2017 Plant Simulation Conference
San Diego

NB Power PLNGS – Simulator Re-Host and Model Upgrade
Topics

- NB Power & WSC Company In Brief
- NB Power PLNGS Simulator Upgrade Project
- Re-Host and Model Upgrade Phases
- Project Challenges
Nuclear Simulator Clients

- KHNP, Shin Kori 3&4 APR 1400 PWR
- APS, Palo Verde PWR
- BNFL: Magnox Simulator Upgrades
- ENTERGY, Vermont Yankee BWR
- FP&L, Seabrook, St. Lucie & Turkey Pt PWR
- Southern SNC, Hatch BWR
- Luminant, Comanche Peak PWR
- Toshiba, STP 3&4 BWR
- TVA, Sequoyah PWR
- INER, Taiwan BWR
- U.S. Navy Bettis/NNS/GD
- WCNOC, Wolf Creek PWR
- KSU (Sweden), R3 PWR
- GE, ESBWR
- Progress, Robinson PWR
- TPC/GE/ADT, Lungmen ABWR
- TPC, Chinshan BWR
- Bruce Power, Bruce B Candu
- NB Power, Point Lepreau, Candu
- OPG, Darlington, Candu
- KHNP, Shin Kori 1&2, Kori 1 PWR
- CNPSC, Ningde & Yang Jiang CPR 1000 and HTR
Recent nuclear new builds and next generation reactors using WSC technology:

➢ Korea Hydro Nuclear Power, Barakah Plants, Shin Kori 3&4 APR 1400 PWR,
➢ China Guangdong Nuclear Power Company, Ningde, Yang Jiang & Fangchengang CPR 1000, CNRSC Generic CPR 1000 with Severe Accident Modelling
➢ Emirates Nuclear Energy Corporation (ENEC) in UAE for Barakah NPP GPWR Classroom Simulator and Full Scope Simulators
➢ GE-Hitachi, ESBWR Simulation Assisted Engineering
➢ Toshiba ABWR, South Texas
➢ Taiwan Power Company TPC, Lungmen ABWR
➢ TerraPower Traveling Wave Reactor
➢ Holtec SMR
➢ Chinergy China HTR SMR
• In May 2015 New Brunswick Power awarded to WSC, a major Simulator Upgrade for Point Lepreau Nuclear Generating Station (PLNGS)

• Two-Phase Approach; Re-Host and Model Upgrade
New Brunswick Power

- Largest Electric Utility in Atlantic Canada.
- Net capacity of 3,513 MW from 13 facilities.
- Mix of Thermal (2), Combustion Turbine (3), Hydro (7) and Nuclear (1).
- 400,000 direct customers with connections to New England, Québec, Nova Scotia and Prince Edward Island.
The CANDU reactor

- Use of natural uranium as a fuel
- Use of heavy water (D2O) as a moderator and coolant
- Online Refueling
- PLNGS - Single Unit
- PLNGS - 710 MW gross
History of PLNGS Simulator

- Build by CAE
- 1996 – DCC Emulator developed.
- 1998 – Desktop for Windows NT.
- 2004 – Re-hosted to Windows/Linux.
- 2008 – Soft panel installed in classroom.
- 2012 – Fuel Handling Simulator commissioned.
- 2016 – Re-hosted to 3KeyMaster.
- 2017 – Model Upgrade with 3KeyMaster Tools.
There are four different simulator environments:

- The Full Scope configuration which includes the Control Room hardware panels and peripherals
- The Fuel-Handling configuration which includes just the Fuel Handling panels
- A Classroom simulator using virtual panels
- Desktop Simulator.

The simulator upgrade was accomplished in two phases:

- Simulator Re-Host with 3KM Environment
- Model Upgrades
• 3KEYMASTER real-time executive platform
• Instructor Station
• Schematic diagrams
• Legacy Fortran code
3KEYMASTER Platform

• 3KM is a comprehensive simulator real time executive platform which replaces outdated legacy systems

• Ability to expand and customize 3KM features (search engine, customizable dialogs, scenario capabilities)

• 3KM supports several mechanisms in communication with external applications and third party software (OPC, DDE, Tasks, TCP/IP and named pipes protocols)

• Multiple clients support (through user settings and workspaces)

• Legacy database porting into MS Access database, legacy database utilities are not required

• Communication with IO systems
Instructor Station (3KEYMASTER IS)

- IS provides full-featured simulation control
- IS Look and Feel Customization
- Porting of legacy simulation diagrams and schematics
- Porting of virtual panels in two operating modes - Instructor and Operator
Environment Upgrade – IS

