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The Nuclear European Platform of Training and University Organisations (NEPTUNO) project

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SUMMARY

Under the sixth European Framework Programme, the project Nuclear European Platform of Training and UNiversity Organisations (NEPTUNO) proceeds with the implementation of the results of FP5 European Nuclear Engineering Network project (2002 – 2003) in the field of academic education and extends its harmonisation and coordination activities into the fields of PhD research, professional training and continuous training. Thirty five partners, involving universities, training organisations and research institutions, participated to the project from January 2004 till December 2005.

NEPTUNO integrates European education and training in nuclear engineering, nuclear safety and other nuclear fields with the major objective to secure qualified curricula in the nuclear disciplines at European universities with sufficient harmonisation to ensure mutual recognition according to the Bologna declaration, and to harmonise professional training and accreditation schemes.

This report gives an overview of NEPTUNO project, with emphasis on the main achievements and the conclusions of the Working Groups. The first Working Package realised a comprehensive and documented survey of courses and training packages currently offered in the enlarged European Union.

The second Working Package established electronic communication systems and internet access to databases of relevance to education and training activities, elaborated on principles and applications of distance and E-learning for nuclear disciplines, and provides an overview of contacts and coordination activities of the European Nuclear Education Network with education and training networks outside Europe.

The third Working Package fully implemented the European Master of Science in Nuclear Engineering certification and its essential base elements of mutual recognition, international exchange courses and student mobility. Recommendations and guidance documents were produced on postgraduate training, PhD research work, advanced courses and continuous life-long training in a European context.

The fourth Working Package addressed the problem of harmonising professional training by selecting a set of key functions in the nuclear industry and investigating their qualification characteristics and the corresponding training programmes. A training programme assessment body, the European Academy for Nuclear Training is proposed to evaluate and harmonise the training programmes in view of trans-national recognition of licenses and qualifications.

The fifth Working Package evaluated current education and training packages in order to design reference courses of broad interest to the nuclear community, complying with international recommendations and criteria with respect to their content and organisational features.

The sixth Working Package conducted the actual pilot courses following the selection, designs and recommendations made by the fifth Working Package. The international pilot courses implemented in the framework of the NETUNO project were a new edition of the three-week Eugene Wigner course on reactor physics, a two-week seminar on the nuclear fuel cycle, a three-week nuclear safety course, and two one week events, respectively a nuclear safety course for WWER subcontractors and a broad review course on current and future perspectives of nuclear energy and nuclear power plants in Europe.

The conclusions and the recommendations formulated by the Working Groups are presented in the final sections of the report. The perspectives and remaining challenges for the future development of nuclear education and training in the European Union, its harmonization at the European level and the exchange of best practices among the different European actors involved, are elaborated in the final section. The vision of European Nuclear Education Network Association and its programme after the end of the NEPTUNO project is presented.

1. INTRODUCTION

The NEPTUNO project builds on the achievements of the fifth European Framework Programme, which led to the establishment of the European Nuclear Education Network – the ENEN Association. The ENEN Association has the ambition to deliver quality labels to education and training in nuclear disciplines. In addition to the further integration and qualification of curricula in nuclear disciplines at European universities, the NEPTUNO project attempted to enhance the harmonisation of professional accreditation criteria and the associated training programmes across the European Union.

The overall goal of this project is to better integrate European education and training in nuclear engineering and safety to combat the decline in both student numbers and teaching establishments. It thereby provides the necessary competence and expertise for the continued safe use of nuclear energy and other uses of radiation in industry and medicine. The project focuses on a harmonised approach for education and training in nuclear engineering in Europe and its implementation, including as well the better integration of governmental and industrial resources and capabilities at the respective national levels.

The objective is an operational network for academic education at the master, doctoral and post-doctoral level, as well as for training and life-long learning schemes, underpinning:

- Sustainability of Europe's excellence in nuclear technology, thereby contributing to the creation of a European Nuclear Knowledge Management Strategy;
- Preservation of competence and expertise for the continued safe use of nuclear energy and other uses of radiation in industry and medicine;
- Harmonised approaches to safety and best practices, both operational and regulatory, at the European level within and across all Member States;
- Harmonised approach for training and education in nuclear engineering.

In synergy with the European mobility programmes, this should allow the Academia to preserve European nuclear knowledge, to counter the decline in student numbers and teaching establishments, and to provide an increasing number of postgraduates with the adequate nuclear background. The NEPTUNO project also anticipates on the needs for nuclear scientists and engineers when a decision to reactivate the nuclear programmes would be made, in view of the Kyoto environmental requirements or on the basis of energy security and economic arguments. Recent decisions such as the construction of an EPR in Finland and most probably in France are already paving the way for such a nuclear revival and renaissance. In addition the NEPTUNO project contributes to the creation of the European Research Area.

As for the political and social objectives, the NEPTUNO project supports the efforts deployed for keeping nuclear energy as a key element of a sustainable future energy supply system. Fulfilment of its objectives will ensure that the necessary skills will be available in the future to continue the safe and efficient operation of Europe’s nuclear industry, to develop the next generation of nuclear power plants, and to take care of nuclear waste in a safe and environmentally acceptable manner.

