52-001

Memo from:
J. N. FOX
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9/16/92

Chet,

Please give a copy of this presentation to Clare Goodman. She wants this put on the docket. I guess it referenced in the FSER.

Thanks

Jack

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GE Nuclear Energy

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GE Nuclear Energy

Advanced Reactor Programs

ABWR Control Room Design

Presented to
USNRC

M. A. Ross

April 3-4, 1992

Tokyo, Japan

DISCUSSION TOPICS

- Background
  - ABWR control room design development
  - ABWR control room design
  - Design certification

- Issues
  - Key features (III)
  - Fixed inventory (II)
  - Workload and control room staffing (VI)
  - Prototype (IV)
  - DSER items (V)
  - (Japan) design process (I)

ABWR General Design Objectives

- Eliminate past problems/design issues
- Enhance public safety/plant investment protection
- Enhance plant operability, availability, and maintainability
- Improve man/machine interface
- Control/minimize costs
- Adapt state-of-the-art technologies
- Utilize proven designs

Specific "MMIS" Design Goals

- **Eliminate trips/system unavailability due to human error/single instrument channel failures**
- **Minimize burden on operator**
  - Human engineered interface
  - Reduce "manual" data processing
- **Minimize burden on maintenance staff**
  - Improve self-diagnostics/fault indication
  - Simplify servicing
  - Minimize equipment
  - Minimize spare parts inventory
- **Provide load following over 50% - 100% power**

ABWR DESIGN DEVELOPMENT

- 1978-79 Conceptual Design
  - GE - Led advanced engineering team
  - Participation by worldwide BWR manufacturers and AEs

- 1980-85 Design Development & Confirmatory Testing
  - GE/Hitachi/Toshiba joint technical effort (common engineering)

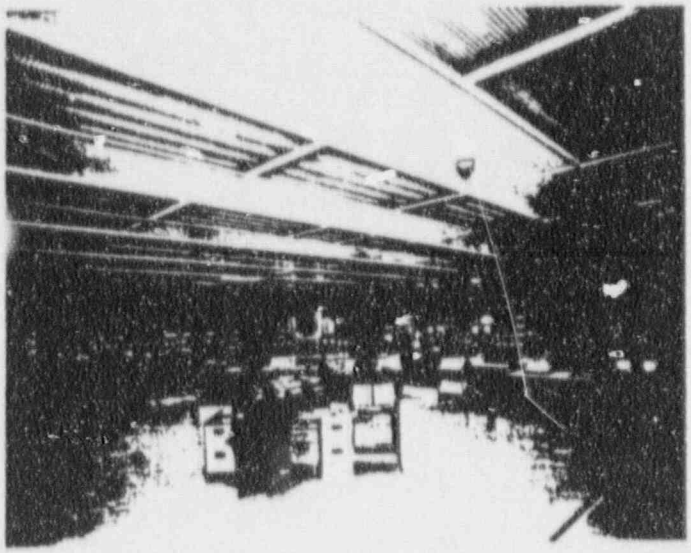
- 1986+ Lead Project(s) in Japan

ABWR STATUS

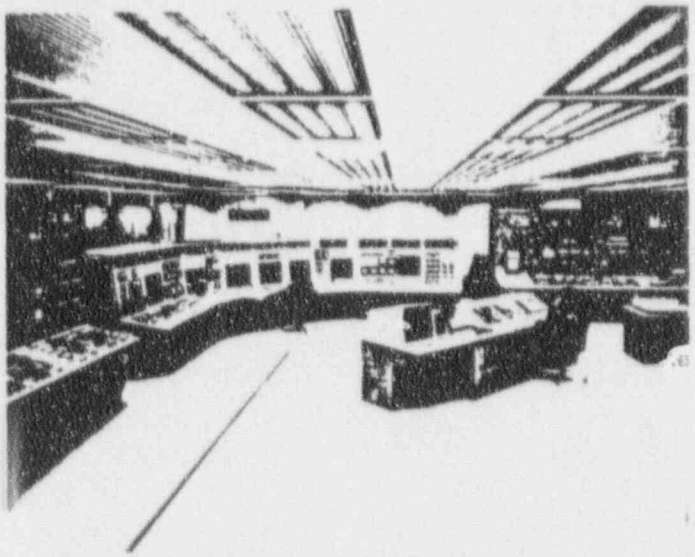
- TEPCO proceeding with lead units
  - Kashiwazaki 6 & 7 (K6/7)
  - GE/Hitachi/Toshiba joint venture
  - project schedule
    - licensing application 1988
    - K/6 commercial operation 1996
    - K/7 commercial operation 1997
- GE to supply nuclear steam supply, fuel, turbine/generators
- Hitachi/Toshiba to supply remainder of total plant
  - Toshiba to supply main control room on K/6
  - Hitachi to supply main control room on K/7
- K6/7 designs are to be the same down to level of procured equipment
  - common K6/7 designs developed through common engineering

PRE-1986 CONCEPTUAL DESIGN ACTIVITIES

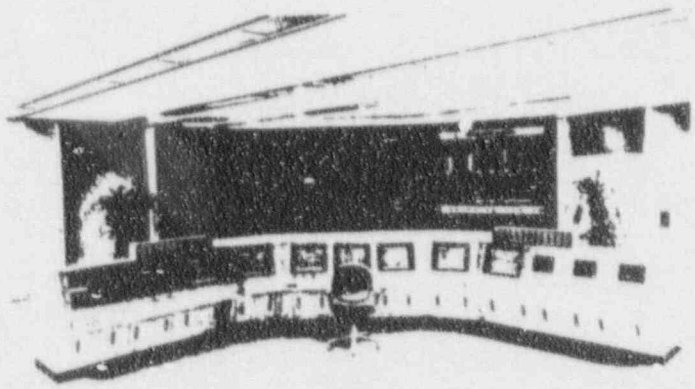
- Produced an advanced control room design concept
  - extensive plant-wide automation
  - advanced technologies for MMI
    (e.g., touch screen CRTs)
  - large overview display board



Conventional Panel



Current Panel
PODIA



Advanced Panel
A-PODIA

TOSHIBA

ABWR CONTROL COMPLEX DESIGN OBJECTIVES

- *Provide an organization and arrangement of control center modules to maximize simplicity of plant control*

- *Optimize the quantity of data, and the method of data presentation, to improve operator response time and reduce the potential for operator error*

- *Integrate operator interface functions for all interfacing systems to provide a uniformity in function and appearance*

- *Incorporate human factors criteria into all aspects of control center design*

COMMON ENGINEERING

- Development of (VISION) design process and procedures
  - industry codes, standards and guidelines
  - full scope of design and production
    - plant automation
    - software design and V&V
    - human factors
  - reflects the iterative design process necessary over the complete design and production cycle
  - incorporates customer (user) review and design inputs
    - consistent with ALWR model
- Development of common designs that are independent of vendor's equipment
  - consistent with US design certification program

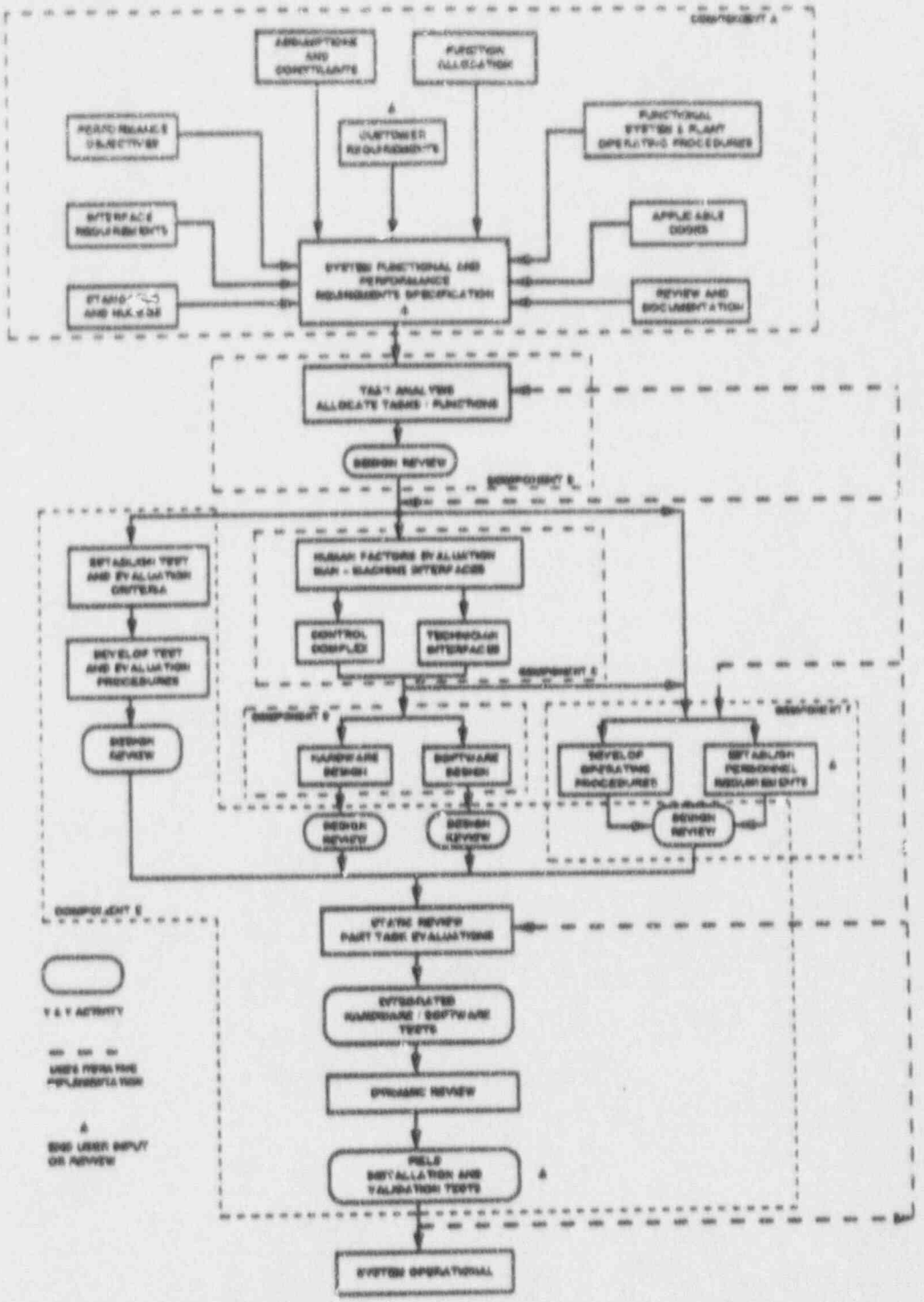
"MMIS" DESIGN AND IMPLEMENTATION PROCESS

- Comprehensive program plan

- Integrated procedures
  - System functional and performance requirements
  - Function allocation/task analysis
  - Human factors/Man-Machine interface
  - Hardware/software design
  - Verification and validation
  - O&M/personnel requirements

