Mental Workload and Situational Awareness Evaluation of APR1400 ESF-CCS Activation Systems using Augmented Reality

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INSTUTUTION: KINGS

2016 KNS Fall Conference Venue: HICO



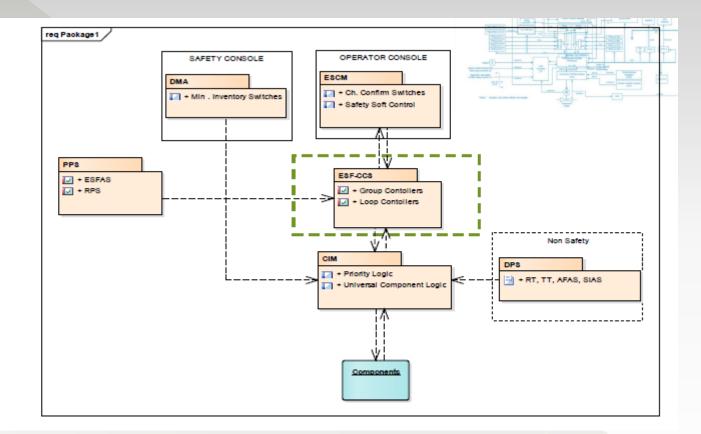
Contents of Presentation

- 1. Introduction
- 2. Objectives of study
- 3. Methods of conducting the study
- 4. Solution methods
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Introduction

The ESF-CCS

ESF-CCS: The interface between the ESFAS portion and the remote actuation devices



Introduction

Situational Awareness and (Mental) Workload

Situational Awareness put simply is knowing what is going on around you. Tied to this knowledge is an understanding of what is important to know and what isn't.

Workload is a term that represents the cost of accomplishing mission requirements for a human operator.

It can be measured as Mental, Physical, Temporal, Frustration, Effort, and Performance.

Introduction

Augmented Virtual Reality

Superimposes a computer-generated image on a user's view of the real world, to provide a composite view. "Stay in the real world but see simulated objects



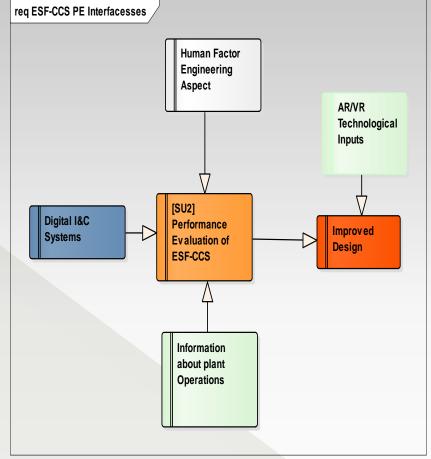


Objectives - Design

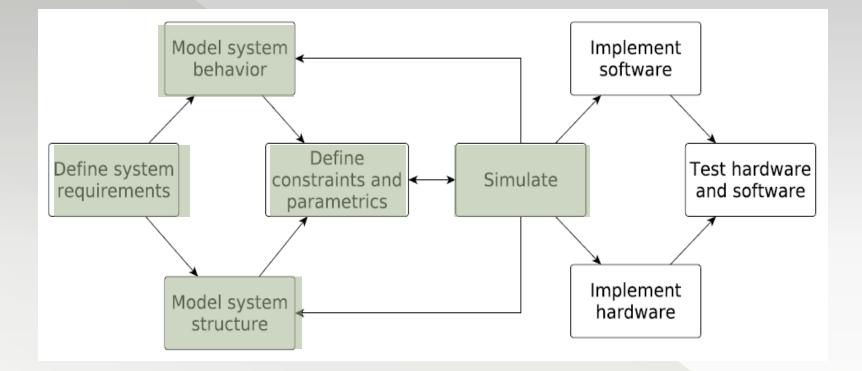
To explore how Augmented Virtual Reality (AVR) can be used in NPP control systems to determine whether:

1.) Operator(s) performance could be enhanced by introduction of an improved cognitive method of monitoring plant information during an Emergency Operating Procedure (EOP) and

2.) In correlation, inform the performance of the diverse safety systems on the basis of human factors.



