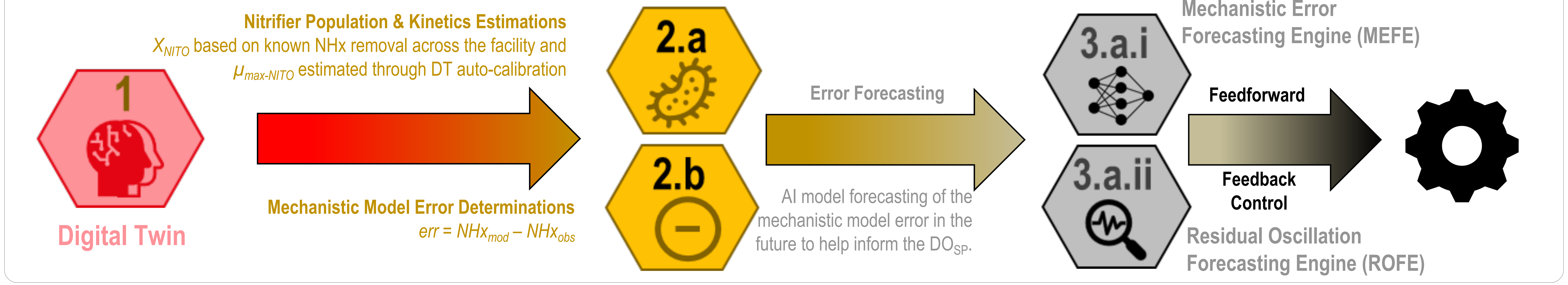
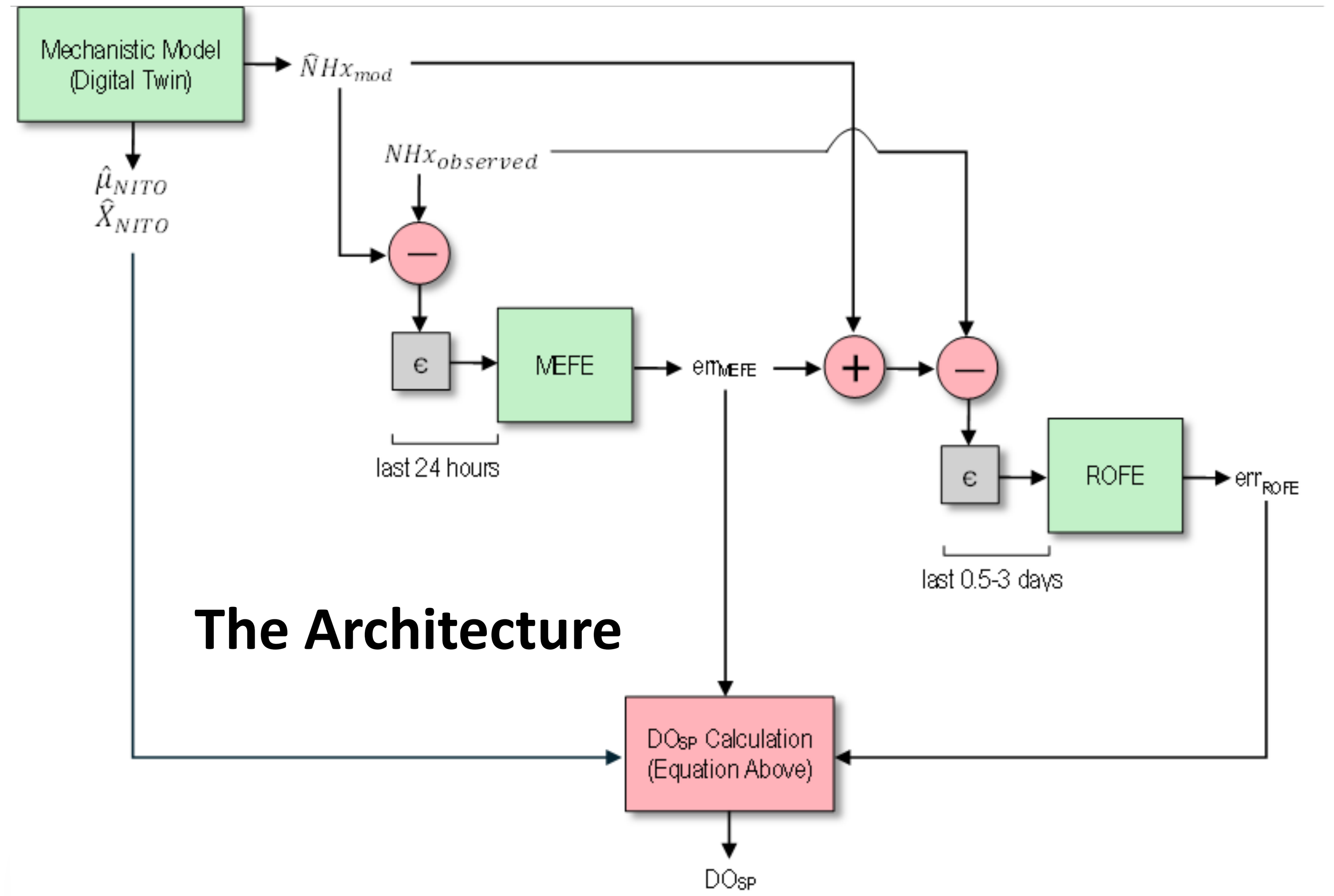
HAMPTON ROADS SANITATION DISTRICT (HRSD)
Next-Gen Nitrogen Removal at a Full-Scale WRRF

