MAJOR SIMULATOR UPGRADE FOR DUNGENESS B

- L3 MAPPS Inc. | Power Systems and Simulation

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Outline

• Background

• Simulator Upgrade Project
  – Project Overview
  – Two-phase Deployment
  – Schedule
  – Challenges/Strengths/Successes

• Conclusions
BACKGROUND

Major Simulator Upgrade for Dungeness B
EDF Energy’s Current Nuclear Sites

- L3Harris supported facilities
  - Stations
    - Dungeness B
    - Hartlepool
    - Heysham 1
  - Hinkley Point B
  - Sizewell B
  - Other Training Facilities
    - Campus
    - Nuclear Power Academy (Barnwood)
Dungeness B Power Station

- Dungeness B was first commercial AGR power station to be constructed
- The £89 million contract was awarded in August 1965 to Atomic Power Constructions (APC), a consortium backed by
  - Crompton Parkinson
  - Fairey Engineering
  - International Combustion and Richardsons
  - Westgarth and Co
Dungeness B Power Station

• Two Advanced Gas-Cooled Reactors (AGRs)
  – Graphite moderated / CO2 primary coolant
  – 4 x boiler / gas circulator units
  – Pre-stressed concrete pressure vessels
  – Single control room for both reactors

• Commercial Operation
  – Unit 1 (R21) → 1983
  – Unit 2 (R22) → 1985

• Current operating lifetime up to 2028
Dungeness B Power Station Common Control Room (CCR) Simulator

- Original simulator and training team based at Oldbury Training Centre in Gloucestershire from the mid-1980s
- Simulator moved into a purpose-built building at Dungeness B site in 1999
- Unit 1 and Common plant systems simulated
- Unit 2 plant systems not simulated
- Hardware based on Silicon Graphics (SGI) IRIS servers and Hytec Electronics CAMAC I/O
  – SGI ceased operations in 1989
  – Hytec ceased operations in 2016

Legacy SGI Computers
Legacy CAMAC I/O System
Dungeness B Power Station CCR Simulator

• 10 years Plant Life EXtension (PLEX) approved until 2028

• EDF Energy recognizes importance of simulator
  – Reliability
  – Maintainability
  – Latest Simulation Technology

• Simulator Upgrade project funded by PLEX program
  – Goal: Modernize simulator and ensure it can fulfil its mission until plant end of life
SIMULATOR UPGRADE PROJECT

Major Simulator Upgrade for Dungeness B
Simulator Upgrade Contract Award Criteria

• Commercial
  – Compliance (conditions of contract and tender instructions)
  – Supplier financial status
  – Pricing and payment terms
  – Warranty
  – After sales service

• Technical
  – Competence (capability and qualifications)
  – Previous project experience, capability and qualifications
  – Risk management
  – Innovation (technical solution and project flexibility)
Simulator Upgrade Contract

- EDF Energy awarded contract to L3Harris in December 2016
- Contract extended in early 2017 to include replacement of legacy CAMAC I/O system
  - Additional work had impact on original planned project tasks/schedule, however change in scope accommodated without impacting any key delivery dates
- Project broken down into two distinct phases

<table>
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<th>Phase 1</th>
<th>Phase 2</th>
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| • New computer system  
  • Rehost Unit 1 configuration  
  • Unit 1 I/O system replacement  
  • Classroom simulator | • Unit 1 configuration updated with new core/RCS/SG models  
  • New Unit 2 configuration  
  • Unit 2 panels and desk |
Phase 1 – New Computer System
Phase 1 – Rehost

- New operating systems and third-party software
- Orchid® simulation environment
- Rehost legacy simulation software to Orchid®
  - Source code
  - GFLOW models converted to Orchid® Modeling Environment graphical models
  - Database
  - Initial conditions
  - Training exercises (scenarios)
  - Triggers (conditions)
  - Etc.
- New soft panels
- Converted tutor diagrams
- Stimulated/simulated external systems
- Upgraded A/V system
Phase 1 – Orchid® Instructor Station

