UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

December 12, 1996

MEMORANDUM TO: David B. Matthews, Chief
Generic Issues and Environmental
Projects Branch
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

FROM: Eileen McKenna, Senior Reactor Engineer Eileen McKenna
Generic Issues and Environmental
Projects Branch
Division of Reactor Program Management
Office of Nuclear Reactor Regulation

SUBJECT: SUMMARY OF NOVEMBER 14, 1996, MEETING WITH THE INDUSTRY GROUP ON THE DYNAMIC SAFETY SYSTEM (DSS) PROJECT TO DISCUSS THE DSS DESIGN AND SCHEDULE FOR IMPLEMENTATION AT OCONEE

On November 14, 1996, representatives of the Electric Power Research Institute (EPRI) and Duke Power Company met with representatives of the Nuclear Regulatory Commission (NRC) in Washington D.C. Attachment 1 provides a list of meeting attendees.

The purpose of the meeting was to discuss the dynamic safety system (DSS) project design and schedule. The DSS is designed to be a replacement for a reactor protection system which is planned to be installed at the Oconee station. DSS is one of three projects for which the Electric Power Research Institute (EPRI) is a co-sponsor (the others are the EPRI-PLC and ASICs projects). The other sponsor of the DSS project is Duke Power (Oconee Nuclear Station). The DSS project encompasses completing a conceptual design for the DSS digital system modification, a cost benefit analysis at Oconee, and determining the level of detail needed to revise the operator training necessary to accommodate the new tasks consistent with the DSS project. The DSS project at Oconee Nuclear Station consists of four separate phases discussed below:

Phase 1 is the cost benefit analysis and operator training/procedure impact study. Phase 1 is to be completed in early 1997. Upon completion of Phase 1, a report will be made available to the staff. Phase 2 encompasses preparation and submittal of the topical report and is scheduled to begin in 1998. Also included in Phase 2 are the application specific licensing submission, and the delineation of modifications to operator training and procedures. Phase 3 is the actual implementation of the DSS at Oconee Nuclear Station (ONS), which is scheduled to begin in the Spring of 1998. The project Phase 4 consists of the project performance verification. Performance verification is planned to conclude in the fall of 2000. Completion of the DSS project may be prolonged due to the lack of DOE participation; however, once completed, the DSS project team estimates that the payback in the investment of implementing the DSS is predicted to be forthcoming in 2 to 5 years.

DF03 1/1

During the presentation of the utility perspective and project plan, there was an expressed desire by the project sponsors to get Entergy (licensee for ANO-1) involved. Members of the DSS project anticipate that other utilities which have Babcock & Wilcox (B&W) plants will be participating in this project. The reactor protection system (RPS) will be upgraded on the three ONS units, and the upgrade will include on-line monitoring and integration with the plant computer. The design for the upgrade was presented as being failsafe; an extension of ladder logic to digital design. No on-line surveillances will be required, the design is modular, there will be low maintenance costs, a reduction in spare parts inventory will be seen, and the upgrade will have a low probability of failure. During the presentation of the cost benefit analysis, it was anticipated that spare parts reductions would be on the order of 70 percent to 80 percent.

Some members of the DSS project team had meet previously with representatives of Nuclear Electric's (UK) Dungeness and Sizewell plants to discuss concerns and issues with the DSS and with digital systems in general. The concerns and issues were identified and are being addressed in the DSS project at Oconee.

An update on the conceptual design was presented. The DSS can be configured as 4 or 6 channels. Each channel is comprised of one or more signal conditioners, one or more data collectors, one trip processor, and one actuator drive. The trip processor encompasses the trip algorithm computer (TAC) and the vote algorithm computer (VAC). For each channel, multiple signals can feed into multiple collectors which feed into the trip processor. The data collector is comprised of a number of hardware and software functions which provides for the promulgation of diagnostic information to the network. The trip processor consists of a number of hardware and software functions. Fiber optics are used for transmission of data from the VAC to the monitors. The actuator drive functions are hardware. Both the TAC and VAC are programmed in Ada. The DSS addresses the diversity issue by using a combination of hardware and software to eliminate the software common mode failure concerns along with their "fail-safe" concept.

The NRC brought to the attention of the DSS project team the need to consider issues associated with analysis of accidents and transients in accordance with Standard Review Plan Chapter 15, as well as the need to modify the plant simulator based on the changes made to the plant due to the DSS implementation. The DSS project team recognized the concerns raised by the NRC and further indicated that the Chapter 15 issues would be addressed in the Phase 2 portion of the project.

