Robust Online Monitoring Technology for Recalibration Assessment of Transmitters and Instrumentation

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ABSTRACT:
The goal of this research is to develop the next generation of online monitoring (OLM) technologies for sensor calibration interval extension and signal validation in nuclear systems, through the development of advanced algorithms for monitoring sensor/system performance and the use of plant data to derive information that currently cannot be measured. Specific objectives are: (i) apply methods for data-driven uncertainty quantification (UQ) to develop methodologies for high-confidence signal validation; (ii) develop robust virtual sensor technology to derive plant information that currently cannot be measured (either due to sensor failure or lack of sensors); and (iii) develop a general framework for OLM of both calibration and response time assessment for current and future sensors and instrumentation. These advances are expected to improve the safety, reliability, and economics of current and planned nuclear energy systems as a result of higher accuracies and increased reliability of sensors used to monitor key parameters, as well as targeted instrumentation maintenance actions during planned outages. The research will focus on temperature, pressure, level, and flow instrumentation used for measurement of process variables for control of the plant and monitoring of its safety. In addition, the project will include an assessment of sensor response time technology for integration with OLM and thereby provide a complete picture of health, reliability, accuracy, and speed of response of process instrumentation in legacy and future nuclear facilities.

Safe, efficient, and economic operation of nuclear facilities (nuclear power plants, fuel fabrication and storage, used fuel processing, etc.) relies on accurate, timely, and reliable measurement of process variables. During operation, components of nuclear facilities, including sensors, may degrade due to age, environmental exposure, and even maintenance interventions. These factors (which could lead to failure of the sensing element) result in anomalies, such as signal drift and response time changes in the measured signal and failure of the sensing element, and challenge the ability to reliably distinguish between signal changes due to plant or subsystem performance deviations and those due to sensor or instrumentation issues. OLM is a non-invasive approach to assess measurement accuracy and component condition, and provides an alternative to periodic sensor recalibration (the dominant current approach to addressing these instrumentation problems) which is costly, radiation intensive and time consuming. No U.S. plant has implemented OLM except for demonstration and research purposes. This is partly due to several technical gaps that must be addressed in order to provide the technical and regulatory bases for these technologies for existing and future plants.

This project addresses the needs of the NEET-2.2 Program Element and closes critical gaps that currently hinder the deployment of OLM technologies in nuclear facilities through the development of advanced algorithms for monitoring sensor/system performance and enabling the use of plant data to derive information that currently cannot be measured. Expected outcomes of this project include technologies for high-confidence signal validation, virtual sensors with integrated uncertainty quantification, and demonstration of the technologies in an appropriate test-bed environment. This project will lay the groundwork for wider deployment of advanced OLM in US nuclear facilities by developing a methodology to: (1) support the regulatory basis for OLM-based calibration assessment, (2) provide the high confidence levels needed for signal validation, (3) provide virtual sensor estimates with meaningful confidence, (4) integrate response time testing of pressure transmitters with the OLM framework, and (5) evaluate the efficacy of these techniques for new sensors systems.

The research project is a collaborative effort between the Pacific Northwest National Laboratory (PNNL), University of Tennessee Knoxville and AMS Corp., and will leverage earlier R&D in this area that developed data-driven uncertainty quantification (UQ) methods. The project team includes technical experts in signal analysis and data fusion (**PI** Dr. Pradeep Ramuhalli), uncertainty quantification (Dr. Guang Lin), simulation models (Dr. Susan Crawford), research in signal validation and OLM (Dr. Jamie Coble), and OLM research and implementation (Mr. Brent Shumaker and Dr. Hash Hashemian). PNNL will lead tasks related to virtual sensors and OLM in next-generation sensors, UTK will lead tasks related to signal validation and (co-lead) virtual sensors, and AMS will lead efforts in response time OLM and verification and validation methods.