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

June 4, 1992

Docket No. 52-002

APPLICANT: Combustion Engineering, Inc. (ABB-CE)

PROJECT: CE System 80+

SUBJECT: MEETING HELD ON MAY 19, 1992, REGARDING CHAPTER 18 OF CESSAR-DC (HUMAN FACTORS)

On May 19, 1992, a public meeting was held at the ABB-CE facilities in Windsor, Connecticut, between representatives of ABB-CE and the Nuclear Regulatory Commission (NRC). Enclosure 1 lists the attendees, Enclosure 2 is the material presented by ABB-CE, and Enclosure 3 is the material presented by NRC to ABB-CE. Selected issues with regard to the human factors review in Chapter 18 of CESSAR-DC were discussed.

ABB-CE provided an overview of their NUPLEX 80+ design. Discussions included the advanced control complex and success paths for critical functions. ABB-CE's discussion followed the outline provided in their handout (Enclosure 2). This discussion was followed by a tour of ABB-CE's static mockup, a demonstration of their prototype, a comparison of the NUPLEX 80+ to current control rooms, and a comparison of the NUPLEX 80+ design process to NRC's draft review criteria.

The NRC staff provided ABB-CE a copy of the human factors review model and acceptance criteria utilized as the review criteria in the General Electric advanced boiling water reactor design review (Enclosure 3). ABB-CE agreed to provide their comments on this document to the NRC by July 1, 1992. ABB-CE's comments on this document would then be reviewed by the NRC staff in July, and any differences would be resolved with ABB-CE during a meeting planned for early August between the NRC staff and ABB-CE. This meeting will discuss ABB-CE's comments on NRC's proposed human factors review model and acceptance criteria. The staff would then have criteria for the human factors engineering review of ABB-CE's NUPLEX 80+ by September 1, 1992. It is the staff's intention to use this criteria as the basis for the NUPLEX 80+ review.

ABB-CE agreed to provide to the NRC that information which ABB-CE had referenced in a May 15, 1992, submittal which ABB-CE determines is necessary for the staff to rely on to make a finding of adequacy of design. A listing of this information and a schedule for when this information is to be provided will be submitted by ABB-CE to the NRC on August 1, 1992.

Original Signed By:

Robert C. Pierson, Director
Standardization Project Directorate
Associate Directorate for Advanced Reactors
and License Renewal
Office of Nuclear Reactor Regulation

Enclosures:
As stated

cc w/enclosures:
See next page

DISTRIBUTION:

Docket file	PDST R/F	TMurley/FMiraglia	DCrutchfield
NRC PDR	WTravers	RPierson	JNWilson
RBorchardt	TWambach	JMoore, 15B18	GGrant, EDO
PShea	ACRS (10)	EJordan, MNBB 3701	CMcCracken, 8D1
JRoe, 10H5	JWermiel, 10D24	DEckenrode, 10D24	

OFC:	LA:PDST:ADAR	PM:PDST:ADAR	SC:PDST:ADAR	D:PDST:ADAR
NAME:	PShea:tz	TVWambach	JNWilson	RPierson
DATE:	06/1/92	05/02/92 06	06/3/92	6/4/92

OFFICIAL RECORD COPY: CESUM.TVW

DF03
1/1

ABB-CE agreed to provide to the NRC that information which ABB-CE had referenced in a May 15, 1992, submittal which ABB-CE determines is necessary for the staff to rely on to make a finding of adequacy of design. A listing of this information and a schedule for when this information is to be provided will be submitted by ABB-CE to the NRC on August 1, 1992.

Robert C. Pierson, Director
Standardization Project Directorate
Associate Directorate for Advanced Reactors
and License Renewal
Office of Nuclear Reactor Regulation

Enclosures:
As stated

cc w/enclosures:
See next page

cc: Mr. C. B. Brinkman, Acting Director
Nuclear Systems Licensing
Combustion Engineering, Inc.
1000 Prospect Hill Road
Windsor, Connecticut 06095-0500

Mr. C. B. Brinkman, Manager
Washington Nuclear Operations
Combustion Engineering, Inc.
12300 Twinbrook Parkway, Suite 330
Rockville, Maryland 20852

Mr. Stan Ritterbusch
Nuclear Systems Licensing
Combustion Engineering, Inc.
1000 Prospect Hill Road
Post Office Box 500
Windsor, Connecticut 06095-0500

Mr. Daniel F. Giessing
U. S. Department of Energy
NE-42
Washington, D.C. 20585

Mr. Steve Goldberg
Budget Examiner
725 17th Street, N.W.
Washington, D.C. 20503

Mr. Raymond Ng
1776 Eye Street, N.W.
Suite 300
Washington, D.C. 20006

Mr. Mark McCabe
U.S. Department of Justice/EAG
555 4th Street, N.W.
Room 11-809
Washington, D.C. 20001

Enclosure 1

MEETING ATTENDEES

MAY 19, 1992

NAME	ORGANIZATION
Bob Pierson	NRR/ADAR/PDST
Dick Eckenrode	NRR/DLPQ/LHFB
Jack Roe	NRR/DLPQ
Jerry Wermiel	NRR/DLPQ/LHFB
Regis Matzie	ABB-CE
Robert Fuld	ABB-CE
Robert L. Rescorl	ABB-CE
Ken Scarola	ABB-CE
William J. Gill	ABB-CE
Stan Ritterbusch	ABB-CE
Charles Brinkman	ABB-CE

Enclosure 2

MEETING - MAY 19, 1992
NRC MANAGEMENT AND ABB-CE
ON
NUPLEX 80+ HUMAN FACTORS REVIEW

BACKGROUND

- NRC STAFF AND ABB-CE HAVE BEEN UNABLE TO REACH AGREEMENT ON AN ACCEPTABLE DESIGN PROCESS FOR THE SYSTEM 80+ CONTROL ROOM.

  - NRC STAFF'S REVIEW GUIDELINES EXPECT SIGNIFICANT UP FRONT ANALYSIS TO ESTABLISH DESIGN REQUIREMENTS.

  - ABB'S PROCESS HAS RELIED HEAVILY ON THE EVOLUTIONARY NATURE OF SYSTEM 80+ AND NUPLEX 80+, USING INDUSTRY PUBLICATIONS AND EXPERIENCED PERSONNEL.

MEETING OBJECTIVES

- INTRODUCE NRC MANAGEMENT TO THE NUPLEX 80+ DESIGN.

- COMPARE NUPLEX 80+ TO CURRENT CONTROL ROOMS.

- COMPARE ABB'S DESIGN PROCESS TO THE NRC STAFF GUIDELINES.

- DISCUSS ADDITIONAL DESIGN PROCESS ACTIVITIES.

AGENDA

NUPLEX 80+ OVERVIEW

NUPLEX 80+ PROTOTYPE DEMONSTRATION

YGN 3&4 I&C WALK-THRU

COMPARISON OF NUPLEX 80+ TO CURRENT CONTROL ROOMS

COMPARISON OF ABB DESIGN PROCESS TO NRC HFE PROGRAM ELEMENTS -

- SIMILARITIES
- DIFFERENCES
- PROPOSED RESOLUTION

SUMMARY/ACTIONS

NUPLEX 80+

ADVANCED CONTROL COMPLEX

NUPLEX 80+ I&C SYSTEMS
KEY FEATURES

- FIELD PROVEN COMMERCIAL PRODUCTS

  HARDWARE - EXECUTIVE SOFTWARE

- ALL DIGITAL PROCESSING

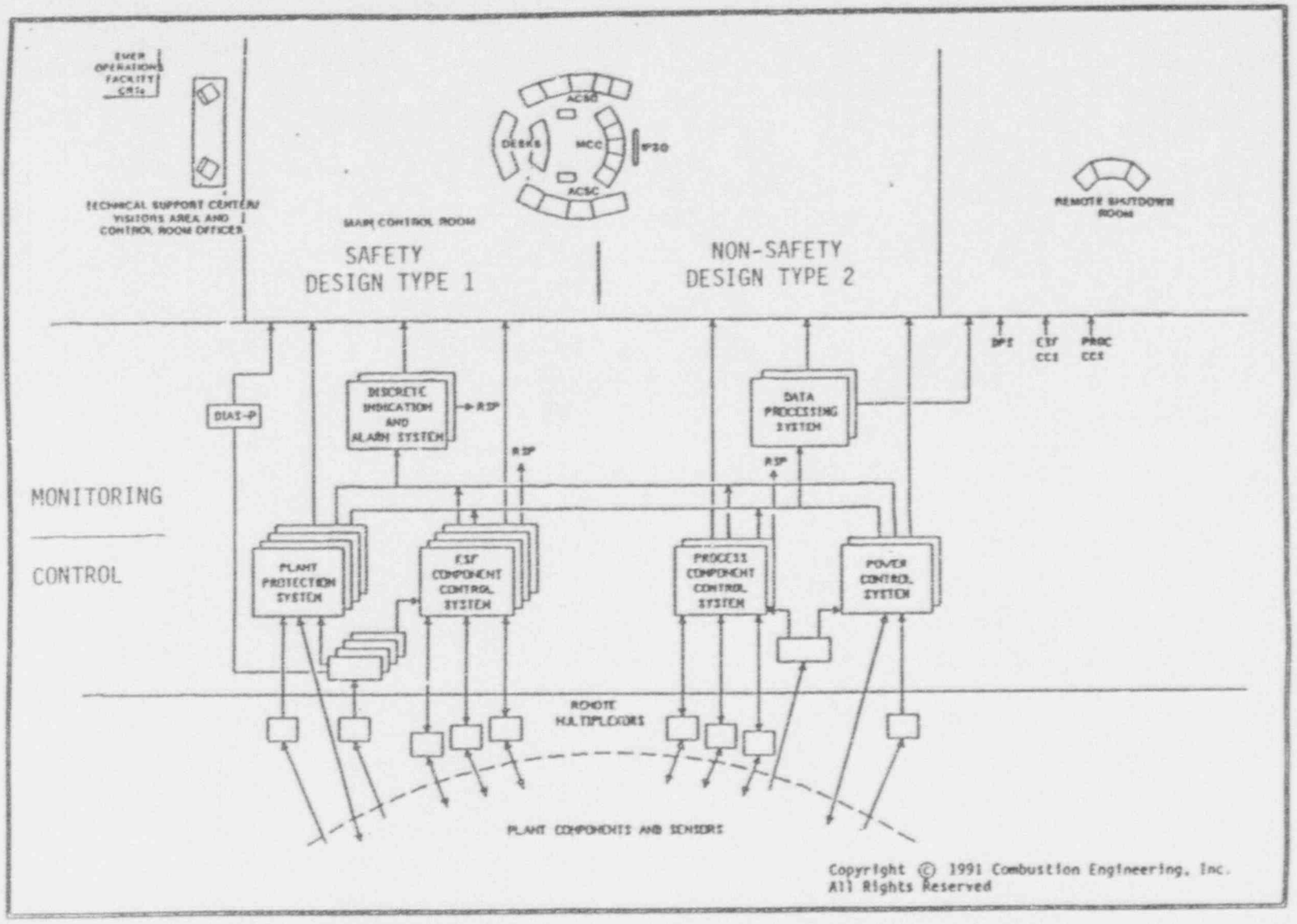
  CONTROL - PROTECTION
  MONITORING - DISPLAY

- GEOGRAPHICALLY AND FUNCTIONALLY DISTRIBUTED ARCHITECTURE

  70% CABLE REDUCTION (NO CABLE SPREADING ROOM)
  FIRE PROTECTION
  SECURITY ENHANCEMENT
  GRACEFUL FAILURE MODES

- MAXIMUM STANDARDIZATION

  HARDWARE-SOFTWARE-DESIGN METHODS
  LIMITED DIVERSITY MAINTAINED FOR DEFENSE-IN-DEPTH



Six Major Nuplex 80+™ Systems Provide for Control and Information

ABB

MISC02/1

SUCCESS PATHS FOR CRITICAL FUNCTIONS
TABLE 1

CRITICAL FUNCTION		SUCCESS PATH			
		NON SAFETY		SAFETY	
REACTIVITY CONTROL		ROD CONTROL	CVCS (BORATION)	SAFETY INJECTION SYSTEM	REACTOR TRIP BREAKERS
VITAL AUXILIARIES	AC	MAIN TRANSFORMER	GAS TG	EMERGENCY DIESEL	S/U TRANSFORMER
	DC	STATION BATTERY		STATION BATTERY	
RCS INVENTORY CONTROL		CVCS (CHARGING/ LETDOWN)		SAFETY INJECTION SYSTEM	
RCS PRESSURE CONTROL		HEATERS/SPRAY	CVCS (CHARGING)	SAFETY INJECTION SYSTEM	SAFETY DEPRESSURIZATION SYSTEM
CORE HEAT REMOVAL		FORCED CIRCULATION		NATURAL CIRCULATION	
RCS HEAT REMOVAL		MAIN FEED		EMERGENCY FEED	SHUTDOWN COOLING & SAFETY INJECTION SYSTEM
CONTAINMENT ISOLATION		CONTROL VALVES		ISOLATION VALVES	
CONTAINMENT ENVIRONMENT		?	?	FAN COOLERS	H_2 PURGE
RADIATION EMISSION			MONITOR AND CONTROL RADIATION RELEASE PATHS	ISOLATION OF RELEASE PATHS	

NUPLEX 80+ ADVANCED CONTROL ROOM
KEY FEATURES

- EVOLUTIONARY, NOT REVOLUTIONARY

  TOTALLY NEW DESIGNS OFTEN CREATE MORE PROBLEMS THAN THEY SOLVE

- MAINTAIN STRENGTHS OF CURRENT CONTROL ROOMS

  SPATIAL DEDICATION OF KEY INSTRUMENTATION, ALARMS, CONTROLS

  SELECTIVE USE OF AUTOMATION

  BENEFITS: AVOID TUNNEL VISION

  OPERATOR IS PART OF THE PROCESS, NOT JUST A SPECTATOR

  OPERATOR VIGILANCE

  DESIGN FOR N+1 EVENT

NUPLEX 80+ ADVANCED CONTROL ROOM
KEY FEATURES (CONT'D.)

