Proposal: AI-Enabled Post-Quantum Models in Quantum Cyber-Physical Systems

# 1. Introduction

This proposal outlines a framework for integrating AI-enabled post-quantum cryptography (PQC), Quantum AI (QAI), and Quantum Machine Learning (QML) models into Quantum Cyber-Physical Systems (QCPS). The framework leverages Bhadale IT’s QAI Processor, QAI Datacenter, and Product Lifecycle Management (PLM) to build secure, intelligent, and autonomous CPS systems across domains such as drones, robots, IIoT, and social robotics.

# 2. 3D Layered Cube Framework

The proposed layered cube model consists of the following layers:  
- \*\*Foundation Layer\*\*: QAI Processor, QAI Datacenter, PLM backbone.  
- \*\*Cryptographic Layer\*\*: Post-Quantum Cryptographic (PQC) protocols.  
- \*\*AI/ML Layer\*\*: Quantum Machine Learning models, Reinforcement Learning, Generative AI.  
- \*\*Cognition Layer\*\*: Human-in-the-loop decision support, machine consciousness modules.  
- \*\*Autonomous Operations Layer\*\*: Task execution in drones, robots, IIoT systems, and Social Robo Helpers.  
- \*\*Governance & Compliance Layer\*\*: AI ethics, ISO/NIST/IEEE standards, cybersecurity and safety policies.

# 3. Modules, Functions, I/O, Technology Stack

The framework integrates the following key modules:  
  
1. \*\*Modules\*\*:  
 - Quantum Cryptographic Engine (PQC).  
 - AI/QML Model Execution Unit.  
 - Cognitive Decision Layer (with human-in-the-loop controls).  
 - Cyber-Physical Integration Engine.  
  
2. \*\*Functions\*\*:  
 - Real-time secure communication.  
 - Adaptive learning and control.  
 - Multi-agent coordination (robots, drones, IIoT).  
 - Predictive analytics and anomaly detection.  
  
3. \*\*I/O\*\*:  
 - Inputs: Sensor data, environmental conditions, human instructions, threat intelligence.  
 - Outputs: Actuator signals (motion, response), alerts, optimization reports.  
  
4. \*\*Technology Stack\*\*:  
 - Hardware: QAI Processor, FPGA/ASIC hybrids, Edge CPS devices.  
 - Software: QAI OS, QAI Datacenter orchestration, PQC libraries.  
 - Standards: ISO 27001, NIST PQC, IEEE 2413 (IoT), IEC 61508 (safety).

# 4. CPS Operations and Control

The CPS operations under this framework support both \*\*autonomous execution\*\* and \*\*human oversight\*\*. Key features include:  
- Autonomous drones for logistics, defense, and surveillance.  
- Industrial IoT control for predictive maintenance and optimization.  
- Social Robo Helpers for healthcare, education, and smart homes.  
- Human-in-the-loop supervisory control for mission-critical systems.

# 5. Text-Based Block Diagram

Textual Representation of Block Diagram:  
  
[Foundation: QAI Processor + QAI Datacenter + PLM]  
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[Cryptographic Layer: PQC Protocols]  
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[AI/ML Layer: QML, RL, GenAI]  
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[Cognition Layer: Human-in-the-loop, Decision Modules]  
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[Autonomous Ops Layer: Drones, Robots, IIoT, Social Robo Helpers]  
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[Governance Layer: Standards, Compliance, Ethics]

# 6. Mapping Tables

## Table 1: Framework to Standards Mapping

|  |  |
| --- | --- |
| Framework Component | Applicable Standards |
| Cryptographic Layer | NIST PQC, ISO/IEC 14888 |
| AI/ML Layer | IEEE 7000, ISO/IEC 22989 |
| Cognition Layer | AI Ethics Guidelines, IEC 61508 |
| Autonomous Ops Layer | IEEE 2413, ISO 26262 |
| Governance Layer | ISO 27001, GDPR, NIST CSF |

## Table 2: CPS Operations to Functions Mapping

|  |  |
| --- | --- |
| CPS Operation | Functions Enabled |
| Drones | Autonomous navigation, Surveillance, Secure comms |
| Robots | Multi-agent coordination, Human assistance, PQC-secured tasks |
| IIoT | Predictive maintenance, Fault detection, Optimization |
| Social Robo Helpers | Healthcare support, Education, Human-AI interaction |