A future meeting is planned but the date has not been set due to uncertainties in the funding of this project. The five part slide presentation by the DSS project team is provided as attachment 2.

Attachments: As stated

cc w/atts: See next page

Project No. 669

A future meeting is planned but the date has not been set due to uncertainties in the funding of this project. The five part slide presentation by the DSS project team is provided as attachment 2.

Attachments: As stated

cc w/atts: See next page

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NRC/EPRI MEETING ON DYNAMIC SAFETY SYSTEM
LIST OF ATTENDEES
November 14, 1996

NAME	ORGANIZATION
Deidre Spaulding	NRC/HICB
Jerry Mauck	NRC/HICB
Jared Wermiel	NRC/HICB
Mike Miller	Duke Power/Oconee
Ian Smith	Campbell Love Associates
Graham Adams	AEA Technology
Dan Wilkinson	EPRI
Don Miller	Ohio State University
Brian Hajek	Ohio State University

Attachment 1

DYNAMIC SAFETY SYSTEM PROJECT TEAM MEETING WITH NRC

NOVEMBER 14, 1996

SHERATON WASHINGTON HOTEL, EISENHOWER ROOM

2:00 pm	Introduction and Project Overview	Dan Wilkinson/EPRI
2:15 pm	Utility Perspective and Project Plan	Mike Miller/Duke
2:35 pm	Conceptual Design Update	Graham Adams/AEA
3:05 pm	Training/Procedures Evaluation	Brian Hajek/OSU
3:25 pm	Cost/Benefits and Phase 1 Report	Ian Smith/CLA
3:50 pm	General Discussion	All
4:30 pm	Close	

Attachment 2

DSS Project Overview

- Project Structured in 4 Phases
- Phase 1: Completion scheduled for 2/97

  Joint funding by Duke and EPRI

  Tailored Collaboration

  Two tasks: Cost/Benefit Evaluations

  Operator Training/Procedures Eval.

  Meetings Completed With Nuclear Electric Dungeness & Sizewell plants.

  Phase 1 Report
- DOE Participation Under Negotiation
- Other Utilities
- "Licensing Digital Perception" Potential Impacts:

  SRP Update

  National Research Council Study

  Plant Life Extension

  Plant Economics Under Deregulation
- Phase 2: TBD Early 1997

DSS/NRC Meeting November 14, 1996 - Washington, DC
DYNAMIC SAFETY SYSTEMS APPLICATION PROJECT

UTILITY PERSPECTIVE AND PROJECT PLAN

M H Miller

Duke Power Company

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DYNAMIC SAFETY SYSTEMS APPLICATION PROJECT

- **PROJECT TEAM**
  - Duke Power Company - Oconee Nuclear Station
  - EPRI
  - AEA Technology
  - Ohio State University
  - Campbell Love Associates
- **OTHER PROJECT ASSOCIATES**
  - Nuclear Regulatory Commission
  - Dungeness 'B' Nuclear Station
  - Sizewell 'B' Nuclear Station
  - Entergy Operations
  - Nuclear Electric

DSS/NRC Meeting November 14, 1996 - Washington, DC

DYNAMIC SAFETY SYSTEMS APPLICATION PROJECT

- **BRIEF REVIEW OF DSS PROJECT**
  - Upgrade/Replace Reactor Protection System (RPS) on 3 Units at Oconee
  - Redundant RCP power monitor, Additional Delta T Trip
  - On-line sensor monitoring and integration with plant computer
  - Fail-Safe Design - Extension of Laddic logic to digital design
  - Continuously Self-Testing
  - No On-Line Surveillances
  - Modular Design
  - Low Maintenance Costs
  - Reduced Spare Parts Inventories
  - Low Cost of Ownership and High Rate of Return
  - Extremely Low Probability of Failure to Trip On Demand

DSS/NRC Meeting November 14, 1996 - Washington, DC

DYNAMIC SAFETY SYSTEMS APPLICATION PROJECT

- **PROJECT STATUS**
  - EPRI TC 4385-001-10759 - Duke Power Company & EPRI
- **PROJECT REVIEW**
  - Four Phase Project
  - Phase I - Cost Benefit Analysis and Operator Training/Procedure Impact
    - » Activities initiated Spring 1996
  - Phase II - Licensing and Specification Development
    - » Activities originally Projected to begin October 1996 based upon Phase I
  - Phase III - Hardware Implementation
    - » Activities projected to begin Spring 1998
  - Phase IV - Project Performance Verification
    - » Activities begin with 1st installation and conclude in Fall 2000

