



Advanced Sensors and Instrumentation – NRC Research Status Update

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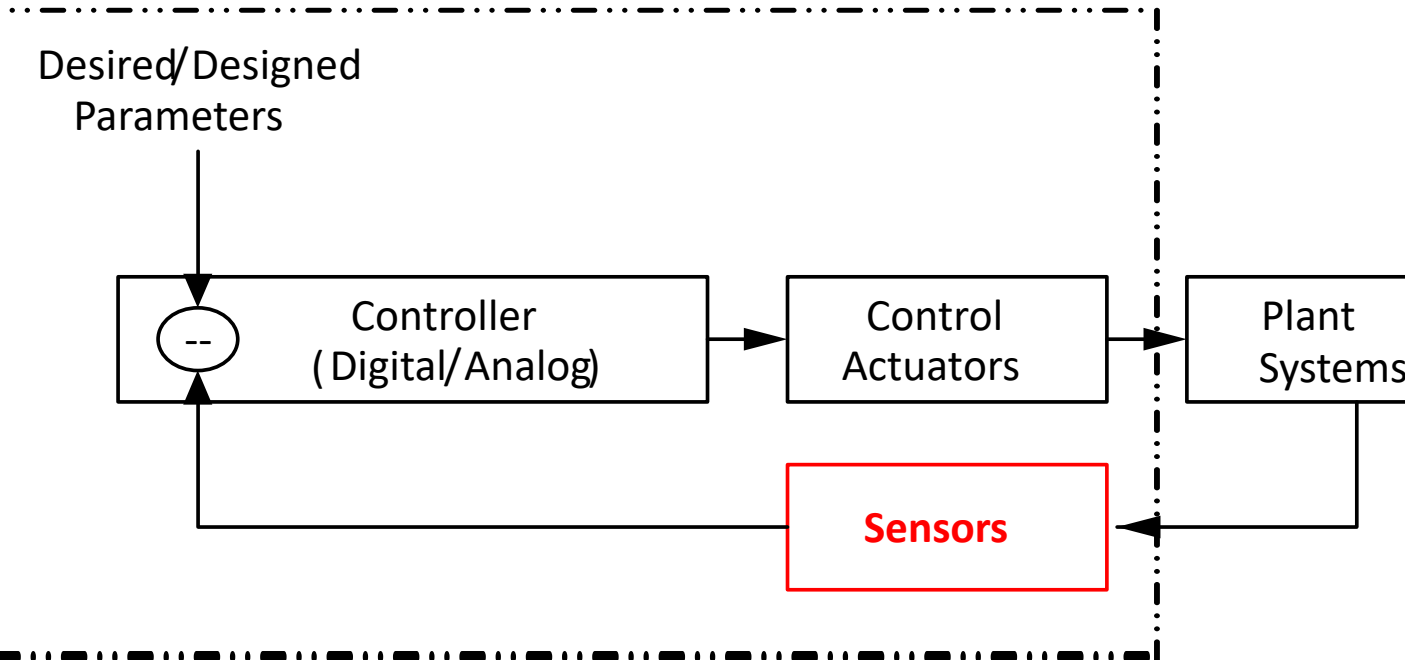


Key Messages

- The Office of Regulatory Research staff research and support current and future NRC activities related to Instrumentation and Controls (I&C)
- New sensor technologies are applicable for both modernizing the operating reactor fleet as well as advanced reactors
- Staff are proactively looking at these technologies to be ready for the future

Regulatory Importance in Current NPPs

Sensors are the “center” of I&C System Designs...



