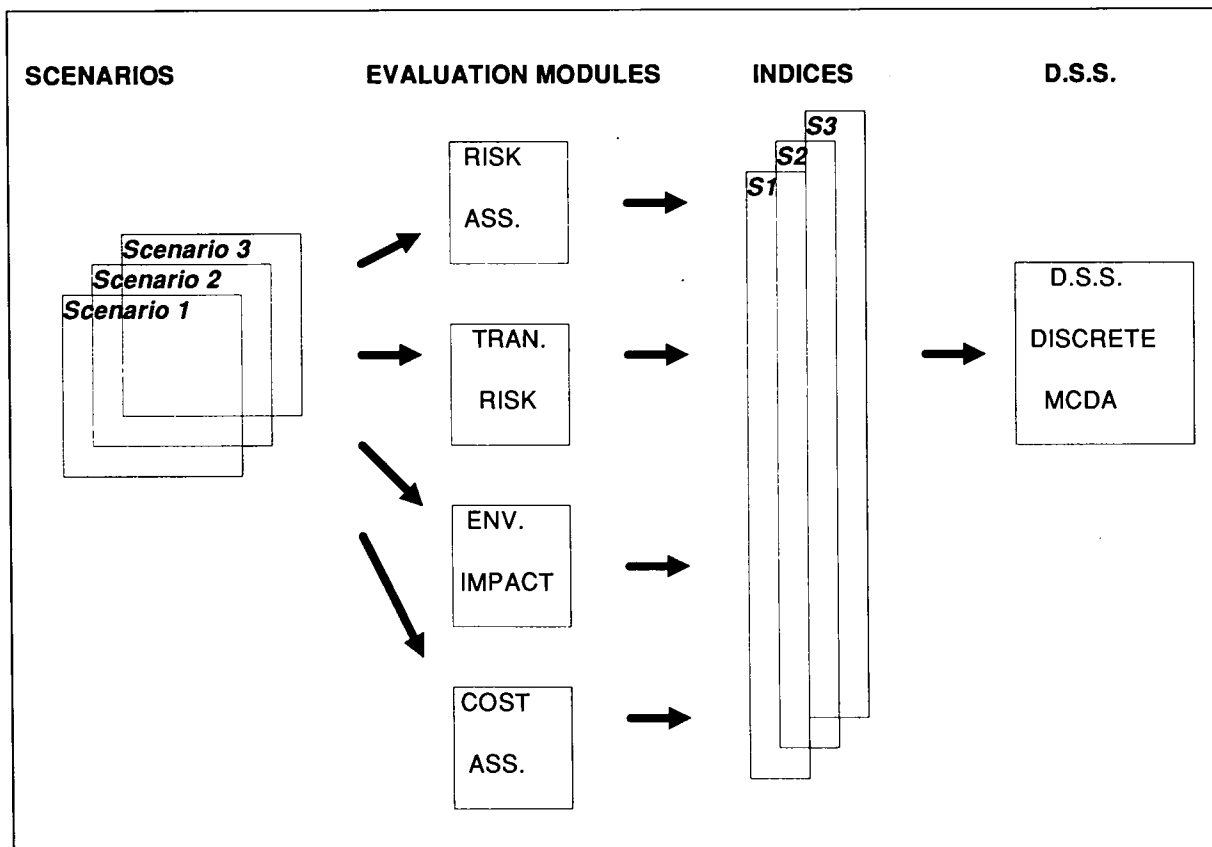

Fig. 5.5. System operation diagram

propylene and similar substances, 3) analysis of the effective transport routes in collaboration with the customer, and 4) a semi quantitative risk analysis.

In order to carry out the study, all accidents, from the open literature, on a world-wide basis, involving propylene and similar substances (butylene, propane, butane, LPG) were extracted (in total 305 accidents), and their distribution with regard to modes (rail, road, pipe, loading/unloading and fixed installations) was found. Of the 305 accidents thus identified, 144 accidents after the year 1969 involved human fatalities and these accidents were analysed in detail. For fixed installations and for each transport mode cumulative frequency-consequence histograms (fN diagrams) were constructed, and it was found that, apart from loading/unloading, the accident statistics provide no basis for assuming that the accident consequences of the various transport types and fixed installations are different. It seems rather that the consequences are linked to the material involved. The absolute frequency with which these accidents happen are naturally different, depending on the underlying transport and storage patterns.

The customer provided the routes for transport indicating the amounts and the composition of the trains. To calculate the frequency of fatal accidents a simple (approximate) model was used based on the frequency of collision or derailment per train kilometre, combined with the conditional probabilities for release, explosion and/or fire, resulting in fatalities.

The literature survey provided enough data to allow a rough estimate of the overall risk of having a fatal accident, though the uncertainty in the estimate was recognised to be considerable. From this data an approximate fN diagram was constructed and compared with international criteria for acceptable risk.

The work was carried out in collaboration with the Major Technological Risks sector.

CINEAS

CINEAS is an abbreviation for "Consorzio Universitario per l'Ingegneria nelle Assicurazioni" and they are interested in insurance problems in relation to transport of dangerous goods by road. The contract was initiated in 1992, and is expected to be finalised by mid 1993.

The contract has the following objective: "To develop a model suitable for the evaluation of the risk of transport

of dangerous goods by road to be used as the basis for determination of insurance premiums and insurance policy conditions."

Most of the work still has to be carried out, and includes:

- A comparison on worldwide scale of the risks from fixed installations and transport of the same type of substances. Comparison between the insurance coverage of the two types of risks.

- Evaluation of the type and flow of dangerous goods in Italy and in a region of Italy (tentative proposal: Lombardy). Estimation of frequency and consequences of transport incidents in these areas.

- Definition of a procedure for the evaluation of risk of transport of dangerous goods and of the insurance premiums, to be used by the insurer. This procedure should be based on a model for evaluation of the consequences, which takes a number of parameters into account: the substance, transport mode, geographical area, industrial sector, and historical experience.

- Development of guidelines for the application of the procedure and for the necessary informatics support.

The contract foresees an intermediate report to be delivered in mid January 1993.

TPW Pilot Application of STARS to Off-Shore Systems

Client: Shell Internationale Petroleum Maatschappij

In this TPW project a small pilot application of STARS to a typical subsea production system was performed.

The general objective of the study was to demonstrate how some of the functionalities and capabilities of the STARS methodology and software could be applied to off-shore systems.

In particular the problem addressed was to assess the likehood of hydrocarbon spill and to pinpoint the critical causes of such event in a changing situation in which system configuration as well as component characteristics evolve with time.

A small knowledge base with the component classes necessary in the pilot application was extracted from the generic STARS component KB and complemented with classes for typical subsea equipments.

The plant editing tools of STARS were used to build a stuctural model of the target system based on the classes in the KB.

The STARS fault tree construction and analysis tools were used to construct fault trees for a set of critical events and system configurations.

COMPUTER AIDED ENGINEERING

Activities promoted in the area of CAE aimed at the involvement of the European industries into joint operations in order to enable more competitiveness of their products or productivity. Marketing and professional consultancy efforts were directly addressed to identify and to solve problems of the industrial partners. Taking advantages of the STEERING (Trademark of the collaboration agreement between the ISEI/TESLA Laboratory and the SPAZIOSYSTEM Company) Assistance and Expertise, the modern ways of CAD/CAE modelling and structural analysis have been applied. In particular the following engineering services have been fulfilled:

– New EC - Normative Conformity and Validation Tests Control committed by a private European company. Computer simulations of the driver head impact on the car steering wheel with the evaluation of energy dissipation inside the additional collaps-ing body during such an accidental event. Design solutions of the collapsing body were proposed.

– Technological innovation of big devices requested by a European manufacturing industry (MECOF Company). Combined numerical/experimental Validation Studies with accurate comparison and high precision of both numerical results and experimental data. A process of machine conception improvement has been gained by examining increased mechanical performances.

– Design optimisation and certification agreed with a European transport industry. Several structural analysis were performed for complex 3D transmission pieces and gear box components under static and fatigue loading conditions. All the numerical modelling approaches are then validated experimentally in order to satisfy and overcome the severe civil transport certification normative.

