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NUCLEAR ENERGY AGENCY
COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

MEETING SUMMARY
OF THE SECOND CSNI SPECIALIST MEETING
ON SIMULATORS AND PLANT ANALYZERS

Current Issues in Nuclear Power Plant Simulation

Espoo, Finland
29 September - 2 October 1997

English text only

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ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Pursuant to Article I of the Convention signed in Paris on 14th December 1960, and which came into force on 30th September 1961, the Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and a rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral. non-discriminatory basis in accordance with international obligations.

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996) and the Republic of Korea (12th December 1996). The Commission of the European Communities takes part in the work of the OECD (Article 13 of the OECD Convention).

NUCLEAR ENERGY AGENCY

The OECD Nuclear Energy Agency (NEA) was established on 1st February 1958 under the name of the OEEC European Nuclear Energy Agency. It received its present designation on 20th April 1972, when Japan became its first non-European full Member. NEA membership today consists of all OECD Member countries except New Zealant and Poland. The Commission of the European Communities takes part in the work of the Agency.

The primary objective of the NEA is to promote co-operation among the governments of its participating countries in furthering the development of nuclear power as a safe, environmentally acceptable and economic energy source.

This is achieved by:

- *encouraging harmonization of national regulatory policies and practices, with particular reference to the safety of nuclear installations, protection of man against ionising radiation and preservation of the environment, radioactive waste management, and nuclear third party liability and insurance;*
- *assessing the contribution of nuclear power to the overall energy supply by keeping under review the technical and economic aspects of nuclear power growth and forecasting demand and supply for the different phases of the nuclear fuel cycle;*
- *developing exchanges of scientific and technical information particularly through participation in common services;*
- *setting up international research and development programmes and joint undertakings.*

In these and related tasks, the NEA works in close collaboration with the International Atomic Energy Agency in Vienna, with which it has concluded a Co-operation Agreement, as well as with other international organisations in the nuclear field.

COMMITTEE ON THE SAFETY OF NUCLEAR INSTALLATIONS

The NEA Committee on the Safety of Nuclear Installations (CSNI) is an international committee made up of scientists and engineers. It was set up in 1973 to develop and co-ordinate the activities of the Nuclear Energy Agency concerning the technical aspects of the design, construction and operation of nuclear installations insofar as they affect the safety of such installations. The Committee's purpose is to foster international co-operation in nuclear safety amongst the OECD Member countries.

CSNI constitutes a forum for the exchange of technical information and for collaboration between organisations which can contribute, from their respective backgrounds in research, development, engineering or regulation, to these activities and to the definition of its programme of work. It also reviews the state of knowledge on selected topics of nuclear safety technology and safety assessment, including operating experience. It initiates and conducts programmes identified by these reviews and assessments in order to overcome discrepancies, develop improvements and reach international consensus in different projects and International Standard Problems, and assists in the feedback of the results to participating organisations. Full use is also made of traditional methods of co-operation, such as information exchanges, establishment of working groups and organisation of conferences and specialist meeting.

The greater part of CSNI's current programme of work is concerned with safety technology of water reactors. The principal areas covered are operating experience and the human factor, reactor coolant system behaviour, various aspects of reactor component integrity, the phenomenology of radioactive releases in reactor accidents and their confinement, containment performance, risk assessment and severe accidents. The Committee also studies the safety of the fuel cycle, conducts periodic surveys of reactor safety research programmes and operates an international mechanism for exchanging reports on nuclear power plant incidents.

In implementing its programme, CSNI establishes co-operative mechanisms with NEA's Committee on Nuclear Regulatory Activities (CNRA), responsible for the activities of the Agency concerning the regulation, licensing and inspection of nuclear installations with regard to safety. It also co-operates with NEA's Committee on Radiation Protection and Public Health and NEA's Radioactive Waste Management Committee on matters of common interest.

MEETING SUMMARY

of

THE SECOND CSNI SPECIALIST MEETING ON SIMULATORS AND PLANT ANALYZERS

Current Issues in Nuclear Power Plant Simulation

Introduction

The Second CSNI Specialist Meeting on Simulators and Plant Analyzers: Current Issues in Nuclear Power Plant Simulation was held in Espoo, Finland, from September 29 through October 2, 1997. It was organised by CSNI Principal Working Group on Coolant System Behaviour (PWG2), Task Group on Thermal Hydraulic Applications (TG-THA), in co-operation with Technical Research Centre of Finland.