- Standardized design

- Design implementation
  - Utility (user) inputs
  - Equipment details



STRUCTURE FOR CONTROL & INSTRUMENTATION SYSTEM DESIGN

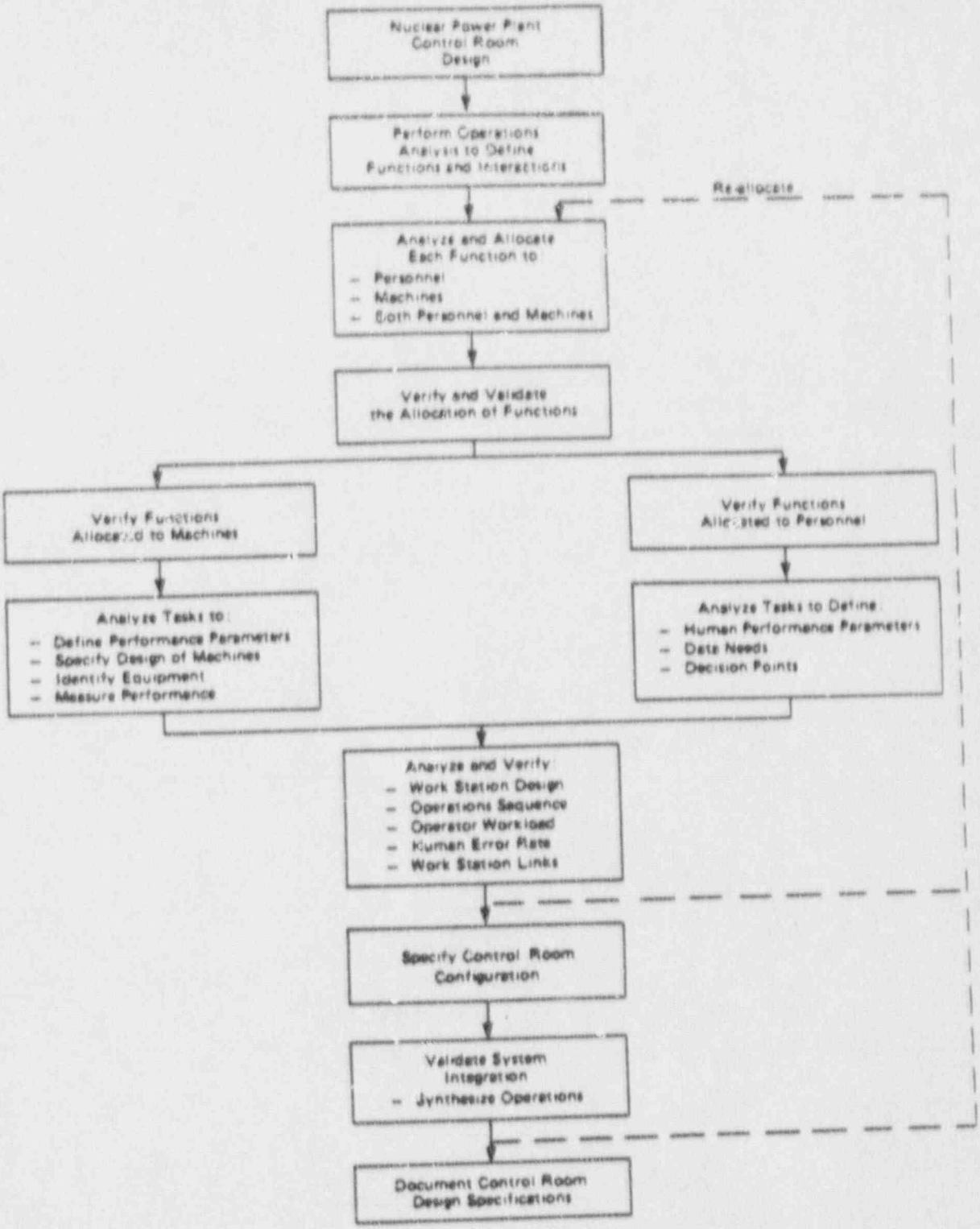
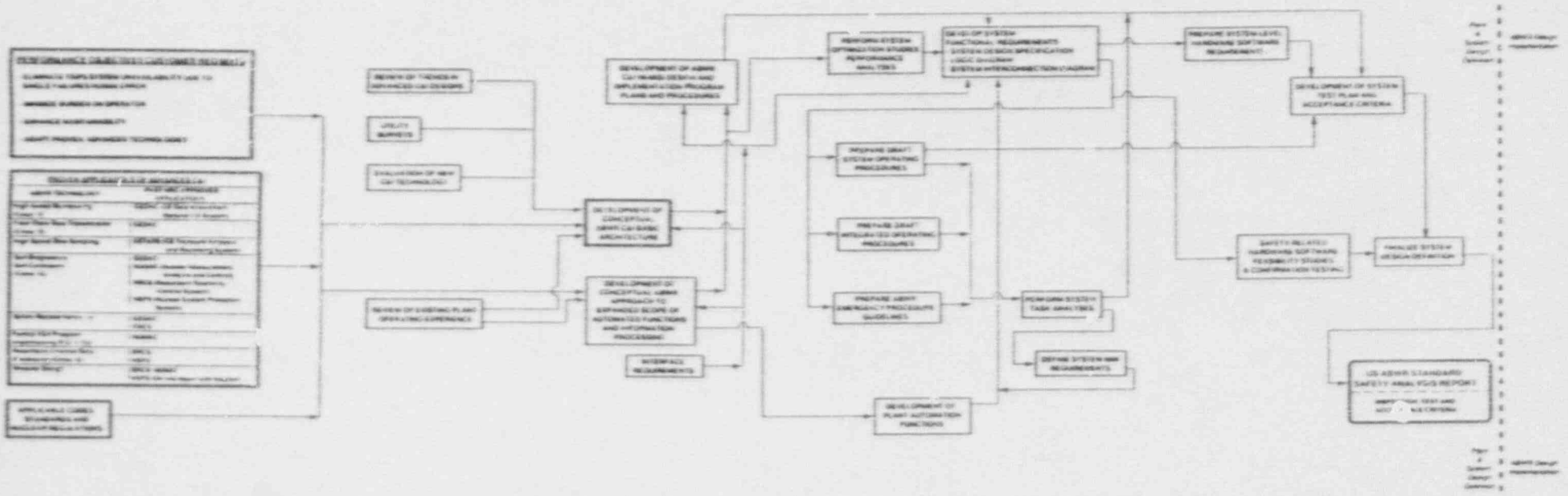
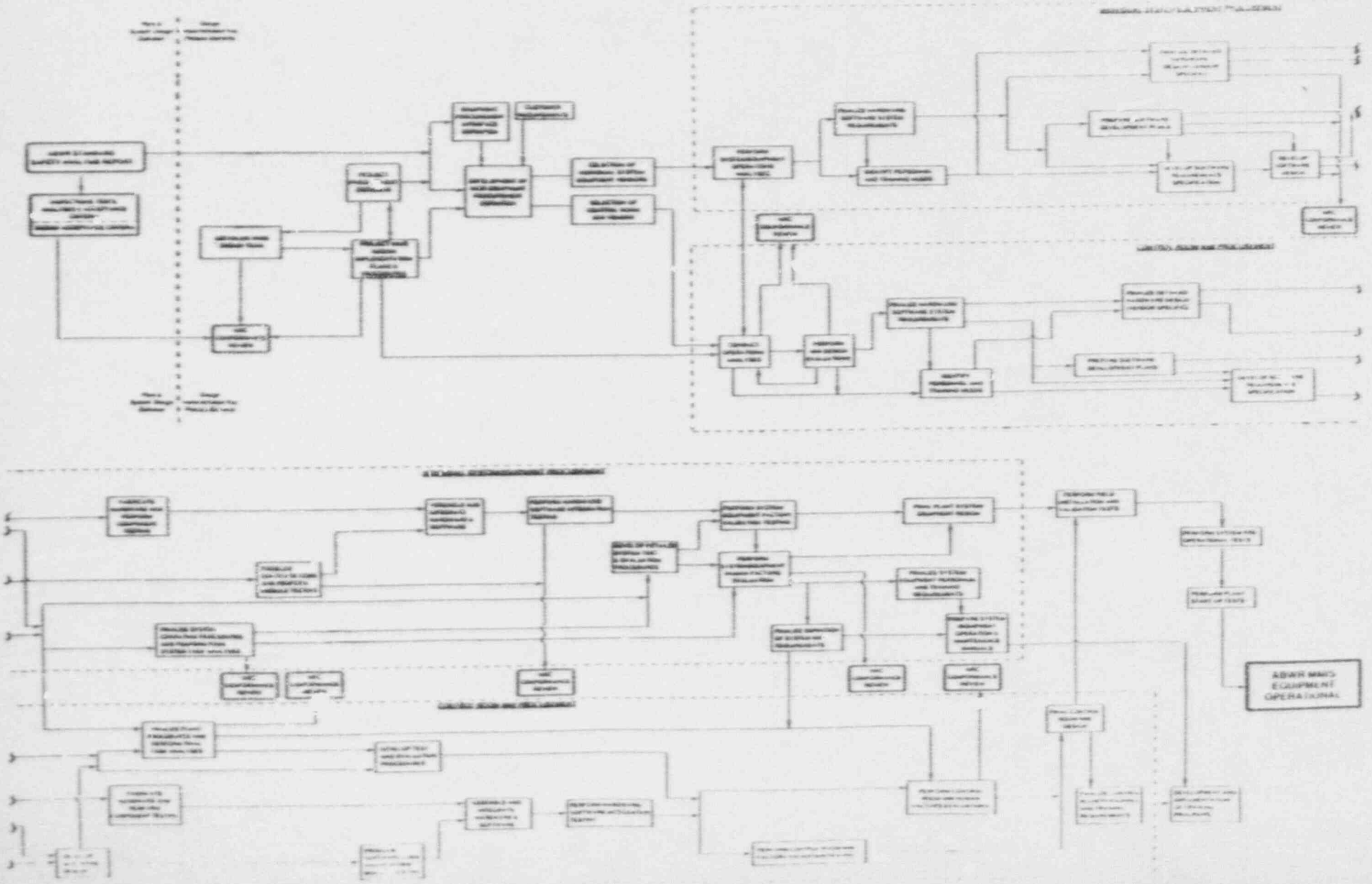


Exhibit B-1. Proposed structure for control room design.

ABWR MMIS DESIGN DEVELOPMENT



ABWR DESIGN IMPLEMENTATION PROCESS (TYPICAL)



CONTROL ROOM DESIGN R&D

- Operator interviews
- Evaluation of MMI technologies
  - Equipment performance testing
- Operator workload analyses
- Evaluation of automation scope
- Evaluated response to system upsets
- Panel mock-up and reviews
  - Team of veteran operators
- Results fed back into ABWR common engineering designs

R&D - OPERATING CREW SIZE

- Evaluation of reduced staff size
  - Control room operating crew of seven for common two-unit control room
- Adoption of "evaluation" goal for one man operation
  - (later embraced in the ALWR requirements)
- Conclusion to maintain current staffing level
  - ABWR design certification in compliance with 10CFR50.54(m)
    - two Senior Reactor Operators and two Reactor Operators
    - in agreement with ALWR requirements

R&D - CRT SCREENS

- Previous experience
  - NUCLENET, PODIA, NUCAMM
  - other industries

- Evaluation of characteristics
  - format flexibility
  - ease of access
  - space requirements
  - reliability

R&D - LARGE SCREEN DEVICES

- Technologies
  - large video screen projectors
  - light emitting devices
  - flat displays (e.g., liquid crystal, plasma)
- Evaluation of characteristics
  - brightness
  - contrast
  - legibility
  - resolution
  - colors
  - visibility throughout the control room
  - speed

R&D - ALARM SYSTEMS

- Operator saturation
- Alarm suppression
- Alarm hierarchization
- Alternate presentation methods and media
- Elimination of unneeded alarms

R&D - MAIN CONSOLE DESIGN

- Number of operators at consc'e
- Operator workload
- Information presentation media
- Quantity of information presented to operator(s)
- Emergency operations

R&D - FLAT PANEL DISPLAY DEVICES

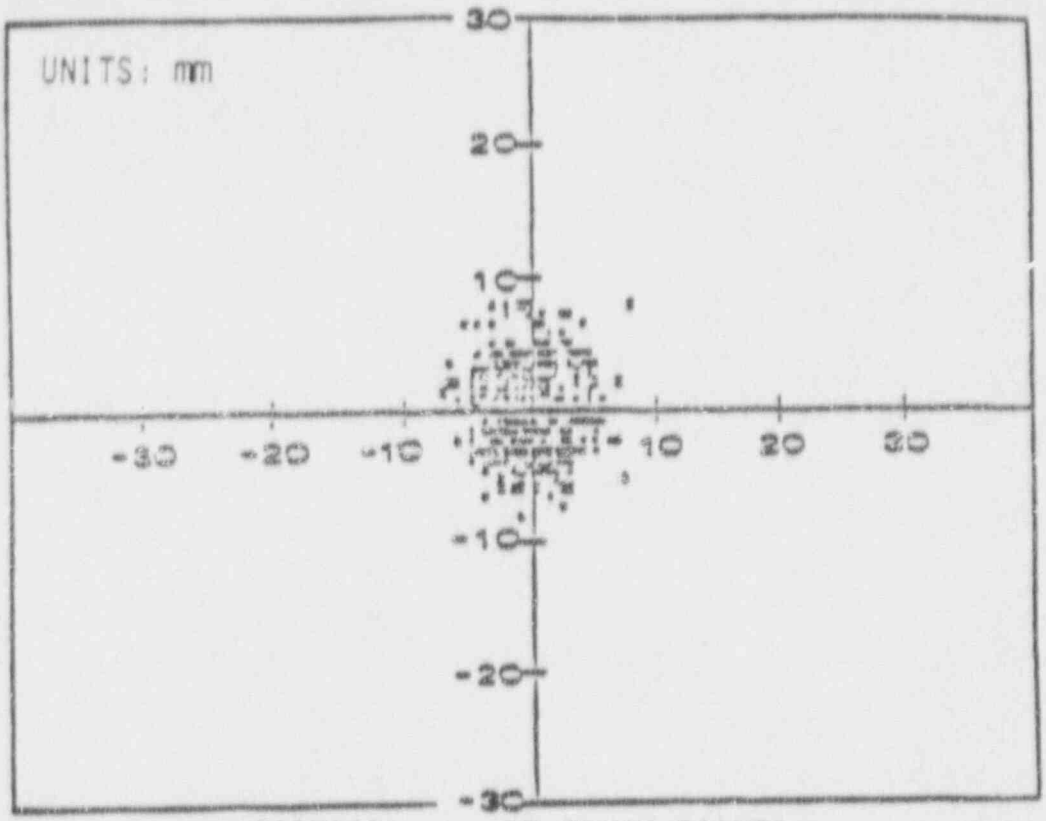
- Technologies
  - electroluminescence
  - plasma
  - liquid crystal

