

..... 최신 인간공학프로그램 현안 및 대응

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1. Introduction

❖ Goal of Presentation

- 원자력발전소 인간공학 관련 신규 현안 리뷰
- 신규 현안에 대한 인간공학 측면의 대응 방안 토의

❖ Organization of Presentation

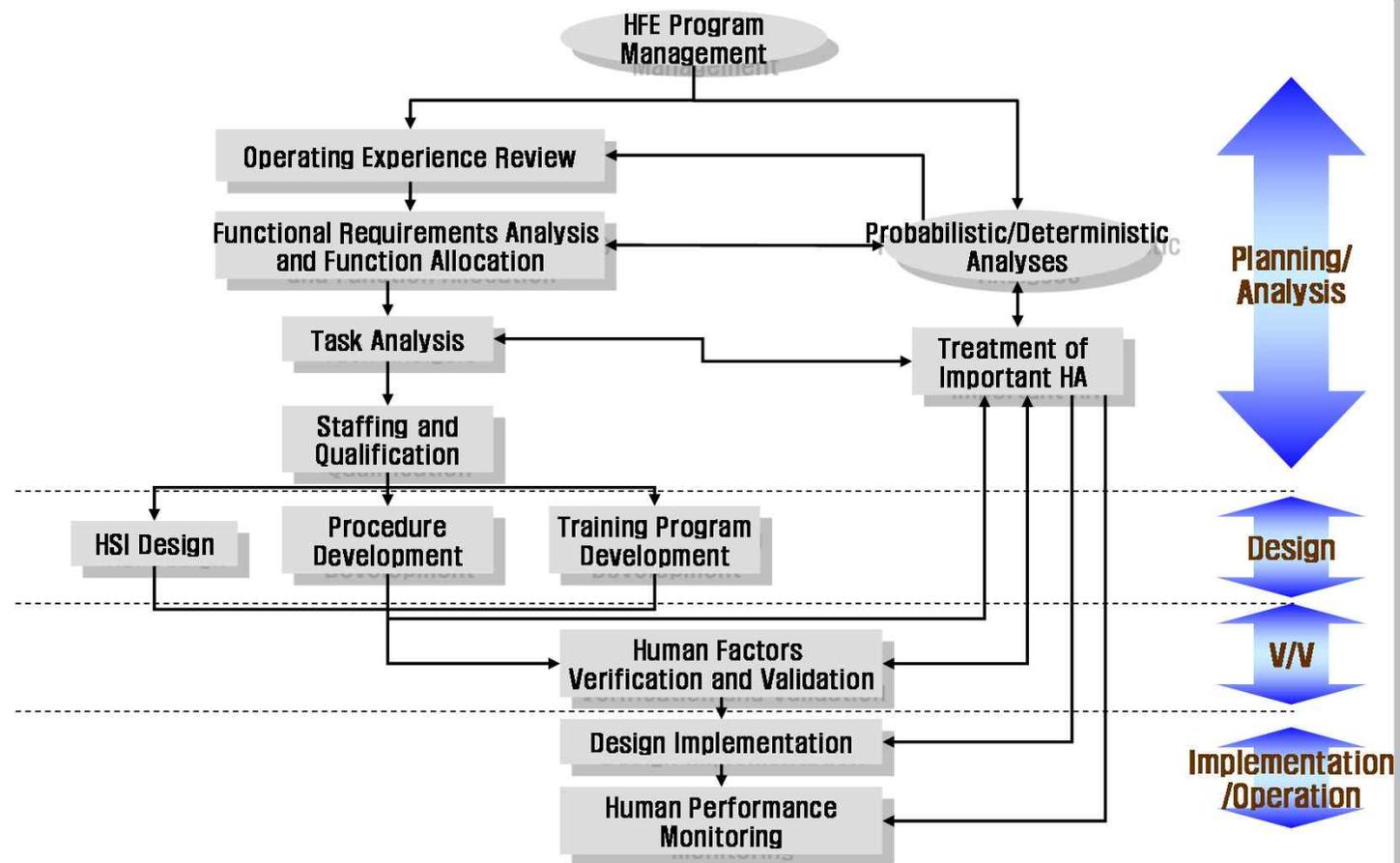
1. Updates in the NUREG-0711 Revision 3
2. Human Factors Engineering in Stress Test
3. Human Factors Engineering for New Types of Reactors
4. Discussion: Approaches to Challenges



