RECENT SIMULATOR DIGITAL CONTROL UPGRADES

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Outline

• Background Information
• Simulator Implementation Strategies & Selection Factors
• Planning for Simulator DCS Upgrades
• Recent Case Studies
• Conclusions
BACKGROUND

Recent Simulator Digital Control Upgrades
Background Information

• Majority of US NPPs built in the 1970s and 1980s with analog controls
• More European NPPs built with digital controls, but systems are being upgraded for multiple reasons
  − Increased safety, redundancy and/or cyber-security requirements
  − High cost of ownership of current control system
  − Insufficient OEM and/or secondary market support
  − Inability to implement/integrate plant changes with current system
  − etc.
• Number of DCS upgrades and replacements has accelerated in recent years
Recent Simulator Digital Control Upgrades
Simulator Implementation Strategies

There is more than one answer

Stimulation

Emulation / Virtualization

Simulation

[More info in back-up slides]
Simulator Strategy Selection Factors

• Technical Factors
  − Plant Upgrade Strategy (schedule, use of simulator for V&V, etc.)
  − Development/Classroom Simulators (portability of simulation)
  − Availability of Translator and/or Emulator
  − Configuration Management (ease to implement future plant changes)

• Non-Technical Factors
  − Intellectual Property Considerations
    − Licensing (emulator, HMI, stimulated DCS, etc.)
    − If/when/which data available for simulation
  − Who defines and contracts the Simulator Scope of Work
    − Plant Engineering (itself, or included in DCS Vendor contract)
    − Simulator Engineering
  − Cost
PLANNING FOR SIMULATOR DCS UPGRADES

Recent Simulator Digital Control Upgrades
**Contractual Approaches**

<table>
<thead>
<tr>
<th>Simulator work included in Plant DCS Vendor contract</th>
<th>Simulator work contracted separately by Simulator Team</th>
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<tbody>
<tr>
<td>DCS Vendor typically subcontracts Simulator vendor</td>
<td>Simulator Team typically subcontracts Simulator vendor but may perform some of the work itself</td>
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<tr>
<td>Intellectual Property rights and data transfers handled by DCS Vendor</td>
<td>Simulator Team needs to manage scheduling, data, Intellectual Property, etc.</td>
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<td>Reduced workload for simulator upgrade</td>
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<td>Plant Engineering will drive Tender evaluation</td>
<td>Increased flexibility of technical solution, including possible addition of non-DCS scope of work</td>
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<tr>
<td>Simulator requirements need to be well defined from the beginning, more difficult to change later if proposed solution not satisfactory</td>
<td>Good reasons to couple project with simulator platform upgrade [More info in back-up slides]</td>
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Simulator DCS Upgrade Requirements

• Specifications to Plant DCS Vendors / Tenderers shall include Simulator requirements
  - If not properly defined in the Plant DCS contract, you may inherit a Simulator Project with
    - Lack of DCS Vendor support, data, licensing, etc.
    - Unreasonable schedule (required data available too late to implement in simulator and meet training requirement)
    - Cost overruns / underestimated budgets
    - Solution does not meet simulator functional requirements
  - Detailed requirements at this stage will help → Simulator Vendor can assist

• Training overlap between Old and New controls
  o Plan for hardware and software switchover
OUR TECHNOLOGY FOR SIMULATOR DCS IMPLEMENTATION

Recent Simulator Digital Control Upgrades
Controls Simulation

• **Graphical Models**
  – Creation of object libraries with control algorithm blocks
  – Creation of schematics
    – Automatic process → XML / ASCII import of control sheets from plant system export
    – Manual process → manual creation of control sheet schematics
  – Accessible from within Orchid® Instructor Station

• **Non-Graphical Models**
  – C/C++ source code
    – Automatic process → translator generating database and control code
    – Manual process → manual database and coding
HMI Simulation

- Based on Real-Time Data Acquisition and Control System (capability to execute code)
- Client/Server Architecture (can run concurrently on same computer)
- Powerful Graphic Editor
  - Automatic Process → translator generating graphic pages
  - Manual Process → manual creation of graphic pages
- Database Maintenance Tools
- Supports
  - Trends
  - Alarm Lists
  - Popups (e.g. confirmation, point display, etc.)
  - etc.
- Inherent Support for Simulator Commands (e.g. Freeze/Run, Store/Restore, Backtrack/Replay, etc.)
- Highly Customizable
Instructor Station and Glass Panels Graphics

- **Real-time Advanced Visualization Environment**
- **Photo-realistic Interactive Control Room Panels (virtual panels)**
  - Instructor Mode → access to panel instrument overrides (failures)
  - Operator Mode → plant operations
- **Plant Interactive Schematics (active schematics)**
  - P&IDs
  - Electrical One-line Diagrams
  - Control Diagrams
  - etc.
- **Supports Zoom, Pan, Tilt**
- **One-world (continuous panels)**
- **Supports Importing Vector Graphics and Bitmaps**
- **Accessible from within Orchid® Instructor Station and Orchid® Touch Interface**
Integration of Controls / HMI simulation / Glass Panels

Orchid®
Touch Interface

+  

Orchid®
Graphic Editor

+  

Orchid®
Control System
Examples of DCS/I&C on L3Harris Simulators

Westinghouse
Common Q
AC160
Ovation

SIEMENS
OM690
SPPA-T2000
SPPA-T3000
TELEPERM ME
SIMATIC PCS7

MITSUBISHI ELECTRIC
MELTAC

ABB
Advant Controller 160
Advant Controller 450
MicroSCADA
Symphony Plus
OS500
UNITROL