Objectives - Scope



Objectives – Problem Statement

Problem statement

The operating procedures in a power plant provide a measure of the availability of I&C systems.

Availability of the ESF-CCS, being a system that is critical during emergency operations, and its subsystems is largely determined by human operations, behavior and awareness during abnormal plant conditions

It is therefore sought to consider how HFE can be used to determine the performance of safety critical digital I&C systems in order to ascertain their availability.

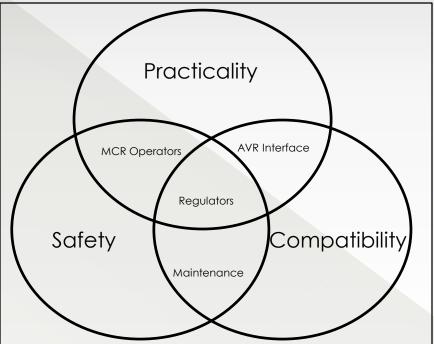
Objectives – Operation of research

- 1. Review of ESF-CCS design description
- 2. Review of HFE program Requirements
- 3. Development of a Requirements Definition based on systems needs
- 4. Identification of the workload and Situational Awareness processes required for evaluation
- 5. Development of performance evaluation tool to gather initial Situational Awareness data

Problem 1: System Requirement Definition

>elicitation was conducted by interviews, conversations and consultations with industry professionals.

| Concern | Elaboration |
|---------------|--|
| Safety | S1. The AVR system shall be used during EOP-LOCA along with the CPS. |
| | S2. The AVR system shall provide critical information/data needed by a Senior Reactor |
| | Operator (SRO) during an Emergency |
| | Operation Procedure (EOP) for his |
| | monitoring/ checking/advisory tasks. |
| | S3. The AVR system shall assure that the correct transition of plant procedures |
| | S4. The AVR system shall validate the Entry |
| | conditions for emergency operation. |
| | S5. The AVR System shall not affect the |
| | normal execution of the current system |
| Compatibility | C1. The AVR system software shall be integrated with existing system without requiring down time |
| Practicality | P1. The AVR system shall reduce/release work burden to the STA during the EOP |
| | P2. The AVR system shall, by introduction of improved situational awareness, be more intuitive to the STA than existing system. |
| | P3. The AVR system shall reduce the amount of navigation required by STA during EOP execution. |
| | P4. The AVR system shall seek to find a |
| | means of reducing the human factor related |
| | operator performance degradation during safety critical operations (EOP)-stemming |
| | from human errors, and reduced readability. |
| | P5. The AVR system shall provide more |
| | comprehensive plant status information to |
| | the STA to enable him to more effectively keep track of the changing plant conditions |

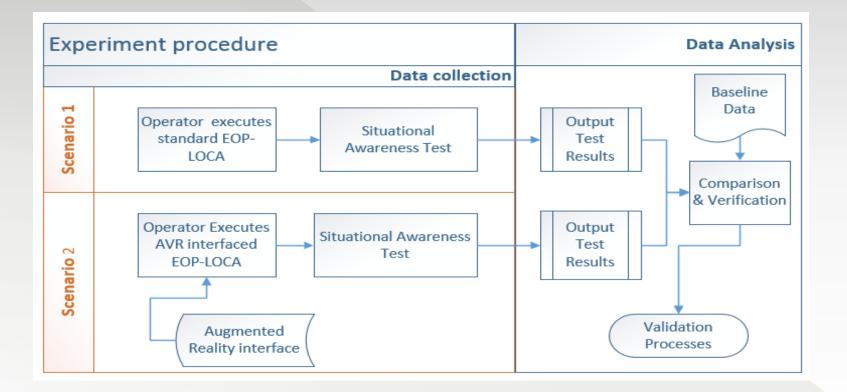


- Problem 2: Choice of Mental Workload and Situational Awareness measurement methods
 - NASATLX was chosen to assess the mental workload due to its wide acceptance, quick and easy implementation and accuracy.
 - > 2. SART was chosen to assess SA due to accountability for cognitive demand and considerable diagnostic capability.

