

# Faulty Behaviors Simulation in Industrial Cyber-Physical Systems for Safety Analysis

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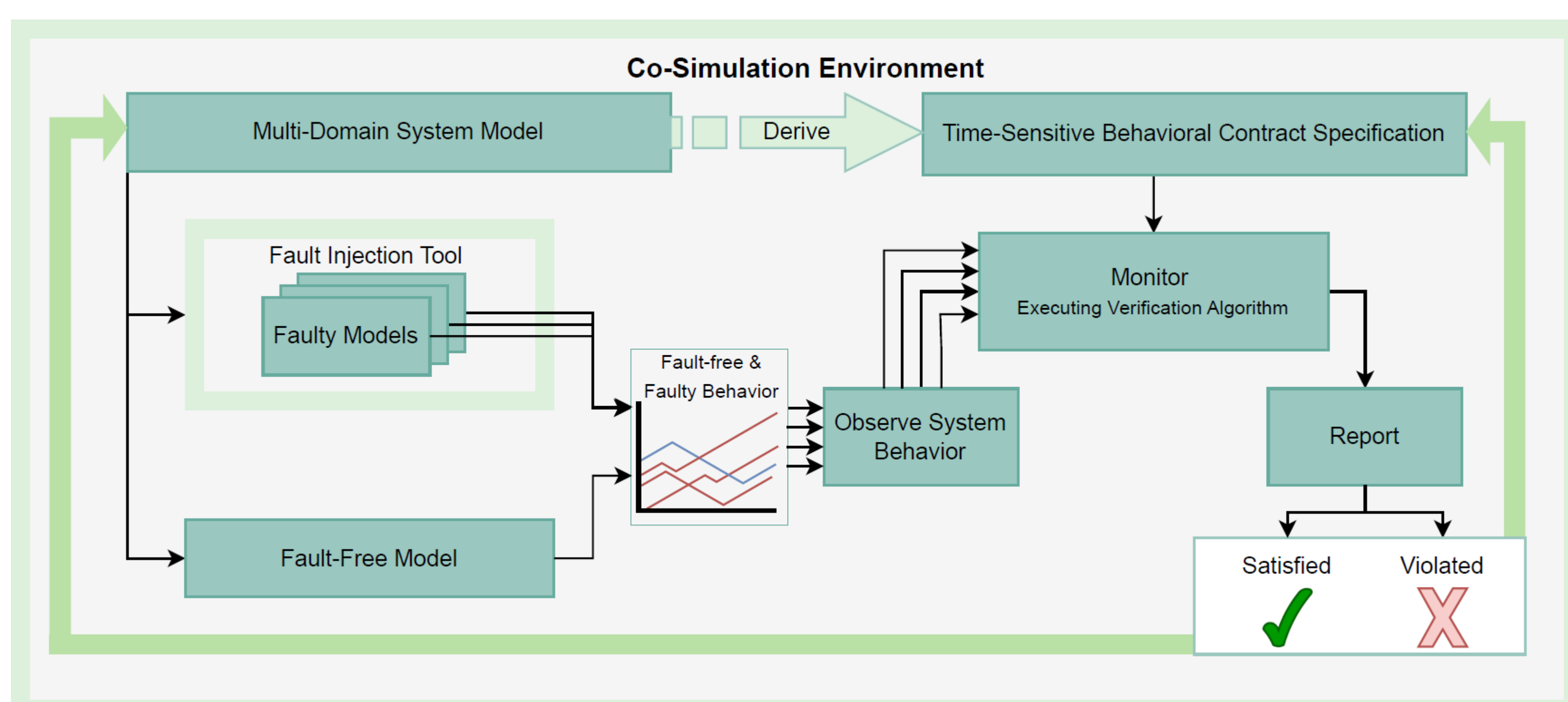
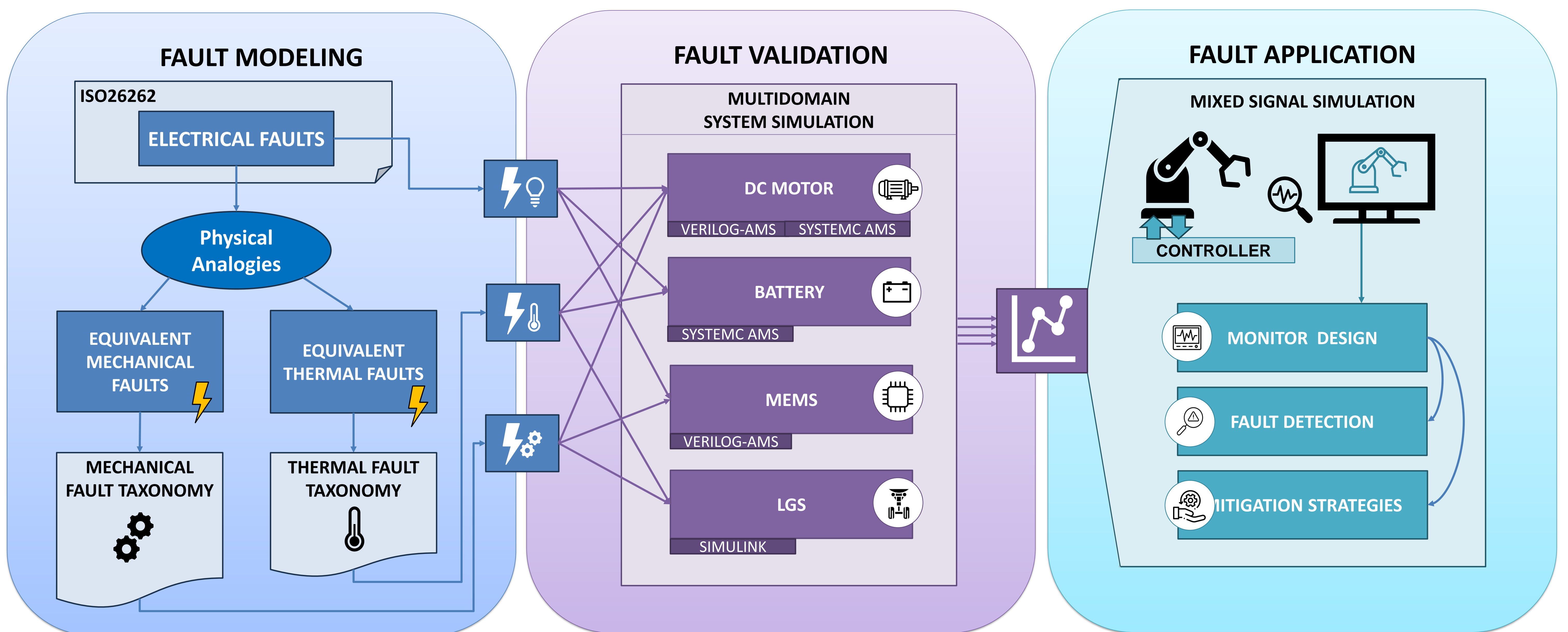
## Motivations