6 ASSOCIATED LABORATORIES

Partners in Collaborative Projects

Associations

Human Capital & Mobility

6 ASSOCIATED LABORATORIES

PARTNERS IN COLLABORATIVE PROJECTS

Fusion Association Technology Porgramme for the Next Step

- Institute for Systems Engineering and Informatics of JRC
- ENEA (I)
- KfK -Kernforschungszentrum Karlsruhe (D).

SRG Systems Response Generator

ISEI/IE/Man-Machine Interaction Sector
CRI Computer Resources International, Birkeröd, DK
APSYS/Aerospatial Protection Systèmes, France.

HEAT- Human Error Analytical Taxanomy

ISEI/IE/Man-Machine Interaction Sector
TECNIMONT, Milano, Italy
HIMONT/ Terni, Italy
ROHM and HAAS, Jarrow, UK
VTT/SEL,SF.

DYLAM-TRETA

ISEI/IE/Man-Machine Interaction Sector
CSN Consejo de Seguridad Nuclear, Madrid, Spain.

STRESS

ISEI/IE/Man-Machine Interaction Sector
CNR Consiglio Nazionale di Ricerca, Roma, Italy

ASSOCIATIONS

TEAM (Testing Electromagnetic Analysis Methods)

- ISEI / IE/ CS-TESLA Laboratory
- ANSALDO Ricerche e Università, Genova (I)
- EdF (Electricité de France) - DER, Clamart (F)
- LEG, Ecole Polytechnique, Grenoble (F)
- Vector Fields, Oxford (UK)
- Consorzio Universitario Sud-Italia, Napoli (I)
- Institut Montefiore, Liege (B)
- Technical University, Graz (A)
- University of Bath (UK)

EAMA

The EAMA group is made up by Italian laboratories working in the area of acoustic emission with primary focus on materials and components from the aerospace industry. The group is presently constituted by the following laboratories:

1. Dip. Ing. Chimica e dei Materiali, Università La Sapienza - Roma
2. Dip. Ingegneria Materiali e Produzione, Università di Napoli
3. Nondestructive Testing Group, ALENIA, Spa
4. Centro Italiano Ricerche Aerospaziali (CIRA)
5. Ingegneria Sperimentale, AERMACCHI Spa
6. SIAI Marchetti - Gruppo AGUSTA,
7. NAMICON Srl
8. Diagnostics and Reliability Sector, IE-ISEI-JRC Ispra (Coordinating laboratory).

ESReDA - European Safety, Reliability and Data Association

ESReDA is a relatively new European Association established to promote research, application and training in Reliability, Availability, Maintainability and Safety (RAMS). The Association provides a forum for the exchange of information, data and current research in Safety and Reliability and a focus for specialist expertise. ESReDa was formed by combining the forces of EuReDatA (European Reliability Data Bank Association) and ESRRDA (European Safety and Reliability Research and Development Association), the integration of the two providing a stronger basis for furthering the understanding, development and dissemination of RAMS research and methods throughout Europe.

Membership of ESReDA is open to organisations, private or governmental institutes, industry researchers and consultants who are active in the field of safety and reliability. Membership fees are currently 1000 ECU for organisations and 500 ECU for universities and individual members.

ESReDA seminars provide a forum for presentation and discussions on selected topics. They are held 6 monthly in conjunction with the Assembly meetings. Recent topics have included

- The Use of Expert Systems in Safety Assessment and Management, London (UK), Oct. 1991
- Safety of Systems Relying on Computers, Amsterdam (NL), April 1992
- Equipment Aging and Maintenance, Chamonix (F), Oct. 1992
- Safety in Transport Systems, Huddersfield (UK), April 1993.

The next two seminars will deal with:

- Organisational and Operational Safety, Lyon (F), Oct. 14 and 15, 1993
- Maintenance and System Effectiveness (provisional title), Chamonix (F), April 1994.

ESARDA

The European Safeguards Research and Development Association was founded in 1969. Several Institutes of JRC namely EI, IRMM, ISEI, IST, ITU are playing an active role in the life of ESARDA. It is worthwhile to recall the main objectives of the Association as laid down in the Association's Agreement.

The purpose of the Agreement is to facilitate collaboration on R and D in the field of safeguards and on the application of such R and D to the safeguarding of source and special fissile material. Collaboration shall be effected as appropriate by coordination of the research, development or application work, by the exchange of information and assistance on the personnel and technical levels and by the joint execution of these programmes or parts thereof.

Concerning the activities, the general secretariat of ESARDA is performed by ISEI. This included the organi-

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sation of the annual meeting of the Association at Salamanca, May 1992 on measurements of nuclear waste and on containment and surveillance measures in intermediate and long term storage of irradiated fuels. Six meetings of the governing bodies were organised.

Furthermore the Association's bulletin and the proceedings of the Annual Meeting were edited.

The six working groups of the Association held their regular meetings during this period.

HUMAN CAPITAL & MOBILITY

ISEI partecipates in three projects under the Human Capital & Mobility Programme of the Community:

"Interactive Image Synthesis and Processing on Innovative Computer Architectures"

The project is organised around three main topics:
– Parallel and innovative architecture for multidimensional image synthesis and analysis
– Object oriented languages for interactive image manipulation
– Realistic Image and holographic processing and synthesis.

SMART (Semi-autonomous Monitoring And Robotics Technologies)

The SMART Research Network was approved in November 1992 and activities will officially start only in 1993. Apart from the JRC/ISEI, 10 research laboratories and 3 small/medium industries from six different countries (DK, F, I, IRL, P, UK) are involved in SMART. The network aims at the development of human resources for the technologies of monitoring and surveillance, autonomous robotics and tele-operation. This objective will be achieved by having coordinated projects, and by transferring technological results to industry.

Diagnostics and Reliability of Composite Materials and Structures for Advanced Transportation Applications

The network intends to unite various scientific approaches to the problem of structural reliability. The aim is to combine different testing and characterizing methods and non destructive techniques that are complementary to set up more suitable criteria for lifetime of industrial parts. The emphasis is laid on the joint application of techniques to get a more consistent knowledge of the mechanisms that occur during service life of structures. The purpose is to characterize the defects due to the industrial manufacturing and transforming processes, to model damage development during prescribed loading paths, including environmental loading, and to relate the macro failure behaviour to the micro structure of the material.

7 ISEI PARTICIPATION
IN EUREKA PROJECTS

Formentor

ISEI PARTICIPATION IN EUREKA PROJECTS

FORMENTOR

The FORMENTOR project (Eureka #19) /1/2/3/4/ is developing realtime decision support systems to help operators of complex hazardous plant. The project aims particularly at abnormal or unusual situations where the plant is functioning outside its normal conditions. The objective is one of "total loss control", that is avoiding loss of life, damage to the environment, and economic loss.

The partners in the project are:
- ISEI
- Airospatiale Protection Systemes - "APSYS" (F)
- Cap Gemini Innovation (F)
- Det norske Veritas (N)

(By agreement among the partners, APSYS, a subsidiary of Airospatiale, took over its parent's share of the project in autumn 1992.)

The functionalities required from a FORMENTOR system are those of:
- monitoring the plant, watching for precursor signs which indicate that an abnormal situation is arising;
- interpreting the data from the plant so as to deduce the plant's current state (significant features of which are not in general directly observable) as well as the underlying causes which have given rise to this state;
- predicting the future evolution of the plant under different hypotheses, both to see what sequels are possible from the present state, and to evaluate any alternatives considered;
- constructing a plan of action, which may comprise several actions in sequence, in order to return the plant to normal functioning conditions;
- and indicating to the operator what are the risks associated with the present plant state and what procedures should now be followed.

The work of the FORMENTOR project is divided into various workstreams, and in 1992 major milestones were achieved in several of these.

One of the two Pilot Applications, the Satellite Application, was finished successfully, including system integration, validation, and user tests against a simulator of the target system (a cryostat to be installed in an infrared observatory satellite). This application, which was carried out principally by the French partners in the project, is described more fully in /5/. The system developed has proved capable of:
- following the evolution of long term problems;
- offering a global view of the state of the target system;
- identifying the best compromise between conflicting objectives;
- and simulating the results of an operator's action without having to put it into effect.