2. LIST OF CONTRACTORS INVOLVED

Partic. Role*	Partic. No.	Participant name	Participant short name	Country	Date enter project**	Date exit project**
CO	1	Atomic Energy Commission – National Institute for Nuclear Sciences and Technology	CEA-INSTN	France	Month 1	Month 24
CR	2	Katholieke Universiteit Leuven	KUL	Belgium	Month 1	Month 24
CR	3	Université Catholique de Louvain	UCL	Belgium	Month 1	Month 24
CR	4	Atominstitut de Österreichischen Universitäten	ATI	Austria	Month 1	Month 24
CR	5	Helsinki University of Technology	HUT	Finland	Month 1	Month 24
CR	6	Delft University of Technology	DUT	The Netherlands	Month 1	Month 24
CR	7	Swiss Federal Institute of Technology Lausanne	EPFL	Swizerland	Month 1	Month 24
CR	8	University Politehnica Bucharest	UPB	Romania	Month 1	Month 24
CR	9	Consortium Interuniversitario per la Ricerca Technologica Nuclear	CIRTEN	Italy	Month 1	Month 24
CR	10	Universidad Politecnica de Madrid	UPM	Spain	Month 1	Month 24
CR	11	Kungl Tekniska Högskolan	KTH	Sweden	Month 1	Month 24
CR	12	Jozef Stefan Institute	JSI	Slovenia	Month 1	Month 24
CR	13	Czech Technical University in Prague	CTU	Czech Republik	Month 1	Month 24
CR	14	Budapest University of Technology and Economics	BUTE	Hungary	Month 1	Month 24
CR	15	Tecnatom	TECNATOM	Spain	Month 1	Month 24
CR	16	Studiecentrum voor Kernenergie – Centre d'Etudes Nucléaires	SCK-CEN	Belgium	Month 1	Month 24
CR	17	Slovak University of Technology in Bratislava	SUTB	Slovakia	Month 1	Month 24
CR	18	Lappeenranta University of Technology	LUT	Finland	Month 1	Month 24

CR	19	Gesellschaft für Simulatorschulung	GfS	Germany	Month 1	Month 24
CR	20	Institute for Safety and Reliability	IsaR	Germany	Month 1	Month 24
CR	21	University of Ljubljana Faculty of Mathematics and Physics	UL-FMF	Slovenia	Month 1	Month 24
CR	22	Technical University of Sofia	TUS	Bulgaria	Month 1	Month 24
CR	23	Uppsala University	UU	Sweden	Month 1	Month 24
CR	24	Universiteit Gent	UG	Belgium	Month 1	Month 24
CR	25	Instituto Tecnologico e Nuclear	ITN	Spain	Month 1	Month 24
CR	26	Technical Research Centre of Finland	VTT	Finland	Month 1	Month 24
CR	27	University of Stuttgart	IKE	Germany	Month 1	Month 24
CR	28	Center of Technology and Engineering for Nuclear Projects	CITON	Romania	Month 1	Month 24
CR	29	Ustav jaderného vyzkumu Rez	REZ	Czech Republik	Month 1	Month 24
CR	30	Technische Universität München	TUM	Germany	Month 1	Month 24
CR	31	National Technical University of Athens	NTUA	Greece	Month 1	Month 24
CR	32	HMS Sultan - Nuclear Department	HMS	United Kingom	Month 1	Month 24
CR	33	Paks Nuclear Power Plant	PAKS	Hungary	Month 1	Month 24
CR	34	The Victoria University of Manchester (BNFL)	UNIMAN	United Kingom	Month 1	Month 24
CR	35	Technicatome	TA	France	Month 1	Month 24

*CO = Coordinator
CR = Contractor

3. NEPTUNO MAIN ACHIEVEMENTS

The main achievements of the NEPTUNO project are described in the following paragraphs.

3.1 A state of the art report on education and training in the enlarged European Union

Under Work Package 1, the NEPTUNO partners collaborated to establish a comprehensive database on education and training in the enlarged European Union. As a starting point, the extensive data collected for the ENEN FP5 project (FIR1-CT-2001-80127) were taken, concerning essentially academic courses. New data were collected by means of a questionnaire, including as well advanced courses and professional training courses. The on-line questionnaire is operated in the framework of the NEPTUNO – Communication System, which was developed by the Institut für Kernenergetik und Energiesystem (IKE) within Work Package 2 and available at the following address : http://www.neptuno-cs.de (see below under § 3.2).

ENEN's FP5 data and the new collected data on education and training courses were introduced into a working folder. The institutions responsible for these courses were requested to verify the data, update them as necessary and finally validate them. At the date of issue of this report 296 courses from 38 institutions have been "Approved" and the data concerning these courses are available on the public area of the NEPTUNO CS website.

The survey that has been realised under Work package 1 includes 497 courses divided into the 15 following subjects:

1. Nuclear Energy : Introduction
2. Introduction to Nuclear Physics
3. Nuclear Reactor Theory
4. Nuclear Thermal-Hydraulics
5. Nuclear Materials
6. Experimental Reactor Physics
7. Nuclear Fuel Cycle
8. Radiochemistry
9. Operation and Control
10. Radiation protection and Nuclear Measurements
11. Reliability and Safety
12. Waste Management and Decommissioning
13. Nuclear Fusion
14. Advanced courses
15. Others

The survey includes data from 24 countries, out of which 20 are EU25 members and 3 are candidate countries. No suitable contact points have been established and no data have been collected from Ireland, Cyprus, Estonia, Lithuania and Malta.

Details concerning each course are available on the website. This survey completed the work started during the FP5 ENEN project, mainly by collecting more information on academic courses and establishing a new data base on training courses. Still, a large fraction of the data collected during

NEPTUNO project awaits approval and updating by organizing institutions. Those data have also to be coupled with another survey covering the experimental facilities available for practical training work, which constitutes a fundamental part of the educational basis. Under the coordination of the ENEN Knowledge Management Committee, members of the ENEN Association will be asked on a regular basis to update the data and to upgrade the information concerning their academic and training courses.

3.2 Development of NEPTUNO Communication system (http://www.neptuno-cs.de)

To meet the main objectives of the NEPTUNO project, a communication system was developed to assist the nuclear community in:

- Making knowledge in the nuclear engineering field easily available;
- Improving teaching methodologies;
- Providing an infrastructure which will support exchange of information and cooperative work among the members of the European nuclear community.

The NEPTUNO communication system includes a database on nuclear know-how and developed nuclear technology. The date base is accessible through the internet and is expected to enable the integration of education and training efforts from other European research projects.

The system is based on SINTER technology of the second generation and provides an environment for nuclear know-how data collection, e-learning and simulation.

