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# Efficient and Secure Satellite-Ground Communication

*An AI-Driven Quantum Computing Approach*


**Designed by**

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# Research Question

How can we achieve secure and low-latency satellite to ground communication using quantum key distribution, while optimizing performance with AI?

### Focus Question

Secure low-latency satellite-ground communication

### Key Technology

Quantum key distribution (QKD)

### Optimization

AI-enhanced performance improvements

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# Aim & Objectives

## Aim

Design and evaluate a quantum-secure satellite-ground system using BB84, AI, and error correction.

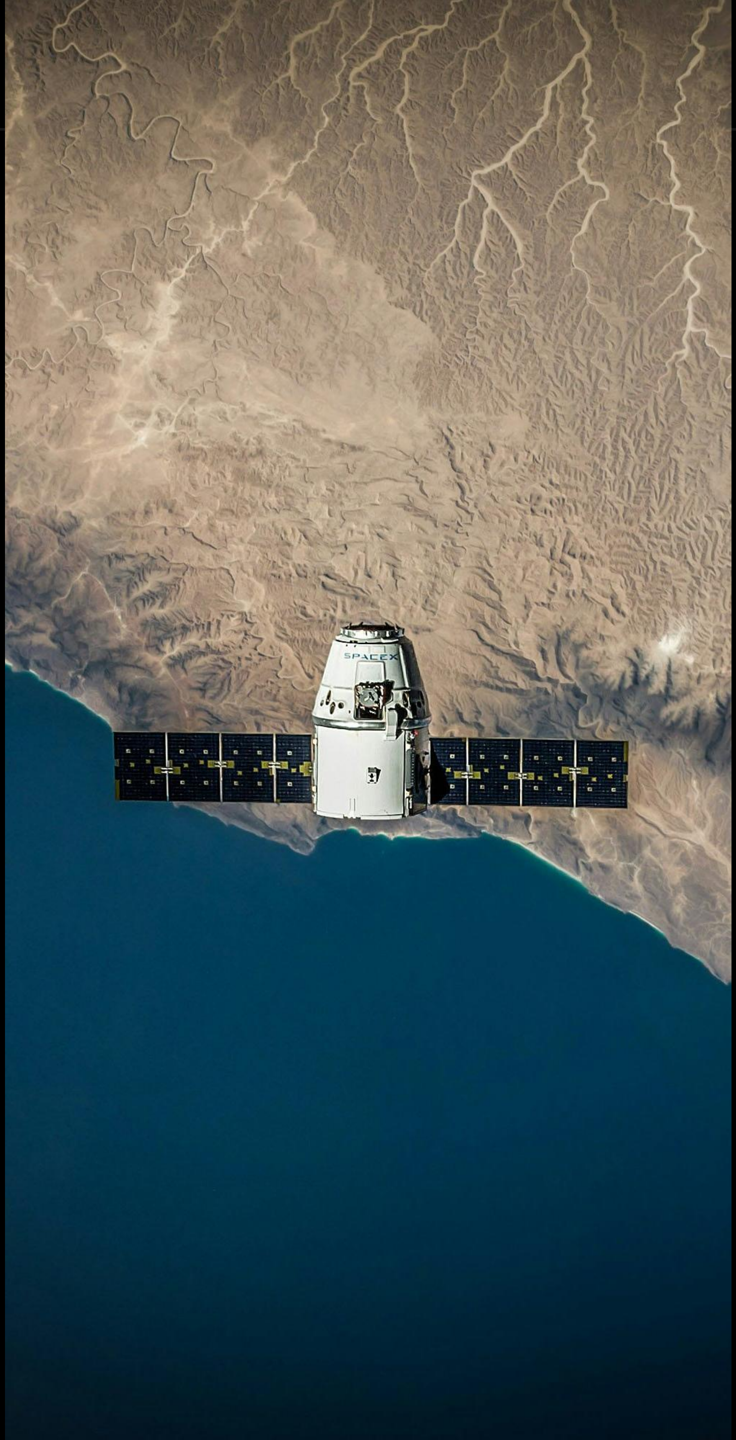
## Objectives

01 Simulate BB84 QKD with noise and photon loss

02 Apply Shor's Code for quantum error correction

03 Optimize latency and success rate using AI

04 Analyze with MATLAB & compare with classical methods



BB84 QKD

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# Research Gap

No current implementation unifies BB84 QKD, Shor’s Code, and AI latency optimisation in satellite-ground simulation