...and Licensed Operation (Tech Specs)

3.4.6 RCS Loops-MODE 4

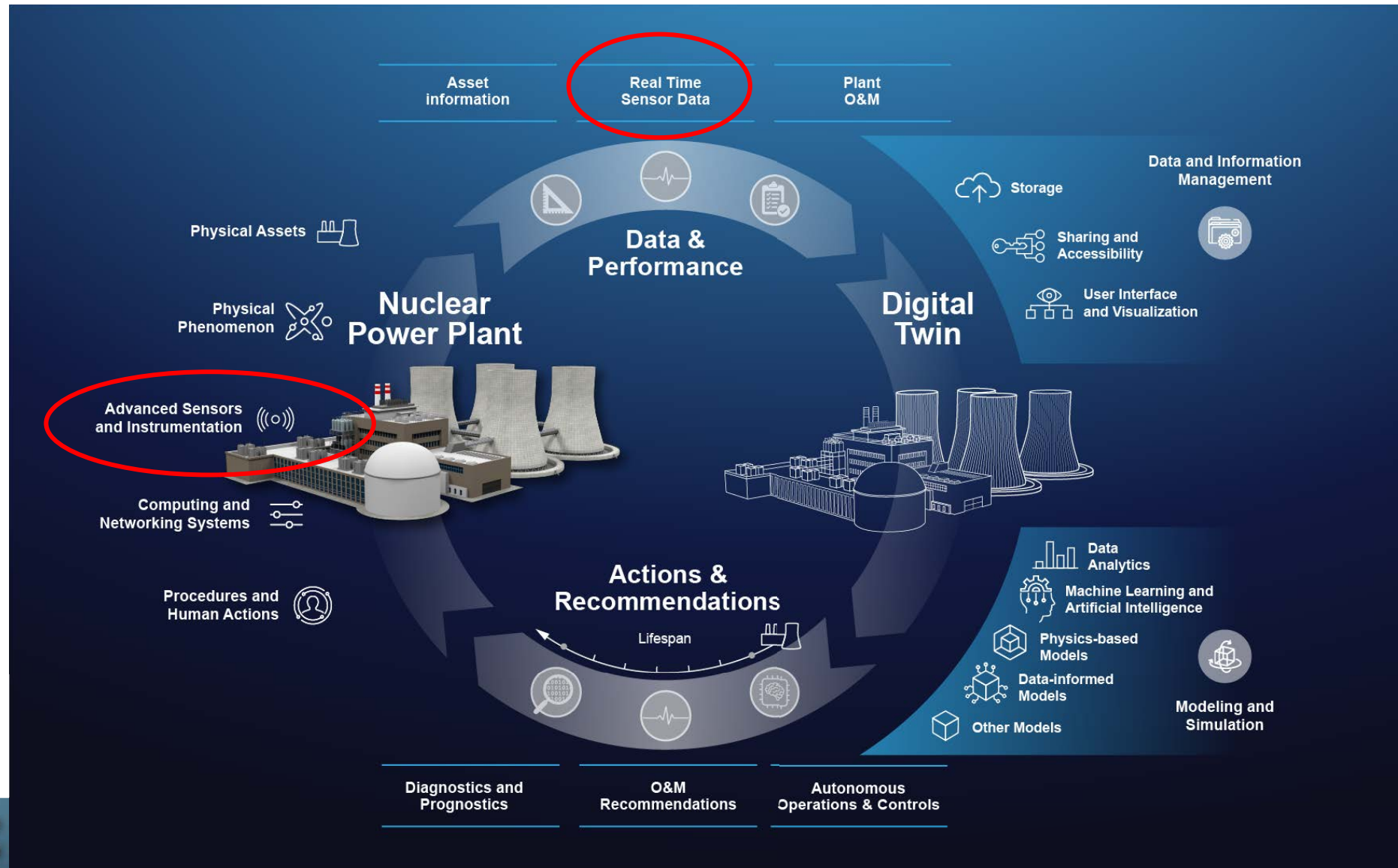
LCO 3.4.6

Two loops consisting of any combination of RCS loops and residual heat removal (RHR) loops shall be OPERABLE, and one loop shall be in operation.