- CORRECT CURRENT CONTROL ROOM DEFICIENCIES

  MAXIMIZE INFORMATION QUALITY - SIGNAL VALIDATION

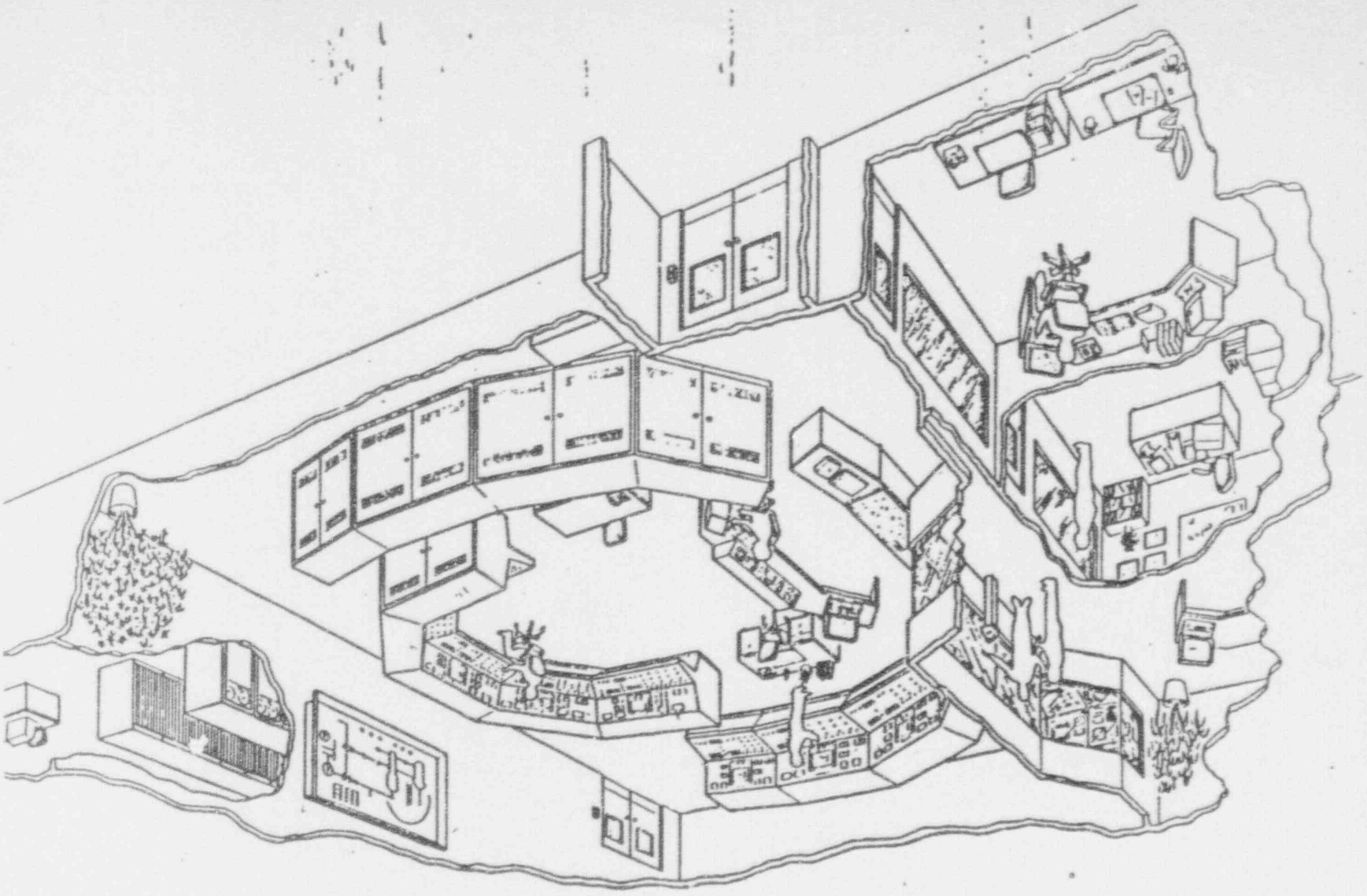
  MINIMIZE NUISANCE ALARMS - MODE DEPENDENCY

  REDUCE INFORMATION OVERLOAD - SELECTABLE DISPLAYS AND CONTROLS; DATA REDUCTION PROCESSING; INFORMATION/ALARM PRIORITIZATION

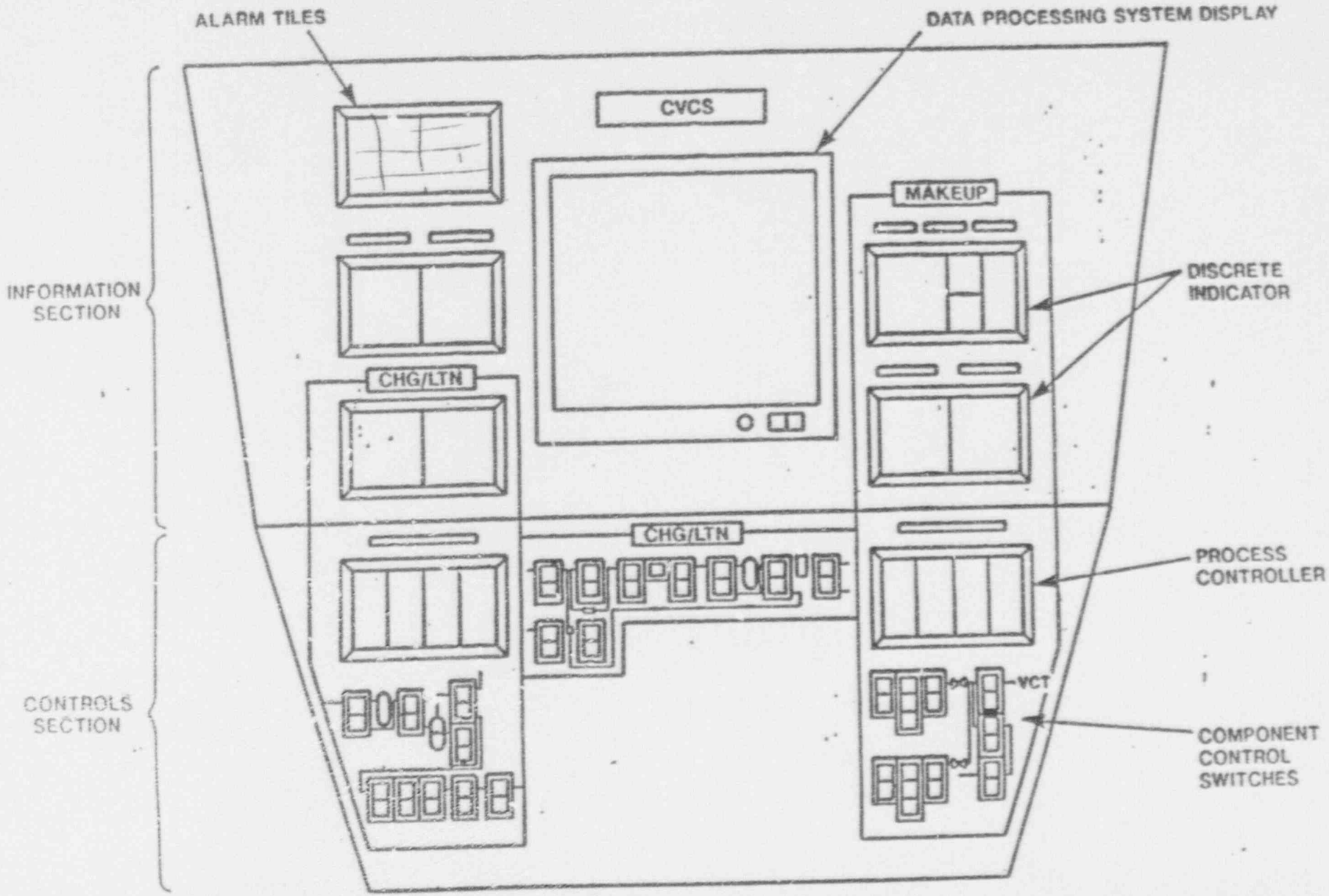
  ELIMINATE UNUSED BACK-UP INSTRUMENTS

  ENSURE MMI SUPPORTS PROCEDURES AND TASKS

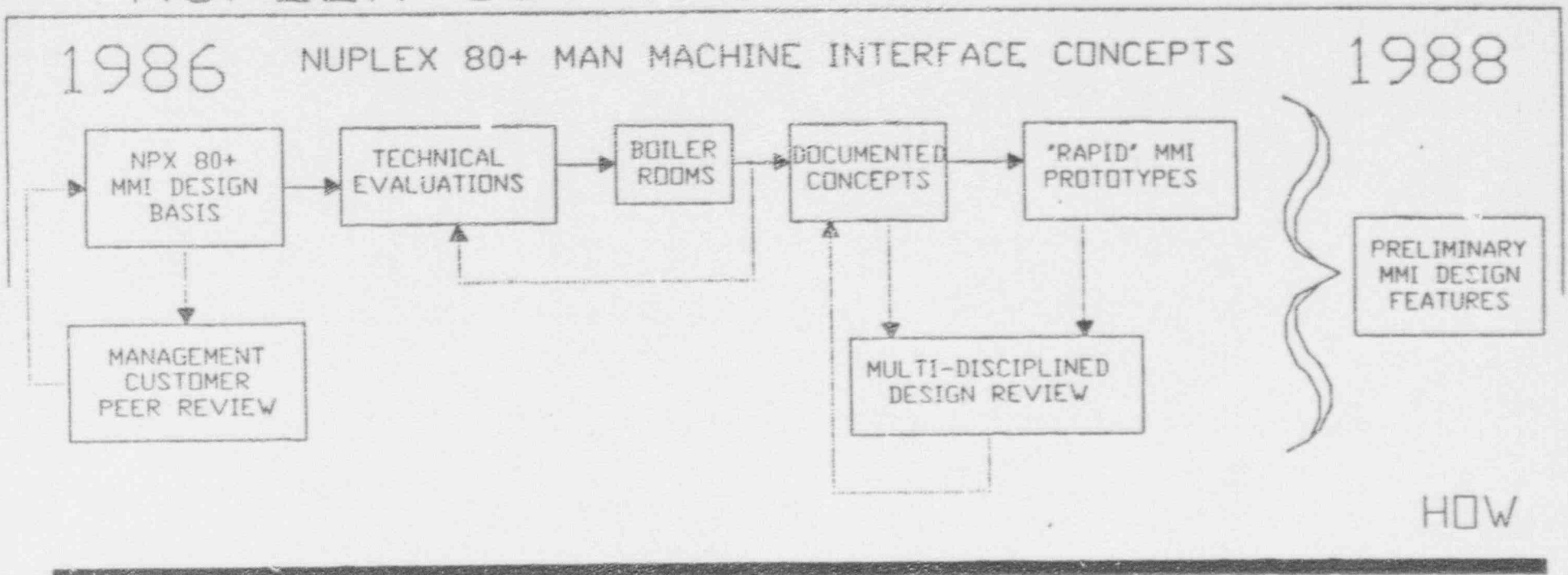
  DESIGN FOR PEOPLE - EXTENSIVE HUMAN FACTORS ENGINEERING