Schneider Electric
TRICON
Foxboro I/A

ALSTOM
ALSPA P320
ALSPA CONTROSTEAM

Cegelec
SIP

Thales
DPS

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Recent Case Studies

Recent Simulator Digital Control Upgrades
TH1: Project Overview

- Plant: Tihange Unit 1 (Belgium)
- End Customer: ENGIE Electrabel
- Contractor: ENGIE Tractebel
- Plant Modification: Replace the CEGELEC Turbine and Control Systems with a GE Alspa ControSteam on the Dual-Turbogenerator Unit 1 simulator

- Strategy
  - Controls $\rightarrow$ Graphical simulation with Orchid® Modeling Environment
  - HMI $\rightarrow$ Simulation with Orchid® Control System

- Status: Ready-for-Training (RFT) May 2019
TH1: Controls Solution

- Orchid® Modeling Environment library replicating ControSteam functional block
- Mature library used on multiple projects
TH1: HMI Solution

- Orchid® Control System HMI simulation
- Features tailored to customer requirements
PSL: Project Overview

• Plant: St. Lucie (Florida, USA)
• End Customer: Florida Power & Light
• Plant Modification: Replace previous Rods Control System with Westinghouse Ovation; retain other previous controls

• Strategy
  − Previous Controls → Non-Graphical simulation, L3Harris-developed Translator
  − Previous HMI → Simulation with Orchid® Control System, L3Harris-developed Translator
  − Ovation Controls → Non-Graphical simulation, DCS Vendor Translator
  − Ovation HMI → DCS Vendor emulation

• Status
  − Unit 1 Glass Panels Simulator Ready-for-Training (RFT) June 2019
  − Unit 2 Glass Panels Simulator Ongoing, Planned RFT 4Q 2019
  − Unit 2 Full Scope Simulator Planned RFT 1Q 2020
PSL: Multi-Phase Approach

• Simulator reference to Plant Unit #2

• Plant DCS replacement schedule requires training first on Unit #1

• Differences between both Units
  − Reactor core, rods and instrumentation configuration
  − Shutdown cooling systems

• Simulator development and initial training on Glass Panels simulator

• Orchid® Control System and Ovation HMI integrated in soft panels

• Unit #2 Glass Panels simulator developed in next phase, followed by Full Scope Simulator
SQ1: Project Overview

- **Plant**: Susquehanna (Pennsylvania, USA)
- **End Customer**: Talen Energy
- **Plant Modification**: Replace existing Automatic Voltage Regulators (AVRs) by new ABB UNITROL series Digital AVR (DAVR) system

**Strategy**
- Modification of current Automatic Voltage Regulator (AVR) electrical model
- Functional simulation of the ABB Control algorithms in simulator using Orchid® Modeling Environment schematics
- Implementation of simulated simplified Excitation Control Terminal (ECT) HMI using Orchid® Control System HMI Simulation

**Status**
- Project completed in 4Q 2019
Recent Simulator Digital Control Upgrades
Conclusions

• Digitalization of analog controls or further upgrades to existing DCSs will continue into future

• Several technical and non-technical factors to be considered before selecting simulator digital controls implementation solution

• L3Harris has extensive experience in implementing digital controls in legacy simulators using multiple strategies (stimulation, emulation, simulation, hybrid)

• Orchid® simulation suite offers all features required for digital controls implementation in fully integrated environment for
  − operator training simulators (FSS and classroom)
  − engineering simulators
Recent Simulator Digital Control Upgrades
Simulator Implementation Strategies

- Stimulation and Emulation very similar from a Simulator Environment standpoint
  - Main difference is the Hardware Footprint
  - DCS seen as “external system” with communication link to simulator environment
  - Plant DCS software runs as-is, or with minimal modifications in simulator
  - Availability of emulator / virtual controller depends on DCS vendor

- Simulation of controls come in many flavors
  - Automated translation
    - Available from DCS vendor
    - Available or developed by simulator vendor
  - Simulation models developed manually

- Simulation of HMI developed manually or partly automated translation
  - Fully-automated translation is possible but seldom the most advantageous solution

- Hybrid solutions typically involve Simulated controls and Stimulated / Emulated HMI
Combining Simulator DCS Upgrade with Platform Upgrade

- Simulator Platform at or near End-of-Life → Reasons to consider combining a Platform Upgrade
  - Incompatibility of current platform with newly introduced hardware or software (HMI and/or controls)
  - Obsolescence prevents increasing capacity (new test bench, development simulators, etc.)
  - Many activities required for Simulator Platform Upgrade already needed for DCS Upgrade
    - Software installation, setup, testing program, etc.
    - Combining both can result in valuable savings over sequential upgrades
  - Simulator budgets are being reduced throughout the industry, it might be easier to get funding through a plant project by building a solid case
  - DCS Upgrade project will end with larger than usual non-DCS deficiency backlog
    - During DCS Upgrade project, fewer resources to address non-DCS deficiencies
    - Non-DCS deficiencies will be discovered during the project’s extensive testing program
    - Be prepared to tackle this additional workload
      - Latest simulation technology is more efficient, intuitive, and with better troubleshooting features
      - A state-of-the-art, modern platform delivered with a comprehensive training program refreshes your simulator’s performance, capabilities and maintenance engineers’ skillset