Human Resources Training, Qualification and Knowledge Management in Reactor Physics Analysis

Eduardo Villarino[1], Ignacio Mochi[2] and Pablo Sartorio[3]

[1]*Av. Cmte Luis Piedrabuena 4950,Bariloche, Rio Negro, 8403, men@invap.com.ar*
[2]*Esmeralda 356, Ciudad Autónoma de Buenos Aires,1035, imochi@invap.com.ar*
[3]*Av. Cmte Luis Piedrabuena 4950,Bariloche, Rio Negro, 8403, psartorio@invap.com.ar*

I. INTRODUCTION

INVAP designs and builds research reactors [1] with high demanding requirements, which need better prediction capabilities to reduce the design margins due to numerical and engineering uncertainties. INVAP uses computational tools to predict the behavior of the reactor to be built; every new reactor needs a more detailed analysis from different points of view, mainly, nuclear safety and fulfillment of user requirements (flux and production levels, spectra requirements, perturbation, etc). This detailed analysis must be modeled with consistent level of detail from all the engineering variables and the analysts play a very important role in the development of the accurate models which are used to simulate the system under analysis. The analyst´s capacity to perform new accurate models to design or calculate new research reactors or irradiation facilities can only be evaluated through his/her knowledge and experience.

INVAP deals with all the related aspects of the reactor design using different approaches, namely:

- A clear and well-defined calculation methodology
- Continuously improving calculation codes validated in a wide spectra of nuclear reactors
- A set of procedures for the proper management of the project data and requirements and the generated calculation results and analysis
- Proper training and qualification of the project analysts

This paper will focus in the human resources training, qualification and knowledge management in reactor physics analysis, but general discussion of all the related aspects of nuclear reactor design will be given.

II. DESING METHODOLOGHY

The need for continuous improvement of the design methodology is mainly driven by the increasingly demanding nuclear safety analyses and design requirements of each new research reactor.

INVAP's design methodology [2] is presented in Figure 1 with the following concepts:

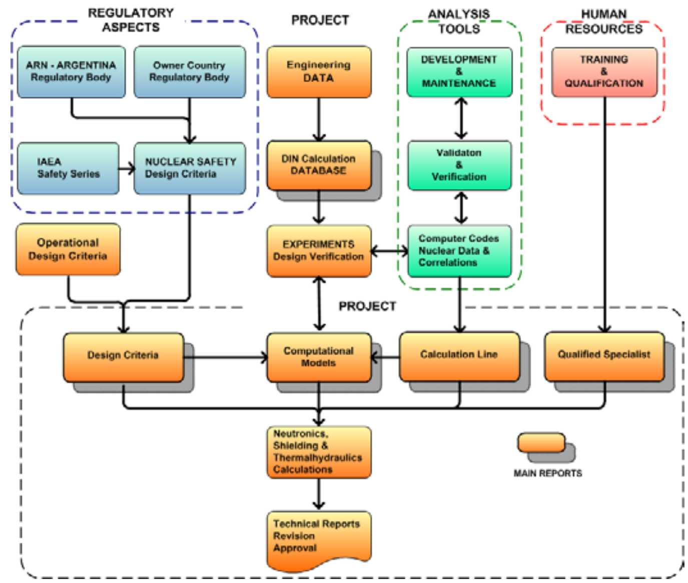

Figure 1. Design Methodology Flowchart

- Safety as priority: Using the requirements of the regulatory body of the country where the reactor will be built, the Argentine regulatory body requirements and the IAEA safety guidelines or recommendations.
- Custom designed reactor: All the operational design criteria are taken into account and all the specific project engineering data is collected in a database which is used as a baseline throughout the development of the project.
- Minimize risk using proven technology: Additional to this concept, when a novel design is needed experiments or mock-ups are used to adequately verify the design.
- Qualified methods, tools and procedures: The codes are in a continuous development, improvement and maintenance process, with a proper verification and validation stage.
- Well trained nuclear analyst: The design team is continuously trained or retrained to properly develop accurate models for solid understanding of the reactor under design.

