Lessons Learned and OE from Digital I&C Upgrades

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Westinghouse Operating Plant Business

Exelon Generation – Braidwood Station

Digital I&C Upgrades

- Digital Feedwater (DFWCS), Turbine Driven Feedwater Pumps (TDFWP), and Feedwater Heater Control Systems provide a number of benefits to utilities
  - Full-range automatic control and elimination of single point vulnerabilities (SPV)
  - Avoidance of plant obsolescence issues
  - Reduced operator intervention and field tuning
  - Reduction in maintenance and calibration hours
  - Increased monitoring capabilities
  - Improved plant performance yielding efficiencies that translate into additional revenue
  - Supports transient capability with reduced risk of reactor trip
  - Can be installed in new or existing cabinetry

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Lessons Learned and OE from Digital I&C Upgrades

During implementation of Digital Upgrades, Learnings should be leveraged from ALL team members

- I&C Vendor
- Utility
- Supporting subs

Integrated Team for Success

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Learnings Throughout Project

- Lessons Learned from recent digital control system upgrades come from all phases of project:

- This presentation will walk through the Lessons Learned details and OE examples from each phase

Lessons Learned during Design

- Understand the benefits of the upgrade to ensure project buy-in from all groups involved
  - Operational improvements in control
  - Efficiencies that translate into additional power production revenue
  - Avoidance of parts obsolescence
  - Drives business case for justifying the upgrade investment
- Plan Ahead: Complete advance benchmarking at other sites - Proven designs and processes minimize project and outage risks
- Have “experienced” personnel from vendor and utility that work as a team – include key stakeholders from Day 1
  - Utilize personnel that know the plant design, problems, interfaces and processes
  - Identify a plant operations representative from start to end of project

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Lessons Learned during Design (con't)

- Early Engagement of Utility OPS
  - Define operational needs & expectations (buy-in on features, functionality)
  - Simulator and Training constraints
  - Human Factor Evaluations (HFE) of MCR Layout and operational tasks
- Need to have a good understanding of plant/operations vs "build to spec"
- Carefully evaluate SPVs for cost/benefit analysis
  - Deploy some level of input/output redundancy for functions that immediately impact the plant in a negative way (trip, transient…)

Lessons Learned during Design (con't)

- Consider scenario of controller redundancy failure – human error or power failures
  - What happens to the plant if control processing stops
  - What happens to the plant if control processing gets restarted online – human error, power fluctuations, or cyber attack
  - Is there a backup layer of redundancy
- Review existing procedures for workarounds which impact control system operation
  - Evaluate for impacts to new control system functional design

OE from Design Phase

- Example: Valve Gear Split During DFWCS Upgrade
  - Successful planning and integration for mechanical mod as part of digital upgrade
    - Incorporated utility, valve gear vendor and I&C vendor into one design team
    - Performed multi-discipline design review to confirm design and validate assumptions
    - Completed detailed planning for installation phase
    - Successfully modified (split) valve gear on critical component

❖ **Proper planning can make an I&C and mechanical modification a success**

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OE from Design Phase (Valve Gear Split with FW Upgrade)

OE from Design Phase - Braidwood

- Example: Evaluation of SPVs During Design Study for DCS Upgrade
  - During the early design study, the vendor and utility stakeholders including Operations reviewed the various SPVs to determine which should be addressed (with redundancy) in the upgrade project
    - Vendor provided list of control solutions that allowed for elimination of all SPVs (30+)
    - Utility Engineering and Operations reviewed the SPVs in a cost / benefit analysis
    - Upon reviewing the site operational procedures and associated requirements, the collective team was able to reduce the scope including in the project to less than 10 SPVs

Reducing Scope of a Digital Upgrade Can Improve the Viability and Cost / Benefit Analysis of the Project

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OE from Design Phase - Braidwood

- Example: Upgrade to Electrical Overspeed Protection for TDFWP During Digital Control System Upgrade Project
  - Linking separate control system projects together when the primary control system is being upgraded can be advantageous if it is closely integrated
    - Upgrading the Electrical Overspeed Protection for TDFWPs was a separate project. Adding it to the NSSS Upgrade allowed the use of local panels and simplified the resolution of design issues (conductor limitations, interconnections of custom components, etc.)