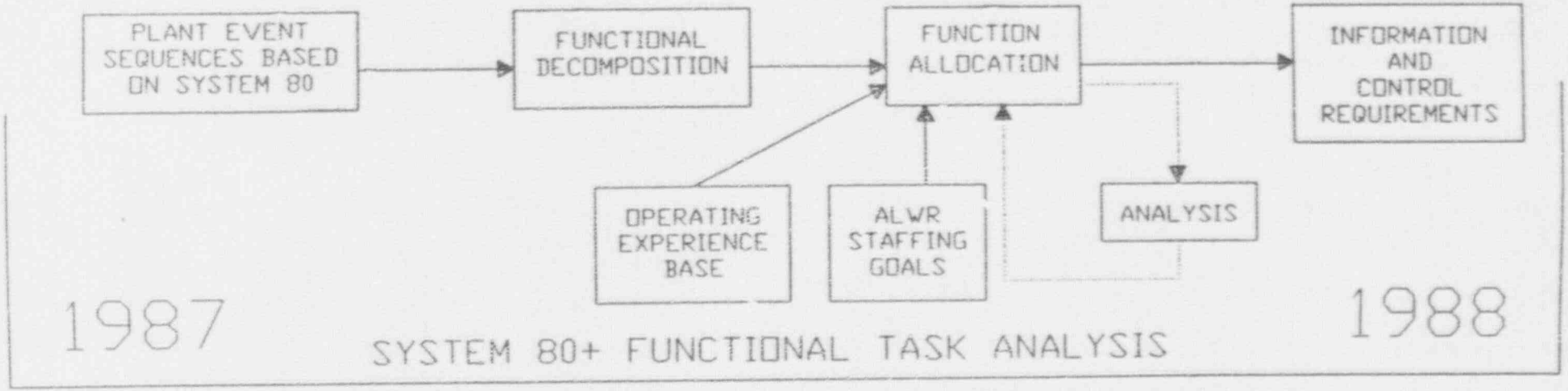
TYPICAL CONTROL PANEL LAYOUT (CVCS) IS BASED ON OPERATOR TASK ANALYSIS



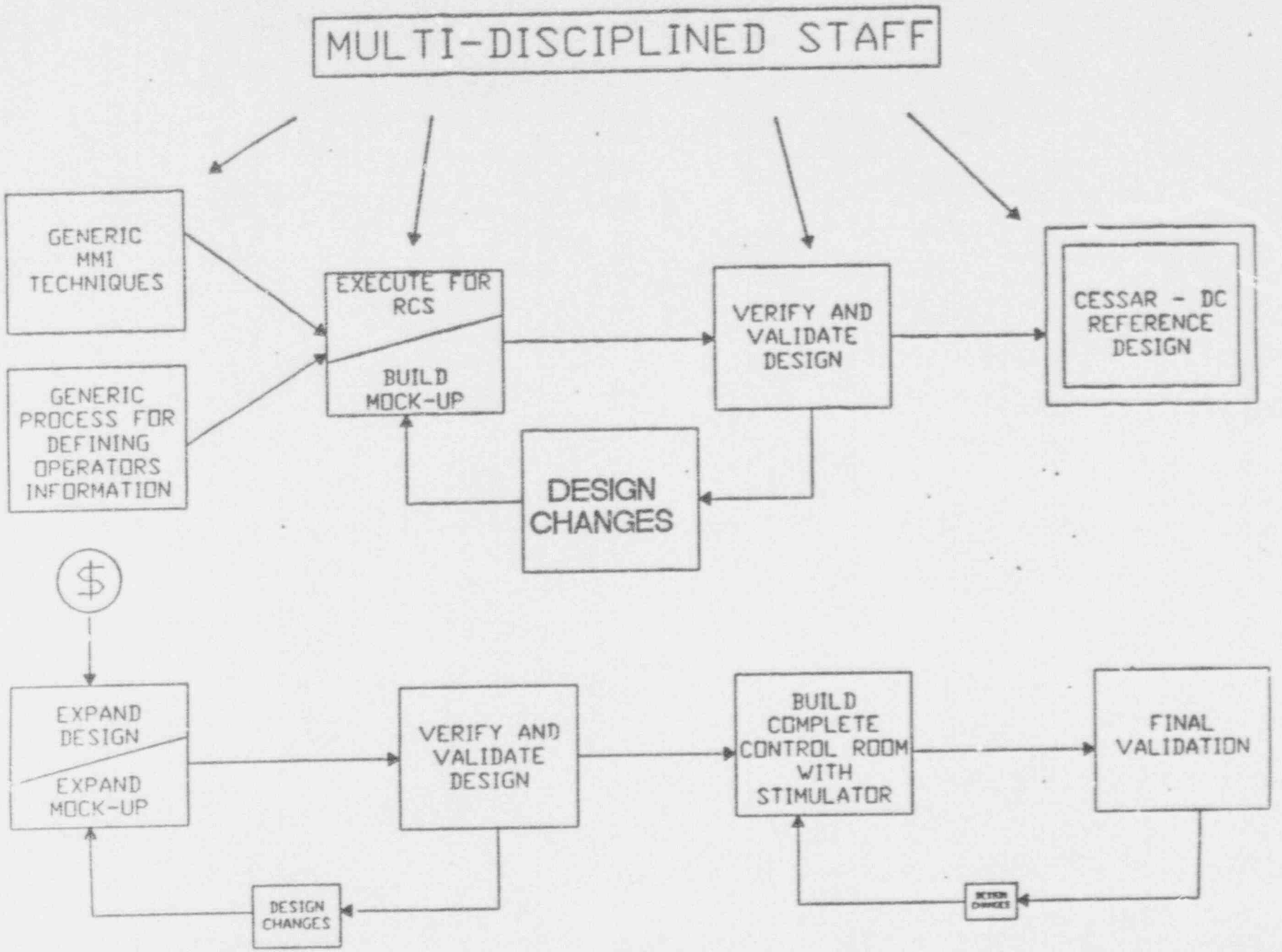
NUPLEX 80+ MMI DESIGN PROCESS



WHAT



NUPLEX 80+ MMI DESIGN PROCESS



CONTROL ROOM VALIDATION ACCEPTANCE CRITERIA

- MCR EVALUATED WITH COMPLETE COMPLEMENT OF REFERENCE AND SUPPORT MATERIAL (E.G., PROCEDURES)

- OPERATIONAL VALIDATION USING FULL SCOPE SIMULATOR

EVENT	ACCEPTANCE CRITERIA
NORMAL OPERATION - HEATUP - STARTUP - POWER CHANGES - SHUTDOWN - COOLDOWN - REFUELING	- ACHIEVE DESIRED STATES WITHOUT TECH. SPEC. VIOLATIONS OR PPS PRE-TRIPS

CONTROL ROOM VALIDATION ACCEPTANCE CRITERIA

- OPERATIONAL VALIDATION USING FULL SCOPE SIMULATOR

EVENT	ACCEPTANCE CRITERIA
ABNORMAL CONDITIONS - UNCOMPLICATED RX TRIP - LOCA - SGTR - ESDE - LOOP - LOAF - STATION BLACKOUT	- IDENTIFY EVENT, SATISFY SAFETY FUNCTION STATUS CHECKS, MEET EPG EVENT SPECIFIC CRITERIA
N+1 EVENT	- USING FUNCTIONAL RECOVERY MEET CRITICAL SAFETY FUNCTION ACCEPTANCE CRITERIA

KS318.WP-3

COMPARISON OF
NUPLEX 80+ TO CURRENT CONTROL ROOMS

KEY DESIGN FEATURES

- CONFIGURATION
- IPSO
- INDICATORS
- ALARM TILES
- CRT DISPLAYS
- CONTROLS

COMPARISON FORMAT

- SIMILARITIES TO CURRENT CONTROL ROOMS
- DIFFERENCES AND DESIGN BASIS

CONFIGURATION

SIMILARITIES TO CURRENT CONTROL ROOMS

- CONTROL ROOM ARRANGED BY PLANT SYSTEM ORIENTED CONTROL PANELS
- CONTROLS AND INSTRUMENTS ARE SPATIALLY DEDICATED IN FIXED LOCATIONS
- DIVISION OF WORK AMONG OPERATORS IS BY PLANT SYSTEMS WITH FUNCTION COORDINATION BY THE CONTROL ROOM SUPERVISOR

DIFFERENCES AND DESIGN BASIS

- PLANT-WIDE INFORMATION IS AVAILABLE AT ALL PANELS, INCLUDING SUPERVISOR CONSOLE TO MINIMIZE UNNECESSARY MOVEMENT AND MIS-COMMUNICATION AMONG PERSONNEL

IPSO

SIMILARITIES TO CURRENT CONTROL ROOMS

- IPSO OPERATIONAL AT BORSSELLE SINCE 1988
- BYPASS OR INOPERABLE STATUS PANELS PER REG. GUIDE 1.47 (CONTINUOUS DISPLAY)
- CRITICAL FUNCTION STATUS DISPLAY PER NUREG-0696 (CONTINUOUS DISPLAY)
- LARGE FORMAT (PRIORITIZED) ANNUNCIATOR WINDOWS

DIFFERENCES AND DESIGN BASIS

- NUPLEX 80+ IPSO INTEGRATES ADDITIONAL KEY INFORMATION INTO ONE LOCATION VISIBLE BY ALL PERSONNEL (PLANT MODE, EOP, SUCCESS PATH PERFORMANCE)
- ICONS FOR RAPID COMPREHENSION
- WELL FOCUSED CRITICAL FUNCTION DESIGN BASIS, SUPPORTED BY INDUSTRY/REGULATORY PRECEDENCE

INDICATORS

SIMILARITIES TO CURRENT CONTROL ROOMS

- BAR GRAPHS, TRENDS, NUMERICAL READOUTS
- SYSTEM ORIENTED WITH RELATED CONTROLS/ALARMS
- DEDICATED FIXED INFORMATION

DIFFERENCES AND DESIGN BASIS

- FIXED LOCATIONS FOR CRITICAL FUNCTION AND SUCCESS PATH PERFORMANCE INDICATORS ONLY TO REDUCE INFORMATION OVERLOAD
- SINGLE INDICATORS COMBINE SENSOR DATA FROM ALL CHANNELS AND ALL RANGES TO REDUCE MENTAL DATA PROCESSING
- NO UNUSED BACK-UP INDICATORS TO ENSURE OPERATORS ARE FAMILIAR WITH MMI EXPECTED TO BE USED DURING EMERGENCIES (PER REG. GUIDE 1.97) [THIS WOULD BE IMPACTED BY PROPOSED NRC STAFF POSITION REQUIRING BACK-UP ANALOG INDICATORS.]

KS318.WP-7

ALARM TILES

SIMILARITIES - CURRENT CONTROL ROOMS

- SPATIAL DEDICATION (WITH SYSTEM ORIENTATION) FOR RAPID RECOGNITION
- REFLASH TO ACCOMMODATE GROUPED ALARMS
- GLOBAL ACKNOWLEDGEMENT TO STOP FLASHING
- AUDIBLES TO PROVIDE ALERTING FEATURES
- VISUAL CODING TO DISTINGUISH ALARM PRIORITIES

ALARM TILES (CONT'D.)

DIFFERENCES AND DESIGN BASIS

- SPATIAL DEDICATION FOR KEY ALARMS ONLY TO AVOID INFORMATION OVERLOAD
- PLANT DATA IS PRE-PROCESSED TO AVOID NUISANCE ALARMS AND TO DISTINGUISH ALARM RELATING TO SIGNIFICANT OPERATOR ACTIONS
- OPERATOR STATUS AIDS SEPARATED FROM ABNORMAL CONDITIONS (ALARMS) TO AVOID MISUSE OF ALARM TILES
- REFLASH ALLOWS DISTINCTION FOR SOME NEW/SOME CLEARED VS. ALL NEW/ALL CLEAR TO AVOID CONFUSION
- GROUPED ALARMS ARE INDIVIDUALLY IDENTIFIED TO HELP DIAGNOSTIC ACTIVITIES
- ACKNOWLEDGEMENT BY INDIVIDUAL ALARMS OR RELATED GROUPS TO ENCOURAGE RECOGNITION. STOP FLASH IS SEPARATE TO ELIMINATE VISUAL NOISE, WITH DEFERRED ACKNOWLEDGEMENT
- MOMENTARY AUDIBLES WITH SEPARATE UNACKNOWLEDGED REMINDER. ELIMINATES JUMPING FOR SILENCE BUTTON OR BLIND ACKNOWLEDGEMENT.

CRT DISPLAYS

SIMILARITIES TO CURRENT CONTROL ROOMS

- GRAPHIC DISPLAYS OF PLANT MIMICS, ALARMS, TRENDS
- HISTORICAL DATA REPORTS
- OPERATOR AIDS FOR CORE OPERATING LIMITS, CRITICAL SAFETY FUNCTIONS, POWER OPTIMIZATION, BYPASSED INOPERABLE STATUS

DIFFERENCE AND DESIGN BASIS

- MORE CRT'S TO BRING ALL DATA TO ALL PERSONNEL (CRT'S AT PANELS, OFFICES AND TSC).
- DISPLAY NAVIGATION THROUGH GRAPHICAL TOUCH MENUS WITH ALARM HIGHLIGHTING TO REDUCE SEARCH TIME
- OPERATOR AIDS ADDED FOR PERIODIC TESTING, CRITICAL FUNCTIONS FOR POWER OPERATION, SUCCESS PATH PERFORMANCE TO CONVERT LARGE QUANTITIES OF RAW DATA INTO KEY INFORMATION

CONTROLS

SIMILARITIES TO CURRENT CONTROL ROOMS

- SPATIAL DEDICATION BY PLANT SYSTEMS
- BACKLIT PUSHBUTTONS FOR BINARY CONTROLS
- BAR GRAPH TYPE CONTROLS AND MODULATING CONTROL LOOPS

DIFFERENCES AND DESIGN BASIS

- SPATIAL DEDICATION FOR MAIN FLOW PATHS IN SUCCESS PATH SYSTEMS; OTHER LESS IMPORTANT CONTROLS ARE SELECTABLE TO IMPROVE ACCESS TO MORE IMPORTANT CONTROLS
- WHERE BINARY CONTROLS ARE SUBFUNCTIONS OF MODULATING CONTROLS, THEY ARE SELECTABLE VIA MODULATING CONTROLLERS (DUE TO LESS IMPORTANCE, INFREQUENT USE)
- MODULATING CONTROLS ARE GROUPED BY FUNCTION TO BETTER DEPICT CASCADE AND INTERACTIVE RELATIONSHIPS

COMPARISON OF NUPLEX 80+ DESIGN PROCESS TO NRC DRAFT REVIEW CRITERIA

ELEMENT A - HFE PROGRAM MANAGEMENT

SIMILARITIES

- CONFORMANCE TO GOALS OF NUREG 0700 APPENDIX B
- COMMITMENT TO INTEGRATING HUMAN FACTORS THROUGHOUT THE ADVANCED CONTROL COMPLEX DESIGN
- DEVELOPMENT OF AN HFE PROGRAM PLAN
- USE OF MULTI-DISCIPLINARY DESIGN TEAM AND INDEPENDENT MULTI-DISCIPLINARY REVIEW TEAM
- ESTABLISHING A DEDICATED HFE OPEN-ISSUES TRACKING SYSTEM

COMPARISON OF NUPLEX 80+ DESIGN PROCESS TO NRC DRAFT REVIEW CRITERIA

DIFFERENCES

- INTEGRATED HF ROLE VS. DOMINANT STATUS OF HF DISCIPLINE
  - TEAM FOCUS ON WHOLE DESIGN
  - RECOGNITION OF COST AND SCHEDULE CONSTRAINTS
  - STOP WORK MECHANISMS FOR SAFETY RELATED DEFICIENCIES CONSISTENT WITH ALL OTHER ENGINEERING AND QA DISCIPLINE

