ISSN 1018-5593

ANNUAL·REPORT·94

Institute FOR Systems Engineering AND Informatics

JOINT RESEARCH CENTRE
EUROPEAN COMMISSION

Report
EUR 16286 EN

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EDITOR: I. GERBAULET

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Luxembourg: Office for Official Publications of the European Communities, 1995

ISBN 92-827-4273-3

Printed in Italy

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FOREWORD

The Annual Report 1994 of the Institute for Systems Engineering and Informatics is to be considered in conjunction with the Institute's Annual Reports of 1992 and 1993 and continues to be based on the formal perspective of the structure of the JRC's multi-annual programme 1992-1994. It is important to complement this perspective by considering the two most important assets of the Institute, staff and investments, which represent the source of all our activities.

STAFF

The trend towards reducing the number of permanent staff of the Institute, which was already established in previous years, continued in 1994: over the year the number of permanent staff was reduced from 215 to 195. The Institute's success in participating in the European Community Human Capital and Mobility Programme made it possible to compensate this reduction of permanent staff by a significant increase of non-permanent or "mobile" staff - grand-holders and visiting scientists. At the end of the year the mobile staff consisted of 70 scientists, in addition to some 30 students working on their thesis. This mobile scientific staff allowed the overall profile of staff expertise to be reshaped substantially, while the creativity of the younger researchers was particularly valuable in exploring new avenues to answer the challenge of research in modern society.

Along with the engagement of non-permanent staff a significant internal mobility was put into force in the Institute, mainly towards the end of the year in order to adapt the staff deployment to the needs of the new multi-annual programme 1995-1998. While the formal structure of the Institute was not changed, about 15% of staff members were re-deployed within the Institute.

A substantial training and education effort was undertaken during the year, especially to coordinate with this re-deployment of permanent staff. About 2% of the global working time was spent in training courses inside and outside the JRC (excluding participation in scientific conferences and seminars). While the figure is still lower than the ideal target, it does represent a significant step forward.

INVESTMENTS

The Institute was particularly well funded in 1994 in terms of operational credits, a situation which allowed the setting-up of new laboratories: the Optical Prophilometry and Stereophotogrammetry Laboratory, the Environmental and Urban Application Laboratory, and the Cockpit Resource Management and Air Traffic Control (CRM/ATC) Laboratory, as well as the completing of the Surveillance and Containment Laboratory (LaSCo) and the Parallel Computing and Image Processing Laboratory. These laboratories significantly strengthen the potential of the Institute in preparation for the competitive activities planned for the 1995-1998 programme.

ACTIVITIES

During 1994, which was the final year of a multi-annual programme, the output of the Institute was higher than in previous years, both in research results and publications.

The multi-annual programme 1995-98 has changed substantially compared to the 1992-94 programme and some activities which were pursued over recent years no longer feature the new programme. In particular the work on "Accident Prevention" (under the "Working Environment" heading) and on "Structural Diagnostic by Optical Techniques" (under the "Measurement and Testing" heading). However, by the end of 1994 significant orders for Third Party Work had been won in these domains, and the Institute is currently preparing proposals for co-operative Cost-Shared Actions; thus the existing technical know-how will continue to be exploited in the future.

Departures and arrivals of staff are also important events for the working community of the Institute. 1994 saw the departure of the Director, Mr R.W. Witty, who, after five years as Director of the Institute, left in October to take up an important post in UK industry. While this meant that he was not able to contribute to the editing of this Annual Report, the successful achievement of the activi-

ties described herein is testimony to his guiding hand over the last years.

Finally, we have to welcome the arrival during 1994 of the first staff members from the new Member States of the European Union: Austria, Finland and Sweden. As the boundaries of "our" Europe expand, we can foresee with increasing confidence, a successful future for the Institute for Systems Engineering and Informatics.

Giuseppe Volta
Acting Director

1 EXECUTIVE SUMMARY

1 EXECUTIVE SUMMARY

INTRODUCTION TO THE INSTITUTE

The Institute for Systems Engineering and Informatics (ISEI) is one of the eight Institutes which constitute the Joint Research Centre (JRC) of the European Commission. *(see Fig. 1.1).*

The mission of the Institute is "to be the European Communities central and independent centre of excellence in the field of "complex systems" engineering, focusing on the safety and standards aspects of pan-European human and environmental systems issues."

The Institute has two main tasks:
- the development and assessment of methods and tools that require the integration of various technologies and the manipulation of a large mass of information and;
- the provision of informatics services and expertise to other JRC Institutes.

The 1992-1994 JRC programme activities were as follows:
- Research and develop ment under the European Framework Program (1990-1994)
- Scientific and technical support to the Commis-sion policies
- Exploratory research
- Contractual work for third parties

ISEI's contribution to the Framework Programme is made through the following lines (specific programme):
- Work Environment
- Measuring and Testing
- Environment
- Nuclear Fission Safety
- Controlled Thermonuclear Fusion
- Human Capital and Mobility

The scientific-technical support to the Commission policies is organised according to the customer/contractor principle. Multiannual actions are covered by contracts with the interested Directorates General, calling for work assignment and resources accountability.

Exploratory research projects have the purpose of improving scientific vitality and potential, exploring suitable and promising avenues, testing new ideas or concepts on a small experimental scale and improving opportunities for visiting scientists and research fellows.

Contractual work for third parties is intended as a means for the JRC to valorise the results of its research and,

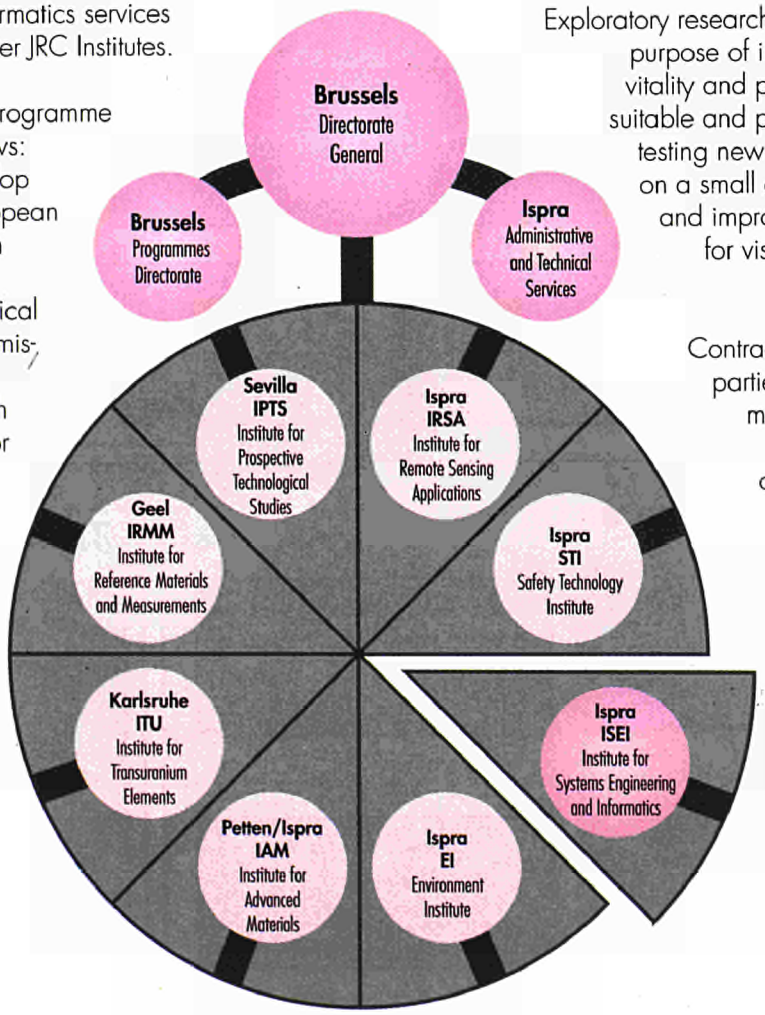

Fig. 1.1. The Institutes of the Joint Research Centre.

at the same time, to measure its competitiveness in the public and private market.

For the execution of programme activities, the Instituteis organised into Units *(Fig. 1.2.)*

The human resources made available on the average in 1994 amounted to 298 people and included the following categories:

- Authorised statutory staff, scientific-technical and administrative 205
- Young visiting researchers (grantholders), mainly chosen and financed in the framework of the HumanCapital and Mobility Programme 48
- Senior visiting scientists and staff seconded from organisations (detached experts) in the Member States, mainly financed with the envelope of statuary staff credits 6
- Visiting stagiaires, mainly students hosted in the laboratories for training and education 38

The 1994 average staff distribution among the various categories is shown in *Fig. 1.3.*

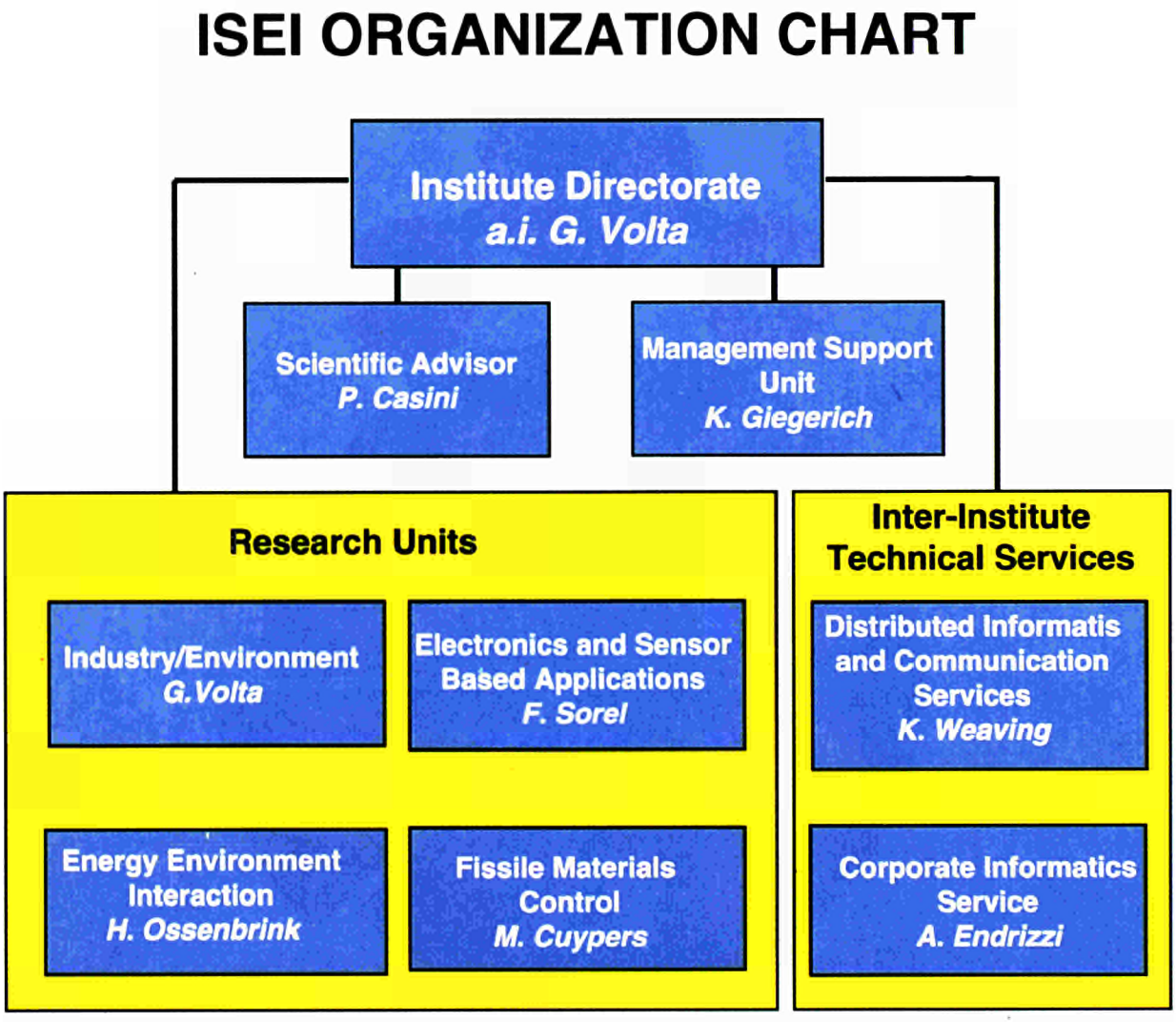

Fig. 1.2. Structure of the Institute for Systems Engineering and Informatics.

In 1994 the financial resources of ISEI amounted to 48 million ECUs, of which about 41% were allotted for Specific Programme Activities, 27% for support to the Commission Policies, 4% for Exploratory Research, 24% for Informatics Services and Support to other JRC Institutes and 4% for Third Party Work. *(see Fig. 1.4.)*

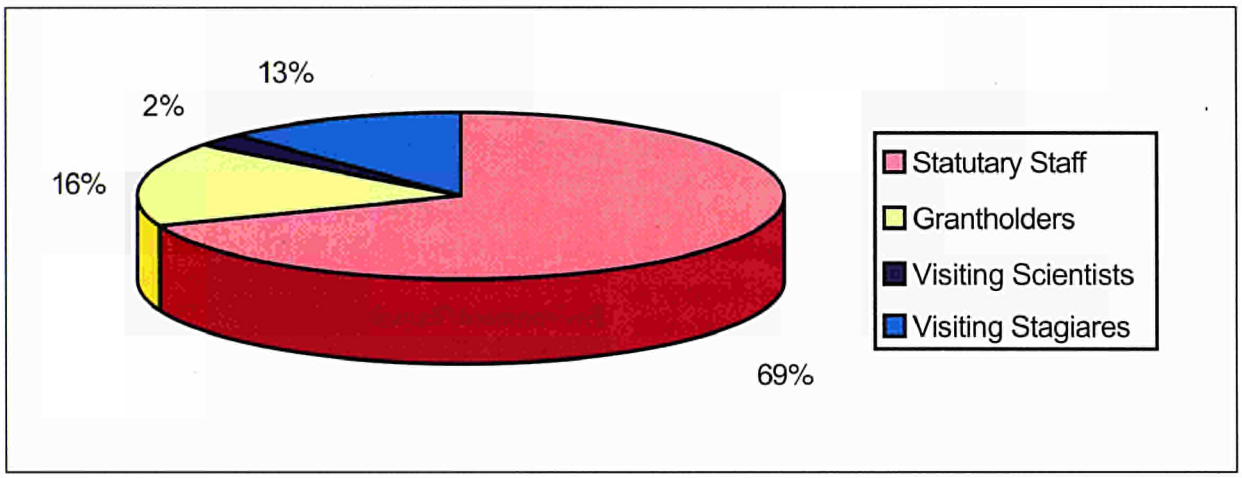

Fig. 1.3. ISEI Human Resources (Average 1994)

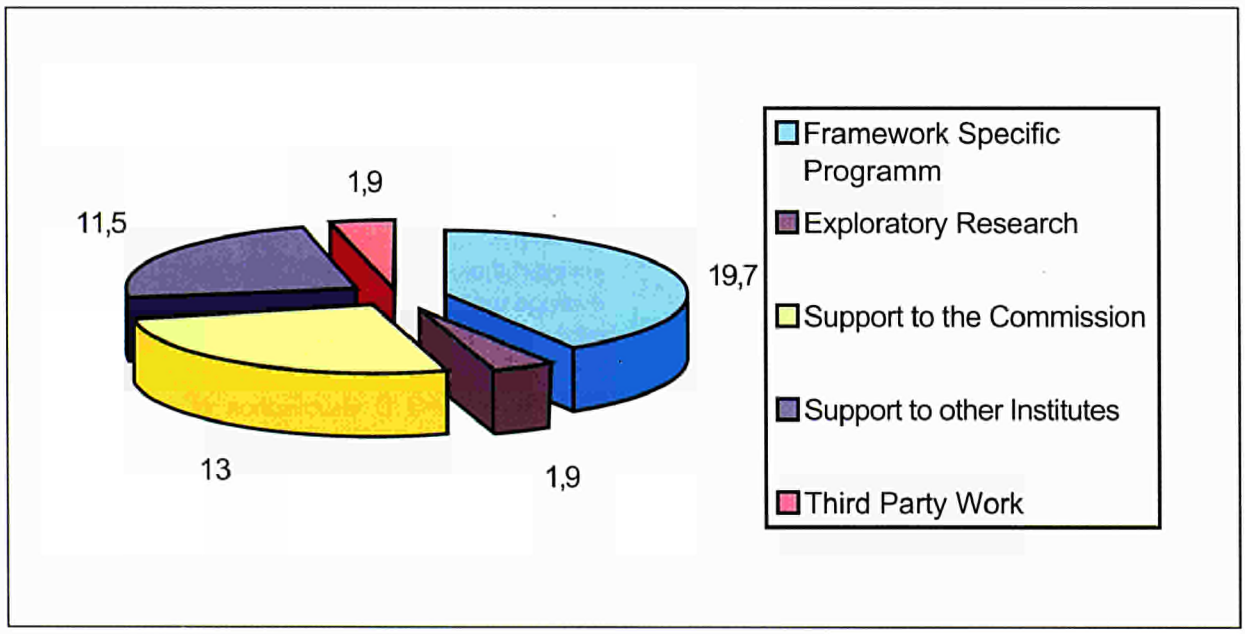

Fig. 1.4. ISEI Financial Resources in 1994 in Millions of ECU.

SUMMARY OF ACTIVITIES

The Institute for Systems Engineering and Informatics (ISEI) contributes to the specific research programmes on Working Environment, Measurement and Testing, Environment , Nuclear Fission Safety and Fusion. It carries out several activities in Support of the Community Policies and is engaged in Exploratory Research and in Third Party Work.

SPECIFIC PROGRAMME

Working Environment/Accident Prevention

Cognitive ergonomics (analysis of reasoning and decision making processes in work places) were applied to air control for the study of complex working conditions. Field studies led to developing an operative model aimed at better designing interfaces and communications between operators and means of control. Safety at work studies were applied to airline-pilot interaction and resulted in a method for identifying the root causes of human error. A new cockpit resource management approach was designed for pilot training. Process statistical diagnostics were applied to the start-up/shut-down of industrial plants, which are typically complex, non-linear processes. This methodology will help developing tools for early fault diagnosis.

Measurement and Testing

In photovoltaic systems, pre-normative research resulted in a final check on the fast sampling flash radiometer, for special irradiance measurements of very short (1 ms) light pulses. A patent was requested. Emphasis was put on setting up a quality assurance system following the ISO 9003 standard, and on participating to the first phase of a world-wide calibration of reference solar cells, which would lead to a world photovoltaic reference scale recognised by national standard bodies. The technology gained on amorphous-silicon thin-film modules was used on the ECOCENTRE ELSA-facade. System identification for energy savings in buildings was continued.
A new, portable instrument called the Electronic Speckle Pattern Interferometer (ESPI), based on laser interferometry, was successfully tested to investigate the state of conservation of old Italian paintings. A procedure for mechanical characterisation of stone materials thanks to a multiple ESPI system has been displayed to industries with a view to marketing the system. A coherent radar system for surface profilometry (to be used as a high precision dimensional control of small industrial components) was also developed and successfully tested. Acoustic techniques are being developed, in collaboration with industry, for the quality control of glued joints.

Environment/Remote Sensing

ISEI contributed to the CEO (Centre for Earth Observation) project, where a survey of the present infrastructure in Europe and of the requirements of satellite data users has been launched. A workshop on European data networks and user information services was organised at the end of 1994, in collaboration with the European Space Agency.

A new release of original signal compression techniques, based on wavelet fast transforms and holographic simulation synthesis has been realised, implemented, demonstrated and tested on satellite images like NOAA, SPOT.

An analysis of 10 years of meteorological data has uncovered an unexpected 30 day oscillation in the earth average surface temperature. Possible effects of the lunar orbit on the earth weather are being investigated.

Techniques for 3 D visualisation of oceanographic modelling data have been developed. This has enabled highly effective analysis of processes in the Atlantic Ocean and the Adriatic Sea.

Environment/Industrial Hazards

A new set of software tools for the knowledge-based Systems for safety and reliability assessment - STARS v. 2- was started on the expertise gained from the first STARS project.

The TOMHID project, an overall knowledge-based methodology for hazard identification, ended in July 1994 providing a comprehensive framework to present a process plant as a socio-technical system. which includes technical, human and organisational aspects.

FORMENTOR, the real time knowledge based system for on-line decision support for operators of complex plants has entered its industrial development phase. The first industrial application started with TOTAL, France, at the beginning of 1994, which will probably continue in 1995 with a view to developing full-scale industrial application.

New decision support models for environmental management were developed. They are being applied for pollution control in urban areas and water resources management. An accident database based on worldwide public sources was added to the software TRIM (Transportation Risk Management), Geographical Information Systems (GIS) and spatial analysis techniques in decision support systems for environmental management were applied to real case studies, e.g. management of water in Ireland and Italy. The Multi Criteria Decision Aid (MCDA) technique coupled with GIS and generic algorithms was applied to generating alternatives in site facilities for toxic waste treatment.

There is a need for theoretically sound but practical methods and tools for the successful deployment of highly dependable systems with embedded computer-based components. ISEI started research related to methods for the development and assessment of Safety Critical Computer Systems.

Fission Reactor Safety

This set of tools, based on the STARS (Software Tools for the Analysis of Reliability and Safety) structure and regularly updated PSA (Probabilistic Safety Assessment) concept, was successfully applied to the analysis of the auxiliary feedwater system of the Grohnde power plant. A collaboration with TÜV (Technischer Überwachungs Verein) Süd-West was undertaken, to validate the STARS fault tree analyser. Investigations were made to better evaluate operator error probability in accident sequences. Advanced models for knowledge extraction from reliability data bases and estimation of reliability parameters were further developed.
The development of integrated software tools for the safety management of nuclear power plants was pursued.

The pressurised thermal shock experimental activity, in the context of nuclear fission safety, has been concluded. A review of plant ageing results obtained during the 3rd Framework Programme is being published.

Fission Safeguards

A remotely guided vehicle was able to detect unforeseen obstacles thanks to ultrasonic data and a neural network. Techniques for remote monitoring dealing with storage, encryption and transmission of safeguards data were investigated

In the LaSCo (Laboratory for Surveillance and Containment), attempts were made to integrate video surveillance with other sensors for safeguarding nuclear material storage areas.

First experiments were made in the TAME (Tank Measurement lab) to investigate precision measurements on liquid content.

Controlled Thermonuclear Fusion

Computer simulation and experimental validation of remote handling procedures went on in the ROBERTINO facility, to help design the blanket handling device for ITER (International Thermonuclear Experimental Reactor)). Post-accidental thermal transient analyses for design guidelines and assessment were carried out for ITER and for SEAFP (Safety and Environmental Assessment of Fusion Power): The dynamic structural integrity of ITER's vacuum vessel and of SEAFT's blanket structures in case of a plasma disruption is being assessed.

Human Capital and Mobility

The Institute participated in the following Human Capital and Mobility Networks:
- SMART- Semi-Autonomous Monitoring and Robotics Technologies
- Design of Robust Human Machine Interaction
- Human Factors in Complex Real Systems
- OLOS - A Holistic Approach to the Dependability Analysis and Evaluation of Control Systems Involving Hardware, Software and Human Resources

- Diagnostics and Reliability of Composite Materials and Structures for Advanced Transportation Applications
- Reliability of Metal Matrix Composites
- Interactive Image Processing and Synthesis on Innovative Computer Architectures

EXPLORATORY RESEARCH

Exploratory activities dealt with, a.o. advanced neural network techniques, the analysis of local optical correlation decay, numerical stereophotogrammetry, advance visualisation of dynamic data, safety study of high-velocity transport in off-normal conditions and safety features improvement of energy storage in superconducting windings.

SUPPORT TO COMMUNITY POLICIES

Work continued on informatics systems for antifraud projects and on the computer-aided management of parliamentary petitions (Secretariat General).

Neural network tools were implemented for statistical applications (EUROSTAT).

A system, based on image processing, developed by the JRC for designing information verification of complex nuclear facilities was installed at the International Atomic Energy Agency (IAEA). Training courses were organised for IAEA inspectors on volume and mass determination, surveillance in tanks and sealing techniques. Video equipment for inspectors was tested (DG I).

Work on safety critical computer systems began with a collection of existing information, to prepare the Safecomp '95 conference and to draw up a workplan for 1995-1998. A 3D image synthesis software in the computer CONCERTO was completed for DG III.

The ISEI Laboratory for Containment and Surveillance was involved in a project on electronic identification of farm animals using implantable transponders (DG VI).

A pilot Co-ordination Centre for Aircraft Incident Reporting Systems (EEC-AIRS) is being completed and will be operational in 1995 (DG VII).

A Major Accident Hazards Bureau will be in charge of operating the Major Accident Reporting System, the Community documentation centre in Industrial Risk and the scientific/technical co-ordination of technical working groups, for drafting guidance notes on issues arising from the Seveso directives. Guidance notes for safety reports and safety management systems have significantly progressed. Guidelines for public information were published. Assistance work in biotechnology was pursued, and activities on environmental impact assessment in Member States are being compared (DG XI).

Valorisation activities included holographic compression techniques for image synthesis, ultra high sensitivity interferometric sensors and tagging/sealing applications (DG XIII).

Review stations of recorded surveillance images, based on a cyclic image buffer, were developed for computer assisted review. A system for identifying fuel element numbers using pattern recognition was designed (DG XVII/EURATOM Safeguards Directorate).

European demonstration project proposals in the areas of photovoltaics, heating, building, transport and industry sectors (THERMIE programme) were appraised. Assistance was extended to ALTENER and SAFE programme activities, in the area of a rational use of energy in buildings and industry (DG XVII).

INFORMATICS SERVICES

The Corporate Informatics Services continued along the 1993-1996 multiannual plan for the modernisation of the information systems in support of the administrative/managerial activities of the JRC. The main achievements in 1994 were the installation of advanced systems in various service Units: the geographical information system for the Ispra site facilities management, the integrated library system, the publications and contacts data bases for the public relations services. A major effort has also been devoted to the development of a new financial and accounting system in co-ordination with other Commission services.
The main achievements of the Distributed Informatics and Communication Services concerned the installation

and activation of a 64 Kbps connection of the Institute for Transuraniens in Karlsruhe to the German research network and the installation of the XNS software in Seville (Spain), allowing the Institute for Prospective Technological Studies to communicate with the rest of the JRC. Improvements in electronic mail systems were made and new software for office automation were tested.

OTHER PROJECTS

The Euro-Quebec Hydro-Hydrogen Pilot Project (HQHHPP)

In July 1994 the first of three hydrogen busses constructed by Hydrogen Systems, Belgium, has been presented to the Commission and the public. ISEI's activities continued in 1994 on contract supervision, i.e. technical supervision of ongoing works. Furthermore the technical annexes for the new Phase II.0-4 contracts were prepared.

The Ispra ECOCENTRE Projects

The project aims to demonstrate the application of available technologies for the modernisation of ageing premises of research centres under ecological and economical aspects. The international competition for the retrofitting of elderly buildings (the first building will be the Cafeteria) on the Ispra site has been evaluated and assigned. Photovoltaic technology in its application to a building facade was demonstrated as an example for future renewable energy technologies.

SHARED COST ACTIONS

In 1994 four shared cost actions were approved with the participation of ISEI. Two in the framework of Safety and Reliability: "Enhancing technological awareness and technology transfer in the area of advanced intelligent computer system for the assessment of the remaining life, reliability and safety of power plant components" and "Small punch test method assessment for the determination of the residual creep life of service exposed components". Two in the framework of Renewable Energies: "Photovoltaic integration in developing countries", and "ElectricHome - assessment of all non-electrified houses in southern Europe and development of standard systems for accelerated large-scale deployment of renewable energies".

WORK FOR THIRD PARTIES

Calibration of photovoltaic cells and quality testing of modules still are regular sources of income. Other activities included environmental management studies for regional administrations, software for industrial plant supervision and for safety and reliability assessment and management as well as root cause analysis of human error studies and sealing systems fabrication for nuclear safeguards.

TEST FACILITIES

The test facilities ESTI, European Solar Test Installation, the TELEMAC Laboratory and LaSCo, Laboratory for Containment and Surveillance have been improved and/or completed.

2 SPECIFIC PROGRAMMES

Working Environment/Accident Prevention

Measurement and Testing

Environment/Remote Sensing

Environment/Industrial Hazards

Fission Reactor Safety

Fission Safeguards

Controlled Thermonuclear Fusion/ Fusion Technology and Safety

Human Capital and Mobility Networks

2 SPECIFIC PROGRAMMES

WORKING ENVIRONMENT/ACCIDENT PREVENTION

The activity in the Working Environment (WE) Programme has been focused on 3 main topics of research, namely:

- Cognitive Ergonomics and Organisational Factors, for the study of the human element by direct observation of the Working Environment.
- New Technologies and Safety at Work, for the evaluation of the interaction between Information Technology (IT) and human operators.
- Process Diagnostics, for early fault detection and the diagnosis of malfunctions of installations.

Cognitive Ergonomics and Organisational Factors

The research performed under Cognitive Ergonomics and Organisational Factors has been centred on experimental and field research in the Air Traffic Control (ATC) working environment. The research has been performed in concurrence with the Human Capital and Mobility research programme and partly as a collaboration with the Italian National Council of Research (CNR). The methods applied have been: observation of individual and team behaviours in real settings, video and audio recording and administration of stress rating scales.

In particular, the interactions that take place between the various components - human beings and machines - of complex organisations such as Air Traffic Management (ATM) have been analysed. Such an organisation can be seen as a co-operative system where human operators, supported by assistant tools, interact and communicate from their "working position" (i.e. Approach Control, En-Route Control, Tower Control).

The ATM system is characterised by co-operative connections between the different human operators involved, namely the Pilots, the Tower Controllers, the En-Route Controllers and the Approach Controllers *(Fig. 2.1)*.

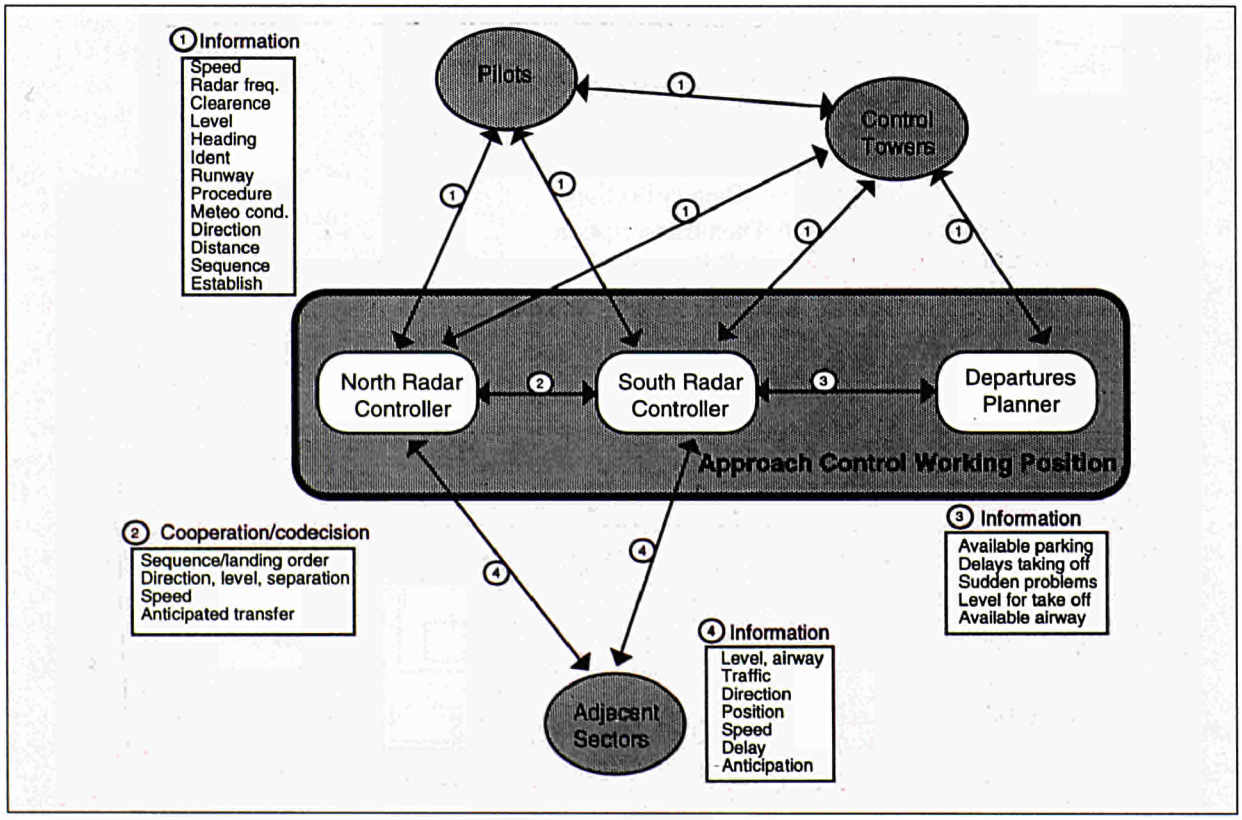

Fig. 2.1. Approach Control organization.

The control of an aircraft demands perfect synchronisation between the various ATC working positions. Indeed, an aircraft has to be taken in charge by different working positions managing different geographical sectors; these sectors being co-ordinated through complex communication channels. Working positions for Approach Control contain one or more Air Traffic Control Operators (ATCOs) between whom the tasks are shared following pre-defined guidelines which allow some flexibility in the task distribution. This flexibility level depends on the control centres, on the geographical sectors and on the ATCOs themselves. The ATCOs must dynamically process and exchange large amounts of information from various sources (e.g. radar screen, headphone, telephone, radio frequency) to decide on an action within short time periods.

The Approach Control task is analysed in order to develop a COmmunication MODel in cOoperative work (COMODO model). *Figure 2.2* gives a global view of this approach which is based on Etnomethodology, i.e. a methodology for the combined study of the cognitive, social and environmental factors affecting human-machine interaction. Data analysis based on data collected in the actual working place and on transcription of human communication enables the identification and the interpretation of (a) the co-operative work mechanisms for the individual and collective task management and (b) the critical aspects of the ATC task, linked to co-operative work and workload. An experimental platform integrating two Approach Control working positions permits the study of COMODO features through an air traffic simulation with human controllers.

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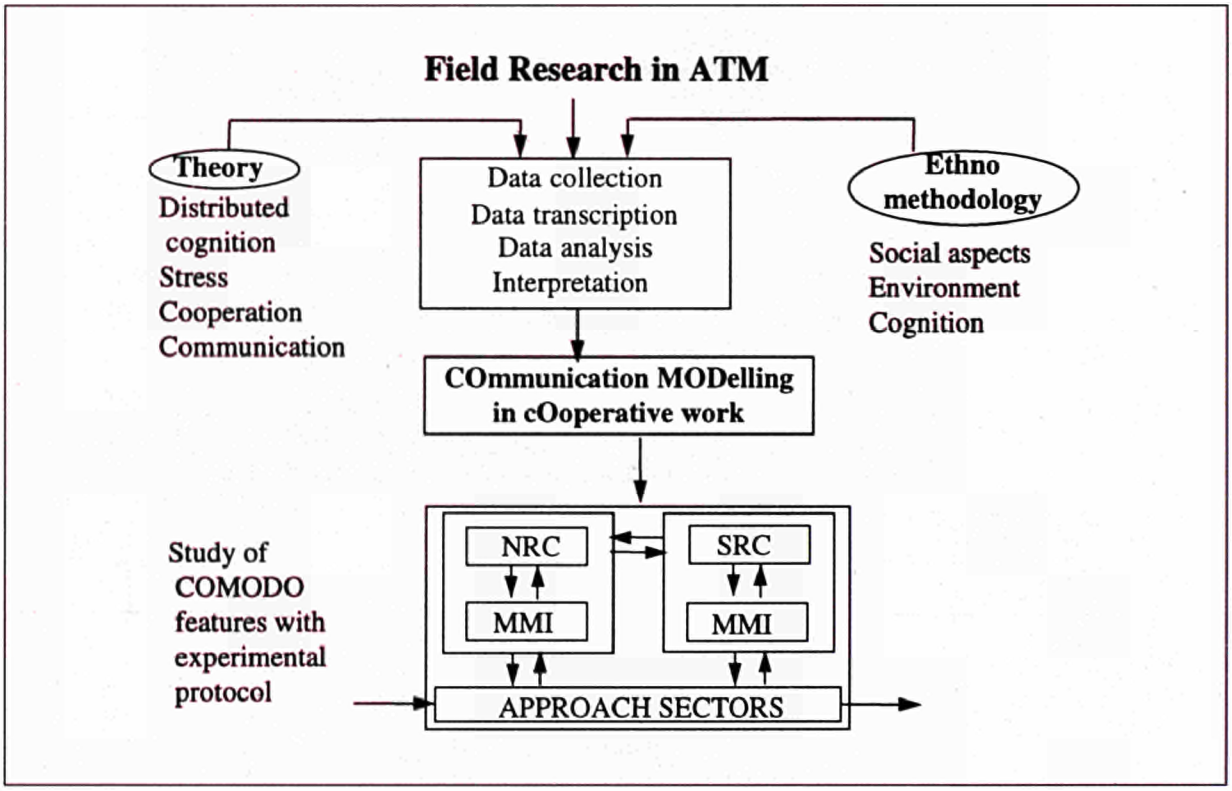

Fig. 2.2. Approach for the COMODO study.

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New Technologies and Safety at Work

The activities in the area "New Technologies and Safety at Work" have concentrated on:
- Development of a Crew Resources Management (CRM) Course, for training pilots in the Human Factors problems in flight management.
- Human Factors Studies.

The STEP Project 83 System Response Generator, which was developed in the previous years 1992-93, was formally terminated in January 1994.

The Crew Resources Management Course

The safety of air transport has improved considerably since the early attempts to fly less than a century ago. Today's aircraft have evolved into highly reliable means of transport.

Aircraft accidents do, however, still occur. Analysis reveals that approximately 70% of all aircraft accidents have human factors as their primary cause. Training in human factors has become one of the most powerful tools in the enhancement of safety in airline operation.

ISEI has developed a human factors training product for airline instructors and pilots. The product is designed to improve pilots' awareness of human factors onthe flight deck, and to provide them with practical knowledge. The product is characterised by being:
- modular
- adapted to the culture and to the target airline
- developed together with airline pilots
- based on the latest development in human factors training

Phase I	Phase II	Phase III	Phase IV
Analysis of Airline Characteristics	Facilitators Skills Training	Computer Based Training	Human Factors Seminar

The strategy for creating awareness and knowledge of human factor issues in the airline organisation is composed of four phases:

Initially, an analysis of organisation and safety culture at the target airline is done in order to establish a good knowledge of the airline and to identify its characteristics. The analysis is based on a mixture of interviews with pilots and on questionnaires. These highlight characteristics of the pilot body and clarify their own assessment of behaviour and co-operation patterns. The results of the analysis are used as active elements in the preparation of the training product as well as during the training. The Human Factors Seminar will be conducted by the airline's own trainers. In order to prepare them for the specific requirements for facilitating CRM training, a seminar is given to develop their skills in presenting material and evaluating training sessions. The seminar mixes theory with practical sessions in which the trainers facilitate video-taped sessions and receive feedback.

The computer-based training (CBT) is a self-paced preparatory course using multimedia technologies combining video, audio, text and graphics on a computer. The participant controls pace and direction using only the mouse of the computer. The CBT is based on accident case studies, and consists of the following training modules:
- An introduction to human factors issues provides the background for understanding why knowledge about human factors is important in daily operations.
- The Kegworth accident (engine failure, but wrong engine shut down) is presented as one example of human error. Information about the accident sequence is given, and the participant is invited to create his own opinion on the causes. He will be guided by a short list of questions. The answers will be used in the introductory part of the seminar.
- The Sioux City accident (crash landing after total loss of all flight controls) is used as an example of good crew performance. The case focuses on the human as the last safety barrier, and on how intelligent crew resource management on the flight deck can enhance performance in an unforeseen situation.

The major component of the CRM course is the Human Factors Seminar.
The seminar is a 17-hours long intensive group training for pilots, facilitated by the airline's own instructors. The seminar involves the participants as individuals and as a group through guided discussions, exercises, and lectures using video material, questionnaires and games.

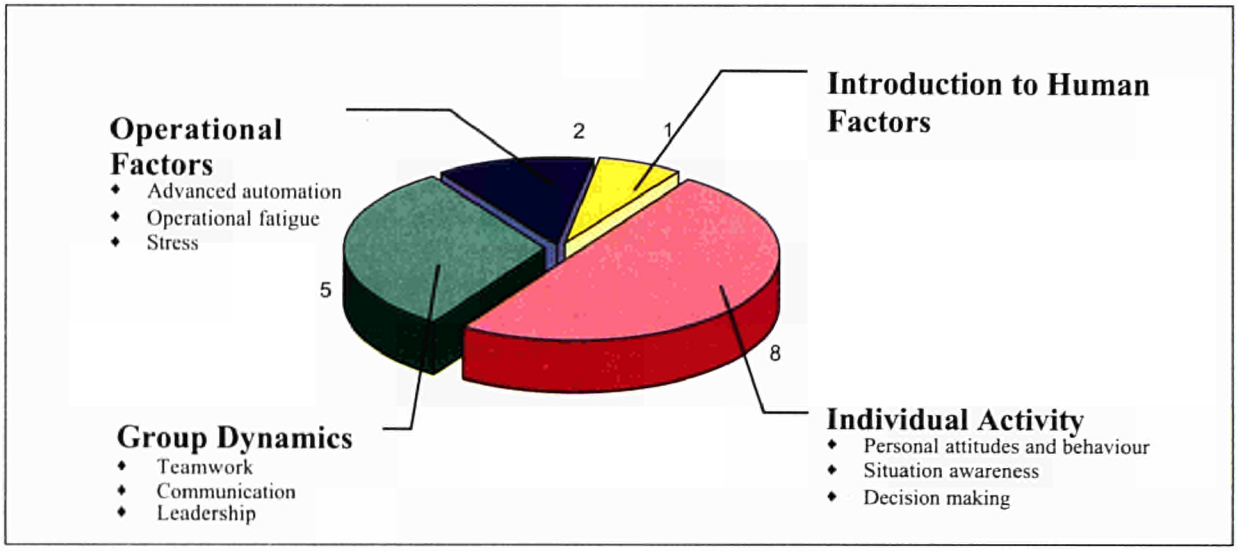

Fig. 2.3. Human Factors Seminar

The seminar is structured around three major modules: individual activity, group dynamics and operational factors, which are timely distributed according to the following diagram *(Fig. 2.3)*.

The first Module - **Introduction to Human Factors** - introduces Human Factors at the flight deck. The training module makes active use of the results derived from the computer-based preparatory course.

The second Module - **Individual Activity** - focuses on the individual pilot and his activity. This training module displays the potentiality of the pilot to ameliorate the flight operation. The notion of cognition is de-mystified through a better knowledge of the pilot's own *personal features* and on the factors interfering with his cognitive activity. Personal features are addressed including both those that are inherent to the individual, and the individual's specific history and experience. The focus will be on the danger of predisposition to hazardous attitudes.

Staying aware of the situation (*Situation Awareness*) is crucial for being fully in control of the aircraft. Distractions, and heavy workload, often trigger phenomena that lead to a wrong picture of what is going on. Based on case studies, and by sharing experiences, solutions for preventing and detecting loss of situation awareness are elaborated *(Fig. 2.4)*.

Decision Making on the flight deck encompasses the process that starts with diagnosis of what is happening from the perceived situation, up to the implementation of a course of action. The context in which decisions are taken makes the pilot particularly vulnerable to certain biases.

The third Module - **Group Dynamics** - concerns the performance of the team of pilots which depends to a large extent on the co-ordination of activity, communication, and inter-personal relationship. Group dynamics on the flight deck is treated in the following training modules.

The cockpit *crew forms a team* on the flight deck, sharing goals and co-ordinating activity. The aim of this training module is to illustrate that the performance of a team can exceed the performance of an individual. The characteristics of a team are outlined and examples of problems in the establishment of *team work* are discussed, such as co-ordination, group decision-making and achieving a shared understanding of the situation.

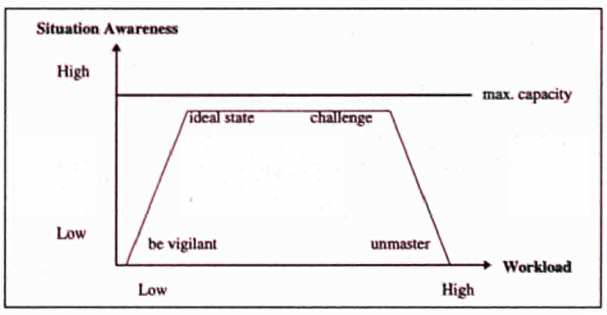

Fig. 2.4. Model showing relationship between workload and situation awareness.

This training module focuses on the function of *communication* on the flight deck, the factors that might influence the communication and how to achieve effective communication.

Leadership, expressed through the task of facilitating the crew's activity towards the accomplishment of its task, is the key to sustaining teamwork. This training module identifies different leadership styles and their impact on crew performance.

The forth module - **Operational Factors** - concerns the management of factors influencing operative effectiveness. The specific training modules depend on the characteristics of the airline. The following two training modules reflect the specific needs of a particular client operator.

The impact of *fatigue* from, e.g. long-haul flights, and the *stress* that is a natural part of flight operations, compromises the performance of the individual and may change the performance of the flight crew. This module discusses the background for understanding fatigue and stress, and provides solutions concerning how to avoid these factors and how to cope with them.

It is important to understand the pitfalls of *automation*: it is usually considered as a help in the operation of the aircraft, leaving the pilot with resources to cope with other tasks. The module gives the background to understand when it is desirable and necessary to be aware of this issue.

Human Factors Studies

The Human Error Reliability Methodology for Event Sequences (HERMES) has been further developed in conjunction with the corresponding activity performed in the Reactor Safety programme. HERMES covers both prospective use, i.e. the forecasting of human errors, and retrospective use aiming at the assessment of the causes of human erroneous actions. In particular, the prospective use of HERMES is based on an integrated simulation of the man-machine environment, properly driven by the DYLAM code, and on a suitable error taxonomy. The in-house research has been reinforced through collaboration with the Human Reliability Associates (UK) that aims at the further development of the error taxonomy and its prospective and retrospective uses.

The activities developed in this area are focused in the aeronautics and aerospace domain. A HERMES application previously developed by ISEI for studying the approach to the landing phase of a Boeing *747* to the Malpensa Airport has been extended to cover the case of commission errors made by the pilot /1/. The results of the dynamic analysis have been also discussed and compared with reference to a classic human reliability analysis method.

A study on the Traffic Collision Avoidance System (TCAS) has been conducted in collaboration with the Dipartimento di Ingegneria Aerospaziale of the Politecnico di Milano. TCAS is the latest adopted among the support systems dedicated to pilots. Depending on the employed TCAS type, the system is able to warn about hazardous traffic conditions as well as to suggest escape manoeuvres to the pilot. In *Figures 2.5 and 2.6* two of the typical interfaces of the system are presented. In order to study the system, two simulation models of the TCAS system have been developed, one based on the actual logic implemented in the real system and a new one based on fuzzy logic /2,3/. Both models have been integrated in a simulation environment particularly suitable for man-machine interaction studies.

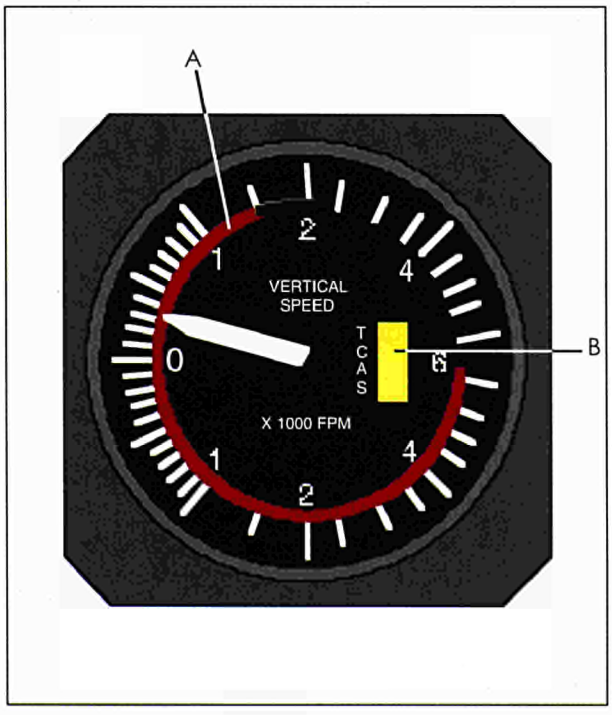

Fig. 2.5. Vertical speed indicator with TCAS resolution advisory display.

