Millstone Unit 3 PPC Replacement

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Millstone Unit 3 Overview

- 3650 MWth, Westinghouse/GE PWR
- Waterford, CT
- Operating license in November 1985
- Commercial Operation: April 23, 1986
- Existing PPC is a Circa 1980 Modcomp Classic 395, 7840 CPU’s
- Data Acquisition Modcomp Modacs III
- Station Employees: 1,270
- Extended Operating License Expires: November 25, 2045
- The Millstone site covers about 500 acres
- Millstone earned OSHA's top award for workplace safety

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PPC Replacement Time Line

Task	Start Date	Completion Date	Duration
Award of Contract	21-Jan-08	N/A	0 Days
Preliminary Hardware Design Complete	21-Jan-08	1-Jul-08	5 Months - 12 Days
SRS Documents Approved	8-Apr-08	5-Mar-09	11 Months - 2 Days
SDD Documents Approved	5-Aug-08	11-May-09	9 Months - 10 Days
Software Ready for Integration	31-Jul-09	N/A	0 Days
I/O Hardware Received at Factory	24-Apr-09	N/A	0 Days
FAT Documents Approved	17-Apr-09	28-Aug-09	4 Months - 13 Days
FAT Test	14-Sep-09	8-Oct-09	0 Months - 24 Days
Plant PPC Hardware Shipped	4-Nov-09	N/A	0 Days
SAT Documents Approved	13-Oct-09	22-Dec-09	2 Months - 10 Days
SAT Test	12-Apr-10	24-Jun-10	2 Months - 13 Days
PPC Turned Over to Operations (Estimated)	27-Aug-10	N/A	0 Days
I/O Installation (Estimated)	23-Aug-10	19-Nov-10	2 Months - 28 Days
Complete PPC Project Time Line	**21-Jan-08**	**19-Nov-10**	**2 Years - 10 Months - 13 Days**

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MP3 R*TIME Server 12.7 Features and changes

- In addition to the standard R*TIME functionality, 24 custom PWR applications were written.

- RCS/Pressurizer Heat-up and Cooldown Rate
- RCS Leakage
- Rod Monitoring
- N-16 S/G Leakage Detection
- Meteorological Data Communication Link
- Reactor Plant Aerated Drains Water Inventory
- Water Quality and Meteorological Data and Environmental Data Acquisition (EDAN) Link
- Leading Edge Flow Meter (LEFM) Interface
- RCS Flow
- Inadequate Core Cooling Monitoring (ICCM) Link
- Digital Radiation Monitoring System (DRMS) Link
- Safety Parameter Display System (SPDS)
- Balance of Plant (BOP)
- Plant Calorimetric
- Rod Supervision
- Reasonability Check and Time Average of In-core Thermocouples
- Tilting Factors
- Xenon/Samarium Prediction and Follow
- Engineered Safeguards System Actuation
- Slave Relay Response Times Report
- Boration and Dilution Calculator
- Reactivity Calculator
- Deviation and Redundant Measurements
- Environmental Equipment Qualification Area Temperature Monitoring System

MP3 R*TIME Server 12.7 Features and changes

- First implementation on Windows Server 2008.
  - Allows accurate archival at speeds of up to 3 msec. Previous versions of windows could do no better than ~15 msec.
  - Allows R*TIME to run under a native account rather than the system account. This eliminates the needs for second tier services such as Excel Interface.
  - Much more advanced Task Manager and Resource Monitor.
- First implementation of a Storage Area Network (SAN) device.
  - High reliability network archives reduce failover considerations and provide increased flexibility.

MP3 R*TIME Server 12.7 Features and changes

- New set of interpretive calcs with client specific quality handling.
- Added SOE and alarm search by point name(s) and point groups.
- Added delta times SOE reports..
- Implemented C++ Classes for TCP-IP and COM Communication and FIFO for external Systems interfaces.
  - Gave all external apps a similar look and feel all the way from SRS-SDD to code to FAT and SAT test.
  - Reduced time to implement by up to 75%.
  - Time and expertise to maintain should be significantly reduced.

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DAS Hardware

Largest single Unit I/O replacement performed by Scientech.