2. Update in the NUREG-0711 Revision 3

❖ NUREG-0711 Revision 3

- Date Published: November 2012



2. Update in the NUREG-0711 Revision 3

❖ Major Updates in the Revision 3

1. Functional Requirement Analysis: Power Generation
2. Beyond-DBAs and Severe Accidents
3. Automation-related Guidelines
4. Interaction with Deterministic Safety Analysis Included
5. HFE V&V Simplified



2. Update in the NUREG-0711 Revision 3

❖ Functional Requirement Analysis

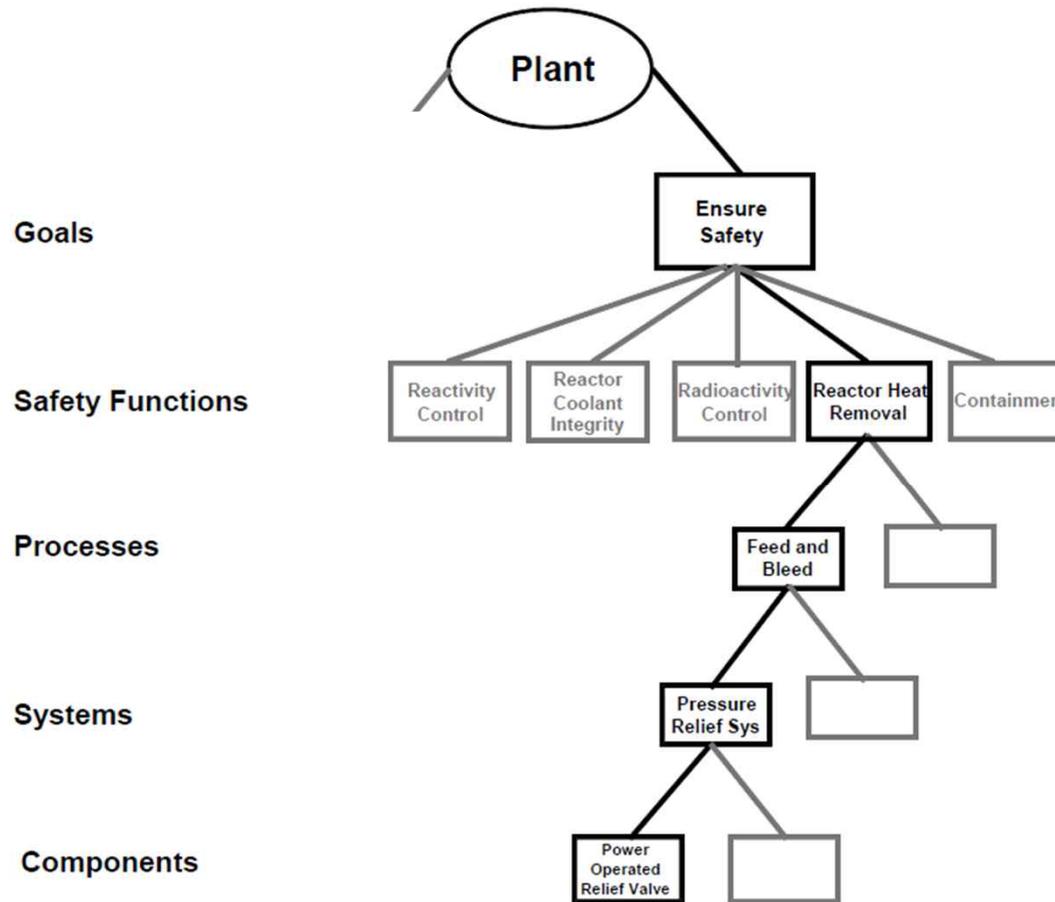


Figure 4-1 Vertical slice through a plant's functional hierarchy for ensuring safety



2. Update in the NUREG-0711 Revision 3

❖ Beyond-DBAs and Severe Accident

Rev. 2	Rev. 3
<ul style="list-style-type: none">• HFE V&V, Sampling Dimensions: B-DBA• HRA: Level 2 PSA	<ul style="list-style-type: none">• Task Analysis: Severe Accidents• Treatment of Important Human Actions: Level 2 PSA, D3 Coping Analysis (B-DBA)• HSI Design, Post-accident monitoring: core damage• HFE V&V, Sampling Dimensions: B-DBA