The basic system components are located in the server side access layer. They include:

- Authorisation (via username and password) and session management;
- A role concept to regulate different views on the database with different access rights;
- Easy to use web forms to gather data and populate the database;
- Report generators based on special selectors for automatic report generation and data analysis, etc.

The role-based data access model provides three different kinds of views: the user model, the content right and access mode and the navigation model. Guidance documents concerning the procedures to input data and on the generation of new questionnaires have been produced, as well as a short manual for using the NEPTUNO communication system questionnaires.

The database includes information on:

- Education and training courses
- Education and training facilities
- Coordinates of professors and instructors
- PhD thesis opportunities and associated research work
- News
- Job offers.

Any registered user can provide information on a course (education or training) which will be classified according to its status of being “approved” or “not approved”. Only “approved” courses, which means “validated and sustained by the organising institute”, are available to the public access section of communication system.

The course search criteria operable by public visitors are the following: course category, country, title, language, university, keywords, and lecturers.

Much information has been provided and introduced in the NEPTUNO-CS but still more data have to be collected concerning the coordinates of professors and instructors, on PhD and master Thesis projects and job offers. This will be completed by the members of ENEN Association under the responsibility of the ENEN Knowledge Management Committee.

3.3 Report on E-learning and E-learning test platform

Within the scope of NEPTUNO Work Package 2 it was not intended to develop new e-learning technologies but rather:

- To introduce to the nuclear community E-learning as an option which should supplement teaching when necessary;
- To make teaching more attractive;
- To open new channels of communication and cooperation for teaching and learning in a European context.

Following an introductory chapter on E-learning, the report exposes and elaborates different categories of e-learning systems such as:

- Course management systems (CMS);
- Learning Management Systems (LMS);
- Synchronous environments;
- Total solutions integrating the three categories.

The report provides a list of important E-learning tools, which represent the state-of-the-art, and describes the current standards for information technology, education and training systems, learning objects and their metadata, and the LOM standard which is under development. The last chapter explains how E-learning can be integrated with traditional courses to enrich them.

An E-learning platform has been developed and a demonstration of a pilot session has been given to all partners during the third and final progress meeting held in Helsinki in June 2005. Also in the UK (Manchester) there is considerable experience with the development and dissemination of E-learning modules, and with blended forms involving E-learning with practical work, group activities, etc.

3.4 ENEN Exchange Courses

In order to apply for the ENEN certificate of European Master of Science in Nuclear Engineering ENEN Certification, students are required to acquire at least 60 ECTS within a selection of “purely” nuclear courses including at least 20 ECTS of nuclear core courses or substitute core courses in a foreign university or training organization, which is member of the ENEN Association. This requirement implies of course that such courses are offered by the members of the ENEN Association on a variety of nuclear topics within the curriculum for nuclear engineering, and in a compatible way with higher education teaching schemes and student mobility schemes.

Those courses, bearing the label of ENEN Exchange courses, should conform to a number of criteria with respect to language, tuition fee, quality assurance, admission, examination and participant feedback, which have been developed, discussed and accepted in the framework of the NEPTUNO project.

Five distinct phases can be identified in the realization of this concept. The first phase concerns the design, development and preparation of the course by one single university or organization or preferably by the joint effort of a small group of ENEN members in a specific region. This phase takes time and resources, in particular to provide lectures and documents in English. When it is well targeted to students needs and interests, the basic work needs to be done only once for several editions of the course. The second phase is the dissemination of the information and advertising of the course. This is not only the role of the organizers, but it should be strongly supported by the ENEN and NEPTUNO communication channels and by each ENEN member on a local basis. Experience has shown that this aspect has been neglected in the past, resulting in poor attendance of some courses. The third phase is the actual conduction of the course. Some courses are standalone courses on a modular basis covering a few days to a few weeks. Some courses are embedded in a larger schedule or in a semester. They are sometimes conducted in combination with other ENEN exchange courses or with unrelated courses. The reason has to be found in the long term tradition of universities and academic education to dedicate only a few hours per week to a particular course over longer periods or over a whole semester. Considerable reluctance from teachers is felt for switching to compact modular courses covering the full scope of the subject in a short period, and the pedagogical argument that students need time to digest and assimilate the complex material has some validity as well. The result is that the courses do not attract the attendance they would deserve on the basis of their content and the resources spent for their development. The fourth phase is the recognition of the value of the course by the ENEN member community and the promotion of the attendance to the course to the local students, motivating them, supporting them and searching for grants or mobility funds for their temporarily subsistence abroad. This phase as well has still to be developed in a more positive and committing attitude towards the ENEN exchange courses from the ENEN member community. Student mobility funds are available, if nothing else, and to some extent from the ENEN Association itself. The culture of student exchange certainly has to be developed and strengthened. The last phase is the evaluation of the course by the participants and by the ENEN Quality Assurance Committee. For several courses the information from the participants and teachers has been collected and evaluated, but only a few courses have been evaluated by the ENEN Quality Assurance Committee as well. The list of the ENEN Exchange courses is given in Tables1, 2 and 3. A summary status of the courses already conducted is described in the following paragraphs. More information is available on the NEPTUNO web site.

3.4.1 ENEN Exchange Courses by INSTN

The courses are identified under N°s 5, 6 and 7 in Table 1. Results on the courses N° 5 (International Seminar on the Nuclear Fuel Cycle) and N° 6 (Nuclear Safety) are presented under Work Package 6 below. The course N° 7 on Nuclear Reactor Systems was less successful.

