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Improving NPP Performance with an Integrated KM System: The Smart CANDU Approach

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Improving NPP Performance with an Integrated KM System – The SMART CANDU™ Approach

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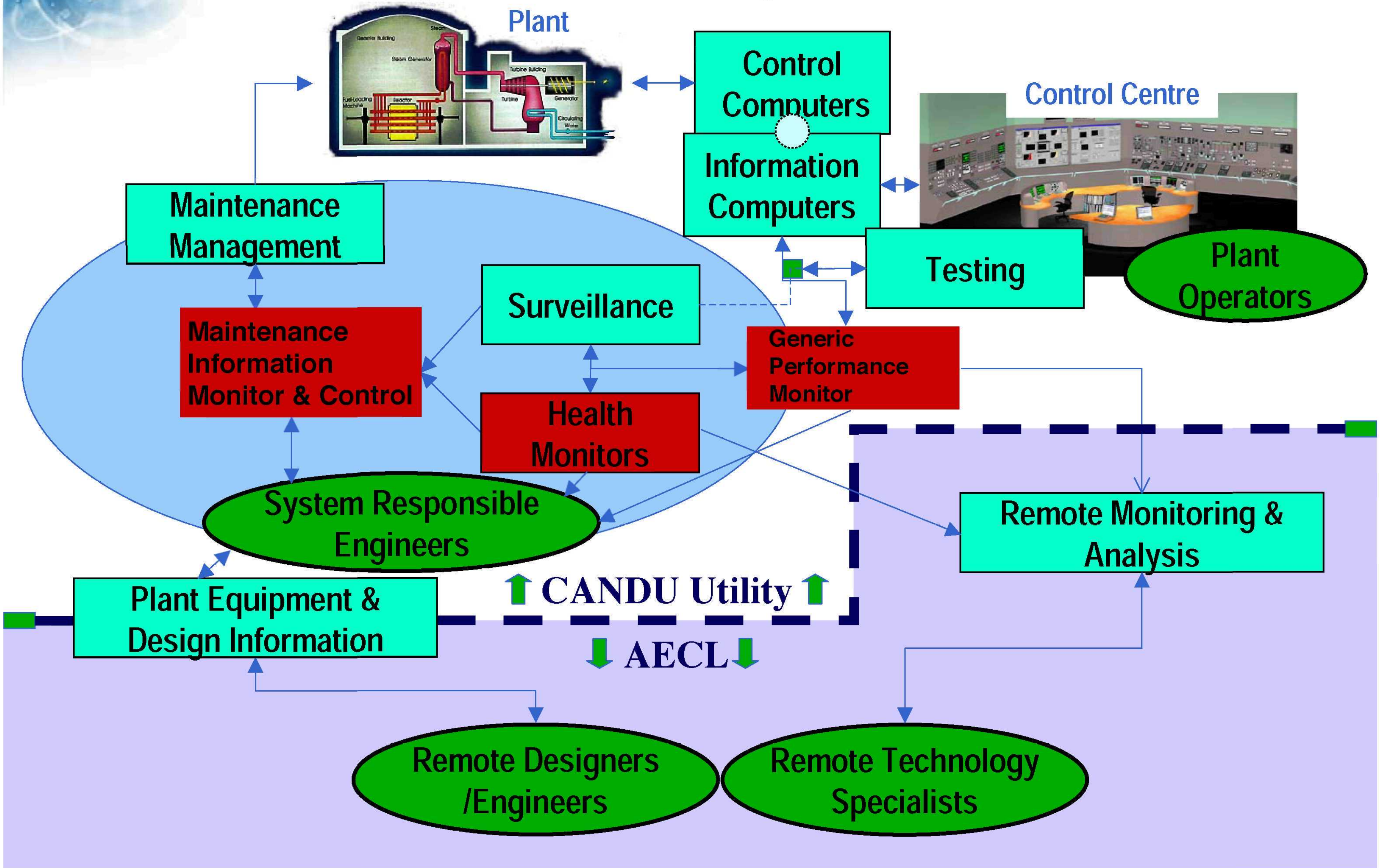
AECL EACL

Outline

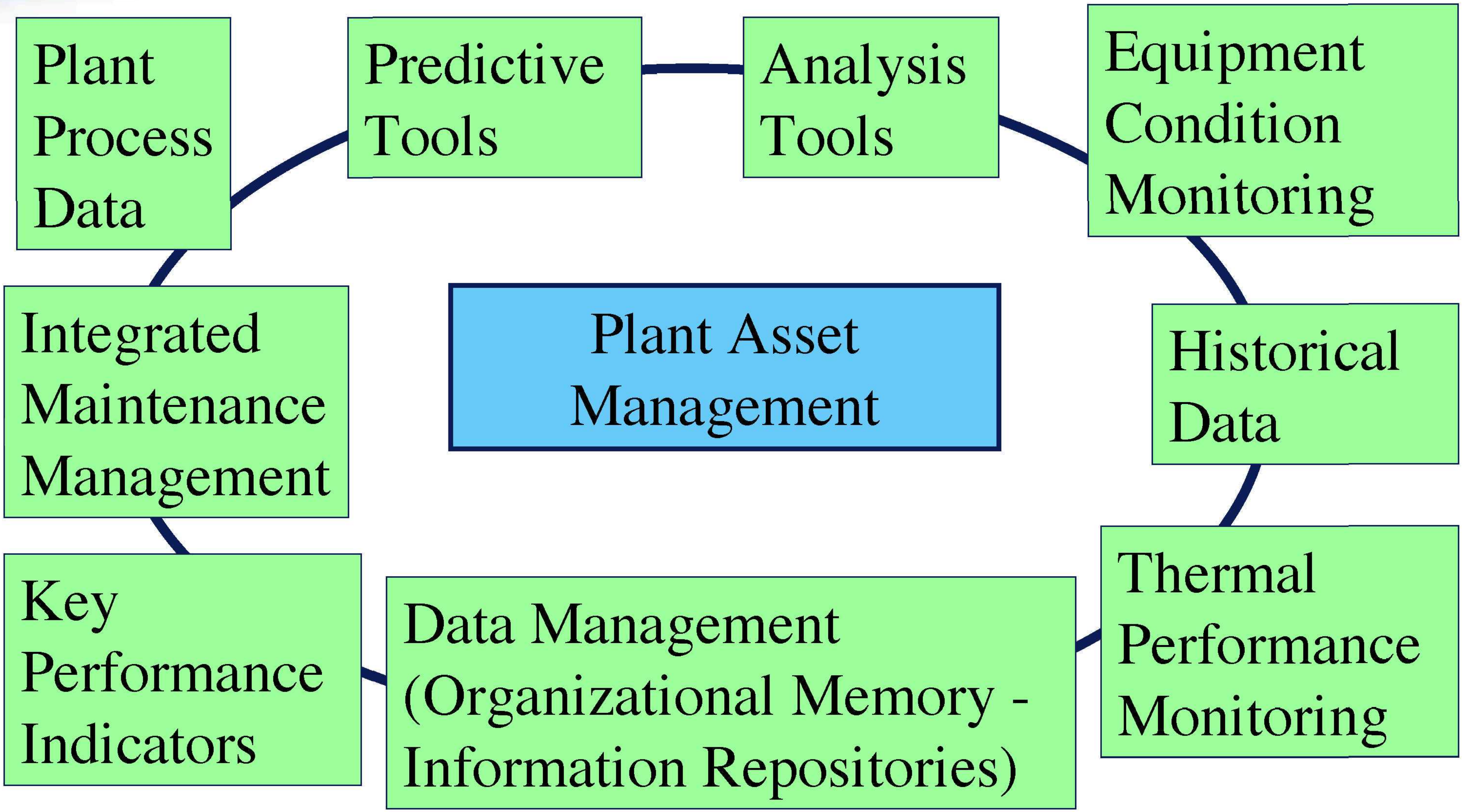
- The Nuclear Power Plant Context
- The KM link to performance
- Importance of Supporting IS Technology & Infrastructure
- KM Tool Requirements for NPPs
- The SMART CANDU Approach
- SMART CANDU Examples
- A Closer Look Example – Chemistry Management with the "ChemAND^{TM}" System
- Summary

The Nuclear Power Plant Context

Examples of Knowledge Flows and Stores

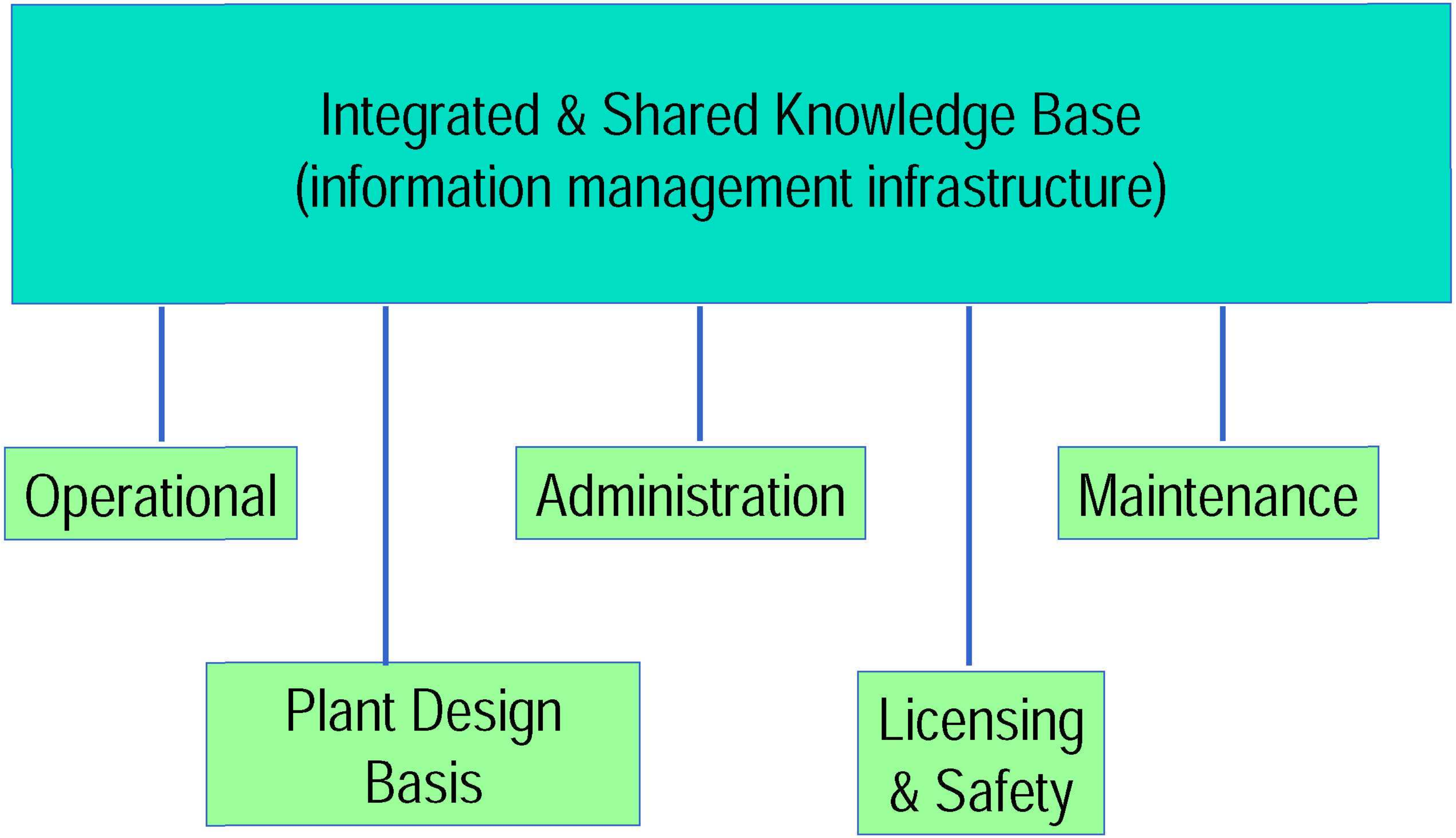


KM for Operations (examples)