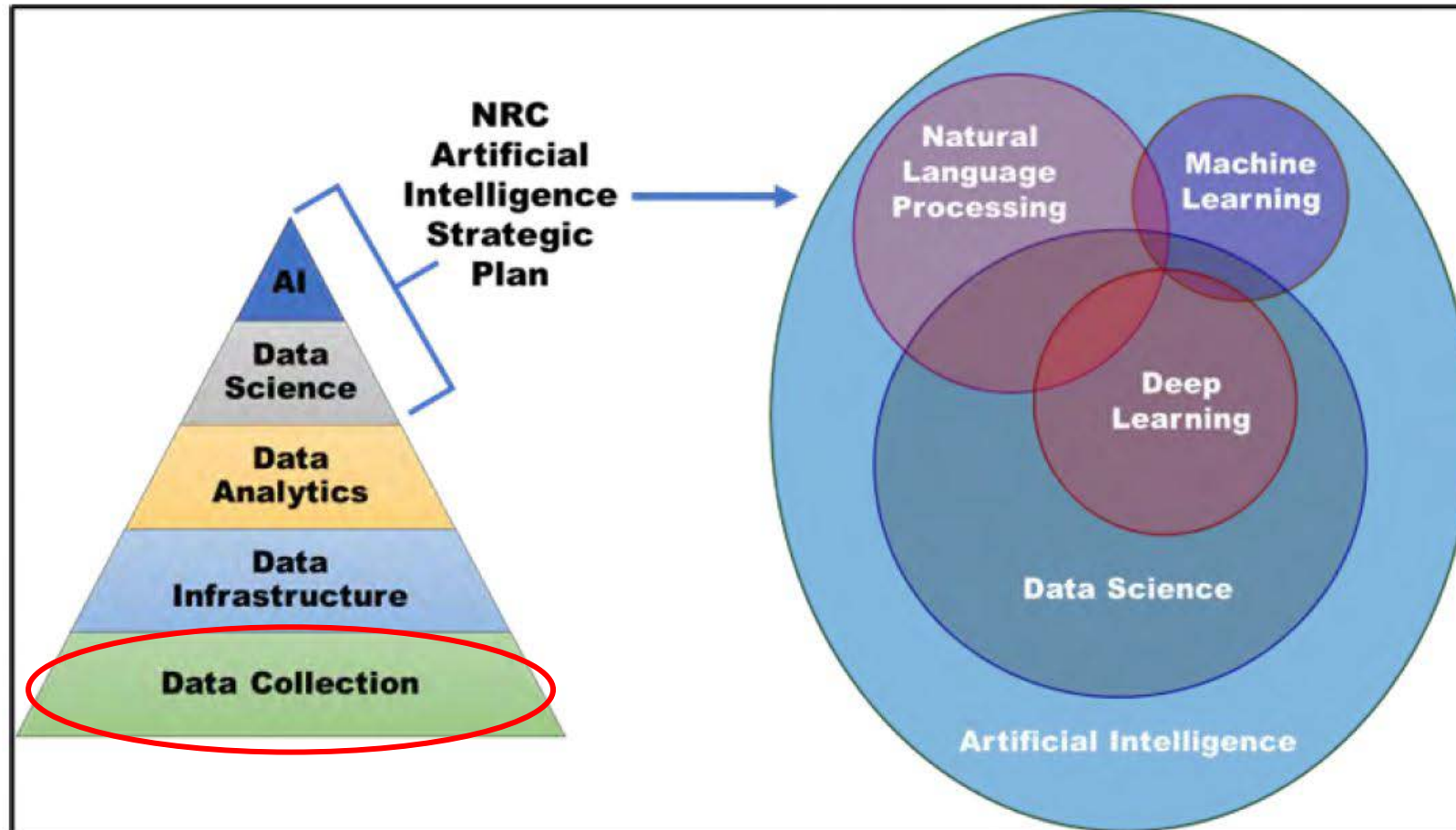
NOTES

1. All reactor coolant pumps (RCPs) and RHR pumps may be removed from operation for ≤ 1 hour per 8 hour period provided:
 - a. No operations are permitted that would cause introduction of coolant into the RCS with boron concentration less than required to meet the SDM of LCO 3.1.1; and
 - b. Core outlet temperature is maintained at least 10°F below saturation temperature.
2. No RCP shall be started with any RCS cold leg temperature \leq Low Temperature Overpressure Protection (LTOP) arming temperature specified in the PTLR unless the pressurizer water level is less than 50%, OR the secondary side water temperature of each steam generator (SG) is $< 50^{\circ}\text{F}$ above each of the RCS cold leg temperatures.