DSS/NRC Meeting November 14, 1996 - Washington, DC

DYNAMIC SAFETY SYSTEMS APPLICATION PROJECT

- **PHASE I ACTIVITIES STATUS**
  - TASK 1.1 - Develop a Standardized Generic Cost Benefit Analysis for DSS Safety System Application
    - » Cost Benefit Analysis Report in Developmental Stage
      - Using EPRI Tools and Duke Methods
    - » Meetings held with Nuclear Electric in the UK
      - Dungeness "B" NPS
      - Sizewell "B" NPS
    - » Meeting held with AEA in the UK
    - » Results to date show payback in 2 - 5 years
    - » Phase I Completion impacted by current Oconee Plant status (2/28/97 to 3/31/97)
    - » Phase II Decision Expected 01/01/97

DSS/NRC Meeting November 14, 1996 - Washington, DC

DYNAMIC SAFETY SYSTEMS APPLICATION PROJECT

- **KEY POINTS ON MEETING WITH NE AT DUNGENESS"B" NPS**
  - First computer based protection system on a power reactor in the UK
  - Two systems each with five years operating experience
  - Low component failure rate confirmed from field data
  - Routine on-line monitoring has replaced calibration of channels
  - Overall, low cost of ownership confirmed

DSS/NRC Meeting November 14, 1996 - Washington, DC
DYNAMIC SAFETY SYSTEMS APPLICATION PROJECT

- **KEY POINTS ON MEETING WITH NE AT SIZEWELL"B" NPS**
  - Computer based Primary Protection System is combined with an Analog Secondary Protection System
  - Tech. Specs do not permit operation of the plant if either of the two protection systems is inoperable
  - The added functionality of the PPS may have contributed ~10% improvement to power output and reduced fuel costs vs analog SPS on its own (based on postulated scenarios and discussions with Nuclear Electric staff from Sizewell"B" and Barnwood Design Offices)

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DYNAMIC SAFETY SYSTEMS APPLICATION PROJECT

- **PHASE II ACTIVITIES STATUS**
  - Decision to begin Phase II based on Phase I results and availability of Duke Power resources and priorities
- **PHASE III ACTIVITIES STATUS**
  - Decision to begin Phase III follows decision on Phase II
- **PHASE IV ACTIVITIES STATUS**
  - Decision to begin Phase IV follows Phase III activities

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DYNAMIC SAFETY SYSTEMS APPLICATION PROJFCT

- **PROPOSED ROUTE AHEAD FOR DSS PROJECT IN 1997**
  - Review project scope, schedule and funding vs DOE status
  - Total project funding level in 1997 $ 3.5 M
  - Total project cost estimated at $ 11.498 M
  - Schedule dependent on aggressive funding and resources
    - Unit 1 Restart Activities
  - Some 1996 activities and funding may roll over into 1997
  - Decision awaited on Phase II
    - » Oconee Units 1, 2 & 3 currently shut down
    - » Other Activities and Commitments have higher resource priority
      - Unit 2 Restart Activities
      - Unit 3 Early Refueling Outage and Restart Activities
      - Oconee Service Water Project
      - Other major plant modifications
    - » Oconee License Renewal Activities

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DYNAMIC SAFETY SYSTEMS APPLICATION PROJECT

- **OUTLOOK FOR PROJECT**
  - Continue to interest other utilities in benefits of the DSS project
  - Duke continues to allocate resources to this project
  - Oconee will replace the existing RPS due to obsolescence
  - Non-participation of DOE has be a determining factor on interest and schedule
  - Competing near term requirements for Oconee resources and priorities will also be a major factor
  - License Renewal Activities and strategy may impact I&C Upgrade programs
  - Deregulated Industry concerns influence short term planning

Inherently Safe Automatic Trip (ISAT) System

Presentation to NRC at Washington DC

by

Graham Adams

14 November 1996

AEA Technology

Subsystems in a single ISAT™ equipment channel

- one or more Signal Conditioners
- one or more Data Collectors
- one Trip Processor
- one Actuator Drive

