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

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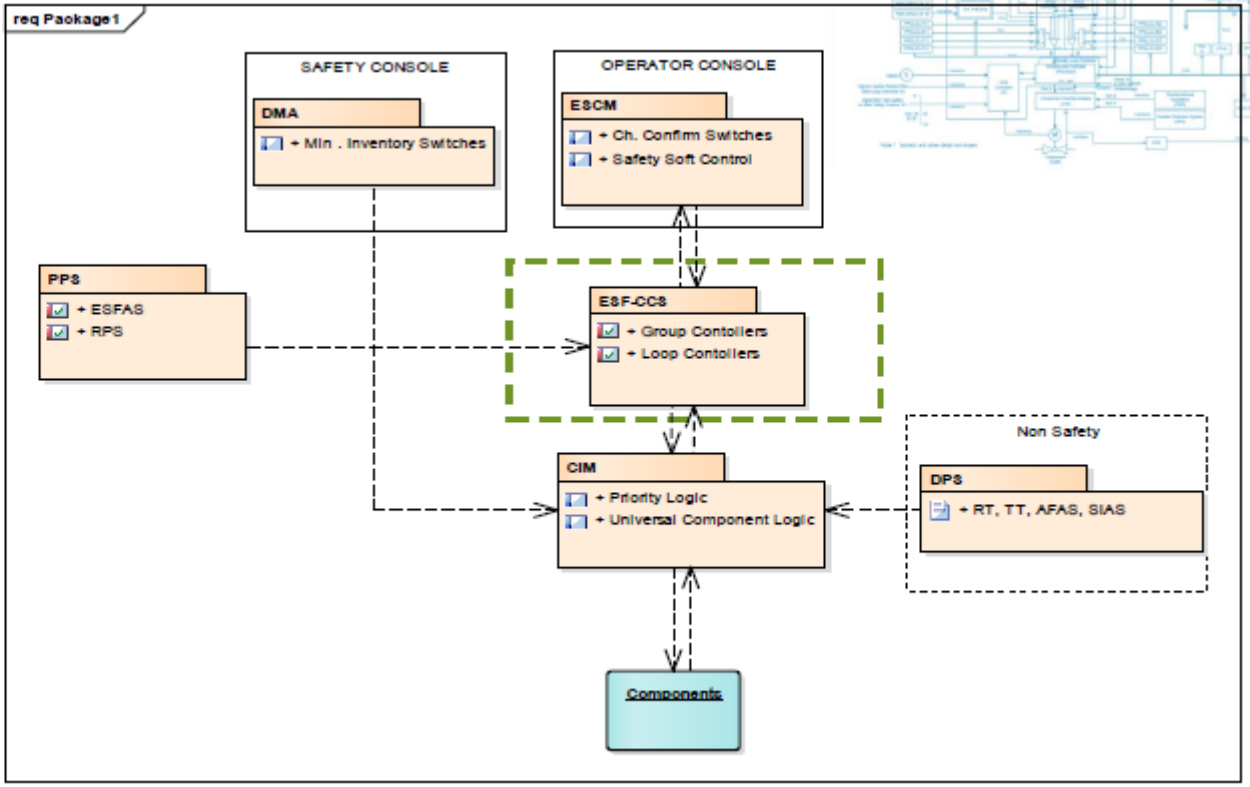
Introduction

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.