- RESPONSIBILITY FOR HF PRODUCT FROM, VS. LEVEL OF HF EFFORT REQUIRED AT, SUBCONTRACTOR'S SITE

PROPOSED RESOLUTION

- INCORPORATE RAI COMMITMENTS AND COMMITMENTS FROM CURRENT MEETINGS INTO EXISTING PLAN

COMPARISON OF NUPLEX 80+ DESIGN PROCESS TO NRC DRAFT REVIEW CRITERIA

ELEMENT B - OPERATING EXPERIENCE REVIEW

SIMILARITIES

- GOAL IS TO IDENTIFY AND RESOLVE PROBLEMS AND ISSUES WITH PREVIOUS GENERATION DESIGNS
- REVIEW OF INDUSTRY DOCUMENTATION FOR HF ISSUES (LER'S, EPRI ALWR URD, DCRDR, ETC.)
- IDENTIFICATION OF ISSUES THROUGH FEEDBACK FROM EXPERIENCED OPERATORS

DIFFERENCES

- "BOILER ROOM" MEETINGS AND SUMMARY DOCUMENTATION VS. FORMAL ANALYSES, INTERVIEWS AND REPORTS
- DOCUMENTATION OF ACC DESIGN BASES (RESULTING FROM REVIEW) VS. DOCUMENTATION OF REVIEW RESULTS

PROPOSED RESOLUTION

- NEW DOCUMENT - DESIGN BASES FOR NUPLEX 80+ INFORMATION SYSTEM DESIGN

COMPARISON OF NUPLEX 80+ DESIGN PROCESS TO NRC DRAFT REVIEW CRITERIA

ELEMENT C - SYSTEM FUNCTIONAL REQUIREMENTS ANALYSIS

SIMILARITIES

- GOAL IS TO IDENTIFY FUNCTIONAL REQUIREMENTS TO ENSURE ADEQUACY OF MMI FOR SAFE PLANT OPERATION
- CRITICAL SAFETY FUNCTIONS FRAMEWORK

DIFFERENCES

- USE OF PREVIOUS GENERATION MCR FUNCTIONS VS. COMPLETE FUNCTIONAL REASSESSMENT (SYSTEM 80+ PLANT OPERATOR FUNCTIONS HAVE CHANGED LITTLE FROM SUCCESSFUL SYSTEM 80 FUNCTIONS)
- NUPLEX 80+ FUNCTIONS NEARLY UNCHANGED FROM PREVIOUS GENERATION VS. ANALYTICAL METHODS THAT COULD RESULT IN AN UNPROVEN NEW SET OF FUNCTIONS

PROPOSED RESOLUTION

- NEW WHITE PAPER - EXPLAINS SYSTEM 80+ CRITICAL SAFETY FUNCTIONS AND SUCCESS PATHS (SUMMARY OF CEN-152)

COMPARISON OF NUPLEX 80+ DESIGN PROCESS TO NRC DRAFT REVIEW CRITERIA

ELEMENT D - ALLOCATION OF FUNCTION

SIMILARITIES

- GOAL IS TO ENSURE ACCEPTABLE ALLOCATION OF FUNCTIONS TO OPERATORS, MACHINE OR A COMBINATION

DIFFERENCES

- MAINTAIN PREVIOUS GENERATION ACCEPTABLE ALLOCATION WITH CHANGES TO ADDRESS PROBLEMS IDENTIFIED THROUGH OPERATING EXPERIENCE

VS.

FORMAL FUNCTION ALLOCATION ANALYSES

- PROCEDURES FOR ALLOCATION
- DETERMINE OPTIMUM CONFIGURATION
- ITERATIVE RE-ALLOCATION
- FORMAL REPORTS AND DOCUMENTATION

PROPOSED RESOLUTION

- NEW DOCUMENT - DESIGN BASIS FOR NUPLEX 80+ INFORMATION SYSTEM DESIGN

- NEW WHITE PAPER - EXPLAINING BASIS OF SYSTEM 80+ MAN MACHINE ALLOCATION FOR CRITICAL SAFETY FUNCTIONS (REFERENCED TO SYSTEM 80+ BASELINE)

COMPARISON OF NUPLEX 80+ DESIGN PROCESS TO NRC DRAFT REVIEW CRITERIA

ELEMENT E - TASK ANALYSIS

SIMILARITIES

- PERFORMANCE OF TOP DOWN TASK ANALYSIS TO SUPPORT DESIGN, VERIFICATION AND VALIDATION EFFORTS
- SCOPE TO INCLUDE ALL OPERATIONAL MODES
- INCLUDES IDENTIFICATION OF ALL INFORMATION AND CONTROLS REQUIREMENTS
- CRITICAL TASKS BEING IDENTIFIED AND ANALYZED (AS PART OF PRA)

DIFFERENCES

- DETAILED TASK ANALYSIS DOCUMENTED AS PART OF VALIDATION
- MINIMUM STAFFING VIEWED AS LIMITING WORK OVERLOAD CASE; OTHER CREW SIZES EVALUATED DURING VALIDATION VS. SEPARATE TASK ANALYSIS FOR EACH CREW SIZE

PROPOSED RESOLUTION

- FTA'S FOR REMAINING PANELS
- FINAL INSTRUMENT AND CONTROLS CHARACTERISTICS REVIEW (ICCR)

KS318.WP-17

COMPARISON OF NUPLEX 80+ DESIGN PROCESS TO NRC DRAFT REVIEW CRITERIA

ELEMENT F - HUMAN SYSTEM INTERFACE DESIGN

SIMILARITIES

- GOAL IS TO APPLY HFE PRINCIPLES AND CRITERIA THROUGHOUT MMI DESIGN PROCESS [10CFR50.34 PARAGRAPH (F)(2)(xxx)]
- UTILIZATION OF TASK ANALYSIS RESULTS AS PRELIMINARY TEST AND GUIDE TO DESIGN
- HUMAN ENGINEERING GUIDANCE TO DESIGNERS PROVIDED THROUGH HF STANDARDS AND GUIDELINES
- USE OF MOCK-UPS AND DYNAMIC SIMULATION PROTOTYPES FOR EVALUATION, TEST AND DEMONSTRATION OF MMI

DIFFERENCES

- ADEQUATE HUMAN PERFORMANCE WILL BE VALIDATED USING FULL SCOPE SIMULATION VS. EXHAUSTIVE ANALYTICAL EFFORTS (BEYOND TASK ANALYSIS) TO QUANTIFY HUMAN PERFORMANCE
- CHOICE OF METHODS, MEASURES, LEVEL OF DETAIL

PROPOSED RESOLUTION

- MMI DESIGN DOCUMENTATION FOR REMAINING PANELS (INCLUDING DOCUMENTS IDENTIFIED IN ELEMENT A)

COMPARISON OF NUPLEX 80+ DESIGN PROCESS TO NRC DRAFT REVIEW CRITERIA

ELEMENT H - HF VERIFICATION AND VALIDATION

SIMILARITIES

- GOAL IS TO DEMONSTRATE ACCEPTABILITY OF MMI DESIGNS
- VERIFICATION OF SUITABILITY USING STATIC AND PART-TASK DESIGNS OF INDIVIDUAL ELEMENTS
- VERIFICATION OF AVAILABILITY OF INFORMATION AND CONTROLS AFFORDED BY MMI
- DYNAMIC VALIDATION OF THE MMI ENSEMBLE
- DESIGN REVISIONS WHERE NECESSARY

DIFFERENCES

- NO SIGNIFICANT DIFFERENCES

COMPARISON OF NUPLEX 80+ DESIGN PROCESS TO NRC DRAFT REVIEW CRITERIA

SUMMARY

- ALL ELEMENTS OF THE NRC PROGRAM EXIST IN THE ABB-CE PROGRAM
- NRC PROCESS FOR EACH ELEMENT DOES NOT CREDIT THE EVOLUTIONARY NATURE OF THE DESIGN AND, THEREFORE, THE APPLICABILITY OF OPERATING EXPERIENCE
- THE NUPLEX 80+ DESIGN BASIS WITH SUPPLEMENTAL REPORTS SUBMITTED TO DATE PROVIDE AN ADEQUATE BASIS TO JUDGE THE ACCEPTABILITY OF THE GENERIC NUPLEX 80+ DESIGN FEATURES
- VERIFICATION AND VALIDATION OF THE INTEGRATED DESIGN IS AN EFFECTIVE METHOD TO ENSURE THE FINAL DESIGN PRODUCT HAS MET ABB-CE AND NRC GOALS FOR SAFE AND RELIABLE OPERATION
- WHEN REVIEWED, ABB-CE IS CONFIDENT THAT THE STAFF WILL FIND NUPLEX 80+ TO BE A SIGNIFICANT IMPROVEMENT OVER THE CURRENT GENERATION OF CONTROL ROOMS
- ADDITIONAL ANALYSIS AND DOCUMENTATION MAY ASSIST THE STAFF IN ESTABLISHING A FORMAL BASIS FOR THEIR REVIEW BUT WILL DO LITTLE TO IMPROVE THE SAFETY OR OPERABILITY OF THE END PRODUCT
- NRC DRAFT REVIEW CRITERIA DOES NOT PERMIT CLOSURE OF ANY OF THE REVIEW PROCESS ELEMENTS AT TIME OF CERTIFICATION

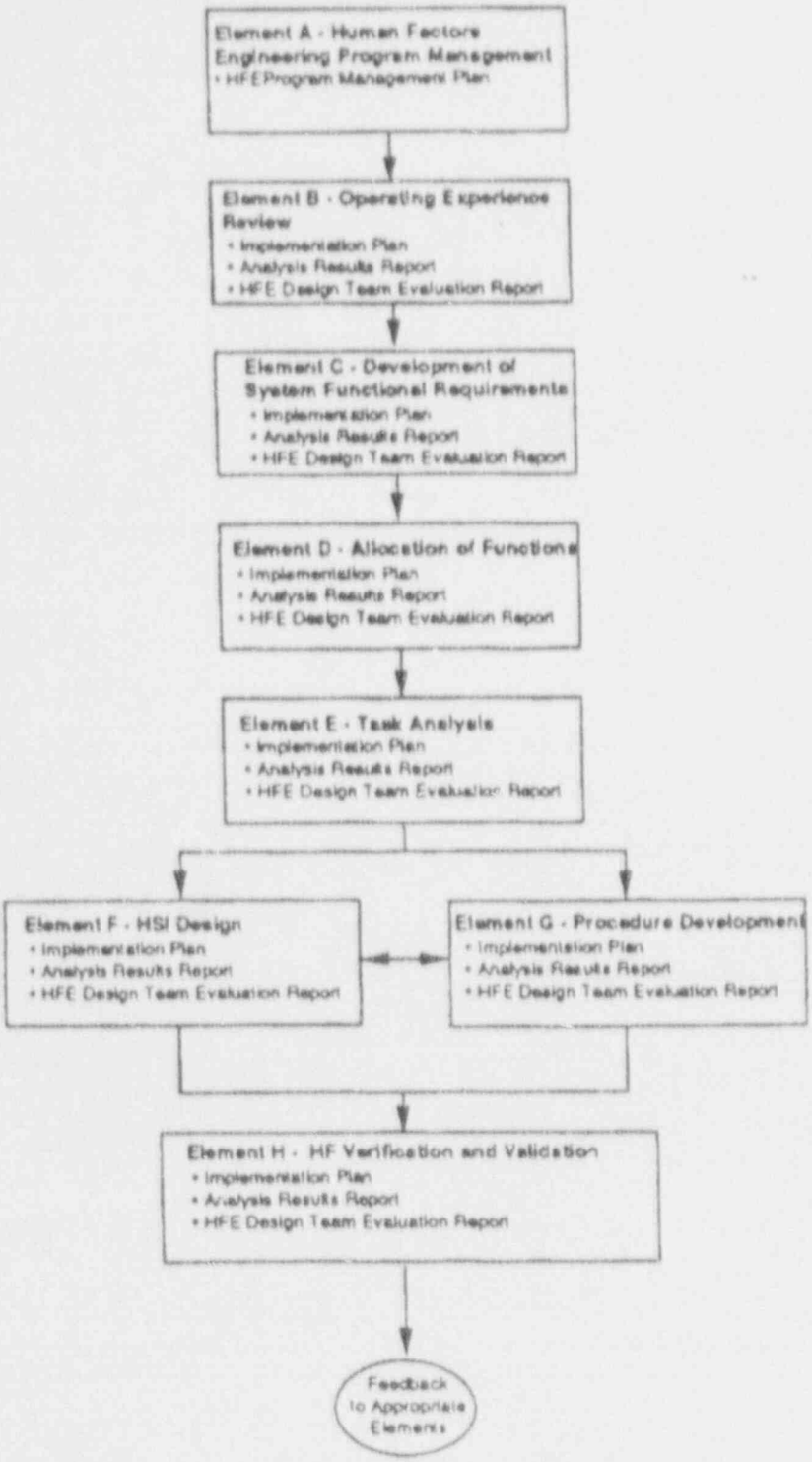


Figure 1. HFE Elements

(Draft 4/17/92)

Enclosure 3

APPENDIX A

HFE PROGRAM REVIEW MODEL AND ACCEPTANCE CRITERIA

APPENDIX A
CONTENTS

Page

A1 MODEL DEVELOPMENT

A1.1 Objectives

As indicated in TER Section 2, one issue to emerge from the DSER review was that detailed HSI design information would not be available for review prior to design certification and that certification would be based partially on the approval of a design and implementation process plan. The process must contain: (1) descriptions of all required HFE program elements for the design, development and implementation of the ABWR human-system interfaces, (2) identification of predetermined NRC conformance review points, and (3) design acceptance criteria (DAC) and Inspection, Test, Analysis and Acceptance Criteria (ITAAC) for the conformance reviews.