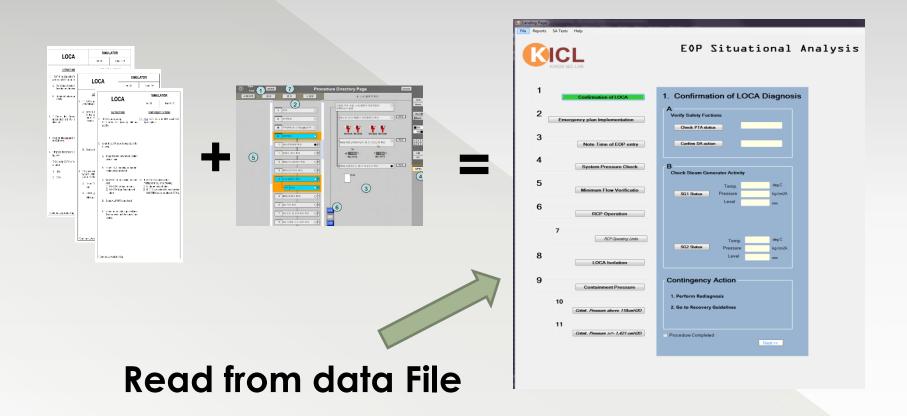
Both methods allow for individual assessment

- Problem 3: Determination of goal of the MW/SA measurement
 - The EOP was chosen as the scenario for modelling because it is the one of the critical plant conditions that requires human intervention.
 - The workload and situational awareness evaluation will justify the benefits of the system towards mitigation of human error.
 - > The primary goal of the designed system is to leverage the existing infrastructure and system data sources to implement a method that can reliably measure the efficacy and performance level of the emergency response system using SA measurement analysis

 Problem 4:Modelling the existing system to incorporate MW/SA measurement.



Problem 4: Modelling the evaluation tool.



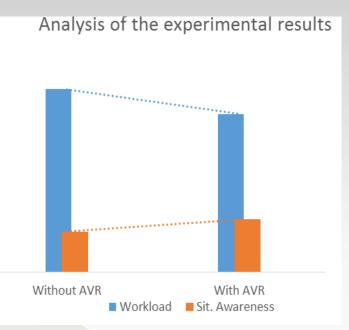
Problem 4: Modelling the existing system to incorporate MW /SA measurement.