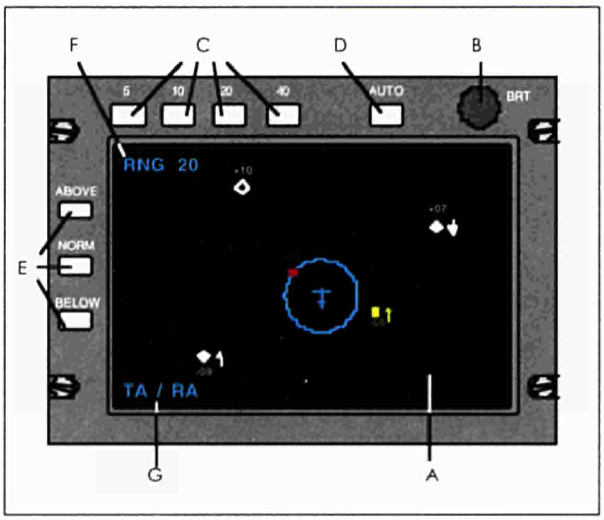

Fig. 2.6. Typical TCAS traffic advisory display.

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Process Diagnostics

Integration of Diagnostics Methodologies for Large Scale Systems

Process diagnostics methods and the relevant statistical procedures implemented /4,5,6/ started with practical applications to the class of Auto Regressive Moving Average with Auxiliary Input (ARMAX) processes because these models are able to suitably represent a large class of real systems. Nevertheless, the authors were aware that some typical situations of technological installations, still belonging to normal operation conditions, need a different kind of modelling. In particular, three topics had to be dealt with to take into account normal behaviours which cannot be inserted in the ARMAX context, nonlinearity, normal steady state changes and modelling interconnections between subsystems ruled by "different clocks". Studies for integrated diagnostics in the technology of large scale systems have produced the following results:

Non-linear models

Two types of models, Bilinear and Volterra, have been studied and procedures for identification and testing have been implemented, /3/.
A Bilinear model differs from an ARMAX one, since it includes product terms. Its response $\mathbf{X}_t$ has the following general form:

$$X_t = \sum_{i=1}^{p} A_i X_{t-i} + \sum_{j=1}^{q} B_j U_{t-j} + \varepsilon_t + \sum_{i=1}^{p} \sum_{j=1}^{q} \sum_{k=1}^{r} C_{i,j,k} X_{t-i} U^k_{t-j}$$

where $\mathbf{U}_t$ is the input process, ε_t is a white noise and $A_1, A_2, \ldots, A_p$, $B_1, B_2, \ldots, B_q$ and $C_{1,1,1}, \ldots, C_{p,q,r}$ are coefficient matrices.

The more general class of Volterra processes is composed by the sum of linear, quadratic and cubic and higher power terms components. Its general form is given by:

$$X_t = \sum_{i_1=0} h_{i_1} U_{t-i_1} + \sum_{i_1,i_2=0} h_{i_1,i_2} U_{t-i_1} U_{t-i_2} + \sum_{i_1,i_2,i_3=0} h_{i_1,i_2,i_3} U_{t-i_1} U_{t-i_2} U_{t-i_3} + \ldots\ldots$$

the functions $h_{i_1,i_2,i_3,\ldots,i_n}$ are called Volterra kernels.
The series (3) clearly shows how the process is decomposed into the sum of linear, quadratic and cubic components. The identification of Volterra kernels can be made through a non parametric method, /1/.

Predictive diagnostics

Trajectory analysis of system responses, which was developed for stochastic models in Euclidean space (where each observation coincides with a trajectory point), has been extended for function spaces, such as Hilbert space, where trajectories of functions can be described by stochastic models. In particular, trajectory segments of a non-stationary process (the phases of normal steady state changes, e.g. the start-up and shut-down operations of a plant) can be considered. Effective statistical tests have been implemented and their efficiency verified for typical cases as tools. These tests are able to capture and analyse steady state change signals. Unexpected and even unknown events (uncoded symptoms belonging to an unknown and specific symptomatology) can be monitored on-line and detected to anticipate unforeseen situations.

Variables with different clocks

In a large scale system, subsystems and interconnections may complicate the modelling because of the different variability rates with respect to time of the variables of interest. Some variables vary slowly and others vary rapidly. The interconnections between subsystems give rise to situations in which variables with different "clocks" are simultaneously present. In such a case two typical problems arise: how to get statistical-mathematical models to represent multivariate physical systems with different clocks; and how to find methods of standard representation. The solution for these problems is not trivial and is conditioned to the feasibility of suitable variable transforms. A new representation can be obtained if the solution of the Riccati problem for block diagonalization of ill conditioned systems exists /2/ when applied to the transform coefficient matrices.

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MEASUREMENTS AND TESTING

Photovoltaic Systems

Major innovations during 1994 were

- the development of an electronic load for our two single-flash solar simulators. The principle uses active forward coupled feedback and proved to be more reliable than the electronic loads used at that time;
- participation in a round robin on the characterisation of various New Technology Photovoltaic Cells (CIS, CdTe, and multilayer Thin Film devices) led to a precise description of the measurement principles used during characterisation of photovoltaic (PV) devices at the European Solar Test Installation (ESTI);
- an upgrade of a Spectral Response facility was performed to measure the Spectral Responsivity of PV devices with higher accuracy.

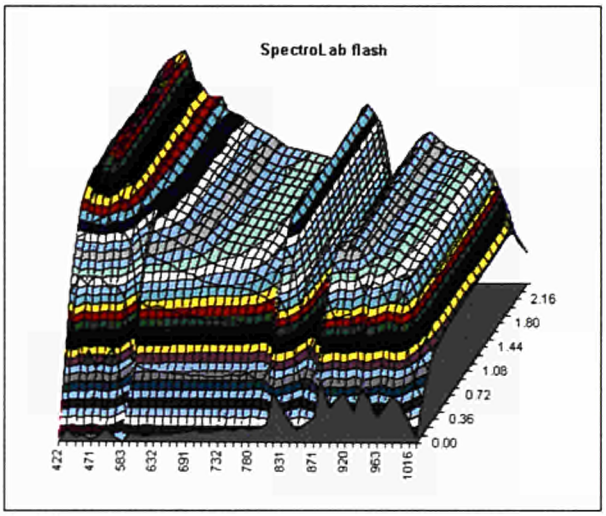

Fig. 2.7. Spectral intensity variation during the flash period of the SpectroLAb LAPSS.

SpectraCube

The SpectraCube, a device able to measure Spectral Irradiance changes during the short time (2ms) of our Flash Solar Simulators, was made operational. The system consists of a 64-channel detector with optical interference bandpass filters. The range of the detector system can be adapted to the wavelength range of interest.

The ESTI-Sensor

The ESTI-Sensor was developed and presented by ESTI in 1992. Meanwhile the Sensor has been chosen for the market as a reference device for monitoring and evaluation of PV installations because it measures both the irradiance the plant is exposed to as well as the operating cell temperature of the installed photovoltaic modules. In fact the ESTI-Sensor became a new standard for PV power plant monitoring systems. By the end of the year 1994 some 500 ESTI-Sensors had been sold.

Facade

As pursuer of one of the biggest amorphous silicon photovoltaic facades in the world, ESTI monitors data of interest every five minutes. This data gets stored and evaluated to demonstrate the functioning of the whole installation as well as the performance of its components. As a result of the evaluation one can say that the set-up of the system is extremely reliable compared to previous monitored PV plants within European demonstration programs.

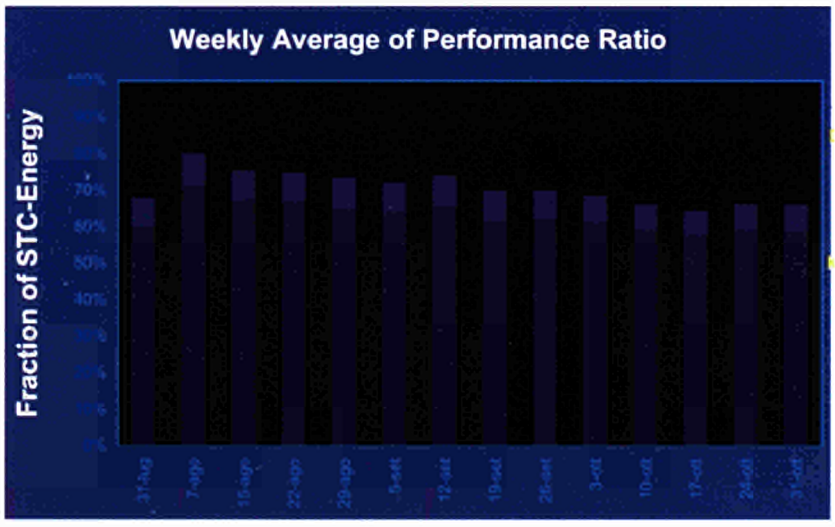

Fig. 2.8. Performance Index of the PV-Facade. The figures within the bars show the energy generated per week in kWh, both for DC and AC power.

Structural Diagnostics by Optical Techniques

Several research actions have been performed in this field in collaboration with national laboratories and companies (University of Loughborough; University of l'Aquila; Opificio delle Pietre Dure - Florence; Politecnico of Milano; CRN - Strasbourg; etc.). The actions, whose main achievements are hereafter briefly reported, belonged to two major application areas: deformation analysis and surface profilometry.

Deformation analysis

Field Testing and Application of the ESPI (Electronic Speckle Pattern Interferometer)

The ESPI is an easy-to-use instrument allowing microdeformation measurements, by means of speckle interferometry. The ESPI has some very important advantages over traditional double exposure interferometry:

- the fringe images are directly registered in digital form by a CCD camera;
- the relevant interferograms are obtained, by digital subtraction, in 40 ms, so that deformation images can be captured at the video camera acquisition rate;
- this allows a real time measurement and display of slowly varying deformations;
- the effect of environmental vibrations are greatly reduced;
- operation is also possible in day-light and with a continuous wave laser.

The portable prototype realised in 1993 was improved and then extensively used for a complete and very successful campaign of measurements on ancient Italian paintings. The measurements were performed at the Restoration Laboratories of the Opificio delle Pietre Dure in Florence. The Opificio is part of the Italian Ministry for Cultural Heritage (it. Ministero per i Beni Culturali ed Ambientali).

A system composed of an optically isolated pigtailed laser diode with polarisation maintaining fibre and the thermoelectric cooler was used as a coherent light source. The laser (emitting an optical power of 50 mW at the typical wavelength = 785 nm) was coupled to a polarisation maintaining single mode fibre. Special devices were introduced for the elimination of amplitude instabilities, frequency drifts and astigmatism and for accurate temperature stabilisation.

The paintings inspected were all on wood panels; some results are shown in *Figures 2.9 to 2.10*. Firstly, the

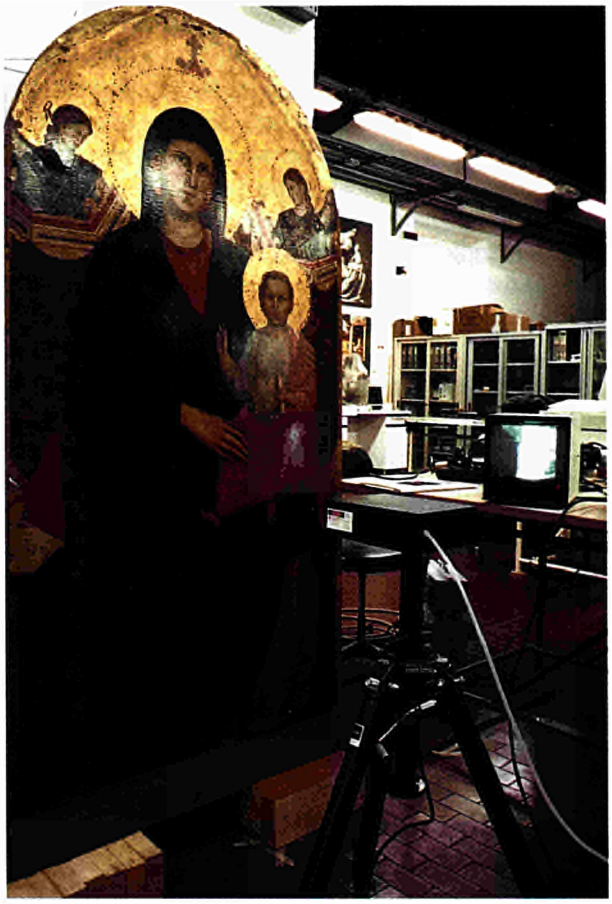

Fig. 2.9. "Madonna in trono con Bambino" by Giotto (1266-1337), wooden panel.

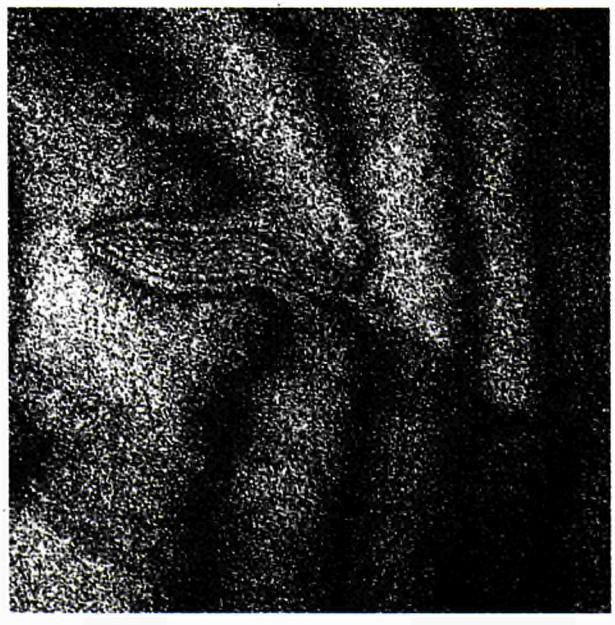

Fig. 2.10. Interferogram relative to an area in the middle of the Giotto panel indicating the existence of a detachment and of a crack along the horizontal direction.

wooden panel (190 x 97 cm) "Madonna in trono con Bambino" by Giotto (1266-1337) was carefully inspected. The panel was simply leaned against the wall and rested on two wooden blocks on the ground *(see Fig. 2.9)*. *Fig. 2.10* presents the interferogram relative to an area in the middle of the panel. The anomalous density and shape of the fringes at the centre of the image clearly indicate the existence of a detachment (whose extension is also identified) and of a crack along the horizontal direction.

Measurements were also performed on the "Incoronazione della Vergine" by Lorenzo Monaco (15th century). This painting, which comes from the Galleria degli Uffizi of Florence, consists of a panel (450 x 350 cm), a *predella* and three *cuspidi*. *Fig. 2.11* shows the simple set-up for the examination of the *predella*, while *Fig. 2.12.* shows the results obtained for two cracked regions. In both cases the behaviour of the fringes indicate that a detachment was also present.

The above examples show the ability of the ESPI to detect, locate and size defects still in their early stage of development and not yet detectable by visual inspection and the ability to identify the type of defect (crack or detachment).

This interferometry technique can also be used to control repair and restoration work. *Fig. 2.13* shows the results of measurements made before and after repair on the

Fig. 2.11. Predella of the "Incoronazione della Vergine" by Lorenzo Monaco (15th century), from Galleria degli Uffizi, set-up for examination by the ESPI.

Fig. 2.12. Detail of the predella, with indication (white squares) of two cracked regions identified using ESPI, and relevant inspection results (lower part of the picture). The behaviour of the fringes indicates that a detachment was also present.

wooden panel (42 x 125 cm) "Trionfo di David", by Imitatore del Pesellino (15th century), from Museo Horne - Florence: the relevant region of the panel is shown in *Fig. 2.14*. From the interferogram of *Fig. 2.13*, left side, a large detachment was detected. Moreover, the small closed fringe above this defect indicated the presence of another detachment. The interferogram was used by restorers as a guide for repair work, after which the fringe pattern showed no residual anomalies *(see Fig.2.13, right side)*.
More details on these measurements can be found in /1,2/.

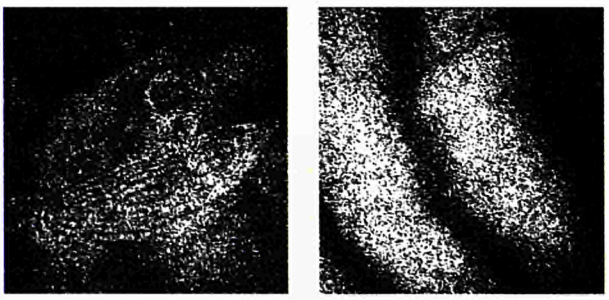

Fig. 2.13. Results of ESPI measurements made befor (left side) e and after (right side) repair of a detachment on the wooden panel "Trionfo di David".

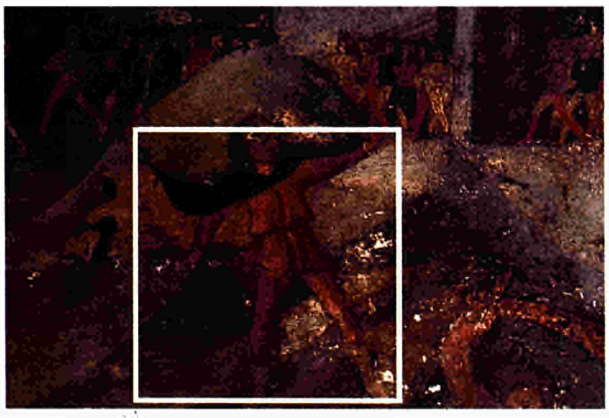

Fig. 2.14. "Trionfo di David", wooden panel, by Imitatore del Pesellino (15th century), from Museo Horne - Florence: region of the panel containing the defect shown in Fig. 2.13.

Double-ESPI for material characterisation

Multiple ESPI systems, combining optical instrumentation and bench testing machine, have been developed and tested. The systems, completely controlled by a computer, can give, in real time, interferograms related to different components of the deformation of the objects under test. *In Fig. 2.15 and Fig. 2.16* a scheme and a detail of a double ESPI system, for the simultaneous measurement of in plane and out of plane deformation, are presented. This procedure turns out to have some advantages over traditional methods:

- being non contacting it does not interfere with specimen behaviour: the influence of glued strain gauges was demonstrated and the advantages of using the ESPI technique was highlighted;
- it allows full-field visualisation of displacements; .
- it allows the real-time study of the evolution of deformation on the whole surface of the specimen.

Many different materials and structures have been tested with the above system: steel materials, composites, wooden panels, stones.

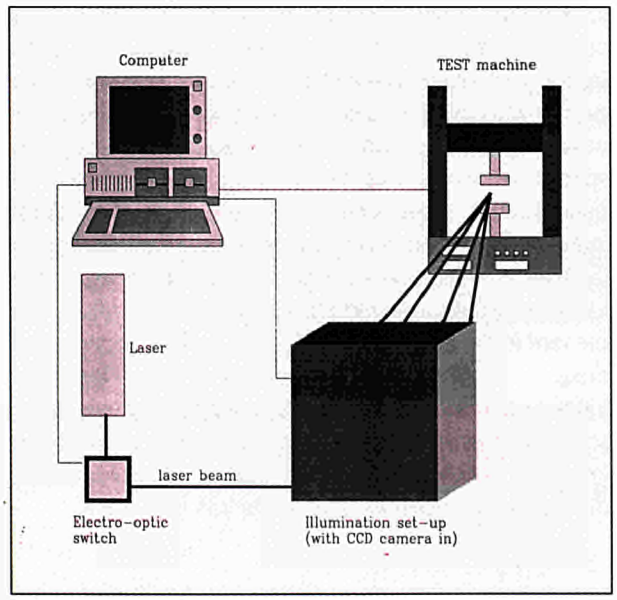

Fig. 2.15. Scheme of computer controlled, opto-mechanical configuration (double-ESPI application) for interferometric measurement during compressive tests.

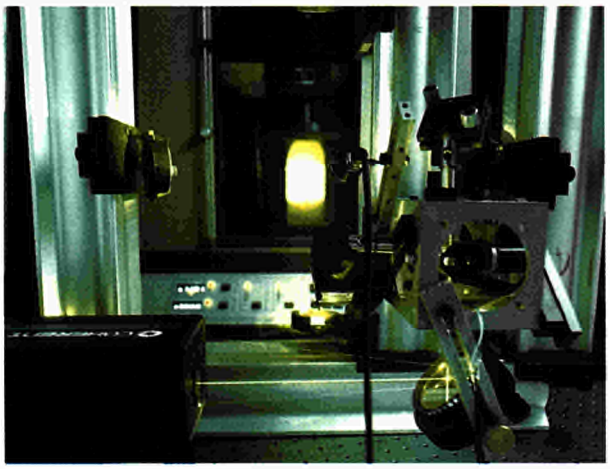

Fig. 2.16. Picture showing a detail of the system of Fig.2.15.

Contacts and collaborations have been established with the Structural Engineering Departments of the Politecnico di Milano and of the Politecnico di Torino and joint experiments performed. The behaviour of building materials has been studied from a qualitative and quantitative point of view. Classic techniques (e.g. glued strain gauges) are unable to cope with structural discontinuities and poor spatial homogeneity of these materials and are hence unable to achieve their full mechanical characterisation. Full field, optical techniques constitute the breakthrough. Some materials parameters, such as Poisson's Ratio and Young's Modulus, were evaluated very precisely: a plot of results obtained from a compression test on a brick specimen is presented in *Fig. 2.17*. The system makes it possible to perform studies about the propagation of fissures or cracks in these types of materials. During the tests performed, cracks were detected at a very initial stage and it was possible to observe where they started and how they propagated in the material before causing specimen failure. This methodology can therefore be quite useful for attempting early prediction of structural failures. *Fig. 2.18* shows the fringe (corresponding to ISO-deformation lines) image from a brick-mortar interface; a higher deformation and a rotation effect are present in the mortar. *Fig. 2.19* is a clear example of detection of a crack (evidenced by a higher density of fringes and fringe discontinuity) propagating in a small scale masonry model (the white lines represent the interface between bricks and mortar); no deformation difference between the two materials is present.

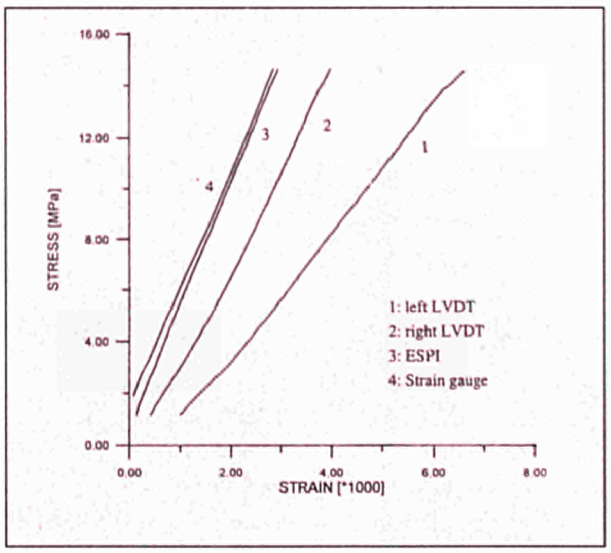

Fig. 2.17. Plot of data obtained from a compression test on a brick specimen. Curves refer to data obtained with classical extensimetric tools and the optical interferometric technique.

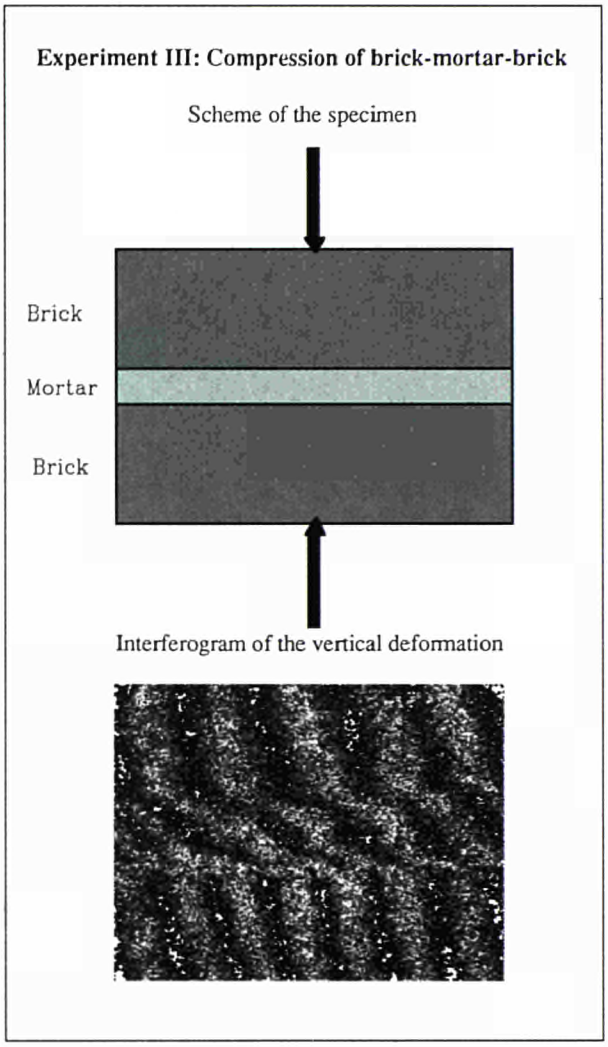

Fig. 2.18. Multimaterial specimen (two bricks with mortar in between): isodeformation fringes obtained using double-ESPI

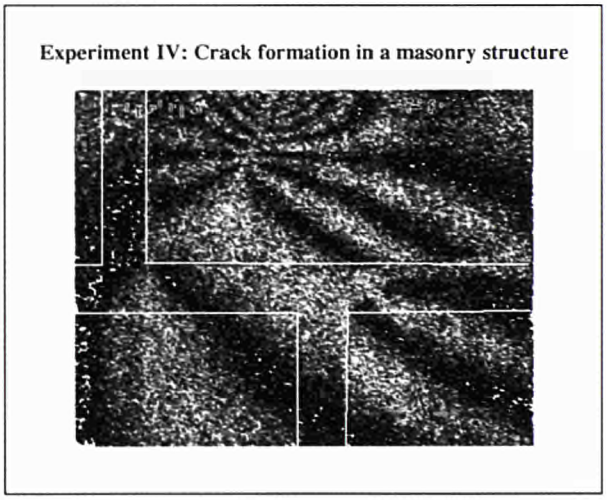

Fig. 2.19. Multimaterial specimen (bricks and mortar): detection of a propagating crack using double-ESPI.

ESPI application to the analysis of vibration characteristics and structural integrity of musical instruments

The collaboration with a private restoration company (Carlson Cacciatori & Neumann s.n.c.) and mainly with the Cremona Violin-Making School (Istituto Professionale Internazionale per l'Artigianato Liutario e del Legno - Cremona) enabled us to use the facilities of their acoustic laboratories and to organise and perform some pilot measurements on antique violins combining acoustic and optical (interferometric) techniques /3,4/. The simultaneous use of acoustics and optics is turning out to be a very powerful and useful tool for violin characterisation during the making as well as restoring of these instruments.

Optical fibre interferometric transducer

Optical fibres can be used like transducers because of their changing optical behaviour under strain; particularly, the phase of the light travelling the fibre changes if the refraction index or the initial length of fibre (or both) change. A number of different techniques can be used to detect and measure the phase changes, but interferometry offers higher performances as far as precision and range are concerned. A complete fibre optics system, based on interferometric techniques, has been realised and tested. A new optical strain gauge has been developed and will soon be internationally patented. Its main advantages over traditional strain gauges are:

- no sensitivity to electromagnetic field disturbances;
- higher resolution;
- higher frequency response.

No more details can be given before the patent is registered. *Fig. 2.20* presents vibration plots obtained by our optical strain gauge and a high sensitivity semiconductor strain gauge.

Surface characterisation and profiling

The facilities of the 3D Profiling Laboratory were improved when two powerful equipments (3D white scanner, digital photogrammetric system) were made operative; they, together with the special instruments for surface analysis and profiling developed on the site (coherence radar, speckle decorrelation measurement system), give the laboratory quite a wide range of potentialities both for research and third party work.

3D White Scanner

A 3D White Scanner system was set up. Such a scanner provides a method to retrieve real 3D image data in extremely short periods of time. A laser source creates a line shaped beam that sweeps over an arbitrary surface. At any position this luminous line is observed by two CCD sensor cameras (or by one sensor camera working from different observation angles by means of a mirror system). After a single sweep an entire object surface can be retrieved in true 3D co-ordinates. The system has two retrieval units: a semi-portable unit for linear motions and a lab system for rotary motions. The linear system can work with two different resolutions and two different working distances, while the rotary system is confined to a single head. The rotary system is also capable of linear motion.

Typical resolutions are in the fraction of a millimetre range, typical object sizes are several tens of centimeters. Objects that do not fit into this size have to be retrieved by several scans. Uniting the scans has been studied by means of the software package Plexus.

Digital photogrammetry system

The purpose of photogrammetry is the characterisation of large objects (aircraft; pressure components, build-

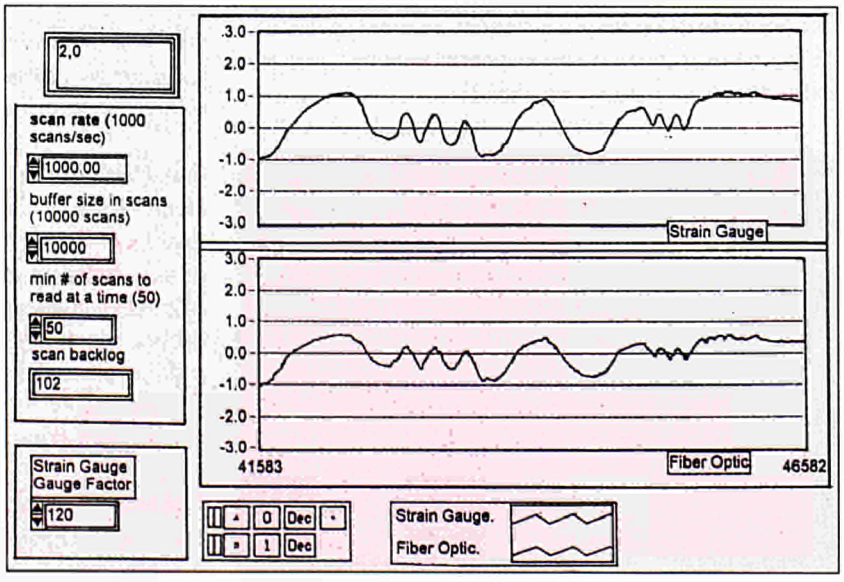

Fig. 2.20. Comparison of vibration plots obtained by our optical strain gauge and a high sensitivity semiconductor strain gauge.

ings, etc.) that are visible on photographs. The output of a photogrammetric evaluation can be:
- a set of co-ordinates assigned to points visible on photographic images;
- scaled drawings of objects visible on photographic images, maps or plans;
- images of objects, i.e. maplike images with a constant image scale.

Photogrammetry is inherently non-intrusive and requires a fairly small amount of field work, i.e. the necessary input for a photogrammetric evaluation is just a set of photographs plus some additional information like reference points on objects and camera parameters. Apart from the photographic exposures a few geodetic measurements (typically done by means of theodolites) may be necessary. The precision reached by photogrammetry is mainly dependent on the average scale of the primary photographs. This leads to a certain versatility of this method, but the better the scale the more photographs have to be evaluated. Classical photogrammetry requires a set of expensive opto-mechanical instruments that are difficult to handle. Digital photogrammetry allows a somewhat smoother handling of photogrammetric procedures. Complicated opto-mechanical machinery is replaced by a high precision scanner converting classical photographs into digital images. The direct usage of digital cameras is still not wide spread due to inferior image qualities.

The JRC's Laser and Applied Optics Laboratory started to implement this technology in 1994 purchasing several pieces of equipment and training personnel. Extensive use of the system is already planned in 1995/1996 in the frame of a large contract with Sicily Region (operative from December 1994).

Available equipment:
- Metric roll film camera CRC-2 using 5"x5" films and equipped with a film flattening mechanism. This camera has been studied and tested in detail and computer field-depth calculations have been performed /6/;
- Leica Wild DIOR theodolite with distance meter to measure point co-ordinates from a single theodolite position without using retrorefractive targets;
- Leica Helava Digital Scanning Workstation DSW 100. This is a computer-controlled precision scanner designed and built for photogrammetric purposes. It moves with a resolution of 1 μm and has a geometric accuracy of 3 μm.This equipment communicates with a;
- Leica Helava Digital Photogrammetry Workstation DPW 770 based on a Sun WS and a Vitec Image computer plus a Tektronix SGS625 screen for stereoscopic viewing by means of LCD shutters, circular polarisation and lightweight spectacles.

Dual fibre fringe projection

The dual fibre fringe projection technique is part of the group of fringe projection contouring techniques using coherent light sources. Our system is based on an optical fibre version of the Young's interferometer. Interference fringes are formed with the coherent light of two single-mode fibres, which replace the pair of pin-holes in the Young's configuration. In the classical version the power losses associated with the pin-holes are compensated for by focusing the light onto their apertures. By doing so, however, Airy diffraction disks become visible and the regularity of the fringe pattern is altered as a consequence. These disadvantages are eliminated by the introduction of the optical fibres, which allow Young's fringes to be projected with low power-laser sources.

In our optical set-up, the light of a 35 mW He-Ne laser has been launched into the input fibre of a single mode coupler which equally divided the light between the two output fibres. The fringe spacing d on a screen normal to the propagation direction turned out to be independent of the distance from the point sources and to be readily changed by adjusting the distance between the fibre ends:

$$d = \lambda f / a$$

where λ indicates the laser light wavelength and f the focal length of the collimating lens on the focal point of which the fibre ends have been placed.

Several measurements have been made on metallic and stone material surfaces. Of particular interest are the results obtained with the measurements performed on marble samples in correspondence to surface regions altered by corrosion and erosion. *Figs. 2.21 and 2.22* show respectively the contour fringes on a marble surface eroded by 200 years of exposure to natural weathering on the Duomo of Milan and the mesh plot of the same zone of eroded marble surface /2/.

Coherence radar

The above name indicates a high resolution and wide dynamic range optical instrument for full field, non contact surface 3D profiling and roughness measurement. The origin of the instrument is a competitive

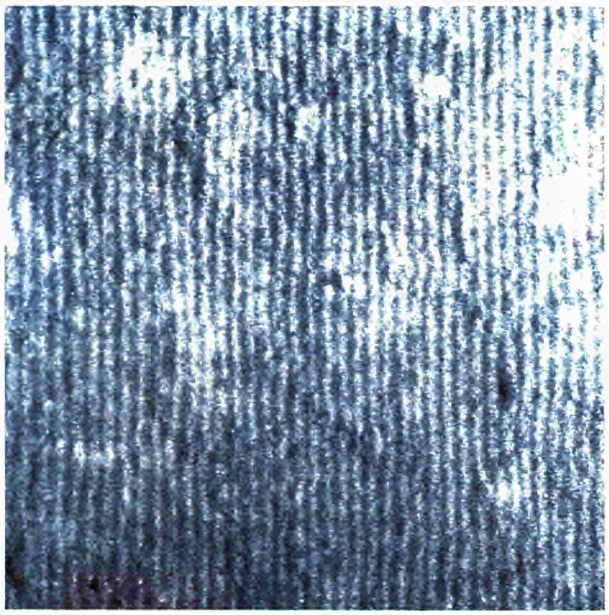

Fig. 2.21. Contour fringes on a marble surface eroded by 200 years exposure to natural weathering on the Duomo of Milan

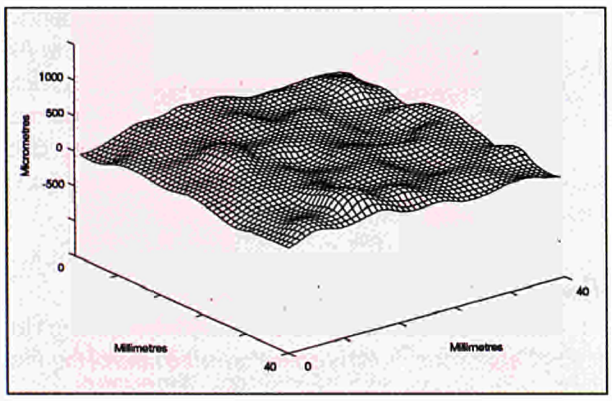

Fig. 2.22. Mesh plot of the same zone of eroded marble surface

exploratory research activity carried out in 1993 that ended with two main achievements:

- the establishment of a fundamental analytical relationship explaining the speckle contrast dependence on all physically relevant parameters, namely:
  - spatial and temporal coherence length of the used radiation;
  - optical path difference;
  - statistical properties of the inspected rough surface;
  - optical characteristics of the image acquisition system;
- setting up and testing of a prototype instrument for 3D profilometry of objects with the following main characteristics:
  - high reflectivity surfaces (mainly metallic materials);
  - dimension of inspected surface of some square centimetres;
  - surface roughness of the order of the light wavelength (visible and near infrared);
  - depth range from ten microns up to some millimetres.

The depth resolution of the instrument can be easily changed from 1 - 2 microns to 50 microns. The lateral resolution attainable is in the order of 10 microns. Successful tests were performed on materials with relatively high reflectivity (mainly metallic ones). *Fig.2.23* shows the 3D profile of a metallic surface presenting a 30 micron step.

As the result of this research work /7/ performed in ISEI's laboratories during 1994, the instrument prototype has been improved by reducing chromatic aberration and by adding a more precise and reliable reference mirror translation stage. Other innovative improvements have been introduced in the software for the automatic control of the system and for the 3D data acquisition procedure.

On the 9th of March 1995 a patent proposal, regarding both the method and the instrument described above, was submitted to the European Commission Patent Office.

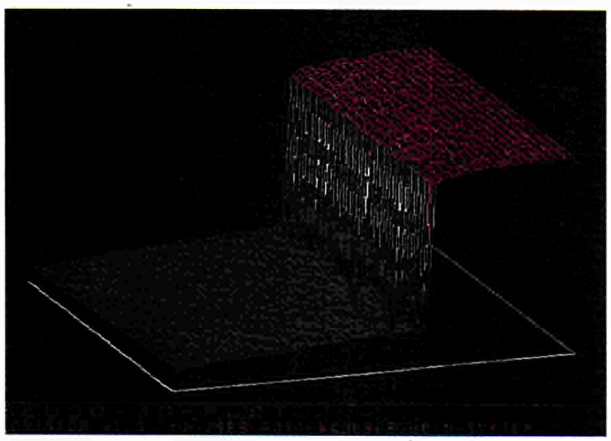

Fig. 2.23. Surface contouring, obtained by the coherence radar measurement of a metallic surface presenting a step.

Structural Diagnostics by Volumetric Techniques

Acoustic Emission adhesive bond quality assessment
The first phase of this work, conducted within the frame of the activities of the Italian group EAMA (Acoustic Emission from Aerospace Materials and Structures), is close to completion. Its objective was to investigate on the possibility of utilizing acoustic emission techniques for assessing the bond quality. The underlying idea is that AE activity coming from ideal practice procedures must be different and discernible from that coming from modified ones; the ultimate goal of this research would be the development of a bonding procedure with a self-controlling capacity provided by an acoustic emission monitoring feedback.

This would be an important industrial contribution, since adhesive joints are increasingly entering the construction engineering field, and in particular that of avionics. They offer certain advantages over other connector forms (bolts, rivets), such as reduction of stress concentrations across the joint, increased joint stiffness, possibility of joining dissimilar materials etc. In fact the aluminum specimens and the adhesive have been supplied by the aerospace firm ALENIA (Pomigliano d'Arco, Italy), while the CIRA (Italian Centre for Aerospace Research) is actively involved in the experiments.

Acoustic emission activity during adhesive curing was detected using a PAC LOCAN-AT instrument. Resonant sensors (at approximately 150 kHz) was employed. A supported film epoxy adhesive was used whose polymerization cycle is approximately 120°C in a hot press for 90 min at a pressure of 0.5MPa. Temperature was measured with two thermocouples.

In these experiments the polymerization cycle was kept constant for all tests while reduced adhesion surfaces were introduced to represent the defect situation (zero-volume void). Three series of specimens were prepared:
- ideal, 100% coverage of the overlapping area by adhesive film;
- partially defective, central 50% coverage of the overlapping area by adhesive film;
- fully defective, a completely isolated adhesive film of dimensions equal to the overlapping area was put in place, thus polymerization occurred but no adhesion.

Some of the results obtained can be summarized as follows:
- As observed in the Cumulative counts versus time curves for ideal joints, there exist three distinct regions closely corresponding to the three phases of polymerization. There is an initial pronounced AE activity (heating up), a rather mild AE period (constant temperature), and again increasing AE activity (cooling off);
- This behaviour is also evident in the counts rate versus time curve (corresponding to the same specimens). Clearly, more AE activity is present during the first and third phases of the cycle;
- By contrast the curves for partially and fully defective joints do not exhibit this characteristic behaviour. An almost continuously increasing cumulative counts versus time curve is noted there with a slight evidence of a first phase, which seems again to be more AE active;
- Features which may identify this differential behaviour should be sought outside the initial heating phase, where external factors (moisture, entrained gases etc.) influencing the AE activity are usually present and potentially obscure the AE coming from polymerization. More promising for distinguishing between polymerization and adhesion is the AE behaviour during the cooling down phase, where the AE should be due to residual stresses and micro-cracking. This in turn could be associated with thermal mismatch phenomena and with the quality and extent of adhesion.
  More details can be found in /8,9/.

Thermal emission measurement
An informal collaboration with the Centro Ricerche Fiat (CRF, Orbassano, Italy) is going on in the field of thermal emission, namely:
- Experimental/theoretical approaches to fatigue limit estimation via adiabatic thermal emission measurement techniques and stored energy concepts; 82 specimens, prepared by the JRC, with material provided by the CRF, have been delivered to the CRF. The CRF will carry out the fatigue cycling of these specimens according to the agreed specifications, and will send them gradually back to us for thermal emission testing.

The collaboration with FIAT includes a second project as well:
- Experimental assessment of the quality of adhesive joints using acoustic emission and other NDE (Non Destructive Evaluation) methods. Within a feasibility study, acousto-ultrasonic methods have been applied to assess the quality of several joints supplied by the CRF. The technique, which involves pattern

recognition, classification of signals etc., seems to be promising.

Damage accumulation modelling

Analytical work on the evaluation of several stochastic crack propagation models in metals has been conducted. Approaches involving the generalised least-squares and the maximum likelihood techniques have been implemented for the estimation of the parameters of crack growth laws /10,11/.

The possibility of estimating the modal damping of damaged structures by comparing experimentally derived (via laser interferometry) natural frequencies with theoretical ones has been confirmed /12/.

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/1/ Lucia, A.C.; Zanetto,P.; Fronchi,M.; Aldrovondi,A.; Matteini,M.; Cianfanelli,T.; Riitano,P. "Contribution of laser diagnostic techniques to restoration: ESPI measurements on ancient Italion paintings", Technical Note No.I.94.110

/2/ Zanetta,P. "Optical techniques applied to measurements in art", Loughborough University of Technology, Ph.D. Thesis, 1994

/3/ Langhoff,A.; Facchini,M.; Zanetta,P. "Static deformation measurements on violins by optical TV-holography", 4th International Conference on Non-Destructive Testing of Works of Art, Berlin, October 1994

/4/ Langhoff,A. "Considerazioni sulla statica del violino con esempi relativi a violini antichi e moderni", triennale degli strumenti ad Arco - Cremona - Italy, October 1994

/5/ Zürn,M. "A two-shutter camera for pulsed laser holography and interferometry using thermoplastic hologram processing" Meas.Sci. Technol. 5 (1994), 251-254

/6/ Florensa,M.; Schwarz,U.; Zurn,M. "The Metric Camera and its usage at JRC Laboratory LAO" Technical Note No I.94.68 ISEI/IE 2730/94

/7/ Lulli,A. "Sviluppo e applicazione di un nuovo metodo ottico per profilometria tridimensionale basato sulle variazioni locali di contrasto nella interferenza speckle in luce parzialmente coerente" Graduation Thesis, Politecnico di Milano, 1994

/8/ Lucia, A.C., Solomos, G.P., Santulli, C., Marini, R., Coretta, A., "Valutazione della resistenza di strutture in materiale composito mediante emissione acustica", invited lecture, Convegno "Attuali Applicazioni e Prospettive dell' Emissione Acustica" CISE Segrate Milano, 10 Nov. 1994.

/9/ Solomos, G.P., Lucia, A.C., Santulli, C., Caretta, A., "Adhesive joint quality assessment via acoustic emission monitoring ", Proceedings 6th European Conference on Non Destructive Testing, Nice France, 25-28 Oct.1994.

/10/ Dimou, C.K, Solomos, G.P., "Evaluation of Stochastic Crack Propagation Models", Tech. Note No.I.94.165, ISEI/IE/2824/94, JRC-Ispra, Dec.1994.

/11/ Moussas, V.C., Solomos, G.P., and Lucia, A.C., "A General Method for Raw Fatigue Crack Growth Data Processing and Structural Reliability Assessment", Proceedings 2nd International Conference on Computational Stochastic Mechanics, Athens Greece, 13-15 June 1994.

/12/ Solomos, G.P., Zanetta, P., Facchini, M., Lucia, A.C., "Modal damping assessment via laser interferometric techniques", Proceedings 10th International Conference on Experimental Mechanics, Lisbon Portugal, 18-22 July 1994.

ENVIRONMENT/REMOTE SENSING

Contributions to the Centre for Earth Observation (CEO)

In 1994 the CEO Group of the ISEI Institute performed a significant amount of work in support of the Pathfinder Phase of the CEO project, that started end 1993 and will be completed by end 1995.

The goal of the Pathfinder Phase is to produce a project plan for the Design and Implementation Phase (1996-1998) containing sufficient information and understanding of the system to bring the CEO successfully into being.

The work of the Pathfinder Phase is organised by Activities. There are 5 Activities, of which the first two (Activity 1: Survey and understand the present infrastructure status, and Activity 2: Capture user requirements) take place simultaneously at the start of the Pathfinder Phase. The third Activity (Synthesis) starts during Activity 1 and 2, and ends when the implications of those Activities are fully assimilated. The fourth Activity (plan the Design and Implementation phase) then starts. Throughout the Pathfinder Phase, the fifth Activity (Cost and Benefits of the CEO elements of the system) maintains an up to date estimate of the probable cost of the programme.

ISEI contribution has been mainly addressed to Activities 1 and 2 and to the organisation and management of the CEO Pathfinder Phase Steering Committee Meetings.

Activity 1 - Survey and understand the present infrastructure status

ISEI assured the overall coordination of this activity throughout the period and also the major part of the related work in order to identify the environment in which the CEO will exist. In this framework two workshops have been organised; the first one was held in Ispra (2-3 February) under the title "Overview of the EO Data Networks and Projects in Europe" and was attended by the Pathfinder Phase Steering Committee (PPSC) Members and some national Experts. The second one was organised by ISEI staff in collaboration with ESA-ESRIN and has been held in Marino (Roma) the 13-15 December 1994 under the title "1st EEOS Workshop on European Data Networks and EO Services: survey and consultation"; ISEI was responsible for the definition and the technical coordination of Panel 1 of the Workshop (European Data networks) while ESA was in charge of Panel 2 (EO Services). The workshop was attended by more than 170 persons representing all European Countries (EU and EFTA).

The results of the second workshop are an important input to a study contract on "Analysis of existing and planned European Data Networks" issued by ISEI staff at the end of 1994 and awarded to an European Consortium. Scope of the study is to provide a complete description of the existing and foreseen (1994-98) data communication infrastructures and networks services and polices in Europe in order to envisage possible solutions for the access to information and services related to Earth Observation.

The communication between the distributed service providers on one side and the users on the other side is one of the major objectives of the CEO project. A first model of the service exchange has been implemented on a CEO server based on available and well performing technology (World Wide Web and Mosaic). The home page contains official CEO documents, a "what is new" rubrique, a forum for User feedback and the possibility of links to other EO sites in Europe and the US (*see Fig. 2.24.*).

Always in the frame of Activity 1 the following project proposals have been defined: "Integrating the access to heterogeneous Databases" and "Monitoring the Quality of Services in a distributed Information System".