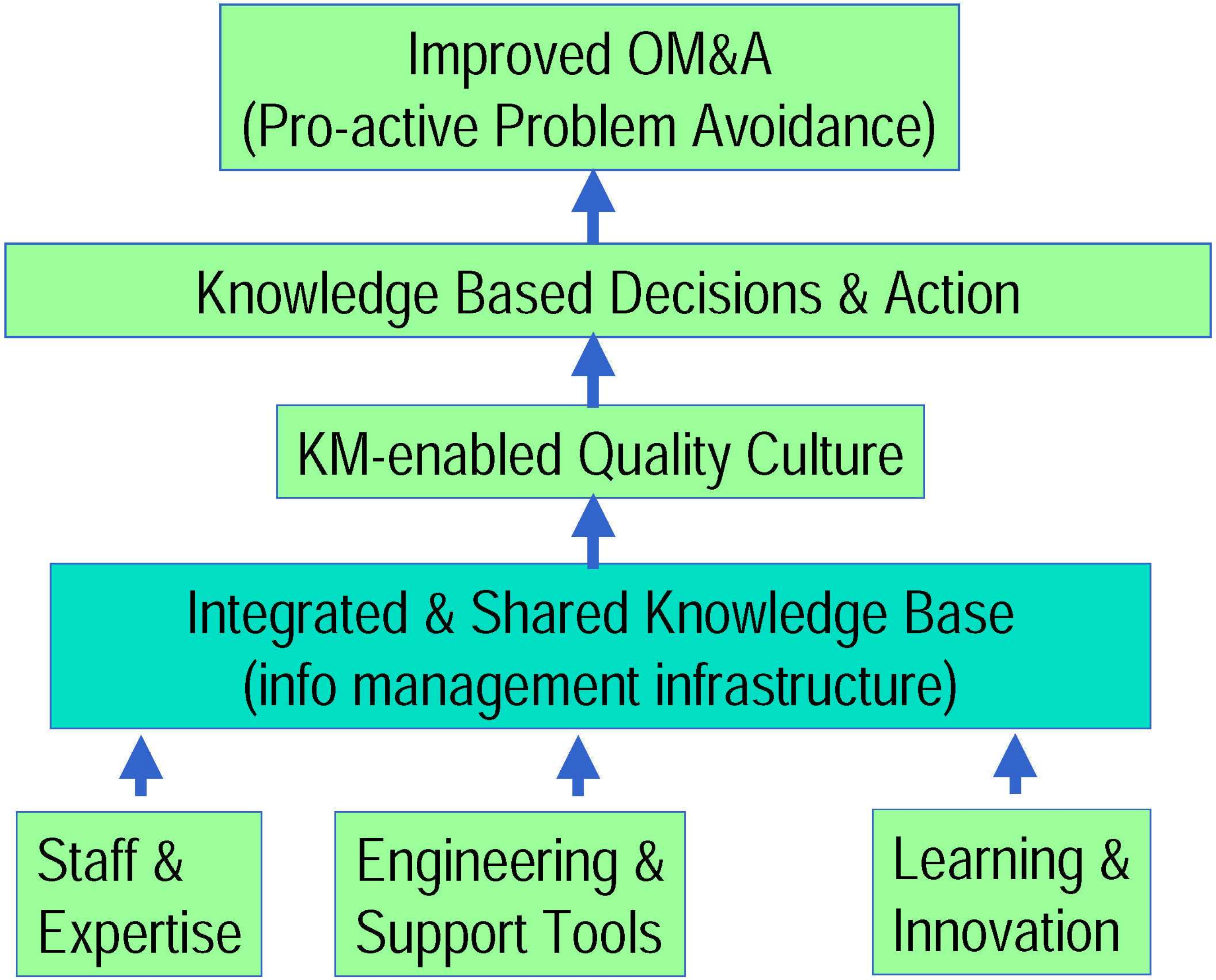


The KM Link to Performance

Improving the Knowledge Base



Performance Concepts



Importance of Supporting IS Technology & Infrastructure

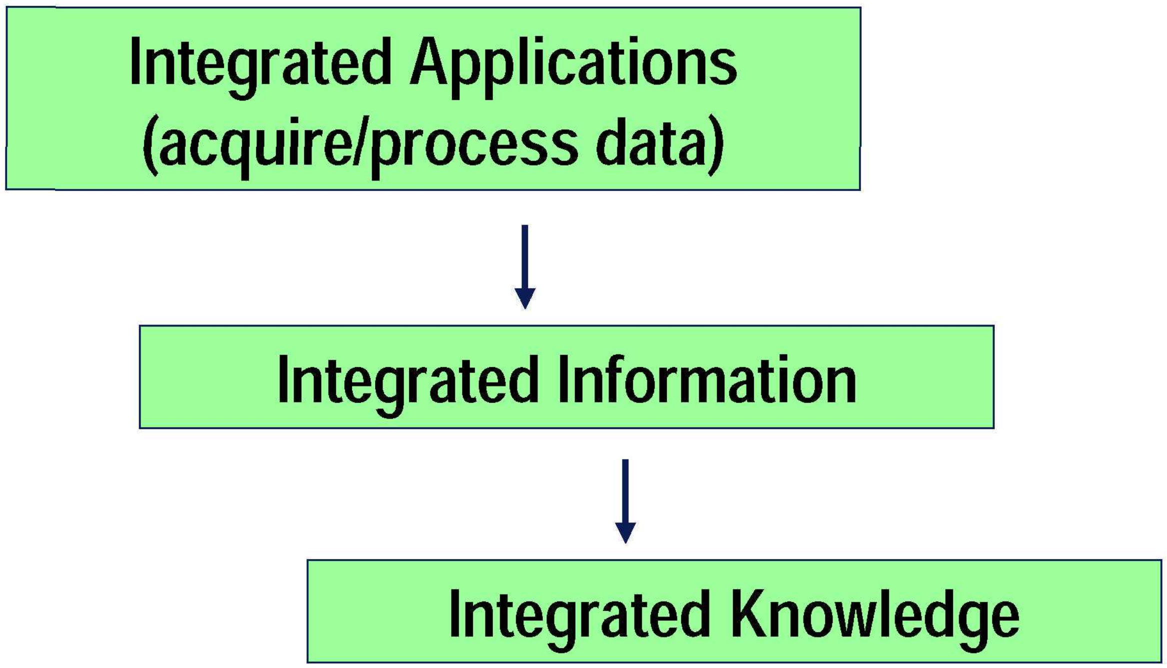
IS Technology & Infrastructure

- a key to enabling & support of KM
- Seen as necessary element in optimizing KMS in NPPs
- Should be important focus of underlying measures of KMS performance
- NPP design organizations see this as a way to future cost reduction and competitiveness!

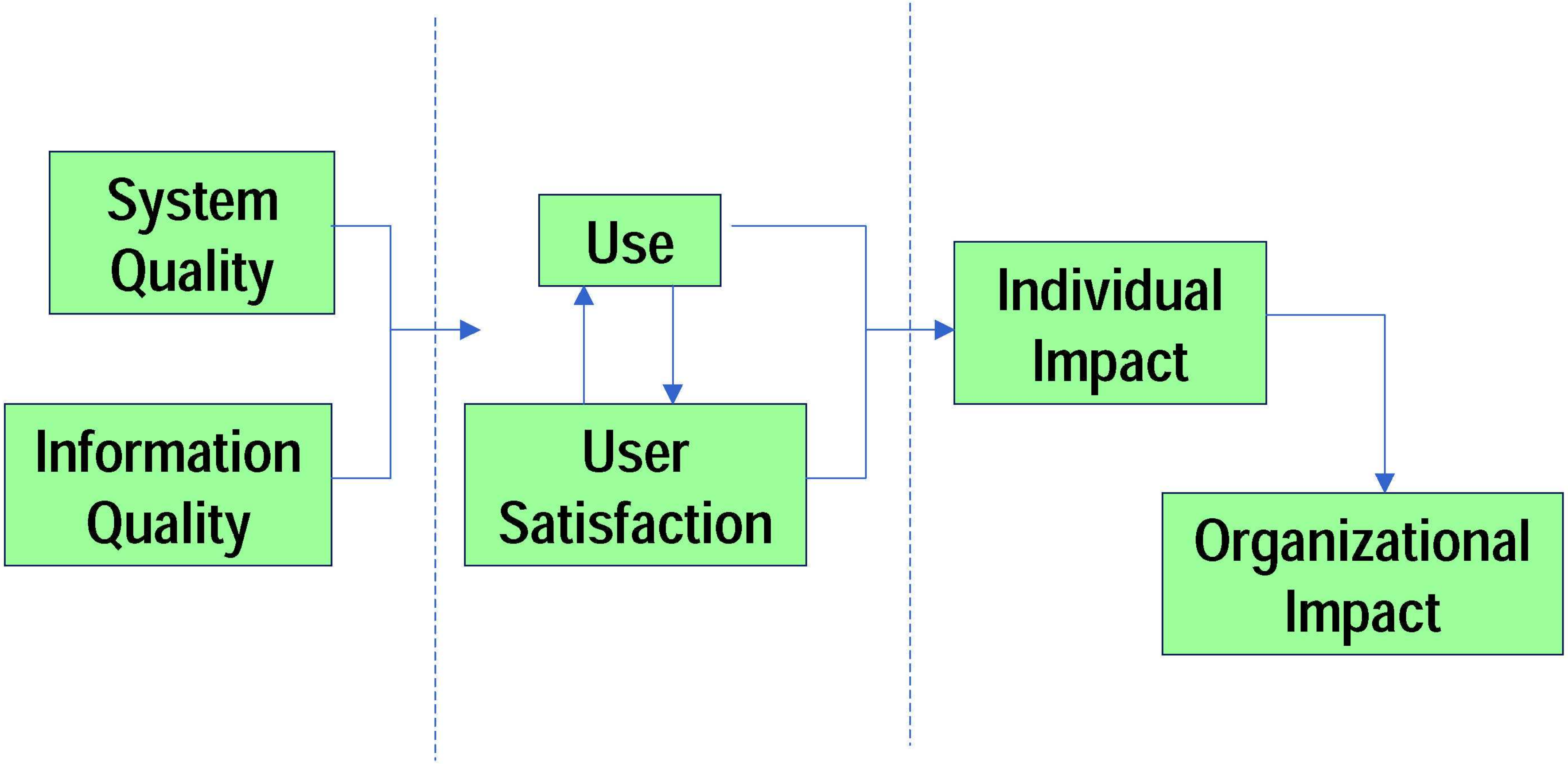
Importance of Tool Support

- Tools permit means of data/information management:
  - Capture, Transfer, Organization, Storage/Archival
  - Conversion to information
  - Visualization, analysis, compilation
- Knowledge generation (learning and capture):
  - Plant System Patterns and behaviors
  - Test and Verify assumptions, premises
- Capturing tacit knowledge in decision support or process/procedure/task support tools:
  - Decision rules, constraints
  - Sequence, interdependencies, guidance
  - Limits and constraints

IT and IS Support for KM



IS and IT Success Model
(DeLong and McLean, '92)



Information Management Infrastructure

CAD Model & Drawings

Operating Procedures

O&M History

Doc/Records Management

Plant Reliability

Specific OM&A Strategies

Policy, Practices & Procedures

Integrated & Shared Knowledge Base (information acquisition, management, dissemination)

Plant State

Models & Codes

Outage Planning

Maintenance & Programs

Work Control

System Surveillance & Health Monitoring

Quality System

Plant Configuration Management

KM Tool Requirements for NPPs

Requirements for NPP KM System

- Manage operating data over time scale ranging from seconds to years – analyse, store and retrieve
- Manage data, information, & knowledge in a wide range of formats
- Manage data, information, & knowledge over the entire plant life cycle – design, build, commission, operate, life extension and decommission
- Data, information, & knowledge must be readily accessible for application and re-use
- Support decisions that affect plant performance and protect safety and key assets
- Support training and learning