The meeting in Espoo attracted some 90 participants from 17 countries. A total of 49 invited papers were presented in the meeting in addition to 7 simulator system demonstrations. Ample time was reserved for the presentations and informal discussions during the four meeting days. The previous meeting held in Lappeenranta, Finland, in 1992 collected some 85 participants from 12 countries, presenting a total of 40 papers.

The meeting was structured into 6 sessions covering the important aspects of development and use of simulators and plant analyzers:

Session I: New objectives, Requirements and Concepts
This session covered the progress experienced since the 1st simulator meeting and tried to address the changing role of simulators based on the changes in users' needs and developing possibilities.

Session II: Trends in Simulation Technology
This session was reserved for studying the current trends in the simulation technology: software environments, visualisation, simulator configuration tools, programming languages and computer systems.

Session III: Training and human factor studies using simulators
This session was created for studying the status of different uses of simulators such as educational simulators, human factor studies and integrated safety assessment in addition to traditional training. Regarding to the severe accidents, a question was raised whether the simulator use should be for training or education.

Session IV: Modelling techniques
The session on modelling techniques was included to cover recent developments in the modelling techniques applicable to training simulators and plant analyzers. One of the main interests were the interconnection of analysis level models in real time applications.

Session V: Plant analysis applications
This session was planned to cover the various applications of plant analyzers in plant design evaluation, system qualification, development of operation procedures and safety analysis. The new concepts such as multifunctional simulators and Living Plant Analyzers supporting many of the above mentioned applications and adding features like evaluation and testing of new control systems and operator support tools.

Session VI: Simulator validation and qualification
This session concentrated on simulator validation and qualification procedures followed in the training centers as well as on the problems encountered in areas such as severe accidents and accident management. The requalification of the simulator was also a topic of discussion.

Major conclusions of the meeting

The major conclusions of the meeting can be summarised as follows:

- The role of simulators is changing and the applications are becoming more diverse.
- The differences between training simulator and plant analyzer software are disappearing.
- It would be useful to establish a basis, or a set of rules for comparison of simulators. A small group of experts should be formed to study feasibility and benefits of such an exercise and possible comparison criteria.
- The themes of SAMOA meetings appear almost as a subset of this series of meetings. In the future, these meetings could well be combined.
- A suggestion was made to develop a simulator for plant maintenance procedure practices.

Opening Remarks

The opening remarks were delivered by the representatives of the organising parties, André Drozd from OECD/NEA and Lasse Mattila from VTT.

Summary of Sessions

I New Objectives, Requirements and Concepts

A total of four papers were presented in this session, the first paper 'Summary of the 1st Specialist Meeting on Simulators and Plant Analyzers held in Lappenranta' (VTT) covered the results of the previous meeting in 1992 and compared the visions presented in the meeting with the developments actually realised. Many of the simulator concepts and tools presented in the previous meeting still exist in a more mature form. Specifically the gap between the analysis codes and the simulator models is disappearing, much due to the dramatic increase of affordable computer power available today. The developments also include successful interconnection of thermal hydraulic and reactor kinetics models as well as the appearance of multifunctional simulators and research on human factors, all foreseen in the previous meeting as part of the desirable co-operation between specialists of different disciplines.

The second paper 'Human Machine Interaction Research Experience and Perspectives as seen from the OECD Halden Reactor Project' (Halden) covered the research experience of Halden Reactor Project. The major topics were the studies and related methodological development on the operator cognition and information processing performance in control room environment (HAMMLAB), the performance and problems related to information presentation and the development of plant surveillance and support systems. A Virtual Reality Center has been founded as a complementary extension of HAMMLAB for studies of existing and future control rooms. As a response to increased interest in human factors research, a project has been launched to create a new facility HAMMLAB-2000, equipped with realistic PWR and BWR simulators.