III. CALCULATION LINE

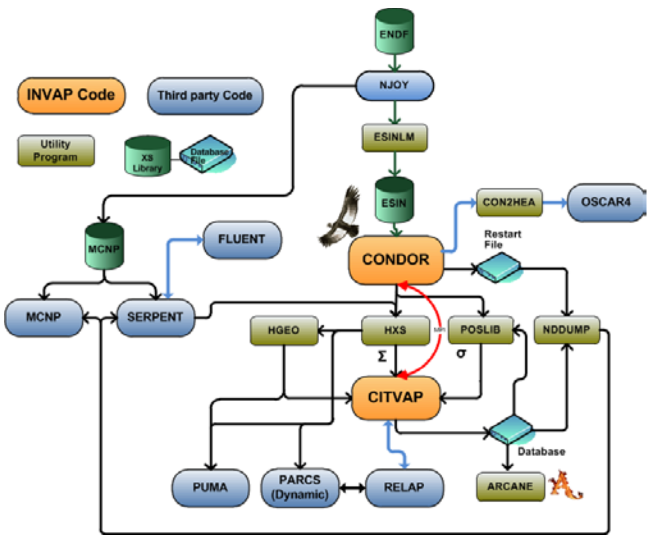

Figure 2. INVAP Neutronic Calculation Line

Figure 2 shows INVAP´s calculation line [3] [4], which has been used by INVAP and several of its customers for the design, optimization and follow-up of several reactors throughout the world obtaining optimal results, like RA-6, NUR, RA-8, ETRR2, OPAL, CAREM, CNA-II, LPRR, etc.

The improvements in the computational systems allow the development of innovative methods for reactor calculations, including not only better theories and numerical methods, but also adding more prediction capabilities and additional engineering information to perform the numerical analysis of the system [5-9]. These innovative methods help to improve the analysis work on the calculated systems, and could ease the input preparation process. But, in some cases, they also enable the un-experienced user to venture in the design of a new model and to perform reactor physics calculations without a solid understanding of the set of characteristics that constitute an accurate model taking into account all the engineering aspects of the system under analysis.

In order to make a proper use of all these capabilities, well trained analysts are required.

IV. CALCULATION PROCEDURES

The calculation activities are carried out on a Linux cluster where the analyst has clearance to perform his/her input preparation and calculation activities. The calculation staff has a project leader, who is responsible of project planning, the activities carried out for the analysts and some administrative tasks for the proper development of the project [2].

Each project starts with the creation of a directory structure to fulfill all the concepts commented. Figure 3 shows a scheme of the directory structure of a generic project.

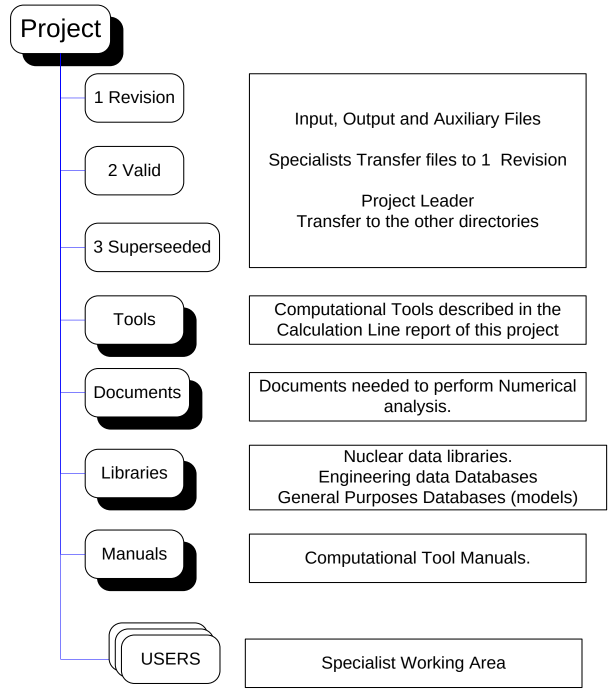

Figure 3. Project Directory Structure

The reactor physics project leader has the administrative control of this structure. He/she is responsible to properly document the tools and libraries that are to be used.

