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Training Programmes for Industry

THE NFI TOKAI SD SYSTEM

- MANAGEMENT OF THE CAPABILITIES OF OPERATORS IN FUEL FABRICATION PLANTS -

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ABSTRACT

Since the JCO criticality accident occurred in 1999, even more emphasis has been placed on the management of nuclear safety in Japan. This is particularly true for the education of operators and the observance of operational procedures. Even prior to this accident, Nuclear Fuel Industries, Ltd., NFI, regarded the education and development of skilled operators very seriously and we have developed an education system, called the SD system (Skill Development system), to assure the careful education of the operators and the improvement of their skill in order to prevent human error events. Our education system in the Tokai works, is explained.

1. Introduction

1.1 Outline of NFI's business activities

Nuclear Fuel Industries, Ltd., NFI, was established in 1972. Since then, it has been manufacturing nuclear fuel with modern equipments and facilities under the strict quality control. NFI's business has grown to encompass a wide range of activities, such as development, design and manufacturing of nuclear fuel, reactor core management service, nuclear fuel-related engineering services, and also inspection and repair services. NFI has two manufacturing sites; Tokai Works, which manufactures BWR (Boiling Water Reactor) fuel, and Kumatori Works, which manufactures PWR (Pressurized Water Reactor) fuel, and has been developing its activities mainly through these two works.

1.2 Circumstance about nuclear safety in Japan

On September 30, 1999 a criticality accident occurred at a uranium re-conversion plant operated by JCO ,Ltd. Three plant workers were exposed to high levels of radiation in the accident. This resulted in death of two workers making this an unprecedented nuclear accident in Japan which had been utilizing nuclear energy for more 30 years at that time. The primary cause of the accident was the use of illegal procedures. After the accident, strong emphasis has been placed on the management of nuclear safety in Japan, especially on the education and training of operators and the observance of operational procedures. Even prior to this accident, NFI recognized the importance of them very seriously and we have developed a careful training system, to assure improvement of operator's skill in order to prevent human error events. Also we have been trying to avoid mannerism by providing with many kinds of skills through the system. We introduce the system which we call the Skill Development system (SD system).

2. SD system

2.1 Structure of the SD system

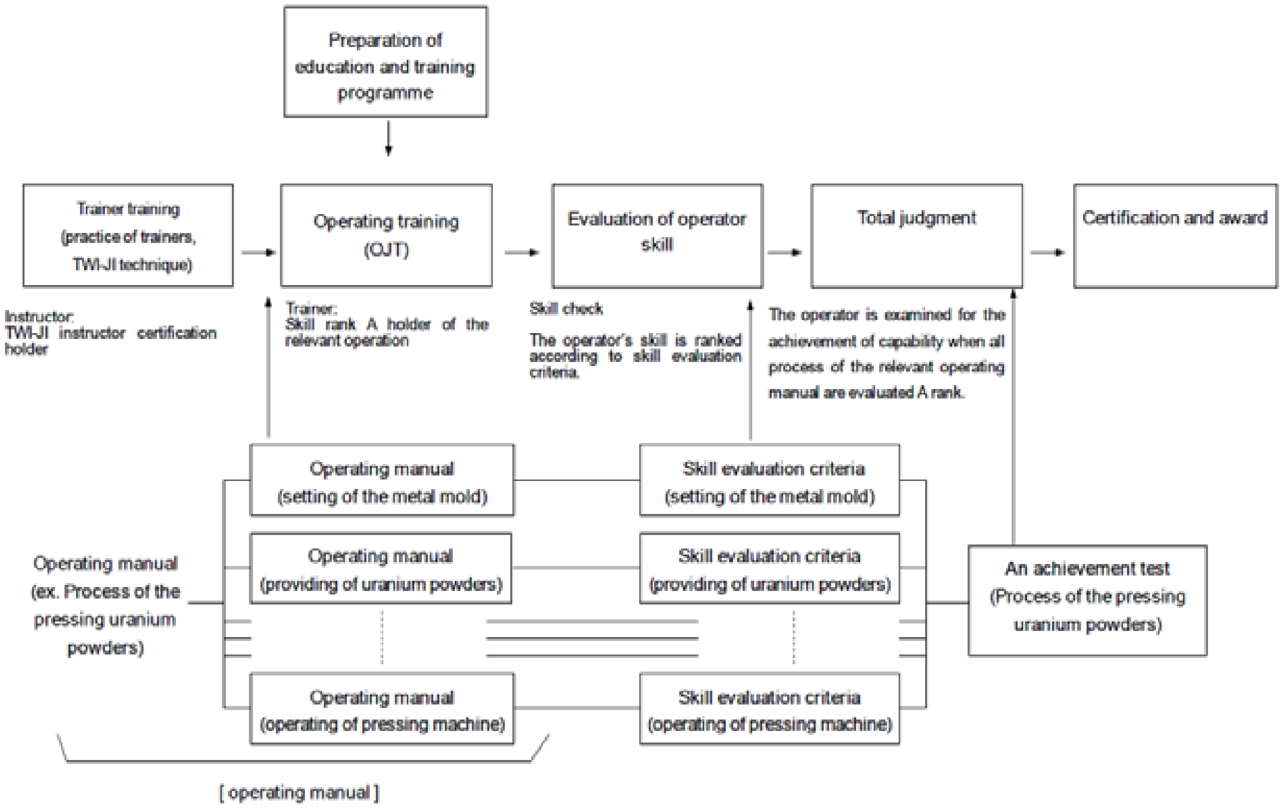
The SD system was introduced in 1986 to improve the skill of the operators and to assure the transfer of skills to the next generation. These are fundamentals for safe operations and product quality. The SD system is also proven as an effective tool for managing skill level of the operators.

The SD system is composed of the following four steps.

1. Preparation of instructors to educate trainers out of operators
2. Preceding education of the trainers by the instructors
3. On the Job Training (OJT) for operators by the trainers
4. Evaluation and certification of the operators’ skill level

The SD system is featured as a system adopting many techniques of “Training Within Industry for supervisors – Job Instruction (TWI-JI) “. TWI-JI was developed in USA during 1940’s as a method of teaching with easiness and immediate effectiveness. The instruction methods were introduced by many countries in the world, and also have been used as tools of business training by many companies in Japan.

Conceptual diagram of the SD system



2.1.1 Preceding training of the trainer

It is true that whether the training is successful and effective or not depends on the motivation of operator. We are also sure that more important factor for the success is existence of excellent trainers. Therefore we prepare an education programme for the instructor who trains the trainer. With the programme we nurture two new instructors per year. At first, two instructor candidates shall learn the TWI-JI methods for 6 days in the instructor training programme by external education institution and shall be certified as instructor. Then the certificated instructors teach TWI-JI techniques for 10 hours as trainer course to in-house potential trainers who have skill rank-A. (Skill rank will be mentioned later) Training method in TWI-JI has the following features.

- Fixed procedures.
- Based on discussion and demonstration.
- Emphasize practical skill over knowledge.
- Teaching with easiness and immediate effectiveness.

These characteristics are suitable for training of unskilled operator. In addition, TWI-JI’s credo, "If the worker hasn't learned, the instructor hasn't taught", is consistent with our education policy. From these reasons, NFI has been using TWI-JI methods since introduction of the SD system. Now, we have 23 instructors, and all of the operators aged 30 and older are learned TWI-JI technique by them.

2.1.2 OJT for operators

A designated trainer, who is certified as skill rank A for the relevant operating procedure and finished the trainer course, trains the operator with OJT. We explain the OJT procedures as below.

The first step, the line manager plans a training program for his operators, such as “who”, “which operation”, “when by” and “ to which rank of skill”, taking account of importance and priority of processes and experience of the operators.

OJT is carried out based on the operating manual. We have established it for each process, in manufacturing, inspection/chemical analysis, radiation control and facilities maintenance. In the operating manuals, we divide the operation into some processes according to TWI-JI’s technique, ”operation breakdown”, and emphasize vital points for the each process of safety and quality. We are trying hard to write down into manual even know-how of the operation such as knack and hunch to share them among operators and transfer them to the next generations.

Operating manual format

Process	facilities	Operating procedure	Essential points	Precaution for safety

During OJT, the operator is trained through “four basic steps”, (1) prepare the worker, (2) present the operation, (3) try out performance, and (4) follow up. Trainer shall coach the operator with patience and make sure of his understanding. As we recognize that an important point of OJT is to follow up the operator after coaching, we request the trainer to make additional coaching if necessary while watching job performance and workmanship of the operator.

2.1.3 Evaluation and certification of the operators’ skill level

After the operator is trained with OJT, he is appraised by the trainer. The operator’s skill level is ranked and authorized according to the skill evaluation criteria. We classify operator’s skill into the three classes, Rank A, Rank B and Rank C. We prepare criteria of the Ranks for each work in the operating manual. For the purpose of securing of skill’s reliability, we disallow skipping a rank.

Skill rank (Classification based on skill level)

Skill rank A	He has knowledge and skill about the operation enough to coach a member as a trainer.
Skill rank B	He has knowledge and skill to execute the operation alone.
Skill rank C	His knowledge and skill aren’t enough to execute the operation alone. He shall operate with coaching by a trainer.

Example of skill rank evaluation criteria

Operation name	Heating-up and cooling-down of a sintering furnace
Skill rank B	- He can implement heating-up and cooling-down operation of a sintering furnace with referring to the operating manual. - He can confirm the program of heating/cooling for the electric temperature control device. - He can identify a gas piping by a unique color. - He understands characteristics of each gas. - He can correctly set the graphite crucible with paying attention to its direction to furnace.
Skill rank A	- He understands seriousness of influence caused by malfunction of the gas supply system. - He can correctly teach the procedure of the operation to low ranker.

We judge the operator’s skill not only based on correctness of his operation but also based on his understanding of human error related- risk and past experience. The criteria prepared by this concept make sure to transfer valuable experiences to young operators. We also confirm his skill level is maintained once a year for Rank A operators, because it may decrease with time.

The skill management of our operators mentioned above has been used for preparation of our manning schedule, and it has been contributing to safety of the plant operation and high quality of our products.

The person who has Rank A skills for all of the operations in the specific process can take a final examination for all aspects of the process. If he successes in the examination, he is awarded the certification from the plant superintendent as a professional of the process. This recognition system is significantly contributing to maintain and assist operators' desire to improve themselves.

2.2 Horizontal development of the SD system

We have applied the SD system not only for manufacturing work but also for the other works surrounding it. (ex. radiation control, facilities maintenance)

It is said that accident or trouble is more probable to happen in unusual work or infrequent operation. We are trying to apply the SD training to such work and/or operation by periodical review of them and relevant operating manual including view point of "3H work" (Hajimete in Japanese: for the first time, Henkou: revised or modified, Hisasiburi: after a long time).

In general, Europe tend to aspire toward one-job skilled worker, Whereas Japan tend to aspire to multi-skilled worker. Both ways have drawback and advantage. NFI has been promoting for its workers to have many skills, because we should consider about flexibility in case of their absence due to illness, activation of workplace and cost reduction by optimization in arrangement of personnel while securing nuclear safety and workers' health and safety with the highest priority. We think that the SD system greatly contributes to development of the production activity.

2.3 Challenges for the future

We recognize it is important to improve efficiency of the OJT continuously. To make trainees' learning easier, we consider to visualize operating manuals and to show them in workplace by introducing large monitors so that operators can easily remember the procedures of operation.

3. Conclusion

Japan now faces a declining labour population due to its longstanding low birth-rate. In this circumstance, we have to maintain high skilled human resources necessary for operation of the fuel fabrication plant. We believe smooth skill transfer among operators and their generations is essentially important and achievable with the SD system. We therefore will maintain and improve the SD system continuously in the future.

Finally, we hope our experience of the SD system helps you to review and/ or plan control of your operators' skill and which contributes nuclear safety in the world.

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FINNISH SOLUTION TO INCREASED BASIC PROFESSIONAL TRAINING NEEDS IN NUCLEAR SAFETY

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ABSTRACT

The Finnish nuclear energy organizations have in cooperation arranged basic professional training courses on nuclear safety due to fast increased education needs. Especially the new nuclear power plant construction project turned the situation acute, but there was also a need to preserve the tacit knowledge of many nuclear experts retiring within the next ten years. From 2003, the YK courses have been arranged five times with altogether 270 participants. The need of this kind of complementary education is still seen high in Finland, and the YK6 course is to be arranged during the next winter. There has not been seen to be legal incompetence due to the likelihood of bias in the education even that the participating organizations have differing and/or opposing roles. It is seen that a real safety culture presumes that nuclear safety is a common goal, and even the competition for market shares is no obstacle for cooperation.

1. Introduction

Nuclear technology is facing a regeneration phase in Finland, and nuclear safety is a prerequisite for utilization of nuclear energy. In fall 2002, Finnish nuclear organizations started to discuss, how to find a solution to fast increased education needs in nuclear safety. Especially the new nuclear power plant (NPP) construction project turned the situation acute, but there was also a need to save the tacit knowledge of many nuclear experts retiring within the next ten years: the four NPP units began their operation nearly simultaneously 1977-1981. The education goal was seen common for all organizations in the nuclear energy area, and they decided to establish an organizing committee to develop and organize a basic post-graduate professional training course for new recruits and staff members. The developed national course on nuclear safety was entitled the YK course. Since fall 2003, YK courses have been arranged five times with above 50 participants and about 100 lecturers each time. The number of professionals with academic degree working within nuclear energy in Finland was estimated to be 600 in the beginning of this century, and has grown maybe 50 % now. Half of them have a special degree on nuclear energy. The national YK courses with altogether 270 students have been an essential help in this fast expansion.

The need for the course is not expected to decrease, vice versa: now there are three new environmental impact assessment (EIA) processes in different phases for three planned construction projects. However, TVO, Fortum, and as a newcomer also the Fennovoima utility must first have the Government’s Decisions in Principle (DiP) in favour of the new units being considered to serve the overall interests of the society before they can seek for construction licenses. Also the Finnish Parliament must ratify these possible DiPs. The new unit of TVO is now estimated to be commissioned in 2011 with electric output of approximately 1600 MW.

2. Academic nuclear energy education system in Finland

Nuclear engineering and reactor physics are taught in two universities in Finland. The professorships are in the Department of Energy and Environmental Technology of the Lappeenranta University of Technology (LUT) and in the Department of Engineering Physics of the Helsinki University of Technology (TKK). However, there are only two professorships altogether in the nuclear energy area including fission and fusion energy. Nuclear energy related areas are taught also in several other universities (e.g. nuclear physics, radio chemistry, material sciences and construction, power engineering, automation, geology).

Four levels can be seen in nuclear energy education: first the basic courses on ideas of nuclear physics, engineering and safety, second the thorough education on the Master level, third the professional training courses, and fourth the post-graduate studies. The basic courses are given in some, and should be given in all universities giving degrees on nuclear energy related areas. In LUT the basic course gathers yearly much over hundred participants.

Masters level education on nuclear energy is given in LUT and TKK. A Finnish speciality in all technical areas is the tight connection of the technical university students with industry as well as research institutes and authorities. During the studies the students get acquaint with the industry and other bodies as summer trainees, and the diploma theses are often made straight for the other stakeholders, the students working outside the universities.

The post-graduate level education is a huge challenge with so few professors in the area, and international co-operation is thus very important. Both LUT and TKK are members of ENEN and WNU. The research on doctorate theses has mainly been carried out within the national research programs on nuclear safety, now SAFIR2010 [1] and KYT2010, and in the EU research projects participated by research institutes and universities.

In the professional training level after graduation the YK courses are the most extensive in Finland. They are especially important for those participants who come from other subject areas than nuclear energy but are needed to work e.g. in NPPs. There are also courses on radiation safety and waste management given separately. However, it must always be remembered that this kind of training courses cannot substitute the long-term nuclear energy education in universities.

3. Organization and structure of the YK courses

The YK course is aimed for basic post-graduate professional training of new academic recruits and staff members; i.e. for an audience of graduate engineers having their own expertise, but not necessarily that in nuclear engineering. The YK course structure and syllabus were originally based on a similar course developed by the IAEA [2], but it has been applied for Finnish needs, especially to include more information on the issue of new construction. All materials have been renewed, and are partly renewed again every year.

The organizations arranging the course are: Ministry of Employment and the Economy (TEM), Lappeenranta University of Technology (LUT), Helsinki University of Technology (TKK), Teollisuuden Voima Oyj (TVO), Fortum Oyj (Loviisa power station and the Fortum Nuclear Services Oy), Posiva Oy, the Technical Research Centre of Finland (VTT), and the Radiation and Nuclear Safety Authority (STUK). The Finnish application was developed in order to make visible different standpoints of all organizations in the area. Concretely, also the location of the different modules rotates between different organizations.

Best experts from Finland were chosen as lecturers, altogether about 100. They mainly come from the above mentioned organizations as well as the participants. Half of the lecturers came from the utilities TVO and Fortum, a quarter from the authority STUK, and the rest from VTT, universities and others. Actually, the right to send participants was “bought” by giving lectures. No fees are gathered except the power companies taking care of the running expenses.

.Part No	**Course number**	**YK 1**	**YK 2**	**YK 3**	**YK 4**	**YK 5**	**Order YK 5**
	Part subject	**The number of hours of lectures + team work**					
1	Principles of nuclear safety	10+2	7+1	7+1	7+1	5	**3**
2	Nuclear reactor principles	11+2	12+2	12+2	12+2	14+2	**1 + 10******
3	Radiation protection	2+1	3+1	4+1	4+1	2+1	**5**
4	Design of a nuclear power plant	20	13	13	13	9*+1	**2**
5	Siting considerations	3	1	1	1	4	**4**
6	Licensing and construction of a NPP	8	6	6	6		
7	Safety classification	4+1	2	2	2 +1	2	**6**
8	Quality management	6+1	4	4	4	3	**20**
9	Deterministic accident analysis	10+4	9+4	9+4	9+4	9+4	**7**
10	Probabilistic safety/risk assessment	10+4	7+4	7+4	7+3	4+3	**8**
11	Human performance	7+1	3	3	3	3	**9**
12	Operational safety	7	4	4	4	6***	**11**
13	Surveillance and maintenance programs	6+1	5+1	5+1	5+1	4+1	**12**
14	Plant modifications and upgrades	7	7	7	7	5	**14**
15	Limiting conditions for operation	5+2	5+2	4+2	5+1	3+1	**15**
16	In plant accident management	9	9	9	9	6	**16**
17	Decommissioning considerations	1	1	1	1	7**	**13**
18	Waste management	4	4	4	4		
19	Regulatory control	9	7	8	8	7	**17**
20	Emergency prepared-ness and response	6+1	6+1	4+1	4+1	4+1	**18**
21	Safety culture	5+2	5	4	4	3	**19**
22	Public communication, operational experience	4+1	5	4	4	2***	**21**
	Nuclear power plant & waste facility visits	+24	+24	+24	+24	+13	
		(=154+47)	(=125+40)	(=122+40)	(=126+39)	(=102+27)	
	Total course duration	**201 h**	**165 h**	**162 h**	**162 h**	**127 h**	
	Weeks / periods YK5	6	5	5	5	6	
	Lecturers, guides etc.	120	~100	~100	~100	95	
	Participants	51	56	52	55	57	

* number of lectures will again be increased in YK6 ** includes also the front end of fuel cycle
*** operational experience moved together with operational safety ****10.= test facilities and reactor

Table 1. The structure and volume of courses YK1-5 in 2003-2008

The course is arranged in six modules each lasting 2-4 days during 6 months. The nuclear safety subjects are extensively covered as seen in Table 1. The main part of the course is lectures, but visits to the operational NPPs and their waste facilities, full-scope simulator exercises, as well as group works are also essential parts of the course. The materials include about 2000 pages of slides and 900 pages of abstracts gathered by LUT, coordinator of the course. The focus is on the Finnish requirements on nuclear safety as well as the structures and practices of the Finnish operational and constructed NPP types.

The domestic need has been such large that there has not been room for foreign participants. Due to the very fast time table in the creation of the course for the first time, all the lecturers were gathered from Finland and the habit has not been changed so far. However, there is no principal obstacle to change the situation. Also the subcontractors working in Finland have been interested in the course. The Finnish experiences of the courses were dispensed within the EC 6th FP project NEPTUNO, the Nuclear European Platform for Training and University Organisations which worked in close contact with the ENEN association, the European Nuclear Education Network.

4. Development of the YK courses based on feedback and evaluation

The structure and the content of the courses have roughly remained the same, but some changes have been done based on the feedback collected from participants and lecturers [3]. The YK courses were also independently evaluated in 2007, and suggestions were given for further development [4]. These suggestions were partly taken into account already in the course YK5 just finalized. E.g. the YK5 course was arranged using shorter lecture periods, which do not disturb other duties of the participants as much as the whole week periods applied earlier.

The course has been gradually compacted mainly in order to decrease the overlapping of lectures. It can be seen in Table 1 that the compacting has been carried out in most of the topics. The overlapping is continuously seen as a problem mainly due to the large amount of lecturers. A problem is also that hundred lecturers cannot all be pedagogically professional teachers despite them all being professionals in their own fields. However, it has been seen that there still are more advantages of having many lecturers: differing points of view, e.g. by authorities and NPP workers as well as deeper expert knowledge are the most important. Summer seminars for the lecturers have been arranged from the year 2007 to increase the coordination.

There has been positive feedback on practical arrangements of the courses as well as on excellent lecturers with high expertise. Also the good team works and high quality materials have been remarked. However, the course should be more interactive. One way to do this would be to limit the quite large amount of participants in each course, which has been over twice of the amount applied in the international courses, but the education needs in Finland are too acute for this solution.

The wide content of the course has been seen acceptable even though the participants have seen that every topic is not as useful for everybody. The students have different backgrounds and it has now been decided to include preceding reading and exercises in the course. The heterogeneity of the knowledge level and the differing working areas of the audience make the teaching process challenging for the lecturers. However, the networking aspect of the common course has been seen to be an overwhelming benefit compared to separate courses. Participants have admitted that one important assignment of the YK courses is to get to know each other and all significant nuclear organizations in Finland.

The Finnish language is seen to be important in the materials because the NPPs utilize the course materials also in their internal training. However, the terms should be given and learned also in English.

5. Conclusions

The arranging of the YK courses has demanded a lot of work from the whole nuclear community in Finland. The straight yearly investment is at least 7 person years. However, this effort is seen to be very valuable in the education of new generation and in the knowledge management of tacit know-how as well. The need of this kind of complementary education is still seen high in Finland, and the YK6 course is to be arranged again during the next winter.

The course has been arranged and participated by Finnish nuclear energy organizations having differing and even opposing roles. However, there has not been seen to be legal incompetence due to the likelihood of bias in the education area. On the contrary, it is seen that a real safety culture presumes that nuclear safety is a common goal, and even the competition for market shares is no obstacle for cooperation in education.

Acknowledgements

The members of the organizing committee of the YK course, the lecturers, and the producers of the materials are acknowledged for enabling the course despite of their other duties.

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EDUCATION FOR THE NUCLEAR POWER INDUSTRY - SWEDISH PERSPECTIVE

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ABSTRACT

In Sweden, about 50 % of the electricity is produced by nuclear power. The nuclear power industry hires about 50 people per year on a masters or PhD level, and engineers on a bachelor's level are hired as reactor operators. Of these, essentially all have their background in other areas than nuclear engineering.

To educate the staff, the nuclear power industry has formed a joint education company, Nuclear Training and Safety Center (KSU). KSU provides education and training programs for all levels of professional skills. Reactor operators undergo an extended training program over many years, where training in simulators constitutes an important part. In addition, courses aiming at a deeper theoretical understanding of reactor physics and thermohydraulics are provided. The latter types of courses are given in collaboration with Uppsala University.

To ensure that nuclear competence will be available also in a long-term perspective, the Swedish nuclear power industry and the Swedish Nuclear Power Inspectorate (SKI) have formed a joint center for support of universities, the Swedish Nuclear Technology Center (SKC). SKC has established collaboration with three Swedish universities, where undergraduate and PhD education is undertaken. In the present contribution, the activities of these organizations will be outlined.