In addition, this application has been important to the project in other ways: it enabled several of the methodological choices proposed to be implemented and tested; the software architecture, as well as several of the specific software modules, developed for the application, represented an important testbench for the toolkit workstream (see below); and the Man-Machine Interface developed made an important contribution to the development of generic MMI (see *fig. 7.1*) guidelines for the project /6/. *Figs. 7.1* and *7.2* show two examples of operators' interface screens developed for this application.
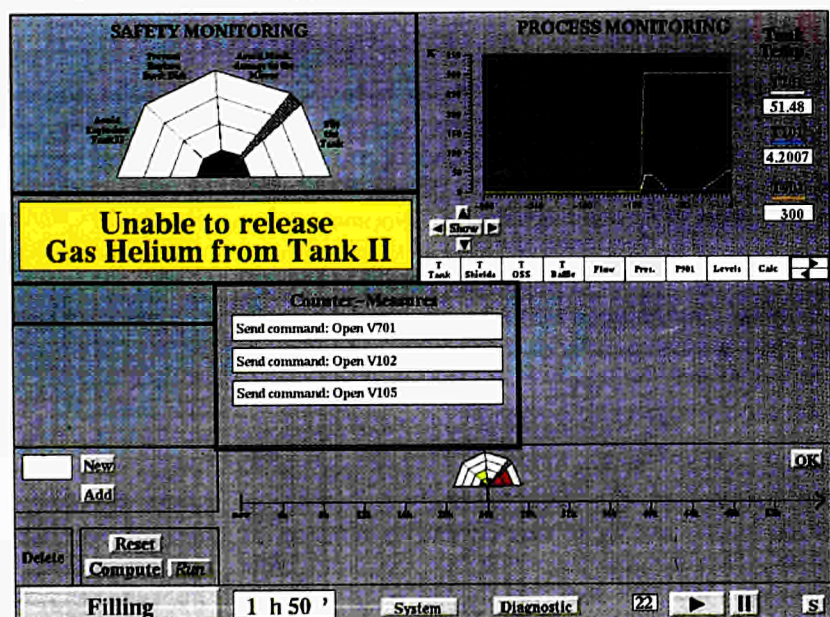

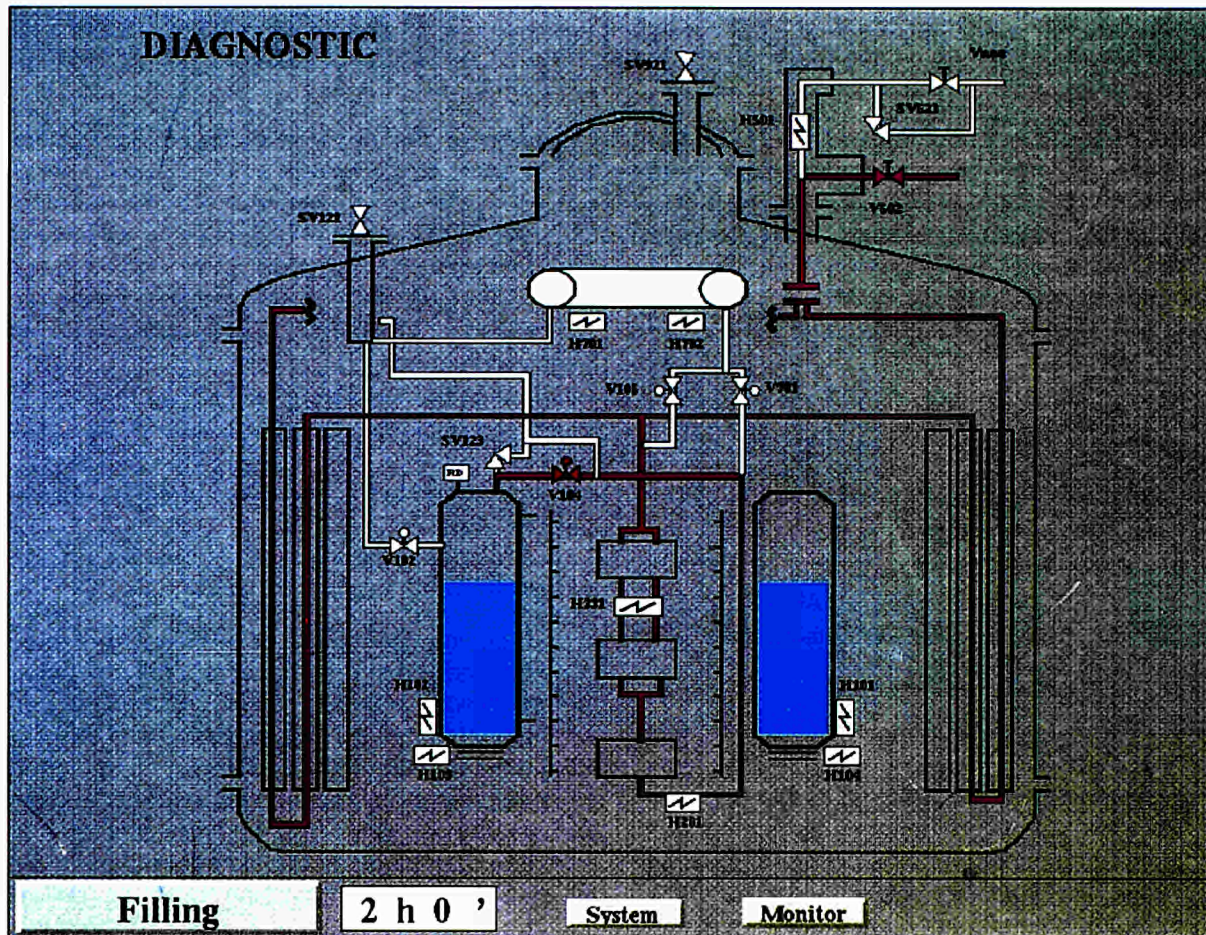Fig. 7.1. Formentor MMI for Satellite Application: Monitoring Screen

Fig. 7.2. Formentor MMI for Satellite Application: Diagnosis Screen

The other Pilot Application, the Petrochemical Application /7/ being carried out under the leadership of ISEI staff in cooperation with BP International and the Cap Gemini group, is due to finish in Spring 1993. This application has involved the development of a multilayered functional model of the target plant, a Butadiene extractive distillation plant in the UK. Based upon this functional model, two separate but complementary reasoning methods for the FORMENTOR system have been developed, Heuristic Causal Reasoning and Model Based Reasoning.

In autumn 1992, the application carried out successfully the first major software integration and test. On the basis of the results shown, it was agreed to proceed as planned to full implementation running against a plant simulator. The next step, developing a full operator interface and running the FORMENTOR system against the real plant, does not form part of the workplan

originally approved, but is under consideration for 1993/4. Fig. 7.3 shows the current version of the engineers' interface screens for this application.

The third FORMENTOR pilot system was finished in 1992. This system was developed as a case study to enable the testing of different formalisms for system modelling and different system architectures. The target system chosen was the emergency cooling system of a nuclear power plant (at the design stage). The results from this work, carried out largely by ISEI staff, were put to use in the Pilot Applications described above, and also in the development of the generic FORMENTOR toolkit. The methodological basis for this work is described in more detail in /8/.

The first version of the FORMENTOR toolkit was also developed during 1992. This toolkit consists essentially of two parts: a set of off-line tools, intended to facilitate

Fig. 7.3. Formentor MMI for Petrochemical Application

the task of a FORMENTOR system developer, and a set of online tools, which are integrated into the final FORMENTOR application system. See /9/ for a more detailed description.

Methodological work in the project included the finalisation of the first version of the FORMENTOR Handbook, which presents in a condensed format, for FORMENTOR Application system developers, the results of the various methodological investigations carried out to date, as well as a synthesis of the results from the pilot workstreams described above.

At the end of 1992 the project partners were considering the best way to put to use the methodology, skills, and software products developed in the project so far. Discussions were under way with representatives of various industries to see whether further development should be in the form of a continuing Eureka project or within another framework.