- **Plan ahead to ensure that Digital Upgrade projects are performed at the right times when there are multiple projects impacting a system**

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Lessons Learned during Implementation/Test

- Ensure that digital upgrade system design meets current dynamic regulatory environment and requirements
  - Licensing / 50.59 Evaluation
  - Software Hazard and Susceptibility Analysis
  - Failure Modes and Effects
  - Requirements Traceability Matrix
  - System Security & Cyber Security
- Appropriate use of tools
  - Plant Representative Engineering model for dynamic testing, verification
    - High fidelity models focused on normal range of operation and transients
    - Use as part of the factory acceptance process
  - Simulator for operator training
    - With use of high-fidelity engineering models in support of design/implementation/test, it can provide important updates to the plant simulator models
  - Use of Simulator or MCR for HFE Evaluation

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Lessons Learned during Implementation/Test (con't)

- Digital systems provide Configuration Management challenges
  - Platform configuration tools should provide levels of self documentation
  - Asset Management System (AMS) Device Manager software provides configuration capture features
  - Utility likely has different configuration management requirements at site than vendor has at factory acceptance test
- Review and challenge scope of modification
  - Ensure modification scope fit in outage window with minimal risk
  - Plan work in pre-outage (on-line) to reduce risk
  - Use phased upgrade approach
    - Allows operations "kicking of tires" & OE of first upgrade
- Consider a Mockup
  - When reusing a suite of cabinets a mockup can validate the fit of new equipment, determine interferences, signal cable lengths & routing and allow training of the installation crews

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Lessons Learned during Implementation/Test (con't)

- Tracking and distribution of drawing revisions during work planning and installation will help to ensure that work is planned, executed, and verified under the newest revisions of drawings
  - Ensure all affected groups are included on distributions of new revisions
- Ensure dedicated around-the-clock coverage of modification/installation testing support to adjust for fluid outage schedule changes
  - Vendor
  - Engineer of Choice (EOC)
  - System Engineering

OE from Implementation/Test Phase - Braidwood

- Example: Digital Control System Infrastructure Upgrade
  - I&C equipment delivered to site under configuration control
    - Changes in design can occur through the review process – need to ensure flexibility with implementation in field
    - Reviews by utility and any 3rd party reviewers need to happen in parallel to avoid late changes
    - Updates completed through field FCN versus vendor configuration control

Develop plan to implement changes early on in the project to understand requirements and limitations

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Lessons Learned during Commissioning

- Plant operation procedures should be updated, approved and used during the initial plant commissioning and startup
- Ensure stakeholders and operations staff are fully trained on the system and have confidence to take the appropriate action
- Often the technicians field troubleshooting can cause system issues without realizing it – especially with redundant output circuits
- When using patch panels, they should be point-to-point tested prior to connecting up the external cables

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Lessons Learned during Commissioning (con't)

- Flexible commissioning procedures need to be put in place to allow "straightforward" software or system changes (5 minute change should not take a work day to get written and approved)
- Recognize that replacement Digital Positioners have internal PID control and form an outer control loop
- Valve and/or pump work during same outage as Control System Upgrade can impact control system
- Digital systems allow the users to see things in the plant that they were not aware off – often end up chasing ghosts
- Avoid startup tuning by utilizing a robust testing & validation plan that incorporates closed loop engineering models

