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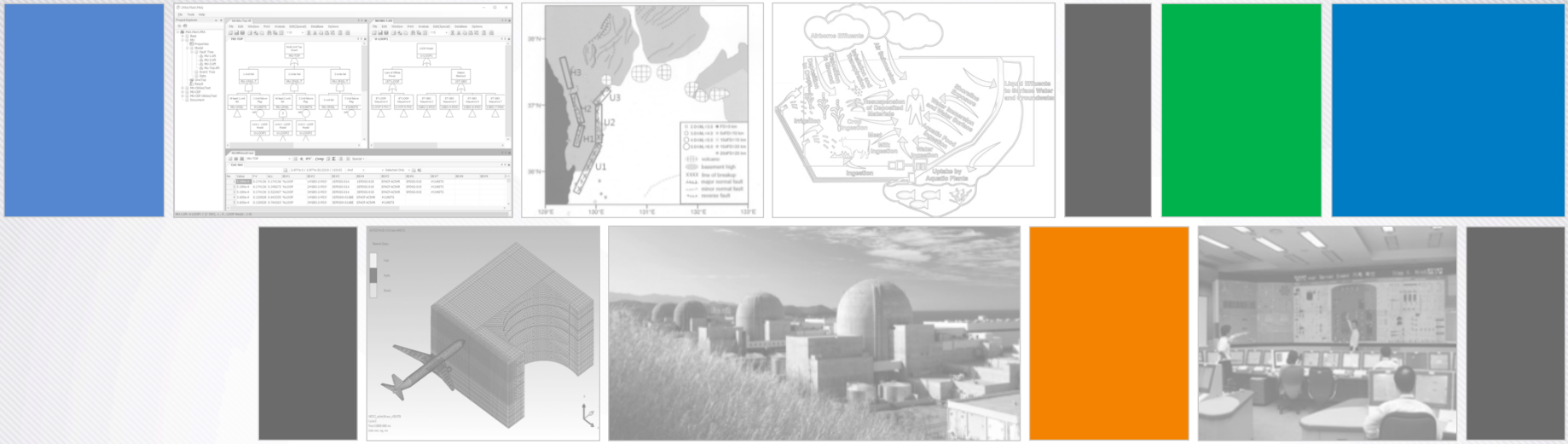