- Evaluation of characteristics
  - legibility
  - brightness
  - color capability
  - contrast
  - reliability

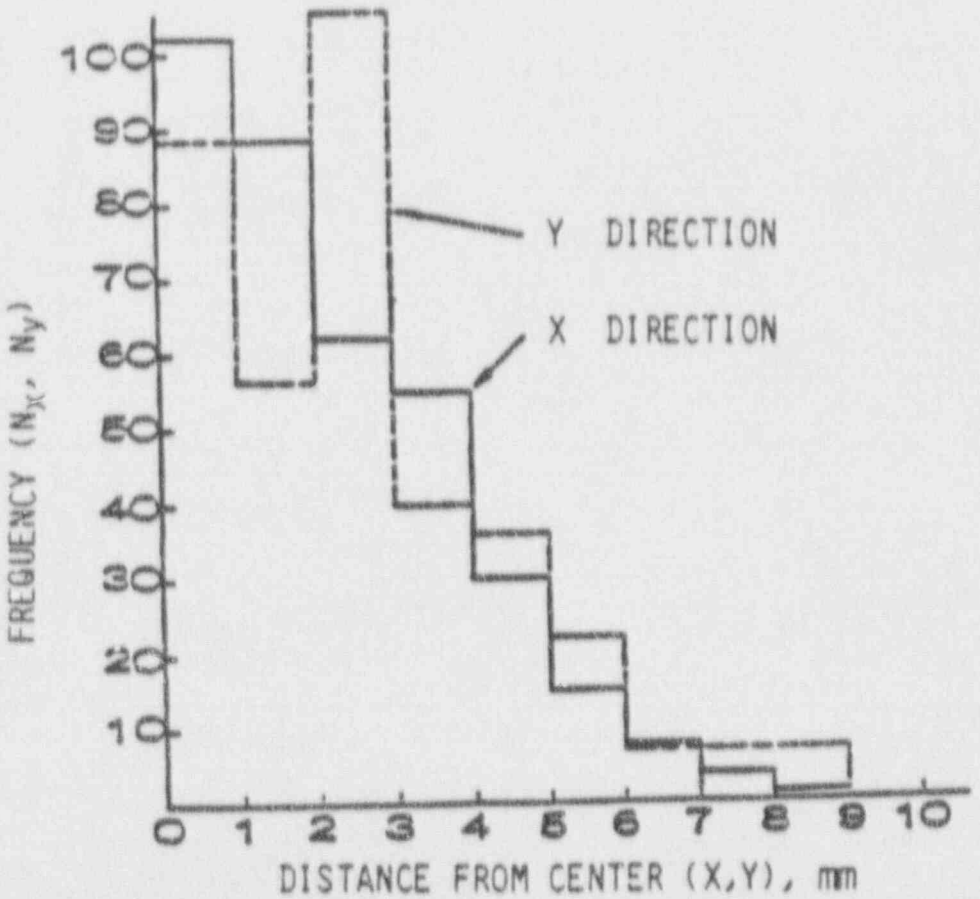
R&D - INPUTTING DEVICES

- Scope
  - touchscreen
  - track ball
  - mouse

- Characteristics
  - location precision
  - durability
  - reliability
  - interaction speed
  - space requirements
  - screen legibility



DISTRIBU OF TOUCH POINTS



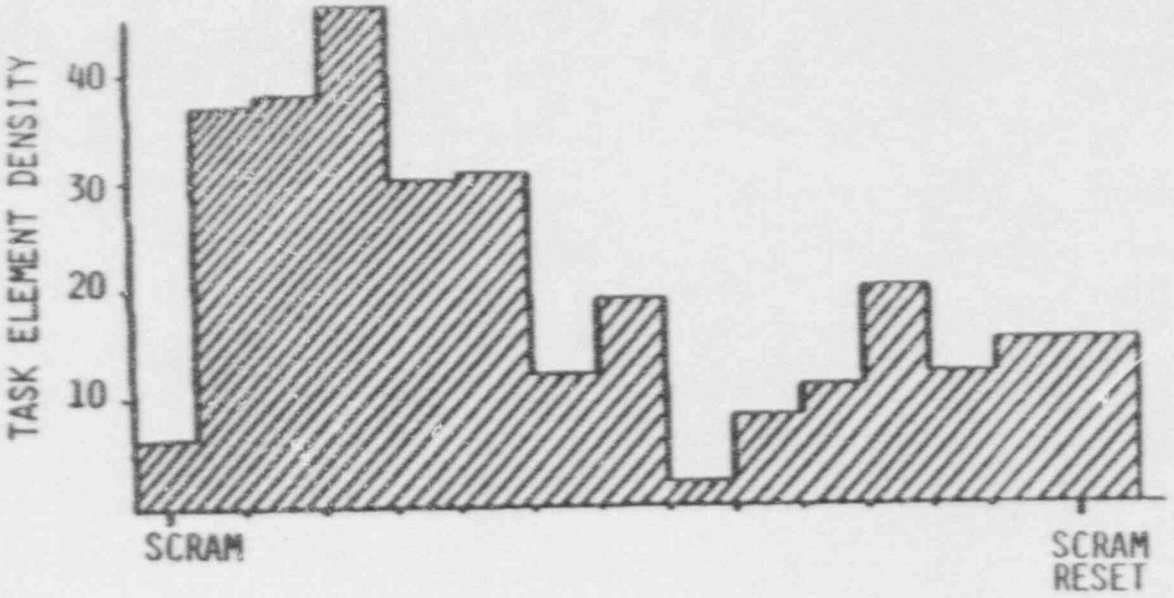
R&D - SYSTEM CONFIGURATION

- Computer system
  - performance and reliability
- Operator assistance functions
- Control panel arrangements
  - large display
- Control panel layouts
- Operation with equipment outage
- Maintenance operations

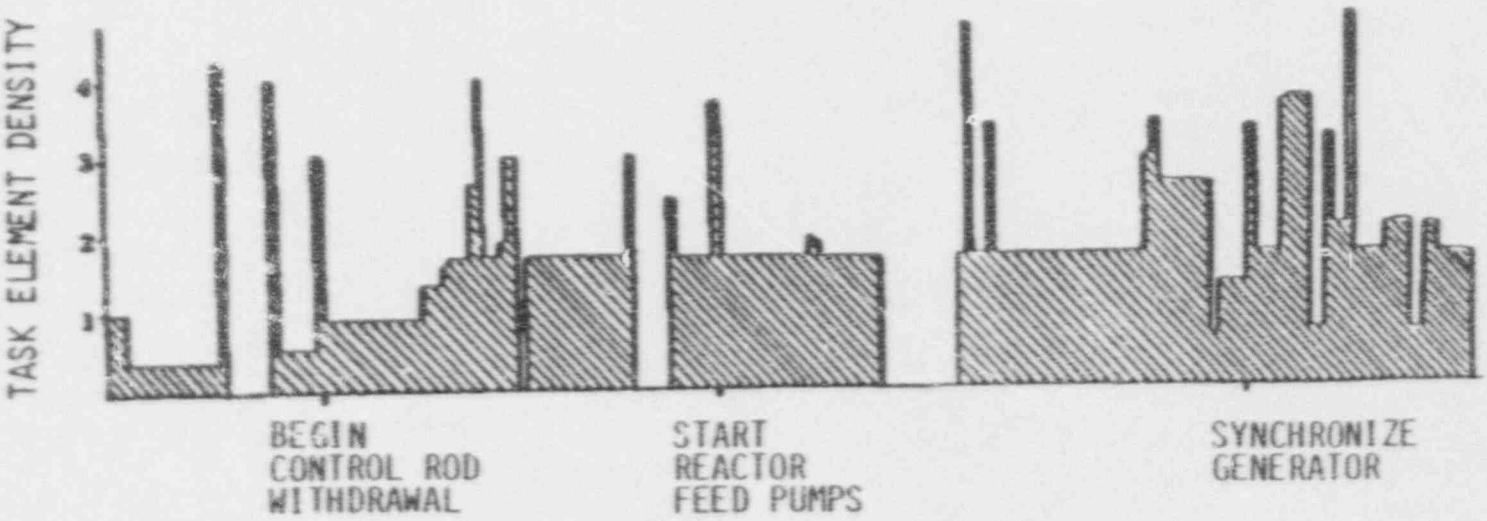
R&D - AUTOMATED PLANT OPERATIONS

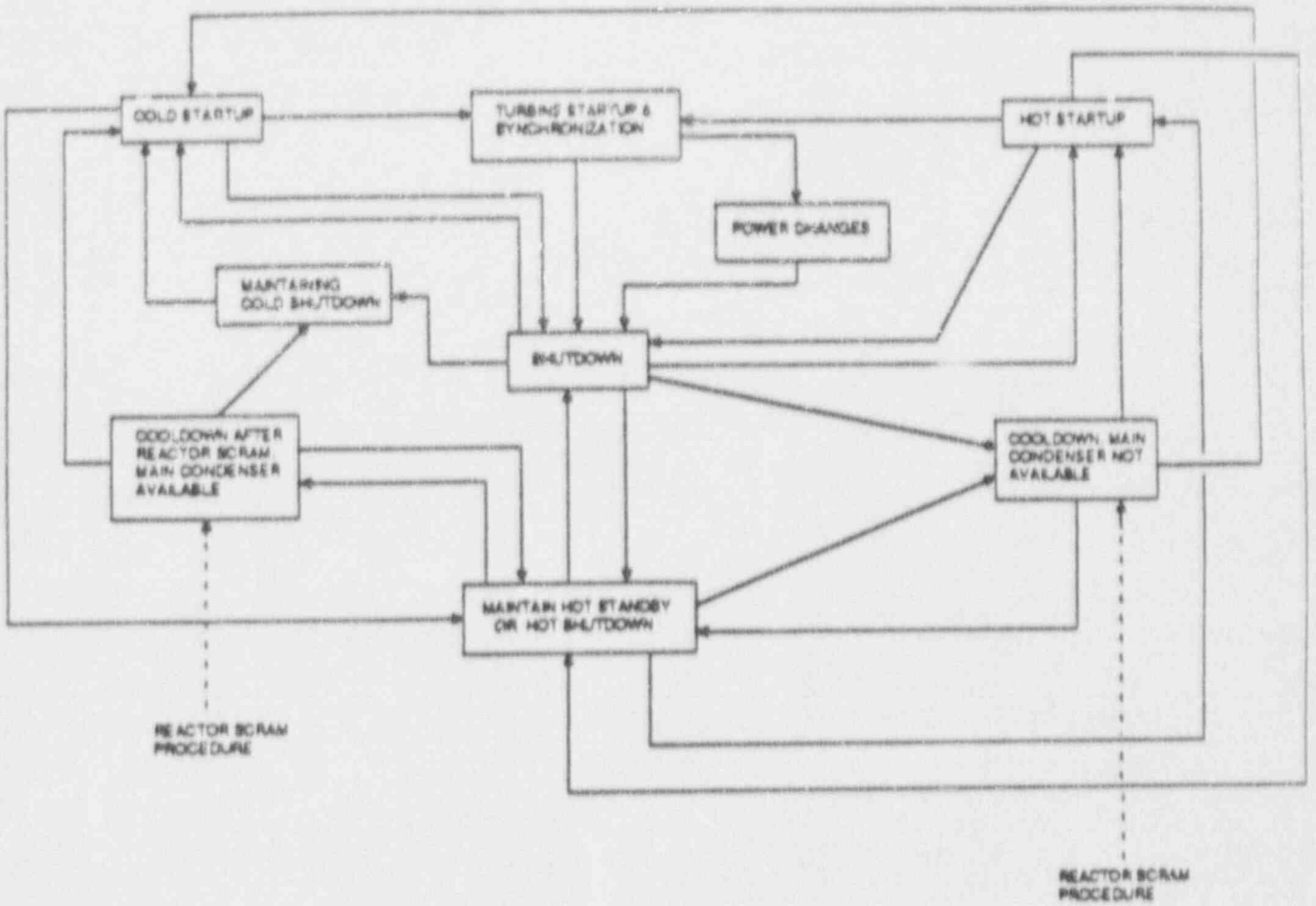
- Operator workload analysis
- Operator fatigue
- Specd and reliability of automated systems
- Scope of automated operations
- Modes of automated operation
- Automated system response to equipment failures
- Automated system response to abnormal plant events

