

# Towards Cyber-by-Design Security for Digital Twins: Implementing Zero Trust Architecture

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**Abstract—** Industry 4.0 has positioned digital twins as key enablers for real-time monitoring, simulation, and intelligent decision-making across industrial environments. While their integration enhances operational efficiency, it also expands the attack surface, introducing critical cybersecurity challenges. This paper explores recent research efforts aimed at embedding Zero Trust Architecture into digital twin platforms, promoting a cybersecurity-by-design approach tailored to the needs of connected, dynamic industrial systems. The proof-of-concept is implemented within an Asset Administration Shell-based open-source software infrastructure dedicated to create, deploy and monitor Digital Twins.

**Keyword—** Digital twins, Industry 4.0, Cybersecurity, Zero Trust Architecture



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