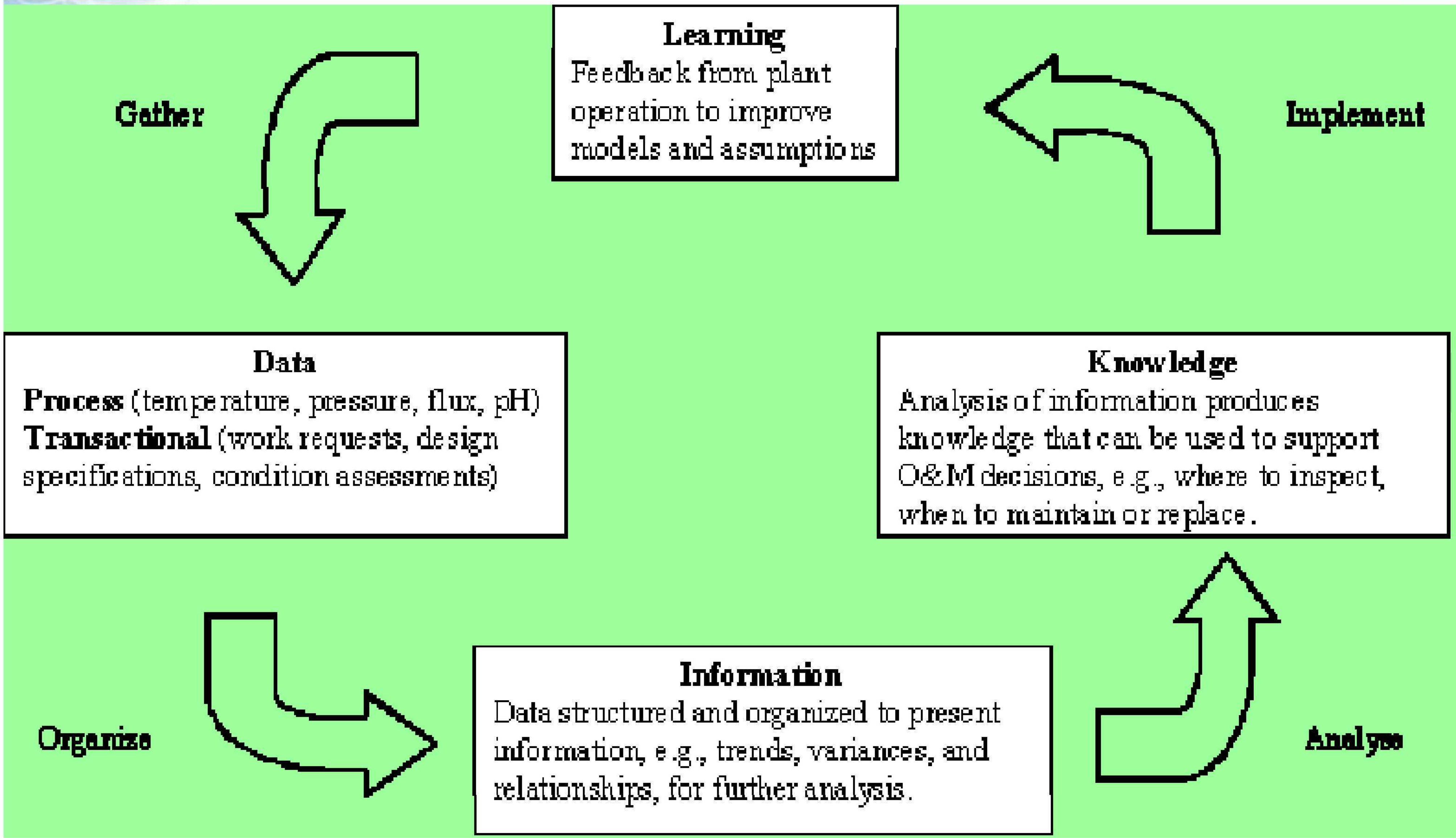
Meeting Utility Requirements

- Chief requirement is Safe, Reliable and Economical performance – performance needs to be predictable
  - Safe
    - Designed for safe, economical operation
    - Operator's focus – err on side of caution
  - Reliable
    - Degradation known and managed
    - Operates as expected – no surprises
  - Economical
    - Predictable & high capacity factor – no unplanned outages
    - Maintenance necessary and sufficient

Key Decision Points that Affect Plant Performance

- First Operator
  - Alarms, operating procedures, re-fuelling, work authorization, testing
- System Engineer/Operations
  - Address emerging issues, prioritize and schedule work, long-term planning and reporting
- Planning
  - Maintenance, inspection, monitoring programs
  - Outage, life cycle management, life extensions

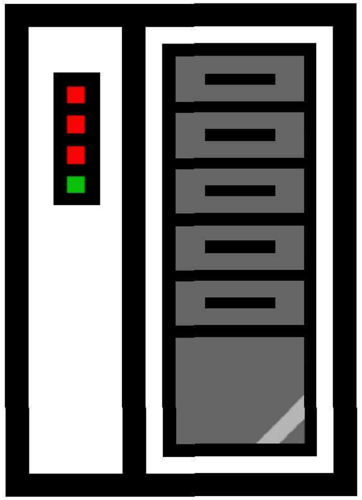
Making the Right Decision



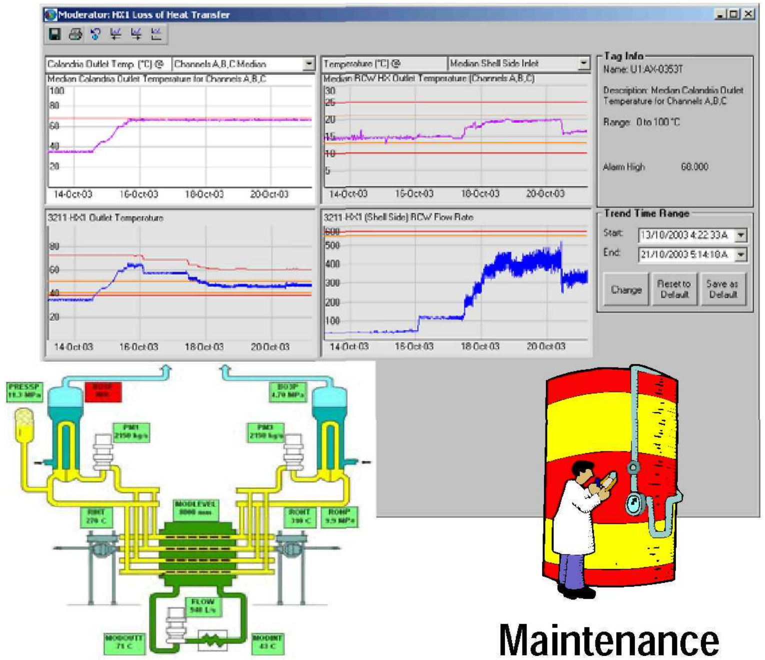
NPP Knowledge Management Context

Safety & Control	Plant Data	Operations & Planning

Reactor Control &
Annunciation
Safety Monitoring
& Testing



Process
Transactional
Configuration
OPEX



System Health Monitoring

Maintenance
Inspection
Monitoring

Gather, Test & Distribute	Store & Retrieve	Display, Analyze, Act & Review

The SMART CANDU™ Approach

Implementation of a KM System to Improve NPP Operation

- AECL is developing a KM system to improve NPP operation
  - Referred to as "SMART CANDU™" suite of products.
- SMART CANDU™ goal is to facilitate:
  - Decision-making process in all aspects of NPP operation
    - safety & control, operations, maintenance, planning, work management, etc.
  - Assist with the safe, reliable and economical plant performance
  - All Core Processes of NEI Model for NPP
  - Help manage plant configuration and plant data from design to decommissioning

Nuclear Energy Institute Core NPP Processes

Operate Plant
- Monitor systems & components
- Manage chemistry & effluents

Configuration Control
- Maintain design basis
- Manage configuration

Work Management
- Perform planning & scheduling
- Perform maintenance

Reliability
- Maintenance program
- Health & performance monitoring

Materials & Services
- Inventory control
- Procurement

SMART CANDU™ Strategy

- Application of advanced technology and KM principles
- AECL (design organization) becoming more of a strategic partner in plant operation and maintenance process (leverage expertise of plant and design organization staff through advanced technology)
- Focus on infrastructure and tools to provide data access, system surveillance and health monitoring, problem identification and analysis, and decision support)
- Key areas: plant design basis and CM, safety, physics, thermo-hydraulics, chemistry, plant operations, plant equipment reliability and maintenance.

Specific SMART CANDU™ Objectives

Enhance the Integrated and Shared Knowledge Base:

- Achieve a more integrated support relationship with stations by developing new KM support tools that leverage both designer & utility expertise for O&M
- Enhance Design, EPC&C tools so they can be carried forward into plant operations and maintenance phase
- Develop/deliver new KM tools for in-station O&M use
- Provide guidance/support to establish & maintain an effective KM System

SMART CANDU™ – NPP KM System

Safety & Control
Advanced Control Centre Information System

⇕

Plant Data
Life of Plant Historian
Configuration Management Toolset

⇕

Operations and Planning
My Information Management Centre

Predictable Performance

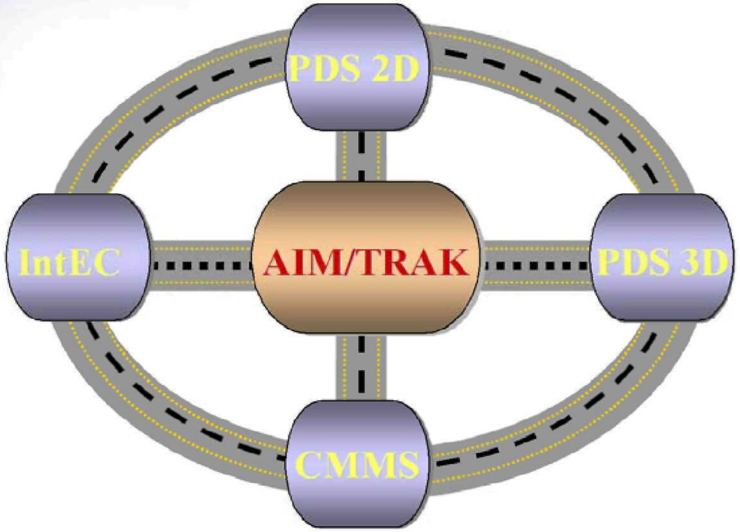
- Safe
  - Control room alarm prioritization
  - Safety-related displays and on-line procedures
- Reliable
  - Configuration management toolset and Life-of-Plant historian
  - On-line plant status with warnings and alarms
  - On-line diagnostic and analysis tools to manage health and performance
- Economical
  - Targeted, prioritized, rationalized maintenance
  - Increased operability

KM for Predictable Performance

- Right information to the right person at the right time in the right format
- SMART CANDU™ facilitates this by:
  - Synthesizing data into information and presenting it in a way that supports making proactive and informed decisions
  - Integrating data with diagnostic and predictive models to manage performance
  - Incorporating data management tools – configuration management and data historian – to make all data readily available throughout the plant life cycle