PLANT TRIP



PLANT STARTUP





INTEGRATED OPERATING PROCEDURES

OPERATING PROCEDURES

1. Symptomatic Emergency Operating Procedure Guidelines
   MPL A80-3010, 23A6146

2. Plant Integrated Operating Procedures. MPL A80-3020

   1. Approach to Criticality (23A6169AA)
   2. Heatup and Pressurization (23A6169AB)
   3. Turbine Startup and Generator Synchronization (23A6169AC)
   4. Power Ascension and Power Changes (23A6169AD)
   5. Unit Shutdown to Unit Off-Line, Main Condenser Available (23A6169AE)
   6. Cooldown to Cold Shutdown, Main Condenser Available (23A6169AF)
   7. Cooldown to Cold Shutdown, Main Condenser Not Available (23A6169AG)
   8. Unit Off-Line to Hot Standby or Hot Shutdown (23A6169AH)
   9. Maintaining Hot Standby or Hot Shutdown (23A6169AJ)
   10. Unit On-Line from Hot Standby or Hot Shutdown (23A6169AK)

3. NSS System Operating Procedures, MPL A80-3030

   1. Nuclear Boiler System (23A6179AA)
   2. Reactor Recirculation and Flow Control System (23A6179AB)
   3. Rod Control and Information System (23A6179AC)
   4. Control Rod Drive System (23A6179AD)
   5. Feedwater Control System (23A6179AE)
   6. Standby Liquid Control System (23A6179AF)
   7. Neutron Monitoring System (23A6179AG)
   8. Reactor Protection System (23A6179AH)
   9. Steam Bypass and Pressure Control System (23A6179AJ)
   10. Residual Heat Removal System (23A6179AK)
   11. High Pressure Core Flooder System (23A6179AL)
   12. Reactor Core Isolation Cooling System (23A6179AM)
   13. Leak Detection and Isolation System (23A6179AN)
   14. Reactor Water Cleanup System (23A6179AP)
   15. Fuel Pool Cooling System (23A6179AR)
   16. Suppression Pool Cleanup System (23A6179AS)

Automation Design Approach

- **Operating procedures developed and task analyses performed**
  - Based entirely upon manual operation
- **Operator workload evaluations conducted**
  - Candidate items for automation identified
- **System level sequence master control functions developed**
- **Simple safety system operations not automated**
- **Tedious or repetitive operations provided with new automated functions**
  - Automated control rod operation
  - Automated load following
- **Breakpoint control logic incorporated**
  - Assures that operator remains cognizant and in control

Comparison Table of Automatic Operation

	Major Operation		1F Type Central Control Board	2F-3/4 Type Central Control Board	ABWR Type Central Control Board
Start-up	Reactor System	Switching of mode SW	M	OG + M	OG + M
		Low pressure feed water system standby mode	M	OG + M	OG + A(S)
		Reactor de-aeration	M	OG + M	OG + A(S)
		Pulling-out of control rod	M	M	A(F)
		Switching of IRM range	M	M	
	Turbine System	Start-up gland seal system	M	OG + M	OG + A(S)
		Start-up of air extractor of steam type in off-gas system	M	OG + M	OG + A(S)
		Start-up of feedwater and condenser pump	R	OG + M	OG + A(S)
		Switching of reactor feedwater pump	M	A(F)	A(F)
	Main Turbine	Warning of control valve	M	A(F)	A(F)
		Increase of pressure setpoint	M	A(F)	A(F)
	Main Generator	Increase of turbine speed	M	A(F)	A(F)
		Increase of load setting	M	A(F)	A(F)
		Generator synchronization	M	A(F)	A(F)
Surveillance Test	Emergency core cooling system		M	OG + M	OG + M
	Safety and protection system		M	OG + M	OG + M
	Turbine system		M	OG + M	OG + M
Immediately After Scram	Switching of mode switch		M	M	M
	Turbine trip		M	M	A(I)
	Turbine-driven reactor feedwater pump trip		M	M	A(I)
	Mode switching of air extractor of steam type		M	M	A(S)
	Switching of gland seal steam		M	M	A(S)
	Switching from 3 elements to a single element		M	M	A(I)
At the Time of Accident	Scram and start-up of emergency core cooling system by safety and protection system		A(I)	A(I)	A(I)
	Start-up and stopping of emergency core cooling system		A(S)	A(S)	A(S)
	Mode switching of residual heat removing system		M	M	A(S)
	Start-up of boric acid solution injection system		A(S)	A(S)	A(S)
	Stopping of emergency gas processing system		M	M	A(S)
	Opening of main steam isolation valve		M	M	A(S)

M : Manual: Each equipment is to be operated manually.

A(S): Sequential automatic operation: A series of operation of fixed pattern is interlocked sequentially by mode SW (manual).

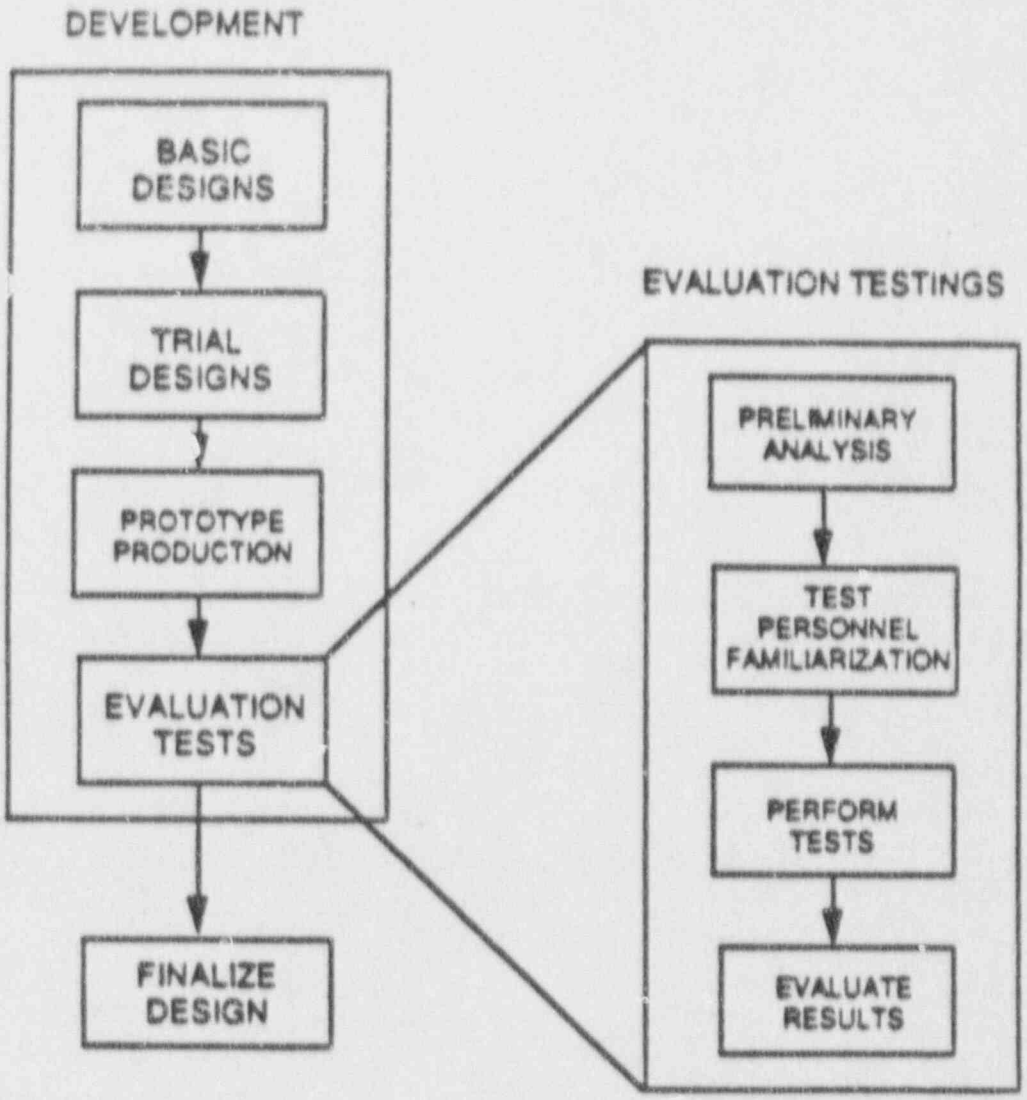
A(F): Feed-back automatic operation: After receiving the manual start-up command, the control equipment makes automatic control, which judging individual operational timing for speed change due to continuous change of the setting value.

A(I): Interlock automatic operation: Action predetermined by interlock in single action in principle is automatically carried out, once certain conditions are satisfied.

OG : Operation guide: Process computer judges operational timing and operation permitting conditions and makes CRT display of the operational message.

R&D - PROTOTYPE TESTING

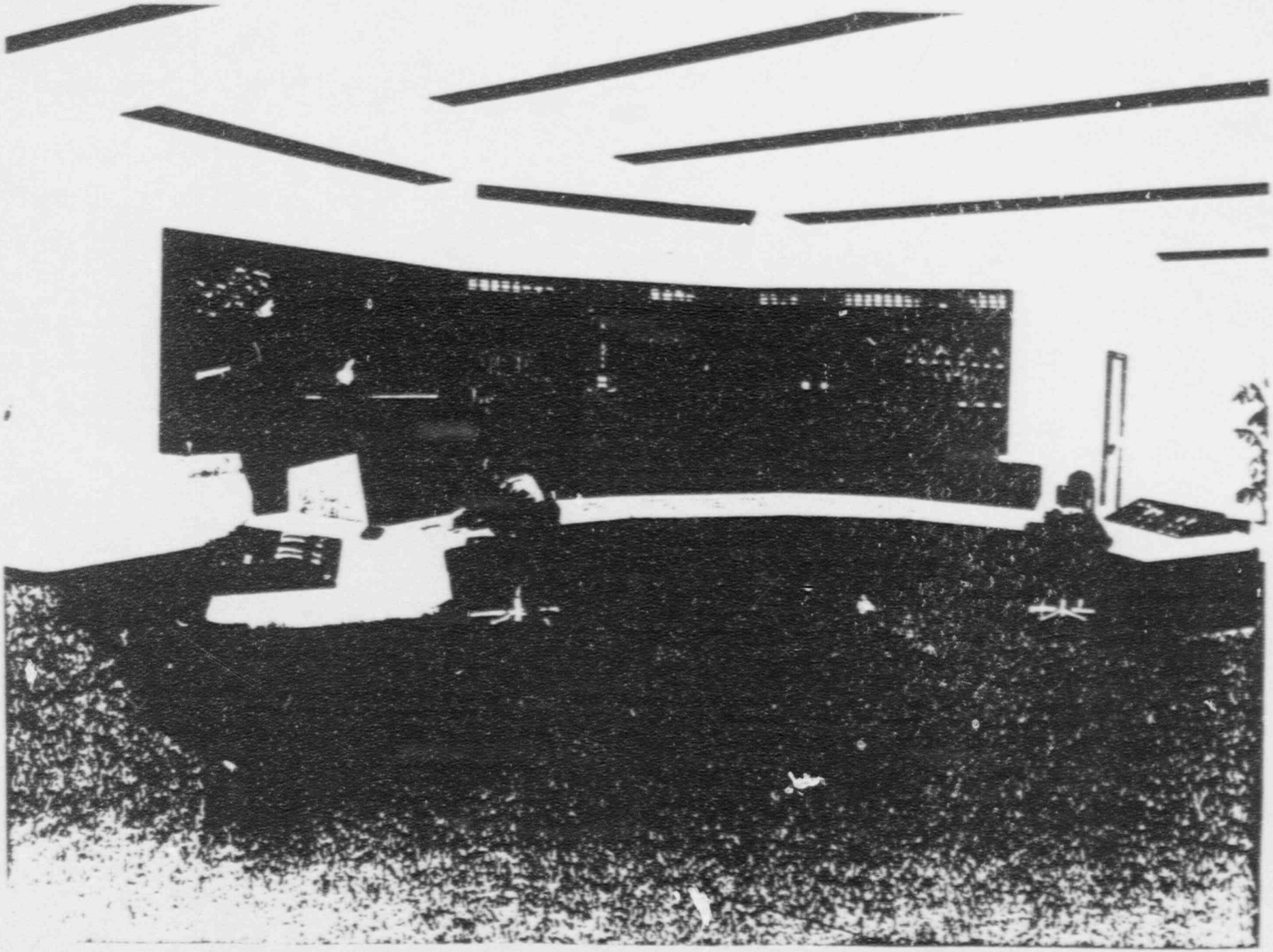
- Tests conducted with Utility Operator
  - Human Factors Reviews and Dynamic Tests
- Test Sequences
  - Reactor criticality, cold and hot plant startups
  - Reactor heatups and pressurization
  - Power adjustment to support drywell inspection
  - Turbine startup and synchronization
  - Condensate/Feedwater System Alignment
  - Power ascension
  - Generator trip/turbine trip
  - Reactor isolation
  - LOCA
  - Feedwater pump trip/recirculation pump trip
  - Station blackout
  - Loss of automated operating mode
  - Loss of process computer