HRA Data for Performance Shaping Factors Reflecting Digital MCR

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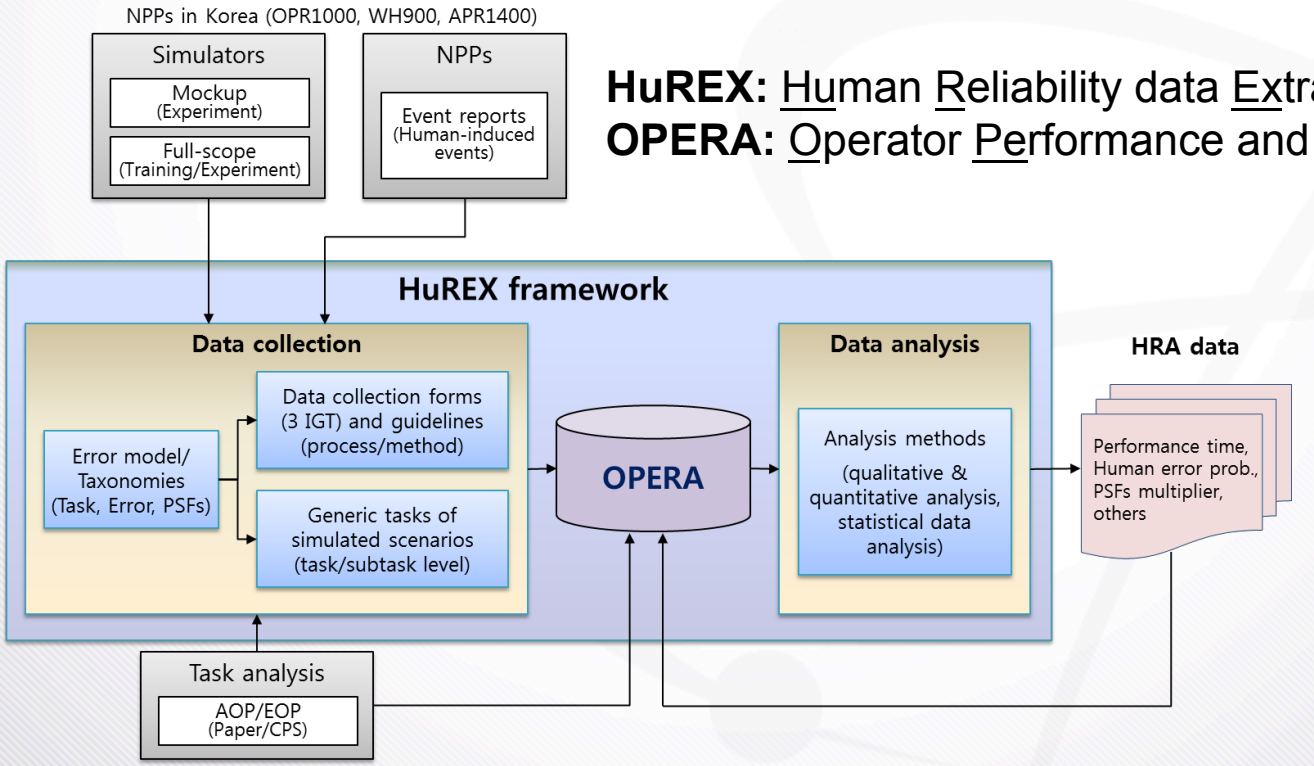
CONTENTS

HuREX (Human Reliability data EXtraction)

- **KAERI's project to** generate HEP (human error probability) data using a framework for HRA data collection
  - HuREX framework including the detailed guidelines of HRA data collection was established
  - Data collection with simulator training data has been performed to identify UA (Unsafe Act)
  - HRA data was extracted by the HuREX from the full-scope simulator records



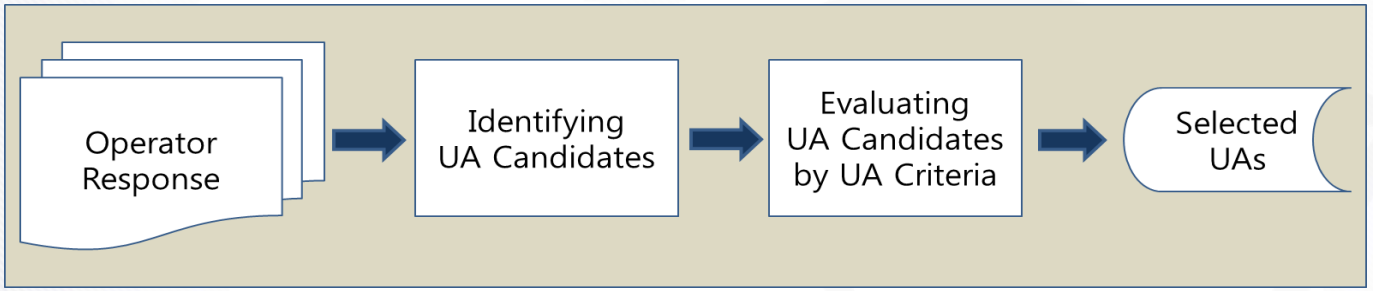
HuREX: Human Reliability data Extraction
OPERA: Operator Performance and Reliability Analysis

Unsafe Act (UA) Identification

UA definition

- UA is an inappropriate operator behavior that has a potential for leading the safety of NPPs toward a negative direction

UA identification process



- UA candidate: All kinds of deviations from the following procedure (AOP/EOP)

UA selection criteria

- Inappropriate manipulation or manipulation omission
- Inappropriate notification or notification omission
- Inappropriate procedure progression (procedure or step)

AOP: Abnormal Operating Procedure / EOP: Emergency Operating Procedure ♪

Data Fields of IGTs (Information Gathering Templates)

Overview IGT

1. Plant/Simulation Overview
2. Crew
3. Training & Education
4. Environment
5. Observed Response
6. Scenario
7. Crew characteristics & Dynamics

Response IGT

1. Conducted Task Information
   - Time
   - Procedure / Step
   - Contents
   - Task Type
   - Number of Demand
   - Number of Success
   - Operator
   - Component Type
   - System Type
2. UA Analysis
   - UA Candidate
   - UA Code
   - EOO / EOC
   - Description

UA IGT

1. UA Information
2. UA Initiator
3. Plant/System State
4. Time Pressure
5. Task Familiarity
6. Task Complexity (Decision-making)
7. Task Complexity (Execution)
8. Procedure Quality (Clarity)
9. Procedure Quality (Description level)
10. HMI Information Quality
11. Communication Quality
12. Recovery Information

UA Type Classification

Cognitive activity	Task type	Abbreviation	Error mode*
Information gathering and reporting (IG)	Checking discrete state - Verifying alarm occurrence♪	IG-alarm♪	EOO, EOC♪
	Checking discrete state - Verifying state of indicator♪	IG-indicator♪	EOO, EOC♪
	Checking discrete state - Synthetically verifying information♪	IG-synthesis♪	EOO, EOC♪
	Measuring parameter - Reading simple value♪	IG-value♪	EOO, EOC♪
	Measuring parameter - Comparing parameter♪	IG-comparison♪	EOO, EOC♪
	Measuring parameter - Comparing in graph constraint♪	IG-graph♪	EOO, EOC♪
	Measuring parameter - Comparing for abnormality♪	IG-abnormality♪	EOO, EOC♪
	Measuring parameter - Evaluating trend♪	IG-trend♪	EOO, EOC♪
Response planning and instruction (RP)	Entering step in procedure♪	RP-entry♪	EOO♪
	Transferring procedure♪	RP-procedure♪	EOO, EOC♪
	Transferring step in procedure♪	RP-step♪	EOO, EOC♪
	Directing information gathering♪	RP-information♪	EOO, EOC♪
	Directing manipulation♪	RP-manipulation♪	EOO, EOC♪
	Directing notification/request♪	RP-notification♪	EOO, EOC♪
Situation interpreting (SI)	Diagnosing♪	SI-diagnosis♪	EOO, EOC♪
	Identifying overall status♪	SI-identification♪	EOO, EOC♪
	Predicting♪	SI-prediction♪	EOO, EOC♪
Execution (EX)	Manipulation - Simple (discrete) control♪	EX-discrete♪	EOO, WDEV, WDIR♪
	Manipulation - Simple (continuous) control♪	EX-continuous♪	EOO, WDEV, WDIR, WQTY♪
	Manipulation - Dynamic manipulation♪	EX-dynamic♪	EOO, WDEV, WDIR, WQTY♪
	Notifying/requesting to MCR outside♪	EX-notification♪	EOO, EOC♪
Other (OT)	Unauthorized control - Unguided response planning and instruction♪	OT-planning♪	EOC♪
	Unauthorized control - Unguided manipulation♪	OT-manipulation♪	EOC♪
	-♪		Timing error (too fast/too late)♪

*EOO (Error of Omission); EOC (Error of Commission); WDEV (Wrong Device); WDIR (Wrong Direction); WQTY (Wrong Quantity)

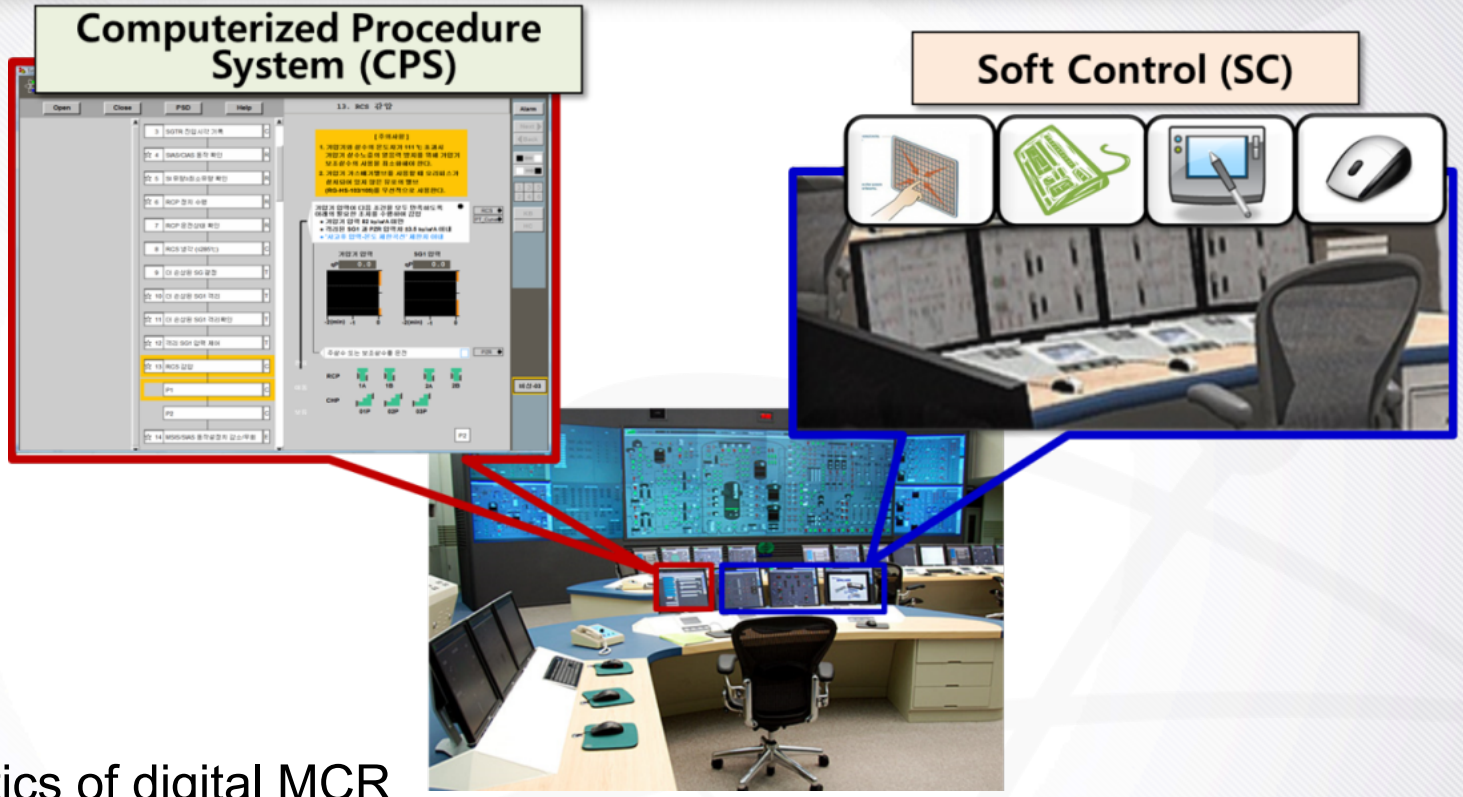
Expansion of the Study into Advanced MCR

Conventional MCR

Advanced MCR

- **HRA Data Analysis Reflecting Digital MCR Based on Hu REX Framework**
  - New research project to develop HEPs and extract HRA data using a simulator at the APR 1400 (Advanced Power Reactor 1400MWe),
- **The purpose of this paper**
  - To describe the characteristics in a digital MCR and operator behavior characteris tics of a digital environment from simulator data
  - To develop HRA data items for UA IGT to reflect the characteristics of a digital MC R

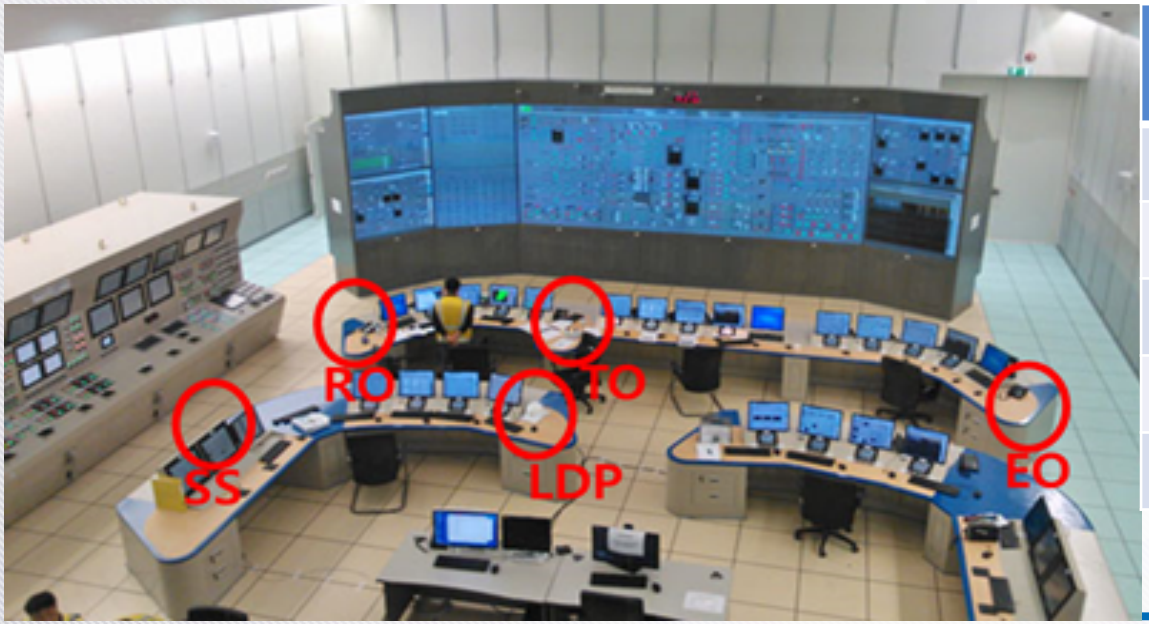
Environment of Digital MCR



- Characteristics of digital MCR
  - IPS (Information Processing System)
  - LDPs (Large Display panels)
  - CPS (Computer-based Procedure System)
  - SCs (Soft Controls)

