Introducing Digital Controls on Legacy Simulators

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Topics

• Background Information
• Digital Controls - Simulator Implementation Strategies & Selection Factors
• L3 MAPPS’ Technology for Digital Controls
  – Controls Simulation → Orchid® Modeling Environment
  – HMI Simulation → Orchid® Control System
  – Soft Panels → Orchid® Graphic Editor
  – Classroom → Orchid® Touch Interface
• Case Studies
  – St. Lucie CVCS Digital Controllers (Yokogawa YS1700 Controllers)
  – Cernavodă Main Generator Excitation System (GE EX2100e)
  – Callaway Main Feedwater Control System (Siemens T3000 DCS)
• Conclusions
Majority of US NPPs built in 1970s and 1980s with analog controls
Plant Digitalization - Ultimate Goal

- Digital Human-Machine Interface (HMI) replacing, to a large extent, conventional analog HMI
- Analog control and command (relays, switches, comparators, etc.) being replaced with digital I&C systems (DCS)
- Sensors, detectors, transmitters, actuators increasingly incorporating digital technologies
Reality is that digital systems are slowly being introduced
Simulator Myths/Realities

• Digitalization complexity creates uncertainty
• Simulation has a large role to play to overcome this uncertainty/complexity

**Myths**

– Simulators are for operator training, not for design, not for engineering
– Many simplifications are made to simulate plant behavior for simulator to run in real time
– This “conventional wisdom” comes from 1970s post-TMI simulators

**Realities**

– Simulators are for operator training and for supporting plant/system design and verification & validation (goal: identify and resolve design issues early)
– Computing power and simulation technology have come a long way: one-to-one replication of design/plant
– Numerous successes experienced with NNB and legacy NPP programs where simulation serves as design assist tool
Simulators are a part of the answer

- Today’s simulation is based on real-time, high-fidelity and graphical models
- One-to-one simulation of plant design can be done now
- ALL models are generated in a single, integrated environment (Orchid®)
- Make sure components, systems, integrated systems, the full plant behave the way they are designed
- Validate I&C/DCS upfront
Digital Controls - Simulator Implementation Strategies & Selection Factors
Simulator Implementation Strategies

- There is more than one answer

  Stimulation

  Emulation

  Simulation

- A hybrid strategy is also possible where the controls and HMI use different solutions (e.g. simulated controls and stimulated HMI)
Simulator Strategy Selection Factors

• Project Strategy
• Data Availability (plant vs. simulator timing)
• Digital Controls Vendor (OEM IP considerations)
• Cost of Hardware, Development and Software Licenses
• Licensing Restrictions
• Project Schedule
• Development/Classroom Simulators (portability of simulation)
• Configuration Control/Management (ease to implement future plant changes)
• Fidelity Requirements
• Preference
• etc.
L3 MAPPS’ Technology for Digital Controls Simulator Implementation
Controls Simulation

• Graphical Models
  – Creation of object libraries with control algorithm blocks
  – Creation of schematics
    ▪ Automatic process → XML 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
HMI Simulation

Orchid® Control System Sample Trend Display

Orchid® Control System Sample Translated HMI
Soft Panels

• Real-time Advanced Visualization Environment
• Photo-realistic Interactive Control Room Panels (virtual panels)
  – Instructor Mode → access to panel instrument overrides (failures)
  – Operator Model → 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 (classroom)
Integration of Control Simulation/HMI Simulation/Soft Panels
Integration of Control Simulation/HMI Simulation/Soft Panels
Examples of Third-Party DCS/I&C on L3 MAPPS Simulators

- Common Q
- AC160
- Ovation
- TELEPERM XS
- QDS
- OM690
- SPPA-T2000
- SPPA-T3000
- TELEPERM ME
- HOLLiAS
- MELTAC
- DCC
- Advant Controller 160
- Advant Controller 450
- MicroSCADA
- ALSPA P320
- ALSPA CONTROSTEAM