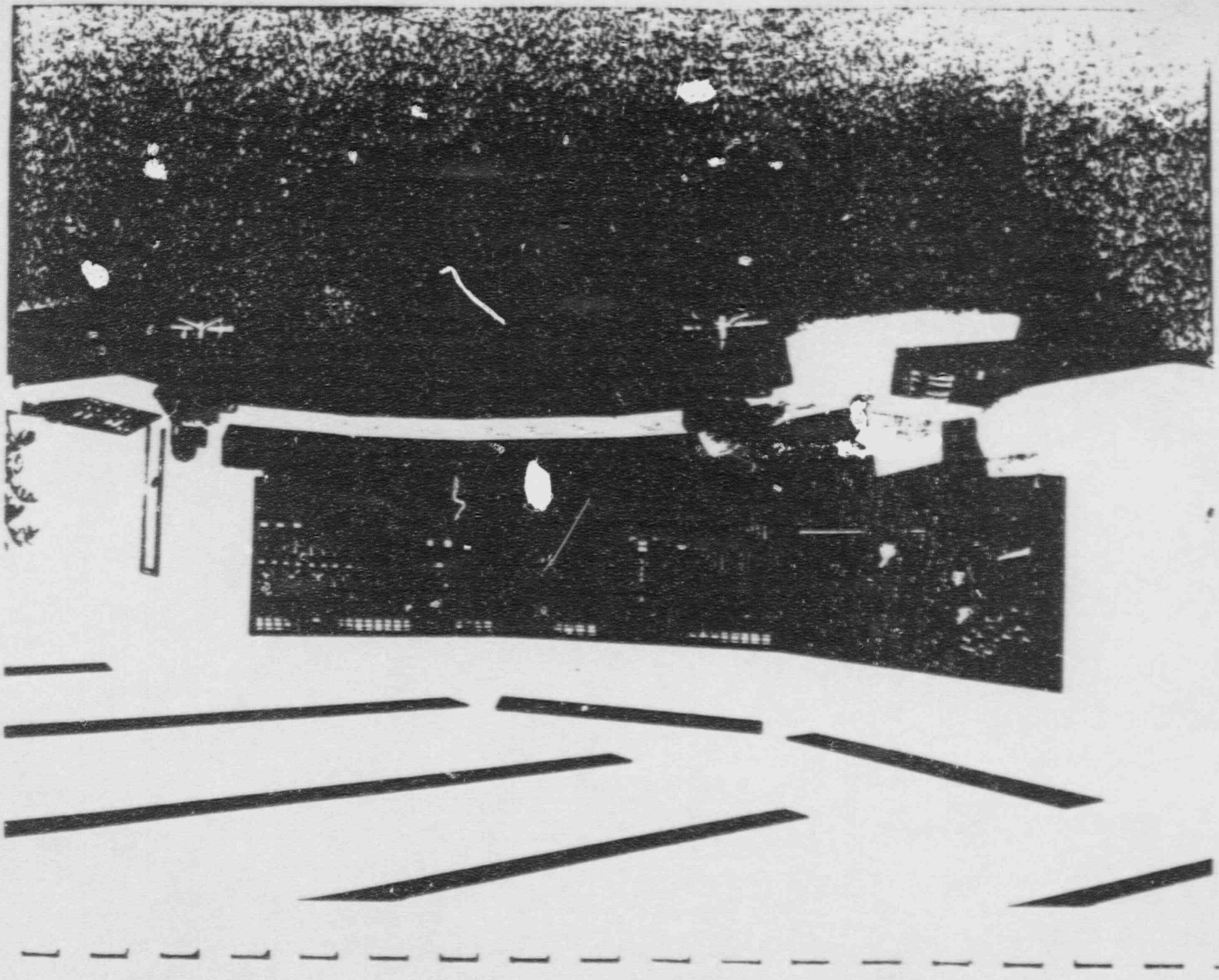

DEVELOPMENT
BASIC DESIGNS
TRIAL DESIGNS
PROTOTYPE PRODUCTION
EVALUATION TESTS
FINALIZE DESIGN
EVALUATION TESTINGS
PRELIMINARY ANALYSIS
TEST PERSONNEL FAMILIARIZATION
PERFORM TESTS
EVALUATE RESULTS

CKT-47
3/6/90

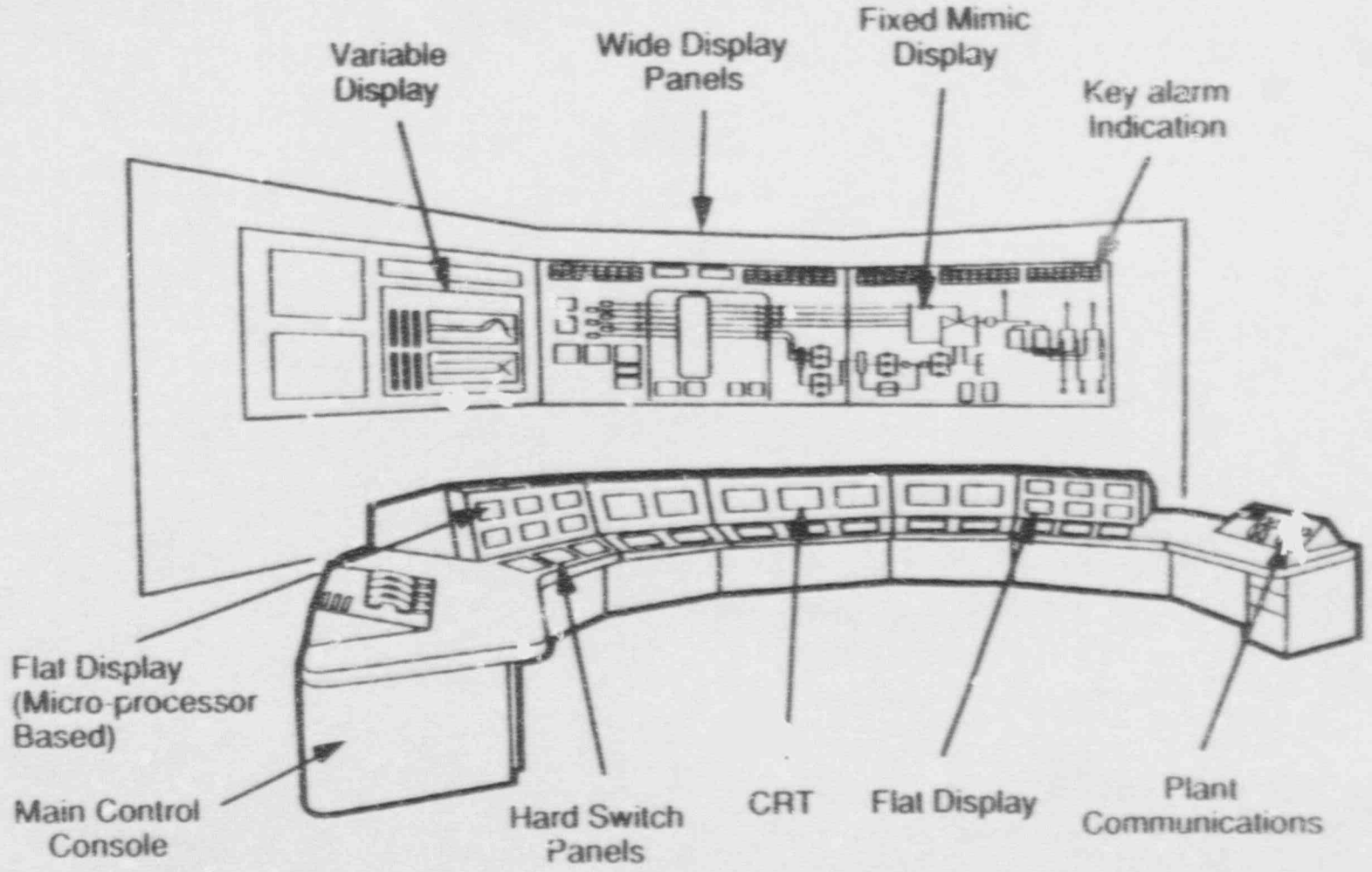
Control Room Configuration

- **Main control console**
  - Primary operator interface
- **Wide display panel**
  - Plant summary status
- **Supervisors console**
  - Monitoring
- **Plant I&C architecture**
  - Multiple levels of redundancy
  - Diversity in operator interface