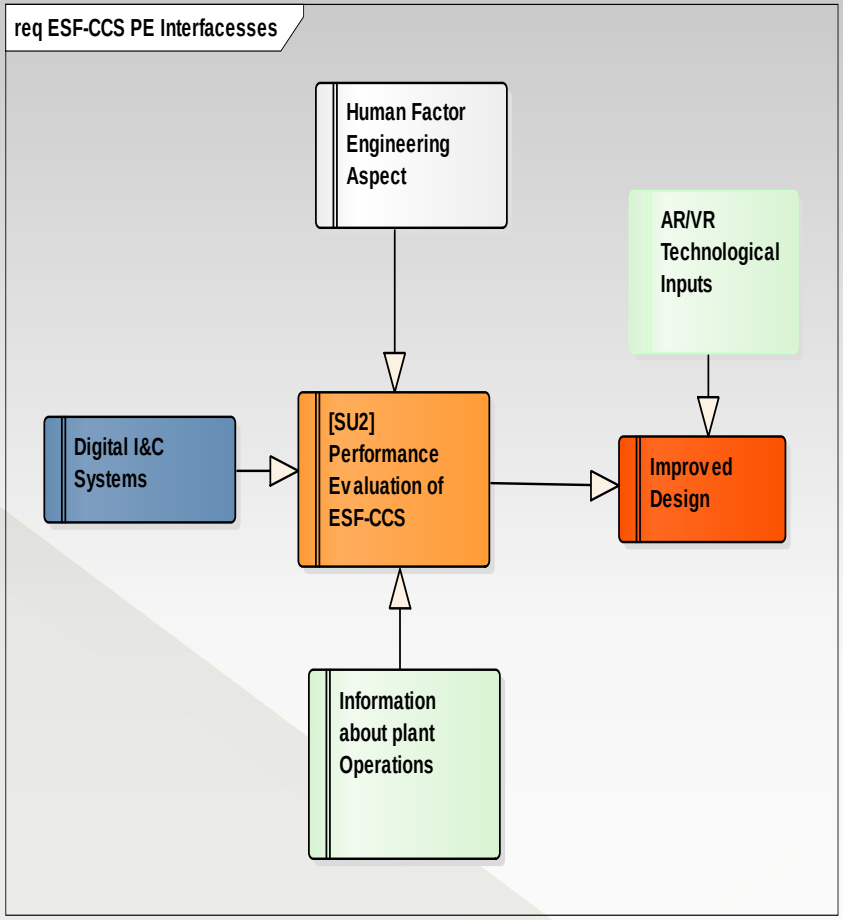
"Stay in the real world but see simulated objects

Objectives - Design

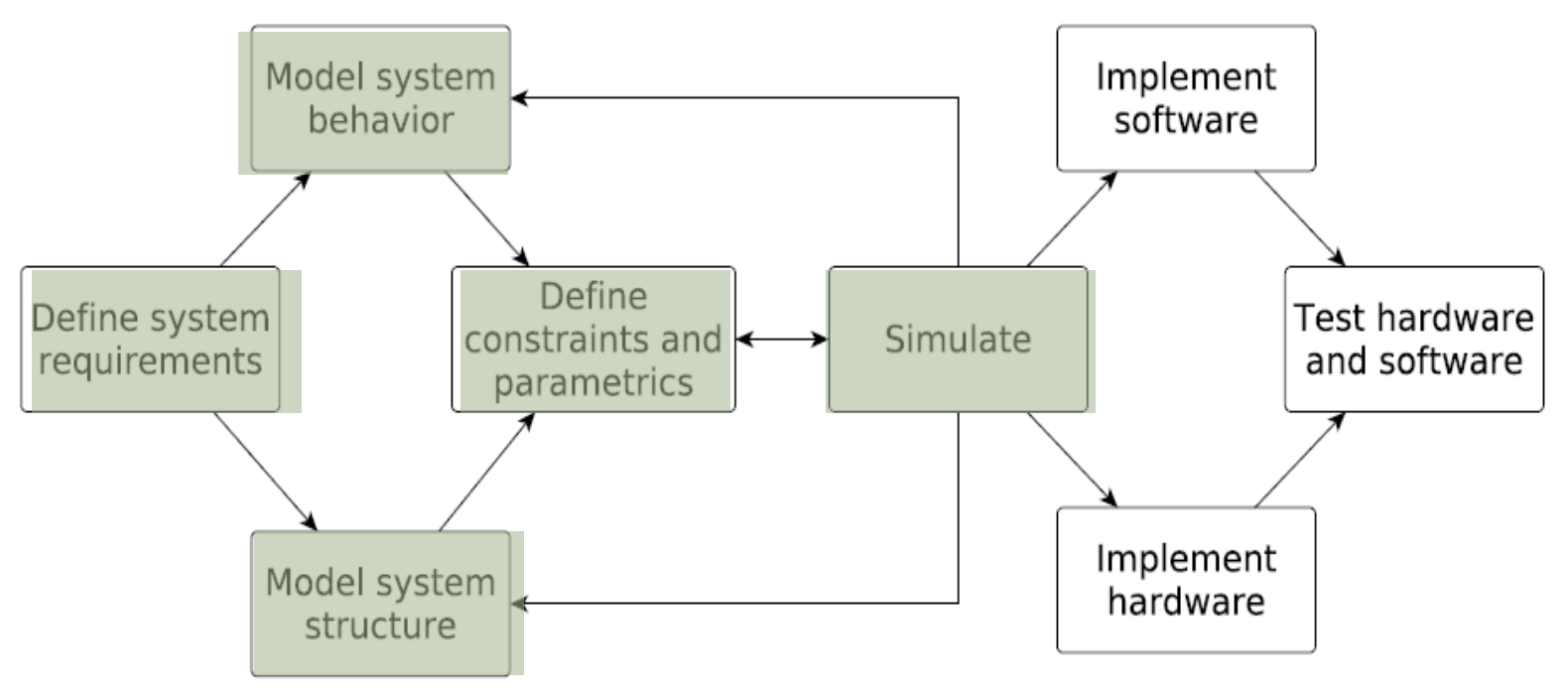
To explore how Augmented Virtual Reality (AVR) can be used in NPP control systems to determine whether:

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

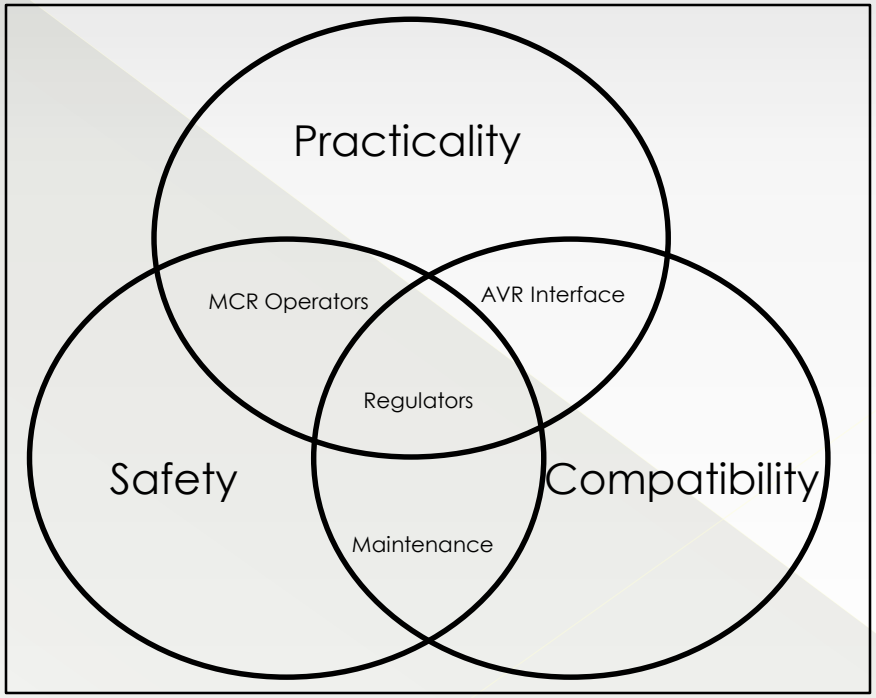
1. Review of ESF-CCS design description
2. Review of HFE program Requirements
3. Development of a Requirements Definition based on systems needs
4. Identification of the workload and Situational Awareness processes required for evaluation
5. Development of performance evaluation tool to gather initial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

Solution Methods

- 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



Solution Methods

- Problem 2: Choice of Mental Workload and Situational Awareness measurement methods
  - 1. 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