SMART CANDU™ Examples

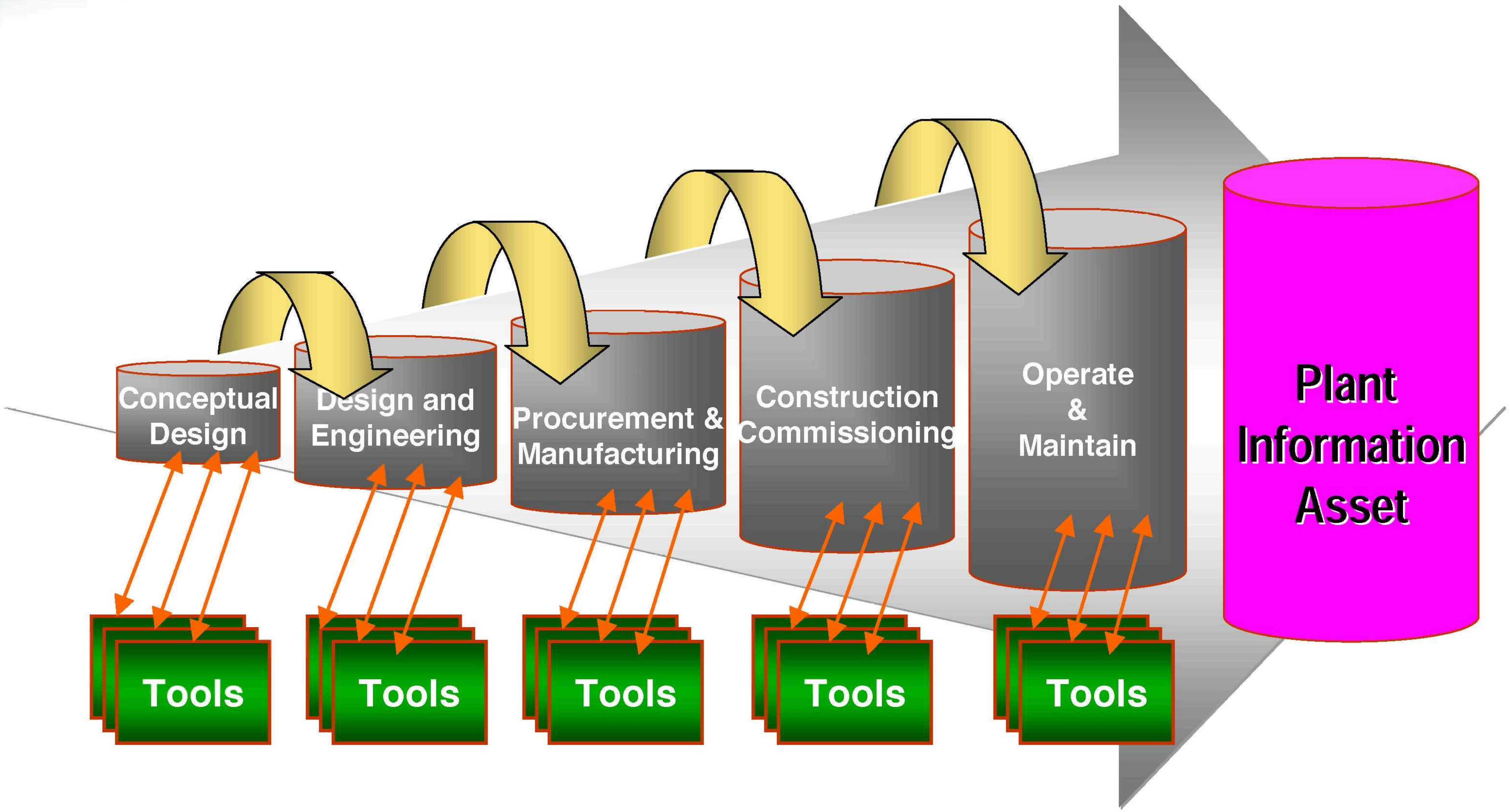
Plant Data - Configuration Management Toolset



- Complete, correct, timely, accessible and readily useable information during design, construction and operation of NPP

- CMMS : CANDU Material Management System for supply chain management
- IntEC – signal, equipment, wiring and cable design and installation, plus configuration management during operation
- AIM/TRAK – document management and work process control
- PDS 2D/3D – 2D/3D plant design system

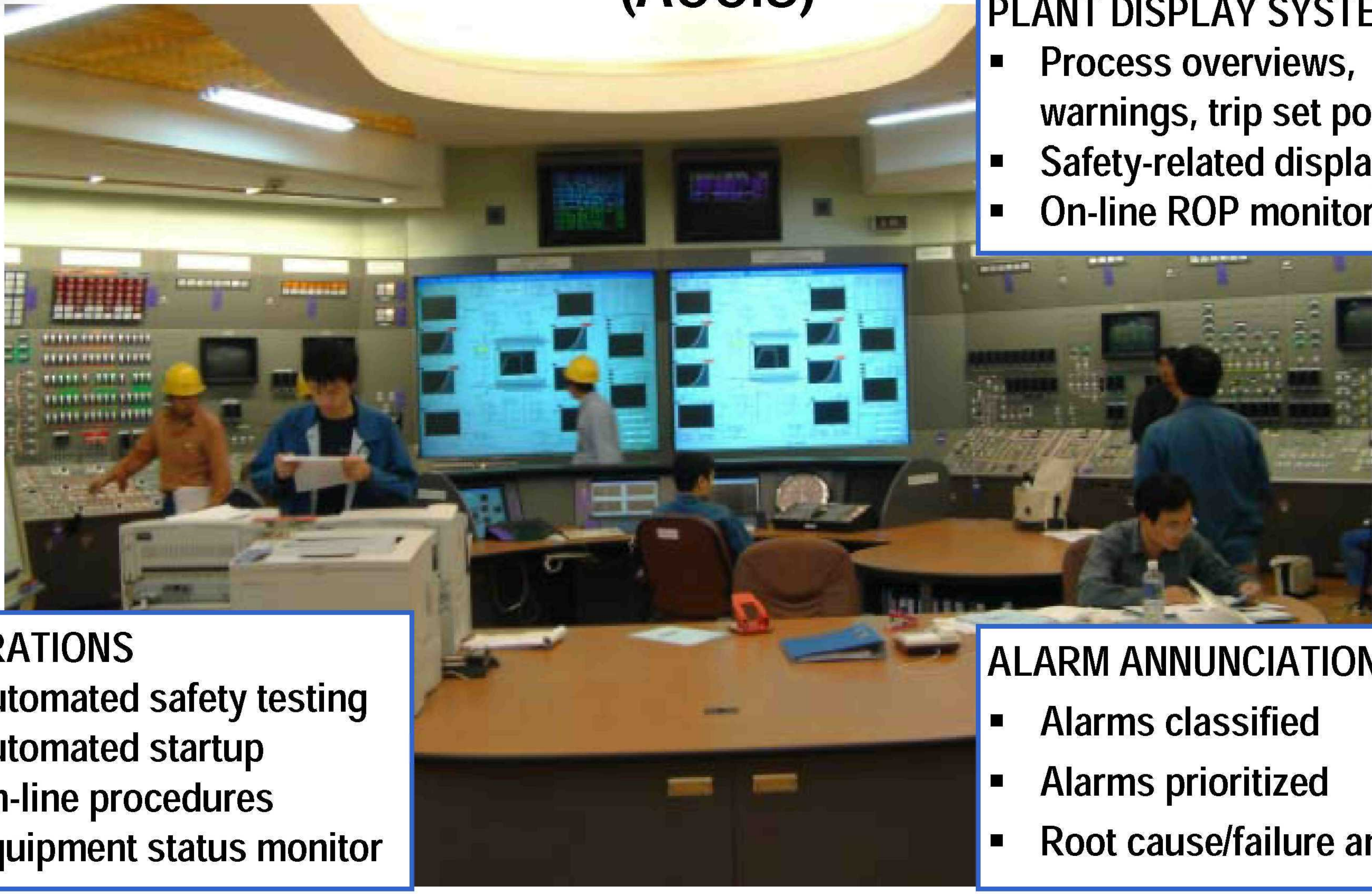
Plant Information Management Life-Cycle



Plant Data – Life-of-Plant Historian

- All data stored and readily available over the entire plant life cycle
  - Process: temperature, pressure, chemistry, etc.
  - Alarm, testing, inspection and analysis
  - Transactional: work order #s, event log, walk downs
  - OPEX, tribal knowledge
- Supports planning, post-incident analysis, condition and life assessments, and system health monitoring

Advanced Control Centre Information System (ACCIS)



PLANT DISPLAY SYSTEM
- Process overviews, warnings, trip set points
- Safety-related displays
- On-line ROP monitoring

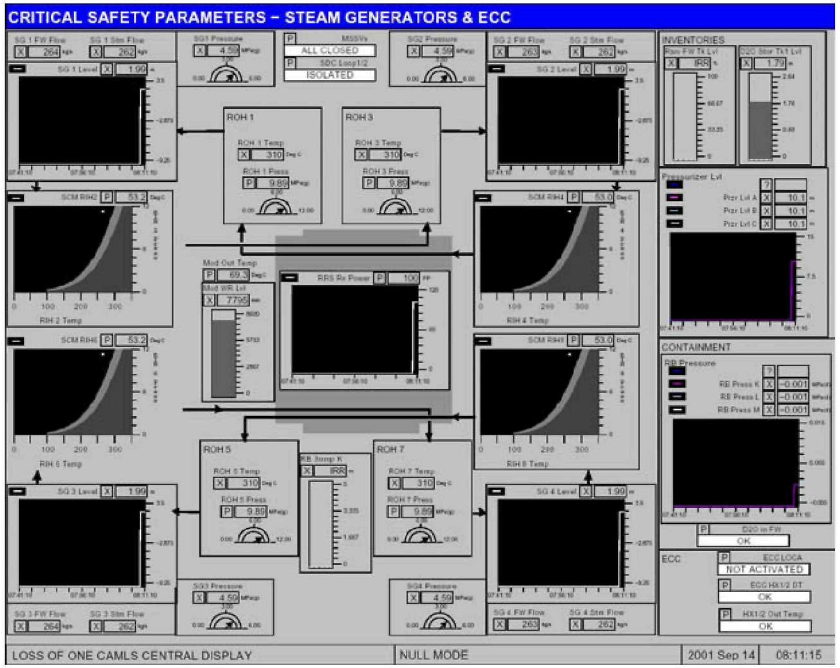
OPERATIONS
- Automated safety testing
- Automated startup
- On-line procedures
- Equipment status monitor

ALARM ANNUNCIATION
- Alarms classified
- Alarms prioritized
- Root cause/failure analysis

Real-time plant display, monitoring and supervisory control

Display and Annunciation

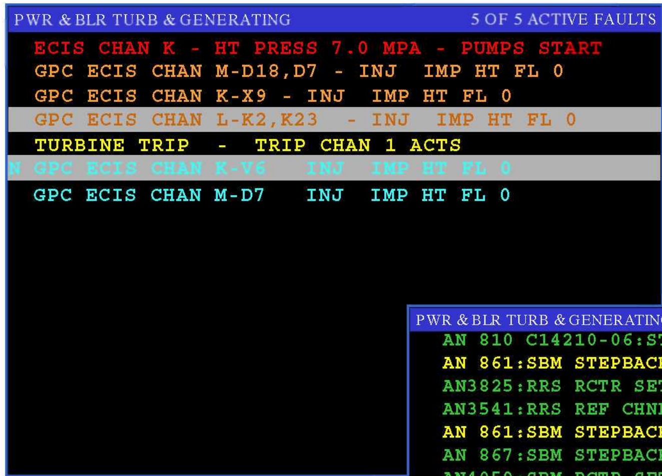
Safety Parameter Display System



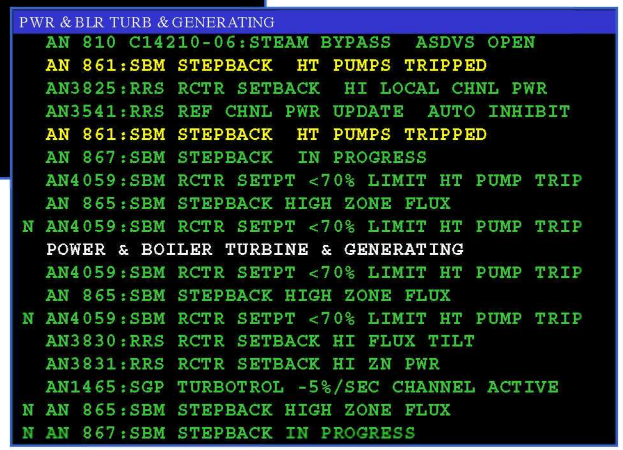
Provides a safety-related perspective on the current plant state with respect to meeting the 'control, cool and contain' requirements

Computerized Alarm Message List System (CAMLS)