The analyst shares the information in all the directories that belong to the same project, but he/she has permission to write only in his own working area, and in the "1 Revision" directory.

The procedures used for documentation, input and output handling, and calculation of the required parameters allow to the sharing of knowledge, databases and models between the analysts of a project, or different projects, giving to the analysts a solid understanding of the reactor design.

V. KNOWLEDGE MANAGEMENT CONCEPTS

The knowledge management within the Nuclear Engineering Department (DIN Spanish acronym) seeks to preserve and improve the operational capability of the department and it is developed through an integrated and systematic plan of human resources, processes, analysis tools, and regulatory aspects. The Figure 4 shows graphically this integration based mainly if the design process. This management aims to identify, share, preserve, distribute, improve and expand the strategic and operational knowledge to be used in the processes of its concern, adding value to the activities performed in INVAP.

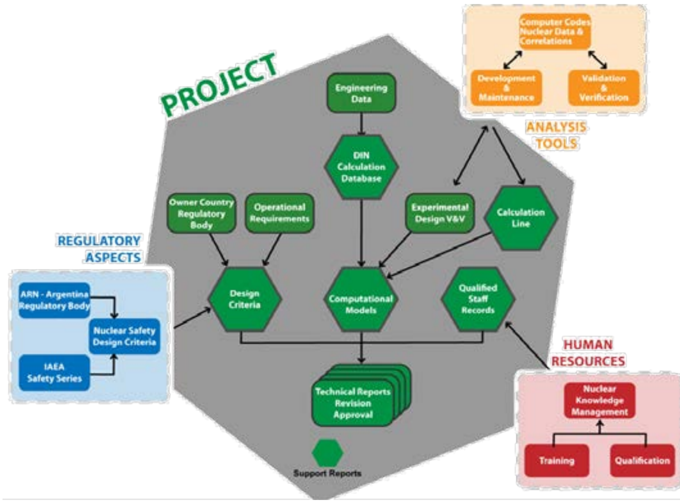

Figure 4. Design Methodology Flowchart

The DIN has clearly defined the roles and competencies of its structure, describing the knowledge, skills and attitudes required for each position [10]. The management of these competencies is clearly described in the documentation [11] and covers all the mentioned aspects by means of internal and external courses, mentoring, on-the-job training, retraining, teamwork and academic activities. The activities are developed in an ambience whose work culture covers aspects such as openness, trust, communication, respect and professionalism.

Another aspect taken into account in the knowledge management is the dynamics of the personnel. This management covers from proper definition of roles and corresponding competencies, the selection and incorporation of personnel (its induction, training and qualification), talent management, including its recognition, performance evaluation, development and succession planning, the career plan within the department (experts, human resource management, project coordinator, etc.), and handling contingencies due to personnel leaving the department (either because they leave INVAP or move to another area within INVAP).

INVAP understands training is not only the formal acquisition of knowledge. Thus, INVAP also promotes the following training-related activities to its personnel such as: self-training, acting as trainer of internal courses, participating as technical advisor in engineering, master or PhD thesis and participating in IAEA CRP activities.

A very important component in knowledge management is the Design Manual [12] that covers all the processes included in DIN's operational capability. This manual is a conceptual, methodological, integrated and descriptive guide for the application of specific procedures for the processes involved in each stage of a project's development (conceptual, preliminary and detail engineering, construction, commissioning, operation, etc.). This design manual covers the four essential areas that are applied in the development of a project such as Regulatory Aspects, Engineering Processes, Analysis Tools, and Human Resources.

The procedures used for documentation, input and output handling, and the calculation of the required parameters [13] allow to share knowledge between the different analysts.