2. Update in the NUREG-0711 Revision 3

❖ Automation-related Guidelines

- Automation, automatic, automate 용어 사용 회수

Rev. 2	Rev. 3
35 회	72 회

Rev. 3 Automation 관련 주요 요건 예

- The “Function Requirements Analysis and Function Allocation” element better addresses modern implementations of automation.
- if a computer operated support system, a computerized procedures system, or advanced automation are planned to be used, the OER should describe the HFE issues associated with using them.
- TA: tasks related to monitoring of automated systems that are important to plant safety, and the use of automated support aids for personnel, such as computer based procedures.
- HSI Design: the responsibilities of the crew for monitoring, interacting, and overriding automatic systems and for interacting with computerized procedures systems and other computerized operator support systems.
- HFE V&V: Automatic System Monitoring – The sample should include situations in which humans must monitor a risk-important automatic system.



2. Update in the NUREG-0711 Revision 3

❖ Interaction with Deterministic Safety Assessment

Rev. 2	Rev. 3
<ul style="list-style-type: none">• Human Reliability Analysis<ul style="list-style-type: none">- Risk important human action from HRA/PSA	<ul style="list-style-type: none">• Treatment of important human actions<ul style="list-style-type: none">- Risk important human action from HRA/PSA- Operator actions credited in Chapter 15- Operator actions identified in the D3 coping analysis



2. Update in the NUREG-0711 Revision 3

❖ HFE V&V Simplification

- The Verification and Validation element was revised to simplify and streamline the guidance on scenario development, performance measurement, and human engineering discrepancy evaluation.
 - (John O'Hara, Human Factors Engineering Program Review Model (NUREG-0711) Revision 3: Update Methodology and Key Revisions, NPIC-HMIT 2012)
- Scenario Sampling 예외
 - Scenario Definition 추가: detailed scenario 요구

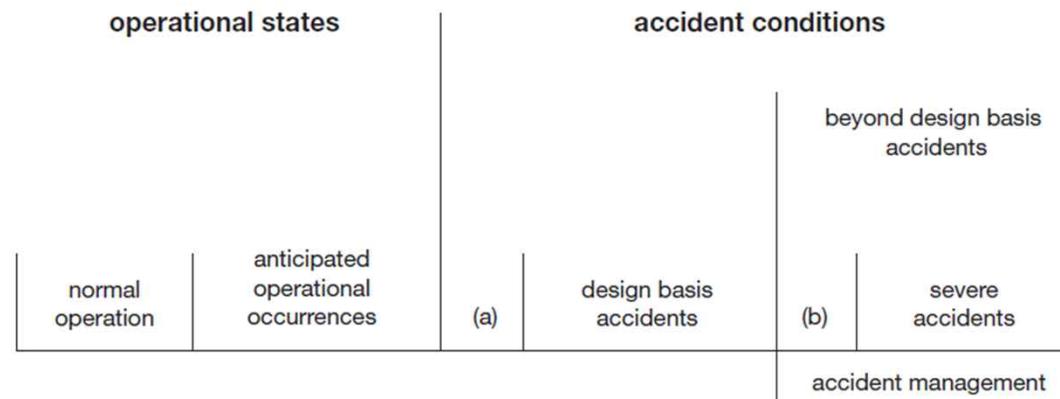


3. Human Factors Engineering in Stress Test

❖ Stress Test

▪ Stress Test 목적

- 후쿠시마 사고와 같이 발전소의 안전기능을 위협하고 중대사고 이
를 수 있는 극한의 자연재해 상황에서 발전소의 발전소의 안전 여유
도를 재평가
 - 극한 상황에 발전소의 거동을 평가하고
 - Defense-in-Depth 개념에 따라 초기사건, 안전기기의 동작, 중대사고
관리 등의 발전소의 사고예방, 사고완화의 조치들을 평가



- (a) Accident conditions which are not explicitly considered design basis accidents but which are encompassed by them.
(b) Beyond design basis accidents without significant core degradation.