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# Literature Insights

### Micius satellite

Yin et al., 2017

Micius satellite achieved space-based QKD over 1200 km

### QKD Security Limits

Pirandola et al., 2020

Practical limitations in QKD

### Quantum Error Correction

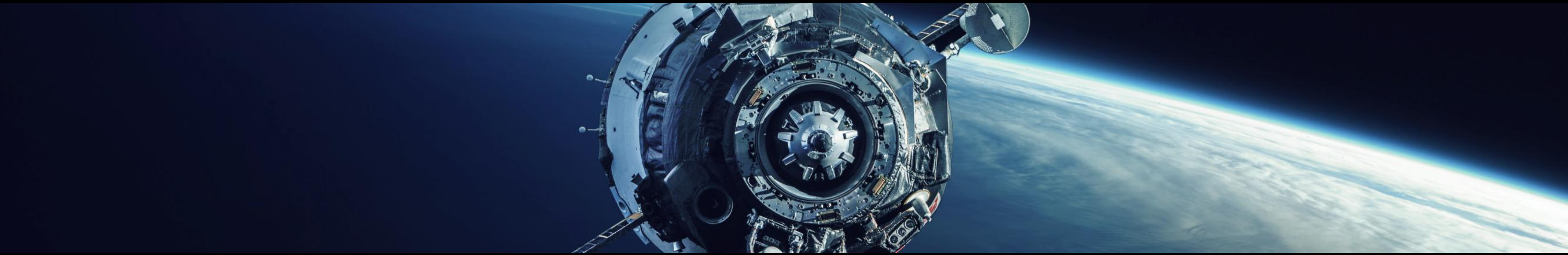
Laflamme, 2022

Shor's Code boosts error tolerance

### AI in Network Optimisation

Saeed et al., 2022

Enhanced routing, beamforming, prediction



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# Methodology

## Design-Based Research

Iterative development approach