NEAA26 RESEARCH & TECHNOLOGY

National Environmental Achievement AWARDS

The Foundation for Advanced Control





Bringing AI to Biological Process Controls

Two AI models, developed and tested by HRSD staff, were integrated into an Ammonia-Based Aeration Control (ABAC) scheme. These AI models, **coined the MEFE and the ROFE**, resulted in controller performance improvements that **are setting the stage for robust** downstream process operation, including **shortcut nitrogen removal and indirect potable reuse**.

The solution:

The first full-scale Digital Twin built for nitrification enhancement

Mechanistic Digital Twin + Machine Learning Models = Hybrid Model for Control

Built by:

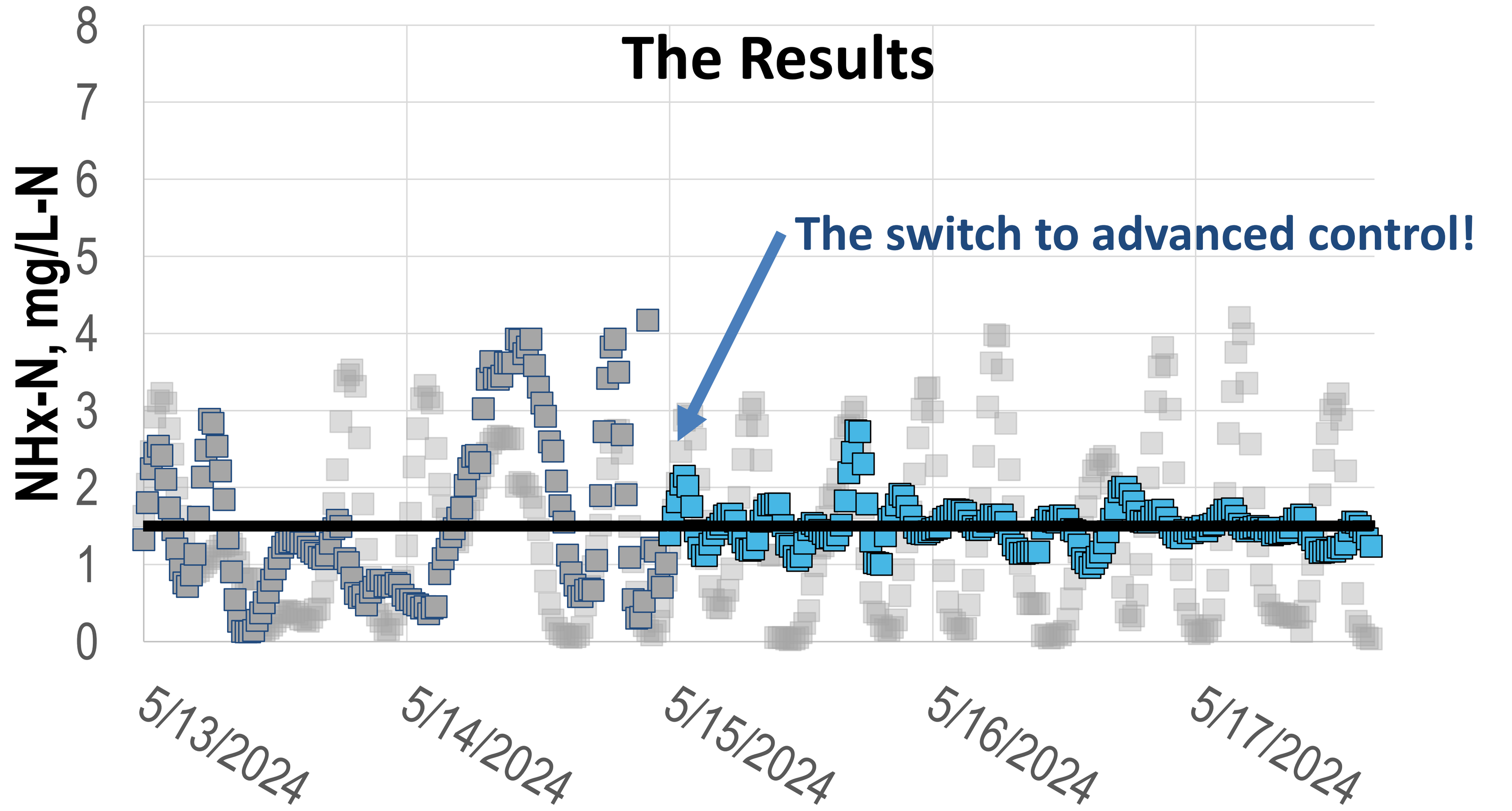
Collaborative group comprised of academics, software providers, and utility staff

Sets the Stage for:

Robust Indirect Potable Reuse

Robust Shortcut Nitrogen Removal

The People



Member Spotlight (321 words)

Hampton Roads Sanitation District's Nansemond Treatment Plant (HRSD NTP) has taken a big step toward steadier water quality and lower operating costs by pairing a targeted Digital Twin (DT) with a modern, AI-enabled aeration controller. The goal was simple, and that was to keep ammonia right on target all day, every day, even as flows and loads swing dramatically. This was historically a challenge given the tank dynamics and orientation.

