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EVOC, THE FIRST MULTIMODAL TEACHING PLATFORM FOR THE NUCLEAR INDUSTRY

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An innovative immersive training project at the service of the skills of the nuclear industry

Within the CEA, the INSTN is developing, in collaboration with the LIST (an institute of CEA Tech) and the CEA Nuclear Energy Department, a multimodal teaching platform serving the skills of the nuclear industry: the EVOC project, *Enhanced Virtual Open Core*.

The EVOC multimodal platform enables the INSTN to offer full-scale immersive training. Thanks to realistic multi-physics simulation, starting in the last quarter of 2018, trainees and students will be able to carry out unprecedented practical work. EVOC is based on a training reactor and on an initial experimental pool-type reactor, where the pedagogy of teaching physical phenomena is preserved. Thus, learners can practice in groups or individually on training courses combining real and virtual resources as close as possible to the physical phenomena of reactor operation.

A world first in terms of augmented virtual reality (AVR), this innovative and unique teaching tool is intended for students and operators in the nuclear industry. Thus, it makes it possible to carry out dematerialised training and to free oneself from the constraints of a reactor in operation, in particular its availability and physical accessibility.

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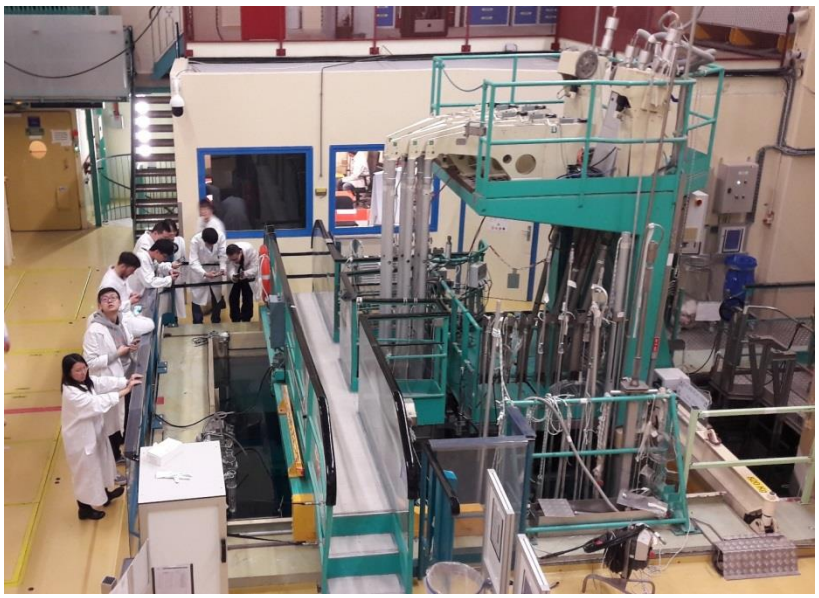
From a teaching reactor to a multimodal platform

For many years, the INSTN has been setting up **practical work on the Isis teaching reactor**, an installation based at the CEA Paris-Saclay centre, as part of a diploma or continuing professional training course. These practical exercises provide an understanding of the main operating principles of a reactor. The topics covered are reactor physics, reactor operation, kinetics, subcritical approach, divergence, reactivity and temperature effects and fuel loading.

Due to their quality and high demand, these practical works attract 400 trainees each year, a third of whom are foreigners.

Today, a variety of factors, such as the highly regulated access conditions to the Isis reactor and its future planned closure in 2019[1], have led the INSTN to completely rethink this practical work and to launch **the development of an alternative solution: the EVOC project**.



An ISIS reactor hall, a model of the EVOC platform - ©CEA

The creation of a solution adapted to the needs of training and education

In the summer of 2017, the INSTN launched the **Enhanced Virtual Open Core (EVOC) multimodal platform**. This is a transversal CEA project, initiated by the INSTN, developed by the LIST Institute, and based on the expertise and data of the Isis experimental reactor of the CEA Nuclear Energy Directorate. The project is therefore based on national and international recognition in education, and on the mastery of the nuclear and digital fields for high-level training.

The INSTN has a strong expertise in reactor training thanks to the use of Ulysses and Isis reactors. Following the announcement of the planned closure of Isis, the Institute has chosen to continue to

[1] The last practical classes on this installation will take place in December 2018.

make its expertise available, using a different method adapted to 21st century technologies and also open to a wider public.

Following extensive studies involving several teams from the INSTN and CEA, the project to design a multimodal platform called **EVOC (Enhanced Virtual Open Core)** was born.