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/4/ A Real-Time Expert System for Risk Prevention: The Formentor Project, N. MITCHISON, A. POUCET, J-P. NORDVIK, & M. WILIKENS to be presented at European Safety and Reliability Conference ESREL '93, Munich, May 1993

/5/ The FORMENTOR ISO-Satellite Application: A Structured, Distributed and Model-Based Approach to Safety Monitoring, R. Pennings (June 1992) to be presented at Avignon '93 Conference, May 1993

/6/ FORMENTOR: Interface générique et ergonomique, A. CASALE & C. CZERWINSKI in ERGO-IA 92, Biarritz, Oct 92

/7/ FORMENTOR BP Pilot Application - Technical Progress Report, M. Wilikens, M. MASERA Technical Note No. I.92.104, JRC, Ispra 1992

/8/ FORMENTOR: A Real-Time Expert System for Risk Prevention in Complex Hazardous Environments - A Case Study, M. WILIKENS, J-P. NORDVIK & A. Poucet in Proceedings of IFAC/IFIP/IMACS International Symposium on Artificial Intelligence in Real-Time Control , Delft 1992

/9/ FORMENTOR. A Data Model Based on Information Propagation and Propagation Control for Real-Time Distributed Knowledge Based Systems, G. GERLINGER submitted to 2nd International Conference on Parallel and Distributed Information Systems, Jan 1993.

8

SPECIAL COMMISSION PROJECT

The Euro-Quebec Hydro-Hydrogen Pilot Project (EQHHP)

8 SPECIAL COMMISSION PROJECTS

THE EURO-QUEBEC HYDRO-HYDROGEN PILOT PROJECT (EQHHPP)

The 100 MW pilot project is to demonstrate the provision of clean and renewable primary energy in the form of Quebecian hydropower, converted via electrolysis into hydrogen and shipped to Europe, where it is stored and used in different ways: electricity/heat cogeneration, fuel cell operation, power/drinking water generation, steel fabrication, public transport and aviation propulsion.

The Project has the Commission of the European Communities and the Government of Quebec as sponsors. The project is based on a concept conceived by the Joint Research Centre of the CEC and is carried out by a group of industrial firms/institutions. A Joint Management Group is charged with the project management, the JRC/ISEI coordinates the project.

Milestones of the Project

The project is to be carried out in 4 Phases :

- Phase I:
  assessment; completed by March 1987.

- Phase II:
  detailed system definition, 1/1/1989-31/3/1991
  supplementary task, 1991-1992

- Phase III.0:
  1. investigation for Phases III & IV
  2. hydrogen applications demonstration projects, 1992-1993/94.
  3. operation of the demonstration projects + complementary studies, 1993 - about 97.

- Phase III:
  detailed engineering & specifications; planned to last 1-2 years.

- Phase IV:
  construction; planned to last 4-5 years.

Present Status of the Projects

For reasons of thermodynamic properties, availability of technology and end use, two different modes of vectorisation have been investigated namely liquid hydrogen LH_2 and methylcyclohexane (MCH) in order to have hydrogen in both forms, liquid and gaseous, available for the end use requirements. Weighting the advantages/disadvantages of the LH_2 vs MCH vector, it was decided to abandon the latter.

With that, the following main characteristics of the system for the reference case, i.e. the LH_2 vector, have been elaborated :

- hydropower   100   MW
- electrolysis (net)   74   %
- annuity (8% interest,
  15 yr pay back)   11,7   %
- load factor   95   %
- hydrogen delivered
  in Hamburg   74   MW = 614 Gwh/y
- hydrogen transmission
  efficiency   74   %
- total energy
  ransmission efficiency   45-60 %
- plant investment costs   415   Mio Ecu
- specific hydrogen
  energy costs   14,8 C_{ECU}/kWh

The diagram shows the concept / system of the EQHHPP (*fig. 8.1*).

The following contracts for the demonstration programme on the utilisation of hydrogen in five fields (Phase III.0-2), have been finalised and the work is in progress :
- public transport
- aviation propulsion
- steel fabrication
- cogeneration
- storage technology.

ISEI Activities 1992

The JRC-ISPRA in in charge of the coordination of the project. A part of the coordination activities exposes were presented at the following conferences/symposiums :
- 9th World Hydrogen Energy Conference, Paris, June 1992
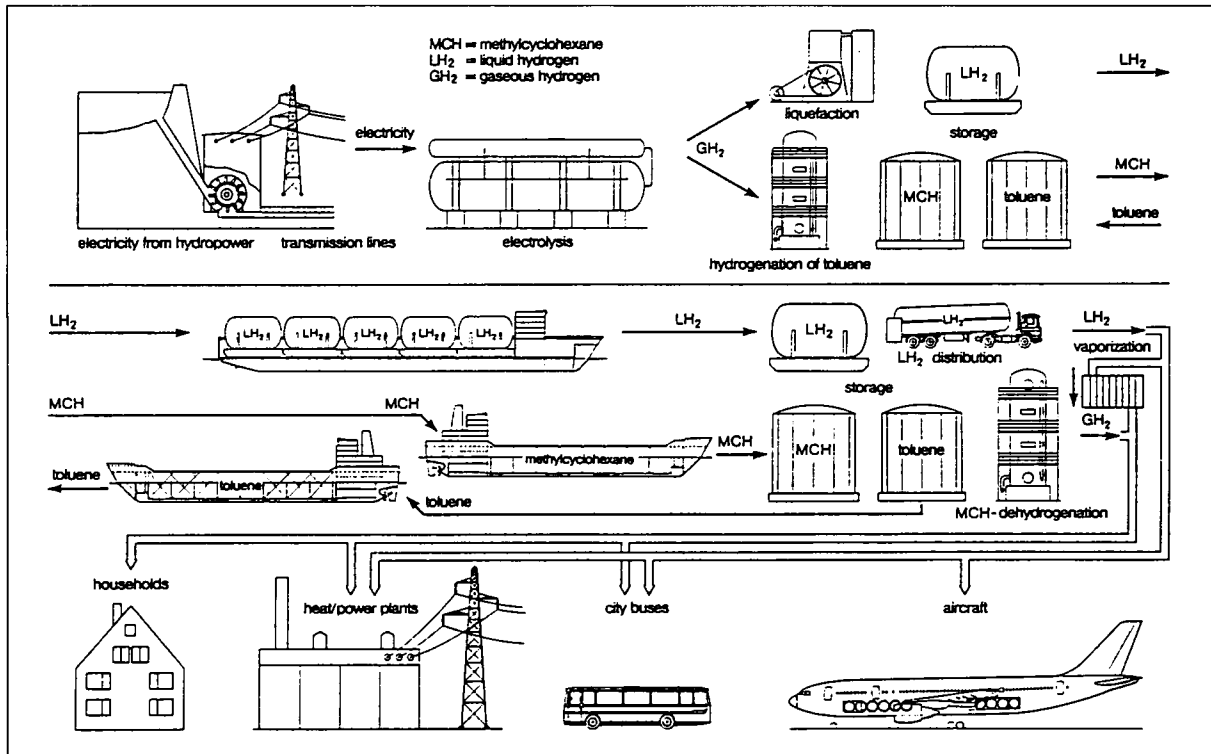- The Low Temperature Engineering and Cryogenics Conference, Southhampton UK, July 1992.

Fig.8.1. Concept / System of the EQHHPP

- 2nd World Renewable Energy Congress, Reading - UK, September 1992.

The following contracts on the operation of the components contracted under Phase II.0-2 have been finalised (Phase III.0-3)
- public transport
- aviation propulsion
- steel fabrication
- cogeneration
- storage technology

In addition the following new contracts (Phase III.0-2/3):

- prototype of a fuel cell boat for inland navigation
- LH_2 fuelled cogeneration unit with fuel cells

and the following study contracts have been finalised (Phase III.0-3):

- study on Shannon (Ireland) as an European Centre for the reception of Clean Energy
- improvement of hydrogen liquefaction / vaporisation
- environmental neutral fuel production road transportation concept (methanol)
- operational management system for hydrogen buses
- transatlantic power beaming with a satellite system.

9 LARGE INSTALLATIONS AND SERVICES

Corporate Informatics Services

Distributed Informatics & Communication Services

CAE Laboratory

TELEMAC Laboratory

TELSA Laboratory

General Design Office

ESTI

9 LARGE INSTALLATIONS AND SERVICES

CORPORATE INFORMATICS SERVICES

The JRC central informatics services which are operated at Ispra by the ISEI Institute on behalf of the other Institutes and Administration, have been the subject of a substantial revision. Such a revision, based on guidelines produced by both users and service providers in the course of the 'JRC Informatics 2000' planning exercise, has affected all aspects of the service including the associated staffing and budgetary resources.