The paper 'Regulatory Perspectives on NPP Simulator Applications' (SKI) considered the regulatory perspectives on the NPP simulator applications. Traditionally the focus of interest of the regulatory bodies has lain on three major topics: the operator training, the safety analyses using advanced plant analyzers and the procedures for preparedness and emergency operating procedures. In the future, the major issues will be the large NPP modernisation and back fitting projects being carried in many countries and their relation to the public conscience of the risks involved. The confidence among public erodes quickly, if problems arise causing unplanned interruptions or shutdown due to safety problems. To prevent this, the measures taken must be explainable: robust and simple. In case of transients, incidents or anomalous plant behaviour, a careful analysis using advanced plant analyzers or other modern analytical tools is considered essential. Answers should also be found to 'What if' -types of questions, trying to find the often small, trivial looking incidents that have the tendency to develop into accidents.

The last paper 'Operator Aids for Severe Accident Management' (AVN) was a summary of the second OECD specialist meeting on Operator Aids for Severe Accident Management (SAMOA-2) held in Lyon, 8-10 September, 1997. The scope of the meeting covered operator aids for accident management, analysis methods and relevant simulation tools for operator training. The general conclusions indicate that the development and implementation of operator aids for accident management is in progress but proceed slower than expected. The training for severe accident management (SAM) is gaining acceptance, while there is still a debate on the orientation of the training: skill or knowledge oriented. The tools for SAM training are still in infancy. For concrete results, international collaboration should be increased.

II Trends in Simulation Technology

The session 'Trends in Simulation Technology' dealt with aspects of new technologies in the development of simulators and NPAs. The first three papers, 'Experiences on the Software Development Platform ALICES' (CORYS T.E.S.S), 'CISO: Charter of Integration for Simulation Openness' (EDF/SEPTEN) and 'APROS - a Multifunctional Modelling Environment' (VTT) were concerned with the modelling environment. The efforts are directed towards providing homogeneous modelling environments, establishing model interfaces in an object-oriented fashion, and enabling reuse of components, thus reducing simulator development time and costs. In particular, the requirements of developers concerning user interfaces which provide high flexibility in adapting existing system designs and models are addressed. A step further in the direction of a multifunctional environment for a wide range of various applications including non-nuclear simulators is taken by APROS. Its layered architecture allows to model increasingly complex systems by using the features of lower layers.

In paper 'GRASS - the Graphic Simulation System' (KFKI) a slightly different approach of constructing source code directly from a user defined graphic network was described, with reusable graphic components instead of predefined models. The system is integrated with the real-time executive and the data base of the simulator.

In paper 'The Trend towards Windows NT Platform for Real Time Simulation' (RNI) a strong case was made for utilising PC's running Windows NT in simulators. The main advantages are seen in the availability of well-proven third party tools at costs much lower than in the UNIX world, decreased operating and maintenance costs, as well as the ready access to spare parts. The increasing number of simulators in operation or ordered on this basis is proof to the strong impact of Windows NT in the simulator world.

A study in paper 'Using Intranet with Simulation' (GSE) on network-wide simulation as to the possibilities offered by the Internet and the Internet-aware programming language Java, along with the prototype of a distributed client-server architecture, showed the feasibility of such an approach.

The paper 'Enhanced Productivity of Simulation Engineers' (GSE) made clear, how productivity of simulation engineers has steadily increased in accordance with advancing technology. It is claimed that with the modern modelling environments and tools available today, simulation engineers may concentrate on their proper tasks, without the burden of computer science heavy on their shoulders.

In summary, the impact of the object-oriented approach in software development has reached simulator development. Strong efforts are seen to provide standard interfaces to reuse models written in different styles and languages, to group objects to form more complex systems, and to provide user interfaces relieving the simulation engineer of many software engineering problems. According to the general trend in migrating applications to Windows NT, the first simulators are appearing on a PC-basis. For the future, the direction of client-server architectures, which has already been realised in some plant analyzer applications, will be taken further to distribute simulations on the Internet. With respect to openness of simulator environments and standardised model interfaces, it remains to be seen if these concepts will extend beyond the scope of single simulator manufacturers.

