UPDATING SIMULATOR PLATFORM, MODELS, I/O SYSTEM (AND MORE) IN ROMANIA

L3Harris MAPPs Inc. | Power Systems and Simulation

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Outline

> About Us
> Reference Plant and Simulator Background
> Recent Simulator Upgrade – Plant Training Needs and Project Scope
> Project Schedule, Challenges and Road to Success
> Conclusions
Power Systems and Simulation Portfolio

Nuclear Learning Services for Effective Personnel Development

Full Scope Operator Training Simulators/Upgrades for Operator Licensing

3D Immersive Simulators for Plant Design Support and Plant Team Training

Early Learning Technologies

Simulation Assisted Engineering for Plant Design, Development and Deployment

Technology-enabled Training Services Build-Own-Operate-Train

Plant Control Computers CANDU Plant Digital Control Hardware and Electronic System Reverse Engineering
Cernavoda Nuclear Power Plant

> Cernavoda Nuclear Power Plant operated by Societatea Nationala “Nuclearelectrica” S.A. (SNN)

> Situated in Cernavodă, Romania

> Operates two CANDU* 6 reactors, producing ~705 MWe each
  – Unit 1 commissioned 2 December 1996
  – Unit 2 commissioned 28 September 2007

> Refurbishment
  – Unit 1 activities ongoing; planned completion 2029 – adds 30 years
  – Unit 2 expected ~2037

> Project Development
  – Preparatory stage to build Unit 3 and Unit 4 (CANDU 6)
  – Expected commissioning in 2030 (Unit 3) and 2031 (Unit 4)

> Operator Training Simulator (OTS) based on Unit 1 – supports training for Units 1 and 2

> Latest 2-stage OTS upgrade project started 4Q 2019

*CANDU is a registered trademark of Atomic Energy of Canada Limited, used under license by Candu Energy Inc., a member of the SNC-Lavalin Group.
## Cernavoda Operator Training Simulator Timeline

<table>
<thead>
<tr>
<th>ID</th>
<th>Operator Training Simulator</th>
<th>Start</th>
<th>Finish</th>
</tr>
</thead>
<tbody>
<tr>
<td>318</td>
<td>Platform Upgrade, PHT/Containment Models Upgrade, Severe Accident Simulation, I/O System Replacement</td>
<td>2019</td>
<td>2021</td>
</tr>
<tr>
<td>265</td>
<td>Dual DCC (X/Y) Emulation</td>
<td>2016</td>
<td>2017</td>
</tr>
<tr>
<td>252</td>
<td>Main Generator Excitation Simulation (GE EX2100e)</td>
<td>2015</td>
<td>2016</td>
</tr>
<tr>
<td>86</td>
<td>Platform Upgrade, Partial Graphical Models, DCC X Emulation</td>
<td>2003</td>
<td>2005</td>
</tr>
<tr>
<td>66</td>
<td>Instructor Station, Desktop Simulator</td>
<td>2000</td>
<td>2001</td>
</tr>
<tr>
<td>30</td>
<td>Full Scope Simulator (2-phase)</td>
<td>1992</td>
<td>1998</td>
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*Source: SNN*
Plant Training Needs and Project Approach

> Simulator Model Upgrades
  - New training requirements demanding improved hydraulic model scope/fidelity

> Addition of Severe Accident Simulation Capability
  - Resulting from Fukushima Daiichi incident
  - Regulator requirement for further severe accident scenarios preparedness

> Input/Output System and Power Supplies Replacement
  - I/O system and power supplies design unchanged since initial delivery in 1994
  - Robust system; difficulties maintaining and procuring spare parts

> Computer System Re-platform and Simulation Environment Upgrade
  - Old computer hardware (servers clients)
  - Linux-based Simulator Server; robust but no longer supported
  - Dated graphical simulation modeling environment
    - ROSE® 4

> Simulator Upgrade Project Approach
  - Stage I: Computer Complex Re-platform, Simulation Environment Upgrade, Simulator Models Upgrade, Severe Accident Simulation
  - Stage II: I/O System Replacement
Stage I: Computer System Re-platform

- Simulation Servers (3) – each with 2 Virtual Machines
- Network-Attached Storage for backups
- Engineering workstations
- Instructor Station workstations
- Ramtek Display System monitors and emulation computers
- Laptop for I/O Diagnosis
- Time Server, Terminal Server, Network Switches, UPS, etc.
Stage I: Simulation Environment Upgrade (1)

> Replacement of Simex Plus (Linux) & ROSE® 4 with latest Orchid® Simulator Executive and Orchid® Modeling Environment

> All previous files (models, sources, libraries, etc.) moved to Orchid® Modeling Environment for better configuration control

> Conversion of original Isis™ instructor station lessons, malfunctions, etc. to Orchid® Instructor Station [Touch Version]

> Conversion of TIGERS virtual panels and ~450 active instructor schematics to Orchid® Graphic Editor
Stage I: Simulation Environment Upgrade (2)