1. Swedish nuclear power – an introduction

About 50 percent of the Swedish electricity is produced by nuclear power. This puts Sweden among the top five countries when it comes to percentage of nuclear power in the electricity production. Counted by installed power per capita, Sweden is the number one nuclear power country in the world.

Twelve light-water reactors were connected to the power grid between 1972 and 1985. Of these, nine boiling water reactors (BWRs) were produced in Sweden and the remaining three reactors are pressurised water reactors (PWRs) originating from the USA.

Nuclear power has had a political dimension in many countries, but Sweden has in some aspects an especially complicated relation between politics and nuclear power. In 1978, a three-party coalition government resigned from office because of disagreement on nuclear power. To my knowledge, this is the only event anytime, anywhere where a government has resigned because of nuclear power.

In 1980, an advisory referendum was held on the future of nuclear power in Sweden, a referendum that can be described as an aftermath of the Three Mile Island (TMI) accident the year before. In this referendum, three alternatives were on the ballot, neither of which indicated operation of nuclear power indefinitely. One alternative was closure within ten years, and the other two, which were to a large degree identical, suggested operation of the already built or planned reactors, i.e., the twelve finally taken into operation, to be run "for their technical lifetime", after which no new reactors should be built. The votes for latter two alternatives were considered merged by the Swedish parliament. The technical lifetime was assumed to be 25 years by the parliament. Since the last reactor should go critical in 1985, this meant that nuclear power should be phased out by 2010, which was thereby set to be the final date of Swedish nuclear power.

Over time, the perception of nuclear power by the general public has become dramatically more positive. All recent polls indicate that a large majority, 60-80 % of the population, would like to continue running the existing reactors as long as they fulfil the safety criteria. About 20-30 % of the population would prefer new reactors to be built in favour of deployment of fossil fuel-based electricity generation, and less than 20 % would like to see a rapid phase-out of nuclear power [1].

By now, it is clear that the technical life span of these reactors is more than 40 years, and operation for 60 years is seriously considered. With the preset closure in 2010 approaching, it became increasingly clear that a nuclear power phase-out would be very expensive, and it would be detrimental to the environment. This resulted in a new parliamentary decision in 1997 to withdraw 2010 as closing date. Instead, it was decided to close two reactors, not because of safety reasons but to prove that the government was serious in its strive to phase out nuclear power. The remaining ten reactors should be “phased out with even time intervals”, but the exact time interval has never been defined.

All these political maneuvers have resulted in a situation where nuclear power for a long time was considered a no-future industry. Not surprisingly, it has not been a prime career choice for young people. As a consequence, the enrolment in nuclear engineering studies dwindled to very small numbers, and about ten years ago, less than ten students in the whole country graduated in nuclear engineering from the technical institutes. This perception has, however, changed dramatically in a rather short time lately. Nuclear power is no longer politically incorrect among young people. On the contrary, it is generally seen as environmentally friendly and economically sound.

These backgrounds are necessary to understand the current situation. For about twenty years, investments in the reactor park were hampered by the decision to close them, and the lack of attraction among young people led to that nuclear engineering almost vanished from the curriculum of Swedish universities. Because of this, the industry had a difficult time getting its personnel needs satisfied by the universities. Instead, the industry had to hire other types of engineers, often relatively mature in age, and to educate them at work.

2. Training and education in the industry

The Swedish nuclear power industry employs more than 50 new people per year for duties where knowledge of nuclear physics and engineering is required. Of these, only a minor fraction has reactor physics or nuclear engineering in their curriculum. The vast majority have engineering degrees with specialization in other fields, with electrical engineering, machine technology and engineering physics being the most common.

This category can roughly be divided into two subgroups, operators and others. A majority of the reactor operators today have high-school education only. There is, however, a strong trend that the newly employed operation staff typically has a bachelor’s level degree. There is a many-year career track to become an operator. A period of at least three but typically five years as general technical support at the power plant is required before education to become an operator is initiated. During this first phase, the staff undergoes an education programme of typically two years. For promotion to operator, an additional education programme of one year is mandatory. There are, however, two categories of operators, turbine and reactor operators. These fulfil different duties in the control room during regular operation, and are recognized as different positions. The turbine operator education always comes first and some continue to the second step to become reactor operator. Each of these two levels requires one year full-time education.

This education is composed of regular teaching as well as training in simulators. For all reactors, there are corresponding simulators. Until a few years ago, the simulators were located at the Studsvik site south of Stockholm, which then served as a central hub in the education. Recently, most of the simulators have been moved to the power production sites to increase the accessibility for the personnel.

Finally, there is an educational programme to become operative leader of the production (shift manager), which comprises about half a year. This programme is mostly focused on leadership aspects, organization, etc., but it also involves some technical education.

It is required by the nuclear power inspectorate that an operator undergoes education and training of at least ten days per year, whereof simulator training for at least five days per year. It is not uncommon that a person has dual competence, e.g., both as reactor and turbine operator, and therefore has to spend twice this time per year in simulator training. In reality, personnel with only a single competence, i.e., as turbine operator, nevertheless spends ten days on training.

To meet the educational demands, the power utilities have jointly formed a dedicated education company, called Nuclear Safety and Training Centre (KärnkraftSäkerhet och Utbildning AB in Swedish, abbreviated KSU) [2]. KSU is owned by the utilities with proportions roughly corresponding the share of the total nuclear electricity production. The company is non-profit in the sense that the employers are charged for the course participation of their staff, such that KSU neither makes profit nor loss when integrated over a few years. Due to this construction, the KSU courses are open to participants also from non-owner organizations, because the fees are set to cover the full costs for the education.

KSU owns and operates the simulators, and provides the regular teaching near practical operation. The courses on general understanding of reactor-relevant physics, from hereby referred to as higher education, is provided by the Division of Applied Nuclear Physics of the Department of Physics and Astronomy of Uppsala University [3].

3. Education at universities

To promote long-term sustainability of reactor-relevant research and education at Swedish universities, the Swedish Centre for Nuclear Technology has been established [4]. The centre is financed by the power plants in proportion to installed power, with added contributions from Westinghouse (Nuclear Fuel production in Västerås) and the Swedish Nuclear Power Inspectorate (Statens KärnkraftInspektion, SKI) [5].

The fact that the inspectorate contributes might call for an explanation. There is a long-term tradition in Sweden that the inspectorate primarily acts proactively. Thus, instead of just inspecting and handling the judicial aspects after possible incidents, the inspectorate involves itself in a continuing discussion with industry with the aim to guarantee or preferably also raise the security. The mission of the inspectorate to promote nuclear safety has been interpreted to also encompass support to education and research, because such activities are viewed as crucial to uphold a high safety standard.

SKC has long-term collaboration agreements with three universities, Chalmers Institute of Technology (Chalmers Tekniska Högskola, CTH) in Gothenburg [6], the Royal Institute of Technology (Kungliga Tekniska Högskolan, KTH) in Stockholm [7], and Uppsala University (UU) [3]. As part of these agreements, the universities have committed themselves to uphold positions relevant to SKC. In addition, SKC supports research projects. Without this support, it is likely that very little activities – if any – would have prevailed.

One particular aspect needed to understand the structure of the research and education is the absence of research institutes. Besides the Swedish Defence Research Agency, there are essentially no research institutes in Sweden. Instead, industry-oriented research is either carried out in industry itself or at the universities. A consequence of this feature is that only a minor fraction of the industry-oriented research at Swedish universities is financed by government grants. Instead, the large majority is financed by external industry grants to the universities, and nuclear engineering is no exception from this rule. In fact, essentially all the research and PhD education is financed via industry grants. Only the undergraduate education is to a significant degree government-funded, but this is a truth with qualification. There is a system to finance teaching that barely covers the costs for the actual teaching, but if no other funding was at hand, the teacher would have to work full time on teaching only just to cover the own salary costs. In reality, this would be impossible because it is out of question to fill the agenda so efficiently. Therefore, some additional funding must be present just to have the teaching capability available, and this is provided by SKC.

4. Synergy effects

With the organization outlined above, it has been possible to achieve an efficient utilization of limited resources. As has been described above, the KSU courses for industry personnel have been designed for newly employed personnel. A pre-requisite for such courses to be useful for the industry is that they are concentrated in time. This requirement, however, also makes them well suited for PhD students. Accordingly, whenever there are free seats available during a KSU course, PhD students from any Swedish university can participate. This has contributed to a marked increase in the total course volume. Moreover, the fact that course participants come from different backgrounds have resulted in increased student activity in the courses, simply because of the need to explain various concepts across professional barriers, and because questions are being asked from a wider range of perspectives.

Up to now, this collaboration has been established in general courses on nuclear power technology for newly employed industry personnel. The content of these courses is essentially basic reactor physics and thermo-hydraulics, with moments of nuclear power safety. Thus, these courses are giving a broad introduction to nuclear power, but they do not go deeply into the subject. Thereby, they are useful to PhD students working in areas related to nuclear power, but where the focus is not on reactor technology. A good example is nuclear chemists working with partitioning. For them, a broad view of nuclear power is useful to put their work into a larger perspective, but their cutting edge knowledge has to be in chemistry. Other examples are nuclear physicists, PhD students working with reactor applications like neutron scattering for materials investigations, boron-neutron capture therapy (BNCT), etc.

This student category is fairly large. For the students in more reactor-oriented research, these courses can provide an introduction, to be followed by more specialized courses. An example of synergy effects also in more specialized education is a two-week course on probabilistic safety analysis (PSA), where typically about half the participants come from academia and half from industry and the regulatory body. The course is provided by a commercial company that performs PSA studies on demand. Neither participant category is sufficiently large to carry the costs for such a course, but by joining forces, the total number of participants is sufficiently large to make the cost per participant realistic.

Recently, the cross-disciplinary collaboration has been taken a step further. As described above, in the introductory KSU industry-oriented courses above, PhD students have been accepted as participants for a few years. Since these courses are nowadays taught at a university, they are now available also to undergraduate students. For simple geographic reasons, up to now mostly local students have taken the chance to follow the course whenever there are available seats. This has resulted in a number of new aspects of this teaching. First and foremost, this has allowed an expansion of the total volume of nuclear power education. Because of this teaching, a team of five young professors has emanated, and suitable teaching material has been developed. This has opened new opportunities for other courses, targeting undergraduate education on nuclear engineering. Second, it has rapidly become popular among undergraduate students to follow these courses because of the unusual format. The students strongly appreciate the presence of industry personnel, because they benefit from their knowledge, and it makes the education feel more realistic. A common student complaint on undergraduate education is that it is poorly linked to industrial reality. Therefore, taking a course originally intended and designed for industry and where half the participants work in industry is perceived as an utterly positive experience.

5. Outlook

Sweden is a country with a small population on a relatively large area. This has to a considerable degree prompted the solution that courses within a relatively small subject, like advanced nuclear engineering, are organized in such a way that students and teachers meet full time during a relatively short period (one or a few study periods of 1-2 weeks each). With such an organisation, the education is already well suited for integration into a larger European perspective. The time and cost to travel is not dramatically different within Sweden and within Europe. Belgium has already re-organized its nuclear engineering education with a similar course structure, however for other reasons [8]. Moreover, in Belgium this has also been done for undergraduate education. Within ENEN [9], similar organisational changes have been undertaken in many European countries.

I believe it is possible that nuclear engineering education can increase both in popularity and quality, already in a short time perspective. Even if that happens, however, I do not foresee that this will lead to that industry can fill even half their vacant employment positions with well-educated nuclear engineers or doctors. Nuclear power is nowadays a mature technology, and in all mature technologies the required competence is primarily built by hiring people with general technology skills, followed by education for their particular duties through training programs. This has long been the situation in the paper and pulp industry, in forestry, mining, etc., i.e., mature industries. Because of this, training and education in industry is not likely to diminish even if the undergraduate education situation improves.

Sweden is such a small country that we simply cannot afford duplication in the long run. In this report, I have given a few examples of how synergy effects have been possible to achieve through cross-disciplinary activities during the last few years. I do not believe that all possibilities of collaboration for clever use of resources have been exhausted. On the contrary, I foresee increased synergetic activities. Last but not least, it should be stressed that efficient use of resources is not the only benefit that can be obtained through cross-disciplinary initiatives. Such approaches are also important because they have a potential to improve the quality. When people from various environments meet, new challenges and opportunities emanate, and this provides – more or less intrinsically – quality assurance.

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THE ESSENTIAL ELEMENTS OF AN ETTECTIVE EDUCATION AND TRAINING PROGRAM FOR NUCLEAR POWER PLANT SOFTWARE ENGINEERS

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ABSTRACT

It is realistic to start planning for training workforce for the imminent spurt in the growth of nuclear power generation capacity world-wide. In the U.S., the refurbishment of tens of existing plants; and design construction, and operation of at least thirty new power plants, will require the services of thousands of software engineers capable of handling tasks involving application of software in nuclear power industry. Software is critical for the operation of instrumentation and controls, nuclear reactors, safety systems, and many other key segments of a nuclear power plant. The next generation of software engineers must be familiar with the state-of-the-art processes for software engineering, quality assurance, standards, HCI, and software project management. This paper documents one of the first attempts to delegate a program for training software engineers with skills and competencies that map onto the application of software engineering in nuclear power plant design, construction, operation, and regulation.

1.0 Introduction and Background

1. 1 Nuclear Power and Software

In the list of major non-defense areas of concern for the U.S. and many other industrialized nations in the world, energy shortage ranks high. At this time, nuclear power (electricity) is rapidly becoming the preferred option for meeting the rapidly growing demand for electrical power. This phenomenon represents a paradigm shift in the U.S., where concerns about the safety of nuclear power plants (accentuated by the Three Mile Island accident, nearly twenty-eight years ago), and problems associated with the disposal/storage of used fuel, have resulted in no new nuclear plants coming on line during the last twenty-five years. Although about 25% of all nuclear power generating capacity in the world is located in the U.S., it accounts for only 15% of the total electricity generating capacity in this country. Therefore, even a doubling of this installed nuclear power generation capacity will keep the percentage of total electrical energy generated in the U.S. coming from nuclear power plants below 30% (compared with 62% in France). During the last few years, plans for the construction of thirty new nuclear power plants in the U.S. have been announced (1). Most of these plants will start generating electricity between 2015 and 2022. At the same time, a much larger number of new nuclear power plants are expected to become operational in other parts of the world, with China and India accounting for a major proportion of this total.

There have been very significant improvements in the design of nuclear reactor and, in most other components/systems in a nuclear plant during the last forty years. During the same time period, information technology that supports the instrumentation and control systems in these power plants has gone through several stages of increasing sophistication, complexity, and reliability. The most dramatic advances have occurred in software engineering, evidenced by the transition from: (i) analog to digital designs; (ii) text-based human computer interaction to Graphical User Interface (GUI) systems; (iii) traditional structured programming to Object-Oriented software designs; and (iv) stand-alone software to embedded software systems (2). Additionally, the classic development life cycle for software, which involved development and then maintenance, has been replaced by a process in which software undergoes modification to code and associated documentation due to a problem or the need for improvement or adaptation [ISO/IEC12207, 1995] (3). This change in the definition and process of software maintenance requires more direct involvement by user engineers, and utilization of Computer

Aided Systems Engineering (CASE) tools. Since the new concept of software maintenance requires regression testing of software being maintained, all previous test cases and results of these tests have to be retained as part of a “Configuration Management” repository (4).

1.2 Need for Training Nuclear Power Software Engineers

As stated earlier, the stagnation in the nuclear power industry in the U.S. during the last thirty years has created a situation in which nearly 40% of the 90,000 employees in this industry are expected to retire during the next five years. This attrition, coupled with the work force requirements for construction and operation of the planned new nuclear power plants during the next fifteen years, will create a need to add at least 80,000 trained professionals to the work force in this industry during the next fifteen years. Several thousand current workers in this industry will have to be retained to install and operate nuclear power plants incorporating new designs and operational protocols (5).

Although it is difficult to estimate the number of nuclear energy sector workers who will require training/re-training in the utilization of state-of-the-art software engineering techniques for maintenance of IT systems associated with the construction and operation of nuclear power plants, it would be realistic to assume that this is going to be a five digit number during the next fifteen years. This figure could be augmented significantly by professionals employed by foreign nuclear power companies who enroll in U.S. based software engineering training programs.

Currently, there are no academic programs in the U.S. for preparing software engineers for handling assignments associated with the utilization and maintenance of software in nuclear power plant design, construction, nuclear power plant construction project management, nuclear reactors, nuclear power plant simulators, and miscellaneous operational and regulatory tasks.

The required academic/training programs should be designed to expose the trainees to new software engineering processes/techniques, and the coverage of traditional computer science topics (programming languages, logic, etc.) should be somewhat limited (6) (7). Therefore, an effective program for training nuclear power software engineers should enable the trainees to: (i) acquire adequate knowledge of basic software engineering processes (e.g., Object-Oriented software engineering); (ii) IT application development life cycle (e.g., Rapid Application Development (RAD) methodology); (iii) IT Project Management Applications (e.g., MS Project, Primavera); and (iv) CASE tools utilization. Special emphasis must be placed on Information Security, in view of the terrorist threats aimed at nuclear power plants. The IT elements in the operation of nuclear power plants are among the most vulnerable terrorist targets. Therefore, nuclear power plant professionals need to become well prepared to identify and mitigate IT security related threats in nuclear power plants (8).

2.0 Overview of Software Engineering Skills Needed by IT Professionals in Nuclear Power Industry

A meaningful overview of software engineering skills needed by IT engineers in nuclear power industry should start with the identification of software applications in the design, construction, and operation of nuclear power plants. The next step should be the determination of skills that a professional must possess in order to handle the tasks associated with the creation, implementation, and maintenance/upgrading of these applications. An overview based on this methodology should provide a logical foundation for determining the curriculum/content of an appropriate academic/training program for software engineers in the nuclear power industry.

2.1 Software Applications in Nuclear Power Plants

The design, construction, and operation of a nuclear power plant are the three major segments of a major nuclear power plant project. Because of the unique nature of nuclear energy and serious concerns about safety of power plant workers and general public, safety and security are viewed as a critical element in the design, construction and operation of a nuclear power plant. Safety is so important that safety systems account for 25% of the capital cost of a typical nuclear reactor (9). During the last fifteen years, terrorist threats have made security of nuclear power plants a high priority consideration in the location and operational planning of nuclear power plants. Since most nuclear power plants are relatively well protected against physical attacks, there is a real possibility that terrorists will concentrate on the penetration/hacking of software systems embedded in the instrumentation and control systems for nuclear power plant operation, and electric power transmission (9) (10).

Considerations documented above, coupled with the standard practices associated with nuclear power projects, justify the following list of five relatively distinct application domains for software:

(1) Nuclear Power Plant Design (Reactor, Cooling Systems, Instrumentation and Control, Facilities, etc.)
(2) Nuclear Power Plant Safety (Reactor Safety, Radiation Safety, Hydraulic Systems, Mechanical Systems, etc.)
(3) Nuclear Power Plant Construction (Site Selection, Project Management, Logistics, etc.)
(4) Nuclear Power Plant Operations (General Operations, Fuel Storage, Waste Storage, Power Distribution, etc.)
(5) Nuclear Power Plant Security and Regulation (Physical Security, Cyber Security, Incident Reporting, etc.)

Each of the five application areas listed above can be broken down into tens of discrete or overlapping applications. Doing so would be beyond the scope of this presentation, but would be important when decisions concerning narrowly focused training and education programs are made. In this paper, it would be sufficient to identify the areas of learning and knowledge acquisition that are important for a software engineer in nuclear power industry. These five application areas provide a logical context for determining the learning objectives and skills that should be focused on by students/trainees being prepared for careers in software engineering within the nuclear power industry. Additionally, given the dynamic nature of information technology in general, and software engineering in particular, it is important to consider the state-of-the-art and related trends when we conceptualize and formulate a curriculum/training program to enhance/upgrade the skills of software engineers in this industry.

The rationale presented above leads to the following five knowledge/skill areas that should be covered by an education/training program for nuclear power plant software engineers.

(a) Software Modeling and Analysis (including Software Practice)
(b) Software Design (Including Verification and Validation)
(c) Software Evolution and Process
(d) Software Quality
(e) Software Project Management

Since these five learning/skill areas do not map directly onto the five application areas, it would be appropriate to display the correspondence between the application areas and knowledge/skill areas. This correspondence is displayed in Table 1. In the next section, an overview of a five course certificate program for training/educating nuclear power plant software engineers is presented.

Software Application Area	Software Engineering Knowledge/Skills				
	Software Modeling and Analysis	Software Design	Software Evolution and Process	Software Quality	Software Project Management
Nuclear Power Plant Design	***	*	*	*	*
Nuclear Power Plant Safety	***	***	***	***	
Nuclear Power Plant Construction	*				***
Nuclear Power Plant Operation	***	***	***	***	*
Nuclear Power Plant Security & Regulation	***	***	***	***	*

Legend: * Marginally Relevant
*** Very Relevent

Table: 1
Software Application Areas and
Software Engineering Knowledge/Skills

In the next section, an overview of a five course certificate program for training/educating nuclear power plant software engineers is presented.

3.0 Curriculum for Certificate Program for Nuclear Power Systems Software Engineers.

3.1 Learning Objectives

The list of software engineering knowledge/skills that are desirable for a nuclear power systems engineer to posses can be embedded in a set of five three semester credit hour courses leading to a certificate. These courses are:

(i) Modern Software Modeling and Analysis
(ii) State-of-the-art Techniques for Software Design
(iii) Software Evolution and Process
(iv) Software Quality Assurance
(v) Software Project Management

It is appropriate to mention that courses similar to those listed above are being currently taught at various institutions. However, the currency of these courses is often questionable, and unless all five courses are planned and developed as a set, there will be gaps in the spectrum of skills and competences that a successful nuclear power systems software engineer should possess. After acquiring this certificate, an individual should be able to: (i) determine client needs and convert them into software requirements; (ii) have an understanding of selected models and methodologies currently utilized for software design, development, testing, and implementation; (iii) design effective applications/solutions in the nuclear power systems domain, and implement them for the benefit of power plant operators; (iv) plan and manage significant software development projects, and (v) keep up with new models, processes, technologies and standards as they come into the public domain.

3.2 Summary Description of the Courses in the Proposed Set

(1) Modern Software Modeling and Analysis

- Modeling Foundations/Principles, and Types of Models (E-R Models, Object-Oriented Modeling, Business Process Modeling, etc.)

- Software Requirements Analysis
    - Fundamentals of Analysis (Robustness, Correctness, Quality, Traceability, etc.)
    - Requirements Analysis Considerations (System Boundaries, Scope Crawl and Requirements Management, Architecture Requirements Interaction, Stakeholder Involvement)
    - Requirements Specifications (Documentation, Languages UML, SCR, RSML, etc.)
    - Requirements Validation (Prototyping, Acceptance Testing)

(2) Software Design
- Design Concepts and Issues (Principles, Architecture, etc.)
- Architectural Design Styles (Layered, Transition-Centered, CSLA)
- Human Computer Interaction (User Centered HCI, Cognition, Visualization, Acceptability/Usability)
- Detailed Design/Design Tools/Evaluation (Component Design, Components System Interface, Design Metrics, etc.)
- Verification and Validation (V & V Strategy, Review and Testing HCI Evaluation, V & V Reporting/Follow up)

(3) Software Evolution and Process
- Software Evolution (Modeling, Asking, Planning, System/Process Re-engineering, Reverse Engineering, Refactoring)
- Software Process (Infrastructure, Personnel, Tools, Process Modeling/Measurements, Process Definitions, Life Cycle Models (SOLC, DSDM, RAD), Process Standards (ISO, CMM)

(4) Software Quality Assurance (SQA)
- SQA Concepts (Definitions, attributes, costs, dimensions)
- SQA Standards (ISO 9000 Series, ISO/IEEE12207 Standards)
- SQA Processes (Models/Metrics, ISO 15504 & EET-CMM Processes etc.)
- Quality Assurance (Planning, Techniques for Process Assurance)
- Product Assurance (Product Quality Models, defect tracing and prevention, product quality attributes and metrics)

(5) Software Project Management
- Management Concepts (PM Models, role, organizational structure)
- Project Planning (WBS, Scheduling, Resource Estimation/Allocation, Risk Management)
- Organization and Personnel (Structure, Communications, Staffing, Training, Management)
- Project Control (Monitoring/Reporting, Analysis/Correction, Change Management, Performance Standards)
- System Configuration Management (Revision Control, Release Management, CM Tools, CM Processes, Maintenance)

Variations of the suggested curriculum may be appropriate in the context of specific work situations and/or academic experience/background of the trainees.