III Training and human factors studies using simulators

A total of 11 papers have been presented, covering the state of the art in training simulators and human factor issues. According to the main focus of these presentations, they can be grouped in the three following categories:

7 papers 'Training of Nuclear Power Plants Personnel in the German Simulation Centre' (GSC), 'Nuclear Plant Analyzer: An Efficient Tool for Training and Operation Analyses' (Tractebel), 'Multifunctional Optimized Scope Simulators in Central and Eastern Europe' (CORYS T.E.S.S), 'Leningrad NPP Full Scope Simulator - A new generation Tool for Training and Analysis' (Kurchatov), 'Leningrad NPP Full Scope and Analytical Simulators as a Tools for MMI Improvement and Operator Support Systems Development and Testing' (Kurchatov) and 'An Interactive Graphic Simulator (MAAP4) for Garona Nuclear Power Plant Development and Applications' (Univ.Cantabria) are related to the progress and state of the art in simulators used for training purposes,

2 papers 'An Operator Selftraining System Based upon the Emulation of Instructor Skilling' (Ansaldo Nuclear) and 'Event Tree Simulation Techniques for Integrated safety Assessment' (Consejo de Seguridad Nuclear) where the use of simulators has been proposed in connection with the development or the verification of plant operating/emergency procedures and

2 papers 'HAMMLAB-2000 for Human Factor’s Studies' (Halden Reactor Project) and 'Development of a Research Simulator for the Study of Human factors and Experiments' (TEPCO) dealing with the use of simulators for human factor experiments.

From the first group of presentations appears that quite a substantial progress has been made in the last few years in the performance, accuracy and capability of simulators in the training area. Another interesting aspect is that also accident condition are currently addressed in training programs and that consequently training simulators are now capable to cope with abnormal plant conditions, at least up to Design Basis Accidents. The next challenge is to evaluate the possibility (and the convenience) to have training simulators able to go into severe accidents conditions. Although some research has been done in that direction (an example is the Leningrad training simulator, from Kurchatov Institute), it seems not be agreement on the opportunity to include severe accident conditions in operator training programs.

A topic, which has regrettably been left completely out is the simulator capability for training in shutdown conditions. Although in recent years, the risk of accidents during outages has been evaluated to be comparable to the risk at power conditions (with associated increased human error probabilities), apparently no special efforts have been made in extending simulator capabilities to cope with the special conditions which exist in shutdown. An exception is the full-scope simulator at Doel, where Tractebel has developed a model for mid-loop operation (see Session IV: Mid-Loop Model for Doel 1 and 2 Training Simulator). It is suggested that this issue will be addressed in the near future.

The use of simulators in connection with procedure development/verification is a relatively new issue and, from the presentations on this topic, it seems quite promising, especially when the target is the verification of Severe Accidents Management Guidelines (SAMG). However, this leads back to the need of simulators able to dig well into severe accidents.

Finally, we had a couple of presentations related to the use of simulators for human factors studies. Here the possibility and convenience to run human factor experiments in simulated control rooms has been presented. It includes the evaluation of operator performance in different simulated environments and abnormal conditions. We expect to see in the near future a number of interesting experiments evaluating the usefulness of the many operator support systems which are in development and it is not clear now if and at what extent they could improve the operator understanding during abnormal plant conditions.

IV Modelling Techniques

This session offered an outlook on the coupling of qualified neutronics codes with system codes. There is a general agreement that for many transients, it is necessary to use a 3D neutron kinetics model coupled to a thermal hydraulic model in order to obtain satisfactory results. This need coincides with the fact that one may take advantage of the increase in computing power that has become available.

Five papers 'Coupling of 3D Models with the System Code ATHLET' (GRS), 'Interfacing High Fidelity Core Neutronics Models to Whole Plant Models' (Nuclear Electric), 'Neutronic Aspects of the THOR Core Dynamic Model for Training Simulators' (Scandpower), 'Neutronics and Thermal Hydraulic Modelling in Reactor Dynamics Codes TRAB and Hextran' (VTT) and 'APROS 3-D Core Models for Simulators and Plant Analyzers' (VTT) addressed this concern and presented the on-going activity in Germany United Kingdom, Norway and Finland.

Three papers clearly indicated the current trend to extend the scope of the simulators. The first paper 'Effective Modelling of Hydrogen Mixing and catalytic Recombination in Containment Atmosphere with Eulerian Computer Coded' (Ansaldo) addressed the modelling of Hydrogen Mixing and catalytic recombination in containment atmosphere. Coupling an Eulerian code with a CFD code has been considered in order to predict effectively (with reasonable computer running time) and accurately (i.e. with a high degree of confidence) the natural convection flow patterns and the distribution of steam and gases in the containment.

The second paper 'The Implementation of a Mid-Loop Model for Doel 1 and 2 Training Simulator' (Tractebel) presented the adaptation of an existing full scope simulator in order to simulate some mid-loop operation transients.

The third one 'Latest Improvements on TRACPWR Six-Equations Thermohydraulic Code' (Technatom) presented the latest improvements on TRACPWR six equations code that has been adapted in Spain for implementation in simulators. Beside the code speed up and code platform downsizing the scope has been enhanced for mid-loop operation and for modelling VVER and PHWR.

The paper 'The IMPACT Super-Simulation project for Exploring NPP fundamental phenomena' (NUPEC) presented this ambitious Japanese project (a ten-years program). IMPACT is the name of a program which will perform full-scope, detailed calculations of physical and chemical phenomena in a nuclear power plant for a wide range of scenarios. The main modules are, the Human Interface, the Analysis System, the Data Base, the Knowledge Base and the control system that supervises the whole system.

The paper 'Integration of ANTHEM Thermal Hydraulic Model in ROSE Environment' (CAE) presented the project to integrate a two-phase thermal hydraulic model into a Real-time Object-oriented Simulation Environment (ROSE).

The paper 'Evaluation of Two-Fluid and Drift Flux Thermal Hydraulic Model Capabilities using APROS Plant Analyzer' (VTT) presented an evolution of two-fluid and drift flux model capabilities.

The paper 'A Nodalization Study of Steam Separator in Real Time Simulation' (GSE) illustrated the nodalization effect on the results for some typical BWR transients.

V Plant Analysis Applications

In addition to the well-known use of simulator for training purposes, this session was devoted to a lot of questions concerning the various parts of the NPP operation which may be solved on simulators or plant analyzers rather than on real plants: design evaluation, procedure validation, system testing, accident management. One must, however, keep in mind that such applications can be possible only if the simulator meets the appropriate requirements concerning, in particular, its simulation range (adaptability to plant specific features) and its pertinence.

The paper 'Simulate-3 Core Model for Nuclear Reactor Training Simulators' (GSE) presented the work realised on the main 3D neutronic module SIMULATE-3K, the Studsvik core model. The modifications concern real-time computation, using parallelization techniques (POSIX threads of UNIX or Windows NT), and lead to a new module SIMULATE-3R, utilisable for training. The adaptations have been made for BWR and PWR Core Management System (CMS).

The paper 'ATLAS: Applications Experience and Further Developments' (GRS) presented what has already been done on the GRS-developed ATLAS plant analyser: realisation of supplementary modules like Reliability Advisory System, Procedure Analysis and diagnostic system for SGTR accidents and implementation (in complement to ATHLET thermohydraulics code) of RALOC confinement behaviour and

MELCOR severe accident codes. This allows a very wide range of applications of such a plant analyzer: the adaptation to the plant specific features has already been done for 4 plants (2 PWRs and 2 BWRs) and is under way for 3 others (1 PWR, 1 BWR and 1 Russian VVER 1000/230). In addition some developments, like implementation of Windows NT, tracking simulator and design of a multimedia Analysis Center are planned.

The paper 'SAPHIR: a Simulator for Engineering and Training on N4 Nuclear Type Power Plants' (Framatome) described the new simulator SAPHIR, developed by Framatome for the French N4 reactor type. Advanced codes, like TRACAS for the primary circuit and GVAXIAL for the secondary side of the steam generator, are used for the modelling of the main systems and simulation workshop, for the representation of the fluid, electrical instrument and control networks; the man-machine interface has been also substantially improved.

The paper 'The RELAP-5 Based NPA' for the VVER 440/213 type Paks3 unit (KFKI), presented the work realised performed through a co-operation between Tractebel and KFKI-AEKI, in order to build the NPA interactive graphical tool, using the RELAP5 code, for improving the knowledge of system behaviour and alarms safeguard systems response during transients like scram and loss of primary coolant.