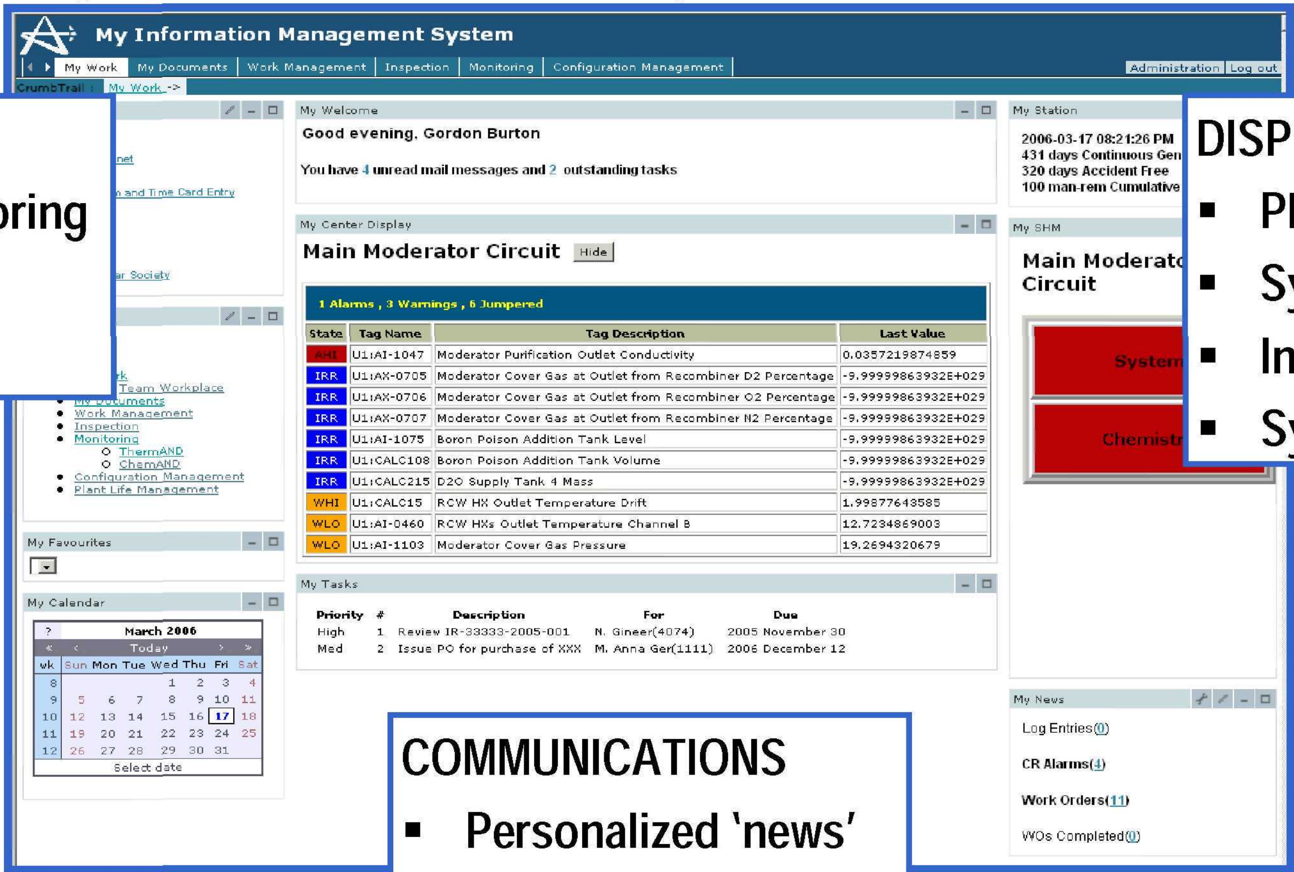
Faults – problems to be addressed



Status – plant state



My Information Management Centre (MIMC)



REPORTS

- Health monitoring
- Performance
- Regulatory

DISPLAYS

- Plant status
- System trends
- Inspection results
- System analysis

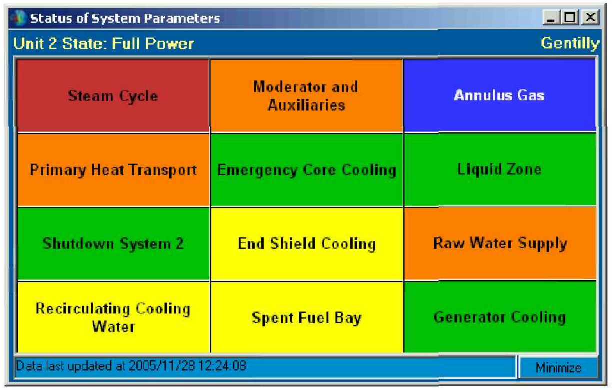
COMMUNICATIONS

- Personalized 'news'
- Work orders, log entries, alarms, tasks, notifications

Portal for information exchange between groups (e.g., technical, management, production)

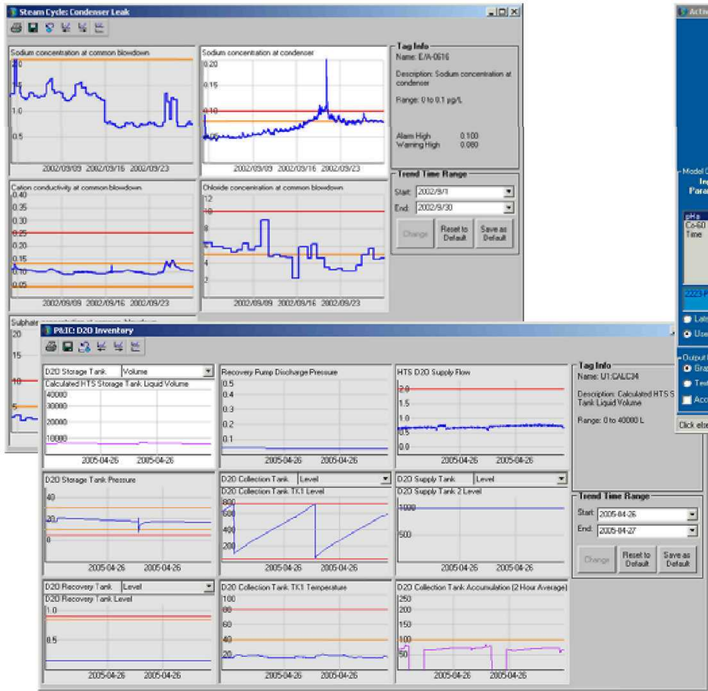
MIMC Displays

Status



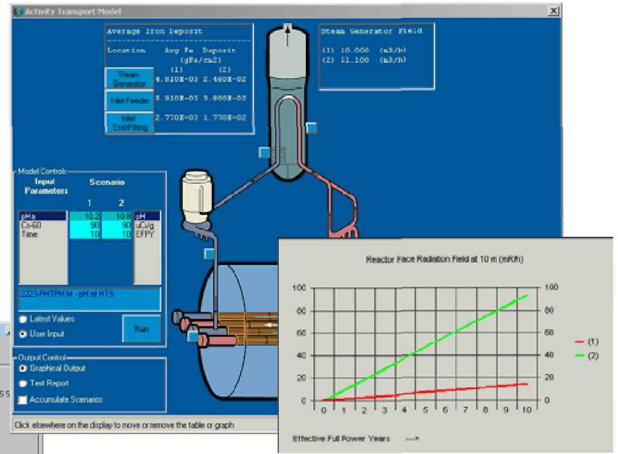
- Chemistry (ChemAND) and process (ThermAND) parameters
- Current value and trend of most recent values compared to user-defined limits
- Colour indicates status of all monitored parameters

Trends



- Trends of correlated parameters help with diagnostics and analysis
- Support proactive decisions

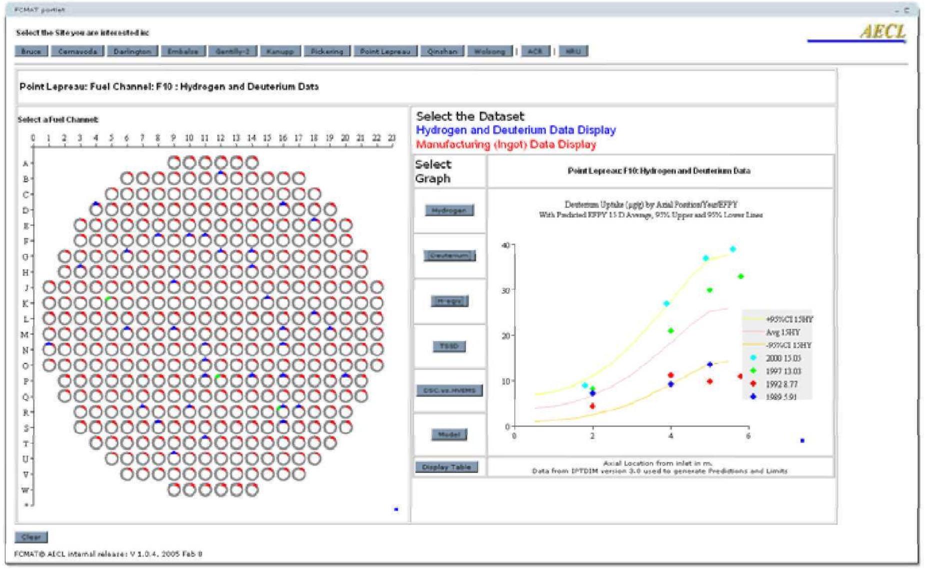
Analysis



- Activity transport
- SG fouling
- Chemistry
- Thermal performance

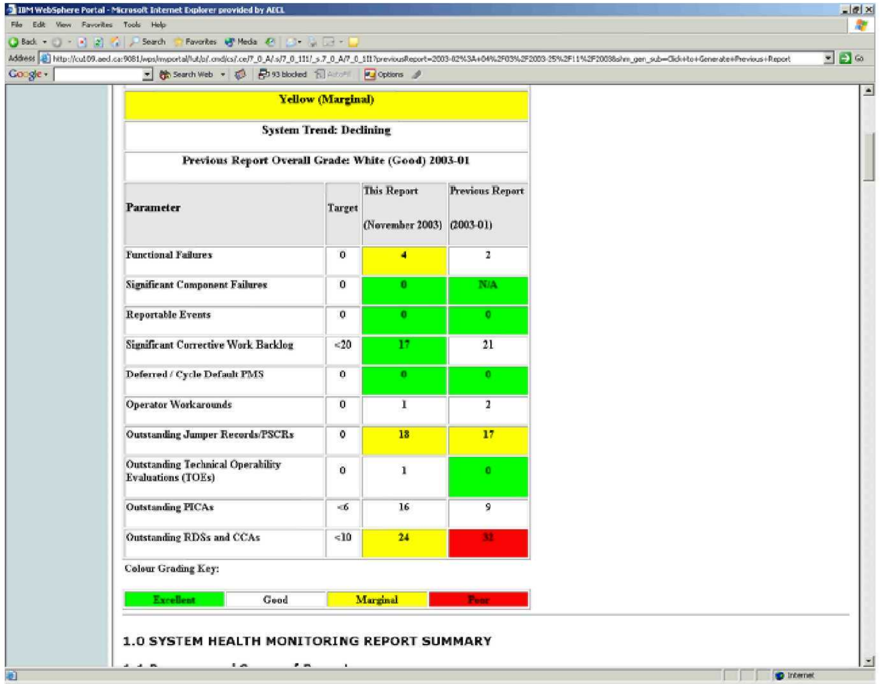
MIMC – Inspection and Reporting

Fuel Channel Monitoring and Assessment Tool (FCMAT)



- FCMAT links manufacturing and operating data with inspection data and model predictions for FC life management
- Web-based communication link between field inspection and analysis teams

System Health Report



Yellow (Marginal)			
System Trend: Declining			
Previous Report Overall Grade: White (Good) 2003-01			
Parameter	Target	This Report (November 2003)	Previous Report (2003-01)
Functional Failures	0	4	2
Significant Component Failures	0	0	N/A
Reportable Events	0	0	0
Significant Corrective Work Backlog	<20	17	21
Deferred / Cycle Default PMS	0	0	0
Operator Workarounds	0	1	2
Outstanding Jumper Records/PSCRs	0	18	17
Outstanding Technical Operability Evaluations (TOEs)	0	1	0
Outstanding PICAs	<6	16	9
Outstanding RDSs and CCAs	<10	24	32

Colour Grading Key:

Excellent	Good	Marginal	Poor

1.0 SYSTEM HEALTH MONITORING REPORT SUMMARY

- System health reports generated in standard form
- Collection and integration of data has been automated