Example Future Use/Need?: Digital Twins



Example Future Use/Need?: AI/ML...



[source: NUREG-2261
at ML23132A305]

Figure 1 Artificial Intelligence Hierarchy and Relationship with the NRC AI Strategic Plan (adapted from [5] and [6])

Instrumentation & Controls Regulatory Framework

- **Part 50/52:** Staff are implementing the vision to develop an integrated strategy to modernize the NRC's I&C regulatory infrastructure. Recent ACRS mtng overview: **ML23123A025** (p. 66 ff.).
- **Part 53:** The staff developed rule package was sent to the Commission on March 1, 2023, with a request to approve and publish the draft proposed rule in the Federal Register for comment. It remains with the Commission.



Current Regulatory Touchpoints:

- **10 CFR 52.47(a)(13):** FSAR must include “The list of electric equipment important to safety that is required by 10 CFR 50.49(d)”. This subsection pertains to Environmental Qualification of electric equipment important to safety for nuclear power plants. See also RG 1.89 (harsh enviro) and related RG 1.209 (mild enviro).
- **RG 1.97:** Starting with Rev 4 of RG 1.97, new instrumentation systems in advanced nuclear power plant designs for severe accident conditions were specified using performance-based criteria to select instrument variables that are needed. This increases flexibility and avoids prescribing the specific variables to be monitored.
- **Regulatory Touchpoints (BTP 7-10):** sensor range/accuracy, redundancy, response time, environmental qualification, pointers other guides (e.g., BTP 7-12), etc.

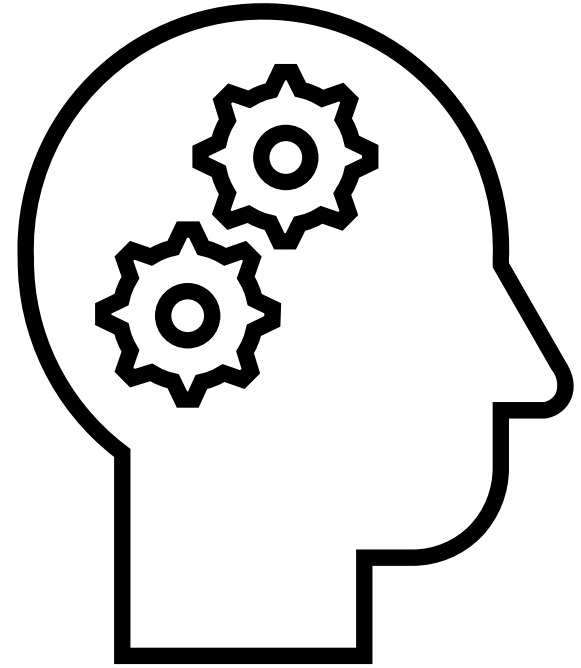
Standard Review Plan, Chapter 7:

<https://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr0800/ch7/index.html>



Advanced Rx Sensor Challenges (a subset):

- Viscosity/corrosive nature of working fluids very different than liquid water and steam.
- Different pressure and temperature regime compared to operating Rx fleet
- Use of new sensor technologies
- Use of new cable types (e.g., fiber optics) and aging in different containment environment