The paper 'NPA Applications Development in the Nuclear Safety Authority Framework' (SNSA) presented what has been done, in collaboration with Tractebel, for realising the first version of a plant analyzer for the Krsko NPP. The RELAP5 (version Mod 3.2) code was used for achieving in 1996 a tool used now for training and for improving the knowledge about the classical design accidents. The coupling with the severe accident analysis code MELCOR is foreseen in order to improve substantially the simulation range.

The paper 'CATHARE Approach Recommended by EDF/SEPTEN for Training (or other) Simulators' (EDF) presented the several steps of simulator implementation in EDF: at first (1980 - 85 design) full-scale simulators, based on DEFI-2 thermal hydraulic codes, about ten years later SIPA (and the SIPACT's) and Fessenheim and Bugey full scale simulators, based on the CATHARE-Simu and CATHARE 1 thermal hydraulic codes, allowing in particular to simulate large breaks. Even improved simulators, based on the fine-modelling of CATHARE 2, are now planned for the next years: the 10 million dollars project SCAR will allow to have, on full-scale simulators, the possibility of processing all operating conditions (except for severe accidents, leading to core degradation like melting).

The paper 'Use of Simulators for Validation of Advanced Plant Monitoring Systems' (Tractebel) described how the Doel simulator was used for the validation of a process monitoring and supervision systems, DIMOS. Through an extensive testing campaign of two versions (one alarm-masking and one non alarm-masking) of this system, the importance of the alarm treatment for the operators was put on evidence.

In the paper 'CAMS as a Tool for Identifying and Predicting Abnormal Plant State using Real Time Simulation' (Halden Reactor Project) it was described how the modular CAMS systems, in particular the tracking simulator module, can provide assistance for the assessment of the future development of accidental situations and in planning mitigation strategies. We may note that, even if this project started at Halden only in 1993, the realised prototype was successfully used during a Swedish crisis drill already in 1995.

The paper 'An Intelligent Diagnostic Aid (IDA) Based upon the Simulated and Operational Experience' (Ansaldo) presented an intelligent system providing help for accidental situation diagnostics, combining expert system techniques, for issuing and managing deduction rules with a NPP simulation tool, adapted from the LEGO code. This system was developed for the Sampierdarena mixed gas-electrical power plant and is now to be adapted for a VVER 1000.

In the paper 'Simulation Strategy in Management of Jose Cabrera NPP' (Union Fenosa Ingeneria) it was shown how the simulation strategy helped in defining management orientations for the Jose Cabrera NPP, especially for the case of nuclear emergencies, and how simulation experience can boost the development of 'general purpose tools'.

The paper 'Experiences of APROS in Nuclear Power Plant Safety Analysis' (IVO) showed, how the APROS simulator took a major part in the revision of the Loviisa plant safety analysis, after the decision of power uprating program (up to 1500 MW as nominal thermal power) implementation; APROS was used for the simulation of the classical accidents (LOCA, ATWS, SGTR,...) with quite satisfactory results. The utilisation experience shows that the fine 6-equation model is only necessary for a small number of transients (such as LBLOCA); for the other operational transients a 5-equation model is sufficient.

It appears clearly, in conclusion, that the 'common denominator' for simulator utilisation is still operator and/or expert training; however some countries are now using such tools for more advanced purposes, like accident management and/or probabilistic risk analysis.

In that perspective, the need of simulator possibility improvement for achieving these goals successfully has been clearly identified; in general, safety analysis requires much more pertinence and simulation range than (pre-programmed) training. Finally, the use of some expert system techniques seems of quite great interest for a highly efficient crisis management system.

VI Simulator Validation and Qualification

The first paper in the session '3D Core Model for Simulation of Nuclear Power Plants: Requirements, Model Features and validation' (Thomson) described the requirements, features and validation of a 3D core model for four nuclear power plants with Siemens reactor control and protection systems, which consist of three staggered systems acting on the control rods imposing very stringent requirements on the core and primary coolant system simulation models. The 3D core model development concentrated on achieving the best possible match between simulation model and the design codes applied in fuel management and safety analyses. The resulting core model has ~3700 3D core cells. The simplified thermal hydraulic calculation is also carried out for each cell. The validation included stand-alone 'separate effects' and global tests as well as coupled global tests in the complete simulator environment.