To review the GE's process, it was necessary to: (1) assess whether all the appropriate HFE elements were included, (2) identify what materials needed to be reviewed for each element, and (3) evaluate the proposed DAC/ITAAC to verify each of the elements. Since a process review has not been conducted previously by the NRC as part of reactor licensing and is not addressed in the presently available guidance, i.e., NUREG-0800, a firm technical basis for such a review was not available. To conduct the review, it was important to identify which aspects of the process are required to assure that safety goals are achieved and to identify the review criteria by which each element can be assessed. Review criteria independent of that provided by GE was required to assure that GE's plan reflects currently acceptable human factors engineering practices and that it is a thorough, complete, and workable plan. Thus, a technical basis for review of the process was developed and is described in this section. The specific objectives of this effort were:

1. To develop HFE program review model to serve as a technical basis for the review of the process proposed for certification by GE. The model requirements were that it be: (1) based upon currently accepted practices, (2) well-defined, and (3) validated through experience with the development of complex, high-reliability systems.

2. To identify the HFE elements in a system development, design, and evaluation process that are necessary and sufficient requisites to successful integration of the human component in complex systems.

3. To identify which aspects of each HFE element are key to a safety review and are requires to monitor the process.

4. To specify the specific acceptance criteria by which HFE elements can be evaluated.

A1.2 Scope

The scope of the HFE Program Review Model was restricted by two factors. First, those elements of a complete HFE program that are already adequately addressed by existing NRC requirements for license applicants were excluded from the scope of the model. Included in this category were training program development and the details of procedure development. The second category of exclusion were those elements that are the responsibility of other NRC review teams. This category includes human reliability analysis which, while important to HFE program development, is the responsibility of the SSAR Chapter 19 reviewers. Therefore, the scope of the model development described below was restricted to those aspects of HFE design review remaining after the above elements are excluded.

A1.3 Development Method

A technical review of current HFE guidance and practices was conducted to identify important human factors program plan elements relevant to a design process review. Sources reviewed included a wide range of nuclear industry and non-nuclear industry documents, including those currently under development as part of the Department of Defense (DoD) MANPRINT program. From this review a generic system development, design, and evaluation process was defined. Once specified, key HFE elements were identified and criteria by which they are assessed (based upon a review of current literature and accepted practices in the field of human factors engineering) were developed.

A generic HFE Program Review Model was developed based largely on applied general systems theory and the Department of Defense (DoD) system development process (which is rooted in systems theory). Applied general systems theory provides a broad approach to system design and development, based on a series of clearly defined developmental steps, each with clearly defined and goals, and with specific management processes to attain them. System engineering has been defined as "...the management function which controls the total system development effort for the purpose of achieving an optimum balance of all system elements. It is a process which transforms an operational need into a description of system parameters and integrates those parameters to optimize the overall system effectiveness (Kockler, F., Withers, T., Podiack, J., and Gierman, M., 1990).

Utilization of the DoD system development as an input to the development of the Generic HFE Program Model was based on several factors. DoD policy identifies the human as a specific element of the total system (DoD, 1990a). A system approach implies that all system components (hardware, software, personnel, support, procedures, and training) are given adequate consideration in the developmental process. A basic assumption is that the personnel element receives serious consideration from the very beginning of the design process. In addition, the military has applied HFE for the longest period of time (as compared with industrial/commercial system developers), thus the process is highly evolved and formalized and represents the most highly developed model available. Finally, since military system development and acquisition is tightly regulated by federal, DoD, and military branch laws, regulations, requirements, and standards, the model provides the most finely grained, specifically defined HFE process available.

Within the DoD system, the development of a complex system begins with the mission or purpose of the system, and the capability requirements needed to satisfy mission objectives. Systems engineering is essential in the earliest planning period to develop the system concept and to define the system requirements. During the detailed design of the system, systems engineering assures:

- balanced influence of all required design specialties;
- resolution of interface problems;
- the effective conduct of trade-off analyses;
- the effective conduct of design reviews; and
- the verification of system performance.

The effective integration of HFE considerations into the design is accomplished by: (1) providing a structured top-down approach to system development which is iterative, integrative, interdisciplinary and requirements driven and (2) providing a management structure which details the HFE considerations in each step of the overall process. A structured top-down approach to NPP HFE is consistent with the approach to new control room design as described in Appendix B of NUREG-0700 and the more recent internationally accepted standard, IEC 964, for advanced control room design. The approach is also

consistent with the recognition that human factors issues and problems emerge throughout the NPP design and evaluation process and therefore, human factors issues are best addressed with a comprehensive top-down program.

The systems engineering approach was expanded to develop a HFE Program Review Model to be used for the ABWR design and implementation process review by the incorporation of NRC HFE requirements. The model was developed independent from the GE design process. Following the development of the model it was revised through iterations with NRC.

A2 GENERAL MODEL DESCRIPTION

In this section an overview of the model is presented to generally describe the HFE elements, products reviewed for each element, and the acceptance criteria used to evaluate the element. A more detailed description of the elements are presented in Appendix A.

The model is intended as the programmatic approach to achieving a design commitment to HFE. The overall commitment and scope of the HFE effort can be stated as follows: Human-system interfaces (HSI) shall be provided for the operation, maintenance, test, and inspection of the ABWR that reflect "state-of-the-art human factors principles" (10 CFR 50.34(f)(2)(iii)) as required by 10 CFR 52.47(a)(1)(ii). For the purposes of model development "state of the art" human factors principles are defined as those principles currently accepted by human factors practitioners. "Current" is defined with reference to the time at which this model was developed. "Accepted" is defined as a practice, method, or guide which is (1) documented in the human factors literature within a standard or guidance document that has undergone a peer-review process, and/or (2) justified through scientific/industry research practices.

All aspects of HSI should be developed, designed, and evaluated based upon a structured top-down system analysis using accepted HFE principles based upon current HFE practices. HSI is used here in the very broad sense and shall include all operations, maintenance, test, and inspection interfaces, procedures, and training materials.

The model developed to achieve this commitment contains eight elements:

- Element 1 - Human Factors Engineering Program Management
- Element 2 - Operating Experience Review
- Element 3 - System Functional Requirements Analysis
- Element 4 - Allocation of Function
- Element 5 - Task Analysis
- Element 6 - Human-System Interface Design
- Element 7 - Plant and Emergency Operating Procedure Development
- Element 8 - Human Factors Verification and Validation.

The elements and their interrelationships are illustrated in Figure A.1. Also illustrated are the minimal set of items submitted to the NRC for review of the COL's HFE efforts. All NRC review items are identified as falling into one of the five review stages:

- HF Management Planning Review
- Implementation Plan Review
- Analysis Results Review

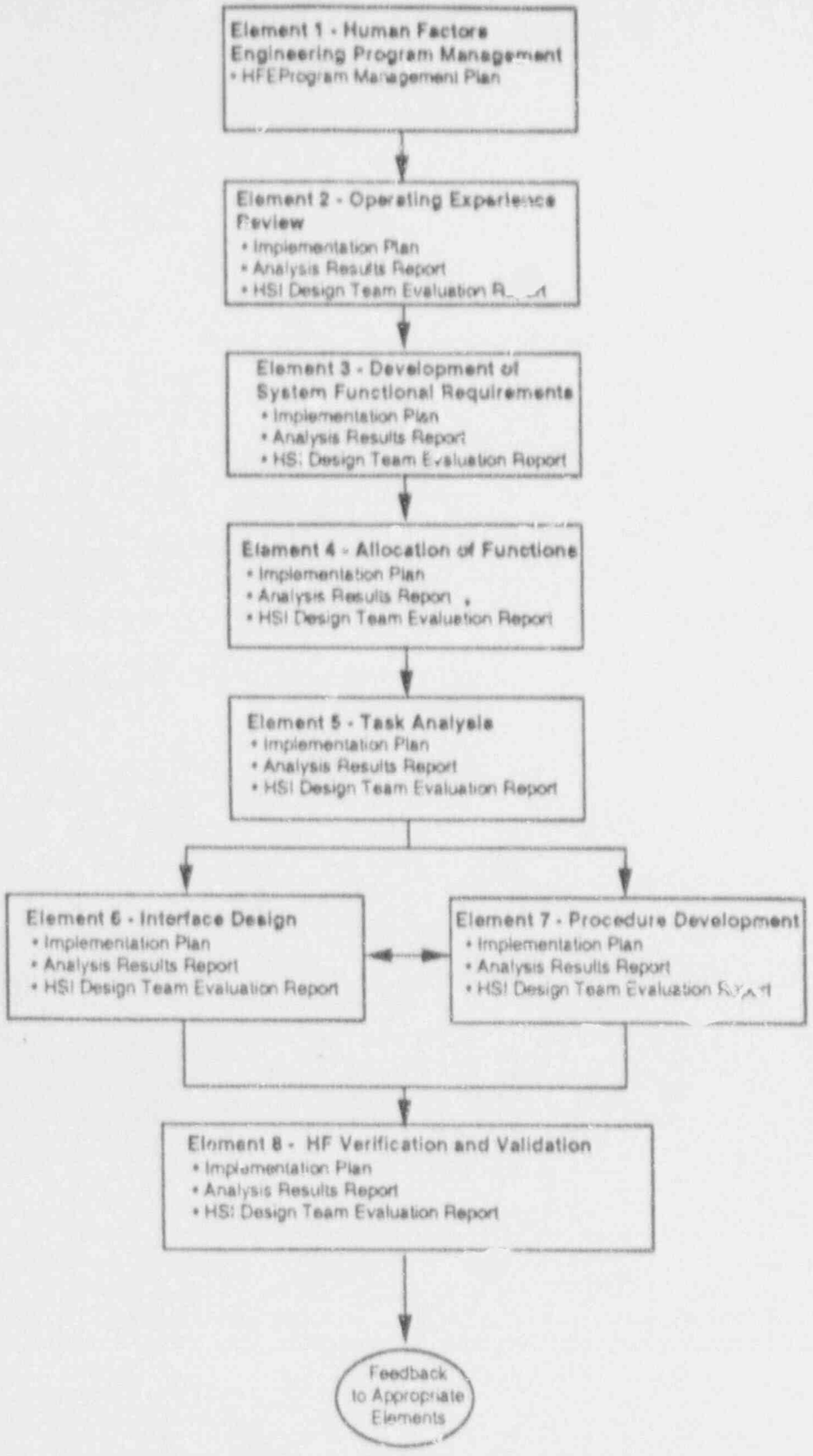


Figure A1. HFE Program Review Model Elements

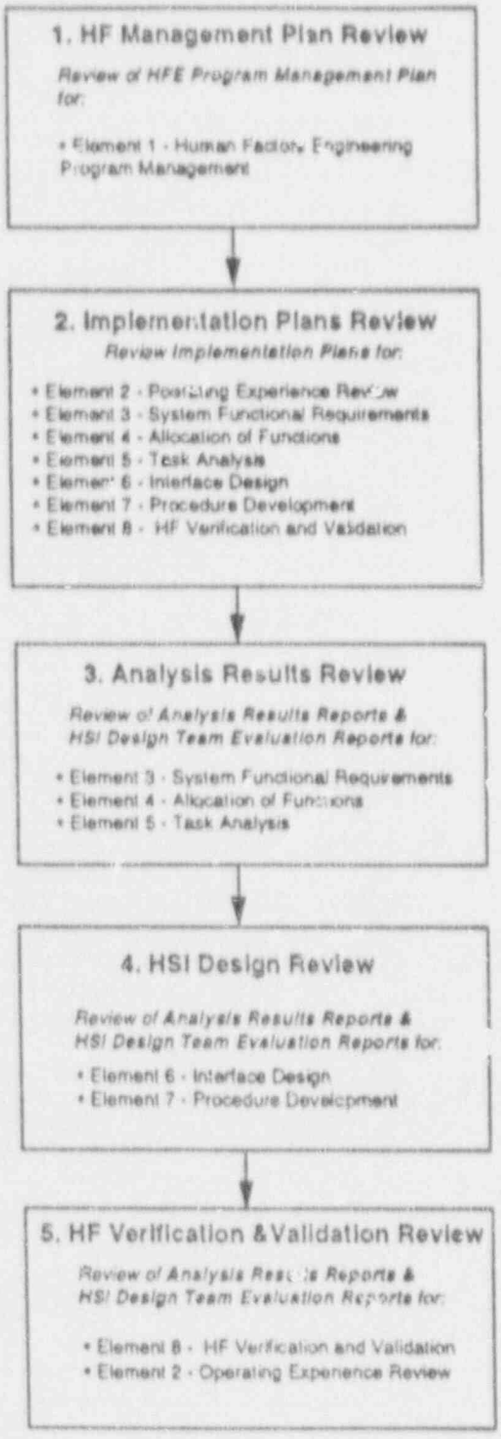


Figure A2. HFE Program Review Stages

- HSI Results Review
- Human Factors Verification and Validation

The materials reviewed at each stage are shown in Figure A.2.

A brief description of the purpose of each element follows:

Element 1 - Human Factors Engineering Program Management

To assure the integration of HFE into system development and the achievement of the goals of the HFE effort, a HFE Design Team and a HFE Program Plan shall be established to assure the proper development, execution, oversight, and documentation of the human factors engineering program. As part of the program plan an HFE issues tracking system (to document and track HFE related problems/concerns/issues and their solutions throughout the HFE program) will be established.

Element 2 - Operating Experience Review

The accident at Three Mile Island in 1979 and other reactor incidents have illustrated significant problems in the actual design and the design philosophy of NPP HSIs. There have been many studies as a result of these accidents/incidents. Utilities have implemented both NRC mandated changes and additional improvements on their own initiative. However, the changes were formed based on the constraints associated with backfits to existing control rooms (CRs) using early 1980s technology which limited the scope of corrective actions that might have been considered, i.e., more effective fixes could be used in the case of a designing a new CR with the modern technology typical of advanced CRs. Problems and issues encountered in similar systems of previous designs shall be identified and analyzed so that they are avoided in the development of the current system or, in the case of positive features, to ensure their retention.