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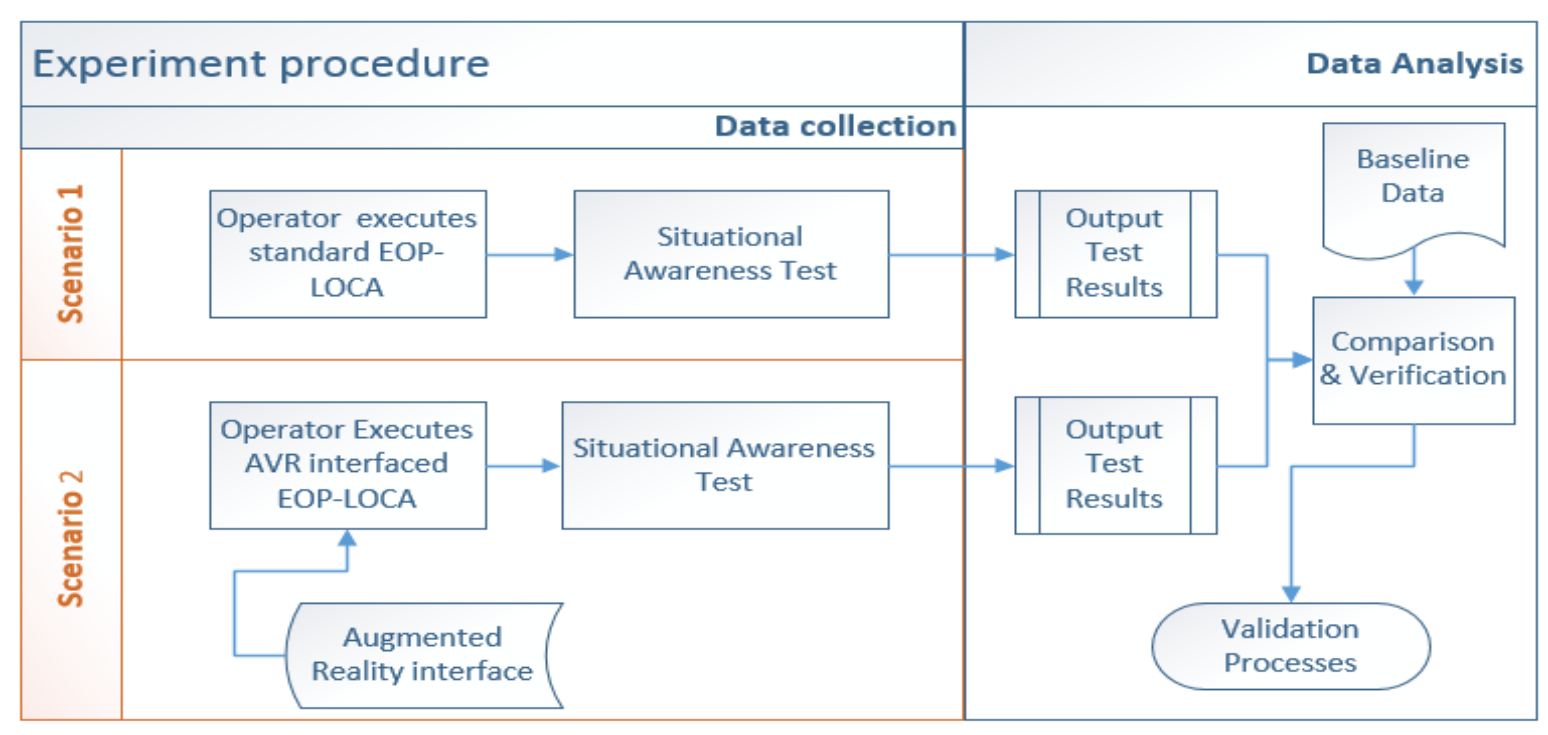
Solution Methods

- 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

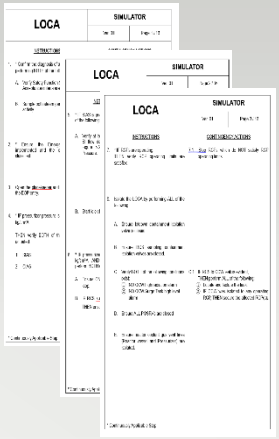
Solution Methods

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



Solution Methods

- Problem 4: Modelling the evaluation tool.



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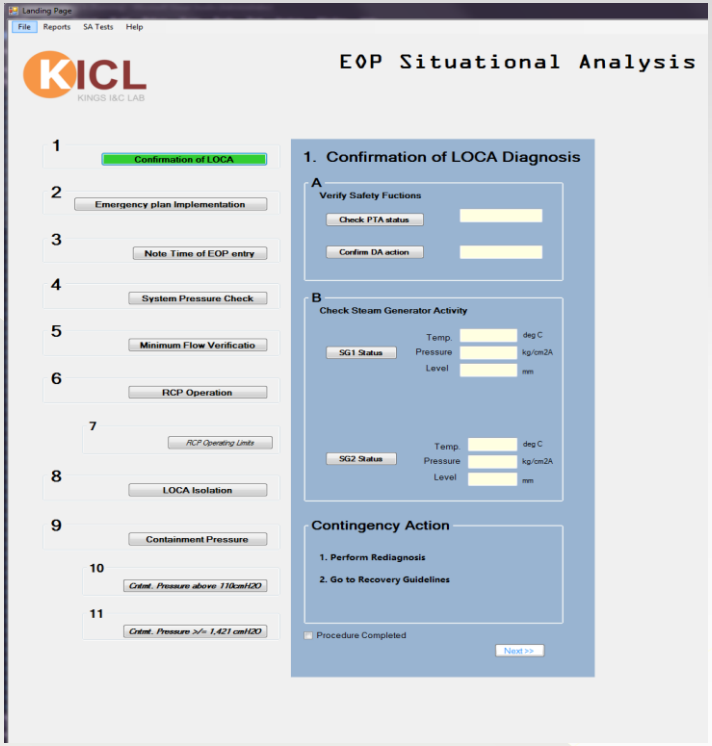
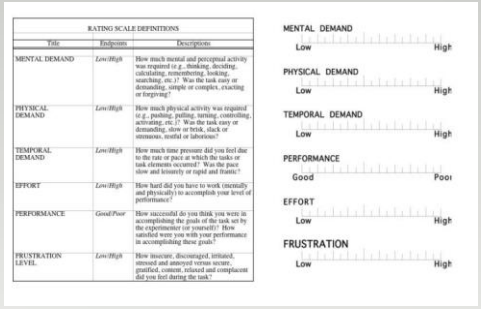