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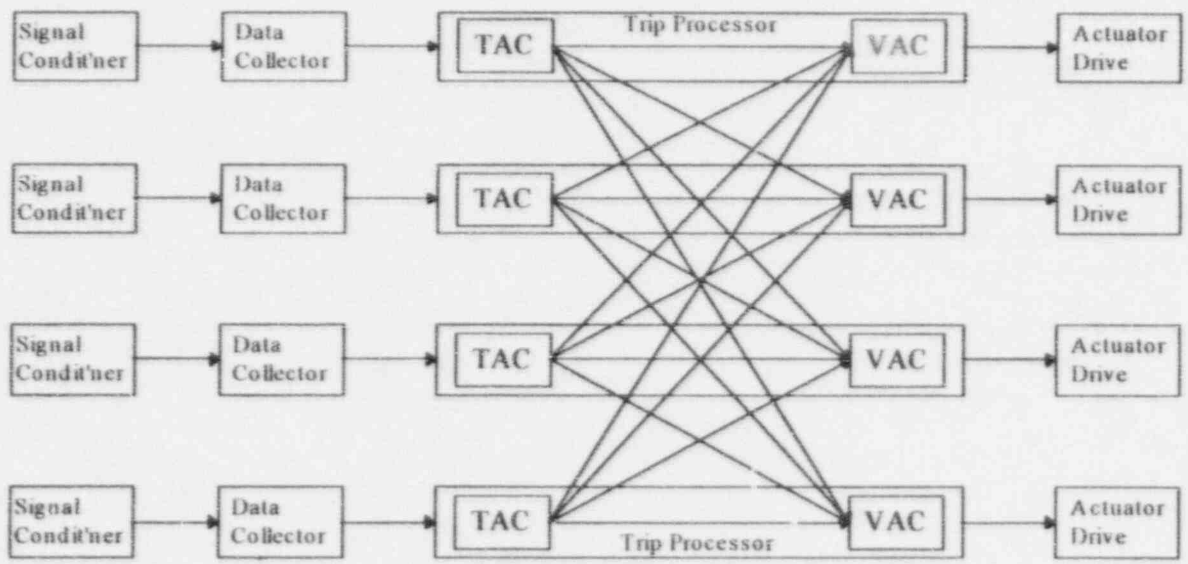
Typical ISAT system configuration



AEA Technology

Slide serial no 3

Signal Conditioner functions

- receipt of a variety of analog inputs *(hardware)*
- detection of the state of volt-free contacts, including mode switches *(hardware)*
- representation of the above as uniform output voltages *(hardware)*
- flagging, via keyswitches on the front panel, of individual faulty signals *(hardware)*

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Data Collector functions

- receipt of analog voltage signals from the Signal Conditioner *(hardware)*
- sampling of received signals *(hardware)*
- conversion of received signals to digital values *(hardware)*
- automatic checking of ADC operation *(hardware)*
- detection of "flagged" signals *(software)*
- arrangement of plant and fixed test values into frame sequences *(software)*
- output of digital plant signals to the Trip Processor *(hardware)*
- output of fixed test values to the Trip Processor *(hardware)*
- output of diagnostic information to network *(hardware)*

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Trip Processor functions

• receipt of digital plant and test data	*(hardware)*
• reformatting of received data	*(hardware)*
• implementation of trip functions	*(TAC software)*
• transfer of trip function results between Trip Processors	*(hardware)*
• implementation of vote function	(VAC *software*)
• deciphering of vote function results	(VAC *software*)
• verification of vote function results	(PRL *hardware*)
• output of dynamic signal to Actuator Drive	*(hardware)*
• output of diagnostic information to network	*(hardware)*
• display on front panel of limited diagnostics	*(hardware)*

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Actuator Drive functions

- receipt of dynamic signal from the Trip Processor *(hardware)*
- provision of diagnostic signal to the Trip Processor to confirm continued operation *(hardware)*
- provision of application-specific output(s) *(hardware)*

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TAC program features

- programmed in Ada
- all calculations performed in fixed point arithmetic
- test data exercises all trip functions, within 2 bits where possible
- test data exercises all trip function statements and branches
- all program exceptions explicitly handled in the program
- test data also exercises the exception handling mechanism
- no interrupts except those associated with exception handling
- timely program execution enforced by hardware operation

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VAC program features

- programmed in Ada
- all calculations performed using simple integer arithmetic
- internal test data exercises all bit-wise voting combinations
- internal test data exercises all vote function statements and branches
- vote function accommodates planned trip demands
- all program exceptions explicitly handled in the program
- timely program execution enforced by hardware operation
- vote result output to PRL only in event of timely PRL data request
- diagnostic data generated in post-trip state

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New design features

- testing of vote function fully automatic
- live values of "bypassed" plant signals available in diagnostic output
- live trip status information available in diagnostic output in post-trip conditions
- support functions for TAC and VAC implemented in hardware

