Diablo Canyon Simulator Upgrade Program & Balance Of Plant (BOP) Model Replacement

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Overview

• Background – How did we get started and organize the upgrade program?
• How did we get to the final phase - BOP Model Upgrade project?
• How did we get it approved?
• What was included?
• How did we execute it?
• What did we learn?
Background

• Original Simulator from Westinghouse in 1980’s
• Maintained exclusively In-House by DCPP personnel & became “1 of a kind” over the years
• Circa 2010 - ENTER Tom:
  – No simulator experience
  – Limited turnover/mentoring
  – No simulator specific training
  – Almost all of the original staff retired
  – Remaining experience leaving in 1-2 years
  – What is the plan to maintain the simulator for next ## years?
Background

• My Answer - Major Multi-Phase & Multi-Year Simulator Upgrade Program:

• Started Capital Project process in 2010

• Proposed program:
  – Phase I – Replace original RTP I/O
  – Phase II – Replace RCS/Core/CVCS Models
  – Phase III – Replace ½ of Remaining Legacy Models
  – Phase IV – Replace rest of Legacy Models
Program Overview

• Why did we plan to do it in this way/order?
• Ability to obtain approval and funding thru the DCPP Capital Project process:
  – No significant $$’s were identified for any major simulator work in any plant budget
  – VERY difficult and unlikely to get funding for entire upgrade at 1 time – needed phases
  – Program presentations began in 2010/2011 and offered a complete multi-phase plan but ONLY requested funding for Phases I & II to keep initial request reasonable
  – Requested that future phases be added to the Plant Long Term Capital Project plan w/ ballpark dates and with estimated funding. Note that the original phases did not end up matching the actual phases of the program.
  – Doing the upgrades in phases put less burden on the staff versus a single large project
  – Able to “sell” the various Phases as mitigating the majority of RISK associated with the simulator and operator training program in terms senior management “understood”
Program Overview

• Phase I (I/O) “sold” to Plant Management as the most vulnerable single point of failure in the DCPP simulator:
  – Direct hardware failure data did not show unfavorable trend & would not “sell” to management. DCPP had lots of spares
  – RTP I/O used an old and no longer supported set of Interface boards (Anybody remember the RTP GSL?)
  – DCPP, as far as we knew, had the only GSL boards on the planet
  – GSL failure represented a very high RISK to the simulator’s availability
Program Overview

• Phase II (RCS/Core) “sold” to Plant Management on simulator reliability & ILT Reactivity Manipulation capabilities:
  – RCS models (an older RELAP model) was responsible for most simulator crashes
  – Simulator core model was not able to consistently pass Startup Physics Test validation in order for it to be qualified for use in getting the required ILT Reactivity Manipulations. Forced ILT to do in plant qualifications (Even noting the Simulator was rarely relied upon for these credits)
  – Simulator Performance Index (PI) was RED due to Reactivity Manipulation problem and recurring RELAP crashes for some time. The PI would remain that way until we could tune the current core model to pass and debug RELAP or DCPP could upgrade those models
  – DCPP would be able to present these upgrades to INPO, NRC, NSOC, etc. as actions being taken to resolve several of the longest standing simulator performance issues

• Also “sold” the overall concept of a simulator upgrade program based on the fact that the DCPP simulator had become a unique and custom simulator with no vendor or peer support.
  – Could not use the lack of in-house expertise (Due to retirements and attrition) to maintain the system as senior management could easily say “Maintaining the simulator and the necessary expertise is simply the job of the simulator team”
  – Emphasizing uniqueness & lack of external support and the RISK that represented to get later phases into the Long Range Budget Plan

• Phase II Included Complete Simulator Re-Host to lay foundation for future phases
• Phases I & II Began in 2012 and completed in 2013
Program Overview

Legacy RTP

BECKHOFF
Program Overview

Legacy

ORCHID
Program Overview

Legacy

ORCHID
Program Overview

Legacy ORCHID
Program Overview

ORCHID SCHEMATIC
Program Overview

ORCHID ME SCHEMATIC
After completion of Phase I & II, went back to the Capital Project Committee for approval to convert Long Term Budget Items for Phases III & IV into “real” budget & “real” project.