Activity 2 - Capture User Requirements

The goal of this Activity is to identify the requirements of the current and potential users of EO data and to derive a comprehensive statement of what CEO must do. In order to achieve this target several approaches are used in parallel. ISEI is contributing to Action 2(c) of the Pathfinder Phase Project Plan, that is " Capture user requirements within Experimental User Communities". A study contract on "Organisation of a Urban Develop-

ment User Community - UDUC" was awarded to an European Consortium at the beginning of 1994, with the aim to start creating a user oriented application network in which environmental information such as numeric data, text, images, digitised maps as well as models, software tools, etc, can be shared among the interested organisations (e.g. data suppliers, thematic centres, data users, local administrators, environmental Agencies, etc.).The study is expected to end in spring 1995, the results will then be merged with the results of other studies on user requirements collection carried on by the CEO team, for which an important collaboration has been given by ISEI in the preparation and issue of the related work programmes.

Along with the development of the above mentioned UDUC study, a new Environmental and Urban Application Laboratory has been created. Dedicated hardware and software will be used to develop and test various techniques of data and images treatment, i.e:

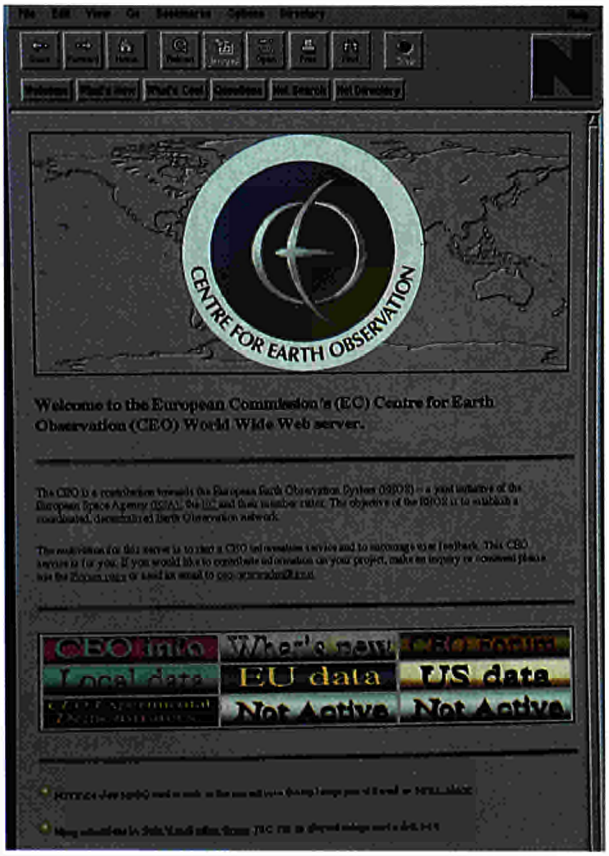

Figure 2.24. The CEO project prototype home page as seen by 'Netscape' a WWW viewer. This interface will be displayed on any workstation screen on the Internet connecting to the server. The coloured buttons provide access to a wide range of information and data concerned with the project as well as providing hypertext links to EO related sites.

- to develop a prototype User Interface for European Wide Service Exchange (CEO Project) throughout a GIS urban case study;
- to establish a standard methodology for integrating Satellite Imagery and other environmental data in a Geographical Information System;
- to illustrate the complementary of the radar and optical satellite data in Urban Applications, by merging ERS-1 data with SPOT and Landsat TM data;
- to discover and better understand the User Requirements within the EO data Users Urban Community, using the in house experience.

A contribution of ISEI in modelling the overall EO process is based on a study contract "Designing the Information Cooperative for Sharing and Analysing the Earth Observation Data - ICSA", whose aim is mainly to understand the current EO business process from users, in order to support the telecooperation between the actors, in quasi real time.

In particular the objectives of ICSA are:
- identifying information technology structures fulfilling user needs (as a contribution to Activity 3);
- designing a common user working environment which will be characterised by its interdisciplinarity, interoperability, knowledge sharing, integration with tailorable user interface, flexibility;
- understanding user requirements, identifying business processes, hinting new links between organisations towards business process re-engineering, facilitating the insertion of new users (as contribution to the use of the Activity 2 results).

The study is expected to end in spring 1995.

Pathfinder Phase Steering Committee Meetings

3 plenary meetings were held in 1994: 1-2 February, 26-27 April and 14-15 September. ISEI staff was in charge for the logistics of the 3 meetings, each one attended by about 50 persons.

Image Compression Techniques

A new release of original signal compression techniques, based on wavelet fast transforms and holographic simulation synthesis have been realised, implemented, demonstrated and tested on satellite images like NOAA, SPOT.

The work consisted of implementing a new release of the present compression software 3D comp. The experimental validation using coherent light and holographic and diffraction grating technologies has been performed in the JRC laboratory.

In the meantime the TRI-DYN hardware and software systems were connected to the CONCERTO parallel machines, and as a consequence, the 3 D comp software was implemented on the parallel TRYDIN-CONCERTO system.

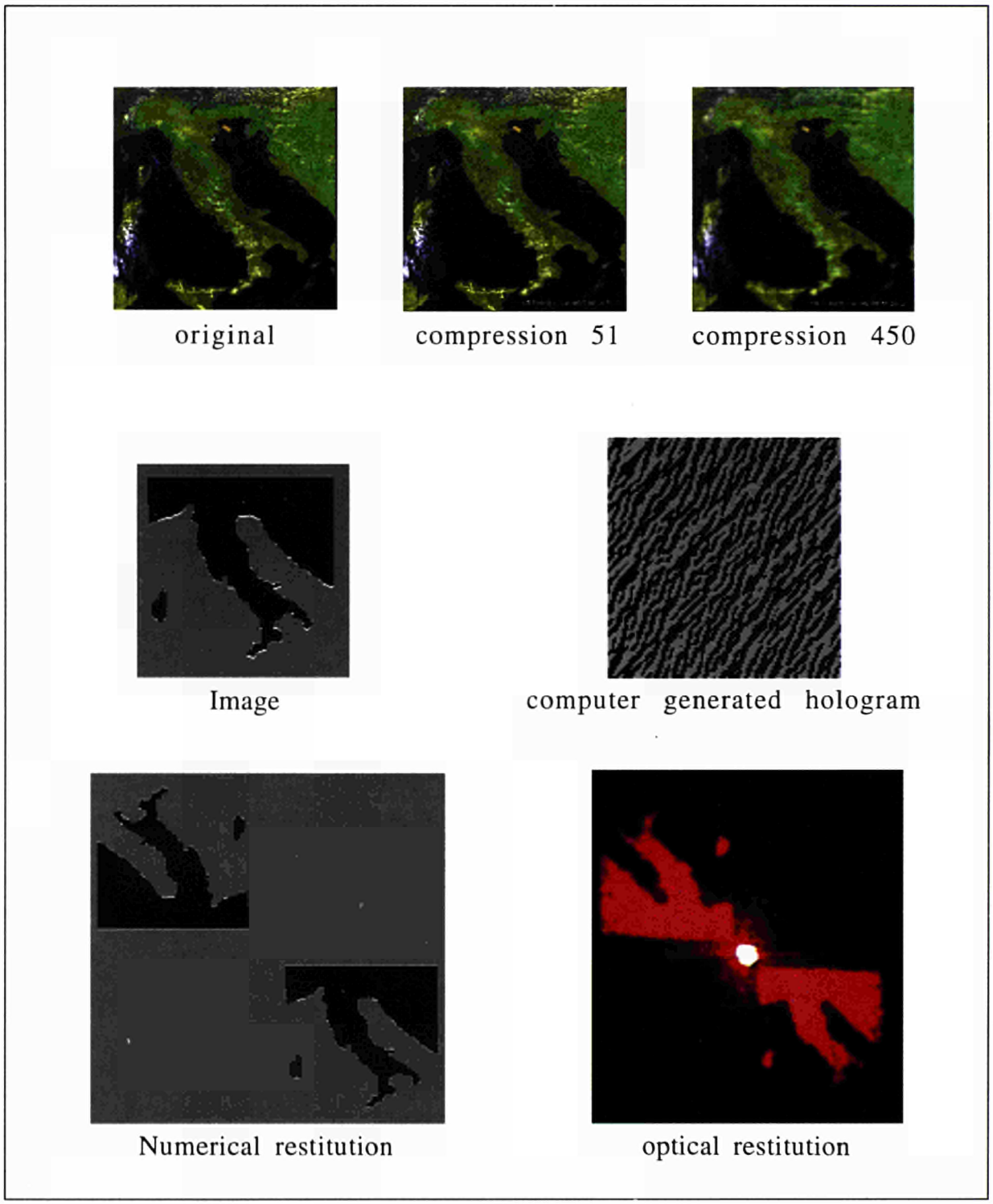

Figure 2.25. ISEI Image Compression results & coherent optical demonstration.

The special implementation realised in the laboratory demonstrated that image compression can still be achieved by a factor of 10 up to 2000.

This software has been selected to promote and establish an advanced common standard for satellite data images distribution, and will be used by a European network, the title of which is "On Line Satellite Data Archiving and Distribution Techniques".

Image and holographic compression software implemented on European massive parallel computers will be tested on a wider base in collaboration with the user communities.

Reference

J.C. Grossetie, M. Hohenadel, ELEMENTS D'ANALYSE DU SIGNAL PAR ONDELETTES, EUR Report 16250 FR, 1995.

Analysis of Global Surface Temperature Data

A large 15 Gbyte database of global surface weather data from the European Centre for Medium Range Weather Forecasting (ECMWF) has been installed on an optical juke box for the Marine Environment Unit of IRSA. This on-line database contains global temperature data each day from 1981 until 1993. An analysis of the surface area averaged temperature of the Earth /1,2/ has been performed from 1986 to 1991. This represents the daily average temperature of the Earth at 12-00 GMT each day. The data were further split into Southern and Northern Hemispheres, Polar, temperate and tropical regions. The yearly averaged data for the Northern Hemisphere show a rise of about 0.5 degrees C from 1986 until 1990, while little change is seen for the Southern Hemisphere.

An analysis of the full daily results has discovered a clear oscillation in the globally averaged daily temperatures for the Northern and Southern Hemisphere of ~ 0.2 degrees Celsius with a time period of 30 ± 3 days. The oscillation is stronger at higher and lower latitudes, and shows an anti-correlation between North and South. Some physical processes related to the lunar orbit of the Earth have been investigated. The monthly orbit of the moon causes a small movement of the earth towards and away from the sun. However, the fractional change in radiant energy seems to be too small to explain the effect (0.01 %). Another hypothesis is that there is some climatic effect caused by the monthly variation in tidal strengths. Possible systematic effects of the ECMWF data assimilation may also be involved.

The Figures below show the main results of the analysis.

References:

/1/ A Study of Global Surface Temperature Data from ECMWF, 1982-1991, C. Best, JRC Tech.Note No.I.94.21

/2/ Observation of a monthly variation in global surface temperature data, Clive H. Best, Geophys.Res.Lett.,21,2369-2372,1994.

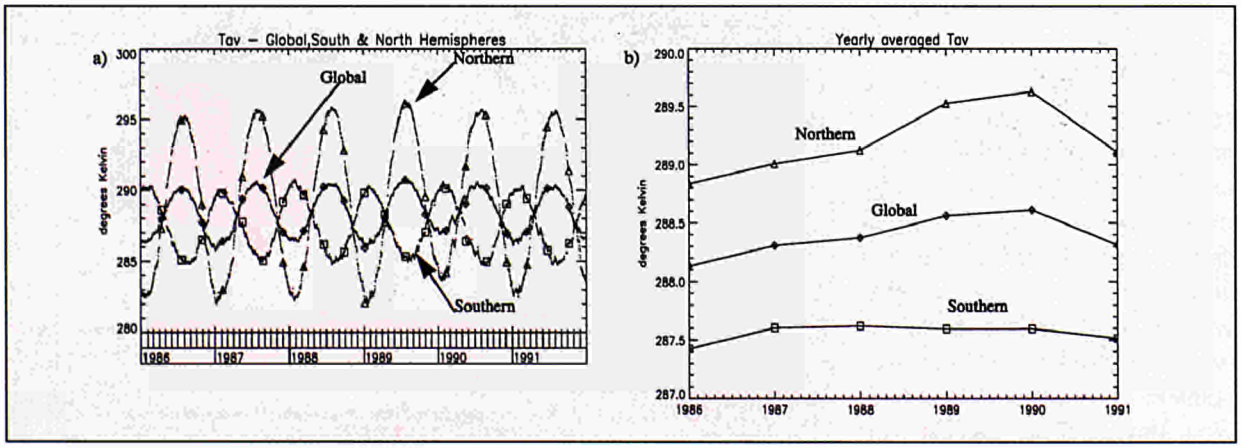

Figure 2.26. a) Daily values of the global average temperature Tav from 1986 until 1991. It is calculated by integrating the surface values of surface values of temperature T from the ECMWF forecast data archive over the surface area. The diamonds show the resultant Tav for the whole globe, the triangles for the northern hemisphere and the squares for the southern hemisphere. The amplitude of the seasonal variation is higer for the northern hemisphere, wich reflects the larger amount of land areas with a lower thermal capacity. The day to day variation is remarkably smooth with a variance of 0,05° K.

Figure 2.26. b) Yearly averaged values of Tav. A rise of about 0.5° K from 1986 until 1990 is seen for the northern hemisphere while little change is sees for the southern hemisphere. In 1991 a fall in temperature of about 0.4 und 0.2° K respectively is observed.

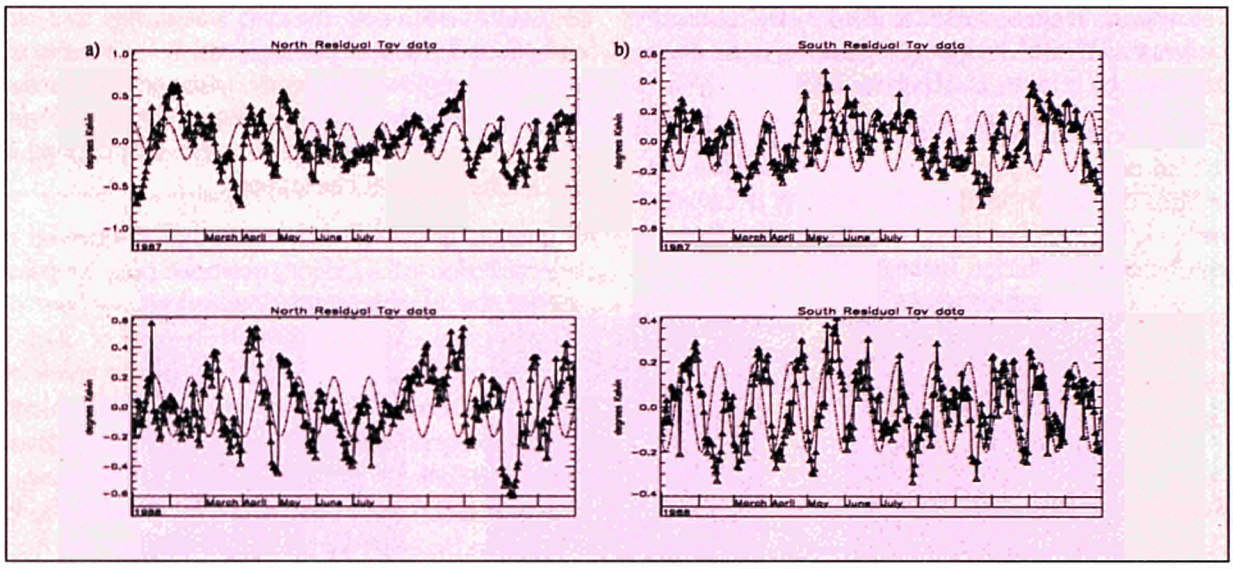

Figure 2.27.a) Residual Tav values for 1987 and 1988 after the seasonal fit has been subtracted from the data for the northern hemisphere. An oscillation with the time period of about 30 days is visible. For comparison, a cosine wave amplitude 0.2° K, whose crest coincide with the new moon is shown.
Figure 2.27. b) Residual Tav values for q987 and 1988 after the seasonal fit has been subtracted from the data for the southern hemisphere. A similar oscillation with a 30 day time period is evident. This oscillation tends to be out phase with the northern hemisphere.

Visualisation software development for Oceanographic Modelling

A 2-d visualisation program, 'HYDRA' /1,2/ for displaying results of the ISPRAMIX hydrodynamic code has been completed for IST. This program has a flexible user interface allowing users to select a 2-d slice within a volume of
Ocean. The data is displayed as contour plots or colour coded images with shaded land. Velocity fields can be displayed with or without overlaid scalar colour fields. Time sequence selection of plots can be made together with an animation facility. In this way time development of a phenomena is viewed in a natural way. The animation can be interfaced with the Digital Video system described elsewhere in this report, and recorded to video tape.

A new true 3-d visualisation program, 'VOLUME' /3/ has been developed in 1994. This program takes the full 3-d scalar fields defined within a volume of ocean, and displays the land topography together with visualisations of the scalar field. The user can select to view the field

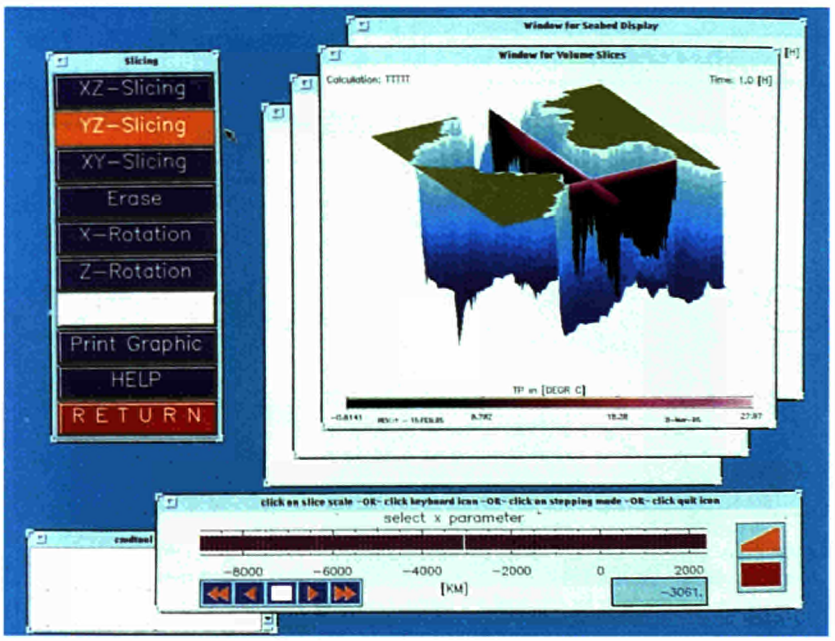

Figure 2.28. A screen shot of the program 'VOLUME'. The user selects slices through the data in X,Y and Z by using a 'point and click' icon. The resultant image is displayed in one of 3 windows. The menu provides a flexible range of display options.

in combined slices, cut-outs or as an ISO-surface. Z-buffer techniques are used to allow the user to view the image from any direction. This software is a very convenient way to have an overview of 3-d model results, while HYDRA produces quantitative plots of 2-d sections. Animation of slices is included in VOLUME and allows to visualise the full 3-d field by scanning slices, cut-outs and ISO-surfaces through the full volume.

Some example images produced by 'VOLUME' are shown in *figures 2.28 and 2.29*. The data are temperature fields for the whole Atlantic.

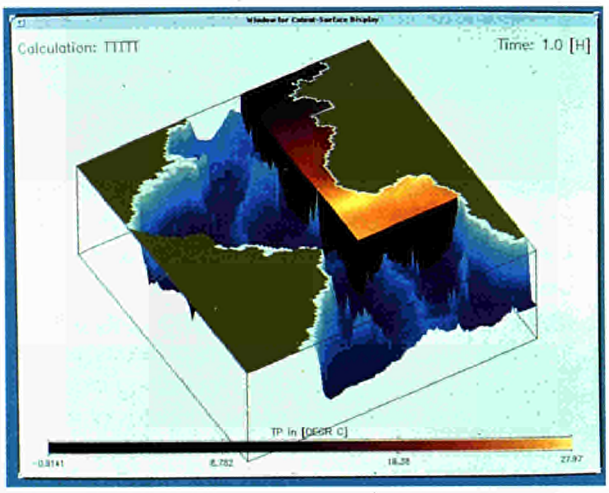

Figure 2.29. A cut-out image showing 3-d temperature profiles for the Atlantic Ocean. The user selects the cut-out region and the scalar values are coloured according to the actual data values. The land topography is taken from the data and visualised in 3-d. The user can rotate the image and animate the cut-out so that it scans the full volume of data.

References

/1/ HYDRA, Visualisation of 3-d Sea Modelling Calculations, D. Roebbelen, C. Best JRC Tech.Note No.I.94.125

/2/ Pre- and post-processor informatics tools for regional computational oceanography, W. Schrimpf, C.Best, D.Roebbelen, S.Caruso, J.Devos, W. Eifler, W. Hammans, Proceedings Hydroinformatics '94, 1994 Balkema, Rotterdam.

/3/ VOLUME 3-D Visualisation of Sea Modelling Calculations from Data Files, D.Roebbelen, C.Best, JRC Tech. Note to be published in 1995.

ENVIRONMENT/INDUSTRIAL HAZARDS

Plant Safety Management

STARS v.2 - Knowledge-Based Systems for Safety and Reliability Assessment

Building on the expertise gained from the STARS project (1989 - 1993) /1/ and from the EUREKA project FORMENTOR /2,3/, the development of a new set of software tools - called STARS v.2 - for safety and reliability purposes was started. These tools take advantage of the methodologies and modelling techniques elaborated during the course of the two projects, as well as of existing software prototypes. The overall objective of this exercise is to integrate and enhance within a single environment the various existing paradigms for the representation of industrial complex systems. These representations support a large variety of activities related to the design, operation and management of industrial systems. Particular attention has been drawn by the use of such representations to derive RAMS (Reliability, Availability, Maintainability and Safety) results.

The STARS methodology and tools have been designed to offer:

- a structured approach for system representation, improving consistency and traceability;
- full integration with knowledge and databases that can be used for capturing the general domain expertise of safety and reliability analysts;
- the possibility of incorporating system experience as well as knowledge and experience deriving from analyses of other systems;
- computer-based explicit documentation of the analysis, its underlying models and assumptions;
- a highly interactive and flexible environment for rapid creation and modification of the representations.

The STARS v.2 toolkit consists of the following tools.

- **STAXED**, Stars TAXonomy EDitor, is a general purpose graphical editor for hierarchically-structured knowledge bases *(see Fig. 2.30)*. The user has access to a taxonomy browser for editing the structure of the knowledge base, to a taxonomy item editor for the definition of the components of the knowledge base, and to dedicated editors for editing individual attributes. Full inheritance of the attributes of the taxonomy items and mechanisms to override their values are provided. These attributes are classified into a number of pre-defined types, including complex types such as graphical icon, production rule and spreadsheet.
- **XPLED**, X Windows Plant Editor, is a computer-aided design editor for modelling complex plants for the purposes of risk assessment *(see Fig. 2.31)*. This includes, for a given system, the construction of its structural and functional models, the management of these models, and their evaluation in terms of user-defined risk assessment criteria. The components of a model are instances of objects created and maintained by the **STAXED** package. Attributes can be inspected and modified by the user for further customisation in an individual model.

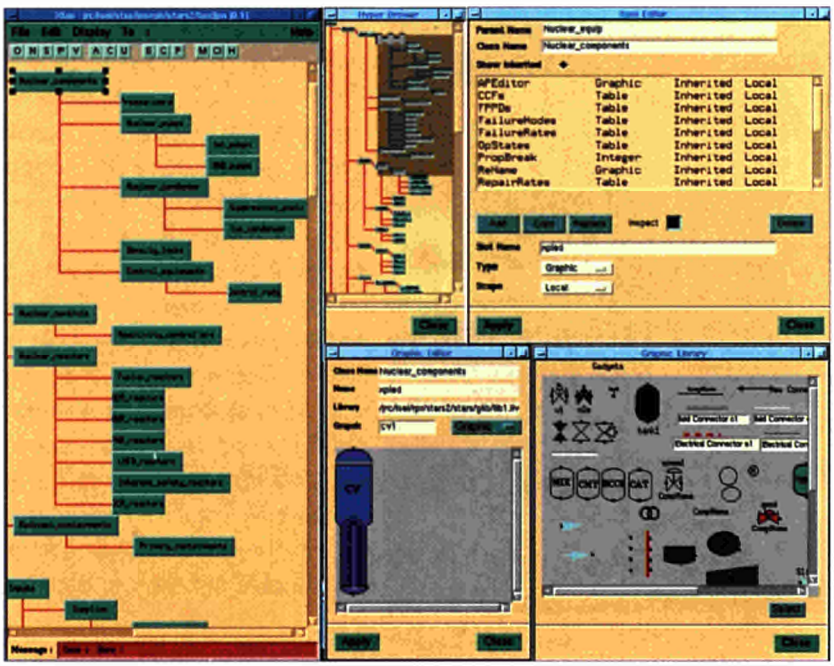

Figura 2.30. STARS v.2. Knoniledge Base Editing Tool.

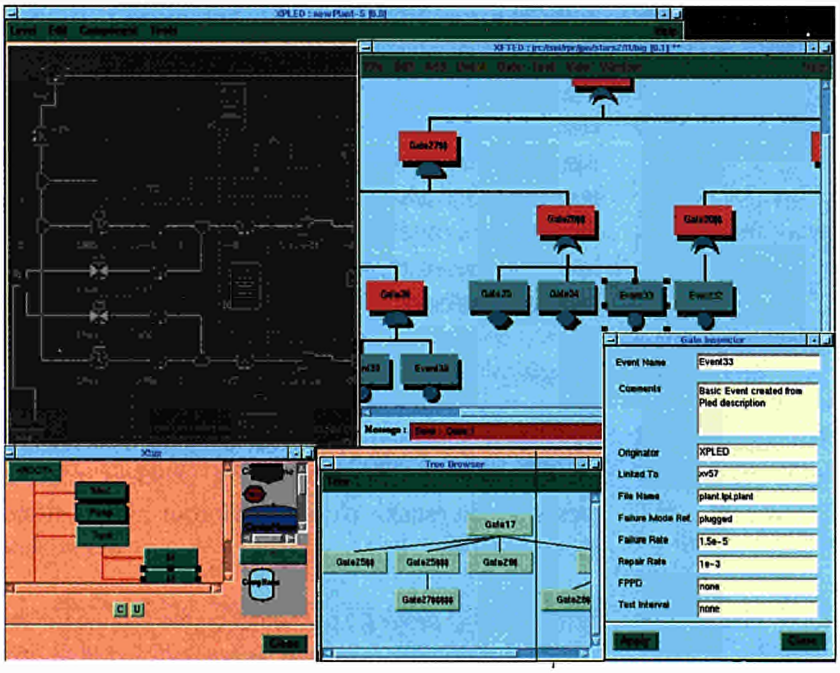

Figure 2.31. STARS v.2. Plant and Fault Tree Editing Tool.

All these tools have been validated on case studies or through intensive test procedures /4,5/, and are available for immediate use on SUN Unix platforms and under PC-Windows on personal computers. Migration to other UNIX platforms (e.g. RS-6000 and Power PC) is planned by mid-95. It is to be noted that all the software packages have been developed according to professional software engineering practices, in C++ with the use of dedicated libraries for cross-platform interface development,. This strategy has led to robust and flexible software products of a quality similar to that of commercial packages.

- **XFTCON**, X Fault Tree Constructor, is a software package for the semi-automatic construction of fault trees. The construction is based on the information available in the **XPLED** models. The construction is initiated by a top event expressed as an abnormal value of a physical variable at a specific location in a plant layout. The fault tree is constructed incrementally and displayed directly to the user who may interactively modify it.
- **XFTED**, X Fault Tree Editor, is a graphical editor for the creation and modification of fault trees *(see Fig. 2.31)*, such as the fault trees generated by **XFTCON**. Typical editing functions are available, such as modification of the structure and of the logic of the fault tree as well as of the reliability characteristics of the basic events. A powerful compress and transfer facility as well as zoom options enable the manipulation of large fault trees.
- **XFTAN**, X Fault Tree ANalyser, is a software package for the qualitative and quantitative analysis of fault trees generated by **XFTED**. The package covers minimal cut set determination, probabilistic analysis and boundary condition handling. Text file reporting and histogram representation are available. Temporal analysis of unavailability and the expected number of failures and their corresponding graphical representations are provided.

STARS v.2, and subsequent services based upon the system, have been the subject of a number of successful commercial activities in which the tools were tailored to specific user's needs for installation on site. One result of these activities has been the integration of STARS v.2 within existing industrial design environments, and its effective interface with existing CAD systems, as a privileged input stream for system representation and further RAMS studies.

Additional applications of STARS v.2 for the nuclear industry can be found in this Annual Report under the section on Reactor Safety.

Within ISEI, STARS v.2. has been used as a software backbone for a number of research activities. A brief description of these activities and of the schedule planned for the development of the related software tools are indicated hereafter.

- Extension of the modelling methodology to functional representations, and integration with the structural representation /6,7/. An independent functional model editor is already available. Full integration of the two representations will be available in a comprehensive plant editor by mid-95.
- Development of a Consequence Assessment Tool to model and analyse courses of undesired events. A number of consequence models have been developed, as well as the bases of a graphical interface to indicate the results of these models on the plant

layout. A "phenomenological event-tree" editor is under development to describe possible event scenarios, with particular attention paid to domino effects. A first stable version of the tool is expected by the end of 95.
- Development of an event tree editor and full integration within the fault-tree editor. An event tree editor is under development. Full integration is expected by the end of 95.
- Development of an FMEA (Failure Mode and Effect Analyses) editor and of algorithms based on the functional/structural representation for the semi-automatic completion of these tables. Full specifications of the algorithms are already available /8/; development of the tool is expected later this year.

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TOMHID - an Overall Knowledge-Based Methodology for Hazard Identification

An important part of safety analysis of a chemical plant is the identification of hazards. This task can be carried out at either the unit or plant level. Methods exist for hazard identification at the unit level, e.g. hazard and operability study (HAZOP) and failure mode and effect analysis (FMEA). For large chemical process plants, the effort required by these methods can be very extensive and it can be very difficult to establish a total risk survey for the plant. Furthermore, the emphasis of these methods is on identification of hazards closely related to the technical aspects of the plant and less on hazards related to the interaction between the plant equipment, the organisational structure and management factors.

The overall objective of the TOMHID project is to develop an overall methodology which can provide assistance and guidance to the user for high level hazard identification of different kinds of chemical process plants (batch reactor plants, continuous plants, mixed reactor plants).

The TOMHID project, sponsored by the CEC STEP research programme, was initiated in 1991 and ended in July 1994. The project was carried out by an international consortium: VTT (Technical Research Centre of Finland), The University of Sheffield (United Kingdom), SRD Division of AEA Consulting (United Kingdom), TRI-Tecsa (Italy), CIEMAT (Spain), Risoe National Laboratory (Denmark) and JRC.

Results from the project provide a comprehensive framework to represent a process plant as a socio-technical system. This framework includes technical, human and organisational aspects and is intended to be used as a first stage in an hazard identification process so as to identify critical areas and, consequently, the possible need for further analysis using existing methods. The final methodology consists of the following main elements:
- a functional description of the plant as a socio-technical system;
- high level hazard identification based on the Concept Hazard Analysis method (CHA);
- plant documentation comprising the functional plant models and the plant level hazard identification;
- evaluation of the safety impact of management factors on the identified hazard;
- software specification and implementation of the methods developed in TOMHID.

A specific analysis, called MIMIX, has been developed to investigate the impact of management factors on plant safety. The MIMIX analysis is performed on selected in-

cident scenarios with the intention to identify critical areas and deficiencies in plant safety management. The general philosophy of MIMIX is to apply an inductive or "bottom-up" approach starting from the events constituting the identified scenarios, assessing the managerial factors that might contribute to the occurrence of these events, and from there proceeding to more general managerial practices and principles assessing the overall Safety Management System. A dedicated paradigm for the Safety Management System has been developed /1/ and is depicted in *fig. 2.32*. A practical example of the application of the MIMIX methodology in a Petrol-Chemical industry can be found in /2/.

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FORMENTOR

The FORMENTOR project aims at developing real-time knowledge-based system software that offers on-line decision support to operators of complex plants who are faced with unusual and potentially hazardous situations /1,2/. The ultimate objective is to avoid major disturbances in a plant that could lead to any type of loss: loss of production, start-up costs related to shutdowns and in particular accident losses. As such, the scope can be categorised as "Total Loss Control" bearing in mind safety objectives as well as particular process objectives.

FORMENTOR is a project in the EUREKA program of co-operative international R&D projects (Eureka #19). The partners in the FORMENTOR Consortium are: the Institute for Systems Engineering and Informatics, Aerospatiale Protection Systems (F), Cap Gemini Innovation (F), Det Norske Veritas (N). British Petroleum was associated as application provider.

The pilot development phase of the project ended during 1993. At the end of the pilot phase, the industrial development phase was carried out and its first year was completed in December 1994. Discussions are under way between the consortium and the relevant EUREKA authorities for extending the industrial phase in 1995. Also under discussion are ways for appropriately exploiting the results afterwards.

The objective of the industrial phase is to allow the Formentor consortium to prepare itself properly for the development of full-scale industrial applications. The first such application was started at the beginning of 1994 for TOTAL, France, under the leadership of Cap Gemini. The aim is to develop a FORMENTOR system applied to a Catalytic Cracking unit of an oil refinery. Acceptance is planned for May 1995. ISEI has been attributed a particular task in this work which is

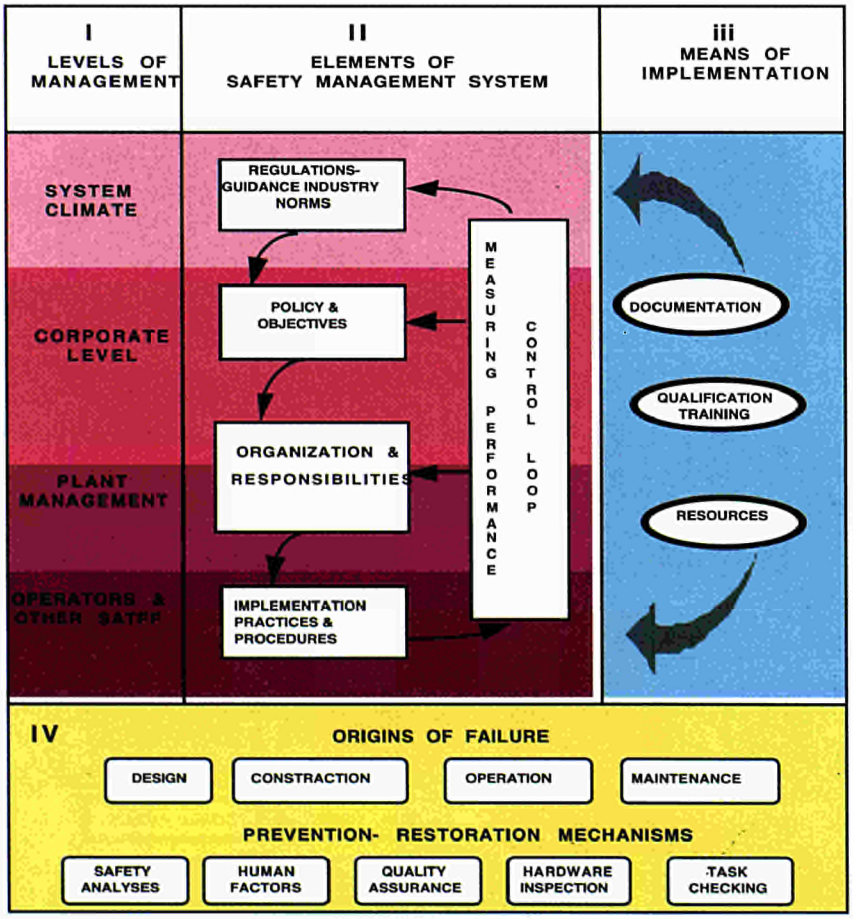

Figure 2.32. THOMID paradigm for a successful Safety Management System.

being executed under the Third Party Work (TPW) scheme.

Parallel to this industrial application development, other preparatory work was done along the following lines:

- A computer demo was developed for demonstrating the FORMENTOR methodological principles and functionalities applied to a sub-system (AFWS) of a nuclear plant *(see Fig. 2.33)* /4/;
- A FORMENTOR workshop was organised in Paris on 25th May 1994 which was attended by a hundred delegates mainly from industry;
- The possibilities of extending the FORMENTOR functionalities towards support of maintenance and safety management were investigated and positively acknowledged /3/.

In all the above activities, ISEI staff was directly involved. In addition, ISEI continued to provide the Technical Management for the project. Also, during 1994, ISEI acted as chairman of the Formentor Management Group.

Other activities performed within the consortium were mainly related to toolset packaging and integration, porting of the tools to C++, updating of the methodology handbook, development of a training package and performing a Return On Investment (ROI) analysis of FORMENTOR applications.

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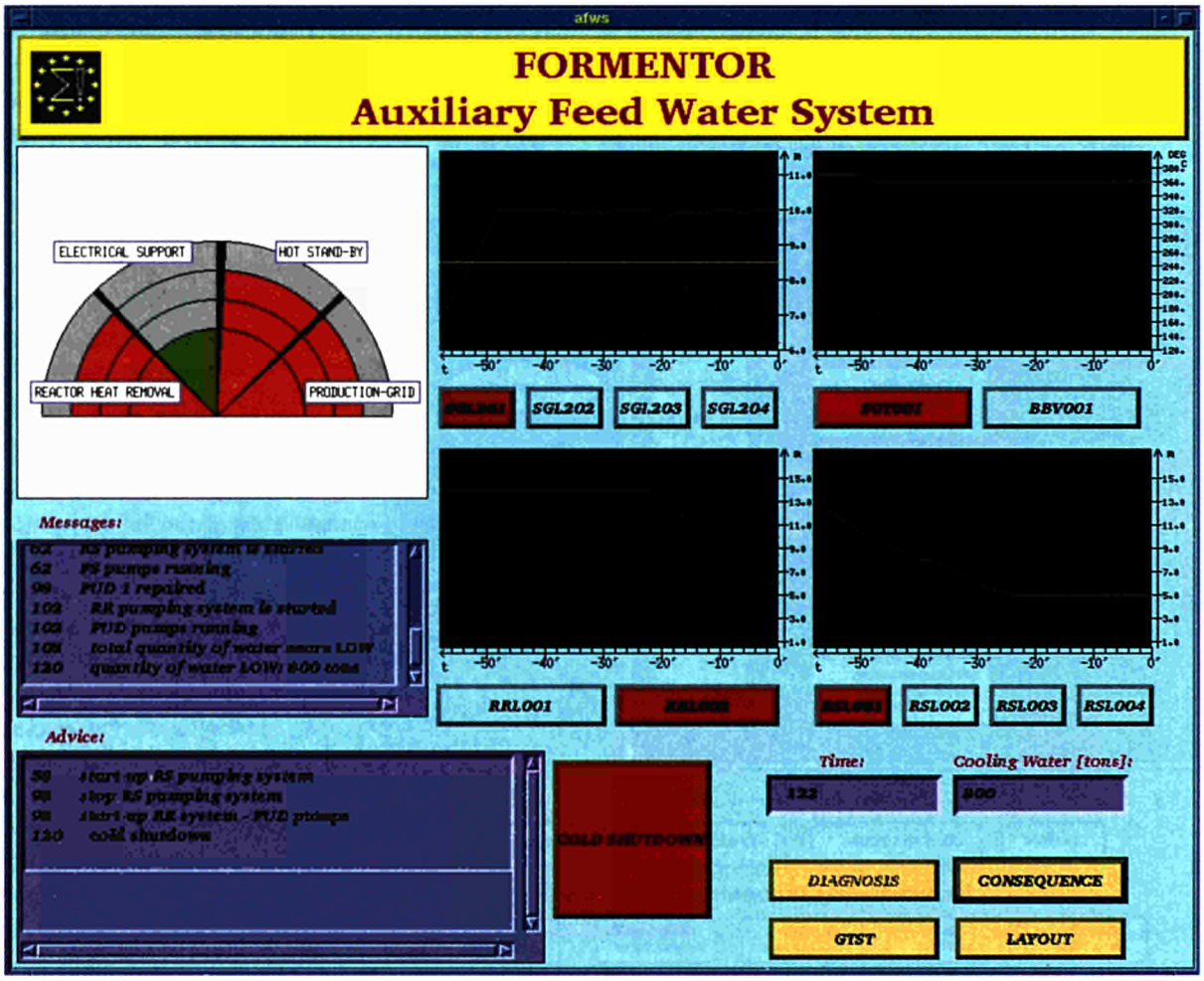

Figure 2.33. FORMENTOR: Auxiliary feedwater system.

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Environmental Management

Multi-Criteria Aid for Decision Making in Environmental Management

During the year 1994, a work was developed for the definition of a general framework for the setting up of a computer-based decision support system for the management of environmental resources. The work shows itself to be also a good background for ongoing work for third parties. In particular it represents the general outline of the POP Sicily Project A (Water Resources).

The system must allow even non-specialists easy access and efficient use of formal information treatment and management systems forming a consistent harmonisation of different models and databases which facilitate the planning and evaluation of alternative strategies in the management of environmental resources.

The system usually runs on a workstation equipped with a menu interface to communicate with the user and to connect together the various modules, models and data banks resident in the workstation itself.

A diagram which describes the general system architecture indicating its functional specifications may have general validity although referring specifically to decision problems concerning water resource management. Such a diagram may be represented by *Figure 2.34.*

In the general sense the component modules, each of which performs a specific task inside the system, are:
- the information system;
- the alternative action scenario definition and evaluation module;
- the decision module;
- the user interface.

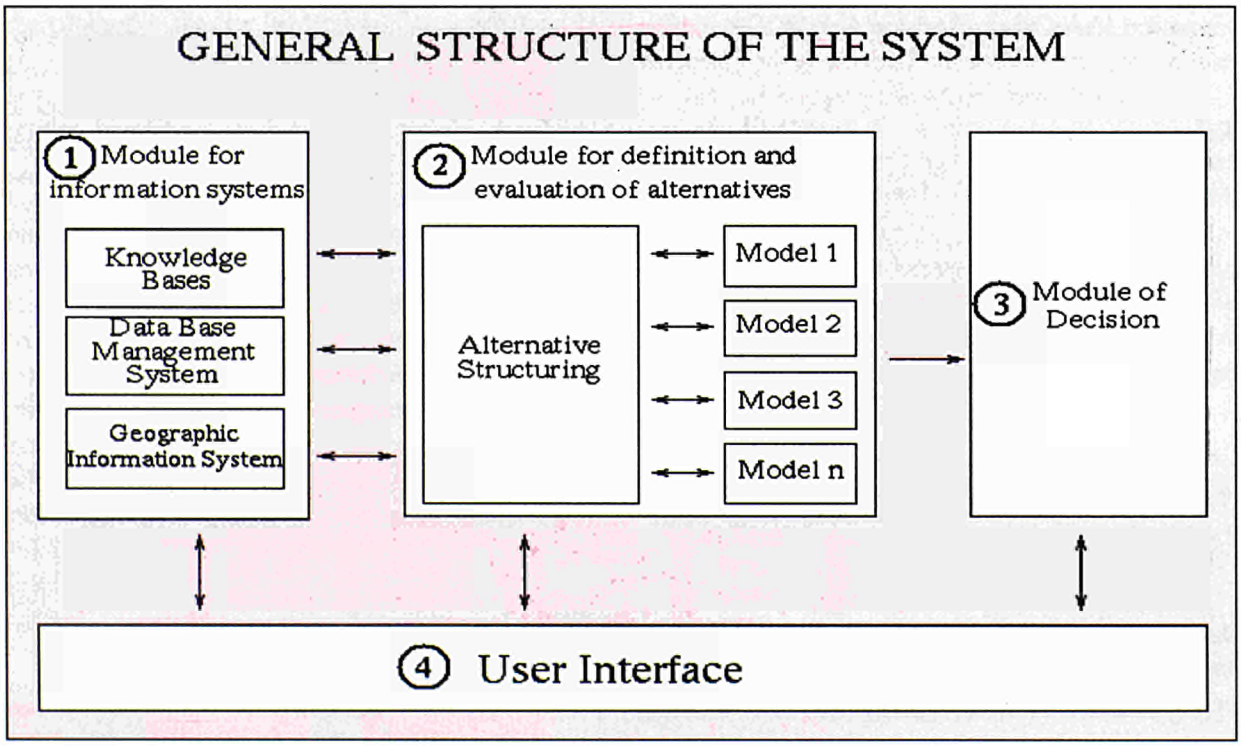

Figure 2.34. DSS scheme.

Basically the user interacts with the user interface which interrogates the other modules and, if necessary, passes control of operations to them.

The system operating scheme follows the flow of information in and out of the various modules which form it. It is based on general system information contained in the first module, made up of different and differently structured databases: possibly a knowledge base for the use of expert systems and certainly a Geographical Information System (GIS). These data can be pre-processed and, when called up by the user, shown on the screen or printed on tables and graphs. The GIS, which in particular contains and pre-processes all the spatially referenced data, normally has its own menu interfaces which can integrate with the user interface.

Regarding the decision module, the goal of criteria comparison is performed using the user preferences structure. This is a fundamental task which is implemented by different multicriteria methods, which are the object of several studies /1/. See particularly the book on multi-criteria techniques applied to environmental management /2/. The engineering and implementation of a decision support system dealing with environmental issues is presented in /3/. The basic approach was also presented at the 40th European Working Group on Multi-Criteria Decision Aid (MCDA) /4/.

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Applications of Geographical Information Systems

The complexity of environmental problems and the large amounts of diverse data to be handled in their management calls for the development of systems that can perform analyses of differing types on spatially referenced data. This work emphasises the importance of integrating different tools, in particular Multi- Criteria Decision Aid (MCDA) and GIS, that work together providing structured and flexible capabilities to support those involved in environmental management. In order to gain acceptance in the decision making process, such tools must be presented to the user through a user-friendly interface.

The main contribution of this work has been to implement one MCDA technique (the reference paint method) directly within a GIS. It has been accomplished by re-using an existing code for the MCDA algorithm and building around it a user interface that facilitates the operability of the evaluation process. The user interface completely incorporates the MCDA evaluation algorithm within the GIS windowing system using windows and dialogue boxes having a look and feel consistent with the GIS environment.

The usage of the prototype for environmental management purposes has been illustrated by applying it to an example siting problem in Lombardy (Italy). Spatial analysis has been employed to build several relevant maps, each one representing the distribution of a spatial phenomenon pertinent to siting problems. Through screening of the region the areas suitable for development were identified. Five different sites were selected and evaluated by the MCDA module through five relevant criteria. An illustration of the user interface applied to this example is given in the *Figure 2.35* which presents an example of evaluation of five site alternatives.

An application to lake eutrophication is developed with reference to the Irish lake Lough Sheelin which was once considered to be one of the finest angling lakes in Europe. The work /1/ resulted in the identification of the requirements for an improved, comprehensive, geographical information system for the catchment area including detailed information on agricultural activities and improved topographic and soil data. It also made several recommendations for management initiatives which are urgently required.

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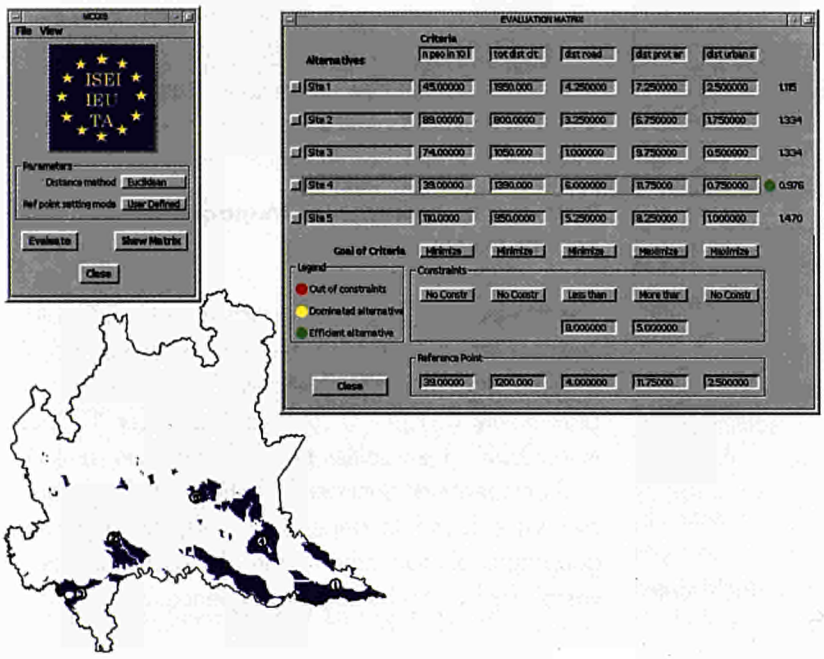

Figure 2.35. Example of evaluation of five site alternatives.