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Case Study:
St. Lucie CVCS Digital Controllers
**Project Overview**

- **Plant:** St. Lucie (Florida, USA)
- **End Customer:** Florida Power & Light
- **Contractor:** L3 MAPPS
- **Plant Modification:** Replacement of three (3) legacy analog Chemical Volume Control System (CVCS) Fischer & Porter controllers with three (3) new digital YS1700 Yokogawa controllers
- **Strategy**
  - Controls → Non-graphical simulation in C code with use of subroutines
  - FSS HMI (Controller) → Same hardware as the plant (Yokogawa YS1700/A34); A34 option provides the TCP/IP Ethernet connectivity; stimulated but using only display functions (control functions disabled)
  - FSS HMI Interface → TCP/IP (Modbus)
  - Classroom HMI → Fully functional soft panels developed with Orchid® Graphic Editor running either inside the Orchid® Instructor Station or on the Orchid® Touch Interface bays
Legacy Analog vs. New Digital Controllers

Fischer & Porter Controllers

Yokogawa YS1700 Controllers
Yokogawa YS1700 Soft Panels
Case Study: Cernavodă Main Generator Excitation System
Project Overview

- **Plant:** Cernavodă (Romania)
- **End Customer:** Societatea Nationala Nuclearelectrica
- **Prime Contractor:** GE Energy Control Solutions
  - Subcontractor: L3 MAPPS
- **Plant Modification:** Replace the existing GE Generrex with a GE EX2100e Main Generator Excitation System also referred to as the Main Generator Automatic Voltage Regulator (AVR)
- **Strategy**
  - Controls → Graphical simulation with predecessor of Orchid® Modeling Environment (ROSE®)
  - HMI → Simulation with Orchid® Control System
Controls Simulation
Exciter Control Operator HMI

Plant

Simulator
Capability Curve Operator HMI

Plant

Simulator
Case Study:
Callaway Main Feedwater Control System
Project Overview

- **Plant:** Callaway (Missouri, USA)
- **End Customer:** Ameren Missouri
- **Contractors:** Siemens & L3 MAPPS
- **Plant Modification:** Implement the Siemens SPPA-T3000 main feedwater control system into the simulator
- **Requirements:** Capability to switch between the following 3 configurations (single software configuration): simulated legacy controls, simulated new controls and stimulated plant system (engineering simulator)
- **Strategy**
  - Operator Training Simulator
    - Controls → Automatic graphical simulation with Orchid® Modeling Environment
    - HMI → Simulation with Orchid® Control System
  - Engineering Simulator
    - Controls → Same hardware as the plant (Siemens SPPA-T3000)
    - HMI → Same as the plant
  - Engineering Simulator Controls/HMI Interface → Compact I/O System (WAGO)
Operator Training Simulator - Simulated Controls/HMI

Plant Controls
Siemens T3000 Workbench

Simulated Controls
Orchid® Modeling Environment

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Switching Between Configurations

Legacy Controls Simulation

New Controls Simulation

Siemens SPPA-T3000 Stimulation

3-way Selector Switch

Process Simulation
Engineering Simulator

Process Simulation

I/O Interface

Siemens Stimulated Equipment

SPPA T3000
Conclusions
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• Digitalization of legacy plants is progressing and will continue in the future
  – Accepted principle in “Delivering the Nuclear Promise”

• Simulators can be used for operator training and for plant/system design and verification & validation helping identify and resolve design issues before introduction in the plant

• Several factors need to be considered before selecting a digital controls implementation strategy

• L3 MAPPS has extensive experience (40+ years) in implementing digital controls in legacy simulators using the different implementation strategies (i.e. stimulation, emulation, simulation and hybrid)

• L3 MAPPS Orchid® simulation suite offers all the features required for digital controls implementation in operator training simulators (FSS and classroom) as well as engineering simulators in a fully integrated environment
Thank you