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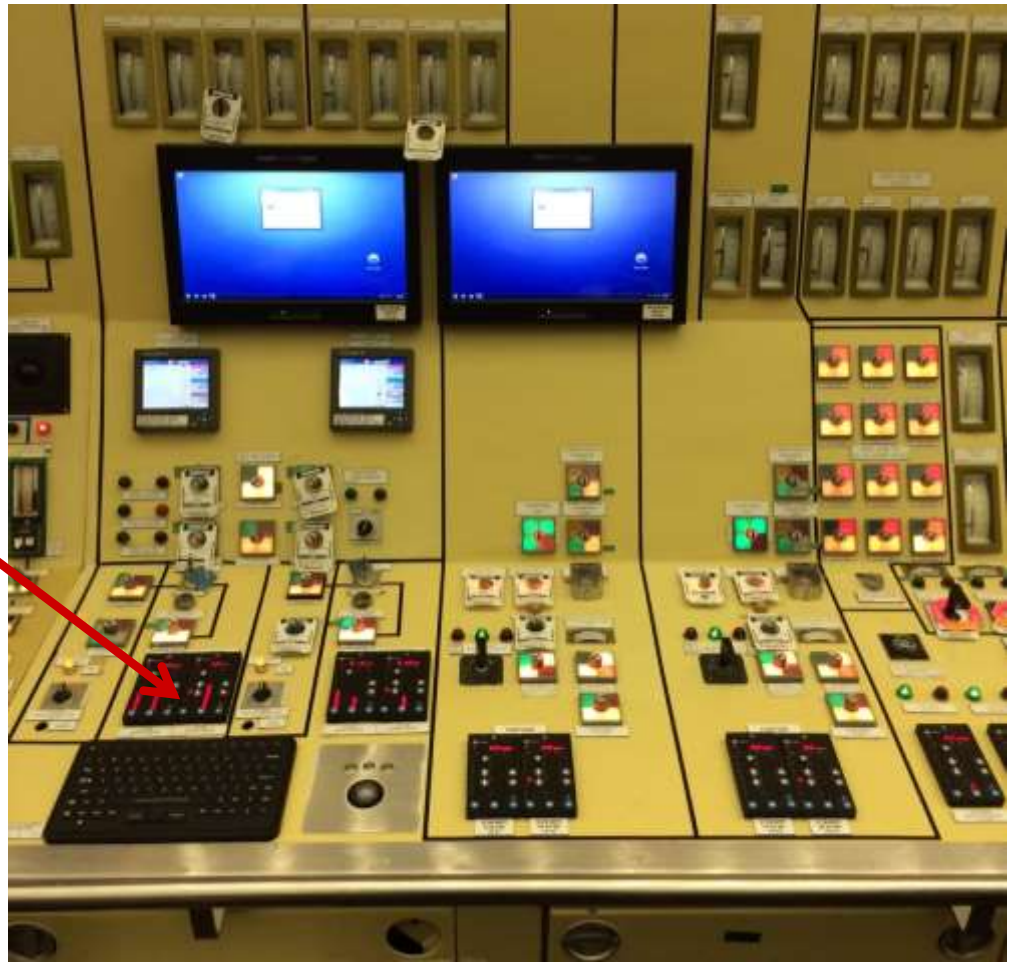
OE from Commissioning Phase

- Example: Digital Feedwater Control Upgrade
  - Manual/Automatic module (SLIM) lost communication during testing as a result of a loop interface module switching from primary to backup
    - Troubleshooting identified that wire connection was broken at termination of interface module in cabinet
      - Could have occurred in shipping, installation, etc.
    - During Factory Acceptance Testing, all loops are tested, including redundant configurations
    - Recommend that all site acceptance / field testing include loop checks similar to factory acceptance – have vendor review modification test procedures

❖ **Have an integrated test plan to ensure robust testing at factory and at site**

SLIM Manual / Automatic Module



OE from Commissioning Phase

- Example: Reactor Water Level Control Upgrade
  - Manual/Automatic module (SLIM) Power Issue
    - Vendor provided new power supplies in I&C cabinet, but cables connected to power supplies were reused during installation that were not properly shielded
    - Troubleshooting found that there was noise from EMI/RFI and a temporary line alleviated issue
    - If EMI/RFI is a concern, vendor can mount SLIM power supplies in or as close to main control board as possible
    - Reusing cables does not always work as anticipated; need to know the requirements of the new components which will be using the existing cables

Ensure cables and power supplies meet shielding requirements, especially during re-use

Summary

- Digital I&C Projects have many benefits to the plant operation and economics, but careful planning and coordination between combined team is important to mitigate risks
- Communication is key in all phases of project
- Leverage the OE and Lessons Learned from the vendors and other utilities to help make the project a success

Thanks for Your Time!

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Questions?