א - SYSTEMS

Phase 0 Technical Overview

Software-first architectures for autonomous quantum computing satellite missions

SPACE-ALEPH - Pre-incorporation research - 2026

1. Introduction

א - SYSTEMS is a research-stage initiative focused on the development of software-first architectures for autonomous and secure space systems.

This document outlines the technical motivation, scope, and early work conducted during Phase 0, with a focus on quantum computing satellite missions.

2. Problem Statement

Modern space missions are increasingly constrained by operational cost, limited ground contact, and growing system complexity.

Advanced payloads-particularly quantum computing and quantum communication systems - introduce additional sensitivity to environmental disturbances, thermal instability, and operational timing.

Traditional ground-driven mission operations do not scale well under these constraints, motivating a shift toward onboard autonomy and software-centric system design.

3. Why Quantum Computing Satellites

Quantum computing satellites represent a class of next-generation space systems with potential applications in secure communications, distributed computation, and fundamental physics research.

However, such payloads impose unique mission-level requirements:

- Strict environmental control
- Limited operational duty cycles
- High sensitivity to faults and disturbances

These characteristics make them a natural driver for advanced autonomy and resilient mission software architectures.

4. Phase 0 Scope and Constraints

Phase 0 is explicitly limited to conceptual design, simulation, and software prototyping.

Scope limitations include:

- No hardware development
- No flight-qualified systems
- No classified or restricted technologies

The objective of Phase 0 is to establish technical foundations, not to deliver deployable space hardware.

5. Technical Focus Areas

During Phase 0, א - SYSTEMS focuses on the following technical domains:

- Orbital mechanics and mission simulation
- Autonomy-oriented mission architectures
- Fault detection, isolation, and recovery (FDIR) concepts
- System-level implications of quantum payload constraints

Emphasis is placed on clarity, modularity, and extensibility rather than performance optimization.

6. Current Work and Artifacts

Ongoing work is publicly documented and includes:

- Mission simulation code for orbit propagation
- Architecture and autonomy research notes
- Early system-level design documentation

Public repositories:

- https://github.com/SPACE-ALEPH/mission-sim
- https://github.com/SPACE-ALEPH/autonomy-notes

7. Roadmap Overview (Phase 1-3)

Phase 1:
Expansion of autonomy logic, fault models, and simulation fidelity.

Phase 2:
Integration with representative mission scenarios and external validation through collaboration or academic partnership.

Phase 3:
Preparation for hardware-in-the-loop testing or hosted payload concepts, subject to resources and partnerships.

8. Status and Next Steps

א - SYSTEMS is currently in Phase 0 (pre-incorporation research).

Immediate next steps include:

- Continued development of simulation tools
- Refinement of autonomy concepts
- Engagement with technical advisors and collaborators

This document will evolve as technical understanding matures.