Description	Quantity
RTP 2300	
2300D Dual-Redundant Controller	3 pair
2300 Remote I/O node, 1-12 Slot Chassis, Dual power supplies	27
2300M Controller 1-12 Slot chassis, Dual power supplies	1
RTP I/O Cards	
24-Channel High-Integrity COS Optically Isolated AC / DC DI Card, 48 V	258
16-Channel Latching, Power Relay Card	3
4-Channel Isolated High Integrity Analog Output Card, User Configurable Redundant Outputs	4
8-Channel High-Integrity Isolated Differential High Level AI Card, 16-Bit A/D	142
64-Channel Digital Input / 32-Channel Digital Output card	2
8-Channel Scanning Isolated Thermocouple	6
8-Channel Scanning Isolated Low Level Analog Input Card	7

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DAS Adaptors

DAS Adaptor cards

Description	Manufacturer	Quantity
Rackmount backplane	CyberResearch	16
HLAI Analog module	CyberResearch	18
HLAI EXT Analog module	CyberResearch	34
LLAI EXT Analog module	CyberResearch	4
Digital In module	CyberResearch	167
Analog Out module	CyberResearch	3
Digital Out module	CyberResearch	2
QPA module	CyberResearch	5

DAS Adaptor cables

Description	Manufacturer	Quantity
CCB 1X15D15-096	CyberResearch	359
CCB 1X15D15-120	CyberResearch	150
CCB 2X15ANA25-120	CyberResearch	146
CCB 2X15DAC25-120	CyberResearch	3
CCB 1509D25-120	CyberResearch	2

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Custom DAS Cabinet Features

- Wheels and feet
- Cut out for cabling
- Extra wide 19” cabinet
- Fully louvered doors

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Networking and KVM Hardware

Cisco Networking Hardware

Description	Product Number	Quantity
Cisco 4506	WS-C4506-e	5
Cisco 3750 24x10/100/1000 4xSFP	WS-C3750G-24TS-S	9
Cisco 2960 24x10/100	WS-C2960-24TT-L	4

Avocent KVM Hardware

Description	Manufacturer	Product Number	Quantity
KVM Server	Avocent	AMX 5000	2
User Stations	Avocent	AMX 5111	6
1000U USB 2-Port Transmitter Receiver KVM Serial Extender	Avocent	LV1000U-001	27
Server Interface Module for VGA, USB Keyboard, Mouse – AMX Series	Avocent	AMIQDM-USB	26

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Misc Hardware

Description	Manufacturer	Product Number	Quantity
SyncServer S350 time server	Symmetricom	1520-S350	1
IOLAN STS16 - 16-Port RJ45 10/100/1000	Perle	04030414	4
21" Flush Panel Mounted Flat Panel Display	CyberResearch	CRBR 21C-U-B	6
HP ProLiant DL580-G5	HP	Proliant	9
EMC^2 with 5.6 TB useable storage	EMC^2	CX4	1

- Currently Servers are running < 7% CPU load.
- Approx 2 TB of Archives created with lots of room for expansion.