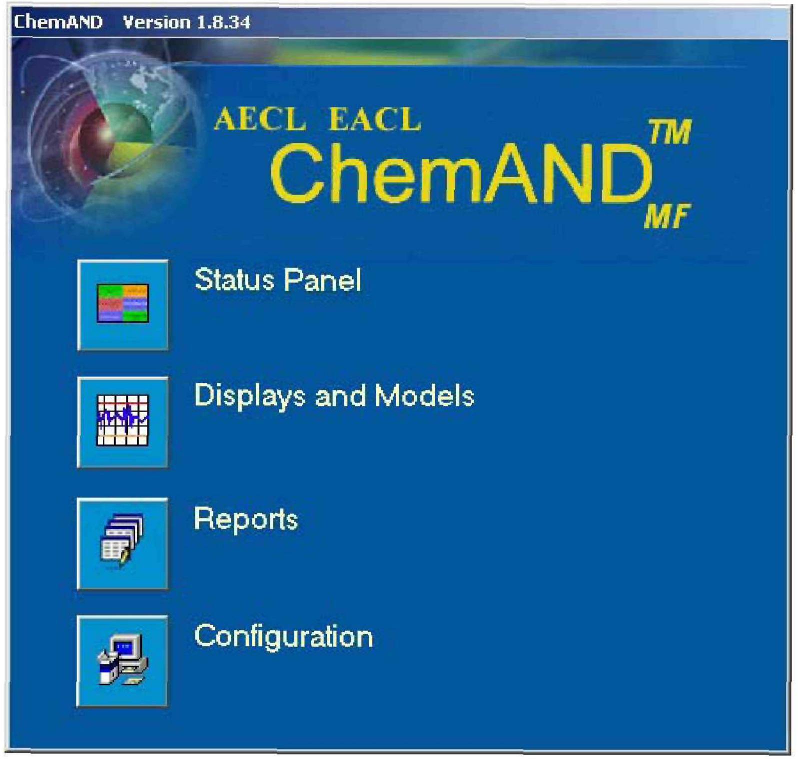
A Closer Look Example – Chemistry Management with the "ChemAND^{TM}" System

Chemistry Operations Requirements

- Proactive chemistry control
- Manage and monitor chemistry in multiple systems
- Make informed operational decisions to maintain safety and protect assets
- Ensure quality checks on data
- Provide chemistry data, graphs, and reports to staff, management and the regulator
- Maintain the configuration of the chemistry monitoring system
- Train staff on chemistry monitoring and diagnostics

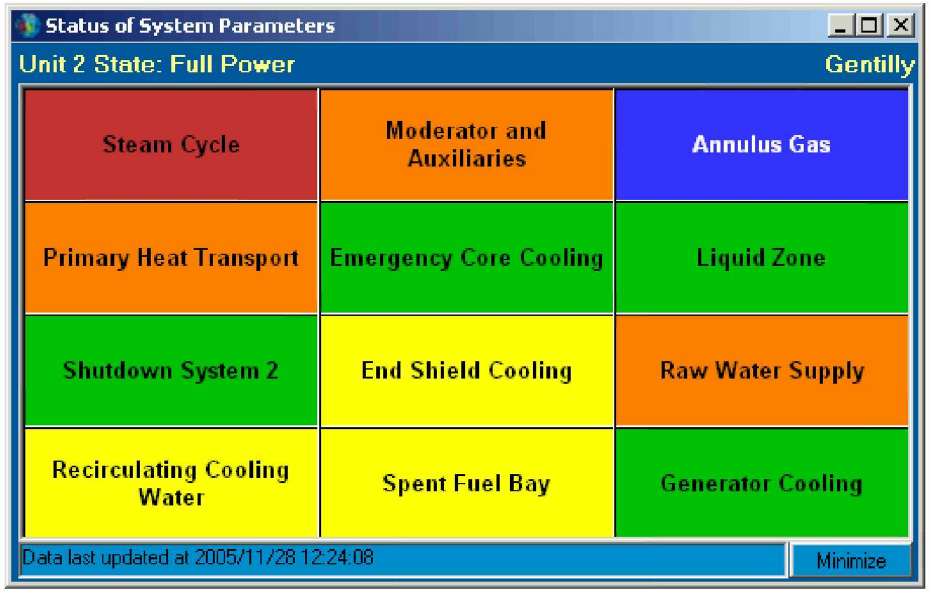
Proactive Chemistry Control

- Warnings and alarms on out-of-specification conditions
- Functional displays to facilitate diagnostics
- Navigational aids to view historical data
- On-line analysis of chemistry data to predict impact on performance
- Automatic generation of performance indices and other reports
- Configuration management application



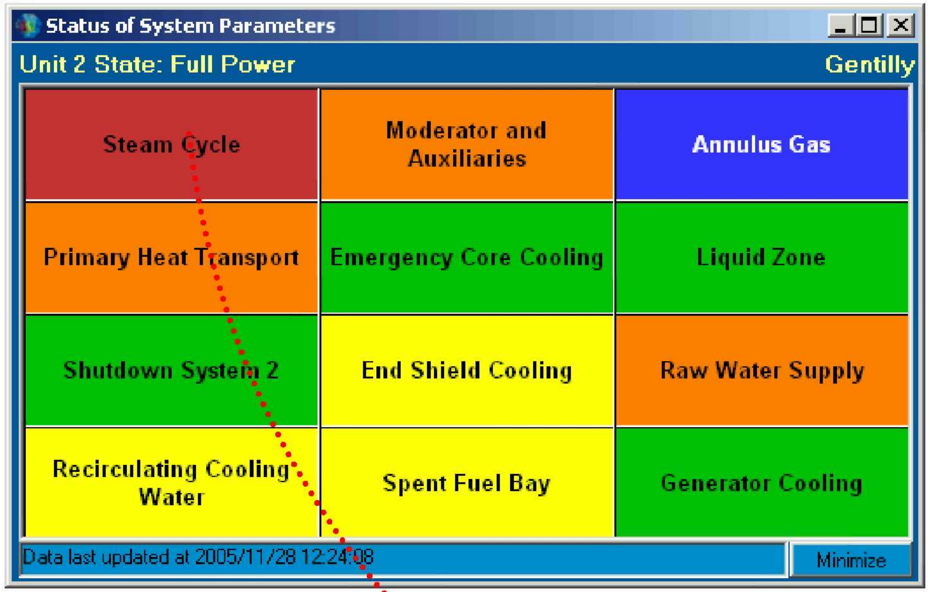
Manage and Monitor Chemistry in Multiple Systems

- Trend rate calculation permits proactive approach
- Current value and trend of most recent values compared to user-defined limits
- Colour indicates status of all monitored parameters

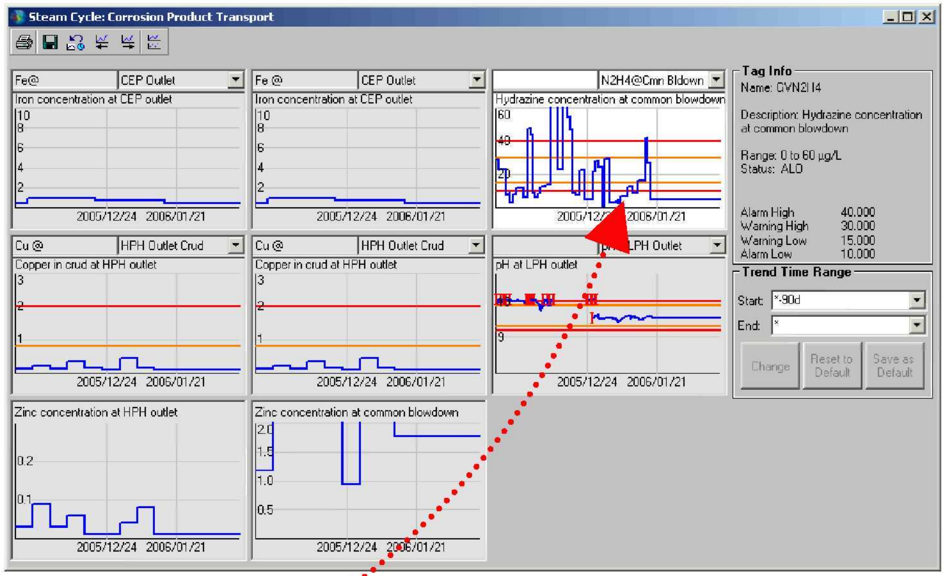


➢ Condition of systems assessed 'at a glance' without the need to review each and every parameter