- Control and monitor all aspects of simulator and trainee performance
- Fully graphical user interface with standard Windows features e.g. drag and drop, window resizing, zoom, pan, etc.
- Highly configurable (e.g. toolbars, plant parameters, feature behaviors, etc.)
- User-defined windows layout
- Client/server application
- On-line PDF user manuals
- Simulation control and maintenance functions (freeze, unfreeze, store, restore, speed-up, slow-down, DORT, etc.)
- Replay scenarios and operator actions (synchronized with the other systems such as Orchid® Multimedia Manager, etc.)
- Insertion of plant component and system malfunctions, instrument overrides and local operator actions
- Direct access to modeling schematics, active schematics and virtual (soft) panels
- On-the-fly creation of active schematics and virtual panels
- Multiple operating modes i.e. instructor, operator, engineer and student
- Built-in exam security
- Focuses on automation and data collection
  - Create/edit graphical scenarios
  - Monitor, record and trend any parameter
  - Monitor and track operator performance
  - Scenario-based Testing and Training (SBT²)
  - Generate training performance records and reports based on ANSI/ANS-3.5 requirements
Phase 1 – New Soft Panels

- **Scope**
  - Unit 1 Desk
  - Unit 1 Panels
  - Common Panels
  - Back Panels
  - Backup/Emergency Panels
  - Sync Trolley

- **Available from Orchid® Instructor Station**
Phase 1 – Tutor Diagrams + External Systems

- **Tutor Diagrams**
  - Legacy tutor diagrams converted to Orchid® Graphic Editor displays using L3Harris’ pre-existing conversion tool, with fine adjustments performed as necessary
  - Identical look-and-feel as legacy tutor diagrams (no tutor learning curve)
  - Available from Orchid® Instructor Station

- **External Systems**
  - ATOS Digital Plant Control System (DPCS)
    - **Stimulated** (complete) DPCS in full scope simulator
    - **Simulated** alarm list with Orchid® Control System in classroom
  - POLARIS Plant Monitoring System (PMS)
    - **Partially simulated** PMS HMI with Orchid® Control System in full scope simulator and in classroom
Phase 1 – Upgraded A/V System

• Hardware
  – 6 analog cameras and microphones retained
  – 2 new digital encoders (4 channels each)
  – New A/V server

• Software
  – Orchid® Multimedia Manager
    – A/V recording and playback
    – Time-synchronized with the simulator for synchronized audio-video playbacks
    – Connectivity with debriefing room
    – Preview of all cameras in a mosaic display for monitoring at all times
    – Stores files using industry-standard “AVI” format
Phase 1 – Unit 1 I/O System Replacement

• Hardware
  – Legacy CAMAC I/O system replaced with new Beckhoff EtherCAT compact I/O system
  – 1-to-1 I/O points

• Software
  – Orchid® Input Output
    – Provides online diagnostics
    – Hardware and communication failure indications sent to Instructor Station (i.e. Simulator Confidence)
    – Conversion from engineering units to electrical units
    – Panel sleep
Phase 1 – Unit 1 I/O System Replacement

Before

After

Legacy CAMAC I/O controllers replaced with interface to mate existing I/O wiring and connectors to new Beckhoff I/O installed on DIN rails
Phase 1 – Classroom Simulator

• 5 Student Workstations (capability to run independent simulations)

• 1 Standard Orchid® Touch Interface Bay
  – Utilized for testing at L3Harris
  – Delivered to Dungeness B during Phase 2

• Mobile Instructor Station with Orchid® Instructor Station
Phase 2 – Dual-Unit Simulation Strategy

• Capability to operate Unit 2 stand-alone or in conjunction with Unit 1 to simulate complete power station

• Similar strategy implemented by L3Harris at Heysham 1

• Benefits of dual-unit simulator
  – Provides very representative and realistic control room environment especially important for plant with common control room
  – Enables training of full shift crews following plant processes and procedures
  – Enhances shift crew teamwork
  – Enhances control room communication skills while directing actions to be performed on a specific unit (communication more complex than before)
  – Allows opportunity for control room personnel to prioritize tasks to perform on training scenarios affecting both units
Phase 2 – New Models