- The targeted staffing level has been achieved through the reorientation of a sizable number of experts (approximately 25% of total) to new activities and in agreement with the involved persons.
  This reduction has been obtained through the progressive removal of the support to the scientific users of the mainframe and an enhanced automation of the administrative procedures. In particular, the 'shift' organisation of the production work around the mainframe computer has been abolished.

- As regards running expenditures, the cost containment goal has been achieved through the removal of non essential hard/software components which allowed 12% savings in the course of 1992.

More substantial savings, in the order of 70%, will be achieved in '93 and beyond, when the contractual arrangements for the new configuration of the administrative server will enter into force.

The new computer system is the result of a public procurement exercise addressed to more than 40 vendors of hardware, software and support services. The selected configuration consists of a downsized version of the present installation. Both the processing and storage capacity are reduced by a factor 50%, approximately.

- As a fallout of the call for tender exercise, offers for the provision of professional services were obtained from various service companies. Competence bound to the nature of specific software products installed at our premises and services of more general nature which are required for the migration/modernisation of sectorial administrative applications are made available at advantageous commercial conditions. Institutes and administrative Units willing to address analysis, consulting, programming projects for their own purposes can make reference to those suppliers.

- The final capacity of the system devoted exclusively to administrative/management tasks is illustrated by the following features: 1*22 Mips CPU, 128 Mby first level memory, 60 Gby disk storage, 1.2 Tby mass storage, 36 Mbps channel connection to the optics fibre network.
  The present printer peripheral emits chloroflourocarbons (CFCs) which are identified as being a cause of damage to the ozone layer. It will be replaced by a new printer featuring no depletion potential.

This change reflects the strategic guideline that forced a clear separation between scientific and administrative informatics.

- The porting of all scientific applications on Institutes' platforms was completed according to plans end June 1992.
  This migration process affected more than 200 scientific users, 35 major application codes, 16 data bases and an indeterminate number of files and programmes of sectorial and disciplinary interest.

Despite the remarkable dimension of the move, it can be reported that, the migration has taken place seamlessly as regards the scientific productivity and the integrity of data and codes. Apart from some large engineering codes which required special measures, the target systems on which the scientific applications were ported, are Unix servers and workstations already installed for scientific purposes at the Institutes' premises. This implies that the migration process has not required sizable investments.

The new administrative server runs data bases and procedures for the JRC budgetary and financial exercise, the management of staff, the global and individual rights and indemnities, the health insurance, the assets and the inventory.

It serves a population of approximately 230 managers and administrators from the JRC Institutes and headquarters in Brussels with a continuous online service and overnight checking, backup and reporting procedures. It interworks with systems installed at the different JRC sites across the international data communication networks and has liaisons with other central systems of the Commission in Luxembourg.

- As regards the major SIBECA/SYSCCR budgetary/financial application, a new organisational structure has been created in order to deal with the inherent complexity of the project. Issues to be addressed are: the responsibility of the long term evolution, the details of the work packages and their priorities, the development initiatives and their follow up, the impact on the organisation and work practices, end-users satisfaction.

- Two new bodies are now operational: Comité Exécutif Sibeca (CES) and Forum des Utilisateurs Sibeca (FUS).

  According to our financial regulations, Sibeca is a joint enterprise between the JRC, DGXIX (Accountant Authority), DGXX (Financial Controller Authority). Therefore CES has memberships from those constituencies. Its remit is to steer the Sibeca project, define plans and priorities, interpret regulations and decide actions to be undertaken by the development and support team.

  FUS is the body of end-user representatives where requirements can be collected from Administrative and Institutes units and the adequate feedback in terms of users' satisfaction can be originated.

The service provider has contributed to this major re-organisational effort with proposals as regards the analysis, software engineering, development, testing, maintenance, documentation and education/training initiatives.

- The SIBECA/SYSCCR support and development team has channelled its interventions on the corrective maintenance of the system as required by the change in financial regulations and the decentralisation of some administrative practices to Institutes.

  In addition, some modules affected by major functional enhancements, have been totally redesigned. This is also part of a long term plan that sees the product migrate towards a full NATURAL 2 programming and production environment, which is considered an essential step for the final adaptation of the system to platforms in conformity with the open systems architecture.

In the framework of the overall modernisation of administrative information systems, an inventory has been produced of programmes and utilities mainly based on old Cobol-DL1/IMS codes, which are in use and require urgent interventions in terms of corrective maintenance and/or new developments. This survey highlights the major problems in the exploitation and operation of the current systems and makes proposals for remedies. Our administrative systems have developed at different pace and on different platforms than companion systems in use at the Commission. This is due to the special mission and organisation of the JRC that stems from the 'direct' R/D and operational responsibilities of its Institutes.

On the other hand, the recent re-organisation and decentralisation of the informatics services of the Commission has added a new dimension to the integration problem.

- Applications such as Sibeca, the inventory, the staff/indemnities and the health insurance are re-considered in the light of a renewed collaboration with the development teams of the corresponding SINCOM, SYSBIEN, SYSPER/PAIE and ASSMAL systems of the Commission.

Proposals have also been produced for the modernisation of those applications that deal with the management and accounting of the infrastructure of the Ispra site.

- The new applications should be based on a Geographical Information System representing the Ispra campus, its buildings, roads and service networks such as water, electricity, telecommunications, heating and cooling with associated relevant cost/performance indicators.

  This system helps in the operation of the site, and, on the other hand, is instrumental to the monitoring and evaluation of the envisaged ECOCENTER initiative (i.e. the project that sees the JRC-Ispra site transform itself into a model example of an economic and environmentally friendly centre).

Some development efforts were devoted to the support of an effective planning and appraisal cycle, according to reflections activated by the JRC top management.

- Prototype informatics tools have been introduced for the integrated production of 'workschedules' that constitute the fundamental documents on which the JCR scientific and financial exercise is constructed. This development needs to be complemented by project management and evaluation techniques to apply in the course of the execution of activities.

Service initiatives to be undertaken in 1993 have been proposed in the framework of a new customer/contrac-

LARGE INSTALLATIONS AND SERVICES

tor relationship that sees the JRC Administration acting as our sole client.

- As a result of the negotiation, some positive steps have been defined for the unresolved problems mentioned above.

  Moreover, a number of projects have been identi-
  fied in the area of office automation and tools for management which are expected to improve the overall quality and performance of the services. Special attention will be devoted to the 'front-office' of all administrative Units. The front-office is expected to deal with new customer requirements and generate information for demanding managerial needs.

DISTRIBUTED INFORMATICS & COMMUNICATIONS SERVICES

During 1992, the Informatics Division was restructured, the result of this being to produce units that are more customer focused, as suggested by the "JRC Informatics 2000" report of 1991. The Distributed Informatics and Communications Services unit has the whole of the JRC Informatics community as its customer, providing services that are predominantly network, or communications oriented. The only exception to this being the Computer Aided Design service that is operated for a well defined, and limited set of users.

This year has been an attempt to implement the services that were negotiated with the customer Institutes, many of which were a continuation of previous services, but with an emphasis on visibility of functionality and transparency in implementation. The philosophy of "JRC Informatics 2000" is being implemented, and an explicit effort being made to improve the level of dialogue between the service providers and our customers. All staff have followed courses on project management, and there is a commitment to introducing formal project management methods into the management of the services. A growing number of projects are already being managed in this way.

The negotiation process that took place in 1991 defined a set of services that are separately financed and controlled. The services provided by the Distributed Informatics and Communications Services unit are grouped around the following principal themes:

JRC Inter-Site Network

The speed and reliability of inter-site communications is being reinforced, including the connection to European R/D networks at 64Kbps for each JRC site. This has required the purchase and installation at each site of X.25 switching nodes that are able to accept these high speed connections, and link them into the local site networks. Even before all of the 64Kbps lines are in place, plans are being made for future high speed connections that will provide even greater bandwidth and additional functionality. A pilot project is also being considered, that would interconnect the JRC sites for data communications using a satellite channel at 2Mb.