4.0 Conclusions and Recommendations

The relative stagnation in the nuclear power industry in the U.S. during the last thirty years has created a work force situation which requires a well planned and urgent response. As explained in section 1.0, the quantum changes in nuclear power technology, and the ongoing and anticipated growth in nuclear power generation capacity during the next fifteen years could be impeded unless trained workforce is prepared to replace current workers and fill positions that will be created in the near future. Software engineering is a vital element in the design construction and operation of nuclear power plants. The nuclear reactor designs have gone through three or four generations of design changes in fifty years, but software engineering goes through similar changes in ten years. The instrumentation and control systems, reactor safety systems, and information systems in nuclear power plant operations are being transitioned from analog to digital technology. Similarly, very significant changes/improvements have been incorporated in human computer interaction systems in nuclear power systems. Therefore, it is critical to train a new generation of software engineers who can handle tasks in all facets of nuclear power plant design, construction, operation, and regulation.

It is recommended that a specialized training program/curriculum for nuclear power software engineers be developed and implemented. Given the fast pace of changes in nuclear power technology and software engineering processes, it is essential to focus the software engineering training on the applications of software in specific segments of nuclear power plant design, construction and operation. It is critical to ensure that the curriculum/content of the proposed education/training programs emphasize state-of-the-art knowledge and competencies. Additionally, the software engineering process should receive as much attention as specific software techniques. The trainees should become adequately aware of the applicable standards for software engineering, case tools, software quality assurance methodology, and software project management process. In view of the high level of concern about nuclear power plant safety and security, the software engineering training must cover cyber-security considerations, and safeguards against terrorist threats.

It is recommended that nuclear power industry consult professional organizations and institutions like ACM, IEEE, Software Engineering Institute (SEI), INPO, CONTE, and ANS in developing the curriculum for training software engineers for nuclear power industry. The set of five courses presented in section 3.2 of this paper is an example of such a curriculum. Since the need for training the next generation of software engineers is an important issue for nuclear power industry outside the U.S., organizations such as European Nuclear Society and its counterparts in Asia and Africa should also be co-opted in this effort. In view of the anticipated spurt in the growth of nuclear power generation capacity, the urgency of training a large number of software engineers for this industry cannot be over emphasized.

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FROM AN “OPERATORS TRAINING FACTORY” TO BECOMING THE SOURCE FOR NUCLEAR-POWER PROFESSIONALS

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ABSTRACT

Ten years ago Spain decided to provide full scope simulators for every Nuclear Power Plant.

Their start-up coincided with the Spanish NPP´s Generational Change and they are playing a very important role in the training process for the new employees who will be responsible for running the plants in the future.

Since 1984, when the Spanish Government declared a nuclear moratorium, the number of students who decide to study Nuclear Engineering has declined.

In fact, some of these degrees are no longer available at several Spanish Universities. Therefore, when the Spanish Nuclear-Power Industry needs Technicians to work at its companies it faces a lack of young people with the necessary knowledge in this field.

This industry has turned to TECNATOM which had been playing the role of an “Operators Training Factory” and has now used its experience to turn electrical, mechanical, instrumentation and other specialized engineers into nuclear experts using the full scope simulators and other training tools.

1. Introduction

1.1 Spanish Nuclear Power Plants

Nowadays, Spain has eight nuclear reactors producing electricity in six different sites with a total power of 7727 Electric Megawatts (1).

Seven of these plants were started up in the eighties and they were deployed across the Spanish geography, from North to South and from East to West.

Nuclear Generation is a very important Energy Source in Spain and represents 9.09% of the installed power but 18% of the average power supply (2).

All the plants are working full power all year round and only stop once every twelve or eighteen months for refuelling shut down.

NPP	Mw	YEAR
ALMARAZ-1	977	1981
ALMARAZ-2	980	1983
TRILLO	1066	1988
ASCÓ-1	1032	1983
ASCÓ-2	1027	1985
VANDELLÓS	1087	1988
COFRENTES	1092	1984
STA. Mª. GAROÑA	466	1971
TOTAL	**7727**	

Fig.1 Spanish Nuclear Power Plants Information

Fig.2 Spanish Nuclear Power Plants

1.2 Industrial Environment and other circumstances

If we try to define the Industrial Environment it is easy to come across with adjectives like uncertain, complex, stormy, global,… and everybody agrees that it is under constant ongoing changes.

The Nuclear Industry is part from today’s reality and it is exposed to the same circumstances: organizational leaves, internal promotions, organizational changes, competition, acquisitions and mergers.

In addition to the previous statement seven of the Spanish Nuclear Power Plants were started up in the eighties and currently are undergoing their generational change.

When companies try to recruit professionals with a vast training in these technologies, they realise that there are not enough graduates with this skill, because the number of students who decided to study Nuclear Engineering began to drop when the Spanish Government declared the nuclear moratorium.

A lot of the students decide to study energy disciplines because their interest in green energies, as a consequence of their important advertising campaigns, and not because they do not want to work in the nuclear industry as some time ago.

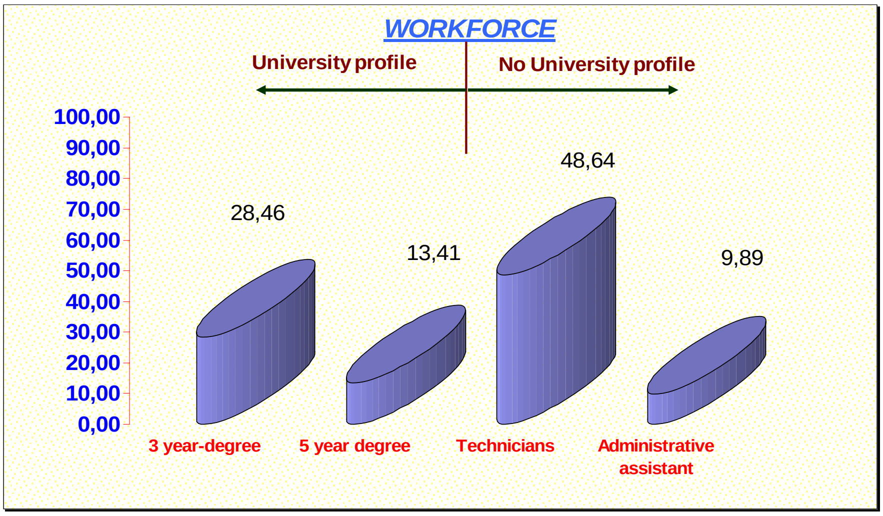

Fig.3 University Profiles in NPP´s

Furthermore, Nuclear Power Plants are located far from the main cities and graduates around 27 years old do not like to move to small villages where there are not a lot of social activities or it could even be very difficult for couples to find a job as a result of the lower industrial activity.

Moreover, 42% of the workforces are graduates, and the plants demand two different degree profiles to cover their job vacancies, three-year degree profiles or five-year degree profiles.

63% of these graduated workers have three-year university degree, which means 13.41% of the workforce (fig.3).

There is not three year-degree in Spain with any nuclear studies. Thus, these new employees must be trained in these technologies before they begin to work.

Besides that, the utilities need qualified professionals from diverse disciplines such as instrumentation, mechanical, electrical… and in their university program of studies nuclear technologies is not included.

It is fitting to point out the fact that in 2007 the Spanish Regulatory Body (Consejo de Seguridad Nuclear-CSN-) published a compulsory rule requiring the plant to have a training program for its personnel. The CSN demands to carry out these programs before working in the plant.

2. How to Transfer Knowledge In the Face of Generational Change

There are a lot of definitions for Managing Knowledge.

Managing Knowledge means to deal with creation, development, diffusion and squeezing knowledge to get organizational capability (3).

Tecnatom has been involved in this process since 1999 when the Spanish NPP Generational Change began, acquiring experience in this field.

The first aim in transferring knowledge is to employ those university graduates who are going to run the plant in the future. The problem is how to make this industry appealing to this new generation taking into account the situation focus on section 1.2.

At this point, the companies have to make their projects attractive to these new employees by providing more possibilities to develop their professional skills, as well as better career development and professional growth possibilities.

They must create a pleasant working environment that will allow them to develop and improve their professional and human skills, moves on innovation, encouraging the participation and fostering learning and team work

Managers should provide their employees key to success by modelling and giving support, looking for the balance between demand and delegation.

And of course this industry has to pay an additional amount to this new employee’s just to assure their loyalty and prevent them from attrition.

Organizational knowledge is a mixture of knowledge and skills. To manage means to deal with and take advantage of it. The Company has to provide the necessary training to perform their job.

Fig.4 Training course in Tecnatom

Knowledge Management is a combination of explicit knowledge and the learned tacit experience of the Master Workers.

The simulators shorten the learning period and make it possible to turn explicit knowledge into tacit knowledge, thereby helping students to become acquainted with this tacit knowledge by using the simulator (4).

Tecnatom is the Spanish Operator's Training Centre, "*Operators Training Factory*", whose mission is to train the operating personnel of the Nuclear Power Plants in technology, knowledge of processes and understanding of their technological fundamentals as well as the development of skills and diagnostic capabilities via practical scenarios on simulators and on the job training. Additionally safety performance is reinforced through soft skills training programs. Its training programs are based on Tecnatom's own Systematic Approach to Training methodology (SAT/ESC), which has been implemented in domestic and foreign plants.

Tecnatom's experience makes Tecnatom attractive to collaborate with the plants in this Generational Change.

Tecnatom has the knowledge to provide customized training for the new employees and the tools for improving a gradual and constant learning assimilation through simulators. Tecnatom "*has become the source for nuclear-power professionals*".

3. The Source for Nuclear-Power Professionals

The Spanish Nuclear industry has turned to TECNATOM which has been playing the role of an "Operators Training Factory", to use its experience to turn electrical, mechanical, instrumentation and other specialized engineers and skilled workers into nuclear experts by using the full scope simulators and other training tools such as workshops and labs.

TRAINEES	
RO/SRO (Licences)	150
FIVE-YEAR DEGREE	150
THREE-YEAR DEGREE	58
SKILLED WORKERS	90
TOTAL	**448**

Fig.5 New students trained in Tecnatom since 1999

During these years Tecnatom has managed engineering training programs by analysing, designing, developing, implementing, and evaluating all the process by means of application of the Training Manual associated to every job position.

Tecnatom also welcomes students from many universities in addition to engineering, such as biology, psychology, law, education, business, mathematics, physics, and chemistry to provide personnel for all the Organization Levels in the plants.

Nowadays we are using simulators not only to train Control Room Operators, but Non-License Personnel. Although this was not the original simulators goal, it makes it easier:

- To understand how the reactor works
- To become familiar with I&C aspects
- To broaden their knowledge in systems
- To know the lay-out of the plant
- To become familiar with emergency preparedness and response procedures
- To assimilate the importance of plant shut down and start up and other critical plant conditions.

Simulators also help to develop Soft-Skills like:

- Preventive human error techniques
- Effective Communication
- Team working
- Conservative decision making
- Leadership
- Safety Culture

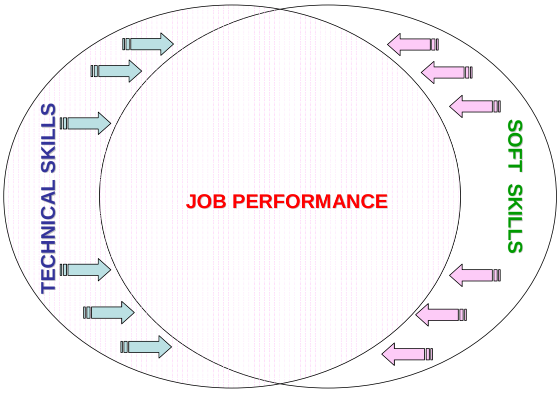

Fig.6 Job Performance

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ENS et 2008
CONFERENCE AREVA TA – CORYS TESS

«VOCATIONAL TRAINING DESIGNED AND IMPLEMENTED BY AREVA TA AND CORYS TESS FOR NUCLEAR INDUSTRY »

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1 AREVA TA AND CORYS TESS PRESENTATIONS

1.1 PRESENTATION OF AREVA TA AND ITS TRAINING ACTIVITIES

The business unit AREVA TA is composed of 2300 people ; its core business activities in nuclear energy is :

- Design of french naval propulsion reactors and land-based prototypes.
- Engineering of a new experimental reactor (Jules HOROWITZ Reactor).
- Production and manufacturing activities :
  - Operating and maintaining nuclear facilities (reactors, fuel storage pools, other facilities).
  - Constructing a power test reactor (RES).
  - Manufacturing fuel for naval propulsion reactors and land-based prototypes.
  - Realising nuclear tests, especially on AZUR research reactor.
  - Qualifying and upgrading nuclear reactor components.
  - Conditioning fuel for dry storage.

The AREVA TA Training Centre has a staff of 22 permanent persons and provides vocational training in its two locations in the south of France, in Aix en Provence and within the Cadarache Nuclear Centre.
The Training Centre implements training sessions on sites, in different countries, and organises catalogue training as well as sessions that meet specific client needs.

Our main training themes are:

- Nuclear engineering and operation and related technologies.
- Training on research reactors and/or simulators (jointly with CORYS TESS).
- Nuclear safety and safety culture.
- Risk prevention.
- Complex systems engineering.
- Project management.
- Nuclear propulsion.

Our main clients are :
France : French Navy, EDF, AREVA NP, AREVA Group, French Atomic Energy Commission (CEA), Nuclear Safety and Radiological Protection Institute (IRSN), AREVA and CEA subcontractors.

Foreign countries : SCK CEN, SUEZ Group (Belgium) - IAEA (Lithuania) - Russian shipyards and institutes (Russia) – CNESTEN (Morocco) - NWU, NECSA (South Africa)

Training session using a research reactor

1.2 PRESENTATION OF CORYS TESS AND ITS TRAINING ACTIVITIES

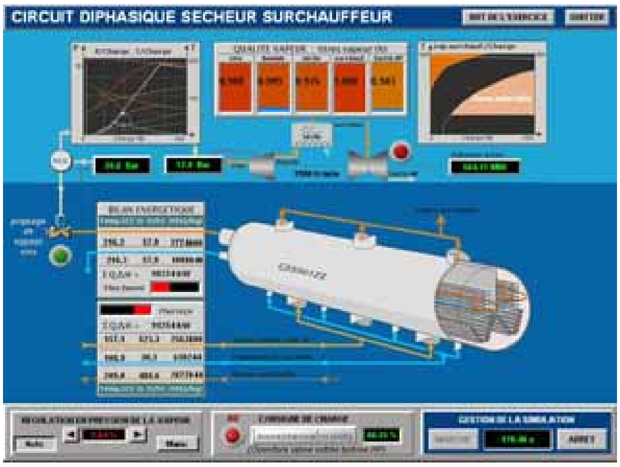
Spin-off of the CEA (French Atomic Energy Commission), CORYS TESS is specialised in the design and production of simulators for training and engineering studies in the power industry and transport sectors.

CORYS TESS is composed of more than 230 engineers, technicians and experts and is organised in multidisciplinary teams : physicists, modelling specialists, software developers, ergonomists, trainers, graphic designers, …

CORYS TESS is a world leader in the design and production of simulators; over 450 simulators are installed in 25 countries on all continents. CORYS TESS has a large know-how acquired in the fields of nuclear, thermal and electric power, and rail transport.

CORYS TESS has from the outset provided training services in the nuclear field, involving sessions on simulators and reactors. CORYS TESS is able to optimise the customer's training systems by integrating multimedia training tools used locally or from distance.

French EPR engineering and full-scope training simulator (under construction)



Example of multimedia training tools

1.3 AREVA TA AND CORYS TESS TRAINING TEAM

The prime objective of nuclear electrical power producers is to take great care of maximum human safety while securing the best possible availability of their facilities, increasing equipment durability and minimising environmental impact.
In addition, the rapidly changing business environment requires more and more flexibility from the personnel as, in one way or another, the working environment is constantly adapted to the evolving needs.

As a result, CORYS T.E.S.S. and AREVA TA have decided to set-up commonly the organisation of a training centre for the energy industry. This consists in the delivery of an integrated training management system where the requirement to offer a procedural training ("do what you are supposed to do") is obviously addressed but completed with knowledge based training ("understand what you are doing").
CORYS T.E.S.S. and AREVA TA propose products and services for energy industry training integrated in a unique concise training system, including distant learning software, simulation, CBT, training development, training support and training delivery on various tools including actual research reactors, and simulators.

CORYS T.E.S.S. and AREVA TA have both a huge experience in the field of training plans for nuclear facilities' staff.
For more than twenty years, CORYS T.E.S.S. has used SILOETTE, a pool reactor located at CEA Grenoble for training power plant staff (EDF control operators and loading supervisors) as well as research reactor

staff from various facilities (Marcoule's PHENIX, Saclay's OSIRIS, Cadarches's EOLE-MINERVE in France, Mol's BR2 in Belgium or Petten in the Netherlands).
AREVA TA has used AZUR at Cadarache for training Framatome (AREVA NP) and EDF operating and test engineers under long-term contracts (pluri-annual), for the start of the French electricity producing nuclear program, and to train operating teams for reactors operated by AREVA TA. On another hand, AREVA TA has been training more than 4500 seamen over the last 40 years in the management and maintenance of naval propulsion reactors. Up until 1990, this training course used the Land-based Prototype (PAT) which was, for training, followed by the New Generation Reactor (RNG) and the research reactor (AZUR).

2 NUCLEAR TRAINING CONTEXT IN EUROPE

Among the needs in vocational training in Europe, the following two main themes are in very close relation with the nuclear renaissance.

2.1 BASIC TRAINING FOR (NEW) ENGINEERS WITHOUT NUCLEAR BAKGROUND AND WORKING ON NUCLEAR ACTIVITIES

There is a strong need for high level training of young specialists in the nuclear sector.
This is due to the combination of the ageing of the actual manpower and the starting of nuclear renaissance. It is critical to maintain the safety and efficiency of the existing nuclear installations and to build and prepare the development of the next generations of facilities. Well designed training is therefore necessary, allowing the handling of the technical challenges with safety assurances.

2.2 SAFETY CULTURE FO ALL PERSONNAL WORKING ON NUCLEAR ACTIVITIES

Nuclear Safety Culture is a topic of paramount importance for all nuclear operators as well as for all operators of installations dedicated to radiology and radioteraphy. Besides the operators, it concerns also the regulators and related support organisations. Its efficient practice is an absolute must in Europe and in the world for the extension in life and possible redeployment of the nuclear power plants, for the production and transport of fissile materials and radioisotopes, and for research activities related to the above and to fusion.

The Safety Culture dissemination contributes to harmonisation according to high standards, and promote the mutual recognition of good practices and behaviours throughout Europe.

3 VOCATIONAL TRAINING DESIGNED AND IMPLENTED BY AREVA TA AND CORYS TESS

3.1 PARTICIPATION OF CORYS TESS AND AREVA TA TO SUEZ NUCLEAR TRAINEES PROGRAM

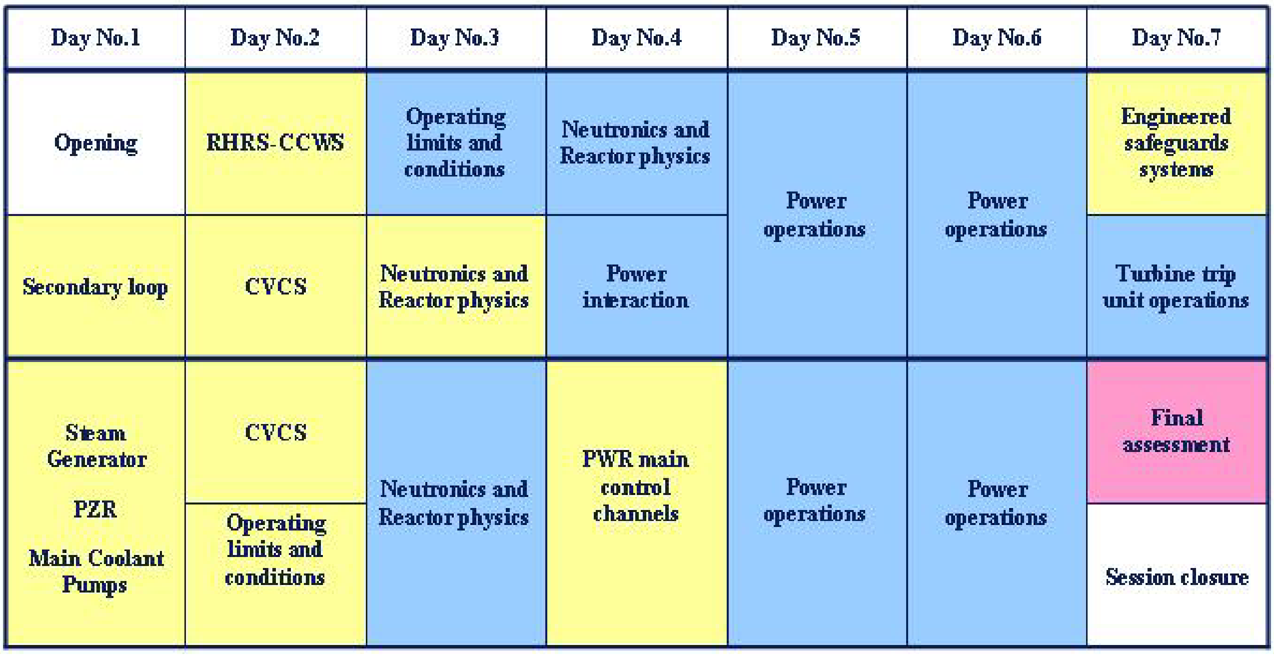
The SUEZ Group has organized a very important training program for their newcomers (SNTP, acronym for Suez Nuclear Training Program). CORYS TESS and AREVA TA participate in this program.

CORYS TESS has in charge the PWR course which is organised on 7 days. This course is done within SUEZ Company and more than 80 trainees are concerned for 2008. A second track is planned for 2009.

This course is interspersed approximately in a middle of the SNTP program and allows :

- Understand how physical phenomena are involved in PWR operation
- Understand (and explain) PWR control

The following table sets the detail of this program :



Day No.1	Day No.2	Day No.3	Day No.4	Day No.5	Day No.6	Day No.7
Opening	RHRS-CCWS	Operating limits and conditions	Neutronics and Reactor physics	Power operations	Power operations	Engineered safeguards systems
Secondary loop	CVCS	Neutronics and Reactor physics	Power interaction			Turbine trip unit operations
Steam Generator PZR Main Coolant Pumps	CVCS	Neutronics and Reactor physics	PWR main control channels	Power operations	Power operations	Final assessment
	Operating limits and conditions					Session closure

This course is organized both with classic classroom training (in yellow on the program) for the theoretical part and with principles based simulators for the practical part (in blue on the program).

For this training, CORYS TESS installs several simulators on client's standard PC's. In this way, the trainees can work in pair for the practical part of the program.

AREVA TA has designed and developed and currently implements the "Waste management" and "Radiation protection" modules. This course is done in the first part of the SNTP program.

3.2 SAFETY CULTURE TRAINING DESIGNED AND IMPLEMENTED BY AREVA TA

Since 1994 AREVA designs develops and implements Nuclear Safety Culture training sessions for the AREVA TA personnel (operation and engineering) with the following characteristics.

NUCLEAR SAFETY CULTURE - Type program

AIMS **The course aims to build awarness of the importance of nuclear safety on a daily basis :** ◆ Achieve a better understanding of the implications related to commitments made, ◆ Exchange experience based on real-life situations, ◆ Identify targets for improving safety	**METHODS** ◆ Interactive discussions ◆ Study of real cases ◆ Group work (exchanging experience) **TRAINEES** Engineers and technicians involved in safety, in charge of achieving and maintaining nuclear safety in engineering and operations
PROGRAM ◆ How nuclear safety is organised, knowing what's at stake ◆ Making commitments in terms of nuclear safety, ◆ Discovering targets for improvement, communication and solidarity Practical aspects ◆ Developing a questioning attitude ◆ Drawing up and using procedures ◆ Providing and using feedback ◆ Developing an efficient communication	**SPEAKERS** Engineers with an excellent knowledge of the different areas of nuclear safety and who have received a specific "training of trainers" Number of participants : 8 to 14 per session Duration : 2 days

For many years, AREVA TA realises specific training sessions for different clients :
AREVA NP Services: “culture safety” training including, “nuclear safety culture” and “security culture”.
SUEZ Group: “nuclear safety culture” including the specificities of the country, of the company, of the NPP.