Summarizing, the Design Manual encapsulates INVAP's experience in reactor design in order to allow all designers to use common methods, conventions and definitions in an effort to share the INVAP knowledge and establish a continually-improving design methodology. This concept can be seen in Figure 5.

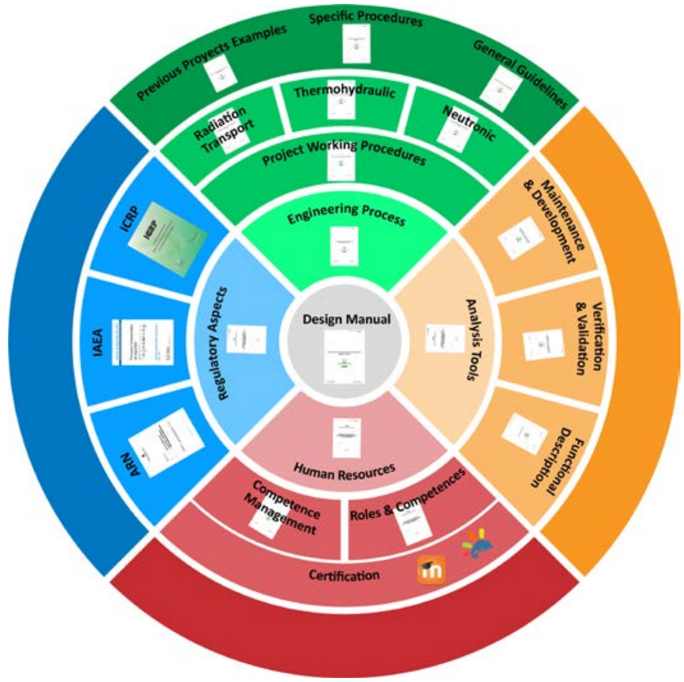

Figure 5. Design Manual Concept

VI. Human Resources Qualification in Reactor Physics

The whole process of staff qualification starts from its incorporation to the company, and continue with the induction, training and retraining of the staff.

In order to qualify for incorporation, a previous educational background is required. This knowledge depends on the position to be covered by the analyst in our department. While we normally prefer Nuclear Engineers, in case a non-nuclear engineer starts working at the DIN, some specific four month courses offered as part of the CEATEN post-graduate diploma (CEATEN is the Spanish acronym for "Specialization Career in Applications of Nuclear Technology") must be approved. CEATEN is offered by the Balseiro Institute. We also require approving the "Reactor Calculation and Analysis" subject which is given in the frame of the nuclear engineering career of the Balseiro Institute.

Besides the required basic knowledge, different skills are also taken into account. For instance: learning capabilities, flexibility to use different calculation tools, capability to communicate their calculation or analysis (in written and oral form), etc. INVAP also take care of the attitude of the staff: openness to receive a critical review of his/her work or analysis, participation in a collaborative working environment, work under a procedural environment, etc.

The induction period basically consists in a short learning period were basically the analyst learn about the DIN design and calculation methodology and procedures [12]. Depending on the previous experience of the analyst a period of preliminary calculation must be carried out, for example one or more calculations of a previous analysis of an INVAP project. In this stage a mentor is assigned with two purposes: assistant for the trainee and a training process for the trainer.

After the induction process, the analyst gets the first level of qualification, which allows performing analyses and calculations in the frame of an INVAP project.

The training process for the acquisition of more experience is carried out not only by means of on-the-job training, but also by performing, for example, a benchmark calculation of non INVAP reactor designs (for example participating in the IAEA CRP's). After this stage the analyst gets the second level of qualification which allows him/her, among other things, to make a completely new model for an INVAP project.

INVAP also promotes academic activities like participating as scientific advisors in Engineering, Magister or PhD thesis, this process not only increases the experience of the staff, but also improves and expands their knowledge. When a new knowledge (method, process, capability, etc.) is generated, INVAP perform two actions: A) It is shared between the DIN staff through an internal presentation or course; and B) it is properly documented (manual, course and/or procedure) to preserve it.