> Rehost of external systems interfaces

> Datapath SC I/O system software replaced by Orchid® Input Output

> Ported over
  – Orchid® Control System HMI simulation of GE Ex2100E Generator Excitation System (delivered 2016)
  – DCC X/Y Emulation (delivered 2017)
Stage I: Simulator Model Upgrades

> Complete replacement of select models in Orchid® Modeling Environment
  – Primary Heat Transport
  – Boilers
  – Containment
  – Primary Auxiliaries

> Enhanced existing BOP models in Orchid® Modeling Environment
  – Heaters, Reheaters
  – Drains
  – Degasser

Stage I: Simulator Model Upgrades

> Digital Controllers Simulation
  – Addition of ~40 controllers simulated on virtual panels
  – Yokogawa controllers and Fischer & Porter controllers
  – Virtual controllers support multi-function displays in Orchid® Graphic Editor
  – Controller logic implemented with Orchid® Modeling Environment
  – Original controller drivers removed from simulator configuration
Stage I: Severe Accident Simulation Integration

> EPRI/COG MAAP5*-CANDU code used for
  – Calandria, PHT, Pressurizer, Degasser, Moderator, Steam Generators and Containment models

> Automatic switchover from L3Harris models to MAAP5-CANDU models
  – Ensuring no step change in values during switchover
  – Not necessary for instructor to preselect SAS configuration or change ICs

*A valid license to MAAP5 from EPRI as well as the right to MAAP5-CANDU from the CANDU Owners Group (COG) is required prior to a customer being able to use MAAP5-CANDU with Licensee’s simulator products. EPRI and COG do not endorse any third-party products or services.
Stage I: Document Management and Bug Tracking

> Document Management System (DMS)
  – OpenKM provided for DMS, integrated with Orchid® Modeling Environment
  – Provides direct access to documents in DMS from Orchid® Modeling Environment
  – P&IDs, equipment specifications, plant operating procedures, etc.

> Deficiencies Tracking
  – Mantis Bug Tracker (MantisBT) for change requests (CRs), integrated with Orchid® Modeling Environment
  – Configuration Management feature enforces assigned CRs to be linked with work/tasks
  – Orchid® Modeling Environment work/task information automatically pushed to MantisBT for associated CR
Stage II: I/O System Replacement (1)

> ~10,000 I/O (AI / AO / DI / DO) points replaced

> Retained Datapath SC-Bus I/O chassis – replaced original I/O cards with rail-mounted Beckhoff compact I/O system
  – Goal: Replacement with least complexity and risk

> Network-based Beckhoff EtherCAT controllers and I/O modules
  – I/O communication with Simulation Server via Ethernet LAN
  – I/O modules mounted on DIN rails
  – Adapter cards interfacing with existing instrument wiring
  – Goal: Retain existing panel instruments and wiring

> Easy to expand I/O system

> Replacement of incandescent light bulbs by LEDs
Stage II: I/O System Replacement (2)

> Centralized DC Power Supply (24VDC) replaced with distributed Power Supplies at each I/O Station

> Old SC-Bus chassis multi-voltage power supply removed as new EtherCAT I/O system requires only 24VDC power source
  – Devices requiring +/-10VDC power supplied by I/O Station 24VDC source

> Each I/O Station contains 2 new 24VDC power supplies mounted directly on DIN rails with breakers and fuses
Project Schedule

> Stage I: Rehost, Environment and Model Upgrade
  – Pre-FAT and FAT - Remote Acceptance Testing
  – 2 independent sites (@Montreal, @Cernavoda)
  – Secure remote access for debugging
  – Skype for audiovisual communications
  – Installation → March 2021
  – SAT - Remote Acceptance Testing → March-April 2021
  – Remote Customer Training → April-May 2021

> Stage II: I/O System and Power Distribution
  – Design & Prototype sent to Cernavoda → March-May 2020
  – FAT - Remote Acceptance Testing
    – February 2021 (remote camera)
  – Complete I/O installation → June 2021

> Integrated SAT (Stage I + II) → June-July 2021 at Cernavoda
Challenges – Road to Success

> COVID-19
– Working from home for most Cernavoda plant personnel & L3Harris team in Montreal
– Restricted access to simulator site @Cernavoda
– Supply chain delays
– International travel restrictions

> Solutions to Novel Problem
– Reviewed and approved documentation working from home
– Remote web meetings used to maximum extent
– Performed remote site survey for I/O and Power solution
– Set up 2 testing sites to perform customer-L3Harris testing remotely (@L3Harris and @Cernavoda)

> Keys to Success
– Dedicated teams on both sides
– Good communication between teams → remote testing
– Early risk mitigation plans → milestones achieved on time
– Project schedule mainly unchanged from start
Conclusions

> Pleased to once again cooperate with valued, long-time customer

> Challenging 2-stage project performed on-time and on-budget despite adjusted working conditions

> Upgrading of highly integrated, graphical development and runtime simulation environment to Orchid® futureproofs OTS

> Dedicated L3Harris project team + SNN flexibility and support keys to success – THANKS!