## Tools

Python, Qiskit, IBM AerSimulator, MATLAB

## Process

Code → Simulate → Export → Analyse

# Tools and Platforms

Qiskit

python™

IBM **Quantum** System One

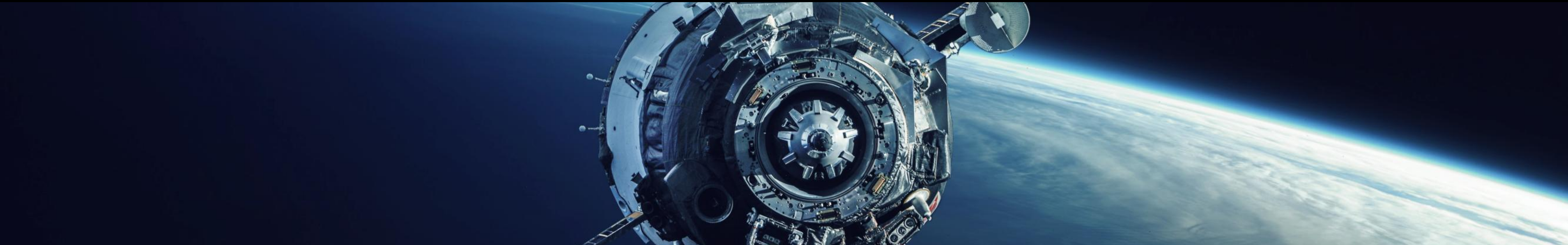
MATLAB®

jupyter

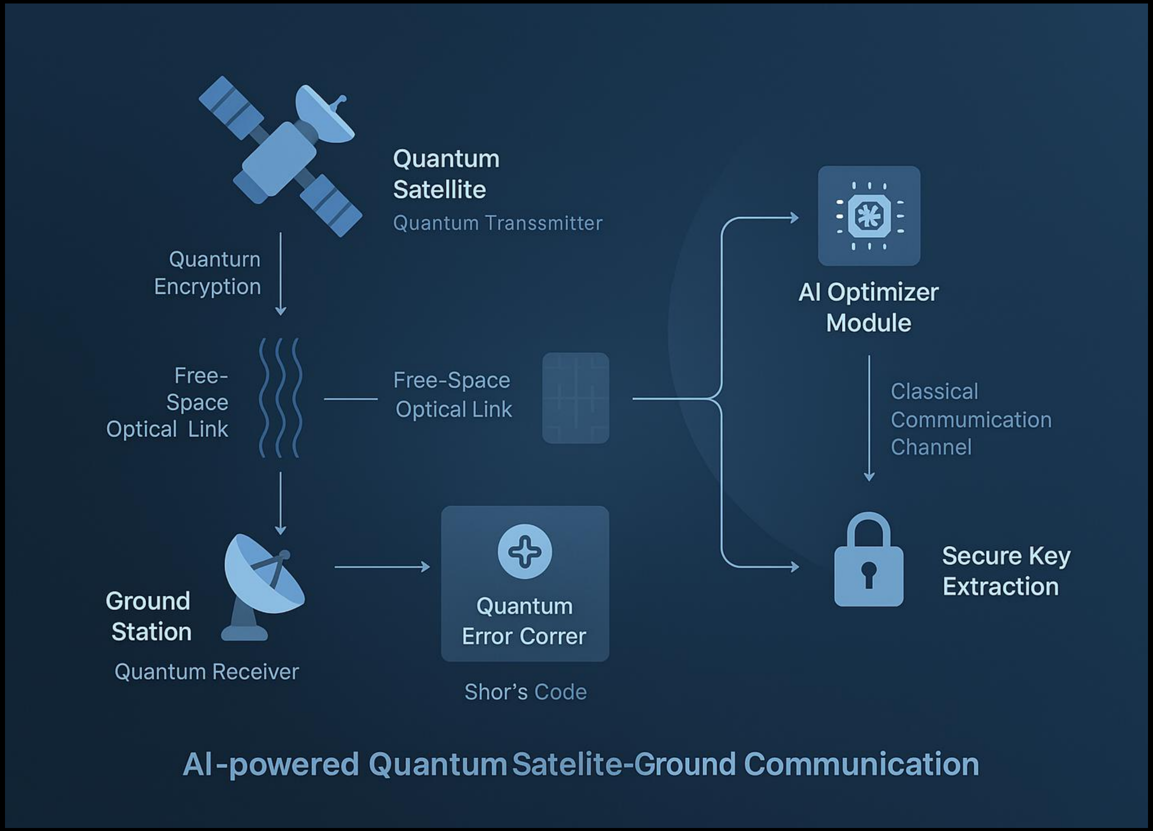
Visual Studio Code

Excel

Microsoft Teams



# System Architecture




This system integrates BB84 protocol, Shor's Code for QEC, and AI latency optimizer.

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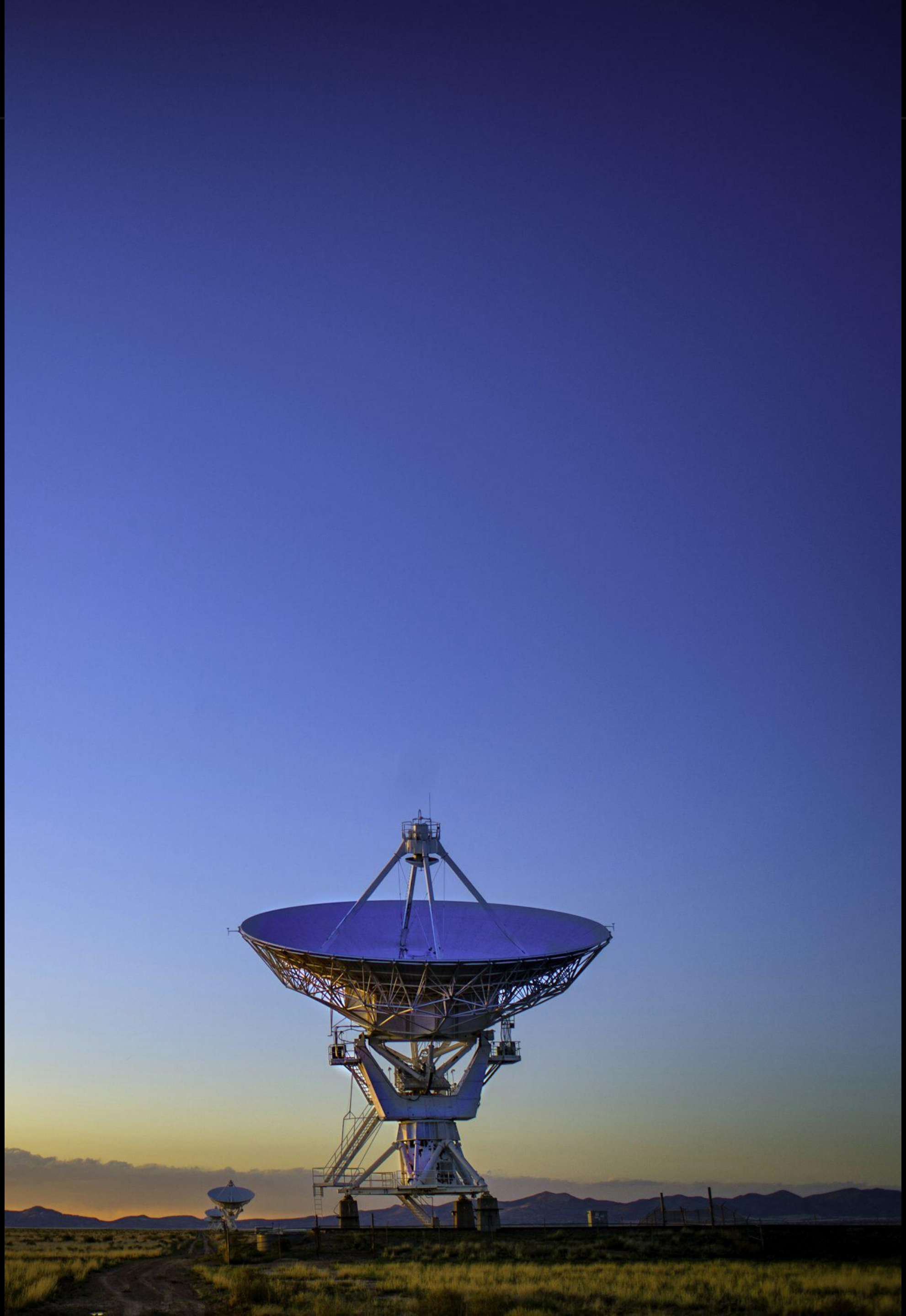
# Design & Implementation