This project uses the CEA's historical expertise but also state of the art of digital technologies to develop an innovative educational solution integrating virtual reality, a neutron kinetics simulator and physical equipment. EVOC is specifically designed to teach reactor physics, the underlying principles of operations and how to operate a reactor.

The training courses offered on this multimodal platform involve the continuing professional training of reactor operators, employees of nuclear industry institutions and students of science and engineering schools, and international masters.

What added value will EVOC bring to existing reactor simulators?

A simulator, however effective, does not have the same psychological effect as a real reactor since operating and handling errors do not have the same consequences as on a real reactor. EVOC is based on this observation, immersion being an important specificity: the trainee must have the impression of being in a real nuclear installation.

- On the one hand, there are simulators based on a replica of a control room to train operators by faithfully reproducing the operation of the installation (e.g. nuclear, aeronautics, rail, etc.).
- On the other hand, applications to immerse the user within a digital model are developing, driven by the rise of Virtual Reality headsets. The first applications concern pre-sales, accessibility studies and consumer applications (games) but training is a natural field for the use of these new technologies.
- EVOC therefore aims to make the link between these two worlds: on the one hand, simulation capabilities of the operation of an installation and tangible objects to represent it and on the other hand a complete immersion and team in the digital model for a better understanding of the phenomena concerned.

To that end, the main characteristics of a real nuclear installation are replicated. These include, for instance, on the ISIS model, the reactor hall, the control room with its console, and all regulatory and safety elements. For example, learners will have appropriate clothing (lab coats) and radiation protection checks at the hall exit. They will even hear sudden alerts and messages in the broadcasting system, or noise from the reactor in operation that may disturb them. These characteristics immerse the trainee in a very realistic reactor room environment far from that of the classroom.

EVOC: advanced technologies for teaching

The multimodal EVOC platform is equipped with three key components:

- **A dedicated place:** composed of two zones, one being a replica of the reactor hall and the other the reactor control room.

  The hall will be equipped with various facilities, such as the entrance with an airlock and pool ramps at scale 1, where practical work will be carried out. The control room will be equipped with a real control panel linked to the virtual reactor, in addition to the standard classroom.

- **A digital simulator**: the neutron kinetics simulator will integrate the characteristics of the Isis teaching reactor. Its qualification was based on experimental tests conducted on Isis itself.

- **Digital technologies for interactive simulation.**

The new digital reactor simulator is based on List virtual reality technologies (LIST XDE[2] software), already applied to many industrial applications. In particular, they make it possible to simulate the interactions between trainees and their tangible environment where the real actions of the operators are simulated in real time by the software, which integrates the physical principles at stake. Learners are equipped with a virtual reality headset that allows them to move on the multimodal EVOC platform while visualising their actions thanks to the hyper-realistic replication of the reactor hall. The software architecture of the device allows the control panel to be coupled to the digital simulator and to the operations carried out in the hall in real or virtual mode.

Several learning modes are accessible, alternating theoretical and practical training, and activities carried out in the real world or simulated in the virtual world.

On the multimodal EVOC platform, learners can "simply" be immersed thanks to the 360° stereoscopic films produced on the Isis teaching reactor. This immersion allows them to observe real operations whether for simple visits, oriented for outreach purposes, or for workshops to learn the operator's business gestures and the integration of safety and security rules. *This includes for example the handling a cofferdam using an electric hoist*.

For practical or business training, trainees are immersed in the 4D digital model, under the supervision of their instructor: a collaborative manipulation in the new hall space, installation of tangible devices in the core, such as experimental devices, or fuel loading.

The objective of this multimodal pedagogical approach is not only to visualise, but also to understand and integrate through practice the follow-up of such an operation and in parallel the realisation of a subcritical approach.

[2] XDE is a virtual reality collision engine, for the simulation of montage, dismantling or assembly operations during the design of mechanical assemblies. From the CAD data, which it automatically imports, it processes rigid, flexible (cables, etc.), deformable parts and the phenomena of shocks, bounces, slips, elastic distortions, etc. These codes can be integrated into a virtual and interactive environment to simulate an operator's actions.

Control console, multimodal EVOC platform - ©CEA

In addition, a complete programme of practical work sessions, requiring the use of virtual reality headphones (virtual mode), can be linked to real sessions in the hall or on the control console (real mode) or in the classroom.