Ispra Network

The use of the FDDI high speed network has been consolidated, with 10 additional buildings being con-

nected to the backbone. Some preliminary experiences have been made with network management tools in order to better understand the behaviour of the campus network. Substantial efforts are being made to improve the throughput and reliability of the network gateways to the external world, including access to the worldwide Internet for Telnet and File Transfer services. There has been an enormous growth in the number of requests for this type of service from within the Ispra site. In addition, a single line at 64Kbps has been installed in order to replace several 9.6Kbps lines as our connection to ITAPAC.

Distributed Systems Management

1992 has seen the launch of this service, which has made significant progress in the second half of the year. Products have been identified and implemented that allow a JRC-wide file service, when installed on each Unix server. Efforts are being made to standardise the configuration of the different systems in use, so that the problem of managing the systems is simplified. An archive of public domain software has been created in which several products are already available in versions that will run on different hardware platforms and configurations.

Electronic Mail

All Ispra users now have access to both SMTP and X.400 electronic mail services, inside and outside of the Ispra site. This ensures total connectivity between the different mail systems used in Ispra. In addition, an online directory service has been implemented that can be accessed by any user from any system, either by a simple telnet connection, or by using an advanced client/server application. The directory is updated automatically on a weekly basis from different databases and mail lists.

Office Automation

Although remaining with the same supplier for Office systems, a move towards Unix based systems as workstations has been made. An analysis has been made of the principle market offerings in the areas of PC Networking, and E-Mail products for PCs. The objective is to propose some of these products as common solutions, for which support will be given in 1993. The

main aim is to improve the level of intercommunication between the different informatics platforms that are in use in Ispra. In the same vein, the standards ODA (Office Document Architecture) and RTF (Rich Text Format) are being used in order to exchange formatted documents between different hardware platforms.

Computer Aided Design

The number of users remains constant for this service which is based on the used of the Medusa product. A plan has been produced that will migrate the existing VMS proprietary system to a Unix based solution in which each user will have an intelligent workstation. The first steps in this migration have been taken with the purchase of the first Unix server, and five workstations.

Conclusion

The Distributed Informatics and Communications Services unit is obviously involved in activities related to development of new services, analysis of existing services, analysis of market trends and analysis of

customer requirements. In some cases this work is performed by internal staff in collaboration with university students performing projects as dissertation of thesis work. These activities were centred around the areas of Electronic Data Interchange (EDI) and transmission of electronic forms, and automatic configuration of PCs and workstations.

In collaboration with the other Institutes, a large Call for Tender exercise was carried out, that has resulted in the establishment of new Framework Contracts with a set of suppliers, that should cover the general Informatics requirements of the Ispra site for at least the next two years. The administrative framework has been put in place that will allow easy use of these contracts by potential buyers.

Finally, the negotiation of the services for 1993 has been successfully carried out, the second exercise of this type. Profit was made from the experiences of 1991, and the process has resulted in the definition of a smaller set of services with increased resources for them in order to guarantee that they will provide an improved quality of service in 1993.

CAE LABORATORY

The CAE (Computer Aided Engineering) Laboratory of the Conceptual Studies Sector, in the Industry Environment Unit, is fully integrated with the activities of the TELEMAC and TESLA Laboratories, providing the necessary support. Moreover to perform structural analysis by means of advanced Finite Elements Methodologies (FEM), the CAE Laboratory is equipped with appropriate tools for Computer Simulation and Animation in the fields of Teleoperation and Transient Loading Conditions.

Computer Simulation and Animation, for determining and evaluating the behaviour of the structural components in Dynamic Conditions, are performed by means of an integrated system of various packages, based on the MEDUSA and CATIA CAD subsystems and including visual simulation modules (KISMET and ISPRA-Simulator, a new 3D simulation package under development at JRC, which will include dynamic simulation, collision detection and avoidance, etc.) together with codes:

- ABAQUS for static and dynamic, thermal, mechanical and instability analysis (linear and nonlinear domains) of structures models generated by CAD. 2D and 3D finite elements computational Methodologies including computer graphics Techniques are used;

- ADAMS (Automatic Dynamic Analysis of Mechanical Systems) Computer Simulation programme for rigid bodies kinematic and Dynamic Analysis.

- CARIDDI, SCILLA and TRIFOU for 3D electromagnetic computations of eddy current and electromagnetic forces, including coupled magneto-mechanical effects.

Different interface tools for CAD modelling (CATIA-PATRAN and MEDUSA - PATRAN), finite elements input/output transfer and animated visualisation of the results are included.

The informatics hardware equipments used in the CAE Laboratory include the following main components:

- Two Workstations specially designed for CAD - MEDUSA use, connected with VAX - 11 / 8530 and with CAE System of NET Team, at GARCHING (MUNICH) by the ITAPAC network;

- A Workstation IBM RISC / 6000 MOD. 53H used for CAD-CAE activities;

- A graphic standalone Workstation CDC-CYBER 910B-731 for Simulation in the field of Teleoperation, connected with video-recorder to animate the results on video-tape;

- Two graphic standalone Workstations CDC-CYBER 910B-447 and 910 B-470 for structural analysis including results visualisation. The latter (910B-470) Workstation is also connected with video-recorder to animate the results on video-tape in the field of Transient Loading conditions;

- Two Tektronix colour displays;

- Various PCs.

All the above Workstations CYBER, IBM, Tektronix and the PCs, are connected with Ethernet Network.

The CAE System of the Conceptual Studies Sector is continuously in a process of development and upgrading of the computational tools, in order to make available the most recent methodologies for a continuous valid and appropriate engineering support to the activities of TELEMAC and TESLA Laboratories.

TELEMAC LABORATORY

Objective of the Teleoperation Laboratory TELEMAC

The TELEMAC Laboratory, belonging to the Conceptual Studies Sector of the Industry Environment Unit is dedicated to the Design, Reliability Analysis and Testing of Remote Handling Equipments and Operations, and to the Validation of numerical simulation Results by Experiments on Mockups. The main current activities in the frame of the JRC Fusion Technology and Safety Programme concern the studies on Remote Handling of the internal components of Fusion Reactors.

Particular consideration is devoted to Safety Related Problems, such as Collision Avoidance, Path Finding, Impact Analysis, Remote Handling Control Workstation, Containment of Tritum and Activated Dusts. In the meantime, the Reliability of Remote Handling systems and Robotics, including both Software and Hardware Reliability aspects, are investigated. The TELEMAC studies contribute in such a way to assess the Safe Maintainability and Operability of the future Fusion Reactors.

Ways and Means

TELEMAC is based on a dual approach to Teleoperation and Robotics problems: Computer simulation. Experimental validation and Reliability Studies. The activities are focused on:

- Advanced Computer Simulation System.
- Facilities for Validation tests on mockups (see *fig. 9.1*).
- Reliability Analysis of the Remote Handling Equipments and of their Control Systems.

An integrated Advanced Computer Simulation System supporting the design of remote handling equipments for the assembly and maintenance of a nuclear fusion plant has been developed. The support provided by the system is based on simulation techniques: kinematic, dynamic and visual simulation. The system accepts design models of remote handling equipments and environment created using CAD system, and supports the assembly of the robot.

The purpose of Experimental Facilities is to validate the results of the simulation activity on reduced scale mockups of the whole Remote Handling Systems. In order to perform this activity, a large gantry robot, the

ROBERTINO facility, was installed above the 1/3 scale mockup of a sector of the NET/ITER fusion reactor. This scale was chosen as a scale big enough to give, at an acceptable cost, significant indications of the behaviour of the full scale systems. This Facility is now used to verify the NET/ITER concept for the top loading of the First Wall and Shielding Modules. It is conceived in a flexible way to be able to verify any possible scheme for the assembly and maintenance of the future Fusion Reactors.