Element 3 - System Functional Requirements Analysis

System requirements shall be analyzed to identify those functions which must be performed to satisfy the objectives of each functional area. System function analysis shall: (1) determine the objective, performance requirements, and constraints of the design; and (2) establish the functions which must be accomplished to meet the objectives and required performance.

Element 4 - Allocation of Function

The allocation of functions shall take advantage of human strengths and avoids allocating functions which would be impacted by human limitations. To assure that the allocation of function is conducted according to accepted HFE principles, a structured and well-documented methodology of allocating functions to personnel, system elements, and personnel-system combinations shall be developed.

Element 5 - Task Analysis

Task analysis shall provide the systematic study of the behavioral requirements of the tasks the personnel subsystem is required to perform in order to achieve the functions allocated to them. The task analysis shall:

- provide one of the bases for making design decisions; e.g., determining before hardware fabrication, to the extent practicable, whether system performance requirements can be met by combinations of anticipated equipment, software, and personnel,
- assure that human performance requirements do not exceed human capabilities,
- be used as basic information for developing procedures,
- be used as basic information for developing manning, skill, training, and communication requirements of the system, and
- form the basis for specifying the requirements for the displays, data processing and controls needed to carry out tasks.

Element 6 - Human-System Interface Design

Human engineering principles and criteria shall be applied along with all other design requirements to identify, select, and design the particular equipment to be operated/maintained/controlled by plant personnel.

Element 7 - Plant and Emergency Operating Procedure Development

Plant and Emergency Operating Procedures shall be developed to support and guide human interaction with plant systems and to control plant-related events and activities. Human engineering principles and criteria shall be applied along with all other design requirements to develop procedures that are technically accurate, comprehensive, explicit, easy to utilize, and validated. The types of procedures covered in the element are:

- plant and system operations (including start-up, power, and shutdown operations),
- abnormal & emergency operations,
- preoperational, start-up, and surveillance tests, and
- alarm response.

Element 8 - Human Factors Verification and Validation

The successful incorporation of human factors engineering into the final HSI design and the acceptability of the resulting HSI shall be thoroughly evaluated as an integrated system using HFE evaluation procedures, guidelines, standards, and principles.

The specification for the NRC review materials and the acceptance criteria to be used for their evaluation are identified in the next section. Generically, each element is divided into three sections: Design Commitment, Inspection/Test/Analysis, and Design Acceptance Criteria.

Design Commitment

A concise and general statement as to the HFE objective of the Element.

Inspection/Test/Analysis

A specification of the inspections, tests, analysis, or other actions (i.e., some action that is required but which is not a specific inspection, test, or analysis, such as development of a program plan) to assure the achievement of the objective. Generally these are divided into three activities: planning, "analysis," and review. The set of materials to be provided to the NRC for review of the element is specified.

Design Acceptance Criteria

Acceptance criteria are typically divided into four sections: General Criteria, Implementation Plan, Analysis Report, and HFE Design Team Review Report. The General Criteria represent the major statement of design acceptance criteria. These are the criteria the element is required to meet and which should govern the Implementation Plan, Analysis Report, and HFE Design Team Review Report development. The general criteria are derived from accepted HFE practices. These are the criteria derived from the HFE model development and HFE literature and current practices review. Applicable guidance documents are referenced.

A3 ELEMENT DESCRIPTION AND ACCEPTANCE CRITERIA

A3.1 Element 1 - Human Factors Engineering Program Management

DESIGN COMMITMENT:

Human-system interfaces (HSI) shall be provided for the operation, maintenance, test, and inspection of the ABWR that reflect "state-of-the-art human factors principles" (10 CFR 50.34(f)(2)(iii)) as required by 10 CFR 52.47(a)(1)(ii). All aspects of HSI shall be developed, designed, and evaluated based upon a structured top-down system analysis using accepted human factors engineering (HFE) principles based upon current HFE practices. HSI is used here in the broad sense and shall include all operations, maintenance, test, and inspection interfaces, procedures, and training needs. The tier 1 commitment addresses main control room and remote shutdown system functions and equipment. Local control stations should be included in the overall program.

State of the art human factors principles is defined as those principles currently accepted by human factors practitioners. "Current" is defined with reference to the time at which a program management or implementation plan is prepared. "Accepted" is defined as a practice, method, or guide which is (1) documented in the human factors literature within a standard or guidance document that has undergone a peer-review process and/or (2) can be justified through scientific/industry research/practices.

INSPECTION/TEST/ANALYSIS:

To assure the integration of HFE into system development: a HFE Design Team shall be established and a HFE Program Plan shall be established to assure the proper development, execution, oversight, and documentation of the human factors engineering program.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. The primary goal of the HFE program shall be to developing an HSI which makes possible safe, efficient, and reliable operator performance and which satisfy all regulatory requirements as stated in 10 CFR. The general objectives of this program shall be stated in "human-centered" terms which, as the HFE program develops, shall be objectively defined and shall serve as criteria for test and evaluation activities. Generic "human-centered" HFE design goals include:

   - The operating team can accomplish all assigned tasks within system defined time and performance criteria.
   - The system and allocation of functions will provide acceptable workload levels to assure vigilance and to assure no operator overload.
   - The system will support a high degree of operating crew "situation awareness."
   - Signal detection and event recognition requirements will be kept within the operators' information processing limits and will minimize the need for operators to mentally transform data in order to be usable.
   - The system will minimize operator memory load.
   - The operator interfaces will minimize operator error and will provide for error detection and recovery capability.

2. The program shall be developed using the following documents as guidance:

<List to be developed>

HFE Design Team

1. An HFE Design Team shall have the responsibility, authority and placement within the organization (as defined below) to ensure that the design commitment is achieved.

2. The team shall be responsible for (1) the development of all HFE plans and procedures; (2) the oversight and review of all HFE design, development, test, and evaluation activities; (3) the initiation, recommendation, and provision of solutions through designated channels for problems identified in the implementation of the HFE activities; (4) verification of implementation of team recommendations, (5) assurance that all HFE activities comply to the HFE plans and procedures, and (7) scheduling of activities and milestones.

3. The scope of the Team's responsibility shall include:

   - Control and instrumentation equipment
   - all operations, maintenance, test, and inspection interfaces and facilities both within and outside the control room,
   - procedures
   - training requirements development.

The team shall have the authority and organizational freedom to ensure that all its responsibility are accomplished and to identify problems in the implementation of the HSI

design. The team shall have the authority to determine where its input is required, access work areas, design documentation. The Team shall have the authority to control further processing, delivery, installation or use of HFE/HSI products until the disposition of a non-conformance, deficiency or unsatisfactory condition has been achieved.

5. The HFE Team shall be placed at the level in the COL organization required to execute its responsibilities and authorities. The team shall report to a level of management such that required authority and organizational freedom are provided, including sufficient independence from cost and schedule considerations.

6. The HFE design team shall include the following expertise:

Technical Project Management

- Bachelor's degree,
- five years' experience in nuclear power plant design or operations, and
- three years' management experience.

Systems Engineering

- Bachelor's of Science degree, and
- four years' cumulative experience in at least three of the following areas of systems engineering; design, development, integration, operation, and test and evaluation.

Nuclear Engineering

- Bachelor's of Science degree, and
- four years' nuclear design, development, test or operations experience

Control and Instrumentation Engineering

- Bachelor's of Science degree,
- four years' experience in design of process control systems, and
- experience in at least one of the following areas of C&I engineering; development, power plant operations, and test and evaluation.

Architect Engineering

- Bachelor's of Science degree, and
- four years' experience in design of power plant control rooms.

Human Factors

- Bachelor's degree in human factors engineering, engineering psychology or related science,
- four years' cumulative experience related to the human factors aspects of human-computer interfaces. Qualifying experience shall include experience in at lease two of the following human factors related activities; design, development, and test and evaluation, and

- four years' cumulative experience related to the human factors field of ergonomics. Again, qualifying experience shall include experience in at least two of the following areas of human factors activities: design, development, and test and evaluation.

Plant Operations

- Have or have held a Senior Reactor Operator license, and
- two years' experience in BWR nuclear power plant operations.

Computer System Engineering

- Bachelor's degree in Electrical Engineering or Computer Science, or graduate degree in other engineering discipline (e.g., Mechanical Engineering or Chemical Engineering), and
- four years' experience in the design of digital computer systems and real time systems applications.

Plant Procedure Development

- Bachelor's degree, and
- four years' experience in developing nuclear power plant operating procedures.

Personnel Training

- Bachelor's degree,
- four years' experience in the development of personnel training programs for power plants, and
- experience in the application of systematic training development methods.

Systems Safety Engineering

- Bachelor's degree in Science,
- certification by the Board of Certified Safety Professionals in System Safety, and
- four years' experience in System Safety Engineering.

Reliability/Availability/Maintainability/Inspectability (RAMI) Engineering Maintainability/Inspectability Engineering

- Bachelor's of Science degree,
- four years' cumulative experience in at least two of the following areas of power plant maintainability and inspectability engineering activity; design, development, integration and test and evaluation, and
- experience in analyzing and resolving plant system and/or equipment related maintenance problems.

Reliability/Availability Engineering

- Bachelor's degree,
- four years' cumulative experience in at least two of the following areas of power plant reliability engineering activity; design, development, integration, and test and evaluation, and
- knowledge of computer-based, human-interface systems.

7. The education and related professional experience of the HFE design team personnel shall satisfy the minimum personal qualification requirements specified in (6) above, for each of the areas of required skills. In those skill areas where related professional experience is specified, qualifying experience of the individual HFE design team personnel shall include experience in the technologies and techniques, of the particular skill area, utilized in the HSI design and implementation activities. The required professional experience presented in those personal qualifications are to be satisfied by the HFE design team as a collective whole. Therefore, satisfaction of the professional experience requirements associated with a particular skill area may be realized through the combination of the professional experience of two or more members of the HFE design team who each, individually, satisfy the other defined credentials of the particular skill area but who do not possess all of the specified professional experience. Similarly, an individual member of the HFE design team may possess all of the credentials sufficient to satisfy the qualification requirements for two or more of the defined skill areas.

8. Alternative personal credentials may be accepted as the basis for satisfying the minimum personal qualification requirements specified in 6 above. Acceptance of such alternative personal credentials shall be evaluated on a case-by-case basis and approved, documented and retained in auditable plant construction files by the COL Applicant. The following factors are examples of alternative credentials which are considered acceptable:

   - A Professional Engineer's license in the required skill area may be substituted for the required Bachelor's degree.
   - Successful completion of all technical portions of an engineering, technology or related science ~~college~~ Baccalaureate degree program may be substituted for the Bachelor's degree. The courses shall be in appropriate technical subjects relevant to the required skill areas of the HFE MMIS Design Team for which the individual will be responsible.
   - Related experience may substitute for education at the rate of six semester credit hours for each year of experience up to a maximum of 60 hours credit.
   - Where course work is related to job assignments, post secondary education may be substituted for experience at the rate of two years of education for one year experience. Total credit for post secondary education shall not exceed two years experience credit.

For example, 90 semester credit hours may be substituted for the Baccalaureate requirement.

HFE Issue Tacking System

1. The tracking system shall address human factors issues that are (1) known to the industry (defined in the operating experience review,see Element 2) and (2) those identified throughout the life cycle of the ABWR system design, development and evaluation.

2. The method shall document and track human factors engineering issues and concerns, from identification until elimination or reduction to a level acceptable to the review team.

3. Each issue/concern that meets or exceeds the threshold effects established by the review team shall be entered on the log when first identified, and each action taken to eliminate or reduce the issue/concern should be thoroughly documented. The final resolution of the issue/concern, as accepted by the review team, shall be documented in detail, along with information regarding review team acceptance (e.g., person accepting, date, etc.).

3. Each issue/concern that meets or exceeds the threshold effects established by the review team shall be entered on the log when first identified, and each action taken to eliminate or reduce the issue/concern should be thoroughly documented. The final resolution of the issue/concern, as accepted by the review team, shall be documented in detail, along with information regarding review team acceptance (e.g., person accepting, date, etc.).

4. The tracking procedures shall carefully spell out individual responsibilities when an issue/concern is identified, identify who should log it, who is responsible for tracking the resolution efforts, who is responsible for acceptance of a resolution, and who should enter closeout data.

HFE Program and Management Plan

1. An HFE Program Management plan shall be developed to describe how the human factors program shall be accomplished, i.e., the plan shall describe the HFE Team's organization and composition and which lays out the effort to be undertaken and provides a technical approach, schedule, and management control structure and technical interfaces to achieve the HFE program objectives. The plan is the single document which describes the designer's entire HFE program, identifies its elements, and explains how the elements will be managed. Generally, it shall address:

   - The scope of the HFE Design Team's authority within the broader scope of the organization responsible for plant construction. Included within this scope shall be the authority to suspend from delivery, installation, or operation any equipment which is determined by the Team to be deficient in regard to established human factors design practices and evaluation criteria.

   - The process through which the Team will execute its responsibilities.

   - The processes through which findings of the Team are resolved and how equipment design changes that may be necessary for resolution are incorporated into the actual equipment ultimately used in the plant.

   - The members and qualification of the team members.

   - The process through which the Team activities will be assigned to individual team members, the responsibilities of each team member and the procedures that will govern the internal management of the team.

   - The procedures and documentation requirements of the HFE Issues Tracking System.

2. The HFE Program Management Plan shall provide the following information:

   1. Purpose and organization of the plan
   2. Literature and current practices review
   3. Overall HFE program goals and objectives
   4. The relationship between the HFE program and the overall plant design program (organization and schedule).
   5. HFE Design Team

- Organization within the HFE program

  - Identify and describe the primary HFE organization or function within the organization of the total program, including charts to show organizational and functional relationships, reporting relationships, and lines of communication.