3. Human Factors Engineering in Stress Test

❖ 인간공학 측면 평가 항목

- 주제어실 및 원격정지실의 Human-System Interface (HSI) 설비
- 통신 및 조명 설비
- 발전소 인력 및 조직
- 발전소 절차서
- 발전소 지원장비



3. Human Factors Engineering in Stress Test

❖ 주요 스트레스테스트 수행지침

- 상황을 인지할 수 있는 방안 및 소요시간(T1), 대처방안 결정 소요시간 (T2), 설비설치 등 대처방안 이행 소요시간 (T3)를 평가하여야 함.
- 다양한 설비활용과 관련한 장비·도구가 갖추어질 수 있고, 장비·도구 활용 전략 및 업무가 명확하게 정의되며, 해당 업무를 이행하기 위한 조직·인력의 확보와 해당 인력이 필요한 업무를 수행할 수 있는 능력을 확보할 수 있는 방안에 대해서 평가
- 인적오류·의사결정오류 발생가능성 평가시에는 목적인 조치를 방해할 수 있는 요소를 고려해야 함
- 사고시나리오는 자동작동조건 → 수동작동조건 → 이동형설비활용조건 → 소외자원 활용조건을 확인할 수 있도록 평가되어야 함
- 다수호기 동시사고를 고려하여, 정의된 주요 비상조치의 이행에 필요한 조직, 인력 및 장비를 평가하여 비상조치가 적절하게 이행될 수 있도록 책임 및 임무가 적절하게 수립되어 있는지를 평가하고, 필요시 개선대책을 마련함



4. Human Factors Engineering for New Types of Reactors

❖ New Types of Reactors

- Small and Modular Reactors
- Research Reactors
- Gen IV Reactors

❖ New Types of Reactors 일반 규제

- 현재 규제 지침이 Light Water Reactor를 기반으로 작성되어 있음.
- Technology-Neutral 규제 지침이 필요



4. Human Factors Engineering for New Types of Reactors

❖ HFE for New Types of Reactors

- NUREG-0711 HFEP의 Framework은 동일하게 적용가능
 - HFEP의 Framework은 Systems Engineering 기반으로 개발되어 동일하게 적용가능
- 각 Element의 세부적인 활동(Analysis, Design, V&V, Implementation, Operation)의 노형별 특성 맞게 수행이 필요

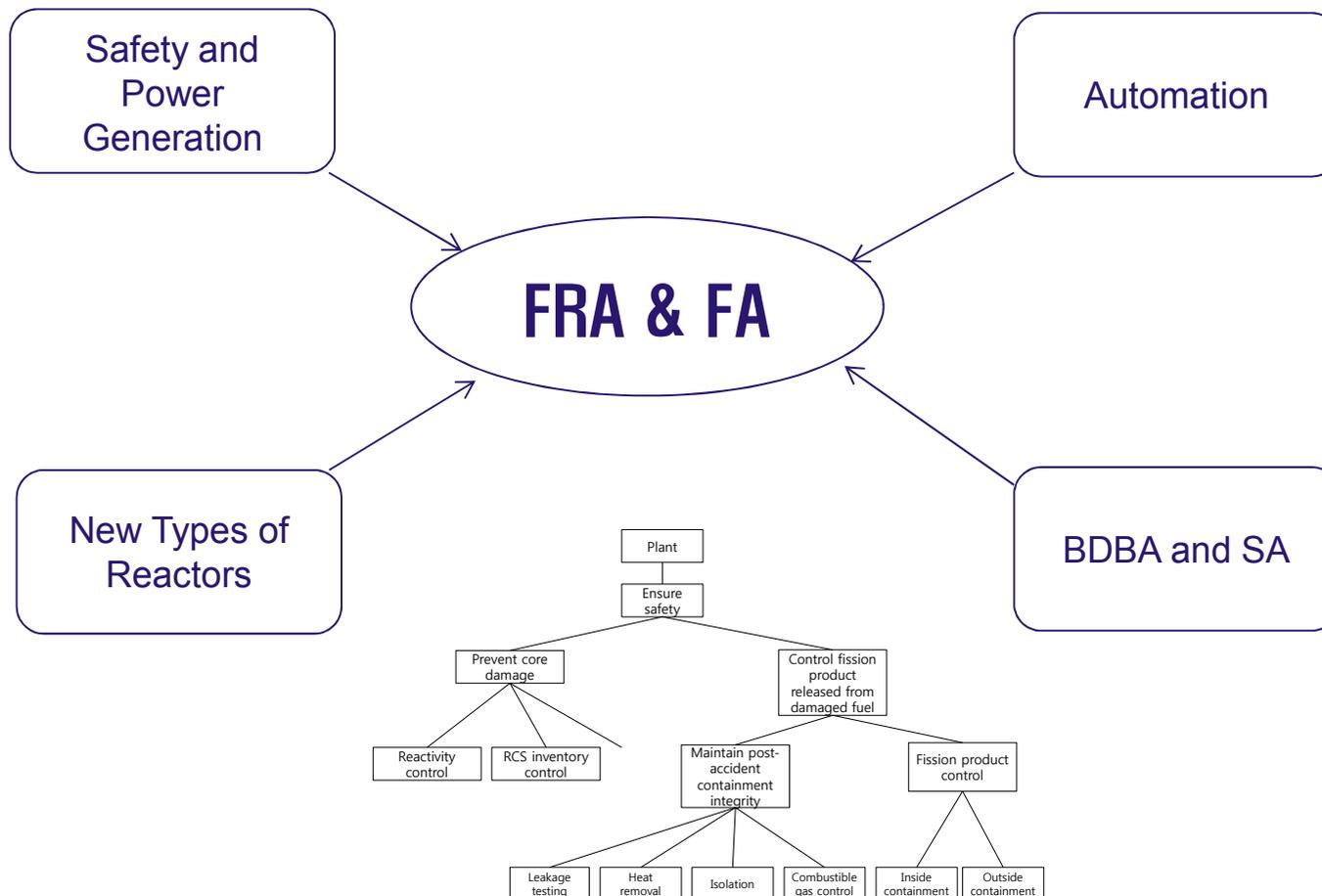
Potential Human Performance Issues relating to SMRs(BNL-96809-2012)

