Credibility Over Accuracy: AI, Physical Fidelity, and the Future of Composites Simulation

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The past decade has witnessed an unprecedented, and at times uncritical, expansion of artificial intelligence across the industrial spectrum. From the modernization of legacy manufacturing to the high-stakes development of First-of-a-Kind (FOAK) emerging technologies, AI is fundamentally reshaping the engineering lifecycle. However, beneath the digital transformation narrative lies a fragmented reality where AI adoption is uneven and its physical boundaries are often poorly defined.

This talk provides a practitioner's cross-domain survey of AI applications across the full industrial value chain, including material discovery, product design, manufacturing, and real-time process control. The presentation explores how accelerated computing is redefining the limits of simulation by enabling a shift from static validation to dynamic, real-time insights. The landscape is evaluated through three distinct lenses:

- **Where AI genuinely transforms practice:** This involves utilizing GPU-accelerated surrogate modeling and physics-informed neural networks to achieve orders-of-magnitude speedups in multi-physics coupling.
- **Where AI is applied in hybrid form:** This involves creative use of AI with complementary methodologies to enhance existing workflows.
- **Where AI faces fundamental barriers:** This includes addressing data scarcity in high-capital FOAK projects, the "black box" interpretability crisis, and the challenge of enforcing rigorous physical laws within learned models.

A critical observation of this survey is the existence of "borrowed successes," which are proven AI methodologies from fields such as fluid dynamics and structural health monitoring that offer high applicability to composites but remain largely underutilized. Central to this discussion is the role of digital twins for predictive maintenance and uncertainty quantification (UQ). In safety-critical workflows where experimental data is often prohibitively expensive, model credibility must be the operative standard rather than mere predictive accuracy.

Drawing from these broad industrial lessons, the session argues that the most productive role for AI in composites is as an intelligent interface layer. This framework manages uncertainty across scales, ensures reliable lifecycle monitoring, and enables transferability across evolving material systems. The talk concludes by defining the validation frameworks and data infrastructure necessary to move toward trustworthy, certification-ready AI integration in composite simulation.