- Raising the **safety level** of Industrial Cyber-Physical Systems (ICPS) in the Industry 4.0 context
- Creating **behavioral simulation** models of ICPS for:
  - improving the system's design phase
  - developing fault models for safety analysis
  - creation of fault detection mechanisms
  - enhance the maintenance cycle of machinery
- Approaching the design and simulation of the **multi-domain** system:
  - through different system design languages
  - to simulate multiple faults scenarios

## Preliminary Results & Current Works

- Multidomain behavioral **fault models** obtained through the physical analogies among the electrical, mechanical, and thermal domains;
- Testing and validation of such fault models on several systems, coded in different simulation environments such as Verilog-AMS, Simulink, and SystemC-AMS;
- Extending the developed methodologies to test the **thermal runaway** scenarios in batteries;
- Application of the proposed fault models to test a fault detection mechanism, which is composed of **monitors** based on **TSBC**;
- Exploring the capabilities of gaming engines for enhancing the effectiveness of the physics system's simulation.

## Overview



## References

- 1) F. Bruns, F. Tosoni et al., "Analyzing Fault Behaviors in Multi-Domain Systems with Contract-Based Monitors," in 2024 29th IEEE International Conference on Emerging Technologies and Factory Automation (ETFA). IEEE, 2024
- 2) F. Tosoni, N. Dall'Ora et al., "Multidomain Fault Models Covering the Analog Side of a Smart or Cyber-Physical System," IEEE Transactions on Computers, vol. 73, no. 3, pp. 829–841, 2024
- 3) F. Biondani, N. Dall'Ora, F. Tosoni et al., "Fault Injection for Synthetic Data Generation in Aircraft: A Simulation-Based Approach," in 2024 IEEE 22nd International Conference on Industrial Informatics (INDIN). IEEE, 2024
- 4) F. Tosoni, N. Dall'Ora et al., "Assessing Robustness of Smart Systems via Multi-domain Analog Fault Simulation," in 2024 IEEE 30th International On-Line Testing Symposium (IOLTS). IEEE, 2024
- 5) F. Tosoni, N. Dall'Ora, et al., "Thermal Digital Twin of a Multi-Domain System for Discovering Mechanical Faulty Behaviors," 2023 IEEE 21st International Conference on Industrial Informatics (INDIN). IEEE, 2023