The DT is a live, computer-based replica of the biological process that updates every minute with plant data. It estimates how active the nitrifying bacteria are and suggests simple actions, like adjusting the sludge wasting rate, that keep the process responsive across seasons. That insight helps operators today and gives designers better information for tomorrow.

On top of that foundation, NTP deployed a hybrid controller that blends first-principles and artificial intelligence. The mechanistic piece calculates the oxygen demand needed to hit a chosen ammonia setpoint. Then lightweight AI models look at recent error patterns and gently affect the oxygen setpoints to keep the ammonia on track. Operators see clear graphics, can toggle the AI aids on or off, and safety interlocks always allow a return to the familiar baseline loop.

The result? Smoother oxygen setpoints, fewer peaks and dips in effluent ammonia, and a measured 94% drop in controller error compared to the previous feedback-only approach. That consistency supports the region's water reuse goals and positions the plant for advanced nutrient removal strategies that can cut both energy and chemical use. Namely, NTP is now poised for successful mainstream partial denitrification anammox (PdNA), a technology that is currently being installed.

This project shows that bringing AI to Water Resource Recovery Facilities (WRRFs) doesn't have to be mysterious or complicated. By focusing the DT on a single objective (nitrification) and keeping the controller design transparent and operator-friendly, NTP delivered a landmark, full-scale demonstration of tools that other utilities can adopt with confidence.