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Changes in trip processor configuration

Oconee demonstrator configuration	*Revised configuration*
Input buffer computer (IBC)	TAC input board
Trip algorithm computer (TAC)	TAC interface board
	Trip algorithm computer (TAC)
	TAC output board
Vote algorithm computer (VAC)	VAC input board
Output buffer computer (OBC)	VAC interface board
	Vote algorithm computer (VAC)
Pattern recognition logic (PRL)	Pattern recognition logic (PRL)
Front panel display board	Front panel display board

AEA

AEA Tec... ...gy

Application-specific configuration options

- channel bypass/trip capability
- on-line set point change capability
- multi-processor TAC program implementation
- flexible vote function
- single chassis Signal Conditioner/Data Collector

AEA

AEA Technology

Dynamic Safety System

OPERATOR INTERACTIONS

WITH DSS

Presented by

Brian K. Hajek
The Ohio State University

November 14, 1996

Dynamic Safety System

PRESENTATION OUTLINE

Control Room Interactions

System Security

Daily Operator Interactions

- System Alarms
- Veto Operations

DSS Maintenance

- Channel Maintenance
- Preventive Maintenance/checks
- Routine Testing

System Faults

Training

Dynamic Safety System

CONTROL ROOM INTERACTIONS

All Control Room interactions are through the Monitoring System (Calibration Test Computer (CTC)), Veto Key switches, and parameter control key switches.

New system will reduce maintenance interaction, transferring power level dependent S/P changes to an operator task, possibly through the use of key switches.

The Monitoring System consists of a CRT display and a keyboard and CRT.

DSS faults and alarms, including valid trips, are displayed.

The operator may use the MS to diagnose faults down to the board level.

The MS is entirely passive relative to DSS. No hardware failures can propagate to the DSS equipment.

Dynamic Safety System

SYSTEM SECURITY

Achieved by:

1. Using Passwords

2. Limiting keyboard to accept minimum of data.

Passwords NOT needed for normal monitor functions.

Passwords (two) required only for:

1. Monitor Startup/Shutdown

2. Veto operations

3. Changing data parameters (trip levels, test levels, ranges) or passwords

4. Alarm testing

Dynamic Safety System

SYSTEM ALARMS

Trip System Equipment Faults

1. Initiate CR Alarms

2. Operator acknowledges, and when condition clears, clears the alarm.

3. One alarm line available on CR display, but alarm page available using Hot Key, to show all currently active alarms.

Monitor System Faults

1. Initiates Monitor Alarm only.

2. Includes everything external to the trip channels.

3. No operator action required.

Dynamic Safety System

VETO OPERATIONS

1. Parameter channel to be vetoed is specified on the Monitor

2. Operator uses keylock at the Amplifier/Scanner Cubicle (back panel cabinet)

3. Monitor checks veto status for all channels after time delay (scan time) and verifies that veto has been properly implemented

4. Monitor also verifies that channel has no veto implemented, or if veto is to be removed, that channel is vetoed

Dynamic Safety System

CHANNEL MAINTENANCE

A single safety channel can be removed for maintenance without causing a reactor scram.

Either the DCS or the TAC/VAC/PRL functions can be powered down independently.

At Oconee, the Signal Conditioner, Data Collector, Trip Processor, Actuator Drive.

Dynamic Safety System

PREVENTIVE MAINTENANCE/CHECKS

Component by component checks are specified for performance during DSS startup.

TAC Trip Level Test Signal Generator is recommended to be tested biennially, preferably during reactor shutdowns.

A quarterly test is performed using the Inhibit pushbuttons per Dungeness Tech Specs to check the voting logic and contactor operation between the PRL and trip actuators.

Dynamic Safety System

SYSTEM FAULTS

All internals are tested by the software.

The Monitoring System provides indications of hardware failures at the board level.

Fault alarms are displayed on the monitor.

These may deal with component faults in the DCS, TAC, VAC, PRL, monitor.

Additional alarms are provided for logic faults and improper trip patterns.

Operator response and diagnosis is through the Monitor CRT and keyboard.

Repair is typically performed by turning off the failed section, swapping out a bad board, turning the system back on, and completing the startup sequence for the failed channel.

Dynamic Safety System

TRAINING

Development of training will follow the Systematic Approach to Training process.

Task analyses will need to be performed.

Training objectives will be developed.

Training materials will be designed and developed to support the objectives.

Training will be performed followed by testing against the objectives.