ID	Course Name	Organisation	Domain	Theory	Training	Advanced
1	Eugene Wigner Training Course for Reactor Physics Experiments	BME et al.	2		■	
2	Nuclear Thermal Hydraulics	BNEN	3	■		
3	Nuclear Reactor Theory	BNEN	2	■		
4	Radiation Protection and Nuclear Measurements	BNEN	6	■	■	
5	International Seminar on the Nuclear Fuel Cycle	INSTN	7	■		
6	Training Course on Nuclear Safety	INSTN	4		■	
7	Nuclear Reactors Systems	INSTN	1	■		
8	Safeguards: Non-proliferation of Nuclear weapons	BNEN	8	■		■
9	Radioisotopes: Iodine 131 Production in an International Context	BNEN	8	■		■
10	Accelerators and time of flight experiments	BNEN	8		■	■

Table 1: Overview of confirmed exchange courses (list 1)

ID	Course Name	Organisation	Domain	Theory	Training	Advanced
A	Neutronics	EPFL	2	■		
B	Radiological Protection	UM	6	■		
C	Use of Accelerated Ions	UL	8	■		
D	Safety and Reliability of Nuclear Facilities	UL	4	■		
E	Reactor Physics Experiments	UL	2		■	
F	Nuclear Safety and Plant Simulation	TUM	4	■		
G	Nuclear Reactor Physics	CIRTEN	2	■		
H	Radiation Protection	CIRTEN	6	■		
I	Nuclear Power Plant Safety	CIRTEN	4	■		
J	Fusion Reactor Engineering	CIRTEN	8	■		
K	Structural Mechanics	CIRTEN	1	■		
L	Fluid Mechanics	CIRTEN	3	■		
M	Mathematical methods for Nuclear reactors	CIRTEN	2	■		
N	Introduction to Reactor Engineering	CIRTEN	1	■		
O	Back-End of the Nuclear Fuel Cycle	UU	7	■		■
P	Introduction to Particle Accelerator Physics and Technology	STUBA	8	■		
Q	Nuclear Safety	STUBA	4	■		
R	Reactor Dynamics and Kinetics	TUD	2	■		■
S	Extension to Eugene Wigner Course	UJV	2		■	
T	Practical Course on reactor Physics and Kinetics	ATI	2		■	
U	Practical Course on reactor Instrrumentation	ATI	2		■	
V	*G. de Hevesy* Course for Radioanalytical Chemistry	BME	8	■		
W	Instrumentation and Control in Nuclear Reactors	BME	2	■		

Table 2: Overview of proposed exchange courses (list 2)

ID	Course Name	Organisation	Domain	Theory	Training	Advanced
a	Master Thesis Project : HMS Sultan	HMS	MT		■	■
b	Master Thesis Project : Technische Universität München	TUM	MT		■	■
c	Master Thesis Project : University Politehnica Bucharest	UPB	MT		■	■
d	Master Thesis Project : Technical University of Sofia	TUS	MT		■	■
e	Master Thesis Project : Slovak University of Technology Bratislava	STUBA	MT		■	■

Table 3: Overview of Master Thesis Projects (List 3)

3.4.2 ENEN Exchange Courses by CIRTEN

The four courses identified under labels G (Nuclear Reactor Physics), H (Radiation Protection), I (Nuclear Power Plant Safety) and J (Fusion Reactor Engineering) in Table 2 were conducted in Torino, Italy, in parallel during seven consecutive weeks (2nd week November till 3rd week December, 2004) for 8 hours per week. They coincide with the regular semester schedule and have

been attended by 11 students, part of them financed through the ERASMUS programmes. The other courses labelled K (Structural Mechanics), L (Fluid Mechanics), M (Mathematical Methods for Nuclear Reactors) and N (Introduction to Reactor Engineering) have been advertised by the University of Pisa but have been postponed by lack of students. Only four students applied (Sweden, Belgium and Italy) and two finally confirmed their attendance.

3.4.3 ENEN Exchange Courses by HMS Sultan

HMS Sultan offers a Master Thesis project (20 ECTS) for several students working in a team on a Reactor Design Study during about 20 weeks (label a in Table 3). The first edition took place in the spring 2005 with the participation of UK and French students. The project is described in a document submitted to ENEN for evaluation with the purpose of receiving the quality ENEN label.

3.4.4 ENEN Exchange Courses by BNEN

The courses N° s 2, 3, 4, 8, 9 and 10 in Table 1 are organised by the BNEN at the Mol Nuclear Research Centre in modular way. Courses N° 2 (Nuclear Thermal Hydraulics), N° 3 (Nuclear Reactor Theory) and N° 4 (Radiation Protection and Nuclear Measurements) have been covered in 2004 and 2005 from January till March, awarding 20 ECTS in total. They have been attended by 5 to 10 Belgian students and 5 to 10 ENEN students.

3.4.5 ENEN Exchange Courses by SUTB, BUTE, CTU and ATI

The Eugene Wigner Course (N° 1 in Table 1) organised through the cooperation of central European Universities completed the third edition in the spring 2005. Without support from IAEA it would not be possible to continue as there were only 10 participants in the last edition, compared to 20 and 17 in the first two editions. The course is planned for September 2006 again on a slightly modified basis in order to reduce the fixed costs and optimise the travel schedule between the different reactor sites. The course has been evaluated by the ENEN Quality Assurance Committee and received the ENEN Quality label.

3.5 Implementation of the European Master of Science in Nuclear Engineering Certificate

The curriculum and criteria for obtaining the ENEN certificate of European Master of Science in Nuclear Engineering have been developed to a large extent under the FP5 European Nuclear Engineering Network project. For the formal implementation, however, a set of procedures, modalities and forms had to be defined and developed as well as the layout and format of the certificate itself. This work has been done under Work package 3 and resulted in the production and publication of an advertising flyer, an application form, the certificate, bylaws and criteria for evaluating the applications and awarding the certificate, and guidelines for the evaluation committee, which is established by the ENEN Teaching and Academic Affairs Committee.

In response to the advertising campaign and call for applications during the summer of 2005, a few applications have been received, and finally three certificates have been awarded during a ceremony on the framework of the European Nuclear Conference 2005, on December 12th in Versailles.
Figure 1 shows a picture of the awarding of the certificates.