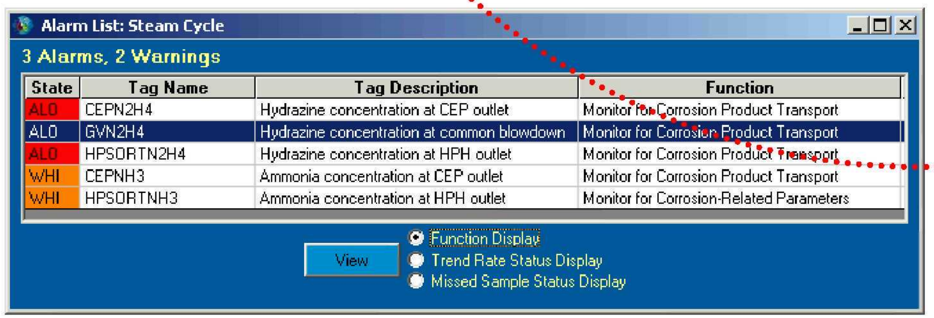
Make Informed Operational Decisions



Status Panel

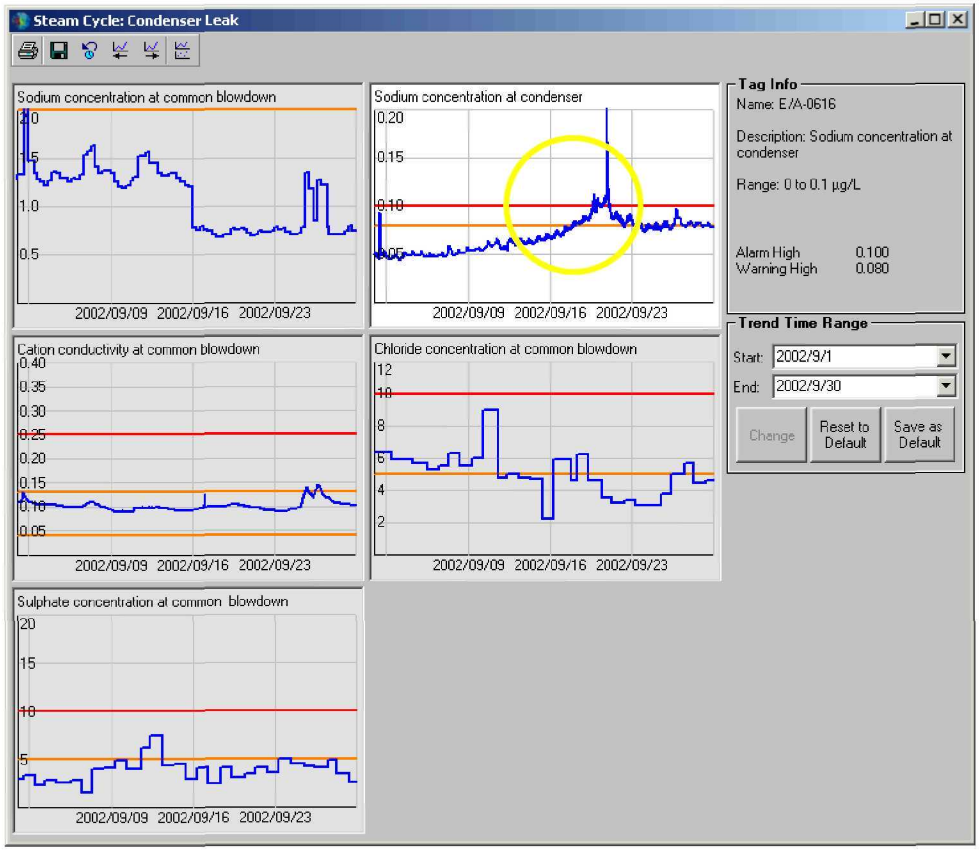


Function-Based Display



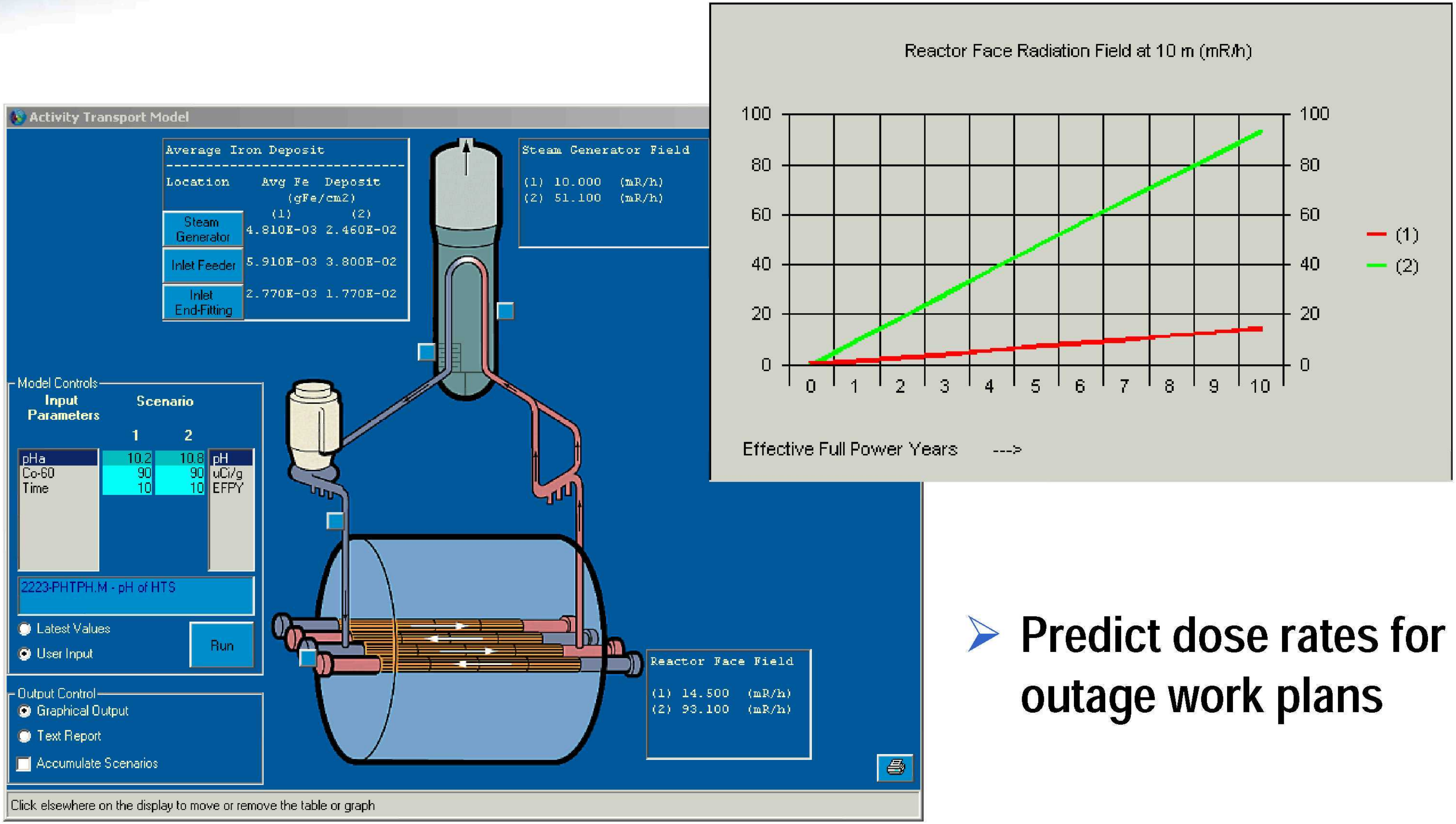
Alarm List

Make Informed Operational Decisions



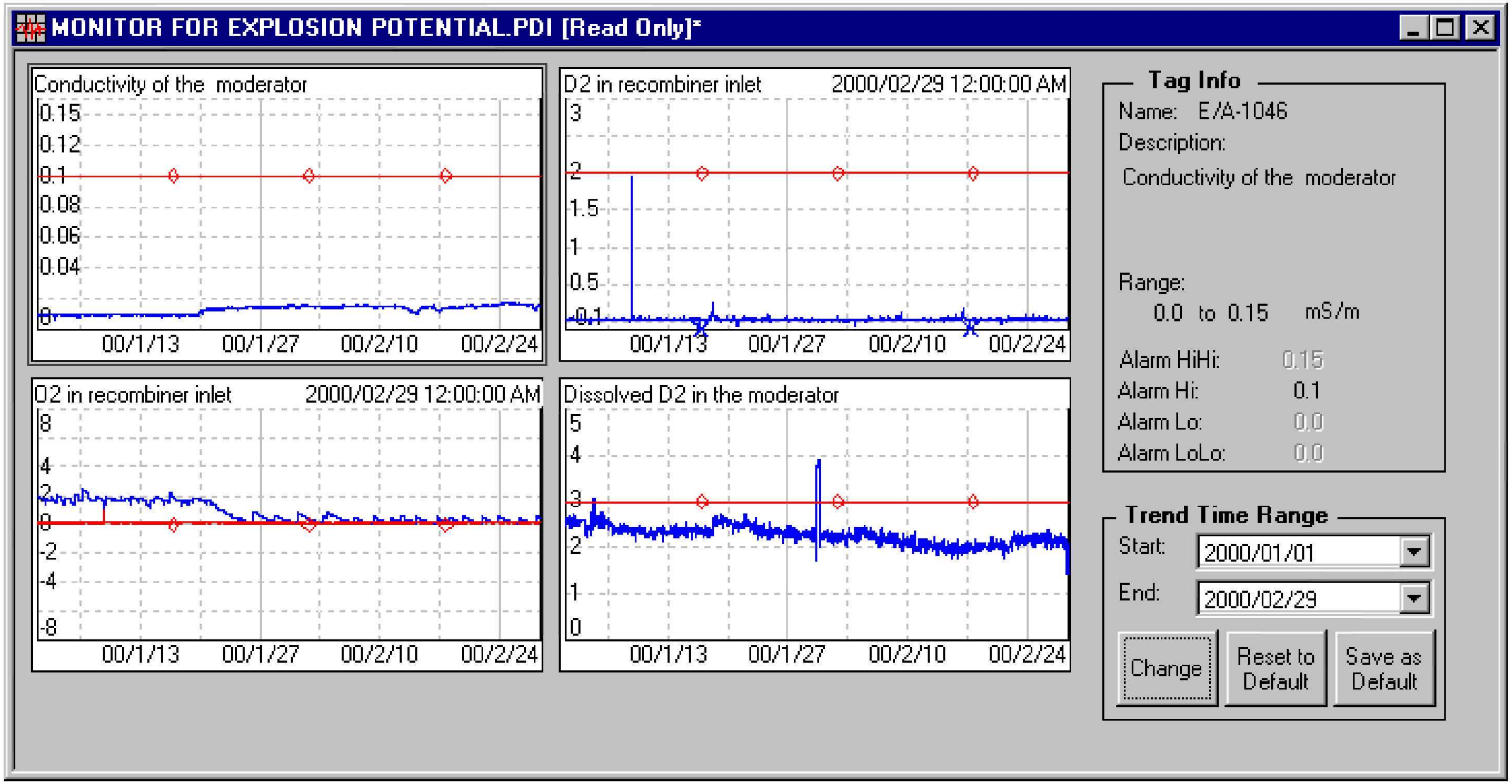
- Alarm in control room on high Na in the condensate
- Trend in condenser hotwell Na caused by drift in calibration, not condenser leak
- Took < 5 min to diagnose and disposition the alarm
- Alarm on high trend rate would have alerted staff to the problem 2 days before the alarm

Maintain Safety



- Predict dose rates for outage work plans

Maintain Safety
Monitor gas mixtures for flammability

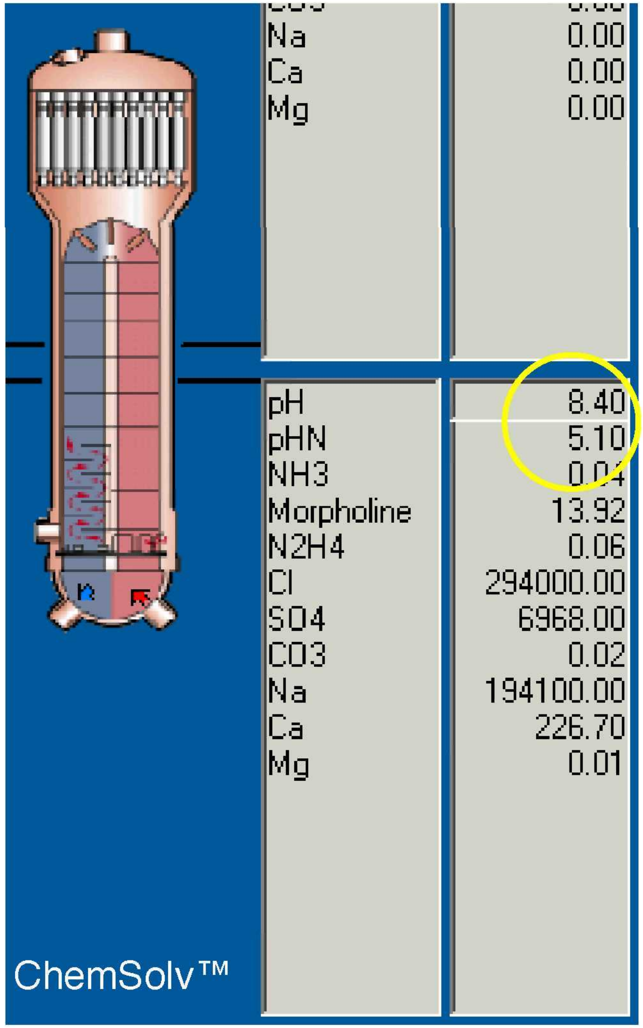


Protect Key Assets

Cation
- Calcium ~36 ppb
- Magnesium ~24 ppb
- Sodium ~2 ppb

Anion
- Sulphate ~130 ppb
- Carbonate ~15 ppb
- Chloride ~14 ppb

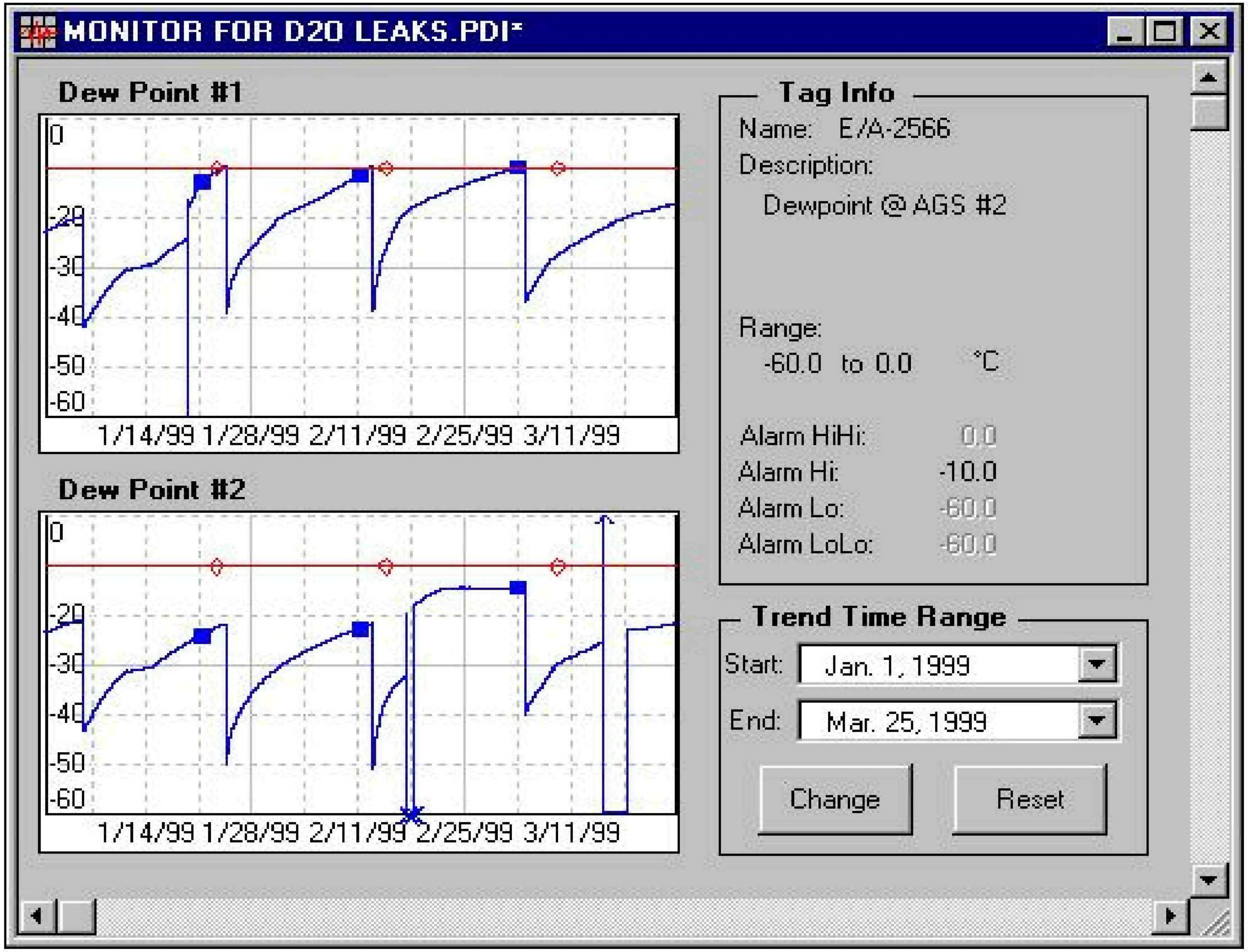
Other
- Morpholine ~4 ppm
- Ammonia ~0.6 ppm
- Hydrazine ~6 ppb