### BB84 with Noise
Simulated realistic quantum channel errors

### Shor's 9-Qubit Code
Implemented for error resilience

### AI Tuning
Optimised latency and key generation success

### MATLAB Export
Quantitative validation through plots



BB84 QKD

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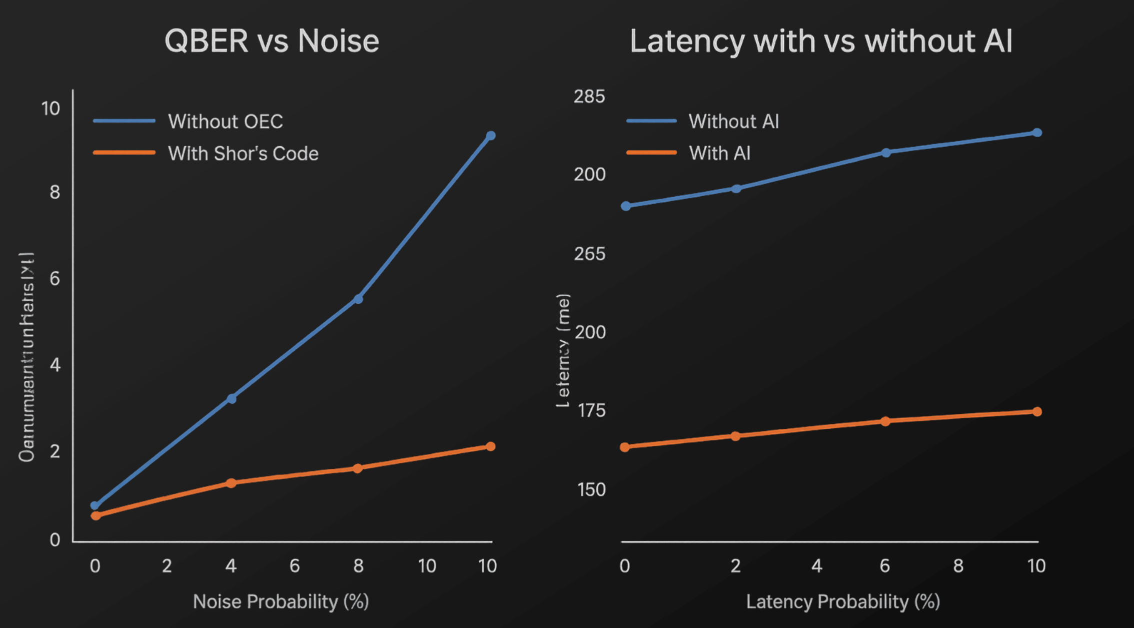
# Results & Analysis