Generating Alternative Routes Uusing Genetic Algorithms and Multi-Criteria Decision Methods Within a GIS

Genetic Algorithms (GAs) have been applied to generate alternative sites for locating facilities described by points /1/2/. The present work described here extends the application of GA's to location of facilities described by routes.

In this study, a route is considered as a concatenation of points since it must be evaluated at all traversal points according to the chosen criteria mapped into raster layers. In this way the loss of information can be minimised compared with procedures where it has to be aggregated in order to reduce complexity. However, the codification of such a chain as a concatenation of single co-ordinates would lead to computational inefficiency.

Figure 2.36 illustrates the way routes are codified into bit strings. For a speed (average speed) of 120 km/h the number of bits in the string is 22 per tuple. The routes are codified as n-tuples (genes) of 6 parameters: a rectilinear extension, a sign of deflection and an angle of deflection, a curvature radius, a minimum curve extension and a sign of curvature. The analysis of these tuples is referred to the starting point and to the end of the route. The length, and therefore the number of traversal cells of the candidate path, may vary, i. e. the specification of routes will vary according to the path's length which is determined by the values of the extension parameters of both the linear stretch and the curve. The decodified route consists of a sequence of the longitudinal path's geometric elements: a linear stretch followed by a transition curve (clothoide), a circular curve and another transition curve. The *plotting* of these elements on the terrain gives the set of cells that the route traverses. In this way the route can be assessed on its technical characteristics as well as on its *geo-referenced* characteristics.

A simulation of a motor-way location problem between two target points is tested using environmental criteria and the technical parameters specified to such facilities in the Portuguese Standards for building motor-ways and main roads. The roads are designed according to the longitudinal path and the transversal path. *Table 1* summarises the suitable values for the technical parameters for motor ways' longitudinal paths.

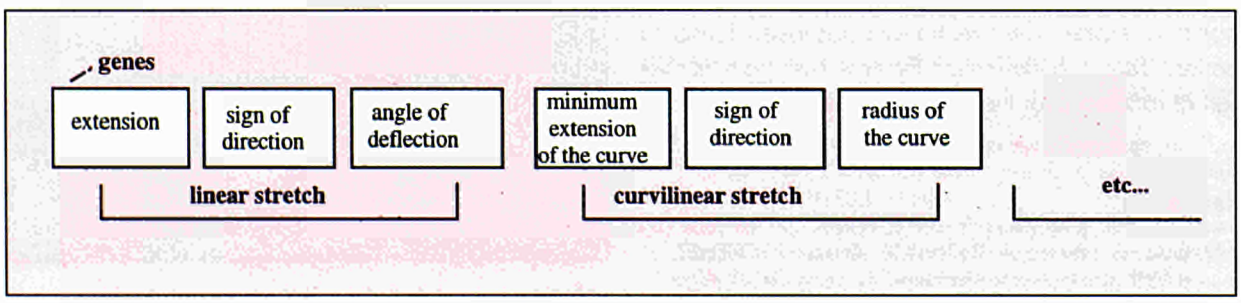

Figure 2.36. Codification of the ruote parameters using GA's.

speed basis	rectilinear	alignment	circular
km/h	maximum extension (m)	minimum extension (m)	minim. curvature radius (m)
120	2400	720	1000
130	2600	780	1200
140	2800	840	1400

Table 1 - Geometric elements and parameters of the path. Adapted from Portuguese Standars NP*-91.

For the string length it was assumed that the total length of the route could not exceed twice the rectilinear distance between the two target points and so the string will vary accordingly. Of course, this gives the rise to different string lengths.

A vector of criteria scores is assigned to each route. The aggregation of these scores is made as described earlier in this paper. Within the population all routes are compared to each others for all criteria, resulting in a *strength* measure Φ. Each of the routes in the current population, is therefore set to survive or to be replaced in the following generation. Selection is carried out as described in the earlier section. Although a sharing technique is applied for simultaneous evaluation of different peaks, it is an adopted elitist strategy that preserves the fitter individuals.

The concept of *hybrid individual* is used together with its inherent feature of being *sterile*. If an offspring route does not attain a set of initial technical conditions it is classified as *hybrid* and therefore cannot be reproduced in the following generation. This set of conditions is related to the feasibility of the route, namely to the length of the route and to the coherence of the gene sequence. This is an implementation of *veto* thresholds inherent to *outranking* methods. Crossover and mutation are applied according to the simpler model of GA's. The crossover mechanism is one point-crossover and it is done only for the separation points of tuples. This mechanism has been found to be less disruptive than when the crossover point is chosen at random over the whole chromosome.

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Risk and Environmental Management of Transport of Dangerous Goods

The transport of dangerous goods in restricted waters, coastal waters and open sea has been studied. An analysis of accident frequencies /1/ has shown approximately 0.009 - 0.07 total losses per 10^6 ship mile, 0.03 - 1 casualties per 10^6 ship mile, and 0.5 - 13 accident/incident per 10^6 ship mile. The frequencies were found to depend on visibility, brightness, geographical environment, age of vessel, and size of vessel. Further the human consequences were studied in terms of fatalities /2/. It was found that fatality curves for marine transport have a different shape than those for other transport modes *(figure 2.37)*.

The figure shows that marine accidents have a relatively higher frequency of accidents with 10 to 50 fatalities, corresponding to the number of crew members on one or two ships. Accidents from marine transport of dangerous goods leading to more than 100 fatalities have so far been collisions between oil tankers and ferries (if excluding cargo transfer accidents). A study of the environmental consequences from marine accidents

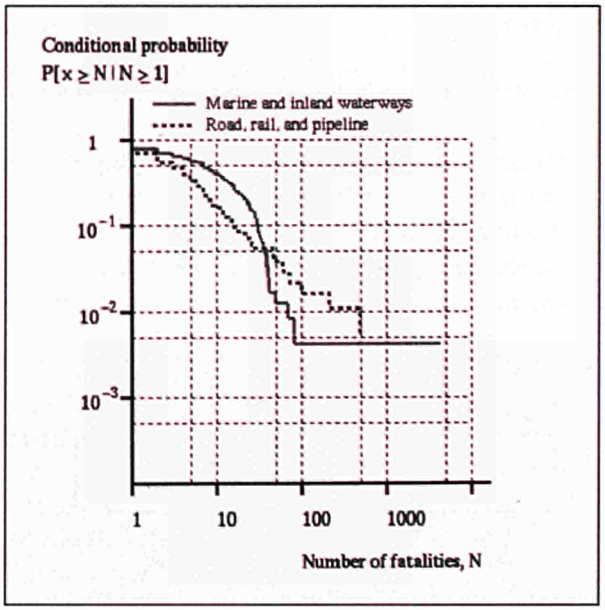

Figure 2.37. Frequency-fatality curves for water and land transport of dangerous goods.

has been initiated. Further a study of accidents on inland waterways has been initiated on the basis of 2880 descriptions of accidents occurrring on the Dutch inland waterways. These data were obtained from the Ministry of Transport, Public Works and Water Management in Holland.

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Post-Normal Science and Environmental Issues

During 1994 work has continue in the research and development of Post-Normal Science and decision-making in the context of complexity /1/2/3/.

A new activity was initiated in the area of Integrated Environmental Assessment in collaboration with DG XII-D5. Integrated Assessment (IA) approaches synthesise knowledge and information from a wide range of sources, aspects and perspectives with the aim of a better understanding of the system and of providing decision-makers with alternative options for action. RAINS and CASM are examples of the modelling modules of such policy tools.

This activity builds on the IA capabilities of the sector, complementing the already existing expertise in the methodological and socio-economic aspects of environmental issues.

Another new research line deals with international bargaining processes in environmental issues. The research aims to define some structural features that would set the basis for the description of a typology of environmental problems and the relative typology of solutions. This is done taking into account the links between the different dimensions of environmental issues according to the post-normal science approach for complex problems. The empirical part of the research focuses on airpollution in some European countries.

The purpose of this research is to analyse the international bargaining process in relation to environmental problems, in order to define a sort of taxonomy of critical attributes to be used as a support tool for decision making in environmental policy. The expected result of this research will be a set of rules based on past experience together with the conceptual analysis. These rules may help in the definition of new agreements, or in forecasting the eventual outcome of ongoing agreement processes.

International negotiations on environmental problems are necessary since these problems are in most cases characterised by a transboundary nature. Thus, a single country may not have under its own control the key means to solve the problem that affects its environment. For instance, the acid rain problem illustrates the type of transboundary issue that cannot be solved without international co-operation.

Another reason for international discussion is the absence of markets for environmental resources. The lack of clearly defined property rights over such finite resources leads to their over-consumption. Economic instruments such as marketable pollution permits, taxes or subsidies to give incentive to specific activities, are insufficient to reach the goal of protecting the environment against free-rider behaviour or over-use of the common resource. Other rules schould be set to complement economic tools, rules based not only on formal regulations such as international law but also on a collective learning leading to new attitudes and perceptions shaping a new type of society /4/.

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Safety Critical Computer Systems

There is an increasing number of situations where we depend on computer-based technology to control and manage the functions of complex and safety critical systems. The term dependability encompasses more specific notions like:

- safety - where we protect human life, property and the environment;
- reliability, availability - where we need to ensure the continuity of valuable system functions.

As a result, there is a need for theoretically sound but practical methods and tools to aid in the successful deployment of highly dependable systems with embedded computer-based components. The SCCS work performed by ISEI undertakes research related to methods for the development and assessment of such systems.

The work executed in 1994 was targeted at specific research topics and the launch of a number of related activities that will possibly form the basis of the JRC contribution to the 95/98 Framework Programme in the field of SCCS and to the support of the Information Technology line.

Since safety-critical uses of computer systems are embedded in multi-disciplinary engineering systems, it is essential to take a broad "systems approach" to the analysis of specific SCCS issues. The work performed builds on the Institute's existing strengths in systems and safety engineering and combines this expertise with software engineering aspects.

The first activity's primary aim is to gain an understanding of the complete lifecycle process of engineering highly dependable computer-based systems, from requirements analysis and design through construction to implementation and testing. In addition we tried to achieve an understanding of the failure mechanisms of software-based systems. Modelling these issues eventually allows to analyse and compare the dependability properties of different development methods. This is supported by the following sub-activities:

- Data collection and analysis of system incidents related to computer software/hardware failures. This work resulted in the development of a measurement framework and the definition of software failure concepts. Field studies on a limited set of currently available data was undertaken to validate the framework /4/;
- A case study aimed at gaining experience in the application of particular software engineering standards and techniques and at evaluating their appropriateness. The case study is related to the in-house development of the safety critical control software for a robot system (ROBERTINO). The work also allowed the study of particular safety aspects related to Robotics/5.6.7.8/.
- Requirements engineering or the identification of methods for capturing, specifying and analysing requirements for computer-bosed systems, in particular dependability requirements. In a first phase, a theoretical study investigates the possibilities of using goal-based modelling approaches for capturing and representing dependability requirements /6/.

A second activity involves developing of methods and tools for allowing safety assessment of industrial systems with embedded software components. The system integration aspects are explicitly considered and will take into account possible system malfunctions originating from software and hardware and will analyse the impact of these malfunctions on the safety of the global system. Classical system safety analysis techniques like fault-tree analysis or FMEA, and their adaptation to the assessment of software systems and integrated systems, will be considered and evaluated. Tools that support such analysis will also be considered, taking into account knowledge-based approaches /2/. The work includes state-of-the-art exploration in the field of software assessment methods.

Finally, a contribution is made to the solution of an important problem related to the engineering of knowledge-based systems (KBS) deployed in safety critical applications /1/. Indeed, a pre-requisite to the successful industrial deployment of such software systems is the assurance of their quality aspects. This work capitalises on the internal expertise in KBS development to respond to a specific technological need. In a first phase, the state-of-the-art was studied. The main problems together with approaches for verification and validation of software systems based on knowledge-based technologies were identified. This pointed out the direction for future action in this field /3/.

A working relationship was set up with the customer DG (Directorate General for Industry, Directorate F: Information Technologies, DG III/F) of the European Commission in the framework of the Institutional Sup-

port to be provided under the framework programme 1995-1998. This support work will provide services and assistance to DG III related to the dependability aspects of Information Technologies.

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FISSION REACTOR SAFETY

The 1994 effort was focused on the launching of a project for the development of a set of integrated software programmes for Nuclear Power Plant (NPP) probabilistic safety assessment and management, based on the STARS structure and living PSA concepts (set named PSA-STARS). The goal has been to develop a tool for the performance of a PSA of an NPP in an integrated and computer assisted way and for assisting the operator in safety monitoring and control over plant life.

PSA STARS project should also take benefit from other advanced techniques such as dynamic event trees and man-machine interaction modelling which could be incorporated in it as a long-term result. The PSA-STARS project was intended to be carried out on a multi-annual scale, in co-operation with national safety authorities, research institutes and nuclear industry, with the aim of creating a consensus by safety authorities, research institutes and nuclear industry on its recognition as a PSA standard at the European level.

As a result of the approval of the 1995-1998 framework programme, the ISEI activity on PSA has been re-oriented towards the severe accident-probabilistic studies, aiming at harmonising risk assessment methods by benchmarking different approaches and by networking national researches on critical PSA issues. As a result of this re-orientation, the PSA-STARS project will be, in 1995, no longer funded as direct research.

The research activities developed in 1994, together with the collaborations and study contracts established, are detailed in the following sections:

- PSA-STARS project;
- Man-Machine Interaction and Dynamic Reliability Studies;
- Feedback from Operating Experience and Data Analysis;
- Structural Reliability.

PSA/STARS

The Software Tool for the Analysis of Reliability and Safety, STARS, is an informatic environment for the automatic generation of Fault Trees and their qualitative and quantitative analysis. STARS exploits the leading characteristic of a KB system: it keeps a sharp separation between the KB, containing facts and rules, and the control strategy expressed in an inferential engine. As it was conceived, STARS main field of application was that of chemical process plants, and its adaptation to the nuclear domain was attempted in preliminary applications during 1993. In 1994 the STARS tool was extensively applied in the analysis of nuclear safety systems to constitute the basis for the development of the PSA/STARS project aiming at extending STARS capabilities beyond the Fault Tree analysis.

A number of international collaborations were activated or foreseen to carry out the project. In particular, an ongoing collaboration with TÜV (Technischer Überwachungs-Verein) has been established to assess STARS capabilities for treating nuclear systems, with the aim to first validate the STARS fault tree analyser and then the fault tree builder. Collaborations have also been established with Politecnico di Torino and Universita di Bologna.

The in-house research concentrated on the problem of handling, within STARS, dependencies and Common Cause of Failures. Indeed, nuclear safety systems are typically redundant: proper treatment of dependencies is at the basis of a correct system analysis and, if not correctly performed, can invalidate a whole PSA study.

The proper treatment of dependencies arising in an NPP is seen in the frame of a suitable modelling of the components. A preliminary methodology for the identification of implicit and explicit dependencies and their modelling at the component level has been developed and applied as a framework to build component models for the STARS KB. The information concerning the function of a component, its boundaries, its states and its failure modes is synthesised in a set of tables from which the rules used in STARS to model de-

pendencies can be simply derived. In this way it was possible to derive a knowledge-base of components suitable for modelling the main dependencies arising in NPP.

In *Figure 2.38* the model of one of the four redundant trains of the Grohnde PWR NPP is reported. The model is obtained with the new KB permitting the treatment of dependencies, indicated as connections among components represented by a dashed line. The Grohnde plant was selected for the study, being in the past the subject of a number of Reliability Benchmark Exercises organised by ISEI.

The generalisation of the concept of dependence also permits the covering, to a certain extent, the case of CCF: in this case the different combinations of failed components are coupled to a dependency generator responsible for the simultaneous failing of all the components belonging to the same common cause component group *(Fig. 2.39)*.

Man-Machine Interaction and Dynamic Reliability Studies

The activity on dynamic reliability studies and Man-Machine Interaction in general has been performed in synergy with corresponding activities in Working Environment research. The code DYLAM-TRETA, jointly developed by JRC-ISEI and Consejo de Seguridad Nuclear, has been applied to a dynamic reliability analysis of a PWR in the case of a Steam Generator Tube Rupture initiating event /3/. The study has included the implementation of emergency and operational procedures. A number of deterministic dynamic event trees (*Figure*

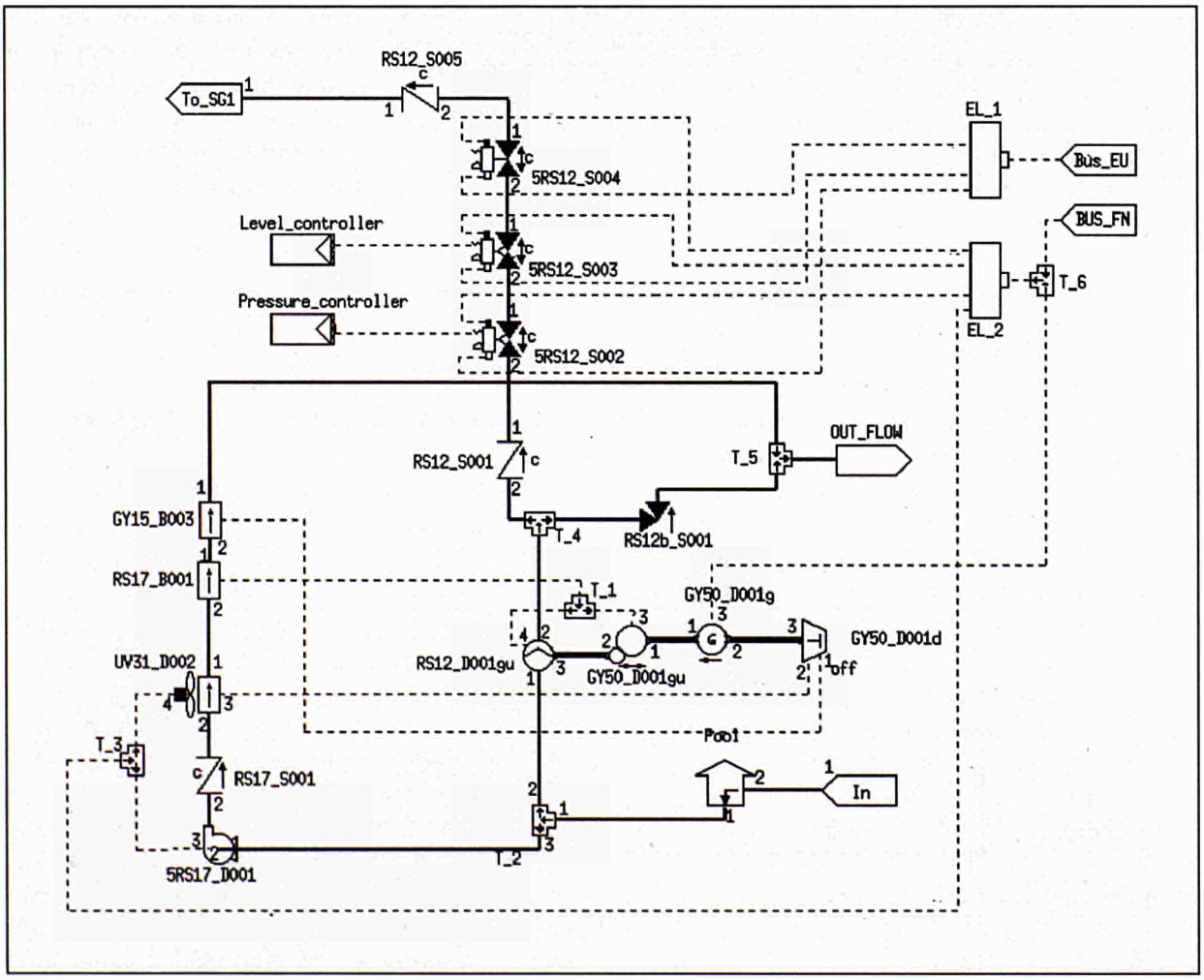

Figure 2.38. STARS model of the Grohnde AFWS with the new Knowledge Base. Dashed lines indicate connections due to physical and spatial dependencies.

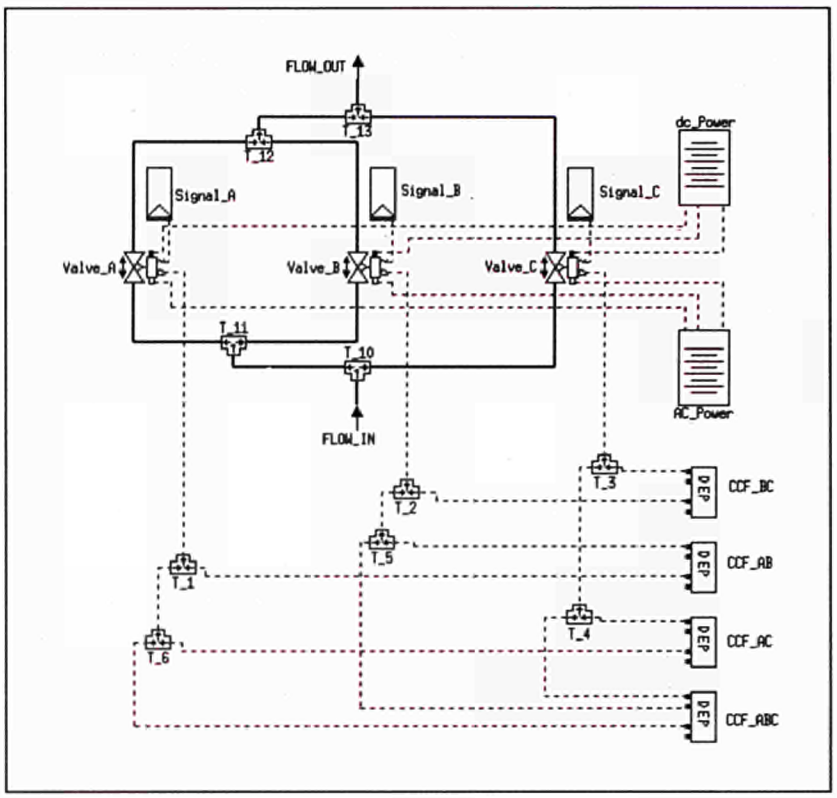

Figure 2.39. STARS model of a system with three parallel identical components subject to Common Cause Failures (CCF). CCF generators are associated to all combinations of component failure. Dashed lines indicate connections due to common cause of failures.

2.40) have been obtained, describing the effects of the component failures as trajectories in the risk plane, in which consequences are plotted versus the probability of the sequence.

The DYLAM approach has been interpreted in the frame of a MonteCarlo simulation: it has been shown that DYLAMs way of handling stochastic transitions can be regarded as an extremely biased MonteCarlo in which instead of the true failure probability density functions, proper Dirac delta functions are used; this implies that the cumulative distributions turn out to be step functions. In this way, the so-called forced collision variance reduction technique is applied in a very strong manner. Indeed the stochastic feature of MonteCarlo is practically lost at this point, with the advantage of a consistent reduction of the number of histories.

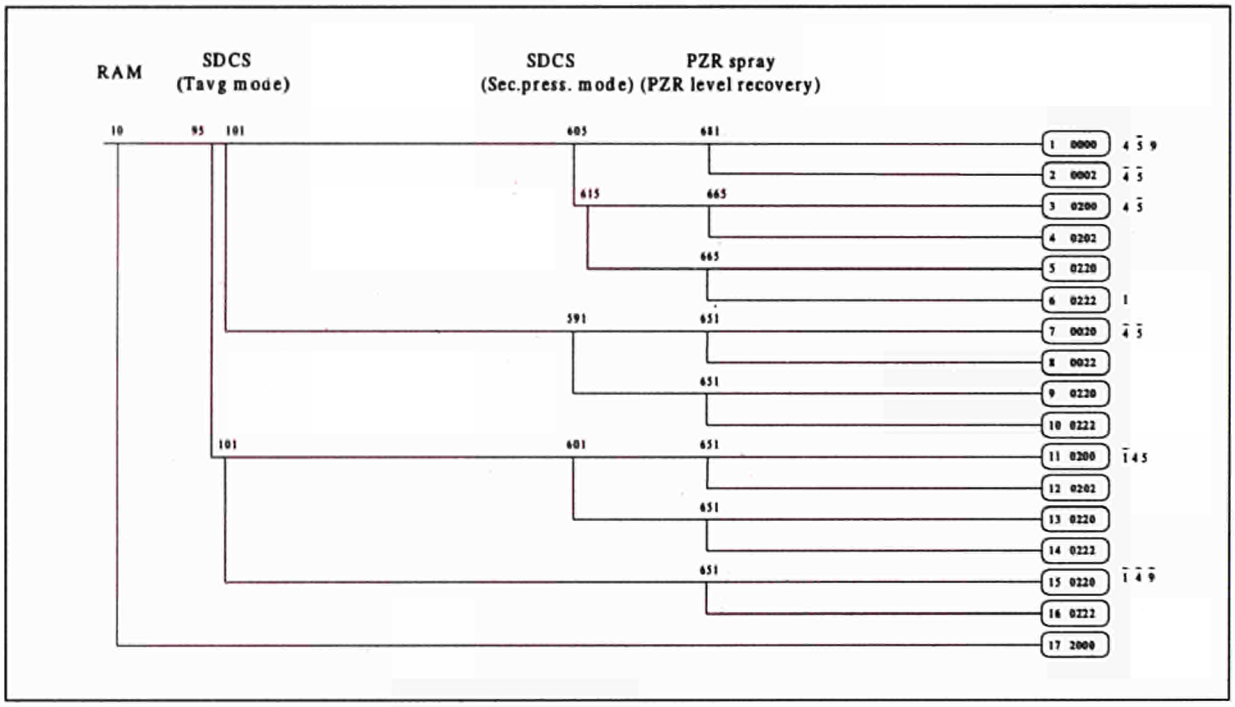

Figure 2.40. Deterministic Dynamic Event Tree (DDET) for the first 30 minutes of Transient in the case of a SGTR initiating event (Izquierdo et. al. 1994). RAM=Radiation Alarm Monitor, SDCS=Steam Dump Control System, PZR=Pressurizer.

The Human Error Reliability Methodology for Event Sequences (HERMES), especially designed for dynamic reliability analysis of man-machine systems, has been further worked out and described in a comprehensive document. The study first outlines the relations existing between safety and human factors. HERMES is then described in detail, together with its practical application to the human reliability analysis of the operation of the AFWS system of a 1300 MWe of French type. An extensive dynamic reliability analysis, performed with DYLAM, according to HERMES methodology, has then been compared with an analysis performed using the classic THERP method.

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/3/ Izquierdo Rocha J.M, Sanchez-Perea M., Cojazzi G., (1994), IV Topical Meeting on Nuclear Technology Operations and Safety. April 5-8, 1994, Hsin-Hua, Taiwan.

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Data Analysis of Operational Experience

Data Analysis

Research and application work for the data analysis requirements of the Reactor Safety Program has continued throughout 1994 and focused on three problems:

- estimation for data books;
- updating estimated failure rates from operating experience;
- sampling from large reliability databases for estimation and testing.

The two estimation problems above have been addressed in the context of the model of population heterogeneity which allows components to have different failure rates. The assessment of our work on the first problem above has developed in a bottom-up collaboration with researchers of the DER/REME group of EdF. This collaboration produced /1/, an updated joint publication which is anticipated to serve the needs of the European industry in safety and availability studies. A repertoire of prior (population) distributions for failure rates have been used for the estimation of population failure rates for components operating in petrochemical plants /2/. Work on a non-parametric empirical Bayes estimation for living PSAs accounting for model uncertainty in the distribution of component failure rates has been presented in /3/.

Data book taxonomies and validation of data stored in large databases have been proposed and implemented by "Intelligent Selections". Their automation via information theory concepts has been a graduation thesis topic /4/.

Seed research in stochastic modelling for system availability and reliability solving systems of integral equations based on the renewal argument has been presented to a wide audience of researchers in industry /5/. It was well received and it is the topic of a starting collaboration with the department of statistical sciences of the University of Padova (I).

Development of an Improved Version of CEDB for PCs

In the framework of a collaboration contract with ENEL/CRAM (the Research Centre for Environment and Materials of ENEL, the Italian Company for electricity production and distribution), a CEDB version of CEDB for PCs has been developed. The CEDB is the Component Event Data Bank developed by the JRC for an Amdahl main frame which operated at the JRC until 1992. The first version of CEDB running on a PC was developed in DB III/CLIPPER. It has the same features as the CEDB operated for Amdahl. The study of the improved version has been started. The envisaged improvements consist of:

- a more complete description of the failure event, and of the repair action;
- a more ample description of the operational characteristics of the component observed
- the insertion of a maintenance report form, to enable the description of preventive maintenance actions.

Maintenance of Various Databases Related to NPP Safety and Reliability

The following databases are available and can be interrogated by the members of JRC staff:

- Incident Reporting System (IRS by OECD);
- Power Reactor Information System (MicroPRIS by IAEA).

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Mosleh, N. Siu, C. Smidts and C. Lui, NUREG/CP-0138.
/4/ De Amicis, F. (1994). "Uso dell' entropia per il trattamento della multidimentionalità con particolare riferimento alle banche dati di affidabilita'", ISEI/IE 2758/94.
/5/ Arsenis, S. P. (1994), "On the Reliability and Availability of Systems of Parallel Components Active, Standby and in Corrective or Preventive Maintenance," in Proceedings of the ESReDA-EdF Seminar on Maintenance and System Effectiveness, ed J. Flamm, S.P.I.93.13.

Structural Reliability

Pressurized Thermal Shock experimentation on a 1/5 scale model of a PWR pressure vessel has been completed with the destructive examination of the vessel and the experimental corroboration of theoretical prediction.

The analytical tools for fatigue damage estimation, failure probability and structural reliability evaluation have been subjected to further testing and given a more user-friendly shape.

A complete review and reporting on the activities carried out at JRC in the field of structural reliability assessment and life-time prediction of the components of the Primary Circuit of PWRs has been performed by an independent body (MPA-Stuttgart) /1/. The relevant report pinpoints the synergistic effect obtained by:
- coupling of the two bench-mark exercises (on Structural Reliability and on Non Destructive Inspection methods);
- matching of results of destructive and non-destructive testing;
- matching of results of destructive testing and prediction models;
- combination of probabilistic FCG model results and experimental evidence.

Among the different topics dealt with and the suggestions given in the conclusion, the report highlights the adequacy of the existing experimental installation (PV long running tests and Pressurised Thermal Shocks) for studies on ageing of structures and corrosion or corrosion-related cracking.

References

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FISSION SAFEGUARDS

Mobile Robotics for the Remote Verification of Fissile Materials

The objective of this project is to apply mobile robotics technologies to the remote verification of advanced storage areas of difficult access to inspectors. The system consists of two main components: a vehicle carrying a manipulator arm and sensors on board, and the system operator console. Considering the application area, particular emphasis has been given to nuclear safeguard considerations as well as to the user interface.

The system hardware architecture was already thoroughly tested in 1993 /1/. The kernel of the software architecture is the communications server /2/ providing modularity at the system level, rationalising data traffic between the system operator console and the remote platform, and ensuring embedded security and safety. Major modifications were introduced in the communications server to improve its modularity and flexibility. It is now possible to change without much effort the communications server and have it tailored to a specific hardware configuration.

Figure 2.41 shows the mobile robot configured for a remote surveillance application with on-board sensors (TV cameras, laser range finder and ultrasonic sensors), and associated equipment, i.e. computer controlled pan-and-tilt-units and motorised zoom and focus lenses.

Manipulator Arm Control

A six degrees of freedom manipulator arm can be installed on top of the mobile platform. Its role is to assist the system operator in remote verification tasks. The human-computer interface for the manipulator arm was developed in previous work /3/. Recent work aimed at the investigation of semi-autonomous aids to relieve the operator from continuous manual control. Semi-autonomous operation is necessarily based on the interpretation of data from the on-board sensors, in this case, visual data from the TV cameras. The specific problem being studied is whether it is possible to use the visual data to make the manipulator arm touch a particular point, say, a switch specified by the operator.

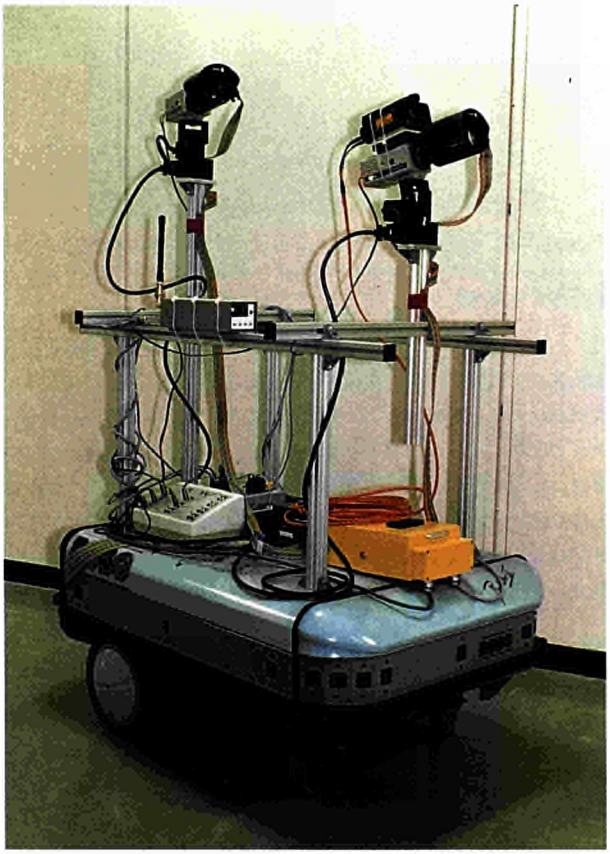

Figure 2.41. Remote verification robot equipped with TV cameras (with motorised zoom and focus lenses), laser range finder, ultrasonic sensors and computer controlled pan-and-tilt units.

The system operator looks at the live display of video images from a surveillance camera, and selects the switch to be pressed by clicking its image on the screen. A projective geometry analysis of the switch image provides a first estimate of the distance to the switch (typically less than 3 m), as well as its pose, i.e. the orientation angle in respect to the robot. The mobile robot then manoeuvres so that the manipulator arm faces the switch. A second image is analysed, and a new distance and pose are computed. The mobile robot starts a second manoeuvre and gets the manipulator arm close to the switch, i.e., less than 15 cm. At this point, the vision servo control switches to a docking camera installed on the manipulator arm near the end-effector. The arm (and camera) initiates a circular motion in order to "see" the switch from different po-

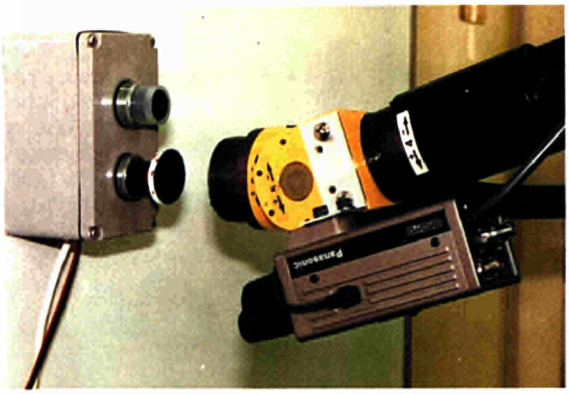

Figure 2.42. Vision-Based Control of the Manipulator Arm: The end-effector autonomously approaches a switch with its wrist already in position to press.

sitions, and consequently compute more accurate distance and pose estimates. Once this procedure ends, the arm's wrist rotates in order to be perpendicular to the switch. The arm then moves and the switch is pressed. *Figure 2.42* shows the manipulator arm getting closer to the switch with the wrist already in position.

Interactive Remote Surveillance

The mobile robot can be configured as an interactive remote surveillance system. This system is composed of:

- TV cameras, equipped with
- computer controlled motorised zoom and focus lenses, mounted on
- computer controlled pan-and-tilt units;
- human-computer interface.

The system was designed either to be part of a fixed surveillance installation, or to be aboard a mobile robot for remote verification purposes. Most of the system's capabilities stem from the human-computer interface, which allows the operator to have full control over the remote equipment. The human-computer interface integrates /4/ different functionalities onto the workstation screen:

- gaze control (i.e. pan-and-tilt orientation, and zoom and focus settings);
- camera control (i.e. image size, brightness, contrast, etc.) and
- display of live images from the surveillance cameras.

Figure 2.43 shows the interactive human-computer interface for controlling the remote surveillance system.

Figure 2.43. Remote Surveillance System: Human-Computer Interface allowing for full interactive control of TV cameras, pan-and-tilt units and motorised lenses.

Vehicle Navigation

In previous work several graphical tools were developed for steering and manoeuvring the mobile robot /5/. Those tools served the purpose of steering the robot under operator control, but did not constitute a complete architecture for navigation. To achieve this navigational architecture, the following functions, as well as the corresponding execution times, should to be considered:

- Path Planning, i.e., defines globally the path to take;
- Path Follower, i.e., makes sure that the robot follows a pre-defined path;
- Local Navigation, i.e., steers the robot taking into account its position, its next goal, and the free space around the vehicle;
- Robot Localisation, i.e., determines the robot's position and orientation in respect to an external co-ordinate framework.

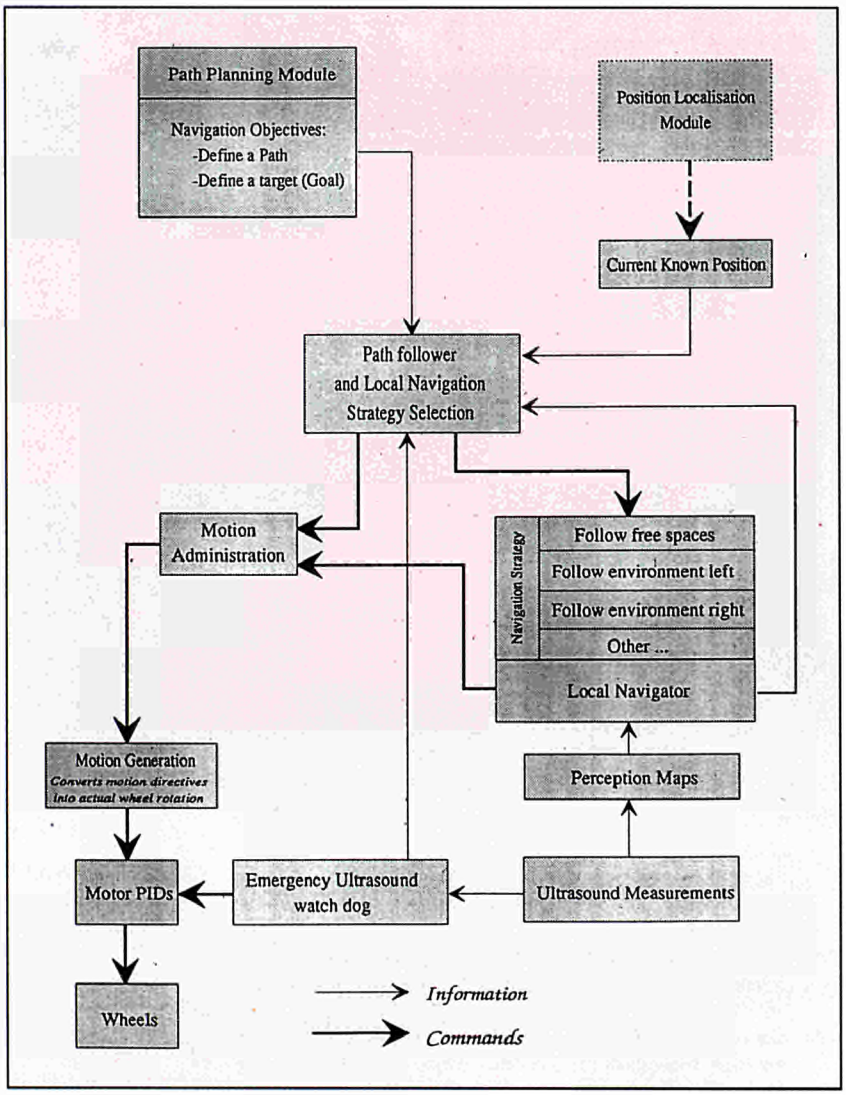

Figure 2.44. Proposed Architecture for Vehicle Navigation.

Figure 2.44 shows a proposal for the navigational architecture to be implemented. This architecture is modular and can be used in different operation modes, i.e. fully manual, semi-automated and autonomous. Low level reactive (behavioural) modules can be easily incorporated into the architecture.

Such a behavioural module is the local navigator. This module is based on the real-time computation of perception maps (updated 3 times per second) /6/ of the free space around the vehicle. A neural network is used to exploit the spatial redundancy of the ultrasonic sensors around the vehicle and to map range data into the perception maps.

The local navigator analyses the perception map according to a given strategy (programmed by the path follower module) and generates the low level motion commands to steer the vehicle. *Figure 2.45* shows the simulated trajectory taken by the mobile robot when programmed to move in a direction where more free space (as measured by the perception maps) was available.

References

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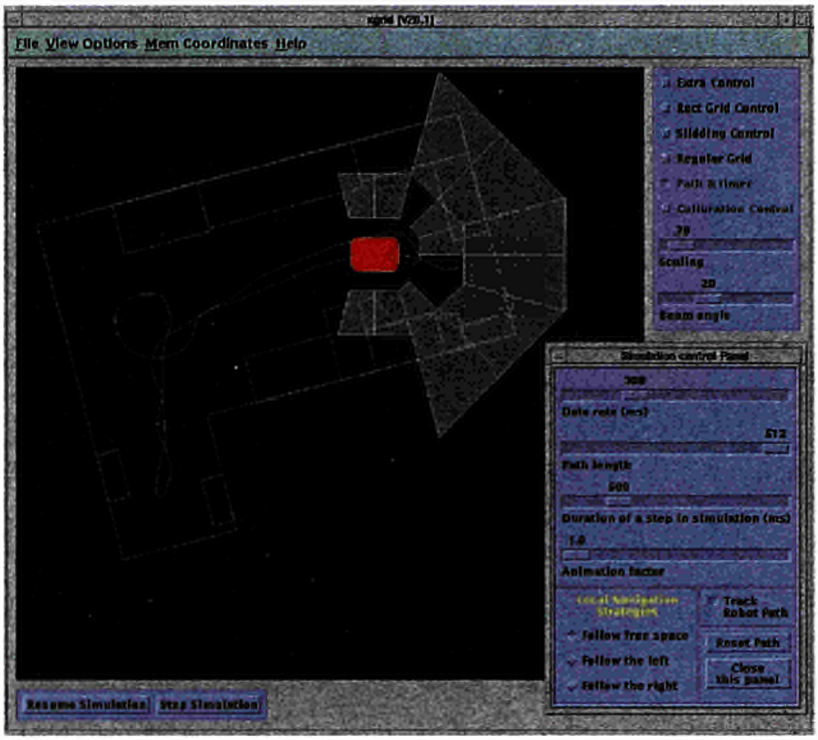

Figure 2.45. Simulated trajectory of a mobile robot when moving in the direction of available free space.

/4/ Nunes J.J., Gonçalves J.G.M. - "An Interactive Mobile Surveillance System", JRC Technical Note No. I.94.164, December 1994.

/5/ Sequeira V.A., Gonçalves J.G.M. - "Control and Navigation of a Mobile Robo", JRC Technical Note No. I.93.137, September 1993.

/6/ Santos V., Gonçalves J.G.M., Vaz F. - "Perception Maps for the Local Navigation of a Mobile Robot: a Neural Network Approach", Proceedings of the IEEE International Conference on Robotics and Automation, vol. 3, pp.2193-2198, San Diego, May 8-13, 1994.

Intelligent surveillance Camera

A new family of miniature vision systems is commercially available for machine vision inspection. Such a system contains an image sensor, framestore, microprocessor and external input/output. For time-critical applications a digital signal processing (DSP) card can be added. The integrated architecture enables a small size, similar to a conventional surveillance camera. The project consists in developing the application software for surveillance requirements in safeguards and testing the performances.

One function required in unattended surveillance is the capture of video pictures during a safeguards relevant event. The intelligent camera can execute this function locally and transmit the digital video picture to the host computer. This year the work focused on the development of the communication software between the intelligent camera and host computer, the image acquisition triggered by an external digital sensor and the storing of a sequence of images in the camera framestore. The software development is carried out on a PC-based development system and down-loaded to the camera microprocessor.

Sealing and Identification Techniques

The effort, started in 1993, for the rationalization of the software used for the identification of ultrasonic sealing-bolts has been continued. This work implied taking into account the experience gained on sites such as the BNFL facility of Sellafield (UK) with spent fuel containers (MEB) and updating the software associated with the actual operating equipment. In the longer term, this development has been planned in four phases: i) updating the existing software without changing the operating hardware; ii) upgrading the software towards more modern language; iii) replacing the current ultrasonic reading instrument by making use of a more compact and recent technology; iv) developing a database system allowing the correct handling of data to prepare and store all inspection related information necessary to HQ and inspectors.

The main effort has been focussed on the software development and on the ultrasonic hardware evaluation, so that by the end of 1994 phases i) and ii) were completed and phases iii) and iv) were at about 60% .

In 1994, an important work topic was the development of systematic methods and relative software to verify the interchangeability of various elements in our technology, in order to assure the continuity of the measurement and verification of all existing sealing-bolts signatures when the reading equipment is or will be up-

graded. Such comparison methods were successfully applied to check the interchangeability of new ultrasonic boards and to verify software, new transducers and new reading heads.

The general study launched on a sealing-bolt system suitable for dry transport/storage containers has been continued. JRC-Ispra has been approached by IAEA, EDF and EURATOM Safeguards Directorate for a preliminary evaluation of the suitability of such a system for several kinds of storages.

A support has been given to DG XII in order to prepare and to man a stand at the International ENC 94 exhibition in Lyons in October 1994. Interest for the JRC ultrasonic sealing system was expressed by several companies, among which EDF for a possible adoption in its future spent fuel storages.

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Performance Assessment of Containment and Surveillance Devices and Systems

The thermal and mechanical testing facilities available in the Laboratory for Surveillance and Containment (LaSCo) were described in detail in the 1993 ISEI Annual Report. Some more equipment now complete the facility:

- a third climatic chamber was installed at the end of 1994, with an inner volume of $1 m^3$ operating in a temperature range of -65C to 150C. This new chamber permits the testing of large systems at very low temperatures;
- a fast transient burst generator was also installed in order to start electromagnetic compatibility tests on equipment. This is a first step in the initiation of a new activity in the LaSCo laboratory, which will continue with the development of a specific test zone for qualification of devices and systems under conducted and radiated electromagnetic fields. All the tests will be conducted under the actual official tests standards such as those of IEC, or as requested by the customer.

During 1994, tests protocols have been defined and specific tests on items have been performed on:

- the Compact Surveillance Monitoring System COSMOS, developed by JAERI (Japan), for which various thermal, humidity and mechanical tests were conducted in order to verify its characteristics and to study its performances under various environmental conditions;
- the Logitec Fotoman camera used in the Gemini surveillance system. After the acknowledgment of the test protocol by the Euratom Safeguards Directorate in Luxembourg, various thermal, humidity and mechanical tests were conducted on the cameras in order to verify their characteristics under various environmental conditions.

The test programme foreseen for 1995 is the following:

- thermal and mechanical qualification of a new parabolic surveillance system based on heat flow transfer developed in the LaSCo laboratory;
- study of the performances under thermal and mechanical stresses of a Multi Channel Acquisition system by Nos-National Instruments for which a detailed test protocol was prepared and submitted to both companies;
- study of the performance of Gemini and EMOS surveillance systems under various environmental stresses;
- study of the performance of the MIVS system under electromagnetic perturbations;
- study of the behaviour of a multi-sensor surveillance system developed in the LaSCo laboratory (Ho.M.M project).

Some of the above activities are performed in support to the Euratom Safeguards Directorate and IAEA.

Demonstration and Development of Containment and Surveillance Devices in Specific Applications.

The activities performed in the Advanced Storage Area installed in LaSCo were described in the 1992 and 1993 Progress Reports of ISEI. After the first results we have optimised the position of some sensors inside of the cell. Different softwares to study the effects of these sensors were developped.

A Horizontal Multisensors Module (Ho.M.M.) has been developed, which is designed for the monitoring of the horizontal storage of plutonium cans. The module is constituted of four different sensors based on different physical principles and its function is to survey the weight and the presence of the cans and the opening

of the storage cell door. The first prototype (Ho.M.M. I) is AC powered and two prototypes with different combinations of sensors are under test. The second generation of Ho.M.M. is battery powered. Alarms, state of health of the module are recorded on a memory block inside the module. Alarms could be interrogated by connecting a portable PC to the module.