Results of the training will be evaluated, and the materials revised accordingly if necessary.

Dynamic Safety System

SUMMARY

DSS provides a significant amount of software and hardware checking.

Fail safe design prevents system with any inoperable components.

Operator interaction with DSS is minimized due to system design.

Operator interaction, except for quarterly surveillance testing, is through the DSS Monitor which provides a one way interaction that does not affect DSS operation.

Training modules for DSS will need to be developed using the INPO/NANT approved SAT process.

DSS OCONEE RPS REPLACEMENT PROJECT

Phase I

Cost Benefit Analysis

Ian Smith

Campbell Love Associates

CLA

DSS OCONEE RPS REPLACEMENT PROJECT

Phase I - Cost Benefit Analysis

Ian Smith
Campbell Love Associates

CLA

Areas Examined - 1

- Power Level Increase
- Reduced Fuel Purchases
- Modifications to the Existing Trip Boundaries or Functions
- Plant Operator Procedures and Training
- Plant Operations

CLA

Areas Examined - 2

- Plant Maintenance
- Spare Parts Reductions
- Standardized Product Platform
- License Renewal and Obsolescence Issues

CLA

Power Level Increase

- Limited by Design Basis Accidents
  - Reduction in Instrumentation Uncertainties
  - Increase in the Speed of Reponse of RPS
  - Maximum Allowable Peaking (MAP) Factors
  - Addition of New Trip Functions
- Limited by other plant components

CLA

Reduced Fuel Purchases

- Maximum Allowable Peaking (MAP) Factors
- Increase in MAP Factors can also be achieved by reducing calculational uncertainties

CLA

Modifications to the Existing Trip Boundaries or Functions

- Provision of New Trip Functions
- Modifications to the Existing Trip Functions
- Modifications to the Existing Trip Boundaries

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Provision of New Trip Functions

- Reactor Coolant Pump Power Monitor
- Delta T Trip Parameter (Thot vs Tcold)
- Additional Excore Detectors

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Reactor Coolant Pump Power Monitor

- Two Pump Coast Down Fault
  - Cannot Guarantee Sensor is "Failsafe"
  - No Credit Taken for Trip Action by Pump Power Monitor
  - Second Fastest Acting Trip is Flux/Flow
  - Provide Second Sensor for Pump Failure

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Delta T Trip Parameter

- Main Steam Line Small Break Fault
  - Delta T Trip Parameter (Thot Vs Tcold)
  - Reduces Cold Water Shielding Effects

UCLA

Additional Excore Detectors

- Asymmetric Rod Faults
  - Add one more excore detector in each of the quadrants
  - trip if any two excores go high either in two different quadrants or in the same quadrant

UCLA

Modifications to the Existing Trip Functions

- Avoid Unnecessary Trip Action Following Plant Component Failure
  - Loss of One RC Pump
  -
  -

UCLA

Modifications to the Existing Trip Boundaries

- Reduction in Safety Analysis Cases
  - Trip Boundaries Determine Operating Envelope
  - Shape of Trip Boundaries Set by Analog Instrumentation Constraints
  - Safety Cases have to be run to cover Regions within the Operating Envelope even if the Regions are not entered in Normal Operation

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Plant Operator Procedures and Training

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Plant Operations

- Simpler by-Pass Action
- Voting Logic More Robust Against
  - Unnecessary Trips While Under Maintenance
  - Tech. Spec. Requirement to Shutdown
- Improved Post Trip Analysis
- Improved Monitoring of Trip Parameters

UCLA

Plant Maintenance

- Reductions in:-
  - Surveillance Testing
  - Calibration (On-Line Monitoring)
  - Retesting During Outages
  - Diagnostic Time
  - Component Failure Rates
  - Time to By-Pass Faulty Equipment

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Spare Parts Reductions

- Reduction in Inventory Holdings

UCLA

Standardized Product Platform

- Adaptable to a Wide Range of Plant Designs
- Capable of providing Enhanced Functionality (CPC)
- Capable of Expansion
- Providing Standard Interfaces to Other Equipments

UCLA

License Renewal and Obsolescence Issues

- Oconee Plants Are Good Candidates for License Renewal
- Decision on License Renewal expected soon
- Could Determine the Timing of Any Replacement Projects

UCLA

Interim Results

- Power uprating under review
- Move to 24 month fuel cycles under review
- License renewal activities on-going
- Interim results of cost benefit financial analysis on replacement of RPS at Oconee show potential payback in 2-5 years

cc:

Mr. Gary Vine
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