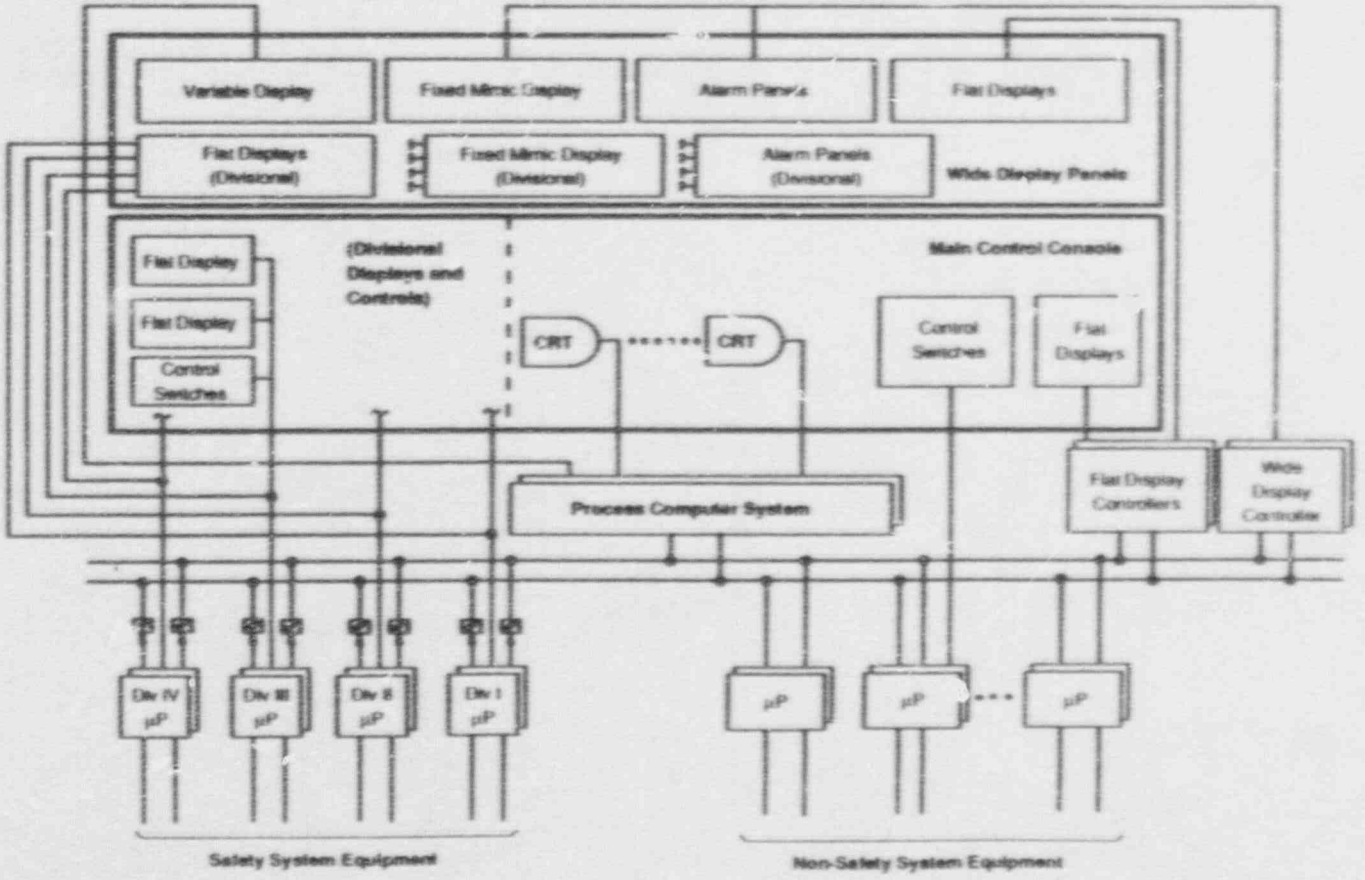




Key Features of ABWR Control Room Design



Configuration of Operator Interface System



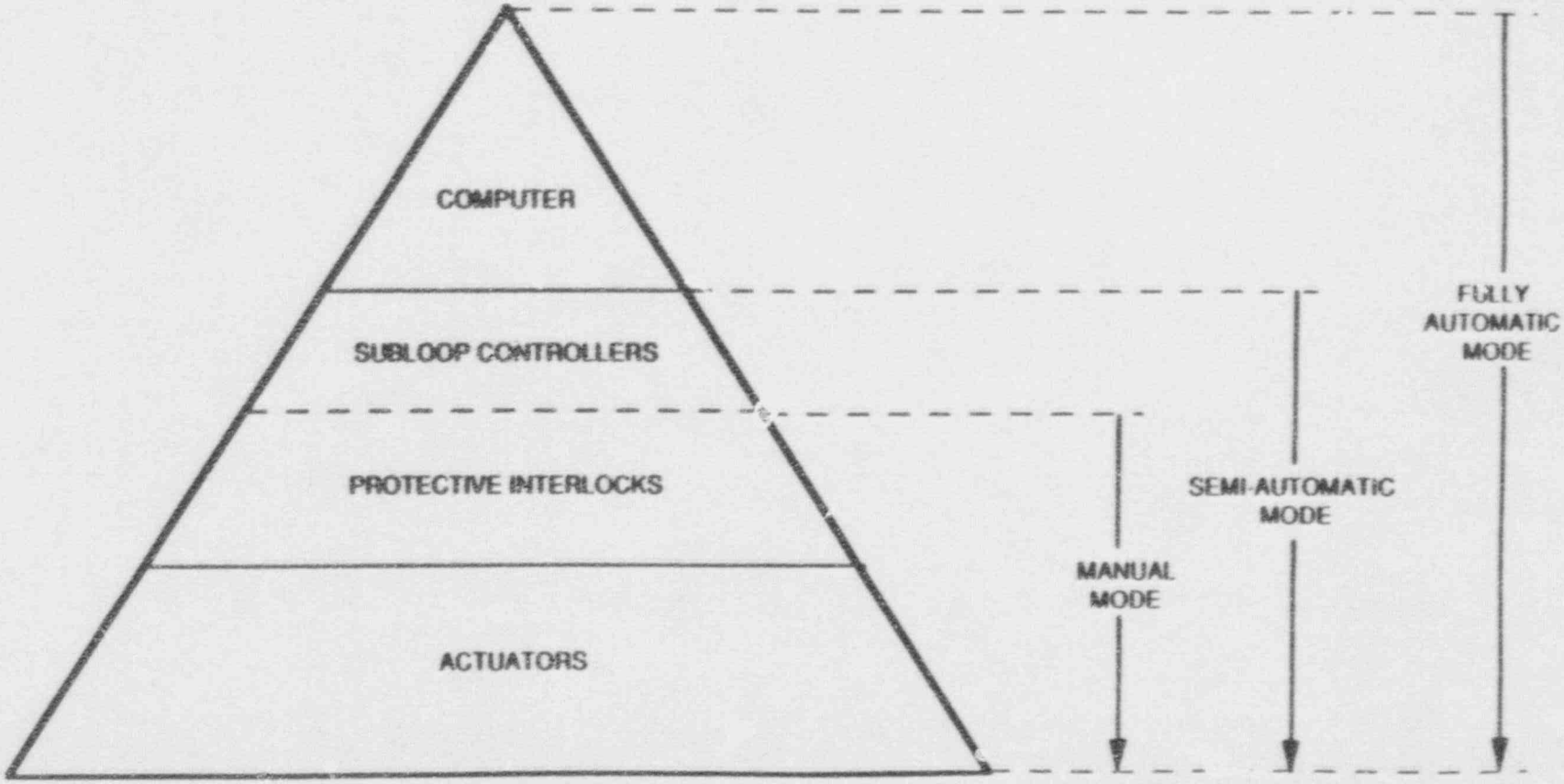
Implementation of Automated Operations

- **Top level "power generation control system" (PGCS) function implemented in process computer system**
  - Based upon proven PGCS design in recent Japanese BWR plants
- **Automatic mode**
  - PGCS performs plant operations
  - PGCS sends mode change commands and setpoint changes to system controllers
  - PGCS provides prompts when operator action required
  - Operator controls status of safety system
  - Operator monitors and controls continued progression of automation operations
- **Semi-automatic mode**
  - PGCS monitors plant operations and provides guidance
- **Manual mode**

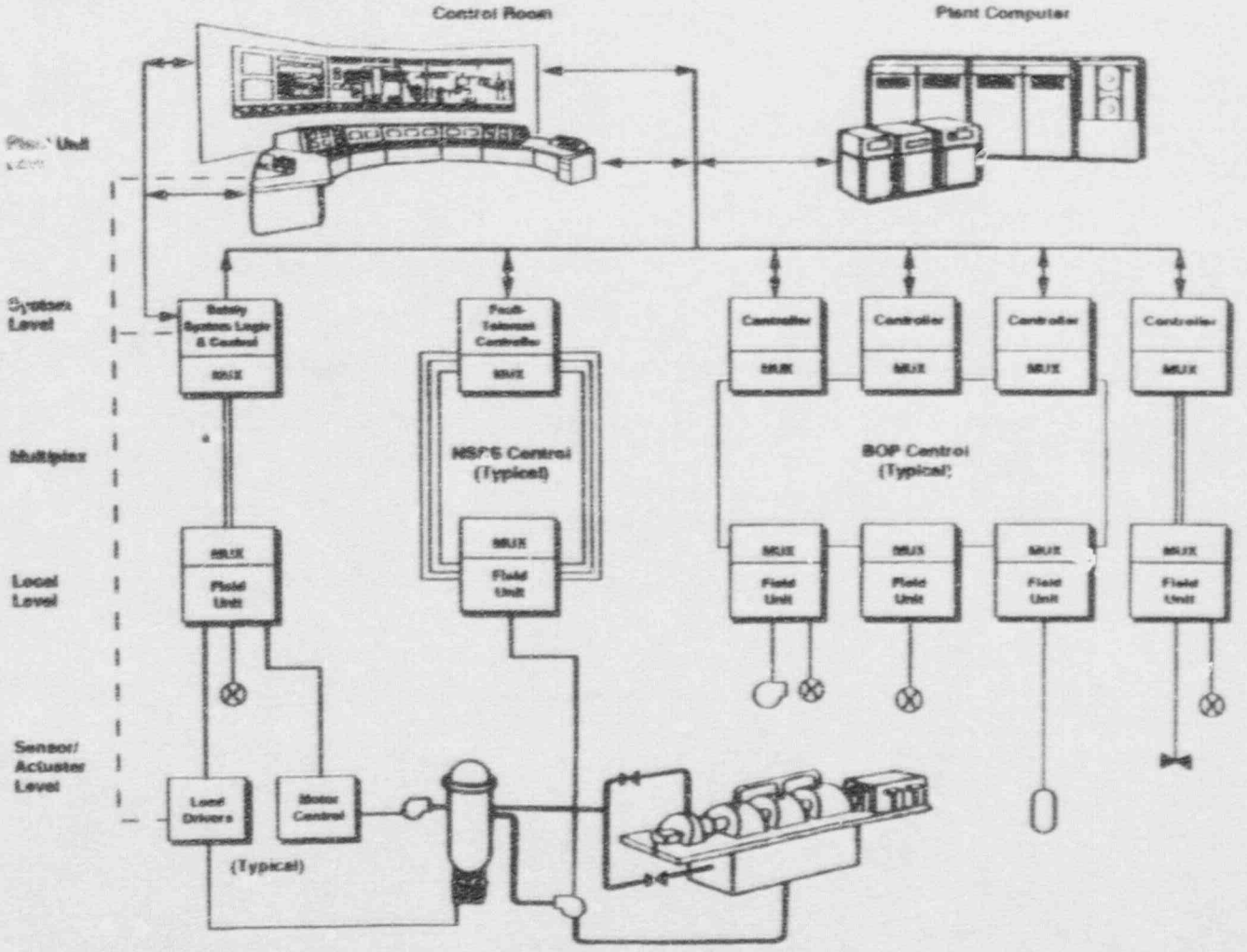
Plant Automation Operation

- **Operator can start/stop automated operation at anytime**
- **Operation automatically reverts to manual mode in event of major plant upset (e.g., scram)**
  - Selected routine post-scram operations are automated at the system level to reduce operator burden
- **Individual systems monitor operational status of the plant automation (PGCS) function and revert to manual if failure detected**

BASIC CONFIGURATION OF PLANT AUTOMATION SYSTEMS



ABWR Plant Data Communications

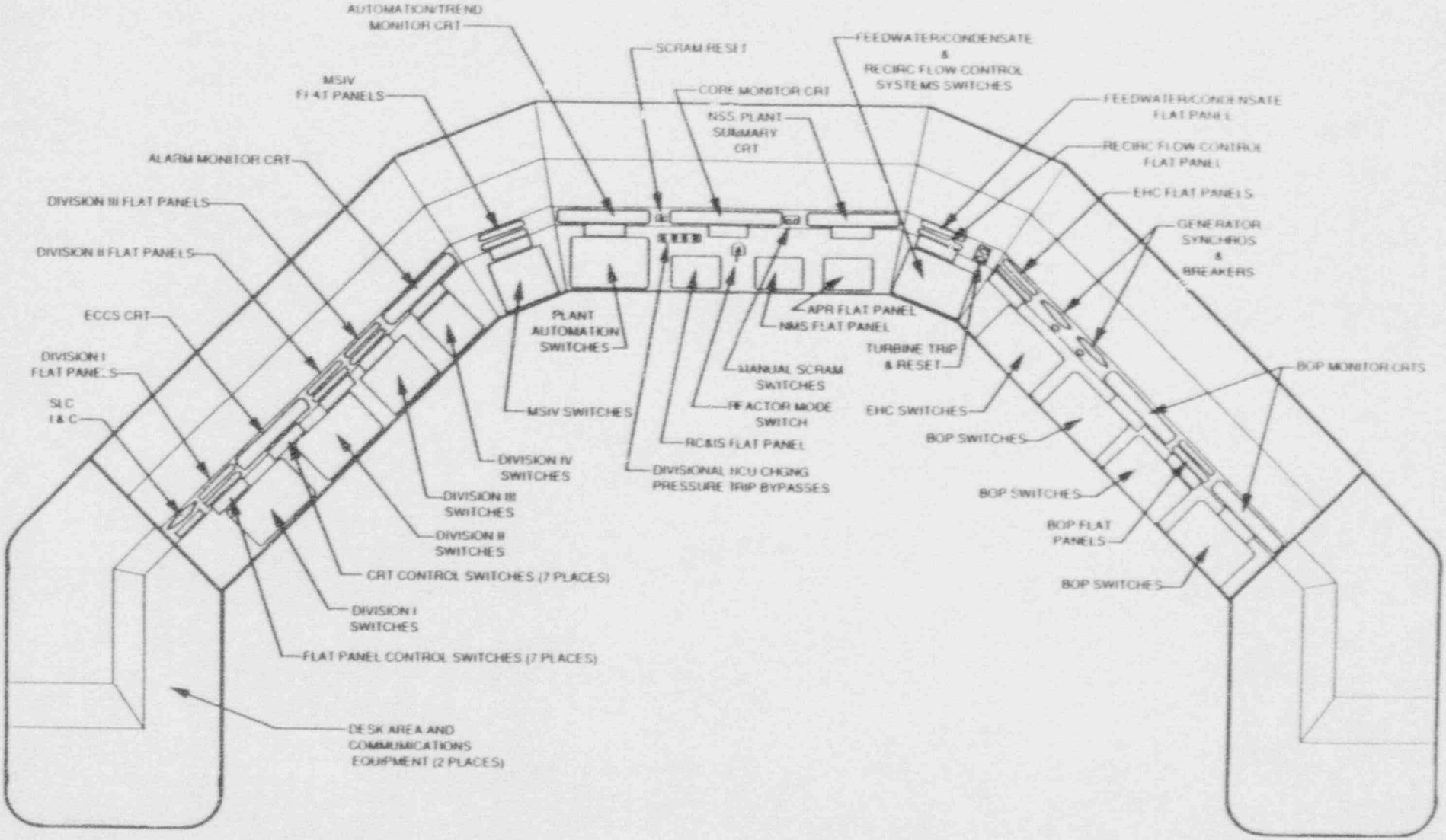


* Represents one of four safety divisions
– Indicates conventional hardwired cables