Practical work on EVOC

In October 2018, the first practical work sessions planned on the multimodal EVOC platform will correspond to the work currently being carried out on the Isis reactor, with the following specific features:

- Practical aspects of entering/leaving an installation;
- Introduction and basic principles of reactors – Isis Reactor;
- Subcritical approach and reactor start-up;
- Reactor kinetics/precursor effect;
- Control bar efficiency, calibration curves, global efficiency measurement with virtual bar drop tests;
- Effect of in-core equipment on reactivity, moderation ratio;
- Temperature effects, self-stabilization and reactor safety;
- Operation of the reactor;
- Operational Radiation Protection.

Naturally, this practical work includes safety and security concepts, which are a priority in the management of a facility.

Isis reactor control room - ©CEA

The increased flexibility of the multimodal EVOC platform will broaden teaching objectives and facilitate the development of practical work such as:

- Thermal balance;
- Fuel loading;
- Effec of higher potency poisons;
- Operational incidents/crisis management.

Unlike a real reactor, where the power used in the presence of trainees is limited (50 kW) for safety and radiation protection reasons, the power of the EVOC multimodal platform's digital simulator is not limited, which offers additional and unprecedented options.

View of the control console integrated into the multimodal EVOC platform- ©CEA

View of EVOC immersion equipment for learners - ©CEA

Imagining the future of education

In the future, the EVOC multimodal platform project, which is currently physically linked to a specific site - the INSTN Saclay site, will have a version that can be transferred to other premises. Furthermore, EVOC is already compatible with the IAEA's international "*Internet reactor laboratory*" programme for distance learning on teaching reactors.

Initially based on the Isis reactor because of its proven effectiveness for training, EVOC could integrate other nuclear reactor models because of its generic architecture.

EVOC, a scalable and modular multimodal platform, is today a world first in terms of augmented virtual reality (AVR) that offers learners immersive training and a practical work program, while faithfully reproducing the physical characteristics of a reactor in operation.

EVOC is a unique digital teaching and training solution that demonstrates the dynamism of the French nuclear industry.

The first EVOC multimodal platform will be fully operational in October 2018 and accessible from the INSTN premises at the CEA Paris-Saclay centre.

About the INSTN, the French National Institute for Nuclear Science and Technology

Created in 1965, the INSTN is a public higher education institution and a national training body administered by the CEA (French Atomic Energy and Alternative Energies Commission). A French education and training institute for nuclear applications, the INSTN's main mission is to train technicians, engineers and researchers that work in the nuclear field.

For 60 years now, the INSTN has supported the scientific and industrial development of the nuclear industry by providing highly specific training and education at all levels of qualification – from operator to engineer. Committed to an international dynamic, the Institute became in 2016 the sole « *Collaborating Centre* » of the IAEA in France and in Europe, for education and training in the nuclear sector.

The INSTN has five sites in France: Saclay (Île-de-France), Cadarache (Provence-Alpes-Côte d'Azur), Cherbourg-Octeville (Normandy), Grenoble (Rhône-Alpes), Marcoule (Occitanie).

To find out more: http://www-instn.cea.fr/

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About the CEA

The French Atomic Energy and Alternative Energies Commission (CEA) is a public research organisation active in four fields: defence and security, low-carbon energies (nuclear and renewable), technological research for industry and fundamental research.

Relying on a recognised expertise capacity, the CEA participates in the implementation of collaboration projects with numerous academic and industrial partners. With 16,000 researchers and staff, it is a major player in the European research area and has a growing international presence. The CEA was identified in 2017 by Thomson-Reuters/Clarivate as the most innovative public research organisation in Europe.

To find out more: www.cea.fr

The LIST Institute

The LIST, an institute of CEA Tech, focuses its research on intelligent digital systems. With major economic and societal challenges at stake, its R&D programs focus on advanced manufacturing, embedded systems, ambient intelligence and control of ionizing radiation for health.

To find out more: http://www-list.cea.fr

The Nuclear Energy Directorate

Within the CEA, the Nuclear Energy Division (DEN) provides the French government and industry with technical expertise and innovation in nuclear power generation systems to develop sustainable nuclear energy that is both safe and economically competitive.

To meet these objectives, the DEN is engaged in three main areas of investigation: Optimising the current nuclear industry; developing nuclear systems of the future - dubbed “4th generation” reactors – and their fuel cycles; developing and operating large experimentation and simulation tools needed for its research programmes. As nuclear operator, the DEN also has to manage and upgrade its own fleet of nuclear facilities. It carries out numerous construction and refurbishment programmes on its facilities, together with clean-up and dismantling programmes for those that have reached the end of their service life.

To find out more: http://www.cea.fr/Pages/le-cea/la-direction-de-l-energie-nucleaire.aspx

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