This last version of the module (Ho.M.M. II) has to be tested and implemented in the Advanced Storage Area demonstration cells.

Software has been designed and implemented on a portable unit for the calibration and routine surveillance of the Ho.M.M. I modules. Calibration data and alarms are recorded and then printed in the Surveillance Report.

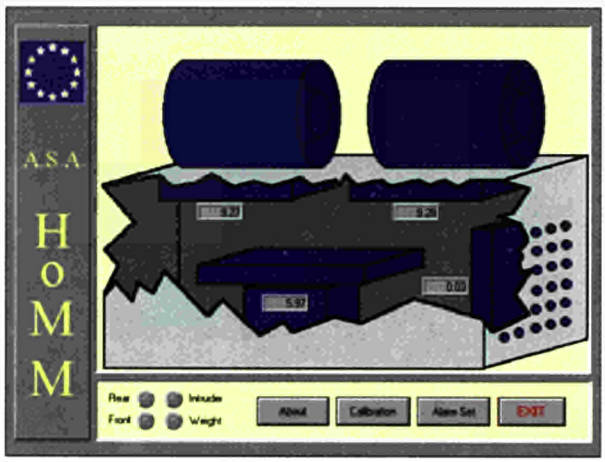

Figure 2.46. View of Ho.M.M 1.

Integration of Safeguards Techniques

This activity comprises four main chapters, respectively dealing with: I) the Analysis of the Safeguards characteristics of the Nuclear Fuel Cycle and of the R&D Safeguards Activities in the EC, ii) the management of the ESARDA Association, iii) the development of statistical tools for Nuclear Material Balance Analysis and iv) studies on volume and mass determination in liquids.

Fuel Cycle and R&D Safeguards Activities Analysis

The enlargement of the EU and the increasing contacts with the East European and the Former Soviet Union Countries have raised the need to analyse the development of the Fuel Cycles of those Countries. The existing databases have been updated as appropriate. A study has been made of the amount of nuclear materials needed for feeding the power reactors of the EU and of the FSU during the next 25 years, and also of the amounts of irradiated assemblies to be safeguarded or reprocessed in the same period. It will be published in 1995.

Management of ESARDA

A revision of the ESARDA Blue Book, containing the forecast of Safeguards needs in the EU, has been initiated in collaboration with ESARDA; forecasts will cover the next 15 years. The databases on Safeguards R&D activities in the EU are being updated as necessary. ESARDA day to day management has been continued, including the organisation of its Annual Meetings, the publication of the Bulletin of the Association, the Secretariat of the Steering Committee, of the Scientific Council and Co-ordinating Board, and of the Executive Committee.

In 1994, the JRC held the Chair of the Association. A complete review of the objectives and of the activities of ESARDA was made, and new targets were defined for its future activities. Also, a revision of the structure of the Association was completed and implemented.

In May 1994 an Internal Meeting was organised in Gent, Belgium, in collaboration with the CEN/SCK Belgium. The Proceedings were published in the ESARDA Bulletin. Two issues of the ESARDA Bulletin were published in 1994.

Statistical Tools

Modification of an existing software for Statistical Analysis of Nuclear Material Balances has been intiated, in view of transferring this software to the Russian Training Centre of Obninsk (for Inspectors and Operators of Nuclear Facilities). The new software will have an improved User-System Interface and will be tailored to the needs of teaching and training.

Mass and Volume Measurements

This activity, performed in collaboration with the TAME laboratory of IST, consists in defining an R&D programme apt to solve problems faced by Operators and Inspectors, designing the needed experiments, developing models for the interpretation of the results and performing their interpretation and evaluation. In 1994, models were developed for the thermal effects and the aerostatic effects in volume measurement; a number of experiments related to these effects were performed and interpreted. Results were published at the 1994 INMM Meeting. Contacts have been established with Operators and R&D Organisations in the U.S. and Japan, and IAEA for performing joint studies.

CONTROLLED THERMONUCLEAR FUSION/FUSION TECHNOLOGY AND SAFETY

The Fusion activities at the ISEI concern the safety aspects of fusion plants, with the objective of evaluating feasibility and acceptability of fusion energy.
These activities pertain to the following critical areas:
- Operational safety and reliability during Remote Handling maintenance.
- Structural integrity during plasma disruptions off-normal events.
- Passive safety and environmental impact of Fusion Energy.

Operational Safety and Reliability During Remote Handling Maintenance

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, by using the ROBERTINO facility, 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.

Simulation of Blanket Handling Operations
- *Blanket Handling Device (BHD) Testing*
- *Maintenance Tests on Mock-Ups of In-Vessel Components - EC Task RHI 1*

(Activity carried out in collaboration with ENEA-Fusion Sector)

Experimental Validation Activity

The final report of the tests campaign carried out during '93, for the ITER Emergency Task EC-RHI.1, was published in January '94 /1/.

Moreover, important feedback indications on the concepts of the Blanket Handling Device (BHD) and the design of the grippers tested so far, as well as on the most appropriate sensors and the control systems to be used for the BHD prototype, results include /5/:
- the definition of some additional tests, on the modified grippers and by using an appropriate load cell with 6 degrees of freedom (d o f) force sensors
- the proposal for the upgrading of ROBERTINO, concerning the drive units and the related control system, in order to improve the mechanical behaviour and the safety conditions of the facility.

On the basis of these indications, the activities carried out during 1994 can be considered as subdivided into two parts; one has been the continuation of the '93 test campaign for the BHD with related preparatory works and the other has concerned the upgrading of the ROBERTINO facility and its control system.

Preparatory Works on Sensors and an Additional Test Campaign on the BHD Concept.
These activities included:

- The setting-up and calibration of a load cell with 6 degrees of freedom (d o f) force sensors:The experience of the tests campaigns carried out during '93 indicated the importance of having on the gripper, for safety reasons, sufficiently precise and reliable indications of force used.The main difficulties are due to the fact that the gripper supports are usually too stiff for being instrumented with normal strain-gauges. In collaboration with ENEA, a first load cell of a new type, adopting semi-conductors strain-gauges has been realised. This cell constitutes highly sensitive 6 d o f force sensors system, to be installed between the facility and the grippers during the test campaign on the modified grippers. The calibration of the cell was performed in time for the '94 test campaign.
- The application of viewing systems and optical sensors:The monitoring of the Remote Handling operations at the ROBERTINO facility is usually done by using TV cameras. An image processing concept for the real position identification of the blanket segments has been developed, as a graduation thesis, in collaboration with the Politecnico of Milano. Another graduation thesis has concerned the use of an optical sensor for the correct grasping of the blanket segments, in order to allow an "intelligent" force-free matching between gripper and segment.The systems developed will be used in the new Control

System, and can be considered as contributions to the definition of a Supervision System for the Remote Handling Workstation.

- The additional tests for the BHD concept: These tests are completions of tests carried out in 1993, concerning the procedures, systems and sensors for guiding, gripping and transporting the blanket segments inside and outside the vacuum vessel, according to the "top loading" concept, where whole first wall/blanket segments are removed from the top of the vacuum vessel, through vertical access ports, with reference to the ITER CDA design. These tests, as those previously performed, were carried out in the ROBERTINO facility on reduced scale (1/3) mock-ups, after modification of the gripping tools and integration of new sensor systems.The new test campaign was mainly focused on sensor-based operation control, on handling sequences with the improved gripping systems, on preliminary timing and on procedures assessment of the real operations expected in the reactor. A set of handling experiments have been done on both inboard and outboard Blanket segments and related grippers; the results analysed in depth constitute an important contribution to the maintenance strategy of the first wall and Blanket.

Up-Grading of the ROBERTINO Facility
This activity included:

- The ROBERTINO mechanical upgrading. The specifications for a mechanical upgrading of the facility were compiled and a contract was established with an external company for such upgrading which will concern the substitution of new driving screws with ball circling nuts for the present screws with bronze nuts, and the related drive units, in order to improve the dynamic behaviour of the facility during trajectories.The mechanical upgrading, undertaken in November '94, after the conclusion of the '94 test campaign, is now in progress in order to have the upgraded facility operative from the beginning of 1995.

- The new ROBERTINO Control System (RCS). The mechanical upgrading represents an opportunity for developing a new Control System, more appropriate for the experimental requirements of the facility and, at the same time, in conformity with the most updated standards, ensuring high reliability and safety conditions. The new RCS will be based on a VXI bus with the operative system VX Works. The User Requirements and the Software Requirements Documents /3,4/ have been prepared and are being used as specifications for the software, which is being developed at JRC with the contribution of a Software Company. The development of the software will be followed as a test case in the framework of the studies for the Safety Critical Computer Systems (SCCS), foreseen inside the Information Technology Programme. The new RCS will be ready for commissioning at the beginning of 1995 in accordance with the time schedule for the mechanical upgrading of the facility.

Figure 2.47. *Simulation of withdrawal of Blanket segments from one sector of the vacuum vessel of ITER.*

Computer Simulation Studies

As result of the tests on various commercial 3D Cinematic Simulators, an appropriate package has been selected (TELEGRIP). This system will be adopted as a reference system by the Fusion Community for all numerical simulation activities. An appropriate hardware

environment has been prepared in order to have the 3D-Cinematic Simulator operational from the beginning of the next year, starting from CATIA CAD models, for simulation studies on design proposals *(see Fig. 2.47)* and, as Synthetic Viewing Master System, for Remote Handling Workstation (RHW) development.

Reliability Studies

The results of the Reliability Analysis carried out on different design concepts for the Blanket Handling Device (BHD) have been published /2/.This study has given the opportunity to identify specific reliability aspects related to Remote Handling in Fusion Machines /6/.The Safety Requirements of the Control Systems, and of the related software have been established. The reliability studies are now oriented mainly towards considering the software for robotics control, as Safety Critical Computer Systems in the framework of the JRC Information Technology Programme.

Setting up of a Remote Handling Workstation (RHW) Application at the RHW to the ROBERTINO facility - EC Task RHT.1

(Activity carried out in collaboration with KfK-Karlsruhe)

This activity is oriented to define and test an European concept of RHW for Fusion Reactors, on the basis of requirements and specifications jointly established with KfK-Karlsruhe.

A RHW prototype will be applied to the ROBERTINO facility at JRC, in parallel to the similar development carried out at KfK Karlsruhe for the RHW of the articulated boom EDITH.

The first version of the Direct Operation Interface (DOIF) has been concluded.

The development of the protocol plus communications channels between DOIF and the new ROBERTINO Control System (RCS) have been established.
?tpt=6dd>The first tests using one of the required control messages has been carried out. During the next period, the linkage between the RHW and the real time control subsystem will be accomplished.

The effectiveness of the designed man-machine interface will be checked through its daily based operation at the ROBERTINO facility. It is expected to assess and partially correct the lacks and misfeatures eventually detected during this first stage of the operation.

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Structural Integrity Assessment During Plasma Disruption Off-Normal Events

The study of electromagnetic (EM) forces caused by off-normal variations of magnetic fields in the conducting structures surrounding the plasma remains one of major items in fusion with magnetic confinement. 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 within acceptable limits the stresses caused by rapid and abnormal magnetic field variations, that occur, for example, during disruptions, in order to avoid damages (e.g. permanent deformations and vacuum losses). ISEI is working, both theoretically and experimentally, in this field.

ISEI has developed 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.

Definition of the Dynamic Loading Test Facility & Testing Programme (EUROPEAN CO-ORDINATION) ITER ETA Task EC-BLR-7

The task objective was the definition of the Operating Parameters required to confirm the performance of the ITER first wall/blanket/shield design solutions and their respective reinforcement systems against off-normal events.

The discussions were based on the ITER components design solutions available at that time (1994). Priority was given to the mechanical dynamic testing of ITER components models using the available European test-rigs.

Step-by-step investigations on mock-ups were envisaged in order to measure the expected performance of the first wall, shield-blanket, blanket attachment and vacuum vessel during off-normal and excursion conditions.

The major deliverables have been:
- summary of available dynamic analysis results in the field of off-normal operating conditions (plasma disruptions) /1/;
- identification of the testing conditions needed for the definition of mock-ups /2/;
- description of testing facilities considering the available European test-rigs /3/;
- identification of the testing programme layout based on a step-by-step investigation on mock-ups /4/.

The conclusions for each deliverable are included in the related Technical Notes. In the Final Report, more space is dedicated to the identification of the testing programme layout based on the following step-by-step investigation on mock-ups:

Stage 1: 3D Computer Simulations
Stage 2: Vacuum Vessel (W)
Stage 3: First Wall (FW)
Stage 4: Blanket Segment (BS)
Stage 5: Blanket Attachment

Dynamic Mechanical Simulation Testing of Vacuum Vessel Models (EUROPEAN CO-ORDINATION) ITER CTA Task EC-T15

This task was related to the simulation by dynamic testing of the expected performance of the vacuum vessel during disruption and vertical displacment event (VDE). The main objective was to assess the dynamic structural integrity of partial vessel models and to improve the safety features of the ITER design.

This task was anticipated by the ETA Task BLR-7 and was launched just before the ISFNT-3 Conference. During the 2nd half of 1994, the first stage of the task dealt with the first computer simulation needed to confirm the operating parameters in agreement with the last ITER design proposal. The testing conditions did mainly reproduce the off-normal operating situations encountered during plasma instability events.

A 3D CATIA model of the vacuum vessel was prepared by JCT and was transferred (Sept. 22, 1994). It represented the starting point for the development of 3D finite element models necessary for the required transient dynamic simulations in 3D electro-magneto-mechanics /5/ (*see Fig. 2.48*).

Fig. 2.48. ITER vacuum vessel mechanical model.

The dynamic electromagnetic (EM) forces induced and transferred to the vacuum vessel were investigated first on simple models and then on more complex shapes. In complement, the contents of the next stages of the present task (called T209 in 1995/1996) were prepared and discussed in collaboration with ENEA/ISMES and the Home Central Team. It has been proposed to start the experimental campaign on the basis of the following mock-ups of the vacuum vessel /6/:
- Basic models;
- Global torus model;
- Specific region model.

Reinforcement Systems of Segmented Blanket Concepts Satisfying Disruption Problematic - SEAFP TASK M6-1

The main objective was to improve the safety features of the blanket design concepts satisfying the disruption problematic. In Tokamaks, the hostile operating environment originated by plasma disruption events requires that the in-vessel components sustain the large induced electromagnetic (EM) forces without significant structural deformation and within allowable material stresses.

Therefore, the analyses of blanket reinforcement systems have been proposed to improve the first-wall/blanket/shield design concepts. In the present subtask, investigations were made on 3D CAD models of the inboard and outboard blanket regions and the related magnetomechanical simulations were illustrated.

As structural materials, stainless steel and vanadium have been considered. After the electromagnetic (EM) simulations by eddy current codes, the mechanical response of the blanket segment against the EM forces was simulated, considering different solutions of internal reinforcement systems for the segmented blanket boxes /7/:

- radial/poloidal ribs defined as vertical plates extending from the first wall to the back plate;
- toroidal ribs defined as horizontal plates connecting first wall, side walls and back plate together.
- toroidal ribs defined as vertical plates connecting the side walls and playing the additional role of shielding from the first wall to the back plate.

In general, it has been observed that the addition of internal ribs or diaphragms, for example in toroidal planes, positively affects the global deformation behaviour of the blanket segment and improves the strengthening of the first wall and blanket box. In the case of vanadium, the benefits of the electrical connection of the first wall and/or the back plate region of the blanket segments has been examined (reduction of the vertical EM resultant forces in the side walls) /8/.

As a general guideline for designers, the following conclusions were drawn:

- the combination of horizontal/vertical toroidal reinforcement ribs (second and third solutions) should be recommended;
- the ribs should be placed between the upper/lower support positions with adapted intermediate distances between them and with varying thickness from the equatorial plane towards the extremities of the blanket segment box;
- in addition, in order to withstand the local peaks of magnetic pressure that could be originated by "halo currents" in the first wall region, a specific reinforcement, e.g. horizontal and/or vertical ribs, should be required;
- finally, particular attention should be paid to the choice of the electro-insulating breaks and/or connections in order to relax the predominant box-type current loop (e.g. first wall and/or back plate continuity).

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Passive Safety Environmental Impact of Fusion Energy

During the normal operation of a fusion reactor 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 after heat). Due to the very efficient thermal isolation of the reactor, in conditions of absence of active cooling the redistribution of the initial temperatures (in the short term) and the decay heat (in the 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 demonstrating the possive 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.

Envelope Post Accidental Temperature Transient in a Commercial Fusion Reactor - SEAPF TASK A 3.2

For the purpose of predicting as reliably as possible the envelope post accidental temperature transient a bi-dimensional model of a complete sector of the reactor midplane (including both inboard and outboard components) has been developed. The geometric effects along the toroidal direction have been thus taken into account. The effects of heat propagation along the poloidal direction (i.e. through the toroidal magnets and the vacuum vessel) have been accounted for by means of additional resistors linking the inboard to the respective outboard components. The only mechanism of heat transport is that of conduction and radiation. At the external part of the cryostat natural convection to the environment is assumed. The latest operating temperatures are assumed as initial conditions.

The transient process, in general, can be divided in three distinct time scales (short, medium and long-term) in each of which the process is dominated by different phenomena. The temperature peak that is associated with the long time scale (i.e. till several weeks after the accident) is by far the most dangerous one, although it cannot compromise the structural stability of the containment. The results obtained were reported in /1-4/ for a variety of reactor configurations, including some parametric studies.

The result of this work caused a modification of the standard SEAFP cryostat by introducing ventilation by natural convection at the space between the steel liner and the concrete /3/. In such a way temperatures always remain at more or less acceptable levels for both the reference and the alternative SEAFP designs. Also, during 1994, various parametric studies have been done, mainly to study the effect of the surface emissivity on the reference and alternative SEAFP designs /1,2/.

Stability of the Be - Air/Steam reaction - ITER Task NID7a - EC task SEA 3.4

(Part of the Comprehensive 1994 ITER Task Agreement of Safety Design Tasks with the EC)

Temperature transients can influence the mechanical integrity of structural materials and significantly enhance chemical reaction rates. Both would lead to release of radioactive isotopes in off-normal events. Temperature increases due to chemical reactions (e.g. Be/Water) is another concern. This task's objective is to favourably resolve these concerns sufficient for the ESECS.

Subjects of this task are the analysis of loss of coolant accidents including Be-water and C-water reactions and the analysis of air ingress into the vacuum vessel, including Be-air and C-air reactions.

In particular, the task of investigating the ignition conditions for hot Be-air or Be-water spots will be undertaken. Close interaction with the JCT is required to ensure maximum realistic and useful results. The task does not depend on design detail but should be coherent with the current orientation of the design. Where necessary, parametric studies will be performed to capture design alternatives/uncertainties. Expected results for chemical reactions will be the determination of tolerable hot spots (size and temperature) to avoid ignition (*see Fig. 2.49*).

During the reporting period the chemical kinetics of the interaction between Beryllium PFCs of ITER and steam have been investigated and a review of the functional dependencies of the oxidation reaction rate and parameters such as temperature and steam pressure have

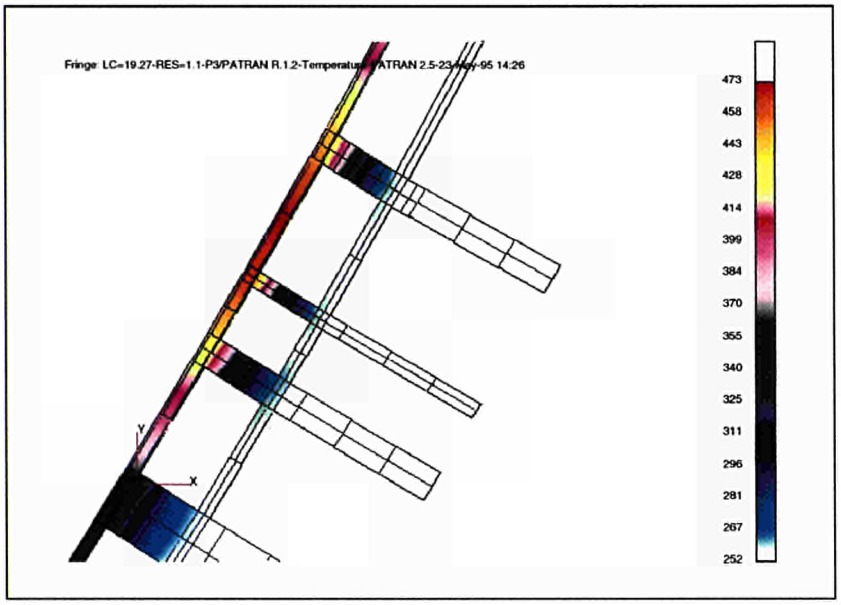

Fig. 2.49. Colour representation of the temperature spatial distribution in the area around the assumed "hot spot" after 1 min from the plasma disruption, taking into account both the volumetric decay heat and the heat of the Be-steam chemical reaction at the PFC surface.

been concluded. An integrated scheme describing the effective reaction rate and the consequent heat production as a function of temperature has been drawn /5/. The initial conditions of the transient oxidation phenomenon after a plasma disruption and a LOCA/LOVA have been investigated. A first, worst case, 1-D calculation was performed: Following a disruptive plasma thermal quench a more or less uniform energy deposition to the first wall is assumed, causing high temperatures all over the first wall. This leaves radial conduction as the only heat removal mechanism. A 2-D model of the whole vacuum chamber has being developed to study in more details the "hot spot" phenomenon and its dependencies. The results from this detailed modelling activity were reported in /6/ and /7/ *(see Fig. 2.50)*. The short-term temperature transient and the associated hydrogen production were very low while Be-ignition was foreseen only under particular in-vessel LOCA conditions without immediate plasma shut-down.

Thermal Transient Analysis for Design Guidelines and Assessments - ITER Task NID7a - EC task SEA 3.5

(Part of the Comprehensive 1994 Task Agreement of Safety Design Tasks with the EC)

The safe removal of decay heat is a key issue in all nuclear facilities. Temperature transients can influence the mechanical integrity of the structural materials and significantly enhance chemical reaction rates. Both would lead to release of radioactive isotopes in off-normal events. This task's objective is to favourably resolve these concerns sufficient for the ESECS.

The general task is the analysis of post accidental thermal transients for the whole Tokamak under various loss of coolant accidents. In particular, global calculations for reference and postulated LOCA and LOFA scenarios for ITER-EDA water/316SS/Cu option will be performed. The analysis focuses on (a) showing what combination of vacuum vessel, cryostat or in-cryostat natural circulation and surface emissivities is adequate for various LOCAs, such as how many cooling loops must be intact, as a function of maximum allowed accident temperature (500-700C), (b) showing what fraction of normal vacuum vessel and in-vessel components cooling is required for decay heat removal as a function of maximum allowed accident temperature (500-700C), (c) passive heat transfer from vacuum vessel to cryostat and environment. The analysis will provide design guidelines concerning, for instance, emissivity, "global" heat transfer, by considering uncertainties in de-

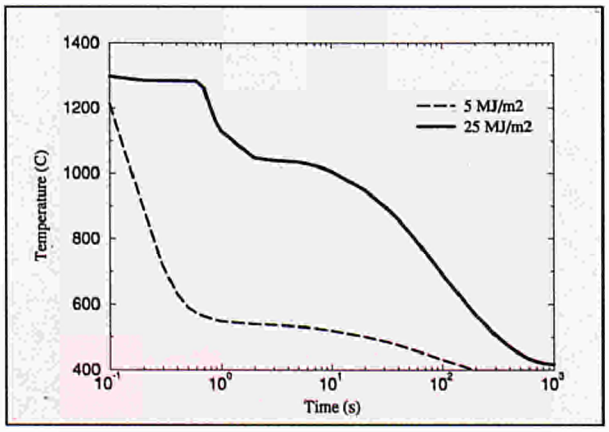

Fig. 2.50. Temperature transient of beryllium coating assuming 1 atm steam pressure, initial Be melting temperature at the surface and initial temperature profile across the first wall corresponding to 25 (5.5) MJ/m2 initial heat load on the FW due to plasma disruption. The 5.5 MJ/m2 curve remains the same even when we assume a tenfold increase of the chemical reaction rate.

cay heat and assessing gas circulation within the cryostat and vacuum vessel. Where necessary, parametric studies will be performed to capture design alternatives/uncertainties.

Expected results are the temperature histories of the first wall/blanket/vacuum vessel/cryostat for the various scenarios such as complete loss of coolant and partial cooling (vacuum vessel cooling only or natural cooling for LOFA) driven by the decay heat and chemical reactions. For the decay heat the time scale should be either several months or the time for establishing a new steady state. For chemical reactions the goal is the determination of tolerable hot spots (size and temperature) to avoid ignition.

During the reporting period the zones to be used for neutronic, activation and thermal transient calculation have been specified /8/. Neutronic and activation calculations have been completed and reported /8, 9/.

The thermal model was set up and the calculations were performed. Unfortunately, the model was too complicated and the results produced were not satisfactory. Consequently, a new 15° model was set up, which produced realistic results (*see Fig. 2.51*). Meanwhile, a different modelling approach integrating the last reactor design changes was agreed upon. This approach involves the detail modelling of only one ITER equatorial sector, the modelling of an equivalent simplified sector calibrated on the detailed one and, finally, the building of a complete 180° model out of the simplified sectors. This also makes up one part of the 1995 EU & ITER tasks and the first results are expected by May 1995.

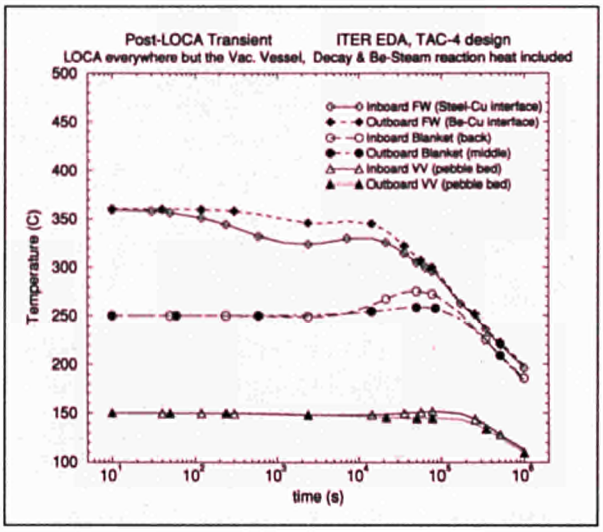

Fig. 2.51. Post-LOCA temperature transients at different parts of the ITER first wall, the blanket, and vacuum vessel (calculations done for a 15 degrees sector of the reactor, decay and Be-steam reaction heat included).

Water-cooled Pb-17Li DEMO blanket line
EU Reference conceptual design and performance presentation

The demonstration plant for a thermonuclear fusion reactor, DEMO, is presently defined as the unique step between ITER and the prototype commercial reactor. Thus, DEMO should contain the full technology of a fusion power plant and significant tests of DEMO components can only be performed in ITER.

Four breeder blanket design concepts have been elaborated and analysed in order to guide and integrate the results of the experimental R&D activities and to provide a framework for the comparative assessment of the potential performance of these blanket lines. This activity was headed by the CEA (Centre d'Etudes de Saclay).

The JRC-ISEI contribution to this activity included the calculation of the tritium control requirements and the preliminary design of the water-coolant detritiation system for all four of the blanket types considered. The critical parameters for system dimensioning and optimisation have been identified, and the available state-of-the-art processing technologies have been put in evidence and documented in /10/.

In the context of in-depth understanding of tritium control mechanisms and characterising the relevant processing technologies with regard to their impact on safety and the environmental burden of fusion power plants, numerically efficient models of hydrogen isotope separation processes have also been developed and documented /11/. Such models combine fundamental (quantum-mechanical) characteristics of hydrogen isotope phase equilibria with numerical short-cuts, allowing thus maximisation of the computational efficiency of hydrogen isotope distillation modelling (i.e. dramatic reduction of computation time and increased accuracy of results).

Systems Aspects of Safety and Environmental Characteristics of Fusion Power

An integrated analysis of the safety and environmental considerations characterising fusion power reactor systems has been undertaken in an attempt to provide a holistic perspective of fusion as a future energy source.

This has lead to new developments in two directions:
- construction of a comprehensive methodological framework for the incorporation of environmental and safety concerns of novel energy and process systems into design and development activities /12, 13/;
- identification of systemic characteristics of fusion with regard to its safety and environmental risk performance /14/, and exemplification of its considerable passive safety aspects /15/.

The results of the above analyses were well documented and communicated to the relevant scientific community in a series of contributions to a book /12/ and invited lectures to Conferences in Italy /14/ and Greece /13, 15/.

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HUMAN CAPITAL AND MOBILITY NETWORKS

SMART (Semi-Autonomous Monitoring and Robotics Technologies)

The Human Capital and Mobility Programme SMART (Semi-Autonomous Monitoring and Robotics Technologies) Research Network was approved in November 1992 and activities started officially in June 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. 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 co-ordinated projects, and by transferring technological results to industry. Several post-doc fellowships are being paid by the network.

Participating Laboratories:

- LIFIA - ADR, Univ. Grenoble, France (co-ordinator);
- University of Aalborg, Aalborg, Denmark;
- Robosoft SA, Paris, France;
- Trinity College of Dublin, Dublin, Ireland;
- DIST, Univ. Genova, Genova, Italy;
- ARTS Lab, Scuola Superiore di Sant'Anna, Pisa, Italy;
- Tecnopolis-CSata, Bari, Italy;
- Altek, Genova, Italy;
- Instituto de Sistemas e Robótica, Lisboa, Portugal;
- University of Leeds, Leeds, United Kingdom;
- University of Reading, Reading, United Kingdom;
- University of Edinburgh, Edinburgh, United Kingdom;
- Joint Research Centre - ISEI, Ispra, Italy.

The SMART Research Network organised two workshops and co-sponsored a symposium:

- SMART Workshop, 14-15 April 1994, Ispra, Italy.
- "Autonomous Navigation and Surveillance Systems", 20-21 October 1994, Bari, Italy
- International Symposium on Intelligent Robotic Systems, 11-15 July 1994, Grenoble, France.

In 1994, SMART provided pre-doc and post-doc fellowships for a total period of more than 180 man-months, 50% of which were used in promoting mobility between laboratories participating in the network.

Research work funded by SMART at the JRC is described under headings "Specific Programmes: Fission Safeguards - Surveillance and Remote Verification" and "Support to Community Policies: DG-I".

Design of Robust Human Machine Interaction

The objective of the network is to analyse and predict human behaviour interacting with complex and dynamic systems equipped with advanced controls. These studies will consider different work load conditions, changes in the work structure, and the impact of automation and Information Technology in the control of complex systems.
The network was formally started in September 1993, with the definition of the goals of each partner. In particular the objective of the Ispra team is to analyse and model human behaviour. As an example, the simple procedural simulation of a pilot and aircraft have been selected for flight control analyses.

The network is composed of 11 partners:

- Eurisco (F);
- ISEI (JRC);
- Bonn University (FRG);
- Delft University (NL);
- Technical University of Denmark (DK),;
- Human Reliability Associates Ltd (UK);
- University of Kassel (FRG);
- University of Reading (UK);
- University of Salford (UK);
- University of Valenciennes (F);
- University of Strathclide (UK).

The contribution of the JRC to the Network has been fully integrated in the Specific Programme "Working Environment", with particular contribution to the research on the modelling of human behaviour and on the analysis of human machine interaction processes.

Human Factors in Complex-Real Systems

The objective of the research is twofold:
- analysis of the co-operative work in the domain of Air Traffic Control;
- development of a method and a computerised tool for Human Factors studies.

The network was formally started in November 1993, with the definition of the goals of each partner. The work assigned to ISEI concerns the validation from the real world experience and the implementation into computerised tools for direct application. The domain of application will be Air Traffic Control (ATC).

With regard to the Human Factors studies, a methodology named HERMES (Human Error Method for Event Sequences) has been developed for retrospective studies of data collected from real accidents and for prospective analyses of consequences due to hypothetical accidents. This methodology will be further developed for ATC application.

The network is composed of 7 partners:
- ARAMIIHS (F);
- JRC-ISEI (I);
- Centre Etude Navigation Aerienne (F);
- University of Laughborough (UK);
- Technical University of Crete (GR);
- Centre Etudes Ergonomiques et Recherches Industrielles (F);
- Russian Centre for Space Control (Russia).

The contribution of the JRC to the Network has been fully integrated in the Specific Programme "Working Environment", with particular contribution to the research on the analysis and modelling of the effects of stress in Air Traffic Control.

OLOS - A Holistic Approach to the Dependability Analysis and Evaluation of Control Systems Involving Hardware, Software and Human Resources

OLOS was proposed by ISEI in May 1994 and approved by the Board of Governors on 7-8 June 1994. The network was formally accepted in December 1994 and a first plenary meeting will take place in Rome on 22-24 May 1995.

OLOS proposes a significant innovation in the dependability analysis and evaluation of safety-critical systems. Instead of regarding the human, hardware and software components as effectively independent, OLOS takes a holistic view which seeks to identify the component inter-dependencies and incorporate the evaluation of these aspects within a common framework. The objectives of OLOS are a) to develop interdisciplinary competencies, especially among young researchers, concerning global system dependability; b) to define and develop the concept of global system dependability in order that various dependability and reliability notions and methodologies can be seen to make a contribution to overall dependability; c) to promote the development of an integrated set of methodologies to be used for the dependability analysis and evaluation of those critical systems that require the combination of hardware, software and human resources.
The network is composed of 12 partners:
- ENEA, Roma (I);
- CSR, City University, London (UK);
- Vrij Universiteit, Amsterdam (NL);
- LAAS-CNRS, Toulouse (F);
- Texas A&M University, (USA);
- Universita di Siena (I);
- IEI-CNR, Pisa (I);
- Adelard, London (UK);
- LFCS, University of Edinburgh (UK);
- Universita di Roma "Tor Vergata", Roma (I);
- Computer Resources International, Copenhagen (DK) and
- JRC-ISEI, CEC (I).

The contribution of ISEI will concentrate on the specification of a methodology for the modelling of complex systems. This methodology will address in a single coherent framework the issues of hardware, software and human factors.

Diagnostics and Reliability of Composite Materials and Structures for Advanced Transportation Applications

The operative commencement date of this project was 1 Nov. 1993, with a duration of 24 months. Its objectives can be summarised as follows: implementation of non-standard diagnostic techniques (laser interferometry, acoustic emission) for assessing transportation employed composite material structures and the calibration of approaches, theoretical methods and interpretation.

The associated Laboratories which come from Universities, Research Centres and Industry are:

- Dept. of Mechanics and Materials, Ecole Nationale Supérieure des Mines de Saint-Etienne, FR, (coordinator: Prof. Alain Vautrin).
- Institut Supérieur de l'Automobile et des Transports, Nevers, FR.
- Università di Napoli, Dip. Ingegneria Materiali e Produzione, IT.
- Hellenic Aerospace Industry Ltd, Research and Development, Athens, GR.
- Dept. of Eng. Science, Section of Mechanics, National Technical University of Athens, GR.
- Dept. of Metallurgy and Materials Engineering, Katholieke Universiteit Leuven, B.
- Instituto de Engenharia Mecânica, Polo I.S.T., Lisbon, PT.
- Instituto de Engenharia Mecânica e Gestao Industrial, Porto, PT.
- Institute for Systems Engineering and Informatics, JRC-Ispra, I.

The ISEI/JRC has completed a big part of its commitments /1/. According to the regulations of the HCM program, a post-doctoral fellow was hosted and trained for eight months, Dec.93-July 94. Tensile and honeycomb sandwich panel specimens have been ordered and prepared. A composite system has been selected, which is composed of a thermosetting epoxy resin and carbon fibres T800. Mechanical tensile tests at room temperature have been carried out on unidirectional [0]8, [90]8, [90]16 and multidirectional laminates [90, 0, 90, 0]2S and [145, 0, 90]2S.

The work performed so far has focused on the utilisation of acoustic and thermal emission. The search has introduced the notion of a hypothetical 'yielding' of the composite material, which is difficult to determine from the classical stress/strain curve. The analogy between the dissipative phenomena which appear during the two emission processes is the so-called "knee behaviour". The results are encouraging, showing that the two techniques are capable of indicating the existence of such a yielding point.

The work regarding the non-destructive evaluation of virgin, artificially defected and impact damaged sandwich panels using optical methods (laser holographic interferometry, ESPI) has started only very recently, and no concrete results are available.

References

/1/ Marini, R.; Solomos, G., "Composites Strength Determination via Acoustic Emission", Tech. Note No.I.94.61, ISEI/IE/2661/94, JRC-Ispra, May 1994.

Reliability of Metal Matrix Composites

The initial list of the associated Laboratories, which come from Universities, Research Centres and Industry, is as follows:

- Chemistry of Solids Laboratory, CNRS, Bordeaux, FR (co-ordinator: Prof. M. Onillon);
- University Claude Bernard of Lyon, CNRS, FR;
- Nat. Inst. Applied Sciences, CNRS, Lyon, FR;
- National Technical University of Athens, GR;
- University "La Sapienza" of Rome, I;
- Nat. Lab. for Engineering & Industrial Technologies LNETI, Lisbon PT;
- University of Porto, PT;
- ZFW, University of Clausthal, D;
- University of Reading, GB;
- Hi-Tec Metals R&D, Southampton, UK;
- Institute for Systems Engineering and Informatics, JRC-Ispra, I.

The initiation of the networks project has experienced several difficulties due to administrative reasons, and due to the drastic reduction of the approved budget. Nevertheless, our Diagnostics and Reliability Lab has managed to go ahead according to the present research program. Given the limited resources, a post-doctoral fellow has been hosted for six months, Aug.94-Jan.95. A first exposure to the testing capabilities of our lab was provided, and a comprehensive report of the state-of-the-art on mechanical testing and NDT of MMC has been produced /1/.

References

/1/ Marini, R., "Metol Matrix Composites - The State of the Art", Tech. Note No.I.95.16, ISEI/IE/2858/95, JRC-Ispra, Feb. 1995.

Interactive Image Processing and Synthesis on Innovative Computer Architectures

Co-operation with:
- CERFACS (F)
- Victoria University of Manchester (UK)
- Rutherford Appleton Laboratory (UK)
- Bilbao University (SP)
- Besançon University (F)
- Swiss Federal Institute of Technology CSCS Manno (CH)
- Institute for Systems Engineering and Informatics, JRC-Ispra (I).

The joint activity is considered to be an advanced research programme in computer vision on innovative transputer architectures. The scientific objectives of the collaboration are:
- advanced development in interactive 3D visualisation techniques;
- new image synthesis and processing techniques including holography.

These two main scientific topics are intended to develop European collaboration in the field of:
- aeronautics and space sciences;
- earth observation laboratory.

As a final result three main topics have been realised: fast transforms libraries, image & hologram dynamic compression software, and holographic synthesis software.

All this software has been implemented on European SPIRIT working stations and on European parallel computers based on transputer microprocessors as well as on the CONCERTO CS1. For this latter point, it has been foreseen to extend the CS1 software on the CS2 machine located at CERFACS and/or at CERN.

The detailed results and activities have been implemented on the international network WWW (World Wide Web) under TCP / IP and IS available using MOSAIC protocol, the access reference is :
http: cube.sm.dsi.unimi.it / Users / imaging / HCM / home-HCM.html.

3 EXPLORATIRY RESEARCH

3 EXPLORATORY RESEARCH

Advanced Neural Network Techniques

The objective of this 1994 Exploratory Research was twofold:

- to take full advantage of the rising trend towards statistics/connectionism cross-fertilisation: study and development of the emerging techniques, then implementation and benchmarking on demanding data sets (e.g. remote sensing data);
- to perform a small parallel implementation of some connectionist models.

The second objective could not be addressed because of an unreasonably large delivery delay for the requested transputer configuration, which is now expected by March 1995.

For the first objective, work on mixed statistical/connectionist techniques has been performed on two hot topics, namely "Bayesian model comparison" and "Bootstrapping":

- *Bayesian model comparison*: Within this complex theoretical framework it is possible to have learning machines which adapt their parameters and tune their hyperparameters (e.g. smoothing constants) simultaneously during the learning phase - an important issue for connectionist models. The implementation for Neural Networks proved to be awkward, as expected, but the main obstacles have been overcome recently and the algorithm is now operational and documented. However, testing on complex data has not been done yet.
- *Bootstrapping*: This is a computer-intensive approach for making statistical inference on neural models. The method has been extensively applied to neural networks which classify pixels from satellite images into true land-cover classes. Inference was carried out on the generalisation performance. The experiments strongly suggest that the bootstrap method may successfully spare additional validation data sets, which is quite promising from an operational point of view because provision of field surveys data is by far the main resource-consuming phase for this kind of supervised classification task.

Reference

/1/ Perrotta D., Maximum Entropy Principles in Backpropagation, Proceedings Neuro-Nimes 1994.

Neural Networks for a Mobile Manipulator

The objective of this work was to use neural networks to control an integrated arm/vehicle system in the absence of a priori models of the environment. By "controlling in real time" it is meant that the neural controller processes information at high speed and that the robot learns on-line and in a few trials.

Before dealing with the integrated arm/vehicle system, this activity addressed some issues on each separate component. Concerning the vehicle, it now moves continuously and smoothly in order to reduce the amount of energy consumption. To achieve this, the neural controller processes information and learns at high speed. This work concluded our exploratory research on reinforcement connectionist approaches to rapid, safe and incremental learning of efficient navigation strategies for autonomous mobile robots /1-5/. As a result, the robot TESEO is one of the few reinforcement-learning robots in the world. TESEO is operational from the very start and improves its performance rapidly and incrementally as it safely explores the environment. To achieve this, TESEO learns on top of built-in reflexes. Also, the neural controller is a modular network which is built automatically. Each module codifies a consistent set of reaction rules. The basic reflexes are preprogrammed as simple reactive behaviour. They are used every time the connectionist network cannot generalize its previous experience to the current sensory situation. The connectionist controller associates the selected reflex with the sensory situation in one step. The sensory situation is represented by a new unit of the network and the selected reflex is codified into the weights of the controller. This new reaction rule is tuned subsequently through reinforcement learning. In this way, the connectionist network gets control (and thus suppresses the activation of the basic reflexes) more often as the robot explores the environment. Experimental results with the real mobile robot demonstrate the appropriateness of our approach to designing practical autonomous learning robots.

Regarding the robotic arm, we have adapted the architecture of the neural controller of the vehicle to control autonomously an arm robot in the case of cluttered workspaces that cannot be modeled a priori. First simulation results have been obtained on how to control the arm in the presence of dynamic configurations of obsta-

cles. At present, no classical planning-based technique can solve this kind of task. In addition, a sensing skin has been designed for the real arm. This skin is an array of range sensors attached around the arm's links, which detect obstacles in the vicinity. This sensing skin is still under development. The arm equipped with the sensing skin is one of the few existing examples of a robot arm able to sense autonomously its surroundings. An autonomous arm like this opens up new avenues for service and industrial robotics.

References

/1/ Millan, J. del R. - "Learning Efficient Reactive Behavioral Sequences from Basic Reflexes in a Goal-Directed Autonomous Robot", In D. Cliff, P. Husbonds, J.-A. Meyer, and S.W. Wilson (eds.), "From Animals to Animats III: Third International Conference on Simulation of Adaptive Behavior", 266-274. Cambridge, MA: MIT Press. 1994

/2/ Millan, J. del R. and Torras, C. - "Efficient Reinforcement Learning of Navigation Strategies in an Autonomous Robot", Proc. of the IEEE/RSJ International Conference on Intelligent Robots and Systems, Special Session on "Learning and Mobile Robotics", pp. 15-22. Munich, Germany. 1994. Invited paper. (Also in V. Graefe (ed.), Intelligent Robots and Systems 1994. Amsterdam, The Netherlands: Elsevier Science Publishers.)

/3/ Millan, J. del R. - "Reinforcement Learning of Goal-Directed Obstacle-Avoiding Reaction Strategies in an Autonomous Mobile Robot", Robotics and Autonomous Systems, Vol. 15, No. 3. 1995. Special Issue on "Reinforcement Learning in Robotics". Invited article.

/4/ Kaiser, M., Klingspar, V., Millan, J. del R., Accame, M., Wallner, F., and Dillman, R. - "Achiving Intelligence in Mobility: Incorporating Learning Capabilities in Real-World Mobile Robots", IEEE Expert. 1995. Special Track on "Intelligent Robotics Systems".

/5/ Millan, J. del R. - "Rapid, Safe, and Incremental Learning of Navigation Strategies", IEEE Transactions on Systems, Man and Cybernetics. 1995. Special Issue on "Learning Approaches to Autonomous Robots Control".

Adding Values on the Workflows Model by Using Multimedia Groupware

The main input of this project was provided by the PCs based groupware laboratory which implemented different groupware systems for supporting and analyzing the cooperation within the work processes team. The main focus of this project is on a specific class of groupware: workflow systems (e.g. Action Workflow System /1/ (AWS). These systems are characterised by both steps of modelling and consistency checking before running, in real time, the processes that have been modelled. It is well known that workflow systems focus on the coordination between different members of process teams. It is also well known that workflow systems are asynchronous in general.

The project aimed to "suggest a pluridisciplinary methodology first for identifying and then distributing the added-values by using multimedia groupware. This new methodology will improve the workflows technology because it extends its use to the re-engineering step" /2/. Note that by re-engineering, it is intended to "augment the added values on the workflows model in order to augment the co-evolution both between the participants themselves and between the participants and the business process (i.e. the dynamic shared knowledge about the business process itself)".

In the following, the three main outputs of this project are described; the main requirements for the multimedia groupware were adding both voice and video media to the regular textual based workflow systems. Three packages which are LAN /3/ based were integrated within the laboratory for this purpase:

- Fujitsu's DeskTop Conferencing (DTC) version 1.4 for sharing, one N-to-M basis, applications;
- VocalChat (VC) version 2.0 for sharing, on a one-to-N basis, voices;
- Personal ViewPoint (PVP) version 1.4 for sharing, on a point-to-point basis, video.

Then, these independent packages were regrouped within one Video Conferencing System (VDS) in order to integrate a flexible management of text, voice and video. However, no synchronization between voice and video is insured using VDS except by using the regular telephone.

A paint-to-point videophony system has been integrated within the laboratory. The system results from two consecutive ESPRIT projects in which both British Telecom (BT) and Olivetti were involved. The hardware and software parts are commercialized by BT and by Olivetti, respectively. The system entitled Personal Communication Computer (PCC) is under version 2.1. PCC is ISDN /4/ based and it integrates text, voice and video media. The merging between both desktop video-conferencing synchronous systems (like VDS and PCC) and workflow asynchronous systems (like AWS) has allowed the methodology to suppart:

- the design and the redesign (in the case of re-engineering, for example) phases of our methodology, in participatory mode;

- the reviewing process, recommended by ISO /5/ 9000 standards, of the results both designing and redesigning the phases, in both participatory (when both reviewers and reviewees are active) and active/passive (when only the reviewers are active while the reviewees are watching) modes.

VDS is based on constructors standards while PCC is based on H.320 and T.120 standards of the ITU /6/. However, VDS and PCC are incompatible because of the conflictual video boards and protocols. H.320 standards used in PCC should allow its compatibility with a studio video-conferencing system. Because of studio video-conferencing unavailability within our organization, this action has not been tested yet.

An infrastructure for teleworking which augments the capability of the participatory mode over the PSTN /7/ is under testing.

The result of this project will be used within the "Designing the Information Cooperative for Sharing and Analyzing the Earth Observation Data (ICSA)" project which aims to deliver a demonstrator of a methodology supporting the analysis and the re-engineering of business processes from different application domains of the Earth observation field.

References

/1/ ActionWorkflow is o TradeMark of Action Technologies, Inc
/2/ This part is extracted from the 1994, Annual WorkSchedule that was proposed in December 17th 1993.
/3/ LAN stands for Local Area Network
/4/ LAN stands for Local Area Network
/5/ ISO stands for International standards Organization.
/6/ ITU stands for International Telecommunication Union. It substitutes the previous Consultative Committee in International Telegraphy ond Telephony (CCITT).
/7/ PSTN stands for Public Switched Telephone Network

Advanced Visualisation of Dynamic Scientific Data

The objective of this project is to develop techniques for representing and animating multi-dimensional time dependent data. Digital video based on image compression is used. Various scientific visualisation techniques are being used to represent multi-dimensional data. The methods are being applied to remote sensing data, oceanographic modelling and computational fluid dynamics.