MCH 911628 7

Main Control Console

- **Compact low profile configuration**
- **Operator seated while performing all functions**
- **Basic arrangement**
  - Normal plant functions performed in central area of console
  - Safety related (NSS) functions on left wing
  - BOP functions on right wing
- **Color-graphic CRTs provide a primary operator interface**
  - Touch screens provide direct control of nonsafety equipment
  - Any display may be selected on any CRT
  - Driven by redundant process computer system



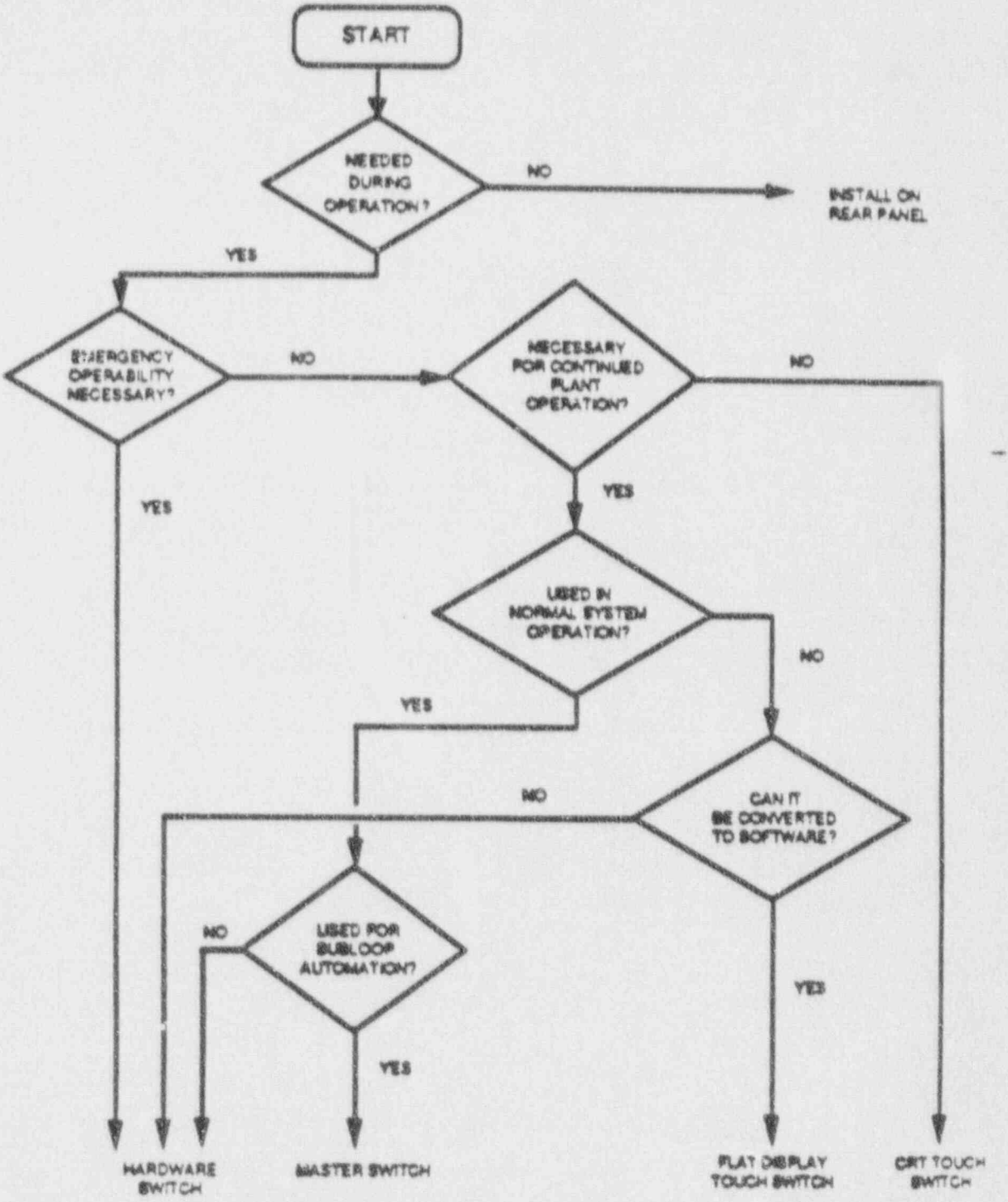
Arrangement of Equipment on Main Control Console

Main Control Console (con't)

- **Flat display devices**
- **Display controllers independent of process computer**
- **Touch control capability**
  - Applied to both safety and nonsafety systems
  - Safety system equipment qualified Class IE
  - Three divisions of ABWR safety systems have two flat displays per division
- **Hard switch panels**
  - Facilitate faster access
  - System sequence master control functions
  - Reactor mode switch
  - Manual scram

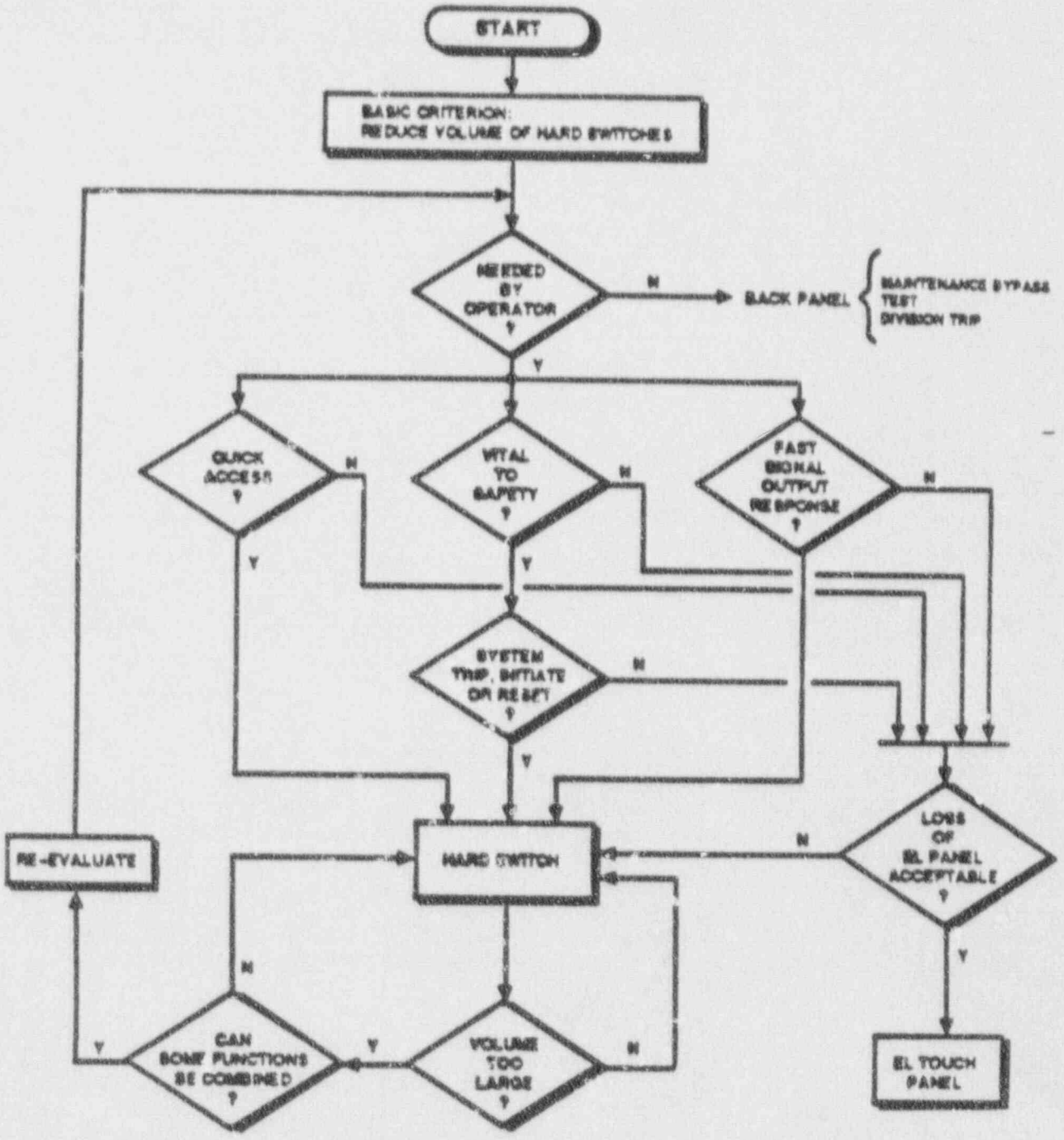
ALLOCATION OF FUNCTIONS MONITORING AND CONTROLS

Control and Monitoring Functions	Allotment of Functions
Hardwired switches	• Manual starting and resetting of safety systems, • Automation console, • Manual starting of emergency backups, • Master switches for subloop automation.
Flat displays with touch controls	• Individual controls of safety system components, • Lineup display of normal systems, • Lineup displays of safety systems.
CRTs with touch controls	• Monitoring of normal systems, individual controls of components, • Individual alarms, • Automation, • Lineup display of safety systems and surveillance guidance.
Dedicated annunciators	• System–level annunciator displays.
Wide Screen panels	• Fixed mimic for monitoring of plant safety status, • Variable display for plant performance summary, • Fixed alarm windows for important alarms



SELECTION OF MAN-MACHINE INTERFACES OF CONTROL FUNCTIONS

CKT-27
3/6/90



SELECTION CRITERIA FOR ASSIGNMENT
OF SAFETY-RELATED SWITCHES TO
OPERATOR CONTROL CONSOLE

CKT-28
3/6/90

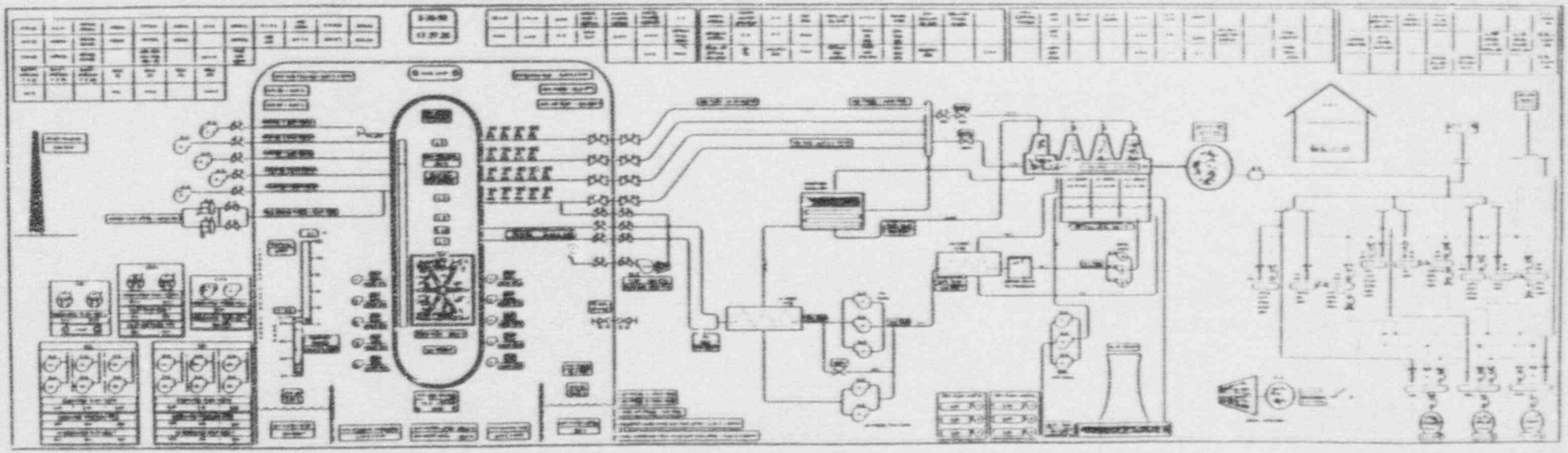
LARGE DISPLAY PANEL - FEATURES

- *Fixed mimic of key plant parameters*
  - *seismically qualified*
  - *dedicated display controllers*
  - *system status*
  - *safety parameter display system (SPDS)*
  - *post accident monitoring (PAM) variables*
  - *power generation summary*

- *Variable display screen*
  - *process computer driven*

- *Fixed position alarm displays*
  - *plant level alarms*
  - *system level alarms*

ABWR FIXED-POSITION DISPLAY



ALARM SYSTEM

- *Top-level alarms fixed position displays*
- *System-level alarms fixed position displays*
- *Subordinate alarms displayed on VDUs*
- *Alarm suppression*
  - *Mode dependent*
  - *Consequential*
  - *Redundant*