Our training scheme objective:
To train personnel in understanding and controlling nuclear and conventional risks in accordance with environmental requirements.
Our objective is in line with the commitments made under the AREVA nuclear safety charter and the TA nuclear safety plan.
These commitments are anchored in our organisational principles and are completely transparent. They build on a safety culture shared by all personnel (AREVA TA and subcontractors) and continually maintained by periodic refresher training.
They are implemented through safety health and environmental management systems.

4 TRAINING TOOLS AND EXPECTED EVOLUTIONS

Significant experience is required to develop or adapt materials that transmit clear, accurate, and easily understood information to trainees.

- ***Written materials:*** Written materials should contain practical examples, exercises, and necessary numerical data.

- ***Audio-visual media:*** A number of audio-visual media are used in training programs, including films, videotapes and videodiscs as well as slides. The advantage of these materials is the ability to transmit information which would otherwise be difficult to describe by oral presentation.

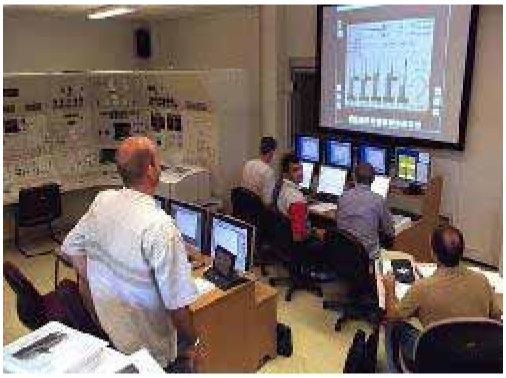
- ***Models and mock-ups:*** Models are used to supplement classroom training, and mock-ups have proven valuable in developing some practical skills, scale models with cutaway sections are used in training for some complex components.

Radiation protection training installations

Hydraulic test facility

- ***Computer-based training:*** The purpose of CBT is to provide continual and consistent training for personnel. The combination of classroom lessons and self-paced, individualized instruction permits training at times convenient to the trainee's work schedules.

- ***Simulators:*** The staff-training objectives that have to be positively met are multiple: to better operate the systems, to increase the safety, to anticipate the incidents and reduce the risks of faulty manoeuvres and to manage efficiently the emergency situations. The training of the operators to extreme behaviours of the system appears therefore more and more as a necessity, and towards this, simulators are the most obvious and most efficient means.



Naval Nuclear Propulsion Simulator

Basic Principles PWR Simulator

- ***Research Reactors:*** They provide an essential practical approach, on the nuclear facilities, to the physical phenomena of reactors. Performing operations on an actual reactor is an irreplaceable experience in an education plan. It allows federating complex theoretical knowledge with practical common sense. It also permits confirmed operators to ask and answer the questions that routine often hides.

All of these different training tools can be developed and operated by AREVA TA and CORYS TESS.

Thanks to the latest computing technologies, the use of simulation as a support of training activities may be generalised, either in "training-centre" configurations or on a stand-alone, mobile basis, thus allowing to face the new training needs of nuclear field.

USE OF REAL-TIME, MODEL-DRIVEN 3D VIRTUAL REALITY SIMULATIONS FOR NUCLEAR PLANT OPERATOR TRAINING AND FAMILIARISATION.

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ABSTRACT

The use of fully interactive 3DVR simulations driven by high-fidelity nuclear plant models allows significant cost savings over the use of physical equipment to achieve required training targets. Changed training requirements due to nuclear plant modifications and operational feedback can be much more readily and cheaply accommodated by changes in simulation software, rather than physical changes in a hardware-based training solution. A high-fidelity interactive 3DVR training solution has been developed by L3 to provide operator procedural training and equipment familiarisation for a complex nuclear safety-related system on the next generation of Royal Navy Astute Class Attack Nuclear Submarines. The generic 3DVR simulation technologies developed and implemented by L3 have applicability not only in the training of submarine crews but also in the much wider arena of nuclear training and nuclear plant familiarisation. In principle any nuclear plant system or subsystem could be emulated virtually and subsequently coupled to a real-time simulation model.

1. Introduction.

Comprehensive and detailed equipment maintenance training forms an important part of the safe operation of any technically complex plant, aviation [1,3] and nuclear systems [2] being an obvious example of this requirement. There are a number of current approaches to providing maintenance training to plant engineers over a wide range of engineering disciplines. The first and most obvious approach is to have a physical 'off-line' copy of the equipment to be maintained, which can be dismantled and reassembled as required within the boundaries of maintaining passive equipment – i.e. equipment which does not have any complex functional interactivity with other plant systems, a pump, or motor, for example. For more complex, dynamic equipment, and particularly those plant systems with safety and monitoring implications, such a passive maintenance approach is unsatisfactory, and a more sophisticated level of operator/engineer training interaction is required. This again can be satisfied by having a physical copy of the system to be maintained. However, using a complex system for training purposes implies the need for some form of simulation to accurately model/drive the behaviour so that the correct operator/engineer responses to any maintenance procedures can be quantified and assessed as the procedure is implemented. This approach avoids the need to physically replicate the entire plant of which the system is a part, but still involves the cost of having physical control panels.

The third approach, and the one that forms the basis of this paper, involves the use of a virtual 3-D simulation environment. This avoids the use of physical equipment, which has obvious advantages from the point of view of changed training requirements or equipment upgrades based on new technologies. The cost savings and safety aspects of such an approach are obvious, as is the relative ease, compared to physical equipment, with which the training environment can be modified and/or upgraded. The 3DVR training and simulation methodologies developed by L3 have currently been implemented for one submarine nuclear-safety related subsystem. However, the simulation techniques are sufficiently generic to be applicable to not only the training of submarine maintenance engineers but also to the much wider arena of nuclear training and nuclear plant familiarisation. The security-sensitive nature of the subject material related to this particular training simulation implies that there will be no in-depth discussion of the systems functional details. However, enough of the global simulation architecture and methodology can be described to at least give some appreciation of the approach used.

2. Simulation System Description.

For the purposes of this paper, the system of interest comprises a highly complex Reactor Control and Instrumentation (RC+I) system, coupled to a high-fidelity model of the associated submarine systems. This in turn is coupled to an interactive 3-D, pictorially accurate representation (exactly as seen on the boat) of the instrumentation cubicles. The graphical representation of the instrumentation cubicles has identical functionality to that on the boat, so operations performed on the individual components, switches, circuit boards etc. on the 3DVR components will have effects identical to those that would be observed on the boat if the same operations were performed on the real equipment. Figure 1 below gives a detailed overview of how the individual components of the simulation interact with each other. The numbered (1 to 12) system components in Figure 1 below are those that comprise/interact with the 3DVR RC+I trainer. The RC+I simulation is a functional enhancement of the whole boat Manoeuvring Room Trainer (MRT) simulation, which is an exact physical replica of the operator control panels in the boat control room, coupled to a high-fidelity simulation model.

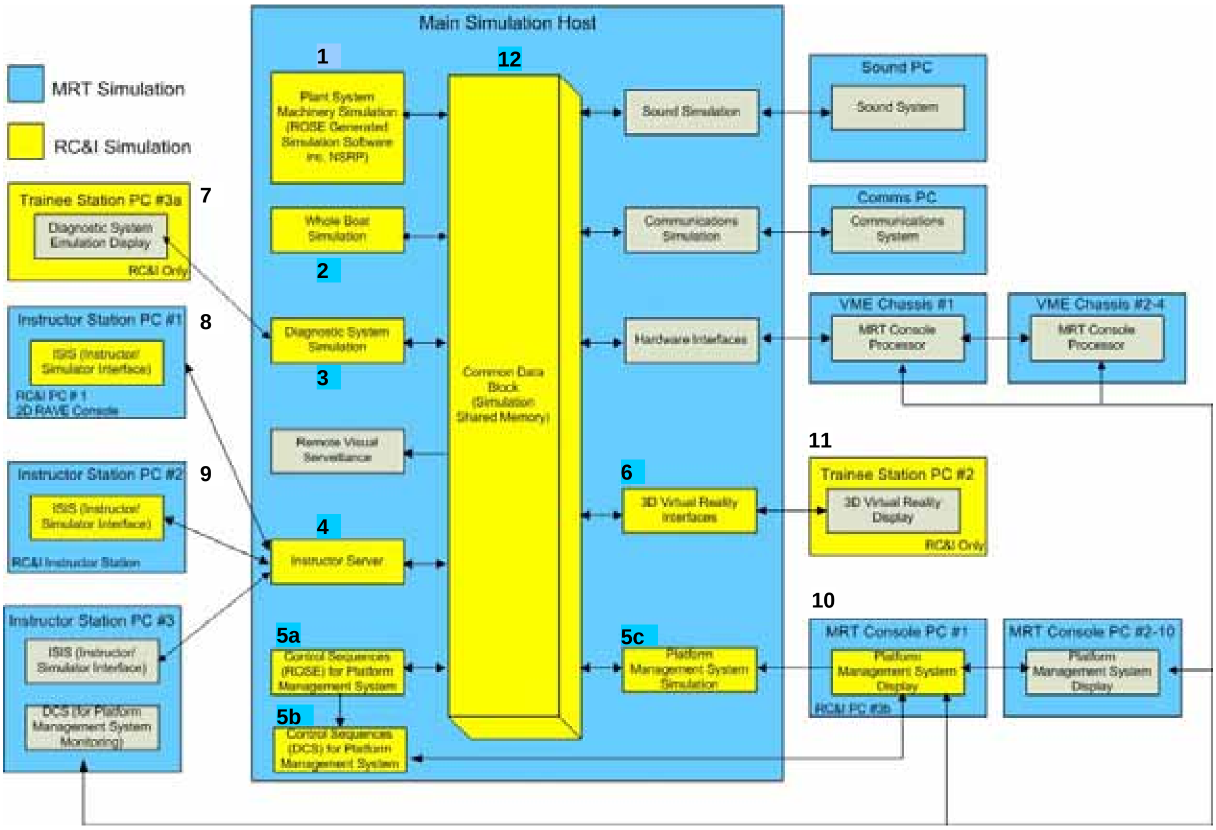

Figure 1 – Detailed overview of simulation model components.

The main simulation host is comprised of several components. The first is the mathematical simulation model of the boat systems. This is the 'Plant System Machinery Simulation' (1) above. This encompasses the reactor model, primary and secondary systems as well as other boat systems - mechanical, electromechanical, hydraulic, control and instrumentation. Also modelled in complete functional detail are the automatic protection (guardline) logic and associated control and instrumentation systems. The 'Whole Boat Simulation' (2) denotes the hydrodynamic aspects of the boat simulation. The 'Diagnostic System Simulation' (3), and 'Diagnostic System Emulation Display' (7) are an integral part of the 3DVR training solution and work synergistically with the operations performed by the trainee on the interactive 3D instrumentation cabinets. The ‘Instructor Server’ (4) is simply an interface for the Instructor Operator Stations (8) and (9), from where the entire training session is co-ordinated. Sections 5a, 5b and 5c are concerned with the Platform Management System, or PMS, which is a complex control and monitoring software package which has very significant global control and display functionality on the boat. This interfaces with (10), the PMS display terminal, which is also an integral part of the 3DVR solution. Sections (6) and (11) comprise the 3DVR interface, which will be described in more detail later. Finally, section (12), the Common Data Block, or CDB, is the simulation datapool.

3. Interactive 3D interface.

The interactive 3D trainee interface with the detailed simulation model is composed of a number of component subsystems. The first and most important subsystem is the instrumentation cabinet 3D mimic. This is derived from a number of sources, as outlined in Figure 2 below.

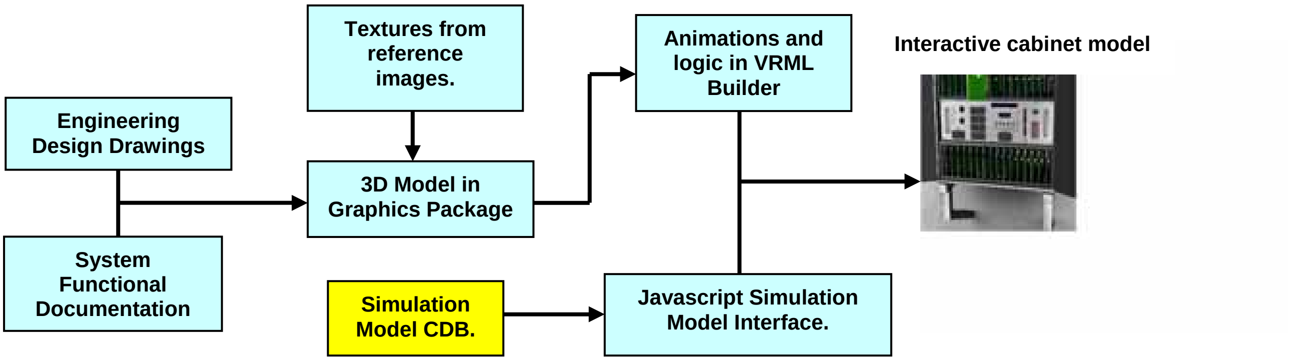

Figure 2 – Construction of interactive 3DVR instrumentation cabinet

Communication of the interactive 3D cabinet with the simulation CDB is based on a client-server architecture (Figure 3), the cabinet being accessed via a web browser.

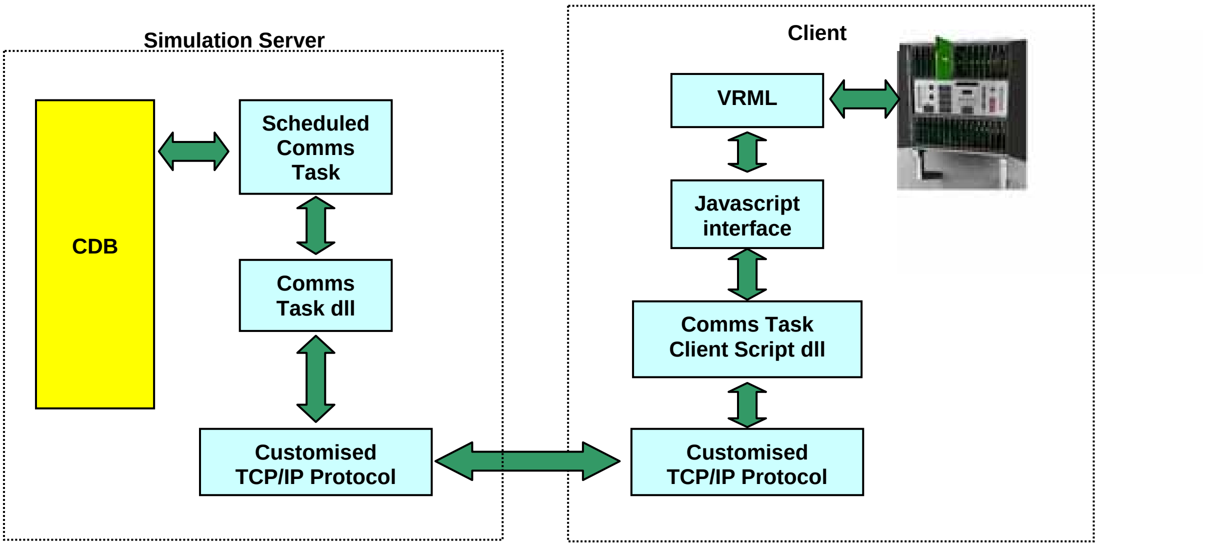

Figure 3 – Client-server communications for 3DVR instrumentation cabinet.

4 Training Requirements - Active Maintenance Training

The RC+I trainer is active in the sense that a sophisticated physics-based and engineering-based simulation model lies behind the 3DVR interface, and provides identical functionality to the interface as would occur on the boat. The majority of the processing logic for control and Instrumentation systems that regulate and monitor the reactor plant are housed in a number of instrumentation cubicles. The electronic modules which comprise these systems can exhibit faulty behaviour and the maintenance engineer is typically required to diagnose the fault(s), carry out repair by replacing the defective component and then bring the systems back on-line without adversely affecting the plant state. A typical training scenario using the 3DVR trainer is outlined below.

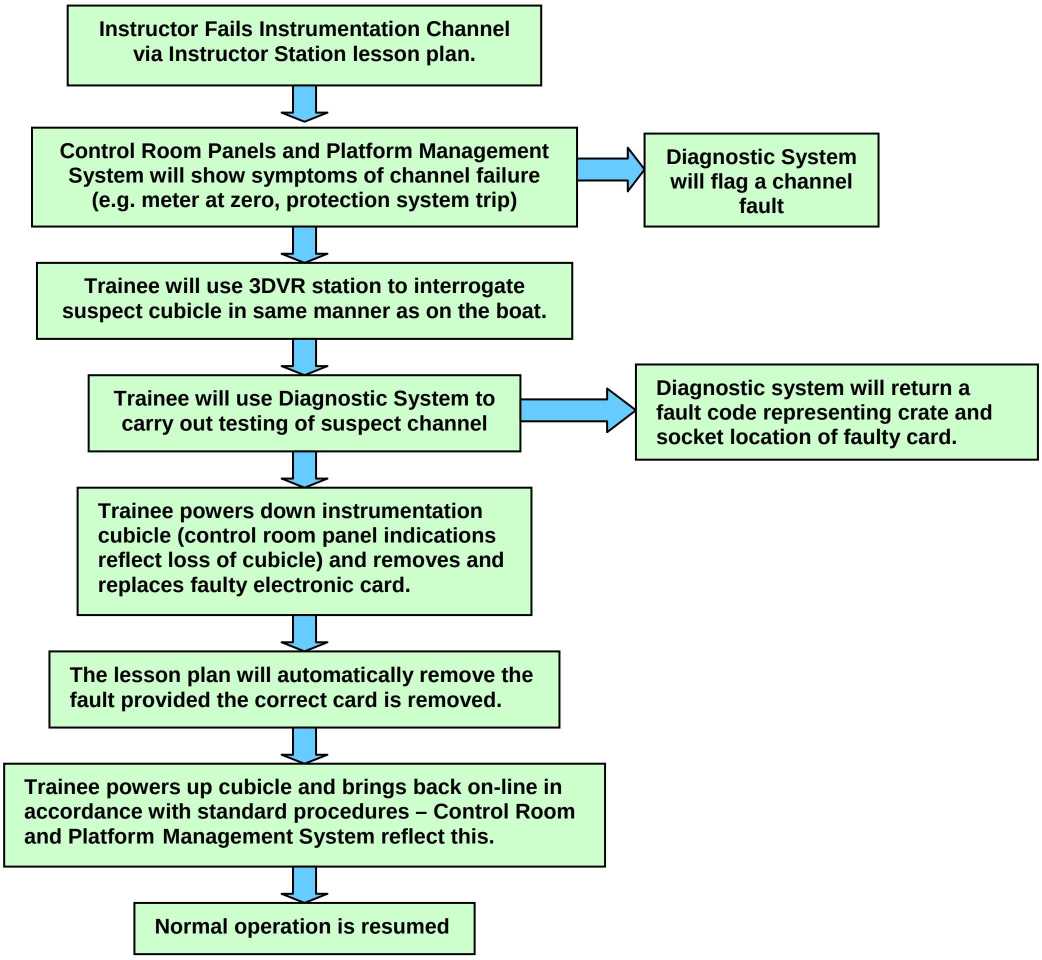

Figure 4 - Typical training operations sequence using the 3DVR trainer

Initiation of the training scenario is automated by use of a lesson plan functionality in the Instructor Operating station. This allows lesson-driven modification of any of the simulation parameters, giving complete flexibility over the construction of any training scenario.

5 Training Requirements – Maintenance Training (Subsidiary systems)

Part of the RC&I solution are offline maintenance workstations which contain high fidelity 3DVR models of various systems on the boat. These systems provide either control, monitoring and/or safety functions. Training functionality is again based on full operator interactivity with an accurate engineering-based, 3D model which can be manipulated (virtually) in exactly the same manner as the real equipment. Demonstration, training, and assessment modes are available for the trainee. A text-to-speech facility gives verbal instructions to the trainee based exactly on the wording and structure of the boat SOPs. The demonstration mode allows simple observation of correct procedures, with verbal commentary based around correct operational procedures; the 3DVR will animate each part of the procedure in sequence with the commentary. The training mode allows the trainee to perform the maintenance procedure without verbal cues. Each 3D model contains various sensors which once enabled by touch, allow the trainee to dismantle and carry out maintenance.

Finally the assessment mode, timed if necessary, monitors the trainee's progress through the SOP providing an accurate assessment of whatever skills and knowledge has been acquired by the trainee from the demonstration and training modes.

6. Summary

The automated lesson-driven instructor toolset allows much greater flexibility in terms of dynamic fault injection and adds to the sense of realism regarding the system behaviour. The solutions and methodologies implemented in this particular training solution have obvious applicability to conventional plant nuclear maintenance training, as well as nuclear plant familiarisation. It is the intention of L3 to fully explore the exciting possibilities afforded by this 3DVR training design approach for several nuclear plant types, both existing and proposed.

7. Conclusions

- The use of a 3DVR model of submarine nuclear-safety instrumentation platforms driven by a high-fidelity real-time simulation has allowed significant cost savings and increased training flexibility compared to the use of a physical copy of the equipment.
- The interaction of the trainee with the virtual trainer is enhanced by the existence of the full-boat simulation underlying the 3DVR solution, which again, increases the sense of functional realism from a training efficacy perspective.
- Ease of modification of the training environment due to operational feedback from boat operations or changed/upgraded equipment can be readily accommodated in the current solution, at significantly less cost than would be the case with more traditional hardware-based training implementations.
- In principle any nuclear plant system or subsystem could be emulated virtually and subsequently coupled to a real-time simulation model.

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A SUGGESETION TO DEVELOP SUSTAINABLE HUMAN RESOURCES FOR RADIOACTIVE WASTE DISPOSAL PROGRAM IN JAPAN

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ABSTRACT

In Japan, needs of human resources for radioactive waste disposal program are expanding with the progress of the program. On the other hand, available human resources have been shrinking due to recent market-oriented principles even in universities as well as industries. Especially in Japan, diminishing human resources are decentralized in more than one implementing body and research organization. To solve this situation and secure sustainable human resources, a suggestion is made from wide discussions by the members from the organizations concerned, such as the implementing bodies, universities, research organizations.

1. Introduction

In Japan, needs of human resources for radioactive waste disposal program are expanding with development of the third generation low level radioactive waste disposal program of JNFL (Japan Nuclear Fuel Limited) and the siting activities for geologic repository of NUMO (Nuclear Waste Management Organization of Japan). On the other hand, human resources have been shrinking in the research organizations such as JAEA (Japan Nuclear Energy Agency) which had large resources at the research and development stage of the program. Recent market-based principles would not allow universities as well as industries concerned to nurture and secure sufficient human resources for the program. Especially in Japan, diminishing human resources are decentralized in more than one implementing body and research organization. To solve this situation to obtain sustainably human resources for the program in Japan, a suggestion is made from wide discussions by the members from the organizations concerned, such as the implementing bodies, universities, electric power company, research organizations and the regulatory organization.

2. Flow of discussions

Preliminary discussions were conducted in 2002 and 2003 to conclude a basic view of human resource development for geological repository program [1]. On the basis of this conclusion, wide discussions were conducted in 2005 and 2006 by the members from the organizations concerned. Flow of the discussions is shown in Fig.1. This paper introduces some parts of the whole discussions.