During 1994 a digital video animation system /1/ was developed based on the JPEG and MPEG compression systems. A system for preparing and editing sequences of images for video production was developed /2/. This system allows for the production of Video titles and includes special effects like fades and zooms. It has a multi-track facility which allows several movies to be played together.

The production of single frames uses the above mentioned techniques of scientific data visualisation. To visualise the results of computational fluid dynamics and oceanographic modelling special purpose graphics programs have been developed. These interact with a database containing the model results and allow automatic frame generation of colour representations of scalar and vector fields in 2 and 3 dimensions.

Ray-tracing software has been applied to realistically render remote sensing and geographic data.

Animation videos have been produced for the following applications:
- 10 years of vegetation index for Africa, MTV unit IRSA;
- Sea surface temperature data, ME unit IRSA;
- Ocean colour (phytoplankton activity), ME unit IRSA;
- Oceanographic modelling results, STI;
- Computational fluid dynamics, STI;
- 10 years of world meteorological data, ECMWF.

Several video presentations of the work have been shown at international meetings. MPEG versions of the animation have been placed on the World Wide Web for public access. These have proved extremely popular, and during 1994 about 10,000 different users connected to view these movies.

References

/1/ A Digital Video Animation System for Scientific Data Visuolisation, C. Best, C. Macmillan, JRC Technical Note No. I.94.03
/2/ VEDIT, a Digital Video Editing System, C. Macmillan, JRC Tech. Note No. I.94.151.

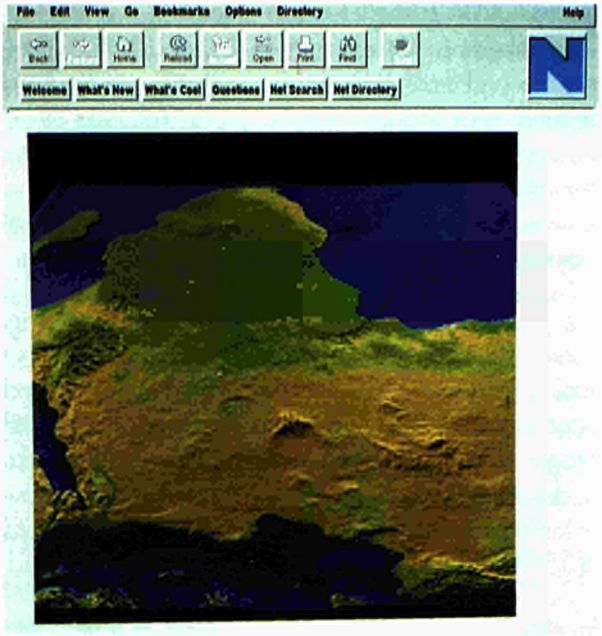

Figure 3.1. A ray-traced 3-d rendering of AVHRR/GAC Normalised Difference Vegetation Index data draped over a digital terrain model of Africa. The data were processed by the Monitoring Tropical Vegetation (MTV) unit of IRSA. A computer generated fly-over of Africa showing dynamic vegetation growth over a 6 year period has been produced. The photograph shows 'Netscape' viewing the image acquired on the World Wide Web.

Numerical Stereophotogrammetry and 3D Graphical Animation

The activity has been aimed at the achievement of the following results:

- creation of a 3D CAD model from a set of point co-ordinates or a DTM (Digital Terrain Model) supplied by a digital stereophotogrammetric system or a laser scanning system;
- fusion of two or more 3D CAD models into a global, realistic model of the inspected monument or building;
- virtual reconstruction of lacking parts of the monument.

The first two objectives have been achieved with the numerical programme MODCAD /1/, able to create a complete 3D model from two or more partial models and starting from databases of points in orthogonal, cylindrical or spherical co-ordinates.

The third objective has been reached with the development of the TRASMOD /2/ numerical programme, which is now in an advanced phase of testing.

References

/1/ Rochez, E.P. "Programma per la generazione di modelli 3D CATIA da un database di coordinate di punti" Techn. Note No.I.94.95, ISEI/IE 2745/94

/2/ Rochez, E.P. "Programma per la modificazione e la elaborazione dei modelli 3D CATIA generati da MODCAD" (Technical Note in preparation)

Quantitative Evaluation of Local Correlation of Laser Speckle

When the surface of an object is illuminated by laser light, its image shows a granular appearance known as speckle. Micro alterations of the surface induce modifications of the speckle image and consequently a decorrelation between the speckle images taken before and after modification took place. We have experimentally proved that the quantitative estimation of local speckle decorrelation can be used to detect and measure surface alterations of the same order of magnitude as the wavelength of the laser light. The technique proved to be portable and more sensitive than traditional methods /1/.

In our experiments we concentrated on stone materials employed in an ancient building whose conservation and protection is conditioned by early detection of salt efflorescence. Two kinds of stone were considered: *Biocalcarenite di Noto* (Sicily-Italy) and *Pietra di Angera* (Lombardy-Italy), both of which have been widely used in the past centuries.

A decorrelation parameter δ (equal to the complement to 1 of the local speckle correlation value ρ) has been found to be proportional to the surface changes and can be taken as the indicator of the efflorescence rate. It is interesting to note that the study of speckle decorrelation allows for following the alteration of the surface in real time and over its whole extension. Furthermore, the correlation technique is able to detect salt formation before any other technique and, when the stone surface is completely covered with salt and it is impossible to detect the new crystallisation front using classic techniques, it is still able to detect it.

Fig. 3.2 shows a plot of δ as a function of the drying time for the *Biocalcarenite di Noto* sample. In the first hour the high values of δ are caused by the evaporation of the relatively large amount of water present in the surface layers of the stone following absorption.

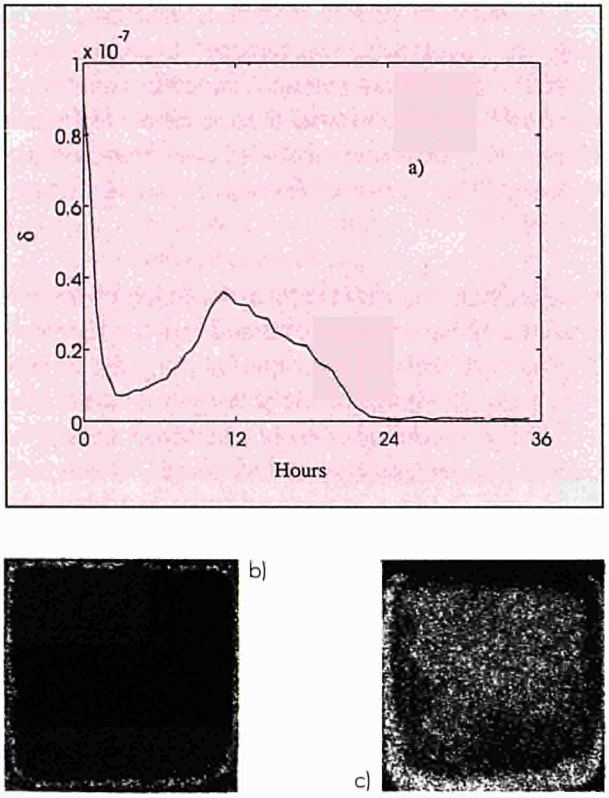

Figure 3.2. Decorrelation parameter δ as a function of the drying time for the Biocalcarenite di Noto sample. Correlation images after b) 5 hours, c) 13 hours (Collaboration with Centro G.Bozza - CNR - Milano - I)

After two hours surface changes occur which can be attributed to salt formation. The correlation method is able to follow the evolution of the process: during this initial phase, maximum salt activity is located at the edge of the sample, and the salt crystals are not yet visible on the surface. The salt formation proceeds towards the centre in a concentric way, reaching its maximum after 11 hours. As the front of the salt development approaches the centre, the rate of formation decreases and the process recommences from the edge. After 13 hours the stone surface is completely covered with salt and only the correlation method still has the capability of measuring further salt increase.

The following conclusions can be drawn:

- the formation of salt crystals on the surface of porous stone materials has been successfully monitored and measured by measuring the local decorrelation of laser speckle;
- information can be obtained not only about the morphology of the surfaces and the presence of micro fissures and other discontinuities, but also on some characteristics of the internal structure which interfere with the evaporation process;
- as well as allowing the study of efflorescence process, this method provides useful information for restoration work;
- the method is much less sensitive to external vibrations or temperature transients than other interferometric methods: this means that it could be readily applied for in-situ measurements;
- corrosion and erosion processes could be detected in their very early stage using this technique.

References

/1/ Lucia,A.C.; Zanetta,P.; Albrecht,D.; Facchini,M.; Realini,M. Study of salt efflorescence on stone surfaces by evaluation of laser speckle decorrelation, in Optical Methods in Biomedical and Environmental Sciences, H.Ohzu and S. Komatsu editors, Elsevier 1994

Safety Study of High-Velocity Transports in Off-Normal Conditions

The objective of this work was the development and application of predictive computer-based modelling, analysis and animation techniques for accident prevention. The investigations were focused on the understanding and use of recent numerical modelling techniques. The application to High-Velocity Trains (HVT) in the presence of critical operating conditions has been investigated.

The computer-based three-dimensional modelling and analysis techniques are even more useful for validation and prediction purposes, in particular, when alternative experimental tests on prototypes are too expensive or impossible.

The aim of this exploratory research was to verify the possibility of realising correct numerical models involving critical operating conditions encountered by HVT /1/, e.g. the derailment simulation of the TGV (Dec. 93). During the present study, two numerical methods have been investigated /2/:

- the finite element method (ABAQUS code with the explicit integration scheme);
- the multi-body formulation (VEDYAC programme for vehicle dynamics & crash).

The investigation has permitted the identification of the specific characteristics of these methods, including advantages/limitations. Of particular importance was the use of non-linear boundary algorithms simulating the contact between train and rail. A numerical test series has been performed considering different velocities (from 200 to 360 km/h) and off-normal conditions of the train-rail interface (specific car suspension and varying rail support length). Simulating the HVT transient dynamic response and vibration effects on the vehicle body, excellent results have been obtained with both numerical methods. In addition, some animation techniques have been applied to visualise the coupled rail-train behaviours.

On the basis of the excellent results achieved, it has been decided to propose the continuation of the activity in a more general way, by extending the methodologies used for the High-Velocity Trains to other cases of Transport Systems by means of predictive computer-based modelling and analysis techniques. This proposal will include, in particular, the study of safety equipment and safety road barriers by numerical simulation of car crash conditions.

References

/1/ G. Pileri, W.Riccardi "Metodi di simulazione numerica per lo studio del comportamento di trasporti ferroviari ad alta velocitò durante situazioni anomale" Technical Note I.94.96 e I.94.143 ISEI JRC Ispra.
/2/ G. Pileri, W. Riccardi "Confronto tra metodo agli elementi finiti e metodo multicorpo per lo studio del comportamento di trasporti ferriviari ad alta velocità durante situazioni accidnetali" Technical Note I.95.27 ISEI JRC Ispra.

Safety Features Improvement of Energy Storage in Superconducting Windings

The objective of this work was to contribute to safety and environmental protection features of new energy storage systems using superconducting magnets (SC), by investigating possible accident scenarios generated by off-normal operating conditions and by examining their consequences by means of computer simulations.

In two preliminary notes the author highlighted the problematic of superconductor technology. The first one was general, whereas the scope of the second one was more specific/1,2/.

The technological aspects were considered only as applied to Superconducting Magnet Energy Storage (SMES) systems. More precisely, the difficulties in handling SMES technology were cited, solutions to the problems arising from these obstacles were proposed and a through investigation of the tools available was performed.

The research has concerned a simulation of the mechanisms of the transition of a coil from the superconducting state to the normal one by using the P-THERMAL code. As the complexity of the geometry is considerable and the characteristic physical proprieties of the materials depend strongly and non linearly on temperature, a simplification of the model was considered by assuming a structure composed of periodic repetitions of a basic cell. The results achieved on the basis of such modelling are now available /3/.

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/1/ I.Sakellaris "Superconducting Magnets: from Modern Technological Applications toward Energy Storage Systems" Technical Note I.93.168 ISEI-JRC Ispra.
/2/ I.Sakellaris "A proposal of Strategy and investigation of Tools wihtin the Conceptual Studies Sector for handling problems concerning SMES" Technical Note I.94.57 ISEI-JRC Ispra.
/3/ I.Sakellaris "Safety features improvement of Energy Storage in Superconducting windings Technical Note I.95.15 ISEI, JRC Ispra.

Environmental Impact and Diseconomies Arising from Renewable Energy Cycles

An assessment of the environmental effects of solar photovoltaic (PV) electricity generation, mainly based on a literature review, has been carried out. The study focused on thin-film PV-modules, namely those containing amorphous silicon, cadmium telluride and copper indium diselenide.

The review has included the environmental issues associated with PV systems which can arise during some phases of their life cycle, namely:

- production and installation of components and system;s
- system operation and maintenance;
- decommissioning of end-of-service system components.

The fabrication of thin-film PV-cells involves in some cases the use of large quantities of gas, some of which are toxic, substantial amounts of detergent solutions and solid wastes as by-products of the deposition processes. These waste streams and emissions cannot be predicted ab initio since they are to a large extent under the control of the plant operator, with the aid of recycling and effluent clean-up procedures. Thus environmental impact assessments of production processes will require the active participation of manufacturers in order to identify and quantify the important outputs. Even so, because of the continual improvement in processing steps, the picture at any one time represents only a 'snapshot' view of the manufacturing process that will need to be updated periodically.

The environmental impact during the operation of this photovoltaic systems concerns visual aspects and use of land and other space, but it is anticipated to be minor. In fact, roof-top arrays can be incorporated into residential and commercial buildings with almost no visual intrusion and without additional land area. Arrays integrated into the envelopes of buildings as facades also involve no additional land use. Although the land area requirements for ground-mounted PV solar plants and for fossil fuel stations of similar capacity are comparable, PV installations have much lower profiles, without the chimneys, cooling towers and large buildings. Large multi-megawatt installations may affect the local microclimate, flora and fauna, and for these an environmental site impact assessment would normally be required at the planning stage.

Various studies have examined the environmental implications of recycling, landfill disposal and incineration of PV-components. The decommissioning of silicon-based modules appears to be unproblematic and the main concern is the possibility of toxic releases from the types of module that contain cadmium compounds. The photovoltaic industry appears to favour the collection and recycling of end-of-service modules and this option would also be preferable from an ecological viewpoint. Although there is little practical experience with recycling photovoltaic modules, the necessary processes would be needed in any case to conserve resource-limited elements. Recent evidence indicates that, at least for one current production type of cadmium telluride module, uncontrolled disposal in municipal landfill sites would be acceptable and that inadvertent incineration of moderate quantities of expired modules would not lead to environmental or public health hazards.

Several studies have noted that the energy storage systems employed in small scale autonomous PV installations account for a substantial proportion of the total cost and the overall environmental impact of the system. Larger scale systems using, for example, electrolytically-generated hydrogen and fuel cells or vanadium redox batteries as a means of energy storage offer potentially more benign environmental characteristics as well as greater flexibility in energy usage. It is emphasised that future economic and life environmental assessment should extend to the entire energy system.

Methodologies for environmental impact assessment of systems for electricity generation are currently being developed as part of the European Community project on the external costs of fuel cycles. Multi-Attribute Analysis and Monetarisation represent the two main approaches. It is suggested that the application of advanced methods such as the Multicriteria Support Systems method, to photovoltaic energy systems would help to confer a degree of robustness on the results obtained.

Reference

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4 SUPPORT TO COMMUNITY POLICIES

4 SUPPORT TO COMMUNITY POLICIES

SUPPORT TO THE SECRETARIAT-GENERAL OF THE COMMISSION

Antifraud Documentation Information System

In the framework of the DAF project (the Antifraud Documentation information system), the JRC continued the development of the DAF authoring and end-user subsystems. For the authoring subsystem, the JRC completed the specifications for a new client-server, MS-Windows front-end, SGML-based solution. For the end-user subsystem, four electronic books containing antifraud descriptions for the UK, GR, SP and PO were prepared and demonstrated.

In the framework of the preparation for future JRC support actions on behalf of the UCLAF, the JRC assisted in the formulation of a number of project funding requests to the Secretary General. At the time of this writing, the JRC is preparing a problem statement for opening up subsets of the database IRENE (official communications on fraud cases) to member state authorities, is preparing a call-for-tender for doing a feasibility study for an integrated information management system for the UCLAF, is doing an exploratory statistical analysis of the IRENE data, and is also offering consultancy on the migration and redefinition of the IRENE database.

Relations with European Parliament Petitions Database

The JRC, in collaboration with the User Service, has specified and implemented a significant number of system enhancements to the Petitions Database through migration to a more powerful platform and also through the addition of several new functionalities. It is expected to install the new facilities in December 1994.

SUPPORT TO THE COMMUNITY STATISTICAL OFFICE

Statistical Applications of Artificial Neural Networks.

The work described below has been undertaken on behalf of the Statistical Office of the European Communities (EUROSTAT), as part of a study of the development of connectionist tools for various statistical applications.

Two unsupervised data analysis tasks were addressed in 1994. The connectionist Self-Organising Map (SOM) model, whose potential for unsupervised clustering is by now fully recognised, has been used in both cases. The SOM algorithm maps the typically high-dimensional feature of socio-economic data sets onto a two-dimensional lattice, while preserving and reflecting the prominent topological characteristics of the raw data distribution.

The main task deals with time series of foreign trade statistics. The data set consists of yearly import/export figures for about 200 countries, 10 product groups, and covers about 15 years. Innovative methods for addressing the following problems have been successfully developed:

- ***Missing data estimation***. This is an important issue because missing reports are frequent in foreign trade statistics. Basically, the SOM model assigns missing values according to well-known nearest neighbour principles. However, a comparison with the more traditional K-means technique showed that the smoothing properties which characterise the SOM approach to quantitization tend to improve the missing data estimation process. And, in absolute terms, experiments on false missing data (some known values are treated as missing) resulted in average estimation errors within the prescribed range.
- ***Semi-parametric estimation.*** Assume that many series may be described with a common parametric regression model (with different regression vectors). Studies have been carried out on several implementations of connectionist models which map, in an orderly fashion, the different instances of the regression curve. A fresh comprehensive representation of the series trends emerges as a result of this generalisation of the SOM model.

A secondary task concerned the identification of stable/unstable seasonality or trend patterns in time-series collections.

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/1/ Alvarez, M., Varfis, A. Decoding Functions for Kohonen Maps; Proceedings of the European Symposium on Artificial Neural Networks - ESANN'94 - Bruxelles, Belgium, April 20-21-22 1994. Edited by M. Verleysen.

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SUPPORT TO INTERNATIONAL CO-OPERATION (DG I)

Collaboration with IAEA on Safeguards

Design Information Verification

The activity deals with the development of dedicated systems for IAEA requirements in the field of design information verification (DIV). For complex nuclear plants, such as large reprocessing facilities, a large number of vessels and their associated pipework must be physically checked and compared to plant design drawings. Once these checks have been completed, the continuity of knowledge for verified plant structures has to be maintained. The activity in 1994 comprised the realisation of a dedicated system based on video image processing (DIVIP) and the development of techniques for a 3D representation based on laser range images.

Dedicated video system DIVIP

A possible solution for the IAEA requirements is based on the use of image processing for comparing video pictures taken at different times. A dedicated system, based on this technique, has been developed and tested /1/. The system includes a colour TV camera, a portable PC equipped with a digital image capture board and a high capacity disk for the digital storage of video pictures . The application software creates reference image files, compares images and evidences changes in the structure. The changes are shown as flashing elements in the picture. The first system was shipped to IAEA in June 94.

A successful demonstration of the DIVIP equipment was conducted by the Agency in a Japanese facility. Some suggestions for improving the system have been made by the Agency inspectors. A major system modification concerns the addition of a magneto-optical disk with a capacity of 600 uncompressed images. The optical disk will also substitute the tape streamer for image back-up. The application software for image storage and retrieval has been rewritten to integrate the optical disk unit. It is expected that the new version of DIVIP will be ready in March 95.

3D-Reconstruction

A second technique for DIV is based on the comparison of the structural CAD model of a plant and 3D data acquired locally by means of a laser range measurement system /2/. Different modules have been developed for this purpose.

Fully Programmable Range Data Acquisition

Existing hardware and software tools allow the acquisition of range views of the environment within a programmable angle of view of up to 270 degrees in the horizontal, and up to 60 degrees in the vertical. Spatial resolution (i.e. the number of samples per angular unit) is also programmable. *Figure 4.1* shows the optical head of the laser range measurement system mounted on a computer controlled pan-and-tilt unit.

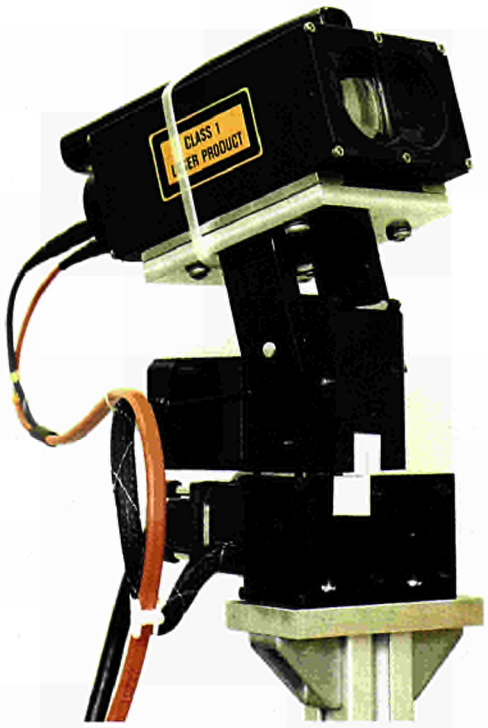

Figure 4.1. Laser Range Acquisition System: optical head mounted on a computer controlled pan-and-tilt unit.

Surface Segmentation

This module takes as input a range image and outputs a description of the surfaces (planar and bi-quadratic) present in the image. The segmentation is based on a hybrid algorithm capable of putting together both edges and surface representations /7/. A 3D boundary representation of all the surfaces found is also provided.

3D Object Representation

Two different approaches have been investigated for representing an object in 3D. In the first approach a 3D Delaunay triangulation is performed for each individual image, and a single polyhedral, triangular faceted representation is obtained by fusing the individual representations /4,5/.

The second approach uses a deformable surface for constructing a 3D representation of the scene from multiple range images /6/. The deformable surface used is a triangular piecewise planar mesh of arbitrary topology. This allows changes in the spatial density of the triangular mesh elements to fit to discontinuities found in the 3D data. *Figure 4.2* shows the results of this technique to the 3D reconstruction of an office scene.

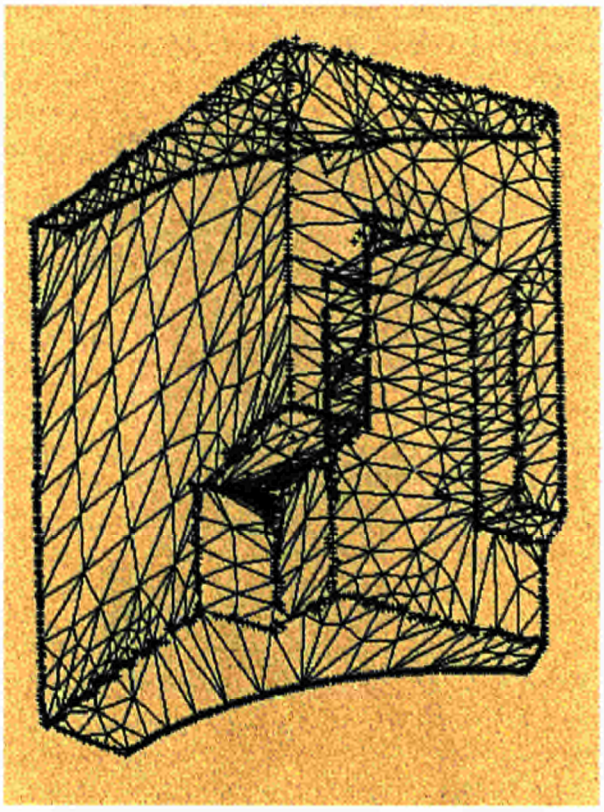

Figure 4.2. Deformable surface fit to 3D data from an office scene. The spatial density of the triangular mesh increases near discontinuities.

Range Image Registration

This module accepts as input two range images, and an initial estimate of the relative displacement between the positions from which the two images were captured /3,5/. It outputs the 3D rigid transformation (i.e. the six degrees of freedom: 3 translation and 3 rotation) between the two viewpoints.

Fusion of 3D Surface Representations

After finding the 3D surface representation of two adjacent range images, there is the need to have a single model representation. This module accepts as input multiple adjacent range images, and outputs an integrated surface representation, as well as the corresponding 3D boundary representation. *Figure 4.3* shows different phases for the 3D reconstruction of an office scene.

References

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/2/ Gonçalves J.G.M., Sequeira V. - "Application of Laser Range Images to Design Information Verification", in Proceedings of IAEA Symposium on International Safeguards, Vienna (Austria), 14-18 March 1994.

/3/ Sequeira V., Gonçalves J.G.M, Ribeiro M.I. - 3D Modelling of In-Door Scenes using Laser Range Sensing, Proc. 4th IAPR International Workshop on Machine Vision Applications, pp. 315-318, Kawasaki (Japan), December 13-15, 1994.

/4/ Sequeira V., Gonçalves J.G.M, Ribeiro M.I. - "3D Environment Modelling Using Laser Range Sensing", Proceedings of the International Symposium on Intelligent Robotic Systems'94 (IRS'94), pp.238-245, July Grenoble (F), 1994.

/5/ Sequeira V., Gonçalves J.G.M, Ribeiro M.I. - "Construction of a 3D Model of an Unknown Environment using Range Data", Proceedings of the Luso-German Workshop on Graphics and Modelling in Science and Technology, June 27-28, Coimbra (P), 1994.

/6/ Iton A., Gonçalves J.G.M. - "3D Scene Representation using a Deformable Surface", JRC Technical Note (to be published in 1995).

/7/ Sequeira V., Gonçalves J.G.M, Ribeiro M.I. - "3D Scene Modelling from Multiple Range Images" (to be published in 1995).

Sealing and Identification Techniques

Owing to a common interest in ultrasonic sealing techniques, the collaboration between JRC-Ispra and the Canadian AECL/AECB has been continued as a contribution to a possible technical harmonization of two different techniques that the IAEA wished to explore. In 1994 JRC-Ispra has devoted a large effort to developing software programs and codes based on the JRC

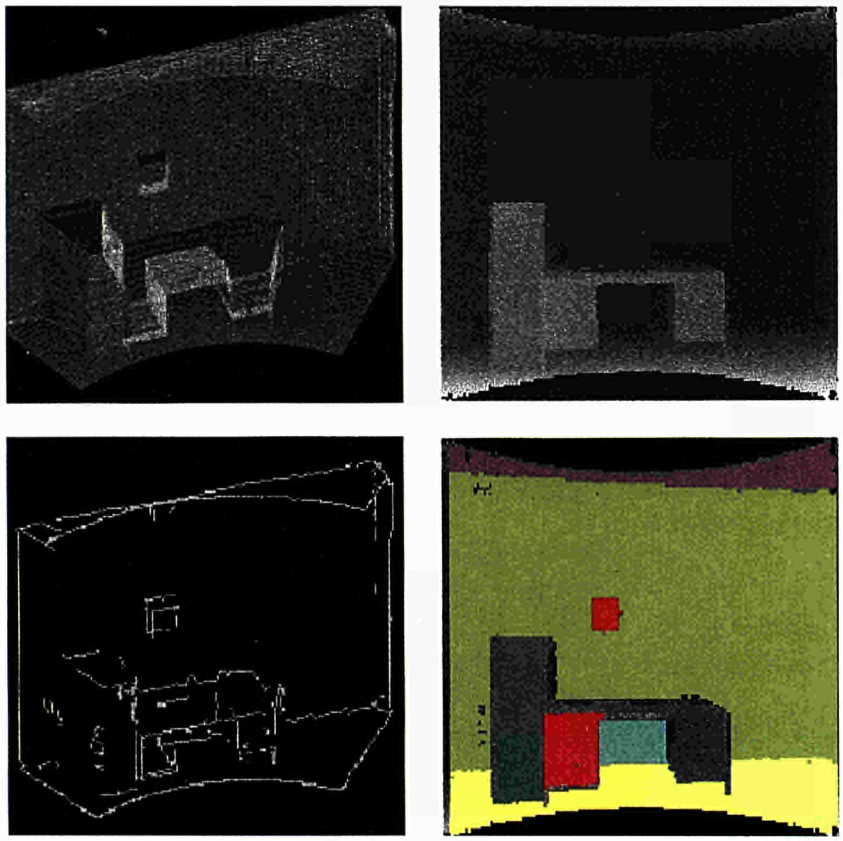

Figure 4.3. 3D Reconstruction of an office scene: 3D wire-frame and grey level representations, 3D edge detection and surfaces representation

technology and suitable to the AECL format. Set of equipment and related know-how were delivered to AECL by JRC-Ispra along with the results of its positive experience with newly selected ultrasonic/electronic hardware boards from the SFT company (F). The selection of a common ultrasonic hardware, and related software, for a future portable equipment is still pending and will require further and accurate evaluation from both sides before a decision is made.

In 1994, 50 sealing-bolts were ordered by IAEA and delivered in time. A larger order of 250 units was placed to JRC-Ispra before end 1994.

Training Courses on Tank Calibration

During this year, in collaboration with the IAEA, a test of the training course on mass and volume determination of liquids in tanks was conducted at the MiniTAME laboratory. The first tank calibrations course was held in April 1994 with the participation of three IAEA inspectors, and a second one in October.

Based on the experience gained, some instrumentation used for dip tube measurements has been replaced with three new pressure portable gauges (PPG). A new concept for the continuous recalibration of tanks has been developed and implemented on the 200 l tank.

A software has been designed and developed in LabView. This software is to be considered as an operator tool and is able to present a plant set-up, to perform data acquisition, traditional calibration or continuous recalibration and to perform data analysis.

The advantage to having the plant set-up option is that mistakes are avoided (valve positions, tanks not empty, etc.). Every action, except one, is carried out from the PC (environmental data acquisition, weights, electrovalves, etc.).

The only manual operation carried out by the trainee is to transfer the desired increment of liquid to the main tank.

In the near future a new continuous recalibration technique should be implemented in the MiniTAME laboratory. An Inspector Unit, consistent of a dual sensors PPG and a portable PC with special software should be ready for the next course scheduled for 1995.

SUPPORT TO THE COMMUNITY INDUSTRIAL POLICY (DG III)

Parallel Computing Applications

The main task of this activity is to contribute to the valorisation of ESPRIT results with particular reference to the European SUPERNODE massive parallel transputer systems and to the new European parallel computers such as the CS-1 (CONCERTO) machines, MULTICLUSTER and MEGAFRAME. Participation within the "Network of Centers of Competence" aims at advancing European industrial and commercial awareness and use of parallel high performance computing and networking systems.

The activity for parallel computing applications has been pursued and the following achievements have been accomplished:

- implementation of an upgrading for the CS-1 CONCERTO parallel machine with 12 nodes and with special peripherical devices;
- development, testing and implementation of special algorithmic tools for designing parallel network applications;
- implementation of parallelised fast transforms techniques, based on the theory of orthogonal polynomials, on CONCERTO and evaluation of the speed factor with respect to standard sequential machines.

In collaboration with the VALUE Programme, many new enhancements of the 3D image ray-tracing and radiosity software have now been pursued.

The specialised TRI-DYN hardware and software systems have been connected to the parallel CONCERTO and TWS 88 SPIRIT machines, and as a consequence, the 3D comp compression software has been implemented on the full parallel TRI-DYN CONCERTO system.

The implementation of a new parallel machine, TN-330 based on a T.9000 Transputer microprocessor

Figure 4.4. TWS ((SPIRIT and CONCERTO CS-1 Parallel Systems.

has been studied. This parallel machine is intended to replace the old SUPERNODE system. All the previous software developed by the "3D Image Processing & Synthesis" Laboratory will be implemented and tested on this new parallel machine.

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/3/ A. Pinti, J.C. Grossetie, MULTI-LAYER NEURAL NETWORKS ON A PIPELINE OF TRANSPUTERS APPLICATION TO AUTOMATIC ALL-NIGHT SLEEP STAGES QUOTING, 2nd International Conference on Softwore for Multiprocessors and Supercomputers, Moscow, 21-23 Septembre 1994

/4/ A. Pinti, J.C. Grossetie, ART 2-A ON T-NODE MACHINE APPLICATION TO AUTOMATIC CLASSIFICATION OF ALL-NIGHT SLEEP STAGES, 2nd African Conference on Reseorch in Computer Science, ORSTOM-INRIA, Ouagadougou, 12-18 Octobre 1994

/5/ R.F. Gloden, PROPRIETES GENERALES DES POLYNOMES ORTHOGONAUX, Technical Note no. 195.05, ISEI/IE 2836/1995.

SUPPORT TO THE COMMUNITY AGRICULTURAL POLICY (DG VI)

Electronic Identification of Farm Animals Using Implantable Transponders

This research project was assigned by the Directorate General for Agriculture (DG VI) FEOGA Unit VI-G-4 in order to prevent fraud and to respond to the specific problems that the registration and identification of individual livestock present.

The project was carried by three teams: Universidad Autonoma de Barcelona (Spain), Instituto Zooprofilatttico Sperimentale della Lombardia e dellEmilia (Italy), and Universidade de Evora (Portugal). The LaSCo laboratory was also involved in this project as neutral partner for the study and the qualification of the system chosen, which consists of subcutaneously implanted transponders *(Fig. 4.5)* read by an antenna connected to a radio frequency module *(Figs. 4.6 and 4.7)*. The readings are stored in a portable computer with a specially developed software, and can be processed in a headquarters which has to be defined.

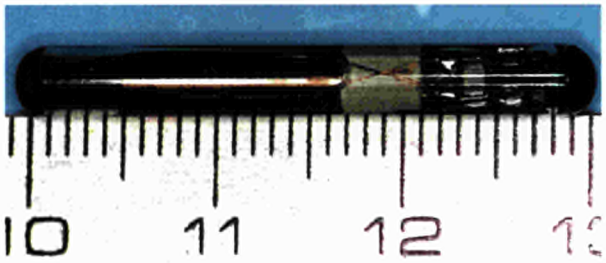

Figure 4.5. View of the transponders used in animal tagging

During 1994, tests were conducted in the LaSCo laboratory on:

- 10 read-only transponders used for animal tagging. The transponders, developed by Texas Instruments, were tested under various thermal, humidity and mechanical stresses in order to study their capability to be used in animal tagging and the behaviour of such. an equipment during the lifetime of the animals concerned within this project: goats, ewes and cattle;
- two radio frequency modules, also developed by Texas Instruments, that were used to read and program the transponders in animal tagging. The first thermal tests were conducted end of 1994 and will continue in 1995. The various tests the equipments was submitted to were picked from among international standards and also from in-field studies in order to study their performance under various thermal and mechanical stresses which can occur in field utilisation.

Various technical meetings took place in Barcelona (June, September), Milano (October), and Evora (December 1994), with the participation of JRC staff, in order to evaluate and to control the progress and the correct operation of the selected equipment on the various animal types, to evaluate the practical problems of such a technology (transponder implantation time, reading time, reading efficiency, loss, transponder recovery in the slaughterhouse) and to provide technical

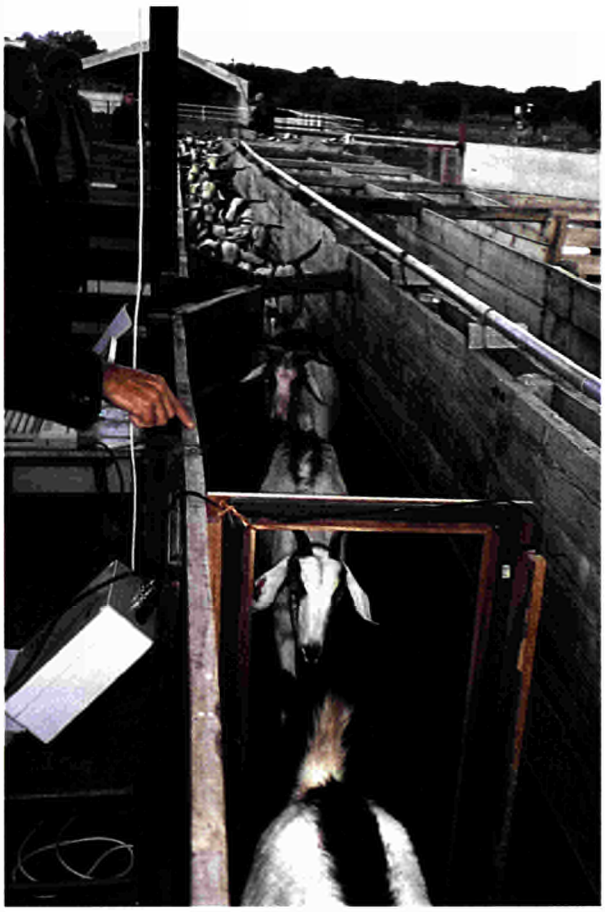

Figure 4.6. View of a farm demonstration in Evora (Portugal)

Figure 4.7. View of the complete reading system (reader, computer etc...)

assistance to DG VI Feoga. The demonstrations took place at an experimental farm, at a normal farm and also in a field trial.

The test programme foreseen for 1995 in this framework is the following:

- continuation of the thermal and mechanical tests on the radio frequency modules;
- study of the behaviour under thermal and mechanical stresses of new programmable transponders;
- study under thermal and mechanical stresses all the available transponders which can be used in animal tagging;
- study of the performances of a portable transponder reader under thermal, mechanical and electromagnetic stresses;
- study of the influence of electromagnetic perturbation on the radio frequency reading capability of the readers; in-field electromagnetic perturbation measurements.

SUPPORT TO THE COMMUNITY TRANSPORT POLICY (DG VII)

Aircraft Incident Database

In 1992 DG VII and the JRC signed an agreement to start the pilot project for the development of the European Co-ordination Centre for Aircraft Incident Reporting Systems (ECC-AIRS). During 1992 and 1993 the hardware and software environment was purchased and set-up, the architecture of the database system was defined and implemented, prototypes of various front-end components were produced and tested and design documentation was created.

In 1994 the database server was put into production. During the year several hundreds of test occurrences, originating from the German reporting system, have been loaded. Using this preliminary data and after an evaluation of the 1993 prototypes, the components for data entry and data retrieval were designed and implemented. Data import libraries have been created for German, British and Scandinavian aviation incidents and the first formal imports for each of these data-sources (total of approximately 50.000 incidents) started at the end of the year. The design of a simple graphical data analysis tool has been completed and is to be implemented. A raw translations of thousands of aviation-related words and definitions have been produced in six languages (French, Dutch, German, Spanish, Danish and Italian). It will be possible to use the front-ends of the database in any of the supported languages.

It is foreseen that the ECC-AIRS project will take until July 1995 to finish. By that time the last software components will be implemented, all available data from Germany, England and Scandinavian countries will be imported and all involved partners (DG VII and

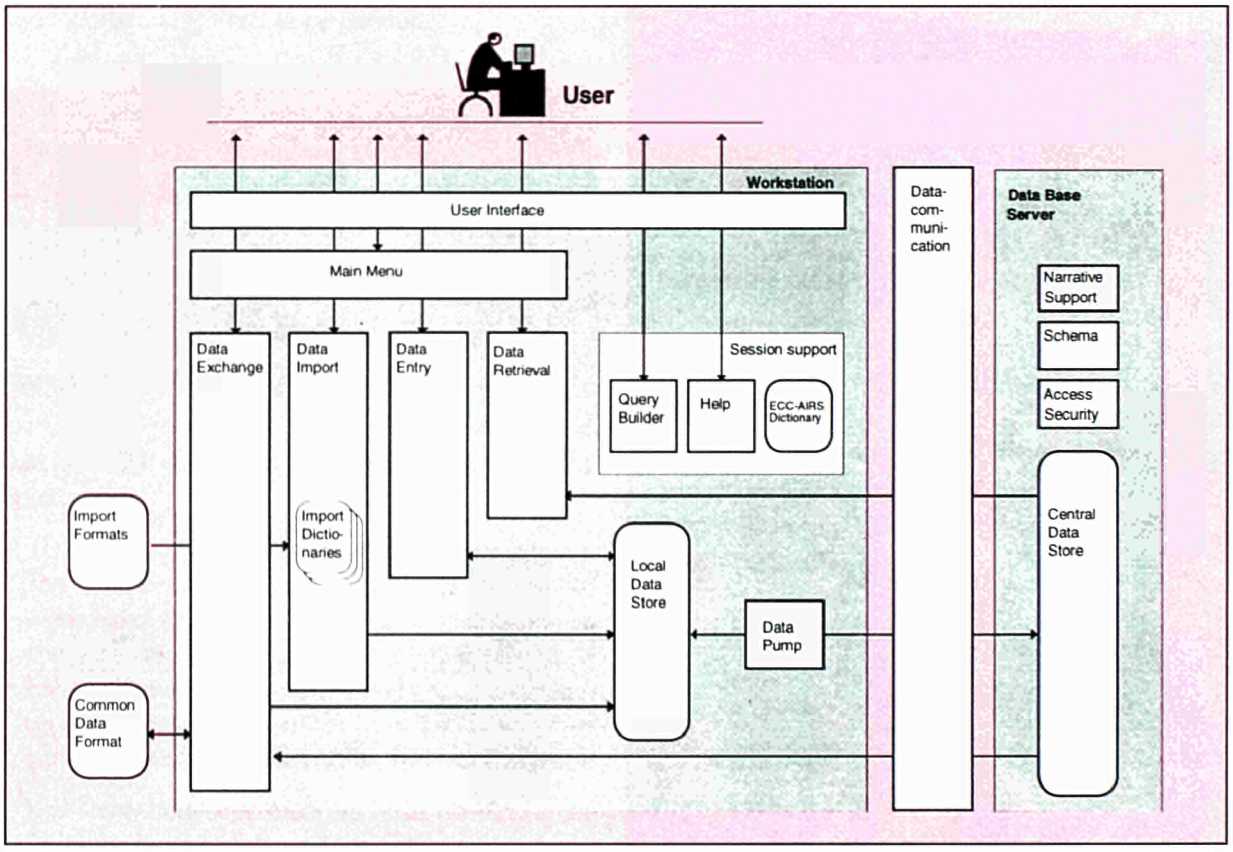

Figure 4.8. ECC-AIRS: Main architecture.

the member-states) will have evaluated the pilot implementation of ECC-AIRS.

If the projects steering committee decides that the ECC-AIRS solution approach is feasible and that the system shall be placed in production, then an additional follow-up project will have to be started to 'industrialise' the system. This will include resolving the bugs and problems found during evaluation, defining the time scale and methodology to introduce the system in local organisations, deciding on which organisation will run the central production system and, if required, updating the ECC-AIRS system to the latest ICAO (International Civil Aviation Organisation) standards for aircraft accident/incident reporting systems (ADREP manual).

For more details on the achievements and the state of the project, see /1 to 7/.

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/2/ Post, W. ECC-AIRS: User Requirements Document, JRC-ISEI-URD, Technical Note I.94.32
/3/ Post, W. ECC-AIRS: Softwore requirements Document , JRC-ISEI-SRD, Technicol Note I.94.33
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/7/ Post,W. European Co-ordination Centre for Aircraft Incident Reporting Systems, 11th Internationol Data Exchange on Aviation Safety (IDEAS), August 1994, Stockholm, Sweden

SUPPORT TO THE COMMUNITY ENVIRONMENTAL POLICY (DG XI)

Major Accident Hazards Connected with Industrial Activities Involving Dangerous Chemicals (implementation of Directive: 82/501 and its revisions).

Support to the implementation of the "Seveso" directive (82/501/EEC) concerns the Major Accident Reporting System (MARS), the Community Documentation Centre on Industrial Risk (CDCIR) and the co-ordination of a technical working group for providing guidance on selected topics implied by the Directive. A memorandum of understanding between DG XI and the JRC for the set-up and operation of the **Major Accident Hazards Bureau** was signed in January 1994 *(Fig. 4.9)*.

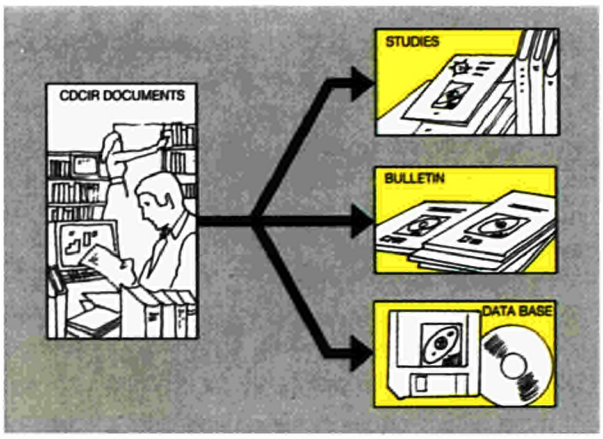

Figure 4.9. Community Documentation Centre on Industrial Risk (CDCIR)

The Community Documentation Centre on Industrial Risk (CDCIR)

The Community Documentation Centre on Industrial Risk (CDCIR) has been regularly operated by increasing the collection of documents, and by diffusing information on safety regulations, on codes of good practice and on accident investigations to authorities, industry and research organisations.

At the same time the CDCIR publication series has been enriched by four new volumes on control of major accident hazards:

- Vol. 18 C. Hamilton, R. De Cort & K. O' Donnell: *Report on land use planning controls for major hazards installations in the European Union*, EUR 15700 EN (1994)
- Vol. 19 P.C. Cacciabue, I. Gerbaulet & N. Mitchison (eds.): *Safety Management Systems in the Process Industry* (Proceedings of the Seminar in Ravello (I) on October 7-8, 1993), EUR 15743 EN (1994)
- Vol. 20 B. De Marchi & S. Funtowicz: *General Guidelines for Content of Information to the Public (Directive 82/501/EEC - Annex VII)* EUR 15946 EN (1994)
- Vol. 21 I.C. Ziomas, PN Tzoumaka, C Fiorentini, A. Romano and M. Locatelli: *Lessons Learnt from Emergencies after Accidents in Greece and in Italy Involving Dangerous Substances*, EUR 15767 EN (1994).

The latter report follows the previous publications on chemical emergencies and lessons learnt in UK, France, Germany, the Netherlands, Ireland and Denmark. Similar studies for Belgium, Luxembourg, Portugal and Spain have been completed and are being edited for publication in the same series.

The Major Accident Reporting System (MARS)

The Major Accident Reporting System (MARS) has continued to operate by recording, analysing and diffusing information on accidents notified (a total of about 200 accidents have been inserted in MARS in 1994). The lessons learnt for preventive policy have been the subject of regular reporting to the Committee of Competent Authorities, and the subject of open publications /1/. After a first book on lessons learnt /2/, a report including the experience gained by ten years operation of the system has been prepared. Its publication is expected by mid 1995.

Technical Working Groups

The objective of the technical working groups (TWGs) established by the Commission (DG XI) is to produce guidance on various aspects of implementation of the Directive. Such groups are co-ordinated by ISEI as far as both the organisation of the meetings and the achievement of the expected results are concerned. As such groups consist both of representatives

of authorities and control organisations and of representatives of industrial parties (CEFIC, CONCAWE, EP FORUM, AEGPL, EPSC), ISEI is becoming a focal point for a constructive dialogue between authorities and industry towards common views on the technical aspects of the control of major accident hazards. In 1994 significant progress was achieved by the technical working groups for the "Safety Reports" and for the "Safety Management Systems" /5/ in collecting, analysing and comparing information on national guidelines, industrial codes of practice and recommendations.

In connection with the works or TWG "Safety Reports" a Seminar on Runaway Reactions was organised in Frankfurt-am-Main (7-8 Nov. 1994) with the objectives of sharing information and lessons from accidents occurred, as well as on methods for preventing, controlling and mitigating related accidents. The resulting recommendations will be included within the hazard identification chapter of the guidelines in preparation.

Furthermore, ISEI received the mandate for producing draft guidelines as a basis of discussions within the TWGs. The guidelines have then to be discussed by the Committee of the Competent Authorities before being adopted by the Commission. The Guidelines for Content of Information to the Public /6/ constitute the first guidance published by the Commission for the implementation of the Directive.

References

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Scientific-Technical Support to the Biotechnology Directives

The activities in the area of biotechnology involve a close co-operation with the Directorate General for Environment, Nuclear Safety and Civil Protection - DG XI - who has the responsibility for the work on the implementation of the biotechnology Directives 90/219/EEC and 90/220/EEC.