ROBERTINO has four movements axes: X, Y, Z and a rotating head. For each axis there is a corresponding joystick for manual control. In addition, there is an automatic mode which can perform movements either by using parameters sent from a PC, or by learning and repeating the "taught" profile. The mechanical data are the following:
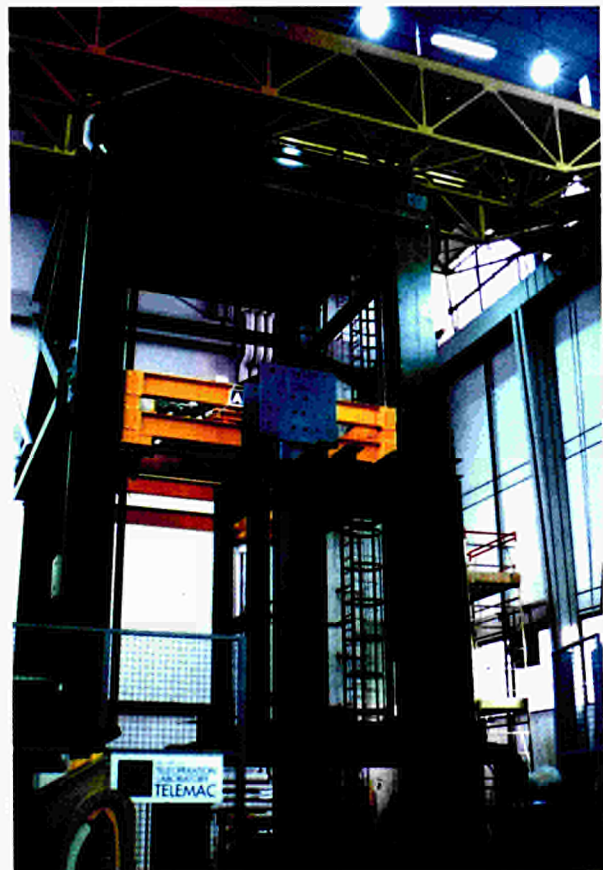
Fig. 9.1. TELEMAC Laboratory - Facility for Validation Tests

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- axis travel lengths: 3000 mm(x), 2200 mm(y), 6500 mm(z);
- rotation axis travel: unlimited
- payload: 5000 kg;
- maximum error in the all workspace: 1 mm
- repeatability: 0,2 mm

On the computer simulator installed on a CDC Cyber workstation, a file is produced following the step size required by the user. The workstation is located in a different building and communication is send to the control room via LAN. Translated into the appropriate format the commands are then sent by a serial link to the control cabinet of the robot.

The mockups of the vessel and of the in-vessel components were designed in the most flexible way, in order to comply with possible changes in the design of the reactor. The vessel sector mockup is installed on a trolley that can be moved under the gantry robot or taken away from it for maintenance and improvement. An upper trolley, with a blanket storage rack, is installed at the ground level.

TESLA LABORATORY

Objectives of the TESLA LABORATORY

The TESLA LABORATORY, belonging to the Conceptual Studies Sector of the Industry Environment Unit, is dedicated to the Modelling, Analysis, Validation & Design in Transient Electromagnetic & Thermomechanics, with the objective of Structural Integrity Assessment in Transient Conditions during Accidental Events. The main current activity in the frame of the JRC Fusion Technology and Safety Programme concerns the Task delivered by the NET Team for the evaluation of the effect of the electromagnetic forces induced in Tokamak-type in-vessel components during transient disruptive instabilities. In that context, the following activities have been brought to maturity and are available for successive actions:

- Completion of the modelling of coupled magneto-mechanical Systems with original numerical methods and an integrated CAD/CAE System.
- Extension of the analysis to the structural integrity assessment and design optimisation in transient conditions during accidental events;
- Development of the combined approach to the validation of recently implemented computational methodologies: numerical cross-examinations and experimental clean measurements. Moreover the available CAD / CAE techniques are proposed to stimulate any industrial products growth.

Ways and Means

The numerical simulation are based on 3D transient electromagnetic codes (CARIDDI, SCILLA, TRIFOU) combined with nonlinear stress analysis programmes (ABAQUS, ADINA). Different interface tools for CAD modelling (CATIA, MEDUSA), finite element pre and post-processing (PATRAN, TRINACRIA) and animated visualisation of the results (Computer Graphics) are included.

The purpose of the combined Validation performance is presently focussed on the ITER design issue of structural integrity assessment of blanket segments. Following the development of computational methodologies in coupled magneto-mechanics, an experimental test-rig, called ELBA (Electromagnetic Basic Experiment) and reproducing transient conditions for the simulation of reference plasma disruption scenarios has been installed (see fig. 9.2). The instrumentation will include a laser source, a pin-hole, an optical sensor of the laser beam signal, a specimen attaching device, and a complex data base acquisition system. The first experiments will consider copper frames and plates of different dimensions. This facility will be used also to investigate on the time-dependent measurements and precision management in a magnetic environment.

An impact onto third party work actions could come from the need to improve the quality management of the combined numerical/experimental validation approach for the conception and innovation of industrial products.
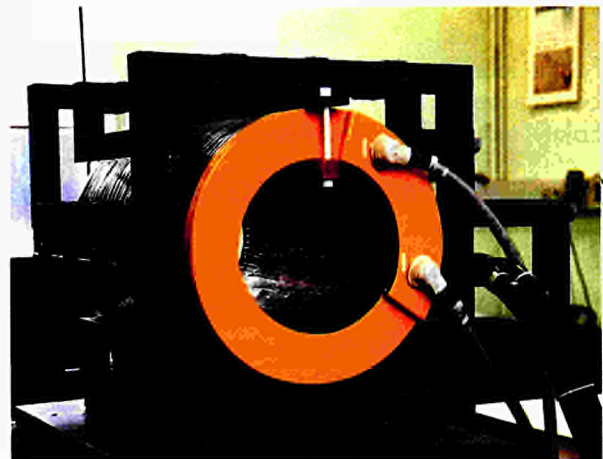
Fig. 9.2. ELBA Experimental Facility at the TESLA Laboratory

GENERAL DESIGN OFFICE

The Institute includes one sector General Design Office (BEG), the main task of which is to carry out drawings, projects, posters, etc. for the laboratories of the Centre.

BEG is also equipped to execute calculations and solve problems of mechanical character (stress analysis) and thermodynamics in complex devices.

There are 3 distinct activities running in this sector:

- Construction design (design and construction drawings for experimental facilities).
- Finite elements analysis (complex structural and thermomechanical modelling also for Third Party Programmes).
- Advanced 2D & 3D presentation graphics.

All these activities are carried out using the most modern CAD/CAE tools like: Medusa CAD package, Patran CAD package Abaqus and P-Thermal Fea codes etc. For the first two activities listed above, there is a close collaboration with the Conceptual Design sector, which performs similar activities in the frame of the Fusion Programme.

For the laboratory of the Centre the work of BEG has been centred principally on projects related to Reactor Safety, Industrial Risk and Alternative Energy.

The main projects in which BEG has been involved during 1992 are:

- FIRES (Industrial Risk): Design work for containers, piping system, pumps and special components.
- FARO (Reactor Safety): Thermomechanical calculations for the UO_2 - release system: design of release valve and auxiliary tank for melting inox.

- LTDF (Dynamical Tests): design of components, load system and specimens.
- Fusion Technology: thermal and mechanical computation related to LOCA (Loss Of Coolant Accident) using the finite elements method.

BEG has also carried out structural analysis studies for Third Parties (Agusta) concerning a planetary crown for dynamic transmission.

Furthermore, the activities of BEG include engineering consultancy on specific problems or topics as thermodynamics, cryogenics, and in the electromechanical field.

Training of students on CAD techniques is also regularly undertaken at BEG.

The demand for engineering services has always been very high. In particular, concerning the above mentioned activities, the situation can be summarised as follows:

Construction design: even if work is often given to external firms, the private support can not substitute the services offered by the BEG, first of all because of the continuous contact between committing laboratories and design office.

Finite Elements Analysis: there is an increasing demand for numerical support, both from laboratories and programmes.

Advanced 2D and 3D presentation graphics: demand for this activity is high and is expected to grow.

ESTI

The Facilities of ESTI (European Solar Test Installation) are used to develop methods and equipment for tests on photovoltaic solar cells, modules and systems.
These tests are executed mainly on request by industry or are undertaken in collaboration with other laboratories.

Output in 1992:
- Calibration of 20 reference cells and modules by indoor and outdoor methods.

- Qualification tests according to Spec.503 for 14 types of photovoltaic modules.
- Electrical Performance tests on more than 700 devices.
- Qualificationstests according to ESTI's new Spec. 701 for 2 types of amorphous thin-film modules.