Figure 1: EMSNE awarding ceremony at the European Nuclear Conference 2005, Versailles

Further under Working Package 3 a series of documents, guidelines and recommendations have been produced related to academic education, to the organisation of the ENEN exchange courses, to the mutual recognition of courses and qualifications, to student and teacher mobility, to advanced continuous training schemes, and to the organisation of Master and PhD theses at the European level. The documents, as well as all NEPTUNO deliverables can be downloaded from the NEPTUNO web site at http://www.sckcen/neptuno.

3.6 Harmonised European Scheme for Training

The NEPTUNO project was rather ambitious with respect to the harmonisation of professional training in the European nuclear industry. In a similar way to the Bologna declaration for academic education and the resulting mutual recognition of academic curricula and diplomas, it was intended to implement a common standard for professional training. Compliance to the standard would be evaluated and verified on an independent basis, leading almost automatically to the mutual recognition of certificates or licences delivered on the basis of such training. The concept involved three separate phases consisting of the identification and selection of reference key positions in the nuclear industry, the elaboration of criteria for the evaluation of the training programmes and best practices for the mutual recognition and mobility of trained professionals, and finally the design, organisation and operation of an independent body in charge of evaluating the training programmes.

3.6.1 Selection of Key Positions

The selection of reference key positions was oriented to the nuclear power plants, being the most numerous representative units in the nuclear industry. The selection was further guided by the importance of the position with a focus on the impact on nuclear safety. Positions were selected in the areas of plant operation, involving direct manipulations of key controls in the plant systems, and in the technical areas supporting the safety and reliability of the plant operation. In the operations area, the reactor operator, the senior reactor operator and the non-licensed operator have been selected. In the technical area, maintenance staff in the mechanical, electrical and instrumentation fields has been selected, together with the chemistry technician, the radioprotection technician and the engineering staff. For each position, a reference job description, a corresponding set of qualifications and competences and a recommended training programme has been developed.

3.6.2 Best Practices for Evaluating Training Programmes

As the best practice for the evaluation of the training programmes, a self assessment with respect to a number of criteria was proposed, followed by an independent assessment through a peer review. The whole process would be supervised by a new body, the European Academy for Nuclear Training, which would define the common standard and thereby ensure mutual recognition of the training programmes and the resulting staff mobility. The assessment would address different parameters of the training process, including the initial training and qualification, the training for performance improvement, the continual training, the management of the training processes and resources, the conduct of the training sessions, the trainee evaluation and the evaluation of the effectiveness of the training programme. The criteria would refer to the systematic approach to training (SAT) concept.

3.6.3 Implementation of the Evaluation of Training Programmes

From meetings with the industries, it became clear that the peer review would to some extent be a duplication of WANO and IAEA OSART evaluations, which include, among many other reviews, as well the review of the training procedures and their implementation a the particular plant. Even between WANO and IAEA OSART, there is some overlap, resulting in a policy to leave a period of at least two years between reviews at a given plant. A third kind of review by peers appointed by the European Academy for Nuclear Training and an in-depth review of their findings by the proposed European Nuclear Evaluation Board would complicate the situation even more and cause an additional burden to the plant operator, without producing much added value. It was recognized, however, that the European Academy for Nuclear Training would be very useful in assisting the industry with the implementation of the recommendations made by the WANO and IAEA OSART reviews in the field of training. Finally the concept of “college credits” was developed based on the training programme evaluation and providing a yardstick to facilitate mutual recognition and job mobility of trained staff. More interaction with the industry is needed, however, to develop a workable concept for the harmonization and mutual recognition of professional training programmes in the industrial environment.

3.7 Pilot training courses organized in the framework of NEPTUNO project

Four pilot training courses were organized addressing mainly young professionals but also students having a first degree in nuclear engineering.

3.7.1 Training course on Improved Professional Performance (IPP) for subcontractors

The approach taken for the IPP training programme for subcontractors was to give the priority to specific nuclear skills and knowledge. A call for available courses, suitable for subcontractors, was launched among the NEPTUNO partners, resulting in the submission of three proposals for a selection to be made during the first progress meeting in Bucharest, 20 – 21 June, 2004:

- A course on Safety of WWER organised by the Slovak University of Technology in Bratislava and the NPPs of Jaslovské Bohunice and Mochovce was selected as the basis. The proposed course encompasses all essential elements defined in the IAEA TECDOC-1232;.
- International School of Radiation Protection, a one week's course organized by SCK-CEN, Mol;
- Training course on facilities operated by CETIC (EDF and Framatome Training centre, Châlons-sur-Saône, France), submitted by CEA-INSTN. This two to three weeks training course includes practical work performed on heavy equipment mock-up installations.

The course on Safety of WWER was selected. In order to be more suitable for the NEPTUNO project, the format was modified to a refresher course of one week, addressing the workers having successfully passed the original Course on Safety of WWER.

This course was intended to provide an overview of the concept of nuclear safety with special emphasis on WWER-type nuclear reactors. It was designed primarily for subcontractors and consultancy companies involved in the process of constructing and operating nuclear facilities in order to improve their competence in specific fields of nuclear knowledge and skills, such as nuclear safety, emergency procedures, site access, radiation protection, etc.

The major topics presented during this course were:

- Nuclear Physics and Technology: Review of nuclear physics; radioactivity, interaction of ionizing radiation with matter;
- Reactor physics: Fission, prompt and delayed neutrons, moderation, reactor kinetics;
- Nuclear Safety: INES, deterministic and probabilistic approach to nuclear safety, defence in depth, application of defence in depth for WWER;
- Safety Systems of NPP: Active and passive safety systems, emergency cooling, control systems;
- Materials of NPP: Radiation damage, nuclear fuel, moderator, coolant, neutron absorption materials, steels, corrosion, fracture;
- Quality Assurance: Legislation in nuclear safety, international rules, quality management;

- Accidents and Events with Impact on the Safety of NPP Operation and WANO Feedback: Classification of accidents and events, methodology of assessment of causes;
- Reliability of NPP: Qualitative and quantitative assessment, probability, reliability of systems, event tree, design of reliable systems;
- Safety Culture and Human Factor: Communication, human factor under stress conditions, hazards, responsibility and stress, choice of operation staff, testing;
- Dosimetry and Radiation Protection: Units, influence of radiation on human organism, dosimeters and detectors used in nuclear power plants;
- RA Waste and NPP Decommissioning: Radioactive waste, treatment of RA waste, spent nuclear fuel, transport containers, decommissioning of NPP.

