1. Introduction

The training cycle of nuclear power plant (NPP) operators has evolved during the last decade in parallel with the evolution of the training tools.

To cover the training needs with limited investment we will propose an optimization in terms of hardware configuration and software specifications of the equipment to be installed in training centers.

2. Training needs in nuclear power plant training center

Whereas simulators have been used for NPP operator training almost from the beginning, the simulators themselves have undergone a tremendous evolution.

In the today training cycles, simulators are used in different phases:

- basic principle learning;
- specific functional training;
- full operating range training;
- detailed accident analyses.

For each of these phases the purpose of the training has to be clearly identified and the training tools adapted to these specificities.

2.1. The need for simulators in basic principle learning

In basic principle learning, classical forms of teaching (such as class room lessons) have reached their limits.

The candidate operators gain a lot of insight by visualizing on a simulator the dynamic interaction between the main systems of the power plant.

At the same time, because of their lack of knowledge of the real control room, they require a simplified environment which represents the main systems of the power plant without the great amount of details inherent to a real control room.
2.2. The need for simulators for specific training on specific functions

The need for a specific functional training before passing on to a full scope simulator, has been felt in different countries, at least in the following cases:

- when the operators are to be trained on a full scope simulator which is not a replica of their own unit. In such a situation, they need specific training for the functions which are specific to their own unit.

- when systems present a high degree of complexity and therefore require a much deeper training compared with the other systems. In this situation, a part task simulator dedicated to those complex systems can save a lot of time on the full scope simulator. Whatever the specific reason might be, the use of part task simulators is, in general, an excellent preparation for the full scope training.

2.3. The need for simulators for full operation training

The training on a full scope simulator is, in many countries, a legal requirement. It is intended to train the operator in an environment which is as close as possible to his real control room.

The focus is directed toward training on plant specific operating procedures and related actions.

2.4. The need for simulators for accident analyses

Training on how to manage accident situations constitutes the most important part of the training program.

Certain degraded plant situations, combinations of failures and scenarios corresponding to situations which have occurred at generating plants elsewhere in the world can only be reproduced on simulators equipped with high precision codes.

Even though such codes can drive full scope simulators, it proves nevertheless interesting to install those codes on a basic principle training simulator environment.

In this environment, the operators have the opportunity to focus on the main phenomena, to display whatever parameter is required to master a deeper understanding of the system behaviour, and so doing to learn to quickly react based on intuitions more than on reflexes.
3. Modern tools for modern needs

The needs as exposed above show that today requirements in terms of training and engineering are growing very fast. The progress in simulation technology and man/machine interface (MMI) gives the training centers new opportunities to improve their training methods and effectiveness in the transfer of knowledge.

To take advantage of these new opportunities a significant investment in simulation tools may be required. It is therefore important to propose an optimized approach when dealing with the overall equipment program for these training centers. Many vendors are willing to take advantage of these new opportunities by proposing numerous types of products. An overall look of tools proposed on the international simulation market shows that there is a need for systematic approach in this field.

3.1. Existing tools versus user needs

The different type simulators existing in the market can be classified as follows:

• Basic Principle Simulators;
• Functional Simulators;
• Full Scope Simulators.

The point is to confront these tools to the needs of the users.

As previously exposed the four training phases require specific equipment:

• Basic principle learning require Basic Principle Training Simulator.
• Specific functional training require a Functional Simulator.
• Full operating range training require a Full Scope Simulator.
• Detailed accident analyses require a Basic Principle Training Simulator type of MMI with sophisticated models or a Nuclear Plant Analyzer type of simulator.

3.2. Equipment optimization in training centers

Since the objectives of a training center should ideally cover all 4 training phases, with limited investment, some optimization will be required in terms of the equipment to be installed.

The basic approach is then to identify the simulation software environment with which one can build up the models with a minimum of development cost and to design a hardware configuration with as many features as possible.
To reduce software development cost, BELGATOM has acquired the ABB simulation tool known as CETRAN. CETRAN is a bloc-structured interactive on-line simulation environment for real-time applications. Based on a large algorithm library CETRAN allows the engineering personnel, not familiar with real-time programming, to create his application by creating blocs associated with algorithms and creating his network by connecting the blocs together. This building process and its tuning can be performed on-line in real-time.

This modular approach allows the user to easily develop new sets of application with a considerable impact on his software development and maintenance cost.

The hardware configuration designed by BELGATOM is based on a micro computer, a graphic generator and CRT-based panels representing, through a retroprojection system, a real size panel. The images represented by the retroprojector are either replica representation of the plant panels, or procedure oriented figures or other optional graphic displays.

With this type of technology a single hardware configuration can cover all the applications:

- basic principle training;
- functional training;
- detailed accident analyses.

4. Conclusions

An investment as significant as that for a full-scope simulator can benefit from additions which make it more effective and which enable it to cover a broad field of training needs.

The addition of a multi-function approach can free the Full-Scope Simulator for operator training needs for which it is intended, and in parallel provide the future operators with basic knowledge in order to speed up their later training on a costly Full-scope Simulator.

The availability of inside system parameters allows the trainee to have a better understanding of the complex phenomena which appear in a NPP.

The multi-functions simulator approach has the following advantages:

- with Multi-Function Simulator type of tool one can cover the basic training needs;
- the same simulator can be used to establish or upgrade operating procedures and to create an operating environment related training, at least for the most complex systems;
- it can be ideally used to perform extensive training on accident situations;
- this type of tool can be delivered within a year or two depending on the scope to be covered;
- the investment is far less than for a full scope simulator.