## Observations

- Latency ↓ ~18%
- Success Rate ↑ to 100%
- QBER ↓ from 9.3% → 0.5%

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# Matlab Results & Analysis

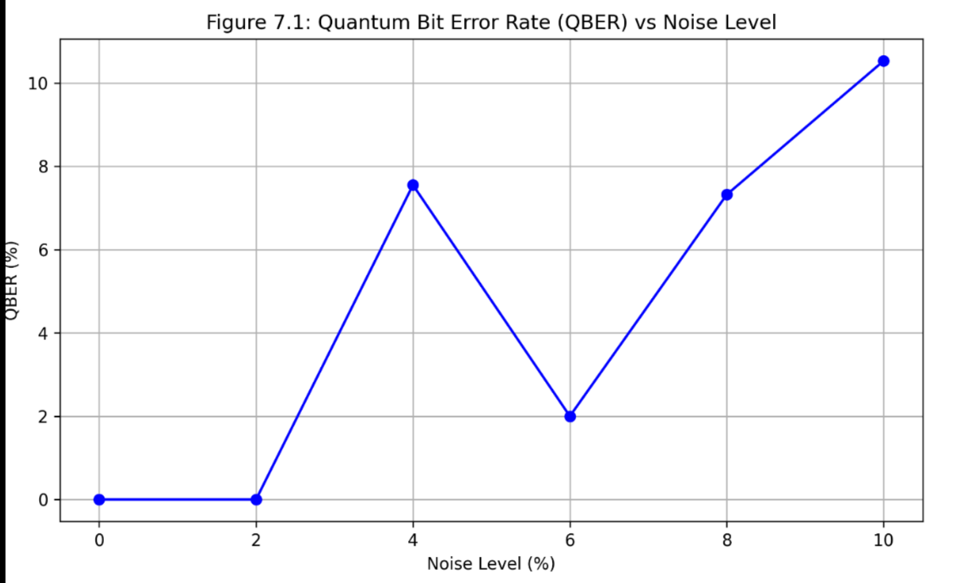


*Figure 27 - Quantum Bit Error Rate (QBER) vs Noise Level. With increasing environmental noise, the QBER increases nonlinearly, and we demonstrate that as the loss of the satellite channel becomes high, making secure quantum communication in this channel increase*

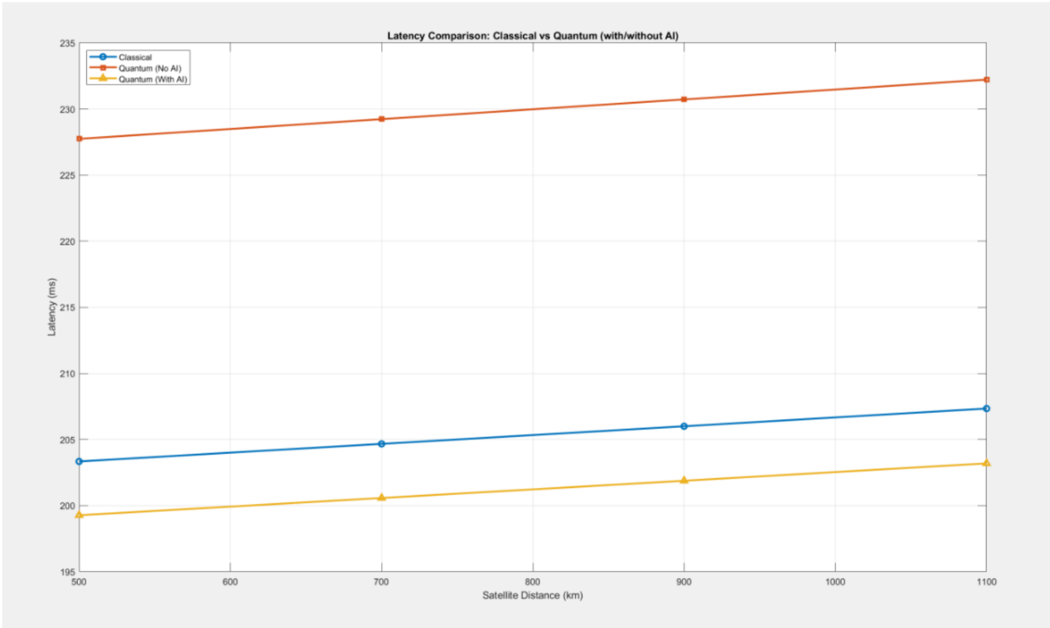


*Figure 29 - Classical vs Quantum Latency Comparison*

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# Evaluation & Reflection

## Strengths

Integrated solution, custom simulation code, accurate MATLAB analysis

## Limitations

- Real-time satellite hardware not tested
- Classical AI models used, not quantum ML

## Validation

Consistent results across simulated satellite parameters


# Conclusion

- Shor's Code reduced QBER by up to 65%
- AI Optimization reduced latency by ~18%
- 100% key agreement rate sustained across noise levels
- Quantum setup outperformed classical in secure key generation and adaptability

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# FutureWork

Post-quantum cryptography integration

Deploy in real optical satellite testbeds

Use quantum-enhanced AI models

# Thanks

For Your Attention