The course was organized in Bratislava, Slovakia May 2 – 6, 2005 with 15 participants.

Figure 2 : leaflets of two training courses organized in the framework of NEPTUNO

3.7.2 Training course on Nuclear Safety

A new 3-weeks' upgraded course on Nuclear Safety was designed based on the 6-weeks' IAEA Basic Professional Training Course on Nuclear Safety.

The experience gained by AREVA-Technicatome (France) on their safety courses, by the Finnish consortium organising Basic Professional Training Courses on Nuclear Safety in Finland (YK courses) and on CEA/INSTN's experience after organising four editions of this course in Saclay

were used to finalise the syllabus and the contents of this 3-weeks' upgraded training course.The training course was organized by CEA/INSTN in Saclay, France, April 4th – 22nd , 2005, with 12 participants including one student. The course participants are expected to be professionals currently employed by regulatory bodies, reactor operating organizations, and technical support organizations. They are also expected to fit the following criteria:

- Have at least a first university degree in engineering or science related to nuclear technology;
- Have two to three years successful professional experience beyond university;
- Be in a first or second-level supervisory position, or in a working level position with promotion potential.

The following main topics were developed in the course programme:

- Design of a Nuclear Power Plant;
- Basic principles of nuclear safety;
- Radiation protection in nuclear facilities;
- Safety classification of structures, systems and components;
- Internal and external hazards;
- Deterministic accident analysis;
- Probabilistic safety analysis;
- Human performance;
- Operational safety;
- Surveillance programmes – Maintenance;
- Severe Accidents;
- Plant renewals, modifications and upgrades;
- Emergency preparedness and response;
- Regulatory control;
- Waste management;
- Safety culture;
- Public communication.

A second version of the course will be organised jointly in 2006 under the ENEN Association label by GfS - Gesellschaft für Simulatorschulung mbH, ISaR - Institute for Safety and Reliability GmbH and the Technische Universität München. The contents will be extended to include the safety of BWR nuclear power plants and the decommissioning of nuclear power plants. The course will as well include training on NPP simulators.

3.7.3 International Seminar on the Nuclear Fuel Cycle

The objective of this seminar was to disseminate comprehensive information and acquire in-depth knowledge on the industrial operations related to the nuclear fuel cycle, starting from the extraction of the uranium ore to the reprocessing of spent fuel, as well as the management of waste produced during the different stages of the fuel cycle. The focus of this seminar was the fuel cycle model implemented in France.

The main topics presented during the course programme were the following:

- Geology of uranium: exploration, mining and resources;
- From uranium ore to yellow cake: the concentration stage;
- From uranium ore concentrates to uranium hexafluoride;
- Uranium enrichment – gas centrifuge process;
- Fuel cycle front-end: technical and economical aspects;
- Fuel assembly: general design - fuel rod and assembly: thermal-mechanical design;
- Options for spent fuel management - French experience with interim storage technologies: spent fuel and high level waste;
- Transport of nuclear fuel cycle materials;
- Reprocessing operations and technology – recycling reprocessed uranium - recycling industry: mixed oxide fuel;
- Inventory of fuel cycle waste - long term waste management;
- R & D in the field of the long-lived nuclear waste management: advanced separation, transmutation, long-term interim storage.

The seminar was organized by the CEA-INSTN centre in Saclay, November 29th – December 10th , 2004 and included one week of technical visits to the FBFC plant (Romans), COMHUREX, the George Besse plant, EURODIF, MELOX (Marcoule), the TU5 workshop, the Treatment plant for liquid waste at Saclay (INB-35), the La Hague plant , the La Manche site, ANDRA, the Bure underground laboratory and the ANDRA Waste disposal site AUBE.

Twenty participants from different countries, including young professionals from India and China participated as well as two students from UPB, Romania, and UL, Slovenia. For the latter ones an examination session was organized on February 17th 2005 in order to evaluate them and as a basis for awarding the 4 ECTS corresponding to the course.

A second edition of this course has been organized from November 21st – December 2nd , 2005, under the ENEN Association label, and a third edition will be organised in the second semester of 2006. An adapted version will be organized in the United Kingdom by the Dalton Institute in close cooperation with Manchester University and BNFL in 2007.

3.7.4 Performance of a Euromasters course “Levelling the Playing Ground for New Nuclear Power Plants in Europe

This course was organized in close collaboration with the European Utility Requirements (EUR) organisation. The EUR course focuses on the European nuclear energy background, the utility needs, the regulators’ position as well as the vendors’ proposals for new nuclear plants in Europe. This course was mainly intended for post-graduate students in nuclear engineering as well as young professionals but was also accessible to any participant having a minimal scientific background.

The main topics developed during this course are the following:

- Main drives to NPP design evolution and harmonisation;
- Introduction to the EUR document and the EUR main requirements;

- EUR safety approach: safety targets, safety approaches to design, safety verification, containment and severe accidents;
- Regulatory background and safety;
- WENRA works on safety harmonisation;
- Projects being developed for Europe, various approaches;
- Vendor projects for Europe;
- HV grid policies: electricity producer standpoint, regulator and grid manager standpoint;
- Perspectives about risk informed approaches in operation and design.

The course, organised over four days, June 6th - 10th, 2005, in Helsinki was followed on the fifth day by a technical visit to the Loviisa NPP. Thirty five participants attended the course including five students.

