Kayhan Space Capabilities White Paper

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This document is in response to the "Technology Gaps for Rapid Response Missions to Near-Earth Objects, Interstellar Objects, and Long-Period Comets" abstract. The material is proprietary and **unclassified**.

Current Contracts and Programs in the SDA Mission Area

Contracting Org.	Contract Type	Period of Performance	Contract No.
NASA	Phase 1 SBIR	5 months	80NSSC22PB062
USAF, AFMC AIR FORCE RESEARCH LABORATORY	Phase 1 STTR – Orbital Prime	6 months	FA8750-22-C-1018
USAF RESEARCH LAB - AFRL	Phase 2 STTR	15 months	FA864921P1517
USAF OFFICE OF SCIENTIFIC RESEARCH	Phase 3 STTR	24 months	FA955021P0008

Executive Summary

The space domain plays a fundamental role in providing our national security and supporting our modern way of life. However, it is also an increasingly contested and congested domain. Rapid response to NEOs, ISOs, and LPCs is a crucial capability to planetary defense and space sustainability.

With extensive experience in spaceflight operations, high-performance computing, and machine learning, Kayhan Space has developed an unparalleled suite of high-performance spaceflight operations and safety tools, namely **Pathfinder**, **Eagle**, and **Gamut**. Through these advanced technologies, Kayhan Space is on a mission to bring next-generation advanced space domain awareness capabilities that directly address the two technology challenges and opportunities listed in the abstract:
- Challenges related to rapid implementation, integration, testing, and launch
- Challenges related to hypervelocity flybys of small target and/or active bodies (i.e. comets)

Kayhan Mission Capabilities

1.   Satellite Conjunction Processing – TRL 8-9

Satellite conjunction assessment (CA) and collision avoidance (COLA) are Kayhan's core competencies. Kayhan Pathfinder is a comprehensive CA and COLA maneuver generation

platform that is currently providing operational support to **more than 500 commercial LEO satellites across more than a dozen operators**.

● *Automatic and Manual On-Orbit CA Screening*: *Pathfinder Rapid Screener* is a high-fidelity, rapid, and full-featured on-orbit satellite CA screening service that is designed for speed and scalability. This service can perform the screening of several space objects against the entire space object catalog in less than 60 seconds. Users can also submit maneuver plans, ephemerides, state vectors, TLEs, SP trajectories, and other file formats to be screened for potential conjunctions against select objects or the entire catalog.

● *Maneuver Planning CA Screening*: The Kayhan team specializes in optimal COLA maneuver generation algorithms. *Pathfinder COLA Maneuver Generator* is a collection of advanced optimization algorithms that consider operators' physics-based and operational constraints to generate maneuver plans that are ready to be executed.

● *Launch CA Screening*: *Pathfinder Gamut* is a high-performance launch CA software that assesses the collision risk of launch trajectories in record time. Gamut rapidly screens launch vehicles and the subsequent stage trajectories for potential collisions with space objects.

2. Orbit Propagation, Estimation, and Visualization – TRL 7-8

Kayhan has developed an advanced, modern, and scalable orbit propagation & estimation library called **Eagle**. Eagle is the workhorse of the Kayhan platform and has been built from the ground up in response to our own needs for fast, scalable, and high-fidelity propagation of space objects. Kayhan Space systems rely on Eagle for tracking and propagating **thousands** of objects concurrently in a high-fidelity orbital environment. Eagle can be used to accurately propagate the motion of space objects in **LEO, GEO, xGEO, Cislunar**, and even **interplanetary** space. The Eagle propagator is paired with a cutting-edge Kayhan visualization tool suite to visualize the propagated orbits, potential conjunction events, maneuver thrust vectors, and much more capabilities.

How Kayhan Space's Capabilities Address Technology Challenges

1. Rapid Implementation, Integration, Testing, and Launch

Gamut, a high performance launch CA software, would allow the proposed spacecraft "stored on the shelf" to be safely and rapidly launched to an intercept trajectory. Additionally, when paired with Pathfinder, the trajectory could be rapidly determined to ensure an accurate and effective flight path to intercept the target object.

2. Hypervelocity Flybys

Pathfinder, powered by Eagle, will help solve the issues of precise, autonomous navigation. The Kayhan Space team has developed advanced, proprietary algorithms that can alleviate the time, cost, and pressure created by ground-in-the-loop processes. Furthermore, the propagation capabilities of Eagle can increase the probability of intercept and decrease the likelihood of a failed flyby.