Current Branch Research: Sensor-Intensive Activities



- Artificial Intelligence & Machine Learning (AI/ML) research for cybersecurity



- Remote monitoring

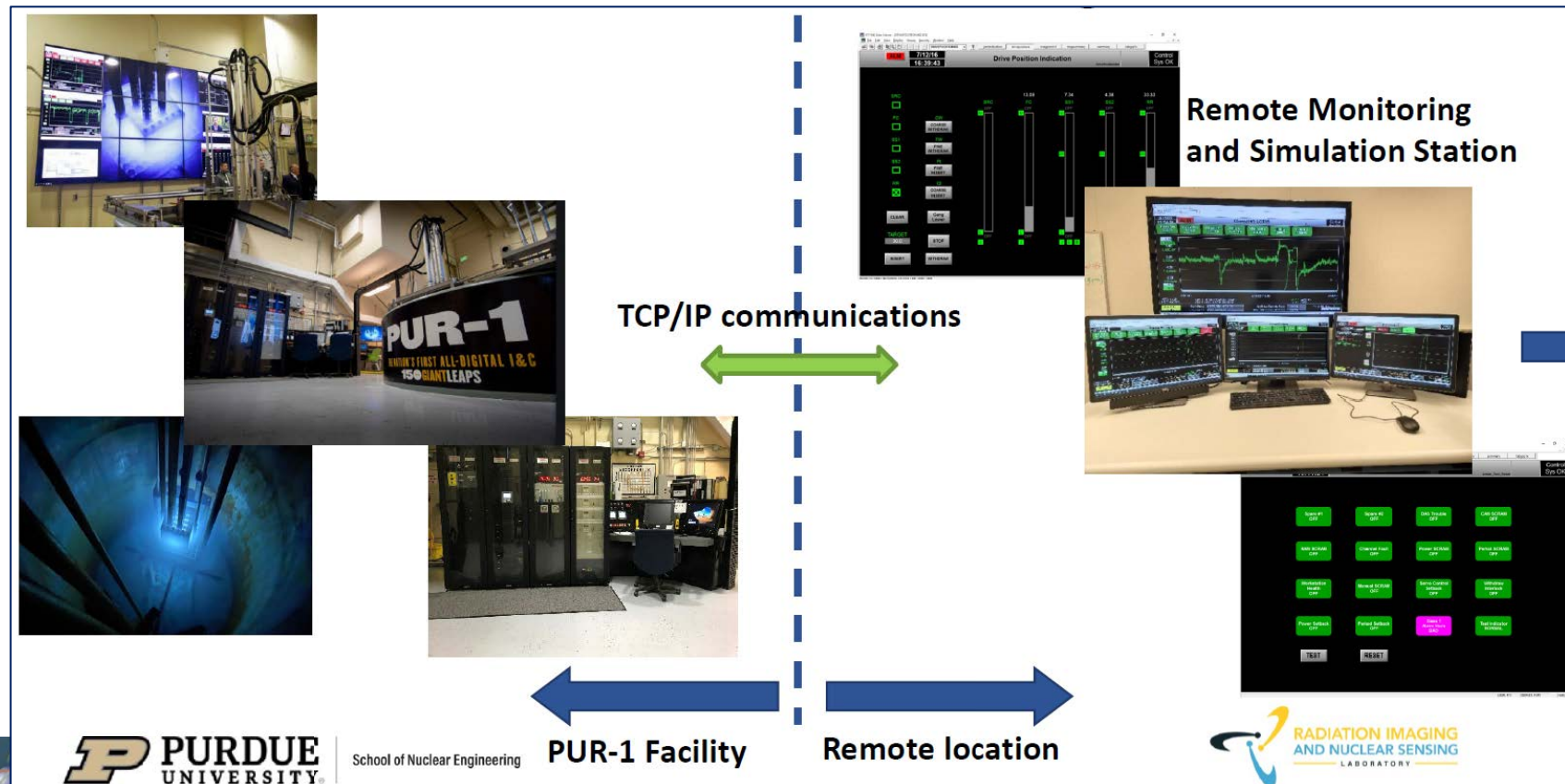


- Wireless safety and security

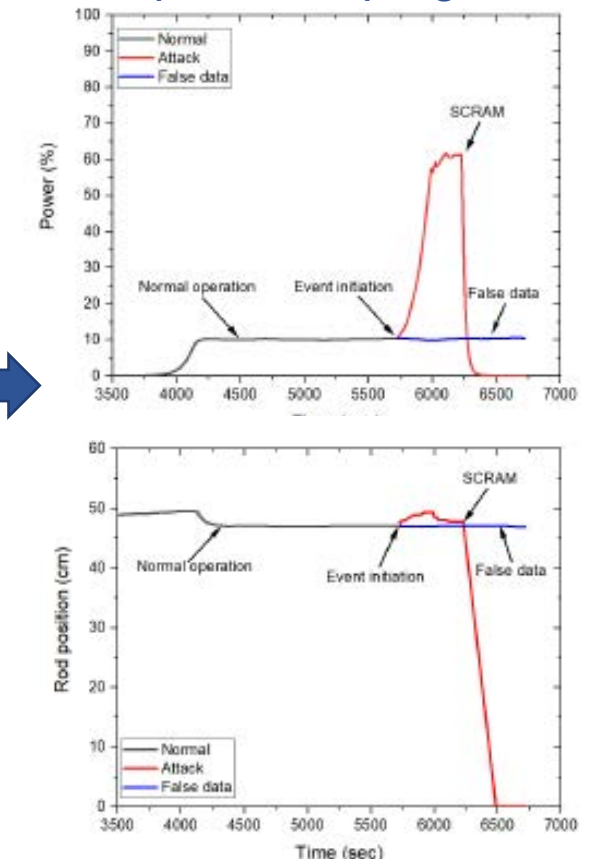
AI/ML Research: FFR for cybersecurity



Perform “future focused research” (FFR) to assess feasibility of AI/ML to identify, characterize, and differentiate nuclear states.



Example event progression



Remote Monitoring



- Researching the current state-of-adoption and application of remote monitoring technologies in non-nuclear industries for industrial controls systems (ICS).
- Motivation/purpose includes:
 - Use of remote access for operations or monitoring can create additional attack vectors.
 - Document insights from technical subject matter experts on these vectors and how they mitigate risk.
 - Document standards and best-practice guidelines on use of remote access for ICS, such as the National Institute of Standards and Technology (NIST) special publications (SPs).

Wireless: Safety and Security

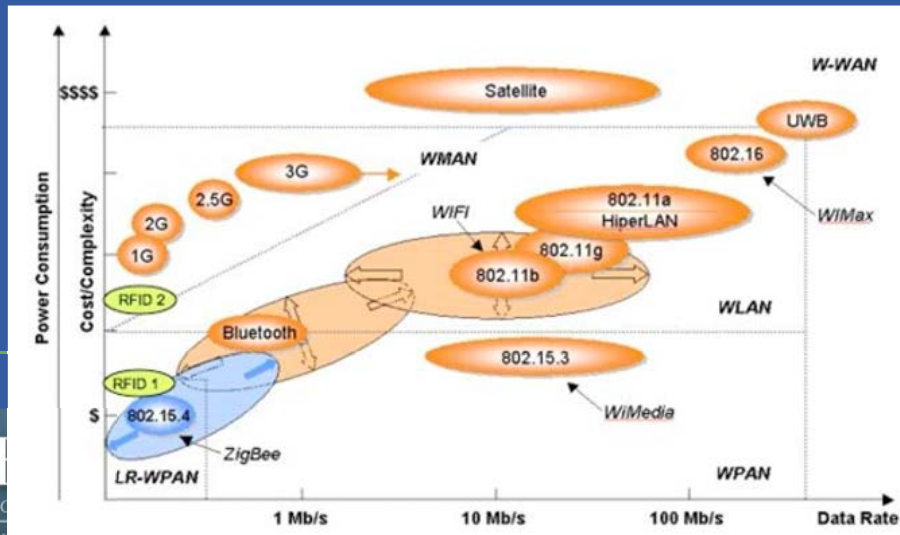


Security:

- Research on cybersecurity insights from other safety-critical industries. See ADAMS ML22180A008

Safety:

- Review of EMI and RFI from modern wireless technologies. Support for RG 1.180 and technical basis for reliability/latency of safety-related applications.



STUDY OF WIRELESS TECHNOLOGY IMPLEMENTATION IN ISOLATED, HIGH CONSEQUENCE NETWORKS

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Conclusion

- Research staff activities are worked in coordination with program office staff to produce **timely and useful products**.
- Technology readiness level and licensees' plans for proposed use of new sensor technologies **factor into research topics**.
- Activities are **aligned to complement** DOE-funded, EPRI-funded, etc., research for differences in mission, purpose, and scope.
- Research staff use MOUs, standards organizations, public meetings and international forums to **calibrate internal priorities** and enable NRC readiness for timely review of future submittals.

Questions?



...and an announcement
that the NRC is **HIRING!**
Openings are available
here:

