Human Performance Factors Related to SMR Operations

Megan Moore

Stakeholders: CNSC, NRCan

Background: Nuclear operators are responsible for maintaining the safe operation of a nuclear reactor via a series of complex systems controlled from the main control room (MCR). New paradigms in the design and operation Small Modular Reactors (SMRs) brings new Human Factors (HF) Challenges. Future Human Factors Engineering plans should address the potential cognitive effects of working in a high stress environment such as an SMR control room.

SMRs are nuclear reactors that:

- Generate a maximum of 300 MW of electrical output
- Can be assembled from factory constructed components
- Have the potential to operate individually, or in series
- Are more heavily automated than current nuclear reactors
- And feature passive *walk-away* safety systems

Human Factors concerns the interactions among humans and other elements of a system [1]

HF associated with new SMRs include (not limited to) :

- Designing control rooms
- Designing training programs
- Presenting information so that operators can gain a sense of situational awareness

Project Objective: investigate the HF considerations to do with new SMR operations, including:

(1) Operation of multiple SMR units from a single control space (Year 1) and

(2) Remote operations (Year 2) to provide guidance to regulators and SMR Vendors on considerations that should be made when designing for situational awareness in the MCR of an SMR.

The implications of the shift from manual to digital controls, and of increasing levels of automation in a control room setting will also be discussed.

(CANDU 6 Program Team, 2005)

(NuScale Power, 2017)

A representation of the changes to the control room style from a computer model of the Candu 6 Control Room [2] to a simulator designed by NuScale Power [3], commissioned in May 2017. Digital controls and further monitoring responsibilities for operators will change the required behaviour and actions of operators when monitoring and steering operations.

Findings to date

HF elements from the air traffic control, pipeline, hydroelectric, transportation and satellite industries were compiled and summarized. The following are some of the recommendations for operating multiple SMR units:

- Training an shift structure can be modeled after navy operations to promote information transfer, and minimize complacency.
- Displays should present operators with an overview of facilities and systems to provide indications of malfunctions.
- Automation should be engaging and transparent.
- SMR controls should maintain some level of human intervention.
- Complexity of controls should be minimized.

Anticipated Results

As part of the year 2 research plan, investigations have examined and will include:

- Control room features that may promote situational awareness for operators monitoring reactor behavior from a remote site.
- On site staffing requirements
- Changes to training requirements for on site personnel
- Psychosocial factors that may influence operation of a nuclear reactor in a remote community

Future Work

Research will be undertaken to form a task analysis of an SMR operator, and explore selection criteria and training methods based on non-technical skills.

[1] Dul, J., Bruder, R., Buckle, P., Carayon, P., Falzon, P., Marras, W., … van der Doelen, B. (2012). *A strategy for human factors/ergonomics: Developing the discipline and profession*. https://doi.org/10.1080/00140139.2012.661087
[2] CANDU 6 Program Team. (2005). *CANDU 6 Technical Summary*. *Instrumentation*. Retrieved from https://canteach.candu.org/Content Library/CANDU6_TechnicalSummary-s.pdf
[3] NuScale Power. (2017). NuScale Commissions SMR Control Room Simulator in Richland, WA. Retrieved from https://newsroom.nuscalepower.com/press-release/nuscale-commissions-smr-control-room-simulator-richland-wa