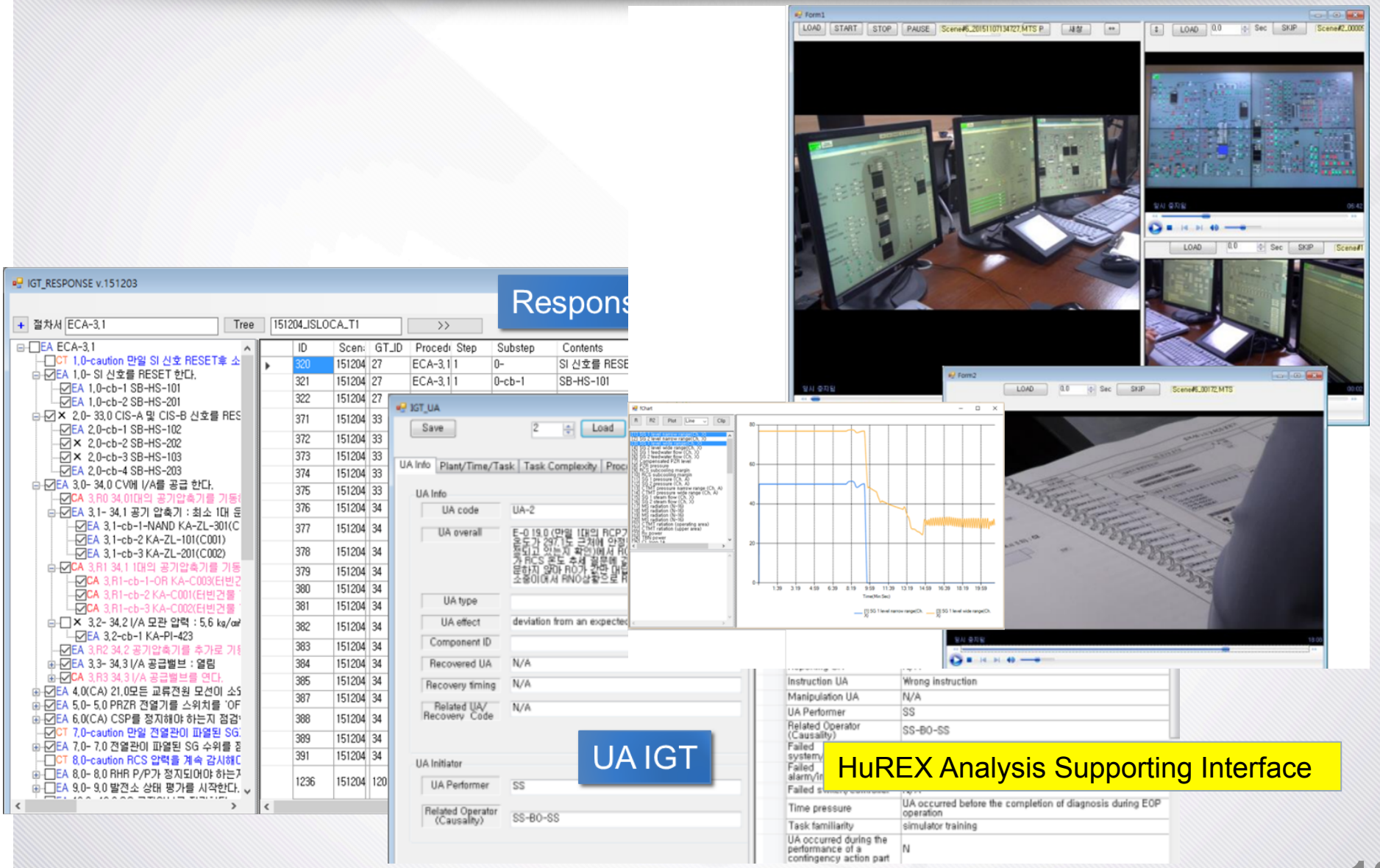
Data Collection & Analysis from APR1400 Simulator

- **From a full-scope simulator**
  - Video/Audio recording data
    - Five cameras
  - Data from questionnaires
    - Operator information
    - Operating culture
  - Simulation log data
    - Process parameter log
    - CPS log
    - Alarm log
    - IPS screen navigation log



No	Period	Data Analysis
1	First half of 2017	Completed
2	Second half of 2017	Under analysis
3	First half of 2018	Under analysis
4	Second half of 2018	To be collected
5	First half of 2019	Undecided

HuREX Analysis Supporting Interface



Characteristics of Operator' Behaviors in Digital MCR

- **Information gathering from a computer based information display system**
  - SS(shift supervisor)' checking/verifying the plant status by observing process parameters and alarms on LDP or IPS
  - Operator's clear measurement of process parameters on LDP and their trends by using graphs on the operator console.
  - Distributed placement of process variables/alarm

  (The type of SS's information gathering, Information on LDP, The type of alarm display)

- **Component manipulation with soft controllers**
  - Operator's screen navigation to find an appropriate screen for a component manipulation
  - Time delay in using soft controls due to significantly different types of devices from the conventional MCR

  (The type of control device for component manipulation, The number of screen changes to the proper control device)

Characteristics of Operator' Behaviors in Digital MCR

- **Procedure operation with CPS**
  - Multiple operators' simultaneous checking/reviewing the other's procedur e operation (cross checking)
  - One operator's multiple procedure operation at the same time
  - Convenience due to CPS automation
    - Logic calculation
    - Highlighting
  - Paper procedural operation in case of a CPS failure
    - Loss of automation provided by a CPS, such as logic processing and highlighti ng.