- Concentrations are higher at start-up than during full power operation, but the water chemistry is balanced and the steam generator tubes protected

➢ Advisory to plant staff to reduce hold times during reactor start-up

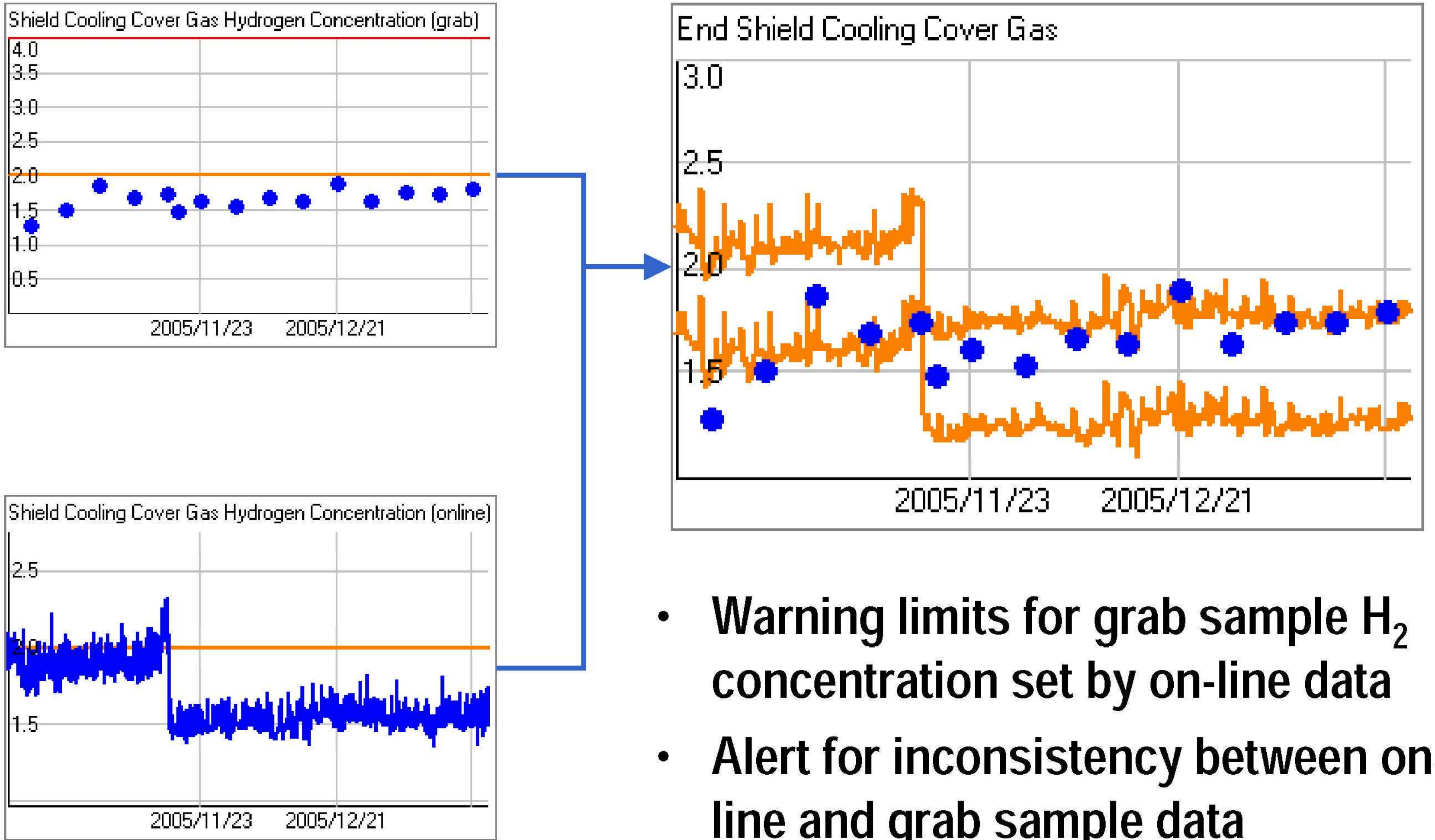
Sensor Validation



Sensor Validation

Grab Sample

On-line



- Warning limits for grab sample H_2 concentration set by on-line data
- Alert for inconsistency between on-line and grab sample data

Report Performance Indices

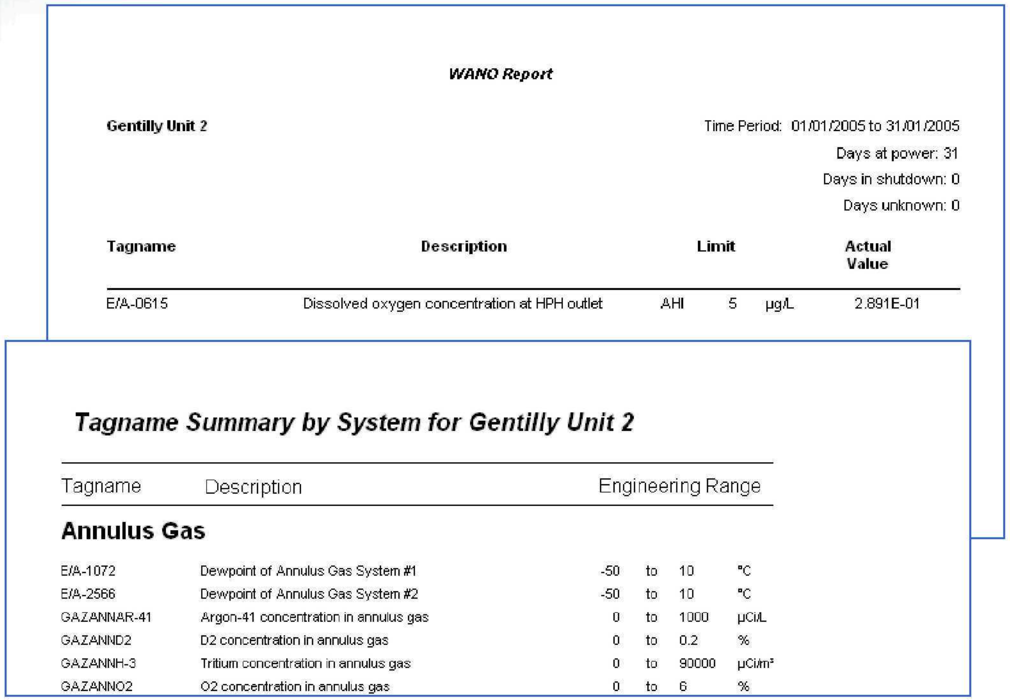
CNSC Report

Gentilly Unit 2

Time Period: 2000/01/01 to 2000/03/31
Days at power: 91
Days in shutdown: 0
Days unknown: 0

Tagname	Out of Spec	Missed	In Spec	Total	%	Description
Chemistry at Power			Average :		**84.51** %	
CALO1D2DISSL	0	14	77	91	84.61	Dissolved D2 concentration in HTS loop #1
CALO1PH	0	0	92	92	100	pH of HTS loop #1 heavy water
CALO2D2DISSL	0	14	77	91	84.61	Dissolved D2 concentration in HTS loop #2
CALO2PH	0	0	94	94	100	pH of HTS loop #2 heavy water
E/A-0613	899	0	3440	4339	79.28	Dissolved oxygen concentration at deaerator inlet
E/A-0615	0	0	4321	4321	100	Dissolved oxygen concentration at HPH outlet
E/A-0617	51	0	4284	4335	98.82	pH at LPH outlet
GAZANNO2	14	0	0	14	0	O2 concentration in annulus gas
GVCL	2	0	110	112	98.21	Chloride concentration at common blowdown
GVNAL	2	4	279	285	97.89	Sodium concentration at common blowdown
GVSO4	1	0	111	112	99.10	Sulphate concentration at common blowdown
HPSORTCU-CRUD	0	2	11	13	84.61	Copper in crud at HPH outlet
HPSORTFE-CRUD	0	2	11	13	84.61	Iron concentration in crud at HPH outlet
HPSORTN2H4	8	0	20	28	71.42	Hydrazine concentration at HPH outlet

Configuration Management



WANO Report

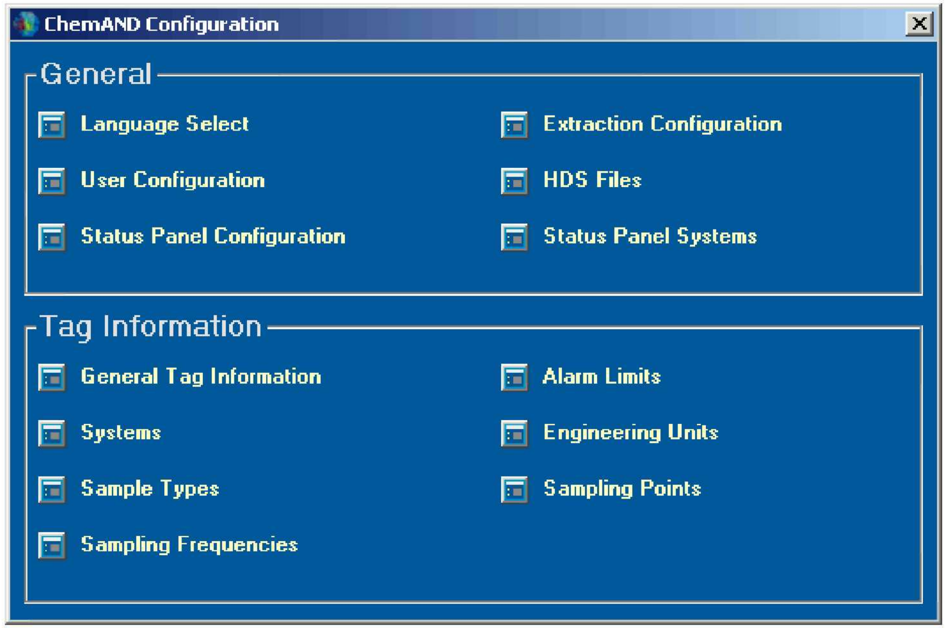
Gentilly Unit 2

Time Period: 01/01/2005 to 31/01/2005
Days at power: 31
Days in shutdown: 0
Days unknown: 0

Tagname	Description	Limit			Actual Value
E/A-0615	Dissolved oxygen concentration at HPH outlet	AHI	5	µg/L	2.891E-01

Tagname Summary by System for Gentilly Unit 2

Tagname	Description	Engineering Range			
Annulus Gas					
E/A-1072	Dewpoint of Annulus Gas System #1	-50	to	10	°C
E/A-2566	Dewpoint of Annulus Gas System #2	-50	to	10	°C
GAZANNAR-41	Argon-41 concentration in annulus gas	0	to	1000	µCi/L
GAZANND2	D2 concentration in annulus gas	0	to	0.2	%
GAZANNH-3	Tritium concentration in annulus gas	0	to	90000	µCi/m³
GAZANNO2	O2 concentration in annulus gas	0	to	6	%



Fully Configurable

Configure management of chemistry tags, engineering limits, warning and alarm limits, sample location and sample frequency

Summary

- AECL recognizes the importance of KM in improving NPP operational performance
- The development of an Integrated & Shared Knowledge Base (i.e. info management systems, supporting IS technology & infrastructure is seen as key)
- SMART CANDU™ is an example of AECL's KM initiative. The program focus is the development of Information Management and Decision Support Systems (e.g. plant chemistry surveillance and health monitoring)
- Other key KM areas include: plant design basis and CM, safety state of the plant, thermal performance, use of process simulation, plant operations support tools, plant equipment reliability and maintenance tools.