3. Features of human resource development for radioactive waste disposal program

Human resource development for radioactive waste disposal program contains some common and uncommon features to those for nuclear power programs in quantities and qualities. As a first step, features of human resource development for the program were perceived;

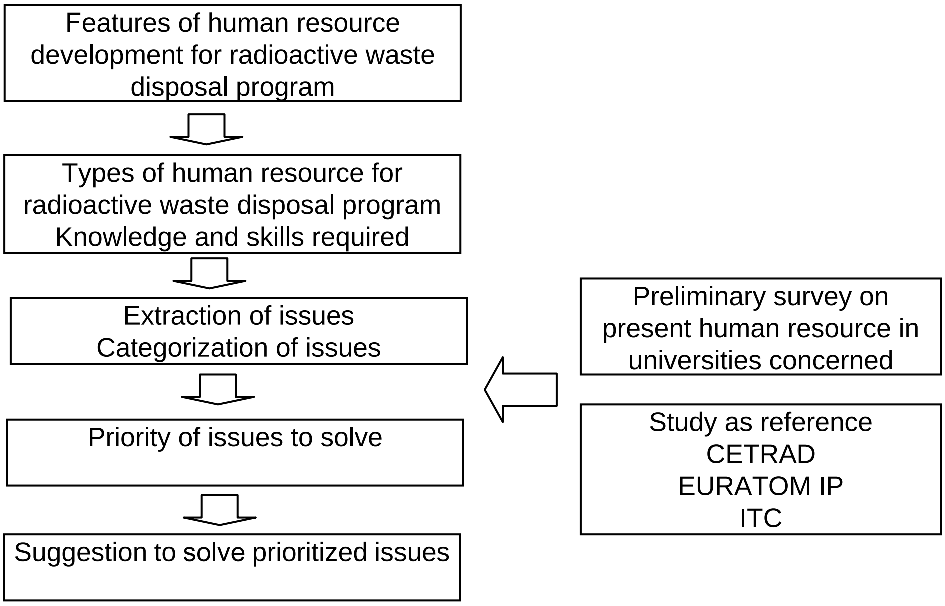

Fig.1 Flow of discussions

- Very long time span of the program requires human resources to create up-to-date knowledge and technologies and definite transfer of the knowledge from one generation to succeeding generations.
- Multiple realms of the program require human resources who have multidisciplinary knowledge.
- Uncertainties in the schedule of the program need a flexible framework for human resource development.
- Public trust essential for the program would be obtained through the safety regulation sectors. For this, sufficient capable human resources need to be secured in these sectors from early stage of the program.
- Technical information would be concentrated in the implementing bodies in the advanced stage of the program. This asymmetry in the information would cause some difficulties in human resource development of the other organizations.
- In Japan, the human resources are decentralized in more than one implementing body and research organization.

4. Types of human resources

In the process of the program, different sectors require human resources with various abilities to perform their own functions. These human resources are categorized into the following types. Suitable procedures for the development of each type were discussed in [1].

- Core human resources; they have broad and profound multidisciplinary knowledge on the disposal to act as key person in each sector. They are responsible for passing the whole knowledge on the program to the next generation. Numbers required are very small, between 10 and 20 for all sectors in Japan, but not sufficient now.
- Practical human resources; they have some specialties required to practice the program, such as civil engineering, mechanical engineering, nuclear engineering, and geology (defined as I-type human resource). They will perform various practical tasks in the program. In addition to their specialties, they should be inspired to have general fundamental knowledge of the disposal (defined as T-type human resource). This type of human resources would be developed according to the practical demand.
- Outside supporters; they would give wide-ranging supports and encouragement to the program from outside.

5. Present situation of human resources in universities

Universities have an important role to supply fresh human resources to the program. Recently, universities have been losing their teaching and researching man-power in this area due to market-based principles over universities. A preliminary survey on the present situation of human resources in the university laboratories involved in research on radioactive waste disposal was conducted with questionnaires to 15 laboratories (10 nuclear or energy engineering and 3 civil or environmental engineering). Results are used to make suggestions to support the university laboratories concerned. Questions are related to the following subjects;

- State of the research activities on radioactive waste disposal
- Structure of the teaching staff
- Jobs for the graduates
- Research funds to secure the teaching staff

5.1 State of the research activities on radioactive waste disposal

Research budget excluding personnel costs is from 3 million Japanese yen (JPY) to 20 million JPY, averaging 9 million JPY per laboratory. As the subsidy from the government has been decreasing, most laboratories are forced to obtain supplementary funds from outside of the universities.

5.2 Structure of the teaching staff

The 15 laboratories have in whole 21 teaching staff engaged in education and research on radioactive waste disposal. They consist of nine professors, nine associate professors and three teaching fellows. More than half of the professors are over 55 years old. The associate professors are concentrated between 40 and 50 years old. Teaching fellows are all under 40 years old. This structure shows aging of the man-power and shortage of young man-power in the universities laboratories concerned.

5.3 Jobs for the graduates

About 40% of the masters (total 89 persons) obtain jobs in nuclear power industries including electric power companies and research organizations. But 60% of the doctors (total 14 persons) obtain jobs in non-nuclear power industries. It is hard for them to get jobs in nuclear power industries due to their own high speciality. Very few of all can get jobs in the implementing bodies and the research organizations to utilize their knowledge and skills.

5.4 Research funds to secure the teaching staff

Some universities allow the laboratories to secure man-power by outside funds. The averaged amount of the research funds corresponding to secure one person per year including all costs, such as salary and research expenditure is summarised as below.

- A professor needs more than 20 million JPY per year. Three laboratories claim more than 30 million JPY for a professor.
- An associate professor needs 17 million JPY per year.
- A teaching fellow needs 8 million JPY per year.

6. Suggestion to nurture and secure the human resource

As a first step to establishing sustainable human resource development for the radioactive waste disposal program, the following suggestion is made from the discussions;

- Conduct research and development projects funded by the government with some views to develop human resource. For example, the projects should conprise workshops to share the research achievements and seminars to activate young engineers and researchers.

- Boost the university laboratories concerned
    - The implementing bodies and the research organizations should show the quantities and qualities of their jobs to the university laboratories. This would help the laboratories to secure students who are interested in this area.
    - The government should provide the research funds with enough term, more than five years and enough amounts to employ young teaching and researching staff. They would be developed to well-skilled I-type human resource (single specialty) in the process of the research.
    - I-type human resource such as post-doctors should be converted to T-type human resource (one specialty with general knowledge) through activities in relevant societies and participation in net work research.
- Role of the implementing bodies
    - Communicate their policy and plan on employment of fresh man-power with the universities.
    - Provide the funds of basic research to the laboratories from long term view point of nurturing young human resources.
- Role of the research organizations
    - Conduct research with the outlook to supply their human resources to the implementing bodies and the regulatory organizations.
    - Employ fresh human resources from universities to compensate the man-power transferred to the implementing bodies and the regulatory organizations.
    - Utilize their facilities for training and education with collaboration of the organizations concerned.
- Establish a system to coordinate the human resource development in Japan. Considering many organizations are involved in the radioactive waste disposal program, sustainable collaboration among the organizations including the universities would be practicable in this system. Its functions are;
    - To check the process of the human resource development and share the information
    - To prepare and renew the human resource data base
    - To plan training courses for the practical human resources and seminars for the top management of the organizations and the industries related to the program.
    - To create a carrier-up system. This should include exchange of the staff among the organizations concerned.

7. Ending remarks

Considering the features of radioactive waste disposal program, a suggestion is made to forward a sustainable human resource development for the program in Japan. This suggestion contains various activities by the government, the implementing bodies, and the research organizations. One of them is to boost the university laboratories involved in the program. A coordinating system among the organizations concerned is proposed to plan and check the human resource development in Japan.

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Acknowledgments

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EUROPEAN SCHOOL ON EXPERIMENTS, THEORY AND EVALUATION OF NUCLEAR DATA (EXTEND)

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ABSTRACT

The CANDIDE (Coordination Action on Nuclear Data for Industrial Development in Europe) consortium launches the first European School on Experiments, Theory and Evaluation of Nuclear Data (EXTEND). The target group of this course are young professionals, primarily recently employed staff in nuclear industry and at research centres, as well as PhD students in the field. The course contains lectures on introduction to nuclear data, experimental methods, application-oriented nuclear theory, evaluation and validation, data handling, nuclear data needs for sustainable energy systems such as GEN-IV reactors and ADS, and outlook to the future. Laboratory exercises will be conducted on cross-section measurement at a reactor, cross-section measurement at an accelerator-based neutron source, theory and data handling. The school will take place September 2008, in Budapest. The ambition is that after the pilot session in 2008, EXTEND should become a recurring event.

1. Introduction – the CANDIDE project

CANDIDE, Coordination Action on Nuclear Data for Industry Development in Europe [1], is an EC-supported Coordination Action (CA), launched with the ambition to establish a durable network on nuclear data efforts that are important in the context of minimising the high-level waste stream of nuclear energy. This implies optimal incineration of all actinides that nowadays constitute spent nuclear fuel, in critical and sub-critical reactors. As a consequence, the scope of CANDIDE encompasses transmutation in fast critical reactors as well as sub-critical accelerator-driven systems (ADS). The purpose is to identify the needs for improved nuclear data, assess the present status of knowledge, and to estimate what accuracy can be reached with state-of-the-art techniques.

This goal cannot be reached without collaboration between industry, academia and research centres. Moreover, education and training are essential for success in this realm. Thus, CANDIDE addresses the following two objectives:

- Establishment of better links between academia, research centres and industry end users of nuclear data. This is reflected in the project name.
- Assessment of nuclear data needs for advanced nuclear reactors. The emphasis is on the radioactive waste issue, i.e., either waste transmutation in critical or sub-critical devices or minimizing the production of nuclear waste in future nuclear reactors, as envisaged in some fast critical systems.

For a long time activities concerning all aspects of nuclear data for commercial nuclear power reactors, i.e., nuclear data production, theory, evaluation, validation and industrial use, have been part of a well-organized international community, monitored by large international organizations, like OECD/NEA [2] and IAEA [3]. The present coordination of nuclear data needs and evaluation efforts is for example channelled through the OECD Nuclear Energy Agency in the Working Party on International Nuclear Data Evaluation Co-operation (WPEC) [4], where activities between the participating projects in Japan (JENDL), the United States (ENDF), Western Europe (JEFF) and non-OECD countries (Russia, BROND; China, CENDL; and the IAEA-based FENDL) are covered. Within the WPEC, a High Priority Request List (HPRL) has been established to find and review data users' needs and to serve as a guide for scientists planning measurements and developing nuclear theory and data evaluation programs. Present requests cover for example new evaluations of cross-sections and uncertainties for advanced reactors.

Recently, a new nuclear data community has been formed around the production of nuclear data for accelerator-driven systems, while the other ingredients of traditional nuclear data work (e.g. evaluation and validation) have to a large degree been missing up to now. The CANDIDE project aims at establishing links for this new community to the existing structure of coordinated nuclear data activities in general, and to provide links to industry in particular.

Another recent development in Europe has been the enlargement of the EU, which opens new possibilities in the realm of nuclear data. Integration - both of different research communities and between new and previous member states - is an important objective of the CANDIDE project. Moreover, improved training and integration are essential parts of the CA, exemplified by the development of EXTEND as part of the project.

In the public literature, the concept of transmutation is quite often used in a restricted sense, synonymous to accelerator-driven systems for incineration of spent nuclear fuel. CANDIDE has been designed with the intention to consider transmutation in a broader, more general sense, i.e., incineration of spent nuclear fuel by changing the nature of the elements through nuclear reactions. As a consequence, the scope of the proposed CA will encompass minimal production and transmutation of waste in fast critical reactors as well as sub-critical accelerator-driven systems (ADS).

The purpose of CANDIDE is not to produce new experimental data or evaluations, but to review the current modes of nuclear data production, assess the present status of our knowledge, estimate what accuracy can be reached with state-of-the-art numerical simulation techniques, identify the needs for improved nuclear data, and suggest appropriate actions to be taken to meet those needs. A large fraction of the existing data were obtained far back in time, and it might be beneficial to identify cases where new experiments on already measured reactions could exploit technology improvements. Key input is expected from industrial partners, since they are closely involved in application of nuclear data libraries and their performance.

The final result of CANDIDE will be a report describing the state-of-the-art and giving recommendations to EC outlining how nuclear data research should be organized in FP7 and beyond. Moreover, the organisation of workshops and a training course will lead to broader European involvement in the subject.

2. The EXTEND school

As outlined above, the CANDIDE project is not limited to involvement of existing activities, but will also promote growth for the future. Therefore, an important part of the project is the development of a dedicated training course on nuclear data for young professionals, the European school on Experiment, Theory and Evaluation of Nuclear Data (EXTEND). The target group of this course are young professionals, primarily recently employed staff in industry and at research centres, as well as PhD students in the field.

Summer schools in nuclear engineering (e.g., the Eugene Wigner School on Reactor Physics [5] within the ENEN [6] association or the Frederic Joliot - Otto Hahn summer school [7]) are regularly organized, and there are relatively frequent summer schools on fundamental nuclear physics. Up to now, however, there have been few initiatives to bridge these two communities. EXTEND has been designed to fill this gap. Moreover, the course will provide a meeting place for young professionals in corporate industry, research centres and academic research, aiming at fostering improved connections between these types of organizations. In addition, EXTEND will put emphasis on being a meeting place of the long-established and new EU member states.

Course content

The course contains lectures on the following topics:

- Introduction to nuclear data
- Experimental methods
- Application-oriented nuclear theory
- Evaluation and validation
- Data handling
- Nuclear data needs for ADS and Gen-IV
- Outlook to the future

The following laboratory tutorial exercises are performed:

- Cross-section measurement at a reactor
- Cross-section measurement at an accelerator-based neutron source
- Theory
- Data handling

The local reactor at BME will be used as well as the accelerator laboratory in Debrecen. The theory tutorial will be performed using the TALYS nuclear cross section code [8]. TALYS is a very user-friendly code that calculates predictions of nuclear cross sections with a minimum input from the user, i.e., the code selects a suitable nuclear theory model unless the user specifies what theory to be employed.

Finally, the data handling tutorial is a set of exercises in data retrieval from the international nuclear data banks, use of suitable visualization tools, etc. Several Web interfaces exist for retrievals, and Fig. 1a shows a screen shot of the evaluated data Web search of the NEA. For the visualization and manipulation of nuclear data, the NEA developed free software JANIS [9] will for example be used. It allows the user to access numerical values and graphical representations without prior knowledge of the storage format. It offers maximum flexibility for the comparison of different nuclear data sets. Developed for engineers and physicists who use nuclear data for their applications with user-friendly navigation tools making it particularly suitable for educational purposes. The nuclide browser of JANIS is shown in Fig. 1b.

Fig. 1. Evaluated (EVA) nuclear data retrievals (a, left) from the NEA web site (www.nea.fr/html/dbdata/eva) and the JANIS software start page (b, right).

In addition to the lectures and tutorials, there will be a tour to the Paks nuclear power plant. In this study visit, the industrial use of nuclear data will be highlighted.

The school will take place September 1-12, 2008, at the premises of the Budapest University of Technology and Economics, located centrally downtown Budapest. There is no fee. The participants will be provided accommodation including full board at the guest facilities of the Budapest University of Technology and Economics.

Additional information is provided by the EXTEND web site, candide.nri.cz/extend.php, or by contacting Jan Blomgren, EXTEND director. The ambition is that after the pilot session in 2008, EXTEND should become a recurring event. Moreover, the constitution of the EXTEND team is such that the focus could optionally be extended to reactor-related issues such as criticality, and more general nuclear energy issues.

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AN INDUSTRY WIDE APPROACH TO ATTRACTING WORLD CLASS GRADUATE TALENT IN AN INCREASINGLY MARKETPLACE - NUCLEARGRADUATES

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ABSTRACT

The Nuclear Decommissioning Authority (NDA) has a remit under the Energy Act (2004) 'to maintain and develop the skills for decommissioning and nuclear clean-up'. In the recent NDA graduate survey (Ref.1) and in work conducted by Cogent (Ref.2), there is evidence that the age profile is skewed towards older workers and there are likely to be skill shortages in the medium term in key areas. The NDA is also looking to achieve a step change in performance as it introduces commercial innovation, openness and transparency and world class performance as key tenants to re-structuring the industry.

This paper details the NDA's 'nucleargraduates[1]' programme, and how it has brought together partners from the United Kingdom's nuclear decommissioning, defence and process sectors to create a unique programme which enables graduates to experience life throughout the supply chain and regulators.

1. Introduction

1.1 The Nuclear Decommissioning Authority (NDA) is a non-departmental public body, set up in April 2005 by the UK Government under the Energy Act 2004 to take strategic responsibility for the UK's nuclear legacy. Following research into the needs of the nuclear industry (Ref.1) within the UK. It has created a 'stakeholder' group which includes Site Licence Companies, regulators and supply chain companies to allow a programme which encapsulates secondments and training that gives exposure to three cohorts of graduates across an entire industry.

1.2 The appetite for this programme is born out of the NDA mission, 'To deliver a world class programme of safe, cost-effective, accelerated and environmentally responsible decommissioning of the UK's civil nuclear legacy in an open and transparent manner and with due regard to the socio-economic impacts on our communities'.

1.3 In line with the mission, the NDA's main objective is to decommission and clean-up the civil public sector nuclear legacy safely, securely, cost effectively and in ways that protect the environment for this and future generations. The NDA does not carry out clean-up work itself and so it is important that those that will deliver, and those potentially interested in delivering, have the right skills set in place to meet the needs of the modern nuclear industry.

1.4 The UK as a whole is suffering from a skills shortage in keys areas such as Science, Technology, Engineering and Maths. The squeeze on talent is particularly prevalent at graduate level.

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[1] "nucleargraduates" is the brand name for the NDA National Graduate Scheme

2. The ‘nucleargraduates’ programme

nucleargraduates

Fig. 1 The brand identity of the NDA National Graduate Scheme

2.1 The NDA has developed three facets that will enable closer working in the nuclear industry around graduate attraction, recruitment and development:

- The nucleargraduates programme
- A joint application tracking system
- Programmes of joint working on attraction and development

2.2 The nucleargraduates programme is driven by a group comprising of companies across the industry including the NDA, Site Licence Companies, Regulators and the supply chain. Uniquely, the programme offers no ‘specific job’ with the NDA after the two year programme is completed. The programme will be integrated into the existing partners’ schemes to ensure smooth progression. The Graduate’s progress after 2 years will be facilitated by a careers service and formal rules governing the behaviour of partners.

2.3 Target graduates include those from the following disciplines areas:

- Civil, electrical, chemical and mechanical engineering
- Environmental sciences
- Finance, procurement and project controls

These disciplines will be expanded for the later cohorts to include areas such as materials, health physics, safety case writing and chemistry.

2.4 The graduates go through a series of four secondments:

- Six months spent working with NDA staff
- Six months working on secondment at a Site License Company or Parent Body Organisation
- Six months spent working with touch points of the nuclear industry such as Tier 2/3 suppliers, government agencies and departments, regulators, local councils, defence and operational organisations or unions
- A three month secondment abroad in either a national authority, e.g. the Department of Energy or international supplier

2.5 Throughout the programme four periods of training will also be carried out. All secondments are in a specific work discipline (e.g. civil engineering) and will have defined projects. Training will be structured and aligned with relevant ‘Institute’ competencies to ensure a route through to chartered status for any graduates wishing to follow this line. There will also be an emphasis on behavioural and technical training to ensure a broad experience for those going through the programme.

2.6 Attraction and recruitment will be formed from two areas:

- Recruitment of “second jobbers” and the ‘hidden graduate pool’ - through innovative marketing, agencies and online recruitment
- Traditional ‘milkround’ recruitment, focussed on advertising, careers fairs, university liaison and specific targeting of particular courses

2.7 A bespoke Socio-Economic Programme, named *Footprints*[2], will deliver:

- *'10% Time'* - a voluntary work in the community programme, which will compliment other training areas, focussing on 'the skills agenda' and bringing the NDA into the heart of the community
- Society 'programme days' introducing the graduates to the role of the industry in society through bespoke away days. These will include visits to facilities such as the Scottish Government, prisons, schools, FE colleges, farms etc. The 'Footprints' programme is themed around specific strands such as education, innovation, community and governance and is targeted at geographical areas aligned to NDA's socio economic plan (Ref.3).

2.8 An online Applicant Tracking System will be used to streamline much of the application and assessment phases of the recruitment phase and capture graduates not suitable for the NDA programme that may be of interest to stakeholders.

2.9 Other areas of joint working such as graduate attraction, academic and skills conferences are planned to highlight the opportunities to academic communities for graduates.

3. Major Achievements to Date

3.1 The first cohort of 13 graduates start on 21st April 2008. These graduates come from a variety of science, engineering and commercial backgrounds. There programmes and training have been defined and planned secondments include the NDA, Sellafield Ltd, Magnox North, Rolls Royce, Jacobs and the Environment Agency. Locations include England, Scotland, Wales, France, the United States and Japan.

3.2 A joint applicant tracking system has been created which will manage those applying to the UK's nuclear industry. Over 1,500 graduates applied for the programme in the first month of the programme opening.

4. Conclusion

4.1 The UK's nuclear industry is at a cross roads in terms of graduate recruitment. The nucleargraduates model of joint working has provided a beacon of best practice for solutions to meeting the increasing challenges of skills shortages for a growing industry.

4.2 Whilst numbers are limited at present (30 places over the next 2 years) success of the programme will lead to developing options for expansion of the original scope to aspire to a larger and more collaborative arrangement of a truly National Graduate Scheme for all participating partners.

References

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NUCLEAR INDUSTRY TRAINEE PROGRAM
FOR NEWLY RECRUITED ENGINEERS

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ABSTRACT

As of 2007, AREVA NP in Germany continues to face a dramatically increasing demand for competent staff for a new six week modular trainee program for nuclear engineers.

All new engineers are invited to attend this trainee program. Here, they learn about the AREVA group and AREVA NP operations. Technical knowledge is enhanced by training on layout, functions, instrumentation and operation of the different types of nuclear power plants, primarily Boiling Water Reactors, Pressurised Water Reactors, and their main systems and components. Furthermore an introduction to quality management, nuclear safety principles and nuclear engineering is given to the trainees.

This paper presents an overview of the needs for and objectives of AREVA NP's trainee program, and the concept for development and implementation of this new program. It discusses initial experiences from the first implementations and the next steps for upcoming courses.

1. Introduction

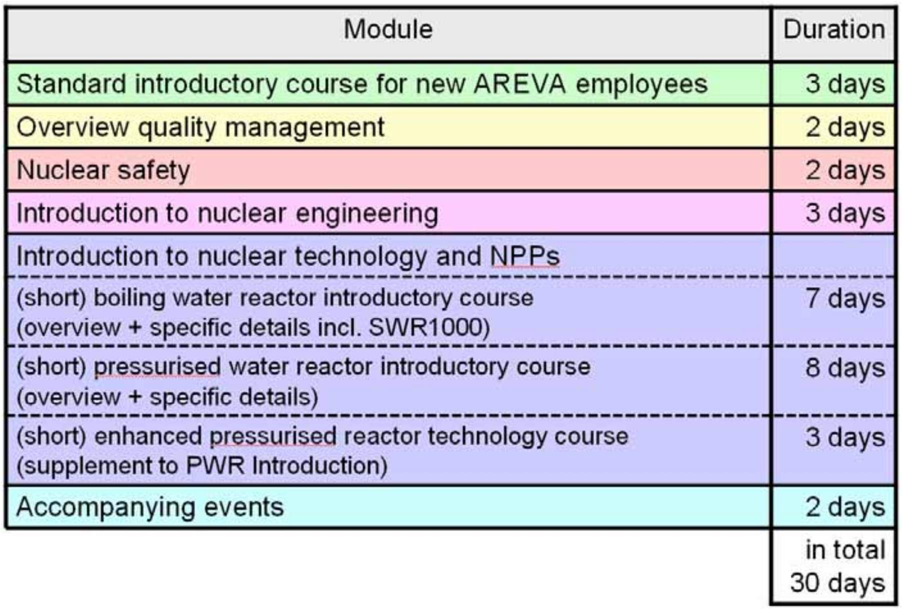
In 2003 the consortium of AREVA (then Framatome) and Siemens started the turnkey construction of the fifth Finnish nuclear power plant in Olkiluoto, which is the first order of its kind in Western Europe for more than 20 years. Furthermore the possibilities of new construction projects in Flamanville, France or Taishan, China, and also the perspectives of additional plant construction projects in countries like South Africa, Great Britain or the Baltic States have now led to a dramatic increase in demand for additional personnel. However, the present shortage of competent employees, particularly intensified by the reticent role of the German educational facilities (universities, technical colleges …) regarding nuclear matters, and the severe company rivalry for hiring the best talents on the market, nowadays poses an overwhelming challenge.