The paper 'The Use of SIPA 2 Simulator for safety Studies: Experience Feedback and Future Development' (IPSN) described the use of SIPA 2 simulator for expert training, development of accident management aids and safety studies during the last 4 years. The extensive use resulted in many proposals for simulator model development and qualification, applicable to many similar systems such as multifunctional simulators.

The paper 'A Verification and Validation Program for Simulators for Soviet Designed Nuclear Reactors' (BNL) describes the verification and validation program for 11 simulators (both full-scope and analytical) for Soviet-designed nuclear reactors in Russia and Ukraine. The program includes V&V course for the NPP staff and the description of a acceptance test procedure.

The last paper 'Interactive graphical Analyzer Based on RELAP5Mod 3.2 NPA' (P.M.S.A.) describes an interactive graphical analyzer based on Relap5/Mod 3.2 -NPA. The model describes the R5 model of a PWR, including primary coolant system, steam generators, secondary system up to turbine and condenser, and the feed water system. The relevant protection and control systems are included. Some modifications have been made in the graphics interface in order to improve the analysis and teaching functions of the NPA. The validation process is underway.

The user experience was in general positive and training using simulators is now given to new categories of personnel (safety authorities, crisis managers, safety analysts). Verification of simulators by assuring the equality of plant and simulator environments important and fairly easy to achieve. Validation of models may be done by comparisons with advanced computer models (transients, accidents) and plant data. It is important that reactor physics data are validated against true plant behaviour. Emphasis is also laid on comparisons with plant transients.

VII Discussion

The Chairman summarised major points of the meeting regarding:

- need for maintaining expertise (analysis, modelling, what about available funds)
- training and education (who, how and to what extent include severe accidents?)
- control rooms and operator support tools (human factors, operator performance)
- simulators and safety analysis tools: all-in-one -tools, qualification (simulator benchmarks?)
- future activities: develop current technology or look for new approaches?

Comments made and issues raised during the follow-up discussion:

A question was raised if we do too much of modelling? There may be some duplication with work of stand alone code developers. Although it may lead to diversity of approaches, too much diversity may become counterproductive. There is a related problem regarding uncertainty. The importance and awareness of it should be increased because too often we are taking the simulator results as “true” plant response, which may not be the case.

There is a trend of merging various codes and/or subroutines that were validated separately. It is also necessary to validate the 'combined' codes, since putting together various modules require some changes that may effect the validation of the final product. There is still a difference in an engineering “culture” and practices between the TH and neutronic code developers. More contact and joint meetings are needed to bridge this gap.

There was a suggestion to establish a possible benchmark for simulators. It is not clear how such a benchmark could be defined, however an example was given of an AI benchmark established about 2 years ago. It was agreed, however, that such a benchmark would be very useful in particular given ongoing MSLB benchmark on TH/neutronic coupling. KOLA simulators was mentioned as a possible model for such an exercise. A recommendation was made to organise a one day brain-storming session to discuss possibility of a simulator benchmark. Such a meeting should include representatives from Halden, PWG4 and IAEA.

An observation was made that the simulator applications have changed during the last 5 years, i.e., there is more training, safety analysis and support for regulators. In addition, the simulators are changing faster and faster leading to a possibility of applications in the areas of MMI and human factors. Question were raised regarding possible establishment of standards for GUIs.

Difference in opinions existed regarding whether SA should be included in simulators' models, in particular in full scope simulators. The benefits of having SA capabilities for operator training were questioned. Most of participants agreed that, although the emphasis should be on plant 'normal' operations and transits, at least some aspects of SA should be included. The SA training should be aimed not so much to operators, but rather to others like technical support center personnel, inspectors and regulators.

There is still an issue about usefulness of the real-time simulators in the control room during accident conditions (but not in normal operations), i.e., the operators may not be able, or would not have the time to take advantage of the simulators results.

An interesting suggestion was made to develop a simulator for plant maintenance procedures practices.

The themes of SAMOA meetings appear almost as a subset of this series of meetings. In the future, these meetings could well be combined. This observation and recommendation was expressed several times.