VII. Conclusions

INVAP has more than 30 years of experience designing and building research reactors with high demanding requirements. To succeed in this process, INVAP uses:

- Validated computational tools: These tools are validated in wide spectra of reactors designs. They are very well integrated between them and continuously updated and upgraded. These tools are used by INVAP and their customers in the design and follow-up of different research reactors, as for example: RA-6, NUR, RA-8, ETRR2, OPAL, LPRR, etc. and also in NPP as for example: CAREM, and CNA-II. The codes are also used by the Balseiro Institute students performing a large number of calculations for different reactor types such as MTR, PWR, BWR, PHWR, TRIGA, FBR and Homogeneous reactors.
- Very well established calculation methodology: The calculation methodology is not only a set of codes integrated in a calculation line, but a set of procedures for the proper management of the I/O data, the project and regulatory requirements and how INVAP perform calculations.
- Qualified staff: The analyst's capacity to perform accurate models to design or calculate research reactors or irradiation facilities can be only evaluated through their knowledge and experience. For this reason, INVAP follows a set of concepts and procedures for the qualification of his staff to properly perform their analysis.

References

[1] E. Villarino, A. Doval. "INVAP´s Research Reactor Designs", Science and Technology of Nuclear Installations, vol. 2011, Article ID 490391.

[2] E. Villarino. "Neutronic calculation methodology for research reactor." 16th IGORR 2014/ IAEA Technical Meeting, 17-21 November 2014, Bariloche, Argentina.

[3] E. Villarino, I Mochi and P. Sartorio . "INVAP neutronic calculation line". XXI Congreso sobre Métodos Numéricos y sus Aplicaciones 23 - 26 de September 2014, Bariloche, Rio Negro, Argentina.

[4] I .Mochi, "INVAP's Nuclear Calculation System", Science and Technology of Nuclear Installations, vol. 2011, Article ID 215363.

[5] D. Ferraro, P. Alberto. E. Villarino, A. Doval. "A Multi-Physics Analysis for the Actuation of the SSS in OPAL Reactor". RRFM 2017. 14-18 May 2017, Rotterdam, Netherlands.

[6] E. Villarino , J. J. Fabisik "Neutronic uncertainties analysis in OPAL reactor". RRFM 2017. 14-18 May 2017, Rotterdam, Netherlands.

[7] E. Villarino. "Detailed Analysis of Doppler Coefficient in CANDU Reactors". 14th IAEA/COG Technical Committee Meeting (TCM) Córdoba, Argentina 21-24 November 2017.

[8] I. Ferrari, E. Villarino."Neutronic Uncertainty Analysis for CANDU Reactors". 14th IAEA/COG Technical Committee Meeting (TCM) Córdoba, Argentina 21-24 November 2017.

[9] C. Pavón, I. Mochi, A. Doval and E. Villarino. Cálculo "best-estimate" de la capa de óxido en combustibles tipo MTR con el código CITVAP XXI Congreso sobre Métodos Numéricos y sus Aplicaciones 23 - 26 September 2014, Bariloche, Rio Negro, Argentina.

[10] I. Mochi. "Definición de Puestos en el Departamento Ingeniería Nuclear y sus Competencias". 0275-0000-0IEGD-002 Invap proprietary document. "Definition of positions in the Nuclear Engineering Department and its Competencies"

[11] I. Mochi. "Metodología de Gestión de las Capacidades del Personal". 0275-0000-0BEGD-001. Invap proprietary document."Capability Management Methodology of the Staff".

[12] I. Mochi. "Manual de Procesos de Diseño del Departamento de Ingeniería Nuclear." 0275-0000-0BEGD-002. Invap proprietary document. "Manual of Design Processes of the Department of Nuclear Engineering".

[13] E. Villarino. "Procedimiento para el manejo de la información generada a partir de cálculos de proyectos" 0275-0000-0PEGD-002. Invap proprietary document. "Procedure for the management the information generated from project calculations".