Phase III (Modified to be an Electrical Model Replacement) “sold” to Plant Management as actionable response to Fukushima event (Timing was fortuitous):

- Original simulator electrical model really inadequate to simulate an event of this type (For example – Battery model was simple with limited ability to model draining, voltage decay and effects)
- Original simulator electrical model lacked fidelity and detail (For example, individual load breakers on various busses not modelled to allow any load shed strategy to be simulated to extend battery life)
- Able to “sell” this as an actionable plant response to Fukushima

Phase IV (ORCHID TI/Glass Tops) – Not in the original program. No need to “sell”. Plant Management through attendance to CONTI and other conferences had seen that most other plants were ahead of DCPP with regard to Glass Top/Classroom Simulators. We actually were asked to include Glass Top simulators in our upgrade program. Purchased 6 bays configured as 2 x 3 bay systems.

Phases III & IV awarded in 2014 and completed in 2015.
Program Overview

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Program Overview

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BOP Upgrade Project

• After completion of Phase III & IV, went back to the Capital Project Committee for approval to convert Long Term Budget Item for Phase V into “real” budget & “real” project. Note that the BOP project size and cost was as much as the previous 4 phases combined

• Phase V (BOP Model Upgrade) - “sold” to Plant Management as:
  – Necessary to eliminate remaining unique legacy models where current staff expertise was limited
  – Eliminated the “hybrid” nature of the DCPP simulator and potential ongoing issues with interfaces between “old” models and “new” models. Interfaces between models are likely to be the highest risk for simulator problems and crashes.
  – Provide add’l modelling fidelity
  – Presented/emphasized the ability to leverage both vendor and peer support going forward, to utilize industry OE and eliminate total dependence on in-house resources for that portion of the simulation and any interface issues between “legacy” and “new” models.
  – Having $$’s already in the Long Term Budget was very helpful in getting approval

• Phase IV approved and awarded in the summer of 2015
BOP Upgrade Project

• Phase V – BOP Model Upgrade – What was included:
  – Replaced all remaining models with the following exceptions:
    • ALL DCPP Triconex controller emulations (MTCS, DFWCS, PCS, RI Rack, POV)
    • RMUCS Allen-Bradley controller emulation
    • DFW Woodward Speed controller emulation
    • EAGLE 21 Reactor Protection System
    • Radiation Monitoring System – some “special stuff”
  – Schedule:
    • Award – July 2015
    • Design Review Complete – February 2016
    • Integration Complete – April 2017
    • Pre-FAT (12 weeks) – Complete July 2017
    • FAT (12 weeks) – Complete November 2017
    • SAT (4 weeks) – Scheduled Complete March 2018
Phase V – BOP Model Upgrade had to be “sold” AGAIN to Plant Management:

- Following PG&E’s announcement in 2016 of their intent to forgo license extension and shutdown the plant at the end of the current NRC Operating licenses in 2024 & 2025, the BOP Model Upgrade project had to survive several plant-wide reviews of all capital projects. Project “defense” was successful:
  
  - Timing of announcement “fortunate” – project was active for about 1 year and roughly 50 – 60 % complete. Potential savings would have been minimal. If the project had started 6 months later maybe it would have been cancelled?????
  
  - Able to restate benefits of eliminating legacy models and old vs new model interfaces
  
  - Able to restate benefits of supportable simulator by both vendor & peers
  
  - Able to restate benefits of being able to apply industry OE to our system
BOP Upgrade Project

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BOP Upgrade Project

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BOP Upgrade Project

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BOP Upgrade Project

• Phase V – BOP Model Upgrade - Execution:
  – DCPP Staffing
    • 1 Part Time Project Manager from the Plant
    • 1 Full Time Project Engineer from Simulator Support group
    • 1 Part Time Simulator Support Engineer
    • 3 Contractors – 2 part time, 1 full time
    • 2 Full Time Licensed Operators for Pre-FAT & FAT
      – Some plant evolutions were difficult to execute with only 2 operators and only 3 GlassTop Simulator bays.
    • Would recommend add’l resources for this large a project but in our case they were not readily available
BOP Upgrade Project