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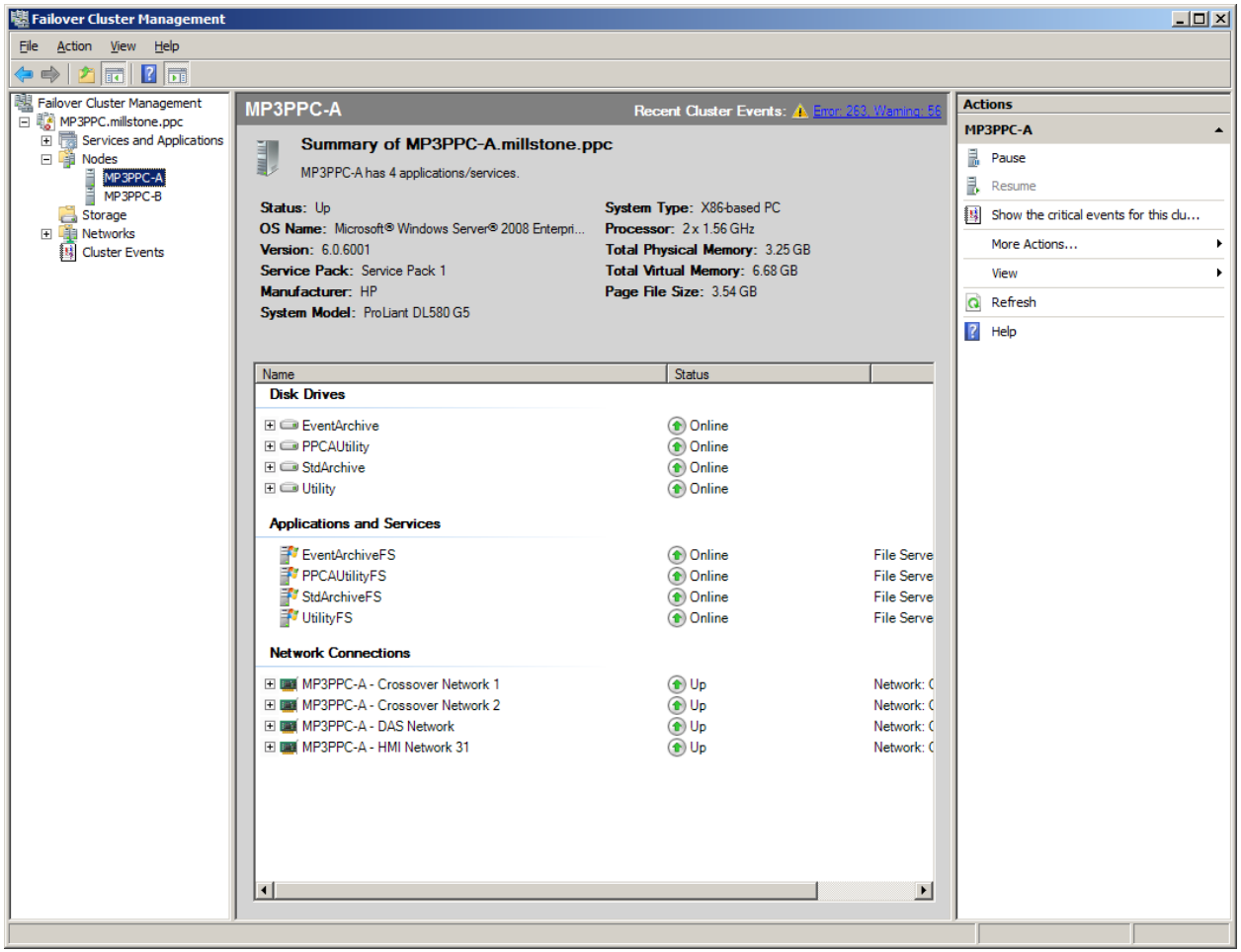
Windows Cluster Manager

- Windows Cluster Manager handles control of the SANS unit.
- Dual Fiber channel Inputs to PPC's



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Simulator Interface – Testing and Installation

- When?
  - Unit testing in Cromwell CT,September 2009
  - Initial install/testing in October 2009
  - Install/SAT in December 2009
  - Retest January-March 2010
- How Long?
  - 2 weeks for pre install work and testing the interface
  - 2 weeks for Install/SAT split between SAT and retest
  - 3 weeks fixing, changing and informally training on the interface.

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Simulator Interface - Obstacles

- Missing simulator specific requirements in System Design Specification.
- Change in Backtrack and IC Reset functionality during Simulator SAT broke developer code designed to run on the Simulator.
- Major changes to DB invalidated the Alarm Shared Memory segments saved in the ICs.
- Simulator staff not fully understanding functionality and differences of the R*TIME system from existing system.

Simulator Interface - Lessons Learned

- Need to stress additional simulator support on PPC replacement projects. (Not just technical staff, but instructors as well)
- Need to get more simulator buy in on SRS reviews of applications.
- Need to stress level of detail on Simulator sections of replacement Specification.
- Need to involve Simulator third party developers (Thunder, Western Services, etc.) in all development and testing.
- Get Simulator instructors using the system and trained prior to simulator turnover.