- Plant Specific IS Window
Virtual Panels Implementation

• Virtual Panel I/O Counts
  - 3,000 DO’s
  - 2,400 DI’s
  - 650 AO’s
  - 70 AI’s
Schematic Diagrams

• More than 500 schematic, in customized AutoCAD format
• Team work in porting the simulator into new environment

• PLNGS Scope
  ▪ DCC Emulator
  ▪ PCS7Server, SimServ
  ▪ SSMS

• WSC Scope
  ▪ Fortran Modules (data structure and preprocessor)
• Scenario Based Testing (SBT) is a tool build into 3KM that allow the execution of an existing Scenario (SCN) for a given Initial Conditions (IC) and to collect the values of a predefined list of Monitored Parameters (MP)

• Also includes tools to compare and visualize the collected data
Configure SBT

• Scenario Based Testing (SBT) screen
• **Re-Hosted Simulator Transient Tests**
  - DCC Emulator response
  - Fortran process module response
  - Large number of IO points

• **SBT Repeatability Tests**
  - Reactor Trip
  - Turbine Trip
V&V Trends results

- Ability to trend live or exported data against a sample in the 3KM environment
CSVCompare Utility Results

CSVCompare Utility

********** DATA COMPARISON **********

Data file 1: WSC AI and DTAB Variables,7-11-2016_17-24-34.csv
Data file 2: AI and DTAB Plant Data.csv
Time Range 00:00:00.000 - 00:00:54.000

********** VARIABLE: YDDT0004X **********

DTAB0004: PLIN I8

********** VARIABLE: YDAI1221X **********

F*I.C. LIN N (CH.A) DCCX -R58$1221 IAX1221F1
Max difference = 1.79914% at 00:00:36.000
First difference at 00:00:00.000

********** VARIABLE: YDDT0012X **********

DTAB0012: PTHM I8

********** VARIABLE: YDDT0010X **********

DTAB0010: PRTD I8
Max difference = 3.08043% at 00:00:18.000
First difference at 00:00:00.000
Model Upgrade Phase

• Scope of the Model Upgrade
  - Reactor Physics (Neutronics)
  - Primary Heat Transport
  - Boilers Secondary side
  - PHT Inventory Control (Feed and Bleed)
  - Shutdown Cooling System
  - Annulus Gas
  - End Shield Cooling

Nestle model
RELAP5
FLOWBASE
• RELAP5 – Non-equilibrium, non-homogeneous 6 equations engineering analysis code
• Nestle - True 3-Dimensional neutronics code
• Flowbase - BOP/primary/auxiliary systems thermohydraulic 4 equations code
• Latest powerful servers allow to run complex simulator software in real time
• RELAP5 correctly simulates primary system drain to the header level
• Ability to resolve pre-existing simulator deficiencies
PHT Nodalization

Boiler#1
Boiler#2
Boiler#3
Boiler#4
Pressurizer
Degasser

Core; 380 channels
24 lumped thermohydraulic channels
Boiler Secondary Side and MS Lines Nodalization

5 different types of Boiler level (narrow/middle/wide/SDS1/SDS2)
• Each of 380 channels can be selected for refueling
• Model supports sequential refueling of the channels
• Fission power, Fuel and Coolant Temperatures, Fast and Thermal Neutron Flux can be selected
Challenges

• Schematic Diagrams porting
• Large number of interfaces with legacy Fortran modules (BOP, ECCS, DCC, Containment, etc.)
• Core Testing (SUI, many different types of reactivity control mechanisms)
• Large scope of ATP’s
• Initial attempt to perform ATP’s automatically
• Real Time concerns (Relap multitreading)
• Resource allocations (FSS and Instructors)
Simulator Testing

- During SAT - Tested the Simulator Against Data and the Plant Procedures
  - Steady State Tests
  - Normal Operation – Drain to Header Level
  - Transient Tests
  - Abnormal Tests – Setback (12 events), Stepback (7 events), Failures of major equipment, safety systems, DCC failure, etc.
  - Core Physics Tests
  - Existing Discrepancies Tests
  - Common Tests - Instructor Station, Real-Time, Repeatability Test
  - Total of 82 Tests
- Used SBT where applicable. Not that efficient as at Re-Host.
Meeting the Project Objectives

The upgraded high fidelity simulator fully supports the NB Power PLNGS staff training requirements for years to come.

New Simulator Benefits in Summary:

- Superior Training with advanced models
- Lower Maintenance cost with up to date software and hardware
- Support Plant upgrades and improvements
THANK YOU

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