4. CONCLUSIONS AND RECOMMENDATIONS

Conclusions and recommendations have been provisionally formulated during the final project meeting, held in Helsinki on June 13th-14th, 2005 and refined during the last six months of the project. Although the information might come from different Working Packages and there is some cross-over and overlapping, the conclusions and recommendations are presented according to the NEPTUNO Working Packages.

4.1 Conclusions and recommendations from Working Package l

Although the number of courses identified is impressive, the validation of the data, indicating that the course is still active and sustained, is proceeding at a slow rate. Whereas sixteen European countries (including Switzerland, Romania and Bulgaria) are currently relying on nuclear power plants, even the most widespread validated courses are available in only 12 of them and several courses, e.g. Nuclear Physics, Nuclear Materials, Radiochemistry, Nuclear Waste Management and Decommissioning are offered in a three to four countries only. There is a serious lack in courses in Europe with respect to nuclear disciplines. In view of the relatively small number of students needed to maintain a sufficient level of highly specialised and qualified staff, and the large investments needed for didactic nuclear infrastructures, the most appropriate way to handle the situation is to increase and facilitate teacher's and student's mobility.

4.2 Conclusions and recommendations from Working Package 2

Following the conclusion above, dissemination of information and advertising of courses across national boundaries is of primary importance as the first step to mobility. The visibility and accessibility of the course database has to be improved and information with respect to teachers and facilities has to be extended. Student registration tools and access to mobility supporting schemes, opportunities and organisations have to be implemented as a part of the NEPTUNO communication system.

Mechanisms, resources and procedures have to be defined and implemented for keeping the database continuously up-to-date. In this respect, the slow validation rate of the courses indicates that more efficient and active mechanisms are required and have to be put in place.

The web access structure, now involving three web sites (http://www.neptuno-cs.de, http://www;sckcen.be/neptuno and http://www.enen-assoc.org) has to be optimised through a single entry-point with subsequent branching according to the customer's profile and requirements. The NEPTUNO communication system has to provide access to other relevant databases, e.g. NUCOC DB (JRC Petten) and the Joint Research Safety Index (IKE Stuttgart), etc.

Web based courses and distance learning form an attractive alternative to student and teacher mobility for self-study. Fully exploiting the Internet and multimedia features and capabilities can lead to excellent didactic materials, which have been demonstrated in the NEPTUNO project. Real interactive E-learning, including examination, authentication and qualification aspects, however, is of a totally different dimension with respect to the implementation modalities and resources needed for its development. It is questionable whether this approach would compete with mobility expenses when only small numbers of students are involved.

Finally, with respect to further networking, it is recommended to maintain and strengthen interactions with other networks for education and training, e.g. the World Nuclear University, The Asian Network for Education in Nuclear Technology, the University Network of Excellence in Nuclear Engineering, etc. in order to avoid competition and duplication and benefit from the exchange of experience and synergism.

4.3 Conclusions and recommendations from Work Package 3

The conclusions and recommendations from this Work Package are arranged in several paragraphs.

4.3.1 General Recommendations

Again the facilitation of student mobility, within the EMSNE concept is recommended, as well as the study and development of tools to stimulate cooperation between European universities, research centres and industry in the framework research and development. In particular a European PhD analogue to the EMSNE is proposed. Based on the experience with advanced courses and the relatively small number of participants, better advertising and trans-national joint organisation of well developed high quality advanced courses for a mixed attendance of students and young professionals is recommended.

The development of a EU coordinated single framework for the promotion of continued academic education and professional upgrading towards all the professionals in the field of nuclear engineering and nuclear sciences is recommended. Extending the recruitment for continued academic education to include learned and professional societies is also recommended.

4.3.2 Recommendations with respect to PhD Research

PhD researchers should be encouraged to partly perform their research at sister European research centres and/or university laboratories for periods of 6 months to 1 year on an exchange basis. To stimulate and strengthen the European Research Area, the organisation of international advanced courses, work shops, and seminars addressing more specialised fields for an audience of PhD researchers is recommended. It is suggested that those courses would deliver ±10ECTS.

Further harmonisation of PhD research work and cross-fertilization between universities and research institutes would result from the inclusion of two or three 'foreign' members in the PhD examination jury and from jointly organised PhD research involving a 'foreign' co-promoter in the PhD work.

4.3.3 Recommendations with respect to Advanced Courses

The organisation of joint advanced courses between research centres, universities, and industrial laboratories within the ENEN framework is encouraged. The format of the courses should be preferably intense and of short duration, using English as the course language. Within the ENEN Association and as a benefit of its existence, the needs for courses and the course offer should be better evaluated and coordinated with respect to content, venue and timing in an international context. Advertising the courses and course information should be available from a single well-known platform (possibly in parallel with other platforms). Courses should be tested by pilot sessions and evaluated to improve further editions.

4.4 Conclusions and recommendations from Work Package 4

Several key positions with associated training packages in nuclear industry have been identified. Harmonisation is needed in particular at lower level job positions and should be based on the transferability of skills, for example by an employment passport. PENTRAC attempts to coordinate different European training centres but is not working properly. The European nuclear industry and utilities are not favouring a concept, which would duplicate or overlap with tasks currently done by WANO, WENRA and IAEA. A European Academy of Nuclear Training (EANT) is of interest if it would cover additional requirements by the utilities currently not covered by WANO, WENRA, IAEA and other organisations.

The EANT should provide quality certification and a quality label in training, in particular in the field of radioprotection. It should serve as a link between industry and the Academic world to assist in the staffing of the nuclear facilities, to cover knowledge preservation and transfer, to develop E-learning, to reduce training costs by harmonisation and outsourcing, to increase the role of contracted work and to counteract negative effects of privatization.