Today's introductory training programs for newly recruited personnel have to instruct engineers from different technical disciplines. In order to boost the needed development within the company, training not only has to establish the basis for knowledge and skill transfer but also has to maintain talent progression and preservation. In a five year perspective, recently hired talents shall become the backbone of the AREVA group. Therefore, it is also very important that new employees understand and adopt the group's values in order to comply with its commitments.

2. Approach for development of technical competence

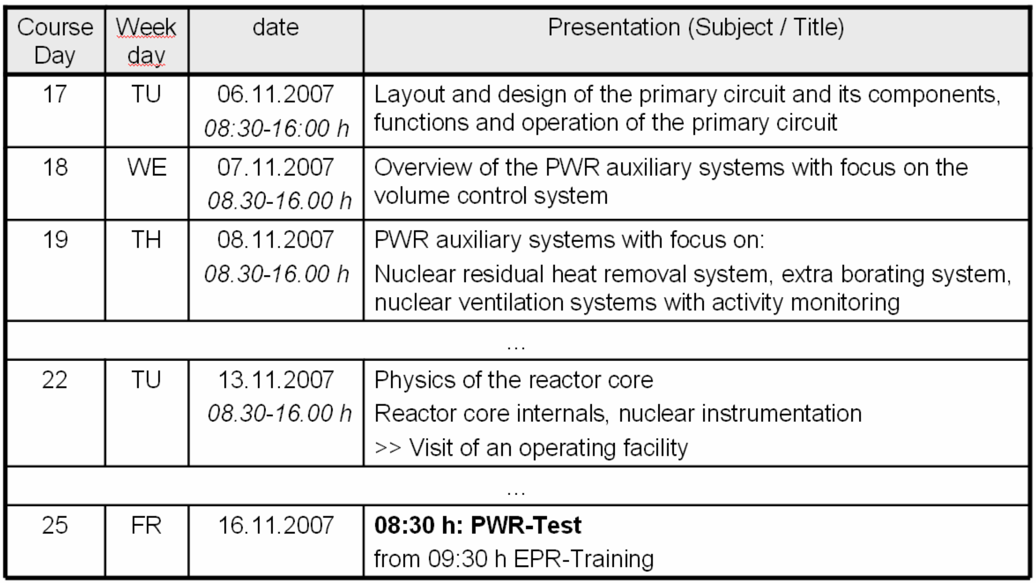
Facing these conditions, AREVA NP started a trainee program for engineers in Germany in April 2007. It was recommended that every newly recruited engineer had to participate in this program during his period of vocational adjustment within AREVA NP.

The main objectives which had to be covered by the new program were to accelerate the development of nuclear and technical competencies of the participants and thereby to ease an efficient integration of the new personnel into the engineering workforce. Additionally on-the-job-training which bind human resources in an unproductive way should be minimized as well as the time and effort needed for a general qualification for newly recruited employees.
Various already existing training modules were taken as a basis for the development of the whole program. Thereby it was possible to develop and implement a six week training course within a short space of time, including a one week break for self-study,.



Module	Duration
Standard introductory course for new AREVA employees	3 days
Overview quality management	2 days
Nuclear safety	2 days
Introduction to nuclear engineering	3 days
Introduction to nuclear technology and NPPs	
(short) boiling water reactor introductory course (overview + specific details incl. SWR1000)	7 days
(short) pressurised water reactor introductory course (overview + specific details)	8 days
(short) enhanced pressurised reactor technology course (supplement to PWR Introduction)	3 days
Accompanying events	2 days
	in total 30 days

Fig 1. Overview of the program modules



Course Day	Week day	date	Presentation (Subject / Title)
17	TU	06.11.2007 *08:30-16:00 h*	Layout and design of the primary circuit and its components, functions and operation of the primary circuit
18	WE	07.11.2007 *08.30-16.00 h*	Overview of the PWR auxiliary systems with focus on the volume control system
19	TH	08.11.2007 *08.30-16.00 h*	PWR auxiliary systems with focus on: Nuclear residual heat removal system, extra borating system, nuclear ventilation systems with activity monitoring
…			
22	TU	13.11.2007 *08.30-16.00 h*	Physics of the reactor core Reactor core internals, nuclear instrumentation >> Visit of an operating facility
…			
25	FR	16.11.2007	**08:30 h: PWR-Test** from 09:30 h EPR-Training

Fig. 2. Extract from the course program (module Pressurised Water Reactor)

As can be seen in Fig. 1, the following training modules have been selected:

- Standard introductory course for new AREVA employees – This course gives an introduction to AREVA with topics concerning organisation, cooperate policy and history, including an overview of AREVA scope of supplies and services. Furthermore human resource issues and market situations are presented. Safety culture as well as the basics of quality management is attributed to this course.
- Two short introductory courses (one for Pressurised Water Reactor and one for Boiling Water Reactor) – A course, which describes the general fundamentals of the entire plant, the functional and operational mode of the primary circuit and the secondary circuit with regard to a Pressurised Water Reactor; and the nuclear steam supply systems together with an overview of the steam condensate feedwater system with regard to a Boiling Water Reactor. It covers the description of core components and the physics of the reactor core, and gives an overview of the auxiliary and ancillary systems and the operational behaviour of the plant, as well as of the dedicated control systems. Finally incidents and accidents are also discussed (see Fig. 2).
- Overview course - Evolutionary Pressurised Water Reactor (EPR) – This course gives a description of the design and development objectives of the EPR and summarizes the difference to AREVA's II generation NPPs. Furthermore it gives an overview of the safety concept focussing on safety systems and severe accidents (e.g. core melt).
- Introduction to nuclear engineering – Organizational structures of the different engineering departments (system, process, component etc …), their main processes and the tools employed are presented.

For the training method, instructor led classroom training outside was selected. The choice of a non "in house" location for this training was a conscious decision to allow the participant the full concentration in lectures as well as to enhance networking amongst other trainees.

While the first module was given by around 20 instructors from different departments, trainers from the Training Center and specialists from the engineering departments carried out the technical part. The introduction to nuclear engineering was given by the department manager of all the different engineering departments.

The participants were able to take notes during the lessons as they were provided with the necessary training material, such as a copy of the presented slides and/or the attributed textbook. In addition, video were also shown in some lectures. For the technology courses, exercises and self-study were performed under the supervision of an instructor. To lighten up the day, guided tours around nuclear power plants and on-site manufacturing facilities were made available to the attendants.

The training was evaluated by regularly collecting trainee-feedback, subdivided into questions concerning the general terms, the administration, the content of the training material and the skill of the trainers. To evaluate the acquired level of knowledge, tests were performed after one technical module had been completed.

3. First Experiences

Since April 2007 four consecutive runs of the nuclear engineering trainee program have been carried out by the Training Center of AREVA NP. Up until now about 100 newly recruited engineers have participated in the program.

Generally the feedback from trainees was positive. They pointed out that they had received a good overview and introduction to nuclear engineering and nuclear technology. Networking between participants from different departments was recognised as a further advantage in their forthcoming daily work. Compared to most of their previous employers the trainees highly esteemed the investment AREVA NP made to have increased the competence of their newly recruited personnel.

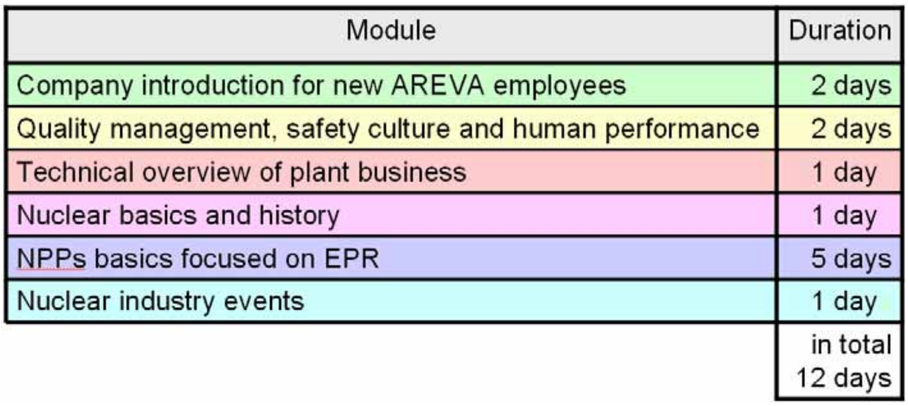
Critical comments were related to overlapping and inconsistencies of the technical content. Furthermore some topics were covered in too much detail during the classroom lectures. More time for repetition, teamwork and self-study was suggested.

These deficiencies could be expected in advance, as already existing independent courses were used as a basis for the development of the whole program. Therefore the modules of the program have been continuously reworked and further developed since the program began in 2007. The first improvement was the introduction of tutorials at the end of each topic, regarding the time balance between lectures and repetition. A parallel rework of general training material on Boiling Water Reactors could be adapted in parts for the third run of the trainee program, so that BWR module training material could be actualised and harmonised. Unifying the training material on Pressurised Water Reactors and on the Evolutionary Pressurised Water Reactor, and including a comparison between Generation II and III reactors, was the last improvement measure. The material could be used in the fourth run. Overall the material is now better suited to the training of newcomers to the nuclear field.

4. Next Steps

The fifth run of the nuclear engineering trainee program will begin at the end of May. The feedback from trainees demands yet another enhancement of some tutorials. Additionally the fifth run will concede more focus to nuclear engineering by discussing case studies, e.g. how a valve should be designed and which steps must be completed before commissioning. But also former reactor operators and shift supervisors will outline reports based on their own experiences in the operation of a nuclear power plant.

Moreover AREVA NP now has decided to modify the program to cover the needs beyond the requirements of nuclear engineering. The prospective program will be broken down into smaller packages and units, to be attended over a time period of about two years after recruitment. According to individual specific previous knowledge and dedicated job position it will be possible to select only those modules which are required. It is also foreseen that different training settings will be used, namely classroom training including lectures and accompanying exercises as well as online courses, self-studies and continuing on-the-job-training under the supervision of a mentor. This will be supplemented by advanced training on an engineering simulator. To allow training to be much more effective the training period will be extended and the training itself will be much heterogeneous.



Module	Duration
Company introduction for new AREVA employees	2 days
Quality management, safety culture and human performance	2 days
Technical overview of plant business	1 day
Nuclear basics and history	1 day
NPPs basics focused on EPR	5 days
Nuclear industry events	1 day
	in total 12 days

Fig 3. Proposed introductory new hire training program

As can be seen in Fig. 3, the following training topics have been selected for the proposed introductory new hire training program:

- Company introduction for new AREVA NP employees
- Quality management, safety culture and human performance
- Technical overview of AREVA NP business – deals with the organisation, interfaces and processes within AREVA NP (business development, project management, design, procurement, erection, commissioning, operation and maintenance) illustrated on one new construction project example and one backfitting project example.
- Nuclear basics and history – includes fission, radioprotection, fuel cycle, the role of moderator and coolant and the different nuclear types.
- NPPs basics focused on EPR – deals with the background of Pressurised Water Reactors basics illustrated using the EPR.
- Nuclear industry events – gives a description of the Three Mile Island, Chernobyl …, events, which includes root cause, human error (if applicable) and lessons learnt.

Additionally, the above training program will be harmonised over the different international regions of AREVA NP. This allows the same levels of competence within the company to be reached on an international level, as well as the use of existing training facilities and human resources to be improved.

5. Conclusions

The first experiences made were quite positive. The nuclear engineering trainee program is well accepted by the nuclear engineering departments. The newly recruited engineers were provided with all the information required for a successful career within the company. Concurrently, enhanced commitment of new personnel to the company may be observed, together with an increased identification.

As a result of the nuclear engineering trainee program within AREVA NP, the company will be well prepared for the expected extension of their business activities worldwide – an increase in new construction and backfitting projects.

CHALLENGES OF EDUCATION AND TRAINING FOR A SLOVENIAN NUCLEAR SERVICE PROVIDER

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ABSTRACT

Generation exchange and expected new constructions in nuclear industry dictate serious reconsideration of personnel knowledge and skills availability. This is not a paramount objective only for the regulatory bodies, institutes, research facilities and NPPs, but also for support industry, including service providers to NPPs. The article illustrates a specific situation in Slovenia and presents a case on the leading Slovenian nuclear service provider NUMIP Ltd. and its daughter company Q Techna Ltd. Discussed is their effort to systematically develop and implement an educational and training program in support of their services to nuclear power generation. Apart from their own and supplemental personnel, Q Techna Ltd. has started to provide training and certification to others in the market. The article is intended to emphasise the importance of the topic for nuclear service providers, and shows a specific effort made despite a small domestic market and limited resources.

1. Introduction

Recently, the situation in nuclear education and training described in OECD/NEA Report [9] has changed due to expected renaissance of nuclear power generation. Consequently, the education and training require even more attention, also on the part of nuclear industry to assure appropriate long-term measures. Even though there are some programs and activities going on at the governmental level, most of the privately owned enterprises have to find their own way to stay and grow in the nuclear business. The paper describes a case on the leading Slovenian nuclear service provider, NUMIP Ltd.

2. Specific situation in nuclear power generation in Slovenia

Many aspects related to nuclear education and training in Slovenia are similar to the ones in other European countries. Yet, when the fact that there is only one nuclear power plant in the country, half-owned by Croatia, is taken into account, the situation can be observed on a different scale. Krško NPP (one unit, two-loop Westinghouse PWR, 700 MWe) follows U.S. Codes and Standards, including 10CFR50, App. B and ASME B&PV Code, as well as Standard Technical Specifications accepted and approved by the Slovenian regulatory body, which imposes certain specifics to education and training. There is no other nuclear power generation facility in the country, which significantly narrows the market for domestic nuclear service providers. The nuclear maintenance services market in Slovenia has been further reduced by the plant’s transition from 12 to 18-month fuel cycle and by shortening outage durations. Apart from decreasing revenue, 18-month cycle implies challenges to maintaining domestic contractor personnel skills, experience, knowledge and qualifications [1].

The Slovenian government has adopted the Baseline for a long-term assurance of support activities in the area of nuclear and radiological safety [11]. Based on that, a Program on a long-term assurance of support activities in the area of nuclear and radiological safety was prepared and consequently confirmed by the Slovenian government in 2006. It actually addresses research and education institutions, organizations authorized by the Slovenian Nuclear Safety Authority and the government-owned industrial support organizations. For privately owned organizations, a burden of assuring adequately educated and trained employees remains their own. Looking at a big picture in terms of maintaining the existing plant and potentially constructing and later maintaining a new one, it is clear that industrial support should be treated as important as other organizations involved in nuclear power generation in Slovenia. Most of the countries with nuclear industry are interested in having adequately developed domestic nuclear support industry.

In the forecast by GEN Energija [5] the needs for newly employed personnel were assessed, taken into account construction and operation of new LILRW repository and Unit 2 of the Krško plant. The results, a total of 2000 additional workers will have to be employed around 2013 (above the 2006 figures), out of which 500 with at least university degree. For contractors, this means an increase in the range of at least 1200 people. Taken into account that an average time to train a newcomer after joining the company is around five years at least for engineers, the time to act is now. These figures are significant for Slovenian circumstances, even more so, as it will be difficult to get qualified workforce even from abroad due to the expected high demand in new plant constructions elsewhere in the same timeframe. Apart from highly educated experts, it is obvious that we have to take into account also appropriate trade workers suitable for nuclear construction and maintenance. Especially welders and fitters are in great demand. For illustration, the "American Welding Society predicts that by 2010 demand for skilled welders may outstrip supply by about 200.000 in US only" [12]. And the situation in the EU is unlikely to be any better.

3. NUMIP Ltd. in brief

NUMIP Engineering, Construction, Maintenance and Production Ltd., was established in 1996 and currently employs 65 people. One third of them hold a university degree, another third are technicians, the rest are highly skilled workers. For complex projects, such as regular outages at the nuclear power plant, around 400 people from up to 30 partner companies are mobilized and managed. NUMIP regularly provides the following regular outage services to the nuclear power plant: pump maintenance - primary side; cranes and fuel handling equipment servicing; containment hatch and air locks opening/closure and servicing; reactor vessel services including disassembly/assembly, handling of internals, cleaning of flange and studs; maintenance of primary valves and operators; HVAC servicing; fitting and welding; crane operation and maintenance; snubber maintenance and testing; various repairs and replacements of piping, vessels, etc. Further, its services to the nuclear market comprise of installation and modification implementation; project management; field engineering; quality assurance and quality control; fabrication of spare parts and structural elements; representation of Enertech, U.S.A. on the CEE territory. From its foundation, the company has been carefully developing its core competencies for nuclear industry with a special emphasis on specialized technical knowledge and skills; modern project management organization, methods and techniques; efficient management of several contracted companies; integrated quality system (ISO 9001, ISO 14001, OHSAS 18001, 10CFR50, App.B); personnel experience and qualification tracking system, continuous improvement process, etc. Further, it systematically provides for a long-term development.

In 2001, NUMIP acquired Q Techna, specialized in quality assurance and quality control, which has grown into a leading Slovenian QA/QC institute, accredited for five NDE methods, currently employing 22 people.

4. Providing education and training for NUMIP's personnel

As indicated above, NUMIP is facing a great challenge to maintain the skills of existing personnel for providing limited amount of services to NPP's on the one hand and to develop personnel to get ready for the new wave of NPP construction on the other. The main issue is to bridge the gap of few years between now and the participation in the expected construction of a new unit at Krško. A trade-off between demand (current and future) and employment needs is inevitable, even though it is obvious that we have to invest in education and training now to meet the needs in the future.

To keep pace with changing environment and markets, NUMIP tries to systematically deal with the education and training of its personnel. For the range of its services, several main areas should be covered with education and training, as illustrated in Figure 1. All of them are intertwined with project management which is the main process in the company.

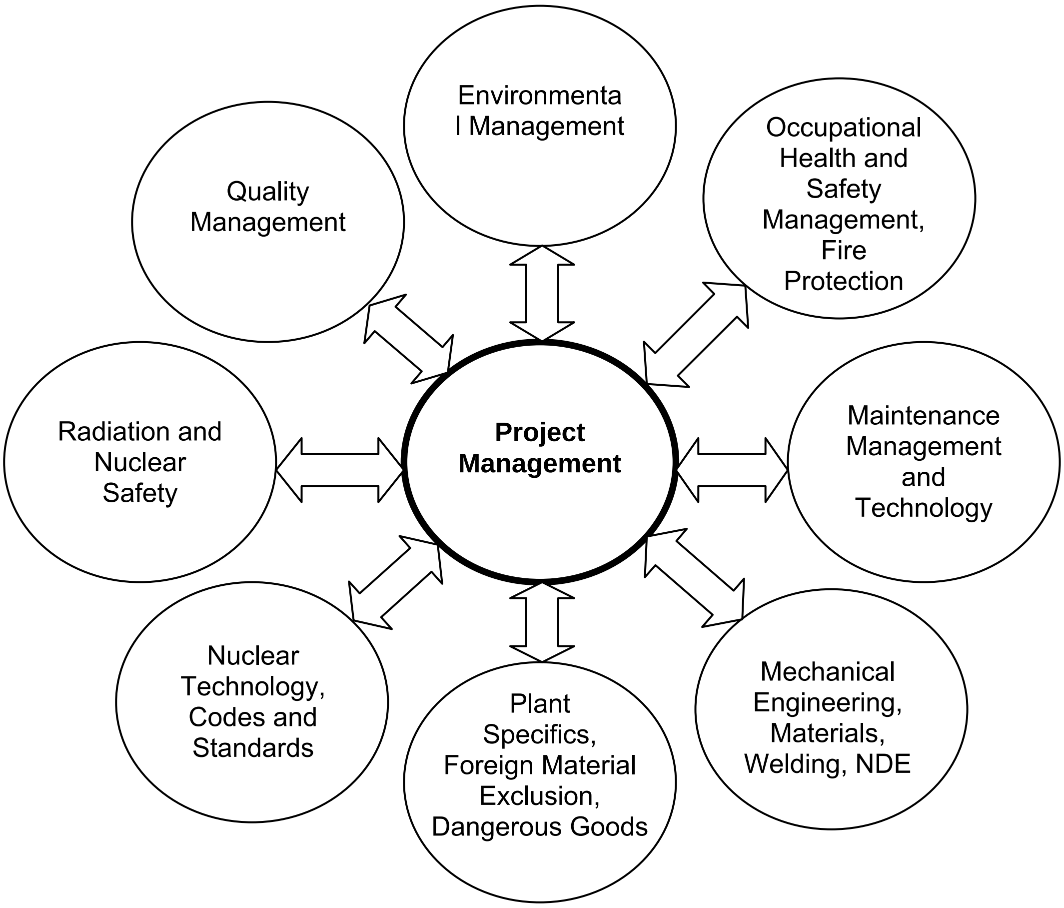

Fig 1. Main areas relevant for education and training in NUMIP Ltd.

As these areas are very diverse, NUMIP uses different ways of obtaining appropriate training and education, i.e. external (domestic and foreign), internal and on-the-job. Training guidelines [8] are used to the extent possible.

Domestic external

Apart from education at Slovenian universities, domestic training comprises of the following:

- NPP Technology courses, delivered by Nuclear Training Centre of the Jožef Stefan Institute, dealing with nuclear and reactor physics, thermal-hydraulics and heat transfer, radiation protection, electrical engineering, materials, nuclear safety and technological systems of NPP.
- Radiation protection courses

- Courses on different nuclear topics, delivered by IAEA

NUMIP also cooperates with universities, provides visiting lectures, supports the thesis work, grants scholarships for students of applicable studies, internships, etc.

Foreign external
Personnel are occasionally sent to different trainings abroad especially aiming at foreign (mostly US) codes and standards, especially ASME B&PV code and EU sponsored courses such as Nuclear Safety for NPP subcontractors.

Internal
Internal training has been increasingly used for specific topics, especially for project management practices, materials, quality management, occupational health and safety, fire protection and, recently, preparation of personnel for work in foreign NPPs in accordance with internally developed procedure. The latter comprises of lectures on: Fitness for Duty, Station Organization & Administration, Nuclear Power Plant Overview, Nuclear Security, Industrial Safety, Fire Protection, Quality Programs, Site Specifics, Radiological Orientation, Nuclear English, etc. Internal assessments are provided after the training to verify the knowledge gained.

On-the-job
This is one of most widely used practices for training of NUMIP's personnel and it requires appropriate mentoring. It is becoming really important as groups of our workers are gaining new skills and experience through work in foreign NPP's, mostly in the USA and France. Strong cooperation with big players at the domestic plant also provides opportunities of gaining new knowledge and skills. On-the-job training, especially through work in foreign NPPs is considered to be an important prerequisite for future participation in new plant constructions.

Apart from the training and education described above, NUMIP plans to focus on the following to keep increasing its competences in the future:
- Use training capabilities and mock-ups of big players for different purposes;
- Employ graduates from a Nuclear Engineering program at the new Slovenian Faculty of Energy Technology;
- Send engineers to post-graduate programs, such as ENEN MSc in Nuclear Engineering;
- Convey the message to the government that the competent nuclear support industry is in the nation's best interest regardless of its ownership.
- Promote the need for an educational program for European Nuclear Technician (like European Maintenance Technician, financed by Leonardo da Vinci program).
- Provide as much services as possible to foreign NPP's in order to maintain and develop knowledge and skills.
- By participation in foreign new plant constructions raise resources in nuclear field and prepare for a new unit construction in Slovenia.

