AeroTwinX™:
A Physics-Aware, AI-Enabled Digital Twin Framework for Aero-Engines

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ABSTRACT

The behaviour of aero-engines arises from strong interactions between fuel delivery, gas-path thermodynamics, shaft rotordynamics, lubrication hydraulics, and structural vibration. Modern test beds measure these subsystems through multi-rate signals such as throttle position, RPM, exhaust gas temperature (EGT), fuel flow and pressure, oil pressure and temperature, compressor inlet pressure, ambient conditions, torque-meter pressure, and high-frequency casing vibration. Conventional condition monitoring typically relies on trending and alarm thresholds, offering limited capability for reconstructing internal physical states or quantifying health in real time.

This talk will describe AeroTwinX™, a physics-aware, AI-enabled digital twin framework developed to address these limitations for aero-engine applications. The platform unifies multi-rate sensing through a common time-aligned architecture, transforming vibration measurements into STFT-based spectrograms while synchronising gas-path, fuel, oil, and environmental parameters. A dual-head neural architecture simultaneously performs fault classification and regression of latent physical states such as shaft speed, thermal load, and torque, ensuring diagnostic outputs remain consistent with underlying engine physics.

AeroTwinX incorporates a mathematically defined Health Index (HI) that combines diagnostic confidence with deviation of predicted internal states from learned healthy envelopes. This provides a continuous and interpretable measure of engine integrity, sensitive to both abrupt faults and gradual degradation. Case studies demonstrate how AeroTwinX advances aero-engine monitoring from reactive fault detection to state-aware digital twinning, enabling predictive and health-centric decision support for propulsion systems.