- Functions and internal structure of the HFE Organization

  - Describe the responsibility, authority and accountability of the HFE organization.
  - Identify the organizational unit responsible for each HFE task.
  - Describe the process through which management decisions will be made regarding HFE.
  - Describe the process through which design decisions will be made regarding HFE
  - Describe all tools and techniques (e.g., review forms, documentation) to be utilized by the Team to ensure they fulfill their responsibilities.

- Staffing

  - Describe the staffing of the HFE Team.
  - Provide job descriptions of personnel of the HFE Team.
  - Indicate the assignment of key personnel and provide their qualifications with regard to the areas of expertise indicated above.

6. HFE Issue Tracking System

- Literature and current practices review
- Responsibilities

  - Responsibilities on Issue Identification
  - Responsibilities for Issue Logging
  - Responsibilities for Issue Resolution
  - Responsibilities for Issue Closeout

- Procedures

  - Issue identification
    - Description
    - Effects
    - Criticality and Likelihood
  - Issue resolution
    - Proposed Solutions
    - Implemented Solution
    - Residual Effects
    - Resultant Criticality and Likelihood

- Documentation
- Audit of the issue identification and tracking system

7. HFE Requirements

- Identify and describe the HFE requirements imposed on the design process
- List the standards and specifications which are sources of HFE requirements

8. HFE program

Identify and describe the development of implementation plans, analyses, and evaluation/verification of:

- Operating Experience Review
- System Functional Requirements Development
- Allocation of Function
- Task Analysis
- Interface Design
- Plant and Emergency Operating Procedure Development
- HF Verification and Validation

9. HFE program milestones

- Identify HFE milestones so that evaluations of the effectiveness of the HFE effort can be made at critical check points and show the relationship to the integrated plant sequence of events.

- Provide a program schedule of HFE tasks showing:

  - relationships between HFE elements and activities.
  - reports
  - reviews

- Identify integrated design activities applicable to the HFE program but specified in other areas.

10. HFE documentation

- Identify and briefly describe each required HFE documented item.
- Identify procedures for accessibility and retention.
- Describe the supporting documentation and its audit trail maintained for NRC audits.

11. HFE in subcontractor efforts

- Provide a copy of the HFE requirements proposed for inclusion in each subcontract.
- Describe the manner in which the designer proposes to monitor the subcontractor's compliance with HFE requirements.

A3.2 Element 2 - Operating Experience Review

DESIGN COMMITMENT:

The accident at Three Mile Island in 1979 and other reactor incidents have illustrated significant problems in the actual design and the design philosophy of NPP HSIs. There have been many studies as a result of these accidents/incidents. Utilities have implemented both NRC mandated changes and additional improvements on their own initiative. However, the changes were formed based on the constraints associated with backfits to existing CRs using early 1980s technology which limited the scope of corrective actions that might have been considered, i.e., more effective fixes could be used in the case of a designing a new CR with the modern technology typical of advanced CRs. Problems and issues encountered in similar systems of previous designs shall be identified and analyzed so that they are avoided in the development of the current system or, in the case of positive features, to ensure their retention.

INSPECTION/TEST/ANALYSIS:

- An Operating Experience Review Implementation Plan shall be developed.
- An analysis of operating experience shall be conducted in accordance with the plan and the findings will be documented in an Analysis Results Report.
- The analyses shall be reviewed by the HFE Design Team and shall be documented in an Evaluation Report.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. The following industry operating experience issues shall be identified:

<List to be developed>

2. The issues shall be reviewed and analyzed for:

   - Human performance issues, problems and sources of human e shall be identified.
   - Design elements which support and enhance human performance shall be identified.

3. The following topics should be included in interviews as a minimum:

   - Display factors
   - Control factors
   - Information processing factors
   - Communication factors
   - Procedures
   - Training factors
   - Staffing and Job Design

4. The review shall include both a review of literature pertaining the human factors issues related to similar systems and operator interviews.

5. The following sources both industry wide and plant or subsystem relevant should be included in review of the identified issues:

- Government and Industry Studies of Similar Systems
- Licensee Event Reports
- Outage Analysis Reports
- Final Safety Analysis Reports and Safety Evaluation Reports
- Human Engineering Deficiencies identified in DCRDRs
- Modifications of the Technical Specifications for Operation
- Internal Memoranda/Reports as Available

6. Each operating experience issue shall be documented in the HFE Tracking System.

Implementation Plan

The plan shall describe the designer's approach to Operating Experience Review. The plan shall address the following:

- Documentation review and analysis
- User survey methodology (for conducting interviews) and analysis plans
- Method of documenting lessons learned
- Integration of lessons learned into the design process

Analysis Results Report

The report shall address the following:

- Objectives
- Description of the Methods
- Identification of any deviations from the implementation plan
- Results and Discussion
- Conclusions
- Recommendations/Implications for HSI Design

HFE Design Team Evaluation Report

The report shall address the following:

- The review methodology and procedures
- Compliance with Implementation Plan Procedures
- Review findings

A3.3 Element 3 - System Functional Requirements Analysis

DESIGN COMMITMENT:

System requirements shall be analyzed to identify those functions which must be performed to satisfy the objectives of each functional area. System function analysis shall: (1) determine the objective, performance requirements, and constraints of the design; and (2) establish the functions which must be accomplished to meet the objectives and required performance.

INSPECTION/TEST/ANALYSIS:

- A System Functional Requirements Analysis Implementation Plan shall be developed.
- An analysis of System Functional Requirements shall be conducted in accordance with the plan and the findings will be documented in an Analysis Results Report.
- The analyses shall be reviewed by the HFE Design Team and shall be documented in an Evaluation Report.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. System requirements shall determine system functions and the function shall determine the performance necessary to carry out the function.

2. Critical functions shall be defined (i.e., those functions required to achieve major system performance requirements; or those functions which, if failed, could degrade system or equipment performance or pose a safety hazard to plant personnel or to the general public),

3. Safety functions shall be identified and any functional interrelationship with non-safety systems shall be identified.

4. Functions shall be defined as the most general, yet differentiable means whereby the system requirements are met, discharged, or satisfied. Functions shall be arranged in a logical sequence so that any specified operational usage of the system can be traced in an end-to-end path.

5. Functions shall be described initially in graphic form. Function diagramming shall be done at several levels, starting at a "top level" where a very gross picture of major functions is described, and continuing to decompose major functions to several lower levels until a specific critical end-item requirement will emerge, e.g., a piece of equipment, software, or an operator.

6. Detailed narrative descriptions shall be developed for each of the identified functions and for the overall system configuration design itself. Each function shall be identified and described in terms of inputs (observable parameters which will indicate system status), functional processing (control process and performance measures required to achieve the function), outputs, feedback (how to determine correct discharge of function), and interface requirements from the top down so that subfunctions are recognized as part of larger functional areas.

7. Functional operations or activities shall include:

- detecting signals
- measuring information
- comparing one measurement with another
- processing information
- acting upon decisions to produce a desired condition or result on the system or environment (e.g., system and component operation, actuation, and trips)

8. The function analysis shall be kept current over the life cycle of design development.

9. Verification

- All the functions necessary for the achievement of operational and safety goals are identified.
- All requirements of each function are identified.

10. The effort shall be performed using the following documents as guidance:

<List to be developed>

Implementation Plan

The plan shall describe the designer's approach to System Functional Requirements Analysis. The System Functional Requirements Analysis Implementation Plan shall address:

- Literature and current practices review
  - Describe the technical basis for the plan.
- List required system level functions
  - Based on System Performance Requirements.
- Graphic function descriptions
  - e.g., Functional Flow Block Diagrams and Time Line Diagrams
- Detailed function narrative descriptions addressing:
  - Observable parameters which will indicate system status
  - Control process and measure/data required to achieve the function
  - How to determine proper discharge of function
- Analysis
  - Define an integration of subfunctions that are closely related so that they can be treated as a unit
  - Divide identified subfunctions into two groups

- Common achievement is an essential condition for the accomplishment of a higher level function
- Alternative supporting functions to a higher level function or whose accomplishment is not necessarily a requisite for higher level function
- Identify for each integrated subfunction:

  * Logical requirements for accomplishment (Why accomplishment is required)
  * Control actions necessary for accomplishment
  * Parameters necessary for control action
  * Criteria for evaluating the result of control actions
  * Parameters necessary for the evaluation
  * Evaluation criteria
  * Criteria for choosing alternatives

- Identify characteristic measurement and define for each measurement important factors such as Load, Accuracy, Time factors, Complexity of action logic, Types and complexities of decision making, Impacts resulting from the loss of function and associated time factors.

- Verification

  - Describe system function verification methodology.

Analysis Results Report

The report shall address the following:

- Objectives
- Description of the Methods
- Identification of any deviations from the implementation plan
- Results and Discussion
- Conclusions
- Recommendations/Implications for HSI Design

HFE Design Team Evaluation Report

The report shall address the following:

- The review methodology and procedures
- Compliance with Implementation Plan Procedures
- Review findings

A3.4 Element 4 - Allocation of Function

DESIGN COMMITMENT:

The allocation of functions shall take advantage of human strengths and avoids allocating functions which would be impacted by human limitations. To assure that the allocation of function is conducted according to accepted HFE principles, a structured and well-documented methodology of allocating functions to personnel, system elements, and personnel-system combinations shall be developed.

INSPECTION/TEST/ANALYSIS:

- An Allocation of Function Implementation Plan shall be developed.
- An analysis of Allocation of Function shall be conducted in accordance with the plan and the findings will be documented in an Analysis Results Report.
- The analyses shall be reviewed by the HFE Design Team and shall be documented in an Evaluation Report.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. All aspects of system and functions definition must be analyzed in terms of resulting human performance requirements based on the expected user population.
2. The allocation of functions to personnel, system elements, and personnel-system combinations shall be made reflect (1) sensitivity, precision, time, and safety requirements, (2) required reliability of system performance, and (3) the number and level of skills of personnel required to operate and maintain the system.
3. The allocation criteria, rational, analyses, and procedures shall be documented.
4. As alternative allocation concepts are developed, analyses and trade-off studies shall be conducted to determine optimum configurations of personnel- and system- performed functions. Analyses shall confirm that the personnel elements can properly perform tasks allocated to them while maintaining operator situation awareness, workload, and vigilance. Proposed function assignment shall take the maximum advantage of the capabilities of human and machine without imposing unfavorable requirements on either.
5. Functions shall be re-allocated in an iterative manner, in response to developing design specifics and the outcomes of on-going analyses and trade studies.
6. Function assignment shall be evaluated.
7. The effort shall be performed using the following documents as guidance:

<List to be developed>

Implementation Plan

The plan shall describe the designer's approach to Allocation of Function. The Allocation of Function Implementation Plan shall address:

- Establishment of a structured basis for function allocation
- Alternative systems analyses
  - Specification of criteria for selection
- Trade studies
  - Define objectives and requirements
  - Identify alternatives
  - Formulate selection criteria
  - Weight criteria
  - Prepare utility functions
  - Evaluate alternatives
  - Perform Sensitivity Check
  - Select Preferred Alternatives
- Evaluation of function assignment
  - The plan shall describe the tests and analyses that will be performed to evaluate the function allocation

Analysis Results Report

The report shall address the following:

- Objectives
- Description of the Methods
- Identification of any deviations from the implementation plan
- Results and Discussion
- Conclusions
- Recommendations/Implications for HSI Design

HFE Design Team Evaluation Report

The report shall address the following:

- The review methodology and procedures
- Compliance with Implementation Plan Procedures
- Review findings

A3.5 Element 5 - Task Analysis

DESIGN COMMITMENT:

Task analysis shall identify the behavioral requirements of the tasks the personnel subsystem is required to perform in order to achieve the functions allocated to them. A task shall be a group of activities that have a common purpose, often occurring in temporal proximity, and which utilize the same displays and controls. The task analysis shall:

- provide one of the bases for making design decisions; e.g., determining before hardware fabrication, to the extent practicable, whether system performance requirements can be met by combinations of anticipated equipment, software, and personnel,
- assure that human performance requirements do not exceed human capabilities,
- be used as basic information for developing manning, skill, training, and communication requirements of the system, and
- form the basis for specifying the requirements for the displays, data processing and controls needed to carry out tasks.

INSPECTION/TEST/ANALYSIS:

- A Task Analysis Implementation Plan shall be developed.

- An analysis of tasks shall be conducted in accordance with the plan and the findings will be documented in an Analysis Results Report.

- The analyses shall be reviewed by the HFE Design Team and shall be documented in an Evaluation Report.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. The scope of the task analysis shall include all operations, maintenance, test and inspection tasks. The analyses shall be directed to the full range of plant operating modes, including start-up, normal operations, abnormal operations, transient conditions, low power and shutdown conditions. The analyses shall include tasks performed in the control room as well as outside of the control room.

2. The analysis shall link the identified and described tasks in operational sequence diagrams. A review of the descriptions and operational sequence diagrams shall identify which tasks can be considered "critical" in terms of importance for function achievement, potential for human error, and impact of task failure. Human actions which are found to affect plant risk in PRA sensitivity analyses shall also be considered "critical." Where critical functions are automated, the analyses shall consider all human tasks including monitoring of an automated safety system and back-up actions if it fails.