New Facilities
- Computer controlled light-soaking test-chamber for execution of qualification tests of thin-film modules.

10 ANNEXES

List of Publications

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Glossary of Acronysm and Abbreviations

10 ANNEXES

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Industrial Hazards

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GLOSSARY OF ACRONYMS AND ABBREVIATIONS

ADABAS	Data Base Management System by the company SAG
AE	Acoustic Emission
AFWS	Auxiliary Feed Water System
AL	Attachment Locking
AORS	Abnormal Occurrences Reporting System
APSYS	Airospatiale Protection Systhemes
ARIPAR	Alti Rischi Industriali e Portuali nell'Area di Ravenna
ATC	Air Traffic Control
BEG	Bureau d'Etudes Générales (General Design Office)
BHD	Blanket Handling Device
BOD5	Biochemical Oxygen Demand
BOSS	Backtracking and Overviewing for Structural Safety
BP	British Petroleum
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CARES	Computer Aided Review Station
CAVIS	Computer Aided Video Surveillance
CD	Compact Disk
CDCIR	Community Documentation Centre on Industrial Risk
CEA	Commissariat à l'Energy Atomique
CEC	Commission of the European Communities
CEDB	Component Event Data Bank
CEO	Centre for Earth Observation
CFC	Chloroflourocarbon
CISE	CISE SpA-Tecnologie Innovative
COD	Chemical Oxygen Demand
COSINE	EUREKA project on open systems standards
CPU	Central Processing Unit of a computer system
CSCEW	Computer-Supported Co-Evolutive Work
DAF	Anti-fraud Documentation Database
DAS	Data Acquisition System
DCI	Data Collection Instrument
DEEP	Database on Energy Efficiency Programs
DITE	Damage Investigation using Thermal Emission

DOE	Department of Energy
DSM	Demand Side Management
DSS	Decision Support Systems
DYLAM	Dynamic Logical Analytical Methodology
E-Mail	Electronic Mail
EAMA	Acoustic Emission for Aeronautical Materials
EB	Empirical Bayes
ECC-AIRS	European Co-ordination Centre for the mandatory Aircraft Incident Reporting Systems
ECOAUDIT	Ecoloogical Auditing
EdF	Eléctricité de France
EDF	Experiment Data Files
EDI	Electronic Data Interchange
EEA	European Environment Agency
EFTA	European Free Trade Agreeement
EI	Environment Institute
EIA	Environmental Impact Assessment
ELBA	Electromagnetic Basis Experimental Test-Rig
ENEA	Ente per le nuove Tecnologie, l' Energia e l'Ambiente - Roma -Italia
ENEL	ENEL SpA, the Italian Company for the generation transmission and distribution of electric energy
EO	Earth Observation
EQHHPP	The Euro-Quebec Hydro-Hydrogen Pilot Project
ERCOFTAC	European Research Community on Flow Turbulence and Combustion
ESA	European Space Agency
ESDA	Exploratory Sequential Data Analysis
ESPI	Electronic Speckle Pattern Interferometry
ESPRIT	European Strategic Programme for Research and Development in Information Technology
ESRIN	European Space Research Information
ESTI	European Solar Test Installation
FARO	Experimental Facility for Fuel Melting
FDDI	Fibre Distributed Data Interface
FIRES	Facility for Investigating Runaway Events Safety
FMECA	Failure Mode Effect and Criticality Analysis
FTA	Fault Tree Analysis

FWBSs	First-Wall Blanket Segments	LCP	Least Cost Planning
FWP	Framework Porgramme	LLW	Low Level Waste
GAs	Genetic Algorithms	LOCA	Loss Of Coolant Accident
Gby	gigabyte = 10^9 byte	LDTF	Large Dynamic Test Facility
GEDN	Global Environment Data Network	LVQ	Learning Vector Quantization
GENET	Genetic Algorithm for Alternative Generation	MAPO	Management of the Po River Basin
GENIUS	Global Environmental space Network Information and User System	MARS	Major Accidents Reporting System
		Mbps	Mega bit per second
GIS	Geographic Information Systems	Mby	Mega byte
GMMs	Genetically Modified Micro Organisms	MCDA	Multi-Criteria Decision Aid
GMOs	Genetically Modified Organisms	Mips	Million instruction per second
HCI	Human-Computer Interactions	MLP	Multilayer Perceptron
HEAT	Human Error Analytical Taxonomy	MLW	Medium Level Waste
HLW	High Level Waste	MMI	Man-Machine Interface
HSE	Health and Safety Executive (UK)	MPa	Mega Pascal
I.A.E.A	International Atomic Energy Agency	MVUE	Minimum Variance Unbiased Estimation
ICAO	International Civil Aviation Organisation	NET	Next European Torus
IEA	International Energy Agency	NET/ITER	Combined study of NET and ITER (see NET and ITER)
IFALPA	International Federation of Airline Pilots Association	NNE	Non -Nuclear Energies
INEL	Idaho National Engineering Laboratory	NNL	Neural Network Laboratory
INES	Integrated Environmental Studies	NPP	Nuclear Power Plant
IRS	Incident Reporting System	NPPDCS	Nuclear Power Plant Data Collection Scheme
IRSA	Institute for Remote Sensing Applications	NRSC	National Remote Sensing Centre Limited
IS	Intelligent Selections	NSF	US National Science Foundation agency
ISEI	Institute for Systems Engineering and Informatics	NUCLAAR	Nuclear Computerized Library for Assessing Reactor Reliability
ISPESL	Istituto Superiore per la Prevenzione e la Sicurezza del Lavoro	ODA	Office Document Architecture
IT	Information Technology	OECD	Organization for Economic Cooperation and Development
ITAPAC	Italian public data network		
ITER	International Thermonuclear Experimental Reactor	OREDA	Offshore Reliability Data
		PID	Proportional Integral Differential
JET	Joint European Torus	PSA	Probabilistic Safety Assessment
JRC	Joint Research Centre	PV	Photovoltaic
KB	Knowledge Bases	RCM	Reliability Centered Maintenance
KBS	Knowledge Based System	RITO	DSS for IndustrialWaste Management (Rifiuti Tossici)
KECU	Kilo ECU		
KfK	Kernforschungszentrum Karlsruhe - Germany	RSO	Ricerca Sistemi Organisativi
		RTF	Rich Text Format
KISMET	Kinematic Simulation, Monitoring and Off-Line Programming Environment for Telerobotic	SAVE	Special Action Programme for Vigorous Energy Efficiency
LAM	Low Activation Material	SEAFP	Safety and Environmental Assessment of Fusion Power
LBL	Lawrence Berkeley Laboratory		

SECT	Significant- Event Compilation Tree	TEAM	Testing Electromagnetic Analysis Methods
SESAME	Databank for R&D, demonstration and technology projects	TELEMAC	Teleoperation Laboratory
SGML	Standard graphic manipulation language	TESLA	Structural Transients Simulation Laboratory in Electromagnetics and Thermomechanics
SGTR	Steam Generator Tube Rupture	THERMIE	European Technologies for Energy Management
SMTP	Simple Mail Transfer Protocol		
SO	Statistical Office	THERP	Technique for Human Error Probability
SO-CNLS	Connection-less data transport standard	TM	Topological Maps
SRG	System Response Generator	TPW	Third Party Work
STARS	Software Tools for the Analysis of Reliability and Safety	TREES	Tropical ecosystem environment observations by satellites
STEERING	SPAZIOSYSTEM TESLA Engineering	TRETA	Transient REsponse Thermal-hydraulic Analysis
STEP	Science and Technology for Environmental Protection		
STI	Safety Technology Institute	VMS	Operating system on mainframe computer
STU	European Statistical Territorial Units	W	Vaccum Vessel
TA	Technology Assessment	WE	Working Environment
Tby	Tera byte = 10^{12} byte	X25	Data Transmission Standard

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This report presents the achievements of the **Institute for Systems Engineering and Informatics (ISEI)** of the Joint Reasearch Centre (JRC) of the Commission of the European Communities (CEC) for 1992. The JRC is a European scientific and technical research centre established by the member states of the EC. Its four sites in Belgium(Geel), Germany (Karlsruhe), the Netherlands (Petten) and Italy (Ispra) house 8 Institutes, each with its own focus of expertise.

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