- Novel Designs and Limited Operating Experience from Predecessor Systems
- Multi-unit Operations and Teamwork
- High Levels of Automation for All Operations and its Implementation
- Managing Non-LWR Processes and Reactivity Effects
- Passive Safety Systems
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5. Discussion: Approach to Challenges

❖ Functional Requirement Analysis and Function Allocation (FRA & FA)



5. Discussion: Approach to Challenges

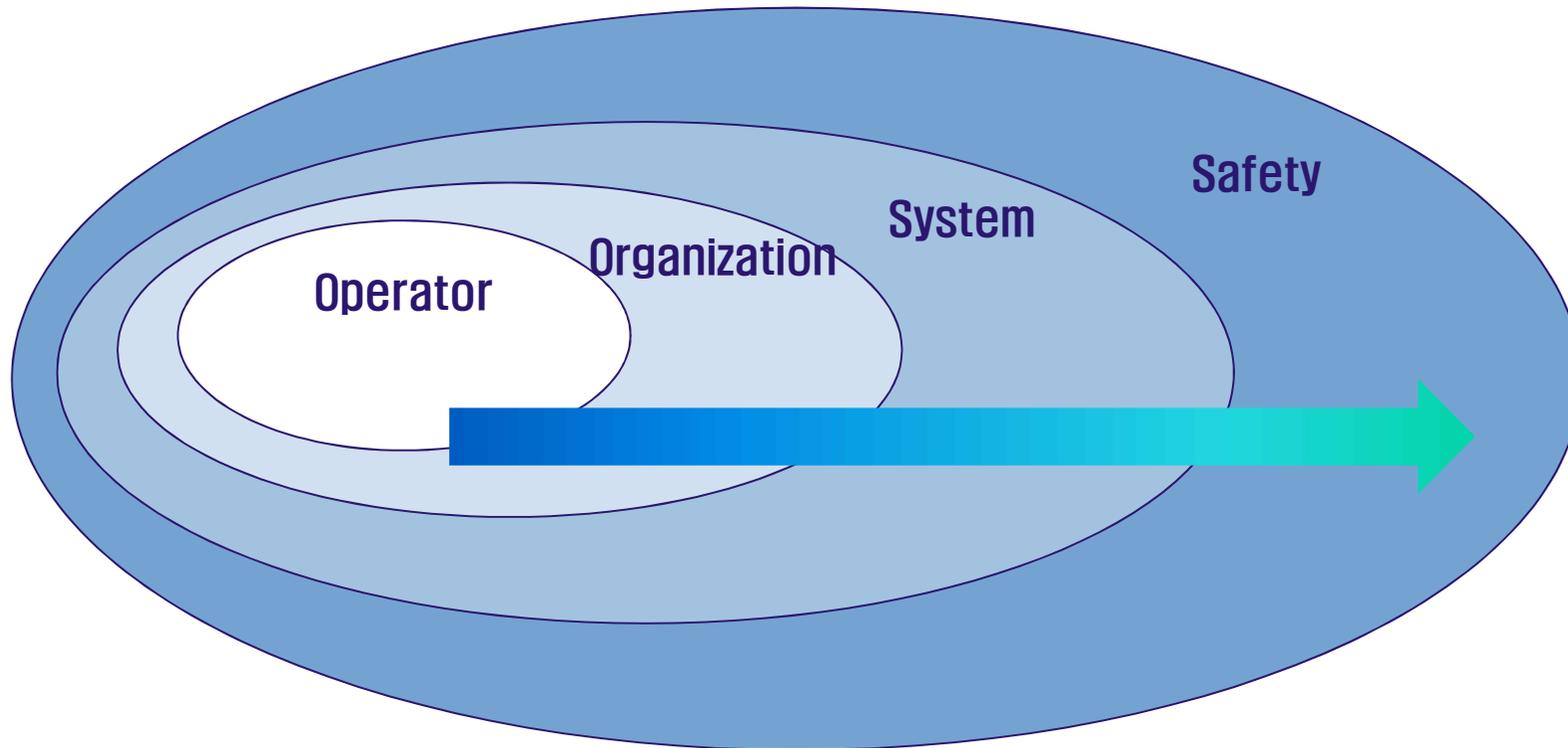
❖ 외부사건 인간공학 활동 기반 조성

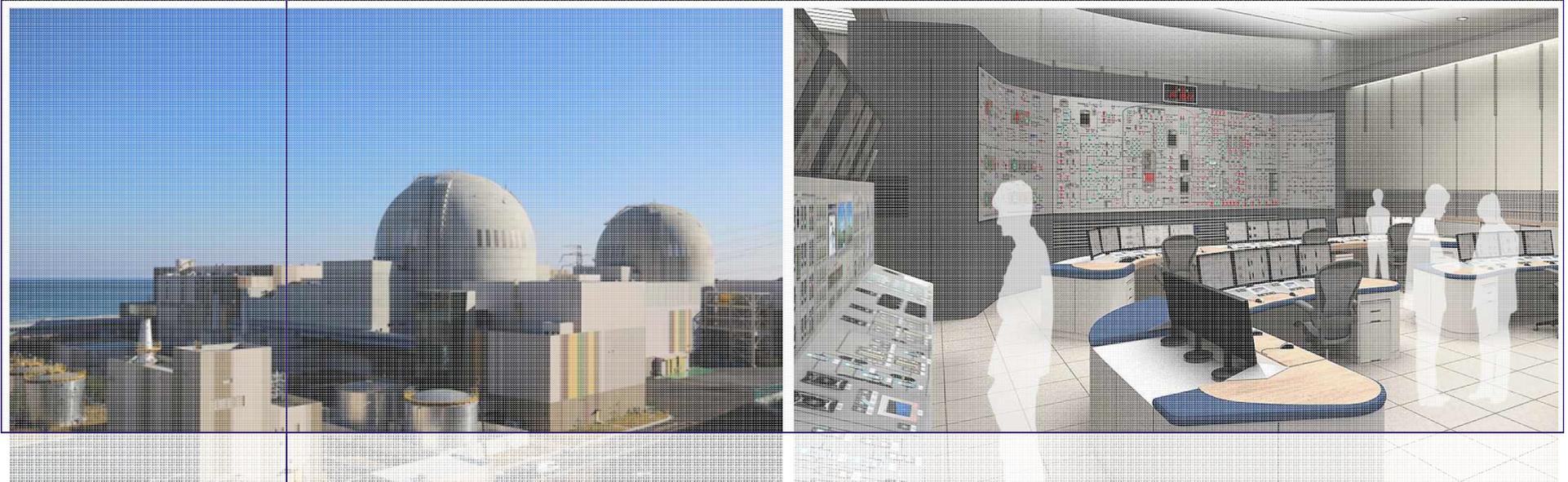
- 지진, 쓰나미, 화재 발생시 인적 수행도에 관한 연구
- 다수기 영향을 고려한 대응 **조직 · 설비**의 적합성 평가
 - Responsibility, Resource, Communication
- 중대사고 모사 시뮬레이터 개발
- 외부사건 대비 운전 · 운영 절차서 작성



6. Conclusion

❖ Scope of Human Factors Engineering





감사합니다.

