


Chapter 12

Cybersecurity Risks in Human-in-the- Loop (HITL) System: Emerging Technologies and Integration

Nidhya Rathinavel

 <https://orcid.org/0000-0002-9962-5478>


PSG Institute of Technology and Applied Research, India

C. Monishkka

 <https://orcid.org/0009-0002-9374-0747>

PSG Institute of Technology and Applied Research, India

K. G. Sukirda

 <https://orcid.org/0009-0002-9374-0747>

PSG Institute of Technology and Applied Research, India

ABSTRACT

This chapter examines cybersecurity risks in Human-in-the-Loop (HITL) systems within emerging technologies and civil infrastructure, focusing on energy systems. As digital transformation accelerates through AI, IoT, and cyber-physical systems, the role of human operators remains critical yet increasingly vulnerable. The chapter explores how human-machine interfaces expand the attack surface, highlights real-world incidents, and analyzes emerging threats targeting both technical and cognitive aspects. By integrating insights from human factors, cybersecurity frameworks, and

DOI: 10.4018/979-8-3373-5621-1.ch012

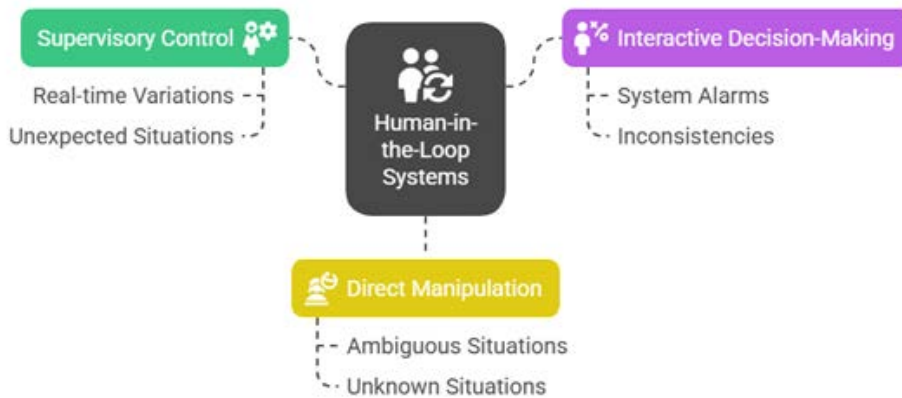
Copyright © 2026, IGI Global Scientific Publishing. Copying or distributing in print or electronic forms without written permission of IGI Global Scientific Publishing is prohibited. Use of this chapter to train generative artificial intelligence (AI) technologies is expressly prohibited. The publisher reserves all rights to license its use for generative AI training and machine learning model development.

infrastructure design, this chapter provides strategies for resilience, governance, and risk mitigation ensuring that HITL systems remain secure, adaptive, and robust in an evolving threat landscape.

INTRODUCTION

The digitization of the civil infrastructure is bringing into being an age where automation and Intelligent systems become vital to efficiency, safety, and sustainability. In this new context, Human-in-the-Loop (HITL) systems have become an important paradigm that combines human judgment with machine intelligence in sophisticated decision-making scenarios. In contrast to fully autonomous systems, HITL systems maintain a core role for the human operator, who remains actively involved in oversight, control, and intervention functions. This is especially crucial in high-consequence civil infrastructure applications such as power grids, water treatment, transportation systems and urban planning, where failures have the potential to cause widespread societal, economic and environmental impacts (Figure 1)(Khan et al., 2024; Natarajan et al., 2025) .

Figure 1. Humans-in-the-Loop Systems in Civil Infrastructure



Human-in-the-Loop systems are computational or cyber-physical systems with human decision-making as an inherent aspect. Unlike fully automated systems, which apply pre-authorized responses or machine learning outputs, HITL systems depend on dynamic interaction between computational components and human agents. Such interaction can be adaptive and iterative in form, allowing the system