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Significant Successes

- Scientech's automated testing hardware used to FAT test the RTP Das at factory.
  - Full end to end test of inputs to the hardware and outputs to the PPC.
  - Hardware could drives 144 digital outputs and 64 analog outputs (10V to -10V) full range of card.
  - Reduced FAT time required from two, three man shifts at 8 weeks down to one, three man shift for two days (Over 1800 hours saved)
  - Issues found during unit testing
    - Database Issues, conversion problems
    - Broken adaptor cables, Phoenix Connectors, wiring issues.
    - Broken and out of calibration RTP cards
    - RTP Net-arrays problems
  - **0 errors in actual DAS FAT test!**

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Stumbling Blocks

- Virus Scanning Software (McAfee 8.7i Enterprise)
  - Problem #1 – Data holes in the PSS archives at the top of the minute.
  - Solution #1 – Set the R*TIME processes to Low-Risk Processes and then to not be scanned by McAfee.
  - Problem #2 – Multi-trend displays have archive data retrieval application blocked.
  - Solution #2 – Remove the TDI driver functionality imposed on Windows by McAfee.

Significant Successes

- FAT complete in 24 days, 2 days ahead of schedule.
- 23 TERs during FAT, < 1 per day.
- 5 Deferred for SAT, all TERs closed prior to start of SAT.

Category	TER Count
1	0
2	2
3	21
ENH	3
Total	**26**

Issue Type	Resolution	Count
TER	Resolved and retested during FAT	18
TER	Deferred for retesting during SAT	5
ENH	Implemented and tested during FAT	1
Total		**24**

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Lessons Learned

- Process
  - Software Requirement Specification reviews and turnaround need to be within the terms of the PPC Schedule. SRS reviews ate almost 6 months of float in PPC Schedule.
  - Get Simulator staff involved in SRS reviews earlier in the process.
  - Post Mortem code review to assure code and documentation match.
  - Having a single lead member of the Millstone PPC replacement team at the Scientech facility fulltime during the FAT significantly reduced management issues.

Lessons Learned

- Process
  - Additional scrutiny on FAT tests. Questions of why code fails in plant after passing FAT test.
  - Develop a more realist approach to TDBM files

    Files should reflect not only normal and extreme test points, but also a real world scenario.

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Lessons Learned

- *Hardware*
  - DAS cabinets constrained (probably artificially by Scientech) to the depth of the old cabinets. A slightly deeper cabinet would have made inter-cabinet wiring much easier.
  - Millstone Security personnel inspected the PPC hardware at Scientech's facility immediately before shipment. As part of the inspection process, the equipment was moved onto the truck which was locked and sealed. Equipment could go immediately onto site and into the protected area without additional inspections. This good experience is practical where the plant is reasonably close to Scientech's facility.

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Lessons Learned

- *Hardware*
  - Dominion configured the domain controllers for the PPC at the Scientech facility to meet its needs and the PPC needs. This was a good experience with the bugs worked out early.
  - Dominion Set UP FAT network to simulate plant network conditions and security.
- *Application Software*
  - Overall, the requirements for most applications were well defined when the contract was awarded. This was very good and needs to be continued.

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Lessons Learned

- *Application Software*
  - Scientech made the decision to implement certain calculations in interpretive calcs. Scientech discovered too late in the process that the calculations really should be implemented as a coded application with SRS and SDD. Scientech needs to look earlier at the complexity of calculations that are considered for interpretive calcs.

Lessons Learned

- *Application Software*
  - The requirements for a complex application (Primary Leak Rate) were being redeveloped by site personnel for the PPC upgrade. Because of other priorities, the requirements definition/equations were late relative to the rest of the applications, impacting software development and FAT tests. Discrepancies found through parallel run. Need to get new applications defined earlier in the project.
  - Factory acceptance test cases need to include data used by site engineers to perform their calculations. In particular, the site engineer had an Excel spreadsheet to assist him with Xenon calculations. The use of that data from the spreadsheet prior to and during FAT would have prevented some problems observed during the parallel operation.

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New RTP DAS Gear

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Intel PPC & SANS

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Overall Equipment Cabinets

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MP3 Simulator Control Room Displays

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Main Board Displays

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PPC Hosts Locations

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PPC DAS Layout

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