5. Training and certification services of NUMIP's daughter company

Q Techna Ltd., a 100% owned daughter company of NUMIP, has been active in the nuclear power plants since its establishment. Key activities performed are inspections and non-destructive examinations. When preparing for the accreditation for the SIST EN ISO/IEC 17025, level III personnel were needed for all accredited NDE methods. For that reason, the first group of experienced inspectors went to Germany for additional training and certification. Recently, Q Techna has become the first accredited institution for NDE in Slovenia. Simultaneously, it became obvious, that our country lacked an appropriate personal training and certification system, even though the demand was increasing. Consequently, Q Techna decided to establish its own training and certification centre providing personnel training and certification in accordance with European (EN 473) and American (CP-189) standards. The programs are delivered in Slovenian language and lay a lot of emphasis on nuclear specifics which in Slovenia mostly refer to ASME B&PV Code. For certification purposes, Q Techna continues cooperation with its German partner. During the last six years, over 500 individuals passed training and certification in their centre. It is a great advantage that Q Techna can request experts it has certified for support in execution of large plant outage projects. This is a guarantee that contracted personnel are also knowledgeable of nuclear specifics. Such scheme had practically been impossible before the centre was formed. Q Techna permanently follows new requirements of codes and standards. In the future, it plans to put more emphasis on specifics related to maintenance of different plant components and to constructions of new NPPs. The latter inevitably introduce new inspection requirements. Further, new training programs are planned to be developed for inspection of mechanical components. One of the main obstacles for faster development of these is lack of certification schemes which may also change in the future.

6. Conclusion

The fact that “nuclear is different” is well understood by most of the players in nuclear industry. This is also crucial for service providers and they have to organize their education and training accordingly. Taking into account that human and financial resources, together with availability of appropriate training programs are limited, the organizations have to make smart decisions as to what trainings and education to choose. The case described in the article shows how a relatively small company can make quite a significant effort despite a narrow domestic nuclear market.

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COMPREHENSIVE EDUCATION AND TRAINING ACTIVITIES AT JAEA NUCLEAR TECHNOLOGY AND EDUCATION CENTER

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Nuclear human resources development (HRD) in Japan has been identified as one of the most important issues these years in nuclear society, mostly due to the decrease of nuclear engineers in industries and students in universities, and to the difficulties of technical transfers. Nuclear Technology and Education Center (NuTEC) at Japan Atomic Energy Agency (JAEA) aims at comprehensive nuclear education and training activities, which cover 1) education and training for domestic nuclear engineers, 2) cooperation with universities and 3) international cooperation. The main feature of NuTEC's training programs is that the curricula places emphasis on the laboratory exercise with well-equipped training facilities and expertise of lecturers mostly from JAEA. The wide spectrum of cooperative activities have been pursued with universities, which includes newly developed remote-education system, and also with international organizations, such as with FNCA countries and IAEA.

1. Introduction

Nuclear human resources development (HRD) in Japan has been identified as one of the most important issues these years in nuclear society, mostly due to the decrease of nuclear engineers in industries and students in universities with the coming peak of replacement of nuclear power reactors around 2030, and to the difficulties of technical transfers between old and young generations. The council on Nuclear HRD among industries, government and universities has been established in September 2007 to investigate mid and long term HRD strategy in Japan. Nuclear Technology and Education Center (NuTEC) was established as HRD division in 1958 soon after Japan Atomic Energy Research Institute (JAERI) was founded in 1956. Japan Atomic Energy Agency (JAEA) established by the integration of JAERI and JNC in 2005 clearly identifies nuclear HRD as one of the missions. NuTEC's HRD activities are conducted in line with governmental policy(1) and programs(2), and aims at comprehensive nuclear education and training program. The main feature of the NuTEC's training program is that the curriculum places emphasis on the laboratory exercise using well-equipped training facilities at JAEA and expertise of lecturers mostly of JAEA(3). NuTEC is aware of the social needs in nuclear HRD and updates its training programs in response to these needs, which include cooperative activities with universities, international training with Asian countries and international cooperation under the scheme of FNCA and IAEA.

2. Education and training for domestic nuclear engineers

There are 3 categories of training for domestic nuclear engineers; courses for radioisotope and radiation engineers, nuclear reactor engineers and national test examinees. Thoroughly-studied lectures and specially prepared texts are used in each of the courses. Technical visits to related facilities including large-scale and advanced facilities, such as J-PARC, NUCEF, NSRR and HTTR, are arranged in most of the courses to enlarge trainee's experiences.

2.1 Training courses for radioisotope and radiation engineers

Training courses for radioisotope and radiation engineers first begun at the Radioisotope School situated in JAERI-Tokyo in 1958. At present, NuTEC provides 6 courses for radioisotope and radiation engineers. All of these courses aim on systematic acquisition of wide variety of knowledge and handling techniques of radioisotopes and radiation through lectures and laboratory exercises. In “Basic Radiation Course”, “Radiation Safety Management Course” and “Radiation Protection Basic Course”, participants learn subjects, such as radiation safety related law, biological effects of radiation, radiation measurement and safe handling of radioisotopes and radiation. The other 3 courses; working environment expert course and 2 radiation protection supervisor courses are legal qualification courses, in which the participants are entitled to obtain a license after the completion of the courses. The current status and total number of participants from each course are shown in Table 1. The accumulated number of participants is more than 14,300 (as of JFY 2007).

Table 1 Training Courses for Radioisotope and Radiation Engineers

Name of Course	Period	Accepted number/time	Frequency	Total number of participants until FY.2007
Basic Radiation Course	15 days	12	Once/year	8,225
Radiation Safety Management Course	14 days	12	Once/year	308
Radiation Protection Basic Course	4 weeks	12	Once/year	200
1st Class Working Environment Expert Course	2 days	16	Twice/year	587
1st Class Radiation Protection Supervisor Course	5 days	32	8 times/year	4,851
3rd Class Radiation Protection Supervisor Course (since JFY. 2006)	2 days	32	3 times/year	143

2.2 Training courses for nuclear reactor engineers

The Nuclear Engineering School was launched at JAERI-Tokai in 1959. At present, 3 courses are provided for nuclear reactor engineers as shown in Table 2. The most significance of these courses is “Reactor Engineering Course”. Since 1959, it has contributed in training nuclear reactor engineers for nuclear power plants, nuclear facilities and research institutes. This course provides comprehensive knowledge of nuclear engineering, nuclear fuel engineering, radiation management and related regulations and laws through various lectures, laboratory exercises and facility visits. Other 2 courses are available as introductory courses: “Nuclear beginners Course” broadly guides through the field of atomic energy, “Introductory Neutron Experiment Course” provides fundamental knowledge required for the use of neutrons, and to familiarize the trainees to its application technology towards the use of J-PARC. The accumulated number of participants is more than 3,000 (as of JFY 2007).

Table 2 Training Courses for Nuclear Reactor Engineers

Name of Course	Period	Accepted number/time	Frequency	Total number of participants until FY.2007
Nuclear Beginners Course	4 weeks	24	Once / y	1,108
Reactor Engineering Course	3 months	12	Twice / y	1,888
Introductory Neutron Experiment Course	3 days	16	Once / y	95

2.3 Training courses for national test examinees

There are 4 courses in preparation of national examinations; “Licensed Reactor Techniques supervisor”, “Professional Engineer on Nuclear and Radiation”, “1st Class Radiation Protection Supervisor” and “Nuclear fuel Protection Supervisor” as shown in Table 3. The training aims at systematic acquisition of knowledge and consists mostly of lectures. Every course contains subjects on its related law/ordinance/regulations. Past examinations are analyzed and mock examinations are conducted in some training courses. Participants are from electric utilities, nuclear fuel handling plants, RI/radiation handling facilities including staffs from JAEA. The accumulated number of participants is more than 2,300 (as of JFY 2007).

Table 3 Training Courses for National Test Examinees

Name of Course	Period	Accepted number/time	Frequency	Total number of participants until FY.2007
Licensed Reactor Techniques Supervisor	10 days	20	Twice / y	1,864
Professional Engineer on Nuclear and Radiation	10 days	32	Once / y	16
1st Class Radiation Protection Supervisor	6.5 days	30	Once / y	232
Nuclear fuel Protection Supervisor	7.5 days	25	Once / y	196

3. Education and training for JAEA personnel

NuTEC conducts 39 courses for JAEA Personnel. These courses are off the job-site training (OFF-JT) and are provided to compensate on the job-site training (OJT). There are 2 categories of courses; safety training courses (13 courses) and nuclear engineering training courses (26 courses), and these courses can be participated stepwise from fundamental courses to application courses. The fundamental courses are designed as basic and necessary training for recruits and primary-grade engineers of nuclear facilities, such as, “Radiological measuring training course” and “Nuclear fuel cycle engineering course”. On the other hand, the application courses are designed as skill-up training for expert engineers, such as “Safeguard course” and “Reprocessing engineering course”. All these courses have special features, i.e., 1) very short period, 2) practicable, 3) open for anyone from 15 JAEA sites (about 4,000 personnel). About 50,000 s have attended these training courses since 1980.

4. Cooperation with universities

4.1 Cooperation with Graduate School of University of Tokyo

In response to the recent expanding needs in the nuclear field, the University of Tokyo has established a new system in 2005 for the nuclear education by setting up two graduate schools; Nuclear Professional School (NPS), and Department of Nuclear Engineering and Management (DNEM). The former is a one-year education system to produce specially qualified engineers in the nuclear field. As NPS is located next to JAEA Tokai, JAEA has a close and wide-range cooperation in the education of NPS students through NuTEC. JAEA dispatched 5 visiting professors and about 60 lecturers for the lectures in 2007, which covered about 60% of all lectures in this school. Around 90% of the experiments in this school are conducted with JAEA facilities instructed by JAEA researchers and engineers. The number of experimental instructors dispatched from JAEA was about 60 in 2007. The education program of DNEM is performed in Tokyo for the graduate students for 2 or up to 5 years. JAEA dispatched 4 visiting professors to DNEM in 2007.

4.2 Cooperative Graduate School Program

Under an education system provided by MEXT (Ministry of Education Culture, Sports and Science), NuTEC has been cooperating with many graduate schools based on the agreements between JAEA and each university. Currently JAEA has cooperation agreements with 14 graduate and one undergraduate schools. Totally 53 JAEA researchers were dispatched as visiting professors or associate professors to each university in 2007. JAEA also accepted about 20 students from these universities for nuclear studies.

A new remote-education system, called Japan Nuclear Education Network (JNEN), has initiated in April 2007 under the cooperation framework among JAEA and 3 universities. JNEN is a multi-directional education system connecting the remote sites of the participating universities and JAEA through Internet. Many kinds of lectures are available through the system at real time. In the first year, 2005, the special agreement for JNEN was signed among JAEA and three universities; Kanazawa University, Tokyo Institute of Technology, and Fukui

University. Through JNEN students of each participating university can take lectures from different universities or JAEA, such as reactor engineering, fuel reprocessing and geological disposal of nuclear wastes. A lecture on the basic nuclear-chemistry from Tokyo Institute of Technology, for example, was distributed to other two universities, and about 50 students in 3 universities took the lecture at each university simultaneously, as illustrated in Fig. 1. Under this program, some experimental courses were also performed using JAEA nuclear facilities to strengthen the effect of the nuclear education by JNEN. The experiments included handling of actual nuclear materials. Such experiments are considered to be highly important and valuable to the participating students. Two universities are scheduled to join JNEN in 2008, and some more are expected to join in the coming years.

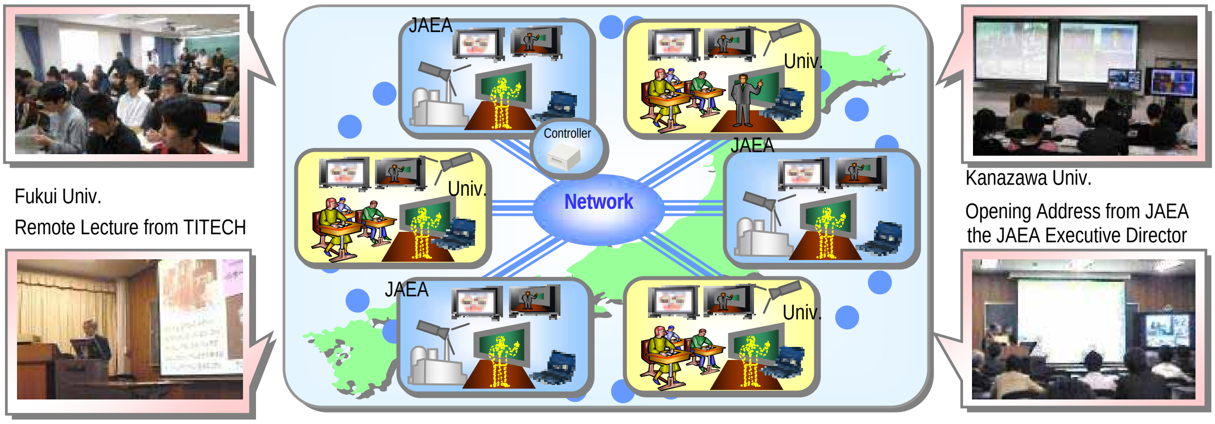

Fig.1 Concept of JNEN Remote Lecture System

4.3 Cooperation with Nuclear HRD Program

A new nuclear HRD Program consisting of 6 subjects has been initiated in May 2007 by MEXT and METI (Ministry of Economy, Trade and Industry) of Japan to support universities and colleges in the education of nuclear engineering and science. For the first year, the programs from 35 universities and 8 technology colleges were adopted, and about half of those universities/colleges expected some kind of cooperation with JAEA, such as dispatch of lecturers, use of nuclear facilities and facility visits. NuTEC has supported in the arrangements to meet these needs.

5. International cooperation

Soon after its foundation, NuTEC organized an international training course, the UNESCO Isotope Training Course, in 1958. NuTEC continued to conduct International Basic Courses for Radioisotope and Radiation for Asian countries, which were completed successfully in 1971 for the utilization of radioisotopes. From 1977, under the sponsorship of MEXT, NuTEC has been conducting International Atomic Energy Safety Technology Training Project to strengthen the training system of nuclear engineers in Asian countries. For the safe utilization of nuclear energy, the project includes three training programs: Instructor Training Program (ITP), Joint Training Course (JTC), and Safeguards Training Course.

5.1 Instructor and Joint Training Courses

NuTEC has been conducting two kinds of training course; Instructor Training Program (ITP) and Joint Training Course (JTC) as more effective and efficient method for developing instructors in a self-sustainable manner for certain Asian countries. ITP is a training program held in Japan to train the instructors who are to be enrolled in JTC, which is held in the partner’s country (Fig.2). To develop teaching ability and techniques as an instructor, several participants are first invited to NuTEC to join the ITP for 4 to 6 weeks. They will learn teaching techniques that match their countries’ needs and then join the JTC as co-instructors with NuTEC’s instructors. Through this system, participants accumulate training experiences in

JTC in their own country to become main instructors. After four-year JTC, the same course named Follow-up Training Course (FTC) is repeated for four more years to ensure its self-sustainability.

Up to now, ITP and JTC had been conducted bilaterally with Indonesia from 1996, Thailand from 1996 and Vietnam from 2001. The theme of the courses is based on the needs in the steering committee meeting held between each country, but all the courses place emphasis on the laboratory exercise with well-equipped training facilities at JAEA and with key-equipments implemented in each country. We believe that the laboratory exercise is essential for the supply of high quality training course. Indeed, the combination of ITP and JTC has proved very effective in technology transfer and stable enrolment of lecturers. The percentage of enrolment of ITP trained instructors is 70 to 92% in those countries. Also, due to the development of self-sustainable instructors, there has been various extended effects, such as development of local young lecturers, development of a new training course and contribution for educational and research activities using supplied training equipments.

Fig.2 JTC in Thailand

5.2 FNCA related activities

Since 1999, NuTEC has organized a workshop to promote HRD activities in Asian countries under the framework of FNCA (Forum for Nuclear Cooperation in Asia) (4). Currently the project focuses on ANTEP (Asia Nuclear Training and Education Program) activity, a network system by utilizing existing nuclear training and education resources in 10 member states, i.e., training and education programs, nuclear research facilities and experts to meet each country's HRD needs. It was agreed at the FNCA Panel Meeting "Study Panel for Cooperation in the Field of Nuclear Energy in Asia" in Tokyo, 2007 that sharing relevant information among FNCA member states on HRD toward nuclear power is important and recommended that information exchange and cooperation on HRD be enhanced by effectively utilizing the FNCA web-site as the first step. This was approved at the Coordinators Meeting in March 2008(5). At present, information on the ANTEP needs with its priority are being updated/uploaded and the results for its possible matching between needs and programs are shown on the FNCA HRD web-site (Fig.3). (http://www3.tokai-sc.jaea.go.jp/nutec/fnca/fnca.htm)

Fig.3 FNCA-HRD website for ANTEP

5.3 Cooperation with IAEA

NuTEC has been organizing safeguards training courses once every two years and contributing to ANSN (Asian Nuclear Safety Network) in close cooperation with IAEA. The Safeguards Training Course invites about 10 trainees from the countries concluding a safeguards agreement based on the non-proliferation treaty for 2 weeks to join the intensive on-the-job training consisting of safeguards technology in Japan, IAEA safeguards technology, supplementary protocol, IAEA system of accounting and physical protection. The course place emphasis on practice, discussion and laboratory exercises to enhance understanding. The selection of trainees and lecturers are conducted in close cooperation with IAEA (Fig.4).

Fig.4 Classroom Lecture

The Asian Nuclear Safety Network (ANSN) activity has started in 1977 as an Extra Budgetary Program of IAEA supported by Japanese government. ANSN aims to strengthen nuclear safety of nuclear power plants and research reactors in this region by pooling and sharing existing and new technical knowledge and practical experiences for the Asian nuclear facilities of today and future. Within this framework, an Internet-accessible database has been set up and operated by the Education and Training Topical Group, with a hub center organized by Japan Nuclear Energy Safety. NuTEC, in cooperation with Radiation Application Development Association in Japan, has contributed to the ANSN activities by providing the database with a variety of information in the field of nuclear safety.

6. Summary

In a situation that we are facing the "Nuclear Renaissance" ahead worldwide, NuTEC at JAEA aims at comprehensive nuclear education and training activities in response to the domestic and international needs. The main feature of NuTEC's training program is that the curricula places emphasis on the laboratory exercise with well-equipped training facilities and expertise of lecturers mostly from JAEA. The wide spectrum of cooperative activities have also been pursued with universities, which includes newly developed remote-education system, JNEN, and with international organizations, such as with FNCA countries and IAEA. The accumulated number of trainees to date amounts to almost 110,000 (Japan:54,500, JAEA personnel:52,700, international: 2,550). With more extended and close cooperation with domestic and international organizations, NuTEC's HRD activities will hopefully and further be conducted in more effective and efficient manner in future.

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SKILLS RENEWAL IN THE NUCLEAR INDUSTRY

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ABSTRACT

The ageing workforce is a concern for the entire nuclear industry at a time when environmental issues such as low-carbon electricity generation are the focus of much public preoccupation. The development of a new electricity generation mix including the building of Gen III NPPs is one of the solutions.

The recruitment of a significant number of young engineers will be required for these future projects and to replace the employees who are approaching retirement.

EDF is now developing and sponsoring, jointly with French and non-French universities and "*Grandes Ecoles*" a major education programme focused on an International Masters Degree dedicated to Nuclear Energy, open to French and non-French students.

During a two-year programme, students will follow a foundation course in nuclear energy, before specialising in different fields such as Engineering, Operations, Decommissioning, Waste management, and the Fuel cycle.

This programme will start in September 2008.

1. Introduction

1.1. The energy context

2007 saw increased awareness of the fact that:

- Energy is becoming a rare and expensive commodity, with the oil price sustainably above $100 a barrel, involving potential consequences for the competitiveness of economies and energy supply security.
- Tackling climate change will be one of the major challenges of the XXIst century.

Global energy needs are increasing just as fossil-fuel resources are reaching depletion: oil companies such as Total forecast peak oil, after which oil production will decline, during the next decade, which is to say tomorrow. Peak gas will follow around twenty years later.

In electricity, International Energy Agency (IEA) forecasts show a need for massive investment over the 2000-2030 period, involving the construction of 660 GW in Europe, where the period of overcapacity is now well behind us, 850 GW in North America and 800 GW in China.

Never before has there been such an opportunity to rethink our primary energy choices. Choosing where to focus will need to take into account three key factors:

- the price of resources
- the security of supply
- the preservation of the environment and, particularly, the reduction in greenhouse gas emissions.

The taking into account of the first two criteria has forced many players to revise their plans to use gas for electricity generation. Some are turning to coal but may be deterred by its high carbon emissions, since CO2 capture/sequestration technology is currently only expected move into the industrial phase towards 2030.

Nuclear is profitable in current fossil conditions. In addition, renewable energies and Energy Saving have a direct impact on the saving of resource. However, unless there is a significant technological breakthrough such as the storage of electricity, renewable energies, which have a low level of concentration and provide only intermittent supply, are likely to remain only limited back-up solutions.

Fissile energies are currently the only technologies which enable the use of fossil energies to be reduced. The medium and long-term forecasts from the IEA suggest that all methods of energy generation will be needed to meet demand. Nuclear will very probably be part of the solution in many countries.

Nuclear has considerable advantages. Only 5% of the cost relates to uranium ore with the rest geared to processing. It is thus, stable, predictable and has a low level of sensitivity to fluctuations in international commodity prices or the dollar.
It is the only thermal energy to generate large quantities of electricity, at a reasonable cost, without greenhouse gas emissions.

The IPCC[1]-GT III report, published on 4 May 2007, takes a positive view on nuclear in the summary for decision-makers. The EU Council meeting of 8 and 9 March 2007 concluded that "the European Council notes the Commission's assessment of the contribution of nuclear energy in meeting the growing concerns about the safety of energy supply and CO2 emission reductions." These points were reiterated in the closing speech at the World Energy Council chaired by Pierre Gadonneix, Chairman and CEO of EDF, on 15 November 2007 in Rome.

1.2. The international situation

First Finland, then France and, more recently, China have decided to build EPR reactors.

In the United States, the NRC has renewed its authorisation process and the Energy Policy Act of 2005 introduced significant financial incentives. Power plant projects have been announced. The implementation of a new policy for the reprocessing of spent nuclear fuel (GNEP) is an additional supporting factor.

The British government has announced the role of nuclear in the renewal of the existing generation assets in the United Kingdom. Different reactor types have satisfied the licensing process.
Large countries such as India and Brazil have included nuclear in their planning for energy generation.

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[1] Intergovernmental Panel on Climate Change

In Asia, in addition to China and India, Japan and Korea are continuing their programmes to build nuclear power plants.

In France, 80% of electricity generation is from nuclear (86% of EDF generation) while, in Europe, this technology is responsible for more than one third of electricity.

For the past thirty years, EDF has operated pressurised water nuclear reactors, whose obligations and advantages are well known. The operating obligations include the safety of individuals, the safety of the facilities and the transparency of information. If nuclear is properly managed and controlled, as it is in France, it may be considered one of the safest sources of energy.

2. Bottlenecks

If we leave aside mineral resource capacity which is currently artificially depressed (40 to 50 years) due to the lack of prospecting over the past 15 years, industrial companies point to two main bottlenecks:

- The availability of large-scale forges

Currently large-scale forged components (particularly nozzle support rings) are manufactured in Japan, with significant constraints on manufacturing lead times and risks of non-negligible delays in the event of faulty manufacturing. Boiler manufacturers are looking at a number of options (new factories, etc.) which will need to be combined, for financial reasons, with the appropriate localisation of the factories, taking into account the marked depreciation in the dollar relative to the euro.

- Skills renewal

In most countries, the nuclear power plants were built and commissioned over a short period, mainly between 1970 and 1985. The Chernobyl accident put this technology on hold for around twenty years.

Employees recruited by the nuclear industry during this period are now approaching retirement and must be replaced in terms of both their number and skills. Recruitment will need to be increased in order to build and operate the new power plants planned by many countries.

Thus, in France, we estimate that 40% of the engineers and executives in this industry will retire over the next decade. During this period, we are going to have to recruit around 1,200 engineers annually, including 500 per year for EDF.

In France, as in many countries, engineering recruitment has been at a very low level over the past 15 years. As a result, training opportunities in engineering schools, technology institutes and universities have been cut back. Furthermore, given this reduced demand for engineers, teaching positions have not been renewed and only a few qualified individuals remain, most of them relatively advanced in years.

Finally, the most able students have turned to professions other than technical: in France, some 30% of engineering graduates have opted for careers in banking, trading, insurance and consultancy (2006 APEC figures).