ABWR TOP-LEVEL ALARM DISPLAY

VARIABLE FIRST EVENT DISPLAY

NEUTRON FLUX HIGH-HIGH	PERIOD SHORT-SHORT	REACTOR PRESSURE HIGH-HIGH	DRYWELL PRESSURE HIGH-HIGH
RAPID DECREASE OF CORE FLOW	C R CHARGING WATER PRESSURE LOW	M S I V CLOSURE	RAPID CLOSURE OF CV
S/P TEMP HIGH	DRYWELL TEMP HIGH	RCIC TURBINE SPEED LOW	MAIN STEAM LINE RADIO-ACTIVITY HIGH
CONDENSOR VACUUM LOW	MAIN STEAM LINE FLOW HIGH	MAIN STEAM LINE PRESSURE LOW	MS LINE AREA TEMPERAT-URE HIGH
R/B RADIO-ACTIVITY HIGH	R F L RADIO-ACTIVITY HIGH		NEUTRON FLUX HIGH
PERIOD SHORT	SLC TANK WATER LEVEL LOW	AREA HVAC DELTA T HIGH	R W EFFLUENT RADIO-ACTIVITY HIGH

SCRI ACTUATED	S R VALVES OPENED		ARI ACTUATED
R P T ACTUATED	RAPID CORE FLOW DECREASE	REACTOR PRESSURE HIGH	DRYWELL PRESSURE HIGH
	SECONDARY CNTMNT FL DRN SUMP WATER LEVEL HIGH-HIGH		RADIATION MONITOR HIGH
INDICATED RPV WATER LEVEL ABNORMAL		R I P RUNBACK	PRIMARY CONTMNT WATER LEVEL HIGH

S C R A M

TURBINE TRIP

MSIV CLOSURE LOGIC ACTUATED

GENERATOR TRIP

L 8			
L 3			
L 2	R C I C ACTUATED	SGTS (A) ACTUATED	SGTS (B) ACTUATED
L 1.5		HPCF (B) ACTUATED	HPCF (C) ACTUATED
L 1	RHR (A) ACTUATED	RHR (B) ACTUATED	RHR (C) ACTUATED
	ADS (A) ACTUATED	ADS (B) ACTUATED	CNTNMNT ISOLATED
RPV WATER LEVEL NOT ABOVE TAF	D G (A) ACTUATED	D G (B) ACTUATED	D G (C) ACTUATED

		R/B DELTA P LOW	T/B RADIATION HIGH
HVAC EXHAUST RADIATION HIGH	AREA TEMP HIGH		S/P WATER LEVEL HIGH/LOW
RPV LEVEL 3 ISOL INCOMPL	RPV LEVEL 2 ISOL INCOMPL	RPV LEVEL 1.5 D/W PRESS HIGH ISOL INCOMPL	C A M S H2/O2 HIGH
STACK RADIATION HIGH	RCW RADIATION HIGH		C A M S RADIO-ACTIVITY HIGH

Control Room Design - Summary

- Highly reliable operator interface
- Reduction of operator burden
- Operator still in charge of plant operation
- Improved operability
- Reduced potential for operator error

DESIGN CERTIFICATION - STANDARD CONTROL ROOM FEATURES

(1) Single integrated control console

- staffed by two operators
- low profile for seated operators

(2) Plant process computer system on-screen control video display units (e.g., CRTs)

- safety system monitoring
- non-safety system control and monitoring

(3) Separate set of on-screen control video display units (VDUs) which are independent of process computer system

- divisionally separated and 1-E qualified VDUs for safety system control and monitoring (e.g., flat panel displays)
- another set of VDUs (e.g., flat panel displays) for non-safety system control and monitoring

DESIGN CERTIFICATION - STANDARD CONTROL ROOM FEATURES (Cont'd)

(4) Control console dedicated function switches

(5) Operator selectable automation of pre-defined plant operation sequences

(6) Operator selectable semi-automated mode of plant operations

- *provides procedural guidance via the control console VDUs*

(7) Conventional manual mode of plant operations

(8) Large display panel

- *presents information for use by the entire control room operating staff*

(9) Fixed position display of key plant parameters and major equipment status on the large display panel

DESIGN CERTIFICATION - STANDARD CONTROL ROOM FEATURES (Cont'd)

(10) Separation of fixed position displays which are safety related

- *critical plant parameters*
- *Post Accident Monitoring (PAM) variables*

(11) Fixed position displays are independent of the plant process computer system

(12) Large display panel includes large video display unit

- *driven by the plant process computer system*

(13) Supervisor's console with VDUs for monitoring of plant status

- *VDUs (e.g., CRTs) driven by the plant process computer system*

DESIGN CERTIFICATION - STANDARD CONTROL ROOM FEATURES (Con't'd)

(14) Safety Parameter Display System (SPDS) function provided on large display panel

- *continuously displayed fixed position displays*

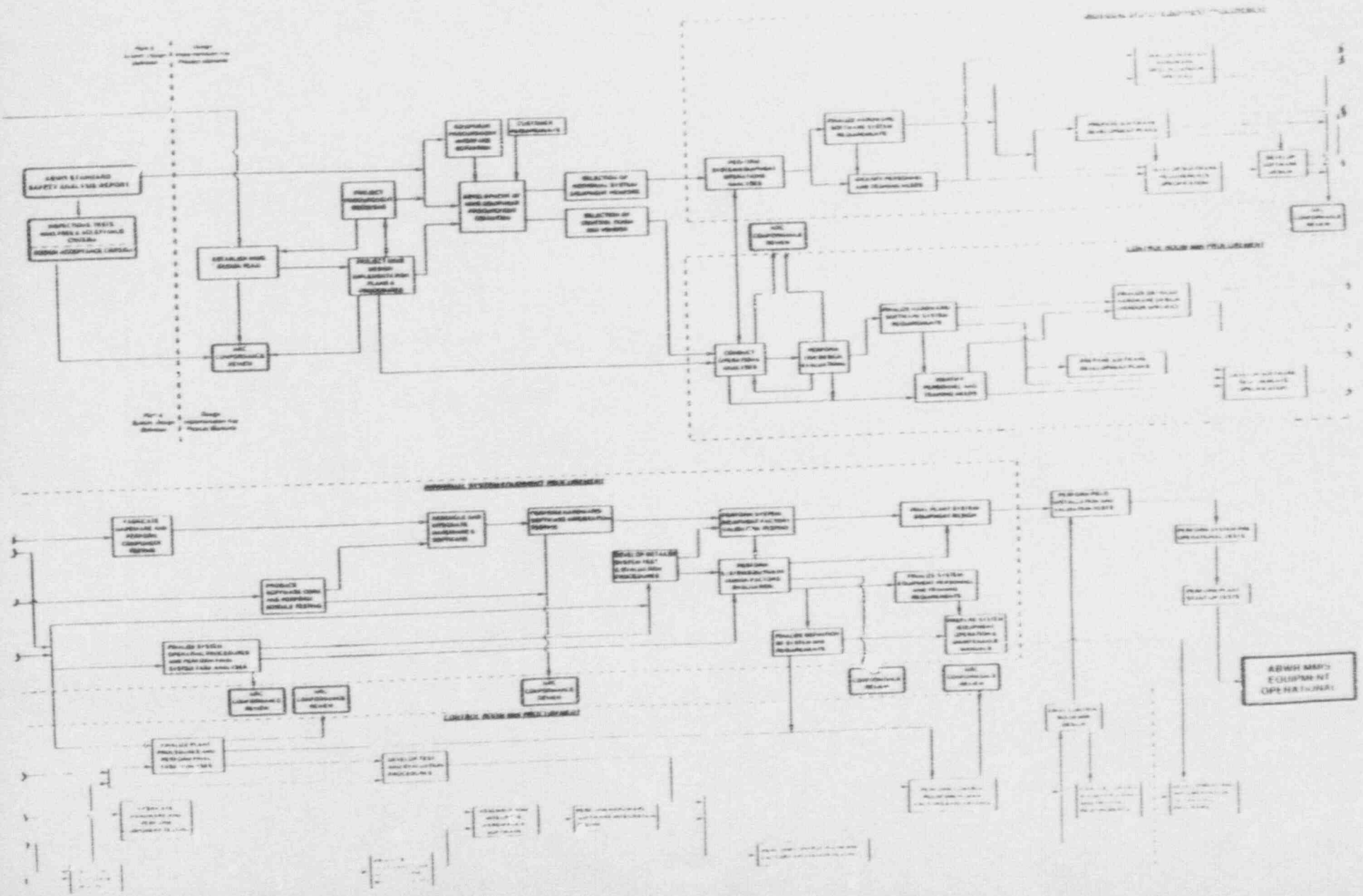
(15) Fixed-position alarm tile on the large display panel

(16) Alarm filtering and prioritization

(17) Additional alarm information provided on control console VDUs

(18) Spatial arrangement of Large Display Panel, Main Control Console andSupervisor's Console

ABWR DESIGN IMPLEMENTATION PROCESS (TYPICAL)



ISSUE - KEY FEATURES

- ABWR Control Complex design objectives used as basis for selection of features
  - experience from previous designs
  - tests and evaluations
- Alternatives considered
  - tests and evaluations completed
  - merits/demerits of each summarized
  - choices made
- Evaluation criteria
  - based upon experience
  - reflective of "new" equipment's characteristics
  - developed during evaluation process

ISSUE - KEY FEATURES (Cont'd)

- *Operating experience a key input*
  - *Maintain positive (e.g., maintain CRTs, low console)*
  - *Eliminate negative (e.g., incorporate Large Display Panel)*

- *Interactive process for integration into Control Room design*
  - *test and evaluation of individual items*
  - *design development and evaluation*
  - *mockups/prototype test and evaluation*

ISSUE - FIXED INVENTORY

- ABWR design development
  - Large display panel (displays and alarms)
    - overall plant status
    - multiple users
    - continuously available
  - Control console (controls)
    - emergency operations (speed/certainty)
    - normal operations (ease of use)
  - Prototype development process
    - operator inputs
    - design developed consistent with objectives
    - evaluations
    - prototype tests

ISSUE - FIXED INVENTORY (Cont'd)

- *U. S. Design Certification*
  - *EOP/PRA operations analysis*
  - *details of implementation of displays, controls and alarms defined based upon ABWR design objectives*
  - *results compared to reference design*

ISSUE - WORKLOAD AND CONTROL ROOM STAFFING

- Original design development goal to support reduction in required operating staff size
  - other benefits of maintaining existing staff size identified

    (similar to ALWR Requirements Document)
- Basis of seated position control console design
  - operating experience at five plants
  - prototype testing

ISSUE - PROTOTYPE

- *Scope*
  - *prototype equipment*
  - *panel mockups*
  - *full scope dynamic prototype for the defined test sequences*
  - *full scope prototype of chosen configuration (included both proven and the new features)*
- *Test scenarios selected to challenge and test new features within the integrated design*
- *Tests addressed all modes of operation*
  - *functional allocation evaluated via operator performance, observations and feedback*
- *Operator (re)training required with introduction of new features*

ISSUE - DSER ITEMS

- Valve indication provided as determined necessary by operations analysis

- Remote Shutdown System is entirely of analog equipment

ISSUE - JAPAN DESIGN IMPLEMENTATION PROCESS

- Background
  - Practical orientation
    - Less emphasis on theory, structure, documentation
  - Evolutionary approach
    - New features defined based upon experience with previous designs and operators' comments
- Basic Process
  - Gather comments from all sources
  - Design approach generated
  - Engineers develop design concepts for widespread internal informal review
    - engineers
    - HFE experts

ISSUE - JAPAN DESIGN IMPLEMENTATION PROCESS (Cont'd)

- Basic Process (Cont'd)
  - Developed conceptual designs distributed for formal review
    - HFE experts
    - Utility engineers
    - Utility operators
  - Reviewers determine what to review and how
    - Review results documented along with justification, as required
  - Review comments resolved through consensus
    - Harmonizing of individual viewpoints and design options
  - Design approaches redefined/refined and process iterated until completion
  - Final results accepted by group consensus

ISSUE - JAPAN DESIGN IMPLEMENTATION PROCESS (Cont'd)

- Design standardization achieved through joint participation of equipment vendors in control room design development

- Basic design objectives guide all phases of product development
  - Design acceptance is by consensus of reviewers
  - Key reviewers are the end users (i.e., operations and maintenance personnel)

- Review points
  - Informal reviews generally held at frequent intervals
  - formal reviews generally held at scheduled completion of key design activities by consensus (judgement) of participants

ISSUE - JAPAN DESIGN IMPLEMENTATION PROCESS (Cont'd)

- *Final design detailed implementation completed through the same type process*
  - *Direction/guidance of end user as part of plant construction activities*

- *Validation of implemented design performed at factory prior to shipment*
  - *Informal reviews during manufacture*
  - *Formal review of configured system*
  - *End user acceptance obtained prior to installation*
- *Parallel training simulator actively provides feedback and supports end user acceptance*