- Unit 1 Legacy Updated
  - New Reactor Core Model
    - Comet Plus™ Reactor Core Model / Orchid® Core Builder
  - New Boiler and Reheater Model
    - ANTHEM™ / Orchid® Modeling Environment
  - New Gas Circuit Model
    - ANTHEM™ / Orchid® Modeling Environment
  - Boundary Interfaces
    - Feedwater, startup vessel, main steam
    - RCS gas bypass circuit

- New simulator load for Unit 2 created
  - Unit 1 used as starting point and updated to match R2 conditions
Phase 2 – Unit 2 Panels and Desk
Phase 2 – Unit 2 Panels and Desk

• Full Hard Panels solution
  – Replace existing Unit 2 Panel mockup with new structure and new operable instruments
  – Retain Unit 2 Desk structure / add new operable instruments

• Best physical fidelity/realism (i.e. look-and-feel)

• Enable most effective training

Existing Unit 2 Panel mockup

New Unit 2 Panel Instruments
Phase 2 – Unit 2 Panels and Desk
• Contract award: December 2016
• In Service: November 2019

**Phase I (Rehost and I/O Replacement)**

- Rehost Design
- Rehost Development and Integration
- Rehost FAT
- I/O Design
- I/O Prototype Build and Test at Dungeness
- I/O Production Build and Factory Test
- Install at Dungeness
- Phase 1 SAT
- Support EDF Training (Remotely from L3M)

**Phase 2 (Model Updates + Unit 2 Panel / Desk)**

- Unit 1 Model Development and Integration
- Unit 1 Model FAT
- Unit 1 Model SAT
- Unit 2 Model Development and Integration
- Unit 2 Model FAT
- Unit 2 Panel/Desk Design
- Unit 2 Panel/Desk Development
- Unit 2 Panel/Desk Integrated FAT
- Site Work: Panel Disassembly / New Panel Install
- Unit 2 Panel/Desk and Model Update
- 2020 Q4
- Unit 1 Training
- Ph1 → Unit 1 Training
- Ph2 Takeover
Challenges

• Schedule
  – New I/O system upgrade scope added, without impacting the final delivery date of Phase 1

• Behavior of retained legacy models and higher fidelity Orchid® replacement models
  – Increased the need for discussions and workshops with plant experts

• Maintenance of multiple configurations
  – Synchronizing field updates from Phase 1 (rehost) training into Phase 2 during model development
  – Synchronizing changes between Unit 1 and Unit 2 configurations during the deployment lifecycle

• EDF Energy support stretched between testing in Montreal and supporting training at Site
  – Overcome by deferring non-critical items to later phases
  – Provision of training load at EDF for remote support
  – Use of automated testing features of Orchid® Instructor Station to reduce face-to-face testing time*

• Obsolescence of panel instruments
  – 3D printed many devices to replicate look-and-feel of originals
*Automated Testing

**Recorded Data**

- Alarm Logs
- Simulator Actions
- Operator Actions
- Scenarios

**SBT²**
- Collated & organized
- Saved in 1 folder
- Can be zipped and/or protected
- Saved in common formats (.doc, .xls, .pdf).
Project Strengths/Successes Expressed by EDF Energy

• Performance
  – EDF Energy pleased with project progress
  – L3Harris’ processes, policies and procedures in all areas of operation (Project Management, Contract Management, Quality Assurance, Engineering) are professional

• Cooperation & Communication
  – Cooperation and communication between L3Harris and EDF Energy on highest standard and allowed project to progress to meet customer requirements

• Flexibility
  – L3Harris’ flexibility in scope change management and commercial arrangements allowed EDF Energy to focus on project with responsive L3Harris team
CONCLUSIONS

Major Simulator Upgrade for Dungeness B
Conclusions

• Project completed successfully to EDF Energy’s satisfaction
• Dungeness B Simulator now on modern and easy-to-use/maintain platform: Orchid®
  – New high-fidelity models provide most realistic responses and easier to maintain using L3Harris’ state-of-the-art graphical modeling tools
    – Orchid® Core Builder
    – Orchid® Modeling Environment
• Obsolete computers and I/O system no longer threat to training program
• Enhanced training capabilities with classroom simulator
• Upgraded simulator sustainable until the end of power station life
• New Unit 2 simulation, desk and panels integrated with Unit 1 simulator provides most representative and realistic control room environment
  – Allows training on dual-unit scenarios – not possible before