Read from data File

Solution Methods

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



NASA TLX Website

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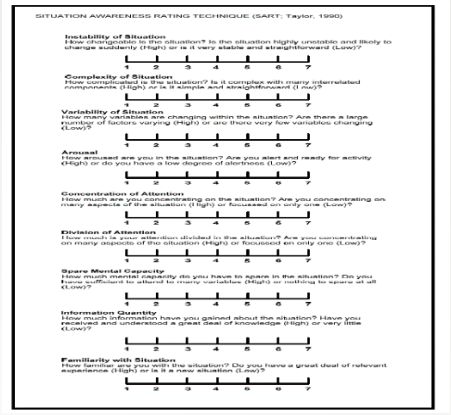

SA Literature [Endsley., 1988]

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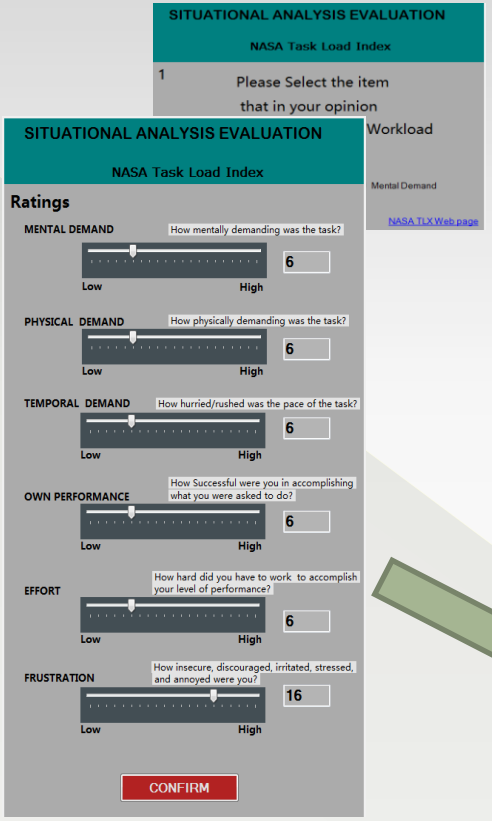
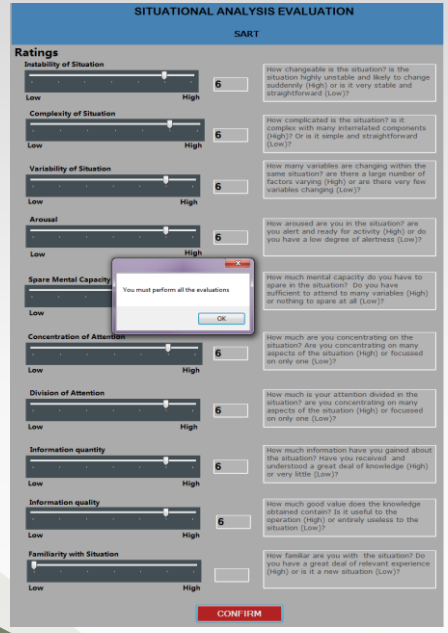
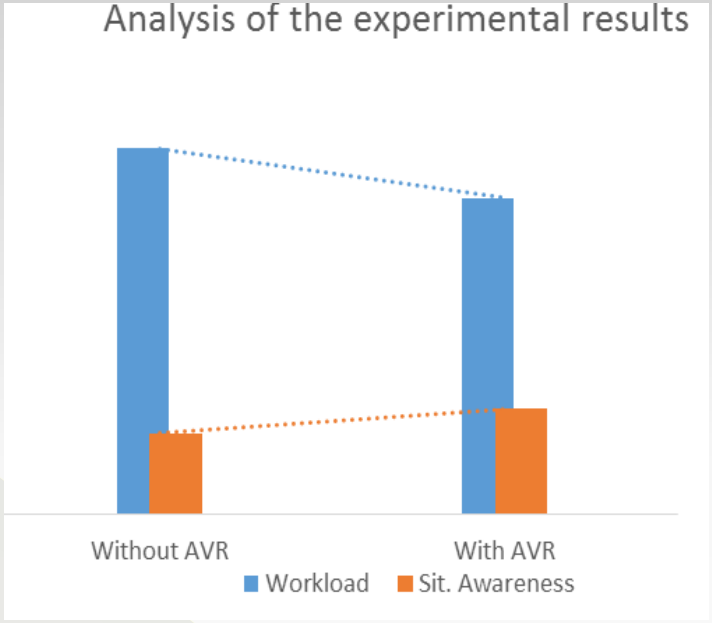




