MAJOR MODERNIZATION OF LEGACY NUCLEAR PLANT SIMULATOR

L3 MAPPS Inc. | Power Systems and Simulation

10 January 2022

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Presented at

PowerPlantSim 2022
Bellagio Las Vegas
Las Vegas, Nevada
Outline

• Introduction to Reference Plant, Simulator Background and Simulator Modernization Scope
• Modernization of Plant Systems, Simulator Platform, Validation Result Example
• Project Schedule and Key Challenge
• Conclusions
INTRODUCTION

Reference Plant, Simulator Background, Simulator Modernization Scope
St. Lucie Nuclear Power Plant

- Operated by Florida Power & Light (FPL)
- Located on Hutchinson Island between Fort Pierce and Stuart
- Combustion Engineering (CE) 2-Loop PWR
  - 2 Steam Generators
  - 4 Reactor Coolant Pumps
  - Pressurizer
- Two Units

<table>
<thead>
<tr>
<th>Began Commercial Operation</th>
<th>Unit 1</th>
<th>1976</th>
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<tbody>
<tr>
<td></td>
<td>Unit 2</td>
<td>1983</td>
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<tr>
<td>License Extension Until</td>
<td>Unit 1</td>
<td>2036</td>
</tr>
<tr>
<td></td>
<td>Unit 2</td>
<td>2043</td>
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<tr>
<td>Power (MWe)</td>
<td>Unit 1</td>
<td>~ 1,000 MW</td>
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<tr>
<td></td>
<td>Unit 2</td>
<td>~ 1,000 MW</td>
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• Originally delivered by L3Harris (then part of CAE) in the mid-1980s
• Numerous updates/additions to simulator over the years, including by third parties → legacy simulator becoming difficult to maintain
• Plant models largely original models (1980s vintage, FORTRAN), lower fidelity than today’s models, mostly non-graphical, plant modifications more difficult to implement, ageing simulator maintenance team → Simulator needed until end of operating license (Unit 2: 2043)
• Contract awarded to L3Harris in late-2019 to perform major software modernization
Simulator Modernization Goals / Objectives

• Goals
  – Modernize St. Lucie Simulator user interface and models
  – Simplify simulator maintenance
  – Facilitate implementation of plant modifications on simulator
  – Increase pool of candidates joining simulator team

• Other Outcomes
  – Improve plant systems modeling fidelity
  – Improve training quality and realism
  – Improve operator skills
  – Improve safety
Simulator Modernization Project Scope

• Full replacement of REMAINING models not in graphical modeling environment (using Orchid® Modeling Environment)
  – Containment
  – Primary Auxiliaries
  – Radiation Monitoring
  – BOP
  – Electrical
  – Instrumentation & Control

• Latest Orchid® software environment including
  – Orchid® Instructor Station [Touch]
  – Data Management System-Orchid® simulator design/data tracking

• Expanded/Enhanced Virtual Panels (back panels and trends)

• Modernization Project results in
  – Seamless Integration of modern, accurate plant system models controlled with a Windows 10-type interface
  – Updated Glasstop simulators, providing more options for training
SIMULATOR MODERNIZATION

Plant Systems, Simulator Platform, Validation Example
Model Improvements

• Simulator Model Upgrade
  – Replacement of all FORTRAN codes with graphically developed and operable simulation models
  – 44 plant system models replaced with Orchid® Modeling Environment

Higher fidelity hydraulic model provides better response for systems with Water/Steam and Non-Condensables
Upgraded system stability during transients by resolving multiple plant system models in grouped hydraulic matrices
More detailed simulation of electrical distribution to instruments and to control power supplies for relay control
Latest Orchid® Simulation Platform

• Orchid® Simulator Executive
  – Offers graphical representation of all simulation modules and their execution timing
  – Modules can be dragged and dropped into different time-bands to create a well balanced call sequence
  – Real time, fast time, slow time, single step execution

• Orchid® Instructor Station
  – Ergonomic user interface for desktops and Windows tablets
  – Same version of tool running on both platforms
  – Windows 10/iPad-like functionality (swiping, flicking, pinching, etc.)
  – Designed for the next generation of simulator instructors and maintainers
Enhanced Virtual Panels

- Supports zoom, pan, tilt
- One-world (i.e. main control room is continuous instead of discrete panels)
- Object-oriented approach (panel object libraries)
- Computerized Systems HMI embedded in Virtual Panels
- Dynamic Recorder
Improved Active Schematics

- For instructors for inserting instructor actions via dynamic flow diagrams
- Updated look-and-feel of Active Schematics
Highly Integrated Environment

• Within Instructor Station
  – Browsing capabilities
  – Models ↔ Active Schematics ↔ Virtual Panels

• Access to Instructor Actions

Access to Instructor Actions from Active Schematics

Direct Access to Graphical Plant Models and Virtual Panels
Simulator Validation Example

- Simulator Validation accomplished using automated scenarios to compare results of upgraded simulator with plant data
- Example: Reactor Trip

![Graphs showing RCS AVERAGE TEMP LOOP 2B and S/G STEAM FLOW with Plant Data and Simulator data compared. Values intentionally omitted.](image-url)
Project Schedule and Key Challenge

Project Schedule, Performance during COVID-19 Pandemic
## Project Schedule

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Achievement Date</th>
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<tbody>
<tr>
<td>Project Start</td>
<td>December 2019</td>
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<tr>
<td>[Remote] Design Review Meeting Held</td>
<td>April 2020</td>
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<tr>
<td>Software Development Complete</td>
<td>October 2020</td>
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<tr>
<td>Pre-FAT Acceptance Testing Start</td>
<td>March 2021</td>
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<tr>
<td>Factory Acceptance Testing Complete</td>
<td>August 2021</td>
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<tr>
<td>On-site Acceptance Testing Complete</td>
<td>October 2021</td>
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Overcoming COVID-19 Limitations

• Project almost entirely run during pandemic
• Remote / Virtual Design Review Meeting
• Bi-weekly customer meetings through MS TEAMS
• Internal Development / Integration / Testing phases all while WFH
• Simulator Factory Acceptance performed remotely due to travel restrictions
  – FPL personnel used Classroom (Touchscreen) Simulator at St. Lucie Training Center to run Acceptance Test Procedures (ATPs)
  – Installed latest Simulator software using remote access
  – Provided updated configurations when required using Secure File Exchange
  – Ran all ATPs as automated scenarios
  – Provided results against plant data
• On-site acceptance testing (SAT) completed on site in Florida with L3Harris support

• Despite COVID-19 restrictions, project successfully deployed
• Close collaboration between FPL and L3Harris
CONCLUSIONS

Wrap-up
Conclusions

- Simulator modernization results in next generation St. Lucie Full Scope Operator Training Simulator
- Project successfully executed during pandemic
- Simplifies simulator maintenance for years to come with unified software (Orchid®) environment and graphical user interface
- GUI facilitates implementation of plant modifications on simulator; numerous improvements planned
- Modern simulation environment facilitates onboarding of new customer simulator team members

### SCORECARD

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<tr>
<td></td>
<td>Major simulator modernization project performed on-time, on-budget</td>
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<td>Pandemic restrictions no match for L3Harris and FPL team</td>
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<td>State-of-the-art simulator allows easier maintenance/updates and recruiting younger team members</td>
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<td>Solid, long-term customer remains satisfied</td>
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St. Lucie Nuclear Power Plant photo by D. Ramey Logan