



U.S. Department of Energy

---

## Reinforcement Learning Validation Framework for Quality Assurance of AI-guided Additive Manufacturing Digital Platforms

**PI:** John Sutherland,  
Purdue University

**Collaborators:**  
Hany Abdel-Khalik, School of Nuclear Engineering,  
Xinghang Zhang, School of Material Science,  
Purdue University

**Program:** Transformational  
Challenge Reactor R&D (NE-3)

---

### ABSTRACT:

The Transformational Challenge Reactor (TCR) program has been conceived to lay the foundations for using additive manufacturing (AM) to revolutionize the design, manufacturing, and qualification of nuclear reactor parts. One such revolutionary potential is the use of in-process monitoring -- via a network of in-situ sensors -- to qualify the fabricated parts during or immediately after the build process. This is sought to reduce reliance on the conventional timely and costly post-build tests. Given this ambitious vision, there is a critical need to upgrade the validation practices by developing novel mathematically-rigorous quality assurance (QA) procedures that can be scientifically defended to the nuclear regulatory body to qualify the risk associated with the AM fabricated parts. To address this need, this project proposes a novel rendition of a well-established artificial intelligence (AI) learning strategy -- the multi-armed bandit reinforcement learning (RL) -- as a basis to assimilate/fuse in-process sensors data and physics-based simulation data to calculate risk measures in the form of failure probabilities for the AM parts.

Therefore, the **primary objective** of this project is the development and demonstration of the proposed RL strategy using TCR data and its associated open source DREAM.3D-based digital platform which will be installed at Purdue University (PU) as guided by input from the TCR team. As a **secondary objective**, a sensitivity analysis will be employed to estimate the importance of post-build tests to improving the confidence in the estimated parts failure probability, thereby providing a quantifiable criterion for reducing the need for post-build testing. Another sensitivity analysis will prioritize the key AM process parameters responsible for observed deviations from per-design specifications, serving as a key ingredient for the future development of feedback control for in-situ monitoring for a full autonomous operation of the AM process.