Output data to File

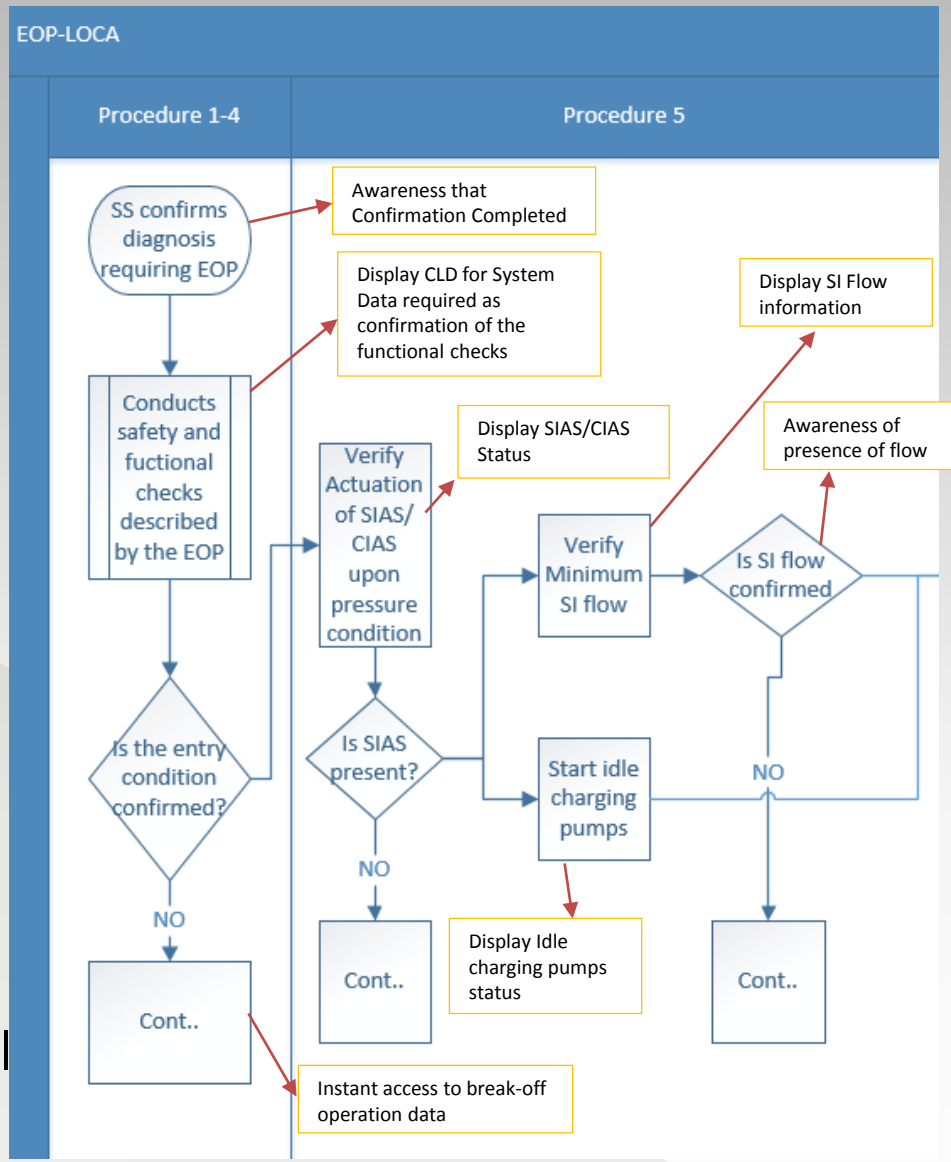
Solution Methods - Initial Test data results

- 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



Solution Methods

- 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.

Q&A