Together with industry representatives, their actual needs and the gaps in the WANO, WENRA and IAEA services should be identified and investigated, with the objective to cover those needs through the development of a properly tailored EANT concept. Also contacts with WENRA should be established in order to identify commonalities, gaps and added value of the EANT approach. It is also observed that the deliverables of Work Package 4 need revision to make them more accessible to the nuclear industries.

Finally it is observed that the sharing of training infrastructures of common interest would be beneficial and contribute to the harmonisation and mutual recognition of professional training packages.

4.5 Conclusions and recommendations from Work Package 5

There is a need and a role for coordination and management of industry specific training. There is a need for a European system for training and qualification including support to manpower mobility.

Training packages should include Occupational Health and Safety Training (OHS) and a corresponding examination (following example of Finnish industries and subcontractors)

Editions the Nuclear Safety training course in the upgraded versions should be organized in a country specific and focused way.

4.6 Conclusions and recommendations from Work Package 6

Conclusions and recommendations to improve further editions of the pilot courses have been formulated from the organisers' experience and the feedback from the participants. The detailed feedback and the evaluations are available from the specific deliverables on the NEPTUNO web site. Some general recommendations are provided below.

New editions of the courses should be organized in a larger cooperation framework in order to have more participants, to be more efficient and have a better cost/benefit balance. The interactive way of teaching and a schedule to provide enough time for discussion and questions is largely preferred. The lectures should concentrate on concepts, whereas the detailed mathematical background should be made available for self-study with an opportunity for questions afterwards. A glossary of terms and acronyms for quick reference and better understanding should be made available. The use of a single common language (English) is preferred with the expectation that the selection of teachers ensures a good command of English as well.

5. FUTURE PERSPECTIVES FOR THE ENEN ASSOCIATION AFTER THE NEPTUNO PROJECT

After founding of the European Nuclear Education Network Association as an outcome of the FP 5 ENEN project and the development of ENEN products (EMSNE certificate, exchange courses, E-learning concepts, databases, communication systems, visibility, etc.) under the FP 6 NEPTUNO project, it was found appropriate to expand the ENEN scope from the nuclear engineering field into other nuclear disciplines and extend the activities from the academic environment into the industrial, regulatory and governmental areas. A follow-up project with the title "Consolidation of European Nuclear Education, Training and Knowledge Management" was designed and submitted to the last call of the EC 6th framework programme. This Coordination Action should consolidate, expand and extend the achievements of the ENEN and the NEPTUNO projects.

Consolidate

"Consolidate" means to implement the education and training modules proposed and developed in the past few years and tested during the pilot sessions. "Consolidate" also means applying the course evaluation criteria to the actual course and training performance, taking into account feedback from the participants and their companies, the end users and other stakeholders.

"Consolidate" includes combining and organizing scattered web sites, data bases and course information in a well-designed and accessible communication and knowledge management system derived from the NEPTUNO communication system. "Consolidate" finally refers to testing in practice, and in collaboration with accreditation authorities, the developed mutual recognition schemes for academic education in nuclear disciplines.

Extend

"Extend" means moving outside the academic education area into professional and even vocational training, thereby strengthening the interactions and collaboration of universities, research centers, training organizations and industries to make training offers better respond to industry needs and enhance mutual recognition of professional qualifications across European countries. "Extend" is as well to make a better use of and facilitate the access to EU tools to increase mobility of students and professors in nuclear disciplines. It includes testing of formulated best practices for mobility, accreditation and recognition of qualified licensed staff and in general all staff needing some form of education, schooling or training before operating in the nuclear industry. "Extend" finally refers to strengthening the links with nuclear education and training networks outside Europe, the World Nuclear University, and by developing viable Erasmus and Erasmus Mundus schemes for the Master of Science in Nuclear Engineering within the ENEN Association.

Expand

"Expand" refers to moving beyond the disciplines related to nuclear engineering for power plant design, construction and operation, into a broader area including nuclear engineering and other disciplines in support of reactor safety, radiation protection, radioactive waste management, radiochemistry, decommissioning and industrial applications of nuclear technologies. "Expand" means strengthening the interactions with other European education and training networks, advising them from the ENEN Association experience and harmonizing the working schemes. "Expand" means the development of networking within the ENEN Association to cover additional fields, e.g. reactor safety, and by establishing new networks, for example for radiochemistry and nuclear applications in industry or agriculture. "Expand" includes developing courses, workshops, seminars and training modules on new topics such as GEN IV, waste management, decommissioning, lifetime extension and other topics to be defined. "Expand" finally by developing a "think tank" functionality on a range of issues in modern societies where nuclear energy and applications are part of the possible options.

Expectations

A higher level of networking of nuclear related organisations and industries at the European level will be obtained, in particular within the nuclear disciplines, such as engineering, radiation protection, radioactive waste management, decommissioning and between the academic institutions, the training organisations and the end-user associations. This will enhance the adjustment of curricula and training packages to the end-user needs, thereby improving the employment and career opportunities, and the qualifications of the young professionals. At the world-wide and intercontinental level, networking will enhance opportunities for European teachers and professionals to disseminate their expertise and produce added value by exporting the leading position of the European Union in nuclear power plant construction and other nuclear applications.

LIST OF ACRONYMS

CEA-INSTN, KUL, UCL, ATI, …..

See also the acronyms of the NEPTUNO partners under section 2.
Those acronyms are not repeated here.

ANDRA	Agence Nationale pour la gestion des Déchets Radioactifs
EANT	European Academy for Nuclear Training
ENEN	refers to the European Nuclear Education Network Association, except when specified to refer to the FP5 project European Nuclear Engineering Network
EU	European Union
EUR	European Utility Requirments
FBFC	Franco-Belge de Fabrication de Combustibles
GEN IV	Generation IV nuclear power plants
IAEA	International Atomic Energy Agency
OSART	Operational Safety Review Team
NPP	Nuclear Power plant
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulator's Association
WWER	Water Water Energy Reactor (Russian version of Pressurised Water Reactor)