- Phase V – BOP Model Upgrade - Execution:
  - DCPP dedicated 2 engineers & 2 contractors for data gathering and providing vendor support during the model design phase – more than ½ time for 5-6 months
  - DCPP Supported final Design Review Meeting with 2 simulator support engineers, 2 contractors (Ex-DCPP simulator support engineers)
  - DCPP Supported final model integration at vendor facility with at least 2 individuals on-site for the 6 weeks prior to start of Pre-FAT

- Integration support based on past experience with Phases II & IV where lack of on-site support impacted the ability to start Pre-FAT with minimal problems. Integration was NOT complete at the start of Pre-FAT. IMHO this effort was critical to our success.
BOP Upgrade Project

• Phase V – BOP Model Upgrade - Execution:
  – DCPP provided Test Plan, Procedures, Training Documents and Lesson files needed to execute the tests including updates necessary to conform to the new models
  – DCPP Provided Project Engineer, Contractor & 2 Licensed operators for entire 12 weeks of Pre-FAT (5 x 10 hours/day + some weekend work)
  – DCPP performed some official Pre-FAT testing on Development systems at Diablo Canyon with 1 Simulator support engineer and 1 contractor to supplement the on-site test team.
  – DCPP Provided Project Engineer, Contractor & 2 Licensed operators for entire 12 weeks of FAT (5 x 10 hours/day + some weekend work)
  – DCPP Performed some official FAT testing on Development systems at Diablo Canyon with 1 Simulator support engineer and 1 contractor to supplement the on-site test team
BOP Upgrade Project

• Phase V – BOP Model Upgrade - Execution:
  – DCPP Project Test Plan Deficiencies
    • Test Plan was overly optimistic & required supplementing the on-site test team with add’l resources at DCPP. Plan included operating the plant from FPSS to Mid-Loop and back to FPSS, ANSI, WOG, Events, JPM’s, LSIM’s and most MALF that are used often. Total > 350 tests.
    • Plan did not allow sufficient time for the operators to become familiar and proficient with using the simulator even though they were using a set of GlassTop simulator panels for their work. Having an instructor would have been nice.
    • Plan did not allow sufficient time for retesting and recursive testing as problem reports were offered for verification and closure. Planned for 2 weeks. Actual performed ongoing retesting on 3rd platform and still had untested corrections at end of FAT. Total # of CR’s written approximately 1250.
    • Plan did not allow sufficient time to validate supporting documentation that was found, in some cases, to be out of synch with current plant procedures and required on the fly updates during testing
    • Plan did not allow time to validate lesson files & scripts referenced in the various test documents requiring on the fly corrections and updates before certain tests could be performed
Summary

• The BOP Model upgrade completed a multi-phase and multi-year simulator upgrade program, successfully navigating the capital project process at DCPP for multiple approvals and funding.

• The overall Simulator Upgrade program was “sold” to senior management based on RISKS they were familiar with rather than technical and staffing issues and concerns.

• Future Phases put into the Long Term Budget process up front so that they were “in the plan” when it came time to request $$’s and approvals to proceed.

• The BOP Model Upgrade had to successfully defend and justify continuance of the project following PG&E’s decision to shutdown the plant at the end of the current NRC Operating licenses in 2024 & 2025. Defense again based on RISK that senior management could relate to.
Summary

- The BOP Model Upgrade phase implemented a number of changes on how the project was supported and executed as we progressed based on the experiences of the initial Simulator Upgrade project phases.

- **Lesson Learned:**
  - Participate & Communicate with your vendor early and often & not just via email. Relationships matter and will be helpful to the entire team.
  - Don’t underestimate the resources needed during the design phase.
  - Be on-site at the vendor’s facility no later than during final integration. DO NOT wait until the start of formal testing to be there.
  - Be conservative on estimating required test time and necessary resources.
  - Have a set of Glass Top Simulators for formal testing – much easier to watch what the plant is doing versus small Instructor System graphics.

- **NET RESULT** - DCPP has a completely new and state of the art simulator, retaining only a few “legacy” items and is positioned to maintain and grow the simulation with vendor and peer support.
Q&A

Questions
Conclusion