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|------------|--|---|--|--------|--|---|-------------------|--|--|--|
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| | RATING SCAL | LE DEFINITIONS | MENTAL DEMAND | | | NASA TASK LO | ad Index | Ratings | | |
| Title | Endpoints | Descriptions | MENTAL DEMAND | | 1 | | | Instability of Situation | | How changeable is the situation? is the situation highly unstable and likely to cha |
| IL DEMAND | Low/High | How much mental and perceptual activity | Low right | | | Please Select t | heitem | 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 | 6 | situation highly unstable and likely to cha suddennly (High) or is it very stable and straightforward (Low)? |
| | | was required (e.g., thinking, deciding, calculating, remembering, booking, searching, etc.)? Was the task easy or | PHYSICAL DEMAND | | | that in your or | pinion | Low | High | |
| | | demanding, simple or complex, exacting or forgiving? | Low High | | | | Workload | Complexity of Situation | | How complicated is the situation? is it complex with many interrelated component |
| CAL. | Lou/High | How much physical activity was required | TEMPORAL DEMAND | | SITUATIONAL ANALY | SIS EVALUATION | workload | | 6 | (High)? Or is it simple and straightforward (Low)? |
| ND | | (e.g., pashing, pufling, turning, costrolling, activating, etc.)? Was the task easy or demanding, slow or brick, slack or | | | | | | LOW | nign | |
| | | strenaous, restful or laborious? How much time pressure did you feel due | Low High | | NASA Task | Load Index | | Variability of Situation | | How many variables are changing within same situation? are there a large number |
| ORAL ND | Lowings | to the rate or pace at which the tasks or task elements occurred? Was the pace show and leisurety or rapid and frantic? | PERFORMANCE | | | | Mental Demand | and the second second | 6 | factors varying (High) or are there very f variables changing (Low)? |
| | | | Good Poor | | Ratings | | | Low | High | |
| т | LowiHigh | How hard did you have to work (mentally and physically) to accomplish your level of performance? | | | MENTAL DEMAND | mentally demanding was the task | NASA TLX Web page | Arousal | _ | How aroused are you in the situation? are |
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| | | satisfied were you with your performance in accomplishing these goals? | FRUSTRATION | | | U | | Spare Mental Capacity | - | How much mental capacity do you have I |
| RATION | Lon/High | How insecure, discounaged, initiated, stressed and annoyed versus secure, gratified, content, relaxed and complacent | FRUSTRATION Low High | | Low | High | _ | Spare mentar capacity | fou must perform all the evaluations | spare in the situation? Do you have sufficient to attend to many variables (Hi |
| | | gratified, content, relaxed and complacent did you feel during the task? | | | | | | Low | | or nothing to spare at all (Low)? |
| | | | | | PHYSICAL DEMAND How | physically demanding was the tas | k? | | OK | |
| | | | | | | | | Concentration of Attention | | How much are you concentrating on the situation? Are you concentrating on man |
| | | | NASA TLX W | ebsite | | 6 | | · · · · · | 6 | aspects of the situation (High) or focus on only one (Low)? |
| | | | | | Low | High | | Low | High | |
| | | _ | | | | | | Division of Attention | | How much is your attention divided in the |
| | | | | | TEMPORAL DEMAND How h | urried/rushed was the pace of the t | ask? | and the second s | 6 | situation? are you concentrating on many aspects of the situation (High) or focusse |
| | | | | | | | | | | on only one (Low)? |
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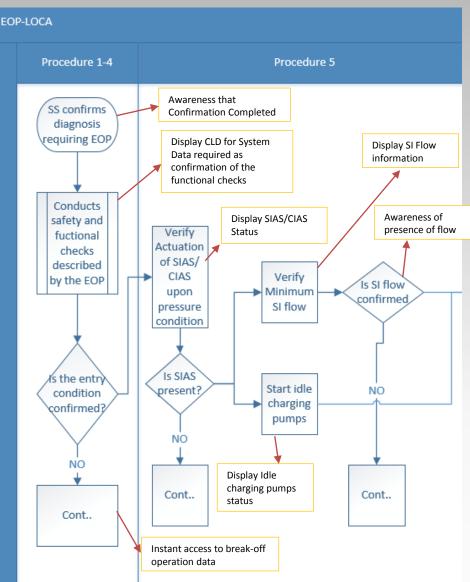
SA Literature [Endsley., 1988]

Solution Methods - Initial Test data results

 Experiments were carried out in order to analyze eleven (11) EOP-LOCA procedures ;using the simulated system verified by standard CPS (computer Based Procedure System) used in the APR1400 MCR



- Next phase 5: Modelling the existing system to improve MW/SA.
 - > Will be accomplished by incorporating AR
 - Complexity analysis will be performed to identify complexity reduction potential.
 - Functional flow analysis will be used to check functional coherence.



Conclusion

- After analyzing the current system by examining EOP LOCA, it was discovered that the performance requirements of ESF-CCS could be evaluated from a HFE pint of view.
- Critical information/data needed by an operator during an Emergency Operation Procedure (EOP) for his monitoring/ checking/advisory tasks was identified
- By conducting a SA analysis it was determined that the work burden could be reduced/ released from the operators during the selected EOP.
- Further work is needed to develop the improved system that will make operations conducted in the MCR by operators more intuitive through the introduction of improved situational awareness using AR-VR design.