3. Task analysis shall begin on a gross level and involve the development of detailed narrative descriptions of what personnel must do. Task analyses shall define the nature of the input,

process, and output required by and of personnel. Detailed task descriptions shall address (as appropriate):

- Information Requirements
  - Information required, including cues for task initiation
  - Information available
- Decision-Making Requirements
  - Description of the decisions to be made (relative, absolute, probabilistic)
  - Evaluations to be performed
  - Decisions that are probable based on the evaluation (opportunities for cognitive errors, such as capture error, will be identified and carefully analyzed)
- Response Requirements
  - Action to be taken
  - Overlap of task requirements (serial vs. parallel task elements)
  - Frequency
  - Speed/Time line requirements
  - Tolerance/accuracy
  - Operational limits of personnel performance
  - Operational limits of machine and software
  - Body movements required by action taken
- Feedback Requirements
  - Feedback required to indicate adequacy of actions taken
- Workload
  - Cognitive
  - Physical
  - Estimation of difficulty level
- Task Support Requirements
  - Special/protective clothing
  - Job aids or reference materials required
  - Tools and equipment required
  - Computer processing support aids
- Workplace Factors
  - Workspace envelope required by action taken
  - Workspace conditions
  - Location and condition of the work
  - Environment

- Staffing and Communication Requirements

  - number of personnel, their technical specialty, and specific skills
  - Communications required, including type
  - Personnel interaction when more than one person is involved

- Hazard Identification

  - Identification of Hazards involved

4. The task analysis shall be iterative and become progressively more detailed over the design cycle. The task analysis shall be detailed enough to identify information and control requirements to enable specification of detailed requirements for alarms, displays, data processing, and controls for human task accomplishment.

5. The task analysis results shall provide input to the personnel training programs.

6. The effort shall be performed using the following documents as guidance:

<List to be developed>

Implementation Plan

The plan shall describe the designer's approach to task analysis. The Task Analysis Implementation Plan shall address:

- General methods and data sources
- Gross task analysis

  - Convert Functions to Tasks
  - Develop Narrative Task Descriptions
  - General statement of task functions
  - Detailed task descriptions
  - Breakdown of tasks to individual activities
  - Develop Operational Sequence Diagrams

- Critical task analysis

  - Identification of Critical Tasks
  - Detailed Task Descriptions

- Information and control requirements
- Initial alarm, display, processing, and control requirements analysis

  - Develop a task-based I&C inventory

- Application of task analysis results to training development
- Evaluation of task analysis

- The plan shall describe the methods that will be used to evaluate the results of the task analysis.

Analysis Results Report

The report shall address the following:

- Objectives
- Description of the Methods
- Identification of any deviations from the implementation plan
- Results and Discussion
- Conclusions
- Recommendations/Implications for HSI Design

HFE Design Team Evaluation Report

The report shall address the following:

- The review methodology and procedures
- Compliance with Implementation Plan Procedures
- Review findings

A3.6 Element 6 - Human-System Interface Design

DESIGN COMMITMENT:

Human engineering principles and criteria shall be applied along with all other design requirements to identify, select, and design the particular equipment to be operated/maintained/controlled by plant personnel.

INSPECTION/TEST/ANALYSIS:

- A Human-System Interface Design Implementation Plan shall be developed.
- An analysis of Human-System Interface Design shall be conducted in accordance with the plan and the findings will be documented in an Analysis Results Report.
- The analyses shall be reviewed by the HFE Design Team and shall be documented in an Evaluation Report.
- -The Human-System Interface Design Implementation Plan, Analysis Results Report, and HFE

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. The design configuration shall satisfy the functional and technical design requirements and insure that the HSI will meet the appropriate HFE guidance and criteria.

2. The HFE effort shall be applied to HSI both inside and outside of the control room (local HSI).

3. HSI design shall utilize the results of the task analysis and the I&C inventory to assure the adequacy of the HSI.

4. The HSI and working environment shall be adequate for the human performance requirements it supports. The HSI shall be capable of supporting critical operations under the worst credible environmental conditions.

5. The HSI shall be free of elements which are not required for the accomplishment of any task.

6. The selection and design of HSI hardware and software approaches shall be based upon demonstrated criteria that support the achievement of human task performance requirements. Criteria can be based upon test results, demonstrated experience, and trade studies of identified options.

7. HFE standards shall be employed in HSI selection and design. Human engineering guidance regarding the design particulars shall be developed by the HSI designer to (1) insure that the human-system interfaces are designed to currently accepted HFE guidelines and (2) insure proper consideration of human capabilities and limitations in the developing system. This guidance shall be derived from sources such as expert judgement, design guidelines and standards, and quantitative (e.g., anthropometric) and qualitative (e.g., relative effectiveness of differing types of displays for different conditions) data. Procedures shall be employed to ensure HSI adherence with standards.

8. HFE/HSI problems shall be resolved using studies, experiments, and laboratory tests, e.g.

   - Mockups and models may be used to resolve access, workspace and related HFE problems and incorporating these solutions into system design
   - Dynamic simulation and HSI prototypes shall be evaluated for use to evaluate design details of equipment requiring critical human performance
   - The rationale for selection of design/evaluation tools shall be documented

9. Human factors engineering shall be applied to the design of equipment and software for maintainability, testing and inspection.

10. HSI design elements shall be evaluated to assure their acceptability for task performance and HFE, criteria, standards, and guidelines.

11. The effort shall be performed using the following documents as guidance:

<List to be developed>

Implementation Plan

The plan shall describe the designer's approach to Human-System Interface Design. The Human-System Interface Design Implementation Plan shall address:

- I&C requirements analysis and design

- Compare Task Requirements to I&C Availability
- Modifications to I&C Inventory

- General HSI approach selection

  - Trade Studies
  - Analyses

- The criteria to be used to meet General Criterion (selection and design of HSI hardware and software approaches), described above
- HFE design guidance development and documentation
- HSI detailed design and evaluations

  - Use of design/evaluation tools such as prototypes shall be specifically identified and rationale for selection

Analysis Results Report

The report shall address the following:

- Objectives
- Description of the Methods
- Identification of any deviations from the implementation plan
- Results and Discussion
- Conclusions
- Recommendations/Implications for HSI Design

HFE Design Team Evaluation Report

The report shall address the following:

- The review methodology and procedures
- Compliance with Implementation Plan Procedures
- Review findings

A3.7 Element 7 - Plant and Emergency Operating Procedure Development

DESIGN COMMITMENT:

Plant and Emergency Operating Procedures shall be developed to support and guide human interaction with plant systems and to control plant-related events and activities. Human engineering principles and criteria shall be applied along with all other design requirements to develop procedures that are technically accurate, comprehensive, explicit, easy to utilize, and validated. The types of procedures covered in the element are:

- plant & system operations (including start-up, power, and shutdown operations)
- abnormal & emergency operations
- preoperational, start-up, and surveillance tests
- alarm response

INSPECTION/TEST/ANALYSIS:

- A Plant and Emergency Operating Procedure Development Implementation Plan shall be developed.

- The procedures shall be developed in accordance with the plan and the results will be documented in a Procedure Development Report.

- The procedure development shall be reviewed by the HFE Design Team and shall be documented in an Evaluation Report.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. The task analysis shall be used to specify the procedures for operations (normal, abnormal, and emergency), test, maintenance and inspection.

2. The basis for procedure development shall include:

   - Plant design bases
   - system-based technical requirements and specifications
   - the task analyses for operations (normal, abnormal, and emergency)
   - significant human actions identified in the HRA/PRA
   - initiating events to be considered in the EOPs shall include those events present in the design bases.

3. A Writer's Guide shall be developed to establish the process for developing technical procedures that are complete, accurate, consistent, and easy to understand and follow. The Guide shall contain sufficiently objective criteria so that procedures developed in accordance with the Guide shall be consistent in organization, style, and content. The Guide shall be used for all procedures within the scope of this Element. The Writer's Guide shall provide instructions for procedure content and format (including the writing of action steps and the specification of acceptable acronym lists and acceptable terms to be used).

4. The content of the procedures shall incorporate the following elements:

   - Title
   - Statement of Applicability
   - References
   - Prerequisites
   - Precautions (including warnings, cautions, and notes)
   - Limitations and Actions
   - Required Human Actions
   - Acceptance Criteria
   - Checkoff Lists

5. All procedures shall be verified and validated. A review shall be conducted to assure procedures are correct and can be performed. Final validation of operating procedures shall be performed in a simulation of the integrated system as part of V&V activities described in Element 8.

6. An analysis shall be conducted to determine the impact of providing computer-based procedures and to specify where such an approach would improve procedure utilization and reduce operating crew errors related to procedure use.

7. The effort shall be performed using the following documents as guidance:

<List to be developed>

Implementation Plan

The Plant and Emergency Operating Procedure Development Implementation Plan shall address:

- Identification of source data/information to be used as a basis for procedure development
- Methodology for the evaluation of procedures (plan shall describe tests and analyses that will be used to evaluate procedures)
- Requirements for the effective development and use of a Procedural Writer's Guide
- Procedures for training program - procedure integration
- Verification and validation procedures
- Procedure development documentation requirements

Procedure Development Report

The report shall address the following:

- Objectives
- Description of the Methods Used
- Identification of any deviations from the implementation plan
- Results, including a list of procedures developed, and a discussion of the resulting procedures including sample procedures
- Conclusions
- Recommendations/Implications for HSI Design

HFE Design Team Evaluation Report

The report shall address the following:

- The review methodology and procedures
- Compliance with Implementation Plan Procedures
- Review findings

A3.8 Element 8 - Human Factors Verification and Validation

DESIGN COMMITMENT:

The successful incorporation of human factors engineering into the final HSI design and the acceptability of the resulting HSI shall be thoroughly evaluated as an integrated system using HFE evaluation procedures, guidelines, standards, and principles.

INSPECTION/TEST/ANALYSIS:

- A Human Factors Verification and Validation Implementation Plan shall be developed.
- An analysis of Human Factors Verification and Validation shall be conducted in accordance with the plan and the findings will be documented in an Analysis Results Report.
- The analyses shall be reviewed by the HFE Design Team and shall be documented in a.. Evaluation Report.

DESIGN ACCEPTANCE CRITERIA:

General Criteria

1. The evaluation shall verify that the performance of the HSI, when all elements are fully integrated into a system, meets (1) all HFE design goals as established in the program plan; and (2) all system functional requirements and support human operations, maintenance, test, and inspection task accomplishment.

2. The evaluation shall address:

   - Human-Hardware interfaces
   - Human-software interfaces
   - Procedures
   - Workstation and console configurations
   - Control room design
   - Remote shutdown system
   - Design of the overall work environment

3. Individual HSI elements shall be evaluated in a static and/or "part-task" mode to assure that all controls, displays, and data processing that are required are available and that they are designed according to accepted HFE guidelines, standards, and principles.

4. The integration of HSI elements with each other and with personnel shall be evaluated and validated through dynamic task performance evaluation using evaluation tools which are appropriate to the accomplishment of this objective. A fully functional HSI prototype and plant sim. lator shall be used as part of these evaluations. If an alternative to a HSI prototype is proposed its acceptability shall be documented in the implementation plan. The evaluations shall have as their objectives:

   - Adequacy of entire HSI configuration for achievement of safety goals

- Confirm allocation of function and the structure of tasks assigned to personnel
- Adequacy of staffing and the HSI to support staff to accomplish their tasks.
- Adequacy of Procedures
- Confirm the adequacy of the dynamic aspects of all interfaces for task accomplishment
- Evaluation and demonstration of error tolerance to human and system failures

5. Dynamic evaluations shall evaluate HSI under a range of operational conditions and upsets, and shall include:

   - Normal plant evolutions (e.g., start-up, full power, and shutdown operations)
   - Instrument Failures (e.g., Safety System Logic & Control (SSLC)Unit, Fault Tolerant Controller (NSSS), Local "Field Unit" for MUX system, MUX Controller (BOP), Break in MUX line)
   - HSI equipment and processing failure (e.g., loss of VDUs, loss of data processing, loss of large overview display)
   - Transients (e.g., Turbine Trip, Loss of Offsite Power, Station Blackout, Loss of all FW, Loss of Service Water, Loss of power to selected buses/CR power supplies, and SRV transients)
   - Accidents (e.g., Main steam line break, Positive Reactivity Addition, Control Rod Insertion at power, Control Rod Ejection, ATWS, and various-sized LOCAs)

6. Performance measures for dynamic evaluations shall be adequate to test the achievement off all objectives, design goals, and performance requirements and shall include at a minimum:

   - System performance measures relevant to safety
   - Crew Primary Task Performance (e.g., task times, procedure violations)
   - Crew Errors
   - Situation Awareness
   - Workload
   - Crew communications and coordination
   - Anthropometry evaluations
   - Physical positioning and interactions

7. A verification shall be made that all issues documented in the Human Factors Issue Tracking System have been addressed.

8. A verification shall be made that all critical human actions as defined by the task analysis and PRA/HRA have be adequately supported in the design. The design of tests and evaluations to be performed as part of HFE V&V activities shall specifically examine these actions.

9. The effort shall be performed using the following documents as guidance:

<List to be developed>

Implementation Plan

The plan shall describe the designer's approach to Human Factors Verification and Validation. The Human Factors Verification and Validation Implementation Plan shall address:

- HSI element evaluation
  - Control, Data Processing, Display audit
  - Comparison of HSI element design to HFE guidelines, standards, and principles
- Dynamic performance evaluation of fully integrated HSI
  - General Objectives
  - Test methodology and procedures
  - Test participants (operators to participate in the test program)
  - Test Conditions
  - HSI description
  - Performance measures
  - Data analysis
  - Criteria for evaluation of results
  - Utilization of evaluations
- Documentation requirements
  - Test & Evaluation Plans and Procedures
  - Test Reports

Analysis Results Report

The report shall address the following:

- Objectives
- Description of the Methods
- Identification of any deviations from the implementation plan
- Results and Discussion
- Conclusions
- Recommendations/Implications for HSI Design

HFE Design Team Evaluation Report

The report shall address the following:

- The review methodology and procedures
- Compliance with Implementation Plan Procedures
- Review findings