BIOSAFE is a Documentation Centre that collects relevant information on safety issues and on regulatory aspects of biotechnology. It reviews the regulatory developments in the European Commission as well as in the Member States. Whereas documents on new legal developments occupy a special place in the bulletin, equally importance is given to the background documents produced by or on behalf of the Commission and Member States. A section is also devoted to pertinent books and articles published in the field and to results of risk assessments carried out prior to field releases.

In addition, appropriate applications of biotechnology inventions submitted to the European Patent Office or to the World Intellectual Property Organisation are surveyed. The reason is because they contain very detailed descriptions of the inventions, which are in some cases relevant for the risk assessment carried out by the Competent Authorities and which sometimes give a global indication of the developments in the sector.

All documents are held in Ispra at the disposal of the interested reader and photocopies can be made available if not protected by copyright.

BIOSAFE has produced and published a new issue of a bulletin of publications with abstracts, a keyword index and an index of all documents. This bulletin was circulated to all Competent Authorities responsible for the implementation of the Biotechnology Directives, and to any other interested party, free of charge. The BIOSAFE mailing list contains about 1,000 addresses. In the course of 1995 a project has been initiated that endeavours the electronic publication of the bulletin.

ISEI has also provided direct scientific-technical information to the Committees of Competent Authorities. Substantial information has been found by exploiting the numerous connections to on-line databases that

the JRC has established over the last few years. It should be noted here that the biotechnology group has built up a well-appreciated reputation in the area of informatics, and especially in the area of development and management of databases.

ISEI has contributed strongly in various DG XI activities. Regular discussions with the Committee of Competent Authorities and the activities in the Working Group on risk assessment in connection with the release of transgenic organisms should be mentioned. A substantial period has been spent at the DG XI headquarters in Brussels to digest the data and to produce reports on the deliberate release of transgenic organisms in the EU.

ISEI presents its activities on a regular basis at international meetings and symposia. For 1995, an international EC-US Symposium on the deliberate release of transgenic plants will be organised at the JRC site. Previous editions have demonstrated that these workshops, co-chaired by the European Commission (DG XI), the US Department of Agriculture (APHIS) and by the US Environmental Protection Agency (OPTS) provide unique opportunities to exchange views and share experiences related to the deliberate release and placing on the market of genetically modified organisms.

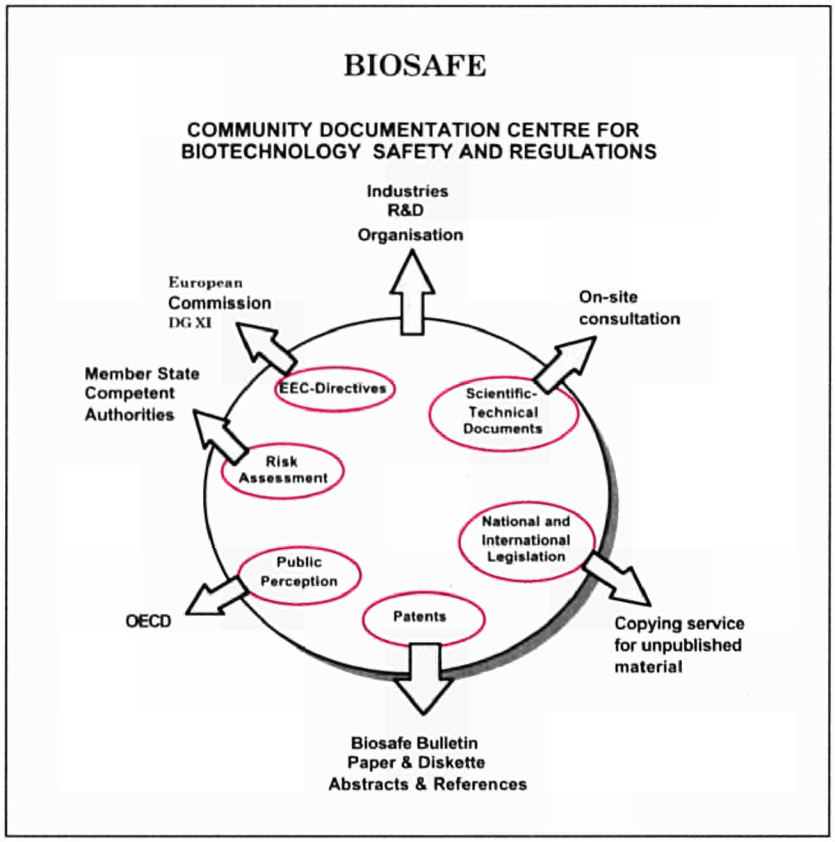

Figure 4.10. The Biosafe Scheme

Comparative Study on the Environmental Impact Assessment (EIA) of Installations for the Disposal of Toxic and Dangerous Waste

A review of the implementation of the EIA Directive /1/ adopted in 1985 was undertaken by the Commission in 1993, in accordance with Article 11, which provided for an assessment of its application and effectiveness. The Commission's Report covers the period up to March 1992. One of its conclusions was: /2, page 65/: "*. . . the review reveals that, in a number of Member States, only a minority of EISs are of satisfactory quality*". DG XI requested ISEI to undertake a study to identify the common approaches and the main differences in the indicators, impact prediction methods and terminology used in Member States when carrying out environmental impact assessment. The projects considered are waste disposal installations (incinerators, chemical treatment installations and landfills) for the treatment of toxic and dangerous waste listed in Annex 1, paragraph 9, of the EIA Directive. The main aim of the study is to contribute to the improvement of the quality of the Environmental Impact Studies (EISs) produced in the Member States. The study also aims to contribute to the effective consultation in the case of projects with transboundary impacts considered both in the EIA Directive and in the Espoo Convention /3/.

EISs Collected, Identification Form and Report on Each EIS

The total number of EISs collected is 28 and they concern 35 installations (some plants include more than one installation). They have been supplied by developers

and/or consultants, via contact persons at the competent authority of each Member State, and are written in the nine official languages of the Union.

From each EIS, an "Identification Form", that summarises the main "general information" about the EIS and a "Report", that analyses the main "technical information" of interest are produced. All these documents are written in English. Data concerning the identity of the developer, and other confidential data, are reported only in the identification form, which is an internal document and will not be included in the final report.

The main information contained in each identification form is as follows: reference code; background (context in which the plant has been presented and authorised); title of the study; short description of the plant and type of installation(s) located in the plant; type of waste treated; location, area and capacity of the plant; cost of the project and cost of the EIS; addresses of developer, competent authority and consultant; submission and authorisation dates; status of the plant; EIS arrival date at JRC Ispra and list of the material received.

The report on each EIS is structured in five sections: Background, Description of the Plant, Indicators, Impact Prediction Methods, Uncertainty Analysis Methods and Evaluation Criteria, Risk Assessment Methods and Overall Comments on the EIS. The report also includes two appendices: List of the Documents Received and Main Scientific/Technical Terms used in the EIS.

A list of environmental (natural and human) factors is used as a reference in analysing each EIS. It has been compiled taking into account the factors explicitly mentioned in the EIA Directive as well as factors mentioned in national legislation and/or considered relevant in technical and scientific publications (see, e.g. /4,5/). Thus the list includes the following factors: human beings, air, climate, surface water, soil and ground water, landscape, land use, flora and fauna, ecosystems (interactions), noise and vibration, material assets, cultural heritage, economic system, social system, traffic, other factors.

Preliminary Results and Final Report

One EIS analysed in the study concerns a plant which treats waste from an industry producing antibiotics by a fermentation process. The plant includes two installations: an installation for biological treatment of waste water and an incinerator to treat the micro-organisms used in the fermentation process together with those produced as an excess in the biological treatment. The incinerator treats toxic and dangerous waste. The table next page summarises, for each environmental factor, the indicators, the impact prediction methods and the uncertainty analysis methods considered in the part of the EIS that concerns the incinerator. The factors most affected by the proposed project, and which were analysed in more detail, are air and noise.

The preliminary results indicate that prediction methods used within EISs of this category are often not stated. Where prediction methods are stated in most cases they are poorly explained (e.g. data used, application of models, numerical or graphical results obtained). Some environmental factors (e.g. climate, flora and fauna) are often not considered while uncertainty analysis is rarely undertaken.

The study is expected to be completed by the end of 1995. One foreseen development is the production of guidelines to assist in the choice of methods for impact prediction and evaluation used in the environmental impact assessment of waste disposal installations.

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INCINERATION INSTALLATION. INDICATORS, IMPACT PREDICTION METHODS AND UNCERTAINTY ANALYSIS METHODS CONSIDERED FOR EACH ENVIRONMENTAL FACTOR.

Environmental Factor	Environmental Indicators	Impact Prediction Methods	Uncertainty Analysis Methods
Air	Temperature, dust, organic carbon, CO, HCl, HF, SO_2+SO_3, NO_x and odour	Gaussian model to estimate dispersion of pollutants. Method proposed by German law TA-Luft 86 for the optimisation of the height of the stack	Worst case analysis both in the dispersion model and in the optimisation of the stack height
Climate	Amount of energy exchanged and contaminants composition in output flow	Subjective judgement based on the chosen indicators	–
Soil	Area of the plant	–	–
Landscape	Visual impact	Normal visual techniques	–
Flora and fauna	Presence of uncommon or protected species in the zone affected	–	–
Noise and vibration	Noise intensity	Iterative calculation of noise intensity at the perimeter of the plant based on addition of mitigation measures to meet legislative thresholds	Noise intensity estimation based on the worst case situation (no air attenuation)
Economic system	Number of new employees required for the plant	Management and planning of the industry (creation of employment)	–
Social system	Press articles and complaints by the public involved	–	–

Safety of Nuclear Installations

ISEI has given scientific and technical support to DG XI during 1994 for the second year. In particular support to specific actions of DG XI-F in the safety of nuclear installations has been given, for the activities hereafter described. Moreover ISEI attends regularly the meetings of the two advisory expert groups of DGXI, for the reactor safety: the Nuclear Regulators Working Group and the Reactor Safety Working Group.

Monitoring, or Assessment of the Results, of Study ContractsGgiven by DG XI.

During 1994 a number of technical reports has been received from DG XI for a technical evaluation.

The results of a study contract reviewing EUROPEAN NATIONAL PSA PRACTICES, with a view of possibly deriving a general EUROPEAN PSA PRACTICES having the consensus of European practitioners, have been assessed.

As a basis for the assessment, the EUR Report 15720, Regulatory Action Related to Probabilistic Safety Assessment Studies, was also taken into account as an additional source of information.

During 1994, the Report National and Community Research Policies and Programmes on Reactor Safety was issued as a EURATOM report (EUR 15618), compiled by E. Della Loggia, on the basis of national contributions and the support of IST and ISEI.

Monitoring the Activities of the Joint CEC/USNRC Project on the Uncertainty Analysis of the AccidentCcodes

COSYMA and MAACS for the Probabilistic Assessment of the Consequences Following a Radioactive Release from a Nuclear Power Plant
This project is based on a wide use of Expert Judgement (EJ) Techniques and is relevant to PSA level 3. The project is funded by DG XII (Research on Radioprotection) and DG XI (Safety of Nuclear Installation Unit and Radioprotection Unit). A procedure guide for the application of EJ techniques will be produced by the Technical University of Delft. We recall that EJ techniques are being widely used for PSA level 2 and, to a lesser extent, for PSA level 1 (see, for instance, NUREG 1150) and may have an important impact on PSA results. ISEI attended a three-day meeting in Brussels and devoted a seminar on EJ and the organisation of a panel of experts to be elicited.

Participation in IAEA Expert Group Meetings or Specialist Meetings on Behalf of DG XI

During 1994, ISEI participated in:
- the last meeting of an IAEA working group for the Development of Safety Principles for the Design of Future Nuclear Power Plants. The final version of a Technical Note (to be issued as IAEA TECDOC) has been produced by the group;
- a specialist meeting in Halden on Advanced Information Methods and Artificial Intelligence in NPP Control Rooms.

Issuing Catalogues of Historical Earthquakes Data

ISEI has conducted a study on the representation by a Geographic Information System (GIS) of data on historical earthquakes that have occurred in some European Union countries. A spatial analysis of these data has also been performed. This activity had the purpose of:
- demonstrating the potentiality and possibilities of using GIS for storing and interrogating the Catalogue of European Earthquakes (Van Gils J. M. and Leydecker G. 1991);
- investigating possible correlations among earthquake events, population and location of nuclear facilities;
- identifying a suitable data format with a view to the future publication of an updated version of the European catalogue or catalogues covering other geographic areas.

A report on the activity, entitled Spatial Analysis and Earthquake Risk Assessment, has been presented to the Reactor Safety Working Group, one of the two DG XI advisory group of experts from the various European Union countries.

The installation of the European Earthquake catalogue on the Geographical Information System has demonstrated significant improvements in the possibilities for viewing, interrogating and analysing the events in the catalogue. The possibilities for selecting and displaying events according to position, time, intensity or other database attributes are found to be highly useful for those working with such data. The GIS facilities also provide useful ways for investigating some of the acknowledged weaknesses of the present catalogue with respect to duplications of events and homogeneity across countries. Furthermore the possibility to use the multimedia approach to retain links to historical records, by including scanned photographs and text in the database, has been shown to be feasible and practical for future improved catalogues.

SUPPORT TO THE COMMUNITY INDUSTRIAL INNOVATION POLICY (DG XIII)

Image Processing and Synthesis and Holographic Processing and Synthesis

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 are to develop visualization on advanced parallel computers and new color holographic flat screen for industrial applications.

There are two main objectives. First, the applications of new signals and images compression techniques based on advanced photonic technologies and on present available mathematical tools like fractals and wavelets. Second, miniaturization of optical systems by substituting classical optical components like lenses and mirrors with holographic diffractive gratings.

Within the framework of the previous VALUE Programmes, theoretical studies involving the enhancement of classical diffraction theory and the realisation of diffraction grating have been done during the last three years. As a result, mathematical synthesis of monochromatic volume holograms has been achieved. Seven patents have been obtained including optoelectronic peripherical devices.

Marketing studies, performed under the responsibility of DG XIII Direction C Innovation, demonstrated that applications of the JRC European patents have to be developed.

Starting from the results obtained in 1993 and following the final report from NODAL International Consulting , the valorisation of the achievements in the following areas have been recommended.

- holographic compression techniques associated with fractals and wavelets;
- realisation of holographic diffractive gratings:
  - demonstration of the present JRC compression technologies to various industries which are mainly interested in the field of satellite images, medical images and information signal compression technologies for telecommunications;
  - development of a holographic diffractive grating prototype based on mathematical hologram synthesis, in order to demonstrate the applicability of this technology to 3D holographic color screens and to high resolution digital television.

The following achievements have been accomplished:

- theoretical developments on basic ray-tracing and radiosity techniques, initiated four years ago, have been pursued;
- concerning the holographic synthesis, theoretical developments have also been pursued and comparisons with experimental data have been demonstrated;
- experimental setups for holograms in true colours have been accomplished and associated holographic diffractive gratings have been realised;
- furthermore, demonstrations of the present JRC holographic synthesis and compression technologies have been presented to various industries which are mainly interested in the field of satellite images and information signal compression technologies for telecommunications.

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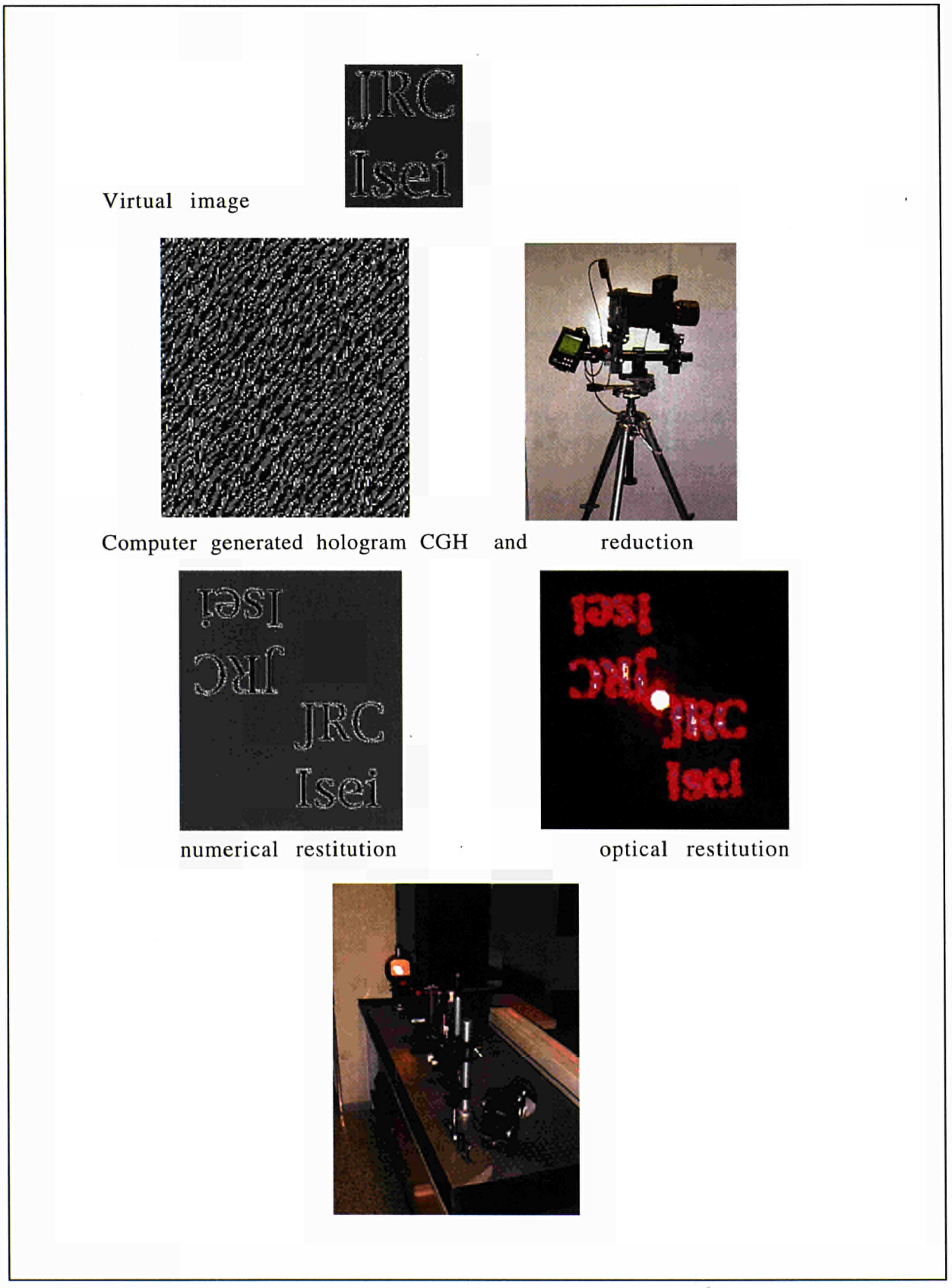

Figure 4.11. JRC Holographic Synthesis and Image Compression Techniques

Ultra High Sensitivity Interferometric Sensors

During 1994, co-ordinated testing campaigns have been designed and carried out in Ispra (Laser and Applied Optics Laboratory) and in Strasbourg (GOA/CRN). These tests allowed the quantitative characterisation of the three following interferometric devices /1, 2, 3/:

- interferometric sensor for the detection of radiation flux transient;
- all-optical interferometric modulator;
- interferometric device for the detection of micro-vibrations and gravitational interactions.

The performances of the devices were further enhanced especially with regard to their stability and calibration. A clear distinction was obtained between thermal and optical effects (i.e. radiation pressure). Distinct response times were registered for radiation pressure (fast response) and thermal effects (slow response).

These results were achieved, in collaboration with CRN/GOA - Strasbourg, by evaluating the temporal and spatial variation of the interferometric fringes. This required the development of special image processing correlation hardware and software. Clear correlations between input stimuli and output device responses were found. Experiments, at CRN/GOA and JRC Ispra as well, regarding all of the sensors, proved the repeatability of their performances.

During this work the sensitivity of the devices, in particular the fully optical switch, was further improved using excitation of less than 0.01mW.

Extensive work has been performed on the optomechanical detector, which is a device for detecting weak low frequency (0.1-20 Hz) mechanical vibrations. This detector is essentially a dynamic interferometer coupled to an air floated optical table. Critically bolanced vertical plates produce between them a Fabry-Perot type interferometer. The resulting dynamic fringe pattern produced by the two inner vibrating surfaces can then be examined. The mechanical properties of the plates and of the gas membrane between them produces a system which is sensitive to weak, low frequency mechanical excitation. Holographic gratings recorded on the plates increases the observable changes in the interference pattern. The device operates at room temperature and pressure is robust and has been shown to give reproducible results. Sensitivity has been shown to increase with decreased temperature.

Further development of the sensor has required the modelling and examination of the behaviour of optical tables (vibration isolating platforms) at frequencies outside their design range. The mechanical properties of the sensor have been modelled using various approximate methods. A full model (which is still under development) requires the inclusion of mechanical effects due, for example, to surface tension effects, electrostatic charges, contact forces, thermal and mechanical properties of the plates and fluid flow between the plates

Comparisons of our laboratory prototype (which has not been optimised) with commercially available accelerometers show that our device gives better performances and is potentially less expensive to manufacture. Work to produce an industrial prototype is currently being pursued.

Further details on the work performed and the results achieved can be found in /4,5,6,7/.

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Industrial Production of Ultrasonic Sealing Systems

In view of the possible demand to produce larger quantities of sealing-bolts developed in the Nuclear Safeguards Programme, JRC-Ispra has commissioned the NODAL company, in agreement with DG XIII, to perform a study on the optimization of production of the mechanical parts composing the seals in case of hypothetical series of more than thousand units. The study has indicated ways to subcontract the various phases of the production, and has shown that orders on more than 2,000 units at one time, would benefit from a manufacturing cost reduction.

SUPPORT TO THE COMMUNITY ENERGY POLICY (DG XVII)

Support to Euratom Safeguards Directorate/ Surveillance Techniques

The objective of the work is the development of equipment and software in the field of surveillance and monitoring for applications of the Euratom Safeguards Directorate. The main tasks are:

Video Review Station (CARES II)

Video surveillance generates a large amount of recorded images that have to be reviewed for detecting safeguards relevant events. The new CARES II station allows both manual video reviewing by an inspector and automatic, unattended, video reviewing. The hardware consists mainly of a video recorder, video demultiplexer and a PC based computer with an image grabbing board. The image memory is used as a cyclic buffer for real-time storage of a sequence of video pictures /1/.

In manual mode the inspector can stop the tape playback at any moment and browse through the last images stored in the buffer.

In automatic, unattended mode the polyline method for scene change detection has been used. The software development mainly dealt with the extension of the polyline method to several video channels and the high speed storage of alarm pictures on the computers hard disk. A new software structure had to be developed for the frame synchronous processing of the video images.

Three existing CARES systems installed in UK have been upgraded with the new features for the manual operation mode.

Identification of Fuel Elements

This development is a part of an integrated system for unattended measurement of fresh LWR fuel elements. The system integrates the radiation measurement system, developed by the Institute for Safety Technology, and the identification system of fuel assemblies developed by ISEI.

The identification system comprises a personal computer connected to a video camera and an illuminator.

Figure 4.12. Review station for video surveillance.

The identification procedure starts by having a video camera read a unique number engraved on the element's assembly head. The image is first stored for archiving purposes, and then processed to enhance the characters constituting the identification number. Pattern recognition techniques are then used for character identification. *Figures 4.13a and 4.13b* show a grey level image with sample plates similar to those found in a fuel element, and the result of character enhancement and segmentation. Preliminary results indicate that good recognition rates can be obtained with the approach followed.

Remote Monitoring Link

The objective of this task is to set up a link between Euratom Luxembourg and Ispra for testing the technical features of remote monitoring. The transmission of data from several surveillance cameras and digital sensors is foreseen. The system will perform image compression and data encryption before transmitting data over public networks. A technical proposal with the system configuration has been prepared. The configuration comprises a data cryptor based on DES algorithm, a video storage and compression unit and a universal modem. Ten video channels and ten digital alarm inputs can be connected to this system. The tests will be carried out in 1995.

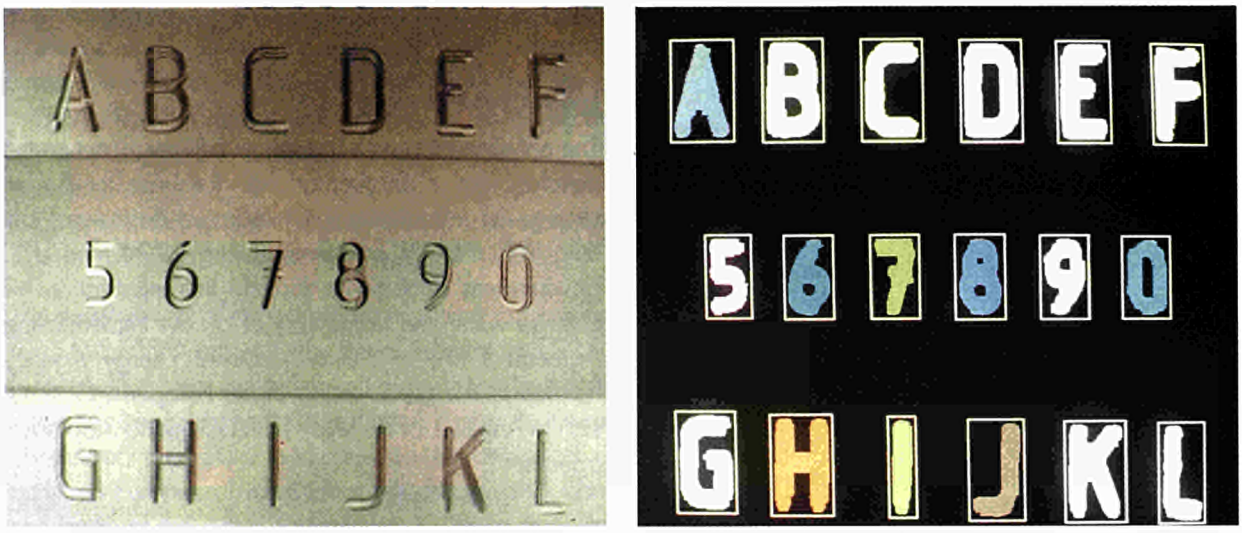

Figure 4.13. Grey level image of sample metal plates containing engraved characters (a), and the result of image enhancement and segmentation (b).

Integrated System BUD-CAVIS

The scope of this project is to combine the system BUD (Burn Up Device), developed by CEA, with the system CAVIS (Computer Aided Surveillance System) developed by JRC /2/. BUD is installed in the plant at La Hague to verify in unattended mode the number of spent fuel assemblies transferred from a storage pond to a shearing cell. It measures the gamma and neutron activity. CAVIS performs the data recording on 16 video, 16 analogue and 48 digital channels.

The development work on integration deals mainly with the following aspects:
- merging of alarm detection from both systems
- control of the sampling rate of the acquisition process
- correlated review of data

The CAVIS computer will act as the data concentrator of the integrated system. The BUD alarm will be transferred over digital channels to CAVIS and integrated in the alarm history table. The installation of the integrated system BUD-CAVIS in the La Hague plant is planned for April 1995.

Sealing and Identification Techniques

Based on the experience acquired in field since 1991, ISEI has continued its support to EURATOM inspectors on duty at Sellafield in order to timely deliver the quantities of sealing-bolts required for the sealing of a large number of Multi Element Bottles (MEB) stored in the ponds, and to provide still safer and efficient equipmemt on site. The Transfer Bay location for installing and verifying sealing-bolts has been replaced by a working station in the modern THORP storage pond to which ISEI has adapted its handling equipment.

Several installation/verification campaigns took place in 1994 a few of which were attended by ISEI staff. On an approximate monthly basis the last 200 sealing -bolts provided by ISEI could be installed and verified by the end of 1994.

A new order of 500 sealing-bolts was placed in September 1994 by DG XVII, requiring that ISEI organize a new production schedule and produce 50 units per month. The first delivery of 100 units took place in November 1994, two months in advance with respect to the schedule.

In addition to the above, ISEI has been involved since 1993 in the development of both a new operating software for site inspections and a modern data bank necessary for handling sealing-bolt data at the headquarters in Luxembourg and at the ESD office in Sellafield. The new site software anticipates the installation of new hardware planned for 1995, whereas the database has become a necessity in view of the large amount of sealing-bolts to be installed and checked in the coming years.

Nuclear Material Accountancy

In connection with the development of a new database for inspection data, made by the Euratom Safeguards Directorate, a number of software packages had to be re-designed or transferred to a different environment (UNIX + ORACLE). ISEI supported the Commercial Safeguards Directorate by providing consultancy on how to carry out some of the work needed, and also by providing through software houses completely new software packages for the following areas: i) execution of manual data entry to the main database, ii) creation of - and access to - the Nuclear Installations database, iii) tracing and verification of consistency of data coming from different sources, iv) re-design of the software MADES, used for statistical analysis of the data, according to the new environment and the new needs recently emerged.

Work has been completed for points i), ii) and iii). Point iv) will mainly be developed in 1995.

Data Processing

The Euratom Safeguards Directorate (ESD) of Luxembourg requested to develop an Electronic Clipboard for Inspectors. Inspectors currently use clipboards for consultation of listings and working popers which are often uneasy to handle when moving around the plant on inspection. The task objective is to explore the market of available notebooks and palm-top computers to identify a candidate machine showing features which correspond sufficiently to the ESD requirements.

Market research was performed for ESD and a palm-top computer with 8 hours autonomous functioning and weighing 900 g. was choosen. The procedures for data transfer from/to a PC were implemented. Some examples of applications were demonstrated to the ESD staff. According to the favourable results obtained, the ESD will decide the priority list of real applications to be treated by the palm-top computer.

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Support to the SAVE Programme

Least Cost Planning

The collaboration with Lawrence Berkeley Labs on the development of an international database for the exchange of information on Integrated Resource Planning (IRP) projects continued during 1994. The U.S. governments decision to provide this information exchange within the framework of a new Implementing Agreement (IA) of the International Energy Agency has led to the participation of the European Commission in Annex 1 of the IA on DSM (Demand Side Management).

The JRC has been asked to follow the IEA work in order to ensure that the datobase under development (called INDEEP), incorporates information suitable for European needs, bearing in mind that the level of implementation of IRP is at a very preliminary stage in many Member States.

The JRC has also been asked to develop common guidelines and reporting formats for the SAVE/DSM projects.

The 1994 activities of the JRC in this field were the following:

- conclusion of a preliminary critical review of the American database DEEP with particular emphasis on the viability of the Data Collection Instrument proposed by LBL;
- presentation of the INDEEP concept proposal to CENELEC (European Committee for Eletrotechnical Standardisation) and determination of the interest of European utilities;
- report for the DG XVII Magazine ENERGY IN EUROPE /1/;
- participation in the IEA Annex 1 Experts Meetings held in Madrid and Washington D.C, on behalf of DG XVII;
- participation in the Executive Committee of the DSM IA held in Washington D.C, on behalf of the DG XVII;
- attendance at the Conference on DA/DSM, Paris, November 1994;
- S & T Contribution to the Annex 1 activities.

ISEI is contributing to the Annex work by means of

- direct theoretical support for all conceptual items;

- investigation, reporting and establishing links with utilities of EU Member States not participating in the Annex and, in particular, with those that have SAVE/DSM contracts with the EC. A limited scale market survey for assessing INDEEP acceptance is underway;
- co-operation in the preparation of a workshop to be held in Vienna at the end of January 1995.

The development of final standard reporting formats for the SAVE/DSM projects has been delayed to 1995. In fact, until a clear agreement on many theoretical concepts has been reached within the IEA Annex 1, it was considered premature to decide on the choice of a common European evaluation methodology and, consequently, of the reporting formats.

Building Energy Certification

A second request to the JRC for technical support involved checking progress in the implementation of Building Energy Certification in the EU Member States (MS). To this end, the ISEI organised a Seminar on the topic, combining the event with a SAVE Contractors meeting. The Seminar was organised together with the French agency ADEME, which is the leading organisation for SAVE events, and was held in Sophia - Antipolis, FRANCE, June 27-29, 1994.

ISEI took care of the main conceptual and technical aspects of the Seminar, whereas ADEME looked after the organisational efforts. The meeting was sponsored by the European Insulation Materials Association (EURIMA).

ISEI gave a technical contribution at the meeting /2/ and reported the main outcome of the Seminar. The conclusions and suggestions were also reported and discussed at a SAVE Conference, organised by the European Commission (DG. XVII), (Florence, October, 26-28, 1994), in order to determine preferences and gather new ideas for the forthcoming SAVE-2 programme.

Main problems needing further effort in the field of Building Energy Certification are the following:

- certification should not be an additional bureaucratic burden but an effective tool to foster investment decisions. Every Certification scheme should, therefore, include the energy conservation measures to be implemented;
- Audit Requirements: simplified and user-friendly audit tools should be made available. Standardisation of auditing procedures, databases of building typologies, meteo-data and reference values should be set up, possibly on a European basis;
- information to consumers should be improved;
- present Building Energy Certification schemes should be marketed by professional teams in a positive perspective (higher building quality, more comfort, etc.) rather than in a reductive view (lower consumption, savings, etc.);
- give priority to corporate actions, looking for sponsoring from construction and manufacturing industries;
- link Certification to building quality and environmental aspects, on the one hand, and on the other to building related activities, such as purchasing, financing and insurance audits.

During 1994, the development of advanced building audit and certification tools and in particular of the BEAMES (Building Energy Auditing Management Expert System) package, continued at ISEI. This prototype was presented at various meetings (a dedicated Workshop was organised at Ispra in January 94), and its usefulness and viability discussed with many scientists and building research and management organisations. The application of BEAMES as a Building Certification and decision aid was discussed with DG XVII in Brussels and a report on this issue was prepared for the Florence SAVE Conference, in which the advantages of linking BEAMES with Building Energy Certification computational models were described /4/.

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5 INFORMATICS SERVICES

Corporate Informatics Services

Distributed Informatics and Communication Services

5 INFORMATICS SERVICES

CORPORATE INFORMATICS SERVICES

The Plan of Actions

In September 1993 a report was addressed to the Board of Governors with the description of a JRC multi-annual plan for the modernisation of its administrative information systems. This plan aims at the improvement of internal work-practices through the accelerated penetration of office tools and the revision of information systems. The plan asks for a total of 2.27 MECU development/migration investments over the 94-96 period. The plan received favourable comments from the ISEI Visiting Group and its specific chapter devoted to the Informatics Services.

The Steering Idea

In large service-oriented organisations, the adoption of modern ICT tools and methods is reported to produce some 15% reduction in service costs devoted to no-value-added tasks. Other important advantages are obtained in terms of image, accountability, transparency, service quality, customer satisfaction, staff mobility and empowerment. One additional key factor is that ICT facilitates the process of change in the organisation and the introduction of new administrative and management practices.

The Approach

The modernisation project involves the solution of 41 business problems as identified by an audit exercise extended to all our administrative, operational and managerial processes. In order to capture the experience gained by other organisations in terms of procedure optimisation, process re-engineering, work flow management and associated informatics support tools, a world-wide call for tender exercise has been activated. This has led to the selection of a short list of suppliers of informatics support services which help our internal analysts in the deployment of adequate information and office systems. In addition to ICT expertise, the modernisation effort requires the re-organisation of many aspects of internal work-practices. This can only be achieved through the active and enthusiastic participation of end-users in all phases and aspects of the project.

The Developments

Essentially, the modernisation project develops along four major axis of actions (*see Fig. 5.1*):

- the migration of all existing information systems from the old-fashioned mainframe server towards decentralised platforms;
- the construction of new tools for the management of corporate data;
- the installation of advanced back-office systems in support of the work carried out by the various service Units;
- the provision of advanced front-office systems that facilitate the interaction between service providers and end-customers.

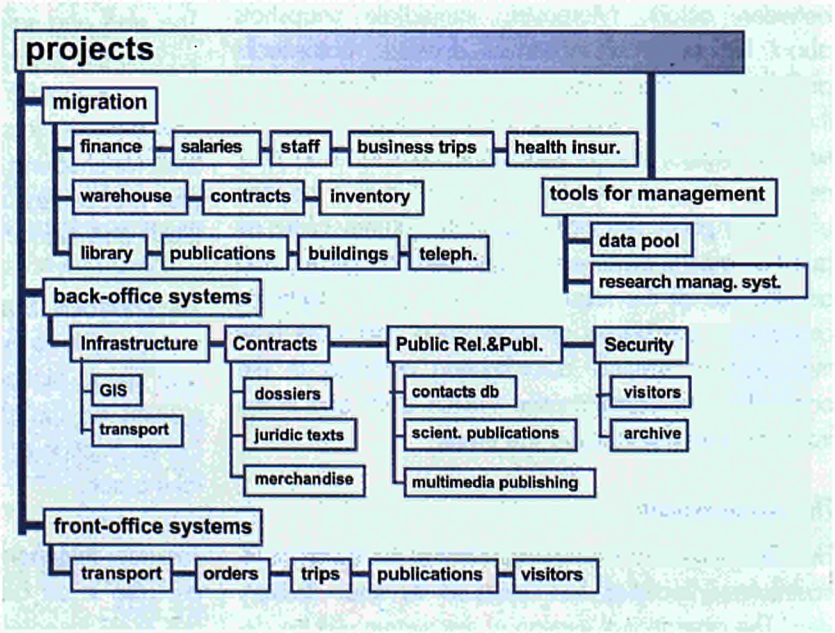

Figure 5.1 The modernisation of Administrative information systems.

The migration takes place either through the full integration with the equivalent systems in force at the Commission (typical cases are the finance, staff, health insurance systems) or through the installation of new ad-hoc systems (typical cases are the geographical information system for the management of the Ispra site facilities, contracts, library, publications and inventory). From 97 and beyond this migration effort will produce a 0.5 MECU/year reduction of running costs due to the removal of the old software/hardware platforms.

Data extracted from the regulatory/operational information systems such as those listed above are collected into a data pool and made available to complex aggregation and correlation procedures as required by managers in their strategic, planning, accounting and speculative tasks. This information warehouse complemented by adequate document archives, multimedia archives and sophisticated information navigation/discovery tools becomes the reference library of information about JRC facts and activities.

Many administrative steps that are necessary in order to request, produce and deliver services that involve multiple functional units and multiple verification/authorisation decisions imply the physical manipulation and the exchange of paper documents. Electronically stored work in progress allows processes to include parallelism in tasks, to make steps visible and measurable and to increase interactions and communication between actors. Moreover, immediate snapshots about the status of individual dossiers, bottlenecks and flaws in the procedures can be identified and the optimisation of work can be facilitated. Procedures such as orders, contracts, visitors, transport and business trips are presented to the end-customer in the form of friendly prompters that support the journey of his request across the organisation until the final delivery and acceptance of the requested service item. Electronic procedures are bosed on workgroup and work flow management systems co-ordinating activities in the back-offices of administrative service Units and in the front-office workstations of the users.

The Achievements

The ***GIS*** project for the management of the Ispra-site infrastructures/facilities has reached its final delivery step. The operational version of the system will be demonstrated to a wide audience in Feb. 95. On top of the basic topographic maps, thematic aggregates are produced with alphanumeric data relevant to the management of buildings, offices, allocated staff, telephone/fax/photocopier devices, cleaning, maintenance interventions and other services.

The new***Library*** system has been installed and loaded with the historical catalogues derived from the old system. It provides query and application functions to the end-user, loan management, inter-library consultation and loan facilities, accounting and service follow-up. The capabilities of the new service will be demonstrated to the community of users in Feb. 95. This will be followed by intense training and customisation sessions.

The new ***Publications*** database is now loaded with the historical bibliographic data and is ready to collect the new submissions. As a by-product, the Bulletin of JRC Publications in its version for final distribution is produced.

The new ***Contacts*** database for use by our Public Relations service is in its acceptance phase. It is meant to collect relevant information about meetings, events, interest groups and mailing lists according to the specifications required for the management of JRC contacts with Member States authorities, visiting and control Bodies, Scientific and Industrial circles.

The ***staff and salaries*** information systems have been successfully migrated to independent and cheap platforms. During 95, the parallel operation of both the new and the old system is foreseen. This verification allows for checking the consistency of results across complex procedures such as promotions, changes in salary levels and indemnities.

The ***contracts, business trips and staff allocation*** information systems have been migrated to independent and cheap platforms. The performance of those new systems will be checked against the old ones and if the verification proves successful, the replacement will take place.

The new ***telephone and transport requests*** databoses are also in an advanced phase of development and are likely to enter operation by mid 95. A new car transport reservation, management and accounting sys-

tem has been designed that eliminates a great deal of paper work and human interventions. The end-users and the operators of the transport service are supported by a work flow manager that supervises the circulation of the requests and their follow-up.

The information system of the Ispra site *Security Service* has been redesigned in order to improve the overall efficiency as perceived by our visitors. In particular, the new system includes new logistic arrangements at the reception desk integrated with the databases on badges, cars and movements. The security-check function is best served by an electronic information base. The system has its own work flow manager for the production and the follow-up of the visitor request.

The New Financial & Accounting Information System

A joint project with membership from DG XIX, DG XX and JRC has been set-up for the production of SINCOM2, the new financial & accounting information system in force at all Commission services.

The JRC contribution has been considered essential in the light of the experience gained in the design and operation of the existing Sibeca system. The project has entered the detailed specifications phase which will be followed by the development phase and demonstrator phase planned for mid 96. The demonstrator operated at the JRC will serve as a test bed before the delivery of the final version of the system to all other Commission services takes place.

As regards the JRC installations, this would conclude the migration of the existing information systems from the expensive mainframe server. The mainframe server itself is expected to be dismantled at the end of 96.

The Orders Work Flow

One major effort has been undertaken in order to introduce modern work flow management techniques in the order process for the procurement of goods and services.

This is the most complex and pervasive in-house administrative procedure in the house. In order to check the technical feasibility of the approach, a fully paperless and machine-assisted prototype has been demonstrated to our administrators. The project now requires the analysis of the details of the procedure as executed by the various actors (requester, authoriser, financial controller, accountant, inventory, customs, warehouse) in the spirit of a newly re-engineered process. For this purpose, a task force has to be set-up with the mandate of devising new work-practices, test environments and the final deployment of the system. The ISEI and ITU Institutes volunteered to act as leaders of this experience.

DISTRIBUTED INFORMATICS AND COMMUNICATION SERVICES

The services provided in 1994 were those that had been negotiated with our customers during 1993. Moreover, these services and the activities of the DICS Unit were evaluated during 1994 by the same "Visiting Group" of international experts that had performed a similar evaluation in 1993. The negotiation process was continued during 1994 in order to define services and resources for 1995.

Network Services

At the beginning of the year the 64 Kbps connection of Karlsruhe to the German research network was installed and activated, thus completing the connection of all JRC research sites to a network infrastructure at 64Kbps . This connection was managed by the Megapac node that had been sent from Ispra some months earlier and put into service. Once the necessary addressing modifications had been performed, the new connection was used to provide all of the data communications connections between Karlsruhe and the rest of the JRC. The most noticeable improvement was the response times for SIBECA users, although the connection also improved the speed of Xerox communications. Discussions have also begun in order to ensure the connection of the Seville establishment to the research network in Spain at 64Kbps (which interfaces to EuropaNet), thereby adding the recently moved Institute to the "JRCNet" at 64Kbps.

During 1994 it became apparent that the 64 Kbps connection to SWITCH that provided access to the Super computer at Manno, and also IP access to the World-Wide Internet was frequently becoming saturated. Negotiations took place with SIP (the provider of the physical connection) and SWITCH in order to increase the speed of the connection to 512Kbps. This increase in speed was implemented in September 1994.

A limited round of extensions to the Ispra FDDI backbone network has taken place, as no additional FDDI nodes were installed. Improvements in network efficiency were made in several buildings by the installation of modern cabling subsystems based in the use of twisted pair cables which replaced the traditional ethernet yellow cable or thin cable.

A new software version was installed on the bridges in the network that allow filtering of the traffic to be carried out. A new software product for the management of the tables on which the filtering is based was also installed. It is hoped that the use of this mechanism will substantially reduce the unnecessary traffic on the backbone.

First trials were carried out with the installation of ISDN circuits. An initial group of 3 primary rates (2Mb) and 30 basic rates (144Kbps) was made specifically for data and video transmission applications.

Distributed Systems Management (DSM)

During this period some presentations have been made to Institute representatives on the DSM service and progress made in 1994, in an attempt to give more publicity to what is available through this service. Also individual contacts with some user groups have been made for the same purposes. These have increased the amount of use made of the DSM facilities.

There have been more substantial changes in the hardware components of the DSM service. First the "dicscs4" SUN Sparc 1000 has been put into operation as the principal DSM service machine. It is a multiprocessor system that is currently running with 4 CPUs, and is connected to the FDDI concentrator that gives it full 10MB access to the backbone network. This action should greatly simplify the systems management problem for the service providers (there will be a smaller number of system configurations to manage).

A new aspect of the service was launched; the availability on a server of the Usenet Network News. This set of news conferences can be read by any client that can handle NNTP (Network News Transfer Protocol), so no specific reader programs are necessary. Public domain tools such as Netscape that are already being used for accessing the World Wide Web, can also be used for accessing this information.

A scan was made of the security of all systems on the Ispra site using the ISS tool. The results, which made interesting reading, were given to those responsible for the management of the systems. Repeating the exercise in the near future is intended to ascertain what actions have been taken to tighten up the security of the individual systems.

An evaluation of the Novell Networking software (Netware 3.11) for the PC environment was completed. The conclusions were very positive, particularly in relation to its use in the administrative environment where some units had already decided on implementation. A limited number of scientific groups had also decided to use Novell, and DICS has co-ordinated these various implementations and provided some support during the installation phases.

Electronic Mail

Many important changes took place in 1994. The Bull DPX systems that were used to provide the mail service and which were nearing obsolescence were replaced in 1994 by a set of Unix MTAs (Message Transfer Agents), and a new SMTP server introduced. The mail broadcast service that has been so successful for advertising meetings and seminars was automated and the rules for its use were published.

The X.400 and SMTP mail services with the outside world continued throughout this period without any apparent modification, even though the servers providing this service had been replaced.

The ISOCOR X.400 product was installed on many PC systems, and several MTAs installed. The overall level of use has grown tremendously and is extremely encouraging. The use of X.400 allows document exchange to take place rather than just message passing.

An installation of these products was made in the JRC Institute newly installed in Seville to provide the X.400 e-mail service for both PC and Macintosh users.

Limited developments were done in the use of e-mail, together with EDI (Electronic Data Interchange) and work flow, to automate some of the procedures used by the Financial Control in remotely managing the other JRC sites. Several versions of the prototype were demonstrated during the year. An operational version should be ready for early 1995.

Office Automation

Testing and evaluation was carried out on new versions of Xerox GlobalView for open platforms. These were specifically GVWin for PCs with MS-Windows, and GVX for UNIX systems with X-Windows. As a result of these tests it was decided to recommend the general use of GVX, but the first version of GVWin was considered not suitable for general use.

The version of GVWin that arrived later in the year was considered much better than the first, and it was decided not only to recommend it for general use, but to recommend that all Xerox users migrate towards the PC platform with GVWin. This will also bring the JRC more into line with the Commissions informatics strategy for office systems.

An installation of the XNS software was made in Seville, allowing the Institute to communicate with the rest of the JRC. The DG in Brussels was connected directly to the EMPB network, thus reducing the costs for inter-site connections while maintaining the same level of service.

Computer-Aided Design

Steps were taken to complete the migration of this service from a central one to a distributed one, in that additional workstations were installed so that by the end of 1994 no users were left on the central system, which was then closed down.

The central service will be discontinued.

6 OTHER PROJECTS

The Euro-Quebec Hydro-Hydrogen Pilot Project (HQHHPP)

The Ispra Ecocentre Project

6 OTHER PROJECTS

THE EURO-QUEBEC HYDRO-HYDROGEN PILOT PROJECT (HQHHPP)

An important project being developed in the frame of renewable energies, is the one bound to the generation, transport and use of hydrogen.

The initial 100 MW pilot project was intended as a DEMO, to demonstrate the feasibility and the advantages of converting through electrolysis, Quebecian hydropower into hydrogen to be shipped and used where energy sources are scarce.

The project is based on a concept conceived by the JRC and is carried out by a group of industrial firms/institutions. The JRC /ISEI co-ordinates the project.