(Logic of the state identification or instructions, The procedure type , Hold step, The number of procedures performed at the same time , Design consistency of back up procedure, CPS-IPS direct link, CPS automation level)

HRA Data Reflecting Digital Environment for UA IGT (1/2)

Category of UA IGT	HRA Data	HRA Data Attributes
Task complexity (decision-making)	The type of SS's information gathering	- Independent confirmation w/o direction to BO - Direction to BO - Notification to BO after independent confirmation
	Logic of the state identification or instructions	- NOT ,- AND, - OR, - NOT & AND, - NOT & OR' - AND & OR - NOT & AND & OR - Simple Statement (No Logic)
Task complexity (execution)	The procedure type	- Paper based procedure - Computer based procedure - Back up procedure
	The type of control device for component manipulation	- Conventional device - Mouse (non-safety) - Mouse+ESCM (safety) - Device on safety console
	The number of screen changes to the proper control device	- 0, 1, 2, 3…
	Hold step	- Y/N
	The number of procedures performed at the same time	- 0, 1, 2, 3…

HRA Data Reflecting Digital environment for UA IGT (1/2)

Category of UA IGT	HRA Data	HRA Data Attributes
Procedure quality (Clarity)♪	Design consistency of back up procedure	- Y - N
HMI & Information quality♪	The type of alarm display	- Alarm on dedicated alarm (alarm tile) - Alarm on process mimic display - Alarm on alarm list only
	Information on LDP	- Y - N
	CPS-IPS direct link	- Y - N
	CPS automation level	- 1 (Manual Operation) - 2 (Shared Operation) - 3 (Operation by Consent) - 4 (Operation by Exception) - 5 (Autonomous Operation)

CONCLUSION

- **In this paper,**
  - Operator behavior characteristics of a digital environment including t he design characteristics in digital MCR are described
  - New 12 HRA data items based on the characteristics of a digital MC R, such as an IPS, LDP, CPS, and SCs are derived based on the op erator' behaviors found from the simulation data
  - And the 12 HRA data are connected with the category of the existin g UA IGT for a conventional MCR
- **In a further analysis,**
  - We are to develop HEPs for an advanced MCR and identify the rela tion between UAs and PSFs
  - We investigated more various HF issues through a literature survey and discussed additional HRA data items.
    - For example, several researches insisted on the issue of operator' fatigue owing to the digitalized device in a digital MCR
  - We plan to continue to modify or add HRA data items through a furt her simulation data analysis

THANK YOU

Human Factor Issues in Digital MCR

Design Element	HF Issue	Description
Computer based information display system	Information Overload	• Overlapping windows • Too much information • Faster information than visual process of human
	Interface management tasks	• Navigation task before the primary task • Losing the information because of secondary task under workload condition
Computerized procedure	Team performance	• Breakdown in communication between operators
	Situation awareness	• Reliance on computerized procedures
	Level of automation	• Automation level
	Keyhole effect	• The limitation of parallel processing
	CPS failure in complex situation	• The conversion to paper procedures
Soft controller	Unintentional activation	• Unintended activity
	Description errors	• Error by ambiguous information
	Mode errors	• Mode error
	Disordering the components of an action sequence	• Skip, repetition, and reverse
	Capture error	• Confusion with the task performed infrequently
	Loss of activation errors	• Errors induced by the limited memory of operator