



## **Typhoon HIL - Industrial Challenge Proposal for IECON 2025**

*Advancing Digital Power Control with Model-Based Engineering*

### **1. Problem Statement and Specific Goals**

The design, development, and lifecycle maintenance of digital controllers for power electronics, power systems, and industrial applications are becoming increasingly complex. This is driven by the integration of advanced control strategies, including AI/ML-based algorithms, multi-domain interactions, distributed architectures, virtualization, among others – all of which add to the complexity and require rigorous validation, which can become overwhelming if not properly managed. Traditional development and deployment approaches that are highly fragmented and siloed often lead to significant inefficiencies, late-stage issue discovery, costly and expansive design iterations, and integration challenges.

This Industrial Challenge invites student teams to explore **Model-Based Engineering (MBE)** methodologies as structured workflows for designing, validating, and **implementing control and optimization for intelligent digital power applications**. Participants will have the opportunity to demonstrate the relevance, innovation, and technical soundness of their **application-specific contributions** while **integrating and applying MBE principles** across different stages of system development, from early modeling to real-time implementation.

Participants are welcome to base their proposals on ongoing research projects, including papers presented at IECON 2025, or build upon existing examples available in [Typhoon HIL Control Center](#), provided they introduce significant contributions or advancements beyond the existing material.

#### **Key Objectives:**

- Encourage participants to adopt a unified MBE development approach, leveraging simulation-based techniques for control design and validation.
- Explore a range of industrial applications, within unified environment, including Renewable Energy, Smart Grid, Microgrids, Energy Storage, Transportation Electrification, and Industrial Cyber-Physical Systems.
- Assess the completeness and rigor of the development process, including system modeling, verification, and real-time validation.
- Recognize teams that effectively demonstrate a structured workflow using different simulation methodologies (Model-in-the-Loop, Software-in-the-Loop, Controller Hardware-in-the-Loop) and test automation strategies.
- Evaluate the application-specific contributions of each project, assessing its relevance, technical accuracy, and innovation within the chosen domain.



## 2. Challenge Scope and Topic Areas

Participants are encouraged to apply their MBE workflows to any relevant industrial domain under the scope of IECON, **including but not limited to**:

- **Renewable Energy & Smart Grids:** Advanced control strategies for power converters, grid-forming inverters, energy storage systems, microgrids.
- **Industrial Cyber-Physical Systems & Automation:** Intelligent control, embedded systems, and automation strategies for industrial applications.
- **Transportation Electrification:** Control of electric vehicle powertrains, charging stations, and charging infrastructure.

The challenge **does not prescribe specific requirements for the technical application**, although the relevance, innovation, and technical consistency of the application-specific contribution will be evaluated by the panel of experts.

Teams are free to choose a problem within these domains as long as they demonstrate **a structured and systematic approach to control development and validation using Typhoon HIL integrated toolchain**. Additional details are provided in the evaluation criteria.

## 3. Target Participants

- **Eligibility:** Teams of 2 to 5 people. (outside team mentoring allowed)
  - Open to undergraduate, master's, PhD students, and post-doc.
  - At least one of the members from the team must have a [HIL Specialist 2.0](#) certification (certificate to be presented together with the deliverables of the first stage).
  - **HIL Specialist 2.0 course is free and to be done online.**
- **Recommended Skills:** Knowledge of control systems, power electronics, embedded systems, or industrial automation is beneficial but not mandatory.

## 4. Registration Fees

Participation is free for all participants registered in the IECON 2025 conference.

## 5. Competition Format and Evaluation Criteria

### A) First Stage: Remote Development & Simulation

- Teams will develop their models and control strategies using Typhoon HIL offline simulation tools such as [TyphoonSim™](#), Virtual HIL (VHIL), and their test automation solutions using the [TyphoonTest™](#) framework.



- They will submit a **technical report (white paper format) along with simulation files and a short video**, explaining their workflow, methodology, and preliminary validation.
  - The technical report (white paper) should have a maximum of 5 pages.
  - Simulation files must include all files necessary for the results to be reproduced. These files will not be shared with anyone outside the challenge organization or evaluation committee unless explicitly authorized by the authors.
  - The short video should be a maximum of 10 minutes long.
- **Evaluation will focus on:**
  - Application-specific contribution: relevance, technical accuracy and innovation within the chosen application domain.
  - MBE workflow integration: how the team structure and apply different simulation methodologies and modelling approaches (Model-in-the-Loop, Software-in-the-Loop).
  - System modeling and simulation depth.
  - Quality of verification and validation strategies, including the definition of relevant performance metrics for the problem being considered.
  - Automated tests to validated submitted models and control code.
  - Technical report (white paper) quality.

#### **Selection Process:**

- A panel of experts will assess submissions and select finalists based on the technical rigor and completeness of their approaches.
- The best teams will be selected as finalists based on their submissions.

#### **B) Final Stage: In-Person Challenge at IECON 2025**

During IECON 2025, finalist teams will:

1. **Present and pitch their solutions**, explaining their design and validation process as well as highlighting a structured MBE workflow.
2. **Additional Evaluation Criteria:**
  - Deploy their controllers in real-time using MIL or SIL approach, validating them on an available Typhoon HIL real-time simulator (**extra points**).



- Implementing their controller on an embedded hardware platform (e.g., digital signal processor) and performing Controller Hardware-in-the-Loop (C-HIL) testing (**additional points**).
- Exploring advanced MBE extensions, such as the idea of digital twins for lifecycle maintenance (**bonus points**).

The final ranking will emphasize both the quality of the **technical solution for the application-specific problem, and the systematic use of MBE methodologies using Typhoon HIL integrated toolchain.**

## 6. Resources and Support Provided

Typhoon HIL will provide:

- **Software access** to TyphoonSim, VHIL, TyphoonTest, and Typhoon Test IDE, for remote development.
- **Real-time simulators** during the final stage at IECON 2025.
- **Texas Instruments Launchpad** LaunchXL-F28379D and HIL TI LaunchPad Interface for hands-on implementation in the final stage.
- **Guidance** on MBSE best practices, evaluation frameworks, and training materials for the integrated simulation toolchain.

## 7. Awards and Recognition

The winning teams will receive:

- 1<sup>st</sup> Place:
  - Cash award: 1000 EUR
  - HIL Expert Certificate recognition.
  - **Donation\*\* of a complete flagship Typhoon HIL Teaching Station**, comprised by
    - one [HIL101 real-time simulator](#)
    - one [TI Launchpad Interface board](#)
    - access to the complete [Typhoon HIL integrated toolchain](#).
- 2<sup>nd</sup> Place:
  - Cash award: 500 EUR
  - HIL Expert Certificate recognition.
  - **Donation\* of a complete HIL Teaching Station**, under the same conditions as the 1st place prize.



- 3<sup>rd</sup> Place:
  - Cash award: 500 EUR
  - HIL Expert Certificate recognition.

Additional Recognition:

- Certificate of Recognition at the IECON 2025 banquet
- Potential internship or collaboration opportunities with Typhoon HIL
- Opportunity to have the case study and white paper published through Typhoon HIL's toolchain and media channels.

\*The donation will be made to the educational institution of one of the members of the Team, subject to local restrictions and availability.