Milestones of the Project

- ***Phase I:*** Assessment, completed;
- ***Phase II:*** detailed system definition (completed) and supplementary tasks (postponed);
- ***Phase III.0.:*** hydrogen applications demonstrating projects (under way);
- ***Phase III:*** detailed engineering and specifications;
- ***Phase IV:*** construction.

Present Status of the Project

The project is now oriented towards its present phase III.0, i.e. demonstration projects for the application of hydrogen.

New contracts have started in 1994 for

- the operations of a passenger boat;
- certification of testing of containers, including a scientific and experimental programme;
- safety tests of a composite material vehicle tank investigation of cryo/pressure adsorption of hydrogen.

Results

In July 1994 the first of the three hydrogen buses that Hydrogen Systems, Belgium, constructed under Phase III.0-2 have been presented to the Commission and the public. All other projects are duly under way, some of them with acceptable delays.

ISEI activities in 1994

The co-ordination of the project done by ISEI consisted in contract supervision, i.e. technical supervision of on-going works including visits to the construction sites and in-house verification of contractual and financial matters. Furthermore the technical annexes for future contracts have been prepared.

THE ISPRA ECOCENTRE PROJECT

Low Energy Retrofitting of Elderly Buildings

1994 was the second full year of the ECOCENTRE Ispra Project. The aim of this project, funded by the European Parliament, is to demonstrate how the environmental impact of an ageing research centre, such as the JRC's Ispra Establishment, can be reduced by a series of carefully chosen, cost-effective measures. The eco in ECOCENTRE stands for both ecological and economic.

The Energy/Environment Interaction unit has taken an active part in this project since its inception, making a number of important contributions in the current year. These were:

Building Retrofitting

As described in the 1993 Annual Report, an international competition was organised for the innovative low-energy retrofitting of a number of elderly buildings. The winners were awarded contracts to develop their designs into fully-detailed engineering projects, in close collaboration with the JRC. So far, retrofitting work has actually commenced on one building, a large experimental hall, and the design of the most complex project, that of the cafeteria or Mensa, has been finalised.

The Ispra Mensa is actually a conglomeration of buildings comprising 2 cafeterias; the Old Mensa on the north side and the New Mensa on the south, with a kitchen situated between them and a guest dining room

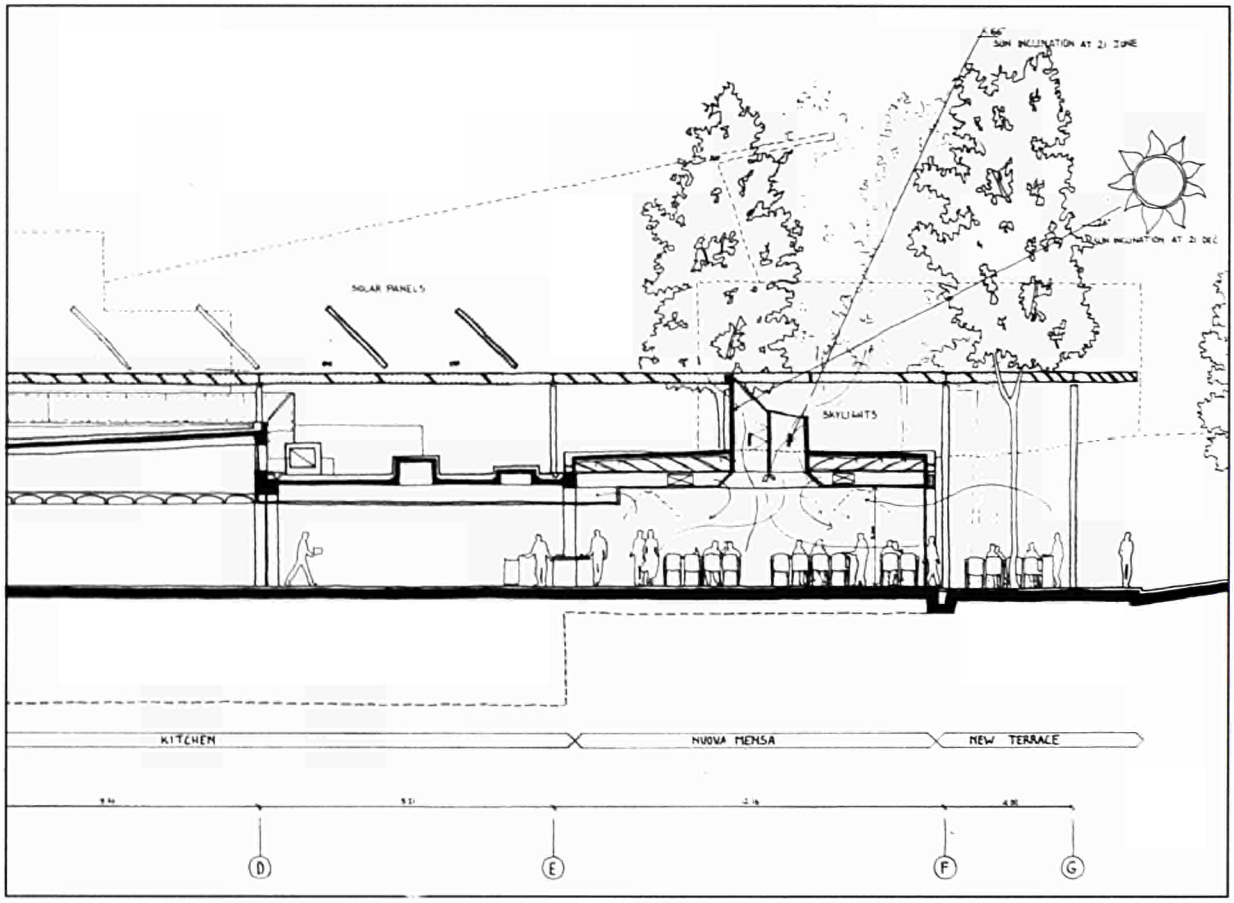

Figure 6.1. Cross Section of Retrofitted Mensa Showing the Pergola and a Skylight.

to the east. The winning retrofit project, designed by the Paris based Italian architect, Mario Cucinella, proposes to give visual unity to these buildings by covering them with a wood and steel pergola (*Figure 6.1*).

This structure will, however, have a number of important practical functions:

- to provide shading for the whole roof, thus reducing the cooling load, prolonging the life of the waterproof membrane and more than tripling the shaded outdoor eating area;
- to provide a platform for solar water heaters for dishwashing, replacing the electrical heaters which are used in the summer months when the superheated water supply is turned off;
- to provide a structural support for large ventilating and daylighting skylights which will be inserted in the roof of the New Mensa (*Figure 6.1*).

The ceiling of the New Mensa will be rebuilt with sound proofing and low energy lighting, and the whole building will be given double glazed windows and external insulation. The overall energy saving for heating, cooling and electricity is predicted to be about 70% of the present total or almost 90 TOE (tonnes of oil equivalent) per year in primary energy terms. This corresponds to a reduction in CO2 emissions of around 200 tonnes per year. Simple pay-back time is predicted to be within the 20 years set by the completion.

A sensitive aspect of the Mensa retrofit is the proposal to minimise summer use of the existing air conditioning system by providing greatly improved natural ventilation. This will be achieved through air buoyancy promoted by the chimney like shape of the above mentioned skylights and many more opening windows. The aim is to achieve pleasant indoor conditions similar to those experienced by someone sitting out-of-doors, in a shady spot with a gentle breeze. In physical terms, this involves extending the Thermal Comfort Zone (TCZ) of the psychometric chart (*Figure 6.2*) to areas of higher temperature and relative humidity by the introduction of a third parameter, air speed.

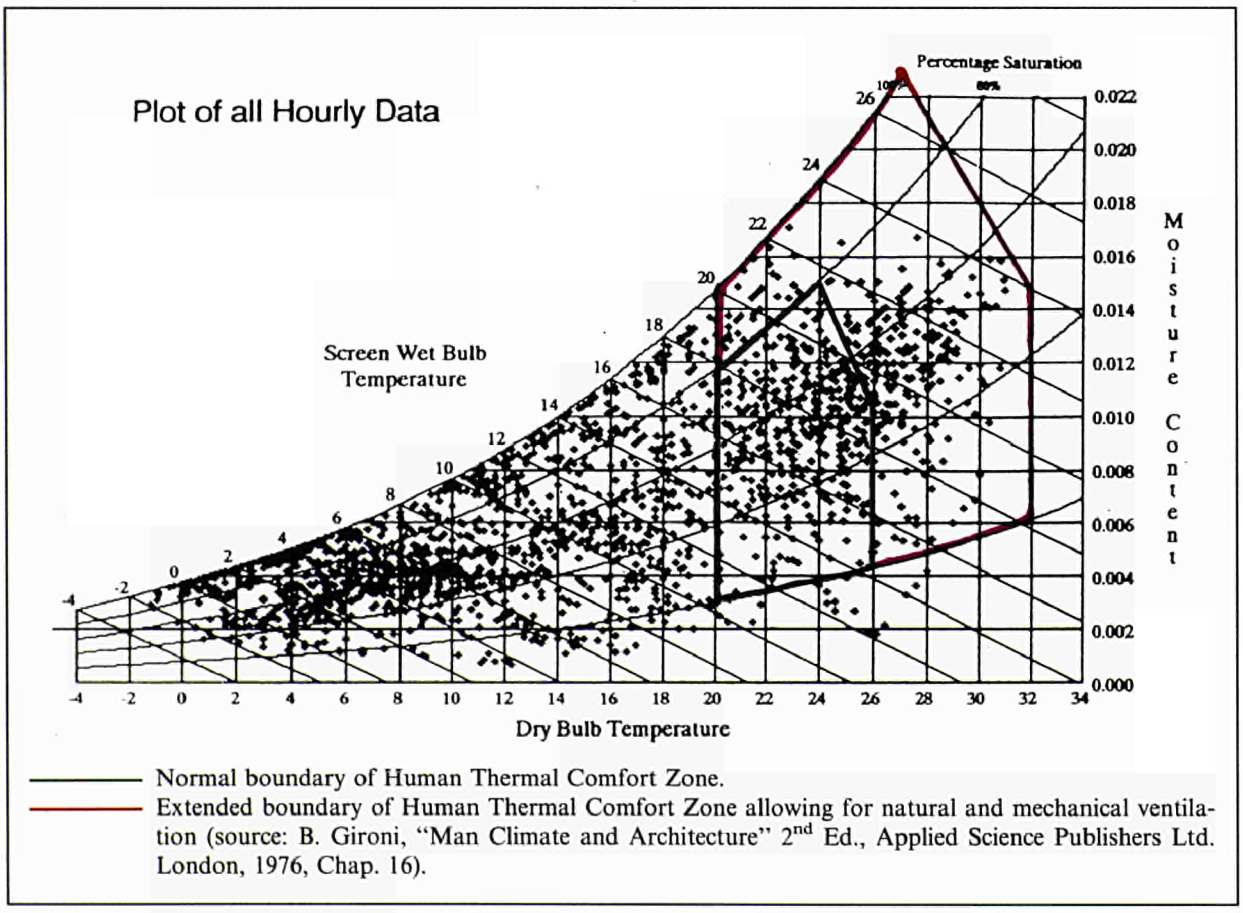

Figure 6.2. Psychometric Chart showing hourly weather data for Ispra and Human Thermal Comfort Zone.

There is, however, no commonly agreed boundary to the TCZ in these conditions. Initially, therefore, a trial boundary will be programmed into an intelligent building management system which will keep internal conditions within a moderately extended TCZ, as much as possible, by controlling the air speed. This will be achieved by automatically opening or closing upper windows and ventilation grills in the skylights. If the internal conditions cross the boundary of the TCZ, the existing air-conditioning plant will come on. The initial boundary will be modified according to the results of opinion surveys carried out among Mensa users. This 3 - parameter control is a totally new concept, in keeping with the ECOCENTRE principle of applying innovative techniques for energy conservation.

As a first step, questionnaires were distributed on one day during the summer of 1994 to find out what clients thought of the pre-retrofit conditions. Analysis of the 300 replies showed *(Figures 6.3)* very distinct differences between sexes and age groups. The clients most satisfied with the indoor conditions were men over 50 years old, whilst the largest proportion of dissatisfied clients was found in the "women over 50" age group! Moreover, the younger the person, the greater the preference for eating out-of-doors and the older, the greater the preference for eating indoors. Much of the divergence of opinion, naturally, centres on the individuals definition of a comfortable indoor temperature in air conditioned spaces. Indications are that allowing the temperature to rise slightly would please many (although displeasing others) and would, of course, reduce energy consumption significantly.

Building Monitoring

In order to evaluate the energy savings achieved, the buildings to be retrofitted have been equipped with detailed monitoring systems. These measure indoor air temperatures (to within 0.10) and relative humidities at a number of points, together with all energy flows. Since heating and cooling on the Ispra site is provided by a district network, these include super heated water,

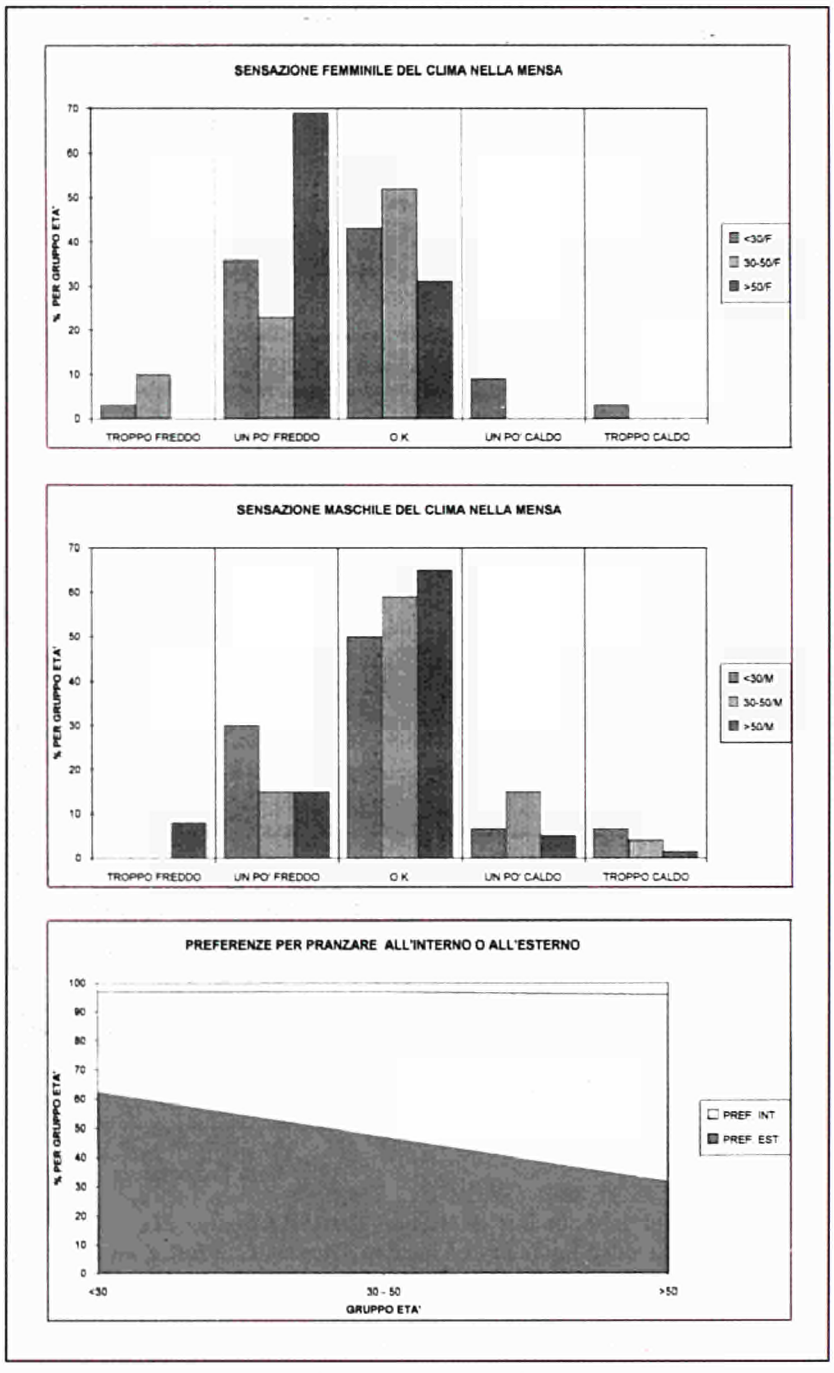

Figure 6.3. Results of Survey of Cafeteria Users Opinion of Indoor Climate on a Summer Day.

refrigerated water and lake water, in addition to electricity. All temperatures and flows are recorded at 1 minute intervals and averaged over 15 minute periods.

The monitoring system in each building is controlled by a local computer (PC) which carries out the averaging and stores the data for daily transmission to a central PC. When fully operational, the specially developed software, resident in this PC, will provide automated data analysis and reporting facilities.

Building Rules

Apart from the ECOCENTRE building retrofit competition, there is a continual demand for the construction of new buildings and the renovation of existing ones on the Ispra site. To ensure that this work respects the principles of the ECOCENTRE project, a set of Building Rules has been drawn up. These specify construction standards designed to produce buildings with significantly lower energy requirements than those built to current Italian norms. They also restrict the use of materials which could have a negative impact on the environment. Once approved, all constructors on the Ispra site will be obliged to observe them.

Building Integration of an Amorphous Silicon Photovoltaic Facade

The ECOCENTRE project aims to demonstrate the application of available technologies for the modernisation of ageing premises of research centres under ecological and economical aspects. The results are intended to be transferable to other sites. Among other projects, the demonstration of photovoltaic technology in its application to a building facade was chosen as an example of future renewable energy technologies.

Objectives

The objectives for the project were set out as follows:

- demonstrate to architects that the application of photovoltaic solar energy on facades provides for a new and additional design element;
- make use of existing building engineering to reduce the area-related costs of a photovoltaic array;
- take into account a future extension to a hybrid system which also harnesses thermal solar energy;
- improve the overall appearance of the building;
- demonstrate a turn-key system feeding reliably the electricity grid.

Technical Details

Given the objectives of the ECOCENTRE project main emphasis was put on visibility and design features, rather than maximising the power output with high-efficiency photovoltaic modules.

The building chosen houses experimental facilities for earthquake simulation (ELSA: European Laboratory for Structural Assessment); its southern face has the dimensions 65 m (wide) by 25 m (high). Not all of this surface could be covered, as an adjacent office complex limits the unobstructed area to the top 12m of the building

As the amount of financial resources was limited, the main design constraint was the lowest possible cost per unit area. Only amorphous silicon technology was considered feasible under this condition without sacrificing the goal of covering the whole available area of the southern building facade.

The total area available is therefore 720 sqm. Taking into account framing losses, non-optimal distribution of modules, initial degradation of amorphous silicon and an minimum efficiency of 3.5 %, the designed peak power was 21 kW. Accordingly, the grid-connected inverters were designed for this input power, in four blocks of 5 kW AC each.

These consist of a-Si substrates manufactured by Advanced Photovoltaic Systems (Princeton, NJ, USA) which were laminated by the German Flachglas Solar GmbH (FlagSol) in a double-glass compound utilising a proprietary process. A total of 420 modules, size 0.84 x 1.50 sqm were delivered. Aluminium profiles from a building facade industry were attached to the internal structure of the building and provided the mounting support and cable trays for the PV-modules. As the total weight of the retrofit is approximately 20 tons, additional reinforcement of the building was necessary.

The generated electricity is fed in the local distribution grid by means of four electronic inverters. These inverters are cascaded in a "master-slave" mode and are tracking the maximum power operating point of the ar-

Figure 6.4. Outside View of the Facade on Building 48.

ray. This concept guarantees highest transforming efficiency even at very low sunshine levels.

A dedicated data monitoring and visualisation system was installed to measure the relevant parameters of the photovoltaic facade. Apart from the capability to remotely control and monitor the system, special emphasis was put on an interactive visualisation of the operation of the plant, in order to make the functioning of the photovoltaic facade understandable and visible to a wider audience.

An acceptance test was performed to verify the installed power. The 7 main strings, operating at approximately 300 Volts were measured to deliver 30 kW under Standard Test Conditions. This initial performance exceeds the design value by 40%. The monitoring systems reveals the major meteorological and electrical parameters in five-minute intervals, which are transmitted at night to a remote computer server. Major interest in analysing the data lies in the determination of the initial degradation, the possible loss due to vertical mounting and a preliminary assessment of the potential of thermal heat recovery.

Conclusions

The goal to demonstrate a-Si technology as a design element for industrial building complexes has been achieved. The problem of retrofit and the related necessity of enforcing existing structures was underestimated at the beginning of the project. The experience with thin-film technology is so far positive, both from the aesthetics and the performance point of view.

Technical data

Total Facade Area	771.1	sqm
Module Area	1.3	sqm
Covered with 420 Modules	543.8	sqm
Active area	505.2	sqm
Design Power	21000	W
STC Power	30000	W

Modul Daten OPTISOL A056001			
	Module	Facade	
Voc	58.5	468	V
Isc	2.05	107	A
Imp	1.74	90.6	A
Vmp	41.3	330.3	V
Pmax	72.0	30000	W

7 SHARED COST ACTIONS

Copernicus Programme

Renewable Energies Programme

7 SHARED COST ACTIONS

COPERNICUS PROGRAMME

Two projects have been approved in the course of 1994. For both of them the beginning of the activity is planned for the first months of 1995.

TINCA: Enhancing Technological Awareness and Technology Transfer in the Area of Advanced Intelligent Computer System for the assessment of the Remaining Life, Reliability and Safety of Power Plant Components

Date of start: March 1995

Duration: 3 years

Partners:

MPA, Stuttgart Germany
ISQ, Lisbon Portugal
JRC, Ispra, EC
Korona, Ljubljiana Slovenia
DME, Miskolc Hungary
EROKAR, Budapest Hungary
LENENERGOREMONT, St.Petersburg Russia

Small Punch Test Method Assessment for the Determination of the Residual Creep Life of Service Exposed Components

Date of start: March 95

Duration: 3 years

Partners:

MPA, Stuttgart , Germany
CISE, Milano , Italy
JRC, Ispra, EC
IRM, Brno , Czech.Rep.
IMT, Ljubljiana, Slovenia
IMTM, Cracow, Poland

RENEWABLE ENERGIES PROGRAMME

Photovoltaic Integration in Developing Countries

Start of Contract: 1 Jan. 1995

Duration: 18 months

Proposer: EUREC Agency

Coordinator: Wirtschafts und Infrastruktur Planungs GmbH, Muenchen (DE)

Partners: IT Power (UK)
GENEC (FR)
Uni Karlsruhe (DE)
FhG-ISE (DE)
IES (ES)
Uni Nova Lisboa (PT)
Conphoebus (IT)
JRC-ESTI (EC)

Support: UNESCO
UNIDO
UN-Commission for Centres of Excellence
European Photovoltaic Industries Association (EPIA)
EUROSOLAR

ElectricHome - Assessment of All Non-Electrified Houses in Southern Europe and Development of Standard Systems for Accelerated Large-Scale Deployment of Renewable Energies

Start of Contract: 1 Jan. 1995

Duration: 18 months

Proposer/Coordinator: Wirtschafts und Infrastruktur Planungs GmbH, Muenchen (DE)

Partners: Clean Power (GR)
ETA (IT)
UGC/SEMAI (ES)
UNL/FCT (PT)
JRC-ESTI (EC)

8 WORK FOR THE PARTIES

Photovoltaic Component Testing

Support to Regional Development: Sicily Project

Software for Industrial Plant Supervision

Root Cause Analysis of Human Errors Study

Software for Safety and Reliability Assessment and Management

Ultrasonic Seals for Safeguards

8 WORK FOR THIRD PARTIES

Photovoltaic Component Testing

During 1994, 35 quotes were prepared in response to requests from 23 clients. These quotes led to 15 contracts for third party work with a total value of 203 kecu, of which 88 kecu have been invoiced to date. Nine of these contracts, worth 187 kecu, were for photovoltaic module qualification testing work. The remaining six, worth 16 kecu, were for reference device calibrations. The calibration of cells and modules was requested increasingly due to major improvements in response time and quality of results.

74 modules of 13 different types were subjected to CEC Specification 503 module qualification tests. Two module types failed to meet the test requirements, but the remaining eleven types received qualification certificates. Note that all the modules received for testing were of crystalline silicon technology. No modules using thin-film technology have been submitted for testing. 35 reference devices (modules and cells) were calibrated. This work was carried out despite the inconveniences caused by the ECOCENTRE building modifications.

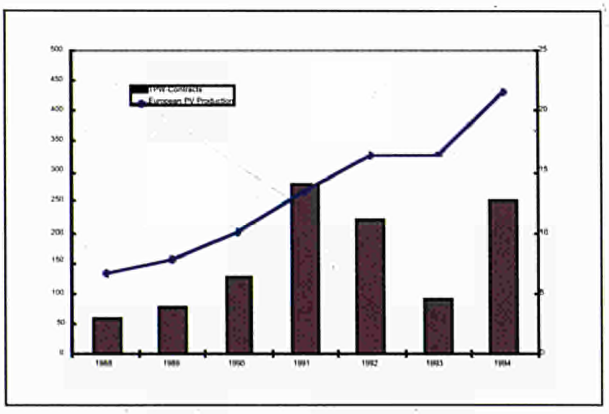

Figure 8.1 Third-Party Work Contracted 1989-1995.

Support to Regional Development: Sicily Project

Two Conventions between the Regione Siciliana and the JRC and between the Regione Siciliana and three Sicilian Universities, (Catania, Messina, Palermo) were signed on April 27, 1994, by the General Director of the JRC, the President of the Regione Siciliana and the Rectors of the Sicilian Universities /1/. The conventions have become operative, after the approval by the Sicilian Corte dei Conti, on December 14, 1994.

Funding for JRC activity is assured by regional funds, while the universities are funded by EC Structural Funds. The overall budget of the Convention is of about 23 MECU, 6.5 of which are for JRC.The Convention contains six projects /2/:

Project A: Water supply management monitoring of quality and quantity of water resources and decision support.

Project B: Air pollution in industrial and urban centres; data collection on pollution, modelling and decision support.

Project C: Pollution and erosion of the soil; study and control of soil erosion and pollution.

Project D: Safety and reliability of chemical and petrochemical installations; risk identification and analysis; prevention and mitigation of consequences of accidents.

Project E: Cultural heritage; study of the degradation of monuments and stone material works of art of the Sicilian cultural heritage; development of protection and restoration methods.

Project F: Reference values of trace elements in inhabitants of Sicily Region; systematic monitoring of trace elements (Al,As,Cd,Co,Cr, etc) and relevant analysis for estimating the reference values.

The work is being performed in Ispra by four Institutes: IE, IRSA, ISEI and IST.

The work repartition among them is given in *Fig. 8.2.*

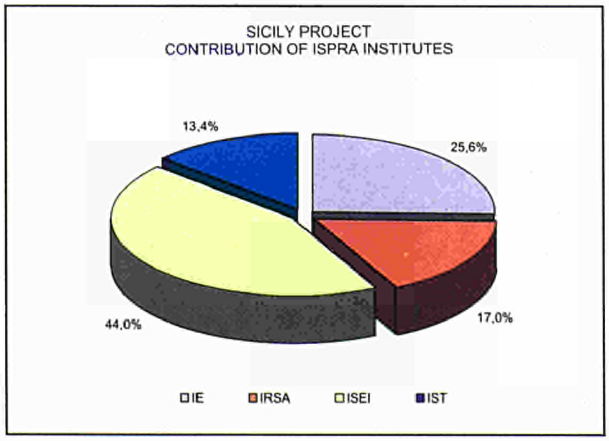

Figure 8.2. Effort Repartition for the Execution of the Sicily Project.

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/1/ Convenzione tra Regione Siciliana e Comunità Europea, Taormina, April 27, 1994/2/ Progetti di ricerco presentati dalle Università degli Studi di Catania, Messina e Palermo in collaborazione con il Centro Comune di Ricerca della Commissione delle Comunità Europee, Allegato N.1 alla Convenzione tra regiane Siciliana e la Comunità Europea, 1994.

Software for Industrial Plant Supervision

In the framework of the FORMENTOR project, the first Industrial Application was started at the beginning of 1994. The objective of this application is to supervise a Catalytic Cracking unit of an oil refinery exploited by TOTAL France. The application is led by Cap Gemini.

ISEI was requested to provide the necessary methodological input for allowing the extension of the functionality of a typical FORMENTOR system in order to support plant maintenance tasks. This work will be completed in April 1995.

Root Cause Analysis of Human Errors Study

The third party work, ordered by an Italian industry, started in 1993 on the development of a methodology for root cause analysis of human error, has been completed. A general methodology for the root cause analysis of human errors has been developed based on a suitable representation of incidental sequence by means of an event time line /1,2/. Once the erroneous actions have been identified, the root cause analysis is performed with a suitable error taxonomy. The methodology has been described in a sample application taken from the aeronautical domain. In particular the Zurich accident of November 1990, in which an Alitalia DC 9-30 crashed onto the Stadelberg hill has been analysed with the proposed methodology /3/.

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/3/ Cojazzi G., Pedroli M., (1994b), A Root Cause Analysis Methodology, Commission of the European Communities, Tech. Note I.94.59, ISEI/IE 2697/94.

Software for Safety and Reliability Assessment and Management

The software STARS (Software Tools for the Analysis of Reliability and Safety) methodology has been applied to a number of specific industrial cases.

In the first case, the objectives of the contract were to develop a customised version for a power generating plant of the software package able to represent specific components and systems, and to develop additional application modules for integration within STARS. In particular, a new modelling technique based on a functional decomposition of the industrial system has been developed. This functional model supports the automatic construction of Failure Modes and Effect Analyses (FMEA) tables, and is at the basis of new algorithms for the semi-automatic construction of event trees.

In other cases, the STARS methodology and software package, in particular the parts related to the modelling of industrial systems and to the semi-automatic construction of fault trees, have been the subject of contracts with different industrial companies as a contribution to the design of transport equipment. In one case, the application of STARS concentrated on the use of hierarchical descriptions of functional specifications for qualitative risk assessment during the early stages of the design process. In another case, STARS is to be interfaced with existing industrial CAD systems to take advantage of existing low-level design specifications and to automatically provide safety and reliability information on the imported designs. These two applications illustrate the flexibility of the STARS system in providing an integrated framework for safety assessment during the various stages of the design process, from high level design to low-level specifications.

Ultrasonic Seals for Safeguards

The work on the contract between JRC-Ispra and the Japanese company Power Reactor and Nuclear Fuel Development Corporation has continued. A particular effort has been devoted to developing a new ultrasonic seal, called a "clamping seal", able to be fastened on PNC owned COGEMA Pu O_2 casks (FS-47) *(Fig. 8.3)* used for transportation from France to Japan. Along with the seal the design of a new portable reading head has been achieved and a functioning prototype was terminated by the end of 1994.

In October 1994 a first demonstration was organised at the PNC facility of Tokai (J) and two MK5 clamping seals could be attached to the cover (shock absorber) of one empty cask in real conditions. One seal was then removed and later on correctly reverified back at JRC-Ispra. A dummy reading head was also tested as to its ease in operating conditions.

An evaluation study to select a portable and sturdy computer to fit the new ultrasonic boards from the Sofratest company was also completed leading to the selection of two possible instruments from U.S. and from German companies.

A second visit to Tokai is planned in Spring 1995 where a series of MK5-CL seals will be tested with a complete reading equipment in actual transportation conditions.

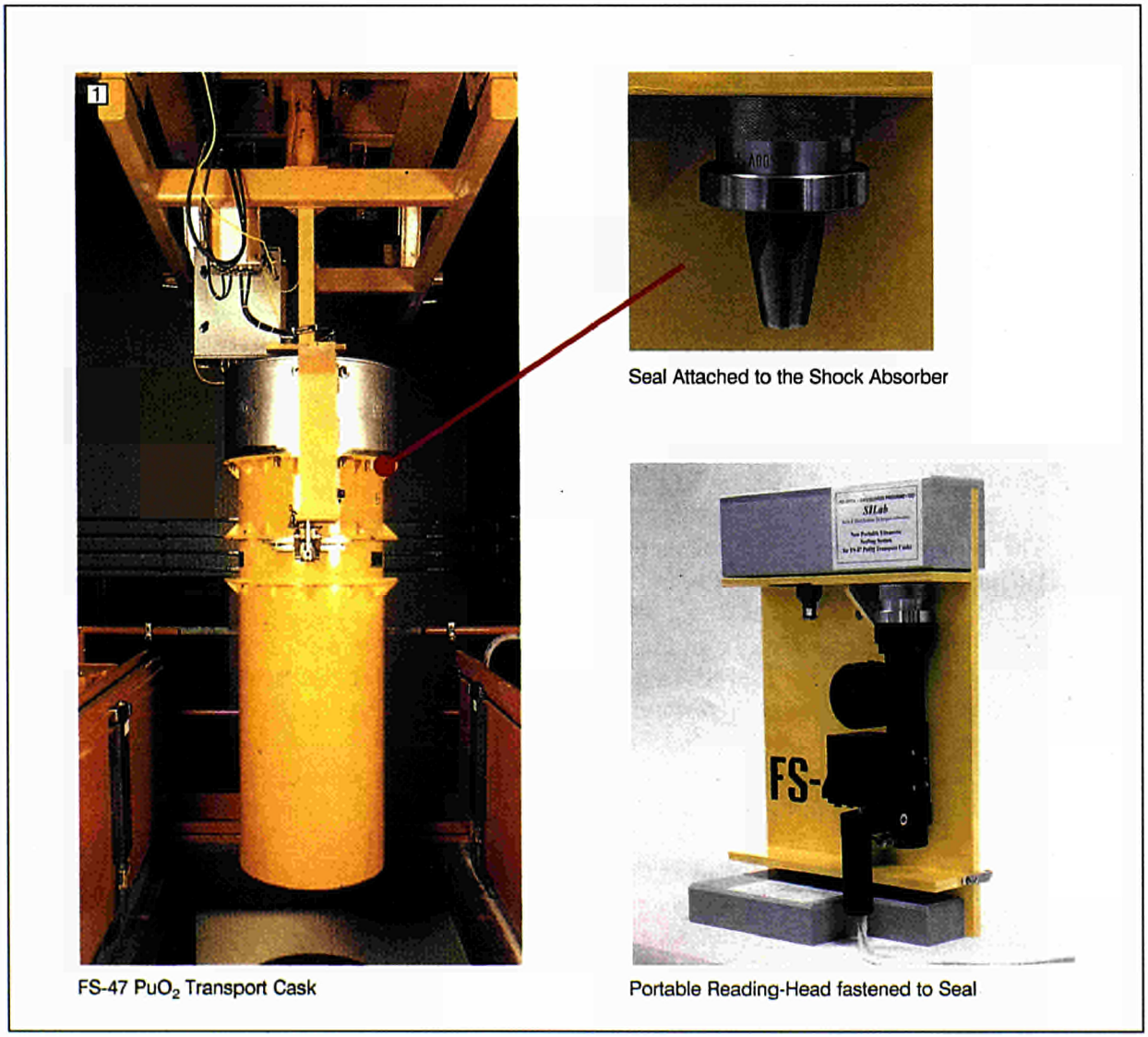

Figure 8.3. New Portable Ultrasonic Sealing System for Nuclear Containers.

9 TEST FACILITIES

ESTI, European Solar Test Installation

Telemac Laboratory

LaSCo, Laboratory for Containment and Surveillance

9 TEST FACILITIES (upgrading during 1994)

ESTI, European Solar Test Installation

Quality (ISO 9002 and EN 45000)

ESTI is one of the first facilities of the JRC to seek Laboratory accreditation according to the European Norm 45000. This requires not only implementation of a quality assurance system (e.g. ISO 9002), but also the full traceability of physical quantities for which the laboratory is certified. For this purpose an effort has been made to achieve accreditation for the *Calibration of Solar Reference Devices* and *Type Approval of Photovoltaic Modules*. The request for accreditation will be made during 1995, after the traceability laboratory for temperature, voltage, resistance and irradiance is set-up and the quality assurance system is fully operational.

Module Type Approval

Among the modules tested were the biggest currently in mass production (ASE Americas ASE-300 type 1.8 x 1.2 metres). This work required modifications to the climatic chambers and the purchase of specialised trolleys for transportation. Spectral response measurements were also performed on ASE GmbH modules with dimensions up to 1.5 x 1.0 metres.

With the gradual adoption of the ISO 9000 quality standards, requests for periodic reference device calibrations have been received from leading European manufacturers. This type of work will become more important in the future, and will increase device calibration revenues, especially if the ESTI laboratory achieves accredited status.

To improve the technical content of the qualification test reports, the test systems are being equipped with better data acquisition equipment to demonstrate that all devices tested attain the conditions described in the test specifications. Test-bed control systems are also being upgraded to improve reliability of operation.

The next new test bed will be a large-area UV irradiation facility using fluorescent tubes as the light source. This system shall irradiate an area of approximately 8 square metres, and is aimed at testing the large-area modules which are becoming more important in architectural PV applications.

Equipment Available

- WEISS Light Simulator + Climatic Test Chamber
- BOSCH Steady State Large Area Solar Simulator
- SPECTROLAB Large Area Pulsed Solar Simulator
- GLOBAL PHOTOVOLTAIC SPECIALISTS Large Area Pulsed Simulator
- PASA Large Area Pulsed Solar Simulator
- Mechanical Load Simulation System
- Hail Impact Simulation System
- Ultraviolet Radiation Unit
- High Temperature/High Humidity Climatic Chamber
- Thermal Cycling/Humidity Freeze Climatic Chamber
- High Voltage Test System
- Laser-Scanning Facility
- GER Spectroradiometer
- Semiconductor Spectroradiometer
- CIP PMO6 Absolute Cavity Radiometer
- Field Array Testers up to 100 kW
- Infrared Imaging System

TELEMAC Laboratory

The main equipment of the TELEMAC laboratory, dedicated to the computer simulation of heavy robotics tools and to the validation of numerical simulation results from experiments on mock-ups, was described in the ISEI Annual Report 1993.

The main facility of the laboratory , ROBERTINO, (*see Fig. 9.1*) a large gantry robot for experimental validation tests in the field of heavy robotics, has been upgraded in order to ameliorate its control system and dynamic behaviour during the movements, in particular for avoiding induced vibrations. The pay load was increased to 6 tones, resolution and repeatability were ameliorated to 0.1 mm. The vertical translation is obtained now by the synchronised movement of four brushless servo-drives, each moving one screw; the horizontal movements are obtained each by the synchronised movement of two brushless servo-drives moving precision screws with ball-circling nuts.

A new control system has been developed for a more autonomous and flexible operation of the facility. The new control system, based on VXI-bus with VX-works as operating system, is appropriate for the experimen-

Fig. 9.1. Detail of Robertino facility.

tal requirements of the facility and, at the same time, it is in conformity with the most updated standards. It will ensure high reliability and safety conditions and it will allow the testing of interactive autonomy operations and procedures for large and complex systems in the field of heavy robotics.

LaSCo, Laboratory for Containment and Surveillance

The thermal and mechanical testing facilities available in the LaSCo laboratory were described in detail in the 1993 Annual Report of ISEI.

Some additional equipment now completes the facility:

- a third climatic chamber was installed end of 1994, with an inner volume of $1 m^3$ operating in a temperature range of -65C to 150C. This new chamber permits the testing of big systems at very low temperatures;
- a fast transient burst generator was also installed in order to start electromagnetic compatibility tests on equipment. This is a first step in the development of a new activity in LaSCo laboratory, which will continue with the development of a specific test zone for qualification of devices and systems under conducted and radiated electromagnetic fields. All the tests will be conducted under actual official test standards such as those of the IEC, or as requested by the customer.

During 1994, tests protocols were defined and specific tests on items were performed on:

- the Compact Surveillance System COSMOS, developed by JAERI (Japan), for which various thermal, humidity and mechanical tests were conducted in order to verify its characteristics and to study its performance under various environmental conditions;
- the Logitec Fotoman camera used in the Gemini surveillance system. After the acknowledgement of the test protocol by the Euratom Safeguards Directorate in Luxembourg, various thermal, humidity and mechanical tests were conducted on the cameras in order to verify their characteristics under various environmental conditions.

The test programme foreseen for 1995 is the following:

- thermal and mechanical qualification of a new parabolic surveillance system based on heat flow transfer developed in the LaSCo laboratory;
- study of the performance under thermal and mechanical stresses of a Multi-Channel Acquisition system, Nos-National Instruments, for which a detailed test protocol was prepared and submitted to both companies;
- study of the performances of Gemini and EMOS surveillance systems under various environmental stresses;
- study of the performance of the MIVS system under electromagnetic perturbations;
- study of the behaviour of a multi-sensor surveillance system developed in the LaSCo laboratory (HOMM project).

10 ANNEXES

10 ANNEX

LIST OF PUBLICATIONS

Industrial Hazards

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LIST OF ACRONYMS AND ABBREVIATIONS

ADREP	Accident/Incident REPorting (ICAO)
AE	Acoustic Emission
AECL	Atomic Energy of Canada Limited (CDN)
AECB	Atomic Energy Control Board (CDN)
AFWS	Auxiliary Feed Water System
APHIS	US Department of Agriculture
ARMAX	Auto Regressive Moving Average with Auxiliary Input
ATC	Air Traffic Control
ATCO	Air Traffic Control Operators
ATM	Air Traffic Management
AWS	Action Work Flow System
BEAMES	Building Energy Auditing Management Expert System
BHD	Blanket Handling Device
BIOSAFE	Documentation Centre for Biotechnology Safety and Regulation
BNFL	British Nuclear Fuels Plc (UK)
BUD	Burn Up Device
CAD	Computer Aided Design
CAE	Computer Aided Engineering
CARES	Computer Aided Review Station
CASM	Co-ordinated Abatement Strategy Model
CAVIS	Computer Aided Surveillance System
CBT	Computer Based Training
CCF	Common Cause Failures
CDA	Conceptual Design Activity
CDCIR	Community Documentation Centre on Industrial Risk
CEC	Committee for Economic Co-operation
CEDB	Component Event DataBank
CENELEC	European Committee for Eletrotechnical Standardisation
CEO	Centre for Earth Observation
CERFACS	Centre Européen de Recherche et de Formation Avancée en Calcul Scientifique
CERN	European Centre for Nuclear Research
CHA	Concept Hazard Analysis
CNR	Italian National Council of Research
COGEMA	Compagnie Générale des Matières Nucléaires (F)
COMODO	Communication Model in Cooperative Work
COSMOS	Compact Surveillance Monitoring System
COSYMA	Code System from Maria
CRM	Cockpit Resource Management
DAF	Antifraud Documentation Information System
DDET	Deterministic Dynamic Event Tree
DICS	Distributed Informatics and Communications Services
DIV	Design Information Verification
DIVIP	Design Information Verification Image Processing
DSM	Demand Side Management
DSM	Distributed Systems Management
DSP	Digital Diagonal Processing
DSS	Decision Support System
DTC	Desk Top Conferencing
DTM	Digital Terrain Model
DYLAM	Dynamic Logical Analytical Methodology
DYLAM-TRETA	Dynamic Logical Analytical Methodology-Transient Response and Test Analyser
EAMA	Acoustic Emission from Aerospace Materials and Structures
ECC-AIRS	European Co-ordination Centre for Aircraft Incident Reporting Systems
ECMWF	European Centre for Medium Range Weather Forecasting
ECMWF	European Centre for Medium Range Weather Forecasting
EDA	Engineering Design Activity
EdF	Electricité de France
EDI	Electronic Data Interchange
EDITH	EDITH
EFTA	European Free Trade Agreement
EIA	Environmental Impact Assessment
EIS	Environmental Impact Studies
EJ	Expert Judgement
ELSA	European Laboratory for Structural Assessment
EM	Electromagnetic
EO	Earth Observation
ERS-1	European Remote Sensing - 1
ESA-ESRIN	European Space Agency
ESARDA	European Safeguards Research and Development Association
ESD	Euratom Safeguards Directorate
ESPI	Electronic Speckle Pattern Interferometer
ESTI	European Solar Test Installation
EU	European Union
FDDI	Fibre Digital Data Interface
FMEA	Failure Mode and Effect Analyses
FMEA	Failure Mode and Effect Analysis
GA	Genetic Algorithm
GIS	Geographical Information System
GVWin	Xerox Global View for Windows
GVX	Xerox Global View for X-Windows
HAZOP	Hazard and Operability
HCM	Human Capital and Mobility
HERMES	Human Error Reliability Methodology for Event Sequences

Ho.M.M	Horizontal Multisensors Module
HQHHPP	Euro-Quebec Hydro-Hydrogen Pilot Project
HVT	High-Velocity Trains
HYDRA	Program for visualisation of 3-d sea modelling calculations
IA	Integrated Assessment
IA	Implementing Agreement
IAEA	International Atomic Energy Agency
ICAO	International Civil Aviation Organisation
ICSA	Information Co-operative for Sharing and Analysing the Earth Observation Data
ICSA	Information Co-operative for Sharing and Analysing the Earth Observation Data
IEA	International Energy Agency
INDEEP	International Database on Energy Efficiency Programmes
IRP	Integrated Resource Planning
IRS	Institute for Remote Sensing
ISDN	Integrated Services Digital Network
ISEI	Institute for Systems Engineering and Informatics
ISS	Internet Security Scanner
IST	Institute for Safety Technology
IT	Information Technology
ITER	International Thermonuclear Experimental Reactor
ITU	Institute for Transuranium Elements
JRC	Joint Research Centre
KBS	Knowledge Based System
KfK	Kernforschungszentrum Karlsruhe
LaSCo	Laboratory for Containment and Surveillance
LOCA	Loss of Coolant Accident
MACS	MELCOR Accident Consequence Code System
MAHB	Major Accident Hazards Bureau
MARS	Major Accident Reporting System
MCDA	Multi- Criteria Decision Aid
MEB	Multi Element Bottles
MIMIX	Method for Investigating Management Impacts on causes and consequences of specific hazards
MMC	Metal Matrix Composite
MTAs	Message Transfer Agents
MTV	Monitoring Tropical Vegetation
NDT	Non-Destructive Testing
NNTP	Network News Transfer Protocol
NOAA	National Oceanographic Atmospheric Association
NPP	Nuclear Power Plant
OPTS	US Environmental Protection Agency
PCC	Personal Communication Computer
PFC	Plasma-facing Components
PNC	Power Reactor and Nuclear Fuel Development Corparation (J)
POP	Programme Operative Plurifondo (Multi-funded Operative Programme)
PPG	Pressure Portable Gages
PPSC	Pathfinder Phase Steering Committee
PSA	Probabilistic Safety Assessment
PSTN	Public Switched Telephone Network
PV	Photovoltaic
PVP	Personal Viewpoint
PWR	Pressurised Water Reactor
RAINS	Regional Acidification INformation Simulation model
RAMS	Reliability, Availability, Maintainability and Safety
RCS	ROBERTINO Control System
RHW	Remote Handling Workstation
SAVE	Special Action Programme for Vigorous Energy Efficiency
SC	Superconducting
SCCS	Safety Critical Computer Systems
SEAFP	Safety and Environmental Assessment of Fusion Power
SMART	Semi-autonomous Monitoring and Robotics Technologies
SMES	Superconducting Magnet Energy Storage
SMTP	Simple Message Transfer Protocol
SOM	Self-Organising Map
STARS	Software toolkit for advanced reliability and safety analysis
STAXED	Stars TAXonomy EDitor
STEP	Project Safety Technology in Environmental Protection
TCAS	Traffic Collision Avoidance System
TCZ	Thermal Comfort Zone
TESEO	Reinforcement-Learning Mobile Robot
TESLA	Structural Transients Simulation Laboratory in Electromagnetics and Thermomechanics
TGV	Train à grande vitesse
THORP	Thermal Oxide Reprocessing Plant
TINCA	Technology Transfer in the Area of Advanced Intelligent Computer Systems for the Assessment of the Remaining Life, Reliability and Safety of Power Plant Components
TOE	Tonnes of Oil Equivalent
TOMHID	Overall knowledge based methodology for hazard identifacation
TPW	Third Party Work
TÉV	Technischer Éberwachungs Verein
TWG	Technical Working Group
UDUC	Urban Development User Community
VC	VocalChat
WE	Working Environment
XFTCON	X Fault Tree Constructor
XPLED	X Windows Plant Editor

European Commission

EUR 16286 – Institute for Systems Engineering and Informatics – Annual report 1994

Editor: I. Gerbaulet

Luxembourg: Office for Official Publications of the European Communities

1995 – 168 pp. – 21.0 x 29.7 cm

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ISBN 92-827-4273-3

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