

**4⁺D DIGITAL ENGINEERING FOR ADVANCED NUCLEAR ENERGY SYSTEMS****Seo G. Jeong^{1,2}, Seung K. Nam², Kune Y. Suh^{1,2*}**¹Seoul National University, San 56-1 Sillim-dong, Gwanak-gu, 151-744, Seoul, Korea²PHILOSOPHIA, Inc., San 56-1 Sillim-dong, Gwanak-gu, 151-744, Seoul, Korea,E-mail: *kysuh@snu.ac.kr***ABSTRACT**

Nuclear power plants (NPPs) require massive quantity of data during the design, construction, operation, maintenance and decommissioning stages because of their special features like size, cost, radioactivity, and so forth. The system engineering thus calls for a fully automated way of managing the information flow spanning their lifecycle. In line with practice in disciplines of naval architecture, aerospace engineering, and automotive manufacturing, the paper proposes total digital systems engineering based on three-dimensional (3D) computer-aided design (CAD) models. The signature in the proposal lies with the four-plus-dimensional (4⁺D) TechnologyTM, a critical know-how for digital management. The so-called OPIUM (Optimized Plant Integrated Ubiquitous Management) features a 4⁺D TechnologyTM for nuclear energy systems engineering. The technology proposed in the 3D space and time plus cost coordinates, i.e. 4⁺D, is the backbone of digital engineering in the nuclear systems design and management. Based on an integrated 3D configuration management system, OPIUM consists of solutions NOTUS (Nuclear Optimization Technique Ubiquitous System), VENUS (Virtual Engineering Nuclear Ubiquitous System), INUUS (Informatics Nuclear Utilities Ubiquitous System), JANUS (Junctional Analysis Numerical Ubiquitous System) and EURUS (Electronic Unit Research Ubiquitous System). These solutions will help initial simulation capability for NPPs to supply the crucial information. NOTUS contributes to reducing the construction cost of the NPPs by optimizing the component manufacturing procedure and the plant construction process. Planning and scheduling construction projects can thus benefit greatly by integrating traditional management techniques with digital process simulation visualization. The 3D visualization of construction processes and the resulting products intrinsically afford most of the advantages realized by incorporating a purely schedule level detail based the 4⁺D system. Problems with equipment positioning and manpower congestion in certain areas can be visualized prior to the actual operation, thus preventing accidents and safety problems such as collision between two machines and losses in productivity. VENUS applies the virtual reality (VR) technology in nuclear industry. VR provides an interactive real-time motion with sound and tactile and other forms of feedback. Therefore, management and workers are able to comprehend the work process better by visualizing precisely how activities relate to one another, thus reducing conflicting interpretations and communication problems. VENUS can contribute to dealing with public acceptance about the NPP. Visualization of NPP can comfortably familiarize the public with existing or planned systems. INUUS provides with effective information management and methodology of expression. Information is offered variously in the field of nuclear industry for example real-time data on the spot, result of computational analysis in the process of plant design and information of documents for drawing or dividing drawing. INUUS resorts to 3D object oriented methods to efficaciously manage voluminous information with. For example, INUUS can be used as a 3D pre-processor for a NPP system analysis code. JANUS extracts the geometric data directly from the CAD files to import to multidimensional computational codes. JANUS uses these joint-CAD analysis methods so that time and efforts of the user can be minimized. EURUS combines the VR technology with a wide spectrum of high-precision, high-resolution analysis techniques and virtual design development environment so that a system can be designed and analysed in the

cyber space. EURUS realizes the cyber experiment with which the behaviour of such complex structures as NPP can be simulated and reflected onto the design. The 4⁺D TechnologyTM is slated to bring about revolutionary change in improving the NPPs lifecycle starting from the conceptual design to decommissioning. It will also eventually lead to paperless design and paperless plants in the near future.