3. Skills renewal in the nuclear industry

A detailed mapping exercise of engineering training in the nuclear field was carried out in 2007 by the High-commissioner for Atomic Energy (French CEA) on behalf of the French government. It highlights the need to increase the number of training opportunities. Capacity in France is currently slightly above 300 graduates per year and can be rapidly increased to around 900, which is still not enough to meet French needs (1,200 per annum, see above).

In order to support this growth and meet requirements in France but also internationally, EDF has engaged in some major initiatives in this area, supporting and participating in the development of a number of programmes:

3.1. Engineering training

EDF is supporting engineering school final year specialisations in energy and particularly nuclear. The curricula have been developed or strengthened in numerous schools, most of which will be operational in autumn 2008.

Sensitive areas such as operating chemistry, safety and radiation protection will be the subjects of new specialisations.

The development of apprenticeship internships is being encouraged.

The strengthening of Atomic Engineering (French GA) staffing by the National Institute for Nuclear Science and Technology (INSTN) is already underway. This specialist training for French and non-French engineers will see the number of students increase from 45 to 150 individuals per year over a four-year period.

3.2. Specialised Masters Courses (Post Master Professional certificate)

A number of specialised Masters courses (one year Post Master specialist training) will be operational as of the autumn of 2008 with the support of EDF. For example:

- Nuclear safety from design to operations, including the transport of nuclear materials and waste.
- Nuclear engineering and the chemistry of the fuel cycle.

This training is intended for a more limited number of students (both French and international). Industrial companies will be able to recruit the future experts they require from amongst these students.

3.3. “Nuclear Energy” International Masters

EDF is supporting the creation of a "Nuclear Energy" International Masters with numerous partners in the academic world:

- A number of engineering schools: *Ecole Polytechnique*, *Ecole des Mines de Paris*, *Ecole Nationale des Ponts et Chaussées*, ENSTA, *Ecole nationale des Arts et Métiers*, *Ecole de Chimie de Paris* (regrouped within *ParisTech*), *Ecole Centrale Paris*, *Supélec*
- *Université de Paris-Sud* (Orsay)
- INSTN

This high-level training is aimed at French or non-French students holding a Bachelors degree in a scientific subject.

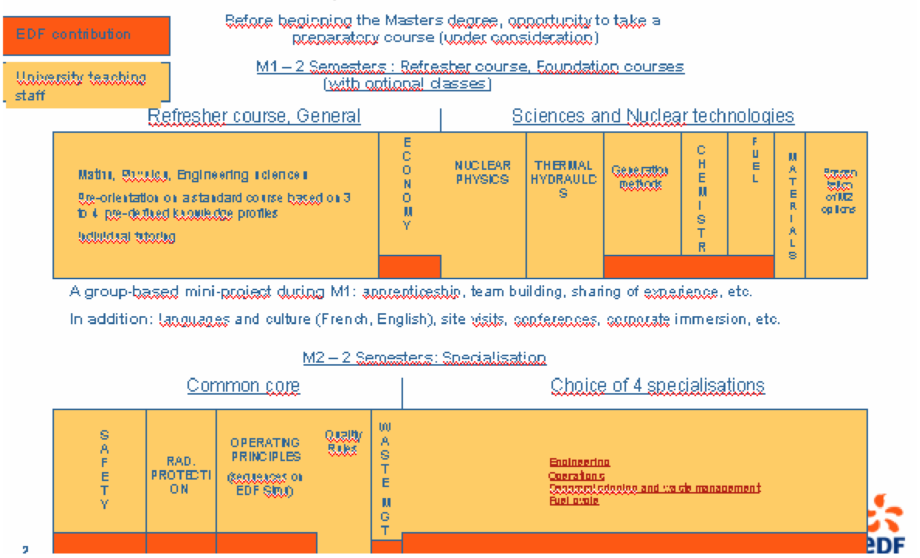
Lasting for two years, the course will give participants all the knowledge they require to pursue a successful career in the nuclear industry.

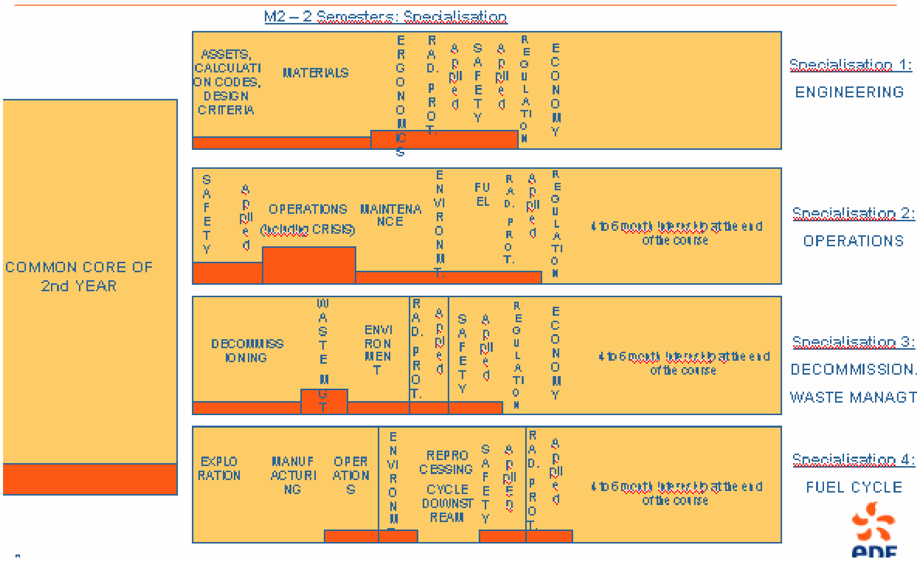
In order to foster the international dimension of this programme, the classes will be conducted in English.

The curriculum will be based on around 1,000 hours of training, organised in four major phases:

- Personalised refresher courses at the beginning of the programme
- Coursework to acquire a foundation in nuclear science and technologies
- Applied knowledge (safety, radiation protection, etc.), focusing on the transverse and systematic understanding of the nuclear industry
- Specialisation in a major area with a choice of options: engineering, operations, decommissioning and waste management, fuel cycle.

An internship in the industry and the submission of a Masters thesis with a view to securing the diploma will end the programme.
The overall framework is presented below:





Part of the programme will start in September 2008 (capacity 50 students) and the programme will be fully operational in autumn 2009 (200 students).

EDF will make grants available to non-French students in order to enable them to follow this programme in the best-possible conditions and to begin their career within the EDF Group (parent company and subsidiaries or affiliates).

3.4. Support for these programmes

In addition to active participation in the development of these curricula, EDF will provide support in various ways:

- Creation and financing of teaching and research professorships linked to certain areas of the International Masters,
- Award of grants to French and non-French students,
- Increased internship opportunities and thesis proposals,
- Increase in the number of EDF employees giving courses in engineering schools and universities,

- Availability of EDF “full scope” simulators to students in these programmes who will be able to take "discovery" courses,
- Closer relations with schools and universities and with students in order to highlight career opportunities in nuclear energy.

4. European Foundation for Tomorrow’s Energies

All these initiatives will be the responsibility of the "European Foundation for Tomorrow's Energies" which has just been created by EDF with a view to developing training and research dedicated to renewable and sustainable energies, including, of course, nuclear.
This Foundation is under the aegis of the *Institut de France* whose scientific authority is renowned worldwide.

With an initial annual budget of €5 million, this Foundation will provide the funding critical to the success of these programmes, particularly the International Masters.

With a prestigious Scientific Advisory Council, the foundation will organise international events on "low carbon" energy issues, including decentralised generation.
It will award an annual “International Prize for Tomorrow's Energies”, in recognition of an individual or group of individuals’ contribution to a significant advance or educational initiative in this field.

ASSESSMENT OF THE 2007 WNU SUMMER INSTITUTE

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ABSTRACT

An assessment of the 2007 World Nuclear University Summer Institute (WNU-SI) held in Daejeon, Korea from 14 July through 24 August 2007 was carried out by Fellows and Mentors. Three different assessment components were completed using the 2007 WNU-SI website during the six weeks of the Institute: (1) Assessment of each Lecturer & lecture topics (2) Assessment of Mentors and (3) Post-Institute assessment of the entire Summer Institute. The questionnaires consisted of yes-no questions, some multiple choice, and open-ended questions. This paper details the process and results of the assessment, leading to findings and recommendations for future WNU-SI programmes.

1. WNU Summer Institute 2007

The World Nuclear University Summer Institute 2007, held in Daejeon, Korea from 14 July through 24 August 2007, produced yet another major success in exposing an elite group of young nuclear professionals to the global aspects of nuclear technology. Following the highly successful WNU Summer Institutes held in Idaho Falls and Stockholm in 2005 and 2006, respectively, the 2007 event drew 102 Fellows from 35 countries; the highest number of participants so far.

The purpose of the Summer Institute is to provide a unique educational experience aimed at building future global leadership in fields of nuclear science and technology from among promising young nuclear professionals [1]. To this end, the Summer Institute is designed to enable participants to

- Gain awareness of cutting-edge knowledge and broad international perspective on issues related to peaceful applications of nuclear technology
- Hear from leading thinkers and educators on topics relevant to nuclear applications
- Experience practical teamwork and establish lasting bonds with peers from many nations
- Be inspired to commit themselves to advancing the global contribution of nuclear science and technology.

The 2007 programme was designed to achieve the Summer Institute goals, and consisted of many components, including:

- ***Lectures*** by international experts on a variety of issues that will influence the future use of nuclear technologies
- ***Team Building Activities*** designed to initiate and enhance relationships and teamwork among Fellows
- ***Small Working-Group (Breakout) Sessions*** led by Mentors to promote sharing of differing perspectives and to discuss major ideas/issues presented by the lecturers.
- ***Case Studies*** in nuclear law, safety culture, radiation effects and radiological protection, knowledge management and public communication on nuclear issues.

- ***Distinguished Speaker Presentations*** by persons who have made notable contributions in the nuclear domain, bringing ideas and information related to their achievements in the real world of nuclear energy, painting "big pictures" and encouraging the Fellows to think of an exciting career dealing with challenging issues.
- ***Global Issues Forum*** dealing with significant nuclear issues with international implications, including: Non-proliferation policy; reprocessing policy; limitation of fuel production and enrichment capacities etc. This provided an opportunity for self-directed intensive teamwork amongst the Fellows with Mentor guidance.
- ***Field Trips*** to several Korean nuclear and industrial sites, including Kori NPP, Wolsong NPP, Doosan heavy industries, Hyundai automobile plant, Pohang steel company plant, Pohang accelerator laboratory, National fusion research centre and Korea atomic energy research institute.
- ***Receptions, Social Events and Group Recreational Activities*** to encourage socialization and strengthen relationships among Fellows, Mentors, presenters and other Institute participants.

Participants are classified into four main groups:

- The 102 Fellows were from 35 countries with an average age of 32. Twenty-two per cent were female. The majority of the Fellows (66%) held an MSc or PhD degree in nuclear science or engineering, 7% were still pursuing a nuclear related PhD, and some have a non-scientific background, including law, business etc., but had some professional nuclear knowledge. 93% of the Fellows were professionals.
- The 14 Mentors were experienced, internationally diverse senior level professionals in the nuclear field, facilitated the working-group (breakout) sessions, which comprised groups of about ten Fellows from different countries.
- The 34 Lecturers made presentations on the following areas:
    - Global settings: World energy demand and supply, climate change, clean water shortage, global emission reduction, nuclear technology in sustainable development, and a survey of nuclear politics;
    - International regimes: Safety standards and global safety culture, safety and security; non-proliferation and safeguards, radiation effects and radiological protection, waste management, decommissioning, and nuclear transport;
    - Nuclear industry operations: Nuclear excellence and operational focus, risk assessment, industry economics, nuclear fuel market, and public communication;
    - Technology innovation: Next generation nuclear reactors, advanced fuel cycle, new technologies including hydrogen and fusion, non-nuclear technologies, and space applications.
- The 15 Distinguished Speakers were leaders in nuclear and related fields, spoke in a very direct and informal way with the Fellows.

2. Assessment Process

The assessment process was designed to gain as much information as possible with a view to better understanding what worked well and what needed to be improved, and to making future WNU offerings even more effective.

Three different assessment components were completed by 102 Fellows and 14 Mentors using the 2007 WNU-SI website (www.2007wnu-si.org) during the six weeks of the Institute: (1) Assessment of Lecturers and lecture topics (2) Assessment of Mentors and (3) Post-Institute assessment of the entire Summer Institute. Fellows and Mentors carried out the assessments using on online mechanism.

The questionnaires consisted of yes-no questions, some multiple choice, and open-ended questions. A four-point Likert scale [2] was used in the multiple-choice questions of the post-Institute assessment. Answers to open-ended questions were categorized using qualitative data analysis technique [3].

The summary data and analysis results regarding the value and effectiveness of the 2007 WNU-SI were obtained using quantitative and qualitative analysis. All the assessments carefully have been analysed, the findings and recommendations are discussed for the next SI.

3. Assessment Results

3.1 Lecturer & Lecture Topic Assessment

Most Fellows and Mentors provided their responses on the SI website soon after the lecture during five of the six weeks of the institute. One week was a technical tour. The average number of respondents was 99 for Fellows (out of 102) and 12 for Mentors (out of 12). The questionnaire consisted of the following yes-no questions and gave opportunity for comments for every Lecturer and lecture topic. The average "yes" response followed the question:

- Do you recommend that the Lecturer come to the WNU SI next year? (90% Fellows and 80% Mentors)
- Do you recommend the topic for WNU SI next year? (94% Fellows and 92% Mentors)

Table 1 shows the number of Lecturer & lecture topics whose ratings fall within each percentile band. The number who received affirmative responses of more than 70 per cent is 34 for Fellows and 27 for Mentors. Concerning lecture topics, the figure is 37 for Fellows and 33 for Mentors. The results will be used as the basis for inviting Lecturers and to choose lecture topics at the next Summer Institute.

Table 1. Number of Lecturers & lecture topics in the values of the yes response score (The total number of Lecturers and lecture topics is 37)

Yes response score (%)	Number of Lecturers		Number of lecture topics	
	Fellows	Mentors	Fellows	Mentors
90 -100%	27	21	31	30
80 – 89%	4	5	4	1
70 – 79%	3	1	2	2
60 – 69%	2	2	0	1
50 – 59%	1	4	0	3
40 – 49%	0	1	0	0
30 – 39%	0	2	0	0
0 – 9%	0	1	0	0

3.2 Mentor Assessment

The purpose of the Mentor assessment was to learn about the Fellows' perspective regarding the Mentor program and the effectiveness of their particular Mentor. Another purpose was to enhance future Institutes. The survey consisted of four statements, to which you could respond "always or sometimes" and two "yes-no" questions. There was also an opportunity for comments: and comments as follows:

- My mentor is easy to talk to… (90%, always)
- My mentor encourages open discussions in the group (87%, always)
- My mentor listens respectfully to my ideas (92%, always)
- My mentor is a good coach for the group (77%, always)
- Would you recommend your mentor to come back to next year's WNU Summer Institute? (93%, Yes)
- Was the mentor program of value to you personally? (90%, yes)

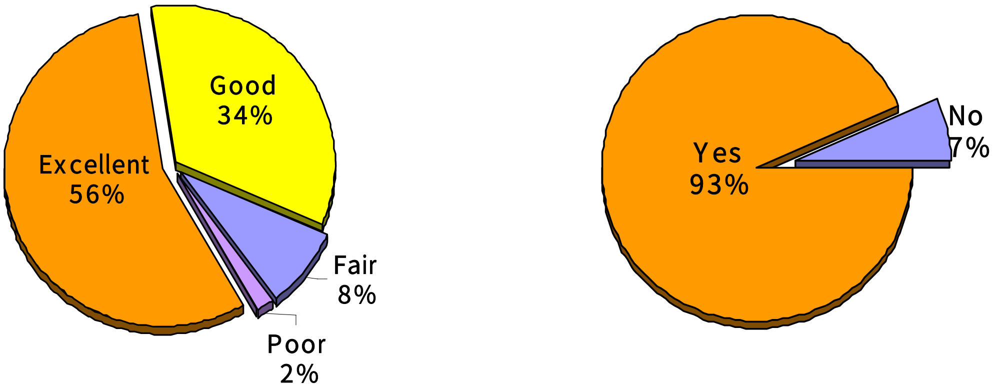
It is noticeable that Fellows answered "always" in over 75% of Fellows. Ninety-three per cent of Fellows were happy to recommend their Mentors to come back to next SI. It also is noteworthy that ninety per cent of those responding said the mentor program was of value to them personally.

According to the comments, some Fellows thought Mentors should be more proactive in making Fellows explore their own ideas, and reduce their involvement during discussion; on the other hand, some Fellows wanted Mentors to join fully Fellows' discussions and to share their experience and knowledge. The balance between supporting is clearly difficult one to maintain. Overall, however, the data obtained supported the strong impression of those who participated in the Institute that the mentor program was an important and valuable component of the Summer Institute.

3.3 Post-Institute Assessment

The questionnaire consisted of 14 main items; 39 multiple-choice questions, 10 yes-no questions and 39 open-ended questions. The 14 main items covered in the post-Institute assessment are as follows:

- ***Local Organisation:*** Hotel, WNU staff on-site services, Social and cultural activities, Special Korean lectures, Internet access, SI web-portal
- ***WNU-SI 2007 Programme:*** Announcement, Communication with Fellows before the SI, Objectives of the SI, The Mentors role in general, General Curriculum, Distinguished speakers, Technical tours
- ***Overall assessment:*** Overall assessment



(a) (b)

Figure 1. Average value of the post-Institute assessment results: (a) multiple-choice questions, (b) yes-no questions.

The total number of respondents per item ranged between 96 and 109 with an average of 104. In the Figure 1 (a) and (b), we can see that more than 90 per cent of the respondents evaluated the 14 items positively. This means the Fellows were satisfied or greater with almost all aspects of the Summer Institute.

There were some interesting findings based on data obtained:

- More than half of Fellows learned about this SI through their organisations, and 15 per cent of Fellows learned from previous Fellows.
- The Fellows' two main objectives in attending were to improve their knowledge and their understanding of global nuclear issues, and to network with Fellows professionals.
- Fellows thought the most useful aspect of the WNU-SI was providing opportunities of networking with Fellows, and a great understanding of global nuclear issues.
- Fellows wanted more lecture time on nuclear safety, public communication and reactor technologies, less time on nuclear law. Fellows also wanted to add lectures on safety,

anti-nuclear arguments and leadership; they also wanted more time on forum issue activity.
- Fellows wanted to have more free time to know each other and to have social room to talk.
- The WNU Summer Institute website was received a good evaluation. However while it is considered effective for getting and sharing information, some Fellows wanted an FTP site for large uploads and downloads.

There are some recommendations based on data from the assessment process.
- The SI should be targeted toward less experienced professionals.
- Distinguished Speakers' presentations should focus more on their work experience and lessons in leadership.
- During small group sessions, there should be less time reviewing lectures, and more time on activities.
- Put the FTP site on the SI website for large uploads and downloads.

The questionnaire helped to provide data on the 14 items that the Summer Institute organiser wished to assess. The data obtained will be useful when considering how much time and effort to expend on the various elements of the Summer Institute.

4. Conclusions

An assessment was carried out to obtain summary data and analysis regarding the value and effectiveness of the 2007 WNU Summer Institute. The Fellows and Mentors completed assessments of each Lecturer and Mentor and a post-Institute assessment of the entire Summer Institute. The data obtained was carefully analysed, the findings and recommendations were discussed for the next SI.

The assessment has shown that the goals of the SI were accomplished and the 2007 WNU Summer Institute was an outstanding success. Two key benefits to the Fellows have been stated repeatedly: (1) obtaining a much broader global perspective on many aspects of the nuclear field, (2) the opportunity to interact with international peers in the nuclear field that will lead to lifelong professional relationships and personal friendships.

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Improving Plant Performance through Improved Human Performance

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Introduction

The US commercial nuclear industry is, by almost all counts, a major success story. Safety levels and electric production are at unprecedented high and continue to exceed even high industry goals. Nuclear energy continues to keep the highest priority on performance improvement programs and highly trained/qualified people that maintain its record setting safety and reliability of operations. Along with this, recent political support has led the way for utilities to seriously consider the construction of new plants.

In spite of this, the current debate on nuclear energy continues to roil, making it more important than ever to make sure the industry continues to capitalize on its fine record of safety and efficiency that it has displayed over the last two decades. In fact, some who scan current articles detail the intensity of the debate on whether or not nuclear energy should be seriously considered as a partner in the war on global warming. Consequently, the more the industry can demonstrate a safe and efficient record, the stronger its position as a viable option to declining fossil fuels.

The resulting challenge is how to more effectively manage risk and improve performance even further in a generally high performing organization. Newer technology and more training by themselves are not the answer. Rather, the answer will lie in the human side of the organization and management's ability to tap into the unused potential of employee commitment and productivity. It is people who offer the greatest potential for organizational success. Given the fact that human performance has been demonstrated to yield higher rates of return than physical capital, it makes good business sense to determine how to encourage the behaviors in the workplace to manage the risk that will accompany efforts to boost the nuclear industry to new heights of excellence. This means effectively developing a performance improvement culture through identifying measurable performance indicators and determining how behaviors can best be influenced to improve those indicators. It also means seeing a culture of performance improvement and risk management as a strategic planning tool rather than a solution to a particular problem.

Description

One of the most effective ways to develop this culture of performance improvement and effectively managing risk is to apply the principles of Human

Performance Technology (1), or HPT, to the nuclear workplace. HPT is a relatively new field that has been emerging over the several decades. Its principles are derived from the research and practice of behavioral and cognitive psychologists, instructional technologists, training designers, organizational developers and various human resource specialists. Relying heavily on general systems theory as applied to organizations, HPT takes a systemic approach to risk assessment and performance analysis/ change as opposed to making piecemeal interventions which often happens in designing training programs intended to be the only fix specific short term organizational behavior problems.(Stolovitch and Keeps, 1999) Specifically, HPT methodology emphasizes examining any given problem in relation to the more global aims of the setting or environment within which the problem is identified. Its consistent driver is measurable performance and the structuring of elements within the system to improve and reward desirable performance and effective risk management. In general, HPT is more than another way to look at training, HPT is a systemized process that combines selection, analysis, design, development, implementation, and evaluation of programs to most cost effectively influence human behavior and accomplishment. (Brethower, 1999; Rosenberg, Coscarelli, and Hutchison, 1999; and Rummler, 1999) By taking a systems view of organizations rather than discreetly focusing on pockets of concern within an organization, it seeks to link the actions and interventions of all the organizational elements that affect overall performance. It does this through identifying, among other things, current performance levels, required performance levels for effective risk management, exemplary performance, and developing measurements for each step in the process. It examines such things as the external and organizational environments as well as the influences that directly impact individual performance.

Direct application to the nuclear industry is evident when considering the temper of the times. For nuclear organizations to stay viable performance improvement processes will have to be part of their culture in order to better manage risk and to achieve and maintain ongoing success. Greater plant performance will be directly related to greater human performance. To be successful, the nuclear industry, like any other organization, must clearly understand its purpose, structure itself to achieve that purpose, structure appropriate internal relationships, establish a realistic incentive/reward system, establish efficient work processes and assure knowledgeable and supportive leadership (Dean, 1999).

Conclusion

Using the principles of Human Performance Technology can provide a structure for helping the industry in general as nuclear facilities individually take steps to accomplish these goals. Taking strategic steps to develop these elements will result in higher levels of production efficiency, better risk management, higher customer service/satisfaction and an ability to successfully meet ever changing environmental and business demands. Human Performance Technology is proven effective methodology to help in the successful development of these strategic steps. This session will offer a discussion of the basics of HPT, as well as some specific examples of how it can be applied to nuclear facilities to effectively manage risk and drive enhanced performance.

1. Human Performance Technology (HPT) has its roots in what was the National Society for Programmed Instructions (now known as the International Society for Performance Improvement – ISPI). ISPI offers certification programs and its principles are currently supported by other professional organizations such as the American Society for Training and Development (ASTD) and the International Federation of Training and Development Organizations.

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